THE

EDINBURGH

PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF

THE PROGRESS OF DISCOVERY IN NATURAL PHILOSOPHY, CHEMISTRY, NATURAL HISTORY, PRACTICAL MECHANICS, GEOGRAPHY, STATISTICS, AND THE FINE AND USEFUL ARTS,

FOR

JUNE......OCTOBER 1819.

CONDUCTED BY

DR BREWSTER AND PROFESSOR JAMESON.

TO BE CONTINUED QUARTERLY.

VOL. I.

EDINBURGH:

PRINTED FOR ARCHIBALD CONSTABLE AND COMPANY.

1819.

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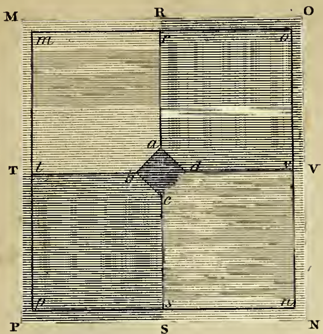

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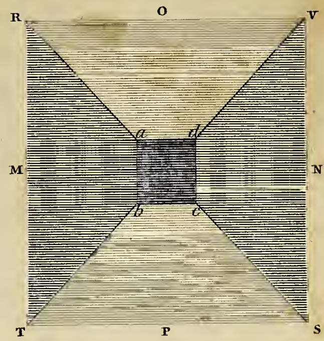

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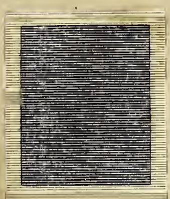

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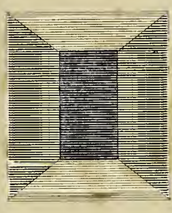

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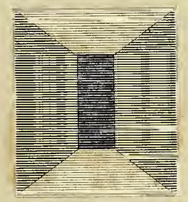

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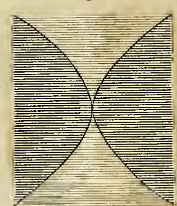

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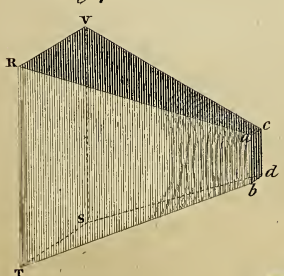

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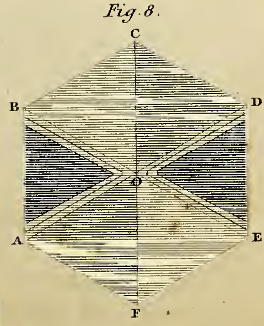

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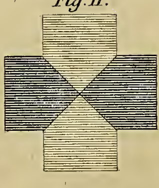

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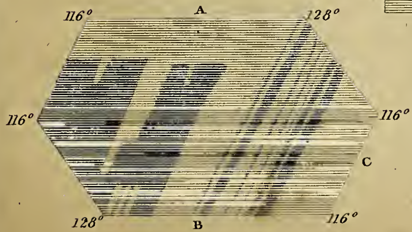

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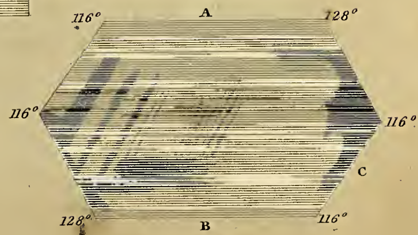

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PLATE II.

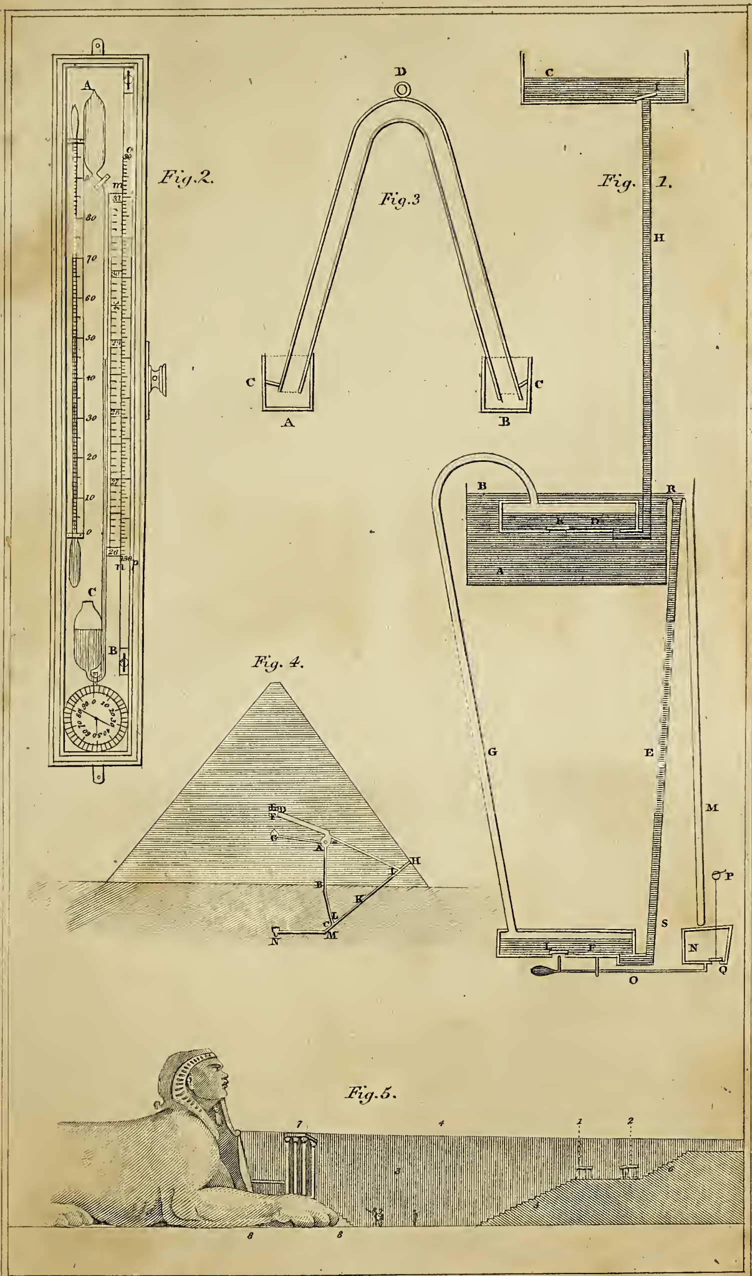

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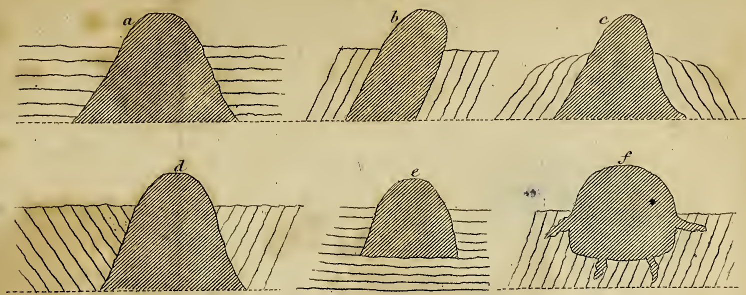
PLATE III.

Fig. 1.
Granite.



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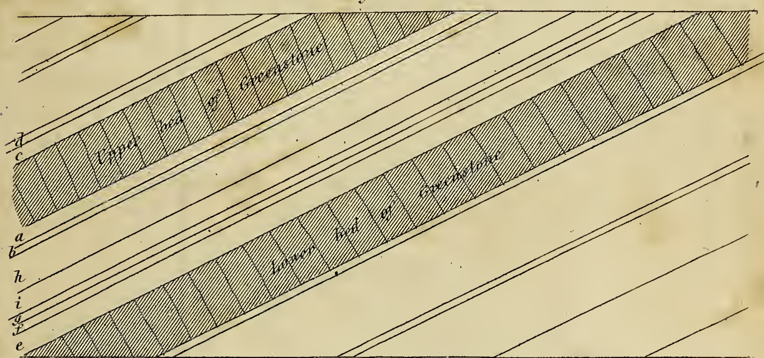

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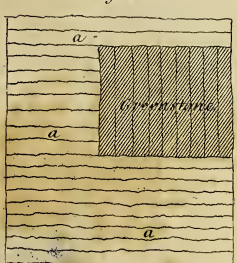

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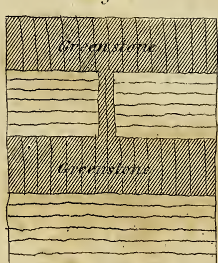

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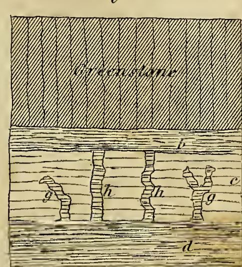

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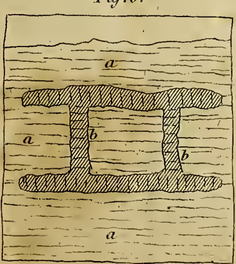

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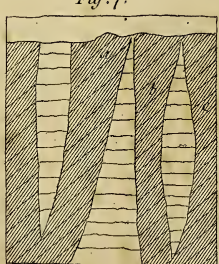

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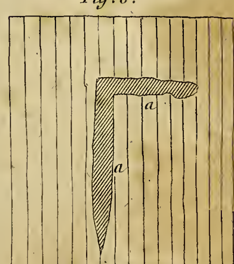

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PLATE IV.

IEW OF THE UPPER PART
of Bagnes, after the Debacle of the 16th June 1818.

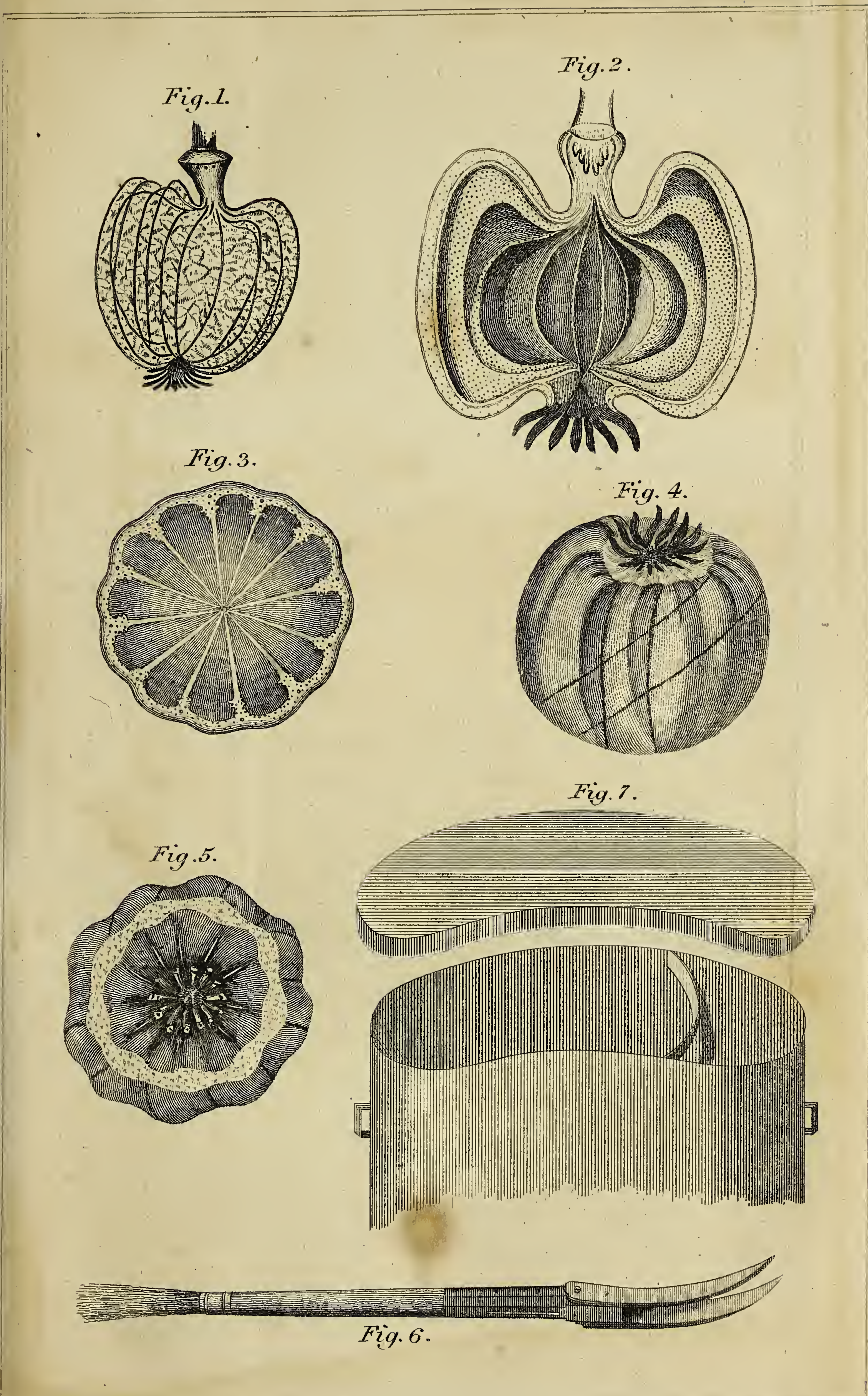
Drawn by M. Burdallet, Geneva; for the Ed

Engraved by W. & D. Lizars Edin.r

Drawn by M. Burdallet, Geneva, for the Edin. Philosophical Journal

Engraved by W. & D. Lizars Edin.

PLATE V.



Drawn by J. Young

Engd. by W. & D. Lizars

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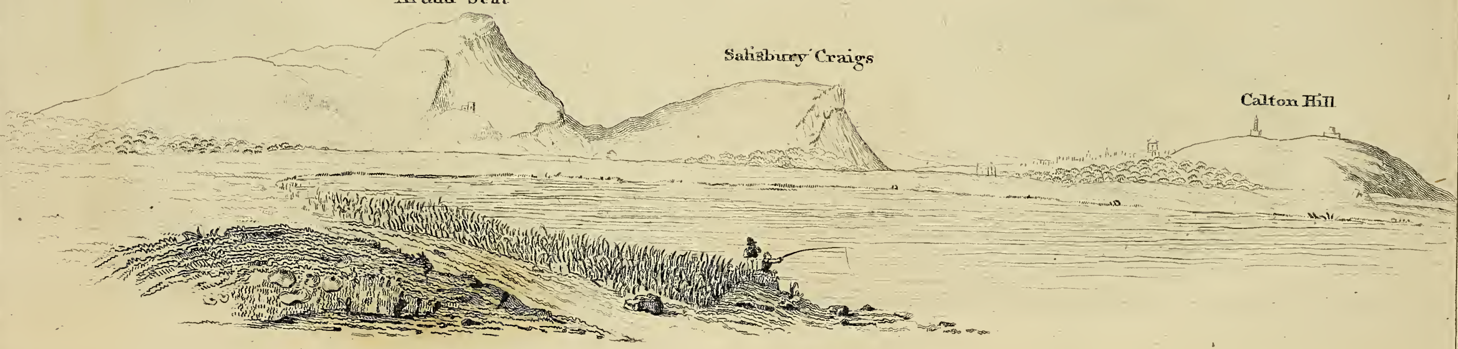

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BARTHOLINUS ON DOUBLE REFRACTION

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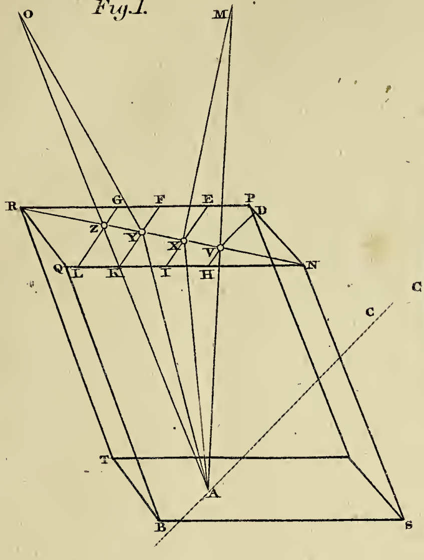

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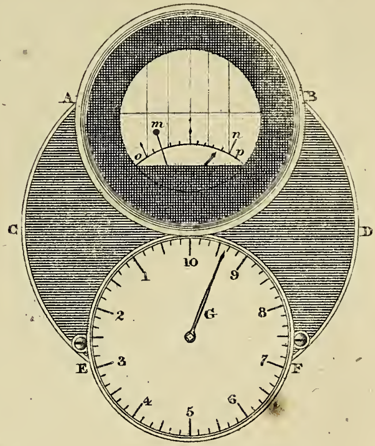

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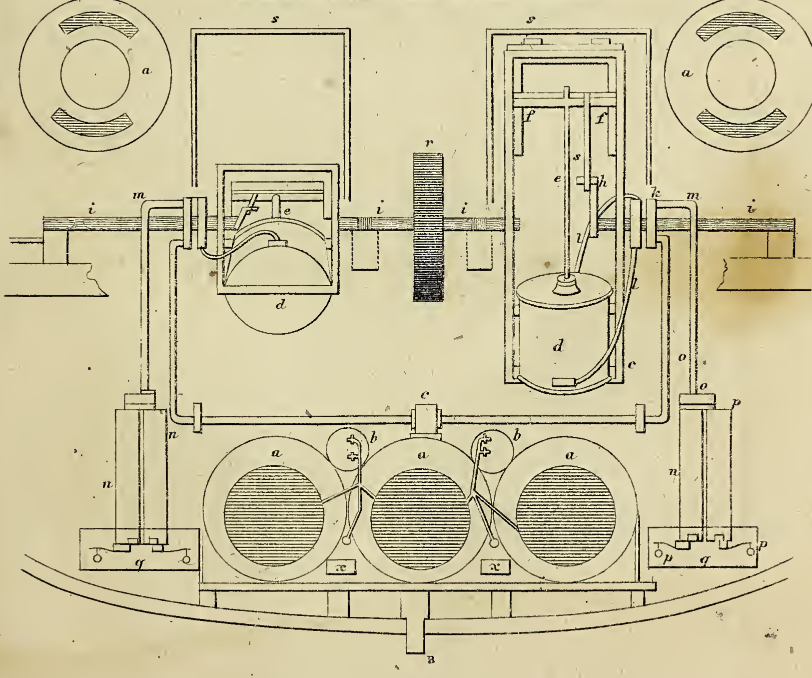

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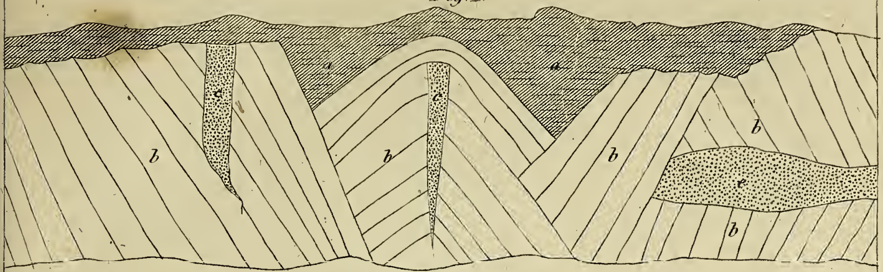
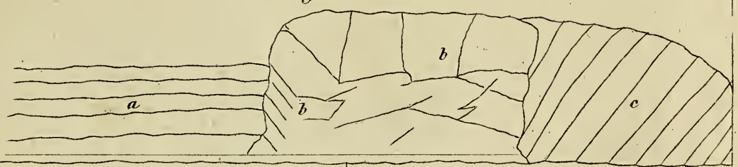
PLATE VIII.

Fig. 1.



Section in Albany Street

Fig. 2.



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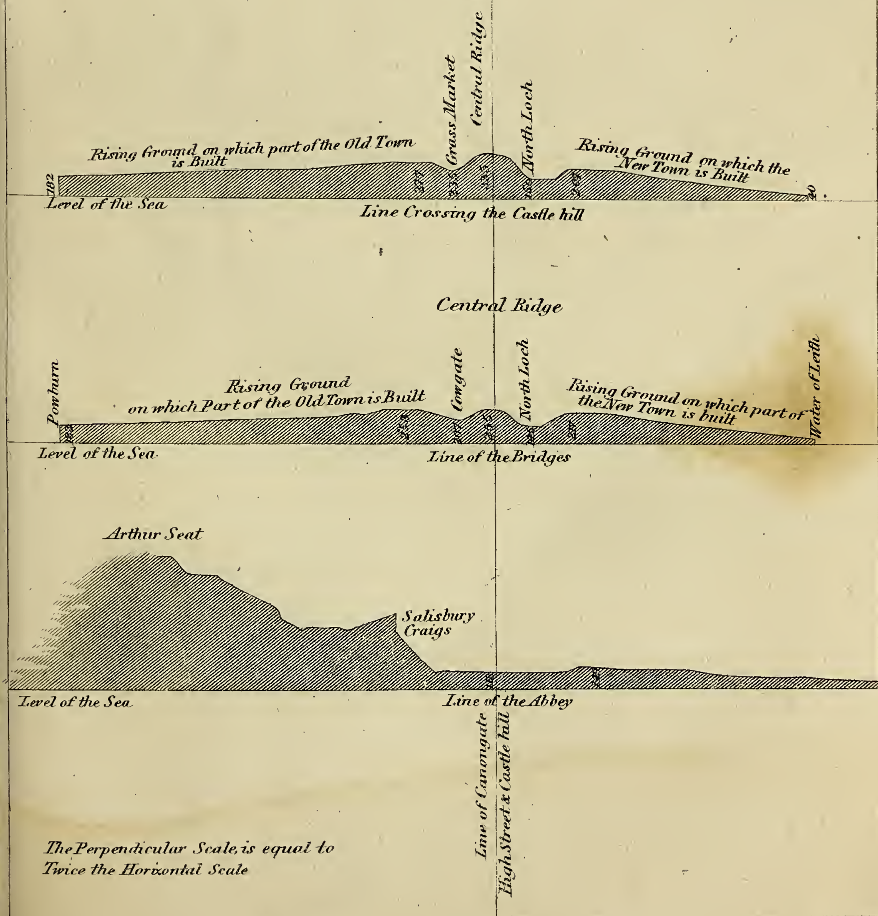

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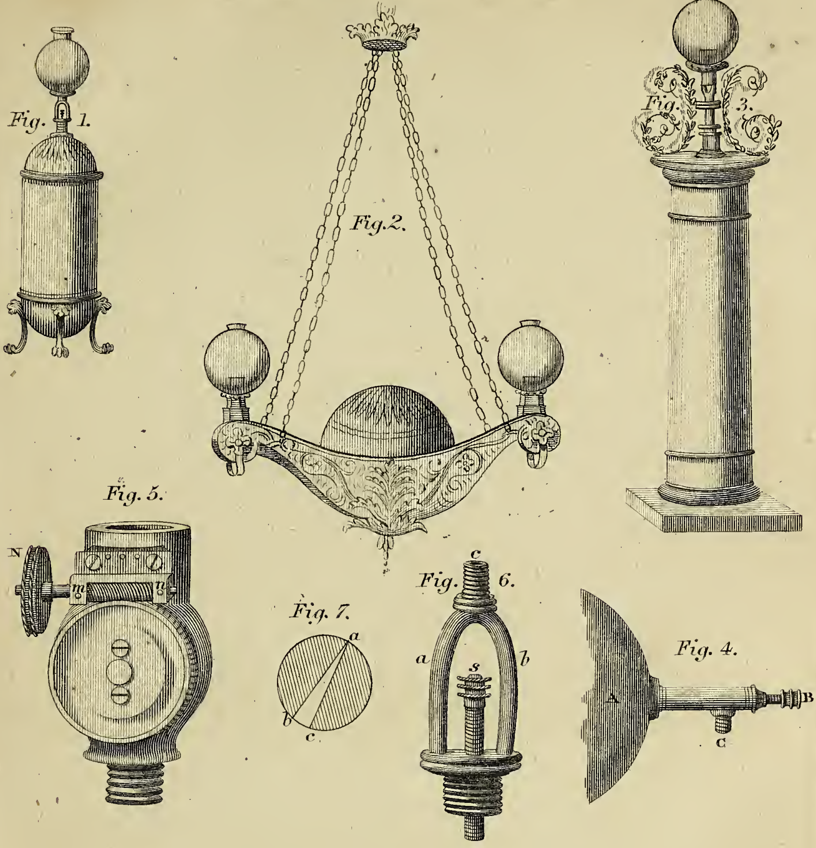
Mr. GORDON'S PORTABLE GAS LAMP.



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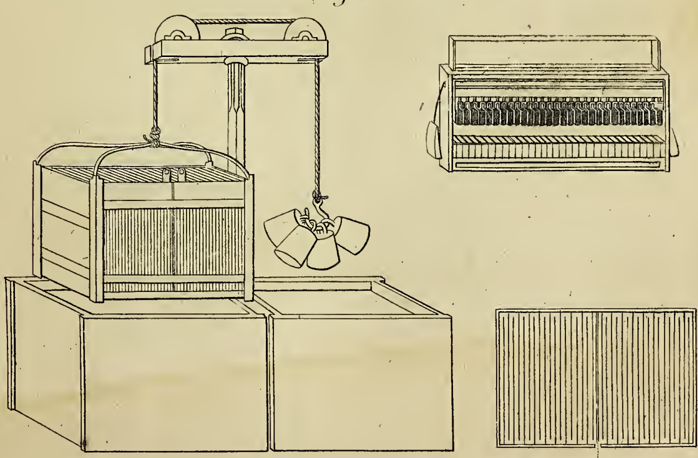

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THE

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PHILOSOPHICAL JOURNAL.

ART. I.—*On a New Optical and Mineralogical structure, exhibited in certain specimens of Apophyllite and other minerals.** By DAVID BREWSTER, LL. D. F. R. S. Lond. and Edin. Communicated by the Author.

ABOUT the end of the year 1816, I received from Major Petersen some fine crystals of the *Apophyllite surcomposée* of Haüy, from Fassa in the Tyrol. Upon exposing them to polarised light, I found that they had one axis of Double refraction; but I was surprised to observe, that the system of coloured rings, with which this axis was surrounded, was composed of unusual tints, the only colours of the first orders being *bluish-violet* and *greenish-yellow*, separated by a ring of *white* light. In order to ascertain the origin of these anomalous colours, I collected all the Faroe Apophyllites which could be procured, and upon subjecting them to a minute examination, I discovered the very extraordinary structure of this mineral, and was led to the results which it is the object of the present paper to describe.

The Apophyllites from Faroe, crystallize in quadrangular prisms, with flat summits, having an almost imperceptible truncation upon the angles, and also in single and double four-sided pyramids, the planes of which correspond with the small truncations upon the prism, and form angles of 60° with those on the opposite side. The greater proportion of the quadrangular prisms have their planes highly polished, and very much stri-

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* This paper was read before the Royal Society of Edinburgh on the 1st of February 1819.

ated; but there are others where the surface is less splendent, and where the crystal has the appearance of being more perfectly formed, as well as more compact and more transparent.

Having cut off the slice, about the fiftieth of an inch thick, which formed the summit of a quadrangular prism, I found that it had only one axis of double refraction, and produced the same set of coloured rings, with the same anomalous tints, as the apophyllite from Fassa; but upon removing a second slice of the same size, it exhibited the beautiful appearance shewn in Fig. 1. This figure, resembling a tessellated pavement, is composed of four rectangles, RT, RV, VS, ST (Plate I. Fig. 1.), surrounded by a border MROVNSPT, and having at its centre a rectangle *a b c d*, with its sides opposite to the angles of the quadrangular prism. The tints depolarised by the four squares, were below the *white* of the first order, and that of the central rectangle was imperceptible; but in order to display the full beauty of the figure, and to ascertain the character of its tints, I placed the slice upon a plate of sulphate of lime, which polarised a yellow of the second order, so that the line MN coincided with the principal axis of that crystal. The brilliant yellow of the sulphate of lime was raised to a bright red, by its union with the tint of the squares RT, VS of the apophyllite, and was depressed to a fine blue by the opposite action of the tints in the squares RV and ST. The rectangle *a b c d* remained yellow, and the border MONP had the same tints as the adjacent rectangles.

Some of the pyramidal crystals are destitute of the tessellated structure, while others exhibit nearly the same phenomena as those which we have described; but owing to the truncation of the angles, the pattern has the appearance shewn in Fig. 2. where the border shewn in Fig. 1. is completely wanting. By taking a succession of slices from the pyramids, we see the structures shewn in Figures 3, 4, and 5, and we sometimes obtain the appearance represented in Fig. 6, where the central rectangle is wanting, and the *tesselæ* are bounded by irregular curves.

If we place the slices of apophyllite upon a divided apparatus, and expose them to a polarised ray, it will be found, that at a perpendicular incidence, the first slice, and the rectangle *abcd* in subsequent slices, have no effect whatever in depolarising the incident light, but that they acquire it by inclining the polarised ray, and have therefore one axis and a circular system of rings round the axis of the prism. The rectangles RV, VT, on the other hand, will be found to depolarise a bluish white of the first order, when the lines RS or TV are parallel or perpendicular to the plane of primitive polarisation, but all their tints vanish when the lines MN, OP come into that plane, in the same manner as in plates of mica, and all other crystals with two axes.

If we incline the apophyllite in the direction MN or OP, when RS or TN are in the plane of primitive polarisation, the tint will gradually diminish; and at an angle of about 17° 4′ with the axis of the prism, it will entirely vanish, as the refracted ray now passes through one of the poles of no-polarisation. By increasing the inclination still farther, the tints recommence, but with an opposite character, and the whole square MONP is covered with an uniform positive tint, the boundaries of the four large rectangles and the small central one being no longer seen. The cause of this singular result will be better understood from the following deductions, which the preceding experiments authorise.

1. The apophyllites from Fassa and Uto, have one axis of double refraction and polarisation, which is positive like that of quartz.

2. The central rectangle *a b c d* of the tessellated apophyllite from Faroe, and the minute stripes of it formed by the lines *m o n p m*, *a r*, *c s*, *b t*, *d v*, have likewise one axis of double refraction.

3. The four rectangles RT, RV, ST, SV, have two axes of double refraction, the principal one of which is positive, and the inclination of the resultant axes is about 34°.

4. The plane of the resultant axes of the rectangles ST, RV, passes through their diagonals MN; but the same plane in the rectangles RV, ST passes through OP. Hence it follows,

5. That the four rectangles, even if they were not separated by the portions with one axis, would not form an uniform plate, and that RV is the same as RT turned round 90°; SV the same as RT turned round 180°; and ST the same as RT turned round 270°.

6. This singular construction has no resemblance to that of macled or hemitrope crystals, for the four rectangles are por-

tions of one crystal, whereas the combined crystals which form a macle, preserve each their separate form, and are merely two crystals mechanically united.

These conclusions enable us to explain the uniformity both in the colour and character of the tints, over the whole plate MNOP, when it is inclined more than 17° 4′ in the plane MN. Beyond this inclination, we observe the tints in RT, SV, without the poles of no-polarisation, and therefore they are positive, or have the same character as the tints produced by the rectangle *a b c d*, and the rectilineal portions that have only one axis;—that is, these tints will rise into higher orders when crossed with sulphate of lime. In like manner, in the rectangles RV and ST, we observe the tints in a plane perpendicular to that of the resultant axes; and as these will also rise to higher orders when crossed with sulphate of lime, the character of all the tints in the plate will be positive, and they will nearly have the same intensity when the inclination of the plate exceeds half the inclination of the resultant axes.

In examining the action of Apophyllite in planes perpendicular to the axis, I had the advantage of very large pyramids which Major Petersen, to whom I had exhibited the preceding results, brought me from the Faroe Islands in the autumn of 1817; and from the free access which I have at all times had to the cabinets of Mr Allan and Sir George Mackenzie, which are peculiarly rich in apophyllites, I have been enabled to obtain results of greater generality and interest.

Through one of these pyramidal crystals, which is shewn in Fig. 7, I observed the two images formed by double refraction, and found that the principal axis was positive, and that the maximum deviation of the extraordinary ray was much inferior to that of Mesotype. Upon transmitting polarised light through two of the broadest faces, they appeared covered with fringes, as shewn in Fig. 7, those near the summit *a b* being *bluish-violet* and *greenish-yellow*, and those produced at a greater thickness being *green* and *pink*. The fringes were bent at the meeting of the pyramidal planes, as shewn in the figure; and, when the light was transmitted through the faces VR*a c*, TS*d b*, the same fringes appeared; but the green and pink tints commenced at a greater distance from the summit than formerly, although the thickness *a b* was now 0.09 of an inch, whereas *a c* was only 0.02. In some of the pyramidal crystals, I have found the force of the axis in the plane of the laminæ to be so weak as to be nearly *four* or *five* times less than in the quadrangular prisms; and, in several of these last crystals, the maximum tint decidedly varies in different parts of the length of the prism, so as to produce a succession of coloured bands at the same thickness.

Of all the crystals which have one axis of double refraction, Apophyllite is the only one in which the colour of the rings deviates from those of Newton's scale. This deviation is very common, and, indeed, almost universal, when the rings are formed by the joint action of two axes; and hence it appears more than probable, that the single positive axis of the Fassa apophyllite is the resultant of two equal and rectangular negative axes lying in the plane of the laminæ *.

It appears from the preceding observations, that there are at least three different kinds of Apophyllite, which may be distinguished from one another by physical characters of a very palpable kind †. The tessellated structure which is possessed by one of these kinds is a property so singular and so distinctive, that I would propose to mark it by the name of *Tesselite.*

The optical structure of apophyllite, which I have now described, may be discovered without the aid of polarised light, in specimens of this mineral that are in the course of decomposition. In a specimen of the variety called *Albin*, from the cabinet of Mr Brooke, I have observed the central rectangle in a state of integrity and translucency, while all the surrounding portions had assumed a white opacity, from partial disintegration.

The interior conformation of Apophyllite presents us with the new fact in crystallography, that a regular crystalline form arises

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* See *Phil. Trans.* 1818, p. 247.

† We trust that some able analyst will be induced to examine the chemical composition of these different substances.

Since this paper was printed, I have learned from M. Berzelius, that he has analyzed the Apophyllite of Uto; and, as this distinguished chemist has kindly offered to undertake the analysis of the Tesselated Apophyllites from Faroe, we expect to be able, in our next number, to publish the results of his analysis.

in some cases from the union of smaller crystals, whose homologous sides are not parallel to each other. The Abbé Hauy very ingeniously conjectured that the hexaedral Arragonite was a compound crystal of this kind, consisting of four rhomboidal prisms; and Malus has shewn that such a combination is quite compatible with its doubly refracting structure. If Arragonite had only one axis, as Malus believed, the mineralogical hypothesis would not have been at variance with the optical results; but as I have elsewhere shewn * that Arragonite has two axes, and that their united action is not symmetrical round the axis of the prism, it follows that the hypothesis of Haüy is radically incompatible with the optical phenomena of Arragonite.

These remarks are equally applicable to every hypothesis respecting the formation of Arragonite, in which a given line in one crystal, lying in the plane of its resultant axes, is not parallel to a line similarly situated in all the other crystals. In many Arragonites which I have examined, the hexaedral prism is composed of irregular portions, one set of which has the plane of their resultant axes in a direction different from the other set; but there was no appearance of a tessellated structure, as will be seen from Figures 9 and 10, where the shaded parts represent those portions which have the plane of the axes in the direction AB, while the white parts have the plane of their axes in the direction AC.

In examining the optical phenomena of Sulphate of potash, I have discovered a singular tessellated structure, which may throw considerable light upon that complicated crystalline form, the Bipyramidal Dodecahedron. My first experiments on this salt were made with rhomboidal prisms, whose angles were 114° and 66°, which I found to have two axes of double refraction. Among other crystals of sulphate of potash, I found hexaedral prisms and bipyramidal dodecahedrons †. The former had only one axis, and I therefore expected that the bipyramidal crystal would have the same property. Upon cutting a plate, however,

* See *Phil. Trans.* 1818, p. 201, 202;—and the *Journal of the Royal Institution*, vol. iv. p. 112.

† Count Bournon makes the primitive form of sulphate of potash the bipyramidal dodecahedron. See his *Catalogue*, &c. p. 181.

perpendicular to the axis, I was surprised to observe the tesselated structure shewn in Fig. 8, and to find that each of the six equilateral triangles had two axes of double refraction, of the same character and intensity as those which occurred in the rhomboidal prism. The general tints in the triangles AOB, DOE, descended to zero by a series of fringes at their junctions with the adjacent triangles, and the plane of the resultant axis bisected each of the angles at the centre of the hexagonal section. These facts put it beyond a doubt, that the bipyramidal dodecahedron was, in this case, neither derived from the rhomboid, which has always one axis of double refraction *, nor was the primitive form of the crystal; but was formed by some new process, which had not been recognised by mineralogists. The perfect similarity between the properties of the rhomboidal prism and the bipyramidal crystal, suggested the idea that the latter might be composed of the former, in such a manner that each of the opposite faces of the pyramid were the two sides of the prism. Upon measuring the angle formed by these opposite faces, I found it to be 114°, the very same as the angle of the rhomboidal prism; and, as I had observed that these two forms were the product of the same crystallization, and that the one was sometimes united to the other, I had no longer any doubt that this was the true origin of the bipyramidal dodecahedron of sulphate of potash.

A structure somewhat analogous to the one we have now described appears in the cruciform Harmotome, which Romé de Lisle supposes to consist of two compressed dodecahedrons, crossing one another at right angles, so that their axes are coincident. Haüy † considers this opinion as highly probable; but he at the same time remarks, that the cruciform variety may still be regarded as a simple crystal. In order to determine this point, I formed two planes perpendicular to the axis, and having exposed the crystal to polarised light, I was enabled not only to confirm the conjecture of Romé de Lisle, but also to ascertain the manner in which the mutual penetration of the crystals takes place.

* Since the publication of my paper on the laws of Polarisation and Double Refraction, in the *Phil. Trans.* for 1818, I have ascertained that crystals whose primitive form is the acute rhomboid, and the bipyramidal dodecahedron, have only one axis of double refraction.

† *Traité de Mineralogie*, tom. iii. p. 197.

The appearance exhibited by the cruciform harmotome is shewn in Fig. 11, where each of the compressed dodecahedrons is reduced as it were to nothing at its axis, by two opposite grooves, in order to admit of a symmetrial combination. Now, it is quite obvious, that the only difference between this compound crystal of harmotome, and the compound double pyramid of sulphate of potash, is, that the former is composed of two crystals, crossing one another at angles of 90°, whereas the latter consists of three crystals, crossing one another at angles of 60°. The combined crystals of Harmotome, however, have not the remarkable property of forming one of the simple primitive forms of crystals, as is done by the combined rhomboids of sulphate of potash.

In various other crystals, I have observed phenomena that have some analogy with those which are the subject of this paper. In Nitre, they are very common, so as to exhibit two adjacent triangles turned round 30° ; and I have noticed a very remarkable appearance of the same kind in a specimen of sulphate of lime from Montmartre, which contained a film of the form of an oblique parallelogram turned round 25°, while all the films around it had suffered no change in the position of their axes.

The results which I have now endeavoured to explain, possess a considerable degree of interest in their optical relations. Their influence upon the doctrines of crystallization is very obvious, and the mineralogist will not scruple to admit, that, if the physiology of mineral bodies shall ever attain the dignity of a science, its foundations must be laid upon optical results, and its progress directed by the unerring light of optical analysis.

EDINBURGH, *Jan.* 29. 1819.

ART. II.—*On the Hyposulphurous Acid and its Compounds.* By J. F. W. HERSCHEL, Esq. F. R. S. &c. Communicated by the Author.

THE experiments about to be described, were occasioned by the following accident. Having set aside, for a few days, a solution of hydroguretted sulphuret of lime, I was struck by observing a bitterness in the liquid, when almost wholly decomposed and colourless, similar to that of sulphate of magnesia, which I could not account for. I at first suspected the presence of that salt, from having possibly employed a magnesian limestone, or from some accidental source, but soon satisfied myself to the contrary. The liquid had lost its property of precipitating iron or copper from their solutions in the state of sulphurets, though it still gave a copious precipitate to the carbonated alkalis, and of course retained lime in some state of union with an acid, which could not be either the *sulphuric* or *sulphurous*, neither of these forming soluble salts with lime. The inquiry now became highly interesting; the experiments of Berthollet, as reported by Dr Thomson in the 2d volume of his Chemistry (4th edition, p. 52), on the decomposition of this identical solution by atmospheric exposure, as well as those of the latter eminent chemist himself on the similar compound of potash (Chem. vol. iii. p. 385), expressly with a view to this point, appearing definitive as to the formation of mere sulphates under these circumstances; while a few trials were sufficient to establish marked distinctions between the acid in question, and any with which I was then acquainted.

Some time after, and when most of the experiments I have to relate were made, and a great part of the present essay written, a friend pointed out to me the following passage in the 5th edition of the work above mentioned: "Besides the two acid compounds of sulphur and oxygen, we have the fullest evidence of the existence of a third, composed of one atom sulphur + one atom oxygen, or of sulphur 100 + 50 oxygen by weight, to which the name of Hyposulphurous Acid may be given. This acid has not hitherto been obtained in a separate state, but can be readily enough obtained united to bases." I immediately procured the edition in question, but found little farther satisfaction. The distinctive characters of the acid, which are very peculiar, are not mentioned; and only one or two of the hyposulphites described in a very general and imperfect manner, while the reader is referred to a paper by Gay Lussac, in the 85th volume of the Annales de Chimie, which I have not yet been able to procure; but, from the known accuracy of Dr T. as a compiler, I have little doubt he has extracted all that is contained on the subject in the French chemist's memoir. On this account, then, and because the composition assigned there to the acid (though sufficiently probable *a priori*, and correct in point of fact, as will soon appear), is supported by no experiment adduced, I may yet venture to hope, that the following experiments, imperfect as they are, being made in the absence of most of the *conveniences* for chemical research, may possess some novelty as well as interest. Even to have verified a known fact, by independent observation, is something, as it gives an air of reality, and a body to science: but such is the nature of chemistry, that it is next to impossible to pursue an independent train of investigation, without encountering some novelty worthy to be recorded.

The Hyposulphurous Acid (which seems to me a better epithet than the Sulpho-Sulphurous, by which I had proposed originally to designate it,) not appearing capable of a separate existence, or, at least, not being procurable in that state in any quantity, or without great difficulty, its characters can only be ascertained by examining its combinations with bases. Some of the principal of these are as follow.

They are (with one or two exceptions) easily soluble in water, and their solutions have usually either an intensely bitter, or an intensely sweet taste.

When heated to a degree below redness, they are decomposed; and, while sulphur separates, a sulphite, or, in some instances, a sulphuret, of the base remains; in which latter case, the sulphur separated is in the state of sulphurous acid. Hence they are for the most part inflammable in the open air. The action of nitric acid, or a stream of chlorine passed through their solutions, converts them into sulphates, separating, at the same time, a quantity of sulphur and free sulphuric acid.

The hyposulphites and their solutions are decomposed by all the other acids except the carbonic (and perhaps one or two more of the less powerful ones), especially when heated with them. Sulphurous acid is disengaged (though not immediately), and sulphur precipitates.

They precipitate lead from its solutions in a white powder, which is hyposulphite of lead.

Oxynitrate of silver, and nitrate of mercury, dropped in excess into a dilute solution of any hyposulphite, precipitate their respective metals in the state of sulphurets. The phenomena of this precipitation, which, in the case of silver, are very curious, will be detailed hereafter. Nitrate of bismuth, when heated (but not otherwise) undergoes the same change; while solutions of manganese, iron, zinc, copper, tin, suffer no such precipitation.

One of the most singular characters of the hyposulphites, is the property their solutions possess of dissolving muriate of silver, and retaining it in considerable quantity in permanent solution.

I shall now proceed to describe the salts I have succeeded in forming, beginning with that of lime, as being the most readily obtained in a state of perfect purity, and therefore best adapted to afford a knowledge, by its analysis, of the composition of its acid.

Hyposulphite of lime may be formed by exposing the hydroguretted sulphuret of that alkali in a flat vessel for ten or twelve days to the air, and in this manner it was also obtained in an experiment described by Dr Thomson. As this mode of proceeding is, however, very tedious and inconvenient, I soon began to look out for more expeditious, as well as more productive processes.

When sulphite of lime is boiled with sulphur in a large quantity of water for a considerable time, the hyposulphite is formed, but usually in small quantity. This process, however, succeeds more certainly, and yields a larger product with some of the other bases than with lime. But, when sulphur is presented in sufficient abundance in a nascent state, to a sulphite also nascent, the circumstances would seem particularly favourable to the union of the sulphurous acid with an additional dose of sulphur; and, on trial, I found it the readiest mode of obtaining the salt in question. But before I describe the process I employed for this purpose, it will be necessary to say a few words on the combination of sulphur with lime.

If three parts of slaked lime, and one part sulphur, be boiled for an hour with twenty parts water, and the liquid decanted while yet hot from the undissolved portion, into bottles exactly full and stopped, a few delicate bundles of orange-coloured crystals, of a plumose or acicular form, are deposited after some days standing; and on emptying the bottles into a flat vessel, a small quantity more forms immediately. If, on the other hand, the solution be allowed to cool, and remain for some hours in contact with the sediment, a very copious formation of them takes place throughout its whole substance, bristling over its surface, and even hanging down from that of the liquid. These crystals, which I do not find described in any of the usual works, are easily separated, by washing, from the greater part of the impurities in which they are formed, though a portion adheres obstinately. They cannot be dried in contact with air, without immediate decomposition, but, by subjecting them under an exhausted receiver,* to the absorbent power of a large surface of sulphuric acid, they may be obtained free from adhering moisture, after which they are permanent in a dry atmosphere. They are very sparingly soluble in cold water. By keeping a large excess of them in that liquid for a month, between the temperatures 32° and 45° F., with frequent agitation, their solution had no higher specific gravity than 1.0105; it had a wine-yellow colour, and an acrid, bitter and sulphureous taste. Hot water dissolves a much larger portion, which it does not deposit on cooling, unless lime or some other body in fine powder be added. Their figure, when slowly formed, (by keeping a portion of their solution formed by heat, but allowed to grow quite cold, on lime for a month,) is that of hexangular plates, with two of their sides longer than the rest; or, which comes to the same, quadrilateral prisms somewhat elongated, and terminated by diedral summits.

I was not able to procure this substance in any quantity in a state of sufficient purity for exact analysis, so that the following must be regarded as only approximative, and to be corrected by the theory of definite proportions.

43 grains, decomposed by dilute muriatic acid, gave 32.72 carbonate, answering to 18.43 lime, or 42.88 per cent. Sulphuretted hydrogen was developed, and a quantity of sulphur separated, which, after fusion, weighed 5.35 grains (12.44 per cent.). Now, 42.88 lime, if united to sulphur in the proportion expressed by the formula 2L + S, would require 12.08 of that substance.

* This beautiful discovery of Mr Leslie, promises to be of extreme utility in experimental chemistry. I have had occasion to experience its efficacy, in estimating the total saline contents of mineral waters by evaporating them in a frozen state, and have satisfied myself, by comparative experiments, that no portion of the solid matter is lost—an inestimable advantage, which enables us to operate on a few ounces with as much exactness as on as many quarts in the usual way.

40 grains, in a less state of purity, were ignited in a glass tube blown into a bulb and coated, the extremity being plunged under mercury. A copious evolution of sulphuretted hydrogen in great purity took place on the first impression of the heat, which, reduced to the temperature 32°, and pressure 30 inches at perfect dryness, equalled 2643 grain measures, or 4.09 grains (10.21 per cent.) taking 1.1912 for the specific gravity of this gas, and $\frac{1}{769.44}$ for that of dry atmospheric air. This quantity contains 9.57 sulphur, and 0.64 hydrogen. The tube weighed, well washed out with muriatic acid and dried, lost 23.7 grains (59.25 per cent.), which is the weight of the residue; while, in another experiment, 15 grains of the crystals left 8.99, or 60.00 per cent. This residue was of a pinkish white colour, and retained exactly the shape of the crystals. Abundance of water distilled over. These results give, for the ultimate component parts,

Lime,	42.9	
Sulphur,	26.0	viz. 9.57 in the sulphuretted hyd. + 16.39 in residue after ignition.
Hydrogen,	0.6	
	69.5	
	30.5	water and loss.
	100.0	

Now, if we calculate on the atomic composition of the substance, as being $2L+(2S+H)$ neglecting its water of crystallization, we shall find these 69.5 parts to consist of

Lime,	43.92	
Sulphur,	24.75	} = 25.58 bisulphuretted hydrogen.
Hydrogen,	0.83	}
	69.50	

With regard to the water, as it was not actually collected, the estimation 30.5 per cent. may be somewhat erroneous. Were it 28.75 per cent. it would exactly agree with 4 atoms water (4 W.); and the difficulty of procuring the crystals in any definite state as to dryness or integrity of composition, admits an error to even a larger extent. Calculating the composition, then, from the formula $2L+(2S+H)+4W$, we have

Lime,	45.04	
Bisulphuretted hydrogen,	26.21	(=25.37 sulphur + 0.84 hydrogen)
Water,	28.75	
	100.00	

One half the sulphur contained in the crystals is therefore 12.68; and, as this coincides very nearly with the 12.44 disengaged by muriatic acid in the first experiment, we are authorised to conclude, that the other half would precisely saturate the hydrogen present, if in the state of sulphuretted hydrogen.

When sulphurous acid is ground with these crystals in a mortar, its smell disappears; and when filtered, it is found to be a solution of hyposulphite of lime. The same result is obtained when a current of sulphurous acid gas is passed through any lixivium formed by boiling lime with sulphur, or through the hydrosulphuret. The whole of the sulphurous acid is converted into hyposulphurous; and when the latter method is employed, pure sulphur, unmixed with an atom of sulphite of lime, is precipitated, while the hyposulphite remains in solution.

When this solution is boiled down to a certain degree of concentration, it begins to be rapidly decomposed, and sulphur and sulphite of lime separate in such abundance, that nothing is gained by continuing the ebullition. (These may be again united into hyposulphite by digestion in a large quantity of water.) If we would obtain the salt in crystals, the solution must be farther evaporated at a temperature not exceeding 130°, or at most 140° F. Filtered while hot, it then yields, on cooling, large and exceedingly beautiful crystals, which affect a great variety of very complicated forms. The most common, however, is the hexangular prism, whose sides are inclined to each other at angles of 141° 39′, 110° 45′, and 107° 36′, and two of whose sides are usually much smaller than the others. These crystals have a natural joint or cleavage, parallel to the axis, and the two smaller sides (or dividing the larger angle of the prism) as perfect and well defined as that of any crystallized mineral; besides which, indications of natural joints, parallel to the two other sides, may be detected. They are doubly refractive, the indices for the two refractions being respectively about 1.583

and 1.628. When a beam of polarized light is transmitted nearly at right angles, through a plate of this salt, bounded on either side by the principal natural joint, and analysed at its egress by a prism of Iceland spar, in the usual manner, a set of coloured fringes is seen, whose elliptic figure, as Dr Brewster has shown in his elaborate researches on this subject, indicates the existence of more than one polarizing axis in the crystal.

Hyposulphite of lime is very soluble in water, that fluid, at 37° F., being capable of dissolving nearly its own weight, during which the thermometer falls to 31°. The specific gravity of a solution, saturated at 50°, is 1.300; and when the specific gravity is 1.114371 at 60°, the solution contains 0.2081 of its weight. Its crystals are not altered by exposure to air of the usual degree of moisture; but, when dried by sulphuric acid *in vacuo*, or at 100° F. in the air, they become covered with a white crust, like phosphate of soda, which destroys their lustre, without impairing their figure. They are insoluble in alcohol of 0.82344, which also precipitates them in spiculæ, from their solution in water.

In order to attain a knowledge of the composition of this salt, I made the following experiments.

1454.75 grains of the crystallized salt, carefully dried in a very moderate temperature, were dissolved in distilled water. The weight of the solution so produced (which I shall call, for distinction's sake, the standard solution), was 6365.62 grains, so that every hundred grains contained 22.8532 of the crystals.

600 grains of this solution, containing 137.12 of the crystals, were precipitated with carbonate of ammonia, adding, at the same time, some of the pure alkali, to absorb a slight excess of carbonic acid, which prevents the precipitate adhering to the vessels. Collected with extreme care and no loss, and gently ignited, the carbonate of lime weighed 53.01, (or 38.66 per cent., equivalent to 21.77 lime). 100 grains of the crystals themselves, from the same parcel, gave, by a similar process, 38.65 carbonate, or 21.765 lime.

130 grains of the same parcel of crystals, decomposed by heat in a small retort over a powerful Argand lamp, underwent a partial fusion into a white opake cream; after which, the decomposition was indicated by sulphur separating and attaching

itself to the upper part of the vessel. Meanwhile, water distilled over, smelling slightly of sulphuretted hydrogen, and rendered turbid by a minute quantity of sulphur. It weighed 49.8 (38.3 per cent.); but this is undoubtedly too small, the heat of a lamp being not strong enough to expel all the water, a full ignition being requisite for that purpose. The retort was now washed out with hot muriatic acid, which caused a copious disengagement of sulphurous acid, and 15.61 grains of sulphur were collected on the filter, including 0.05 obtained by evaporating the distilled fluid, and that attached to the neck and vault of the retort, which was clearly washed out by the acid. This sulphur amounts to 12.04 per cent., and, as we shall presently see, is almost exactly half what the salt contains, the other half escaping in the state of sulphurous acid. The muriatic solution, precipitated by carbonate of ammonia, gave 50.18 carbonate of lime (38.68 carbonate, or 21.72 lime per cent.).

To determine more exactly the quantity of water, 100 grains carefully dried, were brought to full ignition in a closely covered platina crucible, and lost 54.05, of which, by the last experiment, 12.04 were sulphur. Hence the water amounted to 42.01. Sulphite of lime remained.

To determine the quantity of acid, and its composition, 100 grains of the standard solution, diluted in 4000 grains of water, were first precipitated by a large excess of pure crystallized oxynitrate of silver, and 22.45 grains of thoroughly dried sulphuret of silver were collected. In a second experiment, 22.37 grains were obtained. Taking the mean, 100 parts of sulphuret of silver so obtained, answer to 101.88 of the crystallized hyposulphite. In both experiments, the filtered liquid, freed from its excess of silver by muriate of ammonia, gave a copious precipitate of sulphate on the addition of a solution of muriate of baryta, marking the production of sulphuric acid in this process.

500 grains of the standard solution were now decomposed by nitrate of lead, in large excess. The precipitate, thoroughly washed thrice by subsidence, then washed and drained several times alternately on a filter, and dried six hours on hot sand, amounted to 135.91 grains hyposulphite of lead. The washings, which were considerably voluminous, were now treated with excess of oxynitrate of silver, the hyposulphite of lead though nearly

insoluble, not being absolutely so, and 2.61 grains sulphate of silver were thus collected. Now, the hyposulphurous acid contained in 2.66 grains of the crystallized salt, would, by the last experiment, have afforded this quantity, which amount must therefore be deducted from the 114.27 grains present in 500 grains of the standard solution, leaving 111.61, to which the precipitate obtained is equivalent. Hence, 100 parts crystallized hyposulphite of lime, are equivalent to 121.77 parts hyposulphite of lead. But these have been shown to contain 21.75 lime, taking a mean of the three foregoing estimations; and from these data, without knowing the composition of the precipitate (from the fact that the liquid, neutral before precipitation, continues so after), we may deduce at once the composition and weight of the acid; for, the number representing lime being L=35.5, while that of litharge is l=139.5, we have, supposing x the number of the acid,

$$\frac{l+x}{L}=\frac{121.77}{21.75}$$

whence,

$$x=\frac{121.77}{21.75}\times L-l=59.25$$

for the number representing hyposulphurous acid, and $x\times\frac{21.75}{35.5}=36.32$ for the quantity of it united with the lime of the hyposulphite. Thus our result will be, from experiment alone,

Lime, - -	21.75
Hyposulphurous acid,	36.32
Water, -	42.01
	100.08

But, as the acid is evidently a definite compound of sulphur and oxygen, and it is impossible the above experiments can err so widely as 1 per cent., we are authorised to take 60 for the value of x, (which an infinitely less error in the analysis would give it,) and the only atomic compounds we can form to produce this number, being 2S+2O=40+20=60, and S+4O=20+40=60, the latter of which is excluded by all the characters of the compounds in question; we have 2S+2O or 2(S+O) for the composition of the acid in this state of union with bases, that is, two atoms of acid to one of base, the acid being composed of oxygen and sulphur, atom to atom. If, now, we calculate the composition of the salt from the formula

$$L+2.(S+O)+6W$$

we find,

$$\left.\begin{array}{r} L=35.50 \\ 2.(S+O)=60.00 \\ 6W=67.96 \\ \hline 163.46 \end{array}\right\} \text{ or per cent. } \left\{\begin{array}{lr} \text{Lime,} & 21.71 \\ \text{Acid,} & 36.71 \\ \text{Water,} & 41.58 \\ \hline & 100.00 \end{array}\right.$$

which agrees almost precisely with that deduced solely from experiment.

It will now be observed, that the same result might be immediately derived from the decomposition of the burnt salt, by muriatic acid: for, since one half of the sulphur remains, and the other is driven off in sulphurous acid; the oxygen present in the hyposulphurous acid must be precisely sufficient to bring one half its sulphur to that state, and we ought therefore to have $S+(S+2O)$ or $2(S+O)$, for the formula representing it. But the loss of weight in sulphurous acid, not having been ascertained, we had no direct evidence that the *whole* of the lime was there in the state of sulphite.

The decomposition of the oxynitrate of silver is now readily explained. Denoting the atom of oxide of silver by $s+O$, and that of nitric acid by N, we have, for the atoms present before the decomposition,

$$\left\{ L+2(S+O) \right\} + \left\{ N+(s+O) \right\}$$

which afterwards groupe themselves thus,

$$\left\{ L+N \right\} + (S+s) + (S+3O)$$

that is, one atom nitrate of lime, one of sulphuret of silver, and one of free sulphuric acid. This is confirmed by the experiments above related; for although the quantity of standard solution operated on in those experiments, ought to have given 23.6 instead of 22.37 or 22.45 grains of sulphuret, taking s at 136, the coincidence is quite near enough, considering the small quantity operated on, to establish this point. The production of free sulphuric acid observed in those experiments, is additional and conclusive evidence.

I shall now proceed to describe some other compounds of the hyposulphurous acid.

Hyposulphite of Potash.—This salt is readily prepared either by precipitating that of lime by the carbonated alkali, or immediately decomposing hydrosulphuret or hydroguretted sulphuret of potash by sulphurous acid, and evaporating to a pellicle. It then crystallizes into a confused mass of spiculæ. It has a penetrating taste like nitre, succeeded by bitterness, and is very deliquescent, the deliquiated salt crystallizing in fine needles by a slight diminution of temperature. By the action of a graduated heat, it boils down to a dry white mass, then takes fire, and burns much like a piece of tinder, but with a weak blue flame. It dissolves muriate of silver, even when very dilute, with great readiness. This salt is formed when the hydroguretted sulphuret of potash is decomposed by atmospheric exposure, though Dr Thomson concludes, from his own experience, that it is only the sulphate which is so produced; probably he tested his liquid with solutions of lead and baryta, which in this case are ambiguous.

Hyposulphite of Soda—may be formed in precisely the same manner. It crystallizes on cooling, when evaporated to a syrup, in silky tufts radiating from centres, which at length extend through the whole liquid, and become almost solid. By the action of sulphuric acid *in vacuo*, it effloresces, but in the open air is extremely deliquescent. Its taste is intensely bitter and nauseous. Heated, it first undergoes the watery fusion, then dries into a white mass, and at length takes fire, burning with a vivid deflagration, and a bright yellow flame. It is totally insoluble in alcohol of 0.82344, which precipitates it from its solutions in a thick syrup. Muriate of silver, newly precipitated, dissolves in this salt, when in a somewhat concentrated solution, in large quantity, and almost as readily as sugar in water.

Hyposulphite of Ammonia.—This salt is not easily procured in regular crystals. When much concentrated it cools into a confused pappy mass of very minute spiculæ. Its taste is bitingly pungent, succeeded by a disgusting bitterness. Heated, it burns with a weak flame, and evaporates entirely. It does not appear to possess any remarkable properties. I made some attempts to analyse it, but the difficulty of procuring it in a definite state as to dryness, rendered them unavailing. In a dry state it would be composed of 1 atom ammonia $=21.65+2$ atoms acid $=60$.

Hyposulphite of Baryta.—This salt precipitates copiously when muriate of baryta is poured into a solution, not very dilute, of hyposulphite of lime. The precipitate thus obtained from 500 grains of the standard solution, amounted, after thorough washing, to 101.92 grains; while, calculating on the supposition of its being anhydrous, and composed of $B + 2 . (S + O)$ it should have been 102.76: The difference, 0.84 is attributable partly to the unavoidable use of the filter, and partly to the solubility of the precipitate, which, though small, is perceptible. The salt so obtained is a white, brilliant, scaly powder, which is soluble in dilute muriatic acid, without the evolution of sulphur, and consequently without decomposition. It would not dissolve in 2000 parts water; but, however often it is washed with that liquid, the washings continue to strike a deep brown-black, with nitrate of mercury. When the solutions from which it is to be precipitated are mixed in a somewhat dilute state, as in the case of a solution containing $\frac{1}{20}$ hyposulphite of lime, some minutes elapse before any precipitation or cloudiness commences; small crystalline grains then form, which are speedily followed, on brisk agitation, by a copious separation of the barytic salt. When heated on a platina foil, it is thrown into a singular agitation, and seems enveloped in a kind of fog, caused by its own dust thrown up in an infinite number of minute explosions. It takes fire at a very low heat, and sulphur burns off.

Hyposulphite of Strontia.—When muriate of strontia is poured into hyposulphite of lime, no precipitate falls; and this is, in consequence, a soluble salt. I prepared it by passing a current of sulphurous acid gas through a solution of hydroguretted sulphuret of strontia, and evaporating. It does not suffer partial decomposition, like hyposulphite of lime, during this process, or in a very slight degree. It crystallizes, on cooling, in flat rhombs, having the plain angles of their more extended surfaces about 64° 45′ and 115° 15′, but whose solid form is that of an oblique parallelopiped, whose sides are inclined to each other at angles of about 76° 30′, 96° 45′, and 97° 13′. It is doubly refractive; a thin rhomb laid down on a minute object under a microscope separates the two pencils in the direction of its longer diagonal. This salt has a great tendency to form macled or hemitrope crystals, being interrupted parallelopipeds, composed of two of those above described, joined by the edges of 97° 13′, so as to have their adjacent faces on an exact level; and, when this is the case, they separate readily at the juncture, the fracture being a perfect and highly polished plane. This tendency to form hemitrope crystals I have observed in other salts. In nitre, it is even rare to meet with an hexagon free from this inversion of structure, which is not discoverable on external inspection, but manifests itself by certain optical phænomena of extraordinary splendour, which I shall take some future opportunity to describe, and which may possibly indicate some yet unnoticed property of polarized light.

This salt is soluble in about 4 times its weight of cold water (45°) and 1¾ of hot. Its taste is purely bitter. It is insoluble in alcohol, unless very dilute, and is in consequence precipitated by it from solution in water, in scaly crystals. Like the rest of the hyposulphites, it readily dissolves muriate of silver, and alcohol precipitates the solution in a sweet syrup. Heated, it whitens without losing its figure, and burns with a very faint flame.

Hyposulphite of Magnesia.—This salt may be formed very readily by boiling a solution of sulphite of magnesia with flowers of sulphur. It is intensely bitter, but, though very soluble in water, apparently not deliquescent. Being much more soluble in hot than in cold water, it readily crystallizes in cooling. Laid on a hot iron, it burns with a weak blue flame, but is incapable of maintaining the combustion *per se.* Heated in the flame of a blowpipe, it swells into a fungous mass, by the escape of sulphur, just as borax does by that of water. Pure magnesia remains soluble slowly and silently in acids.

Hyposulphite of Alumina.—I should pass over this salt, which I endeavoured to insulate in various ways without success, but for a fact of some moment observed in the attempt. The mode which seemed to promise best, was to precipitate hyposulphite of lime by oxalate of alumina; but, to my great surprise, on mixing the two solutions, though perfectly neutral, not the slightest cloud was produced. This singular suspension of one of the strongest chemical affinities, has not, to the best of my knowledge, been noticed. It is not peculiar to the hyposulphite; as the muriate, nitrate, and, I presume, any other salt of lime, may be substituted with the same success. When citrate of alumina is used, a precipitation takes place, but it is not abundant, and a portion of both the undecomposed salts remains in solution. Sulphate of alumina concentrated precipitates it much more copiously; but here, again, some of both salts remains undecomposed. This latter precipitant would probably, however, give a satisfactory result with the hyposulphite of strontia; but my stock of that salt being very small, I had no opportunity of making the trial properly. When sulphate of alumina is boiled with sulphur, the solution gives up nearly all its saline contents, but evaporated, leaves small gritty grains, of no determinate form.

Hyposulphite of Iron.—Berthollet, in a memoir communicated to the French Academy in 1789, has shown that, when iron is subjected to the action of sulphurous acid, the acid is decomposed, and a sulphite formed "avec lequel le soufre degagé a assez d'affinité pour se tenir en dissolution." The fact is, that a true hyposulphite is formed, precipitating nitrates of silver and mercury in sulphurets, &c.

When sulphurous acid is poured on newly precipitated carbonate of iron, a deep red-brown solution is slowly formed. When heated *per se*, this undergoes decomposition, but if boiled on sulphur, the whole forms hyposulphite of iron. Its taste is strongly ferruginous, it is nearly colourless, and precipitates ferro-cyanate of potash white. When concentrated by evaporation, it does not crystallize, but settles into a glutinous mass of a dirty white colour, not unlike glazier's putty. This salt may likewise be formed by boiling hyposulphite of lime on carbonate of iron, a portion of the carbonate being at the same time converted into sulphuret. The theory of this will be more obvious when we have become acquainted with

Hyposulphite of Copper.—Sulphurous acid, according to Berthollet, has no action on metallic copper. When digested, however, on carbonate of copper, either cold or assisted by heat, the carbonate being in excess, I have observed that a blue solution is formed with effervescence, having every character of a sulphate, while a beautiful orange-red powder remains behind, which, digested with an additional quantity of acid, is merely heightened in its colour by the decomposition of the carbonate it contained. It is therefore obvious that the oxide is decomposed, being partly converted into the orange or protoxide, while the disengaged oxygen converts part of the sulphurous into sulphuric acid. Thus, *c* denoting copper, S sulphur, and O oxygen, we have (the carbonic acid escaping as fast as disengaged),

$$2.(c+O)+2.(S+2O)$$
$$=\left\{(2c+O)+(S+2O)\right\}+(S+3O)$$

that is, two atoms of sulphurous acid disengage the carbonic from two of the carbonate, producing one atom of sulphite of protoxide, and generating one of sulphuric acid, which, in its turn expelling the acid from one more atom of the carbonate, unites with its base, forming sulphate of peroxide. Whether this be any thing like the true statement of the changes, the following first approximation to an analysis of the red powder will tend to show. 14.1 grains were gently ignited, in a small retort of glass tube; sulphurous acid was disengaged in abundance, which was received over mercury, and its purity ascertained. Scarcely any perceptible dew was disengaged, and the loss of weight was 5.2 grains, consisting in part of a very small quantity of the powder itself, carried over by the successive slight explosions with which it was decomposed. Orange oxide of copper remained in the retort. The above composition would require 4.34 grains to be thus expelled; but, as I said before, I do not give this as an exact analysis.

It should appear, then, that sulphurous acid is incapable of combining with the peroxide of copper, and that what is usually stated as to its forming super and sub salts with that oxide, requires re-examination. When the sulphited protoxide above described is boiled with sulphur, sulphate is formed, sulphurous acid disengaged, and a black powder, consisting probably of sulphuret, remains behind; but no distinct trace of hyposulphurous acid could be found. Copper, then, seems to form an exception to the production of a hyposulphite by this mode of operating.

The hyposulphite of copper may, however, be formed by digesting hyposulphite of lime on carbonate of copper, or by mixing sulphate of copper with hyposulphites of lime, potash, &c. not, indeed, in a state of purity, but sufficiently so to ascertain its more obvious properties. It is colourless, of an intensely sweet taste, followed by a mawkish sweetness like liquorice root, but with no metallic flavour. It is not decomposed by ammonia, nor turned blue by an excess of that alkali, provided the air be carefully excluded, though a minute or two's exposure gives it that colour. The copper in this salt is therefore in the state of protoxide.

Hyposulphite of Zinc.—A portion of this salt, mixed with sulphate, is formed when metallic zinc is acted on by sulphurous acid. The solution precipitates silver in the metallic state, but mercury in that of a sulphuret.

Hyposulphite of Manganese—remains in solution when that of lime is precipitated by sulphate of manganese.

Hyposulphite of Tin.—Muriate of tin occasions no precipitate in the solution of an alkaline hyposulphite. When a piece of clean tinfoil is kept some days in sulphurous acid, it becomes brown and semitransparent, while the liquid almost coagulates with the quantity of oxide deposited. If now examined, however, it exhibits but faint traces of the hyposulphurous acid.

Hyposulphite of Lead.—When a solution of nitrate of lead is gradually added to a neutral hyposulphite, a white precipitate falls, whose first portions are re-dissolved by agitation, forming, probably, a double salt with that in solution; for the hyposulphite of lead is very sparingly soluble, requiring not less than 3266 parts of water to prevent its precipitation. When hyposulphite of ammonia is used and precipitated at a raised temperature, this re-dissolution takes place to a pretty considerable extent. As the nitrate is added, the double salt is, however, at last decomposed again, and nearly the whole acid falls in combination with litharge. This precipitate is a white mealy powder, which, held long in the mouth, leaves an impression of sweetness. When heated, even below 212° F. it turns black; and, when the heat is raised, takes fire, becoming red hot, and burns with a weak flame. If now removed from the fire, the ignition and combustion may be maintained for any length of time, by cautiously adding small quantities of the substance.

To analyse this salt, I counterbalanced a platina crucible, and introduced into it 100 grains concentrated sulphuric acid, which was warmed over a spirit lamp ; 100 grains of the hyposulphite were then added, which were decomposed with so little commotion, that I could scarcely believe, on weighing it, that nearly 25 cubic inches of gas had made their escape, which was sulphurous acid. Being then fully ignited, 95.50 grains remained in the crucible. To ensure the complete conversion of the salt into sulphate, this was moistened with nitric acid, and again ignited; 95.50 grains were still found remaining. Hence 100 grains hyposulphite of lead are equivalent to 95.5 sulphate, and consequently contain 70.30 litharge. I had previously assured myself, by ignition in glass vessels, that the salt under examination contained no sensible quantity of water, only a slight dew being evolved, hardly amounting to 0.1 in 100 grains.

Hence we have for the composition of the salt,

Oxide of lead,	70.30
Acid, -	29.70
	100.00

Now, if we compute the composition from the formula $(l + O) + 2. (S + O)$ where $l = 129.5$ the number representing lead, we find

Oxide of lead,	69.92
Acid, -	30.08
	100.00

The slight deviation in excess of about 4 parts in 1000 may be accounted for by a minute quantity of sulphate of lead in the acid used, though purified by distillation.

When hyposulphite of lead is subjected to heat in a retort, over a lamp, it is converted into a black brilliant powder,. and loses 20 per cent. of its weight. The only product is sulphurous acid gas, which, received over mercury, is found to be perfectly pure, the air of the retort being allowed for. When fully ignited in a close crucible, it loses 20.60, but a small portion of this is sulphur, as in the experiment in close vessels, a minute quantity of sulphur, varying from 0.2 to 1.0 per cent. sublimes into the neck of the retort. Regarding this residuum as a sulphuret of lead (of which it certainly has all the appearance), I was kept for some time under the erroneous impression that 2 S + O must be the formula of composition of the hyposulphurous acid. Convinced, however, by the whole tenor of the preceding results, and their exact coincidence with 2 S + 2 O, it becomes necessary to consider it as a sulphuretted oxide (l + O + S) or 1 atom litharge + 1 atom sulphur, which agrees precisely with a loss of 20 per cent. sulphurous acid.

Hyposulphite of Silver.—When a solution of pure crystallized oxynitrate of silver, considerably diluted, is added cautiously, drop by drop, to a very dilute solution of any hyposulphite, a white cloud is first produced, which redissolves on agitation. On adding more of the precipitant, the cloud reappears and aggregates into a dirty grey flaky precipitate, which subsides without any farther change of colour. The liquid has now acquired a very sweet taste*, and is not precipitated by muriate of soda, though hydrosulphuret of ammonia throws down sulphuret of silver from it. On the addition of yet more of the precipitant, the grey precipitate changes rapidly to brown, and finally assumes the deep blackness and curdled appearance which characterize sulphuret of silver. The liquid has now entirely lost its sweet taste; and, if tested with a muriatic solution, the presence of undecomposed nitrate is rendered sensible. This grey precipitate seems to be an hyposulphite of silver; but it is manifestly extremely difficult, even in dilute solutions, and altogether impossible in concentrated ones, to hit the exact point without converting any portion into sulphuret. When the nitrate is added at once to a dilute hyposulphite, to decompose the whole of its acid, the precipitate is at first a white light cloud, which undergoes a rapid aggregation into flakes, changing its colour, as its consistency increases, from white to light yellow,

* The sudden production of intense sweetness, on mixing two such disgustingly bitter liquids as nitrate of silver and hyposulphite of soda, is very striking, and shows how little we know of the way in which bodies affect the organs of taste. Sweetness and bitterness, like acidity, seem to depend on no particular principle, but to be regulated by the state of combination in which the same principles exist at different times.

greenish-yellow, yellow-brown, rich orange-brown, purplish-brown, and finally to a deep brown black, at which period it is collected in heavy curdled masses at the bottom. When the hyposulphurous acid in a solution amounted only to one part in 97800, I still found this test give a very sensible brown tinge, after a few minutes standing.

Muriate of silver newly precipitated is soluble in all the liquid hyposulphites, and, as has been before observed, in that of soda, with great ease and in large quantity. This solution is not accomplished without mutual decomposition, as its intense sweetness proves,—a sweetness surpassing even that of honey, and diffusing itself over the whole mouth and fauces, without any disagreeable or metallic flavour. This curious solution, when newly filtered, is colourless, but at length grows slightly turbid, and deposits a brown sediment, which may be retarded, if not altogether prevented, by dilution. Like the hyposulphite of copper, it is not precipitated by ammonia, neither do the carbonates of that alkali, or of potash, or ferrocyanate of potash, in any way affect it. Muriatic acid, or a neutral muriate, at first cause no cloud, unless added in very copious excess, though, on long standing, the former produces a separation of muriate of silver. Alcohol precipitates it in an intensely sweet syrup. A coil of zinc wire speedily separates the silver in a metallic state, thus affording an easy mode of analysis of the muriate of silver *viâ humidâ.* Muriate of lead newly precipitated is, in like manner, dissolved by the hyposulphites, though less abundantly than that of silver.

Hyposulphite of Potash and Silver.—We have already seen that carbonate of soda does not affect the solution of muriate of silver in hyposulphite of soda. When potash, however, or a concentrated solution of its carbonate, is poured into that solution, a copious precipitate falls, which, washed and dried, is found to consist of small pearly scales, similar to those of boracic acid, of a grey colour. The supernatant liquid, by evaporation, yields a few more of them. They are soluble in a large quantity of water, have a most intensely sweet taste, and before the blowpipe, blacken, melt, and yield a bead of silver, in the midst of a saline mass which spreads on the charcoal.

Hyposulphite of Mercury.—Pure nitrate of mercury, entirely free from oxynitrate (the white crystals which form spontaneously when nitric acid of 1.34, diluted with an equal weight of water, is allowed to stand on a large excess of mercury at 45° F.) causes an instant black precipitate in the most dilute or the most concentrated solution of an hyposulphite. When the solution contains a 10,000th of its weight of hyposulphurous acid, it immediately strikes a deep brown, and when only a 100,000th is present, it opalesces on a few minutes standing. Hyposulphite of the protoxide of mercury, therefore, does not exist. Calomel is also immediately blackened by any hyposulphite.

When corrosive sublimate, dissolved in 20 times its weight of water, is poured in small quantity into a very dilute hyposulphite of lime, the usual redissolution of the first portions of the precipitate takes place (though to a very small amount), and when added in large excess, a light-yellow muddy precipitate separates in abundance. 100 grains of the standard solution so often mentioned gave 32.27 grains of this substance, well dried, and the filtered liquor afterwards afforded 21.50 grains ignited sulphate of baryta, that is, respectively 141.2 and 94.1 per cent. on the crystallized salt, or 384.7 and 256.3 on the acid itself. These numbers (at least the latter) I can reconcile to no theory. The former certainly agrees in some measure with the acidification of one atom of sulphur, as in the case of oxynitrate of silver. The only probable explanation of this precipitation seems to be, the simultaneous formation of hyposulphite of mercury, calomel, and sulphuric acid, accompanied by a deposition of sulphur, though this will agree but ill with the numbers set down. Yet the experiment was made with every precaution to secure exactness.

My trials to obtain hyposulphurous acid in a separate state, though not fully successful, seem not entirely to preclude a hope of accomplishing it. The displacement of this acid by all the more powerful ones is accompanied with decomposition, but when sulphuretted hydrogen was made to act on hyposulphite of lead suspended in water, though by far the greater portion of the acid was uniformly destroyed, I did certainly once succeed in procuring a liquid which, when filtered, had a weak, acid, rough, and sulphureous taste, which reddened iris paper, which grew turbid, and deposited sulphur on standing, and, when boiled, gave off sulphurous acid, and finally which, saturated with ammonia and concentrated by evaporation, acted upon every re-agent exactly as a solution of hyposulphite of ammonia would have done. But the acid so obtained was in such small quantity compared with that contained in the metallic salt, that I will not venture to speak decidedly on the subject, but propose the earliest opportunity to try, as a last resource, the action of the voltaic pile.

Slough, *Jan.* 8. 1819.

Art. III.—*Application of the Indeterminate Analysis to the elimination of the unknown quantities from two Equations. By* William Wallace, Esq. F. R. S. Edin. Communicated by the Author.

When two unknown quantities are to be determined from two equations, one of which is of the second order, we may, by known theorems in the indeterminate analysis, eliminate both the quantities, and derive from them a new equation containing only one unknown quantity, of which each of the other unknown quantities is a given function.

1. For example, let us suppose that the equations are,

$$x^2+y^2=m^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$ax^2+bxy+cy^2=n^2 \ldots\ldots\ldots\ldots (2)$$

This last is taken of the second order for the sake of brevity, but it might be of any order whatever.

Let us assume

$$x=\frac{(r^2-s^2)m}{r^2+s^2}, \qquad y=\frac{2\,r\,s\,m}{r^2+s^2}$$

$$\text{Then } x^2+y^2=\frac{r^4+2\,r^2\,s^2+s^4}{r^4+2\,r^2\,s^2+s^4}m^2=m^2$$

Thus, it appears, that the first equation is satisfied by the nature of the functions x and y, independently of any particular value of r and s.

Let $\frac{r}{s}=v$, then $x=\frac{(v^2-1)\,m}{v^2+1}$, $y=\frac{2\,v\,m}{v^2+1}$. These values of x and y being now substituted in the second equations, it becomes, after proper reduction,

$$(a\,m^2-n^2)\,v^4+2\,b\,m^2\,v^3+2\left\{(2\,c-a)\;m^2-n^2\right\}v^2$$
$$-2bmv=n^2-a\,m^2,$$

an equation of the fourth degree, by which v may be determined, and thence the values of x and y.

2. Let the equation, which is of the second degree, be

$$x^2+axy+by^2=c^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and let the other be

$$x^\alpha\,y^\beta+\mathrm{A}\,x^\gamma\,y^\delta+\&c.=0 \ldots\ldots\ldots\ldots (2)$$

an equation of any order whatever.

In this case, we must make

$$x=\frac{(r^2-b\,s^2)\,c}{r^2+ars+bs^2},\quad y=\frac{(2\,rs+as^2)\,c}{r^2+ars+b\,s^2},$$

and then, independently of any particular values of r and s, we shall have $x^2+axy+by^2=c^2$; if we now make $s=1$, (which comes to the same thing as to substitute $v=\frac{r}{s}$) we shall have x and y expressed by functions of r only; and these being substituted for x and y in the second equation, the result will be an equation involving only v: this being resolved, will give v, and thence x and y.

3. The most general equation of the second degree may be put under this form:

$$x^2+axy+by^2+c\,x+dy=e.$$

This, by the usual transformations taught in books on Algebra, may be changed to

$$x'^2+\mathrm{A}\,y'^2=\mathrm{B},$$

where x' and y' denote certain functions of x and y, which are at least rational in respect of these quantities, although they may contain known irrational numbers. This equation will be satisfied, if we make

$$x'=\frac{(r^2-\mathrm{A}\,s^2)\,\sqrt{\mathrm{B}}}{r^2+\mathrm{A}\,s^2},\quad y'=\frac{2\,r\,s\,\sqrt{\mathrm{C}}}{r^2+\mathrm{A}\,s^2}.$$

The values of x and y deduced from these, will satisfy the original equation, and the same values, when substituted for x and y in any other equation, will produce an equation, from which $\frac{r}{s}$ may be found, thence x' and y', also x and y may be found.

4. Equations of the third order, involving two unknown quantities, may, in certain cases, be satisfied by indeterminate functions of x and y; when such an equation is combined with any other equation, the method here explained will apply.

5. By the analytical artifice here explained, equations which involve functions of unknown angles may be transformed into common algebraic equations.

For example, let it be required to determine the angles φ and ψ from the equations,

$$m \sin. \varphi = n \sin. \psi, \ldots\ldots\ldots\ldots\ldots (1)$$
$$a \tan. \varphi + b \tan. \psi = c \ldots\ldots\ldots\ldots (2)$$

In addition to these, the arithmetic of sines furnishes the two equations,

$$\text{Cos.}^2 \varphi + \sin.^2 \varphi = 1, \quad \cos.^2 \psi + \sin.^2 \psi = 1,$$

which are satisfied by making

$$\text{Cos. } \varphi = \frac{1-r^2}{1+r^2}, \quad \sin. \varphi = \frac{2r}{1+r^2}, \quad \cos. \psi = \frac{1-s^2}{1+s^2},$$

$$\text{Sin. } \psi = \frac{2s}{1+s^2}; \text{ hence we find } \tan. \varphi = \frac{\sin. \varphi}{\cos. \varphi} = \frac{2r}{1-r^2},$$

$$\tan. \psi = \frac{\sin. \psi}{\cos. \psi} = \frac{2s}{1-s^2};$$

By substituting, the equations (1,2) become

$$\frac{mr}{1+r^2} = \frac{ns}{1+s^2}$$

$$\frac{ar}{1-r^2} + \frac{bs}{1-s^2} = c$$

The values of r and s may now be found by the usual methods.

Royal Military College,
Feb. 4. 1819.

Art. IV.—*Description of a New Hygrometer, made of the internal membrane of the Arundo Phragmites**. By Alexander Adie, F. R. S. Edin. Communicated by the Author.

In the winter of 1816, I made many trials of different substances, for the purpose of ascertaining their hygrometric powers, in order, if possible, to find one which should possess sufficient sensibility, and, at the same time, not be liable to change the extent of its contraction between the extremes of dryness and humidity. Among the various substances which I tried, those that changed their bulk in a considerable degree by a change of humidity were Rottenstone, Chalk, unbaked Clay made very thin, and Mountain Cork. Though, from the friable nature of the three first, it was found difficult to use them, yet I am of opinion that they may be advantageously employed in the construction of hygrometers, and there is reason to think that they will not be subject to any alteration in their scales.

Charcoal, from its known durability, likewise presented itself as a proper substance for the above purpose; and it was found, upon trial, to be sensibly hygrometric, although its range was very limited.

Most of the above substances were formed into hollow cylinders, and cemented to the end of thermometer tubes; and their expansibility was tried by filling the cylinder and tube with mercury, in the usual manner.

But the substance which was found to possess by far the most delicate sensibility, and extensive range, was the internal membrane of the *Arundo Phragmites*. A small bag, made of this membrane, is attached to the lower end of a thermometer tube, so as to form, as it were, its bulb. It is then nearly filled with quicksilver, which rises and falls, in consequence of the contraction and dilatation of the membrane, by any change of moisture; and these changes are indicated upon a scale attached to the tube, the zero of this scale marking absolute humidity, and the other extremity of the scale absolute dry-

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* This Paper was read before the Royal Society of Edinburgh, on the 1st of February 1819.

ness. The lower end of the glass tube, instead of being merely inserted into the top of the bag, may pass through it, the quicksilver in the bag communicating with that in the tube by one or more openings made through the sides of the tube. By this means, the bag is supported by the glass, and prevented from being injured by any slight accident; and the instrument is also less affected by any change of temperature.

A convenient portable hygrometer may be made, by employing a slip of this membrane, and attaching its extremities to the end of a lever, somewhat like the small pocket metallic thermometers. The external appearance of one of these instruments is shewn at the bottom of the Patent Sympiesometer, represented in Plate II. Fig. 2.

Although this membrane is not entirely free from the change to which all animal and vegetable substances are liable, yet hygrometers made of it possess a considerable degree of uniformity amongst themselves; and, in point of sensibility, this membrane exceeds every other substance that I have met with.

Art. V.—*Account of an Excursion to Thebes, and of the Antiquities recently discovered in that City.* In a Letter from a Scotch Gentleman in Cairo.

Cairo, *August* 11. 1818.

FINDING that I was to be detained here for some time, you will not be surprised that I undertook an excursion to "the city of a hundred gates." I considered a sight of its temples, &c. as forming an era in a person's life; and a more favourable opportunity for visiting them, could not possibly occur. As soon as I had determined upon the journey, I was favoured by Mr Salt with letters for several people established near my route, and having a Firman from the Pacha, which I afterwards found was quite unnecessary, as the peasantry are every where anxious to serve and to oblige, a *canja*, or pleasure-boat, was procured, which cost us little more than a palanquin hire in India. We left Cairo on the 25th June 1818, and made very rapid progress, as my time was limited to about forty days. The season of the year was particularly favourable; for, as we left Cairo before the Nile commenced rising, and consequently before the current was strong, we were able, with the fresh northerly winds which prevailed, to go on at a great rate; owing to which, I had not only sufficient time to visit almost every thing of any note as far as Thebes, but was able to remain there twelve days. To his other kind attentions, Mr Salt added that of letting us have the benefit of one of his servants to act as an interpreter. We were no sooner on the Nile, than we felt an agreeable change in the climate, from the oppressive heat in the confined streets of Cairo. You will easily believe, that having so many objects of novelty and interest around us, and so many more in prospect, we were quite elated, and enjoyed ourselves to the utmost. When we were tired admiring the banks of the Nile, the numerous villages, the groves of palms, &c. &c., we had a reserve in our little cabin, which contained ample food for the mind, in the books Mr Salt had kindly lent us; and when we wanted a supply of a more substantial nature, we had only to stop at any of the villages, where we had, every morning, large draughts of new milk, bought half a dozen fowls for sixpence, and, if we required them, a hundred eggs for about half as much. We had no small addition to our comforts in bathing, perhaps, twice every day, without being disturbed by crocodiles; which, as far as I can learn, instead of being ever on the watch to devour, are the most harmless timid creatures that exist. On the 28th, we passed the Coptic Convent of the Pulley, standing upon a very high perpendicular rock, which in many places hangs over the Nile in the most picturesque manner. Although we were sailing pretty fast at the time, some poor fellows belonging to the convent, who appeared to be quite of an amphibious nature, swam off to us, and kept hanging by the boat, supplicating for charity, until we gave them a few piastres.

On the 29th we stopped to visit the catacombs of Benihassan. These are huge chambers cut in the rock; but for what purpose they were intended, is, I believe, quite uncertain. The largest of them which we entered was from thirty to forty feet long, and about twenty feet high, with a small recess at the farther end, where three statues had formerly stood. It is supported by four large fluted columns, without either base or capital. One of these is broken, leaving about eight feet of the shaft hanging from the roof. The roof and walls are covered with hieroglyphics and painted sculptures, the colours still remaining. Three hours after leaving Benihassan, we reached the village of Sheik Abadi, where we landed to see the remains of the ancient Antinoè. We were gratified with the sight of some fine Corinthian columns of granite: The other ruins are large mounds of broken bricks and pottery; and this is all that remains of a famous Roman city, upon which, if we judge from the quantity of granite that has been used, the greatest labour and expence have been bestowed: and the temple of Dendera, built probably more than a thousand years before, is still perfect. About eight in the same evening we arrived at the village of *Radam*, and went to the house of Mr B. an Englishman, who has engaged in a concern with the Pacha, and had undertaken to refine Egyptian sugar, and to distil rum from the molasses obtained in the process. He has completely succeeded. The sugar is equal to any loaf-sugar we see in Europe; and the rum is so excellent, that all the great Turks are forgetting the sober and salutary precepts of the Koran.

We had here a most agreeable surprise in meeting with Mr B. who went to India with me last year. He left the ship by which he had returned from India at Koseir, crossed the desert to Kenè, and, after visiting the wonders about Thebes, was now on his way to Cairo.

On the morning of the 1st of July, we passed Monfaloot, a pretty town, containing a number of white-washed mosques and minarets. In the afternoon we stopped at Siout, where we received a visit from Dr M. to whom we had an introduction. He invited us most pressingly to pass a day with him, which, in our anxiety to get to Thebes, we were obliged to decline. On the 2d, we stopped at the village of Gaivè, where there was formerly a temple, but now only one column remains erect; others appear to have been lately taken down by the Arabs, for the sake of the metal clamps with which the stones were joined. Large masses of stones lie near the pillars, which probably formed the roofs. Norden mentions the whole temple as standing in his time. On the 5th, we reached Dendera, and set out early in the morning, mounted on donkeys, to visit the Temple, having a pleasant hour's ride through groves of date trees.

I find I can give you but a feeble description of the temples in general. The accounts even of Denon and Hamilton are far from enabling one to form a just idea of them; and, indeed, no description is capable of doing this without entering into a minute detail of their plans, dimensions, variety of sculpture, style and painting, that would, from its very length, probably prove, if not fatiguing, at least tedious and prolix. Nor have these authors succeeded much better in the prints which accompany their works. With the exception of two or three representations of temples given in the French national work, no engravings have yet appeared from which a true idea can be formed of their grandeur.

The first appearance of the temple at Dendera, surrounded as it is with mounds of ruins of an Arab town, is very unfavourable; but, perhaps, this serves to increase the surprise and admiration, which are excited by a nearer approach. It is nearly in its original state. It is certainly the most perfect, and perhaps the most beautiful, of all the temples, and justly deserves the preference which has been given it by Denon. The figures, and even the smallest hieroglyphics, with which its walls, roofs, pillars, are completely covered, are all in relief; and it is inconceivable with what precision and elegance they are executed, and what richness of effect they produce. All travellers have justly remarked the striking contrast between the simplicity in the outlines and plans of the temples, and the minuteness and variety of their ornaments. It is more observable in this than in any of the rest; for the outline of the temple of Dendera, although beautiful, is so extremely simple, that it may be expressed on paper by a few straight lines. The state of perfection in which it still remains, increases the regret one feels at the barbarous spirit which has defaced many of the human figures. The greatest injury has been done to the beautiful heads of Isis, forming the capitals of the massy pillars in the great portico, all of which have been more or less defaced by the chisel. This was done by the primitive Christians, who used one of the chambers as a church; and who, it appears, had industriously attempted to deface all the human heads; but finding, probably, that it was rather a laborious undertaking, they fortunately had recourse to an easier and more harmless method of satisfying their prejudices, and contented themselves with plastering all the walls, pillars, and roofs, with a thick crust of clay, a great part of which remains in the interstices of the sculptures.

Nothing more than the sight of the temple of Dendera is required to convince one of the great injustice done to Egyptian architecture and sculpture, by comparing it with that of India. The style and character of their figures form a complete contrast to the grossness and vulgarity of those met with in any piece of Hindoo sculpture. A reference to Mrs Graham's etchings, in her Letters on Hindoo Mythology, will explain the kind of figures I allude to. The etchings in themselves are indeed wretched, but no allowances which can be made will in the least degree alter the contrast. The very large collection of statues, which Mr Salt is about to send to the British Museum, will lead to a better and more correct opinion of Egyptian sculpture, than has hitherto been entertained.

On the 7th, we arrived late in the evening at Thebes; and in the following morning we got up very early to ride to the valley of Biban-ul-Motuc, where Mr B. resides. We reached it before sunrise; you will of course imagine that we had a very cool ride, and will perhaps be inclined to doubt my veracity, when I tell you, that the thermometer then stood at 102°, in the royal residence of Mr B., the entrance to a tomb of one of the ancient kings, and that it had reached about 15 degrees higher at noon. This is, as you may well think it ought to be, by far the warmest spot about Thebes, being in a very narrow part of the valley, where the rocks are very high on all sides. This hot-house was chosen by Mr B. on account of its vicinity to the splendid tomb lately discovered, in making representations of which, he and Mr —— are now employed. In the entrance to the tomb it is quite cool enough; and, as they remain there a great part of the day, they suffer but little from the heat of the valley. An acquaintance is very soon formed in such a place as that; Mr B. and myself soon became very great friends. The three first days were occupied in making a complete round of the antiquities on both sides of the river. We met every morning in one or other of the temples, as concerted the evening before, and employed the whole day in drawing and finishing two or three rough sketches; for these temples are extremely tedious objects to put upon paper, when the views are taken near, where all the figures and other ornamental parts are discernible. We had our breakfast and dinner brought to us, and in the evening we returned, he to his tomb, and I to my boat.

In our daily excursions, we were always attended by some of the natives of Goornoo, inhabitants of the innumerable excavations in the rocks. Their character seems to be completely changed since the days of Pocock and Norden, and even since Denon's time. They appear to us to be the most obliging and attached set of people that exist. Mr H. whom I took with me as "compagnon de voyage," and who preferred rambling about with them in search of little figures, and other antiques, to taking plans or drawings of temples, became quite a familiar acquaintance, and explored many of their dwellings. Besides the family, consisting of themselves, donkey, cow, and an assemblage of dogs, they keep in their dwellings a small stock of poultry, all which is easily maintained from the cultivation of a small piece of ground; but their principal stock in trade is what they find in the least known tombs and mummy-pits, small idols of pottery and wood, sculptured pieces of stone, mummies of animals, small stone statues, wooden figures of dogs, foxes, and birds, and above all, a papyrus, which is a little fortune to the lucky finder. All these are carefully preserved till they meet with travellers, who eagerly purchase them. Mr H. has got a very large collection of these curiosities, which nearly overloaded the boat; and I have myself got, if not a *queen*, at least a lady of very high rank, in the shape of a mummy, as she is very highly ornamented, with fine painted figures, on the double case which encloses her. I have also some mummies of dogs, foxes, &c. &c.

The tombs of the kings engrossed much of my attention. The accounts which have been given of them by Mr Hamilton are very correct. One of the first which we entered contained, in a very small chamber off the entrance, Mr Bruce's famous harpers. Of these Mr Salt has made a coloured drawing, which, though a perfect *fac simile*, is as different from the coloured engraving of the French national work, as theirs is from Mr Bruce's representation. The work mentions this view as having been coloured on the spot by the artists ; and states, that as their time would not admit the other coloured drawings to be completed in the same manner, they were afterwards coloured and finished in a style analogous to this: But, as in this drawing they have actually put black for white, and changed other colours, some idea may be formed of the accuracy of the rest. Yet they have posted poor Bruce for his errors. Over the harper is written, probably by one of the same artists, "Bruce est un menteur." A tomb much superior to any of the others, and totally different in plan, discovered within these few months by Mr Belzoni, is likely to make some noise in England. This gentleman is employed in taking models, in plaster of Paris, of all the figures, and a young painter is tracing the whole upon paper, for the purpose of having an Egyptian tomb represented in London. It will be attended with an enormous expence; and I think its ultimate success is doubtful. The plan is singular. A long descending passage, beautifully sculptured and painted, is terminated by a deep well, to prevent farther progress. This arrested Mr B. only for a short time, and seemed but to make him more anxious to proceed. With great labour he got the well filled up, and passed on to a large chamber, supported by several square columns, all painted in the most brilliant manner. This led to several others. After wandering about, admiring every thing, and looking in vain for the sarcophagus, he came to a broad descending flight of steps, in descending which, he found himself in a second story below, consisting of more chambers than that above, and equally beautiful in sculpture and painting. In the farthest chamber, which was unfinished, stood an alabaster sarcophagus, perfectly transparent, covered with hieroglyphics. This tomb, like all the others, is cut in the solid rock; it surpasses them all in size, and in beauty of colouring, the freshness of which is the same as if newly finished. One of the chambers, which has no large figures, but is entirely covered with small hieroglyphics, looks like an elegant modern room, newly and richly papered.

The roofs are all blue, with little stars, which has a very fine effect; and the sides are painted upon a ground of the purest white. Lady B., who has been travelling in this country with her husband and family, gave, perhaps, the best description of them when she said, "they were like elegant drawing-rooms, newly finished and painted, and ready to receive the furniture." The sarcophagus contained nothing, but is quite perfect, except the lid, which is broken in many pieces. Whether it ever received the body for which it had been destined, and which may have since been disturbed, it is difficult to determine: the broken state of the lid seems to imply that it has. The mouth of the tomb was completely concealed with broken stones and chips of rock, found in the excavations, and large mounds of which are seen in all parts of the valley. The sarcophagus chamber was strewed over with little wooden idols, with hieroglyphics on them. These, when collected together, formed a large heap several feet square. After visiting a great many of the tombs, we descended some mummy-pits. One of these had three small chambers near the entrance, on the walls of which were fine representations in painting of musicians and dancers. The mummies were contained in a chamber below, in which they were heaped up nearly half way to the roof.

From the mummy-pits we went to the temples, and began with what is called "The Memnonium." This has a very picturesque appearance at a distance, presenting long files of pillars, and forming several insulated buildings, but it is neither so perfect, nor in such a fine style of sculpture, as that at Dendera. In their plan of this temple, the French give part of one wing as standing which does not exist, and leave out, on the other side, a whole range of pillars. I chose this temple as the best calculated for affording good views, and employed myself several days in making sketches of it, taken at six or eight different points of view, which give the whole temple complete, while the views are sufficiently varied to make them all interesting. The colossal statue, which has been called that of Memnon, and is a very interesting object, is formed of two immense masses of granite, which compose the seat and figure. The head is lying "face up," instead of down, as Denon says, but so much spoiled, that the features are not discernible. This, like every other monument here, might still have been perfect, had it not been intentionally destroyed.

On our way from this to Medinet-Aboo, we passed the two colossal statues on the plain, one of which has so many Greek and Roman inscriptions on it, in testimony of the author's having heard the *voice* of Memnon. This statue appears to have been broken and built up again, as the back is formed of *several* stones, instead of being in one piece, like the others. We then successively visited the temples of Medinet-Aboo, Luxor, and Cannar. Of these it would be tedious to enter into any description. I took a sketch of the beautiful entrance to the first, which, I think, has been given only by Norden, and in a very poor style, as he had but little time, and many difficulties to combat. One, also, of part of a great court and gateway in the interior—and two views of Luxor from the river—but I am afraid to begin with Cannar, as the interior of it is a complete forest of pillars, and as one cannot form an idea of the plan of it till after long examination. It appears to be a series of temples within temples; and, although the most laborious destruction has been employed against it, still what has been destroyed forms but a very trifling part of the whole; and it has the great advantage, as a ruin, of standing by itself, and amidst its own fragments, without having its chambers half choked up with the ruins of a church or village, as at Dendera, or its courts occupied by an Arab town, as at the temples of Luxor and Medinet-Aboo. There are also two other temples remaining at Thebes, on the western side of the river; and, besides these, the foundations and ruins of three others have been very lately discovered by Mr Salt, in the excavations which he has been carrying on. In digging near the temple of Carnac, he and the French ex-consul *Douretti* found about thirty statues, consisting of sphinxes, female figures with lion's heads, and several sitting and standing human figures, all of them more than six or eight feet, and mostly of granite; a great many of them quite perfect, and some of them admirably sculptured. They were all found in one place, where, no doubt, they had been concealed, as they were built over with unbaked bricks, which were again covered with soil. On the western side, also, Mr Salt has found a great many valuable antiquities, principally fine statues, among which there is another head similar to that which was sent home last year. Mr Belzoni, when in Nubia, a few months ago, opened a temple at Ipsambool, which he describes as being the largest excavation either in that country or in Egypt, containing fourteen large chambers, and an immense large hall, with eight colossal statues, thirty feet high, and four others in the sanctuary, all perfect. The walls were covered with hieroglyphics, and the colours in high preservation.

You will easily imagine how highly pleased I was with this little tour, which occupied, most agreeably and usefully, about forty days, which I must otherwise have spent either at Cairo, or on board the ship in the harbour of Suez.

Art. VI.—*Experiments on the Structure and Refractive Power of the Coats and Humours of the Human Eye.* By David Brewster, LL.D. F. R. S. Lond. & Edin., and the late John Gordon, M. D. F. R. S. Edin *. Communicated by the Author.

Having discovered a very remarkable structure in the crystalline lenses of fishes and quadrupeds, by exposing them to polarised light †, I was anxious to examine with care the organization of the cornea, the iris, and the crystalline of the human eye. My friend, the late Dr Gordon, who had studied with much success the structure and functions of this important organ, took a deep interest in the inquiry, and was so kind as to procure for me an eye a few hours after death, and to prepare, by dissection, the different parts of it that I wished to examine. From the great difficulty of obtaining this organ in such a fresh state, he suggested the propriety of embracing the opportunity which was thus offered to us, of obtaining correct measures of the different parts of which it is composed. The aqueous and the vitreous humours had hitherto been supposed to have the same refractive power as water; and even Dr Wollaston, the most accurate of our experimental philoso-

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* An account of the experiments contained in this paper was read before the Royal Society of Edinburgh on the 3d of February 1817.

† Phil. Trans. Lond. 1816, p. 311.

phers, has made the refractive power of the vitreous humour 1.336, the very same number which he obtained for water.

This similarity in the refractive powers of these two fluids, appeared to us in some measure improbable, as the albumen, which enters in a slight degree into the composition of the aqueous and vitreous humours, is known to have a much higher refractive power than water, and as there is no example of any fluid or solid body being inferior to water, or even so low, in its action upon light.

In order to determine this point, we formed a hollow prism with two plates of parallel glass, fixed at an invariable angle, and, that there might be the least possible chance of error, we compared the refractions occasioned by the two humours, directly with that produced by water. The difference of the deviations arising from refraction, afforded an accurate measure of the refractive powers, by comparing them with that of water, which is fixed at 1.3358. A portion detached from the outer coat of the crystalline lens, and a portion detached from a coat nearer the centre, were compared in a similar manner with water; and in order to obtain an average result for the whole of the crystalline lens, we placed it in its entire state in the hollow prism, and measured the refractive deviation which it occasioned. From these and other measurements we obtained the following results:

Refractive power of water,	1.3358
Ditto, of the aqueous humour,	1.3366
——— vitreous humour,	1.3394
——— outer coat of crystalline,	1.3767
——— middle coat of ditto,	1.3786
——— central part of ditto,	1.3990
——— of the whole crystalline,	1.3839

	Inch. Thous.
Diameter of the crystalline,	0.378
——— cornea,	0.400
Thickness of the crystalline,	0.172
——— cornea,	0.042

When the human crystalline was exposed to polarised light, it exhibited the phenomena of double refraction, and produced four luminous sectors like the crystalline lens of quadrupeds. The human cornea produced a double refraction of an opposite kind to that of the crystalline, and the iris, which is semitransparent, gave the same phenomena as the crystalline.

Since the preceding notice was read, M. Chossat of Geneva * has performed a very extensive series of experiments on the refractive powers of the humours of various animals. His results for the human eye confirm those which we have given above, and, as they were obtained by a different mode of observation, it can no longer be doubted that the two humours of the human eye have a higher refractive power than water; and that the refractive density of the vitreous exceeds that of the aqueous humour.

The following is a comparison of our observations with those of M. Chossat:

		Chossat's Results.
Aqueous humour,.......	1,3366	1.338
Vitreous humour,................	1,3394	1.339
Outer part of crystalline,.......	1,3767	1.338
Middle Coats of ditto,..........	1,3786	1.395
Central part of ditto,............	1,3999	1.420
Whole crystalline,................	1,3839	1.384 Mean.

The experiments of M. Chossat give a much greater variation of refractive density to the crystalline humour, though the mean of his three measures is almost exactly the same as that which we obtained for the action of the whole crystalline. I have no hesitation in considering our result as the most accurate, not only from the precautions which were taken to avoid error, but from the improbable circumstance that the first coat of the crystalline lens should be inferior in refractive power to the vitreous humour, and from the coincidence of our result for the central part of the crystalline with that obtained by Dr Thomas Young, in his able dissertation on the mechanism of the Human Eye †. He makes the ratio of the refractive power of

* M. Chossat's Experiments were published in the *Bulletin des Sciences, par la S c. Philomath.* for June 1818, p. 94.; and in the *Bibliotheque Universelle* for September 1818, p. 26.

† Phil. Trans. 1801, or Nat. Phil. Vol. ii. p. 580.

the crystalline after death to that of water, as 21 to 20, which gives 1.4025 for the index of refraction, differing only 0.0035 from our measure, and 0.0175 from that of M. Chossat. It is by no means improbable, however, that the crystalline employed by M. Chossat had actually a greater refractive density than ours. The one which we used was that of a female above fifty years of age.

In the preceding observations I have limited myself to a general notice of the polarising structure of the crystalline lens; but, in the course of an extensive series of experiments upon the anatomical conformation of this part of the eye in animals of all kinds, I have ascertained the precise manner in which its fibres are arranged, from the examination of a great variety of crystalline lenses, and by the use of new methods of observation. This series of experiments, which is now nearly ready for publication, was undertaken at the particular request of Dr Gordon, for the purpose of ascertaining if the polarising structures exhibited in the crystalline lens, had any connection with that singular arrangement of its fibres, which had been remarked by Leuenhoek, Sattig and Dr Young. In the results which I obtained, after a very few experiments, no such connection appeared; but the anatomical structure of the lens presented several curious phenomena, which, with the aid and encouragement of Dr Gordon, I was induced to investigate. The premature loss of this distinguished individual put a temporary stop to pursuits, which owed their origin and continuance to his wishes; but though the inquiry was in some degree foreign to my own studies, and by no means inviting to one unaccustomed to anatomical operations, I have resumed and completed it from the same motives which induced me to undertake it. Whatever importance may be attached to it by physiologists, it will always have to me the higher value, of being the only memorial I can leave of a friendship which I deeply valued, and the best tribute I can pay to the memory of distinguished talents and exalted worth.

Art. VII.—*Demonstration of a Theorem relating to Prime Numbers.* By Charles Babbage, Esq. F. R. S. &c. Communicated by the Author.

The singular theorem of Wilson respecting Prime Numbers, which was first published by Waring in his *Meditationes Analyticæ,* and to which neither himself nor its author could supply the demonstration, excited the attention of the most celebrated analysts of the continent, and to the labours of Lagrange and Euler we are indebted for several modes of proof; and more recently it has been considerably extended by the profound investigations contained in the *Disquisitiones Arithmeticæ.*

It is well known that, in the theorem in question, a certain expression is asserted to be divisible by n, whenever that number is a *prime*, but it is not divisible if n is not *prime*. In attempting to discover some analogous expression which should be divisible by n^2, whenever n is a prime, but not divisible if n is a composite number, I met with those properties of primes which form the subject of the present paper.

The theorem of Wilson asserts that

$$1.2.3\ldots.\overline{n-1}+1$$

is always divisible by n when n is a prime number, otherwise it is not. The theorem which I have arrived at is as follows, that

$$\frac{\overline{n+1}.\overline{n+2}.\overline{n+3}\ldots\ldots\overline{2n-1}}{1.2.3\ldots.\overline{n-1}}-1$$

is always divisible by n^2 when n is a prime number, otherwise it is not. The demonstration is very simple. Let $\left(\frac{n}{0}\right)$, $\left(\frac{n}{1}\right)$, $\left(\frac{n}{2}\right)$, &c. represent the coefficients of the nth power of $(1+n)$, so that

$$\left(\frac{n}{0}\right)=1,\quad \left(\frac{n}{1}\right)=\frac{n}{1},\quad \left(\frac{n}{2}\right)=\frac{n.\overline{n-1}}{1.2},$$

$$\left(\frac{n}{3}\right)=\frac{n.\overline{n-1}.\overline{n-2}}{1.2.3}\ \&c.$$

then

$$\left(\frac{n}{n-2}\right)=\frac{n.\overline{n-1}}{1.2},\left(\frac{n}{n-1}\right)=\frac{n}{1}\frac{n}{n}=1$$

n being a whole number, now it is well known, that the sum of the squares of the coefficients of a binomial whose index is n, is equal to the coefficient of the middle term of another binomial whose index is $2n$, we have therefore the equation

$$\frac{2n.\overline{2n-1}.\overline{2n-2}\ldots\overline{n+1}}{1.2.3\ldots\ldots n}=1^2+\left(\frac{n}{1}\right)^2+\left(\frac{n}{2}\right)^2$$
$$+\left(\frac{n}{3}\right)+\&c.+\left(\frac{n}{n-1}\right)^2+1^2$$

or

$$2\left\{\frac{\overline{n+1}.\overline{n+2}\ldots\overline{2n-1}}{1.2.3\ldots\overline{n-1}}-1\right\}=\left(\frac{n}{1}\right)^2+\left(\frac{n}{2}\right)^2$$
$$+\left(\frac{n}{3}\right)^2+\&c.+\left(\frac{n}{n-1}\right)^2$$

But the quantities $\left(\frac{n}{1}\right)$, $\left(\frac{n}{2}\right)$, $\left(\frac{n}{3}\right)$ &c. or their equals,

$$\frac{n}{1},\ \frac{n.\overline{n-1}}{1.2},\ \frac{n\overline{n-1}.\overline{n-2}}{1.2.3},\ \&c.\ \frac{n.\overline{n-1}\ldots 2}{1.2.3..\overline{n-1}}$$

are all divisible by n when n is a prime, but they are not all divisible by n when n is not a prime ; and, since the quantities on the right side consist of the sums of the squares of these, it is divisible by n^2, and consequently

$$2\left\{\frac{\overline{n+1}.\overline{n+2}\ldots\overline{2n-1}}{1.2\ldots\overline{n-1}}-1\right\}$$

is always divisible by n in the same circumstances, as 2 cannot be divisible by n except $n=2$ we may omit that factor. The same theorem may also be put into the following form :

$$2\left\{\frac{1.3.5\ldots\overline{2n-1}}{1.2.3\ldots n}.2^{n-1}-1\right\}$$

is always divisible by n^2 when n is a prime: This is immediately deduced from the former by the equation

$$\overline{n+1}.\overline{n+2}\ldots 2n=2^n.1.3.5\ldots\overline{2n-1}.$$

Several theorems of a similar kind may be deduced from the investigations of Euler, relative to the properties of the co-efficients of a binomial. See the *Acta Acad. Scient. Petrop.* 1781.

Retaining the notation already employed, it is there shewn, that when p n and q are any whole number, we have

$$\binom{p+n}{q+n} = \binom{n}{o}\binom{p}{q} + \binom{n}{1}\binom{p}{q+1} + \binom{n}{2}\binom{p}{q+2} + \text{\&c.}$$

Let $q = p - n$, and this becomes,

$$\binom{p+n}{n} = \binom{n}{o}\binom{p}{p-n} + \binom{n}{1}\binom{p}{p-n+1} +, \text{\&c.}$$
$$+ \binom{n}{n}\binom{p}{p}$$

All the terms except the first and last are divisible by n, and by p if both numbers are primes; therefore we have,

$$\frac{p+n.\,p+n-1\ldots\ldots n+1}{1.2.3\ldots\ldots\ldots p} - \frac{p.\,p-1\ldots n+1}{1.\ 2\ldots p-n} - 1$$

always divisible by $n\,p$, when the numbers $n\,p$ are primes: if $p=n$, this resolves into the former theorem.

If p is a prime, and greater than n, then since $\frac{p.p-1\ldots n+1}{1.2\ldots p-n}$ is divisible by p, we have,

$$\frac{p+n.\,p+n-1\ldots\ldots n+1}{1.2.3\ldots\ldots p} - 1$$

always divisible by p, whatever n may be, if $p=$ a prime, otherwise, it is not divisible.

This expression is also divisible by n, for the numerator is $n+1.\,n+2\ldots.n+p$; and if this be arranged according to the powers of n, the term independent on n will, when divided by the denominator, leave unity, which is destroyed by the -1, and all the remaining terms are divisible by n, so that the expression

$$\frac{p+n.\,p+n-1\ldots n+1}{1.2\ldots\ldots p} - 1$$

is always divisible by $p\,n$, if p is a prime, otherwise it is not divisible by p, but only by n.

By considering the coefficients of the cube, and other powers of

$$1 + \binom{n}{1}x + \binom{n}{2}x^2 + \binom{n}{3}x^3 +, \text{\&c.}$$

we might arrive at other theorems respecting prime numbers; but the number of the combinations which occur in all the higher powers, seem to exclude that simplicity in the expression, which we have found in those deducted from the co-efficients of the square of a binomial.

In case $n-1$ should be a prime number, we may find formulæ divisible by $(n-1)^2$, thus: If instead of subtracting the two extreme terms of the co-efficients, we subtract the two first and two last, we have,

$$2\left\{\frac{n+1.n+2\ldots 2n-1}{1.2\ldots n-1}-1-\frac{n^2}{1^2}\right\}$$

$$=\left(\frac{n}{2}\right)^2+\left(\frac{n}{3}\right)^2+\text{, \&c. }+\left(\frac{n}{n-2}\right)^2;$$

and since, if $n-1$ is a prime, each term on the right side of the equation is divisible by $(n-1)^2$; the expression on the left side is always divisible by $(n-1)^2$ in the same circumstances; or the expression

$$\frac{n+1.n+2\ldots 2n-1}{1.2\ldots n-1}-2n$$

is always divisible by $(n-1)^2$, if $n-1$ is a prime number, otherwise it is not divisible. It is obvious that similar theorems might be deduced, in which the prime divisors should be $(n-2)^2$, or $(n-3)^2$, &c.

Art. VIII.—*Description of the Diamond Mine of Panna.* By Francis Hamilton, M. D. F. R. S. & F. A. S. Lond. & Edin. Communicated by the Author.

During the rainy season of the year 1813, on my way from Agra to Chunar, I made an excursion from the Yamuna (*Jumna*, Rennell,) to visit the Diamond Mine at Panna, and first proceeded up the Ken in my boats for two days; but I made very little progress, owing to the strength of the current, and the badness of the ground on the bank for tracking. The Ken is not a great deal smaller than the Yamuna, and resembles it much in having very high banks intersected by numerous ravines. Its channel abounds in pebbles of agate and jasper; but, in the rainy season being entirely filled with water, scarcely any were procurable; nor did I obtain any good specimens. These pebbles are not so much variegated by zones of different colours, or dendritical figures, nor do they contain so much crystallized matter, as those of the Son; but the jaspers are more perfect, and are red, honey colour, and black, some of the latter especially admitting of a fine polish.

After two days labour, with a strong fair wind, I was told that I was only four coses nearer Banda, than when I left the Yamuna, the whole distance being reckoned ten coses; but, leaving my boats and travelling by land, it took me from six in the morning to eleven to reach the town in a palanquin, during which time I must have gone twenty miles. The coses of Bandelkhand, the district of which Banda is the capital, are therefore very long. From Banda to the Diamond Mine is reckoned twenty-nine coses: but I took eighteen hours to perform the journey in a palanquin, with relays of bearers, and making no halt that was avoidable. The distance, therefore, must be seventy miles, as the roads, when I went, were tolerably good. As it rained much on my return, the roads were bad, and I took much longer time. I must here observe, that the latest maps of India, which I have seen published, even by far the best, that of Mr Arrowsmith, represent this part of the country very imperfectly.

Singhapur is a small town at the northern side of the hill, on which is built Ajaygar, or the Invincible Fortress, and is twenty-four computed coses from Banda. The country between the Yamuna and Singhapur is in general level, with, however, many projecting insulated rocky hills. That immediately adjacent to Banda consists chiefly of a small-grained granite; some of which contains red felspar, white quartz and black mica; and some is composed of white felspar and quartz, with black mica. Besides the granite, this hill contains also large masses of quartz and felspar, very irregularly intermixed rather than aggregated into one solid rock. From the ruggedness of their appearance I judge that the other small detached hills are of similar materials; but I had no opportunity of examining them.

At no great distance to my left, in going to Singhapur from Banda, I had a ridge of hills, which is a continuation of that which, commencing at Rohitasgar and Sahasran on the banks of the Son, passes behind Mirzapur and Allahabad, and which, from the last-mentioned place, takes here a large sweep to the south, and then bends north to Goyaligar, and from thence behind Agra and Dilli, being the northern boundary of the Vindhyan mountains. The portion of this ridge passing through Bandelkhand, has a very similar appearance to the part of the same range that passes through the Shahabad district, only it is less sterile and rugged; for the trees in most places ascend to the very summits of the hills, and it is only in some places that the table land on the top is bounded by an abrupt precipice of rock, such as surrounds the whole eastern end of the ridge. The nature of the strata seems, however, perfectly similar throughout its whole extent, consisting of horizontal rocks, which, near the surface, are a kind of free sandstone, very fit for building; but in the interior of the mountain, the rock is too hard, approaching near in nature and appearance to hornstone or granular quartz. The colour is various, red, brown, and white; and, in general, it is more or less dotted with black.

On the summit of this range, is a table-land of great extent, and from about 500 to 1200 feet of perpendicular height above the level of the Gangetic plain. To the side of this table-land most remote from this plain, I have not reached; but from the side next the Ganges, there project many small ridges of the same materials, which run towards the Ganges and Yamuna, as at Sahasran, Chunar, Mirzapur, Allahabad, and at Famos, where a ridge not only penetrates across the channel of the Yamuna, as others in several places do, but rises into a small rocky hill on the left bank, thus forming the only hill in the ancient kingdom of Antarbeda, now called the Dooab by the Muhammedans.

The very strong and remarkable fortress of Kallangjar is on one of these ridges, projecting to the west from the main range of hills, but separated by a narrow gap. I passed it both coming and going in the dark, so that I had no opportunity of examining the strata; but the buildings of the town, no doubt taken from the hill, are of the free sandstone usual in this range.

Ajaygar, another fortress, seven computed coses from Kalangjar, stands also on a ridge projecting to the Ken river; but the portion of the hill occupied by the fortress, is separated from the east and west ends of the ridge by two deep ravines that penetrate the hill almost to the level of the plain. Although the upper part of the hill occupied by the fort, consists of the usual freestone, the lower part, on the south side at least, towards the market-place called Katra, consists of a very fine perfect granite, with large concretions of red felspar. According to a manner of reasoning usual with several mineralogists, we should call this granite *incumbent* on the sandstone, the latter occupying the higher and central part of the ridge. I will venture to say, that in the world there is not a more perfect granite, nor one which has less the appearance of stratification; and it must be observed, that in many parts between the Sandstone range and the Ganges and Yamuna, there are scattered small detached peaks of the rocks usually called Primitive, as at the hill near Banda, already described. Beyond these peaks there is no rock whatever, until we come to the Himalya mountains.

From Singhapur, adjacent to Ajaygar, I proceeded in an easterly direction, through a narrow valley, for about four miles, to Vizramgunj, at the bottom of the main sandstone range of hills. Here, as the name implies, had been a neat resting-place, with a reservoir of water, and various accommodations for travellers. From the style of the buildings, they would appear to have been erected by the Muhammedans, and are said to have been destroyed out of mere wantonness by the last Marhatta officer stationed at the place. From this resting place, I ascended the hill by a very bad road, but practicable for loaded cattle or palanquins, and conducted with total disregard to art, as it leads straight up the steepest ascents. The total height is very considerable, perhaps five or six hundred feet perpendicular. In the middle of the way has been another place of refreshment, built in the same style with that below, and probably also a Muhammedan work. The hills here abound in Sagwan (Tectona grandis), and in a species of Diospyrus producing Abnus (Ebenus). The former, so far as I can learn, never reaches to a size fit for use; the latter is nowhere larger or better. The tree is by the natives called Tenged; it is only the black heart that is called Abnus,—a Persian term, from which our Ebony is derived; and I am well informed that, in the Sangskritta, there is no term for this wood, polished timber, it would seem, having entered little into the economy of the ancient Hindus. Bamboos are also abundant on these hills.

The table land above the ascent is more level, and freer from rocks, than that in the Shahabad district; but, although I advanced on it about three miles, and to within full view of the town of Panna, I saw not the slightest trace of cultivation. I did not proceed to Panna, because I found the people at work in search of diamonds, and thus satisfied my curiosity without being obliged to remain a night destitute of comfort in the formality of a visit to the Raja.

The whole plain on the table land for several miles round Panna in all directions, wherever it happens to be of a gravelly nature, is said to produce diamonds. In most parts, the soil is very red, in others it has only a slight tinge of that colour, and is of a dark brown. This soil is from two to eight cubits deep; and, where the diamonds are found, contains many small pebbles, a good deal resembling some ores of iron that I have seen in Bhagalpur. The diamonds are found intermixed with this, but never adhering to any stone or pebble. The workmen lift up the gravelly earth in baskets, throw it into a shallow pit filled with water, and wash out the earth. They then spread the washed gravel thin on a smooth piece of ground, and separate the useless pebbles with their hands, moving eight or ten pieces at a time, so that no diamond can possibly escape their notice. Many days are thus often spent without success; but a very few diamonds in the year repay the workman for his labour. The greater part of the diamonds are not worth more than 500 rupees *. A good many, however, are found worth from 500 to 1000. Very few are found worth above the latter value. The Raja is said to have at present one valued at 50,000 rupees; but he has not been able to find a merchant, and has placed the gem in the head of an image. The workmen assured me, that the generation of diamonds is always going forward, and that they have just as much chance of success in searching earth which has been fourteen or fifteen years unexamined, as in digging what has never been disturbed; and, in fact, I saw them digging up earth which had evidently been

* The rupee contains 179½ grains of silver.

before examined, as it was lying in irregular heaps, as thrown out after examination.

The Rajah has guards all around, and some watchmen attend the labourers; but no great precaution to hinder smuggling is apparent to the visitor. The workmen I saw were Rajputs, and had every appearance of poverty. The men appointed to guard them were common soldiers, probably allowed two or three rupees (5 to $7\frac{1}{2}$ shillings) a month, and such as in the Company's government would be open to every sort of peculation. The barbarous severity of the petty chiefs, such as the Raja is, probably, in a great measure, prevents illicit dealing. The whole diamonds are collected at one house, where they are weighed and sold to the merchants residing at Panna. The workmen are allowed three-fourths of the value of those about the size of a pea or still smaller; two-thirds of the value of those about the size of a hazel nut; and one-half of the value of those larger than a filbert, but few of these are found. Any man that pleases may dig, and it is said, that, on an average, about a thousand men are employed in the search.

The rock immediately under the gravel and earth, among which the diamonds are found, is a white granular quartz, evidently of the same nature with the sandstone usual in this range of hills, but rather too hard to be cut for building. In many places, it is stained red, and contains more black spots or dots than usual. On the ascent of the hill, the rock is white free sandstone, very fit for building.

LENY, 18*th March* 1819.

ART. IX.—*Description of the Patent Sympiesometer or New Air Barometer.* *By* ALEXANDER ADIE, F. R. S. Edin. Communicated by the Author.

MY attention was first directed to the improvement of the Barometer, with the view of rendering it susceptible of indicating any of those minute changes in the weight of the atmosphere, which might be supposed to arise from the action of the Sun and Moon. A very sensible instrument was obviously necessary for such a purpose; and I was therefore led to the idea of measuring the pressure of the atmosphere by its effect in compressing a column of common air. Upon constructing an instrument of this kind *, however, I found that the air was absorbed by the fluid with which it was inclosed, and that a good and permanent barometer could not be made upon such a principle till this radical defect was removed. I therefore directed my attention particularly to this object, and succeeded beyond my most sanguine expectation, in freeing the Air Barometer from this great source of inaccuracy.

The name of *Sympiesometer* which I have given to this improved instrument, is derived from the Greek words συμπιεζω to compress, and μετρον a measure, denoting the property it possesses of measuring the weight of the atmosphere by the compression of a gaseous column.

The principle of the Sympiesometer, which is represented in one of its forms, in Plate II. Fig. 2., consists in employing an elastic fluid or gas, different from air, and any liquid, excepting quicksilver, which neither acts upon the gas which it confines, nor is perceptibly acted upon by the air, to the contact of which it is in some measure exposed. Hydrogen gas, azotic gas, or any of the gases not liable to be absorbed by the inclosing fluid, may be used; but I prefer hydrogen gas as superior to any other that I have tried. The liquid which answers best is an unctuous oil, or a mixture of unctuous and volatile oils. I consider almond oil, coloured with anchusa root, as the most eligible.

The Sympiesometer consists of a tube of glass A B C, of about 18 inches long, and 0.7 of an inch diameter inside, terminated above by a bulb A, about two inches long inside, and half an inch diameter, (but this will vary, as the instrument is required to have a greater or lesser range); and having the lower extremity B bent upward, and expanding into an oval cistern C, open at top.

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* When I constructed this instrument, I was not aware that Dr Hooke had employed the compression of a column of air to measure the weight of the atmosphere. The Sympiesometer, however, will be found to have no resemblance to his instrument but in this particular.

The bulb A at the upper end of the tube is drawn to a slender thread, and is at first left open. In order to introduce the gas and oil, I fill the bulb and tube with quicksilver: Then, holding the tube horizontal, a communication is formed between a gasometer, containing the gas to be used, and the slender pipe at the end of the bulb A, by means of a flexible tube. As the tube is brought to a vertical position, the quicksilver flows out till it descends in the tube to the level of the top of the cistern, and the gas enters to supply its place. The slender pipe is then to be sealed hermetically close to the bulb A, by a touch of the flame of a blowpipe.

The tube A B C is now to be inverted, and the mercury poured out of the cistern C, allowing the column which occupies the tube to run towards the bulb, to prevent the escape of the gas. The tube being again turned into a vertical position, the portion of quicksilver which remains is removed, by pouring some of the oil over it, and heating the gas until, by its expansion, it forces the column of quicksilver which is left at the lower end of the tube, into the cistern; then, holding the tube nearly horizontal, the oil will enter as the gas cools, and the remaining quicksilver may be poured out of the cistern C.

The inclosed gas which has thus been introduced, changes its bulk, or occupies more or less space, according to the pressure of the atmosphere upon the surface of the oil in the cistern C. The scale *m n* for measuring the change in the bulk of the gas occasioned by a change of pressure, is formed experimentally, by placing the instrument in an air-tight glass-case, along with an accurate barometer and thermometer.

The glass-case is furnished with a condensing and exhausting syringe, by which any density may be given to the inclosed gas, so as to support a column of quicksilver in the barometer of 28, 29, 30, or any other required number of inches. The height of the oil in the tube of the Sympiesometer corresponding to these points being marked on its scale, and the spaces between being divided into an hundred parts, these parts correspond with hundredths of an inch, on the scale of the mercurial barometer.

As the bulk of the gas is altered by any change that takes place in the temperature of the atmosphere, it is necessary to apply a correction on this account. For this purpose the principal or barometric scale *m n*, is made to slide upon another scale *o p*, placed either below it or on one side of it, which is divided into degrees and parts, so as to represent the change of bulk in the gas produced by a change of temperature under the same pressure, and corresponding to the degrees of a common Thermometer attached to the instrument.

This scale is constructed in the same manner as the scale of a common thermometer, by changing the temperature of the bulb while the pressure is the same, and noting the range of the oil occasioned by it.

In using the instrument, observe the temperature by the thermometer, and set the index which is upon the sliding Sympiesometer scale, opposite to the degree of temperature upon the fixed scale; and then the height of the oil, as indicated on the sliding scale, will be the pressure of the air required.

When the height of one place above another is to be measured by the diminution of the pressure of the atmosphere, another correction is necessary to insure perfect accuracy in all instruments indicating this change, because the pressure of a column of air of a given altitude varies according to its humidity or moisture. I have therefore added to the Sympiesometer a new Hygrometer, which has already been described in a preceding article. See page 32.

In some of the Sympiesometers which I have made, the scale is divided into parts corresponding to the increase in bulk which takes place in the gas by the diminished pressure of the atmosphere on ascending a given height, the temperature being 32° of Fahrenheit. This scale is also formed by experiment, as follows: The instrument being placed in the glass-case as before described, increase the density of the inclosed air until it support a column of quicksilver of 31 inches, the temperature being 32°. Mark this point zero; then from the logarithm of 31 subtract .0100, and find the corresponding number, which is 30.294; regulate the density of the air to support a column of quicksilver of this length; number this point on the scale 100, and divide the space into 100 parts; each part will equal the increase of bulk or fall of the oil in the tube by ascending one fathom. In the above manner proceed, by subtracting .0100 from the logarithm last found, and marking the points corresponding to these densities, until the scale is complete.

By the above scale, the approximate height will be given without the aid of a table of logarithms, by subtracting the number of fathoms indicated by the Sympiesometer at the under station from that indicated at the upper station, the difference being the number of fathoms which the one station is above the other.

Previous to laying this instrument before the public, I wished to have it submitted to a fair trial, by comparing it with observations made in the same ship with the Marine Barometer. For this purpose Quintin Leitch, Esq. of Greenock, the proprietor of the ship Buckinghamshire, obligingly sent one of the first which I had made with this ship on her voyage from the Clyde to the East Indies, in the year 1816; and the following is the report given of the instrument by the late Captain Christian, the commander, on his return.

"I am glad to say that I consider your Barometer a valuable instrument at sea, having given it a fair trial on the outward passage to India, by keeping a correct register of it, as well as of the common Marine Barometer, taken every third hour, night and day, during the passage; and I not only found that it was fully as sensible of the changes of the atmosphere as the other barometer, but that it had a great advantage over all barometers I have ever seen used at sea, namely, that of not being in the smallest degree affected by the motion of the ship, which will often make the quicksilver in the common tube plunge, or rise and fall, in such a degree as to make it very difficult to come within at least one or two tenths of an inch of the truth, even in the largest ships. On the passage home I also found it very correct in the indication of the winds and weather."

An opportunity of trying the Sympiesometer in a very different climate occurred last year, when the Expedition under Captain Ross sailed to the Arctic Regions. Lieutenant Robertson of the Isabella kindly undertook the charge of this instrument, and regular observations were made every four hours with the Sympiesometer and Marine Barometer, the results of which were highly satisfactory. The observations commenced on the 24th of April, in North latitude 51° 39′, and longitude 1° 7′ E.; and were continued to the latitude of 76° 50′ N. and during the return of the Expedition to Deptford till the 13th of November. These observations, in the form of a graphical representation of the progress of the Sympiesometer and Marine Barometer, have been published in Captain Ross's Account of the Expedition, and will enable navigators to form a correct estimate of the relative value of the two instruments *.

The following is Captain Ross's official report upon the Sympiesometer:

" This instrument acts as a marine barometer, and is certainly not inferior in its powers. It has also the advantages of not being affected by the ship's motion, and of taking up very little room in the cabin. I am of opinion that the instrument will supersede the Marine Barometer, when it is better known."

Lieutenant Robertson, in a letter to the Honourable Captain Napier of Merchistoun, has spoken of it in the following manner:

" The Sympiesometer is a most excellent instrument, and shews the weather far better than the Marine Barometer. In short, the barometer is of no use compared to it. If it has any fault, it is that of being too sensible of small changes, which might frighten a reef in when there was no occasion for it; but, take it altogether, in my opinion it surpasses the mercurial barometer as much as the barometer is superior to having none at all."

I have also had it in my power to make trial of the Sympiesometer on coasting voyages, through the favour of my friend Mr Stevenson, Engineer to the Scots Lighthouse Board, who placed one of them in the cabin of the Lighthouse Yacht beside a good marine barometer. Along with a register of both instru-

* We have now before us a copy of these observations, both in a tabular and projected form. The superior delicacy of the Sympiesometer is very remarkable. It frequently exhibited variations in the pressure of the atmosphere when the Marine Barometer was perfectly stationary, and thus predicted changes in the weather, when the other instrument gave no indications at all. We have likewise seen the observations made with the Sympiesometer by Captain Dalling, of his Majesty's ship Nimrod, who has expressed the highest opinion of the superiority of the Sympiesometer. On one occasion in particular, it enabled him to make successful preparations against a storm, which was not indicated by the Marine Barometer. Ed.

ments, extracted from the ship's log-book, he has favoured me with a communication, which states, that, "after an experience of two years, the Sympiesometer affords the most delicate and correct indications of the weather;" and that "it is a great favourite on board, being commodious even for the smallest cabin, and at the same time easily read off."

"The master, mate, and steward of the Light-house Yacht, (Mr Stevenson adds), give such accounts of the utility and conveniency of the Sympiesometer, as are well calculated to recommend it to the attention of those sailing in vessels of the smallest burden. It is now in use in the service of the Commissioners of the Northern Lights, on board the Light-house Yacht, of 80 tons register, and the Pharos, or Bell Rock Tender, of 45 tons."

EDINBURGH, *March* 20. 1819.

ART. X.—*Method of Weighing Anchors, used by the Natives of the Coast of Coromandel.* Communicated by the Author.

WHEN his Majesty's ship Minden struck upon the Coleroon shoal, on the coast of Coromandel, in September 1814, a bower anchor was laid out by the boats; but after the ship was hove off, these were found insufficient to raise the anchor off the ground; and the water being too shallow for the ship to approach, it became necessary to resort to some other means of effecting this object. While the officers were considering which of the ordinary expedients was best, the master-attendant of Porto Nuovo, who had come on board to give his assistance, suggested that the natives should be allowed to try the method in common use amongst them for weighing anchors. This proposal was immediately agreed to by the Admiral, the late Sir Samuel Hood, whose ardent and inquiring mind caught eagerly at every thing new, which promised to be of use in his profession.

The natives were supplied with a number of spars, such as topmasts, jib-booms, &c. These they lashed together, so as to form a raft in the form of a rude cylinder, between three and four feet in diameter. Round the middle of this, they wound the buoy-rope of the anchor, and made it fast. Thirty small ropes, were now made fast to the spar, and passed round it several times, in an opposite way from that in which the buoy-rope had been wound; thus forming what are technically called "slew-ropes," (turning ropes). Sixty of the natives now mounted the spar, and, having taken hold of the ropes, hauled upon them so as to turn the spar round In a short time, the buoy-rope became tight, which prevented the further rotation of the spar. All the slew-ropes being now rendered equally tight, were held firmly in both hands by the natives, who stood erect, and in a line, along the top of the spar; and, upon a word of command being given, the whole party threw themselves suddenly backwards, so that they all fell flat on the surface of the water at the same moment. By this operation the spar was made to perform one quarter of a revolution; but this of course did not start the anchor, though it made the buoy-rope so tight, as to require a considerable force to prevent the spar from turning back again. The next turn was made by the alternate pairs of men remaining extended on the water, while the rest gradually climbed up to the top of the spar, by means of the slew-ropes. Having reached this point, and having drawn their ropes equally tight, they again threw themselves on their backs, while those who were already down, merely "took in the slack," as it is termed, of their ropes, that is, kept them uniformly tense, while the spar was performing another quarter revolution, by the effort of the number who had climbed up. The same thing was repeated, always by half of the party, till the anchor was fairly lifted off the ground. As soon as this was accomplished, the whole of the natives continued stretched on the water, while the boats towed the spar, together with the anchor, and all the apparatus, into deep water, where the ship lay; and the anchor was then hove up in the usual way.

The anchor in question weighed above three tons, and was much heavier than any which the natives had ever before raised. They complained much of this circumstance; and indeed, it had nearly cost them very dear; for, when they had nearly reached the ship, some of them, either becoming tired or frightened, let go their ropes. This threw additional weight upon the rest, who in their turn, becoming alarmed, also quitted their hold. In an instant the anchor sunk to the bottom, and by unwinding the buoy-rope gave the spar so rapid a rotatory motion that some of the natives were actually carried round along with it, but happily no one was hurt.

The method above described for weighing anchors, though a rude one, is nevertheless founded on good principles, and in the hands of an intelligent seaman, might perhaps be simplified and perhaps rendered practically useful. A prejudice, however, prevails too generally at sea against every new operation of seamanship; and this is the more unfortunate, since all experience shows the importance of adding to the number of those resources which, from the various nature of the services on which he may be employed, and the unforeseen accidents to which he is liable, the practical seaman stands so perpetually in need. It is true that the expedients in common use for raising anchors are numerous; but a case may easily be conceived in which none of these methods will answer the purpose; and the anchor, as is frequently the case, must be abandoned. On such an occasion, the foregoing mode, or some modification of it, might be resorted to, in order to avoid such an alternative.

It would be easy to counteract the tendency which the spar has to turn back again, after the anchor is lifted off the ground, by having two buoy-ropes instead of one, and passing them round the spar *in opposite ways.* It is clear that, when the spar was made to turn by the action of the men falling down, one of these ropes would become slackened; but, at the end of each pull, or quarter turn, this slackened rope might be drawn tight, and then the whole strain exerted by the men might be removed with safety; since the anchor would now hang by two ropes, wound round in opposite directions, and would, therefore, have no more tendency, by its weight, to turn the spar one way, than the other. Practically too, this would be serviceable in other respects, as it would enable the whole number of men to be employed at each pull, instead of one-half: and where there is the least swell, it is obvious that some contrivance of this kind is indispensable.

It may be objected to this method, that it can only be put in practice where a set of amphibious workmen, like those above described, are to be found. But it would not be difficult to form a water windlas, which should be worked by men in boats. In constructing the raft round which the buoy-rope is to pass, a number of handspikes, capstan bars, or other levers, might be inserted and left standing out, like handspikes in a windlas on board ship; or these levers, instead of being lashed in along with the main spars of the raft, might be attached to the outside, and made to act as in the power familiar to the practical seaman, under the name of the Spanish windlas. In this way, the use of slew-ropes would be superseded; and, by lengthening these levers, the power might be increased at pleasure. It ought not to be forgotten, that the smaller the diameter of the raft, compared with the length of the levers, the greater will be the power of purchasing the anchor. In practice, therefore, it may be advisable to make that part of the raft over which the buoy-rope passes, as small, and those parts which bear the levers, as large as possible.

Art. XI.—*Examination of some Compounds which depend upon very weak Affinities.* By Jacob Berzelius, M.D. F.R.S. and corresponding Member of the Institute of France. Communicated by the Author.

So long as we confine our attention to those combinations which owe their existence to very strong chemical affinities, we find a striking simplicity and a constant analogy in their composition: but, if we begin to examine those combinations which depend upon weak affinities, we find, that, as we proceed, the modes of combination continue to increase in number and intricacy. Salts formed by the union of strong acids, with salsifiable bases, belong to the former of these classes; whilst a great part of the productions of the mineral kingdom, where bodies slightly electronegative perform the function of acids, belongs to the latter. This class includes also some other very weak combinations; those, namely, which take place among compound molecules of the second or third order, and which form salts of a double, sometimes perhaps of a triple base. It is sufficiently ascertained, that chemical affinity rapidly diminishes as the number of combining atoms augments. Thus, the affinity of compound molecules of the first order is much weaker than that of elementary bodies; and the difference between the affinity exerted by molecules of the second order, and that exerted by molecules of the first, is immensely greater. Now, it is precisely the study of these decreasing affinities which forms the object of mineralogical chemistry, and without which, that science can never arrive at any higher degree of perfection. The attempt to prove that the combinations which constitute minerals have been formed under the same laws which regulate the union of elementary substances in our laboratories, has met with a degree of success, sufficient to remove all doubts concerning the accuracy of its principle: but in order to reduce the results of not a few mineral analyses into conformity with these laws, the supporters of this opinion have been obliged to admit modes of combination, to which the chemistry of our laboratories offers nothing analogous; and it has been found, in general, that compounds in the mineral kingdom consist of a greater number of molecules than we have it in our power to combine by artificial means. The reason of our inability to form such combinations is not, that weak affinities are inert in our experiments; but that they are destroyed by those greater forces of which we are obliged to make use, in order to obtain the combinations in an isolated state. Hitherto few trials have been made to produce artificial compounds analogous to fossils; but I am fully persuaded that such attempts will succeed, to a degree beyond what is hoped for in the present state of science.

In my experiments upon the composition of silica, (*Afhandl. i Fysik, Kemi* *, *&c.* tom. v. p. 500), I have proved, that if alumina, silica, and an excess of the carbonate of potash, be mixed together, and afterwards heated in a crucible of platina, till the mass has been, for some time, in a state of fusion; we shall obtain a saline mass, of which water dissolves a portion, and leaves a portion undissolved, in the form of a white powder, which may be called felspar with an excess of base. This powder is composed of silica, alumina and potash, in such proportions, that the alumina contains three times the oxygen of the potash, and the silica contains a quantity of oxygen equal to that of the two bases together. This substance, then, in reality, being felspar deprived of two-thirds of its silica, bears to it the same relation

* *Essays on Physics, Chemistry and Mineralogy*, a Swedish Journal conducted by Messrs Berzelius and Hisinger.—Transl.

which the neutral sulphate of alumina bears to the subsulphate. It is evident, from the very operation by which this compound is produced, that it must have an excess of its bases. If, on the other hand, one portion of caustic potash be made to saturate itself with pure alumina, and another portion with silica; and if the former of these solutions be poured, drop by drop, into the latter, without however precipitating all the silica, we shall obtain an abundant precipitate, which contains alumina and potash in the same mutual relation as the preceding compound, but united with a double portion of silica; in other words, the silica contains twice the oxygen which exists in the bases. And this is exactly the composition of vesuvian. I have not yet attempted to produce felspar by artificial means; but I have reason to believe, that it could be accomplished by digesting the precipitate just mentioned in a solution of silica by water *. It is very evident that our knowledge of minerals would gain a much higher degree of certainty, if by synthesis we could confirm our analytical results.

In several double siliciates, we find one of the two component siliciates saturated with silica, in a higher degree than the other. Such, for example, is the composition of emerald, in which the glucina contains a quantity of silica double of that combined with the alumina $= \dddot{Be}\ \dddot{Si}^4 + 2\ \dddot{Al}\ \dddot{Si}^2$. In apophyllite, the potash is combined with a dose of silica double of that with which the lime is combined $= \ddot{K}\ \dddot{Si}^4 + 8\ \ddot{Ca}\ \dddot{Si}^2$.† It would be a simi-

* This expression requires explanation. I have shewn (*Afh. i Fys. Kem. &c.* tom. v. p. 499) that, if crystallised boracic acid be made to absorb a quantity of fluo-siliceous acid, and if these acids be then extracted by means of caustic ammonia in great excess, the silica which remains is visibly soluble in water, and plainly decreases by lixiviation. No fluoric or boric acid can be discovered in it; and the water which holds it in solution, does not act upon the vegetable colours. It does not lose its solubility by boiling; but, when dried, it is soluble no longer. If, in a vessel of water saturated with silica, two small cups, the one containing artificial vesuvian, and the other silica in a state of solubility, were placed contiguous, it may be presumed that the former would be converted into felspar; since the silica, which it might extract from the water, would be continually replaced by the latter.

† M. Berzelius is generally known to have demonstrated, that, (with the exception of those substances which have azote or phosphorus for their base)

lar case, if we should find a combination of an acid sulphate with a neutral one, or of a neutral sulphate with a sub-sulphate. However, the class of double salts, formed by strong acids, has not hitherto presented any instance of such a combination. Whence it is clear, that the discovery of a double salt, analogous to these, and capable of being produced in our laboratories, is of great consequence, for the support it affords to the ideas which we have formed respecting those combinations, and to the formulas by which we express them.

Artificial double salts usually contain only two salts, which have either the base or the acid in common. Hitherto we have discovered only one salt, composed of three different salts; it is obtained by saturating with ammonia, the triple acid composed of the muriatic, sulphurous, and carbonic acids; and, besides, the nature of this triple salt is uncertain, on account of the disputes which subsist with regard to the nature of its acids. In the mineral kingdom, on the contrary, we find a great number of siliciates, with triple and quadruple bases. It is plain, that if these triple salts are not, in fact, mere mixtures, they must be considered as composed of two others; each of which allows itself to be again decomposed into two others, and so on to their simple elements. It follows, therefore, that a triple salt of this kind

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in any chemical compound, of which all the ingredients contain oxygen, the oxygen contained by one of those ingredients is constantly an ALIQUOT PART *of that contained by each of the others.* Upon this principle, combined with the Atomic theory, of which it forms an extension in the highest degree important to chemical science, M. Berzelius proposes to found a new and expeditious method of representing the nature of compound bodies. Each radical, or elementary substance, is designated by the initial letter of its Latin name, whilst the dots above it indicate the number of doses which that radical contains of oxygen. Thus, the formula, $\dddot{Be}\,\dddot{Si}^4 + 2\,\dddot{Al}\,\dddot{Si}^2$ signifies that (1 atom of beryllium with 3 doses of oxygen, or) 1 atom of glucina forms a compound with (4 atoms of silicium, each of which contains 3 atoms of oxygen, or with) 4 atoms of silica; that (1 atom of aluminium with 3 of oxygen, or) 1 atom of alumina forms a compound with 2 atoms of silica; and, finally, that the former of these compounds unites with 2 times the latter, to constitute the emerald. The second formula, $\ddot{K}\,\dddot{Si}^4 + 8\,\ddot{Ca}\,\dddot{Si}^2$, denotes that (1 atom of kalium with 2 of oxygen, or) 1 atom of potash forms a compound with 4 atoms of silica; that (1 atom of calcium with 2 of oxygen, or) 1 atom of lime forms a compound with 2 atoms of silica; and that the former compound, in apophyllite, is united to 8 times the latter. TRANSL.

must be composed either of two double salts, which have one of their bases in common, or of a double salt, combined with one or more molecules of a simple salt. In more general terms, it must be composed, either of two compound bodies of the third order, or of one compound body of the third, and another of the second order. But at present we know not the number to which the orders of compound atoms may amount, or how many atoms of the second order may meet together in the same combination.

Another circumstance about which we have obtained no certainty, occurs in that species of combinations, into which one of the ingredients enters only in very small quantity; such, for example, as plumbago, in which one molecule of iron must be combined with about 200 molecules of carbon. It is very difficult, in such cases, to distinguish between a foreign mixture and an actual combination. In analytical experiments upon minerals, those bodies which appear only in very small quantities, are generally considered as accidental. And although this principle may sometimes lead to erroneous results, it is advisable to adopt it in cases where its inaccuracy has not a certain degree of probability; because without some such help, our researches would be enveloped in endless difficulties. After obtaining a general acquaintance with the subject, it will be easier to rectify the mistakes which may have happened in particular cases.

Examination of a Double Carbonate, having a Base of Potash and Magnesia.—Carbonic acid bears a resemblance to silica, oxide of tantalum and oxide of titanium, in the weakness of its affinities, and in having a greater tendency, than the strong acids, to form compounds analogous to those of silica. The double salt which we are now to describe, is a proof of this.—A solution of bi-carbonate of potash was mixed (slightly in excess) with a solution of the muriate of magnesia. No precipitate was formed; but some days afterwards, a salt had arranged itself in crystalline groups, upon the bottom and sides of the vessel. When first separated from the liquid, this salt had no taste, but a few moments afterwards it became alkaline. In pure water it appeared insoluble at first; but some time after it fell into powder, and the water dissolved carbonate of potash from it, leaving carbonate of magnesia undissolved. When heated to the boiling temperature, it lost the water of crystallisation, became opaque and of a milk-white colour, but did not change its form. At a more elevated temperature it softened into blisters, which gave out carbonic acid gas. By roasting, it was half melted, and acquired a strong alkaline taste.

This salt was analysed in the following manner. It was introduced into a bulb of glass, formed at the end of a barometric tube. The bulb had been weighed when empty, and its weight when charged, served to determine the weight of the salt which it contained. The tube was then softened, at the distance of an inch from the bulb, and drawn into a very slender shank, which, being bent at the same time, formed a species of cornute. It was next attached, by means of a tube of elastic gum, to a small recipient made like an enameller's lamp. This recipient ended in a shank equally slender, and was connected by an elastic tube, with a somewhat larger recipient, which was filled with dry muriate of lime. These two recipients, with their attached tubes, were weighed. The salt was then heated in the bulb by the flame of a spirit-of-wine lamp; and the heat was continued till the mass had been red, for a quarter of an hour. By this process, all the water, and a part of the carbonic acid were expelled from the salt. The water was, of course, retained by the apparatus, while the acid escaped into the air. To determine the quantity of this water with all possible accuracy, the neck of the small cornute was cut by a diamond; the carbonic acid which remained in the apparatus, was extracted at the end of the recipient, and the two recipients with their segment of the tube were weighed. To cut the tube is a necessary precaution, because the small drop of water that always adheres to the end of it, which enters the recipient, would otherwise escape our notice. The segment of the tube was then detached, dried and weighed anew. The difference between its weight and the weight last observed, gave what the two recipients had gained by the addition of the water: 100 parts of the salt had yielded 31.24 parts of water. Of the same salt, 100 other parts, when weighed, after being heated to incandescence, in a crucible of platina, left 42.62 parts of half-melted salt. Cold water, when added to this residuum, dissolved carbonate of potash from it, and left caustic magnesia undissolved. This last remainder, when collected upon a filter, washed, dried and heated to redness, weighed 15.74 parts. The alkaline liquid existing in the waters of lavage, was saturated with muriatic acid, in an apparatus calculated to avoid all loss from effervescence. Being afterwards evaporated, and exposed to the continued action of heat, it left 29.48 parts of muriate of potash. Water, when added to this mass, formed a turbid solution of it, from which a drop or two of caustic potash still precipitated a small quantity of magnesia, which, when separated and heated to redness, was found to weigh 0.25 parts. Consequently, the whole of the magnesia amounted to 15.99 parts. But as these 0.25 parts of magnesia were principally muriate of magnesia, a deduction of 0.58 must be made from the 29.48 parts of muriate of potash; the exact quantity of which salt is, hence, 28.9 parts, containing 18.28 parts of pure potash. Wherefore the analysis of this double salt gave,

Potash,...............	18.28
Magnesia,...........	15.99
Carbonic Acid *,...	34.49
Water,.............	31.24

But in order to appreciate this result, we must know not only the composition of magnesia, but also that of the crystallised carbonate of magnesia, and of the crystallised bicarbonate of potash, with as much certainty as we know that of carbonic acid or of potash. In some experiments, which I published six years ago, upon the composition of magnesia, I had found that it contains from 38.8 to 39.8 per cent. of oxygen; but, as a difference of 1 per cent. is too great for being attributed to an ordinary error of observation, I determined to examine the point anew, and to try, if possible, to render it still more exact. The usual method is very simple. We dissolve a given weight of pure magnesia in sulphuric acid, likewise pure, but diluted; we evaporate the salt obtained, heat it to redness, and weigh it.

As on several occasions, I had found, in analysing minerals, that magnesia exerts a very strong affinity to silica, which the magnesia, recovered from the sulphuric acid by muriatic acid, and evaporated, always deposites before drying, in a gelatinous

* Comprehending a small loss, which could not be avoided.

form; I thought it requisite to prepare the magnesia for these experiments, in a manner which should entirely secure its purity from silica. I dissolved some sulphate of magnesia, and added to it, first a few drops of caustic ammonia, and afterwards a few drops of oxalate of ammonia, but the liquid continued limpid. I then precipitated it by a boiling solution of pure carbonate of potash; the precipitate, being carefully washed, was dissolved by water strongly impregnated with carbonic acid gas; and this solution was next filtered and boiled for some time, till the magnesia was again precipitated. From 10 grammes of caustic magnesia thus purified, when dissolved by pure dilute sulphuric acid, and evaporated to dryness, the product being maintained at a red heat for a quarter of an hour in a crucible of platina, by the flame of a spirit-of-wine lamp, I obtained 29.3985 grammes of sulphate of magnesia, soluble in water, without any appreciable residuum.

In several experiments made before I had adopted this method of purifying magnesia, 100 parts of caustic magnesia constantly produced 293.2 parts sulphate of magnesia; but the salt obtained, after its solution in water, left always a residuum, consisting of magnesia mixed with a strong dose of oxalate of manganese.

According to the experiment which I have just detailed, 100 parts of sulphuric acid are saturated by 51.55 parts of magnesia, which must therefore contain 19.954 parts of oxygen. But 51.55 : 19.954 : : 100 : 38.708, agreeing very nearly with the result of my former experiments, in which I had found 38.8 parts of oxygen.

The experiment which, in my former investigation, had given 39.8 parts of oxygen, consisted in decomposing a given weight of sulphate of magnesia by muriate of barytes. I thought it worth while again to examine the analysis, and for this purpose I made use of the pure sulphate of magnesia obtained in the preceding experiment. I then found, to my great surprise, not only that the precipitate gave indication of more sulphuric acid than the salt had contained, but also that the quantity of this precipitate varied in different experiments. 10 grains of sulphate of magnesia should have produced 19.2 grains of sulphate of barytes; but I obtained from 19.64 to 19.81 grains. Having repeated the experiment four times with every necessary precaution, I began to suspect that the sulphate of barytes had not been sufficiently washed. I had continued the purification, till the water which passed had entirely ceased to become turbid on the addition of sulphuric acid. Upon repeating the experiment once more, I took some drops of the water of lavage no longer containing barytes, and evaporated them in a spoon of platina;—a method which I sometimes follow for discovering whether a precipitate is sufficiently washed. There remained a visible spot. Having next tried the waters of lavage by nitrate of silver, I found muriatic acid in them. I continued to wash the precipitate with boiling water added each half hour during four days, and the action of the nitrate of silver was constantly the same as if the water were dissolving a muriate very sparingly soluble. I evaporated a great quantity of the water, and obtained a small residuum, which, when exposed to the continued action of heat, lost its solubility, and shewed itself to be magnesia. A small quantity of muriate of magnesia is, therefore, through chemical affinity, deposited along with the sulphate of barytes, from which it cannot be entirely separated by water. Having ascertained this fact, I took the precipitated sulphate from the filter, digested it in muriatic acid, then filtered and washed it anew. The excess of muriatic acid was soon removed, and the liquid which passed afterwards continued to act upon the nitrate of silver, in the same weak degree as before the addition of the muriatic acid. Having finally dried it, and heated it to redness, I found its weight to be 19.44 grains, which is 0.236 grains more than I ought to have obtained. This proves, at all events, that, by the analytical method in question, no result worthy of confidence can be obtained.

I have several times observed, that when one mixes the sulphate of a weak base with muriate of barytes, a portion of this base is precipitated along with the barytes, combined in such a way as no longer to be separable even by an excess of acid. If, for example, we mix the sulphate of iron or of copper with muriate of barytes, the sulphate of barytes becomes, by calcination, reddish-yellow in the first case, and greenish-yellow in the last; with the sulphate of cobalt it becomes reddish. In all these cases, we must begin with acting upon the oxide, if we wish to discover the exact quantity of the sulphuric acid. It is well known, that the oxides of gold and platina allow themselves to be entirely precipitated, if, to a mixture of their solutions and of sulphuric acid, we add muriate of barytes. I know not the nature of that affinity by which the sulphate of barytes carries these oxides along with it. I dare not hazard any conjecture respecting the nature of their union; but it does not seem improbable, that several substances, which in mineralogy are considered as foreign, may have been introduced by a similar affinity.

But, to return from this digression, to examine the analysis of our double salt:—I have said that we ought likewise to know the composition of neutral carbonate of magnesia. I procured this salt by allowing a solution of magnesia in liquid carbonic acid to evaporate spontaneously. The carbonate deposited itself on the bottom and sides of the glass, in the form of small pellucid crystals, which I dried upon blotting paper. The dry salt was next introduced into a small apparatus, such as I have already described, and heated by the flame of a spirit-of-wine lamp. At the first application of the heat, the salt gave out a great quantity of water, and became milk-white, but preserved the form of its crystals. This salt has the property of efflorescing in dry air, where it loses its water of crystallization, without losing any part of its acid, as I have proved by a direct experiment. I make the observation in this place, because it might be imagined that the efflorescence of the salt was in reality only a transformation of it into magnesia alba.

The salt contained in the small cornute was kept in the flame, till it had been red for a quarter of an hour. The two recipients had gained 38.9 per cent. of water. The glass bulb which held the magnesia was anew exposed to a stronger heat, in a crucible of platina, among burning coals. There remained in it 29.6 per cent. of magnesia, entirely deprived of carbonic acid. The loss, 31.5 per cent., was therefore carbonic acid. The portions of oxygen contained in these quantities of magnesia, carbonic acid, and water, are 11.457, 22.89, and 34.33; or proportional to 1, 2, and 3. Consequently, the acid contained 2, and the water 3 times the oxygen of the base. The composition of neutral carbonate of magnesia may therefore be expressed by the formula, $\ddot{Mg}\ \ddot{C}^2 + 6\ Aq$; whence* we infer that it contains,

Magnesia, - -	29.583
Carbonic acid, - -	31.503
Water of combination,	38.914

It still remained for me to determine the quantity of water, combined with the crystals of the bicarbonate of potash. When treated in the same apparatus as the salts already analyzed, those crystals yielded 9 per cent. of water, and 69 per cent. of carbonate of potash. This result agrees exactly with the formula, $\ddot{K}\ddot{C}^4 + 2\ Aq$ †, which denotes that the carbonic acid contained 4 times the oxygen of the base, as well as of the water.

These different points being adjusted, we again proceed to examine the result of our analysis of the double carbonate, in order to discover its true chemical composition. The 18.28 parts of potash contain 3.0987 parts of oxygen; and the 15.99 parts of magnesia contain 6.1894, or twice as much. The 34.49 parts of carbonic acid contain 25.57 parts of oxygen, or, with a slight error, 8 times the oxygen of the potash. If we seek to connect the acid with its two bases, we shall find, that it must be divided between them, in such a manner that they may contain equal quantities of it; the potash, however, being at a higher point of saturation, or forming a bicarbonate, whilst the magnesia forms only an ordinary carbonate. This becomes evident, if we consider that the *bicarbonate* of potash was employed in producing the salt; and that, if the carbonic acid were divided proportionally between the bases, it would give degrees

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* By applying the law stated in page 65. note 2. the quantities found by the experiment are sufficiently correct to indicate that, in conformity with this law, $\ddot{Mg}\ \ddot{C}^2 + 6\ Aq$, is the exact formula; or that (1 atom of magnesium with 2 of oxygen, or) 1 atom of magnesia joined with (2 atoms of carbonium, each containing 2 of oxygen, or with) 2 atoms of carbonic acid, must be combined with 6 atoms of water, in order to form carbonate of magnesia. But the weight of these several atoms being already ascertained, by numerous and varied experiments, the error of the analysis is rectified accordingly.—Transl.

† The meaning of this expression may be collected from the preceding Note, and that to which it refers.—Transl.

of saturation which are improbable, if not contrary to experience.

It may be observed, that the quantity of water found in this double salt was greater than that contained in the two salts separately; and, as it is to be presumed that the strong base, rather than the weak one, would combine with a more than usual quantity of water, this bicarbonate of potash must have contained three times as much water as in its isolated state; and the water in each of the two salts must have contained three times as much oxygen as the base. The composition of this double salt may therefore be expressed by the formula $\ddot{K}\ddot{C}^4 Aq^6 + 2 \ddot{Mg} \ddot{C}^2 Aq^6$ *: from which we conclude its exact composition to have been,

Potash,	- -	18.28
Magnesia,	- -	16.00
Carbonic acid,	-	34.12
Water,	- -	31.60

I have been minute in describing the examination of a salt which may appear uninteresting and obscure; but I thought it right to be so, because a careful and exact examination of what allows itself to be determined with ease, enables us to judge of what ought to happen in cases where a similar examination is not equally possible. The analysis of this double salt is highly important in two points of view. In the first place, it shews that two salts formed by the same acid, at different degrees of saturation, with different bases, may unite and constitute a double salt. And this fact confirms those formulas, which have been deduced from the analyses of several substances in the mineral kingdom; of the emerald, for example, the apophyllite, the mesotype, the tremolite, and others; the composition of which being found with sufficient accuracy, connects silica with earths which serve it as salsifiable bases, and exhibits siliciates in different degrees of saturation. Secondly, our analysis proves that the quantity of water which exists in a double salt, is not always the same as that which exists in its component salts, taken

* These symbols have already been explained.—Transl.

separately; an important circumstance in analysing those bodies, the composition of which is multifarious and complicated.

(To be continued.)

Art. XII.—*Comparison between the length of the Seconds Pendulum, as determined by Mr Whitehurst and Captain Kater.* By Edward Troughton, Esq. F. R. S.

In examining Mr Whitehurst's experiments on the length of the Seconds Pendulum, Mr Troughton observed, that the result admitted of various corrections, which were not applied by the gentleman who calculated the length of the pendulum from these experiments *. He therefore proceeded to compute the amount of those corrections, and obtained the following results.

The length of the Seconds Pendulum, as calculated by Dr Rotheram, and examined and approved of by Dr Hutton, was 39.11960 inches, when vibrating in a total arc of 6° 40′, and in air at the temperature of 60°.

		Inches.
Whitehurst's length of the pendulum,		39.11960
Correction for circular arcs,	+	0.01654
Correction for the weight of the wire rod,	—	0.00080
Correction for 2° of temperature, in order to compare it with Captain Kater's result,	—	0.00052
Correction for the buoyancy of the air,	+	0.00404
Correction for elevation above the sea,	+	0.00030
Sum of positive corrections,	+	0.02088
Sum of negative corrections,	—	0.00132
Difference to be added to the length of the pendulum,	+	0.01956
Whitehurst's length of the pendulum,		39.11960
Whitehurst's length of the pendulum corrected,		39.13916

* The object of Mr Whitehurst was not to obtain the length of the simple pendulum; but, from two pendulums of different lengths, to obtain a measure, in such a way, that every other person who used the same means could obtain the same measure. He had no occasion, therefore, to apply any corrections to his results.

Now, the length of the pendulum, as obtained by Captain Kater, is 39.1386, at the temperature of 62°; but Mr Troughton has proposed a slight correction upon this length, for the following reasons.

Captain Kater's pendulum was composed of three different kinds of brass, as stated in the following table.

Part of the Pendulum.	Weight in Air.	Specific Gravity.
	lb.	
3 weights (cast-brass,......	3.13	8.417
4 knee pieces (cast-brass),	3.14	7,816
Bar plate brass,............	3.30	8.532

From these numbers Captain Kater deduces 8.469 as the specific gravity of the pendulum, and uses this number in his calculations; but, it is obvious, that the true mean of the above specific gravities, taking into account both the quantity and quality of the brass, is only 8.2601. Beside this circumstance, Captain Kater has omitted to carry the deal ends of his apparatus to the account of buoyancy. When these two sources of error were calculated by Mr Troughton, he found their amount to be 0.00017, which, added to 39.13860, gives 39.13877 for the true result of Captain Kater's experiments. Hence, we have,

Whitehurst's length of the pendulum corrected,.......	39.13916
Captain Kater's length of the pendulum corrected,....	39.13877
Difference,....... .	0.00039

If Captain Kater's table of specific gravities is wrong printed, as Mr Troughton suspects, from the circumstance that no workman was likely to use brass so porous as to have its specific gravity so low as 7.816, then the most material part of the correction of 0.00017 is without foundation.

A result nearly the same as that of Captain Kater and Mr Whitehurst, has been recently obtained at Greenwich by our celebrated astronomer-royal Mr Pond. His experiments were made with the apparatus which had been used in France, and which was left at the Royal Observatory by M. Arago in the summer of 1817.—In our next Number, we expect to be able to present our readers with an abstract of his results.

ART. XIII.—*On the Length of the Seconds Pendulum, observed at Unst, the most northern of the Shetland Isles.* By M. BIOT, F. R. S. Lond. and Edin. Member of the Royal Institute of France, &c. &c. &c. Communicated by the Author.

IN the notice which I published last year of the operations undertaken in England and France for the determination of the Figure of the Earth, I announced that the length of the pendulum at the Shetland Isles, agreed with the oblateness deduced from the lunar theory, and from a comparison of degrees observed in very distant latitudes. This agreement was deduced from a single series of the decimal pendulum, which I had accidentally chosen out of those I had made, and which I had calculated before my departure from Unst. I am now able to give more certainty to this result. I had taken at Unst three systems of measures of the pendulum. In the first I employed a platina ball, different from that which we used in Spain and in France, and the metal of which was given me for this purpose by MM. Cuocq and Couturier of Paris. The length of the pendulum, which was sexagesimal, was measured with a rule of iron, the length of which M. Arago and I had measured in Paris, by comparing it with the metre of the archives. In the second system of observations I employed the same rule, but a platina ball which was used in the experiments of Borda, and which we had also used in France and Spain; and in the third system, I employed the same ball, but I rendered the pendulum decimal, and measured its length with the same rule which we had used at Bourdeaux, Clermont, Figeac, and Dunkirk, in order that the results might be immediately comparable with those which we had obtained on the arc of France and Spain.

The second system of observations, has been completely calculated, partly by myself, and partly by M. Blanc, a young man as much distinguished by the precision as by the extent of his knowledge. The following are the results:

Latitude of the place of observation, -	60° 45′ 35″ north.
Length of the seconds pendulum, reduced to a vacuum, and to the level of the sea,	Metre. 0.994948151. *

* This result, when reduced to English inches, by using the length of the metre, as determined by Captain Kater, namely, 39,37079, gives 39,1719 inches as the length of the pendulum at Unst.—ED.

The time was determined by 49 series of altitudes of the sun, taken with a repeating circle of Fortin, both in the morning and evening, and calculated so as to avoid the influence of the constant errors to which this instrument might be liable. They were observed with an excellent chronometer of Breguet's, which, however, served only as a reckoner; for its indications were transported by comparisons, either before or after each series, and often at both these epochs, to an excellent clock of the same artist, which served for the measures of the pendulum, and which had gone with the greatest uniformity for nearly two months. These results were also confirmed by observing the passages of stars with a fixed telescope.

The latitude is certain only within some seconds, because it was calculated only from three or four series of observations of the sun and stars, made to the south of the zenith. This was more than sufficient for the pendulum; but the exact calculation of the latitude ought to be made from the whole serieses of observations on the sun and stars, which amount to 55.

A correction of this result must still be made on account of the radius of curvature of the knife's edge employed for suspending the pendulum. This correction will no doubt be extremely small; for, upon observing the edge in a microscope, with an excellent micrometer traced upon glass by M. Le Baillif, I found its width to be less than $\frac{1}{190}$th of a millimetre, which gives less than $\frac{1}{380}$th of a millimetre for the radius of the edge supposed to be spherical. The correction, however, depending upon this cause will be given directly both by the observations which I have made at Unst with pendulums of different lengths, but with the same knife edge, and by those which I made at Edinburgh with pendulums of equal lengths, but with different knife edges.

It is easy to see that the preceding length of the pendulum, combined with that of Formentera, Paris, or Dunkirk, and with these last ones taken together, gives a degree of oblateness in perfect accordance with that which has been deduced from the Lunar Theory, or from the comparison of degrees measured at very great distances. But, in order to deduce this element in a definitive manner, we must wait till all the other observations have been calculated. It is very probable that these results will differ very little from the preceding one; for, in the 11 series already calculated, the one which deviates most from the mean, differs from it only $\frac{15}{1000}$ths of a millimetre, and the deviation is below $\frac{1}{100}$th of a millimetre for all the rest. As M. Blanc has begun the computation of the other series, we shall soon be in possession of the result.

All these observations were made in the Isle of Unst, in the house of Mr Thomas Edmonstone. The system of serieses of which I have here given the result, was observed after the departure of Captain Mudge, who had assisted me in the first only, having been obliged to leave me on account of ill health.

Art. XIV.—*Description of an Improved Self-acting Pump.* By James Hunter, Esq. of Thurston. Communicated by the Author.

The Hungarian Machine, or Chemnitz Fountain, as it is generally called, is one of the few hydraulic engines which has been long admired for the ingenuity and simplicity of its construction. It was originally employed at the mines of Chemnitz to raise water, by means of a small pond, placed at a considerable height above the surface of the ground at the mine. This machine, which required the constant attendance of a workman to open and shut the different cocks, by the aid of which the effect was produced, has been rendered self-acting, by Mr John Whitley Boswell, who has thus added greatly to its value.

Before I was acquainted with Mr Boswell's improvement upon the Chemnitz Fountain, I had constructed a very simple self-acting pump, by means of which water may be raised above the original reservoir by the descent of a certain portion of it. This pump, which is represented in one of its forms in Fig. 1. of Plate II. consists of fewer parts, and is less liable to go out of order, than the ingenious contrivance of Mr Boswell.

Description of the Improved Self-acting Pump.

A, is a cistern filled by
B, a spring.

C, a cistern at which water is required.

D, a metal (water proof) box, 12 inches square and 4 inches deep, placed within A, and near the top of it.

E, a pipe of half inch bore, leading from the top of A to the bottom of F.

F, a metal box, similar to D.

G, a pipe of half inch bore, leading from the top of F to the top of D, the upper part of it being above the level of B.

H, a pipe of half inch bore, leading from the bottom of D to the bottom of C, and made as long as from R to S.

I, a valve (opening upwards) at the mouth of the pipe H.

K, a valve (opening upwards) at the bottom of D.

L, a valve (opening upwards) at the bottom of F.

M, a pipe which takes the overflowing water of E to

N, a small light pan, which, if filled with water, bears down O.

O, a lever, which, when pressed down by N, opens the valve L.

P, a pin, to which is fastened a piece of chain, having at its end a flat piece of leather, which, when N is pressed down, leaves it, and opens a hole at Q.

Q, a hole in the bottom of N, which must be made of a proper size, for the purpose of letting the water escape from N, in the same time that is required for D to be filled with water through K.

The following is the mode in which the pump operates.

The vessels D and F being full of air, the water of A runs into E, expels the air from F, through G and D, to I, and fills E, F, and G to the level of B. It then runs over at R into the pipe M, fills N, which is borne down by the weight of water, and opens L and Q, as above described; the vessel F then empties itself at L, is filled with air from D through G, and D is filled with water through K. In the same time, N is emptied through Q, and returns to its place, allowing L to shut, and leaving F and G full of air. The water continues running through E, expels the air from F through G into D, which air expels the water from D through H up to C, until F and G are filled with water and D with air, when the machine is found in the same state as at first, F and G being filled to the level of B.

This self-acting pump may be applied to many uses. If a person has a spring which supplies his house with water at the level of the middle storey, he may place F in the kitchen, and C in the bed-room, and every gallon of water used in the kitchen, will give a corresponding gallon (or very nearly so) in the bed-room.

In using this pump the pipe E may be supplied with impure or even very dirty water, and the whole of the spring B will be raised to C, instead of half of it being perhaps wasted at L; and in this manner any spring may be pumped up to the requisite level without one drop being lost, merely by forming a dam or lead as in mills, and obtaining a fall for a part of the water equal to the height to which it is requisite to pump up the spring.

It is not necessary that R should be on a level with B. It may be far above or below it, and the effect will be nearly the same. The water will rise as high above D as from R to S.

The rain-water collected on the top of a house, will pump up a corresponding quantity of pure water from a well as deep as the house is high; but this pump will be found most useful where a large body of water is to be raised through a small height.

The great superiority of this pump consists in its acting almost entirely without friction.

A pump of the above dimensions (which are very diminutive) continued working without being touched for three months, and raised eight hogsheads of water every day.

Art. XV.—*Account of a New Method of making Single Microscopes of Glass, proposed and executed* by Thomas Sivright, Esq., F. R. S. Edin. and F. A. S. E. Communicated by the Author.

Various methods have at different times been described, by means of which persons of ordinary ingenuity may construct for themselves single microscopes of a very high magnifying power, and possessing a very considerable degree of distinctness.

The most common method is to take up with the point of a wetted wire several small fragments of crown glass, and to hold them in the flame of a candle till they fall down in the form of a small globule. Another method consists in drawing out a thin strip of glass into threads, and holding the extremities of the threads in the flame of a candle till round globules are formed upon them. These globules being carefully detached, are placed between two plates of lead, copper, or brass, the fractured part being carefully kept out of the field of view. The method recommended by Mr Stephen Gray, of making microscopes of drops of water, can be considered in no other light than as an amusing experiment; and the single microscopes made by drops of transparent varnish, upon one or both sides of a plate of glass, as proposed and tried by Dr Brewster, though they give excellent images, are still deficient both in portability and durability.

The defect of the glass globules formed by the ordinary methods is, that we cannot increase their diameter beyond a very small size;—that it is difficult to give them a perfect figure; and that there is considerable trouble in fixing them in the brass or copper after they are made.

The following method recently proposed and executed by Mr Sivright, is free from the greater part of these defects, and we have no doubt will be considered as a valuable acquisition by those who either cannot afford to purchase expensive microscopes, or who are at such a distance from an optician that they cannot be supplied in any other way.

Take a piece of platinum leaf, about the thickness of tinfoil, and make two or three circular holes in it, from $\frac{1}{20}$th to $\frac{1}{10}$th of an inch in diameter, and at the distance of about half an inch from each other. In the holes put pieces of glass, which will stick in them without falling through, and which are thick enough to fill the apertures. When the glass is melted at the flame of a candle with the blowpipe, it forms a lens which adheres strongly to the metal, and the lens is therefore formed and set at the same time. The pieces of glass used for this purpose should have no mark of a diamond or file upon them, as the mark always remains, however strongly they are heated with the blowpipe.

The lenses, which were made larger than $\frac{1}{10}$th of an inch, were not so good as the rest, and the best were even of a smaller size than $\frac{1}{10}$th. As the lenses thus formed sometimes contain air bubbles, the best way is to make several, and select those which are freest from faults. An eye or loop, made by bending the extremity of a platinum wire, may be used instead of the platinum leaf.

The reason for using platinum, is, that the glass is more easily and more perfectly melted in this than in other metals, which may perhaps arise from its being a bad conductor of heat, and from its preserving its brightness. As platinum does not oxidate, the glass adheres better to the edges of the hole, and it may be used very thin, as it does not melt with the heat necessary for the complete fusion of the glass.

Mr Sivright has likewise succeeded in forming, what, in so far as we know, was never attempted, plano-convex lenses by means of fusion. In order to do this, he took a plate of topaz, with a perfectly flat and polished natural surface, which is easily obtained by fracture; and having laid a fragment of glass upon it, he exposed the whole to an intense heat. The upper surface of the glass assumed a spherical surface in virtue of the mutual attraction of its parts, and the lower surface became perfectly flat and highly polished, from its contact with the smooth plate of topaz.

ART. XVI.—*Remarks on the Size of the Greenland Whale, or* Balæna Mysticetus, *designed to show that this animal is found of as great dimensions in the present day as at any former period since the establishment of the whale-fishery* *. By WILLIAM SCORESBY junior, F. R. S. Edin. and M. W. S. Communicated by the Author.

SUCH is the avidity with which the human mind receives communications of the marvellous, and such the interest attached to those researches which describe any remote and extraordinary production of nature, that the judgment of the traveller receives a bias, which, in all cases of doubt, induces him to fix upon that extreme point in his opinion which is calculated to afford the greatest surprise and interest. Hence, if he perceives

* This paper was read before the Wernerian Natural History Society of Edinburgh, on the 19th of December 1818.

an animal remarkable for its minuteness, he is inclined to compare it with something still more minute;—if remarkable for its bigness, with something fully larger. If the animal inhabits an element where he cannot examine it, or is seen under any circumstances which prevent the possibility of his determining its dimensions, his decision will certainly be in that extreme which excites the most interest. Thus, when a whale has first been seen by any voyager, within a sufficiently short distance, we find him generally comparing it to "a mountain," a "floating island," or at least to the size of his ship. But, when he has happened to express himself as if the whale were longer than his ship, any author who followed him would conceive himself justified in calculating that, as his ship, judging from its known size, was 100 or 120 feet in length, the whale the voyager describes must have been 150 or 200 feet. This error would be the more easily committed two or three centuries back, when we know that whales were usually viewed with superstitious dread, and their magnitude and powers, in consequence, highly exaggerated. And errors of this kind having a tendency to increase rather than correct each other, from the circumstance of each writer on the subject being influenced by a similar bias, the most gross and extravagant results are at length obtained. In this way I conceive the erroneous opinions which prevail as to the magnitude of cetaceous animals may be accounted for.

Authors, we find, of the first respectability in the present age, giving a length of 80 to 100 feet or upwards to the Mysticetus, and remarking, with unqualified assertion, that when the captures were less frequent, and the animals had sufficient time to attain their full growth, specimens were found of 150 to 200 feet in length, or even longer; and some ancient naturalists, indeed, have gone so far as to assert, that whales had been seen of above 900 feet in length.

In a modern work of high literary character the following passage occurs:

"Individuals of this species (Balæna Mysticetus) are often caught that measure about 60 feet in length, and nearly 40 feet in circumference: and we are informed, on very credible authority, that whales of at least twice these dimensions have formerly been taken. To this latter size we must at present limit our belief, though ancient naturalists have given accounts of whales above 900 feet long. We are, however, disposed to think, that those writers who discredit the accounts of voyagers and historians of the whalefishery, respecting the great size of whales formerly taken, are not warranted in their disbelief, because they themselves have not seen any of those large dimensions. There can be little doubt, that one natural effect of the long war which man has carried on against these animals, must be to diminish their number, and more especially that of the larger individuals, which, from being more profitable, would be more coveted. Hence, it may be readily conceived, that the whales now taken, are very inferior in size to those killed at or near the commencement of the whale-fishery." *Edinburgh Encyclopædia,* art. CETOLOGY, Vol. V. p. 685.

I make this quotation, not with a view of criticism, but because it conveys a very popular argument as to the reason why whales should have been of much greater magnitude in the early years of the fishery, than they are at present.

With regard to the size of which the Mysticetus at present occurs, it will be sufficient to say, that of 322 individuals, in the capture of which I have been personally concerned, no one, I believe, exceeded 60 feet in length; and the longest I ever measured was 58 feet from one extremity to the other, being one of the largest to appearance which I ever saw. I therefore conceive, that 60 feet may be considered as the size of the largest animals of this species, and 65 feet in length as a magnitude which very rarely occurs *. But, as we have no authority but what I conceive is questionable, for supposing the Mysticetus ever grew to a larger size than at present, my object will be to bring forward some authorities tending to prove, that this animal now occurs of as great dimensions, as at any former period since the commencement of the whale-fishery.

In Zorgdrager's History of the Greenland Fishery, is a list of the success of the Dutch Greenland Fleet, during a period of fifty years, comprehended between 1670 and 1719, from which, in 1677, we find, that 686 whales produced 30.050 quardeelen or barrels of blubber, or 44 barrels *per* fish. These barrels, Zorgdrager intimates in the same work, were of the capacity of 17 steekanan; the steekan, we know, is equivalent to 5.02 gallons wine measure; consequently, the barrel must be 85.34 gallons. Hence, the produce *per* fish comes out 29 butts of 126 gallons, or half a ton each English wine measure. In 1679, the average of 831 whales was 48 barrels, or about 31½

* Sir Charles Giesecké informs us, that in the spring of 1813, a whale was killed at Godhavn, of the length of 67 feet. *Edin. Encycl.* art. GREENLAND. ED.

butts; in 1680, the average of 1373 fish was 38 barrels, or 25½ butts; and, in 1681, the average of 889 whales taken in the Greenland or Spitzbergen fishery by the Dutch fleet, was only 34 barrels, or 23 butts English. The largest average 31½ butts, equal to about 12 tons of oil, corresponds with a whale of 9 or 10 feet whalebone, and 40 to 45 feet in length; the smallest, or 23 butts, corresponds with a fish of about 8 feet bone. But here it may be objected, that the Spitzbergen fishery affords many small whales, and, therefore, the general average can give no idea of the dimensions of the largest. As such, we shall consider the average product of whales taken in Davis' Straits, which have never been found, *cubs* excepted, but of a size capable of procreating the species. This fishery, when first established by the Dutch, certainly afforded whales considerably larger. From 1719 to 1728, the produce of 1251 large whales taken by the Dutch fleet, was 74.152 quardeelen of blubber, being 60 quardeelen per fish; which is the largest average I have observed in the whole list. This corresponds with 40½ butts, or 20¼ tons of blubber, calculated to produce 15 to 16 tons of oil. A whale at present of 10 or 11 feet bone, and 48 to 50 feet in length, usually affords a similar quantity.

In a paper by a Mr Gray, registered in a manuscript preserved in the British Museum, by Mr Oldenburg, secretary to the Royal Society, in 1662-3, and, consequently, referring to a period at least as remote as that, where he speaks of the wages of the men they employed in the fishery, he observes, they have a certain perquisite "for every 13 tons of oil, which we call a whale;" thereby implying, that *this*, which corresponds with the produce of the present whales of 9 or 10 feet bone, and 40 to 45, or 50 feet in length, was the average size then captured.

Captain Anderson, who had made thirty-three voyages to Greenland in the first age of the Spitzbergen fishery, about the year 1640-50, as we infer from the circumstance of his having relieved eight men who wintered in Spitzbergen in 1630, the interesting narrative of whose sufferings is given by Edward Pelham, one of the adventurers, in the fourth volume of Churchill's Collection of Voyages, notices the size of the whale in these words: "An ordinary whale will yield 12 tons of oil, some 20, if large, and taken at a seasonable time." Now, the large whales here mentioned, as yielding 20 tons of oil each, are similar in produce to those esteemed full grown animals, which yet occur in the neighbourhood of Spitzbergen and in Davis' Straits; such as whales of 50 to 60 feet in length, and 11 to 12 or 13 feet whalebone.

In a letter by Captain William Heley, one of the Russia Company's whale-fishers, dated 1617, preserved by Purchas, we read, that 150 whales had been killed that season, from whence 1800 tons of oil had been extracted, besides some blubber left behind for want of casks. We may consider here the average per fish as somewhat more than 12 tons of toil. Another letter, dated 1619, published likewise by Purchas, mentions eight fish having been caught, which made 111½ tons of oil, or 14 tons per fish nearly; and " two very large fish" (not then boiled) expected to produce 36 to 40 tons, or near 20 tons each; which is but just equal to a large fish at the present, and is a quantity indeed that is often exceeded. It is needless to multiply authorities of this description, else I could bring forward the testimonies of Martins, the author of the interesting Voyage to Spitzbergen, of Captains Edge, Salmon, Goodlard and Fanne, employed in the Russia Company's service, and of many others, all of which furnish the same conclusions.

But in none of the authorities yet quoted, is there any direct reference to the length of the whales; the evidence, which is decidedly the most satisfactory, therefore, remains to be considered.

In Purchas's " Pilgrimes," published in the year 1625, we have a description of the whale by Captain Edge, one of the Russia Company's chief fishers, who had been ten voyages to Spitzbergen, in which he calls it " a sea beaste of huge bigness, about 65 foot long and 35 foot thick," having whalebone 10 or 11 feet long, (a common size at present), and yielding about 100 hogsheads of oil. Jenkinson, in his voyage to Russia, performed in 1557, saw a number of whales, some of which, by estimation, were 60 feet long, and are described as being " very monstrous." And at the margin of a descriptive plate, accompanying Captain Edge's paper on the Fishery, is a drawing of a whale, with this remark subjoined,—" A whale is ordinarily about 60 foot long."

I have now only to remark in conclusion, that as I have not met with a single actual measurement of the whale by any voyager or historian of respectability, ancient or modern, which is at all at variance with what has been advanced, excepting where specimens of the Balæna Physalus have been mistaken for those of the Mysticetus, I presume we may conclude, that whales are caught of as great dimensions in the present day as at any period within the last two hundred years, or since the fishery began.

Art. XVII.—*Account of the Recent Discoveries in Egypt respecting the Sphinx and the Great Pyramid.* Drawn up from original Letters, and other sources of information,* and illustrated with Drawings.

THE monumental ruins of Egypt, combining in their structure, as a kind of architectural paradox, at once colossal magnitude and minute concealment, had, for ages past, afforded a subject of inexhaustible investigation to the learned antiquarians and enterprising travellers of Europe; but all the conjectures of the former, and researches of the latter, had proved incompetent to the task of satisfactorily solving these material enigmas. The united ingenuity and labours even of the French philosophers and artists, who prosecuted their inquiries with the full assistance and protection of their military power, had not been able to penetrate the most interesting of these mysteries, or even to accomplish the mechanical removal of the most palpable obstructions. The natural spirit and sagacity of two adventurous individuals, Mr Caviglia and Mr Belzoni, aided by the liberality of a few private persons, and patronised particularly by Mr Salt, the British Consul at Cairo, have effected more in the space of a few months, than had been done in the course of as many preceding centuries. But, without indulging in farther preliminary reflections, we hasten to present a brief abstract of the operations so successfully prosecuted, and so ably directed by one of these gentlemen, in exploring the in-

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* Quarterly Review, &c.

terior of the Great Pyramid, and excavating the bed of the Andro-Sphinx which fronts the pyramid of Cephrenes.

The great pyramid of Gizeh, was explored with extraordinary labour and peril by Mr Davison, British Consul at Algiers, who accompanied Wortley Montague to Egypt in the year 1763; and in order to apprehend the importance of the recent discoveries, it is necessary to understand the extent to which that gentleman had carried his researches.

One of his principal objects was to ascertain the depth of what had hitherto been denominated the Well, C, Plate II. fig. 4*. After descending by means of a rope tied about his body, to the bottom of the first shaft from the opening at A, he found, on the south side, at the distance of eight feet from the lower extremity of that shaft, a second opening which reached in a perpendicular direction to the depth only of five feet; and, at the distance of four feet and a half from the bottom of this shaft, he found a third opening, which was so much closed up by a large stone at the mouth, as barely to admit the body of a man. Having with the utmost difficulty prevailed upon the Arabs who accompanied him, to come down and hold the rope by which he was suspended, he proceeded in his descent, and about half way down he came to a grotto at B nearly fifteen feet long, four or five feet wide, and as high as a man of ordinary stature. From this place the shaft took a sloping direction for a little way, and then becoming more perpendicular, he at length reached the bottom, C, which was completely closed with sand and rubbish. Here he found a rope ladder, which had been used by Mr Wood, (author of the Ruins of Palmyra and Balbec,) who had proceeded no farther than the grotto; and though it had been left there sixteen years before, was as fresh and strong as if perfectly new. The depth of the first of these shafts was 22 feet, of the second 29, and of the third 99, making, with the addition of the 5 feet between the first and second shafts, a total descent of 155 feet.

Upon a subsequent visit, Mr Davison next proposed to explore an opening which he had discovered at the top of the

* The drawings from which the engravings of the Sphinx and the Pyramid were made, were taken by our correspondent on the spot.

gallery D; and for this purpose provided himself with several short ladders, capable of being fastened to one another by wooden pins, so as to extend, when thus united, to the length of 26 feet. Having mounted by the assistance of this ladder to the opening which he had observed, he found a passage two feet four inches square, which turned immediately to the right; but on account of the dust and bats' dung with which it was covered to the depth often of a foot, it was with the greatest difficulty, and the constant hazard of suffocation, that he crawled along with his face to the ground. Upon reaching the end of this passage, he found on the right a straight entrance into a long, broad, and low room E; and, both by the length and direction of the passage through which he had entered, he knew it to be situated immediately above the large room F *. This newly discovered chamber is four feet longer than the one below, but exactly of the same breadth, and its covering is composed of eight stones of beautiful granite. This place could not be found by Niebuhr, though informed of its situation by Mr Meynard who had accompanied Mr Davison, and has never been visited since the time of the last-mentioned traveller, till the date of those recent discoveries which we now proceed to describe.

Captain or Mr Caviglia, the master of a mercantile vessel in the Mediterranean trade, set out from Cairo on the 8th of January 1817, with a resolution to employ his utmost exertions in exploring the numerous passages and interior recesses of the pyramids of Gizeh. Conceiving that the descent of the Well in the great pyramid had never been thoroughly prosecuted, he entered the shaft at A as Mr Davison had done, with a lamp in his hand and a rope about his middle. He describes the different shafts nearly in the same manner as that gentleman does, but discovered the additional fact, that the interior was lined with masonry above and below the grotto B, for the purpose, as was supposed, of supporting one of those insulated beds of gravel, which are frequently found in rock. He found nothing

* This room F is usually called the King's Chamber, to distinguish it from that called the Queen's Chamber G.

at the bottom but loose stones and rubbish; and was compelled, by the excessive heat and foul air, to reascend the shaft with all possible expedition; but, before he reached the grotto, all his lights were extinguished in rapid succession *. Neither this experience of the enervating heat and impure air of these subterranean channels, (which have often been known to cause the stoutest man to faint, even in getting up as far as the gallery,) nor the various histories current in Cairo of persons who were supposed to have perished in these attempts, could deter this enterprising traveller from renewing his researches, with a degree of perseverance as unexampled as his success was unexpected. Having remarked that the ground at the bottom of the Well gave a hollow sound under his feet, he was convinced that there must be some concealed outlet below; and having pitched his tent in front of the pyramid, he hired a number of Arabs to draw up the rubbish from the spot with baskets and cords. With the aid of an order from the Kiaya-Bey, and the payment of enormous wages, " it is still," says Mr Salt, " almost inconceivable how he could so far surmount the prejudices of these people, as to induce them to work in so confined a space, where a light, after the first half hour, would not burn, and where, consequently, every thing was to be done by feeling and not by sight; the heat at the same time being so intense, and the air so suffocating, that, in spite of all precautions, it was not possible to stay below an hour at a time, without suffering from its pernicious effects. At length, indeed, it became so intolerable, that one Arab was brought up nearly dead, and several others, on their ascending, fainted away, so that, at last, in spite of the command laid upon them, they almost entirely abandoned their labour, declaring, that they were willing to work, but not to die for him."

* The language of our correspondent in describing his ascent of this shaft some time afterwards, in company with Mr Caviglia, even when a freer circulation of air had been effected, may convey some idea of the overwhelming fatigue which Mr Caviglia must have encountered in this first visit to the Well. " Leaving the chamber, we returned to the bottom of the Well, which we immediately began to ascend to the height of 200 feet; and after which labour I should be inclined to consider the climbing of the most difficult chimney in Scotland a mere trifle. Covered with dust, oppressed with heat and fatigue, we at last gained the top, where we found it necessary to rest and breathe a little."

Disappointed in this pursuit, Mr Caviglia applied his endeavours to clear the principal entrance of the pyramid H, which had from time immemorial been so much obstructed as to render it necessary for those who entered the passage, to creep on their hands and knees: By this means he hoped to admit a freer passage for the air into the interior. In the course of these labours he made the unexpected discovery, that the main passage leading from the entrance did not terminate at I, as hitherto supposed, but that it continued downwards, with the same degree of inclination, the same dimensions, and the same finish of work at the sides, as at the beginning of the channel. Having cleared out this inclined passage IK to the length of 150 feet, the air became so impure, and the heat so suffocating, that he experienced the same difficulties in prevailing with the Arabs to continue the work, and was himself attacked with spitting of blood, and other symptoms of impaired health. Still, however, persevering in his researches till he had excavated the passage to a distance of 200 feet, his labours were rewarded with the discovery of a door-way L, on the right side, from which a smell of sulphur was soon perceived to issue. Recollecting, that, in his first visit to the pyramid, he had burned some sulphur at the bottom of the Well, for the purpose of purifying the air, he conceived the probability of there being a communication by this door-way with the Well. This conjecture was soon realized by the discovery that the channel HL, opened directly upon the Well, where he found the baskets, cords, and other implements, which had been left by the workmen. The opening of this communication afforded a complete circulation of air along the new passage K, and up the shaft B, so as greatly to facilitate his future operations. This new passage, however, did not terminate at this door-way; but, continuing 23 feet farther, in the same line of inclination, becoming narrower towards the point M, where it took a horizontal direction for the space of above 28 feet, and then opened into a spacious chamber, N, immediately under the centre of the pyramid, and 100 feet below the base. This chamber, with the greatest part of the passage leading to it, is all cut out of the solid rock upon which the pyramid is built," and which projects into the body of the pyramid about 80 feet above the level of its external base. The chamber itself is 60 feet long, 27 broad, with a high but flat roof; and, when first discovered, was nearly filled with loose stones and rubbish. The platform of the floor is irregular, nearly one-half of its length from the entrance being quite level, and about 15 feet from the ceiling; while, in the middle space, it descends 5 feet lower, where there is an opening or hollow, resembling the commencement of another shaft or well; and thence, to the western end, it rises so much, that there is scarcely room, at the extremity, to stand upright between the floor and the ceiling. Some Roman characters, rudely formed, and marked by the flame of a candle, were observed on the walls; but the mouldering of the rock had rendered them illegible. There was no vestige of any sarcophagus; and it is supposed that this receptacle of the dead had been spoiled of its contents by the early Arabs, under Al Mamoun, the son of Haroun al Raschid. On the south side of this chamber is an excavated passage, just sufficient to admit a person creeping along on his hands and knees, and continuing horizontally for the space of 55 feet, when it seems to terminate abruptly. Another passage, at the east end of the chamber, commencing with a kind of arch, runs about 40 feet into the solid body of the pyramid.

Mr Caviglia next proceeded to examine the chamber E, discovered by Mr Davison, immediately above the King's chamber, and found the dust and bats dung with which the floor was covered, increased to the depth of 18 inches. He describes the sides and the roof of this upper apartment as coated with red granite of the finest polish, but its floor as very uneven, in consequence of its being formed by the individual blocks of granite which compose the roof of the chamber below. It is only four feet high; and it is not easy to conjecture for what purpose it could have been intended. Nothing was discovered by Mr Caviglia that could lead to a solution of the long-contested question respecting the original design of these recesses; but it is still considered as the most probable opinion, that they were principally intended to secure the remains of the founders, or of the priests; and it is also conjectured that, among the contents of the sarcophagus, discovered in the pyramid of Cephrenes, some human bones may have been mixed with those of the cow.

The whole intermediate space between the lake Mœris and Gizeh, is so full of pyramids, mausoleums, temples, and subterraneous catacombs, that it may be viewed as one immense cemetery; and it is the conjecture of M. Pauw, that the grand entrance to the whole of the interior communications may be found under the Temple of Serapis, which is placed by Strabo to the west of Memphis. It is worthy of remark that, in all the pyramids which have been opened, the entrance has been uniformly found in the centre of the northern front, and the passages invariably proceeding in a downward sloping direction, at an angle of 26 or 27 degrees; circumstances which seem to indicate some specific design; and the observation of the stars crossing the mouth of these lengthened tubes, is supposed to have been a principal object of this arrangement. Mr Caviglia next directed his attention to the numerous ruined edifices and tumuli which are scattered around the pyramids, and along the left bank of the Nile, as far as the eye can reach. They were generally found to contain several chambers, variously disposed, but similarly decorated with bas-reliefs and paintings, and in all of them were found fragments of bitumen, human bones, and great quantities of mummy cloth. In one or another of these apartments, was always found a shaft or well, from the bottom of which proceeded a narrow passage, conducting to a subterranean chamber; and in one of these was discovered a plain but highly finished sarcophagus, without a lid, of the same dimensions, nearly, as that which is seen in the King's chamber in the Great Pyramid. Many of the paintings in bas-relief represented persons engaged in the different pursuits of agriculture, and in various other occupations. The figures of the buds and animals are executed in a manner which discovers considerable skill in the art of drawing; and the colouring in many of the chambers retained all its original freshness. The human figures are generally ill-proportioned, but the actions in which they are engaged are very intelligibly expressed; and several fragments of statues have been collected which give a higher idea of Egyptian sculpture than has hitherto been entertained.

But the excavations around the Sphinx, which Mr Caviglia conducted with the most indefatigable perseverance, may be regarded as the most interesting of his labours, and were, at least, followed by the most abundant discoveries of Egyptian antiquities. The French savans appear to have done nothing more than uncover the back of this stupendous piece of sculpture; and, if they attempted any other excavations, cannot possibly have proceeded far in their work, as the top of the wall, which has now been discovered, is not above three feet below the level of the sand. Mr Caviglia first begun to open a deep trench on the left or north side, near the shoulder of the figure; but, though this opening was about 20 feet wide at the top, and only 3 at the bottom, it soon became hazardous for the workmen to continue their operations, in consequence of the sand being driven back by the wind. He proceeded, therefore, to carry on his excavations in the front; and, after labouring for the space of nearly four months, with the assistance of from 60 to 100 persons every day, he succeeded in laying open the whole figure to its base. This wonderful production of ancient art is now ascertained to be cut out of the solid rock on which it had been supposed merely to rest; and though, in digging the first trench, it clearly appeared that the external surface of the body below was composed of irregular-shaped stones, carefully built, and covered with red paint, yet this portion of masonry is confined to certain projecting ledges, which are supposed to have been added by the Romans, and to have been intended for the lines of the mantle or dress. The body is in a cumbent posture; and the paws (which are formed of masonry) stretch out 50 feet in advance. Fragments of its enormous beard are seen resting under its chin; and there is a hole in the head, in which the priests are supposed to have concealed themselves, for the purpose of imposing their oracles upon the deluded people. "The face, which is of the negro cast, is considerably decayed, but still presents a mild and even a sublime expression." The sphinx now appears surrounded with a wall (3), at the distance of 30 feet, the top of which is only three feet below the level of the surrounding sand, so as to prove, beyond a doubt, that the ground around it is not higher now than formerly. This wall is built of unbaked bricks, but cased with stone on the inside. From this wall there is a descent in front to the large area, by means of two flights of steps, one of 32 and the other of 14 steps (5, 6); and, upon the lower platform, between these flights, are the remains of two altars (1, 2) covered with Greek inscriptions, considerably defaced. In the centre, between the outstretched paws of the Sphinx, stands a stone platform or temple (7), on which was found a large block of granite, 14 feet high, 7 broad, and 2 thick. The face of this stone fronting the east is embellished with sculpture in bas-relief, with a long inscription in hieroglyphics beneath, and the whole design covered at the top by the sacred globe, serpent, and wings. Two other tables of calcareous stone, placed on each side of the last mentioned, and similarly ornamented, are supposed to have formed part of a temple; one of these was still remaining in its place, and the fragments of the other, which had been thrown down, are now in the British Museum. There were found several fragments of rudely sculptured lions, and particularly a small figure of that animal of the finest workmanship, at the entrance of the temple, with its eyes directed towards the sphinx. On the side of the left or northern paw of the great sphinx were discovered several inscriptions in Greek characters; and one, particularly on the second digit, in pretty deep characters, with the signature of Arrianos, which has been copied and restored with much apparent correctness, by our distinguished countryman Dr Thomas Young. On the digits of the southern paw, were found only a few expressions in honour of Harpocrates, Mars, Hermes, and some of the Roman Emperors.

After the most unremitting exertions, for the space of ten months, Mr Caviglia was seized with an attack of ophthalmia, which obliged him to suspend his labours and return to Alexandria. The expence incurred by his various operations is said to have amounted to about 18,000 piastres, part of which was contributed by Mr Salt, and a few other gentlemen; but with the explicit understanding that, whatever antiquities might be discovered, should be left at the entire disposal of Mr Caviglia. This gentlemen, on his part, has "generously requested that every thing might be sent to the British Museum, as a testimony of his attachment to that country, under the protection of whose flag he had for many years navigated the ocean *."

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* Quarterly Review.

ART. XVIII.—*Observations on the Arctic and Skua Gulls of British Ornithologists. By the Reverend* JOHN FLEMING, D.D. F.R.S. Edin. M.W.S. Communicated by the Author.

THE two species of gulls described by Linnæus, in the twelfth edition of his Systema Naturæ, under the trivial names *Parasiticus* and *Cataractes*, differ from the other birds of the genus with which they are associated, in the peculiar structure of their bills, and in the singularity of their manners. While the upper mandible in the common gulls may be regarded as simple, it presents a more complicated structure in the species to which we have now referred. In these, it consists of two pieces, the most remarkable of which is softer than the other, and forms a corneous plate, situated on the upper side, and extending forwards from the base nearly two-thirds of the whole length of the mandible, without being extended to the margin on either side. This plate has been compared to the *cere*, or thick coloured skin, observed at the base of the bill of hawks and eagles, from which, however, it differs, in not reaching to the gape on each side, and in being of a firmer consistence. The nostrils are situated on the inferior margin of this plate, near its distal extremity.

When in pursuit of food, or engaged in defending their nests, these birds far excel the other gulls in the rapidity of their flight. They live on fish, which they seldom obtain directly by means of their own industry. They watch attentively the efforts of the other gulls while fishing, and when they perceive any of these to have been successful, they instantly fly towards them; and, by an unremitting pursuit, compel them reluctantly to yield the prize. Inattentive observers have mistaken the vomited matter for excrement, and have concluded that they live on the dung of their weaker neighbours.

The other gulls are remarkable for their shyness and timidity at all seasons. These, on the contrary, are bold and vigorous, especially during the breeding season, and will not hesitate to attack birds of prey, dogs, or men, when approaching their young. The claw of the inner toe is more arched than in the other gulls. This character, viewed in connection with its predatory habits, has procured for the largest species the name of Sea Eagle.

The feathers of these birds have a very strong smell, not unlike those belonging to the petrels.

There is no difference of plumage between the sexes. The young birds more nearly resemble the adult ones in the colour of their plumage than those pertaining to the species of true gulls.

With characters so very different from the true gulls, it is necessary to consider these as constituting a distinct genus. *Willoughby*, in his *Ornithologia*, p. 22, when enumerating the British birds, places the *Cataractes*, the species which has been longest known to naturalists, as a genus distinct from the gulls and terns. In the body of his work, however, p. 265, he inserts it in the section of the larger gulls, of a brown or grey colour. *Brisson*, in his *Ornithologie*, afterwards adopted the same genus, under the denomination *Stercoraire*. Buffon named it *Labbe*; and more recently Illiger has termed it *Lestris*.

As Willoughby was the first ornithologist who gave an accurate description of any of the species, and indicated the propriety of placing the one known to him in a genus apart from the gulls; the name which he imposed ought to obtain the preference. It is derived from the Greek word Καταρακτης, a cataract, and alludes to the velocity with which these birds descend through the air upon the objects of their pursuit. The bird to which Aristotle applied this name cannot now be identified, as his description is both short and obscure.

The following may be considered as the systematical character of the genus CATARACTES or *Skua*, by which it may be distinguished from the genus Larus.

Bill strong and straight. The upper mandible hooked at the end; the margin of the under mandible sloping downwards at the apex.

Nostrils linear; rather widest in front; pervious, situated near the middle of the mandible, and covered with a corneous plate reaching to the feathers at the base.

Tongue bluntly bifid.

Claw of the inner toe arched. The back toe distinct.

The Skuas resemble the gulls and terns, in confining their operations to the surface of the water. Like them the body is so thickly covered with feathers, and so light in proportion to the whole bulk, that they appear to be incapable of diving. Only two species have been determined as natives of Great Britain.

1. C. VULGARIS. *Common Skua.* Plumage brown, tail feathers nearly equal, length 25 inches, breadth from 55 to 58 inches, weight from 48 to 54 ounces.

English synonymes—*Skua-gull, Brown-gull.* Scottish synonymes—*Sea-eagle, Skua, Skui,* Bonxie.

Willoughby, Ornithologia, p. 265.
Sibbald, Scotia Illustrata, ii. lib. 3. p. 20. tab. xiv. f. 2.
Ray, Synopsis Avium, p. 128.
Linnæus, Systema Naturæ, 76. 11.
Pennant, British Zoology, ii. p. 529. No. 243.

The bill is two inches and a quarter in length, and of a brownish black colour. The upper mandible is rounded along the margin towards the base; a little prominent in front of the nostrils above, and bent downwards at the end like the hawks. The under mandible is bent inwards at the edges; at the apex it forms a gutter, sloping downwards; at the base it is grooved laterally; and at the junction of the two sides beneath, there is an angular prominence. The eyes are surrounded with a narrow bare black orbit, and the irides are hazel brown. The legs are covered with large black scales. The claws are strong, of a black colour, arched and grooved beneath.

The plumage on the upper parts is dark rusty brown, with yellowish-white oblong dusky spots. Each feather is dusky brown on the edges, and yellowish-white at the end near the shaft. The plumage below is lighter coloured, and on the belly it is tinged with ash-grey. The feathers on the neck are wiry and pointed, and have a narrow oil-green spot on the extremity. The wings reach to the point of the tail. The shafts of the quills are white. The outer web, and the extremity of the first, deep brown; the tips only of the rest, brown; the remaining part, towards the base, is white. The coverts of a few of the secondaries are white. The tail-feathers, which are twelve in number, are blunt; the shafts, and the webs at the base, are white; towards the extremity the webs are brown.

There is no difference between the sexes, either in colour or size, in those which we have examined *. It does not appear to be subject to much variation of plumage with age or seasons. Some individuals have been found having the chin and forehead tinged with ash-colour.

Willoughby is the first British writer who has taken any notice of this bird. His description is drawn up with his usual minuteness and accuracy. He errs, however, in considering it as the same with the Cornish Gannet or Solan Goose.

* We have remarked, that the plumage of the female is darker than that of the male.—ED.

The common Skua is gregarious during the breeding season. It lays two eggs of a muddy green colour, marked with irregular brown spots, and intermixed with smaller white spots. The nest is carelessly constructed of a few dried weeds, and is found in unfrequented moors. It breeds in the Zetland islands, where we have observed it, as in Foulah and Unst, and on Rona's Hill in Mainland.

When the purposes of incubation have been accomplished, it retires from its summer haunts, and leads a solitary life on the ocean. It is found in our seas at all seasons. It is rare in the southern parts of the kingdom*; and even about the Zetland islands, it is by no means a common bird. It likewise inhabits the Ferroe Isles, Iceland, and Norway. It is found in the southern latitudes, having been observed about the Falkland Isles, and termed by our circumnavigators Port Egmont Hen.

The common Skua obtains a great share of its food by pursuing the larger kinds of gulls, and compelling them to disgorge the fish which they have obtained.

During the breeding season, this bird is remarkably active in defending its young. It descends through the air in an oblique direction with amazing velocity, towards any person who ventures to go near its haunts. It seldom, however, inflicts a stroke, generally approaching within a foot or two, when it rises rapidly and flies off about a hundred yards, to return in a straight line with equal impetuosity as before. On dogs it inflicts very heavy strokes with its wings, and generally compels them to seek the protection of their masters. The inhabitants of the Ferroe Isles destroy them with spears or sharp knives held erect over their heads, on which these birds transfix themselves.

The Skua likewise attacks the eagle with success, and drives him to a distance from its haunts. On this account he is a great favourite with the shepherd; and the Zetland fishermen, when they meet him at sea, always throw overboard some fish for his use, the reward for his services as the guardian of their flocks. His robust form, and hooked bill and claws, have induced some naturalists to suppose that he likewise devoured

* We have in our possession a specimen of the Skua Gull, killed in the Solway Frith.—Ed.

young lambs, ducks, and poultry *. In Zetland, however, he is universally regarded as a piscivorous bird.

When observed at sea, this Skua is considered as a stupid inactive bird, although bold and resolute on land. He will suffer a person in a boat to approach very near without being disturbed. When flying, the white roots of his quills appear like a white spot, and the tail is spread out like a fan.

2. C. PARASITICUS. *Arctic Skua.* Plumage above black; the two middle tail-feathers produced; length from 18 to 21 inches; breadth from 42 to 43½ inches; weight from 12 to 16 ounces.

English synonymes—*Arctic bird, Arctic-gull, Feaser, Dung-hunter, Dung-bird, Scull, Boatswain.* Scottish synonimes —*Faskidar, Badock, Allan, Scouti-allan, Dirten-allan, Skui.*

Edward's Birds, tab. 148, 149.
Linn. Syst. Nat. 76. 10.
Penn. Brit. Zool. ii. p. 533. No. 245. tab. 87.

The bill is two inches in length, of a greyish-black colour, darkest towards the point. The upper mandible is rounded along the margin towards the base, a little prominent in front of the nostrils above, and bent downwards at the end. The under mandible is bent inwards at the edges, and at the apex forms a groove sloping downwards; at the base it is grooved laterally, and at the junction of the two sides beneath, there is an angular prominence. The eyes are surrounded with a narrow black orbit, and the irides are of a hazel-brown colour. The legs are of a black colour, rather slender. The claw of the outer toe is short; that of the middle toe broad and grooved below; and of the inner toe, narrow and arched.

The plumage above is intermediate between greyish black and brownish black. At the base of the bill there are a few short reddish white feathers. Round the neck there is an indistinct circle of feathers more wiry and pointed than the others, and of an oil-green colour near the shafts. On the under side of the body the plumage is blackish grey, with a tinge of ferruginous ash. Some of the feathers on the belly are edged with white; those on the vent incline to brownish black. The wings are long, reaching beyond the lateral feathers of the tail. The first feather is the longest. The shafts of the quills are white at the base, becoming black towards the tips. The webs are raven black, lightest at the base, and darkest at the extremities. The tail consists of twelve feathers; the five exterior ones on each side are rounded with a small projection of the extremity of the shaft; the two middle feathers reach two inches and a half beyond the rest, and taper to a point. The shafts are white at the base, and the webs also are light-coloured, but both are raven black towards the extremity.

* Oviedo says it devours not only fish, but also birds and lizards.—ED.

The tongue is fleshy and bluntly bifid. The middle of the palate, and a ridge on each side, are covered with cartilaginous reflected teeth. The trachea at the division of the bronchiæ is furnished with a small bony plate. Rectum with too long broad vermiform appendages. Length 18½ inches, breadth 42 inches, weight 12½ ounces.

The preceding description is that of a male bird shot in September. Considerable variation, however, is observed in the plumage of these birds. In some specimens, nearly similar in other respects to the one which we have described, the yellowish ring of the neck is wanting. In others, this ring is white; the chin also greyish-white, mottled with greyish-black; and the remainder of the under side white, including the cheeks. In some individuals of the last variety the vent is dusky. The birds which have been described by British authors, under the title of *Black-toed gull*, (Larus crepidatus,) are now considered as varieties of this species, or rather as young birds in the first year's plumage.

The *Black-toed Gull* described by Pennant, from the communication of Dr Lysons to the Royal Society, Phil. Trans. vol. lii. p. 135, has not come under the inspection of any recent observer.

"This species (Brit. Zool. ii. p. 532. No. 244. tab. 86.) weighs eleven ounces. Its length is fifteen inches; its breadth thirty-nine. The bill is one inch and a half long; the upper part covered with a brown cere; the nostrils like those of the former (Skua); the end black and crooked. The feathers of the forehead come pretty low on the bill. The head and neck are of a dirty white, the hind part of the latter plain, the rest marked with oblong dusky spots. The breast and belly are white, crossed with numerous dusky and yellowish lines. The feathers on the sides and the vent are barred transversely with black and white. The back, scapulars, coverts of the wings and tail are black, beautifully edged with white or pale rust colour. The shafts and tips of the quill-feathers are white. The exterior web and upper half of the interior web black, but the lower part of the latter white. The tail consists of twelve black feathers tipt with white; the two middle of which are near an inch longer than the others: the shafts are white, and the exterior web of the outmost feather is spotted with rust colour. The legs are of a bluish lead colour; the lower part of the toes and webs black."—Taken near Oxford.

The black-toed gull described by Bewick, in his valuable work on British Birds, is by no means rare. In a specimen shot in October, he informs us, that "the whole upper and under plumage is dark-brown, each feather slightly edged and tipped with ferruginous. The greater wing coverts, and the first and secondary quills are dusky, and more distinctly tipped with rusty spots. The tail consists of twelve feathers; the two middle ones longer than the rest; it is of the same colour as the quills, except at the concealed part of its root, which is white. The legs are slender, and of a lead colour; the thighs and part of the joint, and the toes, black; the webs are of the same colour, excepting a small space between the first joints of the toes, which is white."

The late Mr Montagu, in his Supplement to his Ornithological Dictionary, gives the following description of another variety.

"It has the sides of the head, neck, and throat, buff-coloured; the breast white, shaded into a grey and becoming dark slate-colour, on the belly and parts beneath; the upper parts of the body are also dark slate; the wings and tail black; the legs are yellowish; the knees and the feet, as high as the back toe, black. The sex could not be determined, but the two middle feathers of the tail are of their full length."

According to Pennant, the sexes may be readily distinguished by the plumage, the male being white on the under side, while the female is of a light brown. These marks, however, are not to be depended upon, as we have frequently found those with the belly white to be females, while those with dark-coloured bellies were males. The late Mr Simonds, in the Linnean Transactions, vol. viii. p. 267, in reference to those which he found plentifully on the Isle of Glass, says, "Several varieties were examined, and confirmed the remark that there is no external mark of distinction between the sexes." We are disposed to coincide with this opinion, and to consider the white colour of the feathers on the belly as a mark of age.

Edwards is the first British writer who takes any notice of this species. Linnæus quotes the Coprotheres or Strundt-jager of Ray (Synopsis Avium, p. 127) as synonymous. But, as Ray places his bird among those gulls which are destitute of a back toe, it is obvious that, in quoting from Marten, he was himself ignorant of the species. The Cepphus of Aldrovandus is usually considered by British writers as similar to the varieties which have been noticed under the name of Black-toed Gulls; but the description given by that author is too imperfect to warrant us to refer to it with confidence as synonymous.

This species breeds in unfrequented heaths in the Hebrides and Northern Islands. Its nest is constructed of dry grass. The eggs are in general two in number, about two inches in length, of a dirty olive-green colour, with irregular blotches of liver-brown, most numerous at the thick end. The eggs of this species, however, like those of many kinds of water-fowl, exhibit considerable differences as to colour. In defending its nest when containing young birds, it is remarkably bold and impetuous; and, in its motions, bears a considerable resemblance to the lapwing *. It often feigns lameness, in order to decoy unwelcome visitors to a distance.

In the breeding season, it may be regarded, like the gulls, as gregarious. It appears at the breeding places about the beginning of May, and retires in the end of August. During the remainder of the year, it is dispersed over the ocean.

It is a species widely distributed in nature. It has been found from the twenty-eighth degree of north latitude to the icy shores of Spitzbergen.

The flight of this bird is rapid, and its sight acute. It perceives the success of the common gulls, even at a considerable distance, pursues them with success, and picks up the morsel which they have been compelled to vomit, in general before it reaches the water. It is in this predatory manner that it seems to obtain the greatest part of its food; not exclusively, however, since we are informed by Ghister, in the Memoirs of the Academy of Stockholm, vol. ix. p. 51. that it will, even in the strongest breeze, seize any small fish which the sailors throw in the air; that it even steals away herring from the decks of the fishing vessels; and, if they are salted, washes them previous to swallowing them; that it is the sign of the presence of fish; and, when these are scarçe at sea, it approaches the banks, to feed on the earnings of the weaker gulls.

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* During our six days confinement by a storm, on the dreary and remote rock of Foulah, we had frequent opportunities of observing the Arctic Skua. This bird we found fully as troublesome as the common skua; for the moment we approached near to its nest, it beat us upon the head and in the face with its wings, and continued to pursue us until we quitted its domain.—Ed.

ART. XIX.—*Description of the Nautical Top, as constructed by* EDWARD TROUGHTON F. R. S., and Member of the American Philosophical Society.

IN taking the altitudes of the sun and other celestial bodies at Sea, it is always necessary to perceive the apparent horizon. When the horizon is obscured, and when the vessel has little or no motion, the observations may be made with an *artificial horizon*, consisting either of mercury or tar, placed in a shallow vessel, and protected by a glass cover from partaking of the agitations of the external air. If the ship, however, has the least motion, these artificial horizons are of no use, and it becomes impracticable to make the usual observations for the latitude.

Soon after the value of Hadley's Quadrant became known, every one was anxious to have attached to it an apparatus for taking altitudes, when the natural horizon could not be seen; and all the varieties of pendulums, plumb-lines, and levels, were tried and rejected. Perhaps, among these various contrivances, there were few that, under particular circumstances, might not have been useful; yet their discrepancies were such, that any thing like a standard instrument never appeared, and perhaps none of them answered the purpose better than Astrolabes had done before. The class of instruments above alluded to have never disappeared; they have continually been brought forward under patents and new forms, but, to a very late date, they have succeeded no better than those that preceded them.

Mr Serson, who was lost on board of his Majesty's ship the Victory about the middle of the last century, had observed * that, when a top was spun, its upper surface directed itself in the course of two minutes after it was set up, in a true horizontal plane;—that this plane was not at all disturbed by any mo-

* See *Philosophical Transactions* 1751, vol. xlvii. p. 352.

tion or inclination given to the box on which it was placed; and therefore, that it might be of great advantage as an artificial horizon. When it was spun in the open air, it continued in motion 35 minutes; but when it was made to revolve *in vacuo*, its motion continued during the space of *two hours and sixteen minutes*, preserving a perfect horizontality for the space of three quarters of an hour.

The nautical top, as made by more than one of the first artists, was tried at sea about sixty years ago, by some of the first naval officers, with sanguine hopes of success. These hopes, however, were disappointed, and in a few years it shared the same fate as all the other contrivances that preceded it. Mr Weir, who revived this subject, failed to a far greater extent than any who had gone before him. His instrument, made by the order, and at the expence, of the Board of Longitude, was tried in a King's ship by himself and an astronomer appointed by the Admiralty. It was soon found, that when the ship had any motion, the top could not be depended upon to the amount of several degrees, although on shore it performed within a smaller number of minutes. Mr Weir's machine, which was very large, had a reflecting surface of full 12 inches diameter; it required a man to keep it in motion while observations were made with it. The glass rested its weight upon a blunt point, supported from a chest below. The train of wheels that gave motion to the glass, were connected to the latter by means of leather thongs; and the motion of the ship stretching one of the thongs, and relaxing the opposite one, drew the glass from its due position through the angle mentioned above.

It was in the beginning of last year, that Mr Troughton began his experiments on the Nautical Top, under an idea that this instrument had not hitherto had a decisive trial; and we think it will be allowed by all who are acquainted with the genius and resources of that eminent artist, that, if the idea is susceptible of being brought to perfection, it will be perfected in his hands. His first efforts were very flattering; for, by means of an easy adjustment, he brought the planes of reflection and rotation parallel to each other; a thing of so much importance, that it had been considered as the chief cause of failure in the first constructions, and which cannot be effected but by good workmanship. His next experiments were directed to give the instrument a better form; but, after trying different forms, to the amount of eight, he found himself completely disappointed; for, among that number, there was not one which performed better than that first described. In fact, they were very nearly all alike.

One of Mr Troughton's Tops was sent out with each of the four ships that went last year to the Arctic Regions, and, though they did not give such satisfactory results as were expected, yet he is perfectly satisfied with the reports of the able officers who commanded them. He was never, himself, sanguine of success; but he wished, if possible, to give to the mariner a standard instrument; well aware that, to do this, it must command a degree of accuracy very nearly, if not quite, equal to that of the natural horizon.

The Nautical Top consists of two separate parts; the Top which is to be spun, and a piece of machinery from which it is to receive its rotatory motion.

The form which Mr Troughton first gave to the top, was that of a hollow cylinder of brass, open at the bottom, and terminated above by a circle of dark glass. The inner diameter of the cylinder was $4\frac{1}{12}$ inches, the outer diameter $4\frac{6}{10}$ inches, its height $1\frac{1}{2}$ inch, and the diameter of the reflecting glass $4\frac{1}{2}$ inches.

Mr Troughton afterwards surrounded the cylinder with a solid brass ring, fastened to it by four projecting arms. The upper surface of the ring was on a level with the circle of black glass which formed the surface of the top; and the inner curved surface of the ring was concentric with the outer curved surface of the top.

The improvement which Mr Troughton has made upon the top since it went out with the Arctic Expeditions, consists in giving it the form of an inverted frustum of a cone. The base or lower surface of the frustum is about 6 inches in diameter, the upper surface about 4 inches, and its height about $2\frac{1}{2}$ inches. The thickness of the metal which forms the cone is $\frac{1}{8}$ of an inch. The reflecting plane which occupies the whole upper surface of the conical frustum, rests in a steel cup half an inch wide, and on a steel point which descends about half an inch below the upper surface of the frustum.

Mr Troughton, we know, is still continuing his experiments upon this subject. His present efforts are chiefly directed to the means of preventing the action of the wind, and at the same time removing the effect which the recoil of their own wind produces; a thing which, within moderate dimensions, he finds is not easily effected.

The apparatus for putting the top in motion, consists of a series of wheels, the first and largest of which is put in motion by a winch or handle placed in its circumference. The last axis which is put in motion, and acquires a great velocity from the intermediate wheels and pinions, carries at its lower end a hollow square key like the termination of a clock-key. This hollow key fits loosely the square axis of the top, so that when the one is placed upon the other, and the apparatus put in motion by the hand, the top receives the same velocity as the key and the axis to which it is attached. As soon as the velocity acquired by the top is considered sufficiently great, the whole apparatus is quickly raised; the key leaves the vertical axis, and the top revolves alone with an inconceivable velocity.

In the course of last summer we had an opportunity of witnessing this simple experiment. The top had then the second form which we have described; the images of objects reflected from the revolving plate of glass appeared absolutely fixed; and in consequence of the total disappearance of the projecting arms which held the outer ring of brass, this ring appeared to be absolutely suspended in the air, and to surround the top exactly as the ring of Saturn encircles the body of the planet.

The velocity of the circumference of the base has been calculated at about 30 miles an hour.

EDINBURGH, *April* 20. 1819.

Art. XX.—*On the Geognostical Relations of Granite, Quartz-Rock, and Red Sandstone.* By Professor Jameson. Communicated by the Author.

1.

Granite, which is a very abundant and widely distributed rock, is a compound of felspar, quartz, and mica, disposed in granular distinct concretions of various magnitudes and forms. These concretions, at their line of junction with each other, present appearances which are highly interesting in a general geological view. Frequently the concretions are simply attached to each other, or they are intermixed at their line of junction, the felspar being intermixed with the quartz, the quartz with the mica, or the mica with the felspar; and not unfrequently branches or veins shoot from the one concretion into the other. These phenomena, thus distinctly seen in the small scale, are of the same general nature with those observable at the lines of junction of gneiss, granite, mica-slate, porphyry, limestone, trap, and other rocks.

Quartz-Rock, which is principally composed of granular concretions of quartz, with a little disseminated felspar, and a few scales of mica, when particularly examined, exhibits the same kind of structure as that just described as occurring in granite.

Red Sandstone *.—This rock is principally composed of fine granular quartz, with a considerable portion of felspar and a little mica, disposed in granular distinct concretions, presenting at their junctions the same appearances as in granite and quartz rock.

2.

Mineralogists in general admit the chemical nature of granite, but deny that quartz-rock and its sandstone have been formed by deposition from a state of chemical solution, the characters of these rocks, in their opinion, intimating a mechanical formation. But on what data is this opinion founded? The general arenaceous

* This red sandstone differs from that which lies immediately below the coal formation, as will be explained in a future paper.

aspect, and rolled masses in these rocks, are the circumstances principally adduced in support of this hypothesis. But granite is often arenaceous, and yet it is admitted to be a chemical formation, and no authentic rolled masses have ever been detected in quartz-rock, or in the red sandstone which is associated with it. We must therefore abandon the mechanical formation of quartz-rock and red sandstone, and inquire if they are not products of crystallization. In all rocks universally admitted to have been formed by crystallization, such as granite, syenite, and limestone, the granular concretions of which they are composed, are either simply attached or intermixed at their line of junction, or branches shoot from the one into the other; and these arrangements, which must be considered as indicating crystallization from a state of solution, also occur in quartz-rock and its sandstone; and hence these also are to be viewed as chemical formations.

3.

Small masses of fine granular granite sometimes occur imbedded in coarse granular varieties, and occasionally masses of coarse granular granite are inclosed in fine granular. These masses, at their line of junction with the inclosing granite, are sometimes distinctly separated, or they are intermixed with it, or gradually pass into it, and frequently they send out branches or veins in all directions into the surrounding rock. These characters prove the chemical and also cotemporaneous formation of these masses with the surrounding rock. It frequently happens that masses having all the characters of quartz-rock are imbedded in granite, and these, at their line of junction with it, present the appearances already described in the inclosed granite masses. Similar masses of granite occur in quartz-rock, and in sandstone, and sandstone also occurs in quartz-rock and granite;—facts illustrative of the chemical and cotemporaneous formation of all these rocks.

4.

Having shewn that granite, quartz-rock, and red sandstone, are chemical formations, and that they are sometimes of cotemporaneous formation on the small scale, we may next inquire if the arrangements of these rocks on the great scale are of the same general nature. This investigation will lead us to detail the geognostical relations of Granite, Quartz-Rock, and Red Sandstone.

I.—*Geognostical Relations of Granite.*

It is an opinion entertained by many, (and one which I at one time considered as the most plausible,) that granite is the oldest of all rocks, and was therefore the first formed of the different formations of which the crust of the earth is composed; others maintain, that granite is newer than most rocks. The first opinion is that of the Neptunists, the other that of the Plutonists. Both opinions we consider as improbable, and are rather inclined to consider granite as of cotemporaneous formation with the rocks along with which it is associated. The following statement will shew how far this opinion is consistent with the geognostical relations of granite.

Imbedded Granite.

a. Granite occurs in *imbedded masses*, varying in magnitude from a few fathoms to several miles in extent, and often of great breadth, in rocks of different kinds. These masses sometimes rise above the bounding strata, forming hillocks, hills, mountains, or ranges of mountains. The surrounding strata occur in different positions; sometimes they are horizontal all around the mass, or they rest on the mass on one side, and rise from under it on the opposite side; and occasionally the strata are mantle-shaped, or dip towards the granite from all sides.

In some instances, the strata are observed under the mass of granite, as well as on its sides, thus proving that it is imbedded; and we see no reason why the same may not be the case in all similarly situated masses of granite, of whatever magnitude they may be.

b. These imbedded granite masses, at their line of junction with the bounding strata, present precisely the same series of phenomena as occur among the distinct concretions of granite, and other granular rocks, and at the junctions of smaller imbedded masses of different rocks. Here, then, we have, on the great scale, in junctions often visible for miles, either the intermixture of the granite with the bounding strata, or their mere attachment without intermixture; and often numerous veins of granite shoot from the imbedded mass into the adjacent rocks.

c. The imbedded granite masses are sometimes completely enveloped in the surrounding strata, but more frequently a considerable portion of the mass rises high above the bounding strata. This is owing partly to the influence of the weather removing a part of the superimposed strata, and partly to the original formation of the mass itself.

Granite in Beds.

Granite frequently occurs in tabular masses or beds, which are parallel with the bounding strata. These vary in breadth from a few feet to several hundred feet; and from a few yards to several hundred yards, in extent. These beds, at their line of junction with the neighbouring strata, are sometimes distinctly separated without any transition or intermixture; while, in other instances, transitions are to be observed, and also intermixtures with the superimposed or subjacent strata. Veins or branches of the granite also occasionally shoot from the beds into the bounding strata.

Granite in Veins.

Veins of granite, as already described, shoot from imbedded granite, and also from granite beds into the adjacent strata; but besides these, numerous veins are met with, which are isolated and unconnected with any bed or imbedded mass of granite. These veins vary in magnitude from half an inch to many fathoms in width, and from a few inches to many fathoms in length. They are sometimes very tortuous in their course, and occasionally send out from both sides numerous smaller lateral branches or veins. In some of these veins there is no intermixture of the vein mass and the bounding rock; in others there is an extensive intermingling of the two.

Rocks in which Granite occurs.

Not above forty years ago, it was a general opinion that granite occurred only under, and in contact with gneiss, and was therefore entirely wanting in all the other rock formations. This view is still maintained by some mineralogists, but must ere long be abandoned, as it is now known that granite is associated with many different kinds of strata.

Granite occurs in great imbedded masses, and veins, in *syenite.* These masses, often many fathoms in extent, at their line of junction with the granite, are sometimes simply attached, more frequently appear intermixed with it, or pass into it, and branches or veins shoot from the granite into the syenite.

Porphyry, a very widely distributed rock, sometimes contains imbedded masses and veins of granite, in which we have a repetition of the same phenomena as observed in the masses inclosed in syenite. But many porphyries are mere varieties of granite, in which the base is very fine granular granite.

Granular foliated limestone, in primitive mountains, is sometimes traversed by veins of granite, or contains imbedded masses of that rock.

Gneiss, Mica-slate, Clay-slate, and Grey-wacke, are frequently traversed by veins of granite, and in many districts there are whole hills and ranges of hills, which are the outgoings of imbedded masses, and beds of granite, situated in the rocks just enumerated. But these are not the only rocks which contain granite; for immense imbedded masses, beds, and veins, occur in *quartz-rock*, and also in the *red sandstone* connected with that interesting formation.

This concise enumeration of facts, proves, that granite is not confined to one particular species of rock, but occurs in many, and that it is not of earlier formation than all other rocks, nor of newer formation than most others, but is very often a contemporaneous crystallization with the rock in which it is situated.

II.—*Geognostical Relations of Quartz-Rock.*

Werner was the first naturalist who studied the geognostical relations of this rock, and his view is stated in my Elements of Geognosy. I have traced its distribution in the mountainous districts of the Highlands, and the same has been done by my active and acute friend Dr MacCulloch. We have ascertained that its relations are much more varied than was formerly believed, and that it occupies a greater portion of the crust of the earth than had been suspected by geologists. Werner confines it almost entirely to the clay-slate formation; and Von Buch conjectures that it may be the oldest rock with which we are acquainted. Both of these statements are incorrect; for it is found associated with nearly all the Primitive Rocks of authors; also with those of the Transition class, and is even included in Sandstone; and as there is no satisfactory evidence of one primitive rock being older than another, the whole class appearing to be a simultaneous crystallization, there is no reason why quartz-rock, which occurs along with all the others, should be viewed as the oldest *.

Imbedded Quartz-Rock.

Quartz-rock occurs in masses, in rocks of different kinds. These imbedded masses, according to their magnitude, form hillocks, hills, or ranges of hills. The strata around these masses have the same positions as are observed with imbedded masses of granite; and the lines of junction of the quartz with the adjacent strata, exhibit intermixtures, transitions, and veins, as in granite.

Quartz-Rock in Beds.

The tabular masses or beds of quartz-rock are sometimes so thick and extensive as to form whole hills; and their lines of junction exhibit the usual appearance of veins, intermixtures and transitions.

Quartz-Rock in Veins.

Veins of this rock are very frequently met with in some districts, and these are occasionally several fathoms wide, and of considerable extent.

Rocks in which Quartz-Rock occurs.

Quartz-rock, like granite, sometimes occurs in large imbedded masses in *syenite*, and also in masses and veins in *gra-*

* The arrangements that occur in Galloway, on the east coast of Sutherland and Caithness, on the sides of Loch Ness, and in several neighbouring districts, on the west coast of Ross-shire, Inverness-shire, and in several of the Hebrides, seem to lead to the conclusion, that the transition rocks, and certain kinds of red sandstone, belong to the same grand division as the primitive rocks. We intend to give a full enumeration of the facts illustrative of this view in a future Number.

nite. It is a common rock, in beds, in some *gneiss* and *mica-slate* districts; and frequently, it is distributed very abundantly through hills and mountains of *clay-slate*, in the form of beds, imbedded masses, and veins. It sometimes appears in *greywacke* districts, and great beds of it are observed alternating with *red sandstone.*

III.—*Geognostical Relations of Red Sandstone.*

In general all the different kinds of sandstone have been considered as entirely unconnected with any of the primitive or transition rocks, and strictly confined to the secondary class. This restriction, however, is not consistent with our present knowledge of the geognostical distribution of this rock, and it is now known that some sandstones are connected with rocks, considered by authors as members of the transition and primitive classes.

Red Sandstone in Beds.

This rock occurs in beds of very various magnitudes. These at their line of junction with the bounding rocks, shew intermixtures, transitions, and veins or shoots from the upper and lower side, and from their extremities.

Red Sandstone in Imbedded Masses.

Red sandstone also occasionally occurs in large imbedded masses, like those of granite in syenite, or of quartz-rock in gneiss, in strata of different kinds. Small veins shoot from the sandstone into the bounding rock, and frequently intermixtures and transitions are to be observed, with the neighbouring strata.

Rocks in which Red Sandstone occurs.

Red sandstone occurs, in imbedded masses and beds, in granite, porphyry, granular foliated limestone, clay-slate, and gneiss.

5.

It thus appears that granite, quartz-rock, and red sandstone, exhibit the same relations on the great scale, as they do in the smaller masses mentioned in the 3d section; and hence it follows, that these rocks are chemical deposites, and of simultaneous formation with the various strata in which they are contained.

Art. XXI.—*Account of an Improved Hygrometer.* By John Livingstone, M. D. of Canton *.

Having observed in the process of making ice, that the power of the sulphuric acid was remarkably equable from the point of its highest concentration till it had formed ice twelve or fifteen times, I was led to entertain the expectation, that it might be found to act with sufficient uniformity in a more advanced state of saturation. As the trials which I made were highly satisfactory, I shall briefly describe my method of constructing a Hygrometer upon this principle.

In the scales commonly used as a hydrostatic balance, I placed a small porcelain dish three inches in diameter, containing 21 grains of very pure sulphuric acid, of the specific gravity 1.845, and 29 grains of distilled water. Having exposed it to the greatest degree of artificial moisture, I found that it gained 50 grains in 24 hours. When it was afterwards placed for one night in a platina dish over concentrated sulphuric acid, and under the receiver of the ice machine, its weight was reduced to 50 grains without exhausting any of the air.

Half a grain made the edge of the scale of this balance describe an arch, exceeding an inch both above and below the level. This space I divided into ten equal parts both above and below, or the grain into 20 parts, which, multiplied by the 50 grains, gave me a scale of 1000.

I have used this instrument, inclosed in a glass cover, but sufficiently open below to admit the air freely, for nearly six months; and, from a careful comparison with other hygrometers, I am persuaded it is more accurate than any now in use, though, in its present state, it is less sensible than Kater's.

It has frequently approached in the natural atmosphere, within a few divisions of the point of greatest humidity, and also within 143 of that of greatest dryness. Considering this range,

* We have been favoured with this extract of a letter from Dr Livingstone, by a gentleman who has seen the instrument which it describes. From the same quarter we are led to expect a detailed account of Dr Livingstone's meteorological observations in China, which we have reason to believe will prove in the highest degree interesting.—Ed.

however, as unnecessarily extensive, I have made another with 2.1 grains of acid and 2.9 of water, and exposed this mixture in a common flat watch-glass. The scale was only 100, but by means of a Vernier it may be divided into 1000.

This instrument, which is fully as sensible as Kater's Hygrometer, pointed to 950 (or the mixture weighed $9\frac{1}{2}$ grains) at Macao, on the 7th February 1817, during the prevalence of a remarkably thick fog. It continued so till bed-time; but next morning, at seven o'clock, the wind having changed in the course of the night from S. W. to N. E. it had lost $4\frac{1}{2}$ grains, or had fallen to 100. This is the most remarkable change I have ever witnessed even in China.

I could wish to have scales made of glass as flat as possible, with a small rim perforated with three holes, to be suspended to the beam by means of platina wires, and to have a very light glass-cover suspended by the same wires, within a very small distance of the rim. To the other end of the beam a moveable weight may be appended to mark the larger divisions; the beam may be lengthened to describe any arch of a circle, and consequently the divisions may be as minute as can be wished. Dust will thus be excluded, and should the objection of spontaneous decomposition be considered to have any weight, or in case of exposure to alkaline fumes, the mixture may be renewed with scarcely any trouble.

Art. XXII.—*On the Temporary Residences of the Greenlanders during the Winter Season, and on the Population of North and South Greenland.* By Sir Charles Giesecke, Professor of Mineralogy to the Dublin Society, M. W. S. &c. Communicated by the Author.

The Greenlanders being a migrating people, transfer very often their abodes for the winter season from one place to another. Their houses are generally built near the shores on small islands, or at the mouths of the firths. They cannot subsist in the interior of them, as the sea is frozen there very early in the autumn. The following places were inhabited during the years from 1810 to 1813.

I. Julianas-haab District.—In the South of Greenland, that is in the 60th degree, or the most southern district of Julianas-haab, round Cape Farewell, are inhabited,

1. *Alluk*, (that is, the soles,) two small islands presenting the shape of the soles of the foot.
2. *Kippingujak*, an island to the south of Alluk.
3. *Pysursoak*, a small bay to the north of Staatenhuck.
4. *Nettingiak*, on the continent, eastward from Cape Farewell.
5. *Nennortelik*, (that is, Bear-land,) an island eastward from Cape Farewell.
6. *Tessermint*, a large firth to the north of Cape Farewell, formerly inhabited by the old Norwegians. At the mouth of this frith, there are several Greenland houses, sixty-four miles south from the colony of Julianas-haab, in the 60th degree.
7. *Kognamint*, to the south of Julianas-haab, on the continent.
8. *Innersutalik*, an island forty miles southward from Julianas-haab.
9. *Agluitsock*, on the continent, thirty miles southward from the colony.
10. *Sardlok*, an island sixteen miles southward from the colony.
11. *Omenalik*, twelve miles to the south of the colony.
13. *Upernaviarsuk*, sixteen miles towards the east of the colony.
14. *Itiblik*, twenty miles towards the east of the colony.

At the colony of Julianas-haab, only natives are employed in the service of the trade, who live in Greenland houses.

Between the 61st and 62d degrees are inhabited,

15. *Ikertongoak*, an island eight miles towards the west, at the mouth of the firth called Kakortok.
16. *Narksak*, in the vicinity of the continental ice, twenty miles northward from the colony.
17. *Krimatuluitsanik*, an island forty miles northward from Julianas-haab.
18. *Okaitsermint* and *Kikerteitsiak*, forty-four miles from the colony. Here ends the district called Julianas-haab. It is inhabited by 1762 natives, viz. 754 males and 1008 females.

II. Fredericks-haab District extends from the *Nunarsoi* Island to the Ice-blink, about ⅓ of a degree to the north of Fredericks-haab. Of the southern part of the district are inhabited,

19. *Torngarsuk*, an island thirty-two miles to the south of the colony.

20. *Kangarsuk*, a cape of the continent of Greenland.

21. *Narksalik*, twenty-eight miles southward from the colony; and,

22. *Sioramint*, eight miles to the north of the colony. The population of this district comprehends 552 natives, viz. 234 males and 318 females.

III. Fisker-næer District extends from 62° 52′ to 63½°.

23. The inhabitants of the district *Fiskernœr* have their houses at the settlement of the Moravian Brethren, called *Lichtenfeld.* Their number is 280, viz. 112 males and 168 females.

IV.—Godt-haab.—The district of the colony Godt-haab begins at 63½°, and reaches to 64° 52′.

The following places are inhabited:

24. *Kariœt*, eight miles southward from the colony.

25. *New-Sterrn-Hut*, a Moravian settlement, situated between the firths of Ameraglik and Baals River.

26. *Godt-haab*, the Danish colony in Baals River, and

27. *Sarlok*, to the north-east of Baals River.—The population of this district amounts to 489 natives, viz. 186 belonging to the Danish mission, and 303 belonging to the Moravian mission. The former consists of 81 males and 105 females, the latter of 123 males and 180 females.

V. Sukker-top. The district of *Sukker-top* (sugar-loaf) begins at 64° 52′ and ends at 66° 17′.

In this district the following places are inhabited by natives:

Towards the south of the colony,

28. *Nappasok*, an island situated forty miles southward from the colony.

29. The colony *Sukker-top* itself, called *Manetsok* by the natives; and

30. *Akpamiut*, sixteen miles northward from the colony. The population of this district is 304; viz. 143 males and 161 females.

VI. Holsteinsburg District, is the last in South Greenland.

31. The district of *Holsteinsburg* begins at 66° 16′ and ends with 67° 45′. The natives being employed in the whale-fishery, have all their winter-houses round the colony. The number of the inhabitants of this district is 196, viz. 87 males and 109 females. Thus the whole population of South Greenland, the limits of which are fixed to the Strom Frith in 68°, comprehends a number of 3583 souls.

North Greenland commences in latitude 67° 43′, and comprehends the following districts:

1.	Egedes-mindes district, extending from	67° 43′	to 68°
2.	Christianshaab district,..................	68°	68° 10′
3.	Jacobshavn district,......................	68°	69° 40′
4.	Rittenbenks district,.....................	69° 40′	71°
5.	Omenaks district,.........................	71°	72° 8′
6.	Upernaviks district,......................	72° 8′	76° 30′

The population of North Greenland is not entirely ascertained, but it does not exceed the number of 3000 souls. The country from 67° to 69° is uninhabited. The first district of North Greenland is that of the colony *Egedes-minde.* The natives belonging to this and the other districts situated round Disko-Bay, or Fish-Bay, have their houses at the colonies, for the sake of the whale-fishery.

The Greenlanders of *Omenak district* are the only natives of the whole coast who live during winter in the interior of that extensive firth, having their supply in catching the seals, by means of nets which are set under the ice.

The most northern district is that of *Upernavik*; it begins at 72°, and reaches to the remotest north; but it is only inhabited to the 73°. Southwards from Uppernavik is situated

Kangersoietsiak, an island inhabited by natives.

At *Upernavik*, four or five Greenland families have their abode.

At *Tessiursak*, an island in 74° 15′, eighty miles northward from Upernavik, one family terminates the population of this forlorn country.

Art. XXIII.—*Narrative of an Excursion upon the Island of Jan Mayen; containing some Account of its Appearance and Productions.* By William Scoresby junior, F.R.S. Edin. and M.W.S. Communicated by the Author *.

Jan Mayen received its name from that of its discoverer, who visited this island, according to the Dutch authorities, in the year 1611*; but as their whale-fishery did not commence until 1612, it is probable that it was not discovered until after that period. It is situated in the Greenland Sea, in latitude 70° 49′ to 71° 8′ 20″ N. and longitude 7° 25′ 48″ to 8° 44′ W.

On approaching Jan Mayen, the first object which strikes the attention, when the atmosphere is clear, is Beerenberg†. This mountain rears its icy summit to the height of 6870 feet above the level of the sea, and frequently appears above the clouds. It is seated on a base which is of itself mountainous. The general appearance of the land strikingly resembles that of the coast of Spitzbergen, both in colour and character. As at Spitzbergen, your approach to it seems amazingly tardy. At the distance of ten or fifteen miles, a stranger would suppose himself within half a league of the rocks. This deception arises partly from the great elevation of the sea-coast, and partly from the strong contrast of light and shade, produced by the blackness of the rocks and the whiteness of the snow, with which the land is in a great measure covered. At this time (August the 4th), all the high lands were covered with snow and ice; and the low lands, in those deep cavities where large beds of snow had been collected, still retained part of their winter covering, down to the very margin of the sea.

Between the Capes North-east and South-east, three remarkable icebergs appear. They occupy three hollows in the cliff, which is almost perpendicular, extending from the base of Beerenberg to the water's edge. Their perpendicular height, ascertained geometrically, appeared to be about 1284 feet. These

* This paper was read before the Wernerian Natural History Society on the 6th of December 1817.

* Beschryving der Walvisvangst, dul. ii. bl. 62. † Mountain of Bears.

icebergs differed in appearance from any thing of the kind I had before seen. They appeared rough on the surface, were of a greenish-grey colour, and presented altogether the appearance of immense cataracts, which seemed as if, when in the act of tumbling from the summit of the mountainous coast, they had been suddenly arrested in their progress, and congealed on the spot by the power of an intense frost. Like cataracts, their prominent colour was variegated by snow-white patches resembling foam; they seemed to follow in a great measure the figure of the rocks over which they lay, and were marked with curvilinear striæ, running from the summit to the foot of the icebergs. As in cataracts, also, the jetty points of the most prominent rocks were here and there seen peeping through their surfaces.

I left my ship (the Esk) at three quarters past 1 in the morning, accompanied by Captains Bennet and Jackson, whose ships were close by us at the time, and landed at half-past 2, on a beach covered with coarse greenish-black sand, whereon there was a considerable surf. This was the first place from North-east Cape, four leagues distant, where the coast seemed, at a distance, to be at all accessible. Great-wood-bay, of the Dutch, was immediately on our left (to the westward), separated by a rocky islet; on our right, South-east Cape was at the distance of five miles. The beach was sandy through an extent of two or three miles in length, and about a furlong in breadth. It was strewed throughout with logs of drift wood, some of which seemed to be tolerably good timber, others were much bruised, and a little worm-eaten. One log I observed had been squared, and was marked with the letter G.

I had not advanced many paces before I observed signs of a volcano. The sand *(iron-sand)* was coarse, black, or reddish-brown, mixed with greenish-coloured crystals of augite. The opaque parts of this sand were very ponderous and strongly magnetic. When separated by the magnet, they strikingly resembled cannon gunpowder, both in colour and in the form of the grains. The beach, after a few feet of rise, produced by a vast bed of this sand, which was thrown up apparently by the waves, continued level to the margin of the cliff, which was in this place at the distance of about a quarter of a mile, but seemed only occasionally to have been covered by the sea to that extent. Coarse pebbles, and afterwards large masses of lava, were seen at a little distance from the sea; blocks of burnt clay, and large masses of red clay, partly baked, but still in a friable state, occurred about the base and sides of the cliff; and numerous pointed or angular rocks of the floetz-trap formation, in the form of hillocks, were seen projecting through the sand. These rocks, when broken, appeared of a bluish-grey, or blackish-grey colour. Some of the most compact contained numerous greenish crystals of augite imbedded in them; others, which were porous, but very hard, contained fewer and smaller crystals than the former. This latter seems to me to be the same kind of rock as the celebrated German millstone rock.

After leaving the sea shore, where a few common pebbles, such as quartz, porphyry, indurated clay of various colours, gravel, sand, and other alluvial substances, together with the floetz-trap rocks, were seen, I perceived no other minerals but such as bore indubitable marks of recent volcanic action*. Seeing a steep and peculiar looking mount close by, from which the profusion of cinders, earth-slag, burnt clay, scoriæ, &c. around us, seemed to have been projected, we hastened to climb its loose and rugged sides. The steepness of the hill, and the looseness of the materials of which its surface was composed, made this ascent a most fatiguing undertaking. We sometimes slid backwards several paces, by reason of the nodules of lava rolling away from under our feet. We met with no minerals in our progress but those of the class of lavas, which in many places rung beneath our steps like a number of empty metallic vessels.

About the base of the volcanic mount, we met with vast blocks of a ponderous rock, of a bluish-black colour, containing numerous green-coloured crystalline or vitreous substances (the olivine of mineralogists); about the middle, scoriæ, cinders, and earth-slag, having altogether a brownish-black appearance, together with large lumps of burnt clay, lay in great abundance; towards the top, masses of half-baked red clay of a friable texture, containing semivitrified and crystallized substances, occurred; and

* I have been informed that an active volcano has been seen in this island within the last fifty years.

at the summit, prodigious blocks of the same, ranged along the southern margin, gave the mountain a castellated form of no small magnificence. Beyond these rocks of red clay on the top of the mountain, we beheld the crater, forming a basin of five or six hundred feet in depth, and six or seven hundred yards in diameter. It seemed perfectly circular at the top, and sloped on the sides with a similar steepness as the exterior of the mountain, so that the descent was by no means difficult or hazardous. The bottom of the crater was filled with alluvial depositions, to such a height that it presented a horizontal flat, of an elliptical form, measuring about 400 feet by 240. A subterranean cavern was here seen penetrating the side of the crater, from which issued a spring of water, which, after running a short distance towards the south, disappeared in the sand.

The summit of this volcanic mountain, which was from 1000 to 1500 feet in elevation, afforded a view interesting and grand. To the north appeared Beerenberg, now first distinctly seen free from clouds, rising in majestic importance by a steep and increasing slope from the very verge of the sea on the south, to the height, apparently, of the highest clouds. At the foot of the mount on the south-eastern side, near a stupendous accumulation of lava bearing the castellated form, was another basin or crater of a volcano, of smaller dimensions than the one already described, situated on a level very little above that of the sea. Towards the north-west a thick fog obscured the prospect, which, as it advanced with majestic grandeur towards us, gradually drew the curtain over the distant scenery, until at length the nearest mountains were wrapped in impenetrable gloom; at the same time, the atmosphere of above half the hemisphere lying towards the south, east, and west, was altogether free from obscurity, and the sun shone with resplendent blaze. On the west the whole of the eastern shore of the island was distinctly seen to the south-western point, where it abruptly terminates; and a rock lying at a distance from the shore, exhibited a resemblance so strikingly like that of a ship under sail, that it called forth from the sailors the frequent exclamation of "a ship" or "a sail." Excepting the interest excited by the volcano, on the ridge of whose summit we long admired the sublimity of the prospect around us, Beerenberg sunk every other object into insignificance. A solid mass of ice capped its summit, and an almost uninterrupted stratum of the same extended to the water's edge, about a league to the eastward of us. The blackness of the rocks, the delicate greenness of the ice, and the whiteness of the snow, formed a contrast at once bold, delicate, and beautiful. In the valleys, the snow presented a surface pure and unbroken; on the sides of the hills the naked rocks protruded their black points through the surface of the snow; and on the peaks of the loftier mountains, ice and snow harmonized together, and appeared to be firm and indissoluble as the rocks themselves.

The colour of the cliffs near where we landed, was brownish-black, purplish-black, greenish-black, yellowish-brown, reddish-brown, or ferruginous red. The brownish-black consisted partly of soil and partly of rocks of iron clay; the greenish-black of the same, with an admixture of yellow clay; the yellowish-brown of indurated or half-baked yellow-clay, and the reddish-brown of baked, friable, or burnt red clay.

A rocky hill, with a precipitous side towards the south-west, appearing at a little distance to the westward of me, I descended from the mouth of the crater, and proceeded towards it with the expectation of finding some primitive or at least unaltered rocks; in this, however, I was disappointed. Though I visited the foot of the precipice as well as the top, (which was probably two or three hundred feet high,) I found that it uniformly consisted of a friable yellow clay, containing many crystals and grains of olivine and augite. On the top it was soft and marly, but harder and more ponderous below. Between this precipice and the sea, the beach exhibited numerous hillocks of floetz-trap rock.

A piece of ironstone, which appeared to have been smelted in the furnace of nature, and converted into iron, was found near the volcanic mount; it was laid aside by our party as we ascended, but unfortunately left behind us when we quitted the shore.

When we landed, we could not perceive the least sign of vegetation on any part of the beach or neighbouring land; but, on ascending the sides of the volcano, we saw several plants in flower, specimens of each of which I collected; and, on my return to the ship, had them placed in a box of earth and sand.

Among them we recognised the Rumex digynus, Saxifraga tricuspidata, Arenaria peploides (not very certain), Silene acaulis, and Draba verna. The other specimens we were not able to make out; and, before our arrival at home, they were so disfigured, that they defied the skill of the botanist to ascertain their genus.

Near the sea shore, the burrows of blue foxes were seen in different places, and traces of their feet upon the beach below high-water mark. The foot-marks of bears, and probably of rein-deer, also were perceptible. The birds were neither so numerous, nor appeared in such variety, as I had anticipated. We, however, saw burgomasters, fulmars, looms, sea-parrots, sea-swallows *, &c.

As the icebergs already described suggested the idea of frozen cataracts, a poetic imagination would, in the hollow metallic sound of the earth beneath our feet, as we climbed the volcanic mount, have conceived the cavern of Vulcan; and, in the iron manufactured in the bowels of the earth, the fabrication of the same deity, for the use of his parent Jove.

We returned to our ships at six in the morning, when, the weather being clear, I took bearings of the most remarkable parts of the coast, together with several altitudes of the sun, for ascertaining the longitude by the chronometer.

A fishing party whom I sent out proving unsuccessful in the offing, approached the shore, about two miles to the eastward of the place we visited; where, though the surf was considerable, and the strand very contracted, they succeeded in effecting a landing. They observed much drift wood, a boat's oar, and some other pieces of wrought wood, scattered along the shore. Every mineral they noticed bore the marks of volcanic action. Near some large fissures which here and there occurred in the rocky precipitous cliff, vast heaps of lava appeared, which seemed to have been poured out of these chinks in the rocks. Cinders, earth slag, arenaceous ironstone, and various descriptions of volcanic rocks, covered the beach, and so much of the cliff as they had leisure to examine.

Whitby, *6th October* 1817.

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* This was a beautiful web-footed bird resembling a swallow; it had large wings and tail, with red feet and bill.

Art. XXIV.—*Notice respecting the Journey to the Sources of the Jumna and the Ganges, by J. B. Fraser, Esq.* Communicated by William Fraser Tytler, Esq.

In the year 1815, Mr James Baillie Fraser explored a portion of that unknown and interesting region, which lies in the bosom of the Himalaya Mountains, and gives birth to several of the greatest rivers in India.

Mr Fraser proceeded from Delhi to Nahn, and from thence through the districts of Sirmoor, Joobul and Bischur to the Sutledge. Returning to the banks of the Jumna, he penetrated to the very sources of that river, and viewed it collecting from numerous small streams formed by the melting of the snow. From Jumnatree he crossed the snowy range to the Baghirutee, the greatest and most sacred branch of the Ganges, and, following up the course of this river, he reached Gangootree. Mr Fraser's observations made at this spot, beyond which he found it impracticable to penetrate, tend to confirm the prevailing belief of the Hindus, and the accounts of the ancient Shasters, that this magnificent river, equally an object of veneration, and a source of fertility, plenty, and opulence to Hindostan, rises within five miles due east of Gangootree; and that the Ganges finds its origin in a vast bason of snow, confined within the five mighty peaks of Roodroo Himala. This mountain, reckoned the loftiest and largest of the snowy range in this quarter, and probably yielding to none in the whole Himalaya range, is supposed to be the throne or residence of Mahadeo. It has five principal peaks called Roodroo Himala, Burrumpoore, Bissempoore, Oodgurreekanta, and Sooryarounee. These form a semicircular hollow of a very considerable extent, filled with eternal snow; from the gradual dissolution of which, the principal part of the stream is generated.

Mr Fraser's journal embraces a full account of the very singular state of society which is found among the inhabitants of these lofty regions, who, while in some particulars, they sink under the level of the most barbarous nations hitherto known to us, are in others, particularly in the perfection to which they have carried the art of agriculture, not inferior to the most civilized nations of Europe.

The Natural History of this new region furnishes to Mr Fraser an ample field of inquiry, and his descriptions of animal and vegetable nature, are curious and interesting. Acknowledging with regret his own imperfect acquaintance with the science of Mineralogy, he has, notwithstanding, made every exertion to contribute even to this department of knowledge, by collecting specimens of all the different rocks as they occurred, and marking on the spot their characters, &c. These specimens have been transmitted to the Geological Society of London.

The Geographical observations which Mr Fraser made in the course of his journey, are condensed into a separate memoir. These formed a leading object of his attention. Having carried with him a theodolite, perambulator, and other instruments, a survey, as accurate as the nature of the country and state of the atmosphere would admit, has been made of this region, hitherto a blank in the Geography of Hindostan.

Mr Fraser's Map, which is laid down on the scale of four miles to an inch, is divided into two portions. The first extends from the latitude of Hurdwar to that of Seran on the Sutledge, giving a survey, made from trigonometrical observations, of the districts of Gurwhal, Surmore, Joobul, Bulsum, Rewaeen, and part of Bisehur, with the course of the Sutledge, Jumna, and Baghirutee branch of the Ganges.

The second portion comprehends the course of the Sutledge north of Seran, with that of the Singkechoo or Eekung, the principal branch of the Indus. The whole of this portion of the map is laid down on the authority of native merchants, and the principal points are the situations where fairs are held at different seasons for the purchase of shawl-wool, a monopoly of which is possessed by the Government of Lodach.

It is much to be regretted that Mr Fraser was not possessed of instruments, for ascertaining the altitude which he reached, in crossing the snowy range. The British Camp from which he set out on this expedition, afforded neither a barometer nor thermometer. Judging, however, from his ascent above the region of congelation, as estimated by Mr Colebrooke, he gives tolerable data for fixing the highest position he attained, at about 17,000 feet. Here the cold in the middle of July was intense to the most painful degree. Immediate sleep attended every cessation of motion; and respiration became so difficult as painfully to oppress and debilitate his whole party. From this highest position, Bunderpooch (the Jumnatree of Webb and Colebrooke) was distant in a direct line about two and a half miles, and Sommeroo-purbut, another mighty pinnacle of the range, about one mile. Mr Fraser estimates Bunderpooch, the highest of the two, at about 4000 feet above his position, thereby assigning to it an elevation less than that of Mr Colebrooke by about 4000 feet.

Mr Fraser found that portion of the Himalaya range lying between the Baghirutee and the valley of Nepaul to include the loftiest peaks; the mountains declining in height both to the north-west and south-east; and his general opinion is, that the highest of the Himalaya mountains range from 18,000 to 22,000, or at the utmost 23,000 feet above the level of the sea. His observations coincide with those of Mr Moorcroft, in refuting the idea suggested by Humboldt, that a loftier ridge may yet exist on the side of Tibet. The Caillas ridge, lying on the north of the Himalaya, as described by Moorcroft and Hearsing, evidently consists of hills of far inferior altitude to those seen from the Bengal side.

Twenty-five drawings on a very large scale, executed by Mr Fraser from his own sketches, taken, and many of them coloured, on the spot, accompany the journal: These even, as works of art, possess very distinguished merit; but when we consider them as exhibiting the magnificent features of an alpine country on a scale far exceeding any thing known to European eyes, and as bearing upon them that air of originality and fidelity, which, in the opinion of the ablest judges, so eminently characterizes them, they acquire a higher character, and must add greatly to the value of the work.

Very copious extracts from Mr Fraser's journal, were lately read at the Royal Society of Edinburgh, and from the high degree of interest which they excited, we wait with much impatience for the publication of the whole work.

Art. XXV.—*On the Black Lead or Graphite of Borrodale, of Ayrshire, and of Glenstrathfarrar.* By Professor Jameson. Communicated by the Author.

It is well known, that the most considerable mine of black lead in any country, is that of Borrodale in Cumberland, which has supplied the market for a long series of years with the purest and most esteemed kinds of this useful mineral. Unfortunately, however, that mine has of late years decreased very much in productiveness, and, we are told, at present affords but very inconsiderable returns. This circumstance naturally leads us to inquire, if there are any other mines of this mineral in Great Britain, which are likely to supply the place of that of Borrodale. The mine near New Cumnock, in Ayrshire, and that lately opened in Inverness-shire, have afforded considerable quantities of graphite; and these, if extensively and regularly worked, promise an abundant supply. With the view of directing the attention of mineralogists to the geognostical distribution of plumbago, and of encouraging the more extensive working of the graphite mines of Scotland, we shall now give a very short description of the mines of Borrodale, of Ayrshire, and of Glenstrathfarrar.

I.—Borrodale Black-Lead Mine.

The principal rock of this district is clay-slate, which contains beds of felspar-porphyry, hornstone-porphyry, and of various trap-rocks. The graphite is contained in one of the beds of trap, which is partly greenstone, partly amygdaloid. The amygdaloid is slaty, and frequently contains agates; in this respect agreeing with similar rocks found in trap districts. The graphite occurs inclosed in the trap, in the form of imbedded masses and beds, which are occasionally of considerable magnitude. The beds are very variable in thickness, and are frequently cut off and interrupted by rents or fissures, called by the miners *Dykes.* The principal bed or mass of graphite, is at present lost; and this disappearance is owing, not to the small veins of calcareous spar that traverse the trap, but entirely to the fissures or *dykes*.

II. Black-Lead Mine near New Cumnock, Ayrshire.

This mine is situated about four miles from New Cumnock, in Ayrshire. All the strata of the district belong to that coal formation which occupies so great a tract of this division of Scotland. The rocks are disposed in strata and beds, and agree in their general arrangement and connections with the other rocks of the secondary class. The strata which have been cut through in prosecuting the mining operations, and those which are naturally exposed in the neighbourhood, are the following, beginning with the uppermost, or that immediately under the soil.

1. Sandstone.
2. Slate-clay.
3. Greenstone, with graphite.
4. Slate-clay.
5. Greenstone.
6. *Columnar glance-coal and graphite.*
7. Greenstone.
8. Flinty-slate.
9. Sandstone.

We shall now describe them in the above order.

1.—*Sandstone.*

This rock is principally composed of concretions of greyish-white quartz, with a few scales of mica, and these are rather loosely aggregated. In some parts of the bed, the sandstone is disposed in globular and spherical distinct concretions, resembling those we observe in beds of greenstone and other trap-rocks.

2.—*Slate-clay.*

Immediately below the sandstone is a bed of slate-clay, from ten to twelve feet thick. This clay, in some parts of the bed, appears passing into a mineral, which some mineralogists name flinty-slate; others, basaltic hornstone, or jasper, and which appears to have some relation to compact felspar.

3.—*Greenstone.*

The slate-clay rests upon a bed of greenstone, which is disposed in globular distinct concretions. It contains imbedded portions of graphite, which are often so intermixed, and impregnated with the greenstone, as to prove their cotemporaneous formation.

4.—*Slate-Clay.*

The bed of greenstone is succeeded by one of slate-clay, about twelve feet thick, which in some places passes into the jaspery or felspar rock.

5.—*Greenstone.*

Immediately under the slate-clay is another bed of greenstone, varying from three to ten inches in thickness.

6.—*Graphite and Glance-Coal.*

The bed of greenstone we have just described, rests on this the most remarkable bed of the whole mine. It is from three to six feet thick, and is composed of graphite and columnar glance-coal. The graphite or black-lead is either compact, scaly, or columnar; the glance-coal is disposed in columnar distinct concretions, which are arranged in rows like pillars of basalt. Both substances are mutually intermixed, the graphite being frequently imbedded in the coal, and the coal included in the graphite. In different parts of this highly curious bed, portions of greenstone are met with. These are sometimes pure, or they are intermixed with the coal or graphite, or with both; and these substances are so connected together, as to evince a simultaneous crystallization.

7.—*Greenstone.*

The bed of graphite and glance-coal rests upon a layer of greenstone.

8.—*Flinty-Slate.*

The greenstone rests on a bed from ten to fourteen feet thick of the hard rock already mentioned, and which has been referred to flinty-slate.

9. *Sandstone.*

The lowest bed of the series, and that immediately under the preceding, is a sandstone, agreeing with No. 1. in consistency, structure, and ingredients.

The graphite in this mine varies more in quality than that of Borrodale; and, on the whole, it is to be considered as of inferior value. But the quantity is so considerable, and the average quality so good, as to authorise more extensive workings in this district, and minute and more accurate surveys of other parts of Ayrshire, where it is known or suspected to exist.

III.—Black-Lead Mine of Glenstrathfarrar.

This lately opened mine of black-lead, which is about twenty-two miles from Beauley, in Inverness-shire, is situated in the very romantic and picturesque Glenstrathfarrar. The prevailing rock in the glen, as far up as we examined it, is *gneiss*, which is every where stratified, and varies in colour from red to grey and white. The strata range from north-east to south-west, dip to the east under various angles, and are frequently very tortuous in their direction. The gneiss is traversed by veins of granite, and also of quartz, and beds of these rocks are to be observed alternating with it. The most frequent imbedded mineral is precious garnet. *Mica-slate*, which in other parts of Scotland is so abundant, occurs here in comparatively small quantity, and is to be considered as subordinate to the gneiss. *Quartz-rock* is more frequent than the mica-slate, but like it occurs in beds subordinate to the gneiss. All the varieties of this rock contain scales of mica, and sometimes in such quantity, that they pass into mica-slate.

The rock in which the graphite is situated is gneiss, and immediately beside the workings, the strata run north-east and south-west, and dip under an angle of 80° to the west. The gneiss in some parts is very micaceous, and is intersected by small veins of red granite. The graphite is not in veins or in regular beds, but in irregular masses imbedded in the gneiss. The first mass is about three feet thick where broadest, and several yards in extent. It is not throughout pure graphite, but is much mixed with gneiss, and we observed not only apparent fragments of gneiss, but also the different ingredients of the rock, viz. felspar, quartz and mica, disseminated through it. Precious garnet, which occurs so often in the gneiss, is also very abundantly disseminated through the graphite, a circumstance which materially deteriorates it. The second mass is nine inches wide; and a third mass is about the same dimensions. Besides these masses, we observed others in different parts of the gneiss strata, and we were told that others of considerable magnitude had been discovered, even at the summit of the neighbouring mountains.

The graphite is scaly, and sometimes undulating curved foliated, and occasionally runs into compact. Some of the masses we saw were of good quality.

This mine was discovered by accident in the year 1816, and the proprietor, Fraser of Lovat, immediately determined on its being mined. The working is carried on by ten or twelve men, and is entirely at the day, the miners not having sunk more than a few yards from the surface. The quantity hitherto raised has been inconsiderable; last year, for instance, the quantity sent to the London market did not exceed five tons. This was sold at the rate of L. 93 per ton, thus affording a great profit to the proprietor, as the average expence of mining and transport did not exceed L. 13 a ton.

A road is now cutting from the mine to the high road, which, when finished, will enable the proprietor to work this valuable repository of black-lead in a more extensive manner than is done at present.

We have little doubt that graphite will be detected in Glenstrathfarrar, in much larger masses than those we have already described, and that ere long, if the mining is carried on with judgment and activity, this part of Scotland will afford a considerable supply of this mineral.

Art. XXVI.—*On the Temperature of Air and of Water in the Coal Mines of Great Britain, particularly in those which are of the greatest depth**. By Robert Bald, F.R.S.E. M.G.S. and M.W.S. Communicated by the Author.

The increase of temperature in coal mines, is a fact familiar to every person who has had occasion to frequent them. The instant a dip-pit is connected with a rise-pit by a mine, a strong circulation of air like wind commences. If the air at the surface is at the freezing point, it descends the dip or deepest pit, freezes all the water upon the sides of the pit, and even forms icicles upon the roof of the coal within the mine; but the same air, in its passage through the mines to the rise-pit, which is generally of less depth, has its temperature greatly increased, and issues from the pit mouth in the form of a dense misty

* This article is a brief abstract of a paper which was read before the Royal Society of Edinburgh, on the 5th April 1819.

cloud, formed by the condensation of the natural vapour of the mine in the freezing atmosphere.

The following Table presents at one view the temperature of air and water in the deepest coal mines in Great Britain.

Whitehaven Colliery.—County of Cumberland.

	Fahr.
Air at the surface,..	55°
A spring at the surface,..	49°
Water at the depth of 480 feet,..	60°
Air at same depth,..	63°
Air at the depth of 600 feet, ...	66°
Difference of temperature betwixt water at the surface, and at the depth of 480 feet,..	11°

Workington Colliery.—County of Cumberland.

Air at the surface,..	56°
A spring at the surface,..	48°
Water at the depth of 180 feet,..	50°
Water at the depth of 504 feet from the level of the ocean, and beneath the waters of the Irish Sea,........................	60°
Difference of temperature betwixt water at the surface and the depth of 504 feet,..	12°

Teem Colliery.—County of Durham.

Air at pit bottom, 444 feet deep, in a country a little elevated above the sea,..	68°
Water at the same depth,..	61°
Difference betwixt the average temperature of water at the surface 49°, and water at the depth of 444 feet,..........	12°

Percy Main Colliery.—County of Northumberland.

Air at the surface,..	42°
Water about 900 feet deeper than the level of the sea, and under the bed of the River Tyne,........................	68°
Air at the same depth,..	70°
At this depth Leslie's Hygrometer indicated dryness,..83°	
Difference betwixt the average temperature of water at the surface 49°, and of water 900 feet under the level of the sea, ...	19°

	Fahr.
Jarrow Colliery.—County of Durham.	
Air at surface,	49½°
Water at the depth of 882 feet from the surface,	68°
Air at same depth,	70°
Air at the pit bottom,	64°
Difference betwixt the average temperature of water at the surface 49°, and water at the depth of 882 feet,	19°

The engine pit of Jarrow is the deepest perpendicular shaft in Great Britain, being 900 feet to the foot of the pumps.

Killingworth Colliery.—County of Northumberland.	
Air at the surface,	48°
Air at the bottom of the pit, the depth being 790 feet,	51°
Air at the depth of 900 feet from the surface, after having traversed 1¼ mile from the bottom of the downcast pit,	70°
Water at the most distant forehead or mine, and at the great depth of 1200 feet from the surface,	74°
Air at the same depth,	77°
Difference betwixt the average temperature of water at the surface 49°, and water at the depth of 1200 feet,	25°
This mine is the deepest coal mine in Great Britain from the surface, although Jarrow is the deepest perpendicular shaft; in this mine the temperature of distilled water at the boiling point was	213°
Temperature of same water at the surface,	210½°

Prince's-end Pit, near Tipton, Staffordshire.	
Water at the bottom of the engine pit, above 400 feet deep,	47½°
Air in the mines,	60°

It has been found from experience, that the deeper we perforate the strata, they become drier, and in many instances no water is to be found, so that the roads through the mines require to be watered in order to prevent the horse-drivers from being annoyed by the dust; and there is reason to believe, that the high temperature of the air in Prince's-end pit, was occasioned by the decomposition of pyrites amongst the rubbish of the coal, which frequently produces actual and vehement combustion. The increase of temperature, as given in the preceding experiments, appears to have its origin in a constant natural internal heat in the physical constitution of the earth.

It has been asserted by those who have considered the temperature of mines, that the heat found there arises from the workmen, and from the lights and horses employed in the mines. These causes, however, cannot produce more than a degree or two of temperature, as the air is necessarily kept in constant circulation for the safety of the workmen.

Others have asserted, that the increased temperature arises from the decomposition of pyrites, which abounds in coal and the accompanying strata, and that this is the cause of the high temperature of hot springs. This opinion, however, does not seem to be well founded. Although in the very extensive coal mines of Great Britain, pyrites abounds in great quantities, yet in no instance was pyrites ever found *decomposed in situ*, although the coal abounds with water, and gives out carbonic acid gas and carburetted hydrogen, but never atmospheric air, and the pyrites only decomposes when exposed to the action of oxygen. Had pyrites been liable to decompose *in situ*, the greater part of the coal-fields in the world would have been destroyed by spontaneous ignition; but this spontaneous ignition only takes place in coal mines where the pyrites is thrown into the waste, and exposed to the action of atmospheric air, and the moisture of the strata. If pyrites is the cause of the high temperature of hot springs, these springs would vary continually, both in temperature and composition, according to the extent of surface exposed to the decomposing action.

The celebrated traveller M. Humboldt has stated, that the temperature of the silver mine of Valenciana in New Spain, is 11° above the mean temperature of Jamaica and Pondicherry; and that this temperature is not owing to the miners and their lights, but to "*local* and *geological* causes." He also remarks, that the health of the miners is greatly injured by working in a temperature which ranges from 71° to 80° Fahrenheit. Many of the miners in Great Britain, however, are daily exposed to a temperature within that range, namely, from 70° to 77°.

Edinburgh, *April* 1819.

Art. XXVII.—1. *Secondary Greenstone and Wacke not of Volcanic Origin.—2. Veins which connect Mineral Beds together, not confined to Trap-rocks.—3. Trap Veins (Whin-dikes) probably of cotemporaneous Formation with the trap-rocks which they traverse.* By Professor Jameson. Communicated by the Author.

I.—Secondary Greenstone and Wacke not volcanic.

Volcanists maintain, that *greenstone (whinstone)* is a subterranean lava, which has been projected, in a state of igneous fusion, from the interior of the earth, amongst previously existing strata; while the Neptunists are of opinion, that greenstone and all other trap-rocks have been formed at the same time, and in the same manner, as the strata with which they are associated. Hence, according to the one hypothesis, all rocks found in contact with greenstone are more or less altered by the heat which must have flowed from it whilst in a state of fusion, so that sandstone becomes highly indurated and clay is converted into jasper; but, on the other view, the greenstones are said to exhibit precisely the same general relations as are observable in sandstone, slate-clay, and other similar rocks, which are supposed by the Plutonists to have been formed by deposition from water.

Lothian Street Quarry, Edinburgh.

It frequently happens, that we have opportunities in this neighbourhood of trying the truth of these opinions by an appeal to facts. Very lately in an extensive quarry opened in Lothian Street, in the course of the building operations on the south-east side of that street, a fine section was made of the rocks of the coal-field, in which the appearances proved the fallacy of the volcanic hypothesis of the formation of secondary greenstone, but were favourable to the opinion of the Neptunists. We shall now give such a description of this quarry, as will enable our readers, not only to form a distinct conception of the various alternations and relations of the strata which were cut through, but also to judge how the facts bear on the two hypotheses. The quarry from A to B is about four yards deep. The strata dip to the east under angles varying from 15° to 20°, and are perfectly regular and parallel throughout their whole course. The beds and strata are of *greenstone*, *wacke*, *slate-clay*, and *quartzy sandstone*, which mutually pass into each other, and thus form a perfect whole, the series not being interrupted by any foreign beds or veins. The most important of these rocks is the Greenstone, which exhibits the following characters. Its colour is bluish-green, very imperfectly crystallized, with imbedded crystals of augite, so that it is sometimes porphyritic. It is traversed by small veins filled with calcareous spar, quartz, and heavy spar. Some varieties of it, from the earthy aspect of the mass, and its containing cotemporaneous angular and roundish portions of harder greenstone, appear passing into trap-tuff. There are two beds of this rock in the quarry, an *upper* and a *lower*. The *upper bed* is two feet and a half thick, and preserves the same thickness throughout the whole quarry, and is, in every respect, equally regular with the beds of sandstone and slate-clay. In some parts, the bed is more highly crystallized towards the middle than on the lower and upper sides. On the *lying* or under side, it passes into a very distinct and beautifully marked variety of greyish-green coloured Wacke, which is about five inches thick, *a*, Fig. 2. Plate III. This wacke gradually passes into a reddish-brown clay, about six inches thick, which, in its lower part, is slate-clay, *b*, Fig. 2.

On the hanging or upper side of this bed of greenstone, there is a bed of quartzy sandstone ten inches thick, *c*, Fig. 2., which in some parts has a splintery fracture, glistening vitreous lustre, and considerable translucency, and this is one of the varieties named *Indurated Sandstone* by the Plutonists. Interposed between this sandstone and the greenstone, there is a thin seam or layer of greenish-grey coloured slate-clay; over this bed of quartzy sandstone is a bed of greenish grey-coloured slate-clay, about nine inches thick, *d*, Fig. 2.; this has resting upon it a bed of quartzy sandstone, in many parts equally hard with that which is nearest to the greenstone. Over these are alternations of beds of slate-clay and quartzy sandstone, in which the sandstone has often the same highly crystallized character, as is observed in the bed nearest the greenstone. Such, then, are the appearances observable in the first or upper bed of greenstone, and the subjacent and superincumbent strata.

We shall next describe the second *or lower bed* of greenstone. It is about two feet thick, is perfectly parallel with the strata in every part of the section, and agrees in its imbedded minerals, veins and general aspect, with the greenstone of the upper bed. On the north-east side of the quarry this bed of greenstone terminates, and in this line of direction we have strata of slate-clay and sandstone, as represented in Fig. 3. Plate III., in which *a a* are the clay and sandstone. *Resting* immediately upon it there is a bed of pure quartzy sandstone, *e*, Fig. 2., more highly crystallized than that which occurs above the upper bed. It is two feet eight inches thick, but does not continue of the same thickness throughout. It contains imbedded cotemporaneous masses of slate-clay and clayey marl, and particles of galena. The slate and marl are not in the least affected by the highly crystallized sandstone in which they are contained. The clay is equally soft with the varieties found at a distance from the greenstone and in softer sandstones. Above this sandstone rests a bed of slate-clay, *f*, Fig. 2., not in the least affected by the highly crystallized sandstone. Resting on this bed are two beds of quartzy sandstone, *g* and *h*, Fig. 2., and one of red and green clay, *i*, Fig. 2., which meet with the layers already described as occurring below the first or upper bed of greenstone. This sandstone in the slate-clay is often as highly crystallized as that resting immediately upon the greenstone. The greenstone rests on alternations of beds of quartzy sandstone and slate-clay, *k*, Fig. 2., which continue to the bottom of the quarry.

In this quarry the most interesting geognostical facts are the following:

1. The perfect parallelism of the beds of greenstone, slate-clay, wacke, and sandstone.

2. Beds of pure quartzy sandstone, of the same nature with that resting immediately on the greenstone, alternating with slate-clay.

3. Layers of slate-clay between the most highly crystallized sandstone and the greenstone.

4. Transitions from greenstone, through wacke and slate-clay, into sandstone.

5. The earthy character of the greenstone.

But in what manner are these facts connected with the Volcanic and Neptunian hypotheses?

The parallelism of the greenstone-beds with the thin layers of slate-clay resting upon and lying immediately under them, is not easily reconcileable with the volcanic hypothesis; because, had the greenstone been forced, in the state of lava, amongst the slate-clay, it would have presented a very irregular intermixture at the line of junction, and not the perfectly regular meeting every where visible in this section. But perfect parallelism is what we would expect according to the Neptunian view. The alternation of beds of highly crystallized sandstone (highly indurated sandstone of the Plutonists) with slate-clay, and the circumstance of masses of unaltered slate-clay and marl occurring in the most highly crystallized sandstone, immediately over the greenstone, prove that this crystallization (hardening) is not produced by heat flowing from greenstone in a state of fusion, otherwise the slate-clay ought also to have been melted. *Lastly*, The transitions from greenstone into wacke, wacke into clay, clay into sandstone, prove that the same agent must have presided at the formation of these different rocks,—an explanation irreconcileable with the Volcanic, but in perfect unison with the Neptunian hypothesis.

Section of Alternations of Wacke, Bituminous Shale, &c. at the Calton Hill, Edinburgh.

There is another fine display of stratification, highly illustrative of the mode of formation of greenstone and wacke, at present exposed on the north-east side of the grand road which leads across the Calton Hill.

The following description contains an enumeration of the principal features of this fine section.

The Calton Hill, in a general view, may be considered as a vast bed of porphyry rising above the surrounding rocks of the coal formation. This bed dips towards the east under an angle of 20°, and the direction is north and south.

The rocks we are now to describe, rest on the lowest visible portion of this bed of porphyry, and have the same easterly dip and angle of inclination with the porphyry on which they repose.

1. *Bituminous Shale.*

The first or lowest bed of the section, that which appears to rest immediately on the porphyry, is bituminous shale, about eight feet thick.

2. *Wacke.*

Immediately above the shale is a bed of greyish-green coloured wacke, upwards of twenty feet thick.

3. *Bituminous Shale and Sandstone.*

Resting upon the wacke is a bed of bituminous shale about five feet and a half thick. In the shale there are beds of compact sandstone, one of these nearly a foot thick, and also thin layers of clay ironstone.

4. *Wacke.*

The next bed, which is about twenty-five feet thick, is greenish-grey coloured wacke, disposed in globular and angular concretions, in which the surfaces have a purplish colour. It is traversed by numerous very thin veins of calcareous spar.

5. *Bituminous Shale and Ironstone.*

This bed, which rests on the preceding, is about two feet and a half thick, and consists of bituminous shale, with thin beds of clay ironstone.

6. *Wacke.*

This bed of wacke, which rests on the preceding, is about eight feet thick. It is to be observed passing into bituminous shale.

7. *Bituminous Shale and Ironstone.*

This bed, which immediately follows the preceding, is bituminous shale, with subordinate beds of clay ironstone, and is about five and a half feet thick.

8. *Wacke.*

This is one of the most considerable beds in the section, being about thirty-four feet thick. It is every where traversed by numerous veins of calcareous spar.

9. *Bituminous Shale.*

The thickness of this bed is about ten feet, and, like the other beds of this mineral, it contains layers of clay-ironstone.

10. *Wacke.*

The bituminous shale is again succeeded by a bed of wacke, traversed by numerous small veins of calcareous spar.

11. *Bituminous Shale.*

The lower side of the preceding bed of wacke gradually passes into bituminous shale; on the upper side also a similar gradation is to be observed. The wacke, as it approaches the shale, becomes slaty, and gradually exchanges the green colour for the brownish-black tint of the bituminous shale. The bed is about three feet and a half thick.

12. *Wacke.*

This bed is about eight feet thick.

13. *Bituminous Shale.*

The shale in this bed passes into wacke.

14. *Wacke.*

This bed appears to be from fifteen to twenty feet thick.

Several other alternations of wacke and bituminous shale occur still more to the eastward, when they are succeeded by beds of grey-coloured sandstone, which have the same easterly dip with all the other strata of the section.

In this section, then, the lowest bed is porphyry, and the highest sandstone.

These different rocks, viz. the sandstone, bituminous shale, clay-ironstone, wacke, and porphyry, are members of the same formation, and numerous transitions are to be observed from the one into the other. Thus the porphyry in different parts of the Caltonhill, passes into greenstone, the greenstone into wacke, the wacke, in the section just described, into bituminous shale, the shale on the one hand into sandstone, and on the other into clay-ironstone. These facts prove the simultaneous formation of these rocks, and thus shew that if wacke and greenstone are true volcanic rocks, the sandstones, shales, and ironstones with which they are associated, must have been formed in the same manner;—a position which cannot be maintained in conformity with any of the present systems of volcanism.

II.—Veins which connect Mineral Beds together, not confined to Trap-rocks.

In countries where trap-rocks abound, we sometimes observe in two beds of greenstone which are separated from each other by strata of sandstone, slate-clay, limestone, or other rocks, that they are connected by means of veins that shoot from the floor of one bed into the roof of the other. The Fig. 4. Plate III., represents such an appearance; *a a*, the beds of greenstone, *c c*, strata of limestone, and *x* the connecting vein of greenstone. This arrangement is said to be peculiar to rocks which have been projected from below in a melted form, and hence Volcanists, I presume, would confine it to trap-rocks, as all of these are with them lavas. But this neighbourhood, so rich in illustrations of many contested points in geology, affords us examples of rocks, not of the trap series, with communicating veins. Salisbury Craigs, one of our most interesting hills, is a mass of sandstone with subordinate beds of greenstone, and occasional layers of limestone, slate-clay, and clay-ironstone. On the south-east angle of the hill, in one of the quarries at present working, the following arrangement is to be observed. Greenstone, the uppermost stratum; immediately below it a bed of coarse siliceous limestone; under the limestone a bed of greenish-grey slate-clay; and below the clay, strata of sandstone. Several veins of siliceous limestone shoot from the floor or under side of the bed across the slate-clay, and form a continuous mass with the floor or upper side of the sandstone; and veins shoot from the roof of the bed of sandstone across the slate-clay into the floor of the siliceous limestone, and form with it a continuous mass. In other parts of the same quarry, branches or veins are observed shooting from the roof of the sandstone, and gradually terminating in the bed of slate-clay. These appearances are represented by the plan, Fig. 5., *a*, greenstone; *b*, siliceous limestone; *c*, slate-clay; *d*, sandstone; *e*, veins shooting from limestone across the slate-clay into the sandstone; *f*, veins shooting from sandstone across the slate-clay into the limestone; and *g*, veins shooting from the sandstone, and terminating in the slate-clay.

I have observed connecting veins of the same description in layers of fibrous gypsum contained in the compact kinds. This appearance is represented in Fig. 6. Plate III. where *a* is a mass of compact gypsum; *b b* layers of fibrous gypsum included in it, and *c c* communicating veins. In an extensive limestone quarry about a mile to the eastward of Burntisland, there is a fine example of a communicating vein between two beds of a curious kind of amygdaloid. The beds are separated from each other by numerous strata and beds of bituminous shale, slate-clay, clay-ironstone, sandstone, and limestone, but in one place a vein of amygdaloid shoots across all these rocks, from the lower to the upper bed of amygdaloid.

How are we to explain the formation of such veins? Volcanists say, that communicating veins are proofs of the igneous origin of the rocks in which they occur, and that they are formed by the spouting of the fluid lava through cracks in the rock, at the time when the lower bed was forming, and before the upper one was formed. But this hypothesis will not explain the communicating veins of limestone, sandstone and gypsum, because these, on the volcanic system, are not lavas. We are inclined to view them as illustrations of the simultaneous crystallization of rocks of the same formation.

III. Trap-Veins (Whin-Dikes) probably of Cotemporaneous Formation with the Trap-Rocks which they traverse.

Veins are tabular masses that in general traverse mineral strata and beds of different kinds. According to the Volcanic or Plutonic hypothesis, they were originally open rents or fissures, wide below, but terminating above in the form of a wedge, which were afterwards filled from below with melted mineral matter, projected from the interior of the earth. The Neptunists again maintain, that these fissures and rents were wide above, but terminated below, and were filled from above with their mineral contents. The Plutonists adduce as proofs of their opinion, veins shut above, and widening below, as sometimes happen with metalliferous veins, and also with those formed of mountain rocks, such as granite or trap; while the Neptunists offer as illustrations of the truth of their hypothesis, numerous instances of veins, both metalliferous and saxigenous, in which the crop or outgoing is wide, but the lower part narrow, and terminating in a wedge, or in numerous small branches.

Both statements are correct, and, therefore, the two opinions appear to be plausible. But there is a fact which cannot be reconciled with either of the hypotheses, and which forces us to have recourse to some other mode of explaining the formation of these veins. The fact we allude to is the occurrence of veins that terminate both above and below in the rock which they traverse, in short, are completely inclosed in it. Fig. 7. Plate III., represents the three kinds of veins; *a*, vein open at top; *b*, vein shut above, and *c*, vein terminations in the rock. Such a vein, it is evident, could not have been filled from above, nor is it possible to conceive that it could have been filled from below. We are therefore led to the conjecture, "*that such veins must have been formed at the same time with the rock in which they are contained.*" This view receives considerable support by a careful attention to the appearances presented by the distinct concretions into which many trap-rocks are naturally divided. These concretions, at their line of junction with the bounding trap-rock, exhibit the same phenomena as occur at the meeting of the sides and walls of trap-veins in trap: and they differ from veins only in shape; the concretions being short and massive, whereas the veins are long and tabular. A vein of trap (or a dike of trap) we consider as merely a series of concretions, arranged in a tabular form. But, it will be inquired how, on this principle, we can explain the crossing of trap-veins? This arrangement we consider as an effect of crystallization, and of precisely the same nature as the crossings observed in crystals, or the intersections in tabular concretions. The crossings in crystals require no illustration, but those of concretions may be shortly described. In sections of trap-rocks, as of greenstone, sometimes the cliff is naturally divided into tabular concretions, that extend from the top to the bottom of it. These concretions occasionally vary in their direction, some being horizontal, and others vertical; but the remarkable fact, and that which is highly illustrative of our present view, is this,—that the same table or tabular concretion will continue for some feet or yards parallel with the bounding concretions, and then suddenly turn and intersect these for several yards or fathoms, and then terminate, as *a a*, Fig. 8. Plate III. Now, this concretion in one part of its course is parallel with the others, and terminates amongst them; in another part of its course it intersects these same concretions, and then it ends. It is evident, that if this concretion had continued parallel with the others throughout its whole extent, we would not hesitate to consider it as of cotemporaneous formation with them. If this inference be admitted, and we do not see on what ground it can be refused, it is evident, that, if the intersecting portion of the concretion is a continuation of that parallel with the other, both must be considered as having crystallized at the same time, and as a simultaneous formation with the whole rock in which it is contained. But the tabular concretions intersected by the one part of the concretion, are equivalent to veins or dikes, because they are tabular masses intersected by another tabular mass; and as all these concretions are of simultaneous formation, it follows, that the crossing concretion and that which is crossed, which are equivalent to two veins, of which the one crosses the other, have been formed at the same time.

Edinburgh, *April* 1819.

Art. XXVIII.—*Notice respecting a Singular Optical Property of Tabasheer.* By David Brewster, LL.D. F.R.S. Lond. and Edin. Communicated by the Author.

The substance called *Tabasheer**, has been long known in eastern countries, and formed an important article in the Materia Medica of the Arabian Physicians. In the Gentoo language it is called Vedro-Paloo, or *Bamboo milk;* in the Malabar, Mungel Upoo, or *Salt of Bamboo*; and in the Warriar, Vedroo Carpooram, or *Bamboo Camphor.* It is found in the joints of the female bamboo, sometimes in a fluid state like milk, sometimes with the consistency of honey, but generally in the form of a hard concretion. Some specimens of it are transparent, and resemble very much small fragments of the artificial pastes made in imitation of opal; others are exactly like chalk; while a third kind is of an intermediate character, and has a slight degree of translucency.

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* Pliny clearly describes Tabasheer under the name of Sugar. The word is derived from the Persian *Scher*, or the Sanscrit *Kschiram*, signifying milk. See Humboldt *on the Natural Family of the Grasses.*

The first person that examined the properties of this substance was Mr Macie* (now Mr Smithson), who analysed a portion of the Tabasheer from Hyderabad, which Dr Russell † had the preceding year presented to the Royal Society. "From its indestructibility by fire;—its total resistance to acids;—its uniting by fusion with alkalis in certain proportions into a white opaque mass, in others into a transparent permanent glass, and its being again separable from these compounds entirely unchanged by acids," he considers it "as perfectly identical with *common siliceous earth.*"

In the year 1804, Messrs Humboldt and Bonpland brought with them from America some specimens of Tabasheer, called *Guaduas butter* by the Creoles, taken from the bamboos which grow to the west of Pinchincha in the Cordilleras of the Andes ‡. These specimens were analysed in 1805, by Messrs Fourcroy and Vauquelin §, who found them to be different from the Tabasheers of Asia. Instead of being wholly composed of silex, they contained only 70 per cent. of this earth, and 30 per cent. of potash, lime and water.

The Tabasheer which I employed in my experiments, was sent from Nagpore by Dr Moore to Dr Alexander Kennedy, who was so kind as to favour me with a considerable portion of it. It had the same general chemical characters as the Tabasheer from Hyderabad, which was used by Mr Smithson, the same specific gravity nearly, and the same external appearance; so that I have no hesitation in considering it as also composed principally of silex.

When the semi-transparent specimens of this substance are immersed in water, they imbibe it with great rapidity, emitting numerous bubbles of air. The transparency increases whenever the air has been discharged, and after a few minutes the water pervades, and renders transparent the whole mass.

If a small portion of water, on the contrary, is laid upon the Tabasheer when dry, instead of adding to its transparency as might have been expected, it actually renders it as opaque and white as chalk; and, from the same cause, the Tabasheer which has been saturated with water becomes opaque, as the water eva-

* See *Philosophical Transactions*, 1791, p. 368.

† See *Philosophical Transactions*, 1790, p. 273.

‡ Humboldt's *Personal Narrative*, vol. i. Introd. p. xiii. Note.

§ *Memoires de l'Institut*, tom. vi. p. 382.

porates; reaches its maximum degree of opacity; and recovers its semi-transparency when perfectly dry.

The increase of transparency from the absorption of water, is an effect easily explained, and is one with which mineralogists have been long familiar in the phenomena of hydrophanous opal; but the production of opacity, by the absorption of a smaller portion of the same fluid which produces transparency, is a fact entirely new and not easily explicable upon known principles.

After having determined that the white opacity was not the result of any chemical change, and must, therefore, have resulted from optical causes, I attempted to frame some hypothetical explanation of the phenomenon. In tracing the progress of a ray of light through a porous body, having a small quantity of water in its pores, and through another which had these pores filled with water, I saw that opacity could be produced in the first case only upon the supposition that the Tabasheer had a refractive power considerably lower than water. Improbable as this supposition was, I immediately formed one of the semi-transparent specimens into a prism, and found, to my great surprise, that the refractive power of Tabasheer was not only lower than water, but so much lower, as to be almost intermediate between water and the gases. I repeated this experiment with various specimens from Nagpore, and also upon one from Hyderabad, with which I was favoured by Dr Hope, and which, as it formed part of the parcel of which Dr Russell had presented a portion to the Royal Society of London, was the same as that which was analysed by Mr Smithson*.

The following were the results.

		Index of Refraction.
Air,...		1.0000+
Tabasheer from Hyderabad, yellowish by reflected light,		1.1115
Tabasheer from Nagpore,........	Bluish by reflected light,	1.1454
Tabasheer from ditto, harder,...		1.1503
Tabasheer from ditto,..............		1.1535
Tabasheer from ditto, very hard,		1.1825
Water,...		1.3358

* We trust that some of the Members of the Institute of France will be induced to measure the refractive power of the Tabasheer brought from Quito by M. Hum-

The physical properties of Tabasheer are not less singular than its optical qualities, and indicate a structure of a very remarkable kind.

A detailed account of my experiments on this subject, has been transmitted to the Royal Society of London, and will probably appear in the Second Part of the Philosophical Transactions for 1819.

Edinburgh, *May* 1. 1819.

Art. XXIX.—*Account of the Expedition to Baffin's Bay, under Captain Ross and Lieutenant Parry.* Drawn up from Captain Ross's account of the Voyage, and other sources of information.

In the year 1815, and the two succeeding years, numerous masses of ice were seen floating in the Atlantic; and in 1817, it was reported by vessels from the arctic regions, that a very considerable extent of ice had disappeared between Greenland and Spitzbergen. These unusual appearances directed the attention of the learned to the almost forgotten subject of a passage across the Pole. An ingenious and intelligent writer published several dissertations in the Quarterly Review, for the purpose of demonstrating the practicability of a passage across the polar seas. The breaking up of the ice on the east coast of Greenland held out to him the prospect of arriving directly at the Pole through an open sea; while the want of precision in Baffin's narration of his voyage, combined with physical and hydrographical considerations, induced him to expunge the Bay of Baffin from our maps; and to predict the existence of a passage to Behring's Straits by the northern extremity of the American continent.

Captain Scoresby, who had distinguished himself in no fewer than *sixteen* voyages to the Arctic Regions, had maintained,

boldt, if any of it is still in existence. It will be interesting to know if the 30 per cent. of potash and lime produces any perceptible effect upon the refractive power and other properties of the Tabasheer. I have sent a quantity of the Nagpore Tabasheer to M. Berzelius, with the hope that he may have leisure to submit it to an accurate examination. As this distinguished chemist is now in Paris, he would do a service to science by comparing directly the Asiatic and American Tabasheers.

that the Pole, guarded by a frozen barrier, could only be approached by the alternate use of boats, and of sledges drawn by dogs; while his learned opponent, on the authority of every iceberg that travelled to the south, insisted that a change of temperature had effected an opening through the frozen ridge; and that, while we accomplished the great object of a passage across the Pole, we might execute, also, the more romantic enterprize of releasing the lost colony of Eastern Greenland, whom the accumulated ice was supposed to have for ever separated from the rest of the world.

The public took a deep interest in speculations like these, where the dry details of hydrography were enlivened by discussions and schemes almost bordering upon romance; and though they were assailed by poetical theories of climate, and the usual allowance or malevolent predictions, yet the general expectation of advancing the interests of natural science, and of practical navigation, would not permit itself to be damped; and there were a few, more sanguine than the rest, who expected that the British flag would be fixed upon the Pole of the world, whether it was deposited from a sledge and four, or more formally transplanted from the quarter-deck of a British vessel.

With the greatest liberality and love of science, the British Government equipped four vessels, viz. the Isabella of 385 tons, and the Alexander of 252½ tons, under the command of Captain Ross and Lieutenant Parry, for the purpose of exploring the passage through Baffin's Bay; and the Dorothea of 382 tons, and the Trent of 249, under the command of Captain Buchan and Lieutenant Franklin, with the view of penetrating directly into the Polar regions, by the way of Spitzbergen. These vessels were adapted in the most scientific manner for the perils which they had to encounter, and every precaution was taken for insuring the health and comfort of their respective crews, and for accomplishing in the most satisfactory manner the general object of the expedition.

The expedition under Captain Ross left Deptford on the 18th April 1818. It reached Lerwick in Shetland on the 30th, and on the 1st of June it entered Davis' Straits, after encountering an iceberg about 40 feet high and 1000 feet long. On the 14th of June it reached Whale Islands, in latitude 63° 54′, and longitude 53° 30′; and, on the 17th, a landing was effected on Waygat or Hare Island, where they continued two days making observations in a fixed observatory. After leaving Waygat Island on the 20th, Captain Ross began to experience the difficulties and perils of navigating an icy sea. Followed by thirty-nine sail of Greenland whalers, the Isabella and the Alexander were conducted with great skill and perseverance through narrow and intricate channels, sometimes closed in by floes of ice, sometimes exposed to the impulse of these driving masses, and at other times lifted out of the water by their mutual approach. By warping, towing, and tracking the vessels, which was sometimes performed by the whole ship's company marching to music, they reached the latitude of 75° 50′ where new perils awaited them. The wind having increased to a gale on the 7th of August, the floes of ice closed in upon them on all sides. The pressure upon the vessels continuing to increase, it became a trial of strength between the wood and the ice. Every support threatened to give way. The beams in the hold began to bend, and the iron tanks settled together. At this critical moment, the Isabella rose several feet, and the ice, which was more than six feet thick, broke against her sides, curling back upon itself. The great stress now fell upon her bow, and after being a second time lifted up, she was carried with great violence against the Alexander. The ice anchors and cables broke one after another; and the sterns of the two ships came so violently into contact, as to crush to pieces a boat that could not be removed in time. By this tremendous collision, the anchors were broken, and the result might have proved fatal to both vessels, had not the ice exhausted its fury, and by the separation of the two contending fields permitted the Isabella to pass the Alexander with comparatively little damage.

According to Sir Charles Giesecké, the Island of Tessiursak, in latitude 74° 15′, and about eighty miles north of Uppernavic, was the most northern inhabited part of Greenland. The line of the coast, he was no longer able to trace beyond 72° 30′; but he had carefully examined the numerous islands by which it is fringed, and which are so crowded, that a ship at sea cannot fail to consider them as a part of the continent. Sir Charles had penetrated as far as Nullok, Saitok, and Ujordlersoak, to the latitude of 76° 30′, but had found no inhabitants in any of the twenty-three islands to the north of Tessiursak. Between the parallels of 76° and 77°, however, Captain Ross discovered a tribe of Esquimaux, who reside principally a few miles to the north of Cape Dudley Digges, and who, during the summer months, spread themselves about thirty or forty miles to the north and south. A few of the southern stragglers appeared on the 8th August, in latitude 75° 55′, and longitude 65° 37′, and were recognised by a general shout, which they set up for the purpose of frightening away the ships, whom they regarded as animals sent from the sun and moon to destroy them. They rode in sledges, drawn by dogs, and when their shout was returned from the ships, they wheeled round, and drove off with great velocity to their habitations. In order to induce them to approach, Captain Ross erected a pole, on which he fixed a flag, and a bag, containing presents, and then sailed to a distance. The natives, however, did not reappear, till the 10th of August, when eight sledges were seen advancing by a circuitous route. The natives halted about a mile from the Isabella, ascended a small iceberg, and were induced to approach, when they observed John Saccheuse, a southern Esquimaux, who accompanied the expedition, advancing from the ship, with a white flag and presents. When both parties had arrived as near to each other as a chasm in the ice would permit, Saccheuse soon discovered that they spoke the Humock dialect, which prevails in the Womens Islands, and which he had fortunately learned, when a child. By this means he was enabled to remove the alarm which the sight of the ships had at first occasioned, and to prevail upon them to go on board the Isabella. The scenes which were exhibited at this and subsequent interviews, though extremely amusing to those who witnessed them, do not present us with much new information respecting the inhabitants of these forlorn regions. The dress and the manners of the Esquimaux, their sledges drawn by dogs, their domestic arrangements, their superstitions, and their methods of procuring their food, have been all described with such accuracy by Sir Charles Giesecké, who resided eight years in their country, that it is not easy to gather any new information from the descriptions of more hurried visitors. There are some points, however, in the narrative of Captain Ross, and

Captain Sabine, to which we cannot fail to attach a very high degree of interest. Although the canoe is in universal use among the southern Greenlanders, yet this simple apparatus so easily constructed, and apparently so necessary to the very existence of tribes who are clothed and fed by the produce of the sea, appears to be entirely unknown to this remote people. They have no word for it in their language; and though accustomed to see their waves navigated by icebergs, yet they are said to have considered the two ships of discovery, as living animals swimming upon the surface of the deep. This utter ignorance of the art of navigation, and of every other people but themselves, will appear the more remarkable, when we consider, that the islands of Nullok and Ujordlersoak, which were examined by Sir Charles Giesecké, and are known to the southern Greenlanders, cannot be distant more than thirty miles from the spot where Captain Ross discovered the new Esquimaux*. In the manuscript map of Sir Charles, in the possession of Thomas Allan, Esq. and which we have now before us, the southern side of Nullok is placed in 76° of north latitude, and he has laid down seven islands to the north of Nullok, one of which reaches as high as 76° 30′. Now, the spot where Captain Ross first observed the inhabitants, had little more than 76° of north latitude, and it is not likely that Sir Charles Giesecké could have erred more than half a degree in his latitude.

The existence of meteoric iron in the mountains of this desolate region, appears to have been distinctly ascertained by Captain Ross. The knives of the Esquimaux, one of which we have in our possession, consist of one or more pieces of flattened iron, inserted in a groove, made in a piece of bone. This iron was at first supposed to have been obtained from nails or iron hoops accidentally driven on their shores; but it appeared from a more minute investigation, that it had been knocked by a stone from two large masses lying on a hill near the shore, called Sowallick, derived no doubt from *sowic*, a word which signifies iron. One of these pieces is said to be altogether iron, and about two feet in diameter; while the other was described as a hard and dark rock, from which small pieces of iron were obtained by breaking it.

* From this and many other considerations, we cannot permit ourselves to believe that the canoe is unknown to this tribe.

The iron of which these knives are made, was examined by Dr Wollaston, who found it to contain from *three* to *four* per cent. of nickel; and who remarks, "that it appears to differ in no respect from those masses of which so many have now been found on various parts of the surface of the earth; and which, in some few instances from tradition, and in all, from the analysis, appear to be of meteoric origin."

On the 16th of August, Captain Ross left the Prince Regent's Bay, and after rounding Cape York, he continued his course along the land, among numerous bergs, and pieces of loose ice. The snow on the face of the cliffs presented an appearance of a very singular kind, and appeared to have the colour of the deepest crimson. The colouring-matter seemed to have penetrated in some places to the depth of ten or twelve feet, and the snow had the appearance of having been a long time in that state. These cliffs extended about eight miles, and were denominated the Crimson Cliffs. Dr Wollaston, who examined the colouring-matter of the crimson snow, conceives it to be of vegetable origin. "The red matter itself," he observes, "consists of minute globules, from $\frac{1}{1000}$ to $\frac{1}{3000}$ of an inch in diameter. They appear to be subdivided internally, into about eight or ten cells. The colour seems to belong to the contents of the globule, and not to its coat. The contents, which are of an oily nature, are not soluble in water, but they may be dissolved in rectified spirits of wine."

On the 18th of August, to the north of Cape Dudley Digges, several huts were plainly distinguished, and were supposed to be Petowack, the residence of the Chief of the Esquimaux, who had been obscurely alluded to in the conversations with the natives. Wolstenholm Sound, which agreed precisely with Baffin's description of it, was now in sight. It seemed to be about eighteen or twenty leagues in depth, and was completely blocked up with ice. On the same day Whale Sound was discovered; and Carey's Islands, which appeared to be about twelve leagues from the coast, were distinctly seen.

Captain Ross now sailed across the bay, and in the passage of the ships to the opposite shore, the officers, both of the Isabella and the Alexander, were satisfied that they saw the land distinctly round the top of the Bay. Smith's Sound, the only one which existed in this part of the bay, was completely shut up with ice, so that no farther hopes were entertained of a north-west passage in this direction.

The ships of discovery had now reached the latitude of 76° 55′, and longitude, 74° 56′ 48″ west, and began to descend the western coast of Baffin's Bay. Jones' Sound was seen on the 21st, completely blocked up with ice, and on the 23d, a piece of fir wood was picked up with nails in it, and bearing the marks of the plane and adze. On the 31st the expedition entered Lancaster's Sound. At a little before four o'clock A. M. the land was seen at the bottom of the inlet, by the officers of the watch, but before Captain Ross got upon deck, a space of about seven degrees of the compass was obscured by the fog. This land was a high ridge of mountains extending directly across the bottom of the inlet. At twelve o'clock, Mr Beverly, who went up to the crow's nest, reported that he had seen the land across the bay, except for a very short space; but even this uncertainty was removed about three o'clock, when Captain Ross went on deck, and at the distance of about eight leagues, *distinctly saw the land round the bottom of the bay*, forming a connected *chain of mountains with those which extended along the north and south sides.* Captain Ross also saw a *continuity of ice, at the distance of seven miles, extending from one side of the bay to the other.*

The testimony of Captain Ross thus distinctly given, has been called in question, in an indirect manner, by Captain Sabine, who accompanied the expedition; and who still holds out expectations of a north-west passage through one or other of the Seven Sounds in Baffin's Bay *. We have no hesitation in

* When speaking of the inlets or sounds discovered by Baffin, Captain Sabine says, "It is partly on these inlets that the hopes of persons who have thought since then on the probability of a passage, have been fixed. It has been expected, that one or more will be found to communicate with the northern ocean. They have remained unexplored, and still remain so. There are altogether seven sounds, of which five only are interesting, from being on the northern and western coasts. Of these, the first is Wolstenholm Sound, the entrance of which we passed at a few miles distance, sufficiently near to identify it, by "the island in the midst, which maketh two entrances." Of Whale Sound, we could just discern the opening in the coast, being thirty or forty miles distant from us. Of Smith's Sound, "the greatest and longest in all this bay, and which runneth to the north of 78°," we can say nothing, as our extreme north was in 76° 53′.

admitting, that the land round the bottom of Lancaster Sound was not seen by Captain Sabine, or any of the officers of the Isabella and the Alexander, beside Captain Ross; but this is no evidence at all against the continuity of the land, unless these gentlemen assure us, that they were upon deck, looking out for the land, during the ten minutes when the fog cleared away, and enabled Captain Ross to trace the outline of the hills round the bottom of the bay.

The variation of the needle in Lancaster Sound, as observed on board the Isabella, was no less than 114°; and it is deeply to be regretted, that Captain Ross could find here no harbour, where the variation and the dip of the needle might have been accurately ascertained, out of the reach of the ship's attraction.

As Captain Ross was required, by his instructions, to look for the north-east point of America, or the North-West passage, (as he understood this to mean,) about the 72d degree of latitude, he did not allow himself to be detained by any minor objects, in so high a latitude as Lancaster Sound, and therefore made the best of his way to the south. On the 11th of September, when about seven leagues to the eastward of the island called Agnes's Monument, they fell in with an enormous iceberg, about 4169 yards, or nearly $2\frac{1}{2}$ miles long, 3869 yards broad, 51 feet high, and aground in 61 fathoms of water, so that its real altitude must have been 417 feet. After ascending this iceberg, for the purpose of measuring the dip, and the variation, the party were received on its flat summit, by a white bear. They immediately advanced to attack it, but though at first it shewed some disposition to stand on the defensive, it made for

We were near the entrance of Jones' Sound, but not so near as Baffin, who sent his boat on shore. We had thick weather: the sound was full of ice, and not then accessible. The last is Lancaster's Sound, which Baffin merely opened, but we sailed into it for about thirty miles. It is needless to enter into a detail here, of the many encouraging coincidences which awaited us in this the only one of Baffin's Sounds into which we entered; the great depth of water, the sudden increase in its temperature, the absence of ice, the direction of the swell, the width of the shores apart, (exceeding that of Behring's Straits,) and the different character of the country on the north and south sides, especially in the latter, appearing to be wooded. This magnificent inlet, will no doubt be fully explored by the expedition now fitting; and those who are so employed, will have the privilege of being the first, whose curiosity will be gratified in following where it may lead, or in putting its termination, should there prove one, beyond a question."—*Quarterly Journal*, No. xiii. p. 93.

the other side of the iceberg, and threw itself into the sea, over the edge of a precipice fifty feet high.

During the rest of September, the ships of discovery were employed in coasting along the western shores of Baffin's Bay. On the 19th of September, they reached Cape Walsingham, and on the 1st of October, they were off the Earl of Warwick's Foreland, where Cumberland Strait commences, with a breadth of between thirty and forty miles. In the morning, the tide was observed to carry the ships to the westward, and in the afternoon, to the south-east, at the rate of two miles an hour. This strong current at the entrance of the strait, naturally impressed Captain Ross with the belief, that there was a much better chance of a passage here, than in any other part of Baffin's Bay; but the season was now far advanced, and as his instructions to quit the ice "by the 1st of October, at the latest," were of the most peremptory nature, he had no alternative but to leave the examination of this inlet for another expedition. He accordingly made for Cape Farewell, which he passed on the 9th of October, anchored in Brassa Sound in Shetland on the 30th, and arrived in Grimsby Roads, on the 14th November, without the loss of a single man.

The circumnavigation of Baffin's Bay, as performed by Captain Ross, has no doubt added greatly to our geographical knowledge of the Arctic regions; but we cannot allow ourselves to agree with him in thinking, that it has "set at rest for ever the question of a North-West passage in that direction." There can be no doubt that Captain Ross saw, or thought he saw, land apparently continuous from Disco Bay, round to Cumberland Straits. This apparent continuity in the coast, however, is by no means incompatible with the existence of winding inlets of sufficient magnitude, to form a communication between Baffin's Bay and the Polar Sea.

In the manuscript map of Sir Charles Giesecké, which we have already mentioned, and which is projected on a scale of *one inch and a half* to a degree of latitude, the eastern coast of Greenland is fringed with so many islands, that we have no hesitation in saying, that Captain Ross never saw the coast from the latitude of 69° to that of 76° 30′, the most northern part of the map. This coast indeed, was not traced by Sir Charles Giesecké higher than the latitude of 72° 30′, although he examined minutely the geological structure and mineralogical productions of all the various islands by which it is guarded. We conceive it, therefore, thoroughly established, that the land laid down in Captain Ross's chart, is formed by the western sides of the same islands; and though our evidence for this reaches no higher than the latitude of 76° 30′, yet we think there is reason to conclude, that the new tribe of Esquimaux were the inhabitants of an island, and that the rest of the coast of Baffin's Bay may have been bounded by islands equally large and numerous as those upon its eastern shores *.

But though the opposite shores of Baffin's Bay are probably formed of archipelagos of islands, like the coasts of Norway and Corea, yet we do not think that there is any probability of a passage being discovered to the north of Cumberland Straits. Another expedition to the same quarter, fitted out in a similar manner, could do little more than Captain Ross has accomplished; and if our Government is desirous of obtaining more minute information respecting the Arctic regions, they must send small vessels, with officers and men of science on board, who will have the resolution of wintering, as Sir Charles Giesecké did, among the inhabitants of these desolate regions.

We must reserve for another occasion, a notice of the scientific results of the Arctic Expedition. With the exception of a few good measures of the dip and the variation of the needle, taken upon ice-bergs, science has received few additions from an enterprise, otherwise well planned, and judiciously executed. The cause of this is too obvious to require explanation; and it is a mystery yet to be unravelled, and a stain yet to be removed from the scientific character of Britain, in the eyes of foreign nations, that an expedition should have left our shores, without a naturalist on board, without even a professional draughtsman, and without a man of general science, who could observe and record the interesting phenomena which Nature might have been expected to present at the limit of her habitable dominions †.

* A very curious example of this is given by Captain Berry, in the case of the harbour of Wangeroa in New Zealand, which escaped the penetration of Captain Cook, though he was nearly a month in the neighbourhood. See *Edinburgh Magazine*, April 1819, p. 304.

† Captain Sabine, who was recommended by the Royal Society to make the experiments with the pendulum and other instruments which were sent along with the Expedition at the request of that distinguished body, discharged his duty to their entire satisfaction, and with an ardour and zeal deserving of the highest praise.

Art. XXX.—*On the Quantity of Saline Matter in the Water of the North Polar Seas.* By Andrew Fyfe, M.D. Fellow of the Royal College of Surgeons of Edinburgh, and Lecturer on Chemistry. Communicated by the Author.

Different statements have been given of the quantity of saline matter in the waters of the ocean, some chemists asserting that the waters taken in different situations do not differ materially; others stating that the waters of different latitudes, and at different depths, contain different quantities of saline matter.

According to Gaubius, the sea-water which he examined contained 3.01 per cent. of saline matter. Bouillon, Lagrange, and Vogel, in their experiments on the waters of the English Channel, of the Bay of Biscay, and of the Mediterranean, found that the saline ingredients amounted to 3.47 per cent. Bergman states, that the water from the latitudes of the Canaries, contained 3.59 per cent.; while, according to Dr Murray, the saline matter in the water of the Frith of Forth is only 3.03 per cent. From the experiments of Pages, it appears that sea-water, procured in south latitude 1° 16′, contained 3.5 per cent. of saline ingredients; in south latitude 20°, the quantity was 3.9 per cent.; in south latitude 40°, it was 4 per cent.; and in 46°, it was 4.5 per cent.; the quantity of saline matter gradually becoming greater on receding from the equator.

In the waters collected in the northern latitudes by the same gentleman, the proportion of saline ingredients did not differ from each other, being in the different trials 4 per cent.

From experiments which I have lately made on sea-water, procured in different degrees of *north* latitude, and from different depths, there does not seem to be any material difference in the quantity of saline matter. The specimens which I have examined were given to me by Professor Jameson, for whom they were collected by Captain Scoresby in his voyages to the Greenland Seas, and also by Captain Ross of his Majesty's ship Isabella, during the late northern expedition.

The experiments to ascertain the quantity of saline ingredients in the different specimens of sea-water, were performed on a large scale, that there might be as little chance of error as possible. For this purpose, ten ounces of each were slowly evaporated; the residue of the evaporation was then subjected to a heat sufficient to render it dry, and weighed in the vessel before being allowed to cool, as it very quickly attracted moisture. For the sake of brevity, I shall state the results in a tabular form.

	N. Latitude.	Longitude.	Remarks.	Specific gravity at 45° F.	Saline matter per cent.
A	61° 52′	0° 7′ W.	Blue Sea; water from surface; transparent and colourless,	10274	3.70
B	64° 26′	0° 38′ E.	Ditto, ditto,	10274	3.54
C	66° 45′	1° 0′ E.	Ditto, ditto. Smell of sulphuretted hydrogen, gave a black precipitate with the acetate of lead,	10272	3.79
D	69° 14′	3° 0′ E.	Blue sea; water from the surface, transparent and colourless,	10272	3.75
E	67° 50′	1° 30′ W.	Sea greenish-blue; water from surface; turbid; after filtration slightly opaque, *N. B.* This water was exposed to the air after being collected, by which part of it had evaporated.	10276	3.77
F	71° 10′	5° 30′ E.	Blue sea; water from the surface, transparent and colourless,	10272	3.75
G	74° 34′	10° 0′ E.	Ditto ditto,	10276	3.77
H	74° 50′	59° 15′W.	Water from the surface, transparent and colourless,	10263	3.33
I	74° 50	59° 15′W.	Water transparent and colourless, taken at the depth of 80 fathoms, by Sir H. Davy's bottle; its temperature at the moment that it was drawn was 30½°, H. M. S. Isabella, July 18. 1818.	10265	3.30
K	75° *	65° 32′W.	Water transparent and colourless, from 80 fathoms deep, August 12. 1818.	10256	3.62

* As the label of this bottle was partly destroyed, I am not sure that this is the exact latitude.

	N. Latitude.	Longitude.	Remarks.	Specific gravity at 45° F.	Saline matter per cent.
L	76° 33′	10° 20′ E.	Blue sea; water from the surface, transparent and colourless,	10274	3.60
M	77° 30′	6° 10′ E.	Sea deep olive-green. Some ice water; when taken very thick. After standing, transparent and colourless,	10267	3.42
N	77° 34′	8° 0′ E.	Blue-sea. Among ice-streams. Water from the surface, transparent and colourless,	10267	3.70
O	78° 25′	8° 20′ E.	Sea greenish-blue. Middle Hook of Charles Island, Spitzbergen E. 6 N. 7 leagues. Water from the surface, transparent and colourless,	10276	3.91
P	78° 30′	6° 30′ E.	Sea olive-green. Middle-Hook of Charles Island E ½, S. 9 leagues. Water from surface, transparent and colourless,	10276	3.88
Q	78° 35′	6° 0′ E.	Sea deep olive-green. Some ice; water from the surface. When taken very thick, after standing transparent and colourless,	10256	3.27

The results of the above experiments shew, that the water of the ocean, from north latitude 61° 52′ to north latitude 78° 35′ does not differ essentially in the quantity of saline matter which it contains; the smallest quantity being 3.27 per cent., the greatest 3.91 per cent. The average quantity of saline ingredients in the water within these latitudes is 3.5 per cent.

If the experiments of Pages be correct, the saline substance contained in the water of southern latitudes, is greater than that in the water north of the equator. At south latitude 20° the saline ingredients amount to 3.9, and at south latitude 46° to 4.5 per cent.; while the greatest quantity in the water of the north seas, according to my experiments, is only 3.91 per cent. in water procured at north latitude 78° 25′, upwards of 30 degrees farther distant from the equator than the southernmost latitude at which Pages collected the water on which his experiments were performed.

The above experiments also shew, that the specific gravity of sea-water is a sufficiently accurate indication of the quantity of saline matter which it contains. The water of lowest specific gravity is that of 10256; this, from experiment, contains 3.27 per cent. of saline ingredients: that of the highest specific gravity is 10276, which has from 3.76 to 3.91 per cent. The waters of specific gravity between these contain intermediate quantities of saline matter, though they do not follow exactly the order of the specific gravity. This may perhaps be owing to some foreign matter floating in the water. The difference, however, is so trifling, that I think we may employ this as an easy method of ascertaining the quantity of saline matter which sea-water contains.

Edinburgh, *April* 1819.

Art. XXXI.—*Observations on the Information collected by the Ashantee Mission, respecting the Course of the Niger, and the Interior of Africa.* By Hugh Murray, Esq. F. R. S. E. Communicated by the Author.

It has been justly observed, that in the most important human concerns, more is occasionally effected by chance, than by the best laid plans. After the failure of successive efforts to explore Africa, the present mission, prompted by a mere local and accidental cause, has disclosed information respecting the most interesting regions of the interior, much greater than had been obtained by any of those undertaken since the first journey of Park. Its intelligence has also tended to dispel the damp which our expectations had begun to receive, respecting the unknown portions of Africa. In population, culture, and the arts, Ashantee decidedly surpasses any of the yet explored native states; and Mr Bowdich received information, of a long succession of kingdoms, stretching far to the north and east, several of which appear to be superior, and the whole, on an average, equal in these respects to Ashantee. This space, reckoned from that country northwards to Houssa, and from Bambarra eastwards to the frontier of Bornou, may be calculated at a million of square miles. Supposing the whole as populous as Ashantee, which is reckoned to contain a million of inhabitants in 14,000 square miles, or 70 to the square mile, we should then have seventy millions, in a space which does not perhaps exceed a tenth part of the continent. This is one of the largest masses of connected population to be found in the globe; and one which presents such peculiar features, as to deserve well to be studied and known. Its comparative civilization is indeed alloyed by features of deep barbarism; —the continual and furious wars,—the absolute power of the chiefs, and entire slavery of the body of the people;—in particular, the frightful extent of human sacrifices. There appears, however, to exist in Ashantee at least, an anxious wish to emerge out of this condition, and to assume a higher place in the scale of nations; so that this region appears to offer an advantageous field for the exercise of that highly laudable zeal which has long shown itself in this country, for the improvement of Africa.

Interesting as these considerations are, it is not my intention at present to pursue them farther, but to confine this essay to illustrate the information collected by Mr Bowdich, respecting the great geographical problem of the course and termination of the Niger. He found the capital of Ashantee crowded with Moorish merchants, many of whom had repeatedly crossed and re-crossed this river, and visited the different countries situated on its banks. He collected thus a large mass of intelligence, and arranged it with knowledge and industry, though not always, perhaps, with that skill, which only experience in such operations can teach. I am of opinion, that Mr Bowdich's materials afford a fair promise of the solution of this great question,—but not exactly in the manner that he himself supposes. After the obliging manner in which he has repeatedly alluded to my "History of African Discoveries," he will not, I trust, suspect me of any intention to underrate his very valuable work, when I shall frankly state the points in which my opinion on this subject either agrees with or differs from his.

The intelligence of Mr Bowdich, respecting the course of the Niger, as inferred from the reports of the natives and caravan merchants, may be thus briefly stated. The Niger, after passing through the lake Dibbie, separates, near Tombuctoo, into three branches. One, called the Gambaroo, flows northward of east, through the countries of Houssa and Kassina, till it terminates in the great lake of Caudee or Chadee. Another, bearing the name of Joliba, flows northward to a country called Yahoodee, which carries on a great trade with Tombuctoo. The third, or main stream, under the name of Quolla, rolls southward of east through Gauw, Zamfarra, Noofee, Boussa, and other countries, till, after a long course, it also separates. One branch rolls eastward, and, turning to the north, forms the Egyptian Nile; the other flows southwards, and, again separating, pours itself into the southern Atlantic ocean by several channels, of which the Congo is the principal.

In suggesting some modifications upon this statement, it will be necessary to treat successively of the different lines of river course, delineated from this report of the African merchants.

1. The *Gambaroo.* The existence of this river, and the fact that there are two great parallel streams, instead of one, running through the region east of Tombuctoo, forms a most important and unexpected accession to our knowledge of its geography *. There cannot, it should seem, be the smallest doubt as to there being such a river; for all the merchants who give routes to Houssa, Kassina, and other countries north of the Niger, positively state, that, after having crossed the main stream of the Niger, they come, in ten or twelve days, to this other great river. But, with regard to its being a branch separated from the Niger, and like it flowing eastward, there appears greater room for doubt. It may be first remarked, that this early and permanent separation of a great river into two branches, is a phenomenon very contrary to the general analogy of nature. Without inquiring into the circumstances in the structure of the globe which render it so, it need only be observed, that among all the multitude of known rivers, there occurs only one authenticated instance. This is the canal of the Cassequaire, connecting the Orinoco with the Rio Negro, which is on too small a scale, and under circumstances too peculiar, to form almost any exception to the general rule. The improbability is much increased, when we find the same authority representing the Gambarra itself as immediately separating, and this excessively rare phenomenon as taking place twice within so short a space.

* The fact discovered by Mr Bowdich, of De Lisle, in 1707, having delineated a river near Tombuctoo, under the name "Gambarou ou Niger," is very curious. The notice of such a river by D'Anville, which he refers to as mentioned in my work, exists, as he supposes, only in delineation. I apprehend, however, that the Gambra of Marmol is the Gambia, which often bears that name in the old writers.

It may be urged, indeed, as such a separation is not absolutely impossible, that, if supported by positive testimony, its existence cannot be rejected. But we must here remark certain defects in that mode of evidence upon which Mr Bowdich proceeded, so far as it is applied to ascertain the course and direction of rivers. It was derived entirely from land travellers, to whom the direction of the stream is never an object of any importance. In tropical countries it is not even very observable, unless during the rainy season, when travelling is rarely practised. To a man placed at the confluence of two or more streams, there is even a tendency to use language directly the reverse of the real fact; imagination naturally suggesting them as branches issuing from a trunk. Thus, a Jenné merchant, quoted by the editor of Adams, p. 197, says: "La separation des deux rivieres, est à une demi lieue de Genné, et Genné se trouve entre les deux rivieres comme une isle. Une de ces rivieres court dans le Bambarra, et l'autre va à Betoo." These two rivers are evidently the Joliba and Ba Nimma of Park, which flow *to* Jenné and not *from it*; and the informant was probably aware that they did so, but was led by the analogy above mentioned to use this language. Instances of similar forms of expression are by no means uncommon, even in European writers.

The mere consideration of these circumstances, seems to render it much more probable that these rivers are tributaries falling into the Niger, than branches issuing out of it. There is not wanting positive testimony to the same effect. The Gambaroo being, according to Mr Bowdich, the river which passes close by Tombuctoo, must be Mar Zarah of Adams, who, though not quite positive on the point, yet, in opposition to his examiners, obstinately stated a "preponderating belief," that this river flowed to the *south-west**. The Gambaroo must also

* Adams' testimony has been strongly controverted by statements from America, which undertake to prove that he never could have been at Tombuctoo, (see *Edinburgh Magazine* for October 1818). It is much corroborated, however, by Mr Bowdich, who confirms the name of the river Zah mer (evidently the same as Mar Zarah), and the reign of Woollo and Fatima or Fatoūma, as king and queen of Tombuctoo. These names were quite unknown in Europe when Adams gave his testimony, so that if he never was at Tombuctoo, he must have at least have had some good original information respecting that city.

have been viewed as the Niger by Leo, who, though he had heard contrary rumours, professes a strong belief, derived from observations made during his residence at Tombuctoo, that its course was westward. These testimonies and presumptions combined, leave, I think, very little doubt upon the subject, though, till some more precise report be obtained, I do not wish it to be considered as absolutely certain.

If we suppose that the Gambaroo rolls westward, and falls into the main stream of the Niger, we shall obtain at once a solution of all the mysteries and contradictions which have perplexed this branch of African geography. It appears from Mr Bowdich's statements, that Kano and Wangara (described to him under the name of Oongoroo) lie upon the north bank of the Gambaroo; consequently the Gambaroo must have been the Nile of the Negroes of the Arabians, who always represented that river as flowing westward through these countries. It must, as already noticed, have been the Niger of Leo, represented by him also as skirting the same countries, and as flowing westward. From the position with regard to Kassina, it must have been the river referred to as the Niger by the informants of Mr Lucas, who described it as flowing in the same direction. From these collected testimonies, I was led, on a former occasion, to observe*, that the contradictory accounts on the subject could only be reconciled by the supposition of two rivers flowing through this region, one east and the other west; though he had then no *data* which could lead him to suspect that the point of junction could be at or near Tombuctoo.

2. The *Joliba.*—It appears somewhat odd, that two rivers so near to each other as this and the Joliba of Park, should bear the same name. Without inquiring whether there be not here some mistake, we may remark, that the present river is very probably the Gozen Zayr of Sidi Hamet, which, if the Negro *Zayr* be changed to the Moorish *Ba*, will have a sound nearly similar. In that case it must flow chiefly from the west, which is rendered probable by other circumstances. Yahoodee, I presume to be Hoden, a mart in the western part of the desert,

* *Supplement* to *Encyclopædia Britannica*, art. Africa.

which has long carried on a great trade with Tombuctoo in salt.

3. The main stream of the Niger bearing, according to Mr Bowdich, the name of *Quolla.*—This is another instance of the perplexing transformations to which words transferred from the Arabic language are liable. I agree with Mr Bowdich in thinking, that this name of *Quolla* is essentially the same with *Joli*, between which a link is formed by the name of *Colle*, applied to the Niger by De Barros. I concur also in the opinion, that the *Kulla* of Browne is probably the very same name, river, and country. Its course is said to be southward of east, which confirms the authority of Sidi Hamet, who first reported that direction to Riley *, and also agrees with Browne.

In regard to the termination of the Quolla or Niger, Mr Bowdich found only one opinion among the merchants in Ashantee, as Mr Jackson had found in Morrocco, and Mr Horneman in Fezzan. They all considered it as the same stream with the Egyptian Nile. Such a general concurrence, though it cannot induce our assent to the opinion, seems at least a motive to state anew the grounds on which it is rejected. I would first remark, in addition to the defects already noticed in the testimony of land travellers, their imperfect view of the *continuity of rivers*. When, after travelling along the bank of one river, they strike off and come to another running in the same line, and perhaps the same direction, they are exceedingly apt, without farther evidence, to consider both as one and the same. Hence the extreme difficulty which Europeans long found in distinguishing between the Senegal and Niger, though running in opposite directions, merely on account of their proximity, and forming apparently part of the same line. In several routes collected by Mr Bowdich himself, the Niger is represented as flowing along the frontier of Foota Jallo and Foota Jorra, which shews that the Faleme, the Senegal, and even the Gambia have been viewed as branches of it. The report of a land-

* He likewise concurs as to its finally taking a southern direction. Mr Bowdich did not hear of Wassanah; but African names undergo so many transformations, that much importance cannot be attached to this circumstance. Okandee, or Osanga, might have undergone such a change.

traveller, therefore, as to the course of any river, unless so far as he has actually crossed or coasted along it, is to be considered a mere speculation, or rumour, till it is confirmed by farther evidence. Now, it appears by Mr Bowdich's routes, that the merchants are not at all in the habit of travelling along the continuous line of this supposed river. They strike off as it approaches the Caudee Lake, and travel through Begherme, Darfoor, and Wadey towards Sennaar. Thus leaving the Niger flowing eastward, and coming, after a considerable interval, to the Bahr-el-Abiad, flowing also eastward, their imagination is very naturally led to unite these two streams, though separate, into one.

In opposition to the reports, or more properly opinions of persons living 1000 or 1500 miles from the spot, may be placed the testimony of Browne, an active and intelligent inquirer, who resided for six months in the capital of Darfoor, about 200 miles from the line which the Niger must follow in making this supposed junction. He heard nothing of it, however, but, on the contrary, received a particular account of the origin of the Bahr-el-Abiad, as derived from a number of torrents descending from the Mountains of the Moon. This perfectly agrees with the delineation of Ptolemy, who, though not perhaps nearer than Egypt, resided constantly in that country, and was habitually occupied in geographical inquiries. These two testimonies, therefore, decidedly outweigh those of the merchants in the western extremity of Africa. The truth is, however, when we come to any precise statements on the part of the latter, they are found to be completely at variance with the inference which they have deduced from them. A Moorish merchant, indeed, assured Mr Jackson, that he, with a party of his friends, made a voyage by water along the Nile from Jenné to Cairo; but, he added, that in several places they found its channel almost dry, and were obliged to carry the boats over land. There are certainly some rare instances where a river may continue to flow without receiving accessions, and may even sustain some diminution. But that a stream so mighty as that which is universally described to flow through the heart of interior Africa, should dwindle into so paltry a brook, as not to float a canoe that can be carried on men's backs, is what no one I think can be so credulous as to imagine. A person of credit also assured Mr Horneman, that the communication of the Niger and the Nile is 'very little, unless in the rainy season." This evidently gives up the identity of the two rivers, and implies merely some small connecting cut, like that of the Cassiquaire. This is no doubt possible, though I think not probable, considering the rarity of the occurrence, and the mountainous character of the country described by Browne, to intervene between Darfoor and the sources of the Bahr-el-Abiad.

This hypothesis being disposed of, and there being no mention of any great lake or inland sea upon the course of the Quolla, there appears no alternative but that of its discharge into the southern Atlantic. Upon this subject the Ashantee merchants had nothing to say; but Mr Bowdich having resided for some months at Gaboon, obtained some important information respecting the rivers of that part of Africa. The natives mentioned the Wola, as a river considerably to the north of their country, as the greatest river in the world, four or five miles wide, and flowing to the eastward. There can seemingly be no doubt as to this being the same river called by the Moors *Quolla.* Another river, called the Ogooaway, was also described as communicating with the Wolla, and then rolling southwards through the interior. After pursuing a long and winding course through vast savannahs, it was said to separate into two branches, the largest of which formed the main stream of the Congo, while the smaller one discharged itself into the ocean at Cape Lopez. This would form certainly a very large Delta, which could, however, be less wondered at, as the river, previous to separation, would have held a longer course than any other perhaps in the world. The Gaboon and Danger form two other estuaries, the origin of which is unknown, and which may possibly form part of the same great Delta. Much in short remains to be cleared up; but, upon the whole, the probability seems very strong, that this celebrated stream must find its way by more than one channel into the southern Atlantic.

Art. XXXII.—*Notice concerning David Gilbert Tate, a lad born Deaf and Blind, in the Shetland Islands.* By Samuel Hibbert, M. D. M. W. S., and Corresponding Member of the Philosophical Society of Manchester, &c. Contained in a Letter to Professor Jameson.

Dear Sir,

During a mineralogical excursion in the course of last summer, whilst I was engaged in examining the Island of Fetlar, situated to the north-east of the Shetland group, I there learnt the existence of an adult born deaf and blind. Upon this information, I hastened to pay a visit to so remarkable an object, the knowledge of whom seems not to have extended beyond the insulated place of his nativity, where he has dragged on an unnoticed existence for 25 years. On my return to Edinburgh, the history of this unfortunate being having excited much interest among those to whom it has been communicated, I now take the opportunity, in conformity with your request, of furnishing you with some of the most remarkable features of the case, regretting at the same time, that my engagements have hitherto precluded me from publishing a more finished statement of it. This I shall attempt in my first moments of leisure; in the mean time, I shall be happy if the short notice now submitted to you, will prove acceptable.

I must, at the same time, offer a caution against the expectation of a case equalling in interest that of James Mitchell. The object of this notice, in addition to the loss of certain organs of sensation, appears to add that of his powers of comprehension. The observer, though shrinking from an involuntary association of the name of man, with that of any earthly creature which may exhibit no emotions beyond those which are produced by mere natural appetite, is still incapable of withholding the confession, that, in an exclusion from all sound, in a deprivation of sight and intellect, this unfortunate object has an existence in no degree advanced above that of a race of animals occupying the lowest scale of creation.

David Gilbert Tate is the name of this singularly destitute being. He is said to be twenty-five years of age. His parents are in very indigent circumstances. About two years previously to the birth of this youth, they had a daughter, who, from her infancy, displayed every symptom of idiotism. There was that torpor of the mental faculties which is denoted by an indocility of apprehension, and an articulation which could not be rendered subservient to the purposes of speech. Some time after her birth she became blind. She still lives, and is twenty-seven years of age.

About two years afterwards, was born David Gilbert Tate, having mental defects similar to those of his sister Grace Tate, but adding to them the want of sight and hearing. It may be remarked, that the mother of Tate has had eight other children, who manifested none of the defects which, conjoined in one individual, render his case so singular.

On my visit, in company with Mr Nicholson of Lochend, and Captain M'Dermid, (two gentlemen to whose hospitable kindness in Shetland I am much indebted,) to the miserable hovel occupied by the Tates, one of the worst in the island, the lamentable object of our visit first arrested our attention. He was warming himself by a fire, occupying the centre of the hut, in a posture not unlike that which is described as peculiar to the Moors; that is, he was not actually seated, but seemed most at ease, with his chin occasionally resting upon his knees, whilst his extremities were gathered up to the trunk. The sternum was much protruded. The lumbar and dorsal vertebræ appeared to be somewhat curved, but whether or not this was the effect of disease, as of rachitis, or was an habitual position of the trunk, which was bent forwards equally with the sternum, I could not learn. It was, however, a matter of great surprise, to find that this position was maintained in his gait, and to learn from the mother, that no attempts had been made to teach him to walk erect. The parents of David had, from his birth, regarded him in the hopeless light of a forlorn creature, whose peculiarly bereft lot no tuition could ameliorate. Consequently, if we could be assured, that disease had not induced the position of the body alluded to, it might possibly afford a reply to the question, whether the erect attitude is the natural or acquired position of man.

To David Tate, the erect attitude was certainly not habitual, and when induced by coercion, was maintained with very uneasy feelings, whilst its continuance met with his most determined resistance. In his person, David Tate shewed much emaciation and feeble muscular powers, little inclined, perhaps from the mode in which he was brought up, to exposure in the open air, chusing most frequently to remain in the house, in a place nearest to the fire. When compelled to assume an erect position, an opportunity was afforded of remarking his general physiognomy. His countenance certainly appeared very idiotic. His forehead, which in the lower part protruded, was in the upper part retreating, whilst the occiput appeared rather flattened. His whole body seemed emaciated. His chin was very prominent. His mouth was remarkably wide. His nose very sharp. He was almost in a state of nudity, never having been accustomed to wear more than a coarse blanket, slightly tied round him, so as chiefly to cover his back. The pupil of the eyes shewed the pitchy black and dilated appearance characteristic of amaurosis, and the iris did not contract or dilate upon the sudden application or withdrawing of a candle.

When first observed, David had no sensible object within his grasp. It was then curious to observe the innumerable muscular contractions of his fingers, and the velocity with which their motions were executed, to produce a rapid change of position, shewing from what a simple origin, being neither more nor less than the solitary circumstance of varied muscular contraction, exerted in parts of the body best calculated to produce the effect, that the enjoyments of this individual were derived. Metaphysicians may refer all our enjoyments of touch, as of any other sense, to the same source of varied position, but it is only in such an individual as David, where these are unmixed with motives of action, arising from any other organs of sensation, except occasionally those of smell or taste, that speculations on the abstract sources of tactual pleasure may be confirmed. It was of importance to ascertain, in the next place, what objects, by being opposed to, and consequently resisting the muscular contractions of his fingers, (which is all we mean, when we speak of objects of touch,) appeared to afford the highest gratification. The answer given by the mother, when a question to this effect was put to her relating to her son, was in the highest degree satisfactory. It afforded the most direct proof of the law to which our pleasures are subject. That there may be a continuation of pleasurable sensations, it is necessary that the causes of them should be continually varied. The most beautiful landscapes, or the most exquisite monuments of art, when long opposed to vision, lose all their captivating power. Applying this principle, therefore, to the case of David Tate, and conceiving it highly possible, that the abstract causes of pleasurable sensations in touch, might in this individual be exemplified, the substance of the answer given by the parent to the question, "What did the boy like best to handle?" which was, "Each thing that he can alter the shape of," comprehended all that might have been anticipated. The above was her direct reply. She at the same time referred to the flexible substances in the cottage, as to woollen and linen clothes, materials of cotton, or to straw. These were the objects the form of which he could change, and which consequently yielded the greatest sum of enjoyment.

At the same time, when various objects were presented to him, he preferred smooth surfaces to those which were uneven or rough. Of the latter description, the outside of the tea-kettle, coated with sooty matter, was particularly disagreeable to him.

Upon first hearing of this youth, I naturally expected that his sense of odorous substances would be pre-eminently acute. In this expectation I was disappointed. There was no evidence of this acuteness when I was present; nor from the representation of his parents, am I inclined to think that it was ever exhibited. The question then is, If the sense was blunted or suspended? It certainly, from my own observations, and the inquiries which I made, did not seem to be obliterated. It is therefore very probable, that the circumstance of his idiotism, (to the use of which word I attach no other meaning, than that the law by which ideas are associated in his mind, is, from an organic derangement, comparatively ineffective,) may have prevented the particular exertions of this organ. I paid a second visit to David Tate, for the purpose of satisfying myself upon the state of this instrument of sensation, by the application of various substances to his nostrils; but unfortunately for my purpose, the day on which I returned to the hovel, happened to be the time of his repose, when his parents were naturally very unwilling that he should be disturbed.

It may be here noticed, that David's interval of time set apart for sleep, is never regular; it is very indeterminate in length, and consequently it may so happen, that either the day or the night may constitute his hours of vigilance. This circumstance affords an additional proof, how little David's habits have been under the control of proper tuition.

The sense of taste has, from the scanty means of David Tate's parents, had little opportunity of being gratified by varied objects. All I could learn on this subject was, that, in preference to fish, he chiefly lives on meal pottage. He is always fed by his mother with a spoon.

Pauca de appetitu venereo in hoc adolescente manifesto restant. Hanc enim quæstionem, vir illustrissimus Dugaldus Stewart, in Jacobo Mitchell, sic defendit: "Neque inutile foret, neque ab honestissima sapientia alienum, novisse quo modo hic miserandus, jam puber factus, se habuerit quoad ad res venereas." Davidis Tate seminudum corpus hanc propensionem detegendi facultates quidem copiosissimas præstat. Genitalia ipsa solito ampliora videbantur. Mater ejus (nam pater piscatu occupatus domo longe abfuit) mihi ad rogata respondere parum hæsitavit. In memoriam revocandum est, Davidem semper in casulæ aream suo more sedere assuetum esse. Sæpe ideo evenit, ut crura muliercularum familiariter domum invisentium, pueri omnia contrectantis, digitis occurrerent. Talibus igitur exemplis, mater confitetur se sæpius admiratam esse, qua cupiditate manus ejus muliebribus cruribus adhærerent, et quanta maxima celeritate, per summam omnem cutem haud vestimentis earundem contectam, tactuique ideo subjectam, digiti aberrarent. Interea in miseri corpore, notæ veneris mare desideratæ (scilicet priapismus) in oculos parentis vel adstantium sese manifestas darent. Hæ autem res naturam appetitus venerei insitam clare comprobare viderentur.

Oporteat quoque hoc in loco adjicere, ut in dejectionibus alvi vel vesicæ, nullo pudoris sensu hic miserandus cohibeatur; neque unquam his excernendis locum idoneum ut seligeret doceri potuit.

David's intonations of voice, which I only heard when his painful feelings were intended to be expressed at the erect position in which he was placed, were somewhat remarkable. They were highly melodious, being uttered in almost every key; and if music, as some philosophers state, be the natural language of passion, this idea was perhaps never better illustrated by example, than in the case of this untaught youth.

I have, lastly, to say a few words on the mental faculties of David Tate. Here, however, they must be in relation to the simple question respecting the generation of ideas in the mind, produced after the causes which have excited sensations are withdrawn, and the state of effectiveness in the law by which ideas are associated. The evidence touching the law of ideal association or memory, as existing in the mind of this unfortunate youth, comprehends a few of the most simple events. Previously to receiving food, his mother taps his hand with a spoon, which is recognised by the poor object, as a signal that she is preparing to satisfy his hunger. In an instant, therefore, the hands of David are extended to receive the bason, in which is contained his pottage. The existence of memory, or of an association of ideas, is, in the next place, proved by the attachment which he is said to express towards his mother, who constantly feeds him. This is denoted by a restlessness, when he cannot, by feeling every object around him, detect her presence; her maternal offices of kindness, are also preferred before those of any other individual.

I have already alluded to the idiotism of the sister of David Tate. There is reason to believe, that the brother is in a similar situation, though such a state of fatuity is difficult to be proved in an individual possessing so few avenues, by which externals objects can be conveyed to the mind.

These are the leading circumstances in the case of David Tate. I have now only to apologize for the hasty sketch which I have drawn up, but which I intend to perfect in the first opportunity of leisure afforded to me. The limited time I could conveniently detach from other avocations in Shetland, for the purpose of visiting this remarkable youth, must be a further apology for any deficiency in the history now rendered to you.

I can, however, only add, that as doubtless there are many more circumstances upon which the philosophical enquirer may wish to be satisfied respecting the habits of David Tate, I shall be happy to communicate any information respecting the medium through which his queries may be best answered.—I am, &c.

EDINBURGH, 18*th April* 1819.

XXXIII. *Proofs that the Beaver was formerly a native of Scotland, including an account of some Fossil Remains of that animal found in Perthshire and Berwickshire.* By PATRICK NEILL, F. R. S. ED. F. A. S. & Sec. W. S. Communicated by the Author *.

IT has generally been believed, and probably not without reason, that the beaver (Castor Fiber, Lin.) was once indigenous to different parts of Britain, particularly Wales and Scotland. I shall first notice the evidence of the existence, in former times, of the beaver in Wales; for, in this way, as will presently appear, some light may be thrown on the question of its having likewise been one of the native quadrupeds of Scotland.

The earliest written authority on this subject with which I am acquainted, is contained in a remarkable document of the 9th century, which has been fortunately preserved and published,—the Laws of Howel the Good †. In Book iii. § 11, 12. where the prices of furs are regulated,

The Marten's skin is valued at.. ....24 *d.*
The Otter's (Ddyfrgi or Lutra) at........................12 *d.*
The Beaver's (Llosdlydan or Castor) at no less than 120 *d.*

or at five times the price of the marten's fur, and ten times the price of the otter's. From these brief entries, I think we are entitled to conclude, 1. That the beaver (by the legislator distinguished by the descriptive and appropriate title of *Llosdlydan* or *broad-tail*, and, as it were, contrasted with the *ddyfrgi*, wa-

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* This paper was read before the Wernerian Natural History Society on the 1st of May 1819.

† Leges Wallicæ by Dr Wotton.

ter-dog or otter,) was then hunted in Wales for the sake of its fur: 2. That this skin was held in high estimation; and, 3. That the beaver had already, before the close of the 9th century, become a scarce animal in this country.

The next authority which has come to my knowledge, is contained in the "Itinerarium Cambriæ" of Sylvester Giraldus de Barri. This writer, it may be remarked, made his journey into Wales, towards the end of the 12th century, or about 300 years after the date of the laws of Hywel Dha, as the attendant of no less a personage than Baldwin, Archbishop of Canterbury, whose zeal led him personally to excite the Welchmen to join in the projected crusades. In such company, and on such an errand, Giraldus must have had ample opportunities of intercourse with the best informed people of the districts through which he passed; and that he was inclined to be an observer of nature, is proved by the single fact, that when he arrives on the confines of the river Teivi in Cardiganshire, he immediately seems to forget the object of his mission, makes a long digression on the natural history of the beaver, and enlarges, with evident satisfaction, on the habits of that singular animal. Although he rehearses some of the exploded fables of the ancients, yet other parts of his account are very accurate, and may be considered as bearing the marks of a description made from actual observation. He mentions, for instance, that, in the course of time, the habitations of the beavers assume the appearance of a grove of willow trees, rude and natural without, but artfully constructed within;—that the beaver has four teeth (incisores), two above and two below, which cut like a carpenter's axe;—and that it has a broad short tail, thick like the palm of the hand, which it uses as a rudder in swimming. In the simple and bold language of a man who knew the truth of what he was writing, he says of the Teivi, "Inter universos Cambriæ seu etiam Lloegriæ fluvios, solūs hic castores habet;" and adds, "In Albania quippe, ut fertur, fluvio similiter unico habentur, sed rari *." We may perhaps infer from this cautious mode of expression, that the author intended to contrast the nature of his evidence, and to intimate, that the fact previously mention-

* Itin. Camb. lib. ii. cap. 3.

ed depended on surer grounds, or on his own observation. But the very cautiousness of the language in which the report relative to Albania is repeated, ought to increase our reliance on its authenticity. It would appear, therefore, that in the 12th century, the beaver still existed in Scotland, but was then a scarce animal.

The first of the native topographers and historians of Scotland whose works assumed a printed form, and have come down to us, is Hector Boethius, who wrote his Description and History about 300 years after the time of Giraldus, or towards the end of the 15th century. After describing the dimensions of Loch Ness, he says, "Ad lacus latera, propter ingenta nemora ferarum ingens copia est, cervorum, equorum indomitorum, capreolorum: ad hæc, marterellæ, fovinæ ut vulgo vocantur, vulpes, mustelæ, *fibri* lutræque, incomparabile numero, quorum tergora exteræ gentes ad luxum immenso pretio coëmunt*." Here the *fibri* are enumerated with such perfect confidence among the other quadrupeds whose furs were in request for exportation, that we may seem fastidious as to evidence, if we hesitate to admit that beavers were still to be found at Loch Ness, in the time of the author. But the "incomparable numbers," and "immense prices," of Boethius, are phrases which may well stagger our belief; and they form a singular contrast with the "single river" and "rarity" mentioned by Giraldus three centuries before.

It may further be remarked, that Bellenden, in the translation of Boethius which he undertook (probably about the year 1536) at the request of King James V., while he omits the *cervi*, *capreoli*, and even the *lutræ*, mentions *bevers* without the slightest hesitation. His words are: "Mony wyld hors, and amang yame ar mony martrikis (pine-martens), bevers, quhitredis (weazels), and toddis (foxes), the furringis and skynnis of thayme are coft (bought) with great price amang uncouth (foreign) merchandis †." It must be confessed, however, that the carelessness and looseness of the translation, as evinced by the very passage in question, greatly detract from the conclusiveness of Bellenden's testimony; for it seems at least fully as probable that there were fallow-deer and roes in the forests of Loch

* Boethius, Scot. Hist. † Bellenden, Croniklis of Scotland.

Ness, as that there were wild horses there; and it admits of no doubt whatever, that otters were then to be found on the banks of the lake, for they are so to this day.

In the Statistical Account of Scotland, it may be noticed, no mention is made of any trace of the remains of these animals having ever occurred in the neighbourhood of Loch Ness. What is more remarkable, in the extensive excavations along the line of the Caledonian Canal, from Inverness to Corpach, and in the course of deepening, by means of a powerful dredging-machine, the bed of Loch Dochfour, no bones of the beaver, nor indeed of any other quadruped, have occurred. With the exception of marine shells in the alluvial land next to the sea, the only organic remains hitherto found, have belonged to the vegetable kingdom, and have consisted chiefly of filbert nuts and trunks of oak trees. I state this on the authority of one of the resident engineers, who adds, that ever since the commencement of this national undertaking, all the sub-contractors and overseers have been enjoined to preserve any organic remains, especially skeletons, which should occur in the progress of the work.

The accuracy both of Boece and of Bellenden seems to be strongly impugned by this important fact, that no mention of beavers occurs in any of the public records of Scotland now extant. In an act dated June 1424, c. 22. " Of the custome of furringis," mertricks (martens), fowmartes (polecats), otters and tods (foxes), are specified, but not a word is said of beavers, although these, had they existed, must have been the most valuable of all, not only for their furs, but for the substance called castor, (found in the inguinal glands of the animal), which in those days still retained some share of its ancient repute as a medicine. As it is pretty plain from their writings, that neither the historiographer nor his translator had the slightest claim to the character of being naturalists, and as both give abundant proofs of their nationality, in boasting beyond measure of the products of their country, it may be considered as not improbable that the beaver was extinct in Scotland before their time, although the tradition regarding its existence in former days was then so strong and general, as to lead them to enumerate it without hesitation among the wild animals of the country;—in the same way as the capercailzie, or cock of the wood, may still be found marked, in some popular books, as a native of the Scottish Highlands, although a century has elapsed since it ceased to be heard in our pine forests.

Sir Robert Sibbald does not, on this topic, show any of that precision, and zeal for inquiry, which characterize many other parts of his writings. He contents himself with referring to Boece, in proof of the beaver having formerly been found in Scotland, and adds, with seeming indifference, "An nunc reperiatur nescio *." It should however be remembered, as a partial justification of this apparent remissness, that, at the period in which he wrote, the upper or western parts of the counties of Aberdeen and Inverness, the reputed haunts of the beaver, were difficult of access to a degree now scarcely to be conceived. An enlightened Legislature and Government, by liberally promoting the formation of commodious roads in almost every direction through the Highlands, have converted into a safe and easy tour of a fortnight, what would, in Sibbald's time, have been regarded as a kind of summer's journey, fraught with no little danger.

No modern writer on the natural history of Scotland, seems to have examined the subject. The late Dr Walker, Professor of Natural History in the University of Edinburgh, in his "Mammalia Scotica †," merely states, that beavers formerly existed in this country, but are now wholly extinct, and makes an allusion to the passage already quoted from Giraldus. In his lectures, however, the Doctor used to mention, that the Scots Highlanders still retain, by tradition, a peculiar Gaelic name for the animal.

In order to satisfy myself with regard to the value of this traditionary evidence, I applied to the venerable and learned Dr Stuart of Luss,—a gentleman distinguished both as a naturalist and a Celtic scholar,—who was the friend and fellow-traveller of Pennant and of Lightfoot in their principal excursions through Scotland, and who has devoted a great part of his life to the laborious and important task of translating the Sa-

* Scotia Illustrata, Pars II. lib. iii. p. 10.

† Posthumous Essays on Natural History, &c. 8vo, p. 490. edited by Mr Charles Stewart.

cred Scriptures into the Gaelic language. From him I received a confirmation of Dr Walker's statement, that the ancient Gaelic name of the beaver is still known to the Highlanders in the remote western districts of Scotland. "The name (says the Doctor) is *Losleathan*, derived from *los*, the tail, point or end of a thing, and *leathan*, broad; or, *Dobhran losleathan*, the broad-tailed otter." The similarity between this Gaelic name, handed down by tradition to the 19th century, and the Welsh name (Llosdlydan) recorded in the Leges Wallicæ of the 9th century, is very striking: the etymology of the names is evidently the same; and indeed they may be regarded as identical *. Dr Stuart adds, that he recollects to have heard of a tradition among the Highlanders, which he thinks is probably still preserved in the country, that the "beaver or broad-tailed otter once abounded in Lochaber."

I have now to state, that the evidence, written and traditionary, which has just been detailed, tending to show that beavers formerly inhabited Scotland, has received the most ample confirmation, from the occurrence of unaltered fossil remains of the animal on two occasions; first in a county to the north, and next in a county to the south of the Forth.

The first instance I have to mention, occurred no less than thirty years ago, but has not hitherto been noticed in any publication. From an entry in the minutes of the Society of Antiquaries of Scotland, dated 16th December 1788, it appears, that "Dr Farquharson presented to the Society the fossil skeleton of the head and one of the haunch-bones of a beaver." These bones are still preserved in the Museum of the Society; and I was allowed to examine them, and compare them with others. The back part of the cranium is gone; and the zygomatic arch of the left orbit is shattered; a part of one side of the lower jaw-bone is likewise broken; of the incisores, only some remains of those of the lower jaw now exist. What is called the haunch-bone, is the left os innominatum of the pelvis; it is quite entire. I have not

* It is rather a puzzling circumstance, that, in the Poems of Ossian, no mention should occur of the *losleathan*, an animal whose manners must have struck with admiration a rude people, and whose fur must have been invaluable in the eyes of the Fingalian heroes and their ladies.

had an opportunity of comparing it with the same bone in another beaver; for Edinburgh does not at present afford a complete skeleton of this animal. But I compared it with the corresponding bone in the otter, the badger, and the fox, as the wild quadrupeds most likely to have occurred in Perthshire; and am satisfied that it had not belonged to any of these. The pelvis of the beaver is more elongated; this os innominatum is almost twice the length of the same bone in a full grown otter; and the foramen thyroideum is very large, even in proportion to the bone itself. All the bones are dyed of a deep chocolate colour. From the state of the sutures of the cranium, and from the size of the bones of the nose, which are complete, this animal appears to have been of full growth, but not aged.

On applying to Dr Farquharson, I had the satisfaction to learn, that these were really the remains of a *Caledonian* beaver, having been dug up in the parish of Kinloch in Perthshire, near the foot of the Grampian Mountains. The Loch of Marlee, on the property of Mr Farquharson of Invercauld, is the last or lowest of a series of small lakes, extending almost from Dunkeld to Blairgowrie, nearly in the direction of the high road between these places. This loch had been partly drained, for the sake of the rich stores of marl it contained, which in some places was found in a layer almost twenty feet in thickness. In one of the marl-pits on the margin of this loch, under a covering of peat-moss between five and six feet thick, the beaver's skeleton was discovered. The bones already mentioned, being the firmest and most perfect, were saved by the workmen; and being accidentally seen by Dr Farquharson, were carried by him to Edinburgh, and presented, as already mentioned, to the Antiquarian Society.

In a neighbouring marl-pit, a pair of deer's horns, of large size and with fine antlers, were found nearly at the same time; and along with these, two "leg-bones, so deeply grooved as to appear like double bones." These last, it has been suggested to me by Dr Barclay, were probably the metatarsal bones of the great species of deer, which appears to have been contemporary with the beaver, and to have become extinct much about the same period with that animal. In the Statistical Account of the parish of Kinloch, published in 1796, the occurrence of the deer's horns is mentioned, but no notice is taken of any remains of the beaver having been found.

The second instance occurred so late as October last, on the estate of Kimmerghame, in the parish of Edrom, near the head of that district of Berwickshire called the Merse. Since this estate was acquired by the present proprietor Mr Bonar, banker in Edinburgh, he has made important improvements In the course of these, he drained a morass called Middlestot's Bog. Under the peat-moss here, a layer of shell-marl occurs, varying in thickness from four to eight feet. Different marl-pits have been opened; and in one of these, the remains of the beaver were found. They were situated at the depth of seven feet from the surface, under a layer of peat-moss of that thickness. It is remarked in a letter from Mr Thomas Dickson, overseer at Kimmerghame, to Mr Bonar *junior* (who took a lively interest in this investigation), that a layer of a kind of loose whitish substance, generally occurs between the bed of compact peat-moss and the bed of marl. From a specimen sent to Edinburgh, this substance appears to consist of several musci which grow in marshy situations, much decayed, but among which Sphagnum latifolium, S. capillifolium, and Hypnum cuspidatum can be readily distinguished. The bones of the beaver were imbedded partly in this loose and spongy matter, and partly in the marl below. Only the hard bones of the cranium and face, and the jaw-bones, retained enough of their firm texture to fit them for being removed and preserved in a dry state. Around these, however, dispersed in rather a promiscuous manner *, were many bones, which, from their size and appearance, evidently belonged to the same animal. Several of the long bones and vertebræ, while they remained *in situ*, seemed perfect; but on being touched, they were found to be nearly in a state of dissolution; and though some were carefully taken out, they speedily mouldered down on being exposed to the air, and becoming dry.

Mr Bonar *junior* having carried the skull and lower jaw-bone to Edinburgh, presented them to Professor Jameson, for the College Museum; and at his request I have drawn up this notice. Mr Bonar subsequently transmitted specimens of the different layers of the peat-moss, and of the vege-

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* The apparent dislocation of the skeleton is not to be ascribed to violence, but to the gradual separation of the parts by unequal subsidence. The appearance of the marl, in which delicate shells, of the genera Lymnea and Succinea, can be traced, indicates a long continued state of tranquillity.

table remains which occur in it, and also of the marl. Among the vegetable remains, common filbert nuts, or at least the shells of the nuts, were abundant. A large specimen of Boletus suberosus so greatly resembled the hoof of some animal, that it had been laid aside as such by the workmen; but the tubes and pores are sufficiently distinct to afford characters. The overseer mentions in his letter, that the fossil wood which is found, is "principally birch and alder; with some oak, though not much of it; but no kind of fir-cones have been observed."

Mr Bonar has in his possession a pair of horns belonging to the large extinct species of deer already mentioned, in high preservation, which were found in the same marl-pit, and near the same spot, only two days before the occurrence of the beaver's remains.

The head of the beaver from Berwickshire is in a much more perfect state than that from Perthshire. The cranium and bones of the face are entire; so is the lower jaw-bone; all the four incisores are perfect, retaining the peculiar kind of coloured enamel which clothes the outer half of the circumference of the tooth; the cutting edges remain fully as sharp as in recent specimens from Hudson's Bay. The molares are also complete: It is considered as almost characteristic of the beaver that the grinders are without distinct fangs; but in this specimen, root-like bases are seen projecting from some of the teeth, through their sockets into the orbits. The bones are dyed of a brownish hue, but not nearly so dark as those from Perthshire: the exterior enamel above mentioned, which in recent specimens is of a brownish-yellow or dull orange colour, has become almost jet black.

On comparing these fossil heads with recent ones from Hudson's Bay and Canada, in the possession of Professor Jameson and Dr Barclay, it appears that they all belong to the same *species* of Castor; but although there seem to be no sufficient *specific* distinctions, it may be mentioned that the two fossil specimens have a greater resemblance to each other in general shape and proportions, than to any of four recent specimens with which they have been compared. In the fossil specimens, in particular, the nasal bones are proportionally larger than the same parts in the recent specimens. The difference, however, as far as can be ascertained from a comparison of the bones of the head, cannot be considered as more than sufficient to constitute a *variety;* not being more important than what occurs in varieties in the vegetable kingdom, in which, when the same species of plant happens to be a native of both hemispheres, the eye can at once discern a difference of habit, although often so slightly characterised as to render it difficult to express it in words.

Both the fossil heads appear to have belonged to full grown animals. This opinion rests on two grounds: 1. On a comparison, in regard to general dimensions, with recent specimens from Hudson's Bay, brought home by Mr Auld of Leith, and known to have belonged to full grown beavers; and, 2. On the state of the sutures and ridges of the cranium. In the Perthshire specimen, the squamous sutures of the parietal bones are partly obliterated; and in the Berwickshire specimen, although these sutures are distinct, yet the crest or ridge between the two temporal muscles, in the course of the sagittal suture, is considerably raised; and in the Hudson's Bay skulls, both these characters are known equally to indicate the adult or perfect state. Neither of the fossil skulls, however, had belonged to *old* animals; for, in a Canadian specimen in Dr Barclay's collection, not only are several of the sutures nearly obliterated, but the component pieces of the cuneiform bone, and the cuneiform process of the occipital bone, are united; while in both the fossil specimens, these divisions remain evident; circumstances which satisfactorily show that this Canadian specimen had been older than any of the others, although it is certainly not of larger dimensions.

The Scottish specimens, it may be remarked, seem very much to agree with a fossil beaver's head described and figured by M. Cuvier, in his elaborate "Recherches sur les Ossemens fossiles de Quadrupèdes," vol. iv. sect. *De rongeurs fossiles.* This specimen was found by M. Traullé, in the course of digging a peat-moss in the Valley of the Somme in Picardy; and the same peat-moss afforded, as with us, large horns of deer.

M. Cuvier mentions, that he possesses skulls of the adult Canadian beaver, but that he has not been able to procure the skull of the adult European beaver, to compare with them. It may be remarked, that this writer must, by the term "*adulte,*" here be understood to mean *aged;* for the dimensions assigned by him to the fossil cranium from Picardy, are analogous to those of the skulls of full grown, though not old, beavers from Hudson's Bay in the College Museum. That this is his meaning, is further proved by his description of the skulls of the adult Canadian beavers; in which he observes, "the temporal crests approach each other," so as, at the mesial line, to form a single elevated crest; a tendency which is visible in the cranium of the aged beaver already mentioned as being in Dr Barclay's collection.

CANONMILLS, 20*th April* 1819.

ART. XXXIV.—*Account of the Formation of the Lake of Mauvoisin, by the Descent of a Glacier, and of the Inundations of the Val de Bagnes in* 1595 *and* 1818. Drawn up from the Memoir of M. Escher de la Linth, &c. and illustrated with a map and drawings, communicated by Professor Pictet of Geneva.

THE Val de Bagnes is a valley in Switzerland about ten leagues in length, which stretches from east to west, and, after having joined the valley of Entremont at St Branchier, opens into the extensive valley of the Rhone. It intersects several chains of the great Alpine range which separates Switzerland from Piedmont, and is watered by the river Dranse, which flows in a rocky bed, contracting its channel between precipitous banks, where it cuts the mountainous ridges, and again spreading out upon level and fertile plains covered with smiling cottages, and presenting the most picturesque and beautiful situations.

The river Dranse has its origin in the glaciers of Tzermotane and Mont Durant, (shewn at E and F in the map, Plate IV.) It traverses the valley of Tozembic (shewn at L); and after flowing through a very narrow and deep channel, it passes the bridge of Mauvoisin (C), which connects the two sides of the valley. This bridge is built upon perpendicular rocks, about eighty feet above the bed of the river; and the narrow gorge which it crosses, is formed by the approximating flanks of Mont Pleureur (G) on one side, and Mont Mauvoisin (I) on the other. Between Mont Pleureur and Mont Getroz (H), is a narrow and deep channel, at the top of which lies the glacier of Getroz (D). Enormous masses of ice are constantly precipitating themselves from this glacier into the ravine below, and, descending to the bottom of the valley, fill up the contracted channel of the Dranse.

So early as the year 1595 *, the valley above the bridge of Mauvoisin was completely shut up by the descent of immense avalanches of ice. The water rose to an enormous height, and, on the evening of Sunday the 4th of June, the icy barrier which confined it, was weakened by the influence of the heat, and suddenly gave way. The accumulated waters took a whole hour to escape from their confinement. They descended the valley with irresistible fury, carrying along with them masses of rock of enormous magnitude; tearing up every thing that obstructed their progress; desolating the plains of Bagnes, St Branchier, and Bovernier; and destroying the whole town of Martigny. The unfortunate inhabitants were reduced to the most abject poverty, and no fewer than from sixty to eighty perished in the torrent †.

For several years previous to 1818, the progress of the Dranse had begun to be obstructed by the blocks of ice and avalanches of snow that descended from the glacier of Getroz; and as soon this accumulation was able to resist the heats of summer, it acquired new magnitude during every preceding winter, till it became a homogenous mass of ice of a conical form. This cone, which is shewn in the perspective view of the Lake, Plate IV. had its summit in the ravine, about 100 feet above the Dranse, and, descending at an angle of 45 degrees, its base rested upon the precipitous flanks of Mont Mauvoisin.

The waters of the Dranse, however, still found their way beneath the icy cone till the month of April, when they were observed to have been dammed up, and to have formed a lake about half a league in length. The danger of a sudden efflux of the water was now apparent, and it was deemed necessary to

* M. Ebel informs us, that the village of Bagnes, from which the valley receives its name, was destroyed in 1545 by an inundation, in which 140 persons perished. *Manuel d'un Voyageur en Suisse*, tom. ii. p. 188.

† *Biblioth. Universelle*, Septembre 1818, p. 89.

cut a subterraneous gallery for the purpose of effecting a gradual discharge. With this view, the lower end of the gallery was sixty feet below the line of contact of the cone of ice with the flank of Mont Mauvoisin, and its upper extremity was fixed at the height to which the lake might be calculated to have risen when the gallery was finished. In this way, the water entering the upper extremity of the gallery, might be expected to deepen it by degrees, and thus permit the surface of the lake to descend gradually, till it was nearly emptied. This ingenious and bold scheme was begun on the 10th of May, and finished on the 13th of June, under the direction of M. Venetz, an able engineer of the Valais. The gallery was sixty-eight feet long, and, during its formation, the workmen were exposed to the constant risk of being crushed to pieces by the falling blocks of ice, or buried under the glacier itself.

During the thirty-four days which were spent in the formation of the gallery, the lake had risen sixty-two feet, but from particular causes, the upper entrance to the gallery was still many feet above the surface of the lake. Without waiting for the farther rise of the waters, M. Venetz sunk the floor of the gallery several feet, and the water began to enter it on the 13th of June. At this period, the length of the lake was from 10,000 to 12,000 feet; its average breadth, at the surface, about 700 feet, and, at the bottom, about 100 feet. Its absolute average breadth was 400 feet; its average depth 200 feet; and its contents at least 800 millions of cubic feet.

After the 14th of June, at 11 o'clock, the floor of the gallery began to wear down, and at 5 o'clock the lake was lowered one foot. On the 15th of June, at 6 o'clock A. M. the height of the lake was diminished ten feet; twenty-four hours afterwards, it was diminished thirty-six feet; and on the 16th of June, at 6 o'clock P. M. the total diminution was forty-five feet. The effect of the gallery, therefore, had been to reduce the lake from 800 to 530 millions of cubic feet.

As soon as the water flowed from the lower end of the gallery, the velocity of the cascade melted the ice, and thus wore away the gallery at its mouth. The water which had penetrated the crevices of the glacier, caused enormous fragments of ice to fall from the lower sides of it, so that owing to these causes the body of the glacier which formed the retaining wall of the lake, was so much diminished in thickness, that the floor of the gallery was reduced from its original length of 600 to 8 feet. As soon as the cascade had cut through the cone of ice, it attacked the debris of the base of Mauvoisin, upon which the cone rested, and having carried it off by degrees, it became able to push the soft soil from the foot of Mount Mauvoisin, and excavate for itself a passage between the glacier and the rocky beds which compose the mountain. As soon as this happened, the water rushed out; the ice gave way with a tremendous crash; the lake was emptied in half an hour; and the sea of water which it contained precipitated itself into the valley with a rapidity and violence which it is impossible to describe. The fury of this raging flood was first stayed by the narrow gorge below the glacier, formed between Mont Pleureur and a projecting breast of Mont Mauvoisin. Here it was engulfed with such force, that it carried away the bridge of Mauvoisin, ninety feet above the Dranse, and even rose several fathoms above the advanced mass of the mountain. From this narrow gorge, the flood spread itself over a wider part of the valley, which again contracted into another gorge; and in this way, passing from one basin to another, it acquired new violence, and carried along with it forests, rocks, houses, barns, and cultivated land. When it reached Le Chable, one of the principal villages of the valley, the flood, which seemed to contain more debris than water, was pent up between the piers of a solid bridge, nearly fifty feet above the Dranse, and began to attack the inclined plain upon which the church and the chief part of the village is built. An additional rise of a few feet would have instantly undermined the village; but at this critical moment the bridge gave way, and carried with it the houses at its two extremities. The flood now spread itself over the wide part of the valley between Le Chable and St Branchier, undermining, destroying and hurrying away the houses, the roads, the richest crops, and the finest trees loaded with fruit. Instead of being encumbered with these spoils, the moving chaos received from them new force; and when it entered the narrow valley from St Branchier to Martigny, it continued its work of destruction till its fury became weakened by expanding itself over the great plain formed by the valley of the Rhone. After ravaging Le Bourg and the village of Martigny, it fell with comparative tranquillity into the Rhone, leaving behind it, on the plains of Martigny, the wreck of houses and of furniture, thousands of trees torn up by the roots, and the bodies of men and of animals whom it had swept away.

As the flood took half an hour in passing every point which it reached, it follows that it furnished 300,000 cubic feet of water every second,—an efflux which is five times greater than that of the Rhine below Basle.

According to M. Escher de la Linth, the velocity of the torrent, at different parts of its course, was as follows.

	Distance in feet.	No. of minutes in which it described this distance.	Velocity in feet per second.
From the glacier to Le Chable,	70,000	35	33
From Le Chable to Martigny,	60,000	55	18
From Martigny to St Maurice,	30,000	70	11½
From St Maurice to the Lake of Geneva, ...	80,000	230	6

Description of the Map, and the Perspective Views on Plate IV.

A, the Lake of Mauvoisin.
B, the Cone or Bar of snow and ice.
C, the Bridge of Mauvoisin.
D, the Glacier of Getroz.
E, the Glacier of Mont Durant.
F, the Glacier of Tzermontane.
G, Mont Pleureur.
H, Mont Getroz.
I, Mont Mauvoisin.
K, Mont Corbassu.
L, Valley of Tozembic.

1. Mont Pleureur.
2. Glacier of Getroz.
3. The Cone of snow.
4. Mont Getroz.
5. Valley of Tozembic.
6. Mont Tzermontane.
7. Glacier of Mont Durant.
8. Mont Gelé.
9. Passage of tbe Col de la Fenetre.
10. Rocks of Mauvoisin.

Art. XXXV.—*Proceedings of the Royal Society of Edinburgh.*

Nov. 9. 1818.—A Letter was read from Dr Alexander Kennedy to James Russel, Esq. giving an account of the extraction of a worm from the aqueous humour of a horse's eye, which was performed at Madras by Dr William Scott. Dr

Kennedy presented this worm to the Society. It was found by Captain Thomas Brown to be a new species of the ascaris, to which he gave the name of *Ascaris pellucidus*. In a letter, dated Madras 7th July 1818, which Dr Kennedy has subsequently received from Dr Moore, who was present at the operation, and with which he has kindly favoured us, is the following paragraph: "I received the worm, with the aqueous humour of the eye, in a cup, and it continued to move with great vivacity for some time, until I added a little water, when it instantly fell dead to the bottom of the cup."

Nov. 23.—A paper by Dr Brewster was read on the Action of Crystallized surfaces upon light. This paper was divided into two sections:

Sect. 1.—On the effects produced upon transmitted light by a change in the mechanical condition of the surfaces of crystals.

In this section a method was pointed out and explained, by which either of the images of doubly refracting crystals, could be rendered nebulous or extinguished at pleasure.

Sect. II.—On the influence of the polarising force of doubly refracting crystals upon the polarising force which accompanies partial reflection.

Under this section, the author treated

1. Of the change produced upon the polarising angle by the interior forces of doubly refracting crystals.
2. On the change produced upon the direction of the polarisation of the reflected ray by these interior forces; and
3. On the general results deduced from his experiments.

Nov. 30.—At a general meeting of the Society, the following gentlemen were elected office-bearers for 1819:

Sir James Hall, Baronet, President.

Right Honourable Lord Gray, }
Lord Glenlee, } Vice Presidents.

Professor Playfair, Secretary. James Bonar, Esq. Treasurer.

Thomas Allan, Esq. Keeper of the Museum and Library.

PHYSICAL CLASS.

Sir G. S. Mackenzie, Bart. President. Dr Thomas Charles Hope, Secretary.

Counsellors from the Physical Class.

Colonel Imrie.	Mr James Jardine.
Professor Jameson.	Honourable Captain Napier.
Dr Brewster.	Dr A. Duncan *junior*.

LITERARY CLASS.

Henry Mackenzie, Esq. President. Thomas Thomson, Esq. Secretary.

Counsellors from the Literary Class.

Professor Dunbar.	Reverend Dr Jamieson.
Reverend Mr Alison.	Reverend John Thomson.
Lord Reston.	Reverend Dr Brunton.

Dec. 3.—Professor Playfair read a paper on the Slide of Alpnach. This slide was erected by M. Rupp, in 1812, for the purpose of bringing down to the Lake of Lucerne the fine pine trees which grow upon Mount Pilatus. The wood was purchased by a company for L. 3000, and L. 9000 were expended in forming the slide. The length of the slide is about 44,000 English feet, or about eight miles and two furlongs, and the difference of level of its two extremities is about 2600 feet. It is a wooden trough, about five feet broad and four deep, the bottom of which consists of three trees, the middle one being a little hollowed, and small rills of water are conducted into it, for the purpose of diminishing the friction. The declivity, at its commencement, is about $22\frac{1}{2}°$, and Mr Playfair calculated, that a heavy body, not retarded by friction, would describe the whole length of the trough in 66″. The large pines, with their branches and boughs cut off, are placed in the slide, and descending by their own gravity, they acquire such an impetus by their descent through the first part of the slide, that they perform their journey of eight miles and a quarter in the short space of *six minutes*, and, under favourable circumstances, that is, in wet weather, in *three minutes.* Only one tree descends at a time, but by means of signals placed along the slide, another tree is launched as soon as its predecessor has plunged into the lake. Sometimes the moving trees spring or bolt out of the trough, and when this happens, they have been known to cut through trees in the neighbourhood as if it had been done by an axe. When the trees reach the lake they are formed into rafts, and floated down the Reuss into the Rhine. The very singular phenomena described in Mr Playfair's paper, arise from the diminution of friction, in consequence of an increase of velocity, and may be regarded as an experimental confirmation, on a large scale, of the ingenious views of Coulomb, who had the merit of discovering this remarkable property of friction.

Dec. 17.—Mr Fraser Tytler communicated to the Society extracts from the Journal of Mr James Baillie Fraser, giving an account of his Journey to the Sources of the Jumna and the Ganges. At p. 127. of our present number, will be found an interesting notice of this journey.

Jan. 4. 1819.—A paper by Dr Brewster was read, "On the action of uncrystallized surfaces upon light." This paper contained an account of two new classes of colours, formed by reflection, and hitherto unnoticed. One of these classes was capable of explanation by principles already known; but the other had its origin in a new property of light, which promises to be of great utility in its practical applications. The author pointed out its application to a new instrument for distinguishing precious stones, for discriminating mineral bodies, and for detecting adulteration in oils and other fluids. The instrument itself, constructed by Messrs P. & G. Dollond, was exhibited to the Society.

Jan. 18.—A paper by Dr Ferguson was read, "On the "poisonous fishes of the Carribbee Islands."

The author endeavoured to prove, that in all the larger fishes of prey, the poisonous quality was a rare and accidental occurrence, and that it was found to be present only at certain seasons of the year, in one or two of the smaller species of fish, more particularly in the yellow-billed sprat, (the sardine doré of the French, and Clupea thryssa of naturalists;) from whence he inferred, that the larger voracious fishes, such as the baracosta, (Perca major of naturalists,) &c. became poisonous only at the times they had recently been preying upon the smaller poisonous prey. The notion of these being made poisonous, from being found in copper banks, or their eating the stinging blubbers, (the Medusæ and Holothuriæ,) was refuted. In regard to tests, it was shewn, that none could be depended upon: That nothing whatever could be discovered from inspection of the fish; that the boasted test of boiling a piece of silver with the suspected fish proved nothing, whatever might be its actual quality; that so far from there being any marks of disease in the viscera, or other parts of poisonous fishes, they were generally found to be in the best season, and of the highest quality, in all respects.

The poison of the yellow-billed sprat, was supposed to be inherent in the animal at certain seasons of the year, and not occasioned by its being fed upon any undiscovered local marine poison, from the circumstance of the other smaller fishes of the same genus, that were found in the same places, never partaking of the same poisonous nature; and from the poison of the fish being more potent and deadly than any known, or even supposable article of food could be likely to communicate.

With respect to remedies and antidotes, the efficacy of sugar was alone established as deserving of credit. Wines, spirits, and the condiments used at table, were believed to have obtained occasional credit only from their being used in such slight cases of the poison, as would most likely have passed away without any remedy. As a precaution in all cases of suspicious fish of the larger species, the cleaning them out as soon as caught, was recommended as a useful and proper one, to prevent the carcase being farther tainted by the lodgement of any poisonous matter, (such as that of the yellow-billed sprat,) recently swallowed; though it was shewn at the same time, that the doing so, and even salting the fish afterwards, could not, in any instance, do away with the poisonous impregnation so communicated to these voracious creatures, whose powers of assimilation, from the shortness of the intestines, and great size of the liver, must be supposed to be infinitely quicker than what takes place amongst terrestrial animals. It was useful also in a more humble way, by furnishing the material of the only criterion hitherto discovered for detecting the poison, which was shewn to be that of giving a portion of the liver or offal, to some inferior animal, such as a cat, a duck, or a pig, and ascertaining its effects upon them, before making use of the fish.

Feb. 1.—A paper, by the Reverend Mr Brewster of Paisley, was read, entitled, "Description of a fossil tree found in a quarry at Nitishill, the property of Colonel Dunlop of House-hill." Specimens of the tree were exhibited to the Society.

At the same meeting, Mr Adie communicated to the Society an account of his new hygrometer. See p. 32. of this Number, where it is described.

At the same meeting, a paper by Dr Brewster was read, "On a new optical and mineralogical structure, exhibited in certain specimens of Apophyllite and other minerals." This paper forms the first article of the present Number.

[*To be continued.*]

Art. XXXVI.—*Proceedings of the Wernerian Natural History Society.*

Nov. 21. 1818.—Professor Jameson read a communication from Dr Adam, on the geognosy of the country around the Cape of Good Hope. This interesting account was accompanied with a neatly executed plan, representing the structure of this part of Africa. The rocks are every where distinctly disposed in strata and beds. The principal species of rocks are granite, grey-wacke, grey-wacke slate, clay-slate, and red sandstone. The grey-wacke, grey-wacke slate, clay-slate, and sandstone, are distinctly stratified, and the granite is disposed in the form of beds and veins in the three first mentioned rocks. The sandstone rests on the stratified rocks, and appears to pass into them; thus rendering it probable that the whole are members of the same formation. The observations of Dr Adam were unfavourable to the inferences in regard to the formation of these rocks by Captain Hall, Professor Playfair, and Clark Abel, Esq. This paper will appear in our next number.

Dec. 5.—The following gentlemen were elected Office-Bearers:

Robert Jameson, Esq. Prof. Nat. Hist. Edin. President.

Right Honourable Lord Gray,
John Campbell, Esq.
Sir Patrick Walker, Knight,
Thomas Mackenzie, Esq. M. P.
} Vice-Presidents.

P. Neill, Esq. Secretary. Wm. Ellis, Esq. Treasurer.

James Wilson, Esq. Librarian. P. Syme, Esq. Painter.

Council.

Dr Wright.	D. Falconar, Esq.
Dr Yule.	T. Sivright, Esq.
D. Bridges, Esq.	Dr James Gregory.
Dr D. Ritchie.	Thomas Brown, Esq.

Dec. 19.—Captain Scoresby read a paper on the size of the Greenland whale, which is inserted in this Number, p. 83.

Jan. 9. 1819.—Professor Jameson read the first part of a description of the geognostical structure of the Grampian Mountains. After detailing the general geographical features of this great range of alpine land, Professor Jameson described the N. E. extremity of the range, which may be considered as extending from Stonehaven to Aberdeen. The rocks around

Stonehaven, he described as belonging to the secondary class, and as consisting of red sandstone, with vast beds of conglomerate and trap-rock, and smaller beds of limestone and clay-ironstone. These, as we advance towards Aberdeen, are succeeded by strata of clay-slate, grey-wacke, mica-slate, and gneiss. In these strata, but particularly in the gneiss and mica-slate, are numerous veins, beds, and imbedded masses of granite, also of porphyry, felspar, hornblende-rock, &c.

Jan. 23.—Dr Hibbert read the first part of a geognostical description of the Shetland Islands, an abstract of which will be given in our next Number.

Feb. 6.—At this meeting Professor Jameson continued the reading of his geognostical description of the Grampians. He gave an account of that portion of the Grampians which extends from Fettercairn across the Cairn-o-mount to the river Dee, and continued the section across the mountains by Tomentoul to the Spey. The strata around Fettercairn are of red sandstone; at the bottom of the Cairn-o-mount these are succeeded by clay-slate, containing beds of limestone; as we ascend the mount, mica-slate and gneiss take the place of the clay-slate, and these in their turn are succeeded by granite. The granite continues nearly to the inn of Cuttieshillock, on the north side of the range. Near Cuttieshillock inn, the gneiss again appears, and continues onward to the Dee; in its course, including beds of limestone, hornblende-rock, and other members of the primitive series. From Charlestoun on the Dee, across the mountains to Tomentoul, the strata are gneiss, with vast beds of granite, also mica-slate, clay-slate, and quartz-rock, with beds and veins, and imbedded masses of granite, limestone, and of various primitive trap-rocks. The Professor described a particular formation of red sandstone near Tomentoul, and concluded by tracing the various primitive rocks, in this part of Scotland, down to the banks of the Spey.

At the same meeting, the Secretary read a communication from Mr Sivright, respecting the frequent occurrence of globules of air and water in topaz, rock-crystal, heavy-spar, and other minerals.

[*To be continued.*]

Art. XXXVII.—SCIENTIFIC INTELLIGENCE.

I. NATURAL PHILOSOPHY.

ASTRONOMY.

1. *La Place's Results respecting the Form and Structure of the Earth.*—La Place has given the following very interesting results, as deduced from analysis, and from the experiments made with the pendulum in both hemispheres.

1. That the density of the strata of the terrestrial spheroid increases from the surface to the centre.—2. That the strata are very nearly regularly disposed around the centre of gravity of the earth.—3. That the surface of this spheroid, of which the sea covers a part, has a figure a little different from what it would assume in virtue of the laws of equilibrium, if it became fluid.—4. That the depth of the sea is a small fraction of the difference of the two axes of the earth.—5. That the irregularities of the earth, and the causes which disturb its surface, have very little depth.—6. That the whole earth has been originally fluid.

"These results (says La Place) of analysis and experiment, ought, in my opinion, to be placed among the small number of truths which Geology presents."

2. *On the Libration of the Moon.*—Our astronomical readers are aware, that the moon turns round her own axis in the same time that she performs her mean revolution round the earth; that the inclination of the lunar equator to the ecliptic is constant; and that its descending node coincides with the mean ascending node of the moon's orbit. La Place has shewn, that these results are not affected by the secular equations of the moon's mean motion, nor by the secular displacements of the ecliptic. M. Poisson has shown, that they are likewise not modified by the secular equation which affects the mean motion of the moon's node, but that they correspond to the mean velocity of rotation, and a mean state of the lunar equator. The theory indicates, that this velocity, as well as the inclination of the equator, and the distance of its node from that of her orbit, are subject to periodical inequalities. La Grange has expressed by formulæ the principal inequalities of the velocity of rotation; and M. Poisson has very recently determined the inequalities of the inclination and of the node. The formulæ to which he

has been conducted are given in the *Connoissance des Tems* for 1821, p. 219. which has lately appeared; but the details of the calculus by which he obtained them, will, we suppose, be published in the Memoirs of the Institute.

3. *Repeating Circle.*—In the observations made last year by the French and English astronomers, at Dunkirk, the former discovered a constant error of about two seconds in the determination of the latitude by the repeating circle, and found that it differed in kind, according as the stars observed were on the north or south side of the zenith. The true latitude was obtained by taking a mean between the two results, as was ascertained by its agreeing exactly with the latitude found by the English astronomers, who used their incomparable instrument, the zenith sector made by Ramsden.

4. *First Comet of* 1818.—This comet, which was discovered by M. Pons at Marseilles, on the 26th December 1817, was not seen at Paris till the 29th March 1818. From the observations made in these two places, M. Nicollet has computed the following parabolic elements of its orbit:

Passage of the perihelion, mean time at Paris,	1818, Feb. 26. 6h 0′
Perihelion distance, -	1.19878
Inclination of its orbit, - -	89° 47′ 27″
Longitude of ascending node, -	70 21 10
Longitude of perihelion upon the orbit,	182 56 52
Heliocentric motion, - -	Direct.

This comet is a very remarkable one, from the singular inclination of its orbit, which is greater than that of any other that has been observed, being only 12′ 33″ from being perpendicular to the ecliptic.

5. *Second Comet of* 1818.—M. Pons of Marseilles, one of the most active of our modern astronomical observers, discovered another new comet, in the constellation Pegasus, on the 26th November 1818. The following are the results which he obtained.

			R. Ascen.	South Declin.
Nov. 30.	17h 37′	mean time	179° 38′	29° 17′
Dec. 1.	17 57		180 39	28 47

This comet, which may be seen through a night telescope, has a diameter of from five to six minutes.

The following elements of its orbit have been computed by M. Nicollet:

Passage of the perihelion, 24th Jan. 1819, 23^h 8′	Mean time reckoned from Noon.
Perihelion distance,	0.352593
Longitude of ascending node,	329° 4′ 36″
Longitude of perihelion upon the orbit,	144 15 22
Inclination of the orbit,	14 47 42
Heliocentric motion,	Direct.

This comet has been supposed to be the same as that of 1805, and M. Enke of Seeberg has computed the following elements for an elliptical orbit:

Passage of the perihelion, January 27. 1819, 3^h 13′	
Longitude of the perihelion,	156° 14′ 8″
Longitude of ascending node,	334 18 8
Perihelion distance,	9.52579
Half of the greater axis,	2.343

The larger axis of this ellipse is a little smaller than that of the orbit of Vesta, and corresponds to a revolution of about 3½ years. See *Ann. de Chim. et Phys.* Feb. 1819.

6. *Third Comet of* 1818.—On the 29th November 1818, M. Pons discovered a third comet. The following are the parabolic elements of its orbit:

Passage of the perihelion, 5th December 1818, at noon, at Paris.	
Perihelion distance,	0.85648
Longitude of ascending node,	89° 55′ 14″
Longitude of perihelion upon the orbit,	101 46 58
Inclination of the orbit,	63 10 30
Heliocentric motion,	Retrograde.

7. *Captain Kater's Verification of the Latitude of Arbury Hill.*—Such as have attended to the progress and results of the trigonometrical survey of Britain, know that the figure of the elliptic meridian, as deduced from the observations made in this country, differs from that found by observations made on the Continent, and in other parts of the world. This anomaly has given rise to various conjectures as to its cause. It has been supposed that there may have been some inaccuracy in the determination of the latitude of the station at Arbury Hill near Daventry in Northamptonshire; and accordingly mathematicians

have thought it desirable, that the observation should be repeated. This has been done lately by Captain Kater. He determined the latitude of the station with an excellent repeating circle, and found it to be almost exactly the same as had been determined by that excellent astronomer Colonel Mudge, who has so ably conducted the survey. From this it seems to follow, that the cause of the apparent irregularity in the curvature of the terrestrial meridian, must be sought for elsewhere than in the astronomical observations.

8. *Sir William Herschel's Researches respecting the Distance of the Fixed Stars.*—In a paper published in the *Phil. Trans.* 1818, Part II, this celebrated astronomer endeavours, by computations founded on the known power of his telescopes, and the probable assumption of some certain average magnitude of the fixed stars, to arrive at definite conclusions on the great problem of the arrangement of celestial objects in space. Granting that, one with another, the faintest stars are the farthest distant, their light then becomes, in some rough way, a measure of their distance, which may be compared by a series of equalisations between large and small stars, made with similar telescopes, but of different apertures. He thus concludes, that a single star of the first magnitude would be just lost to the naked eye if removed to 12 times its distance, and to the most powerful telescope hitherto constructed, if to 2300 times. Yet such an instrument still continues to shew stars in the Milky Way, at the utmost limits of their visibility. This wonderful sidereal stratum is therefore fathomless alike by our eyes and by our telescopes.

But though the light of single stars may no longer affect our organs, the united lustre of sidereal systems may reach us from a still greater profundity in space. When the stars of clusters can yet be seen in telescopes, their distances may be estimated by the aperture which just *resolves* them, and in this way we have the distances of 47 clusters actually estimated in this paper. These, in turn, become connecting links with such *ambiguous objects* as our telescopes will not resolve. It is first proved by many observations, that resolvable clusters seen with inferior telescopes, actually put on similar appearances, and the similarity of nature once established, we may compare their distances with those of the former kind, by the same principles as those with the nearest fixed star. The utmost limits of human vision seem attained when such objects are lost to the sight; and this we are led to suppose must take place about the 35000th order of distances.

9. *Asbestus Fibres recommended for Micrometers.*—Professor Wallace, of the Royal Military College, has very ingeniously suggested the application of the capillary crystals of asbestus to the purposes of micrometrical fibres. Upon mentioning this to that celebrated artist Mr Troughton, and putting into his hands a small quantity of amianthus, of a pearly whiteness, Mr Troughton applied a filament, about $\frac{1}{3000}$ of an inch in diameter, to the eye-piece of a telescope. The line was beautifully even, and considerably opaque. As the crystals seem divisible beyond the limit of the senses of seeing and feeling, it is easy to obtain fibres of any degree of tenuity.

10. *Experiment shewing that gravity acts equally upon light and heavy bodies.*—M. Benedict Prevost has devised the following simple experiment for shewing that the retardation in the fall of light bodies is owing solely to the resistance of the air. Place a piece of thin paper on the bottom of a small box, of such a weight, that in falling the bottom will always keep lowermost, and having let fall the box and the paper from the height of two or three yards above a cushion, they will both reach it at the same time; while a piece of paper of the same size let fall at the same time, will flutter slowly and obliquely to the ground. The experiment will succeed if the paper is placed on a crown or half-crown piece, without using a box.

OPTICS.

11. *Singular Optical Illusion seen in Baffin's Bay.*—Among the remarkable illusions which arise from local variations in the density, and consequently in the refractive power of the atmosphere, we are not acquainted with any more interesting than one which was more than once observed by the officers on the expedition to Baffin's Bay. Upon looking at the summits of distant mountains, they were surprised *to observe a huge opening in them, as if they had been perforated, or an arch thrown from one to another.* This effect arose from the apparent junction of the tops of the mountains, produced by a variation of density in some part of the atmosphere between the observer and the tops of

the mountains, but which did not exist at a lower level, so as to affect the inferior parts of the mountains.

12. *Dr Watt's Theory of the Rainbow.*—We have no doubt that our readers will partake in the surprise which we ourselves experienced, at seeing it gravely maintained that the *Rainbow is not produced from rain.* The learned Dr Watt of Glasgow has maintained this hypothesis in the *Annals of Philosophy* for February 1819, p. 131., and has gone so far as to say that he considers his "hypothesis as in a great measure established." He supposes that the rainbow is nothing more than a spectrum produced by the refraction of the edge of a cloud, and that the rainbow must always disappear when the sun emerges from behind this magical prism.

The following are a few out of many reasons why such a mode of formation is absolutely impossible:

1. A cloud with two perfect surfaces, capable of producing such a distinct spectrum, is a thing quite inconceivable.

2. In order that the spectrum may be always concave downwards, like the rainbow, the cloud must always take care and place its refracting angle mathematically in one position.

3. In order that the bow may appear both on the right and left of the observer, as it does in nature, the prismatic cloud must have the common section of its two refracting planes, of a circular form.

We cannot allow ourselves to offer any defence of a theory so palpably true as the ordinary theory of the rainbow. If any doubt were attached to it, it must have been completely removed by the discovery made by Dr Brewster, (*Treatise on Philosophical Instruments*, p. 350), that the light of the rainbow is actually polarised light, in consequence of its having suffered reflection nearly at the polarising angle from the posterior surface of the drops of water. Such a change upon the light could not possibly have been effected by passing through any prism whatever. This indeed is an *experimentum crucis*, which demonstrates Newton's theory to be correct, and Dr Watt's erroneous.

ACOUSTICS.

13. *Velocity of Sound.*—A series of experiments on the velocity of sound has lately been performed at San Jago in Chili, by M. D. Josef de Epinosa, and D. Felipe Bauza, who obtained the following results:

Distance in toises.	Time in which Sound moved through it.	Velocity of Sound per second. Toises.	Metres.	Barom.	Therm. centig.
43,365	38″0	190.2 or	270.7	Metre. 0.697	21°3
50,316	43.3	193.6	377.3		25.0
29,558	26.0	189.5	369.3		25.0
13,841	12.2	189.1	368.6		22.5

The mean of these results is 190.6 toises or 371.5 metres, or 1219 English feet, at a temperature of 23°.5; or if we take the two first observations, which were made at the greatest distances, we shall have 191.9 toises or 374 metres, or 1227 English feet, at the temperature of 23° of the centigrade thermometer.

14. *Poisson's Researches on Wind Instruments.*—A very able and interesting memoir on the theory of wind instruments, by that eminent mathematician M. Poisson, was read at the Institute on the 8th February 1819. An abstract of it is published in the *Ann. de Chim. et de Phys.* for Feb. 1819.

HYDRODYNAMICS.

15. *Compression of Water.*—The compressibility of water, which was long ago established by Mr Canton, and also by M. Zimmerman, has been recently examined by Professor Œrsted. He has found, contrary to the opinion of Zimmerman, that the compression of water is proportional to the compressing forces, as Canton had affirmed on the evidence of a few experiments; and that the actual compression is always three times greater than that which was found by Canton. In confirmation of his own results, M. Œrsted has shewn that the velocity of sound in water, as given by M. La Place, may be calculated from them. At 14° of Reaumur, he considers the compression of water as equal to about the 0.00013, or the thirteen hundred thousandth part of its bulk.

16. *New retaining Syphon.*—A new syphon which has the great advantage of retaining its charge, has been suggested, and used, by Mr Hunter of Thurston. It is shewn in Plate II. Fig. 3. where A, B, are two small cups fixed to the ends of the unequal branches, by two arms C C. When it is charged in the usual way, and has been in use, it will stand vertically upon the boxes A, B, as a base, so that when it is lifted by the ring D, it may be replaced, and will act as formerly. The same

effect may be produced, by turning up the ends of the branches, and fixing to them a plate or piece of metal, upon which they may stand.

ELECTRICITY.

17. *Pyro-Electricity of the Tourmaline.*—The electricity of this mineral may be shewn in a very satisfactory and beautiful manner, by means of a thin slice taken from any part of the prism. In order to perform the experiment to most advantage, the slice should have its surfaces perpendicular to the axis of the prism. It must then be placed upon a piece of well polished glass, and the glass heated to a considerable degree. At the proper temperature, which is about that of boiling water, the slice will adhere to the glass so firmly, that even when the glass is above the tourmaline, the latter will adhere to it for six or eight hours. By this means slices of a very considerable breadth and thickness develope as much electricity as is capable of supporting their own weight. The tourmaline adheres also to all metallic bodies, to wax, and all minerals that have been tried.

Mr Sivright has fitted up a tourmaline, so as to bring the action of its two poles very near to one another. It resembles the letter D, with an opening in its curved part. The straight part represents the tourmaline, and the two curved parts are pieces of silver-wire rising out of two silver caps, one of which embraces each pole of the tourmaline. When a pith ball is suspended at the opening between the extremities of the wires, it will vibrate in a very beautiful manner, in virtue of their opposite actions. Æpinus fitted up the tourmaline in a similar, but less elegant manner, than the preceding. Sir Humphry Davy has stated, (*Elements of Chemical Philosophy*, vol. i. p. 130), that "when the stone is of considerable size, flashes of light may be seen along its surface." We shall be obliged to any of our readers, who have large enough tourmalines, if they will attempt to verify this observation.

18. *Pyro-Electricity of Nadelstein.*—When the Abbé Haüy discovered the developement of electricity in the Mesotype by means of heat, the two substances called Apophyllite and Nadelstein, were comprehended under the name of Mesotype, the former being the *Mesotype epointée*, and the latter the *Mesotype aciculaire* of that mineralogist. Haüy does not appear to

have found pyro-electricity in either of these minerals, but only in the *mesotype pyramidale.* The *mesotype epointée* or apophyllite indeed, exhibits no electricity whatever by heat, as we have ascertained, with very large crystals, the largest we believe that have yet been obtained with perfect summits; but we have found that there is pyro-electricity in the *nadelstein* or *mesotype aciculaire*, the pyramidal summit having vitreous, and the root of the crystal resinous electricity *. Dr Brewster has ascertained that *Nadelstein* is quite a different substance from *Mesotype.*

19. *Electrical Fish.*—A fish resembling the *Silurus electricus* was brought on board the Congo from Embomma, upon the river Zaire. According to the accounts of the natives, it communicated a severe shock to the hand and arm, if any person touched it when alive, or, as they described the effect, " it shot through all the arm." Mr McKerrow describes it as three feet six inches long; head large, broad and compressed; mouth furnished with six long cirrhi, four on the under, and two on the upper-jaw; mandibles dentated; tongue short and eyes small; body without scales; pectoral fins near the branchial openings, the ventral fins near the anus; dorsal fins soft, and placed near the tail; upper parts of the body thickly spotted black, and the under of a yellowish white; skin exceedingly thick. *Narrative of an Expedition, &c.* under Captain Tuckey, p. 359.

MAGNETISM.

20. *Magnetic qualities of Mica.*—M. Biot of the Academy of Sciences, has lately made some very interesting experiments on the magnetic qualities of two kinds of mica, one of which came from Siberia, and the other from Zinwald in Bohemia, mixed with crystals of tin. Although these two micas are very transparent, yet M. Vauquelin found, that the Bohemian mica contained about 20 per cent. of the oxide of iron. Before he analysed the Siberian mica, M. Biot examined their magnetic properties by the ingenious method of Coulomb, of making a rectangular plate of each oscillate between the opposite poles of two strong magnets. These plates were suspended by a deli-

* In the Memoirs of the Institute, tom. i. p. 55., Haüy assures us that the pyramidal summit of mesotype possesses *resinous* electricity; and in his *Traité de Mineralogie*, vol. iii. p. 160., he says that it possesses *vitreous* electricity.

cate fibre of silk, whose torsion was insensible. The mica from Zinwald oscillated twelve times in 55″, and the Siberian mica only seven times in the same period. Hence, the magnetic forces were as $(12)^2$ to $(7)^2$, or nearly as 6.8 to 20. If we suppose, therefore, that the quantities of iron which they respectively contain are proportional to these forces, the Siberian mica must contain 6.8 per cent. of the oxide of iron, and the Bohemian mica contained 20 per cent. It is very remarkable that this result accords exactly with M. Vauquelin's analysis, which was sent to M. Biot after his own experiments were finished. M. Biot does not say that he took the precaution of making the micas oscillate at the same temperature, as it has been ascertained that the magnetic qualities of minerals that contain oxide of iron, and also those of mica, are developed more powerfully by heat. A full account of these interesting experiments will be found in the Memoirs of the Academy of Sciences for 1816.

21. *Variation of the Needle at Stockholm and at Tronyem or Drontheim, in Norway.*—The following results respecting the declination of the magnetic needle at Stockholm, have been published in the Memoirs of the Swedish Academy of Sciences.

		Variation.	
1763, 18th	May	11° 50′ 0″ West.	
1811,	June	15 51 40	
1817,	March	15 35 51	15° 35′ 4″ Mean.
1817,	April	15 34 17	

The following observations on the declination were made at Drontheim in Norway, in north latitude 63° 26′ 16″, and east longitude.

1769,	15° 25′	1777,	17° 45′
1770,	15 30	1778,	17 50
1771,	15 40	1779,	18 0
1772,	16 6	1780,	18 0
1773,	16 40	1781,	18 29
1774,	16 46	1782,	18 30
1775,	16 58	1783,	18 32 *
1776,	17 30		

22. *Diurnal Variation of the Needle.*—We are glad to observe that the very interesting and hitherto inexplicable phenomena of the daily changes in the position of the magnetic needle, are

* See Dr Clarke's *Travels*, Part iii., Sect. 1. p. 751.

likely to be observed with accuracy, and carefully recorded. Our countryman Colonel Beaufoy, has the merit of having begun these observations so early as 1813; and the Board of Longitude of France have caused an excellent apparatus by Fortin, to be placed in the Royal Observatory for the same purpose, while Marshal the Duke of Ragusa has placed a similar one at his chateau at Chatillon sur Seine. A singular change was observed both at Paris and Chatillon on the 31st October 1818, and also at Bushey Heath by Colonel Beaufoy, which M. Arago justly ascribes to the influence of the aurora borealis, which was observed at Bishopwearmouth on the same day. See *Ann. de Chim. et Phys.* Jan. 1819.

23. *Magnetic Observations made during the Arctic Expedition.*—The following table, shewing the dip and variation observed on the ice, out of the ship's attraction, contains the observations made during the Arctic Expedition that are most to be depended on:

Latitude North.	Longitude West.	Variation.	Dip.
73° 23′ 29″	57° 35′ 45″	80° 01′ 22″	
74 01 20	57 56 00	80 30 16	
75 32 00	60 85 00	88 13 00	
75 51 30	63 00 15	87 49 52	
75 58 56	64 41 15	91 17 00	
75 49 38	64 45 00	90 17 42	
75 50 30	64 42 45	91 33 22	
75 54 58	65 39 45	92 44 20	
76 29 46	72 54 00	103 41 14	85° 43′ 15.5″
76 32 45	77 18 00	107 56 16	
76 08 28	78 48 15	109 01 42	85 59 17
76 44 00	75 20 00		86 08 37
70 35 30	77 57 05	86 33 20	

II. CHEMISTRY.

24. *Thenard's recent Experiments on Oxygenated Water.*—At the meeting of the Institute, on the 29th March 1819, M. Thenard announced, that he had obtained water, which contained in weight, *double* its usual quantity of oxygen, that is 100 parts of water may absorb 88.29 of oxygen. This oxygenated water possesses remarkable properties. It is colourless, and has no smell in ordinary circumstances, but a particular odour in a vacuum. Its taste is astringent. It acts upon the skin like a sinapism. Its specific gravity is 1.45. When a drop of it is let fall upon a stratum of oxide of silver, placed at the bottom

of a glass, a detonation takes place. The oxygen of the water, and that of the oxide are disengaged; a great quantity of heat is developed, and light is produced so sensibly, as to be perceived where the darkness is not very intense. The same phenomena take place with silver, platinum, gold, osmium, iridium, rhodium, the peroxide of cobalt, &c.

25. *Hyposulphuric Acid.*—A new acid has been recently discovered by MM. Gay Lussac and Welther, which they have called *Hyposulphuric Acid*, and an account of which was communicated to the Institute of France, on the 5th April 1819. They obtained it by passing a current of sulphurous acid gas, over a solution of peroxide of manganese in water; then filtering and pouring into the liquor, a certain quantity of barytes, and causing a current of carbonic acid gas to pass over it, if there is an excess of this; then by pouring upon it sulphuric acid, the barytes is thrown down, and the new acid is obtained, which is dried under the receiver of an air-pump, by sulphuric acid. The greater number of the salts which it forms with earthy or metallic bases, are soluble, and crystallize. The hyposulphates of barytes and lime are inalterable in air; and the suberic acid and chlorine, do not decompose the hyposulphate of barytes. This new acid is composed of two proportions of sulphur, and five of oxygen.

26. *New Acid in the Viburnum Opulus.*—M. Chevreul has discovered in the fruit of the *Viburnum Opulus*, an acid in every respect similar to the *Delphinic Acid*, which he had previously discovered in the fat of the dolphin.

27. *Purpuric Acid.*—M. Vauquelin, we understand, has been engaged in repeating the experiments on the Purpuric Acid, which Dr Prout has described in the *Phil. Trans.* 1818, p. 420. He has announced, that he does not agree with Dr Prout respecting the existence of this acid, but has not yet published any of the details.

28. *Production of Light, by breaking Glass Balls filled with Oxygen.*—A very curious and important experiment has recently been made by M. Biot. It consists in breaking by means of a suitable apparatus, a ball of glass filled with oxygen gas, and placed in the receiver of an air-pump, in which as perfect

a vacuum as possible has been formed. The effect of this is to produce a brilliant light in a dark apartment.

29. *Dulong and Petit's new Experiments on Heat.*—At the sitting of the Academy of Sciences, of the 12th of April last, these eminent chemists presented the continuation of their able researches on heat *. By means of a very simple instrument of their own invention, they have made numerous experiments, and obtained several very important results respecting the capacity of bodies for caloric. One of the most important of these is, that from the proportion of the atoms of which a body is composed, its capacity for heat may be deduced, and *vice versa*. It appears also from their experiments, that the quantity of heat disengaged in chemical combinations, does not depend on the capacity of the body for heat; and, therefore, that the ordinary theory must be rejected.

30. *New vegetable Alkali called Strychnine.*—This new alkali was discovered by MM. Pelletier and Caventou in the *Strychnos ignatia*, and the *Strychnos nux vomica*. It may be obtained in very minute quadrangular prisms, terminated by pyramids. It has an intolerable bitterness. It is decomposed and carbonised at a temperature inferior to that which destroys the greater part of vegetable substances. It is composed of oxygen, hydrogen and carbon. It is almost insoluble in water, 100 grammes of water, of the temperature of 10°, dissolving only 0.015 g. of it; and 100 grammes of boiling-water dissolving 0.04. It is a very singular fact, that a solution of strychnine in cold water, though it contains only $\frac{1}{6000}$ in weight of the alkali, may be diluted with 100 times its volume of water, and yet preserve a marked degree of bitterness. The principal character of this new alkali is, that it unites with acids in forming neutral salts. M. Magendie found that it exerts a special stimulating action on the spinal marrow, and brings on a true tetanus. A quarter of a grain produced very decided effects upon a large dog. See the *Ann. de Chim. et de Phys.* Feb. 1819.

* An abstract of their published experiments, the most accurate and valuable that have yet been made on the subject of Heat, will be given in a subsequent Number of this Journal.

III. NATURAL HISTORY.

MINERALOGY.

31. *Geognosy of the Appennines.*—Professor Hausmann, who is at present engaged in geognostical investigations in Italy, in the Appennines as far as Florence, found no primitive strata, the principal portion of this part of the range being of transition rocks, viz. greywacke, clay-slate, limestone, and various subordinate beds. In many hills and valleys, the rocks were almost identical with the transition strata of the Hartz; yet in a general view, the Appennine range of transition rocks is distinguished by two striking peculiarities, viz. the great abundance of serpentine, and of diallage-rock (composed of diallage and saussurite,) and the vast beds of marble, of the finest kinds, in some of which are situated the celebrated marble quarries of Carrara.

32. *Mineralogical Society at Dresden.*—A mineralogical society has been established at Dresden, and one volume of Memoirs has just appeared, under the title, "Auswahl aus den Schriften der unter Werners mitwirkung gestifteten Gesellschaft für Mineralogie zu Dresden." We have received a copy of this work, and shall give an account of it in our next Number.

33. *New Systems of Crystallography.*—The descriptive crystallographies of Romé de Lisle and Werner, are well known, and also the mathematical system of Haüy. Very lately, this most important subject has engaged the attention of three learned and distinguished mineralogists, viz. Professor Mohs, successor to Werner in Freyberg; Dr Weiss, Professor of mineralogy, in Berlin, and M. Brochant, Professor of mineralogy in Paris. We are in possession of a full account of the method of Mohs, and also that of Weiss; and Brochant has explained his views in a work we have just received. Mr Breithaupt of Freyberg, who published the last volumes of Hoffmann's Mineralogy, has announced in Gilbert's Annalen der Physik, that he is engaged in framing a system of crystallography, which is at the same time philosophical, chemical, and according to the principles of natural history.—In our next number, we hope to be able to present our readers with a condensed view of these different systems.

34. *Heron de Ville Fosse, De la Richesse minerale.*—The valuable work of Heron de Ville Fosse, "De la Richesse minerale," in three volumes quarto, with a magnificent folio vo-

lume of plates, is just finished, and a copy has reached us, but too late for any further notice at present.

35. *Lampadius on Metallurgy.*—The extensive work on metallurgy by Lampadius of Freyberg is finished. It is very much to be regretted, that hitherto no good work on this subject has appeared in Great Britain, which may be considered as one of the first mining countries in the world. We would recommend the compilation and arrangement of such a work for this country; and are confident, that, if executed with judgment, it would be productive of very beneficial effects in our different mining districts. It is also very remarkable, that we do not possess any English work of authority on the principles and practice of mining, although on the Continent there are many good works of this description.

36. *Submarine Volcano near Shetland.*—The late Rev. George Low, author of the Fauna Orcadensis, in a tour through the Shetland Islands during the summer of 1774 (the MS. of which is in the possession of Dr Hibbert), collected some curious information from the Island of Fetlar, which appears to have fixed the site of a submarine volcano at no great distance from the British Isles. The late Andrew Bruce, Esq. of Urie, in a statistical account of the island, communicated to Mr Low, says, " In 1768, we had the visible signs of a submarine shock, which threw ashore vast quantities of shell-fish of different kinds, and of all sizes, with conger eels, and other sorts of fish, but all dead; at the same time, the sea, for several miles round, was of a dark muddy colour for several days after."

In relation to the same event, the late Mr Gordon, then minister of the Island of Fetlar, reports: " Some years ago, there was a marine eruption, or some such phenomenon, which we could not account for in any other way. There was a vast quantity of sea fish driven ashore of various kinds, and many that had never made their appearance on this coast before. Conger eels above seven feet long, but all dead. The water in the bays was so black and muddy for eight days after, that when our fishermen were hauling haddocks or any small fish, they could never discern the fish until hauled out of the water."

ZOOLOGY.

37. *Comparison of the Skull of an ancient Greek and of a Botecudo cannibal.*—It is well known, that the celebrated Professor of Natural History at Göttingen, Blumenbach, has em-

ployed many years in investigating and describing the skulls of the different races of the human species, and also of the various characteristic tribes of these races. It has always been a principal object with that distinguished naturalist, to obtain skulls of the different nations of antiquity, and he has succeeded in collecting those of Egyptians, Romans, and Germans. Very lately he has been able to add to his very extensive and valuable collection of crania one of an ancient Greek, presented to him by the Prince Royal of Bavaria. It was taken from a grave in Grecia Magna. It is particularly distinguished by the gentle and elegant curve of the brow, and the perpendicular position of the upper jaw. It may be considered as the prototype of the *antique Grecian profile*, and serves to shew that the profiles in Grecian works of art, were not, as De Pau and others say, merely "un style de dessein, adopté dans quelques écoles." Prince Maximilian of Newied, one of the most distinguished amongst the royal cultivators of natural history on the continent, and who, with a rare zeal and intrepidity, exposed himself to all the dangers and difficulties of a journey through the wilds of Brazil, has brought with him to Europe a collection of the crania of the different savage tribes he met with. Very lately he presented to Blumenbach the skull of one of the Botecudos, a tribe of cannibals who inhabit remote districts in the vast country of Brazil. We can scarcely find words to express the very striking contrast of the features of this cannibal cranium, when compared with that of the noble Hellenian already mentioned. The one is the most perfect and beautiful in form ever met with, while the other in its general aspect more nearly resembles the orang outang, than even the most characteristic skull of the Negro race.

38. *Structure of the Cuticle.*—That admirable man and excellent anatomist, the late Dr Gordon, maintained, from actual investigation, that the cuticle or scarf-skin of the human body was without pores, and had neither a true laminated nor fibrous structure. The celebrated Professor Rudolphi of Berlin, in a memoir in the Transactions of the Berlin Academy for 1814–1815, entitled "*Uber Hornbildung*," has confirmed these observations.

39. *The Colour of the different Races of Man situated in the Cuticle.*—The skin of animals is composed of two parts,—the

cuticle or scarf skin, and cutis vera or true skin; and, between these, many anatomists place a third layer, named rete mucosum. This rete mucosum, is supposed by some to be the seat of the colour of the skin, and that, therefore, it is reddish in the European and black in the Negro, and so forth. The late Dr Gordon denied its existence in the European race of the human species, but believed he had found it in the Negro. This opinion is adopted by Lawrence, in his late interesting work on the Natural History of Man. Rudolphi has lately re-examined the human skin, and declares that there is no such part as the rete mucosum, and that the colour of the different races of the human species is seated in the cuticle.

40. *Respiration of Frogs.*—It appears, from a series of curious experiments performed by M. Edwards, and detailed in the Annales de Chimie et Physique for January 1819, that frogs, toads, and lizards, are preserved alive and in health under water for weeks, by means of the air contained in the water, which they abstract, not by the lungs but by the skin.

41. *Live Lizard imbedded in a Seam of Coal.*—In the month of August 1818, when the workmen were sinking a new pit at Mr Fenton's colliery near Wakefield, and had passed through measures of stone, grey buist, blue stone, and some thin beds of coal, to the depth of 150 yards, they came to the seam of coal, about four feet thick, which they proposed to work. After excavating about three inches of it, one of the miners struck his pick into a crevice, and, having shattered the coal around into small pieces, he discovered a lizard about five inches long. It continued very brisk and lively for about ten minutes, and then drooped and died. See *Philosophical Magazine*, vol. lii. p. 377.

BOTANY.

42. *Amici's Discoveries respecting the Motion of Sap in Vegetables.*—M. Amici, professor of mathematics in the University of Modena, has constructed a reflecting microscope, in which the image is formed in one of the conjugate foci of an ellipsoidal speculum. As this instrument gives very distinct vision, it admits of the application of very high magnifying powers, and has enabled M. Amici to make several important discoveries.

One of the most curious of these, relates to the form of the orbit in which the sap circulates in vegetables. He took a small piece of water mallow, we believe, and having observed the sap circulate in a sort of elliptical orbit, he formed a ligature between the two extremities of the vegetable stem, so as to prevent the sap from passing through the ligature. The consequence of this obstruction to the motion of the sap, was to make it circulate in two elliptical orbits, one on each side of the ligature.

This remarkable experiment was shewn by Mr Amici to His Royal Highness the Archduke Maximilian, from whom we had the honour of receiving the preceding account of it. We believe that its learned author has investigated the subject with much attention, and has printed an account of his researches in the volume of the Memoirs of the Italian Society which is soon expected to reach this country.

IV. GENERAL SCIENCE.

43. *Expedition overland from Hudson's Bay to the shores of the Arctic Ocean.*—It is known that Government has fitted out two new expeditions for the arctic regions; the one intended for Baffin's Bay, and the other for Hudson's Bay, and the coast of the Arctic Ocean. The Baffin's Bay expedition is to endeavour to complete the survey left unfinished by Captain Ross, and is therefore almost entirely of a maritime nature; while the other is principally a journey on the continent of America. The party to be employed in the American expedition, consists of Lieutenant Franklin, the commanding officer, Dr Richardson of Leith, medical officer and naturalist, two Midshipmen, and two servants; in all six Europeans. They sailed about the 20th of May in one of the Hudson Bay ships, and expect to reach York Factory about the middle of August. On the intelligence they receive at that place, their future proceedings will in some measure depend; and much will no doubt be left to the discretion of the commanding officer. We do not know what his precise instructions are; but we understand that the primary object is to ascertain the north-eastern boundary of the American continent, and from thence to survey the coast to the westward as far as practicable. In prosecution of this object, we believe it is intended that the expedition should endeavour to trace the Copper-mine River to its termination in the Ocean. The prevalent opinion with geographers in England at present is, that this river, instead of running nearly due north, as described by Hearne, trends away to the eastward, and terminates in Re-

pulse Bay. Among the arguments brought forward in support of this notion, it is said, that Hearne entirely neglected to take the variation into account; and Lieutenant Franklin is in possession of a chart drawn by Matonnabbee, in which the river at its rising has the direction given to it in Hearne's chart; but afterwards it runs nearly east, and terminates on the eastern coast, nearly in the situation given to Repulse Bay in the English charts. Matonnabbee's chart is correct in the position of places, and direction of rivers known to the Hudson Bay settlers. There is a probability, then, by tracing this river to its termination, that the expedition may reach near to the north-eastern point of the continent. The expedition expect to embark in canoes, eight or ten days after their arrival at York Factory, and proceed by Cumberland House, Isle à la Crosse, &c. marked in Arrowsmith's map, to Fort Chepewyan, or, if possible, by Slave Lake. If the autumn is favourable, the party hope to reach Fort Chepewyan before the commencement of winter. The distance of this place from York Factory, by the circuitous route the expedition will be obliged to take, will be about 1400 miles. If circumstances permit, it is intended, after the party become a little inured to the severity of the winter, to endeavour to reach Big Slave Fort, (the most advanced European settlement), before spring. At this place, a party of about twenty Indians, with their wives, will be engaged; and from thence the expedition may be said to commence. They will then be left to their own resources, in a country unknown to Europeans; for Hearne's description has added little to the imperfect accounts he collected from the natives.

Dr Richardson carries with him a variety of philosophical instruments; and we understand the Admiralty have ordered from Mr Adie, for the expedition, two of his portable sympiesometers.

44. *Whirlpools, and Subterraneous Passage of the Congo.*—In examining the quantity of water which passed over a contracted part of the river Congo, Captain Tuckey, Professor Smith and Mr Fitzmaurice were all surprised at its smallness, compared with the immense volume which rolled into the ocean through its deep funnel-shaped mouth; the more so, as they had previously ascertained, in their progress upwards, that not a single tributary stream of water, sufficient to turn a mill, fell into the

river on either side, between the mouth and the cataract; and they concluded, that the only satisfactory explanation of this remarkable difference in the quantity, was the supposition that a very considerable mass of water must find its way through subterraneous passages under the slate-rocks, disappearing probably where the river first enters these schistose mountains, and forms the narrows, and rising again a little below their termination, at Point Sondie, where the channel begins to widen; and from whence to Lemboo Point, a succession of tornados and whirlpools were observed to disturb the regular current of the river. These whirlpools are described both by Captain Tuckey and Mr Fitzmaurice to be so violent and dangerous, that no vessel could attempt to approach them. Even the eddies occasioned by them were so turbulent, as frequently to resist both sails and oars, turning and twisting the boats round in every direction; and it was with the utmost difficulty that they were extricated without being swamped.

45. *Whiteness and luminosity of the Sea.*—After passing Cape Palmas, and entering the Gulf of Guinea, Captain Tuckey observed that the sea had a whitish colour, which gradually increased till they made Prince's Island. The luminosity of the sea also increased, so that at night the ship seemed to be sailing on a sea of milk. In order to discover the cause of these appearances, a bag of bunting, having its mouth extended by a hoop, was kept overboard, and by means of it they collected vast numbers of animals of various kinds, particularly pellucid *scalpæ*, with innumerable little crustaceous animals of the *scyllarus* genus attached to them, to which Captain Tuckey principally attributed the whitish colour of the water. Thirteen species of *cancer* were caught, not above one-fourth of an inch long, eight having the shape of crabs, and five that of shrimps. Among these, the *Cancer fulgens* was conspicuous. When another species was examined by the microscope in candle light, the luminous property was observed to reside in the brain, which, when the animal was at rest, resembled a most brilliant amethyst, about the size of a large pin's head; and from this there darted, when the animal moved, flashes of a brilliant silvery light.—See Captain Tuckey's *Narrative*, p. 49.

46. *Preservation of Fruits by the Carbonic Acid.*—M. Dumont, in a letter to Count Chaptal, has announced the important prac-

tical discovery, that fruits may be preserved by means of carbonic acid gas. Cherries, grapes, pears, apples and chesnuts, were placed in glass vessels, filled with carbonic acid gas, obtained from carbonate of lime by sulphuric acid. Neither the colour nor the taste of the cherries were altered at the end of fifteen days; and at the end of six weeks, they were in the same state as if they had been preserved in brandy. The details of these experiments will be found in the *Ann. de Chim. et de Phys.* Jan. 1819.

47. *Raiz Preta, or Black Emetic Root.*—The natives in the interior of Brazil use an infusion of the root of a plant, somewhat resembling ipecacuanha, with great effect in the cure of dropsy, and in destroying the dangerous effects produced by the poison of serpents. When taken, it produces vomiting, and afterwards acts most powerfully on the urinary organs, occasioning for five or six days an extraordinary flow of urine. One doze is said to be sufficient for the cure of the bite of serpents, but many are required for the removal of dropsy.

48. *Scientific Travellers in Brazil.*—It is probably not generally known, that at this moment scientific travellers are traversing all parts of Brazil, under the protection of the Portugueze, and at the expence of the Austrian, Bavarian and Tuscan Governments. On the part of Austria, the following are employed: 1. Professor Mikan for natural history in general, and botany in particular: 2. Dr Pohl as mineralogist: 3. M. Natterer for zoology: 4. M. Schott as gardener: 5. M. Socher as huntsman: 6. M. Ender as landscape-painter. 7. M. Buchberger as botanical painter, and M. Frick as natural history painter. On the part of Bavaria, 1. Dr Spix as zoologist, and 2. Professor Martinus as botanist. On the part of the Grand Duke of Tuscany, Dr Radi as naturalist.

V. PRIZE QUESTIONS AND MEDALS.

49. *Adjudication of the Copley Medal.*—The President and Council of the Royal Society of London have adjudged the Gold Medal on Sir Godfrey Copley's donation, for 1818, to Mr Robert Seppings, for his various improvements in the construction of ships, communicated to the Royal Society, and published in their Transactions.

50. *Adjudication of the Rumford Medals.*—The President and Council of the Royal Society of London have adjudged to Dr Brewster the Gold and Silver Medals on Count Rumford's donation, given every two years for the most important discoveries on Light or Heat made in any part of Europe during that period.

51. *Establishment of a Physiological Prize in France.*—A sum of money having been anonymously transmitted to the Royal Academy of Sciences in France, for the purpose of founding a Prize in Physiology, the Academy has announced that a Gold Medal of 440 francs value, will be given to the Author of the printed work or manuscript sent to them before the 1st of December 1819, which shall be considered as having contributed most to the progress of Experimental Physiology.

52. *New Fund for the Establishment of Prize Medals in Scotland.*—We have great pleasure in announcing, that the late Alexander Keith, Esq. of Ravelston, has left L. 1000, under the management of the present Mr Keith of Ravelston, Mr Keith, surgeon in Edinburgh, and Dr Brewster, for the purpose of promoting the advancement of the Arts and Sciences in Scotland. We expect to be able, in our second or third Number, to announce the particular purposes to which this liberal donation will be appropriated.

Art. XXXVIII.—*List of Patents granted in Scotland in* 1819.

1. To James Fox the younger, of Plymouth, in the county of Devon, rectifier, for his invention "of an improved method or methods of diminishing the loss in quantity and quality of ardent spirits, and other fluids, during the processes of distillation or rectification." Sealed at Edinburgh 23d January 1819.

2. To James Jeffray of Glasgow, professor of Anatomy in the University, for his invention "of combinations of, and improvements in, machinery to be moved by wind, steam, animal strength, water, or other power, by which means boats, barges, ships, or other floating vessels, may be propelled, or made to move in water, and which invention is further applicable to other useful purposes." Sealed at Edinburgh 2d March.

3. To JOHN SIMPSON of Birmingham, in the county of Warwick, slater, for his invention of "a method of constructing and making harness, on an improved principle, for horses, or any other animals used for the purpose of drawing or conveying carriages, to be called Release Harness." Sealed at Edinburgh 17th March.

4. To EDMUND HEARD of Brighton, in the county of Sussex, chemist, for his invention "of certain processes, means or methods of hardening and improving animal fats and oils, so as to manufacture therewith candles of a superior quality to those at present made from tallow." Sealed at Edinburgh 2d April.

5. To DAVID GORDON, Esq. of the city of Edinburgh, for his invention "of a portable gas lamp." Sealed at Edinburgh 23d April.

6. To JOHN NEILSON of Linlithgow, in the county of Linlithgow, glue-maker, for his invention, "That certain vegetable substances, not hitherto used by tanners and leather-dressers, may be employed in tanning and colouring leather; and that certain vegetable substances, not hitherto used by dyers, may be employed in the art of dyeing." Sealed at Edinburgh 12th April.

7. To PHILIP PINDIN of Farningham, in the county of Kent, shoemaker, for his invention "of an improvement on single and double trusses." Sealed at Edinburgh 11th May.

8. To HENRY PETER FULLER, for "An improvement in the method of preparing or procuring sulphate of soda, soda, subcarbonate of soda, and muriatic acid." Sealed at Edinburgh 11th May.

9. To JOHN THOMAS BARRY of Plough Court, Lombard Street, London, chemist and druggist, for an improved "Apparatus for distillation, evaporation, and exsiccation, and for the preparation of colours." Sealed at Edinburgh 12th May.

Explanation of figures of Granite,—(Pl. III. Fig. 1. and pp. 111, 112.)

a, Central mass of granite, surrounded by horizontal strata.
b, Bed of granite, in strata of gneiss.
c, Central mass of granite, surrounded with mantle-shaped strata.
d, Central mass of granite, surrounded by strata that dip towards it from every side.
e, Imbedded mass of granite, in horizontal strata.
f, Imbedded mass of granite, with veins shooting from it into the surrounding strata.

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PHILOSOPHICAL JOURNAL.

Art. I.—*Account of Meteoric Stones, Masses of Iron, and Showers of Dust, Red Snow, and other Substances, which have fallen from the Heavens, from the earliest period down to* 1819.

Although philosophers have devoted much of their attention to the investigation of the nature and origin of those singular substances which occasionally fall from the heavens, yet we are at the present moment as ignorant of the part of space in which they are formed, and of the manner of their formation, as we were at the very commencement of the inquiry.

As there were no analogous phenomena which could indicate the formation of hard metallic substances within the limits of our own atmosphere *, it was natural to seek for their origin in the nearest of the planets; and hence it has been very generally maintained by many distinguished individuals, that meteoric stones have their origin in the Moon, and that they are projected from her surface within the reach of the Earth's attraction, by some powerful volcanic agency. The improbability of the existence of such a high degree of volcanic force in so small a planet as the moon, has led to other speculations, and it has been maintained that meteoric stones are portions of small invisible planets circulating round the Earth †; that they are the fragments of a large planet which formerly existed between Mars and Jupiter, and of which the four small planets, Ceres, Pallas, Juno and Vesta are the remaining fragments ‡; and, lastly, that they are

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* Speaking of Meteoric Stones, M. Humboldt, who has examined this subject with much attention, remarks, that "they certainly do not belong to our atmosphere."—*Personal Narrative*, vol. iii. p. 345., Note.

† Voigt's *Magazine* 1797, or *Phil. Mag.* vol. ii. p. 1, 225, 338.

‡ *Edin. Encycl.* vol. ii. p. 641.

minerals in their primitive state, which are ejected from the interior of our own globe by volcanoes situated in the polar regions, which produce at the same time the phenomena of the northern lights *.

The last of these opinions is that of the late M. de la Grange, the most celebrated mathematician of modern times; and all his views coincide with the second hypothesis above mentioned, which had been previously proposed by Dr Brewster. La Grange supposes the bursting of a planet to be a very probable event; he maintains that meteoric stones are unchanged minerals from the interior of a planet, and he has investigated formulæ for computing the velocity with which the fragments of a burst planet must be projected, in order to move in elliptical, parabolic, or hyperbolic orbits. Assuming the initial velocity of a cannon ball at 1400 French feet per second, he has shewn that in the case of a planet situated beyond the orbit of Uranus, a velocity twelve or fifteen times greater than that of a cannon ball, would be sufficient to make the fragments move in an elliptical or parabolic orbit, whatever be their dimensions, and the directions in which they are projected.

As a high degree of interest must always be attached to a subject like the present, we have drawn up the following list of meteoric stones, &c. including all those which have fallen, up to the present time. It is taken, to a certain extent, from a list newly published by the celebrated M. Chladni of Wirtemberg †; but we have added to it several which are not included in his list, and have enlarged the account of others, from a manuscript paper on meteoric stones, drawn up by Thomas Allan, Esq., which was read some years ago to the Royal Society of Edinburgh, and which he has kindly allowed us to use. A very great number of the phenomena, as given by Chladni, we have not taken from his paper, but from a very curious work by a Jesuit, Domenico Troili, entitled *Della Caduta di un Sasso dall' aria ragionamento*, Modena 1766, and in the possession of Thomas Allan, Esq. The ingenious author of that work, proves, in the clearest manner, both from ancient and modern history, that stones had repeatedly fallen from the heavens; and nothing can shew more strikingly the universality and obstinacy of that

* La Grange, *Sur l'Origine des Cometes*, in the *Connaissance de Tems* 1814, p. 211.
† *Journal de Physique*, Oct. 1818, p. 273.

scepticism which discredits every thing that it cannot understand, than the circumstance that this work should have produced so little effect, and that the numerous falls of meteoric stones should have so long been ranked among the inventions of ignorant credulity.

CHAP. I.—CHRONOLOGICAL LIST OF METEORIC STONES.

SECT. 1.—*Before the Christian Æra.*

Division I.—Containing those which can be pretty nearly referred to a date.

A. C.

1478. The thunderstone in Crete, mentioned by Malchus, and regarded probably as the symbol of Cybele.—*Chronicle of Paros*, l. 18, 19.

1451. Shower of stones which destroyed the enemies of Joshua at Beth-horon.—*Joshua*, chap. x. v. 11 *.

1200. Stones preserved at Orchomenos.—*Pausanias.*

1168. A mass of iron upon Mount Ida in Crete.—*Chronicle of Paros*, l. 22.

705 or 704. The *Ancyle* or sacred shield, which fell in the reign of Numa. It had nearly the same shape as those which fell at the Cape and at Agram.—*Plutarch, in Num.*

654. Stones which fell upon Mount Alba, in the reign of Tullus Hostilius.— "Crebri cecidere cœlo lapides."—*Liv.* 1. 31.

644. Five Stones which fell in China, in the country of Song.—*De Guignes.*

466. A large stone at Ægospotamos, which Anaxagoras supposed to come from the sun. It was as large as a cart, and of a burnt colour. "Qui lapis etiam nunc ostenditur, magnitudine vehis, colore adusto."—*Plutarch, Pliny*, lib. ii. cap. 58.

465. A stone near Thebes.—*Scholiast of Pindar.*

461. A stone fell in the marsh of Ancona. *Valerius Maximus, Liv.* lib. 7. cap. 28.

* The word אבנים *abenim*, which, according to Parkhurst, signifies stones in general, has been translated, without any reason, *hailstones*, in our version of the Bible. In the Book of Job, however, ch. 28. v. 3., the same word is translated *stones of darkness*, meaning, says Scott, "undoubtedly metallic stones or metals which man searches out." Miss Smith, in her Translation of Job, attaches the very same meaning to the word.

343. A shower of stones fell near Rome.—*Jul. Obsequens.*

211. Stones fell in China, along with a falling star.—*De Guignes,* &c.

205 or 206. Fiery Stones.—*Plutarch, Fab. Max.* cap. 2.

192. Stone fell in China.—*De Guignes.*

176. A stone fell in the lake of Mars.—"*Lapidem in agro Crustumino in Lacum Martis de cœlo cecidisse.*" Liv. xli. 3.

90 or 89. *Eodem causam dicente, lateribus coctis pluisse, in ejus anni acta relatum est. Plin. Nat. Hist.*, lib. ii. cap. 56.

89. Two large stones fell at Yong in China. The sound was heard over forty leagues. *De Guignes.*

56 or 52. Spongy iron fell in Lucania. *Plin.*

46. Stones fell at Acilla. *Cæsar.*

38. Six stones fell in Leang in China.—*De Guignes.*

29. Four stones fell at Po in China.—*De Guignes.*

22. Eight stones fell from heaven, in China.—*De Guignes.*

12. A stone fell at Ton-Kouan.—*De Guignes.*

9. Two stones fell in China.—*De Guignes.*

6. Sixteen stones fell in Ning-Tcheon, and other two in the same year.—*De Guignes.*

Division II.—Containing those, of which the date cannot be determined.

The Mother of the Gods, which fell at Pessinus.

The stone preserved at Abydos.—*Plin.*

The stone preserved at Cassandria.—*Plin.*

The Black Stone, and also another preserved in the Caaba of Mecca.

The "Thunderbolt, black in appearance like a hard rock, brilliant and sparkling," of which the blacksmith forged the sword of Antar.—See *Quarterly Review,* vol. xxi. p. 225. and *Antar,* translated by T. Hamilton, Esq. p. 152.

Perhaps the stone preserved in the Coronation Chair of the Kings of England.

P. C. Sect. II.—*After the Christian Æra.*

A stone in the country of the Vocontini.—*Plin.*

452. Three large stones fell in Thrace.—*Cedrenus* and *Marcellini, Chronicon,* p. 29. "Hoc tempore," says Marcellinus, "tres magni lapides e cœlo in Thracia ceciderunt."

Sixth Century.—Stones fell upon Mount Lebanon and near Emisa in Syria.—*Damascius.*

About 570. Stones near Bender in Arabia.—*Alkoran*, vi. 16., and cv. 3. and 4.
648. A fiery stone at Constantinople.—*Several Chronicles.*
823. A shower of pebbles in Saxony.
852. A stone fell in Tabaristan, in July or August.—*De Sacy* and *Quatremere.*
897. A stone fell at Ahmedabad.—*Quatremere.* In 892, according to the *Chron. Syr.*
951. A stone fell near Augsburg.—*Alb. Stad* and others.
998. Two stones fell, one near the Elbe, and the other in the town of Magdeburg.—*Cosmas* and *Spangenberg.*
1009. A mass of iron fell in Djordjan.—*Avicenna.*
1021. Stones fell in Africa between the 24th July and the 21st of August.—*De Sacy.*
1112. Stones or iron fell near Aquileja.—*Valvasor.*
1135 or 1136. A stone fell at Oldisleben, in Thuringia.—*Spangenberg* and others.
1164. During Pentecost iron fell in Misnia.—*Fabricius.*
1198. A stone fell near Paris.
1249. Stones fell at Quedlinbourg, Ballenstadt and Blankenburg, on the 26th July.—*Spangenberg* and *Rivander.*
Thirteenth Century.—A stone fell at Wurzburg.—*Schottus, Phys. Cur.*
Between 1251 and 1363. Stones fell at Welixoi-Ussing in Russia.—*Gilbert's Annal.* tom. 35.
1280. A stone fell at Alexandria in Egypt.—*De Sacy.*
1304. Oct. 1. Stones fell at Friedland or Friedberg.—*Kranz* and *Spangenberg.*
1305. Stones fell in the country of the Vandals.
1328, Jan. 9. In Mortahiah and Dakhaliah.—*Quatremere.*
1368. A mass of iron in the Duchy of Oldenburg.—*Siebrand, Meyer.*
1379, May 26. Stones fell at Minden in Hanover.—*Lerbecius.*
1438. A shower of spongy stones at Roa, near Burgos in Spain. —*Proust.*
A stone fell near Lucerne.—*Cysat.*
1491, March 22. A stone fell near Crema.—*Simoneta.*
1492, Nov. 7. A stone of 260 lb. fell at nsisheim near Stur-

gau, in Alsace. It is now in the library of Colmar, and has been reduced to 150 lb.—Trithemius, *Hirsaug. Annal.*, Conrad Gesner, *Liber de Rerum fossilium Figuris, cap.* 3. *p.* 66. in his *Opera, Zurich* 1565.

1496, Jan. 26. or 28. Three stones fell between Cesena and Bertonori.—*Buriel* and *Sabellicus.*

1510. About 1200 stones, one of which weighed 120 lb. and and others 60 lb. fell in a field near the river Abdua. "Color ferrugineus, durities eximia, odor sulphureus."—Surius, *Comment.*, Cardan, *De rerum Varietate*, lib. xiv. c. 72.

1511, Sept. 4. Several stones, some of which weighed 11 lb. and others 8 lb. fell at Crema.—*Giovanni del Prato*, and others.

1520, May. Stones fell in Arragon.—*Diego de Sayas.*

1540, April 28. A stone fell in the Limousin.—*Bonav. de St Amable.*

Between 1540 and 1550. A mass of iron fell in the forest of Naunhoff.—*Chronicle of the Mines of Misnia.*

—— Iron fell in Piedmont.—*Mercati* and *Scaliger.*

1548, Nov. 6. A black mass fell at Mansfeld in Thuringia.—*Bonav. de St Amable.*

1552, May 19. Stones fell in Thuringia near Schlossingen.—*Spangenberg.*

1559. Two large stones, as large as a man's head, fell at Miscolz in Hungary, which are said to be preserved in the Treasury at Vienna.—*Sthuansi.*

1561, May 17. A stone, called the *Arx Julia*, fell at Torgau and Eilenborg.—*Gesner* and *De Boot.*

1580, May 27. Stones fell near Gottingen.—*Bange.*

1581, July 26. A stone, 39 lb. weight, fell in Thuringia. It was so hot that no person could touch it. *Binhard, Olearius.*

1583, Jan. 9. Stones fell at Castrovillari. *Casto, Mercati,* and *Imperati.*

—— in the Ides of Jan. A stone of 30 lb. resembling iron, fell at Rosa in Lavadie.

—— March 2. A stone fell in Piedmont of the size of a granade.

1591, June 19. Some large stones fell at Kunersdorf.—*Lucas.*

1596, March 1. Stones fell at Crevalcose.—*Mittarelli.*

In the 16th century, not in 1603. A stone fell in the kingdom of Valencia.—*Cæsius* and the *Jesuits of Coimbra.*

1618, August. A great fall of stones took place in Styria.—*Stammes.*

—— A metallic mass fell in Bohemia.—*Kronland.*

1621, April 17. A mass of iron fell about 100 miles S. E. of Lahore.—*Jehan Guir's Memoirs.*

1622, Jan. 10. A stone fell in Devonshire.—*Rumph.*

1628, April 9. Stones fell near Hatford in Berkshire; one of them weighed 24 lb.—*Gent. Mag.* Dec. 1796.

1634, Oct. 27. Stones fell in Charollois.—*Morinus.*

1635, June 21. A stone fell at Vago in Italy.

—— July 7, or Sept. 29. A stone, weighing about 11 oz. fell at Calce.—*Valisnieri,* Opere, vi. 64.

1636, March 6. A burnt looking stone fell between Sagan and Dubrow in Silesia.—*Lucas* and *Cluverius.*

1637, Nov. 29. Gassendi says a stone, of a black metallic colour, fell on Mount Vaision, between Guilliaume and Perne in Provence. It weighed 54 lb. and had the size and shape of the human head. Its specific gravity was 3.5.—*Gassendi, Opera,* p. 96, Lyons, 1658.

1642, August 4. A stone, weighing 4 lb. fell between Woodbridge and Aldborough in Suffolk.—*Gent. Mag.* Dec. 1796.

1643, or 1644. Stones fell in the sea.—*Wuofbrain.*

1647, Feb. 18. A stone fell near Fwicxau.—*Schmid.*

—— August. Stones fell in the bailliage of Stolzenem in Westphalia.—*Gilbert's Annal.*

Between 1647 and 1654, A mass fell in the sea.—*Willman.*

1650, August 6. A stone fell at Dordrecht.—*Senguesd.*

1654, March 30. Stones fell in the Island of Funen.—*Bartholinus.*

A large stone fell at Warsaw.—*Petr. Borellus.*

A small stone fell at Milan, and killed a Franciscan.—*Museum Septalianum.*

1668, June 19. or 21. Two stones, one 300 lb. and the other 200 lb. weight, fell near Verona.—Legallois, *Conversations,* &c. Paris 1672, Valisnieri, *Opere,* ii. p. 64. 66., *Montanan* and *Francisco Carli,* who published a letter, containing several curious notices respecting the fall of stones from the heavens.

1671, Feb. 27. Stones fell in Suabia.—*Gilbert's Ann.* tom. xxxiii.

1673. A stone fell in the fields near Dietling. "Nostris temporibus in partibus Galliæ Cispadanæ, lapis magnæ quantitatis e nubibus cecidit."—See Leonardus, *de Gemmis*, lib. i. cap. 5., and *Memorie della Societa Colombaria Fiorentina*, 1747, vol. i. diss. vi. p. 14.

1674, Oct. 6. Two large stones fell near Glaris.—*Scheuchzer.*

Between 1675 and 1677. A stone fell into a fishing-boat near Copinshaw.—Wallace's *Account of Orkney*, and *Gent. Mag.* July 1806.

1677, May 28. Several stones, which probably contained copper, fell at Ermundorf near Roosenhaven. Misi, *Nat. Cur.* 1677. App.

1680, May 18. Stones fell at London.—*King.*

1697, Jan. 13. Stones fell at Pentolina near Sienna.—*Soldani* after *Gabrieli.*

1698, May 19. A stone fell at Walhing.—*Scheuchzer.*

1706, June 7. A stone of 72 lb. fell at Larissa in Macedonia. It smelled of sulphur, and was like the scum of iron.—*Paul Lucas.*

1722, June 5. Stones fell near Scheftlas in Freisingen.—*Meichelbeck.*

1723, June 22. About thirty-three stones, black and metallic, fell near Plestowitz in Bohemia.—*Rost* and *Stepling.*

1727, July 22. Stones fell at Lilaschitz in Bohemia.—*Stepling.*

1738, August 18. Stones fell near Carpentras.—*Castillon.*

1740, Oct. 25. Stones fell at Rasgrad.—*Gilbert's Annal.* tom. L.

—— to 1741. A large stone fell in winter in Greenland.—*Egede.*

1743. Stones fell at Liboschitz in Bohemia.—*Stepling.*

1750, Oct. 1. A large stone fell at Niort near Coutance.—*Huard* and *Lalande.*

1751, May 26. Two masses of iron of 71 lb. and 16 lb. fell in the district of Agram, the capital of Croatia. The largest of these is now in Vienna.

1753, Jan. A stone fell in Germany, in Eichstadt.—*Cavallo,* iv. 377.

—— July 3. Four stones, one of which weighed 13 lb. fell at Strkow, near Tabor.—*Stepling,* "*De Pluvia lapidea, anni 1753 ad Strkow, et ejus causis, meditatio,*" p. 4. Prag. 1754.

—— Sept. Two stones, one of 20 lb. and the other of 11 lb. fell near the villages of Liponas and Pin in Brene.—*Lalande* and *Richard.*

1755, July. A stone fell in Calabria, at Terranuova, which weighed 7 lb. 7½ oz.—*Domin. Tata.*

1766, end of July. A stone fell at Albereto in Modena.—*Troili.*

—— August 15. A stone fell at Novellara.—*Troili.*

1768, Sept. 13. A stone fell near Luce in Maine. It was analyzed by Lavoisier, &c. *Mem. Acad. Par.*

A stone fell at Aire.—*Mem. Acad. Par.*

1768, Nov. 20. A stone, weighing 38 lb., fell at Mauerkirchen in Bavaria.—*Imhof.*

1773, Nov. 17. A stone, weighing 9 lb. 1 oz., fell at Sena in Arragon.—*Proust.*

1775, Sept. 19. Stones fell near Rodach in Cobourg.—*Gilbert's Annal.* tom. xxiii.

—— or 1776. Stones fell at Obruteza in Volhynia.—*Gilbert's Annal.* tom. xxxi.

1776 or 1777, Jan. or Feb. Stones fell near Fabriano.—*Soldani* and *Amoretti.*

1779. Two stones, weighing 3½ oz. each, fell at Pettiswoode in Ireland.—*Bingley*, in *Gent. Mag.* Sept. 1796.

1780, April 1. Stones fell near Beeston in England.—*Evening Post.*

1782. A stone fell near Turin.—*Tata* and *Amoretti.*

1785, Feb. 19. Stones fell at Eichstadt.—*Pickel* and *Stalz.*

1787, Oct. 1. Stones fell in the province of Charkow in Russia. —*Gilbert's Annal.* tom. xxxi.

1790, July 24. A great shower of stones fell at Barbotan near Roquefort, in the vicinity of Bourdeaux. A mass, 15 inches in diameter, penetrated a hut, and killed a herdsman and a bullock. Some of the stones weighed 25 lb. and others 30 lb.—*Lomet.*

1791, May 17. Stones fell at Cassel-Berardenga, in Tuscany.—*Soldani.*

1794, June 16. Twelve stones, one of which weighed 7⅞ oz. fell at Sienna. Howard and Klaproth have analysed these stones. —*Phil. Trans.* 1794, p. 103.

1795, April 13. Stones fell at Ceylon.—*Beck.*

—— Dec. 13. A large stone, weighing 55 lb., fell near Wood Cottage in Yorkshire. No light accompanied the fall.—*Gentleman's Mag.* 1796.

1796, Jan. 4. Stones fell near Belaja-Ferkwa in Russia.—*Gilbert's Annal.* tom. xxxv.

—— Feb. 19. A stone of 10 lb. fell in Portugal.—Southey's *Letters from Spain.*

1798, March 8. or 12. Stones, one of which was the size of a calf's head, fell at Sales.—*Marquis de Drée.*

—— Dec. 19. Stones fell in Bengal.—*Howard, Lord Valentia.*

1799, April 5. Stones fell at Batanrouge on the Mississippi.—*Belfast Chronicle of the War.*

1801. Stones fell on the Island of Tonneliers.—*Bory de St Vincent.*

1802, Sept. Stones fell in Scotland.—*Monthly Magazine,* Oct. 1802 *.

1803, April 26. A great fall of stones took place at Aigle. They were about three thousand in number, and the largest weighed about 17 lb.

—— Oct. 5. Stones fell near Avignon.—*Bibl. Brit.*

—— Dec. 13. A stone fell near Eggenfelde in Bavaria, weighing 3½ lb.—*Imhof.*

1804, April 5. A stone fell at Possil, near Glasgow.

——,–1807. A stone fell at Dordrecht.—*Van Beek. Culkoen.*

1805, March 25. Stones fell at Doroninsk in Siberia.—*Gilbert's Annal.* tom. xxix. and xxxi.

—— June. Stones, covered with a black crust, fell in Constantinople.

1806, March 15. Two stones fell at St Etienne and Valance; one of them weighed 8 lb.

—— May 17. A stone weighing 2½ lb. fell near Basingstoke in Hampshire.—*Monthly Magazine.*

1807, March 13. (June 17. according to Lucas,) A stone of 160 lb. fell at Fimochin, in the province of Smolensko in Russia.—*Gilbert's Annal.*

—— Dec. 14. A great shower of stones fell near Weston in Connecticut. Masses of 20 lb. 25 lb. and 35 lb. were found. —*Silliman* and *Kingsley.*

1808, April 19. Stones fell at Borgo San-Donino.—*Guidotti* and *Spagnoni.*

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* We have inserted this notice from Chladni, though we believe that no stones fell in Scotland at the time here mentioned.

1808, May 22. Stones weighing 4 lb. or 5 lb. fell near Stannern in Moravia.—*Bibl. Brit.*

—— Sept. 3. Stones fell at Lissa in Bohemia.—*De Schreibers.*

1809, June 17. A stone of 6 oz. fell on board an American vessel in latitude 30° 58′ N., and longitude 70° 25′ W.—*Bibl. Brit.*

1810, Jan. 30. Stones, some of which weighed about 2 lb. fell in Caswell county, North America.—*Phil. Mag.* vol. xxxvi.

—— July. A great stone fell at Shahabad in India. It burned five villages, and killed several men and women.—*Phil. Mag.* xxxvii. p. 236.

—— Aug. 10. A stone weighing 7¾ lb. fell in the county of Tipperary in Ireland.—*Phil. Mag.* vol. xxxviii.

—— Nov. 23. Stones fell at Mortelle, Villerai, and Moulin-brulé, in the department of the Loiret; one of them weighed 40 lb., and the other 20 lb.—*Nich. Journal*, vol. xxxix. p. 158.

1811, March 12. or 13. A stone of 15 lb. fell in the village of Konglinhowsh, near Romea in Russia.—Bruce's *American Journal*, No. 3.

—— July 8. Stones, one of which weighed 3¼ oz., fell near Balanguillas in Spain.—*Bibl. Brit.* tom. xlviii. p. 162.

1812, April 10. A shower of stones fell near Thoulouse.

—— April 15. A stone, the size of a child's head, fell at Erxleben. A specimen of it is in the possession of Professor Haussman of Brunswick.—*Gilbert's Annal.* xl. and xli.

—— Aug. 5. Stones fell at Chantonay.—*Brochant.*

1813, March 14. Stones fell at Cutro in Calabria, during a great fall of red dust.—*Bibl. Brit.* Oct. 1813.

—— Sept. 9. and 10. Several stones, one of which weighed 17 lb. fell near Limerick in Ireland.—*Phil. Mag.*

1814, Feb. 3. A stone fell near Bacharut in Russia.—*Gilbert's Annal.* tom. L.

—— Sept. 5. Stones, some of which weighed 18 lb. fell in the vicinity of Agen.—*Phil. Mag.* vol. xlv.

—— Nov. 5. Stones, of which nineteen were found, fell in the Doab in India.—*Phil. Mag.*

1815, Oct. 3. A large stone fell at Chassigny near Langres.—*Pistollet.*

1816. A stone fell at Glastonbury in Somersetshire.—*Phil. Mag.*

1817, May 2. and 3. There is reason to think, that masses of stone fell in the Baltic after the great meteor of Gottenburg. —*Chladni.*

1818, Feb. 15. A great stone appears to have fallen at Limoge, but it has not been disinterred.—*Gazette de France*, Feb. 25. 1818.

—— July 29. O. S. A stone of 7 lb. fell at the village of Slobodka in Smolensko. It penetrated nearly sixteen inches into the ground. It had a brown crust with metallic spots.

Chap. II.—List of Masses of Iron supposed to have fallen from the Heavens.

Sect. I.—*Spongy or Cellular Masses containing Nickel.*

1. The mass found by Pallas in Siberia, to which the Tartars ascribe a meteoric origin.—*Voyages de Pallas*, tom. iv. p. 545. *Paris* 1793.
2. A fragment found between Eibenstock and Johanngeorgenstadt.
3. A fragment probably from Norway, and in the imperial cabinet of Vienna.
4. A small mass weighing some pounds, and now at Gotha.
5. Two masses in Greenland, out of which the knives of the Esquimaux were made.—See our last Number, p. 154, 155, and Ross's *Account of an Expedition to the Arctic Regions.*

Sect. II.—*Solid Masses where the Iron exists in Rhomboids or Octohedrons, composed of Strata, and containing Nickel.*

1. The only fall of iron of this kind, is that which took place at Agram in 1751.
2. A mass of the same kind has been found on the right bank of the Senegal.—*Compagnon, Forster, Goldberry.*
3. At the Cape of Good Hope; Stromeyer has lately detected cobalt in this mass.—*Van Marum* and *Dankelman; Brande's Journal*, vol. vi. 162.
4. In different parts of Mexico.—*Sonneschmidt, Humboldt,* and the *Gazette de Mexico*, tom. i. and v.
5. In the province of Bahia in Brazil. It is seven feet long, four feet wide, and two feet thick, and its weight about 14,000 lb.—*Mornay* and *Wollaston*, *Phil. Trans.* 1816, p. 270, 281.

6. In the jurisdiction of San Jago del Estera.—*Rubin de Cœlis,* in the *Phil. Trans.* 1788, vol. lxxviii. p. 37.
7. At Elbogen in Bohemia.—*Gilbert's Annal.* xlii. and xliv.
8. Near Lenarto in Hungary.—*Ditto,* xlix.

The origin of the following masses seems to be uncertain, as they do not contain nickel, and have a different texture from the preceding :

1. A mass found near the Red River, and sent from New Orleans to New York.—*Journ. des Mines* 1812, *Bruce's Journ.*
2. A mass at Aix-la-Chapelle containing arsenic.—*Gilbert's Annal.* xlviii.
3. A mass found on the hill of Brianza in the Milanese.—*Chladni* in *Gilbert's Annal.* L. p. 275.
4. A mass found at Groskamdorf, and containing, according to Klaproth, a little lead and copper.

Chap. III.—List of Falls of Dust and other Substances, either of a soft, dry, or humid nature.

P. C. 472, Nov. 5. or 6. A great fall of black dust, probably at Constantinople, during which the heavens seemed to burn. —*Procopius, Marcellinus, Theophanes, &c.*

652. A shower of red dust fell at Constantinople.—*Theophanes, Cedrenus.*

743. Dust fell in different places, accompanied with a meteor. —*Theophanes.*

Middle of the 9th century, red dust, and matter like coagulated blood, fell from the heavens.—*Kazwini, Elmazen.*

929. A fall of red sand took place at Bagdad.—*Quatremere.*

1056. Red snow fell in Armenia.—*Matth. Eretz.*

1110. A burning body fell in the Lake of Van in Armenia, and made its waters blood red. The earth was cleft in several places.—*Matth. Eretz.*

1416. Red rain fell in Bohemia.—*Spangenberg.*

In the same century, matter like coagulated blood, fell along with a stone at Lucerne.—*Cysat.*

1501. According to several chronicles, a shower of blood fell at several places.

1548, Nov. 6. A red substance like coagulated blood, fell with a meteor, probably in Thuringia.—*Spangenberg.*

1560. On the day of Pentecost, red rain fell at Embden and Louvaine.—*Fromond.*

—— Dec. 24. A meteor and red rain fell at Lillebonne.—*Natalis Comes.*

1586, Dec. 3. Red and black matter fell at Verde in Hanover, with thunder and lightning.—*MSS. of Salomon.*

1591. A shower of blood fell at Orleans.—*Lemaire.*

1618, Aug. A shower of blood, stones, and a meteor, fell in Styria.—*De Hammer.*

1637, Dec. 6. Much black dust fell in the Gulf of Volo and in Syria.—*Phil. Trans.* i. p. 377.

1638. Red rain fell at Tournay.

1640, Oct. 6. Red rain fell at Brussels.—*Kronland* and *Wendelinus.*

1645, Jan. 23. or 24. Red rain fell at Bois-le-duc.

1689. Red dust fell at Venice, &c.—*Valisnieri.*

1711, May 5. and 6. Red rain at Orsion in Sweden.—*Act. Lit. Sueciæ*, 1731.

1718, March 24. Gelatinous matter fell, with a globe of fire, in the Isle of Lethy in India.—*Barchewitz.*

1719. Sand fell in the Atlantic, latitude 45° N., and longitude 322° 45′ from Paris.—*Mem. Acad. Par.* 1719. *Hist.* p. 23.

1744. Red rain fell at St Pierre d'Arena near Genoa.—*Richard.*

1755, Oct. 20. Black dust fell in Shetland, particularly at Scalloway. It was like lamp black, and smelt strongly of sulphur.—*Phil. Trans.* vol. L. p. 297.

—— Nov. 13. The sky was red, and red rain fell in different countries.—*Nov. Act. Nat. Cur.* tom. ii.

1763, Oct. 9. Red rain fell at Cleves, Utrecht, &c.—*Mercurio Hist. y Polit.* Madrid, Oct. 1764.

1765, Nov. 14. Red rain fell in Picardy.—*Richard.*

1781, April 24. Count Gioeni observed, in the third region of Mount Ætna, every thing "to be wet with a coloured cretaceous grey rain," which, after evaporation, left every place covered with it to the height of two or three lines. All iron-work touched by it became rusty.—*Phil. Trans.* 1782, vol. lxxii. p. 1.

1796, March 8. A viscous matter fell along with a meteor in Lusatia. It had the colour and odour of dried brown varnish, and is supposed by Chladni to consist of sulphur and iron. *Gilbert's Annal.* lv.

1803, March 5. and 6. A shower of red snow or dust, fell at Pezzo, at the extremity of the Valle Camonica. It was preceded by a violent wind on the 5th. A similar shower fell in Carniola on the same days, and another shower of a rose colour fell over the whole surface of Carnia, Cadore, Belluno, and Feltri, to the height of five feet ten inches. White snow had previously fallen, and the red shower was again succeeded by white snow. The colouring matter consisted of silex, alumina, and oxide of iron.—*Opuscoli Scelti*, tom. xxiii., *Journ. de Physique*, Ap. 1804; and *Giornali di Fisica*, Nov. 9. Dec. 1818.

1813, March 13. and 14. Much red dust, red snow, and red rain, fell in Calabria, Tuscany, and Friuli, at the time of the fall of meteoric stones at Cutro. Snow and hail, of a yellow-red colour, fell over all Tuscany, with a north wind. Snow, of a brownish-yellow colour, fell at Bologna, the wind being south-west.—*Bibl. Brit.* Oct. 1813, and April 1814. According to Sementini, this dust contained,

Silex, - -	33	Chrome, - -	1
Alumina, -	$15\frac{1}{2}$	Carbon, -	9
Lime, - -	$11\frac{1}{4}$	Loss, - -	$15\frac{3}{4}$
Iron, -	$14\frac{1}{2}$		100

1814, July 3. and 4. A great fall of black dust took place in Canada, with the appearance of fire.—*Phil. Mag.* xliv. 191.

—— Nov. 5. In the fall of meteoric stones in the Doab, each stone was found to be surrounded with a mass of dust.—*Phil. Mag.*

1815. About the end of September, the South Sea was covered with dust to a great extent.—*Phil. Mag.* July 1816, p. 73.

1816, April 15. Brick red snow fell on Tonal and other mountains in Italy. The earthy powder was composed of

Silex, -	8 grains.	Empyreumatic oil,	2
Iron, -	5	Carbon, -	2
Alumina, -	3	Watery ingredients,	2
Lime, -	1	Loss, - -	2.25
Carbonic acid,	0.05		
Sulphur, -	0.25		26.

Art. II.—*On the Tides of the Mediterranean, and the occasional luminous appearances of its Waters.* By Henry Robertson, M. D. Member of the Literary Society of Athens, Physician Extraordinary to his Royal Highness the Duke of Kent, &c. Communicated by the Author.

While at Venice, in the months of April and May 1817, I was very much surprised by perceiving the regular succession of tides in the Mediterranean, surrounding that city, as I was by no means prepared to expect this, either by previously conversing with travellers on subjects of inquiry regarding that sea, or by what had occurred to myself during a residence of several years on other parts of its coasts. It is a commonly received opinion, that there are no tides in the Mediterranean, an opinion which, with the exception above mentioned, I am not disposed to dispute; at the same time, from attentive observation, I am persuaded that the Mediterranean Sea does undergo a sensible elevation and depression of its waters; which regularly recur within the twenty-four hours, but which are by no means so remarkable, or perhaps so regular, as the ebb and flow even of the neap-tides in the ocean.

On the open shores of the Mediterranean, the highest elevation, and greatest depression appeared to me to be about two feet in calm weather *; it also appeared greater at periods corresponding to the spring-tides of the ocean, and was greatly increased on the blowing of the wind towards the coast. I have also observed a regular recurrence of the tides in that part of the Mediterranean surrounding Venice. Within its entrance at Malomocco, the tides are regular, an ebb and flow taking place every twelve hours, in which it appeared to me that the waters could not be less elevated than from eight to ten feet. This I estimated by seeing, that on the flow, boats easily floated over banks that at the ebb were dry, and elevated several feet above the water, and which I had an opportunity of remarking for the period of eighteen days, from the windows of the Lazaretto.

* The Chevalier D'Angos observed a rise of *one foot* at Toulon three and a half hours after the Moon passed the meridian.—Ed.

That portion of the Adriatic in which the city of Venice is built, is separated from the rest of the Mediterranean by a narrow embankment of land, stretching from the Italian coast within the mouths of the Po, and joining a small peninsula opposite, not far from Treviso; through this embankment the openings to the Adriatic are shallow, narrow, and, with the exception of that by Malomocco, are extremely dangerous and difficult.

I apprehend there is a regularity of the tides in other parts of the Mediterranean, greater and more remarkable than what is observed to take place on the coasts of that sea, where it is open, and not intercepted by islands or headlands. Thus, Chateaubriand, in vol. i. p. 123 of his Travels, when speaking of his visit to the Pyræus, in the Gulf of Ægina, says, "M. Favel stopped in the curvature formed by a neck of land, to shew me a sepulchre excavated in the rock; it is now without roof, and is upon a level with the sea. By the regular flowing and ebbing of the tide, it is alternately covered and left exposed by turns, full and empty." During a transitory abode on the banks of the Lago di Guarda, I was fully persuaded that it is also subject to an elevation and depression of its waters, which seemed to me to recur regularly, and independently of the melting of the snows on the summits of the surrounding Alps, for I have seen the rise recur after sunset, and we know that all alpine rivers are fuller during the day, and in the summer, than when the sun is off the horizon, or in the winter.

In addition to these observations respecting the tides of the Mediterranean, I beg leave to offer what I have remarked respecting the very luminous appearance of its waters on the slightest agitation, so frequently perceived after sunset, especially during the warm season. By many people this has been supposed to be caused by certain minute luminous insects existing in the water *, to the disengagement of phosphorus from the excrements, or remains of fishes that have died, and other putrid matters. By seamen, this luminous appearance from the slightest agitation, has been considered as generally the precursor of blowing weather, and I am persuaded from repeated observation, that the remark is as correct as it is general. This

* See our last Number, p. 217. Ed.

luminous appearance is but rarely met with during the winter season, compared to the frequency with which it occurs in the summer and autumn. I have never seen it when the wind blows fresh from a northerly point, or when the temperature of the air is low; nor have I remarked it in any great degree, but in calm weather, when the temperature of the air was high, and especially as the wind was changing towards a southerly point, and I have always observed that this luminous matter was emitted most strongly immediately preceding the fall of rain or an overcasting of the sky, shewing a disposition to the formation of that meteor. Upon the whole, I am of opinion, that this appearance of light on the agitation of the waters of the Mediterranean, is somehow or other connected with evaporation, and that it is occasioned by the rapid evolution of the electric fluid in that process; that probably it rarely depends on phosphoric matters existing in the waters; and after repeated and careful observations by myself and others, I have never been able to trace its appearance as depending on the existence of insects, nor could I ever perceive any thing peculiar in the sensible qualities of water taken up in such circumstances, or that was different from water of the sea when it did not give out this luminous appearance. Moreover, as this appearance is only perceived on the agitation of the water, it would therefore seem that the luminous matter, whatever it may be, does not depend on a matter that is merely blended or mixed in the water, as in such a state its appearance would be equally manifest in a calm, as when there is a gentle ripple on the surface; and it must have been equally discernible in all conditions of the weather; and what I consider as tending to corroborate my opinion, that the electric fluid is generally the cause of this shining appearance, an ingenious Greek physician informed me that he found it always extremely difficult to accumulate the electric fluid in his apparatus on such occasions. In support, however, of the opinion I entertain of the cause of the luminous appearance of the Mediterranean Sea, I may adduce the observations of M. Golbery on this question, as given in the second volume of his Voyage to the Coast of Africa. At the same time, I do not mean to deny that this appearance may be occasionally produced by other causes.

Isle of Thanet, Margate, *March* 1. 1819.

Art. III.—*Account of the Experiments of Morichini, Ridolfi, Firmas, and Gibbs, on the Influence of Light in the developement of Magnetism.*

During the last ten years, the curiosity of philosophers has been frequently excited by notices in the foreign journals, respecting a singular property of the violet light of the spectrum, in virtue of which it is capable of communicating magnetism to small needles, or bars of steel. This effect, though by no means contradictory to any of the established principles of physics, has, in general, been discredited both in this country and in France; and those who have readily believed in the existence of invisible rays at one end of the spectrum, and of deoxidating rays at the other end, upon the testimony of the few eminent men who had repeated the experiments of Herschel and of Wollaston, still continue to resist the evidence of the respectable and distinguished individuals who have actually seen needles magnetised by the violet rays.

Dr Morichini, an ingenious and highly respectable physician in Rome, was the first person who discovered this property of the violet rays. At that season of the year when the light of the sun is most powerful, he admitted it into his chamber, and having formed the coloured spectrum by means of a prism, he collected the violet rays in the focus of a convex lens, and, by moving the lens parallel to the steel needle, he made the focus of the violet rays pass from the middle of one extremity of the needle to the other, and always in the same direction, without touching the other half. By continuing this operation for nearly an hour, the needle was found to be completely magnetised. This remarkable experiment was frequently repeated by Morichini with the same success, and was also performed in the presence of many Italian and English philosophers. When we had the pleasure of meeting our eminent countryman Sir Humphry Davy at Geneva in 1814, on his return from Italy, he informed us, that he had watched with the greatest attention the whole progress of one of Morichini's experiments, and had the most thorough conviction of its accuracy. The needle was distinctly magnetised; and though it was within the limits of possibility, that a magnetic needle might have been substituted in place of the unmagnetised one, during a few seconds when he left the apartment, yet such a supposition was completely excluded by the high integrity of Morichini, and of the young Italian Nobleman who assisted him in the experiment.

It is not, however, on the testimony of Morichini alone that we are disposed to give credit to this new property of light. The very same results were obtained by Dr Carpi at Rome, and M. Cosimo Ridolfi at Florence; and though, under a more northern and less serene sky, the experiment has been unsuccessful, yet, when we consider this difference of circumstances, we cannot regard the evidence of those who have failed as in the least degree invalidating the evidence of those who have succeeded. Dr Carpi maintains, that the temperature is a matter of indifference, but that the clearness and dryness of the air are of essential importance. M. Ridolfi exposed his needles to the influence of the extreme border of the violet ray. He magnetised some in thirty, and others in forty-five minutes; and he considered the chemical rays as contributing to the success of the experiment. His experiments were performed under almost every variety of circumstances. He magnetised the needles when the apartment was rendered very humid; but when the violet ray passed through a column of water in vapour, or when the needle itself was immersed in water, no effect was produced. When the violet light was transmitted through the thick smoke of burning sugar, the needle received only a very slight degree of magnetism *.

M. Berard, an eminent chemist of Montpellier, repeated the experiment of Morichini, when he was engaged in examining the invisible and the deoxidating rays. As we have not seen his own account of the results which he obtained, we must content ourselves with quoting the abstract of them, given by M. Cuvier in his account of the labours of the Institute for 1813.

"Equally decisive results have not been obtained respecting the property of magnetising steel, ascribed to the violet ray by M. Morichini, a well-informed Roman chemist. Although needles exposed to this ray appeared to be magnetised in cer-

* See *Brugnatelli's Journal* 1816, 5th bimestre, or the *Bibliotheque Universelle* 1817, tom. v. p. 1.

tain experiments, they underwent no such change in many other trials; and at present no reason can be assigned for this difference, for in both cases every other known source of magnetism had been carefully removed. The summer of 1813, indeed, was not favourable to these kind of experiments, it was so bad."

About the end of April 1817, when Professor Playfair was at Rome, he availed himself of the opportunity which was presented to him of witnessing this singular experiment, which was performed by Dr Carpi, in the absence of Morichini, before a party of English and Italian gentlemen. The violet light was obtained in the usual manner by means of a common prism, and was collected into a focus by a lens of a sufficient size. The needle was made of soft iron, and was found, upon trial, to possess neither polarity nor any power of attracting iron filings. It was fixed horizontally upon a support by means of wax, and in such a direction as to cut the magnetic meridian at right angles. The focus of violet rays was carried slowly along the needle, proceeding from the centre towards one of the extremities, care being taken never to go back in the same direction, and never to touch the other half of the needle. At the end of half an hour after the needle was exposed to the action of the violet rays, it was carefully examined, and it had acquired neither polarity nor any force of attraction; but after continuing the operation twenty-five minutes longer, when it was taken off and placed on its pivot, it traversed with great alacrity, and settled in the direction of the magnetical meridian, with the end over which the rays had passed turned toward the north. It also attracted and suspended a fringe of iron filings. The extremity of the needle that was exposed to the action of the violet rays, repelled the north pole of a compass needle. This effect was so distinctly marked, as to leave no doubt in the minds of any who were present, that the needle had received its magnetism from the action of the violet rays *.

M. Dhombres Firmas †, who resides, we believe, at Alais in

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* An account of this experiment was drawn up at Professor Pictet's request by Mr James Playfair, and published in the *Bibliotheque Universelle* 1817, vol. vi. p. 81.

† *Ann. de Chim. et Phys. Mars* 1819, p. 286.

the South of France, having repeated at an early period the experiments of Morichini without success, was induced, by Mr Playfair's account of them, to re-examine the subject with great attention. On the 18th October 1817, about 2 o'clock in the afternoon, when the external thermometer stood at 14°, the one in his chamber at 15° and 15° 2, and Saussure's hygrometer at 41°, he admitted the sun's direct rays through an aperture three-fifths of an inch in diameter. A prism placed behind this aperture formed the solar spectrum upon a piece of card perforated so as to allow only the violet rays to pass. A lens was fixed behind this perforation; but instead of making the focus of the violet rays pass over the needle, he found it easier to make the needle pass through this focus always in the same direction. After continuing this process for an hour, the needle being nearly in the direction of the meridian, he could not discover that the slightest degree of magnetism was communicated to it.

The connection between light and magnetism, which appears to be indicated by the preceding results, has been supposed to exist to a still greater extent. In a paper published by Colonel Gibbs in Professor Silliman's Journal *, he goes so far as to consider light as the great source of magnetism. In 1817 he had visited the mine of magnetic iron at Succassanny, and was informed, that the ore in the upper part of the bed was magnetic, while that which was raised from the bottom acquired it only after exposure to the influence of the atmosphere. This effect he ascribed, without any sufficient reason, to the influence of light.

In support of this opinion, Colonel Gibbs attempted to ascertain by direct experiment, the influence of light upon a magnet. For this purpose he "determined the power of his magnet, as it had been shut up in the dark for a long time, and lying down. He then exposed it to the rays of the sun, also lying down, and remote from the iron support, and he found that it had gained 12 oz. power in forty minutes, and 14 oz. power only in five hours †."

A very remarkable analogy between the phenomena of magnets and of glass, either transiently or permanently crystallised,

* *American Journal of Science*, No. 1. p. 89. † *Id.* No. 2. p. 207.

when acting upon polarised light, has been pointed out in the Philosophical Transactions for 1816. This analogy, which we shall have occasion to explain at some length in a subsequent paper, is so complete, that there are few phenomena in magnetism which have not their counterpart in the action of crystallised glass and regular crystals upon polarised light. *

ART. IV.—*Examination of some Compounds which depend upon very weak Affinities.* By JACOB BERZELIUS, M.D. F.R.S. and Corresponding Member of the Institute of France. Communicated by the Author.

(Continued from page 75.)

EXAMINATION of Magnesia Alba.—It is well known, that when this earth is precipitated from a warm solution, by carbonate of potash, an effervescence takes place. The magnesia alba, therefore, contains less carbonic acid than the potash abandons. Is it a subcarbonate? And, if so, what proportion subsists between the acid and the base? My attempts to resolve these questions led to a result very different from what I had at first anticipated.

The analyses which we possess of this substance give very discordant results, as the following table will testify:

	Bergman.	Kirwan.	Butini.	Klaproth.
Magnesia,……..	45	45	40	40
Carbonic acid,..	30	34	36	33
Water,……….	25	21	21	27

The great ease with which the quantity of caustic magnesia, remaining after the calcination of this salt, may be accurately determined, forbids us to suppose that any of the analyses are erroneous in that particular. But the quantities of carbonic acid and of water, may have been somewhat modified by the method followed for obtaining them.

It is easy to see, that, according to none of these analyses, is the carbonic acid combined with twice as much oxygen, as in the ordinary carbonate. It is farther evident, that the first three analyses, in no respect agree with the laws of chemical proportion; whilst that of Klaproth makes the carbonic acid

* All these experiments were proved by Faraday to be fallacious

and the water to contain each an equal quantity of oxygen, and the magnesia two-thirds of that quantity. Although this last result might have been expressed by a formula possessing great probability, and although it proceeded from our greatest master in the art of correct analysis, I thought it necessary to repeat the experiment before founding upon it, with confidence, a calculation respecting the real composition of magnesia alba. Simple as this analysis may appear, it cost me much more time and precaution than many other researches at first sight more difficult; and I did not succeed in finding what I conceive to be the true result, till after sixteen different trials.

I began with precipitating a solution of muriate of magnesia by carbonate of potash, the mixture being kept for some time in a state of ebullition. At first, I left the muriate of magnesia slightly in excess, because I had reason to think, that when the liquid contains an excess of alkali, the precipitate carries with it a small quantity of this alkali, which water is unable to extract. I collected the precipitate upon a filter, and washed it, till the water which passed no longer acted upon the nitrate of silver. When dried and examined in the manner indicated above, it gave, Magnesia, 41.60; carbonic acid, 36.58; water, 21.82. As a repetition of the analysis produced exactly the same result, there could be no inaccuracy in the experiment. But when I dissolved the caustic magnesia, procured by the analysis, in nitric acid, and mixed with the solution a little nitrate of silver, the liquid became clouded, and deposited a small quantity of muriate of silver. The precipitate which I had analysed, must therefore have contained a portion of the muriate of magnesia. Another precipitate, formed by employing the carbonate of potash in excess, gave for its composition, Magnesia, 42.37; carbonic acid, 37.17; water, 20.46. The magnesia in this case contained no muriatic acid.

I repeated these experiments by precipitating the magnesia from its sulphate. When the sulphate was in excess, the precipitate seemed to contain, Magnesia, 42.24; carbonic acid, 37.00; water, 20.76. This magnesia being dissolved in muriatic acid, formed a pretty abundant precipitate, by adding muriate of barytes. When, in the mixture of carbonate of potash and sulphate of magnesia, the former was in excess, the precipitate contained, Magnesia, 43.16; carbonic acid, 36.47; water, 20.37. The superior quantity of magnesia obtained in this experiment, seemed likely to have proceeded from a little potash carried off by the precipitate. To ascertain this, I digested the caustic magnesia produced by the analysis in boiling water. The liquid had a distinct alkaline taste, and restored the blue colour to turnsol-paper. After being saturated with muriatic acid, the liquid was then evaporated, and the remainder heated to redness. This residuum was not dissolved by a few drops of water which were poured upon it; but these drops when evaporated, left on the glass a white pellicle, which was sparingly soluble in water, and which, as it appeared completely earthy, when viewed through a compound microscope, could be nothing but magnesia. From this fact, it seemed reasonable to conclude, that the magnesia produced by the analysis, had contained no sensible trace of potash. My next portion of magnesia alba, was obtained in the form of a precipitate, by boiling a liquid carbonate of the earth. It gave, Magnesia, 43.2; carbonic acid, 36.4; water, 20.4. A second experiment, made upon another portion prepared in the same manner, at a different time, gave, Magnesia, 42.8; carbonic acid, 36.5; water, 20.7. All these analyses appear to agree in indicating, that magnesia alba contains about 43 per cent. of magnesia, and 20.5 per cent. of water. The result of M. Klaproth's analysis cannot, therefore, be regarded as correctly exhibiting the composition of this substance. But, on the other hand, no one of my own analyses agrees with the laws of chemical proportions, or gives a probable formula of composition. Yet, as no anomalous deviation from a general law can ever be admitted, it seemed probable that some circumstance had eluded my attention. Having, for this reason, resumed my experiments, I first examined the carbonate of magnesia, precipitated by the carbonate of potash in a cold state. It gave me, Magnesia, 36.40; carbonic acid, 30.25; water, 33.35. According to these proportions, the quantities of oxygen contained in the acid and water, are (with a slight error in excess) respectively equal to one and a half and two times the oxygen of the base. Though the liquid from which the precipitate had been deposited still contained an excess of sulphate of magnesia, it exhibited strong alkaline properties. By boiling, it became turbid, and deposited a great quantity of magnesia. Now, it is evident, that when a salt, having magnesia for its base, is precipitated by an alkaline carbonate, the salt is decomposed into two portions. The first portion is entirely deposited; but the second, having gained from the former a superior quantity of carbonic acid, is converted into a carbonate of magnesia, soluble in water. As the quantity which is dissolved of this latter portion must vary according to the quantity and temperature of the water employed, the composition of the precipitated substance will be different, on different occasions. What follows, will confirm this. Another portion of that precipitated in a cold state, already analysed, being again mixed with water, at the temperature of + 18° centigr. and agitated for some time, the water became alkaline, and gave an abundant precipitate by boiling. This last precipitate, after exposure to heat, left 38 per cent. of caustic magnesia, 1.6 per cent. more than was formerly obtained. A similar treatment of this last precipitate produced a similar result; and, as often as the operation of washing was repeated, the proportion of caustic magnesia continued to increase.

From these facts I conclude, that when a neutral salt, having magnesia for its base, is decomposed by an alkaline carbonate, there results a corresponding carbonate of magnesia, which is partially decomposed by the presence of water, so as to form a carbonate, soluble in water by an excess of carbonic acid; whilst one part of the carbonate is converted into magnesia alba, and another part is deposited without decomposition,—both in variable proportions, which depend upon the variation of the circumstances in which the decomposition takes place. By each increase of the temperature and quantity of water, the proportion of magnesia alba is likewise increased, till nothing but itself is deposited, and consequently till the precipitate no longer changes its composition, by exposure to fresh quantities of boiling water. Granting that this reasoning is well founded, it only remained for me to seek the maximum of this decomposition produced by water. Having, therefore, taken a quantity of magnesia alba, precipitated by long continued boiling with carbonate of potash in excess, I boiled it with fresh quantities of water; Its quantity was sensibly diminished; the water became alkaline; and, after evaporation, left a residuum of magnesia. I then found that the time, during which the boiling continues, has less influence than the quantity of water, in determining the decomposition of the carbonate which is mixed with the magnesia alba. After the water has produced a certain effect, the remaining precipitate is but very slowly changed by continued boiling. A portion of magnesia alba, which had at first yielded a residuum of 43 per cent., after exposure to boiling water, gave 43.4 per cent. After a second exposure, it gave 44.4; after a third, 44.5; a fourth, 44.58: the fifth and sixth trials produced no alteration, though the water, even when cold, continued to dissolve a portion of the precipitate sufficient to produce a white spot, when a few drops of it were evaporated in a platina spoon;—a circumstance well worth the attention of those who engage in mineralogical analyses.

After having thus found a fixed point of composition, I analysed the substance, according to the method already detailed, and obtained

Magnesia,	-	44.58
Carbonic acid,	-	35.70
Water,	- -	19.72

We can now understand how the analyses of magnesia alba have exhibited results so variable, and why the skilful Klaproth could obtain no more than 40 per cent. of magnesia, whilst Bergman and Kirwan obtained even 45 per cent., which probably was in fact no more than 44.6; for in those times one third of a grain was regarded as a quantity, small enough to be rejected for the convenience of having round numbers.

I remarked another circumstance relative to the analysis of magnesia alba. At the first application of fire, the powder produces a kind of ebullition, in which the vapours of the water carry with them a quantity of the earth, in the form of dust. When the experiment is made in a crucible, as the loss occasioned by this circumstance cannot be observed, it deceives the operator. In the apparatus which I used, this ebullition is instantly discovered, and checked by diminishing the temperature.

By calculating the result of this analysis, it is found that the oxygen of the magnesia is 17.26; that of the water, 17.47; and that of the carbonic acid, 25.73: or one and a half times what is contained by the magnesia. We have still to consider, in what they are united. Those who have paid no attention to the manifold relations which subsist between the oxygen of bases, and that of the acids combined with those bases, (relations which constantly appear, except when the oxygen contained by the acid in its lowest degree of oxidation is to that contained at its highest, as three to two*), will probably say, that magnesia alba is a subcarbonate, composed of 2 atoms of acid, combined with 3 atoms of base, and 3 of water. But let us examine these ratios of combination, before we acknowledge their accuracy. It is plain, that if in reality they constitute a salt having an excess of base, the carbonic acid must possess the property of forming other salts having an excess of base, and saturated with their bases in a similar degree.

It is well known that the green carbonate of copper is a subcarbonate, in which the carbonic acid is combined with twice as much oxide of copper as in the ordinary carbonate, which results from decomposing the neutral sulphate of copper by an alkaline carbonate. But in the mineral kingdom there is another carbonate of copper,—the blue one, which I have attempted to prove, from the analyses of Klaproth and Vauquelin, to be a carbonate of copper, combined with a hydrate of the same metal $= \ddot{C}u\ Aq^2 + 2\ \dot{C}u\ \ddot{C}^2$ †. (Afhandlingar Fysik, &c. iv. 130). This species of the carbonate of copper has since been analysed by Mr Philips; and the result of his investigation agrees, even in the decimal parts, with that calculated from the formula which I have just given. On the other hand, if this substance is not a kind of double salt, composed of the hydrate and the neutral carbonate of copper, (as its colour also seems to indicate), it must be a subcarbonate. But this subcarbonate could neither be analogous to that which may be supposed to form magnesia alba, nor conformable to the laws of chemical proportion, since it would be composed of 3 atoms of base, with 4 atoms of acid. I may observe farther, that the water combined with salts, commonly called their water of crystallisation,

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* Which happens in the acids having nitrogen or phosphorus for their base.

† $\ddot{C}u$ signifies *oxidum cupricum*. The rest of the symbols have already been explained.

adheres to the salt by a slight affinity; and, in most cases, allows itself to be disengaged by a heat very little exceeding that of + 100°. In every case it is disengaged long before the acid. Now, in the analysis of magnesia alba, it is to be remarked, that in the first place a certain quantity of water disengages itself, as if it were water of crystallisation; but that afterwards the carbonic acid and the water are disengaged together, and that the last portion of magnesia alba, though developed at a red heat, still deposites a drop of water, whilst passing through the slender tube which conducts it to the cold recipient. This circumstance, which I have fully demonstrated by experiments made on purpose to verify it, proves that the water is retained by the magnesia alba, with a force greater than that which retains the water of crystallisation, even in those salts which are distinguished by their strong affinity for water. But this affinity can be no other than that by which a part of the magnesia, as a base or substance positively electrified, is combined with water, as an acid, or at least a body negatively electrified, in the form of a hydrate. But in this case, the magnesia alba must be composed of hydrate of magnesia and of carbonate of magnesia; nor is it difficult to conceive that the last portions of the weaker negatively electrified substance may not be expelled by heat, before those of the stronger, since each is combined to its base separately.

In magnesia alba, $\frac{3}{4}$ths of the magnesia combines with the carbonic acid to form a carbonate of magnesia; the remaining $\frac{1}{4}$th forms the hydrate. But as the oxygen of the water is equal to that contained by the whole of the magnesia, it may be asked whether the water is all combined with the hydrate, or partly supplies the carbonate with water of crystallisation. No positive answer can be returned to this question, but it is very probable that the carbonate contains no water; *first*, Because this carbonate is often found, in a natural state, perfectly dry; and because the water, in magnesia alba, is not sufficient to furnish the water of crystallisation necessary for this salt, in an isolated state: *Secondly*, As the water, in this case, performs the function of an acid, (a function more active than that of water of crystallisation), it seems highly probable that, in order to counterbalance the stronger agent, the carbonic acid, the atoms of water must enter into this compound, in a number proportionally greater than those of the carbonic acid. In all double salts, which have a common base and different acids, it is probable that the weaker of those acids must exist at a point of saturation proportionally inferior to that of the stronger acid: exactly as in double salts which have two bases, the weaker of those bases is often less saturated with acid than the stronger base. It is possible, therefore, that when a carbonate combines with a hydrate to form a double salt, the carbonate may contain no water of crystallisation, and that all the water found in this double salt may belong to the hydrate. In magnesia alba, the carbonic acid contains two times the oxygen belonging to that part of the magnesia combined with it; and the water contains four times the oxygen belonging to that part of the magnesia which forms the hydrate; so that the water, in this case, is at a degree of saturation proportional to the bicarbonate of this earth. According to these premises, magnesia alba is $\ddot{Mg}\,Aq^{8} + 3\,\ddot{Mg}\,\ddot{C}^{2}$, from which the composition, deduced by calculation, is,

Magnesia,	- -	44.641
Carbonic acid,	-	35.736
Water,	- -	19.621

which agrees perfectly with the result of our analysis.

Carbonate of Zinc.—The carbonate of zinc is known to be soluble in water, by an excess of carbonic acid; and when the sulphate of zinc is decomposed by an alkaline carbonate, a great quantity of the precipitated oxide remains dissolved in carbonic acid. The resemblance of this phenomenon, to what happened in the case of magnesia alba, gave rise to the suspicion that it was owing to a similar cause, and induced me to submit the carbonate of zinc to a particular examination. I then found that this carbonate has the same composition when precipitated in a cold, as in a boiling, state; and consequently that the usual quantity of water, employed in such an experiment, is sufficient to complete its decomposition. The carbonate of zinc, when precipitated from a solution containing also muriate or sulphate of zinc, always carries with it a portion of muriatic or sulphuric acid, which washing cannot remove. When precipitated by an excess of the alkaline carbonate, it seemed to contain a small quantity of this carbonate; and the result was similar, whether the carbonate of potash or of soda was employed. In different experiments the carbonate of zinc, when precipitated by carbonate of potash, in the smallest possible excess, gave from 73.15 to 73.25 *per cent.* of oxide of zinc. When the liquid contained more alkali, I found from 73.6 to 73.7 *per cent.* of residuum. In the latter case, the oxide, after cooling, was perfectly white; but in the former it had a slight tint of very pure yellow. The oxide of zinc, which I used for these experiments, had been separated, by evaporation, from a solution of this oxide in caustic ammonia. It was then dissolved in an acid, and by adding to the solution a carbonate, sometimes of potash, sometimes of soda, the oxide was changed into the carbonate of zinc. Having analysed this carbonate in the apparatus used for the magnesia, I found

Oxide of zinc,	- -	73.15
Carbonic acid,	- -	14.72
Water,	- - -	12.13

I made several experiments, but their results varied so little, that it is unnecessary to detail them. The oxygen contained in the oxide of zinc is 14.344; whilst that of the carbonic acid is 10.695, and that of the water 10.704. The two last quantities are thus equal: but the oxygen, in the oxide of zinc, is to that in the carbonic acid as 4 to 3; a ratio which does not occur either in blue carbonated copper or magnesia alba, and which affords another proof in favour of those opinions which I have explained above. If we consider the substance now analysed, as consisting of the hydrate combined with the carbonate of zinc, it will appear to contain one molecule of a hydrate of the oxide of zinc, in which the water has 3 times the oxygen of the base, and 3 molecules of a carbonate, in which the oxide and the acid contain equal quantities of oxygen. It is represented by the formula, $\ddot{Z}n\ Aq^6 + 3\ \ddot{Z}n\ \ddot{C}$*; and by calculation the following result is deduced from it:

Oxide of zinc,	- -	73.04
Carbonic acid,	- -	14.79
Water,	- - -	12.17

* $\ddot{Z}n$ represents 1 atom of zinc combined with 2 atoms of oxygen.

I have long suspected that the result of my experiments concerning the composition of oxide of zinc, indicates a small excess of oxygen, occasioned by the presence of iron in the distilled zinc which I employed. My suspicion acquires force from this analysis, which (supposing the substance operated upon equally pure in all cases), it is easy to perform with an accuracy that shall prevent any variation in the first decimal place of the number which expresses the weight, especially of the oxygen. For determining this point, I made several new attempts to obtain zinc absolutely pure, but the recurrence of my former difficulties prevented me from continuing them.

It may be objected to our opinion concerning the nature of the substance now analysed, that the hydrate contains more water than when it occurs in an isolated state; but we have already seen, that in double salts the quantity of water may be different from what exists in the ingredients, taken separately.

In an excellent work, published fifteen years ago, upon the composition of the different ores of zinc, which are named calamines, Mr Smithson, besides the crystallised neutral dry carbonate of zinc, examined another species of earthy carbonate of zinc from Carinthia, and found it to be composed of 71.66 per cent. of oxide of zinc, 13.34 of carbonic acid, and 15 of water. Its composition is evidently the same as that of the artificial substance which we have just analysed. Mr Smithson himself considered this substance as a chemical combination of the carbonate and the hydrate of zinc; and the inaccuracy of the proportions which he assigns to these ingredients must have proceeded from his unacquaintance with those laws of combination which have since been discovered.

Subsulphate and Submuriate of Magnesia.—Before finishing this paper, I shall say a few words of those precipitates which are produced by caustic ammonia, in the solutions of sulphate and muriate of magnesia. It has often been maintained that these precipitates happen, from the tendency which salts of ammonia and magnesia have to form double salts. Mr Pfaff of Kiel even thought it in his power to determine the composition of these double salts, from the quantity of precipitate, obtained by mixing a magnesian salt with caustic ammonia. But this supposition is incorrect; for I have ascertained that the precipitate varies in quantity according to the quantity of ammonia; by employing a very great excess of which, nearly all the magnesia may be precipitated. The precipitates in question are not, however, pure hydrates of magnesia. That which we obtain from the sulphate is half translucent whilst it continues in the liquid; it has a granular appearance, and deposites itself very quickly, as if it were heavy. That which results from the muriate is white, opaque, and mucous; and it is very slowly deposited. In the first I found, magnesia, 67.5 per cent.; sulphuric acid, 1.6; water, 30.9. The oxygen of the water somewhat exceeds that of the earth, wherefore that portion of magnesia which is combined with the sulphuric acid, must be joined to a greater proportion of water, than that other portion of magnesia which forms the base of the hydrate. Since this sulphuric acid cannot be extracted by water, it evidently belongs to the chemical composition of this substance. At present it is difficult to make an analysis of this compound, sufficiently exact for being calculated with certainty, because one of the ingredients is found in such small quantity; but the composition will probably be found to consist of one molecule of a subsulphate of magnesia with water of combination, and of a great number of molecules of hydrate of magnesia. The same is likely to be the case with the precipitate which results from the muriate of magnesia. It is very difficult to obtain this substance in a state of purity, because its mucosity prevents the water from passing, and therefore causes the salt, before it can be washed, to attract a very considerable quantity of carbonic acid. For this reason, I have not been able to analyse it accurately. I perceived, however, that there was about 1 per cent. of muriatic acid upon which the water had no influence.

These researches indicate a species of combinations, which deserve to be examined with more attention than has hitherto been bestowed upon them. It is plain, that the affinities upon which they depend, must have performed an important part in forming the inorganic portion of our globe; and that the study of them may become highly advantageous in our inquiries concerning the nature of mineral substances.

Art. V.—*Account of some Experiments, made with the view of ascertaining the different substances from which Iodine can be procured.* By Andrew Fyfe, M. D., Lecturer on Chemistry. Communicated by the Author.

Sir Humphry Davy, in one of his early papers on Iodine, published in the Philosophical Transactions for 1814, mentions, that he had procured this substance from the

Fucus cartilagineus.	Fucus filiformis.
——— membranaceus.	Ulva pavonia.
——— rubens.	——— linza.

He did not, however, obtain it from the alkaline matter manufactured at Sicily, Spain, and the Roman States, nor did coral and the ashes of the sponge seem to contain it.

Shortly after the publication of this paper, I commenced a series of experiments, to ascertain the different substances from which iodine could be obtained.

An account of these was read before the Royal Medical Society of this place, in the winter of 1815. Since then I have had several opportunities of subjecting other substances to analysis, with the view of ascertaining if they would yield iodine.

I may here remark, that at the time when most of these experiments were made, it was not known that starch proved a delicate test of the presence of iodine. I had therefore recourse to that of silver, as pointed out by Sir H. Davy, when the vapour of iodine did not appear, on the addition of sulphuric acid to the saline substance.

The first object in these experiments, was to ascertain the different marine plants from which iodine could be obtained. For this purpose I procured quantities of all the common kinds of sea-weed growing on the shores of Leith. These were dried by a gentle heat, and then burned, either in a large crucible, or in a chaffer; the temperature never being so high as to cause the fusion of the substances. The product of the combustion was then dissolved in water, and the solution was evaporated to dryness. Sulphuric acid was added to the residue in a glass tube, and heat was applied, by which means the iodine, when present, was driven off in vapour. In those cases in which iodine did not appear by the above method, recourse was had to the more delicate test of the presence of this substance.

In this way I procured iodine from the residue of the combustion of the *Fucus nodosus*, the *Fucus serratus*, the *Fucus palmatus*, and the *Fucus digitatus;* the last of which seemed to afford it in greatest quantity, both from the leaf and stem.

I likewise obtained it from the ashes of the *Ulva umbilicalis*, and of a species of *Conferva*. I repeatedly attempted, but without success, to procure it from the *Fucus vesiculosus*, the ashes o which did not yield the vapour of iodine, on the addition of sulphuric acid, nor did the more delicate test indicate the presence of their substance in their solution. This confirms an experiment of Professor John, in which he failed in obtaining iodine from the Fucus vesiculosus *. Dr Thomson likewise mentions, that a foreign chemist did not succeed in procuring it from the above plant †.

I next endeavoured to procure iodine from plants growing near the sea, not belonging to the class Cryptogamia. With this view the *Plantago maritima*, and *Arenaria peploides*, were subjected to the usual trials, but without success. I also failed in my attempts to obtain it from the ashes of the Salsola Kali. I was led to expect this, as I did not succeed in procuring iodine from barilla, the product of the combustion of different species of Salsola and Salicornia.

From the above experiments, I concluded that iodine was contained only in the plants of the class Cryptogamia. I was naturally led to examine, if all the plants of this class afforded this substance.

For this purpose I procured several of the fresh water cryptogamous plants, and subjected them, after incineration, to the action of sulphuric acid; but no iodine was given off. I likewise attempted to obtain it from the Agaricus campestris, and a Boletus growing near the sea, from the filices (Polypodium filix and aculeatum), from the musci, and from several species of

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* Vid. *Annals of Philosophy*, November 1815.

† Ibid. January 1816.

lichens, but without success. It seemed, therefore, that iodine was confined not only to the class Cryptogamia, but to the marine productions of this class.

The next object was, to ascertain if the marine animals of the lower orders could be made to yield iodine. For this purpose, the residue of the incineration of oysters was dissolved in water; the solution was evaporated to dryness, and sulphuric acid was added, but without any appearance of iodine. Coral was likewise subjected to a similar trial, and with the same result. I however succeeded in procuring it from the common sponge of the shops, after burning it, and treating it in the usual way *.

As from these experiments, it appeared that iodine was afforded only by marine productions, it was of consequence to ascertain if it could be procured from sea-water itself. With this view, I subjected the residue of the evaporation of sea-water, to various trials.

The common method of procuring muriatic acid from the saline matter of sea-water, by the addition of sulphuric acid, convinced me, that if this substance contained iodine, it could not in this way be got from it. I was therefore obliged to have recourse to other means. When sea-water is subjected to galvanism in a gold cup, a small quantity of a black powder is formed; this, it is supposed by Sir H. Davy, might be a compound of iodine and gold. To ascertain if this was the case, a quantity of sea-water concentrated by evaporation, was put into a silver vessel, attached to one end of a galvanic battery; a gold wire from the other end, was introduced into the fluid. The silver in a short time acquired a dark coating, and a minute portion of a black powder was formed. This was subjected to the action of fused potassa, and then to sulphuric acid, but without any appearance of iodine.

During the preparation of kelp, from which iodine is procured, the vegetable matter is subjected to a high temperature. Conceiving that, perhaps, the iodine might be a product of the combustion, some of the residue of the evaporation of sea-water

* In the experiments with sponge, the vapour of iodine was given off copiously, by the addition of sulphuric acid to the ashes. I repeated these experiments several times, as they were at variance with those of Sir H. Davy, *Phil. Trans.* 1815.

was mixed with charcoal in powder, and a high heat applied to it. When cold, the mixture was treated with sulphuric acid, but without obtaining any iodine.

The saline matter of sea-water was subjected to various other trials, but uniformly with the same result.

In the experiments on the substances mentioned, from which iodine was procured, and also, as I have said, in the preparation of kelp, the bodies are subjected to a high temperature,—are we to infer from this, that the iodine is a product of the combustion?

To determine this, a quantity of the *Fucus serratus* was infused in water for some hours. On evaporating the solution, a mass of a syrupy consistence was obtained. When this was subjected to the action of sulphuric acid, with the aid of heat, iodine in vapour appeared. The stem of the *Fucus digitatus*, treated in the same way, afforded iodine. It is remarkable, however, that the infusion of sponge did not in this way yield iodine, though the sponge which had been kept in water for some time, afforded it after being burned and acted on by sulphuric acid.

From the above, we may conclude, as far as these experiments go,

1. That iodine is not contained in sea-water.
2. That it is confined alone to marine productions.
3. That the iodine contained in kelp, is not a product of the combustion.
4. That the substances which afford iodine, belong to the class Cryptogamia, unless, with some naturalists, we consider Sponge as belonging to the animal world. In the classification of Linnæus, however, the Fuci, Ulvæ, and Confervæ, from which I have procured iodine, belong to the class Cryptogamia, subdivision, Algæ aquaticæ. Along with these, Linnæus was inclined to place the sponge, though he was doubtful of the correctness of this arrangement. If, then, we adopt the opinion of Linnæus, we must conclude, that iodine is confined to the vegetable world; if we incline to the former opinion, iodine must be considered a product likewise of the animal kingdom.

May not the fact, that sponge contains iodine, be an argument in favour of the opinion of Linnæus, that this substance, properly belongs to the vegetable world, class Cryptogamia, from the plants of which iodine is obtained.

5. It appears that the iodine contained in sponge, is in a different state of combination from what it is in the other substances, as in the former it is not soluble in water, while it is so in the latter.

Art. VI.—*On the preparation of Opium in Great Britain.* By John Young, Fellow of the Royal College of Surgeons, Edinburgh. Communicated by the Author.

The natural history of Opium, and the manner of collecting and preparing it in the East Indies and in Persia, has been fully detailed by Dr Samuel Crump, in his Inquiry into the Nature and Properties of Opium. He examined the different accounts related by authors, from Dioscorides, Pliny, Kæmpfer, and many others, till the year 1792, when his very interesting work was completed.

The preparation of opium in Britain has long been a desideratum. Premiums have been offered by the Society of Arts, and more recently by the Caledonian Horticultural Society. Specimens of British opium have been produced, and proved to be in no degree inferior to the best foreign opium: But it has not yet been ascertained that this valuable drug can be cultivated in Britain with profit to the grower.

The few experiments which have been made, were conducted according to the eastern mode. But the temperature, winds and rain of this climate, have hitherto been justly considered as insuperable obstacles. Of these the temperature may be held as the least objectionable, for the large White Poppy (*Papaver somniferum* of Linnæus) from which foreign opium is obtained, comes to maturity in this climate. But it is further objected, that the high winds beat down the plants, and the rains wash off the opium, before it can be collected, when the eastern mode of gathering it is practised. It has therefore been proposed to cultivate the garden poppy of this country, because it is not so liable to be damaged by wind as the large white poppy.

It is the object of this article to describe a method by which these obstacles have been completely removed, and to demonstrate from the result of experiment, that opium, superior in quality to the best Turkey opium, can be procured in Britain in sufficient quantity, not only for home consumption, but also for exportation. It is proposed to cultivate the poppy not only for its opium but also for its oil; and it will appear that a crop of early potatoes may be raised upon the same space of ground, with the opium and oil by the same culture, and that such a crop will, in a good season, yield a clear profit of from L. 50 to L. 80 per acre, allowing L. 60 for expences.

The monopoly of the opium, produced from the culture of the poppy, is the third principal branch of the East India Company's *territorial revenue in India**.

In 1773, the contract or extensive privilege for providing opium was granted to Meer Munkeer, in preference (as was stated by Government) to any one else, because, being the person employed by the gentlemen of Patna in that business, he was the best acquainted with the proper mode of managing it, and would account for any outstanding balances. He was to deliver the Bahar opium at 320 rupees, and the Oude at 350 rupees per maund.

Since that time, the East India Company's annual revenue upon that article alone, has risen from eight to upwards of eighty lacs of rupees, or more than a million Sterling. By a report, dated East India House, 29th February 1816, which was at that time laid before Parliament, the sale of opium in Bengal for the year 1813–14, amounted to 96 lacs, 40,729 current rupees, the advances and charges upon which, only amounted to 10 lacs, 77,638 current rupees.

But the opium used in Britain is principally supplied from Turkey. The gross amount of duty upon opium, imported into Great Britain in the year 1816, was only L. 2,651, 13s., while the average quantity consumed in Britain, is 14,400 lb., which is chargeable with a duty of 8s. 8d. per pound. There is besides from 250 to 300 chests of opium imported from Turkey, and lodged in bond warehouses for exportation, each

* *Parliamentary Reports*, vol. vii. p. 23.

chest containing from 150 lb. to 200 lb. of opium. This statement is from a member of the Turkey Company in London.

As the method of gathering opium, about to be proposed, differs materially from any other hitherto in use, it may be proper to observe, that Mr Ball, who obtained a premium of fifty guineas from the Society of Arts, collected his opium according to the Bengal method, which is accurately described by Mr Kerr *, who was an ocular witness, and by A. W. Davis †, whose accounts agree with that given by Kæmpferius ‡ respecting the mode of collecting opium in Persia. The seeds, according to Mr Kerr, are sown in quadrangular areas, the intervals of which are formed into aqueducts for conveying water into each area. The plants are allowed to grow six or eight inches from each other, and are plentifully supplied with water till they are six or eight inches high, when a nutrient compost of dung, ashes, and nitrous earth, is laid over the areas. A little before the flowers appear, they are again well watered till the capsules are half grown, when the watering is stopped, and they begin to collect the opium. This they effect by making, at sunset, two longitudinal incisions from below upwards, without penetrating the cavity, with an instrument that has two points as fine and sharp as a lancet. The incisions are repeated every evening, until each capsule has received six or eight wounds, and they are then allowed to ripen their seeds. The juice which exudes is collected in the morning, and being inspissated to a proper consistence, by working it in an earthen pot in the sun's heat, it is formed into cakes for sale.

In this manner Mr Ball collected four ounces of opium from one fall and twenty-eight square yards of ground, which is at the rate of 22 lb. 8 oz. per acre. But, in another place, he observes, that by a calculation which he made, supposing one poppy growing in one square foot of earth, and producing one grain of opium, more than 50 lb. will be collected from one statute acre of land. But if I take his proposition, and calculate by the rule used by land-measurers, the produce in that case

* *Medical Observations and Inquiries*, vol. v. art. 28.

† *Transactions of Society of Arts*, vol. xvi. p. 273.

‡ *Amœnitates Exoticæ*, Fas. 3. Obs. 15.

would only be 5 lb. 11 oz. and 1 dr. per acre. If Mr Ball's assertions with respect to the probable produce had been correct, there can be no doubt that opium would have been prepared in this country to a considerable extent.

It is probable that Mr Thomas Jones, who was a candidate for the premium offered by the Society of Arts, was misled by the speculations of Mr Ball. Mr Jones only collected 21 lb. 7 oz. of opium from five acres and upwards of poppies, and obtained the premium of fifty guineas for the largest specimen. He collected his opium according to the Bengal method: but some of his poppies, he says, became stunted, and others were entirely destroyed by remarkably dry weather, which continued six weeks from the beginning of May. This may be considered as the reason why he obtained so little from five acres. In another place he says, that the largest quantity which his man, seven children and himself, were able to procure in one morning from 5 to 9 o'clock, was one pound and a half. This happened when the dew was remarkably great, and succeeded one of the warmest days of the summer. And as he admits in another place, that the opium (which appeared upon the heads in a soft ash-coloured substance), when first collected, is, from its union with the dew, much too soft to be formed into a proper consistence; making a proper allowance for the evaporation of its watery part, I conclude that he gathered only in one morning, after a warm day, in the same ratio that they gather opium in the East Indies. They have no rain in India during the season of gathering opium, and Mr Kerr says, that there one acre of poppies yields 60 lb. of opium.

These observations, collected from Mr Jones's paper to the Society of Arts, should be kept in view, as they may help to illustrate one of the objects of this essay, and confirm the superiority of my method of collecting opium in Britain.

Dr Howison, who was some time inspector of opium in Bengal, is the only other person, so far as I know, who has given an account of the result of his experiments for making opium in this country. Although he was not the first who collected the milky juice of the poppy in a fluid state, it is supposed he is the first who, in this country, has given the preference to that mode. Dr Alston collected the milky juice in the fluid state according to Dioscorides*, and also in the Persian way described by Kæmpferius, from several varieties of the poppy. He also collected the true tear, as he calls it, by cutting off the star of several heads, bending them down, and suffering the milk to drop into a tea-cup; yet he says that he collected more by the Persian way than by that described by Dioscorides.

The instrument used by Dr Howison for wounding the poppy-heads, consists of a brass ring, made to fit the middle finger of the operator, in which is fixed a wheel set with lancets, which, when put in motion by drawing the hand along the poppy head, makes with great expedition whatever number of perforations are wanted, each giving out its distinct drop of milk, by which a great surface is afforded, both for support and evaporation, and to prevent the flowing milk from running upon the ground, *the unavoidable consequence of the method formerly in use.* And for gathering the opium, he employs a tin flask, flattened at the mouth about half an inch, with which he *scrapes* off the opium. By means of these instruments, Dr Howison obtained a cake of opium that weighed 8½ oz., and which was collected from a field of poppies measuring about five falls, which is at the rate of 17 lb. weight of opium per acre.

Dr Howison's puncturing instrument and collecting flask, may certainly be considered as a material improvement upon the Hindoo instruments, and he found that they answered his purpose to a certain extent in gathering opium from the garden poppy. But when the unevenness upon the surface of the capsules of the white poppy is considered, it will be found impossible to adapt the mouth of the flask so as to collect the whole of the juice without materially injuring the capsule, and much of the juice would still remain in the interstices of the ridges, which are for the most part found upon the capsules of the white poppy. Besides, the juice very soon acquires a ropiness, and adheres to the mouth of the flask, which must interrupt the gathering, and there is a chance of the juice being spilt by having the flask suspended to the body of the gatherer.

Dr Howison has stated several objections to the cultivation of the large white poppy in this country, and has given the prefe-

* *De Papavere sativo et sylvestri*, lib. iv. cap. 65. p. 427.

rence to the double red garden poppy and its varieties. He says that the white poppy, from its large head and very considerable height, is of all others the most liable to be hurt by winds; and unless they be cultivated in a sheltered situation, few will be found standing when the season for gathering the opium arrives. But independent of this, he says, that it never arrives at such perfection in this climate as to yield milk of proper consistence for making good opium, and that the few that do come to afford milk, continue in that state only for a day, and any attempt to bleed them a little sooner or later would be without success.

Mr Kerr *, however, informs us, that the large white poppy grows in Britain without care, to be a much statelier plant than it does in India with the utmost art; and Dr Alston †, after commenting upon the controversy, whether opium is got from the white poppy or from the black, concludes that, as a medicine, it is of no consequence whether it be taken from the one or from the other. Dr Crump also observes that the white variety is to be preferred, as affording opium in greater quantity than any of the rest, and there can be no doubt that this poppy yields the largest and most juicy heads.

Dr Howison has stated that 200,000 lb. of opium are made annually in Bengal; and that notwithstanding all the care that is taken in collecting it, one third of the crop is lost; but there is reason to believe that the waste is much greater than he supposes. For in whatever way the incisions are made, the milky juice instantly flows in a wasteful stream, and by running upon the ground or upon the leaves, one third of the crop at least must be lost before the gathering commences in the morning. In this climate, he remarks, where the serenest day is often followed by a night of deluging rains, the adoption of the Bengal method would be worse than trusting our fortune to the chance of a lottery.

Although Dr Howison was convinced that the juice of the poppy undergoes no change in its properties by exposure to the air, farther than acquiring a greater consistence from the evaporation of its watery part, he states in another place, that in Bengal, where there is no rain during the opium gathering

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* *Edin. Med. Essays*, vol. v. p. 103. † *Lond. Med. Observ.* vol. v. p. 321.

season, the custom of allowing the milk to thicken, by remaining for some time on the capsule, is highly judicious. While, in another part of his account, he admits that that custom is the only reason why they lose one-third of their crop.

Supposing that if 200,000 lb. of opium give the East India Company L. 100,000 Sterling annually, by Dr Howison's account they lose more than L. 30,000. But were the loss only to amount to half that sum, sufficient importance, it is to be supposed, would be attached to the means by which such a saving could be effected.

Mr Kerr states, that there are about 600,000 lb. of opium annually exported from the Ganges, independent of what is consumed in the interior. He also states, that it is frequently mixed with cow-dung, the extract obtained by boiling the plants and other additions, which are kept secret. It is, indeed, frequently so much adulterated, that considerable quantities are burnt at Calcutta by order of the Government.

In the summer of 1817, I cultivated a small field of poppies, containing about 20,000 plants of the Papaver somniferum of Linnæus, out of which I selected two beds, measuring one fall and fourteen square yards, for the purpose of ascertaining what quantity of opium it would produce. I collected the opium from that part selected for the experiment myself, while the rest of the crop was gathered by the people I employed. I collected as much of the milky juice as was equal to 1 drachm of solid opium in the space of an hour; but as my professional avocations prevented me from regularly superintending the people at work, they did not gather so much as I expected. I ascertained, however, that they could gather at the rate of 1 drachm in the hour.

I had my poppies sown in three different ways. The first broad-cast upon beds, three feet wide with an alley between, and thinned out to the distance of four and five inches, when the plants were about two inches high above the ground. The second on beds three feet wide, in rows, six rows to a bed, and six inches between the plants. The third on the spaces between rows of asparagus, two rows of poppies on each space, eight inches between each row, and six inches between the plants; two feet four inches between each double row of poppies occupied by the asparagus.

The first produced only one capsule, the second two, and the third three capsules.

Having ascertained that the white poppy, when cultivated upon the wide drill plan that I have adopted, not only gives out more capsules, but much larger ones than when cultivated in the broad-cast way, or close rows; it is evident there must be a great saving of labour, for it will take as much time to gather the juice from a small head, as it would do to collect three times the quantity of juice from a large head.

The plants between the asparagus rows having more room to grow, had not only more capsules, but they were much larger than those sown broad-cast, or in beds in close rows; and as early potatoes, cultivated in a piece of ground adjoining my crop, were sold for a high price before my plants began to flower, I proposed the following year to have, by this mode of culture, the same quantity of opium with a crop of early potatoes, as I obtained from an equal measurement of ground where there was nothing but poppies.

Accordingly, in 1818 I selected a piece of ground in the highest state of cultivation, well manured with horse-dung, in which I planted early potatoes, in rows four feet wide. Furrows were first drawn; in these furrows the dung was laid; then the sets were dropped on the dung, about nine inches asunder, and covered by the hoe. The potatoes were planted the first week of February; and the poppies were sown about the middle of April, on the middle space between the potato rows, two rows of poppies on each space, and twelve inches between the rows. When the poppy plants were about two inches above the ground, they were at first thinned out by the hoe, and afterwards by the fingers, to the distance of eight inches between the plants.

In this manner I raised a crop of early potatoes equal to 36 bolls per acre. Although the potatoes will be ready for immediate use before the gathering of opium commences, the whole crop will not be entirely ripe for lifting till after the opium is collected. The early potato gives out but a small stem, but where the soil is rich some of them may spread in the areas, yet they can be easily pushed over to one side, so as to allow the opium gatherers to walk along the areas without trampling upon them.

The distance between the poppy plants being wider than last year, upon an average they produced four full grown capsules each, and some of them produced seven or eight capsules; and I gathered this season at the rate of two drachms of solid opium in one hour, while, by the same method of gathering, I could not collect more than one drachm in the same time last year.

Supposing one acre had been cultivated in the same manner as that piece of ground on which my experiment was made, the produce in that case would have been equal to 57 lb., 9 oz. 4 dr., and 48 gr. of solid opium, which is just twice as much as I collected the year before. But the season of 1818 being so much more favourable than the preceding year, will in a great measure account for the success of this experiment. Therefore the quantity of opium that may be collected depends greatly upon the season; yet the comparative view of the result of the experiment made in 1817, although the season was extremely unfavourable, is sufficient to prove, that my method of extracting and gathering opium, has a decided advantage over any other that has been recommended.

As my poppies were sown about the middle of April, they were ready for bleeding about the middle of July.

For making the incisions I use a double bladed convex edged knife, having all the blade covered with sealing-wax, except so much of the cutting edge as is sufficient for wounding the external rind of the capsule, without penetrating its cavity, and with which I make one or more double incisions, according to the size of the head, at first longitudinally, and afterwards obliquely upwards from the stalk, Plate V. Fig. 4. This operation commences about a week after the flowers fall, when the capsules discover to the pressure a proper degree of hardness.

The instrument I used consisted of two convex edged scalpels, the blades of which were covered with sealing-wax, except about one-sixteenth part of an inch of the edge, and being wound round the handles with waxed thread, the two were fastened together with other thread twisted round them, and thus held at the distance of about half an inch between each blade. It is obvious that the blades are covered with sealing-wax for the purpose of preventing the knife from penetrating the cavity of the capsules; and it can be easily removed and applied again, when the knives require to be sharpened. But it is proposed to have the blades mounted with a metal sheath or guard for this purpose, as shewn in Fig. 6.

When the capsule is sufficiently scarified in the manner described, I then cut off, with a sharp scalpel, the capitellum or star, with a thin slice of the external rind round it, Fig. 2. and by this last incision I obtained more juice than from a scarification upon the side of the head.

It is my method of gathering the milky juice of the poppy in the fluid state, that differs materially from any other that has been used, and it is on that account that I have been more successful than any other that has tried the experiment.

In my communication to Dr Duncan relative to Lactucarium or Lettuce-Opium, published in the second edition of his Observations on Pulmonary Consumption, I proposed to gather the opium by means of a sponge. But when I began to collect opium in that way, I soon found that it would not do; for although the sponge removes the juice more effectually than the flask proposed by Dr Howison, it cannot be again entirely expressed, because the sponge decomposes or separates the component principles of the milky juice, and the resinous part adheres to the sponge, and soon clogs its pores. I therefore adopted the use of a small common hair-brush used by painters, and known to the trade by the name of Sash-tool, which answers the purpose most completely, and with which I gathered the milky juice, even though some of the plants were laid by wind and rain, as well as if they had been standing erect. I used a camel-hair brush, but found the same objection to it as to the sponge. The common sash-tool, rounded a little at the point, without being ground, is that which I prefer.

For the sake of experiment, I exposed myself one morning to a shower of rain for half an hour, while making the incisions and gathering the opium, and succeeded as well as when there was no rain, without any other inconvenience than being wet, and having an additional quantity of water with the opium.

When the brush is sufficiently charged with juice, I scrape it off upon the edge of a tin flask, fastened to the breast of the gatherer, and capable of holding more than a day's gathering, See Fig. 7.

The gatherers follow the bleeders immediately. One bleeder will occupy two gatherers, and if he be very expert at using the knife, he may keep three gatherers constantly employed. When I performed both operations myself, I held the knife between the thumb, fore and middle fingers, and the brush between the ring and little fingers of the right hand, while I held the poppy by the stalk with the left hand.

The juice is afterwards formed into cakes or balls by spontaneous evaporation in shallow earthen dishes, placed in a close room, stirring it occasionally during the evaporation of its watery part, to be afterwards kept in bladders.

The operation for gathering cannot be repeated with advantage oftener than three times a week, upon the same capsules, for no more juice will flow from one wound than what may be collected immediately, and a certain time must elapse before the plant forms more juice. But it is evident a number of hands may be kept constantly employed upon a large field, till the plants cease to give out juice.

One acre will keep twelve gatherers and six cutters constantly employed for thirty days. That number can only gather a third part of an acre in one day, and by the time they have gone through the crop, the capsules at that place where they began to gather, will be ready for the operation being repeated. So that when the milky juice ceases to flow, five operations, as already described, will have been made upon each capsule.

Supposing twelve gatherers to work ten hours in the day, and that each gathers two ounces and a half, or as much of the juice as will make that quantity of solid opium; in thirty days they will gather fifty-six pounds of opium from one acre.

One acre of poppies cultivated according to my method, will yield 1000 lb. of seed, and this quantity of seed will give by expression 375 lb. of oil *.

* An account of the cultivation of the poppy for its oil will be given in our next Number.

Although the produce of such a crop has not yet been clearly ascertained upon a large scale, the following may be taken as the estimate of one acre, from what has actually been produced in my experiment.

Estimated value of the produce of one acre,

56 lb. opium, at 36s.	L. 100	16	0
36 bolls early potatoes, at 24s.	43	4	0
250 lb. of oil, cold drawn at 1s. 6d.	18	15	0
125 lb. ditto warm, at 6d,	3	2	6
500 oil casks, at 18s. per 100,	4	10	0
	L. 170	7	6
Expences,	60	0	0
Total of profit,	L. 110	7	6

Or it may be taken this way,

56 lb. opium, at 17s. 6d.	L. 49	0	0
36 bolls of potatoes, at 24s.	43	4	0
250 lb. of oil, cold drawn, at 1s. 6d.	18	15	0
125 lb. ditto warm, at 6d.	3	2	6
500 oil casks, at 18s. per 100	4	10	0
	L. 118	11	6
Expences,	60	0	0
Profit,	L. 58	11	6

Opium costs the wholesale druggist in London at this time (May 1819) 17s. 6d. per lb., which, with a duty of 8s. 8d. per lb., makes it L. 1 : 6 : 6, and they charge the apothecaries 36s. per lb., which is the present London price of the article. The London price of opium varies so much, that about twelve years ago, it was as high as 84s. per lb., and it seldom falls so low as 24s.

If the crop can be got off the ground by the middle of August, it is proposed to have a second crop of potatoes or turnips, which will give, it is supposed, about L. 30 more.

Comparative View of the experiments of Messrs Ball, Howieson and Young, for ascertaining what quantity of Opium might be prepared in Britain.

	lb.	oz.	dr.	gr. per acre.
Mr Ball, from 576 square feet, or 1 fall and 28 square yards, obtained about	0	4	0	0
Dr Howison from about five falls, obtained	0	8	4	0
In 1817, Mr Young, from 1 fall and 14 square yards, containing 1800 plants, obtained	0	4	0	0
According to Mr Ball's method, 1 fall produced 2 ounces and 2 drachms, or	22	8	0	0
According to Dr Howison's method, 1 fall produced 1 ounce 5 drachms, and 36 grains, or	17	0	0	0
By Mr Young's method, 1 fall produced 2 ounces 7 drachms 2 grains and $\frac{2}{5}$, or	28	12	6	24
In 1818, Mr Young, from 1 fall obtained 5 ounces 6 drachms 4 grains and +, or	57	9	4	48

Explanation of the Figures.

Fig. 1. represents the skeleton of the poppy, and shows the anastomosis of the lactiferous vessels, ramified between the external and internal rind of the capsule.

Fig. 2. represents a vertical section of the poppy.

Fig. 3. represents a transverse section of the poppy.

Fig. 4. represents the double longitudinal and oblique incisions upon the external rind of the poppy.

Fig. 5. represents the poppy with the points of the star or capital cut off, and a thin slice of the external rind round it.

Fig. 6. represents the double bladed convex edged knife, with a brush at one end for gathering the milky juice. The blades at the other end are covered with a shield, except as much of the edge as is necessary for wounding the external rind of the capsule. The blades should be three inches long.

Fig. 7. represents a tin flask, with a slip of tin across its mouth for scraping the brush upon, and for holding the milk. It should be six inches long, four broad, and one inch wide at the mouth *.

Edinburgh, *May* 1819.

* The Society of Arts have recently voted to Mr Young the Gold Isis Medal for his improved mode of collecting British Opium.—Ed.

ART. VII.—*Account of a singular Affection of Vision.* By JAMES RUSSELL, Esq. F.R.S.E. and Professor of Clinical Surgery in the University of Edinburgh. Contained in a Letter to Dr Brewster.

AS I know that you take a deep interest in every curious fact connected with optics, I use the freedom to send you an account of a singular affection of vision which occurred to me some years ago.

A gentleman came to town for a consultation, on account of a severe complaint in his stomach. Previously to the commencement of this complaint, he saw equally well with both eyes, and the focal distance of distinct vision was the same in each of them. This distance, however, had now undergone a change in both eyes; and, what is a remarkable circumstance, the change in the two eyes was in opposite directions, the distance in the one eye having become longer, and in the other shorter, than the original focal distance. But while the two eyes no longer corresponded in their limits of distinct vision, each of them still retained the power of adapting itself to variations in the distance of external objects, so far as its limits of distinct vision admitted. The pupils retained their natural contractility to the stimulus of light. The cornea and the different humours possessed perfect transparency; and the most careful examination did not discover the slightest appearance of disease in any part of the eye.

The gentleman referred the origin of this affection of vision to the disordered state of his stomach, and I saw no reason to entertain the smallest doubt with regard to the justness of his conclusion. The eyes readily sympathise with any morbid irritation of the stomach, though it certainly would not have been expected, that one kind of irritation proceeding from the same source, should have produced such dissimilar effects in the two eyes. The gentleman left town before the complaint in his stomach was removed, which prevented us from verifying our opinion with regard to the dependence of the affection of his eyesight upon the state of his stomach by following the result of the case.

The course of my reading has furnished me with only a single case at all analogous to the one above related. It is given upon the authority of Mr Ware *, "who was consulted by a lady on account of a recent discovery that she was unable to read with the left eye. She held the book at an unusual distance, which was the more remarkable, as she had previously been short-sighted." The interposition of a convex glass of thirty-six inches focus removed all confusion. Upon taking a few medicines to remove some constitutional disturbance, the original focus of the left eye was restored. During all this time, the right eye continued short-sighted. I am, &c.

JAMES RUSSELL.

EDINBURGH, 8*th June* 1819.

ART. VIII.—*Account of the Earthquake which destroyed the Town of Caraccas on the 26th March* 1812. By M. HUMBOLDT.

THERE are few events in the physical world which are calculated to excite so deep and permanent an interest as the earthquake which destroyed the town of Caraccas, and by which more than 20,000 persons perished, almost at the same instant, in the province of Venezuela. The general results of this frightful catastrophe have been long known in this country; but its particular details, so afflicting to human feelings, and the physical phenomena by which it was accompanied, so important in geological speculations, have been only recently described by M. Humboldt †. This distinguished traveller, who had visited the city of Caraccas previous to its destruction, has been at great pains to collect and compare the descriptions of individuals who had witnessed the effects of the earthquake, and has thus been enabled to draw a faithful picture of this terrible convulsion, marked with that glowing eloquence which characterises all his writings. We regret that our limits will not permit us to present our readers with all his reasonings respecting the influence of a system of volcanoes over a vast extent of cir-

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* *Medico-Chirurgical Transactions*, vol. v. p. 263.

† *Personal Narrative*, vol. iv. p. 12.

cumjacent country; but we may afterwards have another opportunity of resuming this branch of the subject.

"The 26th of March was a remarkably hot day. The air was calm, and the sky unclouded. It was Holy Thursday, and a great part of the population was assembled in the churches. Nothing seemed to presage the calamities of the day. At seven minutes after four in the afternoon the first shock was felt; it was sufficiently powerful, to make the bells of the churches toll; it lasted five or six seconds, during which time, the ground was in a continual undulating movement, and seemed to heave up like a boiling liquid. The danger was thought to be past, when a tremendous subterraneous noise was heard, resembling the rolling of thunder, but louder, and of longer continuance, than that heard within the tropics in time of storms. This noise preceded a perpendicular motion of three or four seconds, followed by an undulatory movement somewhat longer. The shocks were in opposite directions, from north to south, and from east to west. Nothing could resist the movement from beneath upward, and undulations crossing each other. The town of Caraccas was entirely overthrown. Between nine and ten thousand of the inhabitants were buried under the ruins of the houses and churches. The procession had not yet set out; but the crowd was so great in the churches, that nearly three or four thousand persons were crushed by the fall of their vaulted roofs. The explosion was stronger towards the north, in that part of the town situated nearest the mountain of Avila, and the Silla. The churches of la Trinidad and Alta Gracia, which where more than 150 feet high, and the naves of which were supported by pillars of twelve or fifteen feet diameter, left a mass of ruins scarcely exceeding five or six feet in elevation. The sinking of the ruins has been so considerable, that there now scarcely remain any vestiges of pillars or columns. The barracks, called *El Quartel de San Carlos*, situate farther north of the Church of the Trinity, on the road from the Custom-house de la Pastora, almost entirely disappeared. A regiment of troops of the line, that was assembled under arms, ready to join the procession, was, with the exception of a few men, buried under the ruins of this great edifice. Nine-tenths of the fine town of Caraccas were entirely destroyed. The walls of the houses that were not thrown down, as those of the street San Juan, near the Capuchin Hospital, were cracked in such a manner, that it was impossible to run the risk of inhabiting them.

"Estimating at nine or ten thousand the number of the dead in the city of Caraccas, we do not include those unhappy persons, who, dangerously wounded, perished several months after, for want of food and proper attention. The night of Holy Thursday presented the most distressing scene of desolation and sorrow. That thick cloud of dust, which, rising above the ruins, darkened the sky like a fog, had settled on the ground. No shock was felt, and never was a night more calm or more serene. The moon, nearly full, illumined the rounded domes of the Silla, and the aspect of the sky formed a perfect contrast to that of the earth, covered with the dead, and heaped with ruins. Mothers were seen bearing in their arms their children, whom they hoped to recall to life. Desolate families wandered through the city, seeking a brother, a husband, a friend, of whose fate they were ignorant, and whom they believed to be lost in the crowd. The people pressed along the streets, which could no more be recognised but by long lines of ruins.

"All the calamities experienced in the great catastrophes of Lisbon, Messina, Lima, and Riobamba, were renewed on the fatal day of the 26th of March 1812. The wounded, buried under the ruins, implored by their cries the help of the passers by, and nearly 2000 were dug out. Implements for digging, and clearing away the ruins were entirely wanting; and the people were obliged to use their bare hands to disinter the living. The wounded, as well as the sick who had escaped from the hospitals, were laid on the banks of the small river Guayra. They found no shelter but the foliage of trees. Beds, linen to dress the wounds, instruments of surgery, medicines, and objects of the most urgent necessity, were buried under the ruins. Every thing, even food, was wanting during the first days. Water became alike scarce in the interior of the city. The commotion had rent the pipes of the fountains; the falling in of the earth had choked up the springs that supplied them; and it became necessary, in order to have water, to go down to the river Guayra, which was considerably swelled; and then vessels to convey the water were wanting.

"There remained a duty to be fulfilled towards the dead, enjoined at once by piety and the dread of infection. It being impossible to inter so many thousand corpses, half-buried under the ruins, commissaries were appointed to burn the bodies: and for this purpose, funeral piles were erected between the heaps of ruins. This ceremony lasted several days. Amid so many public calamities, the people devoted themselves to those religious duties, which they thought were the most fitted to appease the wrath of Heaven. Some, assembling in procession, sung funeral hymns; others, in a state of distraction, confessed themselves aloud in the streets. In this town was now repeated what had been remarked in the province of Quito, after the tremendous earthquake of 1797; a number of marriages were contracted between persons, who had neglected for many years to sanction their union by the sacerdotal benediction. Children found parents, by whom they had never till then been acknowledged; restitutions were promised by persons, who had never been accused of fraud; and families, who had long been enemies, were drawn together by the tie of common calamity. If this feeling seemed to calm the passions of some, and open the heart to pity, it had a contrary effect on others, rendering them more rigid and inhuman.

"Shocks as violent as those which, in the space of one minute *, overthrew the city of Caraccas, could not be confined to a small portion of the continent. Their fatal effects extended as far as the provinces of Venezuela, Varinas, and Maracaybo, along the coast; and still more to the inland mountains. La Guayra, Mayquetia, Antimano, Baruta, La Vega, San Felipe, and Merida, were almost entirely destroyed. The number of the dead exceeded four or five thousand at La Guayra, and at the town of San Felipe, near the copper-mines of Aroa. It appears, that it was on a line running east north-east, and west south-west, from La Guayra and Caraccas to the lofty mountains of Niquitao and Merida, that the violence of the earthquake was principally directed. It was felt in the kingdom of

* The duration of the earthquake, that is to say the whole of the movements of undulation and rising which occasioned the horrible catastrophe of the 26th of March 1812, was estimated by some at 50″, by others at 1′ 12″.

New Granada from the branches of the high Sierra de Santa Martha as far as Santa Fe de Bogota and Honda, on the banks of the Magdalena, 180 leagues from Caraccas. It was every where more violent in the Cordilleras of gneiss and mica-slate, or immediately at their foot, than in the plains: and this difference was particularly striking in the savannahs of Varinas and Casanara. In the valleys of Aragua, situate between Caraccas and the town of San Felipe, the commotions were very weak: and La Victoria, Maracay, and Valentia, scarcely suffered at all, notwithstanding their proximity to the capital. At Valecillo, a few leagues from Valencia, the earth, opening, threw out such an immense quantity of water, that it formed a new torrent. The same phenomenon took place near Porto-Cabello. On the other hand, the lake of Maracaybo diminished sensibly. At Coro no commotion was felt, though the town is situated upon the coast, between other towns which suffered from the earthquake.

" Fifteen or eighteen hours after the great catastrophe, the ground remained tranquil. The night, as we have already observed, was fine and calm ; and the commotions did not recommence till after the 27th. They were then attended with a very loud and long continued subterranean noise. The inhabitants of Caraccas wandered into the country; but the villages and farms having suffered as much as the town, they could find no shelter till they were beyond the mountains of Los Teques, in the valleys of Aragua, and in the Llanos or Savannahs. No less than fifteen oscillations were often felt in one day. On the 5th of April there was almost as violent an earthquake, as that which overthrew the capital. During several hours the ground was in a state of perpetual undulation. Large masses of earth fell in the mountains ; and enormous rocks were detached from the Silla of Caraccas. It was even asserted and believed that the two domes of the Silla sunk fifty or sixty toises; but this assertion is founded on no measurement whatever.

" While violent commotions were felt at the same time in the valley of the Missisippi, in the island of St Vincent, and in the province of Venezuela, the inhabitants of Caraccas, of Calabozo, situated in the midst of the steppes, and on the borders of the Rio Apura, in a space of 4000 square leagues, were terrified on the 30th of April 1812, by a subterraneous noise, which resembled frequent discharges of the largest cannon. This noise began at two in the morning. It was accompanied by no shock; and, what is very remarkable, it was as loud on the coast as at eighty leagues distance inland. It was every where believed to be transmitted through the air; and was so far from being thought a subterraneous noise, that at Carraccas, as well as at Calabozo, preparations were made to put the place into a state of defence against an enemy, who seemed to be advancing with heavy artillery. Mr Palacio, crossing the Rio Apura near the junction of the Rio Nula, was told by the inhabitants that the '*firing of cannon*' had been heard as distinctly at the western extremity of the province of Varinas, as at the port of La Guayra to the north of the chain of the coast.

" The day on which the inhabitants of Terra Firma were alarmed by a subterraneous noise, was that on which happened the eruption of the volcano in the island of St Vincent. This mountain, near five hundred toises high, had not thrown out any lava since the year 1718. Scarcely was any smoke perceived to issue from its top, when, in the month of May 1811, frequent shocks announced, that the volcanic fire was either rekindled, or directed anew toward that part of the West Indies. The first eruption did not take place till the 27th of April 1812, at noon. It was only an ejection of ashes, but attended with a tremendous noise. On the 30th, the lava passed the brink of the crater, and, after a course of four hours, reached the sea. The noise of the explosion ' resembled that of alternate discharges of very large cannon and of musketry; and, what is well worthy of remark, it seemed much louder at sea, at a great distance from the island, than in sight of land, and near the burning volcano.'

" The distance in a straight line from the volcano of St Vincent to the Rio Apura, near the mouth of the Nula, is 210 nautical leagues. The explosions were consequently heard at a distance equal to that between Vesuvius and Paris. This phenomenon, connected with a great number of facts observed in the Cordilleras of the Andes, shows how much more extensive the subterranean sphere of activity of a volcano is, than we are disposed to admit from the small changes effected at the surface of the globe.

The detonations heard during whole days together in the New World, 80, 100, or even 200 leagues distant from a crater, do not reach us by the propagation of sound through the air; they are transmitted to us by the ground. The little town of Honda, on the banks of the Magdalena, is not less than 145 leagues from Cotopaxi; and yet in the great explosions of this volcano, in 1744, a subterraneous noise was heard at Honda, and supposed to be discharges of heavy artillery. The monks of St Francis spread the news, that the town of Carthagena was bombarded by the English; and the intelligence was believed. Now the volcano of Cotopaxi is a cone, more than 1800 toises above the basin of Honda, and rises from a table-land, the elevation of which is more than 1500 toises above the valley of the Magdalena. In all the colossal mountains of Quito, of the provinces of Los Pastos, and of Popayan, crevices and valleys without number are interposed. It cannot be admitted, under these circumstances, that the noise could be transmitted through the air, or by the superior surface of the globe, and that it came from that point, where the cone and crater of Cotopaxi are placed. It appears probable, that the higher part of the kingdom of Quito and the neighbouring Cordilleras, far from being a group of distinct volcanoes, constitute a single swollen mass, an enormous volcanic wall, stretching from south to north, and the crest of which exhibits a surface of more than six hundred square leagues. Cotopaxi, Tunguragua, Antisana, and Pichincha, are placed on this same vault, on this raised ground. The fire issues sometimes from one, sometimes from another of these summits. The obstructed craters appear to be extinguished volcanoes; but we may presume, that, while Cotopaxi or Tunguragua have only one or two eruptions in the course of a century, the fire is not less continually active under the town of Quito, under Pichincha and Imbaburu.

" Advancing toward the north, we find, between the volcano of Cotopaxi and the town of Honda, two other *systems of volcanic mountains*, those of Los Pastos and of Popayan. The connection of these systems was manifested in the Andes in an incontestible manner by a phenomenon, which I have already had occasion to notice. Since the month of November 1796, a thick column of smoke had issued from the volcano of Pasto, west of the town of that name, and near the valley of Rio Guaytara. The mouths of the volcano are lateral, and placed on its western declivity, yet during three successive months the column rose so much higher than the ridge of the mountain, that it was constantly visible to the inhabitants of the town of Pasto. They related to us their astonishment, when, on the 4th of February 1797, they observed the smoke disappear in an instant, without feeling any shock whatever. At that very moment, sixty-five leagues to the south, between Chimborazo, Tunguragua, and the Altar (Capac Urcu,) the town of Riobamba was overthrown by the most dreadful earthquake of which tradition has transmitted the history. Is it possible to doubt from this coincidence of phenomena, that the vapours issuing from the small apertures or *ventanillas* of the volcano of Pasto, had an influence on the pressure of those elastic fluids, which shook the ground of the kingdom of Quito, and destroyed in a few minutes thirty or forty thousand inhabitants?

"In order to explain these great effects of *volcanic reactions*, and to prove, that the group or system of the volcanoes of the West India Islands may sometimes shake the continent, it was necessary to cite the Cordillera of the Andes. Geological reasoning can be supported only on the analogy of facts that are recent, and consequently well authenticated: and in what other region of the globe could we find greater, and at the same time more varied volcanic phenomena, than in that double chain of mountains heaved up by fire? in that land, where Nature has covered every summit and every valley with her wonders? If we consider a burning crater only as an insulated phenomenon, if we satisfy ourselves with examining the mass of stony substances which it has thrown up, the volcanic action at the surface of the globe will appear neither very powerful nor very extensive. But the image of this action swells in the mind, when we study the relations that link together volcanoes of the same group; for instance, those of Naples and Sicily, of the Canary Islands, of the Azores, of the Caribbee Islands, of Mexico, of Guatimala, and of the table-land of Quito; when we examine either the reactions of these different systems of volcanoes on one another, or the distance to which, by subterranean communications, they at the same moment shake the Earth*."

Art. IX.—*Observations of several Occultations of Fixed Stars by the Moon in* 1818 *and* 1819, *and of the Solar Eclipse of the 5th May* 1818, *made at La Valette in Malta.* By Mr Charles Rumker. Contained in a Letter to Prof. Jameson.

When, on my return from the Mediterranean, I mentioned to Captain Heywood that it would give me great satisfaction if any benefit to astronomy could be derived from the observations which I had there an opportunity of making, he pointed out the Edinburgh Philosophical Journal, as the best medium by which any useful information might be introduced to general notice, and encouraged me to address to you the present paper.

The principal object of this Journal being the promotion of science, I hope that the annexed astronomical observations will find a place in it. Occultations are a kind of observations, that receive their final value only by comparison with corresponding observations of the same stars. The present observations were made on the same spot where, in the year 1780, the Grandmaster Rohan fitted out, in the palace of La Valette, an observatory for the Chevalier d'Angos, which was afterwards partly destroyed by a fire that consumed all the papers containing the observations made by this astronomer, who, discouraged by his bad success, returned to France his native country.

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* The following is the series of phenomena which M. Humboldt supposes to have had the same origin :

27th September 1796. Eruption in the West India Islands. Volcano of Guadaloupe.—November 1796. The volcano of Pasto begins to emit smoke.—14th of December 1796. Destruction of Cumana.—4th of February 1797. Destruction of Riobamba.—30th of January 1811. Appearance of Sabrina Island, in the Azores. It increases particularly on the 15th of June 1811.—May 1811. Beginning of the earthquakes in the Island St Vincent, which lasted till May 1812.—16th of December 1811. Beginning of the commotions in the Valley of the Missisippi and the Ohio, which lasted till 1813.—December 1811. Earthquake at Caraccas.—26th of March 1812. Destruction of Caraccas. Earthquakes which continued till 1813.—30th April 1812. Eruption of the volcano at St Vincent's; and the same day subterranean noises at Caraccas, and on the banks of the Apura.

Solar Eclipse, May 5. 1818.

I observed the beginning at $18^h\ 12^m\ 27^s.5$, the end at $20^h\ 29^m\ 11^s.5$, mean time, May 4th, at La Valette, with an achromatic telescope by Gilbert, of 44 inches focal length, and 2.8 inches aperture. The observation was made in Strada St Paolo, nearly under the meridian of the palace, but about 120 fathoms to the north of it. I have used the latitude 35° 54′ 0″.8; and the longitude is supposed to be 14° 30′ 30″ east.

The Baron de Zach observed the end at $20^h\ 15^m\ 28^s.7$, mean time at Genoa, St Bartollommeo degli Armeni, Pallazzo di Durazzo, in latitude 44° 24′ 34″, and longitude 8° 55′ 37″ E., well ascertained.

I have reduced the latitudes to the Earth's centre, and computed its radius by the 3 ratios $\frac{320}{321}, \frac{299}{300}, \frac{329}{330}$, and used a mean.

Place of Observation.	Reduced Latitude.	Log. Radius of Earth.
La Valette,	35 43 49	9.9995309
Genoa,	44 13 12	9.9993285

Let φ be the reduced Latitude,
ω Obliquity of Ecliptic.
b Zenith distance of Nonages.
L ☾'s true Longitude.
D ☾'s equat. hor. Semidiam.
ϱ Radius of the Earth.
μ Arch of Meridian.
λ Longitude of Nonages.
B ☾'s true Latitude.
δ ☾'s augmented Semidiam.
β ☾'s apparent Latitude.
$P-p$ Diff. of Equat. Parallax.
π Diff. of Parallax in Long.
⊙ Sun's mean Longitude.
d Sun's Semidiameter.

Then $\cos\mu\cos\varphi = \cos M$ $\qquad$ $\sin\mu \operatorname{cotang}\varphi = \operatorname{cotang} N$

$\sin M \sin\left(N \mp \omega\right) = \sin. b$ $\qquad$ $\tan M \cos\left(N \mp \omega\right) = \tan\lambda$

$$\varrho \times \frac{\sin(P-p)\cos b}{\cos B}(\cos L-\lambda) = \cos A \qquad \frac{\cos A \tan(L-\lambda)}{2\sin^2\frac{1}{2}A} = \tan.\pi$$

$$\varrho\sin(P-p)\sin b = \sin C \qquad \operatorname{Cos}\pi \times \frac{\cos\frac{1}{2}(B \pm C)\sin\frac{1}{2}(B \mp C)}{\cos B\sin^2\frac{1}{2}A} = \tan\beta$$

$$\frac{1}{2}D \times \frac{\cos\quad \cos\beta}{\cos B\sin^2\frac{1}{2}A} = \delta$$

N, M, and A are auxiliary Arcs.

After these strict formulæ, the Solar Eclipse has been calculated to every second of the quadrant from Taylor's Logarithms. The Sun's and Moon's places, equatorial parallax, semidiameter, horary motion, &c. have been computed from Delambre's Solar, and Burg's Lunar Tables, for the hours 17 18, 19, and 20, mean time at Greenwich, and thence interpolated for the intermediate times as follows:

	For XVII Hours.	XVIII Hours.	XIX Hours.	XX Hours.
L	1^s 12° 58′ 49.″3	1^s 13° 28′ 45.″2	1^s 13° 58′ 40″.	1^s 14° 28′ 33″.
B	0° 23′ 15.″3	26 01	28 46.4	31 31.8
P—p	54 12.4	54 11.5	54 11.1	54 10.5
½ D	14 50.05	14 49.9	14 49.7	14 49.5
H—h	27 31.15	27 30.4	27 29.4	27 28.4
d	15 52.5			
		Beginning at La Valette.	End at La Valette.	End at Genoa.
Mean time at place of obs.		18^h 12^m 27^s.5	20^h 29^m 11^s.5	20 15 28.7
Mean Green^h. time supp.		17 14 25.5	19 31 09	19 39 46.2
L interpolated from above		1^s 13° 06′ 00″.0	1^s 14° 14′ 11″	1^s 14° 18′ 28″.2
B		23 55.4	30 12.1	30 36.0
P—p		54 12.2	54 10.8	54 10.7
D		14 49.76	14 49.6	14 49.6
☉		1 12 28 44.1	1 12 34 20.7	1 12 34 41.5
μ		315° 35 36.6	349 52 13·2	346 26 52
ω		23 27 55.3		
b		49 37 44	36 20 12	44 58 02
λ		333 32 57	7 14 36	10 04 15
A		89 47 44.8	89 25 11	89 28 21
π		32 58.7	26 30	21 44
C		41 15.7	32 04	38 14
β		— 17 24	— 1 59	— 7 42
δ		14 52.9	14 58.7	14 57.87
True conjunction		20^h 19^m 44^s M. T. Val.	20^h 19^m 49^s Val.	19^h 57^m 42^s Genoa.
		Mean 20^h 19^m 46.5 M.T. Valette		

Hence the Longitude of La Valette is 14° 26′ 44″.5 East of Greenwich.

London, *June* 3. 1819.

SERVATION.

Month.	Timekeeper slow of mean time at noon.		☾'s true Place.		Equatorial.		Parallax in longitude.	☾'s appar. latitude.	Augmented Semidiameter.
			gitude.	Latitude.	Parall.	Semid.			
1818.									
Dec. 2.	$1^h\ 53^m\ 07^s.2$		°59′ 27″	4° 57′ 45.5″	59′ 25″	16′ 13.″	55′ 00″	5° 20′ 30″,	16′ 13″.66
5.	1 53 37.7		11 48.5	2 47 29.8	57 00.3	15 33.5	42 18	3 8 23.8	15 42.25
5.			19 13.7	2 42 20.8	56 56.6	15 32.5	53 50.4	2 56 16	15 35.93
15.	1 55 12.6	1	37 08	5 3 50.3	54 05.	14 45.7	21 41.	4 44 33	14 57.6
1819.									
Jan. 4.	1 59 01.3	1							
5.	1 59 16.6		56 25	1 36 12.4	54 54.3	14 59.1	48 49.0	1 23 26,0	15 04.8
9.	2 00 12.2	1							
19	2 2 07.	1							
20.	2 2 19.5	1							
Mar. 12	2 12 37.4		13 06.9	1 43 13.7	56 20.0	15 22.5	52 36.0	1 30 22.8	15 26.8
			46 44.6	1 40 19.8	56 21.3	15 22.9	47 33.2	1 25 15.0	15 30.2
16.	2 13 19.4	1							
16.			24 06.4	3 13 31.8	58 21.4	15 55.6	21 50.	3 59 31.6	16 03.7
16.			9 28.	3 16 51.7	58 22.7	15 56.0	06 19.9	4 6 59.3	16 04.3
16.									
17.	2 13 29.7								
Mar. 8.	Jupiter's fim Delambre's Tables inserted in Vince's System of Astronomy.								

Th, taken on the spot. The error from Meanl, parallax, and semidiameter, are calculated ach, T. Mayer, and Wollaston. Those not ortunity of referring.

Th° 31′ 07″.5, 14° 25′ 10″.5, 14° 26′ 55″, 14° 2 27′ 38″.6.

Tland twenty-eight observations of Stars, calcu

wherber of seconds, by which each respective true mference.

OCCULTATIONS OF FIXED STARS

OBSERVED AT THE

ROYAL PALACE IN LA VALETTE, IN LATITUDE 35° 54′ 01″ N. BY OBSERVATION.

Month.	Timekeeper slow of mean time at noon.	Rate loos.	Constellations.	Magnitd.	Per Timekeeper.	Mean Time at Valette.	Star's Place. Mean Right Ascen.	Star's Place. Mean Declination.	Star's Place. Apparent Longitude.	Star's Place. Apparent Latitude.	Supposed mean time at Greenwich.	☾'s true Place. Longitude.	☾'s true Place. Latitude.	Equatorial. Parall.	Equatorial. Semid.	Parallax in longitude.	☾'s appar. latitude.	Augmented Semidiameter.
1818.																		
Dec. 2.	1^h 53^m $07^s.2$	9	Capricor.	7	7^h 19^m 06^s Imm.	9^h 12^m $16^s.7$ Imm.	318° 28′ 19″.2	21° 36′ 40.″4	10^s 14° 20′ 31″	5° 18′ 09″	8^h 14^m 16^s	10^s 14° 59′ 27″	4° 57′ 45.5″	59′ 25″	16′ 13.″	55′ 00″	5° 20′ 30″.	16′ 13″.66
5.	1 53 37.7		*p* Piscis	6	7 43 20 Imm.	9 37 01.2 Imm.	357 21 15.8	4 33 33.	11 25 45 25	3 7 47	8 38 59	11 26 11 48.5	2 47 29.8	57 00.3	15 33.5	42 18	3 8 23.8	15 42.25
5.			*q* Piscis	6	9 47 17 Imm.	11 40 59.2 Imm.	358 8 20.2	4 02 03.2	11 26 41 05	2 57 36	10 42 57	11 27 19 13.7	2 42 20.8	56 56.6	15 32.5	53 50.4	2 56 16	15 35.93
15.	1 55 12.6	10.8	*υ* 2 Canc.	6	15 08 03 Em.	17 03 23. Em.	124 27 56.3	24 44 18.7	4 01 03 28	4 54 57	16 5 34	4 01 37 08	5 3 50.3	54 05.	14 45.7	21 41.	4 44 33	14 57.6
1819.																		
Jan. 4.	1 59 01.3	15.2	Piscis	7	6 31 37 Imm.	8 30 43.6 Imm.												
5.	1 59 16.6		*ϱ* 2 Ariet.	6	10 41 18 Imm.	12 40 42.4 Imm.	41 24 52.0	17 35 38.7	1 14 20 55.5	1 30 03	11 42 58	1 14 56 25	1 36 12.4	54 54.3	14 59.1	48 49.0	1 23 26.0	15 04.8
9.	2 00 12.2	14.1																
19	2 2 07.	11.3	Virgo	7	14 37 59 Em.	16 40 13. Em.												
20.	2 2 19.5	11.9	Virgo	7	12 54 03 Em.	14 56 28. Em.												
Mar. 12	2 12 37.4	11	*η* Virginis	3	5 56 16 Imm.	8 8 57.1 Imm.	182 40 03.3	0 20 25.1	6 2 18 56	1 22 27	7 11 13	6 01 13 06.9	1 43 13.7	56 20.0	15 22.5	52 36.0	1 30 22.8	15 26.8
			η Virginis		6 58 56 Em.	9 11 37.4 Em.					8 13 53	6 01 46 44.6	1 40 19.8	56 21.3	15 22.9	47 33.2	1 25 15.0	15 30.2
16.	2 13 19.4	10.3	Scorp.	7	10 53 40 Em.	13 07 05. Em.												
16.			Scorp.	6	13 00 31 Imm.	15 13 56.8 Imm.	235 46 44.0	23 59 31	7 28 59 37.5	48 17 8	14 16 06	7 28 24 06.4	3 13 31.8	58 21.4	15 55.6	21 50.	3 59 31.6	16 03.7
16.			eadem.		14 19 38 Em.	16 33 04.4 Em.					15 35 13	7 29 9 28.	3 16 51.7	58 22.7	15 56.0	06 19.9	4 6 59.3	16 04.3
16.			Scorp.	6	15 49 31 Imm.	18 02 58.1 Imm.												
17.	2 13 29.7																	
Mar. 8.	Jupiter's first Satellite.				15 30 12 Imm.	17 42 10. Imm.	Immersion computed 16^h 44^m $36^s.9$ mean time at Greenwich, from Delambre's Tables inserted in Vince's System of Astronomy.											

The 6th and 7th columns contain the original Times of Immersion and Emersion by the Timekeeper, taken on the spot. The error from Mean Time at noon and Rate are carefully ascertained by equal altitudes. The Moon's place, equatorial, parallax, and semidiameter, are calculated from Burg's Tables. The Stars places are taken from the Catalogues of Bradley, La Caille, Zach, T. Mayer, and Wollaston. Those not calculated will probably be found in the Catalogues of Piazzi and La Lande, to which I had no opportunity of referring.

The Longitudes of the Palace, deduced from a comparison with Burg's Tables, are respectively 14° 31′ 07″.5, 14° 25′ 10″.5, 14° 26′ 55″, 14° 24′ 09, 14° 32′ 45″, 14° 26′ 00″, 14° 29′ 27″, 14° 22′ 36″, 14° 30′ 37″.2; the mean of which is 14° 27′ 38″.6.

The Latitude of the Palace 35° 54′ 01″ is the result of 144 circummeridional altitudes of the Sun, and twenty-eight observations of Stars, calculated after the following formula:

$$\frac{n^2 \pi}{1.6} \times \frac{\text{Cos lat.} \times \text{Cos decl.}}{\text{Sin (lat.} \mp \text{decl.)}} = \Delta.$$

where n signifies the time from noon, expressed in minutes and decimal parts of minutes, and Δ a number of seconds, by which each respective true altitude is to be augmented to give the meridional altitude; π the ratio of the diameter to the circumference.

Art. X.—*On the Geognosy of the Cape of Good Hope.* By Professor Jameson.

The peninsula of the Cape of Good Hope is a mountainous ridge, stretching nearly north and south for thirty or forty miles, and connected on the east side, and near its northern extremity, with the main body of Africa, by a flat sandy isthmus, about ten miles broad, having Table Bay on the north of it, and False Bay on the south. The southern extremity of this peninsula, extending into the sea, with False Bay on the east, and the ocean on the south and west, is properly the Cape of Good Hope, and is the most southern point of Africa. At this point, the chain of mountains which forms the peninsula, though rugged, is lower than at the north end, where it is terminated by Table Mountain and two others, which form an amphitheatre overlooking Table Bay, and opening to the north. The mountains of the ridge extending from the Cape to the termination of the peninsula on the north, vary in shape; but the most frequent forms incline more or less to sharp conical. The three mountains which terminate the peninsula on the north, are, the Table Mountain in the middle; the Lion's Head, sometimes called the Sugar Loaf, on the west side; and the Devil's Peak on the east. The Lion's Head, which is about 2100 feet above the level of the sea, is separated from the Table Mountain by a valley, that descends to the depth of 1500 or 2000 feet below the summit of the Table Mountain, which is itself 3582 above the level of the sea. On the west of the Lion's Head, there is a lower eminence, named the Lion's Rump, from which the ground declines gradually to the sea. The amphitheatre, formed by these three mountains, is about five or six miles in diameter, in the centre of which is placed Cape Town *.

The rocks of which the peninsula is composed are few in number, and of simple structure. They are granite, gneiss, clay-slate, sandstone, and greenstone. Of these the most abun-

* *Transactions* of the Royal Society of Edinburgh, vol. vii. p. 271.

dant are sandstone and granite; the next, in frequency, are clay-slate and gneiss; and the rarest is greenstone. The strata in general have a direction from E. to W. that is, across the peninsula. The southern and middle parts of the peninsula have been very imperfectly examined. Captain Basil Hall, in an interesting account of some mineralogical appearances he observed near Cape Town, published in the Edinburgh Philosophical Transactions, remarks, that the same general structure and relations seem to occur all over the peninsula as in the mountains around Cape Town. More lately Captain Wauchope, an active and enterprising officer, pointed out to Mr Clarke Abel a fine display of stratification in a mountain that faces the sea, in the neighbourhood of Simon's Bay. The following is the description, as given by Mr Abel: "The sandstone, forming the upper part of the mountain, is of a reddish colour, very crystalline in its structure, and approaching, in some specimens, to quartz rock. Immediately beneath the sandstone is a bed of compact dark red argillaceous sandstone, passing, in many places, into slate of the same colour. This bed rests upon another of very coarse loosely combined sandstone, resembling gravel. Under this is another layer of dark red sandstone, terminating in a conglomerate, consisting of decomposed crystals of felspar, and of rounded and angular fragments of quartz, from the size of a millet seed to that of a plover's egg, imbedded in a red sandstone base. Beneath the conglomerate commences a bed, which I at first took for granite, and which is composed of the constituents of granite in a decomposed state, intermixed with green steatite, and a sufficient quantity of the dark red sandstone to give it a reddish hue. The felspar of the bed is decomposed, and exactly resemble that of the conglomerate above it. The mica seems, in a good measure, to have passed into steatite. The quartz is in small crystals, frequently having their angles rounded. This bed is several feet in thickness, and gradually terminates in the granite; but the precise line of junction I was unable to trace. The appearances, then, were in the following order:

1. Horizontally stratified sandstone.
2. Bed of compact dark red sandstone, passing into slate.
3. A bed of coarser sandstone, resembling gravel.

2

4. A second layer of compact dark red sandstone, passing

5. Into a conglomerate, consisting of decomposed crystals of felspar, and fragments of quartz in a sandstone basis.

6. A bed composed of the decomposed constituents of granite and red sandstone, passing

7. Into granite *."

The above is the only spot to the southward of the range of mountains near Cape Town, which has been particularly described. To the northward of Cape Town, it is reported that the mountains are principally composed of the same rocks as those which occur throughout the peninsula, and whose characters and position have been examined with considerable attention in the Lion's Rump, Lion's Head, Table Mountain, and Devil's Peak. As these mountains give a good general idea of the composition and structure of the whole peninsula, and also of much of southern Africa, we shall now present our readers with a concise description of them, drawn up from information communicated to us by Dr Adam of Calcutta, and from the published accounts of Captain Hall and Mr Clarke Abel.

Lion's Rump.

The *Lion's Rump* rises by an easy ascent, and, excepting at one or two points, is covered to the summit with a thin soil, bearing a scanty vegetation †.

It is composed of clay-slate, and sandstone. The sandstone rests upon the slate. The clay-slate is distinctly stratified;

* Clarke Abel's *Travels*, p. 295. and 297.

† Dr Adam remarks, that vegetables appeared to be most luxuriant over the sandstone, less so on the soil formed by the decomposition of the granite, and least of all over clay-slate, as on the Lion's Rump, where clay-slate is the predominating rock. Although this latter hill has been cultivated in some places, yet it presents a stunted vegetation, while the upper parts of Lion's Head and Table Mountain, though much more elevated, display rich and more vigorous shrubs. Constantia, so much celebrated for its wine, is situated at the bottom of the range leading from Cape Town to Simmon's Bay, where sandstone is the predominating rock, and the soil of the farm of the neighbouring ground appears to be composed of it, in a state of decomposition and of vegetable mould. That it is the sandstone which essentially contributes to the excellence of the soil, Dr Adam is inclined to believe, from having observed several spots at the foot of the same range nearer Cape Town, with a soil richer in vegetable mould, but whose produce was held much inferior. The principal rock there was granite, and its superincumbent sandstone has suffered less decomposition than that adjoining to Constantia.

the strata on one side of the hill dip to the north, on the opposite to the south, and in the middle or centre of the hill they are nearly perpendicular. Numerous veins of compact quartz traverse the slate in all directions. A quarry, which has been wrought to considerable extent on the east side of the Lion's Rump, and which is shewn in Plate VI. Fig. 1., but on a larger scale than the proportions of the general elevation, affords a fine view of the structure of the clay-slate, and in one place there is a bed of sandstone in the slate. The sandstone, which is of a yellowish-grey colour, is composed of grains of quartz, with disseminated felspar and scales of mica.

Lion's Head.

The strata of clay-slate continue to the base of the *Lion's Head.* Here they are succeeded by strata of compact gneiss, which is composed of grey felspar and quartz, with much dark brown mica in small scales. The gneiss is distinctly stratified, and the strata in some places dip under the next rock, which is granite, in others they dip from it. Numerous transitions are to be observed from the gneiss into the granite, and in the same bed of compact gneiss, one part will be gneiss and another granite. Portions of granite of various sizes are imbedded in the gneiss, and numerous blocks of gneiss, varying much in size, are imbedded in the granite. Sometimes the imbedded portions of granite and gneiss are distinctly separated from the surrounding rock; in other instances they are much intermixed at their line of junction, and veins shoot from the imbedded portions of granite into the surrounding gneiss. Beds of granite appear in some places to alternate with the compact gneiss. Veins of granite, varying from a few inches to several feet in width, traverse the gneiss, and are to be observed shooting from the granite, or are contained in the gneiss, and do not appear to have any connection with beds or masses of granite. Granite forms a considerable portion of the Lion's Head. It is a compound of pale red felspar, grey quartz, and brownish-black mica. It is more frequently coarse granular than fine granular, and is often porphyritic. It is occasionally traversed by veins of quartz, or of felspar, or of granite. It does not appear to be distinctly stratified in any part of the mountain. In some parts the granite is intersected by veins of greenstone, and one of these veins (represented No. 3. of the geological views at the Cape of Good Hope of Mr Clarke Abel) is rather remarkable, as it appears divided and shifted. As we ascend the mountain, we find the granite succeeded first by a reddish sandstone, and this in its turn is covered by a brown sandstone that reaches to the summit. These sandstones are principally composed of granular concretions of quartz, with a few disseminated grains of felspar, and scales of mica. The sandstone is distinctly stratified, and the strata dip under a small angle, all around the Lion's Head, and the north-west side of Table Mountain. On the opposite side of the latter, however, from the sea-beach, we may see it beyond the gorges, making an angle with the horizon of not less than 45°. Dr Adam remarks: "During a ride to Constantia one day, I observed this high inclination more particularly, on the ridge extending from the Devil's Peak by Simmon's Bay; and having afterwards visited the spot on purpose, found the sandstone very much elevated in its position above the common level of the strata, and at one place nearly perpendicular to the horizon, running from north-west to south-east."

Table Mountain.

The next and highest mountain, the *Table Mountain*, presents many interesting mineralogical appearances. The lowest part of the mountain, on one side, is red sandstone; higher up, and apparently rising from under it, are clay-slate and gneiss. These rocks are disposed in strata nearly vertical, with an east and west direction. They alternate with granite, which is the next rock in the ascent of the mountain. The granite at its line of junction with the gneiss and clay-slate, is often much intermixed with them; and numerous veins of granite shoot from the mass of the rock itself into the bounding strata, and cotemporaneous portions of granite are seen enclosed in the gneiss, and of gneiss in the granite. At a higher level than the granite, sandstone makes its appearance, and continues to the summit of the mountain. The lowest sandstone is of a red colour, the next is of a yellowish colour; and the upper part, or that on the summit, of a greyish colour, and sometimes so coarsely granular, as to appear in the state of conglomerate. It many places, the sandstone passes into quartz-rock.

Devil's Peak.

The most easterly mountain of the groupe we are describing, named the *Devil's Peak,* agrees with Table Mountain in the nature and arrangement of the rocks of which it is composed. The lower part of the mountain exhibits strata of clay-slate; these, as we ascend, are succeeded by granite, and the upper parts and summit are of the usual varieties of sandstone *.

General Result.

Such, then, are the grand geognostical features of the mountains near Cape Town, and of those parts of the peninsula which have been examined. Are we to consider all these rocks as having been formed at different times, or are they of simultaneous formation? The advocates for the Plutonic theory maintain, that the slate was first deposited in horizontal strata at the bottom of the sea,—that these strata were afterwards softened by heat, and raised from their original horizontal to their present vertical position, by the action of fluid granite projected from the interior of the earth,—and that after these two operations were finished, a third took place, namely, that of the deposition of the sandstone over the granite and slate. According to this hypothesis, these rocks have been formed at three different periods, the slate first, next the granite, and last of all the sandstone; and two of the formations, viz. the slate and sandstone, are of aqueous origin. while the third or granite is of igneous formation. We consider this explanation as unsatisfactory, and are inclined to view these rocks as of Neptunian and simultaneous formation; because they alternate with, and pass into each other, thus exhibiting the same general geognostical relations as occur in formations composed of sandstone and limestone, or of sandstone and gypsum. The junctions of the granite and gneiss, and of the sandstone and slate, do not present any species of veins, or varieties of intermixtures, or of imbedded portions (fragments of the Huttonians), or convolutions, that do not occur at the junctions of universally admitted Neptunian rocks, such as limestone, claystone, gypsum, and sandstone.

* In Plate VI. is a plan sent by Dr Adam, shewing the form and relative positions of the mountains near Cape Town.

In short, the mountains and hills of the peninsula of the Cape of Good Hope, are to be considered as variously aggregated compounds of quartz, felspar, and mica, and the whole as the result of one nearly simultaneous process of crystallisation. This view affords a plausible explanation of all the varieties of aggregation, structure, position, and transitions, observed in the rocks of this part of Africa.

ART. XI.—*Historical Account of the Discoveries respecting the Double Refraction and Polarisation of Light.* Communicated by the Author.

THE subject of the Double Refraction and Polarisation of Light, though one of the most important and interesting branches of human knowledge, has scarcely, if at all, attracted the attention of English readers. Our chemists and mineralogists have neglected to avail themselves of the lights which it offers to throw upon their respective sciences: Our popular lecturers on Experimental Philosophy have not been aware of the fine experiments and brilliant exhibitions with which it can so liberally supply them; and the greater number of our learned Professors have not yet found leisure to admit it into their course of physical science. This inattention to an inquiry possessing so many claims upon our notice, can have arisen only from an opinion which we believe has too generally prevailed, that the subject of double refraction and polarisation is not susceptible of popular explanation; and from an erroneous notion, propagated by individuals whose pursuits have been eclipsed in the splendour of a new science, that it consists only of insulated facts and extravagant assumptions.

One of the principal objects of the present series of papers is to correct these absurd misapprehensions; and we have no doubt that we shall be able to render the subject intelligible to such of our readers as have but a very slender portion either of physical or mathematical knowledge; and to convince those whose attainments are of a higher order, that almost all the phenomena of double refraction and polarisation, intricate and capricious as they appear to be, have been brought under the dominion of general laws, and can be calculated with as much accuracy as that with which the astronomer can compute the motions and positions of the heavenly bodies.

In executing this task, we shall explain the phenomena in the order of their discovery. By this means each article will be complete in itself, and the reader will be less dependent on the popularity and perspicuity of our illustrations. In the adoption, therefore, of this plan, the materials may be arranged under five periods.

Period I. Containing the discoveries of Erasmus Bartholinus.
II. The discoveries of Christopher Huygens.
III. The investigations, of Newton, Beccaria, Martin, Haüy, Wollaston, and La Place.
IV. The discoveries of Malus.
V. The discoveries made after Malus's death, by M. Arago, M. Biot, Dr Brewster, Dr Young, M. Seebeck, and M. Fresnel.

Before entering, however, on the first of these periods, we shall endeavour to explain in general what is meant by *Double Refraction* and *Polarisation ;* for though the explanation of these and other terms will necessarily be introduced in describing the phenomena to which they have been applied, yet there are many of our readers who will content themselves with the slight knowledge conveyed in a definition, without being at the trouble of any farther investigation.

If a beam of light from the sun or any other luminous body is made to pass through a plate of glass or a mass of water contained between two parallel plates of glass, it will have the same appearance and the same properties after transmission as before it. Hence the glass and the water refract singly, and all objects seen through them will appear single. If the same beam of light is made to pass through a parallel plate of calcareous or Iceland spar, or of various other crystallised bodies, it will be divided, at its entrance into the plate, into two separate pencils or beams. The crystals which possess this property are called *doubly refracting crystals,* and the beam of light is said to be *doubly refracted,* and hence all objects seen through such crystals will appear double. As one of these pencils or images is refracted according to the ordinary law of refraction discovered by Snellius, it is called the *ordinary pencil* or the *ordinary image*, while the other pencil or image is called the *extraordinary* one, from its being refracted according to a law different from the ordinary law.

The light which composes the two images or pencils thus formed by double refraction, possesses properties different from all ordinary light, and as these properties are related to the different sides of the rays or pencils, the rays or pencils of light which possess such properties, are said to be *polarised*, or to indicate polarity, in the same way as particles of iron in the vicinity of a magnet indicate polarity, by possessing a property in one of their sides or extremities, which they do not possess in their other extremity. Now, as the diameter of a beam of light may be reduced to a very small magnitude, and as every portion of the beam in the direction of its length has a progressive motion, and possesses the same properties as the whole beam, we may call these minute portions *Particles of Light*, and speak of the Sides or Poles of these particles, without considering whether light is composed of material particles issuing from the sun's body, or is merely the undulation of an elastic medium.

Period I. *Account of the Discoveries of Erasmus Bartholinus, respecting Double Refraction.*

About the middle of the seventeenth century, Dr Erasmus Bartholinus, a physician at Copenhagen, and the author of several excellent works on geometry, procured from some of the Danish merchants that frequented Iceland, "a crystal stone like a rhombick or rhomboid prism, which, when broken into small pieces, kept the same figure." It was dug out of a very high mountain, not far from the Bay of Roerfiord, in 65° of latitude. "Its whole body was rather clear than bright, of the colour of limpid water, but that colour, when it was immersed in water and dried again, became dull." With this substance, which, from its locality, was called *Iceland Crystal*, Bartholinus made a number of experiments both chemical and optical; and having discovered some of the singular effects which it produced upon light, he published an account of them at Copenhagen in 1669, under the title of *Experimenta Crystalli Islandici Dis-diaclastici, quibus mira et insolita refractio detegitur.* There does not appear to be a copy of this work in this country, and we have learned that it is not to be found in the library of the Royal Society; but the want of it is well supplied by "An account of sundry experiments made and communicated by Dr Erasmus Bartholin, upon a crystal-like body sent to him out of Iceland," addressed to Dr Oldenburgh, and printed in the 67th Number of the Philosophical Transactions. From this account we shall select those parts which relate to double refraction, and shall in general give them in the words of the author.

"1. The objects seen through" this crystalline prism "appear sometimes, and in certain positions of the prism, double; where 'tis to be noted, that the distance between the two images is greater or less, according to the different bigness of the prism; insomuch, that in thinner pieces this difference of the double image almost vanisheth.

"2. The object appearing double, both images appear with a fainter colour; and sometimes one part of the same species is obscurer than the other.

"3. To an attentive eye, one of these images will appear higher than the other.

"4. In a certain position, the image of an object seen through this body appears but single, like as through any other transparent body.

"5. We have also found a position wherein the object appears sixfold *.

"6. If any of the obtuse angles of this prism be divided into two equal parts by a line, and the visual rays do pass from the eye to the object through that line or its parallel, both images will meet in that line, or in another parallel to it.

"7. Whereas objects seen through diaphanous bodies, are wont to remain constantly in the same place, in what manner soever the transparent body be moved, nor the image on the surface move, except the object be moved; we have observed here, that one of the images is moveable, the other remaining fixed; although there be a way also to make the fixed image moveable,

* The sextuple multiplication of the image here mentioned, arises, as will be seen in a subsequent article, from thin contemporaneous veins of Iceland spar intersecting the rhomboidal mass. See *Phil. Trans.* 1816, p. 270; and *Edin. Trans.* vol. viii. p. 165.

and the moveable fixed in the same crystal, and another to make both moveable.

" 8. The *moveable* image doth not move at random, but always *about* the *fixed*, which, while it turneth about, it never describeth a perfect circle but in one case.

" 9. Dioptricks teach, that a diaphanous body having one only surface, sends from one object but one image refracted to the eye, and, having more surfaces than one, it represents one image in each. But, whereas in our substance there occurs but one plain superficies to the eye, and yet a double image of one object, it concerned us to consider whence this double image might be caused. Two ways offered themselves to us, reflection and refraction. How reflection could perform it, was difficult to find. For, having dulled the clearness of the two plain sides of our crystalline prism, thereby to make them unfit for reflecting the light, the rays being directed through its upper and lowermost superficies, the image still appeared double. Again, two species appearing through a great prism, upon breaking of the same into pieces, and so reducing it into divers smaller ones, it came to pass, that through each of these lesser portions the same object was seen always double. Whence I collected, that if it should be said that *one* of the images proceeded from the reflection of the plain *sides*, the former of these experiments would discountenance that assertion. But then if another should derive the cause from some internal reflection of the surfaces of this body, certainly the same effect would not have been found in every one of its parts; but the double appearance that was exhibited in the smallest portion, would have been multiplied in a greater bulk.

" Reflection, therefore, not satisfying, we recurred to refraction. But whereas 'tis known, that no image can pass through two diaphanous bodies of a different nature but by refraction, and that one image supposeth one refraction, it did follow, that, if refraction were made the cause of this phenomenon, there would be a double refraction for a double image. And forasmuch as the appearances of our Iceland crystal are not of the same kind, but one of them is fixed, the other moveth, we shall distinguish the refractions themselves which refract the double rays arriving to the eye, and call the one which sends the *fixed* image refracted to our sight, *Usual;* the other, which transmits the *moveable* to the eye, *Unusual.* And hence, namely, from this peculiar and notable property of the double refraction in this Iceland-stone, we have not scrupled to call it *Dis-diaclastick.*

"This being supposed, it will not be irrational to suspect that these two refractions proceed from different principles. For, since it is commonly known from dioptricks that an object, by visual rays affecting the eye, exhibits some image on the superficies of the diaphanous body, which image is but one as long as the superficies is one, and the upper plain parallel to the lower; as also, that if, the eye remaining steady, the diaphanous body be moved, that image remains always fixed, as long as the object whence it comes remains unmoved. Wherefore in this transparent substance, the image which appears fixed may proceed according to the ordinary laws of usual refraction; but that which moveth, and is carried about according to the motion of the diaphanous body, while the object remains unstirred, sheweth an unusual kind of refraction, hitherto unobserved by Dioptricians.

"Hence, that I might examine the nature and difference of both, I put upon some object, as the point A, Fig. 1. Plate VII. the prism of my double refracting crystal NPRQTBS, and the eye M being perpendicularly posited over the upper plain of the prism NPRQ, I noted whether there was any refraction of the point A, for the usual laws of refraction teach that there is none. But the perpendicular ray of the eye was observed to pass not through the moveable but the fixed image, thereby being conformable to the rules of usual refraction, as striking the eye unrefracted, so that the eye, the image, and the object were seen in the same line. But when in the same scite of the eye, the object A did also exhibit the other image X, at no small distance from the former, I took notice that this object A was not seen unrefracted by the means of the image X, though the eye M remained perpendicular over the plain; and that, consequently, this unusual refraction is not subject to the received axiom of dioptricks, which imports, that a ray falling perpendicularly on the superficies of a diaphanous body, is not refracted, but passeth unrefracted.

"Next, I so placed the eye in O, that the ray from the object A arriving to the eye, might be parallel to the lines RT and QB of the plane RQTB, &c.; then it appeared, that the rays were trajected from the object A without refraction, through the moveable image Q; the object A, the moveable image Z, and the eye O, being in the same line; and that the same object A did transmit to the eye O, remaining in the same position, yet another species Y, through the refracted ray AYO. Whence it was manifest to me, that this unusual refraction had for its rule the parallel of the sides of this double refracting crystal, while the usual refraction was directed according to the perpendicular of the superficies.

"But considering that the place of the point appearing through our diaphanous body cannot easily be determined, as being only obvious in the uppermost part, we shall add the way whereby we have found its diversity, by drawing, on the subjacent Table, a straight line through that point; the place of which line will be determined by the one eye through this crystal, and by the other eye without the crystal. For, in the same Figure, let through the object A be drawn upon the Table a straight line BC. The eye being in M, that double line HD and IE will appear, the species being cast on the upper surface; and, if you will attend well, you will observe one of the images, viz. the fixed HD to be congruent to the adjacent line BC, whilst the other, namely the moveable EI, tendeth towards R. But if afterwards the eye be posited in O, the same object, I mean the line BC, will not only be represented double by the images KF and LG, but also the moveable image GL be congruent to the inferior line BC; while the fixed FK is not so, but tends towards N."

After describing these experiments, Bartholinus proceeds to measure the ratio of the angles of incidence and refraction in the ordinary image, and he finds it to be as five to three, which makes the index of refraction 1.667. He endeavours to account for the double refraction, by supposing that the Iceland crystal has two sets of pores; one, "according to the *ductus* or direction of the sides, and parallel thereto; since, it may be observed, that according to this disposition of the sides it is broken, and the parts severed from one another; and that one of the images, namely the *moveable*, passeth through them. Next, besides these pores lying according to the parallelism of the sides, it hath others, such as glass, water, and right crystals have, through which the right image is transmitted."

Bartholinus next supposes, that there are some directions in which the rays pass through the crystal unrefracted; and though in ordinary diaphanous bodies these directions are perpendicular to their surfaces, yet in other bodies they may have another position. He likewise supposes, that half of the incident pencil is refracted *usually*, and the other half *unusually*; or, what is the same thing, that the *usual* and *unusual* refractions have the same power to refract the incident light.

From this account of Bartholinus's experiments, he appears to have discovered three important facts.

1. That Iceland spar has the property of double refraction.
2. That one of these refractions is performed according to a law which is common to all transparent solids and fluids, while the other is performed according to an extraordinary law which had not previously been observed by philosophers; and,
3. That the incident light is equally divided between the ordinary and extraordinary pencils.

Bartholinus does not seem to have transmitted the ordinary and extraordinary pencils through a second piece of Iceland spar, and it was therefore reserved for the celebrated Huygens to discover, by means of this experiment, the remarkable properties which arise from the polarisation of these two pencils.

Edinburgh, *July* 1. 1819.

Art. XII.—*Sketch of the Distribution of Rocks in Shetland.* By Samuel Hibbert, M. D. M.W.S. Communicated by the Author.

Of the group of islands bearing the name of Shetland, nothing entitled to the appellation of a Chart, intended to comprehend the whole of them, has yet been produced *. From information on which I am most disposed to rely, conjoined with my own observations, the clustre, exclusive of Foula, the Voe Skerries, and Fair Isle, distantly separated from the rest, may

* I know of no actual surveys which have been made deserving confidence, except of four or five miles of coast in the vicinity of Valey Sound, which was all that Captain Preston accomplished, in a chart, to which his name is affixed, pretending to delineate the whole of Shetland; to this may be added a sketch of

be placed between 59° 53′, and 60° 56′ north latitude, and between 52′ and 1° 57′ of west longitude from London.

The stratification of Shetland cannot be considered as falling under the particular views of the celebrated Werner, who supposed that strata lay over each other like the coats of an onion, whilst the whole had reference to an unstratified fundamental rock, as for instance, to Granite. But in the progress of observation, certain other conditions of stratification have been pointed out, particularly by the Professor of Natural History in the University of Edinburgh, to whom we are indebted no less for the introduction in this country of the Wernerian System, than for several important modifications which it has undergone, and which he has been accustomed so ably to illustrate in his lectures.

The denuded state of the rocks in Shetland, recommends this country as a particular object of geological study. It is, however, a country which, by the few geologists who have visited it, has been considered as possessing the greatest possible intricacy of structure. Indeed, on this account, I feel myself under the necessity of employing more precise language than is commonly deemed necessary in subjects of this nature, in order to explain with less difficulty the different circumstances of stratification which presented themselves to me in these islands.

In the first place, in describing strata which are vertical, we may conceive of them as the metallic plates which are ranged in the usual manner in a galvanic trough; or, we may so alter the condition of the series of the plates, as to cause their planes to represent any angle of inclination between a horizontal and vertical position, which a stratum may form with the horizon. A stratum may then be described as having *two lateral planes*,

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the eastern coast of Unst, as given in Arrowsmith's map; and, lastly, an excellent survey of Balta Harbour, published last year by Captain Ramage of the Royal Navy. With this paucity of materials necessary for producing a geological map of Shetland, it is proper to premise, that the sketch annexed to this communication, is the result of observations made with no other instrument than a pocket compass. Still I flatter myself, that, though intended for a country exceeded by no other in the number and tortuous course of its inlets, the sketch will be found adequate to the purpose for which it was designed. I have occasionally availed myself of observations, with which I was favoured by the late Thomas Mouat, Esq. of Garth, a gentleman of considerable intelligence, and particularly versed in the ancient history of his country.

vertical or inclined, by which it is connected to other strata, as the sides of a metallic lamella may be to other plates which are ranged in contact with it. A single stratum may also be represented as having two *lateral edges of attachment;* strata being often found to be opposed to other rocks at their edges, in the same manner that we conceive of the edges of the metallic plates, which are opposed to the sides of a galvanic trough. In this instance, however, they are opposed at right angles; but this angle may, of course, be varied *ad libitum*, to correspond to the different circumstances under which strata are found. A stratum may again be described as having a *superior* or *upper edge;* though this term is perhaps superseded by the equally expressive language which we use, when we speak of the *outgoings* of strata. Again, the *inferior edge* of a stratum is illustrated by that of a metallic plate, which is opposed to the bottom of a galvanic trough. Of course, the relations of the *inferior edges* of strata must be often objects of mere speculation. If, lastly, any metallic plate of a galvanic trough be so altered in its position, that its planes become parallel to the plane of the horizon, it is evident that no other distinction of position can take place in it, or in a stratum under a similar condition, than that there should be a *superior* and *inferior side*, and *certain horizontal edges* *.

But, besides these terms relating to the *sides* and *edges* of strata, other minutiæ of description, when found requisite, will be introduced in the course of this paper.—I shall now, without further delay, attempt to explain the geological structure of the rocks of Shetland.

Strata of Fitful Head.

Commencing our investigations at the most southerly part of Shetland, namely, at Quendal Bay, in the parish of Dunrossness, a small system of strata, forming for the most part Fitful Head, on the west of the bay, will demand our earliest notice.

Crossing the strata in a direction from east to west, we find on the west of Quendal Bay, gneiss traversed by numerous

* The *lateral edges* of our author, are the *ends of the strata* of miners; his *superior* edges, their *outgoings;* and *inferior edges*, the bottoms *of strata:* and when he speaks of *horizontal edges*, we are to understand the *outgoings of horizontal strata.*—Ed.

veins of granite, to which immediately succeeds the mica-slate of Garthsness. More westerly ensues the large assemblage of strata composed of clay-slate, which forms Fitful Head. Still more westerly at Noss, a headland to the north-west of Fitful Head, occur a few strata of gneiss and mica-slate, which are traversed by granite.

The stratification of the whole of this mass is confused, and, as far as an estimate can be made of the direction or line of bearing as it occurs at different places, the lateral planes of the strata cannot be considered as parallel to each other. This unconformity in point of parallelism, is observable where strata are not disturbed by the presence of traversing masses of limestone or granite, as in the clay-slate of Fitful Head. The strata are constantly observed to pass into each other laterally, or to be united by their sides, the tabular seams by which they were separated becoming evanescent; nor can any stratum be traced far, before it is thus observed to be lost, whilst new tabular seams are in equal number appearing at the same time in other places. The strata are also often curved or bent out of their course. Still the direction assumed by the strata may be generally stated at 15° north of east, variations from that point of the compass occurring to the amount of 15° or 20°.

It is worthy of general remark, that circumstances of stratification like these are so constantly appearing, as to render extremely vague the idea of *conformity*, which has been often deemed only applicable to strata, where there is a parallelism of their lateral planes. It is always inconvenient to forego terms that are in common use, but if the term *conformity* is still to be used in speaking of strata, it would perhaps be better that the word should be restricted to those circumstances where strata are found to have no other relation to each other at their junction than one that is *lateral;* for it is worthy of particular notice, that two stratified rocks are often found so to vary in the direction of their respective strata, that where the contact takes place, the sides of one set of strata are opposed to the lateral edges of another set. Here, then, I conceive, is a good ground for the distinction of rocks into *conformable* or *unconformable.* But, at the same time, I would submit, that much more descriptive words, and not liable to such ambiguity, may be found, which might be capable of expressing every condition of strata. Where strata are observed to have a lateral attachment to each other, or where the lines of bearing denote uniformity, it may perhaps be justifiable, in describing such strata, to use the word *Collateral.* This expression of *collateral strata*, will apply to many circumstances where strata are not of equal thickness, or where they occasionally become indistinct, from a transition into each other at their sides, or where, added to this circumstance, they are so curved or bent out of their course, as that their lines of bearing shall occasionally vary several degrees.

When, however, *collateral strata*, if I may be allowed to adopt the expression, are of uniform thickness, and are uninterrupted in their course, we may then properly enough distinguish them farther by the name of *Parallel strata.*

The inclination of the strata of Fitful Head, is with difficulty estimated, owing to circumstances already stated, namely, their distorted state, and their lateral transition into each other. The dip is generally to the east, at an angle of about 40°.

In the mica-slate, about a mile to the west of Quendal, is a thin mass of limestone, the strata of which run east to west, in a direction strictly *unconformable* to that of the adjoining strata: that is, the lateral edges of the mica-slate are opposed to the lateral planes of the limestone. Here is a slight exemplification of the distinction which I have maintained as subsisting in the relations of strata, and tending to justify the use of the term *collateral* strata, as applicable to the mica-slate.

At Garthsness, near Fitful Head, in the mica-slate, occurs a vein or perhaps bed of iron-pyrites, running nearly north and south, which was a few years ago unsuccessfully wrought, for the purpose of finding copper-ore, whilst many hundred tons of iron-pyrites were thrown into the sea. The site of the ore is so much concealed by the fragments thrown up from the mine, that its breadth is not very distinct*. I observed four and a half feet in width, of what the Cornish miners, who worked here, called *Gossan*, which consisted of pulverulent siliceous matter, mixed with iron-ore, and eight and a half feet of what was named by the same men the *Rider*, consisting of iron-pyrites, occurring in a highly in-

* Dr Fleming's account of these mines of Dunrossness, in the Appendix to Shirreff's *Agricultural Survey of Orkney and Shetland*, may be consulted with advantage.

durated blue quartz. In this last substance was contained the sparing quantity of copper-ore, which was the sole object of the mining operations. In the clay-slate of Fitful Head, at the Girths of Quendal, is found a vein or probably bed of iron-mica, noticed by Dr Fleming. It is about twelve feet in breadth, and appears very rich.

I now proceed to show the relations of this system of strata to contiguous rocks, under the impression, that the most important inquiry regarding Strata, is to discover under what circumstances their superior edges or outgoings become first manifest. This inquiry involves the relations which strata exhibit at those lateral edges of attachment, by which they are connected with rocks of a different nature, and at various angles, in the manner that the edges of metallic plates are joined to the sides of a galvanic trough. There is this difference in the junction of a stratum, that it may be at any angle formed by its edges besides a right one, and at any inclination of its lateral plane, besides one that is vertical. This attachment of the strata, by their extreme or lateral edges, must of course be sought for in the line of their direction, and at opposite points of the compass; as in the present instance, at the southerly and northerly boundaries of Fitful Head, the site of the rocks here described. It is unfortunate, for the sake of our first illustration, that the invasion of the sea should cut off altogether the connections of the southerly lateral edges of the strata; but, tracing the tabular seams in a direction of north 15° east, we observe the strata at their northerly extremities or lateral edges coming in contact with a mass of sienite, which, from the great quantity of epidote admitted into its composition, may be properly named an *Epidotic Sienite.* The covered state of the ground prevents us, except in one or two places, from observing the strata actually in contact with the sienite. But here it is proper briefly to hint at the difficulty there is of determining in what relations strata exist with regard to an unstratified rock, from observations made only at the place of junction.

An illustration to this effect is seen in a well exposed section of the junction of a few strata of gneiss and mica-slate south of Noss, and to the N. W. of Fitful Head. Here the rocks so frequently pass into each other, by an interchange of substance, so many small processes from the epidotic sienite, by invading the strata attached to it, disturb their direction, whilst the strata again render irregular their mutual line of connection, by penetrating more or less into the substance of the sienite, that we must have recourse to other observations than those afforded at the actual junction, in order to consider whether strata viewed *en masse* are joined by their sides to an unstratified rock, coating or surrounding it after the manner of the layers of an onion, to which they have been often compared; or if, on the contrary, they are opposed to the rock by their lateral edges in an unconformable position. This is best inferred by a comparison of the general direction assumed by the strata, and the outline of the unstratified mass which is opposed to them. The direction of the line forming the southern boundary of the epidotic sienite is about N. 30° W. whilst that of the strata meeting it is about N. 15° E.; consequently the bounding line of the sienite cannot be conformable to the strata, or, in other words, parallel to, or collateral with them, but must rather be opposed to the lateral edges of the strata, and thus be unconformable to them.

The southern boundary of the sienite may be traced from a small island in Quendal Bay, named Little Holm, where it is joined to a conglomerate rock, to be noticed hereafter; from thence to Cross Island and the Mainland. Passing close to the house of Mr Ogilvie, it is with difficulty traced through a covered country until seen at Noss, connected with gneiss and mica-slate in the manner above mentioned. The northerly line of boundary, with other particulars relating to the sienite, I shall point out on another occasion. One important circumstance, however, in the sienite, remains unnoticed. This concerns the deep form of the rock where it affords an attachment to strata, and which is disclosed by a deep section on one occasion only, namely, at Noss.

Every unstratified mass, in its junction with strata, may exhibit to us different descriptions of surface. For if a vertical line passing through the highest point of the unstratified rock, should not fall within its base, such a surface of the rock, may, for the sake of an important distinction, be described as *impendent* or hanging over. But if the perpendicular, on the contrary, be included within the base, the rock may be considered as having an *inclined* surface. Again, the surface, instead of being *impendent* or *inclined*, may be *vertical*. In the present instance, the sienitic rock in a deep section, formed on the coast by the rock gradually yielding to the inroads of the western ocean, exhibits to us a specimen of the *impendent* surface; the sienite appearing to *hang over* the strata which are connected to it by their lateral edges. Geologists would probably express the relation by the word *superjacent*, as applied to the sienite. There is only one objection to the word *superjacent*, that it assigns a *fundamental* character to the strata, and an *incumbent* character to the sienite; notions which cannot exist, as long as we can conceive that the sienite may shew every variety of surface, as it is observable at different depths: at one certain depth it may be *impendent*, at another *inclined*, and at another *vertical*, these varieties so combining, as to give to the deep surface of the rock, were it exposed, a waved or zigzag appearance. Now, it is evident, that a prolongation or abbreviation of the substance of any individual stratum, to meet those varied forms of which we have supposed the sienite to be susceptible, would, at every increasing depth of the section, exhibit to us the stratum and the mass of sienite by turns, in a superjacent, and in a subjacent position. Certainly, in such a case, we cannot say of any individual rock, that it is both a fundamental and an incumbent one. It is surely more natural to conceive of strata when joined by their lateral edges to an unstratified mass, as exhibiting an irregular or uncertain line in their contact, like the suture by which portions of the human cranium are joined to each other. The words *impendent* or *inclined* may then properly represent only that part of the line of attachment which is visible to us, without relating to ideas of a position either fundamental or incumbent.

There is an important inference arising from this view of the attachment of strata to an unstratified rock. A stratum has been conceived of, as attached by its lateral edge to a mass of sienite, or in other words, meeting it at any angle, which mass on the side affording such attachment, may be either *vertical*, or it may include or exclude a plumb line supposed to be suspended from the highest point of the attachment, being either *impendent* or *inclined*. Now, it is evident, that whatever be the deep form of the sienite, traced from any given point in the section, precisely the same inclination with our horizon will be preserved; the only necessary change in the condition of the stratum will consist in a prolongation or abbreviation of its substance to meet any varied form which the sienite may have assumed. Thus the horizontal inclination which a stratum exhibits in its lateral plane, is perfectly independent of the form of the rock which merely affords to its lateral edge an attachment. It is for these reasons that I have hitherto used the general word *attachment* in expressing the junction of strata, since, in the application, is involved no supposed form of an unstratified rock, which, judging from the angles made with the horizon, has, I apprehend, too often, in laying down vertical sections of a district, been attended with erroneous deductions.

I have dwelt at some length on the system of rocks at Fitful Head, for no other purpose than for the sake of obtaining precise ideas respecting the circumstances of stratification, to which we may apply the terms *conformable* or *unconformable*. The word *conformable*, I have thus applied to all strata, that are from observation found to be attached together by their sides, or, in synonymous terms, to be *collateral* to each other; on the other hand, only one circumstance of unconformity, among certain others peculiar to rocks, has yet been fully shewn, which is, when strata are opposed by their lateral edges to an unstratified rock. At the same time, it must be observed, that the stratification of the rocks of Fitful Head, is too confused, from the causes pointed out, to be recommended for actual observation, as the best illustration of the views now entertained. Much better examples will be noticed in the progress of this demonstration.

The Sandstone and Conglomerate Rocks of the South-east of Shetland.

Leaving for a short time the rocks to the north of the Epidotic Sienite of Quendal, I shall proceed to notice the Sandstone of the east of Shetland as it first appears, in tracing it from the south, at the neighbouring promontory of Sumburgh Head. This sandstone differs from one occurring more westerly, by admitting into its composition no portions or apparent fragments either of the same, or of any other rock, consisting altogether of Granular Quartz, which is, in fact, a more suitable name for it, and, as such, has been adopted by Professor Jameson in speaking of rocks of a similar description. The other kind of sandstone contains portions, or apparent fragments, either of the same or of other rocks, which portions often shew marks of attrition.

The granular quartz, unmixed with portions of other rocks, may be traced from Sumburgh Head to West Voe, where it is occasionally associated with a quartz more compact; when farther north at Grutness Voe, its appearance is interrupted by the advances of the sea. Thus prevented from tracing the granular quartz along the coast in a continued course, we meet with it occasionally at the Ness of Sandwick, at Mousa Island where it is associated with thin alternating beds of limestone, at Holliness, and still farther north at the east of Bressay Island, bounded to the west by a line which may be drawn from the southwesterly extremity of the Island to Aithvoe on the north; and, lastly, at the Island of Noss, where, at the channel dividing this isle from Bressay, it is superficially covered with a sandstone containing large and angular fragments of a rock of its own description.

The direction of the strata, as we trace them from the south, is very various, but it may, perhaps, be stated generally as occurring from N. 30° W. to N. 30° E.

The dip is generally to the east, at angles of inclination from 30° to 40°: occasionally, however, the strata have a westerly inclination.

West of this mass of granular quartz, is a sandstone containing fragments of other rocks. This conglomerate sandstone is indiscriminately associated with a rock of a similar character, but consisting altogether of portions of granite, quartz, and felspar of various magnitude, from a size the most comminuted to that of several pounds weight. These conglomerate rocks occupy a narrow tract of country, from Quendal and certain Islands in the Bay to Rovie Head in the Mainland, including the west of Bressay Island. At Fladabister, however, instead of granite, portions of gneiss with hornblende appear in a conglomerated state; and in Bressay, occasionally, fragments of clay-slate

I shall now proceed to connect in order, all the circumstances attending this remarkable mass.

1*st*, The large portions of granite, quartz, or felspar, which distinguish the coarser kind of conglomerate rock, are either angular, or are so smoothly rounded, as to seem the result of attrition. This is an appearance which immediately suggests a notion of the abrading effects of aqueous elements. But, on the other hand, these apparent fragments are not unfrequently seen to pass into the substance of the mass in which they are contained; which substance consists of portions of a more comminuted description. Here, whilst the graduation is perfectly evident, the line of circumscription in the larger fragments becomes consequently indistinct.

2*dly*, The rock, consisting altogether of conglomerated portions of granite, quartz, and felspar, is often observed to graduate into the sandstone, where similar portions only occur as adventitious substances; sufficiently numerous, however, to give to this rock also a conglomerated character. Such a transition appears to refer the formation of both rocks to one common date.

3*dly*, The whole of this conglomerate rock is very superficial. Subjacent rocks of a different description are frequently detected under it, and these are various. At Quarf, for instance, they consist of a thin series of granite, mica-slate, and clay-slate; and near Fladabister, of quartz, mica-slate and limestone: At the Nab near Lerwick, of clay-slate; and at Grimister, of granular quartz and clay-slate alternated. These strata, which are strictly fundamental considered *en masse*, are often vertical, but most frequently are inclined to the west at angles of about 70°. An exemplification of another kind of unconformable position thus presents itself to our notice, which consists in the inferior edges of the strata of the conglomerate rock coming in contact with the superior or upper edges of the fundamental strata. The strata of the conglomerated rock may be illustrated in their position by taking any set of metallic lamellæ, under different angular inclinations, and by superimposing them on the surface formed by the upper edges of other metallic plates, which are fixed in the usual manner in a galvanic trough. It will then be seen how a fundamental surface is formed by the superior edges of the strata lying below the conglomerate rock, which surface may be variously illustrated by any position or inclination given to the subjacent lamellæ in the trough, agreeably to the variety in this respect, which exists in nature among strata. But care is to be taken, at the same time, that the lower edges of the superimposed lamellæ are in actual contact with the surface formed by the upper edges of the subjacent galvanic plates. For it is an important circumstance if it shall be found to exist in other countries no less than in Shetland, that the attachments of strata to rocks of a different kind on which they repose, should necessarily involve the contact of their inferior edges.

I may here also observe, that if strata were deposited on a fundamental rock like the coats of an onion, to which they have been often compared, it is evident that only the lowest stratum in any series would come in contact with the mass affording them a basis, which attachment would take place from the contact of the lowest *side* of the stratum next to the fundamental rock, and not from that of its inferior edge. But, according to the views now entertained, *there is not an individual stratum to be found in this series of conglomerate strata, that does not by its inferior edge come in contact with the fundamental surface which is common to them* *.

4thly, The greatest diversities of inclination, at every step which we take to examine the strata at present under consideration, are constantly occurring. To account for these diversities, we must assume, that the irregular thickness of the strata, as observable in their outgoings, is continued in the same manner throughout their whole depth. An irregular thickness of the strata may be explained by the tabular seams not being continued uniformly straight at different depths, or by strata again passing laterally into each other, their tabular seams thus becoming extinct, or by new tabular seams appearing in the course of their dip; all of which circumstances, on the supposition that the direction or line of bearing manifested by such strata does not show equal variations, may be included in our ideas of *collateral*, though not of *parallel* strata. The line of

* On a future opportunity, probably, I shall give some reasons for supposing that this is the general mode by which the strata of England, usually named *floetz*, are connected with the rocks upon which they are found to repose.

direction in these conglomerate strata, though certainly variable, is much less so than are the circumstances of inclination, being generally, as we trace their direction from the south, N. 30° E. differing 30° or 40° or more in opposite directions from this point. Now, in connection with the structure lately explained, by which the inferior edges of the strata of the conglomerate rock are in contact with the superior edges, or outgoings, of the fundamental strata, we may, I think, reasonably assign to the conglomerate strata a thickness varying in the course of their depth after the manner pointed out; it may then be easily shewn, how the lateral planes of those strata, which in one place assume a position nearly vertical, differ so much in inclination from collateral strata only a few yards distant, which are nearly horizontal. The truth is, that if the line of bearing, in any set of strata, be only tolerably uniform, in relation to any given point of the compass, it is not necessary for our notion of collateral or conformable strata, that the seams of stratification should exhibit a corresponding uniformity downwards; or, in other words, that the seams should be perfectly straight during the whole deep course through which our imagination may trace them, as from their superior edges or outgoings down to their lower edges, by which they are attached to a fundamental rock.

The circumstances of stratification now pointed out, irresistibly lead to speculations respecting the laws which have influenced the consolidation of the Earth's surface. The laws, which on a minute scale have variously affixed certain crystals to rocks by their terminal edges rather than by their lateral planes in opposition to the laws of gravity, seem identified in those primary causes, which have attached strata to a fundamental rock by their lower edges, rather than in consonance with mechanical notions, by their sides only. But it would be taking too contracted views of the operations of Nature, to suppose that in the present instance the laws of gravity had not their influence also. On the contrary, the strata often show in their outgoings, that they receive some faint impression of the kind of surface on which they rest. In the Island of Bressay, for instance, on the declivity of a hill, strata of sandstone or granular quartz dip at an inclination of 30° or 40° towards a point of the compass which looks in a direction opposite to certain contiguous strata of a conglomerate rock. Thus, whilst the strata of sandstone dip to the east, those of the conglomerate rock dip to the west. Now the strata of the conglomerate rock, where observed in contact with those of the granular quartz, seem perfectly vertical; but on crossing them for a distance of a few yards only, they are immediately observed to form less angles with the horizon, until they acquire a position nearly horizontal. Here the vertical position of the conglomerate strata, in contact with the granular quartz which dips to the east, seems an arrangement that is in conformity to an abrupt or vertical precipice, formed by the outgoing edges or escarpments of the strata of granular quartz,—with which vertical precipice, the contiguous strata of the conglomerate rock appear to range. Such a structure, by which a stratum is affixed to its inferior edge in a vertical position, does by no means bear the marks of a deposit calculated to fill up hollows or valleys. The explanation that I would give of this vertical position is, that the precipice of the granular quartz had influenced the mode in which the conglomerate strata were consolidated, according to certain finite laws of crystallization. But the change in the inclination of the conglomerate strata, which on crossing them are found to acquire nearly a horizontal position, and to dip to the west in a direction contrary to that of the granular quartz, is an arrangement tending to show, that the density of the strata had increased in proportion to their depth, and that the laws of gravity had been opposed to those of chemical affinity. It is thus that an accumulation of matter from below, produced by an increased density of the strata, would, by gradually elevating strata in the order of succession in which we meet them, have produced a position nearly horizontal.

5thly, The next circumstance to be noticed in the conglomerate rocks, is, that they do not graduate into their subjacent rocks by an interchange of substance. The attachment is very firm, showing that an action of a chemical nature, probably assisted by compression, may have induced it. But the line marking the boundary of each rock is perfectly distinct. It may, however, be anticipated, that an appearance diametrically opposite to this occurs elsewhere in Shetland; conglomerate strata imperceptibly graduating into those of quartz, which are fundamental to them.

6thly, These cemented portions occur in such situations, that a reference of their origin to any rocks of the same nature, co-existing in their immediate neighbourhood, seems impossible. They occur, for instance, in the enclosed valleys of clay-slate. But in the conglomerate rocks occupying such situations, no clay-slate is to be found, and, consequently, no accumulation can have filled up the valleys caused by the wearing down or detritus of impending rocks. Also, when the conglomerate rock comprehends portions of granite, quartz, and felspar, the fundamental strata consist, in one place, of quartz, mica-slate, and limestone; in another, of clay-slate and sandstone; and in many places, no other rock than clay-slate appears to be the fundamental one. The conglomerated sandstone might be supposed to have resulted from the decomposition of a contiguous mass, consisting altogether of granular quartz. But we must, at the same time, account for the disseminated portions of granite, which give to this rock its true distinction, and for the association of the conglomerated sandstone with granitic masses of a similar structure. This circumstance must refer the conglomerated rocks to an origin perfectly unconnected with the detritus of contiguous masses.

7thly, No evidence is afforded that the apparent fragments of this conglomerated rock were brought from any distance. We may indeed for the occasion advance such causes as debacles, streams, or waves, the usual agents in geological visions. These would, however, fail to convince us of the *modus operandi* by which the conglomerated strata, and rocks contiguous to them, are made by turns to occupy every possible variety of situation in relation to each other; or why certain districts, necessary in the track of a debacle or wave (or any such convenient agent, by whatever name it may be called), should leave no memorial in the presence of a solitary fragment of a catastrophe of this nature.

It is thus, in the absence of evidence tending to refer this accumulation of cemented portions, rounded as well as angular, to rocks distant or contiguous, that I am inclined to seek repose in the notion, that the conglomerated form is an original peculiarity of structure, subsequently, perhaps, in several instances, altered by causes of a mechanical nature. Thus, there seems an original form of distinct globular concretions, which I shall, on another occasion, point out as existing in a vein of granite, that traverses a mass of gneiss; whilst in this mass no mechanical appearances are elsewhere to be observed. It is easy, then, to conceive, that such a form of globular concretions would, to rocks thus originally constituted, if, at the same time, we summon to our assistance the force of aqueous elements, give every liability to abrasion. But the presence of such aqueous elements literally affords a very navigable ocean for conjecture. I therefore dismiss this protracted discussion, convinced of the multiplicity of circumstances which favour the notion, that the conglomerated appearance is an original peculiarity of structure; but, at the same time, aware of the difficulty of forming an accurate judgment respecting any manifestations which might indicate, that there has been a subsequent modification from mechanical causes.

The Strata forming the Cliff Hills.

I shall now proceed to describe the rocks situated to the north of the Epidotic Sienite of Fitful Head. These consist for the most part of clay-slate, associated with thin strata of quartz and hornblende-slate. The clay-slate forming the long range of the Cliff Hills, runs from near Spiggie and the Loch of Lunabister in Dunrossness, through a long tract of country to Quarf, where there is an interruption of the ridge, and thence to Kibister's Point, on the east of Dale's Voe. The whole of the strata of clay-slate, quartz, and hornblende-slate, seem connected unconformably with the epidotic sienite. The junction is much concealed by the Loch of Lunabister, and by covered ground; but the inference that it thus takes place, is from the visible proximity of both rocks to this site, from the direction of the clay-slate, which, tracing it from the north, is S. 15° W.; whilst the northern boundary of the epidotic sienite, observable from its most southerly point of Cross Holm in Quendal Bay to the west of Dunrossness, is traced in a line of N. 25° W. Thus the junction must take place at an angle, or by the lateral edges of the strata being opposed to the northerly surface of the sienitic mass.

The clay-slate, quartz, and hornblende-slate, are in their position unconformable to each other. The hornblende-slate is associated with the quartz, holding a tortuous course so as generally to interrupt the direction of the strata which it traverses. To show that the associated strata of quartz and hornblende are unconformable with the clay-slate, we must ascertain the course of each rock. In tracing the thin strata of quartz and hornblende-slate from the south, we find that from Lunabister to Maywick, at which latter place there is an interruption to the appearance of these rocks by the sea, also at the Island of Trondra where they reappear, the strata, considered collectively, maintain a course very nearly parallel to that of the clay-slate east of them. But at the Vale of Tingwall, the strata take a more easterly direction of N. 30° E. to Dale's Ness and the Isle of Glitness. Again, tracing the clay-slate from its junction with the sienite to Quarf, we find that little or no deviation is produced in the direction of the clay-slate, but that it is nearly conformable to the course of the strata already said to be situated to the west of it. But at Scalloway a change occurs; the course of the clay-slate is continued in right line, but that of the adjoining strata west of it begins to be inflected to the eastward. Hence, there must be an interception of the strata of clay-slate by the quartz and hornblende-slate; and, accordingly, a termination of all the rectilinear strata, which are thus opposed at their junction by strata crossing them, may be detected, particularly by observations made on the strata of clay-slate north by east from Scalloway.

The interception of a considerable part of the strata, seems to be completed at Dale's Ness. But, in the bed of Dale's Voe, and on its western banks, arises another important mass of quartz, associated with hornblende-slate, and nearly in junction with the similarly associated rocks which we have traced from the south. At Rovie Head, also, situated about a mile to the east of Dale's Voe, arise still other associated strata, consisting of quartz and limestone, continuous most probably to the Island of Greenholm. Lastly, at Kibister's Ness and south by west from it, intermediate to these two masses of Dale's Voe and Rovie Head, appear new strata of clay-slate, assuming, however, a direction much more to the eastward; which altered direction of the clay-slate, considered *en masse*, seems connected with the situation of the two extreme masses, the strata of which have a course calculated to intercept, in a mode similar to that already described, those of the new strata of clay-slate.

All the strata mentioned dip to the west, the quartz, hornblende, and limestone, at angles generally from 40° to 60°; the clay-slate at about 70°.

Thus there are certain general circumstances to be observed in this complicated distribution, materially affecting the general character of the rocks concerned in it. By the curved direction or the peculiar locality of the quartz, hornblende-slate, and limestone, an interception of the rectilinear strata of the clay-slate seems, in the first place, to be effected. But the assumption of a more easterly direction of the clay-slate considered *en masse*, seems to depend not only upon the interception of those rectilinear strata which maintain a direction that is no longer to be continued, but also upon the presence of other masses of quartz, hornblende-slate, or limestone, calculated to afford an attachment to new strata of clay-slate, and by their curvature or peculiar locality to alter the direction, and with it the disposition of the strata intermediate to them. In the application of appearances like these to our speculations regarding the consolidation of the crust of the globe, the influence of the hornblende-slate, quartz, or limestone, apparently exerted on the direction of the strata of clay-slate, strongly resembles that of nuclei in processes of crystallization.

Sufficient has probably been said explanatory of the importance which I attach to the ascertainment, in every junction of rocks of different kinds under circumstances similar to those described, which of the strata are continuous, and which are interrupted; or, in other words, which of the masses has, like a nucleus in processes of crystallization, an *arbitrary*, or which has a *dependent* form.

Returning to the clay-slate, it may be observed, that at Channerwick, an inclosed roundish mass of granite makes its appearance; it is probably about 120 yards in diameter. The strata are, at the contact, much disturbed, particularly in their inclination, which, instead of being at an angle of 76°, is about 23° to 25°.

I shall now state the relations of the clay-slate to the considerable mass of granular quartz situated to the east of Shetland.

The clay-slate is either immediately connected with the sandstone, or is separated from it by the interposed strata which have been described as for the most part lying beneath the conglomerate rock. At Sandlodge there is interposed, for instance, quartz containing innumerable small veins of calcareous-spar; also some little serpentine, talc and chlorite-slate: At Ukersetter, much quartz and limestone; to the north of Fladabister a striated mica-slate; at Quarf, thin beds of mica-slate, and gneiss with granite; at Rovie Head, stratified quartz and limestone.

An alternation of the clay-slate with the granular quartz or sandstone, and a graduation into it, is observed on the shore near Grimmister, which appearance, in reference to a date of formation, assigns that sandstone, which is not characterised by the admission of rounded pebbles, to a place in our systems, where it can be associated with rocks usually supposed to be of the oldest kind.

Near the junction of the clay-slate at Sandlodge, and in that sandstone which consists altogether of granular quartz, some copper mines were, a few years ago, wrought. The profits arising were too small to justify a continuance of the operations. As the shafts are now so much filled with water, as to exclude any observation of the contents of the bed, the best information is to be found in Dr Traill's account, as inserted in the Appendix to Mr Neill's Tour *. The direction of the bed is from north-east to south-west. The copper-ores found were, 1. Friable and amorphous carbonate of copper, colour rich green. 2. Carbonate of an emerald green, crystallized in capillary fibres of a silky lustre, diverging in radii from a centre. This was found imbedded in iron-ore. 3. Sulphuret of copper disseminated through felspar in some places, and in others in great masses of iron-ore. The iron-ore was, 1. Dark brown, fibrous and mamillated hæmatites. 2. Columnar bog-iron-ore. 3. Micaceous iron-ore. 4. Brown iron-ochre. 5. Dark brown stalactitic iron-ore. 6. Earthy matter charged with iron, arising from the debris of other ores.

(To be concluded in our next Number.)

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* Appendix to Neill's *Tour through Orkney and Shetland*, page 170.

Art. XIII.—*On the Physical Distribution of the* Coniferæ, *and their affinity with the* Ephedraceæ; *with observations on the utility of the Bark of the Larch in the process of tanning Leather.* By John Yule, M.D. F.R.S. Edin. and M.W.S. Communicated by the Author.

Of the Tribes of plants forming so many kindred groups, scattered over the surface of the earth, the Coniferæ afford many remarkable instances. The whole of these agree in certain leading characters, but frequently differ in other strongly marked shades, which it is the object of the naturalist to trace and delineate, as not unfrequently indicating the purposes to which they are capable of being applied in the various useful arts. That analogy, in this respect, forms of itself an uncertain guide, is readily admitted; yet the hints thus acquired frequently shorten our inquiries, by immediately directing us towards the more certain tests of chemistry.

Whilst some of these tribes are found approaching the line of perpetual snow, on the shoulders of mountains, within the arctic circle, others, more tolerant of the sun's rays, inhabit the mountains and more elevated plains of the tropics *. On the mountains of Mexico, Humboldt and Bonpland invariably found the true pines possessing the extreme limit of arborescent plants; and Wahlenberg and Von Buch unite in describing trees of the same tribe occupying nearly similar stations on Mont Blanc and Mont Perdu (Lat. 42° 46′), and on Solitelma in Lapland (Lat. 68° north.)

In these last instances, the pines were found approaching nearer the line of perpetual snow than the firs or spruces, which disappeared about 400 feet lower, at the medium temperature of $37\frac{1}{2}$° Fahr. †, the Pines extending to within 2800 feet of

* Humboldt and Robert Brown, to whose accurate and extensive observations we owe so much, note a remarkable fact with respect to the physical distribution of these tribes,—that those of the southern differ from those of the northern hemisphere, on which none of the Podocarpi, Dacrydii, and Araucariæ, &c. have hitherto been detected.

† Wahlenberg.—Linnæus' *Tour in Lapland.*—Humboldt, Geograph. Plant.—Mich. Arbres Forest.

the line of snow, at the mean temperature $36\frac{1}{2}$° Fahr. Again, under the parallel 19° 20′, Humboldt notes another member of the PINE family *(P. australis)*, as occupying a zone of the height of 6000 feet, on Popoc in Mexico.

Next to the Pines, the LARCHES approach nearest the line of snow. This tribe was observed by Michaux, extending from the more elevated parts of the middle countries of North America, to the northward of St Lawrence and Hudson's Bay, within the Arctic Circle; and other members of the tribe are noticed by Gmelin, approaching the same parallel in Siberia, although none of them, except the Cedar *(L. cedrus)*, have hitherto been detected farther to the southward than Mounts Taurus and Libanus *.

There are other tribes of this great series more distantly related to, but generally accompanying them, on the northern hemisphere. The Juniper and Yew, towards the Arctic Circle; and towards the south, the Thuiaceæ, including the verticillated Cupressi, and their ally, the Taxodium of Richard †.

The differences in the geographical distribution, then, is not confined to the distantly related tribes, but extends to those most nearly related, namely, distinct species of Pines, Firs, Spruces and Larches, found at different degrees of elevation, their distribution being influenced, no doubt, by the same general laws, of the particular nature of which we are as yet too little informed to pronounce with certainty. The seeds of plants are dispersed, in a few instances, by man himself, granivorous birds and quadrupeds,—by the winds, and, in numerous instances, by the tides of the ocean. But even independent of climate, it seems evident, that the peculiar structure and economy of the several species must, in a great measure, finally regulate the permanence of their respective stations on the globe. It is in vain that the current from the Gulf of Mexico, flowing along the coast of North America, and setting eastward, deposits the seeds of various tropical plants on the inhospitable shores of Shetland

* Is it not likely that other members of this tribe will be found on the Thibet Mountains?

† *Annales de Museum*, vol. xvi.

and Norway: All of which perish, or at most serve only to enrich the collections of the naturalist.

1. The whole of these Coniferous tribes are social, naturally occupying immense continued tracts, almost to the exclusion of all other trees of a distinct race, which they injure, and frequently choke; an important lesson to planters, who are fond of mixing these lofty inhabitants of the forest with oaks, elms, and other strangers. Even in this country our native pine *(Pinus sylvestris)*, where not prevented by opposing culture, spreads its seeds on every side, and would eventually re-establish the ancient forests.

2. The social disposition, indeed, extends to the more distantly related tribe of EPHEDRACEÆ, in which we must, from the most evident marks of affinity, include Equisetum, which Jussieu, in his admirable work, has at present ranked with the FILICES. The still obscure history of the germinating process, and even our imperfect views of the parts of the fructification in these plants, ought not to oppose conclusions so strongly warranted by other characters.

3. Even externally the stems in Thuia and Cupressus, when young, are distinctly marked with nodes at intervals, surrounded with squamiform dentated leaves, analogous with the dentated sheaths surrounding the joints of Equisetum, Cassuarina, and Ephedra.

4. A perpendicular section of a bud in Thuia affords a distinct view of the structure of the first shoots of the approaching season; the whole resembling a series of cones included within each other, gradually decreasing in size towards the centre, from which the first shoot is evolved.

These buds are successively evolved during the progress of the season, whilst others are continually shooting from their centre, and from the abundant sap, burst from the sides of the various nodes in verticils, particularly in moist soils.

5. Each node in the true verticillated Cupressi, Sabinæ, Thuiæ, Equiseta, Ephedræ, and Cassuarinæ, is accompanied with its respective ciliated or dentate sheath which in Equisetum forms a complete circle; in Ephedra there are two teeth only, in Thuia four. Thuia articulata, figured by Desfontaines *,

* *Flora Atlantica*, t. 252.

well illustrates the link in the affinity of this tribe, with that of the Ephedraceæ. In all these instances, the dentate sheaths originate from the same plane, at the base of the respective nodes. In Equisetum, these are most prominent on the fertile shoots, which they protect and cherish in the commencement of the season; but, in the subsequent barren shoots, being less wanted, they shrink and wither. Even in Thuia and Cupressus, the verticillated dentate nodes scarcely merit the name of leaves, the young succulent shoots supplying their place, and even during winter influencing the motion of the sap, which in this tribe resists the utmost rigour of cold *.

In both these tribes the sap circulates chiefly in the vessels of the external cylinder of the stem, which in Equisetum is hollow, the root only being solid. These vessels extending longitudinally throughout its whole length, are visible even to the naked eye, in a cross section of the stem †.

On the use of the Larch Bark in tanning of Leather.

There are four species of the genus Larix: (1.) *L. pendula* of Salisbury, *Melere d'Amerique, foliis brevioribus, strobilis parvis subglobosis*, Mich. scarcely known to our planters, although far more hardy than (2.) our well known common Larch, *L. pyramidalis*; (3.) *L. microcarpa*, totally unknown in Scotland, but figured by Lambert. (4.) *L. cedrus*, or the Cedar Larch, so well distinguished by its perennial leaves, forming in winter the chief ornament of our lawns.

It is generally admitted, that the Siberian Larch, described by Gmelin, is the same species with our Common Larch, the introduction and extensive cultivation of which we owe to the late Duke of Athol, who originally obtained several young plants from Switzerland, which were planted in the lawn of Dunkeld; and here was manifested the first proof of the incalculable advantages of planting this species. Within a period of fifty-four years, some trees had attained nearly the height of a hundred feet, and, at five feet from the surface, a

* Wahlenberg et Humboldt de Distribut. Plant.

† Casts of the stems of plants, evidently of this tribe, are frequently found in our coal formations.

circumference of eight feet; yet it has been found that this singular rapidity of growth by no means diminishes the density and durability of the timber, which has been already found to be equally adapted to the purposes of naval and domestic architecture. Granting that, for shipbuilding, this larch were inferior to the oak, this affords no solid objection to its use as a valuable addition to the resources of the State, as it attains perfection in one half of the period required for the oak attaining its full value. There is, however, reason to conclude, that the larch has been of late prematurely cut down.

The bark of the oak had hitherto been used almost exclusively in the process of tanning leather; but its daily increasing scarcity and consequent high price, arising from the great demand during the late war with the French, naturally led to the use of the barks of other trees, as substitutes for it. It was common to mix these last with oak bark, but in this way the result could never be accurately ascertained. It was necessary, therefore, to institute comparative experiments of the larch bark with the oak bark separately; and these, to avoid the ambiguity of trials on a small scale, were conducted by an eminent tanner, Mr P. Martin of Haddington.

(1.) Equal weights of skin were taken, as accurately as possible, from the same parts of the animal, and immersed, under the same temperature, that of the atmosphere in summer, in separate cold infusions of the same weight of the bark of the oak and larch, previously ground in the ordinary way, and treated in the same manner. Both sorts of leather were then dried: The same bulk of larch-tanned leather was found to be specifically heavier than that of the oak, but the proportional excess was not accurately ascertained.

(2.) In colour, the specimens sent to me, differed remarkably; the larch-tanned leather being of a light fawn, whilst that tanned by the oak bark was of a deep brown colour.

(3.) The larch-tanned leather absorbed water more readily than that of the oak, in these specimens. Circumstances of an accidental nature, however, sometimes regulate this property; such as more or less compression, by hammering, previous to the operations of the shoemaker; and it is well known that slow drying tends much to regulate this property in leather of every kind. The best oak-tanned leather readily absorbs water when newly finished.

(4.) But, after all, the durability of leather is the great test of the utility of each substance used in this process; and, so far as respects this main object, the two sorts of leather, used as soles to each of a pair of shoes, were found to wear equally well. Were we to estimate *a priori* the relative value of the bark of Oak, Larch, and Leicester Willow, from the proportion of tannin afforded in the experiments of Sir H. Davy, the willow bark would excel that of the two others; but it seems probable that the inferiority of the Larch bark, in his experiments, arose from the trees being cut down in autumn;—a period when the sap, and its constituents of tannin and extractive, are greatly exhausted, from the previous formation of the young wood, in which they are easily detected; indeed, the proportion of extractive and tannin, in the succulent and newly condensed wood, is in some cases nearly treble the quantity existing in the old external layers of bark, especially in autumn; and from this it is probable that the annual prunings of trees, abounding with these constituents, might, with profit, be applied to the purposes of the tanner.

Art. XIV.—*Catalogue of the Right Ascension of Thirty-six principal Fixed Stars, deduced from Observations made in the Observatory at Konigsberg from* 1814 *to* 1818. By William Bessel.

The following important Catalogue of Stars was communicated by its eminent author to Baron de Zach, who has inserted it in his *Correspondence Astronomique*, from which it has been copied, and transmitted to us by one of the Baron's correspondents. M. Bessel has mentioned as a very remarkable circumstance, that the difference between the catalogues of Piazzi and Bradley, which he had found to be $= + 2''.489$;* disappears

* See Bessel's *Fundament. Astron.* p. 296, where he gives an account of this difference.

almost wholly, by taking the following fundamental catalogue as a basis.

Catalogue of the Right Ascension of Thirty-six Fixed Stars.

Names of the Stars.	Number of observations.	Right Ascension in Time for 1815.	Annual Variation for 1815.	Secular Change.	Difference of Catalogues. From that of Maskelyne 1805.	Difference of Catalogues. From that of Piazzi 1805.
α Pegasi,	87	0h 3 43."414	3."0803	+0."0096	—0."266	—0."196
α Arietis,	45	1 56 46.186	3.3565	+0.0200	—0.251.	—0.264
α Ceti,	30	2 52 37.312	3.1243	+0.0096	—0.334.	—0.200
α Tauri,	69	4 25 18,992	3.4290	+0.0108	—0,127	—0.214.
α Aurigæ,	173	5 03 2.380	4.4119	+0.0185	—0,120	—0.157.
β Orion.	159	5 5 39.040	2.8780	+0.0043	—0,132	—0.062
β Tauri,	65	5 14 36.307	3.7855	+0.0093	—0,087.	—0.110
α Orion.	94	5 45 9.467	3·2443	+0.0033	—0,086	+0.001
α Can. maj.	159	6 36 59.561	2.6433	+0.0004	—0.058	+0.045
α Gemini,	94	7. 22 46.463	3.8452	—0.0121	+0.015	—0.068
α Can. min.	75	7. 29 36.720	3.1478	—0.0043	—0.140	—0.060
β Gemini,	205	7 33 58.783	3.6861	—0.0124	—0.136	—0.163.
α Hydræ,	24	9. 18 29.601	2.9462	—0.0015	—0.068	—0.085
α Leonis,	80	9 58 30.481	3.2057	—0.0102	+0.041	+0.054.
β Leonis.	65	11. 39 36.940	3·0680	—0.0079	—0.126	—0.116.
β Virginis,	34	11 41 33.588	3.1259	—0.0007	—0.309	—0.176
α Virginis,	120	13 15 27.657	3.1446	+0.0111	—0.117	—0.164
α Bootes,	174	14 7 13.627	2.7329	+0.0012	—0.129	—0.192
1 α Libræ,	32	14 40 28.491	3.3004	+0.0156	—0,125	—....
2 α Libræ,	32	14 40 39.892	3.3032	+0.0156	—0.188	—0.141
α Coronæ,	54	15 26 51.562	2.5379	+0.0024	—0,204	—0.351
α Serpentis,	43	15 35 9.840	2.9499	+0.0064	—0,194	—0.164.
α Scorpionis,	30	16 18 5.030	3.6621	+0.0157	—0,307	+0.030
α Herculis,	63	17 06 13.035	2.7311	+0.0037	—0,156	—0.259
α Ophiuchi,	89	17 06 21.076	2.7772	+0.0034	—0.186	—0.179
α Lyræ,	141	18 30 40.588	2.0307	+0.0016	—0,112	—0.262
α Aquilæ,	186	19. 37. 27.887	2.8561	—0.0009	—0.126	—0.093.
α Aquilæ,	—	19 41 45.398	2.9295	—0.0015	—0.202	—0.102
β Aquilæ,	199	16 46 13.586	2.9515	—0.0015	—0,170	—0,150
1 α Capricorni,	79	20 7 23.212	3.3341	—0.0081	—0,257.	—0,120
2 α Capricorni,	79	20 7 47.000	3.3393	—0.0081	—0.193	—0.070
α Cygni,	158	20 35 7.725	2.0417	+0.0022	—0,259	—0.269
α Aquarii,	56	21 56 16.805	3.0852	—0.0043	—0,261	—0,144
α Pisc. Austr.	55	22 47 24.405	3.3424	—0.0218	—0,290	—0.130
α Pegasi	49	22 55 33.276	2.9825	+0.0052	—0,254	—0.207
α Androm.	52	23 58 50.870	3.0708	+0.0176	—0.249	—0,292

Art. XV.—*Determination of the Longitudes and Latitudes of thirty-four places in the Mediterranean.* By Mr Charles Rumker. Communicated by the Author.

The longitudes of the places contained in the following Table, have been fixed by measuring, with the timekeeper, their meridional distance from La Valette on several short excursions which I made from that port, the longitude of which has been assumed at 14° 27′ 38.″6, as determined by observations given in a preceding paper. (See p. 280.)

In those places where the latitude is not given, I had no opportunity of observing it with the sextant, the visible horizon being obstructed by land, and the sun's meridional altitude being too great for the artificial horizon. I then made use of the latitude taken from the chart in computing the hour-angle.

Names of Places.	Latitude North.	Longitude East of Greenwich.
Port Chieri, Zante,		20° 53′ 15″ E.
Ithaca Island,		20 32 00
St Maura Island,		20 32 00
Vito Island,	39° 37′ 25″	19 53 40
Corfu Town,	39 36 10	19 49 27
Brindisi Harbour,	per lunar obs.	17 59 00
Syracuse Town,	37 02 00	15 12 15
Ustica Island,	38 43 01	13 5 29
Favignama Island,	38 01	12 12 24
Maritimo Island,	38 01 15	12 01 30
Girgenti Light-house,	37 15 52	13 29 32
Longa Island,	40 34 20	14 24 05
Capri Island,	40 32 00	14 14 15
Punta Campanella,	40 33 30	14 18 35
Cape Sorento,	40 39 00	14 20 05
Castella Mare,	40 41 10	14 28 15
Pompeïa,	40 45 00	14 29 45
Naples Light-house,	40 50 12	14 13 15
Nisitra Island,	40 47 50	14 07 55
Baja Town,	40 48 15	14 03 15
Cape Misene,	40 46 00	14 04 00
Procida Island,	40 45 50	13 59 30
Ischia Island,	40 43 30	13 51 55
Fumicino Tower, at the mouth of the Tiber,	41 45 00	12 10 15
Porto Ferrajo Light-house,		10 13 45
Leghorn Light-house,	43 32 34	10 14 33
Meloria Island,	43 32 47	10 09 11
Genoa Light-house,	44 24 08	8 53 17
Gorgona Island,	43 26	9 54 00
Cagliari Town,	39 12	9 10 15
Cabrera Island,	39 07	2 59 15
Alboran Island,	35 56	3 03 00 W.
Europa Point, Gibraltar,	36 05 15	5 20 15

Art. XVI.—*Account of a new species of Chronometer adapted to the eye-pieces of Telescopes, for reckoning fractional parts of a second in Astronomical Observations.* Invented by M. Breguet, Member of the Institute, and of the Board of Longitude of France.

M. BREGUET has been long known to the philosophers of our own country as well as to foreigners, as one of the most distinguished artists which France has for a considerable time produced. His various inventions connected with Horology and Chronometry, indicate an ingenuity and a fertility of invention which are not often united in the same person, and such is the degree of excellence with which his timekeepers are constructed, that we may justly rank him with the Harrisons, the Arnolds, and the Earnshaws of our own country.

The ingenious instrument of which we propose at present to give a brief description, has been recently laid before the Board of Longitude of France; and though the commissioners have not yet given in their report, we have no doubt that it will be generally considered as promising to supply an important desideratum in practical astronomy. In ascertaining the disappearance of a star behind the wires of a transit instrument, we think there are few astronomers who would venture to say, that in ordinary circumstances they could observe to the *fifth* part of a second of time; but as this quantity corresponds to *three* seconds of right ascension, it becomes a matter of very high importance, in the present perfect state of astronomical instruments, to distinguish more minute portions of time.

The instrument by which M.M. Breguet propose to supply this defect, is shewn in Fig. 2. of Plate VII., where AB is a section of the eye-piece of a telescope through the diaphragm or field-bar placed in the anterior focus of the eye-glass next the eye; the black ring which it incloses representing the diaphragm itself: The box CD contains a chronometer, which, by means of the index G, points out every *ten seconds* upon the dial-plate EG, divided into ten minutes. Other two indices *m*, *n*, are made to revolve through the field of the telescope, and almost in the plane of the system of wires. The shortest of these *n*, marks *units* or single seconds upon the segment of a circle *o p* of 60° divided into 10 seconds. The larger index *m* carries at its extremity an opaque circular disk, whose centre describes in a single second a segment of 60°, which we may also suppose to be divided into ten parts or tenths of seconds. The prolongations of the divisions 1, 3, 5, 7, 9, determine the distances of the wires in the field, so that they may give their aid in estimating the divisions of the scale. The coincidence of the disk with one of the wires, or its situation in the middle of one of the intervals between the wires, will therefore indicate one, or two, or three-tenths. The three needles G, *m*, *n*, move in the same direction as the star in the astronomical telescope. There is a detent for stopping the wheelwork, and a lens near the eye for enabling it to read off the minutes and the tens of seconds upon the dial-plate EF.

In using this instrument, the observer must notice upon the dial-plate EF, the minute and tens of seconds, a few seconds before the star has arrived at the wires; then raising his eye to the field of the telescope, he will observe by means of the shortest needle *n*, the units of seconds which are to be added. The eye of the observer must now be fixed solely on the star which is about to pass behind the first wire, and continuing to reckon the seconds, by observing laterally and indirectly the passage of the disk *m* over the divisions from 0 to 10. As the eye can never be removed for a moment from the star, the estimation of the eighteenths of seconds must always be performed by indirect vision. A little experience will obviously be necessary, to enable the practical astronomer to perform this operation with facility and confidence; and it is stated, that the instant of the transit of the star by the wire can thus be observed very distinctly to the tenths of seconds;—with some practice, to the twentieth of a second, and even to some hundredths of a second by approximation *.

* The particulars from which we have drawn up this notice, are taken from the *Annales de Chimie et de Phys.*, tom. x. p. 431, &c. The interior arrangement of the Chronometer, by which an uniform motion is given to the indices, has not been described, but is promised by the Editor of that Journal, in a future Number.

This ingenious invention may be applied to all kinds of telescopes, and will, we think, be found of great utility for various scientific purposes.

There is one objection, however, of a practical nature, which we think it of consequence to mention, and which we fear is not susceptible of being removed. It has been shewn by Dr Brewster *, that when the eye is eagerly directed to the contemplation of one object, the retina is thrown into such a state, that circumjacent objects, seen by indirect vision, occasionally vanish and reappear, so that if the degree of attention with which the astronomer is obliged to watch the motion of the star, shall be found capable of throwing portions of the retina into a state of partial insensibility, he may lose sight of the disk at the very instant when it might be of the utmost importance to observe it. A singular instance of this illusion will be found in a subsequent article, on the phosphorescence of minerals.

Art. XVII.—*Remarks on Captain Kater's Paper, containing Experiments for determining the Length of the Second's Pendulum in the Latitude of London.* By Mr William Watts. Communicated by the Author.

Long before the Bill for the Equalization of Weights and Measures was thrown out of the House of Lords in 1816, the attention of certain individuals who had promoted the scheme of equalization, had been directed to the determination of the length of the *simple equivalent* pendulum *in vacuo*, vibrating seconds in the latitude of London. On the 30th September 1815, in a letter addressed to Davies Gilbert, Esq. M. P. I stated it as my opinion, that the length of the second's pendulum, in the latitude of London, had never been determined with that degree of exactness which is so desirable, and *even* necessary, in the investigation of many physical problems; such, for example, as the figure of the earth. But it was the length of the second's

* A notice of these experiments, which was read at the Royal Society of Edinburgh, on the 19th January 1818, will appear in an early Number of this Journal.

pendulum adopted by the Committee of the House of Commons, namely 39.13047 inches, which turned my attention to this important subject, as I found that this length differed very sensibly from that deduced from the formula of La Place, given in his *Mecanique Celéste*, tom. ii. p. 151, and which he had deduced from a set of the best experiments that he could procure. This formula gives 39.13881 inches for the length of the pendulum *in vacuo*, vibrating seconds in the latitude of London; and this length thus deduced, differs only two 10,000th parts of an inch from the recent determination of Captain Kater.

Impressed with the importance of the subject, Mr Davies Gilbert, (then Mr Davies Giddy,) resolved to submit it to the House of Commons, having first consulted most of the mathematicians in London, and laid the matter before the President and Council of the Royal Society. By that learned body he was authorised to state the subject to the Government; and, having obtained its sanction, he finally brought it before Parliament, by moving,

"That an humble address be presented to the Prince Regent, praying that his Royal Highness would be graciously pleased, to give direction for ascertaining the length of the pendulum vibrating seconds of time in the latitude of London, as compared with the standard measure now in the possession of this House; and for determining the variation in the length of the said pendulum, at the principal stations of the trigonometrical survey, extended through Great Britain; and also for comparing the standard measure with the ten millionth part of the quadrant of the meridian, now used as the basis of linear measure on the Continent of Europe."

This address, which was moved on the 15th March 1816, was immediately answered by a reference to the Astronomer Royal, in the first instance, and by a request that the Royal Society would be assisting therein. A committee was accordingly appointed, and various plans immediately put into execution for determining the length of the second's pendulum in London, principally consisting of modifications in the manner of suspending and applying a cylindrical rod. No sooner were these measures known in France, than the Institute notified a wish for sending two of its members to assist in extending the observations with the pendulum, on the northern stations of our trigonometrical survey. An answer was immediately returned by our Government, expressive of a wish to receive them; and, at the same time, it was proposed to request from the French a platina metre, taken exactly from the platina standard preserved at Paris.

It was in consequence of these measures, that the Report, which has been recently printed by the House of Commons, on the length of the pendulum, was drawn up by Captain Kater; so that Lord Stanhope's measure in the House of Lords did not render the above address *nugatory*, as has been asserted.

Having been the means of directing Mr Gilbert's attention to the length of the pendulum, and feeling a deep intest in the subject, I have been induced to give Captain Kater's paper a careful examination; and in doing this, I have noticed several minute errors in his calculations, which ought not to be overlooked, since the question is about very minute quantities, such, for example, as the 10,000th part of an inch, or the 391,386th part of the whole length of the pendulum. And since its length may be thus assigned to such a degree of exactness, it evidently follows, that the intensity of the force of gravity may be determined with the same degree of precision; and thus one part in 391,386 will be rendered sensible.

And as it seems probable, that the variation in the density of the strata immediately under the surface of the earth, may produce a change in the intensity of the force of gravity much more considerable than one part in 391,386, it follows that this variation will so sensibly affect the movement of the pendulum, that it will not fail to give information of such irregularity in the density of the strata.

The force with which Schehallien disturbed the plumb line, was found to be about the 34,376th part of the force of gravity, or about eleven parts in 391,386; and I think with the Edinburgh Reviewers, that the presence of an extensive stratum of gneiss, or of hornblende-schistus, or of any great body of granite, immediately under the surface at one place; and of chalk, common sandstone, or limestone at another,—would produce a difference in the intensity of gravity, even greater than the force just now mentioned.

But I ought to state, that Captain Kater has been very fortunate in committing the error which relates to the correction due to the amplitude of the arc of vibration, as it is nearly compensated by a contrary error which he has fallen into, by not employing the appropriate formula for the correction of the arcs of vibration; and that while I take upon me to expose the errors of others, I ought in justice to acknowledge my own. I allude here to a correspondence which I have held with Mr Gilbert, relatively to the pendulum experiments of Captain Kater; and in which I also employed a formula for the correction of the arcs of vibration, that does not give correct results. But in doing this I was misled by the authority of M. Biot, imagining that his theorem was the right one, because he had, at least apparently, deduced from it, by way of corollary, the formula of the Chevalier Borda, which is known to be correct. But there are fallacies in some of the steps of Biot's investigation; and it will be found, by a comparison of the following demonstration with that of M. Biot, given in his *Astronomie Physique*, tom. iii. pp. 169,–172, 2d edition, that this apparent agreement is owing to a compensation of errors, and that his theorem will not give correct results. But by treading warily in his steps, and carefully avoiding his mistakes, I have deduced a formula similar to that delivered by Borda, without demonstration, in his fine memoir on the measure of the meridian, as the difference between his theorem and mine will be found to be nothing in its practical applications.

I am not aware that a correct demonstration of this formula is to be found any where else. I lately, indeed, saw a theorem with Captain Kater, without the demonstration, which he gave to a friend of mine, Mr George Harvey of Plymouth, when we waited on him in London, but I think there is some difference between them. As I state this, however, merely from memory, I cannot speak with any degree of certainty on this head.

Before I proceed to give the demonstration of my formula, it may not be amiss to premise the following extracts from Captain Kater's paper, (see the Report ordered to be printed by the House of Commons, p. 10.), as they will serve, not only to introduce the subject in question, but also to throw additional light upon it.

"The vibrations of the pendulum having been made in different arcs, it became necessary to apply a correction, to determine what they would have been in an arc *infinitely small.* For this correction, I might have used a formula depending on the decrease of the arcs in geometrical progression, whilst the times decreased in arithmetical; but as there is an uncertainty in observing the arcs, amounting to one or two hundredths of a degree, this method, though preferable in theory, would have been an unnecessary refinement in practice." And again, "The error arising from the greater length of the vibration in a circular arc, being nearly as the square of the arc, if the mean of the arcs at the commencement and end of each interval be taken, and its square multiplied by 1.635, the difference between the number of vibrations made by the pendulum in twenty-four hours in a cycloid, and in a circular arc of one degree, the required correction will be obtained, to be added to the number of vibrations computed."

Now, with regard to the first of these extracts, I observe, that the alleged uncertainty of one or two hundredths of a degree in the determination of the arcs of vibration, forms no just objection against the employment of the appropriate formula; and that, with Captain Kater's means, namely, a telescope, microscope, barometer, thermometer, and micrometer, together with a horizontal scale, divided into equal parts, and placed before the pendulum at a given distance from the point of suspension, the deflection of the pendulum on each side of the vertical line, might have been assigned to a great degree of exactness; and hence the angle which it described might have been readily deduced even to seconds of a degree, which would have been sufficiently exact for the purpose of determining the requisite correction, which ought to be applied to any finite arc, in order to reduce it to the case of an infinitely small arc of vibration.

And, with respect to the second extract, I remark, that the number 1.635, which is stated to be the difference between the number of vibrations made by the pendulum in twenty-four hours in an arc of a cycloid, and in a circular arc of one degree, *is incorrect.* It should have been 1.645 nearly; and this error runs through the whole set of experiments.

These observations being premised, I shall now proceed to demonstrate the formula which ought to be employed for determining the correction due to the amplitude of the arc of vibration. And for this purpose I shall employ the following mechanical principle, which has been confirmed by experiments; that is to say, that when the pendulum performs its oscillations in air, the amplitude of the arcs of vibration decreases in geometrical progression, while the times increase in arithmetical.

If, therefore, we call l the length of the equivalent simple pendulum, t the time of one of its oscillations, π the ratio of the circumference to the diameter, and g the force of gravity represented by double the space which a heavy body describes in the first second of its fall, then we shall have, by the theory of the pendulum,

$$t=\pi\sqrt{\frac{l}{g}}\times\left\{1+\left(\frac{1}{2}\right)^2\cdot\frac{b}{2l}+\left(\frac{1.3}{2.4}\right)^2\cdot\left(\frac{b}{2l}\right)^2+\frac{1.3.5}{2.4.6}\cdot\left(\frac{b}{2l}\right)^3+\ldots\right.$$
$$\left.+\left(\frac{1.3.5\ldots(2m-1)}{2.4.6\ldots\ldots 2m}\right)^2\cdot\left(\frac{b}{2l}\right)^m+,\ \&c.\right.$$

When the arc of vibration is small, all the terms of the series after the second may be neglected, on account of their smallness, and then we shall have,

$$t=\pi\sqrt{\frac{l}{g}}\times\left(1+\frac{b}{8l}\right).$$

Let the length of the equivalent simple pendulum be represented by unity, then the time of a complete oscillation will be,

$$t=\pi\sqrt{\frac{1}{g}}\times\left(1+\frac{b}{8}\right);$$

but $b=\frac{a^2}{2}$, very nearly, because $b=\frac{a^2}{2}-\frac{a^4}{24}+\frac{a^6}{720}-$, &c. a being the arc of which b is the versed sine to radius 1; therefore,

$$t=\pi\sqrt{\frac{1}{g}},\left(1+\frac{a^2}{16}\right).$$

The second term of this value of t is the correction due to the amplitude of the arc of vibration. This correction varies with the arc described, when the pendulum vibrates in air; and it is in this respect that the resistance of the medium has a small influence upon the duration of the oscillations.

Let us suppose, therefore, that when the semi-arc of vibration is equal to a, the pendulum is left to vibrate in air. Then, since the arc a will be continually diminishing, it will successively become a', a'', a''', a'''',......$a^{(n)}$, or $\frac{a}{r}$, $\frac{a}{r^2}$, $\frac{a}{r^3}$,......$\frac{a}{r^n}$; $\frac{1}{r}$ being the common ratio of this decreasing geometrical progression; consequently r must, in this case, represent a number greater than unity. Thus each term of the series may be expressed in a function of the first term a, and the corresponding number of small vibrations, counting from the time when the semi-arc of vibration was $= a$, will be,

$$1 + \frac{(a')^2}{16},\ 1 + \frac{(a'')^2}{16},\ 1 + \frac{(a''')^2}{16},\ 1 + \frac{(a'''')^2}{16},\ \&c.$$

or, $$1 + \frac{a^2}{16r^2},\ 1 + \frac{a^2}{16r^4},\ 1 + \frac{a^2}{16r^6},\ 1 + \frac{a^2}{16r^8},\ \&c.$$

so that after the lapse of n finite oscillations, the corresponding number of infinitely small oscillations will be the sum of all the preceding terms. Call this number n', then we shall have,

$$\left.\begin{array}{l} n' = n + \frac{(a')^2}{16} + \frac{(a'')^2}{16} + \frac{(a''')^2}{16} + \ldots \frac{(a^{(n)})^2}{16}, \\ \text{or, } n' = n + \frac{a^2}{16r^2} + \frac{a^2}{16r^4} + \frac{a^2}{16r^6} + \ldots \frac{a^2}{16r^{2n}}; \end{array}\right\} \ldots\ldots\ldots (1).$$

And as the terms of these two values of n', omitting the first term n in each, form a geometrical progression, they may be summed; so that if this sum be represented by S, we shall have,

$$S = \frac{a^2}{16} \cdot \frac{r^{2n} - 1}{(r^2 - 1).r^{2n}} \ldots\ldots\ldots\ldots (2).$$

We may eliminate r from this value of S, and only leave in it the arcs a and b, the first and last terms of the series a, a', a'', a''', ...$a^{(n)} = b$; for if we compare the corresponding terms of the two identical equations No. 1, we shall find that after n finite oscillations have elapsed, there will exist this relation between them, $(a^{(n)})^2 = \frac{a^2}{r^{2n}}$,

or $$r^{2n} = \frac{a^2}{(a^{(n)})^2} = \frac{a^2}{b^2};$$

whence, $$r^2 = \left(\frac{a}{b}\right)^{\frac{2}{n}}:$$

and by substituting these values of r^{2n} and r^2, in equation (2), it will become,

$$S = \frac{(a+b)\ (a-b)}{16\left(\left(\frac{a}{b}\right)^{\frac{2}{n}} - 1\right)}$$

we shall have therefore

$$n' = n + \frac{(a+b)\ (a-b)}{16\left(\left\{\frac{a}{b}\right\}^{\frac{2}{n}} - 1\right)} \ldots\ldots\ldots\ldots(3).$$

But as, in experiments relating to the pendulum, the arcs of vibration a and b, differ very little from each other, the ratio $\frac{a}{b}$ will also differ but little from unity; and this circumstance enables us to extract the $\frac{2}{n}$th root of the number $\frac{a}{b}$, by approximation. To effect this, we remark, that if any number whatever be represented by a, we shall have, by the nature of logarithms, $a = (10)^{\log a}$, the logarithmic base being equal to 10; consequently, $a^{\frac{2}{n}} = (10)^{\frac{2}{n}\log a}$; and for the same reason we shall have,

$$\left(\frac{a}{b}\right)^{\frac{2}{n}} = (10)^{\frac{2}{n}\log\left(\frac{a}{b}\right)}$$

but, since the developement of a^x is $= 1 + Ax + \frac{A^2x^2}{1.2} + \frac{A^3x^3}{1.2.3} +$ &c.; the modulus of the logarithmic tables being $A = 2,302585$, &c.; so by analogy, the developement of

$$(10)^{\frac{2}{n}\log\left(\frac{a}{b}\right)} = 1 + \frac{2}{n}A\log\left(\frac{a}{b}\right) + \frac{2A^2}{n^2}\log^2\left(\frac{a}{b}\right) - \text{\&c.};$$

but as the number $\frac{a}{b}$ differs very little from unity, we may confine ourselves to the first power of its logarithm, and in this case we shall have

$$\left(\frac{a}{b}\right)^{\frac{2}{n}} = 1 + \frac{2}{n}A\log\left(\frac{a}{b}\right);$$

and, therefore, by introducing this result into the value of n' in equation (3), it will become,

$$n' = n + \frac{n(a+b)\ (a-b)}{32\ \mathrm{A} \log\left(\frac{a}{b}\right)}:$$

and the expression for the correction due to the amplitude of the arc of vibration, will be

$$\mathrm{S} = \frac{n\ (a+b)\ (a-b)}{32\ \mathrm{A} \log\left(\frac{a}{b}\right)} \qquad \ldots\ldots\ldots\ldots(4).$$

This formula is very similar to that given by Chevalier Borda without demonstration; for, by only substituting in place of the arcs a, b, $(a+b)$ and $(a-b,)$ the sines of these arcs, we shall obtain,

$\mathrm{S} = \dfrac{n.\ \sin\ (a+b)\ \sin\ (a-b)}{32\ \mathrm{A} \log\left(\dfrac{\sin a}{\sin b}\right)}$, which is the formula given for the correction by BORDA.

But when the arcs a and b are given in degrees, the lengths of these arcs will be 0,01745329 a, and 0,017453296 b, respectively, and, therefore, these values being substituted for a and b, in equation No. 4, it will become,

$$\mathrm{S} = \frac{n\ (a+b)\ (a-b)}{105049{,}57\ \mathrm{A} \log\left(\frac{a}{b}\right)}$$

$$= \frac{n\ (a+b)\ (a-b)}{241886{,}08 \log\left(\frac{a}{b}\right)}.$$

By applying our formula to all the finite arcs of vibration, we shall reduce them to the case of infinitely small oscillations, and by this means we shall be enabled to find the number of *infinitely small* vibrations which the invariable pendulum would have made in the same time.

Let us take for example the 5th experiment, that is, the experiment marked E, the great weight being below, since it appears to be as free from irregularities in the periods of coincidences, and in the decrease of the arcs of vibration in geometrical progression, as any one of the whole set; but even this is not exempt from them.

Here the two first arcs of vibration measured in degrees, are 1°,21, and 1°,09, so that we shall have,

$$
\begin{array}{rr}
a+b=2{,}30, \text{ its log} & 0{,}36172784 \\
\text{and } a-b=0{,}12, \text{ its log} & \bar{1}{,}07918125 \\
n=86056{,}47, \text{ its log} & 4{,}93478550 \\
\hline
& 4{,}37569459 \\
\hline
241886{,}08 \text{ its log} & 5{,}38361095 \\
\log \frac{a}{b} \ldots\ldots \text{ its log} & \bar{2}{,}65666225 \\
\hline
& 4{,}04027320 \\
\hline
\end{array}
$$

Log S = 0,33542139, the logarithm of the correction due to the arc of vibration, and whose number is 2,1648; consequently

$$n' = n + 2{,}1648 = 86058{,}6348.$$

Captain Kater makes it 86058,63, being a small fraction too little; and as this is the case with the remaining arcs, it follows that his determination of the length of the simple pendulum *in vacuo*, vibrating seconds at the level of the sea, and measured at the temperature of 62° of Fahrenheit's thermometer, is also a small fraction of an inch too short.

There is another minute error in the correction due to buoyancy of the atmosphere, amounting to about 0,00002 inch in excess: Captain Kater makes it 0,00544; but it is only 0,00542.

I remark, in the last place, that notwithstanding all the precautions adopted by Captain Kater in the determination of the number of vibrations performed by the brass pendulum during a certain number of seconds, I cannot help thinking, that the different periods of coincidence have not been assigned with the requisite degree of precision, by establishing the limits between which they were found to be comprised, that is to say, by noting when the coincidence *did not exist;* when *it was exact;* and, lastly, when it *had elapsed*, so as to be enabled to reckon with a greater degree of certainty with regard to the instant in which it should be fixed.

Captain Kater asserts, that the disappearance of the disk can be noted only to a *single second*, so that the brass pendulum may arrive at the lowest point of the arc of vibration, either precisely at the second when the disappearance of the disk was observed, or at any part of a second either before or after this observation; so that an error might possibly arise, amounting to 9|10ths of a second, by which the interval deduced from observation would be either less or greater than the truth, and thus an error of one second in the duration of the interval, would occasion a difference of 0,63 in the number of vibrations made by the pendulum in twenty-four hours.

But, I beg leave to ask, why cannot the disappearance of the disk be noted to a quarter of a second, as readily as an entire second? Is the thing inpracticable? By no means; for I imagine that it might be easily effected by means of a stop-watch, with a quarter second-hand, such, for example, as Litherland's patent watch, and regulated, like the clock, according to mean solar time*. If this can be done, and I entertain no doubt of its practicability, then in this case the greatest error in the number of vibrations performed in twenty-four hours may be reduced to a fourth part of what it is in Captain Kater's experiments.

It appears, moreover, that the law of the diminution of the arc of vibration, does not proceed exactly in geometrical progression, as we might naturally expect it would; and the discrepancy is very apparent throughout the whole set of experiments; but more particularly when the great weight is uppermost, in which case, the decrease of the arcs of vibration is much more *rapid* and *irregular* than when it is below.

What are the causes of these irregularities? I imagine, in the first place, that a very considerable portion of these irregularities is due to errors of observation, by not determining the amplitudes of the arcs of vibration with the requisite degree of exactness; and the apparent inconsistencies in the law of decrease of the arcs of vibration, confirm me in this opinion.

Secondly, A part of these irregularities might possibly be occasioned by the great inequality of the weights applied to the brass pendulum, and to the mode of their arrangement; because, when the great weight is above, the reciprocation of the

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* M. Breguet's ingenious invention, which we have already described in p. 323. will, we have no doubt, be found applicable to this class of experiments.—Ed.

action of the weights is such, that the pendulum is much sooner brought to a state of rest, and, consequently, the arcs of vibration will decrease much more rapidly, than when the pendulum is suspended in the reverse position, with the great weight below. Hence it is evident, that the degree of uncertainty in determining the amplitudes of the arcs of vibration, will increase in the same proportion; so that, however unobjectionable the principle of the pendulum may be, generally considered, these circumstances of disparity, in the direct and inverse positions of the pendulum, should seem to form an objection to Captain Kater's mode of applying it.

And, in the third and last place, I imagine that a portion of these irregularities might have arisen from some change that had taken place in the density and moisture of the atmosphere, during the experiments, by the introduction of a quantity of aqueous vapour into its different strata; because this vapour is known to possess the same elasticity as dry air, while at the same time it has less density: for, according to the experiments of Messrs Watt and Saussure, the weight of this vapour is to that of air as 10 to 14, when their elastic force and temperature are the same. And hence it follows, that the introduction of this vapour into the atmosphere renders it equally susceptible of sustaining the same column of quicksilver as before, with a less density; so that the barometer will not always give information when the atmosphere has been suddenly charged with this vapour.

Moreover, as the elasticity of air augments by heat, so that with less density, it is capable of sustaining an equal column of mercury, I should think that the discrepancies observable in the law of the decrease of the arcs of vibration, might partly arise from either of these causes, or perhaps from both. Should this be the case, we may naturally conclude, that when the arcs of vibration do not decrease in geometrical progression, while the times increase in arithmetical, the great weight being below, one or the other of the causes just now assigned, operates in producing the irregularities in question: and that all those experiments in which the law of decrease of the arcs of vibration does not proceed as stated above, ought to be rejected as insufficient for the purpose.

The preceding observations suggest to us the advantage that would be likely to accrue, by having the pendulum constructed without wood, on account of its being more susceptible of moisture than the metals.

CUSTOM-HOUSE, PENZANCE,
24th May 1819.

ART. XVIII.—*Notice of Scientific Travellers in Brazil,—Prince Moritz of Nassau, George Margrave, Von Eschwege, and Prince Maximilian of Wied-Neuwied.*

JOHN Earl Moritz, afterwards Prince of Nassau, was sent by the Dutch Government, in the year 1636, to Rio Janeiro with a military force, to protect the Batavian settlements in Brazil against the Spaniards. He was accompanied by several learned men, of whom the most distinguished were the astronomer George Margrave, a German, and William Piso, a Dutch physician. During a residence of eight years in Brazil, the Prince was actively engaged in collecting objects of natural history from all parts of that vast country. Intelligent men were sent out in every direction, in order to collect animals and plants, also to study the nature of the climate, and of the different productions of nature. This inquisitive and active commander even employed part of his suite in examining the opposite coast of Africa. Margrave, who was ordered on this service, fell a sacrifice to the climate of that country, at Paolo de Loanda, in the year 1644, at the early age of thirty-four. The Prince, on his return to Europe, brought with him the most extensive and valuable collection of the natural history of the New World ever seen in Europe. It was so great, that it not only completely filled the cabinet of the Prince, and the museums of two universities, but afforded abundant and rich supplies to various private collections.

Margrave, the most active of all the Prince's attendants, left behind him an extensive series of papers on astronomical subjects, which appear, however, to have been lost. His observations on the natural history of Brazil, which were numerous and important, had a more fortunate fate. They were preserved, and the Prince delivered the whole to Piso, with an order to prepare them for publication. But Piso, occupied with other concerns, consigned these valuable documents to Dr J. de Laet, who had also accompanied the Prince to Brazil. Laet found great difficulty in decyphering the manuscript, so that frequently inaccurate explanations of passages were given. To increase the evil, the wooden cuts made from the drawings were, from the carelessness of the editor and the stupidity of the printer, inserted in wrong places; so that the descriptions and figures were often at variance. In this imperfect state the work appeared in the year 1648, in one volume folio, under the title *Historia Naturalis Braziliæ.* The first part contains four medical dissertations by Piso; the second part contains Margrave's natural history of Brazil, which is in eight books: the three first treat of plants, four of animals, and the eighth of the country and its inhabitants. In the year 1650, Earl Moritz entered into the service of the great Elector of Brandenburg, by whom he was raised to the rank of Prince in the year 1654. The friendship of these illustrious men continued without interruption untill the death of Moritz in 1679. Some time before his death, he presented to the Elector all the drawings he had made and caused to be executed of the objects of natural history found in Brazil. The drawings were partly in oil, partly in water colours. Those in oil were the most numerous and valuable. The oil paintings were arranged in four folio volumes, and named according to Margrave. The first volume consisted of drawings of fishes, crabs, molluscæ, vermes, &c.; the second of birds; the third of mammiferous animals and insects; and the fourth of plants and fruits. These valuable volumes were lost to the scientific world for about a century and a half, and were only lately discovered in the Royal Library of Berlin by Lichtenstein, the professor of zoology. Had they been earlier found, Linnæus, Buffon, Brisson, and others, would have been spared a world of learned doubt and conjecture. The smaller drawings in water colours have also been discovered, and they contain many figures not in the larger collection of oil paintings. That nothing might be wanting for the elucidation of the work of Margrave, even Prince Moritz's copy of Margrave's work, with the Prince's own remarks, has been lately discovered in Germany. By means of these materials, Professor Lichtenstein has been enabled to correct the apparent inconsistencies in Margrave's work, and to prove the accuracy of his descriptions and observations.

After the publication of the Natural History of Brazil, nothing more was done for upwards of a century, because naturalists were not permitted to travel into the interior of the country. Siebers, who was sent to Brazil by that patriotic and enlightened German naturalist Count Hoffmansegg, was the first who published any observations of importance. In later times, it is true, several naturalists of Vandelli's school have travelled in Brazil; but, with the exception of a few memoirs in the Transactions of the Lisbon Academy, and some ephemeral pamphlets of Feijo and Dr Couto, nothing is known to the public of what they accomplished. The two Velozos occupied themselves principally with the botany of Brazil, of which the Monk Velozo left behind a large Flora in manuscript. There also appeared in 1804, a small work on the present state of the mines of Brazil, by the Bishop of Elvas, Joze Joaquim da Cunha de Azeredo Coutinho. These were the principal writings in regard to Brazil, published before the arrival of the Royal Family from Europe. This event, so fortunate for Brazil, proved also most interesting and important for natural history. A country rich in the most beautiful and interesting productions of nature, was thus rendered accessible to foreigners, the former ill-judged and absurd restraints having been removed. Several interprising travellers, particularly Germans, have of late years visited this quarter of the New World; and it may be remarked as a singular circumstance in regard to Brazil, that Germans should have been its most distinguished investigators and historians. The English work of Mr Mawe of London, Eschwege remarks, is neither correct nor scientific; and the highly amusing and interesting History of our distinguished countryman Southey, contains principally such information as is found in the writings of Fathers Anchietta, Vas-consellos, Almeida, and in the works of the Jesuits Muriel, Montoja, and others.

An active and intelligent German miner and mineralogist, Von Eschwege, has resided in Brazil since the year 1810, and traversed in all directions the Capitania of Minas Geraes. In several of his journeys he was accompanied by the zoologist

M. Freireis, at present in the service of the Prince Regent of Portugal. The journals of his travels are printing in a periodical work entirely dedicated to Brazil, at present publishing in Germany.

But the most remarkable modern traveller in Brazil, is the German Prince MAXIMILIAN of Wied-Neuwied. This enterprising and distinguished person left Europe for Brazil in the month of June 1815. He went without parade or show, for the principal companions of his journey were two men of humble but respectable stations in life; the one was the gardener Simonis, a man of sound judgment, great knowledge, uncommon activity, and fearless of danger; and the other an experienced and expert huntsman. To these, when he landed in Brazil, the Prince added the necessary guides, huntsmen, and attendants. Thus accompanied, he traversed the woods, and marshes, and mountains of a tract of Brazil, extending from south latitude 13° to 23°. For months at a time he was encamped in the midst of vast forests, swarming with musquitoes, and crawling with serpents; and frequently his party were weeks in cutting their way through forests hitherto untrodden by man. The Prince himself was not an idle or inactive spectator; he directed all; he was perpetually occupied in determining the numerous objects he collected, or that were brought to him; he was ever on the watch to notice and record the appearance, habits, and manners of the numerous remarkable animals that presented themselves to his attention; and he did not allow the various magnificent and beautiful forms of the vegetable world to escape his penetrating glance. The appearance of the native tribes and their state of society, particularly of the cannibal Botocudos, afforded him a most interesting field for observation. Our admiration of the perseverance of this intrepid traveller is increased, when it is known that the tremendous and almost incessant rains to which he was exposed, did not for a moment excite any hesitation as to the prosecution of the journey; on the contrary, week after week, and month after month, suffering in a close, moist, and oppressive atmosphere, and tormented with vermin, he continued to traverse the marshes and deep and wet forests of vast unknown tracts. At night, after the fatigues of the day, huts were to be erected, fires kindled, and before sleep could be indulged in, their collections must be dried, their sketches finished, and their packages completed. Many of the party, we are told, were never free from disease; for months they were in a state of fever, and yet still continued, under the animating and enthusiastic example of the Prince, to travel onwards.

The result of this remarkable journey, has been the collection of a more curious and extensive series of observations, and of the natural productions of Brazil, than has been made since the days of Prince Moritz. We are informed, that Prince Maximilian has brought, amongst other collections, the following with him to Neuwied: A series of human skulls of the different tribes of savages, and also those of several quadrupeds, which have not hitherto been examined by naturalists; 76 different species of quadrupeds; about 400 distinct species of birds, of which there are 2,500 specimens; 79 different species of amphibious animals, particularly many beautiful snakes; upwards of 5000 insects, of which many are entirely new; a few shells and fishes; 5000 plants, and a vast collection of seeds; and a portfolio of 200 drawings, made by the Prince, of scenery, different tribes of savages, and other objects of natural history.

We are happy to learn that the Prince of Neuwied has announced his intention of publishing an account of his travels, and of the various objects of natural history he has met with, in four volumes quarto, with maps and plates *.

Art. XIX.—*Account of the Method of colouring Agates.* By John MacCulloch, M. D. M. G. S. Lecturer on Chemistry to the Board of Ordnance, &c. In a Letter to Dr Brewster.

In compliance with your request, I here send you the circumstances which I am able to recollect respecting the colouring of

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* We have just seen a work in two volumes quarto, published at Rio de Janeiro, in 1817, entitled "Corographica Brazilica," certainly the most important literary production which Brazil has hitherto afforded. It contains a pretty accurate description of the geography of the country, of its various tribes of original inhabitants, and treats fully of its moral and political condition; but the natural history is considered in a superficial and unscientific manner.—Ed.

agates by artificial means. It would be necessary to re-examine a collection of these substances, and to repeat some of the experiments on them, to determine the extent to which this art may be carried, and the exact nature of the varieties which are susceptible of the changes in question. As the discovery of the internal structure of agates is your own, no one is more competent than yourself to make these further inquiries, from which I am at this moment precluded.

It has long been known, that zoned agates, formed of laminæ alternately black and white, were brought from India; but it is only since the peace that the same substances have been imported from Germany in considerable quantity; in consequence of which their value has fallen to little more than the price of cutting. These latter are coloured by an artificial process, which is a kind of secret in the trade, and it is not improbable that the specimens from India are produced in the same manner, as the natives of that country possess the art of staining the same minerals white. As the lapidaries are not acquainted with the theory of their process, they are very subject to failures, which also arise at times from the nature of the stones being unsusceptible of the colouring process.

The common process consists in boiling the cut specimens in sulphuric acid; in consequence of which, a particular lamina, or set of laminæ, is rendered black, while others retain their natural colour, or even become whiter than before, thus producing that powerful contrast which is esteemed valuable in this stone. This process often fails, and will always fail, if tried on specimens which have not previously been cut on the lapidaries' wheel. It is, in fact, produced by the action of the sulphuric acid on the oil which has been absorbed by the stone in cutting, and can therefore very obviously be insured, by previously boiling in oil the specimens which are to be subjected to the blackening process. That this is the fact is proved, if proof were necessary, by the disengagement of sulphurous acid gas, which takes place during the action of the acid. To insure success, therefore, it is evident that either the application of the oil must be continued for a sufficient length of time, or that the stone be cut so thin as to admit of its being penetrated by it before the sulphuric acid is applied. You will easily see, that this absorbent property of agates explains the fact of their being occasionally blackened by sulphuric acid, so as to have led chemists to imagine that they naturally contained some carbonaceous matter; and it was a knowledge of this circumstance which led me to subject to long boiling in a solution of potash, those specimens in which I suspected vegetable remains to be entangled, before applying to them the test of sulphuric acid.

The fact itself is curious in another point of view, as it indicates the porosity of agates, and is nearly connected with your interesting discoveries respecting their internal structure. In examining the specimens which are to be subjected to this treatment, it is in the first place evident, that the future changes are not indicated by the colours, as the red, or otherwise coloured laminæ, sometimes become black, while in others the opaque white, or the transparent, are affected. In the few specimens which I possessed at the time I was engaged on this subject, I had no means of determining in what respect the change was connected with apparent differences in the internal structure, and I can only now suggest it to you as a subject for examination. In most zoned agates, some of the laminæ will be found exempt from any apparent internal structure, while in others the appearance of undulating fibres is evident, the fibres themselves varying materially in size. If any conjecture were to be formed *a priori*, it would be expected that the most distinctly fibrous laminæ were the most porous; but it is unnecessary to offer conjectures on what you may so easily put to the test of experiment.

Having mentioned the Indian practice of colouring agates white, it may be remarked, that this is also a secret in the hands of lapidaries, although apparently not generally known to them, and but little practised. Beads of carnelian are sometimes brought from India, ornamented with reticulations of a white colour, penetrating to a small depth within the stone, and equally hard. The black agates of this kind, which are sometimes coloured with complicated or fine lines of white, are often very singular, and, without a knowledge of the mode in which they are produced, have a very puzzling appearance.

They are thus coloured by applying carbonate of soda, and exposing them to the heat of a furnace or a muffle. An opaque white enamel is thus produced, which appears as refractory to steel as the original stone, and cannot easily be distinguished from a natural lamina of white, when used, as it has sometimes been, for producing flat specimens for cameos. By either of these modes, indeed, stones for engravers' work are easily formed, but in the method of blackening the susceptible lamina by sulphuric acid and oil, the effect is more brilliant, and the contrast of the black and white more decided.

Banff, *July* 1819.

Art. XX.—*Account of some important discoveries in Magnetism, recently made by* P. Barlow, Esq. one of the Professors of Mathematics in the Royal Military Academy, Woolwich *.

The Treatise on the Variation of the Compass, lately published by Mr Bain, and the magnetical observations made by Captain Ross and Captain Sabine, in the Arctic Regions, have turned the attention of men of science to the deviation produced by the action of the ship upon the needle of the compass. That eminent mathematician Dr Thomas Young, has constructed a formula and a table from the experiments made on board the Isabella, by which an approximate measure of the deviation may be obtained. Lieutenant Robertson of the Isabella, has also deduced general rules for the same purpose, and Mr Barlow, in investigating the subject experimentally, has been led to several interesting and important results, which could not have been anticipated from the known laws of the distribution of magnetism.

At the commencement of this inquiry, his intention was to avail himself of the favourable opportunity furnished by the immense masses of iron contained in the Royal Arsenal at Woolwich, to make some experiments, with a view of sub-

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* Through the kindness of one of our correspondents, who has seen Mr Barlow's experiments, and from other sources of information, we are enabled to present our readers with this early notice of them. Mr Barlow's paper was read at the Royal Society on the 20th May 1818, and will probably appear in the next part of the Transactions of that distinguished body.—Ed.

mitting to calculation the local effect of a ship's guns on the compass. He began his observations, on the effect of balls of different dimensions, and in the course of these, he was led to the following curious experimental fact, viz. that there is round every globe and mass of iron a great circle inclining from north to south, and forming with the horizon an angle of about 19 or 20 degrees, in the plane of which the iron has no effect in changing the direction of the needle, that is to say, while the *centre* of the needle is found in the plane of this circle, the compass will point north and south, the same as if no iron were present.

The dip of the needle being about 70° 30′, he apprehended that the inclination of this circle was equal to the complement of the dip; and subsequent experiments on an excellent horizontal compass and dipping needle, furnished by Mr Berge, have confirmed the accuracy of these surmises.

This fact being established, his next object was to ascertain what law was observed in the attraction of iron when the compass was removed out of the above circle of no attraction; and with this view, he contrived, by means of an apparatus constructed for the purpose, to carry the compass round the ball (which was 13 inches in diameter, and solid, weighing 288 lb.) in various circles; and by these means succeeded in deducing a law of action, which was singularly uniform, the computed and observed results scarcely ever deviating from each other, by a quantity greater than the daily variation, viz. from 10 to 20, or at most 30 minutes.

The nature of the above laws will be best conceived by the following artificial consideration. Call the circle of no attraction above described, the *magnetic equator of a sphere circumscribing the ball,* and its two poles, the poles of that sphere. Conceive now circles of latitude and longitude to be drawn, the first meridian of the latter passing through the east and west points of the horizon, and the magnetic equator. Then the law in question is this, That the tangent of the deviation of the needle from the north or south, is proportional to the rectangle of the sine of the double latitude and cosine of the longitude; so that, knowing the deviation in one instance only, it may be computed for any other whatever.

It is obvious, that although these laws have been pointed out with reference to the circles supposed to be drawn on the iron ball, or circumscribed sphere, they actually appertain to the needle itself; for when the compass is situated in any particular latitude and longitude with respect to the circles of the ball, the centre of the latter is similarly situated with reference to a sphere conceived to circumscribe the compass, having its centre coinciding with the centre of the needle; and hence the rules become immediately applicable to the determination of the local effect of a ship's guns, viz. find by experiment or otherwise, the centre of attraction of all the ship's iron; then in any part of the world where the dip is known, and at any direction of the ship's head, find the latitude and longitude of the centre of attraction with reference to a sphere circumscribing the compass, as supposed above; and the effect of the attraction may then be computed by means of the above rules, the deviation in any one instance having been previously determined. The only thing that can be considered as doubtful in the above rule is this: Does the circle of no attraction *every where* incline to the horizon at an angle equal to the complement of the dip? Mr Barlow has little doubt that it does, but, to be assured of the fact, he conceives that experiments must be repeated in different parts of the world.

Having ascertained the law of deviation as it regarded position, and which he found to hold in the most irregular masses of iron, Mr Barlow next proceeded to ascertain the law as it regards distance, and he found by the most unexceptionable results, that, all things else being the same, *the tangents of the angles of deviation are reciprocally proportional to the cubes of the distances.*

And again, that, *cæteris paribus, the tangents of deviation are directly proportional to the cubes of the diameters of the iron balls or shells, by which the deviation is produced.*

By combining these laws with those given above, Mr Barlow has found, that the whole may be expressed by the formula, $\tan \Delta = \frac{\text{Sin } 2\lambda \cdot \cos l \, D^3}{A \cdot d^3}$, where Δ is the angle of deviation, λ the latitude, l the longitude, D the diameter of the ball or shell, d the distance of the centre of attraction from the pivot of the compass, and A a constant co-efficient to be determined by experiment.

This formula obtains while the directive power of the needle is constant. When the dip, and consequently the directive power, changes, it becomes

$$\text{Tan}\,\Delta = \frac{D^3}{Ad^3}\left(\text{Sin}\,2\lambda\,.\,\cos l\right)\frac{\cos\frac{3}{2}d}{\cos\frac{3}{2}d'},$$

where d is the dip, A the place where the co-efficient was determined, and d' the dip at the place of observation.

The D in the above expression is to be understood to denote the external diameter of the ball or shell, and is equally applicable to either, the attraction being wholly independent of the mass; *the power of attraction being the same in the thinnest shell and the most solid ball.* Mr Barlow indeed has found, that a tin spherical case ten inches in diameter, and whose weight does not exceed twenty-three ounces, has an equal power of attraction with a solid iron ball of the same dimensions, weighing 128 lb.

This very curious and important fact, the discovery of which belongs exclusively to Mr Barlow, is another striking instance of the analogy between the electric and magnetic forces; and the following deductions from the preceding laws, bring the analogy home again, nearly as strong, to the case of universal attraction.

Since the tangents of deviation are as the cubes of the diameters of the attracting bodies, while the force of attraction is as the surface or squares of the diameters; it follows, *that the squares of the tangents of deviation are directly proportional to the cubes of the forces.*

The same inference may be drawn from the law of the distances, if we assume the force to vary inversely as the squares of the distances. For the tangents being inversely as the cubes of the distances, and the forces inversely as the squares of the same, we shall have, as above, the squares of the tangents directly as the cubes of the forces.

By a due estimation of all the above deductions, Mr Barlow has been able to project an experiment of the most simple kind, whereby the amount of the influence of the guns of a vessel on her compass may be determined at any time, independent of any calculation, and in any part of the world. This plan has been submitted to the Admiralty, and we hope that it will be soon ordered to be put in practice, at least in some one instance, as a test of its accuracy. The whole expence of the apparatus will not amount to twenty shillings.

Art. XXI.—*Account of the Revolving Steam Engine, invented by Mr* Samuel Morey*.

The high degree of importance which is now attached in every part of Europe to the perfection of the new system of navigation by means of steam, gives a great value to any improvement upon the steam-engine, by which it may be rendered more applicable to this useful art. The extensive employment of the steam-boat in navigating the rivers and lakes of the United States, has directed the ingenuity of American engineers, and the enterprize of American capitalists, to the improvement of every part of the machinery by which the progress of the vessel can be accelerated, and the security of the passengers insured; and we do not think that we are derogating in the least from the well known mechanical genius of our own countrymen, when we say, that the steam-boat, though decidedly a British invention, owes its general introduction, and many of its best improvements, to the Americans.

In presenting our readers with a brief description of Mr Morey's revolving steam-engine, we do not mean to recommend it as holding out any very great prospects of advantage, because it has not yet been compared with those of the common form; but as it has been actually constructed, and as it not only displays much ingenuity, but exhibits the engine in a new form, we are persuaded that our engineers will be gratified with an account of it, and may derive some hints, which may be useful in their attempts to give it a still higher degree of perfection.

This engine, as applied in a double form to the steam-boat, is represented in Plate VII. Fig. 3., where A B C is a section

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* The following paper is drawn up from a very full account of this engine given in Silliman's *American Journal of Science*, No. 2. p. 157, by Mr John L. Sullivan.—Ed.

of the steam-boat, *a a a* the steam boilers, *b b* the tar vessels, to be afterwards described, *c* the valve box, *d d* the two cylinders seen in different aspects, *e* the piston rod, *f* the pitman, *h* the centre piece, *i i* the shaft, *k k* the valves, *l l* the steam pipes, *m m* the escape pipes, *n n* the condensers, *t t* the water wheel, *v v* the face of the valves (in the small separate figures), and *x* the tar fire. The frame which holds the cylinders, *d d*, is, by its opposite sides, hung so as to revolve. The centre piece *h*, resembling a crank, is fixed to the end of the shaft or axis *i*, projecting over the cylinder, and from this centre piece the bar or pitman *f* communicates with the cross piece of the piston rod. Two circular pieces or valves *k*, one of brass and the other of iron, are placed on the same axis *i*, but on the outside of the frame, one of them being fixed to the axis, and the other accompanying the frame and cylinder in their revolution. From this last valve proceed the pipes *l l*, which conduct the steam to each end of the cylinder. The valve has a smooth face, which is kept close by springs to the face of the other valve, which is fixed to the shaft. Steam pipes *β β* convey the steam from the boilers through the outer valve into the moving valve, and from the opposite side of the outer valve proceeds the eduction pipes *o o*, which lead to the condensers *n p*.

These condensers are upright vessels (two of which belong to each cylinder), connected at top by a sliding valve-box, by which the steam is made to enter them alternately. They have two valves at the bottom, which are kept closed by weights. A stream of water is injected into the condensers, which escapes by the bottom valves *p p*, by which also the air is blown out at every stroke, in which manner the engine is at first cleared of air.

In order to give a reversed motion to the engine, two cocks and cross pipes are employed, for the purpose of changing the passage of the steam to the opposite sides of the valves.

When the engine is thus constructed, the steam admitted below the piston by the lower pipe *l* forces up the piston rod *e*, and the cross piece at its upper extremity. This cross piece carrying along with it the bar *f*, acts upon the crank *h*, which thus gives a rotatory motion to the shaft *i i*, and of course to the cylinders and frames. This shaft, by means of a pinion, drives the axis *u* of the water-wheel *t t*.

In order to save fuel, the engine has the *Gas Fire** applied to it in the following manner: "The boilers being cylindrical, with an inside flue for fuel, two or three are placed close together, and set in the following manner; first cross bars of iron are laid on the timbers; a platform of sheet iron is laid on these bars, coated over with clay, mortar, or cemented, to keep out the air. Upon the sheet iron, and over the bars below, are placed cast iron blocks, in shape to fit the curve of the boiler, so as to raise it

* The *Gas Fire* or *Water Burner* is the name given to a new method of producing light and heat, invented by Mr Morey, by which he conceives that all carbonaceous fluids may be conveniently burnt, and derive great force from their combination with the oxygen and hydrogen of water or steam, at the moment of ignition. In the first form of this experiment, a tight cylindrical vessel containing rosin was connected with a small boiler by a pipe, which entered near the bottom and extended nearly its length, having small apertures over which were two inverted gutters, inclining or sloping upwards over each other; the upper one, which was longer than the other, being intended to detain the steam in the rosin in its way to the surface. When the rosin was heated, carburetted hydrogen gas issued from the outlet or pipe inserted near the top of the vessel, and, being ignited, afforded a small blaze about as large as that of a candle; but when the steam was allowed to flow, *this blaze instantly* shot out many hundred times its former bulk, to the distance of two or three feet. Tar succeeds better than rosin, and has therefore been used in the steam-boilers. See *American Journal of Science*, vol. i. p. 91, 165, 401.

M. Gay Lussac, in a note in the *Annales de Chimie et de Physique*, tom. x. p. 124, has examined the theory of this process, and is of opinion that no advantage can be gained from it. He maintains, that the tar cannot decompose the water at the temperature employed; and that even if it did, it would not give out more heat or light than by the ordinary process of combustion. This distinguished chemist explains the production of the augmented flame in the following manner: "At the temperature to which the tar is exposed when alone, the elastic force of the inflammable vapour which it produces is not powerful enough to overcome the weight of the atmosphere, and to disengage itself copiously. Hence arises the smallness of the flame which it produces alone. But when the steam is brought against the burning tar, it draws along with it the inflammable vapour which could not disengage itself spontaneously, and therefore the flame is considerably augmented. Essence of turpentine, for example, which boils at 160° cent. will not disengage inflammable vapour at the temperature of 100° cent. and therefore will not inflame; but if a current of steam, or even of azot alone, is directed against it, a very considerable flame will be obtained. It is from the same cause that water, heated to 100° of the centgrade scale, in a vessel almost entirely shut, will not give off any steam, but as soon as we blow upon its surface, the steam is copiously produced.

three or four inches above the platform. The sheet iron is continued up the outsides of the outer boiler, so as to enclose them; and at one end, between the boilers, there are small grates for coal or other fuel.

The tar vessel or vessels are lodged in the space between and upon the boilers, and a small fire may be made under them if necessary. A pipe leads steam in at one end, two pipes at the other; one near the bottom, one near the top, lead out the tar and steam. These pipes unite below; the steam and tar thus mingled, in suitable proportions, flow to the plain fire or the flues of the boilers, as well as to the coal fire below, where the gas and tar are ignited. The fireman judges of the proportion of each by the effect; the object being to produce a nearly white flame, without appearance of tar. Thus flame is applied to the greatest possible surface, and the apparatus adds very little to the cost of the engine."

Mr Morey has also made other two improvements upon the boiler. The first of these consists in lining or covering the flue within with sheet iron or copper, *perforated with small holes*, reaching down its sides nearly to the bottom. By this contrivance, the water is made to circulate rapidly between the flue and the lining up to the top of the flue, and thus protects it from being run dry or heated red hot when the water gets by accident too low. In consequence of this circulation, the lining causes the steam to form much faster. The other improvement consists in an interior boiler or vessel occupying the back part of the flue, and communicating downwards with the water and upwards.

Two engines of Mr Morey's construction have already been erected; one of them at a glass manufactory in the neighbourhood of New York, and the other for a steam-boat intended principally for towing vessels up the river to Hartford. The first of these engines has a cylinder only *nine inches in diameter*, and the piston a stroke of only one foot; and, with steam at 50 lb. in the square inch, its power will be equal to that of ten horses. The Hartford steam-boat is 77 feet long, 21 feet wide, and measures 136 tons. The engine with its boiler occupies a space of 16 feet by 12, or one-eighth part only of the boat; the cylinders being hung on the timbers of the deck over the boilers. Each of the two cylinders has a diameter of 17 inches, and a stroke of 18 inches, and revolves 50 times in a minute. The area of the piston being about 227 inches, it will, when worked with steam of 50 lb. have the power of 100 horses.

Mr Sullivan gives the following enumeration of the properties of this new engine: "It works with or without a condenser;—it has a rotatory movement;—it requires no ponderous balance-wheel;—it is adapted to high steam;—it is attended by no inconvenience from the rapidity of its stroke or movement;—it has no inert mass of machinery to move reciprocally;—it is more powerful, proportionally, from its using steam as strong as that in the boiler;—it is of a simple and durable construction, and, by a combination of two similar machines attached to the same common intermediate axis, operating so as to give nearly an equal power at every moment of its operation, seems to combine every thing desirable in an engine for the purposes of navigation."

Art. XXII.—*Geognostical Description of the Neighbourhood of Edinburgh.* By Professor Jameson.

Part I.

Edinburgh is built on a central and high ridge, about a mile in length, which extends from north-east to south-west; and on two low and rising grounds, having nearly the same general direction and length. On the central and high ridge are situated the Castle, with the lofty and picturesque buildings of the Old City; while the northern rising ground is nearly covered with the splendid streets and squares of the New Town, and the southern principally with the ancient suburbs of the city, and numerous streets of modern date. The northern rising ground rises rapidly to its highest elevation in the centre of the New Town, and again declines first gently, and then rapidly, towards the south, into the valley of the North Loch. Towards the west it is continuous with the neighbouring flat country, and on the east it is bounded by the Calton Hill. The central ridge, for a considerable part of its length, is very steep, both to the north and to the south, and is terminated on the west by the Castle-rock, but declines gradually towards the east, and is lost in the flat at Holyrood Palace. The southern rising ground has a steep ascent from the north, or from the line of the Cowgate,—attains its greatest height in the line of Heriot's Hospital,—and declines gently towards the south when it reaches a lower level at the Powburn. To the west it is continuous with the adjacent flat country, and it declines gradually to the east, where it is bounded by St Leonard's Hill, Salisbury Crags, and Arthur Seat. The *View of Edinburgh from Lochend*, in Plate VI. Fig. 2. gives a good general idea of the form and arrangement of the hills that bound the north and south rising grounds to the east; and the flat between the Calton Hill and Salisbury Crags is the plain which bounds the central ridge on the east. The sections in Plate VIII. Fig. 3. drawn for me by Mr Adie, represent the general form, and also the elevations, of the central ridge and rising grounds on which the city is built.

Having now described the form of the ground on which the city is built, we shall next give an account of its mineralogical structure, beginning with the north rising ground, or that on which the New Town is situated.

Geognostical Description of the Rising Ground on which the New Town is situated.

This hill is composed of rocks that belong to the coal formation, and of various alluvial substances.

These rocks are disposed in strata and beds in which the general dip is to the north, the direction east and west, and the angle of the dip from 20° to 30°. But, as we approach the western extremity of the ground, the dip is to the W. of N., and on the eastern extremity to the E. of N. There are, however, many exceptions to this general arrangement; for, in some places, in digging foundations for houses, the strata in spaces of a few hundred feet were observed dipping in all directions from a centre, thus affording examples of saddle-shaped stratification. Other varieties of stratification will be mentioned when describing the rocks in which they most frequently occur. The strata vary in thickness from a few inches to several yards; and in the same stratum there are often great differences in the structure and compactness of the rock. Veins of different descriptions traverse these strata, and occasionally exhibit interesting geognostical phenomena.

The alluvial beds exhibit great variety in position and structure, but these will form the subject of a separate communication.

The rocks of which the rising ground is composed, are the following: *Sandstone, bituminous shale, slate-clay, clay-ironstone, coal, limestone*, and *greenstone*. Of these the sandstone is the most abundant, and the coal and limestone the least frequent. The sandstone, bituminous shale, slate-clay, clay-ironstone, coal, and limestone, frequently pass into each other, thus proving that they are productions of the same era, and have been formed in the same manner. The greenstone occasionally exhibits intermixtures with the other rocks, but these are not so distinctly marked as in the sandstone or shale.

1. *Sandstone.*—This rock is almost entirely composed of granular concretions of grey and white coloured transparent or translucent quartz, which are intermixed with scales of white-coloured mica, and grains of earthy-looking felspar. Sometimes there is a very inconsiderable clayey or calcareous basis or ground in which these grains are imbedded, but more frequently no basis is observable. These latter varieties, in hand specimens, are often so crystalline, that they cannot be distinguished from the quartz-rock of older formations. Indeed, the resemblance of sandstone to quartz-rock is so great, that it would be an improvement in geognostical nomenclature to substitute the name Quartz-rock for Sandstone.

It is distinctly stratified; the seams of the strata sometimes extend through considerable masses of the rock; in other instances they are of comparatively small extent, and not unfrequently one set of seams is included in others. In short, we observe in sandstone the same series of phenomena as occur in all rocks, from the most highly crystallised granite to the most perfect sandstone or clay-slate, thus rendering it probable that every rock is more or less distinctly stratified. Sometimes thick and short beds of sandstone are surrounded by thin horizontal strata of the same rock, or as in Fig. 2. Plate VIII. horizontal strata *a*, which are continued to *d*, meet the thick bed *b* on one face, but on the other it is met with by nearly perpendicular strata *c*.

Veins of sandstone sometimes shoot from the upper and under sides of strata into the adjacent rocks. These veins in general are very small, not much exceeding half an inch in thickness. This is a phenomenon of the same nature with that observed at the junction of granite with gneiss, mica-slate, &c. Veins of sandstone, from a foot to two feet wide, traverse the strata of sandstone. In Fig. 1. Plate VIII. are representations of veins of sandstone traversing sandstone. *a a* is slate-clay; *b b*, strata of sandstone; *c c*, veins of sandstone traversing sandstone; and *e*, a horizontal mass of sandstone surrounded by inclined strata of sandstone.

The position of the strata and veins of sandstone in Fig. 1. Plate VIII., can only be explained on the supposition of this rock being a chemical deposite, and that, therefore, the whole of these appearances are the result of one process of crystallization. Coaly matter is sometimes intermixed with the sandstone; it also occasionally contains imbedded, disseminated, and venigenous clay iron-ore, iron pyrites, and calcareous spar, and sometimes those imbedded tree-like bodies, which many mineralogists consider as petrified or fossilised vegetables.

2. *Bituminous Shale, Slate-Clay, and Drawing-Slate.*—Of these three kinds of slate, the most frequent are the two first mentioned. The drawing-slate is not pure, and occurs principally in the greenstone quarry at Bell's Mills.

3. *Clay Iron-Ore.*—This valuable ore of iron occurs in thin beds, in bituminous shale and slate-clay, on both sides of the Water of Leith, from Bell's Mills to Stockbridge, and has also been noticed in nearly all the quarries which have been opened on both the acclivities and the summit of the rising ground from Bell's Mills to the base of the Calton Hill. The beds are either continuous, or are naturally divided into globular or quadrangular distinct concretions; and balls or concretions of the same iron-ore occur disseminated not only in the bituminous shale and slate-clay, but occasionally also in sandstone. This iron-ore does not appear isolated in the slate, as some have maintained; on the contrary, there are distinct transitions from the pure slate-clay through all the intermediate shades to the perfect clay

iron-ore; an arrangement which proves that these minerals are of simultaneous formation *.

4. *Coal.*—The coal which is black coal, occurs in beds seldom more than a few inches in thickness, and is generally contained in the bituminous shale or slate-clay, rarely in the sandstone. By the gradually increasing mixture of clayey matter, it passes into bituminous shale. The accompanying bituminous shale and slate-clay contain impressions of ferns, a fact which has been adduced in support of the opinion which maintains the vegetable origin of black coal. We are inclined to call in question the supposed vegetable origin of this kind of coal, and are rather disposed to consider it as an original chemical formation, and that the occurrence of vegetable impressions in the adjacent rocks no more prove its vegetable origin, than the existence of fossil quadrupeds in the gypsum of Paris prove that rock to have been formed from the debris of animals of the class mammalia †.

5. *Limestone.*—This rock, which is of a grey colour, with a splintery or uneven and dull fracture surface, occurs in thin beds, along with sandstone, bituminous shale and slate-clay.

6. *Greenstone. (Whinstone.)*—This rock has been quarried at Bell's Mills, St Bernard's Well, in Broughton, at the Custom-House, in Albany Street; and in Leith-Walk opposite Antigua Street. At Bell's Mills the greenstone is in the form of a bed from 10 to 20 feet thick, which runs from north-east to south-west, and dips to the west under an angle of 25°. It rests on bituminous shale and sandstone, and is covered by bituminous shale. It contains a large imbedded mass of coarse drawing-slate, which includes a singular cotemporaneous mass of greenstone. From the manner in which the rocks were cut at one time by the operations of the miners, I was at first led to believe, that there were two distinct beds of greenstone, separated from each other by the drawing-slate; but a careful study of the positions and connections of the different masses, afterwards convinced me that the two apparent beds were portions of

* Dr Hutton maintains, that this ironstone has not been formed in the same manner as the surrounding slate and sandstone.

† Vide *Wernerian Memoirs*, vol. ii. p. 1.

the same thick bed, only separated by the cotemporaneous included bed of drawing-slate.

The greenstone near to St Bernard's Well, on the Water of Leith, is disposed in veins that traverse the strata of the coal-field. There are two veins, an upper and lower, from three to four feet wide; the lower vein, or that immediately beside the well, is beautifully amygdaloidal, owing to imbedded portions of calcareous-spar.

The greenstone at the Custom House is part of a great vein which has been traced in a nearly easterly direction, crossing the coal-field from the neighbourhood of the Custom House, until it disappears under the soil near the sea shore. It varies in breadth from 60 or 70 feet to 40 feet, is nearly perpendicular, and its known length about two miles. The greenstone quarries in its line of direction are Broughton, Leith Walk, nearly opposite Gayfield Place, new road across the north foot of the Calton Hill, old quarry also in the north foot of the Calton Hill, in Marshall's Entry, and east side of the Restalrig road.

In the greenstone at the Custom House, branches or veins of greenstone were observed shooting from the sides of the great vein into the bounding sandstone and slate-clay, and these either intersected the strata or were parallel with them; in the latter case having the appearance of beds. Portions of the sandstone and slate-clay were imbedded in the greenstone, and frequently at the line of junction of the rocks, there were mutual intermixtures. The greenstone contained disseminated iron-pyrites and calcareous-spar, and also the same minerals in the form of veins. In some parts of the vein the mass was entirely composed of grey-coloured compact felspar, and these masses irregularly distributed in the greenstone, gave it a conglomerated character. Although some of the quarries in other parts of the vein are beyond the limit of the present rising ground, it may not be uninteresting to give a short account of them.

The greenstone quarries at Broughton and Leith Walk are now covered up.

The greenstone in the quarry in Marshall's Entry, now filled with water, exhibited the same phenomena as in that at the Custom House. The greenstone in some parts is compact and dark-coloured, forming the basaltic greenstone of mineralogists; in others, was traversed by cotemporaneous veins of flesh-red compact felspar, or it contained the same mineral in imbedded masses, varying from an inch to upwards of a foot in diameter. These veins and imbedded masses were sometimes unmixed with the greenstone at the line of junction; in other instances there were intermixtures and transitions of the one into the other, and not unoften branches or veins appeared shooting from the imbedded masses and veins into the surrounding greenstone, and from the greenstone into the imbedded masses. These facts prove the cotemporaneous formation of the felspar and greenstone, because any two rocks which are intermixed at their line of junction, and mutually penetrate each other in the form of veins, must have crystallised at the same time.

The greenstone in the quarry just opened on the north foot of the hill, has the same general characters with that in Marshall's Entry, and at the Custom House. In some places it is traversed by veins of greenstone, varying from a few inches to three feet in breadth. Some of these extend only a few feet, and their depth is not greater than their length; others extend for several fathoms, when they at length terminate, and these wedge out or terminate below, a few feet from the surface. Iron-pyrites is abundantly distributed through the greenstone, and sometimes also calcareous-spar. These two minerals also occur in the sandstone strata, which are traversed by the vein or dike of greenstone. The fact of the greenstone and sandstone, containing the same imbedded minerals, would seem to intimate that they are of simultaneous formation.

The greenstone of the great vein, as it appears in the quarry (now filled up) beyond the Restalrig road, offered several fine examples of lateral veins shooting into the adjacent sandstone, and some of these were parallel with the strata, forming beds three feet thick. The sandstone, where in contact with the greenstone, was highly crystallised, and in hand specimens nearly resembled the quartz-rock of primitive districts.

The greenstone of Albany Street is in the form of a vein, from two to three or four feet thick, and which cuts across strata of the coal-field. For several yards it is bounded by bituminous shale, which has the usual characters of that mineral, both where it is in contact with the greenstone and at a distance from it.

Metalliferous Minerals.

Metalliferous minerals, with the exception of the clay-ironstone already described, occurs rarely, and but in small quantity, in this rising ground. The most frequent of the ores, are galena or lead-glance, iron-pyrites, and blende. These occur either disseminated or in small veins, along with calcareous-spar and heavy spar in sandstone. Red cobalt ore, in very small quantity, was found twenty or thirty years ago in a quarry in the grounds now occupied by the east end of Albany Street.

General Result.

From the preceding short description it appears, 1st, That the rising ground on which the New Town is built is almost entirely composed of granular quartz, in the form of sandstone, and that this quartz or sandstone is not an aggregation of broken pieces of quartz or of sand, but is a rock which has been formed by a process of crystallization. 2d, That there are various rocks subordinate to the sandstone, all of which appear to have been formed by a process of crystallization. 3d, That with the exception of common clay iron-ore, this ridge contains but very inconsiderable portions of metalliferous minerals. 4th, That all the rocks belong to the coal formation.

Geognostical Description of the Calton Hill.

1.

As the Calton Hill forms the eastern extremity of the rising ground on which the New Town is built, it will be proper here to give a short description of its general form, mineralogical structure and composition.

The Calton Hill rises to the height of 354 feet above the level of the sea. It is mural, rugged and craggy on the south and the west; very steep, but less rugged and with fewer cliffs on the north west and north; while on the north east and east there are neither cliffs nor precipices, but a gradual slope.

2.

This beautiful hill may be viewed as a vast mass of rock of the nature of felspar, which probably rests upon sandstone of the coal formation, and is partly covered with strata of the same description.

It is often disposed in globular distinct concretions, but less frequently in those of a tabular or columnar form; it is seldom stratified, and where stratification occurs, the strata frequently dip to the east under an angle of 15° to 20°.

The felspar sometimes assumes the form of *clinkstone* or of *claystone*, and occasionally it is simply fine granular, or is more or less iron-shot. In these different conditions, it is either simple, or includes different minerals, and in various forms. The clinkstone, claystone, fine granular felspar, sometimes contain grains and crystals of felspar, thus forming *clinkstone-porphyry*, *claystone-porphyry*, and *felspar-porphyry*; the iron-shot varieties are either porphyritic, forming *trap-porphyry* of some mineralogists, or they contain amygdaloidal portions of calcareous-spar, green earth, &c. when they are named *amygdaloid**.

The felspar frequently assumes a conglomerated character, forming a kind of *trap-tuff*. This trap-tuff has sometimes a basis of felspar, in which are set variously shaped masses, from the size of a pea to several inches in diameter of compact felspar, claystone, porphyry, &c. or these masses are joined together without any basis or ground. It is either compact, or is distinctly slaty. But the felspar forms, besides porphyry, amygdaloid, and trap-tuff, frequently *greenstone*, when combined with hornblende. The greenstone is generally porphyritic, or in the state of *green porphyry*. In different parts of the hill, there are layers of a *slate-clay*, which may also be considered as felspar in an earthy soiled condition.

These various modifications and combinations of felspar, with other minerals known under the names of porphyry, amygdaloid, trap-tuff, and greenstone, are not arranged every where, or even generally, in separate and distinct strata; on the contrary, they are included in each other, in masses of various forms and magnitudes, and the one frequently passes by insensible gradations into the other. Sometimes balls, or angular portions of porphyry and amygdaloid, are imbedded in a loosely aggregated porphyry or trap-tuff, forming a rock having a strikingly conglomerated character, and illustrating, in an inte-

* In the amygdaloidal masses of calcareous-spar, angular or roundish portions of glance-coal are sometimes met with.

teresting manner, the chemical formation of conglomerated rocks.

In various parts of the hill, which have been quarried at different times, masses of *grey sandstone* occur imbedded in the rock. These vary in magnitude from a few inches to several yards in length, breadth, and thickness. They differ also in form, being either sharp angular, blunt angular, tabular, or disposed in beautiful arches. When digging the foundation of the Waterloo Hotel, a fine section was cut in the greenstone-rock, in which were seen highly inclined beds of slate-clay, supporting several arched strata of sandstone, and inclined straight strata of slate and greenstone, and the whole included in the mass of greenstone.

The imbedded sandstone is sometimes intermixed with the greenstone or porphyry at their line of junction, or the whole mass of the sandstone is coloured green, owing to the diffusion of the matter of the greenstone. In many of the quarries formerly open, and in others still exposed on the hill, some varieties of greenstone are quartzose, owing to disseminated quartzy particles; and, on the other hand, some sandstones are so highly impregnated with greenstone, as to appear intermediate between sandstone and greenstone. These appearances are in favour of the doctrine of the simultaneous formation of the greenstone and sandstone rocks.

Some observers may be of opinion, that these masses of sandstone have been broken from previously existing strata, and afterwards included in the greenstone and other felspar rocks of which the hill is composed. The general diffusion of the matter of the greenstone through the sandstone, of the quartzose matter through the greenstone, and the natural arches of sandstone associated with slate-clay, and inclosed in the greenstone, appear to us to favour the opinion of the simultaneous crystallization of the two rocks.

3.

Veins of various descriptions intersect the rock in many directions. These are of *greenstone*, *calcareous-spar*, *limestone*, *agate*, *red jasper*, and *iron-pyrites*. The *greenstone* veins vary from a few inches to three or four feet in width, and sometimes terminate above and below in the mass of the greenstone-rock in which they are inclosed. The sides and walls of the veins have the same characters as the surfaces of tabular distinct concretions, and as these concretions are of cotemporaneous formation with the greenstone in which they are contained, the veins may be considered as having been formed in the same manner, and at the same time, with the rock in which they are contained. The *calcareous-spar* veins vary in breadth from half an inch to five or six inches. They frequently contain, besides the spar, also *celestine*, *calcedony* and *agate*, and these are either arranged in layers with the spar, or are irregularly intermixed with it. In several parts of the hill, these calcareous-spar veins contain disseminated angular or roundish portions of *glance-coal* *.

In the Miller's Know there are very beautiful and interesting displays of the various crossings, shiftings, and changes in the direction and magnitude of the veins. Indeed there is no cliff near Edinburgh which shews so distinctly the different phenomena of veins as that just mentioned. The veins of limestone, agate, jasper and iron-pyrites, present no arrangements which do not also occur in the calcareous-spar veins.

4.

On the east and north-east slopes of the hill, there are numerous strata resting on the porphyry and other rocks already described. These strata dip to the E. or N. E. under angles varying from 15° to 25°. The strata are sandstone, slate-clay, bituminous shale, wacke, and clay-ironstone. Of these the most abundant is the sandstone; the wacke, shale, slate and ironstone being less frequent. The sandstone, of which there are several quarries on the slope of the hill, is principally composed of quartz; but when in the state of conglomerate, the quartz is associated with portions of felspar, red jasper, flinty slate, Lydian stone, and agate. The other rocks, with the fine section of their various alternations, has been already described in pages 141, 142 and 143 of this volume.

* Glance-coal, according to the Huttonian system, is said to have been deprived of its bitumen by the action of heat, yet here it is associated with calcareous-spar, having the usual complement of carbonic acid.

General Result.

From the preceding description it appears, 1st, That the Calton Hill is a great mass of felspar rock in the state of porphyry and greenstone, with subordinate layers and masses of trap-tuff, slate-clay, and bituminous shale and sandstone. 2d, That the porphyry is traversed by numerous veins of different minerals, such as greenstone, calcareous-spar, &c. 3d, That the porphyry appears to rest upon sandstone, and to be covered in part with sandstone and other rocks of the same formation. Lastly, That all the rocks may be considered as belonging to the coal formation.

Art. XXIII.—*Experiments on the Effect of the Pressure of the Sea at great Depths, in augmenting the Specific Gravity of different kinds of Wood.* By William Scoresby junior, F. R. S. Edin. and M. W. S. *

At great depths, the effect of the pressure of the sea is not a little curious. My father met with the following singular instance, in the year 1794, which I have taken from his log-book.

On the 31st of May, the chief mate of the Henrietta of Whitby, the ship my father then commanded, struck a whale, which "ran" all the lines out of the boat before assistance arrived, and then dragged the boat under water, the men meanwhile escaping to a piece of ice. When the fish returned to the surface to "blow," it was struck a second time, and soon afterwards killed. The moment it expired, it began to sink, which not being a usual circumstance, excited some surprise. My father, who was himself assisting at the capture, observing the circumstance, seized a grapnel, fastened a rope to it, threw it over the tail of the fish, and fortunately hooked it. It continued to sink; but

* This very interesting article forms part of Mr Scoresby's valuable and amusing work on the Arctic Regions, which is now in the press, and to the publication of which the public may look forward with the highest expectations. Through the kindness of the author, we are enabled to present our readers with his curious experiments on the effects of the pressure of the sea at great depths; but for many additional and important details, we must refer them to the original work.—Ed.

the line being held fast in the boat, at length stopped it, though not till the "strain" was such that the boat was in danger of sinking. The "bight" or loop of a rope being then passed round the fish, and allowed to drop below it, inclosed the line belonging to the sunken boat, which was found to be the cause of the phenomenon observed. Immediately the harpoon slipped out of the whale, and was, with the line and boat attached to it, on the point of being lost, when it was luckily caught by the encompassing rope. The fish being then relieved from the weight of the lines and boat, rose to the surface; and the strain was transferred to the boat connected with the disengaged harpoon. My father, imagining that the sunken boat was entangled among rocks at the bottom of the sea, and that the action of a current on the line produced the extraordinary stress, proceeded himself to assist in hauling up the boat. The strain upon the line he estimated at not less than three-fourths of a ton, the utmost power of twenty-five men being requisite to overcome the weight. The laborious operation of hauling the line in, occupied several hours, the weight continuing nearly the same throughout. The sunken boat, which, before the accident, would have been buoyant though full of water, when it came to the surface required a boat at each end to keep it from sinking. "When it was hoisted into the ship, the paint came off the wood in large sheets, and the planks, which were of wainscot, were as completely soaked in every pore, as if they had lain at the bottom of the sea since the Flood!" A wooden apparatus that accompanied the boat in its progress through the deep, consisting chiefly of a piece of thick deal, about fifteen inches square, happened to fall overboard, and though it originally consisted of the lightest fir, sunk in the water like a stone. The boat was rendered useless; even the wood of which it was built, on being offered to the cook as fuel, was tried and rejected as incombustible.

This curious circumstance induced me to make some experiments on the subject. I accordingly attached some pieces of fir, elm, and hickery, containing two cubical inches of wood each, to the marine-diver, and sent them to the depth of 4000 feet. Pieces of wood, corresponding with each of these in shape and weight, were immersed in a bucket of sea-water, during the time the marine-driver, and its attached pieces were under water, by the way of distinguishing the degree of impregnation produced by pressure, from the absorption which takes place from simple immersion. On being brought up, they were all specifically heavier than sea-water; and, when compared with the counterparts, the clear effect of impregnation by pressure, was found to be 302 grains in the fir and hickery, and 316 grains in the ash. This experiment was repeated in latitude 78° 2′, on the 7th June 1817, by the immersion of twelve articles of different shapes and sizes, to the depth of 4566 feet. On this occasion, the apparatus was 30 minutes on its way down, rested 40 minutes, and took 36 minutes in drawing up, being altogether 106 minutes under water. The degree of impregnation produced on each of the different substances used in this experiment, is stated in the following Table.

Names of Substances.	Shape.	Solid Contents.	Specific Gravity after Immersion.	Proportion of Weight gained *per* Cubic Inch in consequence of Pressure.
		Cub. Inch.	W. 60°.1000	Drams Avoir.
Hickery	Wedge	1.4436	1.1760	4.606
Elm	Rectang. prism	2.0040	1.1321	5.639
Beech	Ditto	2.0040	1.1806	4.790
Fir	Thin wedge	0.9505	1.1168	4.050
Mahogany	Parallelopiped.	0.8792	1.0523	3.071
Lign. Vitæ	Rectang. prism	1.9356	1.3315	0.336
Bone	Ditto	0.1380	2.1372	0.725

This degree of impregnation is not surprising, when we consider that the pressure of water, at the depth to which these specimens of wood were sent, is equal to, at least, 2031 lb. or 18 cwt. 15 lb. on every square inch of surface.

These experiments were repeated on the 18th July 1818. Finding, on former trials, that pieces of fir wood sent down 4000 feet, were more impregnated with sea-water than others immersed only half that depth, I was in hopes that the degree of impregnation of similar pieces of the same kind of wood might be applicable as a measure of depth. If this were the case, it would serve a very valuable purpose, since all the plans hitherto contrived for measuring depths from a vessel, when sailing slowly, or drifting through the water, cease to be useful beyond 200 or 300 fathoms. With this view, I not only attached pieces of wood of different kinds, to the lead, and provided counterparts for immersion in a bucket of water; but I also fastened cubes of ash, from the same piece of timber, of about one inch solid contents, and of exactly the same weight, to the line, at intervals of about 500 feet; by the weight of which, when taken up, I could ascertain whether the increase of specific gravity was in any way proportionate to the depth. When the specimens of wood for this experiment were procured, a clear grained piece, of double the size wanted for sending under water, was prepared, and then cut in two, and the two parts dressed to the same shape, and to within a quarter of a grain of the same weight: one of these was then adopted as a principal, and fixed to the lead or line; and the other as a counterpart, and put into a bucket of water. The specimens affixed to the lead were eleven in number, and consisted of wood of different kinds, shapes, and dimensions: they were sunk to the depth of 6348 feet, and the line was almost perpendicular for nearly an hour.

Each piece of wood attached to the line, was taken off as hauled in, plunged in a basin of water, and conveyed into the cabin, where its weight in air and in fresh water was immediately taken. The interval between any two pieces was such, that I had just time to determine the specific gravity of one, before the next came up. On the arrival of the lead, the attached specimens were immediately immersed in water, and weighed as quickly as possible, together with their counterparts, which had been secured at the bottom of a bucket of sea-water, during the time the experiment was in progress.

The following Table exhibits the results of this experiment.

			Experiments on the Counterparts, immersed Three Hours in a Bucket of Water.					Experiments on Wood, immersed during Two or Three Hours, at Various Depths in the Sea.							
N.	Quality.	Shape.	Weight in Air.	Weight in Water, with a load of 880 gr.	Weight of an eq. bulk of Fr. Wa. Tem. 60°.	Solid contents.	Spec. gravity.	Depth.	Weight in Air.	Weight in Fresh Water, T. 60°.	Weight of an eq. bulk of pu. Wa. Tem. 60°.	Solid contents.	Spec. gravity.	Increase of Weight by Pressure.	Proportion of Weight gained *per* Cubic In.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.
			Grains.	Grains.	Grains.	Cub. Inch.		Feet.	Grains.	Grains.	Grains.	Cub. Inch.		Grains.	Grains.
1	Ash.	Cube	157	797	240	0.951	0.654	6348	278	40	238	0.943	1.168	121	128
2	—	—	157	797	240	0.951	0.654	5868	290	41	249	0.986	1.165	133	135
3	—	—	157	797	240	0.951	0.654	5370	283	40	243	0.963	1.165	126	131
4	—	—	157	797	240	0.951	0.654	4836	278	39	239	0.947	1.163	121	128
5	—	—	157	797	240	0.951	0.654	4284	288	38	250	0.990	1.152	131	132
6	—	—	157	797	240	0.951	0.654	3708	286	39	247	0.978	1.158	129	132
7	—	—	157	797	240	0.951	0.654	3198	280	37	243	0.962	1.152	123	128
8	—	—	157	797	240	0.951	0.654	2628	277	39	238	0.943	1.164	120	127
9	—	—	157	797	240	0.951	0.654	2058	289	35	254	1.006	1.138	132	132
10	—	Parallelo.	252	743	389	1.541	0.648	6348	493	73	420	1.663	1.174	241	145
11	—	Cube	318	723	475	1.881	0.669	6348	593	88	505	2.000	1.174	275	137
12	—	—	318	723	475	1.881	0.669	3708	594	88	506	2.004	1.174	276	138
13	—	—	449	625	704	2.788	0.638	6348	868	127	741	2.934	1.171	419	143
14	—	—	606	537	949	3.753	0.639	6348	1188	177	1011	4.004	1.175	582	145
15	—	—	606	537	949	3.753	0.639	4836	1180	173	1007	3.988	1.172	574	144
16	Fir	Rect. pris.	220	631	469	1.857	0.473	6348	534	40	494	1.956	1.081	314	161
17	Oak	—	350	758	472	1.870	0.720	6348	589	92	497	1.968	1.185	239	121
18	Hickery	—	407	849	438	1.734	0.929	6348	614	119	495	1.960	1.240	207	106
19	Teak	—	370	777	473	1.873	0.782	6348	574	94	480	1.900	1.196	204	107
20	Elm	—	289	752	417	1.651	0.693	6348	538	54	484	1.917	1.112	249	129
21	Cork	Cylinder	49	711	218	0.863	0.225	6348	86	—94	180	0.713	0.478	37	52

From this table we may observe, that the greatest increase of specific gravity, by pressure, in the specimens of the different kinds of wood submitted to experiment, was obtained by the fir; the next greatest by the ash; the next by the elm; the next by the oak; the next by the teak; the next by the hickery; and the least by the mahogany. The cork gained still less than any of the pieces of wood. The proportion of impregnation of the same kind of wood, in specimens of different sizes and shapes, is derived from the experiments made on the ash; and it is curious to observe, that the largest cube of ash, No. 14, and the parallelopipedon of the same, No. 10, received the greatest proportional increase of weight; while the smaller pieces received less and less additional weight, per cubic inch, as they decreased in size. Thus, No. 14, containing about 4 solid inches of wood, gained 145 grains per cubic inch; No. 13. of about 3 solid inches, gained 143 grains per cubic inch; No. 11. of 2 solid inches, gained 137 grains per inch; and the specimens of 1 inch, solid contents, gained from 127 to 135 grains. It is also a little curious, that the specimens sent to the depth of 2058 feet, were as much impregnated as those sent down above 6000 feet. The cube of ash, No. 11. consisting of 2 solid inches of wood, gained 137 grains per inch, at the depth of 6348 feet, while a similar specimen gained 138 grains, at the inferior depth of 3708 feet. In the same way, a cube of 4 solid inches gained 145 grains per inch, at the extreme depth; and 144 grains per inch, at the depth of 4836 feet. The degree of impregnation of the one-inch cubes of ash, produced by immersion to the depth of 2058 feet to 6348 feet, varies irregularly, but is evidently as great at the depth of 2058 feet, as under any superior pressure; so that it is probable that the greatest permanent impregnation by pressure, of such open-grained woods as ash, elm, fir, &c. is produced at the depth of 300 or 400 fathoms. Hence, it is clear that no use can be made of this effect of pressure, for determining the depth, unless it be within 2000 feet of the surface; and even in this limit, the results may be uncertain.

From a comparison of column VII. with XIII., and column IV. with XV., it appears, that an effect of the impregnation of the wood with sea-water, was to increase its dimensions, as well as its specific gravity; each specimen, on an average, having swelled 0.05 cubic inch in every solid inch of original dimensions, and gained 84 grains on every 100 grains of original weight; that is, an increase of one-twentieth in size, and twenty-one twenty-fifths in weight.

I have little doubt, but the degree of impregnation always increases with the increase of pressure; but the air contained in the pores of the wood, which is never wholly disengaged, exerting an expansive force when the load of pressure is removed, forces part of the water out again. This was clearly discernible in some of the specimens used in the foregoing experiments, at the moment they were hauled up, their surfaces being covered with a thin pellicle of froth. Hence pieces of fir sometimes become buoyant, after being a few hours relieved from pressure, though kept constantly under water; but all other kinds of wood yet tried, though they lose a little of their moisture, yet remain specifically heavier than water, as long as they are kept immersed. Blocks of wood, indeed, are now in my possession, that were soaked with sea-water in the year 1817, and yet remain, at the bottom of a vessel of water, nearly as heavy as when first drawn up out of the sea.

The degree of pressure at the depth to which I sounded in my last experiment, is not a little astonishing, being, under a column of water, 6348 feet in length, at least 2823 lb. or 25 cwt. 23 lb. on one square inch of surface. Hence on the larger cubes of ash used in the experiment, though measuring only 1.59 inches in diameter, the whole pressure must have exceeded nineteen tons!

XXIV.—*Sketch of a Journey through Brazil in* 1817 *and* 1818. By Mr SWAINSON of Liverpool. In a Letter to Professor Jameson.

I DETERMINED on going to South America in the autumn of 1816. The enlightened policy which influenced several of the Continental Sovereigns in sending scientific men to explore those treasures which the country of Brazil offered to philosophical investigation, the moment universal peace was restored, induced me to hope that our own Government would gladly have paid attention to any proposals made to them, of a similar nature. For this purpose I wrote to Sir Joseph Banks, who highly approved of my resolutions, and, I believe, recommended it in the warmest manner. The motives of my travels had been, in the first instance, only individual gratification and improvement; but considering that with very little assistance, and liberal patronage, my plans might have been enlarged, and the sphere of observation more extended, I made the proposal of remitting home as extensive collections as possible, in all the branches of natural history, for our national museums and gardens, provided adequate assistance in a pecuniary way, or even a nominal patronage as naturalist to the British Government, was given me: Both, however, were declined; and thus, from being entirely left to myself and my own resources, the results of my investigations and travels have been comparatively confined within certain limits.

Instead of following the example of all my fellow-labourers, by going in the first instance to Rio de Janeiro, I landed, about the end of December, 1816 at *Recife*, in the province of Pernambuco, 8 degrees south of the line. This province had never been visited by any modern naturalist, and I found that it possessed features, both in its geography and natural history, widely different from the southern provinces. After gaining general ideas of the climate, manners, &c. I made preparations for a journey into the interior, but these were suddenly rendered useless, by the memorable revolt of the 6th March 1817, of which I was an eye witness. This event confined my researches to a limited extent of country round the city; yet so many new and striking objects presented themselves, that I was amply employed during all the time that the country remained in this disturbed state. I had besides made the acquaintance of most of the principal men, who were all more or less involved in this effort to liberate their country, and I thus possessed ample means both of narrating the events, and enquiring into the causes which led to this political convulsion. On the restoration of tranquillity, after remitting all my collections, drawings, &c. home to England, I quitted Pernambuco in June 1817, and, with a small train, directed my course (by a circuitous route towards the interior) for the great river St Francisco.

The face and productions of the inland parts differ most essentially from those of the coast. Water in these dreary tracts is at all times scarce, and the excessive drought that had prevailed frequently exposed us to great privations, and even danger; sometimes our only resource was the water found in crevices and hollows of rocks, rendered putrid by decomposed vegetables. At length we reached the village of Penedu, in the beginning of August. The botanical subjects collected on this journey were numerous and interesting, particularly among the parasitic plants and cryptogamia, which, with the birds, insects, &c. were mostly new. The drought in the interior rendered it impossible to proceed by that route to St Salvador, and I accordingly embarked for that place in a canoe, and arrived in eight days. Here I found the two Prussian naturalists, Messrs Sellow and Freyeries, who had come overland from Rio de Janeiro with the Prince of Neuwied, and had remained in the city from ill health, and also to arrange their collections. I left them, however, soon, and made nearly a complete tour of the bay, and again set out for the *Sertem* or inland country, where I continued, varying my residence, until the month of March following, having in this space made immense collections in every branch of natural history, particularly in the ornithology of the interior, which differs both in species and novelty from those procured by the Prussian travellers on the coast.

I have considered it much more essential, in the observations I have made in this country, to survey Nature as a whole, than simply in its minute parts; by studying her operations in the natural habits and affinities of each particular class or tribe of animals and vegetables. The formation of systems and of genera, and the minute discrimination of species, belong to the naturalist when seated in his closet; but the habits and modes of life which characterise each in a state of nature, are highly interesting, and the accurate observation of them must be conducive to the exaltation and expansion of the human mind.

In the month of April I embarked for Rio de Janeiro, more for the sake of comparing the southern with the equinoctial regions of Brazil, than of increasing my collections in a part already well explored. I found the summer nearly terminated, but the heat far above that of Pernambuco, though

Rio de Janeiro is in lat. 22° 54′, and Pernambuco in lat. 8°. Travellers and men of science from the Austrian, French, Russian and Tuscan Courts, were here. Few of them, however, had been out of the province, and, by some unfortunate mismanagement, five of the Austrian party returned home shortly after my arrival. Among these travellers was Professor Raddi, director of the museum at Florence, who was indefatigable in forming a fine collection of the fruit and seeds of the country: With him I made an excursion to the immense range of mountains, called the Organ Mountains, which for leagues are covered with almost impenetrable forests, abounding in ferns, melastomas, and insects quite peculiar to them. From Dr Langsdorff, the Russian Consul-General in Brazil, I received every assistance and the most liberal attention; and having with his aid embarked my collection, with many desiderata, I returned to England in August 1818.

The number of species, in all the classes of natural history, which I have brought home, cannot be ascertained; but the following statement may give a general idea of the whole.

Of *Birds*, there are 760 specimens, among which are many entirely new species, and others exceedingly rare, particularly in the genus Trochilus, of which family I am now engaged in making a general arrangement; two or three new toucans, a singular goat-sucker, with a tail doubly forked, &c.

The specimens of *insects* amount to more than 20,000. Of course there is a large proportion of duplicates, but it may safely be said to exceed greatly any collection of South American insects ever seen in this country. The family of Hesperia (*Latreille)* alone exceeds 280 species, and, by a peculiar mode of preservation, this part of the collection is in an uncommonly fine state. Drawings and ample descriptions were also made of nearly 120 species of *fish*, mostly unknown, and such as were of a convenient size were sent home in spirits.

Seeds of many new and little known *plants* have been sent to Kew and other botanic gardens, where they are now flourishing. An interesting collection of parasitic plants, together with another of cryptogamia, I presented to my friend W. J. Hooker, Esq. These last have begun to appear in his elaborate work, *Musci Exotici*. My herbarium, containing about 1200 species, is particularly well preserved, the plants having been dried by a new process, which will enable a botanist in a tropical climate to dry nearly 400 specimens in three days. It is very rich in ferns and grasses, as well as other genera little known as natives of the tropics.

I have, besides, a portfolio of drawings, representing the most striking picturesque and vegetable scenery, together with maps of the different routes pursued.

Art. XXV.—*Account of a new Portable Gas Lamp, invented by* David Gordon, *Esq. Edinburgh* *.

The application of inflammable gas to the purposes of illumination, has hitherto been almost wholly confined to the lighting of large cities, extensive manufactories, and public institutions. The ingenious apparatus invented by J. and P. Taylor, for obtaining gas from oil, has enabled gentlemen of fortune to light their houses with gas at a moderate expence, and without being annoyed by any of the disagreeable products which arise from the distillation of coal. But notwithstanding this valuable improvement, gas light has never been rendered portable, and the great body of private individuals, and all the lower classes of society, are unable at this moment to derive any advantage from the extraordinary cheapness of this beautiful light.

In order to remove these limitations to the use of gas lights, and to render them available in every case where lamps or candles can be used, Mr Gordon conceived the idea of condensing a great quantity of gas into a small space, and set himself to construct a lamp, in which this condensed gas could be burned with the same facility and security as an ordinary lamp. The body or reservoir of the lamp, which we have represented in Plate IX, Fig 1. and 2. is commonly made of copper, about $\frac{1}{20}$th of an inch thick, in the form of a sphere or a cylinder, with hemispherical ends. This reservoir may be put into a different apartment from that which is to be illuminated, or may be concealed

* Mr Gordon has secured by patent the exclusive privilege of this invention. We have been enabled to draw up the following short account of it from information communicated by the Inventor.—Ed.

under the table, or, when it is required to be ornamental, it may be put into a statue, or the pedestal of a statue, or may be suspended, as in Fig. 2.

In order to regulate the escape of the condensed gas, Mr Gordon has employed two different contrivances, which are extremely ingenious. The first of these is a stop-cock, Fig. 5. constructed in the following manner: After the cock has been drilled through in the usual manner, the circular hole in the key is contracted at one side, by soldering into it two pieces of brass, which join at one side *a* of the hole, and are about $\frac{1}{20}$th of an inch distant at the other side, as at *b c*, forming an acute angular aperture, (Fig. 7.) By this means the issue of gas can be regulated to the smallest possible stream, by bringing the acute angle *a* of the opening in the key to communicate with the circular opening in the cock; and as the expansibility diminishes as the gas is consumed, the aperture can be increased in the same proportion. But to secure the above object more completely, and to prevent the possibility of turning the cock suddenly, so as to admit too great a discharge of gas, a ratchet wheel is fixed in the end of the key of the cock, in which an endless screw *m n*, Fig. 5. works. By turning this screw with the nut N, the flame may be enlarged or diminished to any extent, however highly condensed the gas may be.

The second contrivance which Mr Gordon employs to produce the same effect, is a conical leather valve, similar to that in the reservoir of an air-gun, placed in the opening of the reservoir of the lamp, where it screws on to the condensing pump. When the reservoir has been charged with gas, and removed from the pump, a set of brass, Fig. 6. is screwed in above the valve. Through this piece of brass there passes a finger-screw, the point of which, when made to press on the valve, forces it back, and allows the gas to issue in any quantity that may be required. A bridge of brass *a b*, consisting of a hollow tube, in the form of a Gothic arch, passes over the head of this regulating screw, for the purpose of giving freedom to the fingers in turning the screw to regulate the flame, and to conduct the gas to the burner, which, in a standing lamp, is screwed on at the centre *c* of the arch.

By either of these contrivances, the latter of which Mr Gordon prefers from the simplicity of its construction, the command of the flame is so complete, that it may be reduced to an almost imperceptible quantity.

The forcing-pump by which Mr Gordon condenses the gas is nearly the same as that of the common condensing syringe, having a solid piston worked by a lever, with shears and a guide, to produce a vertical motion. As a considerable degree of heat is created during the condensation of the gas, the pump must be kept cool by surrounding it with a case filled with water, and changing the water as soon as it becomes heated.

When it is required to fill a great number of lamps with condensed gas, which will no doubt be the case, when it is sold to individuals from the reservoirs of Gas Light Companies, Mr Gordon recommends that the forcing-pump should be wrought by steam, or any other mechanical power, and that the gas should be condensed into a large reservoir, from which the lamps of numerous individuals may be filled at once with the condensed gas. A mercurial gage, similar to that used for ascertaining the force of condensed air, must be fixed to the large reservoir, for the purpose of enabling any person to see the degree of condensation to which the gas has been brought.

As we have had occasion to see Mr Gordon's lamp put to the test of direct experiment, we feel ourselves entitled to speak with confidence of its excellence, and to recommend it as one of the greatest practical inventions which has for some time been presented to the public. Its application to the lighting of private and public carriages, as well as to coal mines, under the safeguard of Sir H. Davy's invention, will be speedily put in practice; and we hope the time is not very distant, when reservoirs of condensed gas shall be established in every town and village of Great Britain, and when the lonely cottages of the poor shall be enlivened by this economical and chearful light. There is one application of the portable gas lamp to which we attach a very high value. By an extreme diminution of the aperture, the flame can be rendered so small (in which case it is reduced to a blue colour) as to give no perceptible light, and to occasion almost no consumption of gas. In this state the lamp may be used in bed-rooms, and the imperceptible flame may at any time be expanded into the most brilliant light, by turning the cock, by means of a metallic rod terminating near the bed.

Description of the Figures in Plate IX.

Fig. 1. is one of the Portable Gas Lamps, 6 inches in diameter and 9 inches high, exclusive of the hemispherical ends and burner at the top. When filled with coal gas condensed 25 times, it will supply a lamp equal to 5 candles, 6 to the pound, for 6 hours; and when filled with oil gas, it will burn for about 12 hours.

Fig. 2. is a sphere of 12 inches diameter, and filled as Fig. 1. will, with two argand burners, equal to 12 candles, burn for upwards of 6 hours with coal gas, and 12 hours with oil gas.

Fig. 3. contains a cylinder 6 inches diameter and 2 feet high, exclusive of the hemispherical ends, and is calculated to supply an argand burner, equal to 10 candles, for 6 hours with coal gas, and for 12 hours with oil gas.

N. B. Although gas made from oil burns longer than that made from coal, yet it is doubtful if the great difference mentioned above does not arise principally from using burners pierced with smaller holes.

Fig. 4. is the reservoir of condensed gas, for supplying lamps with facility. At A, where the gas is to be allowed to issue from the condensed reservoir, the valve is placed. B is the finger-screw to raise the valve. C the perforated male screw, upon which the lamp is to be screwed.

Fig. 5. is the stop-cock, which is constructed as already described.

Fig. 6. is the set of brass, already described, to be screwed on when a valve is used.

Art. XXVI.—*Notice of the Progress of Botanical Science in Bengal, being the substance of a Letter from Dr* Wallich, *Superintendant of the Botanical Garden near Calcutta, to* Francis Hamilton, M. D. F. R. S. & F. A. S. L. & E.

Soon after Dr Wallich's appointment to the Botanical Garden near Calcutta, he obtained the permission of Government, and the sanction of the Honourable E. Gardner, Resident at Kathmandu, to send persons to Nepal, for the purpose of collecting roots, seeds and specimens. The persons chosen were Bharat Singha, a faithful rajput, who had been employed in this manner by Dr Francis Hamilton, when engaged in a statistical survey of Bengal, and a Portuguese lad, the son of an old servant of Dr Roxburgh. The manner in which these two most zealous and industrious men have acquitted themselves of their duty, has far exceeded Dr Wallich's expectations. They reached Nepal in December 1817, and before the 9th of October 1818, they had forwarded to the Botanical Garden upwards of 900 species, " most of which," says Dr Wallich, addressing Dr Hamilton, " are new to every person except yourself, who are the best judge " of what vegetable treasures that country affords." But independent of these mens uninterrupted researches, Mr Gardner always employs six persons, and sometimes a greater number, in collecting plants and other curiosities for Dr Wallich, who receives them along with the dispatches transmitted by his own men. Mr Gardner has besides most judiciously and liberally sent two expeditions to the foot of Gosaignsthan, one of the highest peaks of the Himaliya Mountains, about ten marches from Kathmandu. The productions collected on these expeditions, exceed, if possible, the rarities received from the more immediate neighbourhood of Kathmandu. From that quarter have been received the following interesting plants:

Several lovely Primulas, not to be found in the lower countries.

Some species of Androsace.

A Cornus, not unlike the *florida*, which Dr Wallich calls *aggregata*.

A singular plant, probably a Serratula, with a compacted terminal bunch of flowers, as large as a man's two fists, defended from the snow, among which it grows, by an involucrum, thickly covered by a cotton-like substance.

A Sambucus.

Several new plants of the natural orders Ranunculaceæ, Gentianæ, and Acanthaceæ.

A third new species of Cypripedium. It must be observed, that no plant of this genus was known in India, until Dr Wallich received two beautiful species from Mr Smith, a veteran collector employed for the Botanical Garden in Sylhet.

A Streptopus.

Several species of Carex, of which genus there are very few in India.

An Andromeda, with minute leaves like an Erica, which Dr Wallich calls *cupressiformis.*

Some Potentillas.

A third species of Rhododendron, probably one of those mentioned by Dr Hamilton in his Account of Nepal.

A Ribes.

Several species of Pedicularis and Fumaria, in addition to those found near Kathmandu.

Some species of a new genus of the Bignonaceæ, which Dr Wallich intends calling Didymocarpus, and which is nearly allied to the Incarvillia, of which several species are also found near Kathmandu. This genus may be distinguished, Staminibus 2 sterilibus; ovario pseudo-quadriloculare; capsula lineari elongata pedicellata bipartibili; singula biloculari marginibus dehiscente; seminibus minutis nudis insertis valvularum interiorum marginibus liberis involutis; corollæ labio superiore brevissimo inferiore elongato.

The plants of this genus have a considerable affinity to the genus Sesamum; are herbaceous, and somewhat fleshy, and are mostly covered with short hairs, interspersed with minute resinous dots, occasioning a degree of viscidity. Their stem, when they have any, is generally undivided; the peduncles are slender; the flowers are generally showy, purple, and very tender, which renders the examination of dried specimens very difficult: the plants abound in a resinous fragrant exudation, and among the natives are called by the generic name Kumkuma, yielding a drug of this name. Their primordial leaves dried, form the drug called Rani Govindhi. These drugs are in high esteem, and are used as a sacerdotal offering by the Brahmans, and also as a perfume by the Hindu ladies. Dr Wallich has only been able to rear one species in the Botanical Garden: the others all died shortly after their introduction, the heat probably being too great.

Respecting the vegetables from the vicinity of Kathmandu, Dr Wallich writes, that he has forwarded many of them to Sir Joseph Banks, Mr Lambert, and Sir J. E. Smith, the two latter of whom have all the specimens, drawings, and descriptions brought from Nepal by Dr Hamilton. To Mr Hooker, Dr Wallich, besides a variety of mosses, has transmitted most of his ferns, which of themselves form a very respectable collection. He is about to publish a quarto volume of Contributions to the Botany of India, which will contain a good number of plants from Nepal, with about thirty engravings. In this work, among other plants, will be given an account of the following: Fraxinus floribunda, Ligustrum nepalense, Wulfenia obliqua, Utricularia rotundifolia, Mitrasacmi capillacea, an Ilex, several species of Cornus and Gentiana; one of the latter Dr Wallich from its stem calls *volubilis!* several plants of the order Gentianæ, but not of the genus so named; some species of Lonicera that are new, besides the japonica; a Hydrangea; some species of Viburnum, Viola, Lysimachia, Primula, Androsace, and Mussænda; many species of Impatiens; some plants of the orders of Umbellatæ and Junceæ, (the latter chiefly from Gossaignsthan); a superb species of Lilium, mentioned by Dr Hamilton in his Account of Nepal; several species of Melastoma, Salix, Pinus, and other Coniferæ; an Acer; several species of Thalictrum, Clematis, Bæobotrys, Symplocos, Gualtheria, Andromeda, and Convallaria, one of which has cirrhi; Fritillaria verticillata? species without number of Laurus, or allied to that genus; several Mimosas; a Saxifraga, a Coriaria, an Agrimonia, a Drosera, nearly allied to the *peltata* of Sir J. E. Smith; several of the Caryophyllaceæ, innumerable Rosaceæ, &c. &c.

The Houttoynia cordata of Thunberg, Dr Wallich thinks is unquestionably the Polypora of Loureiro, who has most correctly placed the plant in the Triandria Trigynia.

Dr Wallich has been so fortunate as to procure the ripe fruit of the Paris polyphylla of Dr Hamilton, who, not having seen it, was uncertain concerning the genus of this plant. This fruit Dr Wallich describes as a capsule; but as he does not mention its opening with valves, it may probably be considered as a dry berry. He says: Capsula exsucca flavescens lævis globosa magnitudine cerasi mediocris, carinis 4 et 5 inæquali distantia notata, ad verticem plagula orbiculari marginata, subdepressa, stylo persistente aucto coronata, perianthi foliolis emarcidis suffulta, unilocularis cortice chartaceo. Placentæ quatuor seu quinque carinis capsulæ exterioribus alternantes, tenues, lineares. Semina numerosa ovata lateritia angulata, totam capsulæ farctæ cavitatem implentia, placentis duplice serie ope funiculorum brevissimorum adfixa. Integumentum simplex crassum. Albumen coriaceo-carnosum solidum. Embryo minutus, globosus, nigrescens, basi seminis supra funiculum extra perispermum, forsan etiam extra integumentum positus! This plant, so remarkable from the structure of its seed, has a very poisonous root.

Dr Wallich has in the Botanic Garden four beautiful species of Hedychium from Nepal; of these, the *spicatum* and *ellipticum* have been engraved; and he has besides several new ones from Sylhet. He has also growing the Roscoea, first brought by Dr Hamilton from Nepal; with almost innumerable Orchideæ, among which are the very ornamental Epidendrums, called by Dr Hamilton *præcox* and *humile.*

Art. XXVII.—*Notice respecting Barystrontianite, a New Mineral found at Stromness in Orkney**. By Thomas Stewart Traill, M.D. In a Letter to Dr Brewster.

Agreeably to the wish expressed in your letter to my friend Mr Scoresby, I transmit to you a notice of the Mineral found near Stromness in Orkney.

It occurs in masses disseminated in a rock described by Professor Jameson as "intermediate between schist-ore and indurated clay," (see Mineralogy of Scottish Isles). Its colour is greyish-white externally, where it appears somewhat disintegrated; but approaches to yellowish-white internally, where its lustre is weakly shining and pearly. It is translucent on the edges; brittle, soft. Its specific gravity is 3.703. It effervesces briskly with acids. It does not melt before the common blowpipe.

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* A full account of this mineral, drawn up by Dr Traill, will be published in next Part of the Transactions of the Royal Society of Edinburgh.—Ed.

By careful analysis, two parts yielded,

Carbonate of Strontites,	68.6
Sulphate of Barytes,	27.5
Carbonate of Lime,	2.6
Oxide of Iron,	0.1
	98.8
Loss,	1.2
	100.0

This mineral, on repeated trials, appeared so uniform in its composition, as to deserve being considered a new species, for which the name *Barystrontianite,* or *Stromnite,* is proposed.

Its geological situation is in veins, or rather in nests, accompanied by galena, in the above mentioned rocks, which may perhaps belong to a *grey-wacke* formation. This rock appears to rest on mica-slate, which is in connection with gneiss and small grained granite of a grey colour.

I may add, that a recent attempt to procure fresh specimens of this mineral has been unsuccessful, and a friend, who visited the spot, was only able to find masses of common sulphate of barytes, which I previously knew to be abundant in that neighbourhood.

Liverpool, *July* 31. 1819.

Art. XXVIII.—*Account of a singularly Poisonous Insect which destroys Horses.* By the Reverend Elias Cornelius *.

In the Choctaw Country, 130 miles N. E. of Natchez, a part of the public road is rendered famous by the periodical return of a poisonous and destructive fly. Contrary to the custom of other insects, it always appears when the cold weather commences in December, and as invariably disappears on the approach of warm weather, about the 1st of April. It is said to have been

* This article is extracted from Mr Cornelius's account of the Geology, &c. of Tenessee, &c., published in the *American Journal of Science*, No. iv. p. 328.

first remarked during a snow storm in the winter of 1807, when its effects upon cattle and horses were observed to be similar to those of the gnat and musquito in summer, with this difference, that they were more severe. It continued to return at the same season of the year without producing extensive mischief, until the winter of 1816, when it began to be generally fatal to the horses of travellers. So far as I recollect, it was stated that from thirty to forty travelling horses were destroyed during this winter. The consequences were alarming. In the wilderness, where a man's horse is his chief dependence, the traveller was surprised and distressed to see the beast sicken and die in convulsions, sometimes within three hours after encountering this little insect; or if the animal were fortunate enough to live, a sickness followed, commonly attended with the sudden and entire shedding of the hair, which rendered it unfit for use. Unwilling to believe that effects so dreadful could be produced by a cause apparently so trifling, travellers began to suspect that the Indians or others, of whom they obtained food for their horses, had, for some base and selfish end, mingled poison with it. The greatest precaution was observed; they refused to stop at any house on the way, and carried for a distance of forty or fifty miles, their own provisions; but, after all, suffered the same calamities. This excited a serious inquiry into the true cause of their distress. The fly which has been mentioned, was known to have been a most singular insect, and peculiarly troublesome to horses. At length it was admitted by all, that the cause of the evils complained of could be no other than this insect. Other precautions have since been observed, particularly that of riding over the road infested with it in the night, and now it happens that comparatively few horses are destroyed. I am unable to describe it from my own observation. I passed over the same road in April last only two weeks after it disappeared, and was obliged to take the description from others. Its colour is a dark brown; it has an elongated head, with a small and sharp proboscis, and is in size between the gnat and musquito. When it alights upon a horse, it darts through the hair much like a gnat, and never quits its hold until removed by force. When a horse stops to drink, swarms fly about the head, and crowd into the mouth, nostrils, and ears; hence it is supposed the poison is communicated inwardly. Whether this be true or not, the most fatal consequences result. It is singular, that from the time of its first appearance, it has never extended for a greater distance than forty miles in one direction, and usually it is confined to fifteen miles. In no other part of the country has it ever been seen. From this fact, it would seem probable that the cause of its existence is local. But what it is, none can tell. After the warm weather commences, it disappears as effectually from human observation as if it were annihilated. Towards the close of December, it springs up all at once into being, and resumes the work of destruction.

A fact so singular, I could not have ventured to state without the best evidence of its reality. All the circumstances here related are familiar to hundreds, and were in almost every man's mouth when I passed through the country. In addition to this, they were confirmed by the account which I received from Colonel John McKee, a gentleman of much intelligence and respectability, who is the present agent of the General Government for the Choctaw Nation. He has consented to obtain specimens of the insect for examination when it returns again; and will, I hope, accompany the transmission with a more perfect description than it has been possible for me to communicate.

Art. XXIX.—*On the Phosphorescence of Minerals.* By David Brewster, LL. D. F. R. S. Lond. and Edin.

The phosphorescence of minerals seems to have been first mentioned by Benvenuto Cellini, in his Treatise on *Jewellery* *, which was published early in the 16th century. He there informs us, that he had seen a carbuncle shine in the dark, and that a coloured stone of the same kind had been found in a vineyard, near Rome, by the light which it emitted in the night. In the year 1663, Mr Boyle observed, that a diamond gave out a light almost equal to that of a glow-worm, by the influence of

* *Due Trattati dell' Orificeria.*

heat, or by attrition, or by simple pressure; but he does not appear to have noticed the same property in other minerals.

Although the developement of light in decayed wood, in animal bodies, and in artificial phosphori, was studied with much attention in the 17th and 18th centuries, yet little attention seems to have been paid to the phosphorescence of heated minerals. Fluor-spar, and one or two other substances, had been accidentally found to emit light, when placed upon a hot iron; but the subject had never been investigated with care, till the year 1792, when Mr Thomas Wedgwood laid before the Royal Society, his "Experiments and observations on the production of light from different bodies by heat, and by attrition*." The general method which he employed was, "to reduce the body to a moderately fine powder, and to sprinkle it by small portions at a time, on a thick plate of iron, or mass of burnt luting, made of sand and clay, heated just below visible redness, and removed into a perfectly dark place." By this means, he found the following minerals to be luminous by heat,

Fluor-spar of various kinds.	Steatite from Cornwall.
Marbles of various kinds.	Black flint.
Red feldspar from Saxony.	Rock-crystal from E. Indies.
Diamond.	White asbestos.
Oriental ruby.	Red irony mica.
Iceland spar.	Alabaster.

The Abbe Haüy †, who availed himself with singular success of the physical properties of minerals, has employed their phosphorescence as a distinguishing character. Like Mr Wedgwood, he developed it, by throwing the mineral, when reduced to powder, upon a hot iron, and in this way he found it only in the following substances:

Fluor spar.	Carbonate of Barytes.
Iceland spar.	Carbonate of Strontites.
Arragonite.	Harmotome.
Phosphate of Lime.	Dipyre.
Grammatite.	Wernerite.

* *Phil. Trans.* 1792, vol. 82. p. 28. 270.

† *Traité de Mineralogie*, Par. 1801, vol. i. p. 235. 273.

Having had occasion to examine the nature of the light emitted by phosphorescent bodies, I was led to attend to a subject which I had considered as exhausted by the observations of Haüy; but having seen indications of phosphorescence in substances which were not contained in his list, I resolved to repeat his experiments, and to examine every mineral which I could readily command.

In making these experiments, I never reduced the body to powder, but always placed a fragment of it upon a thick mass of hot iron, carried into a dark room. When the phosphorescence was not readily perceived by this method, I took a pistol barrel, and having shut up the touch-hole, I introduced the mineral into the breach, and placed the bottom of the barrel in the fire. Before a red heat was produced, the phosphorescence was distinctly seen by looking into the barrel, which I sometimes did through a plate of glass, to keep the heated air from the eye, and sometimes through a small telescope, adjusted to distinct vision at the bottom of the barrel. At other times the mineral was not introduced into the barrel till it was taken out of the fire, and till the red heat had entirely disappeared.

In this way, I obtained the following results.

TABLE of Phosphorescent Minerals.

	Names of the Minerals.	Colour of the Minerals.	Colour and Intensity of their Light.
	Fluor spar	Pink	Green
	———	Purple	Bluish
	———	Bluish-white	Blue
	Compact fluor	Yellowish	Fine Green
5	Sandy fluor	White	White sparks
	Calcareous spar	Yellow	Yellow
	———	Transparent	Yellowish
	Limestone from North of Ireland		Yellowish-red
	Phosphate of lime	Pink	Yellow
10	Arragonite	Dirty white	Reddish-yellow
	Carbonate of barytes	Whitish	Pale white
	Harmotome	Colourless	Reddish-yellow
	Dipyre	White	Specks of light
	Grammatite from Glentilt		Yellow
15	——— Cornwall		Bluish
	Topaz, Aberdeenshire	Blue	Bluish
	———Brazilian	Yellow	Faint yellowish
	———New Holland	White	Bluish
	Rubellite	Reddish	Scarlet
20	Sulphate of lime	Yellowish	Faint light
	——— barytes	Yellow	Pale light
	———	Slate colour	Pale light

	Names of the Minerals,	Colour of the Minerals.	Colour and Intensity of their Light.
	Sulphate of strontites	Bluish	A fragment shone pretty bright
	——— lead	Transparent	Faint and by fits
25	Anhydrite	Reddish	Faint light
	Sodalite	Dark green	Pretty bright
	Bitter spar	Yellowish	Faint white
	Red silver ore	Red	Pretty bright, but flitting
	Barystrontianite	White	Faint
30	Arseniate of lead	Yellowish	Bright white
	Sphene	Yellow	Bright white
	Tremolite	Whitish	Reddish-yellow
	Mica	Greenish	Whitish
	—— from Waygatz	Black	White specks
35	———	Brown	Pretty bright
	Titanium sand	Black	Feeble specks
	Hornstone	Grey	Yellowish
	Table spar, Dognatska	Whitish	Yellowish
	Lapis lazuli	Blue	Faint
40	Spodumene	Greenish	Faint
	Titanite	Reddish	Extremely faint
	Kyanite	Yellowish white	Bluish
	Calamine	Brown	Faint
	Augite	Green	Pretty bright
45	Petalite	Reddish tinge	Blue and very bright
	Asbestos rigid	———	Pretty bright
	Datholite	Transparent	Bright
	Corundum	Brown	Bright
	Anatase *	Dark	Reddish-yellow
50	Tungstate of lime	Yellowish-white	Brilliant like a burning coal
	Quartz	The phosphorescence of these nine minerals was observed in the pistol barrel.	Very faint
	Amethyst		Faint
	Obsidian		Pretty bright, dirty blue
	Mesotype from Auvergne		Very faint
55	Glassy actynolite		Little specks
	Ruby silver		Rather bright
	Muriate of silver		Blue
	Carbonate of copper		Very faint
	Green Telesie		Pale blue, and pretty bright

As Mr Wedgwood has maintained that minerals can never be "entirely deprived of this property by any number of heatings or by any degree of heat," I resolved to try the experiment with a specimen of green fluor-spar, which was highly phosphorescent. In order to prevent it from flying to pieces, as it always does when exposed to heat, I wrapped it tightly in platinum foil, and exposed it for about an hour to the heat of a common fire. When taken from the crucible, it had entirely lost its green colour, but was in no way cracked or injured by

* The phosphorescence of *anatase* is entirely different from that of other minerals. It appears suddenly like a flame, and is soon over.

the heat. Its phosphorescence, however, was *entirely gone;* and though I placed one fragment for several days in the rays of the summer sun, and even exposed it to the brilliant light near the focus of a burning-glass, I could not succeed in obtaining from it the slightest indication of phosphorescence. When placed upon the heated iron, it lay quietly in its place without flying to pieces, as it never fails to do before the phosphorescence is extinguished.

Although the property of imbibing light is not necessarily connected with that of giving it out when exposed to heat, yet there can be no doubt that this property is also possessed by several minerals. I have repeatedly observed it in the diamond and in blende, as others had previously done; and we are informed by Dufay, that some emeralds imbibe light, and by Brugnatelli, that lapis lazuli has the same property, while Beccaria maintains that it is possessed by almost all substances whatever.

In examining the nature of the phosphoric light emitted by heated minerals, by analysing it with a doubly refracting prism, I noticed a very singular illusion, which has already been alluded to in this Number. In observing the two images of the luminous fragment, one of them occasionally disappeared during the revolution of the prism, but according to no regular law. I was therefore led to believe that the fluor-spar emitted, by fits, light polarised in different planes. A result so extraordinary required every kind of verification, and I soon found that no such property was indicated when the light was analysed either by reflection or by a prism of calcareous-spar, in which one of the pencils had been extinguished *. The disappearance of one of the images had therefore arisen from its having been seen indirectly, (as one of the two must always be,) in consequence of which the retina occasionally lost the power of perceiving it †.

The following are among the principal results of the preceding experiments.

* See *Philosophical Transactions* 1819, p. 148.

† See page 325, of this Number.

1. That the property of developing phosphoric light, when exposed to heat, is very common among mineral bodies.

2. That when it does exist, it is most commonly found in coloured, or imperfectly transparent minerals.

3. That the colour of the phosphoric light has no fixed relation to the colour of the mineral.

4. That this property may be entirely destroyed by the application of an intense heat.

5. That in general light is not reabsorbed by phosphorescent minerals when exposed to its action.

6. That the phosphoric light developed by heat is unconnected with the light given out by attrition, as bodies deprived of the former still retain the power of giving out the latter.

7. That this phosphoric light has the same properties as the direct light of the sun or any other luminous body.

8. That as there are specimens of most of the substances contained in the preceding table, that are not phosphorescent by heat, it cannot be regarded as an essential character of those minerals that possess it.

ESK-HILL, *August* 31. 1819.

ART. XXX.—*Account of the new Binary Galvanic Pile, invented by* M. ZAMBONI *.

THE galvanic pile recently invented by M. Zamboni, and which he has called a *Binary Pile*, is composed only of two elements, namely, a metal and a fluid. The metallic elements of the pile are twenty-nine small squares of tin-foil, about half an inch long on each side, and terminated by a very fine tail, from two to three inches in length; and the fluid element is distilled water, placed in thirty watch glasses, arranged circularly on a table. The water in every two adjoining glasses is connected with one of the elements of tin, by placing the square portion of the tin in one glass, and the tail in the adjoining one in such a manner that the square portion is wholly immersed, while the tail merely touches the fluid. When the metallic elements

* Published in Gilbert's *Annalen der Physik*, tom. lx. p. 141.

are all arranged in a similar manner, and when the first and last glasses communicate only by means of all the intermediate ones, it will be found by making a communication between the first glass and the ground, and between the last and a good condenser, that the pile has two poles, one vitreous and the other resinous, the former corresponding to the small squares, and the latter to the long tails.

If the pile is constructed with elongated rectangular pieces of tin, no electricity is developed when the two extremities of the rectangles are equally immersed in the distilled water of the watch glasses; but whenever they are immersed unequally, the electricity exhibits itself at the poles, as in the construction already described, the vitreous pole always corresponding to the larger surface immersed, and the resinous one to the smaller surface, so that the same pole may be rendered alternately vitreous and resinous, by immersing more or less of the nearest ends of the rectangles of tin.

When elements of zinc or copper are substituted in place of the tin, the same effects are produced; but no indications of electricity are obtained from oxide of manganese.

A pile constructed in the preceding manner does not charge the condenser instantaneously. The electricity does not appear till about the end of half a minute, and often longer, and it then gradually increases. This effect might be ascribed to oxidation, as the pile would then have three elements; but at the end of several days the developement of electricity was as powerful as at the moment when the apparatus was arranged, although not the slightest trace of oxidation could be perceived. When zinc was substituted for tin, the electricity diminished as the oxidation increased; it then disappeared and afterwards re-appeared, with an opposite character. Hence it is manifest, that the developement of electricity in the Binary Pile is not owing to the oxidation of the metal.

A pile constructed with ten discs of tinned paper, without any other substance, produced, in about half a minute, a deviation of a third of an inch in Bennet's electrometer, furnished with a condenser. The tinned face possessed vitreous, and the paper face resinous electricity. This effect invariably increased with the number of the discs.

Another pile of discs of tinned paper, having the paper face covered with a film of honey, in order to keep up a constant humidity, likewise gave signs of electricity, but it required from forty to fifty discs to produce the same degree of electricity as the preceding pile of TEN discs of tinned paper ; and the electricity was besides of an opposite character, the honey being vitreously, and the tin resinously, electrified. On the following day the electricity had rapidly diminished, and at last it completely disappeared, the paper having been penetrated throughout with the honey, and the tin being *equally in contact* by its two surfaces with the latter substance.

A pile of discs of tinned paper, in which all the discs had been glued together, gave no electrical indications, because the metal was equally in contact with the paper at each of its faces.

When a binary pile, like any of the preceding, has become inactive, its energy may be restored, by simply raising the discs, which, by the action of the air, will diminish the influence of humidity upon one of the faces of each disc. The binary piles indeed do not produce any effect, unless the touching surfaces of the metallic and the fluid element are unequal.

The energy of the binary piles is much influenced by the conducting power of the fluid which forms the humid element. A few drops of a solution of sal ammoniac added to the distilled water, augments a little the electricity of the pile ; but if we continue to add more, a diminution of action takes place, and at last the energy of the pile is destroyed. Hence, it follows, that the humid element must be an imperfect conductor.

ART. XXXI.—*Account of a Remarkable Comet which has returned to our System in* 1786, 1795, 1801, 1805 *and* 18$\frac{1}{1}\frac{8}{9}$ *.

THERE are few events in the natural world, which excite a more general interest than the appearance of remarkable comets. Associated by the vulgar with the physical and political convulsions of our globe, and regarded by astronomers as capable of producing the most overwhelming effects in their passage across

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* This article is drawn up principally from letters of Baron Von Zach addressed to one of our correspondents.—ED.

the planetary orbits, they have acquired, as objects of terror, a degree of importance which they could not have commanded as objects of science.

As the comet of 1682 is the only unequivocal instance in which these bodies have re-visited our system, astronomers have experienced no inconsiderable difficulty in assigning some reasonable attributes to these mysterious strangers. Under such circumstances, the discovery of a comet which has returned *five* times, which never ranges beyond the orbit of Jupiter, and which may therefore be regarded as forming part of our own system, is an event peculiarly interesting to astronomers. Its short period of little more than $3\frac{1}{4}$ years, and its mean distance from the sun, which is not much greater than twice that of the Earth, connect it in a particular manner with the part of the system in which we are placed; and when we consider, that in the performance of its triennial rounds, it crosses the orbit of the Earth more than sixty times in the course of a century, we cannot but consider the probability of a collision as greatly increased.

This remarkable comet was discovered at Marseilles by M. Pons on the 26th November 1818, in the constellation Pegasus. It was easily seen through a night telescope, and had a diameter of from five to six minutes. The parabolic elements which were computed for it by M. Bouvard, did not represent the observations with sufficient accuracy. The difference between the theory and observation, was reduced from 3′ to 30″ by the elliptical elements computed by M. Enke, Joint Director of the Observatory of Seeberg, which we published in p. 200. of our last Number.

As this comet had a short period of little more than $3\frac{1}{4}$ years, or 1202.54 days, astronomers naturally conjectured that it must have been repeatedly observed; and they soon found that it had a considerable resemblance to the comets of 1786, 1795 *, 1801, and 1805. Dr Maskelyne had observed it on the 20th, 21st and 24th November, and compared it with three small stars of the 7th and 8th magnitude, whose positions are unfortunately not known.

The following elements of its orbit as calculated from the observations made in 1795, 1805, and $18\frac{18}{19}$, have such a singular

* Dr Olbers of Bremen suggested that the comet of 1795 was the same as that of 1818.

coincidence, as to put it beyond a doubt that they are the same comet.

Comet of 1795.

Passage of perihelion, Dec. 21. 43881
Mean time at Gotha.

Longitude of perihelion, - -	156° 49′ 32″
——— node, - -	335 13 5
Inclination of orbit, - -	13 45 43
Angle of eccentricity, - -	58 08 43
Logarithm of half the greater axis, -	0.3449907
Half the greater axis, - -	2.2145

Comet of 1805.

Passage of perihelion, November 21. 5064.
Mean time at Paris.

Longitude of perihelion, - -	156° 47′ 19″
——— node, - -	334 20 5
Inclination of the orbit, - -	13 33 30
Logarithm of the perihelion distance, -	9.5320168
Half the greater axis, - -	2.213
Eccentricity, - - -	0.8462
Period, - -	1202.5 days.

Comet of $18\frac{18}{19}$.

Passage of perihelion, mean time at Gotha, Jan. 27. 28977

Longitude of perihelion, - -	156° 59′ 15″
——— node, - -	334 35 0
Inclination of orbit, - -	13 37 0
Angle of eccentricity, - -	58 2 58
Logarithm of half the greater axis, -	0.34500
Half the greater axis, - -	2.2131
Period, - - -	1202.54 days.

From these elements, M. Enke has calculated the following ephemeris for the months of July, August, September, and October.

	Right Ascension.	Declination, South.
1819, July 10.	326° 49′	23° 43′
—— 20.	322 26	24 54
—— 30.	317 47	25 51
Aug. 9.	313 17	26 29
—— 19.	309 20	26 47
—— 29.	306 11	26 48

	Right Ascension.	Declination, South.
1819, Sept. 8.	303° 54′	26° 35′
—— 18.	302 29	26 13
—— 28.	301 51	25 45
Oct. 8.	301 53	25 13
—— 18.	302 29	24 39
—— 28.	303 33	24 2

From this ephemeris, it appears, that this comet is at present in opposition to the sun, and may be seen by very powerful telescopes. Its distance from us, however, is nearly double that of the sun; and though many eminent observers are in search of it, we have not yet heard of its re-discovery, and fear that it may pass to its aphelion without being noticed.

Although this comet approaches nearer Mercury than any of the other planets, and will therefore be disturbed by its action, yet there is reason to think, that astronomers will have frequent opportunities of watching the appearance and motions of this interesting inhabitant of our system, and will thus be enabled to throw new light upon a class of bodies which they have had so few opportunities of studying.

Art. XXXII.—*Notice respecting the discovery of the Skeleton of a Whale, on the estate of Airthrey, near Stirling, the property of Sir Robert Abercromby, Baronet.* Communicated by Robert Bald, Esq. F. R. S. E., M. W. S., and G. S. L.

Immediately adjoining the gate of the east approach to Airthrey Castle, and near the Hill of Dunmyat, one of the Ochill Mountains, there is a considerable piece of flat ground, covered with peat earth. The covering of peat earth varies in thickness, from a few inches to about four feet. Under it lies a blue coloured silt or sludge, many feet in depth, this last being evidently the alluvial deposit of the River Forth at some remote period.

Several years ago, Sir Robert Abercromby, in carrying forward the extensive improvements of his estate, began to drain the above mentioned piece of ground, which was then very soft and marshy. In the course of this operation, the workmen, in deepening the east ditch, forming the march with the estate of Powis, the property of Edward Alexander, Esq. came upon a substance which they conceived to be the trunk of a tree, many small branches of trees having occurred in the digging of this ditch. In the month of July last, in order to render the drainage more complete, the march-ditch was still farther deepened, when the workmen were again obstructed by what they considered as the tree before noticed. They began to cut it with hatchets, but they had not proceeded far with the cutting, before they discovered that the substance was bone, and not wood. This determined them to remove the earth-cover all around. They soon ascertained that the bones belonged to the skeleton of some animal of very great magnitude. This created no common interest, and Sir Robert Abercromby gave orders to his workmen to proceed carefully in searching for the bones. Each day as the bones were found, he caused them to be washed, and deposited in a place of safety in his court of offices.

The skeleton is evidently that of a whale; and the animal appears to have been about 72 feet in length. The greater part of the bones were found at the depth of about four feet and a half, but some were nearer to the surface. The head was lying across the march-ditch, the jaw-bones projecting a few feet over Sir Robert Abercromby's march-line into the estate of Powis. The tail lay in a westerly direction from the head. Though the bones were a little disjoined, yet they lay, upon the whole, in a regular position. The bones which have been preserved consist of the cranium, numerous vertebræ, several ribs, the jaw-bones, and the bones of the swimming-paws, with some smaller bones; likewise some bones of the ear, particularly the mastoid process, which is remarkably hard, and somewhat of the shape of a large shell of the genus Cypræa, for which it was at first mistaken. Some of the ribs are 10 feet in length; and it is remarkable that one of them had been broken and healed again, being, as usual, much thicker at the place of fracture. The bones are in general firm, and in a state of good preservation, excepting the jaw-bones. These last were immured chiefly in the dry bank upon the side of the ditch; and upon exposure to the air, the cellular structure speedily fell to powder. Bones of equally open structure, which lay in the sludge, remain very entire.

The situation in which this skeleton has been found, naturally suggests several very interesting points of inquiry connected with Geology, and in particular with the changes which have taken place in the bed of the River Forth.

The skeleton, and the place where it was found, have been minutely examined by my friends, Thomas Allan, Esq. and James Jardine, Esq. Fellow of the Royal Society of Edinburgh, and by Patrick Neill, Esq. and Melville Burd, Esq. Members of the Wernerian Society of Edinburgh; and Mr Jardine has ascertained, with his usual accuracy, that the place where the skeleton was found, is 20 feet higher than the surface of the highest tide of the river Forth at the present day. This circumstance leads to this legitimate conclusion, that the tides in the River Forth at some former period rose much higher than they do at present. Now, as in all the alluvial land which stretches along the River Forth, beds of sea-shells are found, it appears that the waters of the ocean must, at a remote period of time, have extended over all the flat lands or carses both to the west and east of Stirling Castle. At that period, the picturesque greenstone rocks of Stirling, of Abbey Craig, and of Craig Forth, must have formed islets in the sea, having an aspect somewhat similar to those in the Forth near Queensferry and Leith at the present day. We have every reason to believe that matters continued very long in this situation; for we know from actual trials made, that the alluvial silt or sludge in the district of Stirling, is in some places nearly 100 feet in depth.

To the eastward of the place where the skeleton was found, are the remains of a Roman Causeway. The traces of this causeway were some years ago distinctly seen, while the present road by the foot of the Ochill Mountains was forming. This causeway led southward to the Manor-ford or passing-place upon the River Forth. Here there was a Castellum, which is now destroyed, but which was in good preservation within these last forty years. It appears, therefore, that since the time of the Roman invasion, very little change has taken place either upon the bed of the Forth at this place, or upon the level of the adjacent banks. Whether we suppose the waters of the ocean to have subsided to the extent of twenty feet, or the banks of the Forth to have been elevated to that extent, we may safely ascribe the stranding of the whale, of which the skeleton has now been found, to a period much more remote than the Christian Era.

There was found close by the skeleton two pieces of stag's horns, through one of which a hole appears to have been perforated of about an inch in diameter.

I intend that a plan of the grounds adjoining the spot where the skeleton was found, should be made; and I mean, along with it to give a minute account of every particular attending this very interesting occurrence.

The lovers of natural history are under great obligations to Sir Robert Abercromby, for the attention he paid in searching for, and securing the bones of the skeleton. It may be added, that he has in the most polite and handsome manner presented the whole to the Museum of the University of Edinburgh, where they are now deposited.

Alloa,
1*st September* 1819.

Art. XXXIII.—*Additional Facts relative to the Hyposulphurous Acid**.—By J. F. W. Herschel, Esq. F. R. S. &c.

In order to obtain the hyposulphurous acid in a state of insulation, a dilute solution of hyposulphite of strontia was mixed with a slight excess of dilute sulphuric acid, and the mixture, well agitated, divided into three portions, which were poured on as many filters. The first was received into a solution of subcarbonate of potash, from which it expelled the carbonic acid, giving no precipitate, nor causing the slightest turbidness, thus proving the complete separation of the strontia. The liquid neutralized by acetic acid, affected all reagents precisely as a solution of hyposulphite of potash, somewhat contaminated with

* See p. 8. of this volume.

sulphate and acetate, would have done. The second portion received successively into nitrates of silver and mercury, precipitated the metals copiously in the state of sulphurets, but produced no effect on solutions of copper, iron, zinc, &c. The third had an acid, astringent and very bitter taste. When fresh filtered it was clear, but became milky on standing, depositing sulphur, and evolving sulphurous acid. A moderate exposure or a gentle heat effected its entire decomposition. The same results are obtained when dilute sulphuric acid is made to act on an excess of hyposulphite of baryta, suspended in a large quantity of water.

These results confirm the opinion of Gay Lussac on the constitution of the hyposulphites, by separating their acid with all its characters, while they are unfavourable to the original idea of Berthollet, which makes them sulphurets of sulphites, or $S + \left\{ (S + 2\,O) + B \right\}$ as well as to the strange hypothesis since advanced by Ampere in the *Annales de Chimie* (1816), which regards them as sulphites of sulphurets, $(S + 2\,O) + (B + S)$, making the alkaline quality of the base (B) survive its saturation with sulphur.

The habitudes of oxide of silver in union with this acid are very peculiar. The strong affinity between these bodies is shewn by the following facts. I poured hyposulphite of soda on newly precipitated oxide of silver; hyposulphite of silver was formed, and soda in a caustic state set at liberty, the only instance I believe yet known of the direct displacement of a fixed alkali by a metallic oxide, *viâ humidâ.* On the other hand, hyposulphurous acid, newly disengaged from the hyposulphite of baryta, readily dissolved and decomposed muriate of silver, forming a sweet solution, from which alcohol separated the metal in the state of hyposulphite. Thus, the affinity between this acid and base, *unassisted by any double decomposition,* is such as to form an exception to all the ordinary rules of chemical union.

The neutral hyposulphites readily dissolve and decompose the chloruret, carbonate, phosphate, borate, oxalate and sulphite of silver, the arseniate less readily, and the ioduret very sparingly. The sulphate is converted into sulphuret, and free sulphuric acid is formed. The theory of this change is *,

$$\left\{B + 2\,(S + O)\right\} + \left\{(S + O) + (S + 3\,O)\right\}$$
$$= \left\{B + (S + 3\,O)\right\} + (S + s) + (S + 3\,O).$$

The nitrate is converted into hyphosulphite or sulphuret, according to the relative proportions of the salts present, their degree of dilution and temperature.

I have already noticed the tendency of this acid to form double salts with the oxide of silver and various bases. Of these there appear to be two distinct genera, differing remarkably in solubility, and in other characters as well as in the proportions of their component salts. The double salt, with base of potash, has been described; and we need only add, that as it precipitates not only when the carbonate, but also the sulphate, nitrate, and probably any neutral salt of potash is poured into a saturated solution of muriate of silver in hyposulphite of soda, it may perhaps become a useful test of the presence of the former alkali, the salts of soda producing no such precipitate.

Hyposulphites of Soda and Silver.—When the last mentioned solution of muriate of silver is evaporated gently, a copious formation of thin silky plates takes place, aggregated in tufts, and mixed with a good deal of deposited sulphuret of silver. They have a most intensely sweet taste, and are easily soluble in water. The same solution allowed to cool, after a very slight evaporation, deposits a small quantity of minute, hard, brilliant crystals, in the form of lance heads, with a very sharp and a very blunt point opposite each other, or flattened six-sided prisms terminated by dihedral summits. They are not very soluble, have a sweet taste, blacken by heat, melt and give a bead of sulphuret of silver enveloped in a saline scoria. I could not collect enough for analysis.

Hyposulphites of Ammonia and Silver.—When hyposulphite of ammonia is poured on muriate of silver, it dissolves it; and if into the saturated solution alcohol be poured, a white salt is precipitated, which must be violently expressed between blot-

* B = base; S, sulphur; *s*, silver; O, oxygen.

ting paper, and dried *in vacuo.* It is very readily soluble in water. Its sweetness is unmixed with any other flavour, and so intense as to cause pain in the throat. One grain of the salt communicates a perceptible sweetness to 32,000 grains of water. If the alcoholic liquid be evaporated, thin lengthened hexangular plates are sometimes formed, which are not altered by keeping, and consist of the same principles.

When the hyposulphite of ammonia refuses to dissolve more muriate of silver, if an additional quantity be added, it is rapidly converted into a white crystallized powder. It is extremely insoluble in water, but readily and abundantly in ammonia, forming an intensely sweet solution, from which an acid precipitates it unaltered, even when copiously diluted. Dried *in vacuo*, and kept in a closely stopped vessel, it blackens and undergoes spontaneous decomposition. The phial, whenever opened, is found full of sulphurous acid; and when washed with ammonia, a considerable residue of sulphuret of silver is left. Heat effects the same change at once.

29.3 grains of the soluble variety above described gave 11.9 sulphuret of silver, which agrees within moderate limits with a composition of 2 atoms hyposulphite of ammonia + 1 atom hyposulphite of silver. Hence it is very probable, that the insoluble variety consists of the same component salts united atom to atom.

Hyposulphites of Lime and Silver.—When hyposulphite of lime is made to dissolve as much muriate of silver as it will retain, if alcohol in pretty large quantity be added, and well agitated, a white salt precipitates, which is found to retain scarcely any portion of muriatic acid after washing in fresh alcohol and forcible expression, the whole muriate of lime formed being carried off by the alcohol, which, on examination, is found to contain it in abundance. This proves the mutual decomposition. This salt, however carefully dried *in vacuo*, leaves a portion undissolved when put in water. Like all the other salts of this class, it is intensely sweet, and is decomposed by a moderate heat.

When an additional dose of muriate of silver is added to its saturated solution in hyposulphite of lime, it is immediately converted into a voluminous crystalline powder of very difficult solubility in water, but readily and abundantly taken up by ammonia, giving an intensely sweet solution. If the water in which this salt is washed be evaporated ever so little, thin rhomboidal plates, as acute as those of sulphate of lime, are formed on the surface while hot, though the whole saline contents of the liquid are trifling. This salt suffers partial decomposition by keeping, though in a far less degree than the corresponding salt of ammonia. It seems, from some experiments, to contain its component salts united atom to atom.

Hyposulphite of Strontia and Silver.—There seems to exist but one variety of this double salt; at least when on the insoluble powder formed by the action of hyposulphite of strontia upon muriate of silver, an additional portion of the former is poured, very little, if any, is taken up; the liquid acquires no perceptible sweetness, and scarcely affects hydrosulphate of potash. But the powder itself presents all the phenomena of a double hyposulphite, giving an intensely sweet solution with ammonia, and affording, by analysis, both the hyposulphites and a portion of the metallic muriate.

Hyposulphite of Lead and Silver.—When nitrate of lead is poured into a solution of hyposulphite of lime and silver, both the metallic hyposulphites separate in a white powder, but whether in combination or mixture seems not easy to determine.

The estimation of any muriatic acid which may be present in these and similar compounds, seems most easily accomplished by nitrate of silver, made to act on them in excess, and assisted by heat. This, as I have shewn, determines the complete destruction of the hyposulphurous acid. Sulphuret of silver is formed, mixed with muriate, should any of the latter acid be present. This may be, however, completely separated by treating the precipitate (most carefully washed from any remains of the nitrate) with a weak solution of hyposulphite of soda added in repeated affusions. The washings so obtained may be precipitated by hydrosulphate of potash, and the precipitate which falls, corresponds after the usual reductions, to the muriate of silver or muriatic acid present.

London, *May* 15. 1819.

Art. XXXIV.—*Account of the Large Comet of* 1819.

THIS large and interesting comet was seen at Edinburgh on the 1st of July, about 11 o'clock in the evening. It appeared in the northern part of the horizon, about 15° to the west of north, and with an altitude of little more than 8°. Notwithstanding its proximity to the sun, being only about 19° from that luminary, it exhibited a very large and brilliant nucleus. Its tail, which was so highly transparent, as to permit the smallest stars to be seen through it, was directed to the zenith, and did not extend more than 2° or 3° from its body. The direction of its motion was almost due north, and it was obvious, from the rapid diminution of its magnitude and lustre, that it was moving away from the Earth with a very considerable velocity.

Our celebrated Astronomer Royal, Mr Pond, observed the comet with his usual accuracy, and obtained the following results:

1819.	Mean time at Greenwich.	R. Ascens. of Comet.	Declination North.
July 3.	$12^h\ 6'\ 55''.3$	$6^h\ 51'\ 35''.6$	43° 41′ 13″
7.	11 53 2.0	7 8 9.5	48 17 41
11.	12 6 7.4	7 22 20.2	50 31 22

From these data, Mr Charles Rumker, an excellent and zealous astronomer, computed the elements of its orbit, which he had the kindness to transmit to us on the 16th July, and which, though only a first approximation, were wonderfully accurate, when compared with the results of more numerous observations.

Mr Pond continued to observe the comet on the 18th, 22d, 23d, 24th, 25th and 26th of July, and having communicated the results to Mr Rumker, that gentleman deduced from them the following elements:

Passage of the perihelion, 1819, June 28. 485132.	
Longitude of the node, - -	$9^s\ 3°\ 53'\ 40''$
Longitude of the perihelion upon the orbit,	9 20 47 59
Inclination of the orbit, - -	80 7 41
Logarithm of the perihelion distance, -	9.5592732
Perihelion distance, - - -	0.362476
Motion, - - -	Direct.

The following Table, calculated by Mr Rumker, contains a comparison of Mr Pond's observations, with the results calculated from the preceding elements.

1819.	Mean time at Greenwich.	Observed Longitude of Comet.	Calculated Longitude of Comet.	Difference between Observ. and Calculat.
July 18.	11h 34′ 38″.7	3 17 54 41	3 17 55 33	+ 52″
22.	11 51 49	3 19 29 23	3 19 29 31	+ 8
23.	11 49 58.5	3 19 51 38	3 19 51 49	+ 11
24.	11 48 5	3 20 13 26	3 20 13 34	+ 8
25.	11 46 9	3 20 34 47	3 20 34 50	+ 3
26.	11 44 9	3 20 55 39	3 20 55 34	+ 5

1819.	Mean time at Greenwich.	Observed Latitude of Comet.	Calculated Latitude of Comet.	Difference between Observ. and Calculat.
July 18.	11h 34′ 38″.7	29° 56′ 10″N.	29° 56′ 20″N.	+ 10″
22.	11 51 49	30 19 35	30 19 2	— 33
23.	11 49 58.5	30 22 44	30 20 45	— 1′59
24.	11 48 5	30 25 42	30 18 55	— 6 47
25.	11 46 9	30 28 14	30 19 6	— 9 8
26.	11 44 9	30 30 4	30 20 0	— 10 4

The increasing error in latitude, seems to indicate an elliptical orbit.

M. Santini, Director of the Observatory at Padua, computed the following elements, from observations made under unfavourable circumstances.

Passage of the perihelion, 1819, June 26. 79835.
Longitude of the node, - - 9s 3° 23′ 2″
Longitude of the perihelion, - 9 11 1 4
Inclination of the orbit, - - 81 37 15
Logarithm of the perihelion distance, - 9.489446
Perihelion distance, - - - 0.30863
Logarithm diurnal motion, - - 0.725959 direct.

M. Nicolai, Director of the Observatory at Manheim, obtained the following elements:

Passage of the perihelion, 1819, June 28. 13889, mean time at Manheim.
Longitude of the node, - - 9s 3° 45′ 0″

Longitude of the perihelion, -	9ˢ 19° 16′ 0″
Inclination of the orbit, - -	80 27 0
Logarithm perihelion distance, -	0.35178

M. Bouvard, Director of the Royal Observatory at Paris, has published the following elements in the *Ann. de Chimie et Physique.*

Passage of the perihelion, 1819, August 3. 2 hours.

Longitude of the node, - -	9ˢ 8° 39′
Longitude of the perihelion, - -	0 3 15
Inclination of the orbit, - - -	4 5 15
Perihelion distance, - - -	0.53459

The elements computed by MM. Rumker, Santini and Nicolai, agree very well with one another ; but those of M. Bouvard are so widely different from them, that we are forced to conclude, that some very serious error has been committed in the observations, or, what is far more likely, in the calculations of the French astronomer.

Art. XXXV.—*Quarterly Abstract of the Diurnal Variation of the Magnetic Needle.* By Colonel Beaufoy, F. R. S.

Monthly mean Variation of the Magnetic Needle, Variation West.

		1817.	1818.	1819.
April.	Morning,	24° 31′ 52″	24° 34′ 06″	24° 32′ 36″
	Noon,	24 44 43	24 44 50	24 43 09
	Evening,	24 35 58	24 36 36	24 34 59
May.	Morning,	24 32 20	24 36 18	24 32 42
	Noon,	24 42 35	24 45 49	24 41 22
	Evening,	24 34 45	24 38 35	24 34 10
June.	Morning,	24 31 09	24 33 47	24 31 28
	Noon,	24 42 14	24 45 11	24 41 41
	Evening,	24 34 45	24 37 40	24 35 09
July.	Morning,	24 31 14	24 34 24	24 32 31
	Noon,	24 42 06	24 44 59	24 42 12
	Evening,	24 35 43	24 38 14	24 35 37

Bushey Heath,
Stanmore, *Aug.* 2. 1819.

Art. XXXVI.—*Proceedings of the Royal Society of Edinburgh,*—continued from last Number, p. 195.

Feb. 15. 1819. The continuation of a paper by Dr William Alison was read, entitled, " Observations on some late Inquiries into the Physiology of the Nervous System, particularly into its Connection with Muscular Motion, Secretion, and Animal Heat."

The leading doctrine of this paper is, that there is no proof in the writings of physiologists, of the nervous system being essentially concerned in any of those functions of the living body, which are performed without the intervention or consciousness of the mind,—that is, in any of the functions which constitute the organic life of Bichat and others; that the direct dependence of any of these functions, or any agency of the nervous system is, in the present state of our knowledge, an hypothesis, unsupported by direct facts, and contradicted by much probable evidence; and that the office of the nervous system, in the natural and healthy state, may be said to be merely to minister to the wants of the mind, and maintain the connection between mind and body.

The author arrives at this conclusion, from an examination of the different classes of facts, which have been at different times ascertained by physiologists, in regard to the connection of changes in the nervous system, with muscular motion, secretion, and animal heat. In regard to the first of these, it appears clearly, that two kinds of effect upon muscles have been observed to result from changes in the nervous system. 1. That the contractions of many muscles may be directly excited by such changes; and, 2. That the irritability (or tendency to contraction in certain given circumstances) of all muscles, may be variously modified by such changes. The first kind of agency appears to be exerted solely on the voluntary, the last chiefly on the involuntary muscles. But it likewise appears, from all the facts hitherto ascertained on the subject, that the irritability of muscular fibres in the living body, is inherent in themselves, and is in no case directly dependent on any agency of nerves. So far there is no material difference between the doctrine here maintained, and that of Haller and his followers, which has been lately espoused, and strongly supported by Dr Wilson Philip.

The observations made by this last gentleman, on the different effects of physical agents applied to large and to small portions of the brain, on the two great classes of muscular organs,—the former affecting chiefly the actions of the involuntary, and the latter, particularly when touching the origins of the nerves, exciting the voluntary muscles,—have induced the author of this paper, to add one to the many conjectures already hazarded, in regard to the use of the ganglia, and of the great sympathetic nerve, from which the involuntary muscles are chiefly, and many of the voluntary are partly supplied. These he supposes to concentrate, and to increase the influence, upon the organs which they supply, of changes which extend to large portions of the nervous system; and he gives reasons for conjecturing, that changes of this kind may be produced on the nervous system, by those sensations, emotions, and passions of mind, which are known particularly to affect those muscles, both voluntary and involuntary, which are supplied with nerves from the ganglia; and thence concludes, that the transmission of the effect of such changes, may be the principal object of this arrangement of nerves.

In regard to the connection of the nervous system with secretion, the author contends, in opposition to several eminent physiologists, 1. That the nature of the actions of nerves is probably not galvanic; and, 2. Even if they be galvanic, that these actions appear, from facts already known, not to be essentially concerned in secretion. And in regard to its connection with animal heat, he contends, 1. That no necessary connection between the evolution of animal heat, and any influence that can be derived from the nerves, has been established by the recent inquiries on this subject; and, 2. That the other cause, commonly assigned since the time of Black and Crawford, for this function of animals, certainly exists, and is adequate to the explanation of the phenomena.

If it can be ascertained, by this kind of examination of the facts ascertained in this department of physiology, what functions are merely subject to the occasional controul, and what are permanently dependent on the condition of the nervous system, the author conceives that two advantages to the science will result: 1. That greater simplicity and precision will be given to our views of the office of the nervous system; and, 2. That a more systematic arrangement of the science, than has been usually attempted, will be authorized.

The animal life of Bichat, sensation, thought, voluntary and instinctive motion, are manifestly dependent on the condition of the nervous system, and therefore on the functions of organic life, by which that condition is maintained. What may be called the chemical functions of organic life, secretion, nutrition, &c. are manifestly dependent on the vital property of irritability, as residing in the muscles of involuntary motion; but this property of irritability has only an indirect dependence, either on the rest of the organic functions, or on any of the animal,—on the former for the supply of blood,—and on the latter for the arterialization of the blood supplied. There may be irritability where no action of nerves, and even where no nutrition is going on; but there can be no nutrition, and no action of nerves without irritability. Hence the exercise of this property appears to be the most fundamental of all the functions of living bodies; and it seems as reasonable and expedient to begin the study of the animal economy, by an examination of its laws, as to begin the study of the actions of a machine at the point where the moving power is applied.

March 1.—A paper by Mr Patrick Neill was read, entitled, "Description of a Singular Hail Storm in Stronsay." This paper will appear in a future Number of our Journal.

At the same meeting, Dr Yule read a paper "On the Coniferæ, with remarks on the use of Larch Bark in the Tanning of Leather." This paper is printed in the present Number, p. 315.

March 15.—A paper by Dr Brewster was read, "On the Optical and Physical Properties of Tabasheer." An abstract of this paper was given in our last Number, p. 147.

April 5.—A paper by Robert Bald was read, "On the temperature of Air and Water in the Coal-mines of Great Britain." An abstract of this paper is given at p. 134. of our last Number.

At the same meeting, an extract of a letter from M. Berzelius to Dr Brewster, was read, on the Composition of Water, and on the Weight of an Atom of Hydrogen Gas.

April 19.—Dr Brewster presented a notice respecting the extension of his theory of double refraction, to crystals with more than one axis; and respecting a general law, relative to the composition of any number of polarizing and doubly refracting axes placed symmetrically round a given line.

At the same meeting, James Russel, Esq. presented a notice respecting a cow from Guernsey. This cow had one calf in June 1806, and for several years, she ceased to give milk at the usual time that cows with calf generally lose it. At the end of nine, or nine and a half months, after she had been with the bull, the milk re-appeared in as great a quantity, and of as good a quality, as at any former period, although she had no calf. After this was observed to take place for several years, it was thought unnecessary to make any farther trials for a calf; but notwithstanding the change of circumstances, the cessation of her milk, and its re-appearance, took place exactly as before.

May 3.—Mr Leonard Horner laid before the Society an account of the art of lithography, and an analysis of some of the limestones generally employed.

May 17.—Mr Lizars exhibited to the Society several specimens of his new style of engraving on copper in alto relievo.

At this meeting Dr Brewster laid before the Society an abstract of his experiments on the structure of the crystalline lens in man, quadrupeds, birds, fishes, and whales, the results of which were illustrated by models.

The Society adjourned till November.

Art. XXXVII.—*Proceedings of the Wernerian Natural History Society.*

Feb. 20. 1819.—Dr Hibbert continued the reading of his geognostical description of Shetland.—The first part of an abstract of this paper, will be found in the present number. Art. xii. p. 296.

Mar. 6.—Mr Campbell read an eloquent and interesting memoir on the scale of Being; a report of which will appear in an early number.

Mar. 20.—The Secretary read a communication from Dr Brewster, " On the Connection between the Primitive Forms of Crystals and the number of their Axes of Double Refraction." Dr Brewster finds that all crystals with *one axis* arrange themselves under a certain series of primitive forms, and that those with *two axes* arrange themselves under another series; while the remaining primitive forms are occupied by those crystals whose doubly refracting forces are in equilibrio by the combined action of three equal rectangular axes. It is a curious and important result of these experiments, that they nearly harmonize with the profound views in crystallography proposed by the celebrated Professor Mohs.

April 3.—The Secretary read a communication from Captain Scoresby, On the best means of overcoming the obstacles to Discoveries in the Arctic Regions. Recourse must be had, he thinks, to overland journeys, made in the early part of the season, and in the mornings and evenings while the snow is firm. Small vessels of 100 tons burden, but not exceeding 150 tons, might sail to the northern part of Baffin's Bay, with the view of wintering there. If the ships were to carry out with them Morton's apparatus for drawing ships on shore, (a machine which is now in use in the upper part of Leith harbour), and provided a sloping beach could be found, the vessels could easily be placed beyond the reach of tide or ice, so as to form a tolerably comfortable winter habitation. We do not enlarge on this subject, however, as we have reason to believe that Captain Scoresby's views will be fully stated in the work on Greenland which he has now in the press.

April 10.—Dr Hibbert finished his geognostical description of Shetland.

During the course of his investigation, which continued for five months, Dr Hibbert met with several interesting simple minerals imbedded in the primitive and secondary rocks. These he particularly described when pointing out the character of the extensive series of Shetland minerals which he presented to the Society.

April 24.—The Secretary read a notice by Mr Stewart, lecturer on botany, regarding some rare plants of the class Cryptogamia, lately found by him in the neighbourhood of Edinburgh. One effect of the fine autumn of last year, followed as it was by an unusually mild winter, seems to have been, that several of the musci, which are almost proverbial among botanists as being shy in producing fruit, have produced their capsules in abundance: Among these may be mentioned, *Hypnum proliferum*, *Bryum roseum*, *punctatum* and *ligulatum*. Among the greatest rarities were *Buxbaumia aphylla* and *Diphyscium foliosum*, both which Mr Stewart found on the same turf of peat-moss.

At the same meeting the Secretary read a communication from the Rev. Mr Young of Whitby, on a remarkable fossil animal found in the rocks near Whitby. The description was accompanied with a beautiful drawing, by Mr Bird, of this curious petrifaction.

May 1.—Mr Neill, the Secretary, read an account of the discovery of the remains of the Beaver, dug up in Perthshire and in Berwickshire. This paper is printed in the first number of the Journal. p. 177.

At the same meeting, Mr Bald read a series of observations on the shape of Coal-fields in Scotland and England. He demonstrated by his descriptions, and the numerous beautiful plans and maps which he exhibited, that these coal-fields are in general bason-shaped, and that every where they exhibit the same general geognostical characters. He described particularly the various phenomena resulting from the dislocations or slips in coal-fields, and noticed instances of the unchanged state of the strata of this formation, where vast beds of secondary greenstone overlie them.

May 23.—Professor Jameson read an account of a remarkable section of the mineral beds below Lothian Street, Edinburgh, exposed to view in the course of clearing out the foundations of new buildings there.—See our first number, pp. 138–141.

The Society adjourned for the summer.

Art. XXXVIII.—SCIENTIFIC INTELLIGENCE.

I. NATURAL PHILOSOPHY.

ASTRONOMY.

1. *Second Comet of* 1819.—On the 12th of June 1819, M. Pons of Marseilles discovered a small comet in the Lion. It is invisible to the naked eye, and has no appearance of a tail, and a very indistinct nucleus.

His observations were as follows:

	Mean Time at Marseilles.	R. Ascens.	North Declin.
June 12.	11h 13′ 11″	152h 11′.6	25° 22′.9
23.	10 31 30	156 5.3	23 27.1
29.	9 43 12	158 22.2	21 30.6

The following elements of a parabolic orbit have been calculated by M. Gambard *junior.*

Passage of perihelion, June 26th 10h 6′, Mean time at Paris.

Perihelion distance, - - -	0.88117
Longitude of perihelion, - -	255° 51′
——— node, - - -	107 46
Inclination of orbit, - - -	8 26
Heliocentric motion, - -	Direct.

M. Gambard concluded, that on the 24th July, the distance of the comet from the Earth would be only about the 20th part of the distance of the Sun.

2. *New Orrery.*—The Reverend G. Tough of Ayton has lately constructed an Orrery of a much improved form, which exhibits great ingenuity and mechanical skill.

1*st*, It consists of a large glass globe, mounted on a brazen stand, and splendidly illuminated with circles, golden stars, &c. which exhibit an interesting picture of the Heavens; and at the same time, containing within it all the planets and satellites, adjusted to true time, according to the latest discoveries. It displays the solar system in motion, together with its relation to the celestial sphere, as in nature.

2*d*, The movements being inclosed within the glass globe, are thus effectually secured from injury; and the beauty of the mechanism is preserved from tarnishing, by its not being exposed to the external air.

3d, Its motions are conveyed through slender tubes, and hollow pillars and arms, in such a manner as to conceal from view the clumsy appendages of large wheels, and almost every other part of the apparatus, except the heavenly bodies themselves moving in order round their respective centres.

4th, The diurnal revolutions and those of the satellites can be discontinued at pleasure, in order to exhibit a more rapid circulation of the planets in the ecliptic in their true proportional periods, whereby even the slow motion of the Georgium Sidus is rendered visible to the eye.

5th, When such exhibitions are not required to be made, the whole may be kept in continual motion by a small time-piece, and thus the orrery becomes a perpetual ephemeris, representing on inspection the true positions of the planets, the phenomena of their seasons, occasioned by the inclination and parallelism of their axes, so far as known, the lunar phases, eclipses, &c.

OPTICS.

3. *Curious instance of unusual Refraction.*—When Captain Colby was ranging over the coast of Caithness, with the telescope of the great Theodolite, on the 21st June, at eight o'clock P. M., from Corryhabbie Hill, near Mortlich, in Banffshire, he observed a brig over the land, sailing to the westward, in the Pentland Frith, between the Dunnet and Duncansby Heads. Having satisfied himself as to the fact, he requested his assistants, Lieutenants Robe and Dawson of the Royal Engineers, to look through the telescope, which they immediately did, and observed the brig likewise. It was very distinctly visible for several minutes, whilst the party continued to look at it, and to satisfy themselves as to its position. The brig could not have been less than from 90 to 100 miles distant; and as the station on Corryhabbie is not above 2550 feet above the sea, the phenomenon is interesting. The thermometer was at 44°. The night and day preceding the sight of the brig had been continually rainy and misty, and it was not till seven o'clock of the evening of the 21st that the clouds cleared off the hill.

4. *Form of the Cornea and Crystalline Lens in the eyes of Oxen, &c.*—A very interesting series of experiments has lately been made by M. Chossat of Geneva, on the curvature of the refracting media of the eyes of oxen. His measurements were taken from the magnified images of the parts formed upon ground glass by a Megascope, and by this means he obtained the following results:

1. The cornea of the ox is a segment of an ellipsoid of revolution round the greater axis of the ellipse, which represents the horizontal section of the cornea.

2. This axis is always inclined towards the nose, and forms with the apparent axis an angle of 9° or 10° in oxen from seven to nine years old.

3. The faces of the crystalline lens are segments of an ellipsoid of revolution round the smaller axis of the generating ellipse.

4. The true axis of each face is always inclined without, and the two axes form with each other an angle of about 5° in oxen from seven to nine years old.

5. In the elephant the cornea is hyperbolical.

Our countryman Dr Thomas Young, had long ago remarked, that the curvature of the crystalline lens was sometimes, and perhaps always, either hyperbolical or elliptical.

MAGNETISM.

5. *Variation and inclination of the Needle at Copenhagen.*—The following measures of the variation and dip of the needle have been published by M. Wleugel, who has been occupied for many years with magnetical inquiries.

		Variation of the Needle at Copenhagen.
1649,		1° 0′½ East.
About 1656,	it must have been	0 0
1672,		3 35 West.
1806,		18 25
1817,	Sept. 8.	17 56

The inclination of the needle as recently determined is 17° 26′.

During the interval from 1806 to 1817, the variation on the whole diminished, but with frequent alternations. It has been observed, that the western deviation is greatest in the month of

September, and the daily change is a maximum about 2 o'-clock in the afternoon. The greatest magnitude of the diurnal deviation does not exceed 20 minutes in ordinary circumstances.

ACOUSTICS.

6. *Subterraneous Sounds in Granite Rocks.*—M. Humboldt was informed by most credible witnesses, that subterraneous sounds, like those of an organ, are heard towards sunrise, by those who sleep upon the granite rocks on the banks of the Oroonoko. He supposes them to arise from the difference of temperature between the external air and the air in the narrow and deep crevices of the shelves of rocks. During the day, these crevices are heated to 48° or 50°. The temperature of their surface was often 39°, when that of the air was only 28°. Now, as this difference of temperature will be a maximum about sunrise, the current of air issuing from the crevices will produce sounds which may be modified by its impulse against the elastic films of mica that may project into the crevices. Messrs Jomard, Jollois and Devilliers heard, at sunrise, in a monument of granite, placed at the centre of the spot on which the Palace of Karnak stands, a noise resembling that of a string breaking.—Humboldt's *Personal Narrative*, vol. iv.

GALVANISM.

7. *Improvement upon the dry Pile of Zamboni.*—In constructing the dry galvanic pile of Zamboni with tinned paper and black oxide of manganese, M. Zamboni recommends the use of tinned paper, which, when disposed alone in the pile, has the same polarity as when it is employed along with oxide of manganese. The reason of this is, that a pile of tinned paper has electrical poles. But, whatever be the kind of paper which is used, the pile always increases in energy, and its polarity always coincides with that of a pile of tinned paper and oxide of manganese, when the paper has been impregnated with a solution of sulphate of zinc, and afterwards dried. In preparing the paper M. Zamboni avails himself of a dry season. He spreads the solution of sulphate of zinc over the face of the

paper, which is not covered with tin, and having dried it, but without taking away from the paper its own natural humidity, he covers this face with very dry oxide of manganese. The pile being then constructed, it is carefully defended from the air. If the paper is not fine and unsized, a little alcohol should be added to the solution of sulphate of zinc. The best manner of preserving the pile, as Zamboni has ascertained by long experience, is to inclose it in a glass tube, whose diameter is a little greater than that of the discs, and to run into the intermediate space a moderately warm cement of wax and turpentine. A pile of 2000 discs constructed in this manner, gives a spark visible in day light. M. Zamboni recommends the perfect insulation of all the parts of the pile that require to be insulated.—Gilbert's *Annalen der Physik*, tom. ix. p. 151.

8. *Hare's Galvanic Instrument called a Calorimotor.*—Dr Robert Hare has laid before the Academy of Natural Sciences at Philadelphia, an account of a new galvanic instrument, which he calls *Calorimotor*, from the idea that the principle of galvanism is a compound of caloric and electricity. It consists of 20 copper, and 20 zinc plates, about 19 inches square, supported vertically in a frame, the different metals alternating at half an inch distance from each other, as shewn in Plate IX., Fig. 8. All the zinc plates are soldered to a common slip of tin, and all the plates of copper to another common slip of tin, so that each set forms one continuous metallic superficies. When the copper and zinc superficies are united with an intervening wire, and the whole immersed in a vessel containing an acid solution, the wire becomes intensely ignited; and when hydrogen is liberated, it usually takes fire, emitting a very beautiful undulating or coruscating flame. By means of iron ignited in this apparatus, a fixed alkali was decomposed extemporaneously. When hydrate of potash was applied to the connecting iron wire while in combustion, by placing it in small pieces in a flat hook of sheet iron, the evolution of potassium was demonstrated by a rose-coloured flame.—See *American Journal of Science*, No. IV. vol. i. p. 413.

9. *Sulzer's Galvanic Experiment in* 1767.—M. Sulzer, in his *Nouvelle Theorie des Plaisirs*, published in 1767, has given an accurate account of a modern galvanic experiment, which is well

known. " If we join," says he, " two pieces, one of lead, and the other of silver, so that their two edges form the same plane, and if we bring them in contact with the tongue, we shall feel a taste approaching to that of vitriol of iron, whereas each piece taken separately produces no taste whatever. Is it not probable, that by this junction of two metals, there takes place a solution of one or other of them, and that the particles thus dissolved insinuate themselves into the tongue?" We have taken this curious passage from Aldini's *General View of the Application of Galvanism to Medical Purposes*, p. 95. just published.

II. CHEMISTRY.

10. *Relation between the Specific Heat of Bodies and the Weight of their atoms.*—In our last Number we mentioned the beautiful discovery of MM. Dulong and Petit, that the specific heats of bodies are inversely as the relative weights of their atoms. Hence, the products of the weight of any atom by its corresponding capacity for heat, will be a constant quantity; and it also follows, that the atoms of all simple bodies have exactly the same capacity for heat. The following Table shews the results obtained by these able chemists.

Names of Metals.	Specific Heat, that of Water being Unity.	Relative weights of the Atoms, that of Oxygen being 1.	Products of the weight of each Atom by its corresponding capacity, 4.8777.
Bismuth,	0.0288	13.30	0.3830
Lead,	0.0293	12.95	0.3794
Gold,	0.0298	12.43	0.3704
Platinum,	0.0314	11.16	0.3740
Tin,	0.0514	7.35	0.3779
Silver,	0.0557	6.75	0.3759
Zinc,	0.0927	4.03	0.3736
Tellurium,	0.0912	4.03	0.3675
Copper,	0.0949	3.957	0.3755
Nickel,	0.1035	3.69	0.3819
Iron,	0.1100	3.392	0.3731
Cobalt,	0.1498	2.46	0.7685
Sulphur,	0.1880	2.011	0.3780

The mean of these results is 0.3752, so that if we call S the specific heat of the body, and W the relative weight of its atoms, we shall have $S = \frac{0.3752}{W}$.

11. *Singular Heat developed in the fusion of Tin and Platinum.*—Mr Fox of Falmouth has found, that a very extraordinary degree of heat is developed by fusing together platinum and tin in the following manner. If a small piece of tin-foil is wrapped in a piece of platinum-foil of the same size, and exposed upon charcoal to the action of the blowpipe, the union of the two metals is indicated by a rapid whirling, and by an extreme brilliancy in the light which is emitted. If the globule thus melted is allowed to drop into a basin of water, it remains for some time red hot at the bottom, and such is the intensity of the heat, that it melts and carries off the glaze of the basin from the part on which it happens to fall. We have seen the experiment performed repeatedly in the manner now described. Mr Fox has given an account of his experiments in the *Ann. of Phil.* for June 1819.

12. *New Metal called Wodanium, discovered by Lampadius.*—In examining a metallic mineral from the mine of Topschau in Hungary, which is considered to be an ore of cobalt, M. Lampadius discovered a new metal amounting to 20 per cent. united with sulphur, arsenic, iron and nickel. Wodanium, (so called from an ancient German god,) has a pale bronze colour, similar to that of arsenical cobalt. The specific gravity is 11.470. It is malleable, as hard as fluor-spar, and greatly attracted by the magnet. It preserves its lustre in air, but with heat it is changed into a black oxide. Its solutions in acids are white, bordering upon wine-yellow. Its hydrated carbonates are equally white. The precipitate obtained by caustic ammonia is of a pale blue colour. The alkaline phosphates and arseniates do not produce any precipitate in its saturated solutions. The same is the case with an infusion of nut-galls. Zinc precipitates from its muriatic solution a black metallic powder. The precipitate produced by the triple prussiate of potash is of a pearl grey colour.

M. Breithaupt considers the mineral which contains this new metal as a pyrites, and calls it *Wodanium Pyrites.* It is harder than fluor-spar, but softer than apatite, easily broken, and has a specific gravity of 5.192. Its colour is a deep tin white, becoming grey and brown when tarnished. The fracture is unequal, with large and small grains.—Gilbert, *Annalen der Physik*, tom. lx. p. 99.

13. *Singular Explosions of Fulminating Mercury, and Fulminating Silver.*—During a lecture in the Laboratory of Yale College, about 100 or 150 grains of fulminating mercury lay on a stool, and were covered with a glass receiver of about five or six quarts capacity. A small quantity of the same powder, at the distance of a few feet, were merely flashed by a coal of fire, but without explosion. In a manner not easily understood, the whole powder under the glass receiver instantly exploded with a dreadful report; but, what was particularly remarkable, the glass was merely lifted up a little, and was shattered by its fall, *while the stool, made of fir plank, an inch and a half thick, on which the powder lay, had a hole blown quite through it, almost as large as the palm of the hand.* The whole effect of the explosion was confined to the stool, every thing around having remained uninjured.

An effect almost equally singular took place lately in the same laboratory, with some fulminating silver on the point of a knife, which was about to be put upon a plate of copper, connected with one pole of a galvanic battery in active operation. The other pole was not touched by the experimenter, but, probably by the influence conveyed through the floor of the room, the powder exploded the moment the knife touched the plate of copper. *The knife blade was broken in two, and one half of it thrown to a distance among the audience.*—Silliman's *American Journal of Science*, No. 2. p. 168.

14. *Potash in Sea-water.*—Dr Wollaston has recently ascertained the existence of potash in sea-water. He estimates the proportion of this alkali, which he supposes to exist in the state of sulphate, at something less than $\frac{1}{2000}$th part of the water at its average density.

15. *Analysis of the Water of the Dead Sea.*—M. Gay Lussac, in analysing the water of the Dead Sea, brought home by M. Le Comte de Forbin, found it to consist of

Muriate of soda, - - -	6.95
Muriate of lime, - - - -	3.98
Muriate of magnesia, - - -	15.31
	26.24

Specific gravity at 17° centigrade, 1.2283. It contains also a small quantity of muriate of potash, and traces of a sulphate, which is probably sulphate of lime.—*Ann. de Chim. et de Phys.* tom. xi. p. 197.

16. *New Vegetable Alkali called Delphine, discovered by M. M. Lassaigne and Feneuelle.*—In analysing the seed of the *Delphinium Staphysagria,* these able chemists have discovered a new alkali combined with malic acid. It is a very fine white crystalline powder, without smell, appearing brilliant in the sun. When thrown upon burning coals, it melts, and burns without residue, emitting a white thick smoke of a particular odour. It is little soluble in water, but alcohol and sulphuric ether dissolve it with facility. It forms with the sulphuric, nitric, hydrochloric and acetic acids, salts which are very soluble, and are extremely bitter and acrid. Potash, soda, and ammonia, precipitate the new alkali in a flocculent form.—*Ann. de Chim. et de Phys.*, tom. xi. p. 188.

III. NATURAL HISTORY.

MINERALOGY.

17. *Mineralogical Map of Scotland.*—Professor Jameson has been employed for many years in investigating the mineralogical structure of his native country, and has now, we understand, collected so extensive a series of facts and observations, that he will soon be able to present to the public a Map of the Mineralogy of Scotland. Dr MacCulloch, who has had the good fortune to be employed in mineral researches in Scotland, at the expence of Government, has it also in agitation to publish a Map illustrative of the Geology of this country.

18. *American Geological Society.*—An American Geological Society has been lately established by an association of gentlemen, residing in various parts of the United States.

19. *Mineralogical Society of Petersburg.*—A mineralogical society has been established in St Petersburg, of which Baron Von Vietinghoff is president. When we consider the extent of the Russian Empire, and the extra ordinary variety of mineral

productions which it affords, much important and useful information is to be expected from this newly established and very promising association.

20. *Statue of Memnon.*—Dr Richardson, who accompanied Lord Belmore to Egypt, has presented us with a piece of the famous Statue of Memnon. The rock is a highly crystallized sandstone or granular quartz, in some parts intermixed with red ochre of iron. The same variety is met with in this country, and also abounds in the mountains of quartz-rock that extend through several districts in India.

21. *Quartz-Rock in North America.*—This mountain rock, which was first particularly examined in Great Britain by the author of the Mineralogy of the Scottish Isles, has been discovered in vast abundance in America by Humboldt and other travellers. In the last number of Silliman's "Journal of Science," it is described as occurring in great beds, associated with limestone, clay-slate, mica-slate and gneiss, in the north-west part of Massachusets.

22. *Salt Mines of Villiczka.*—Some mineralogists are of opinion, that the salt-beds of Villiczka are contained in that formation of limestone named "Alpine limestone." The later observations of M. Beudant, however, would seem to prove not only that the salt formation of Villiczka, but also that of Salzburg, merely rests on this limestone, but in no case is included in it, and is covered by a variegated sandstone.

23. *Geognostical situation of Lapis Lazuli.*—Mr Mohr has ascertained by actual examination, that the lapis lazuli of the Lake Baikal occurs along with calcareous spar and silver white mica, in a vein which traverses granite.

24.—*Geognostical Situation of the Blue Copper of Chessy.*—This beautiful copper is frequently associated with malachite and red iron-ore. It is disseminated in a sandstone formation which rests on primitive rocks, and is covered by Jura limestone. The sandstone is a compound of grey felspar, grey quartz, and silver-white mica, and is sometimes intermixed with clay. The sandstone strata alternate with beds of a slate-clay, which inclines to clay-slate. These rocks rest on primitive clay-slate. The clay-slate contains a large vein of copper-pyrites, which does not shoot into the superincumbent sandstone. Seven strata of sandstone have been cut through by the mining operations, of which some are metalliferous, others not.

1st stratum, metalliferous,	-	6 metres.
2d stratum, sterile,	-	5
3d stratum, metalliferous,	-	6
4th stratum, sterile,	-	2
5th stratum, metalliferous,	-	3
6th stratum, sterile,	- -	1
7th stratum, metalliferous,	-	1
		24 metres.

The blue copper occurs sometimes irregularly disseminated in the sandstone; sometimes in masses from the size of a pea to that of a man's head, and these are either pure or intermixed with grains of felspar and quartz, or the crystals are enveloped in a fine clay. The malachite and red iron-ore have the same geognostical position as the blue copper. Cordier, to whom we owe the preceding description, considers the sandstone as a mechanical deposit, and hence has great difficulty in explaining the mode of occurrence of the ores. We are convinced that the sandstone and ore have been in solution at the same time, and therefore are to be considered as the result of a cotemporaneous process of crystallisation.

25. *Primitive Form of Chromate of Lead.*—M. Soret of Geneva has described sixteen crystallisations of this valuable mineral: he makes its primitive form an oblique prism, of which the transverse section is a rhomb of about 91° 27′ and 88° 32′, and in which the incidence of P upon the arret H is 102° 51′. The ratio of one of the sides of the base to one of the arrets of the prism is as 7 to 18. This primitive form, as well as that given by Haüy, is compatible with the optical properties of this crystal, as determined by Dr Brewster. See the *Annales des Mines,* 1818, tom. iii. p. 479.

26. *Primitive Form of Cinnabar.*—From the examination of two crystals of cinnabar, the Abbé Haüy was led to consider its primitive form as a regular hexahedral prism. In consequence, however, of having received a complete set of crystals from the mine of Almaden in Spain, he has now found that its primitive form is an acute rhomboid. The smallest incidences

of the faces are 71° 48′, and the greatest 108° 12′. The semi-diagonals of each rhomb are one to another as $\sqrt{3}$ to $\sqrt{8}$. This form is also compatible with the optical properties of cinnabar. See *Ann. de Chim. et Phys.* vol. viii. p. 64., and *Wernerian Transactions*, vol. iii. p. 52. now in the press.

ZOOLOGY.

27. *Edinburgh College Museum.*—The classical collection of zoology, purchased by the University of Edinburgh from M. Dufresne of Paris, has arrived in excellent condition, and is now deposited in the College. The most striking and valuable part of the collection is the birds. These are in a state of perfect preservation, and are so put up as to be capable of any arrangement the Professor of natural history may choose to adopt, and besides, are admirably fitted for the purpose of study. When added to the present collection in the Museum, it will form a most interesting and splendid display of fully 3000 specimens. A very beautiful collection of upwards of 800 eggs, accurately named, adds to the value of this department of the Museum. The cabinet of insects contains upwards of 12,000 specimens, all in the highest preservation. To these there has just been added 1500 specimens of splendid and rare insects from the Brazils. The collection of shells amounts to nearly 4000 specimens, arranged and named according to the system of La Marck. Along with this part of the cabinet of Dufresne is a valuable series of fossil shells, and a numerous collection of echini, asteria, and corallia.

28. *Curious fact respecting the Swallow.*—Captain Carmichael, an intelligent and active observer, mentions to us the following fact respecting the natural history of the swallow. Swallows are birds of passage at the southern extremity of Africa, as well as in Europe. They return to the Cape of Good Hope in the month of September, and quit it again in March and April. Captain Carmichael happening to be stationed for some time at the eastern extremity of the colony, a pair of these birds (*Hirundo capensis*) soon after their arrival built their nest on the outside of the house wherein he lodged, fixing it against the angle formed by the wall with the board which supported the eaves. The whole of this nest was

covered in, and it was furnished with a long neck or passage, through which the birds entered and came out. It resembled a longitudinal section of a Florence oil flask. This nest having fallen down after the young birds had quitted it, the same pair, as he is disposed to believe, built again on the old foundation in the month of February following; but he remarked on this occasion an improvement in the construction of it, which can hardly be referred to the dictates of mere instinct. In building the first, the birds were satisfied with a single opening, but this one was furnished with an opening at each side; and on watching their motions, he observed that they invariably entered at one side, and came out at the other. One object obtained by this improvement, was saving themselves the trouble of turning in the nest, and thus avoiding any derangement of its interior economy. But the chief object appeared to be, to facilitate their escape from the attacks of serpents, which harbour in the roofs of thatched houses, or crawl up along the walls, and not unfrequently devour both the mother and her young.

29. *Discovery of Human Skulls in the same formation as that which contains remains of Elephants, Rhinoceri, &c.*—Some years ago Admiral Cochrane presented to the British Museum a human skeleton, incased in a very compact alluvial aggregation of coral and other similar matters. This curious specimen was at first considered as a true Secondary limestone, and therefore as affording evidence that the human species had been called into existence during the formation of the Secondary strata. Geologists pointed out the inaccuracy of this opinion, and proved that the inclosing mass was not a portion of the older strata of the crust of the Earth, but merely a portion of one of those calcareous formations daily taking place on the shores of the West India islands. It is well known to geologists, that several extensive tracts in Germany are covered with a deep deposit of calcareous tuffa, which contains fossil remains of the mastodonton, megatherium, Irish elk, (Alci gigantea, Blum.), and elephant (Elephas primigeni), and other colossal animals, which are now considered as extinct. In this very ancient alluvial formation, human skulls have been discovered; and if the statements given in regard to this interesting discovery, at Meissen in Saxony, be correct, we have obtained a proof of the co-existence of

the human race, with the gigantic megatheria, elks, and elephants.

30. *Wolves of Hudson's Bay.*—Mr Macnab informs us, that in Hudson's Bay there are three varieties of the species, distinguished by the size of their skins, and colour of the fur. In two kinds the colours of the pelt are alike, the greatest number are grey, interspersed with black hairs, particularly about the upper part of the hind legs; a few of both sizes are found black, and some of a dingey-white; the largest are always in woody regions, seldom seen in numbers together; seven is the greatest assemblage ever seen at one time The small sized are found in the plains and boundless prairies where the buffaloes resort: there they are numerous, and are often seen in dozens, annoying and feeding on these animals. These never change to a white colour in winter. The third are of a beautiful white, like the arctic fox, the fur being much longer, thicker, and more valuable; they are never found but in sterile and desert regions, where the solitary Esquimaux ranges the dreary waste.

BOTANY.

31. *Red Snow found to be produced by a Fungus of the genus Uredo.*—Mr Francis Bauer, whose dexterity in the use of the microscope is well known, has published in the *Quarterly Journal*, N° xiv. p. 222. a series of microscopical observations on the red snow found in Baffin's Bay by Captain Ross. He has put it beyond a doubt, that the colouring particles consist of a new species of *Uredo*, which grows upon the snow, and to which he has given the appropriate name of *Uredo nivalis*. He found the real diameter of an individual full-grown globule of this fungus to be the *one thousand six hundredth part of an inch*. Hence, in order to cover a single square inch, *two million five hundred and sixty thousand* of these are necessary.

IV. GENERAL SCIENCE.

32. *Detonating Mud in South America.*—Don Carlos del Pozo has discovered in the Llanos of Monai, at the bottom of the Quebrada de Moroturo a stratum of clayey earth, which inflames spontaneously when slightly moistened, and exposed for

a long time to the rays of the tropical sun. The detonation of this muddy substance is very violent. It is of a black colour, soils the fingers, and emits a strong smell of sulphur.—Humboldt's *Personal Narrative*, vol. iv. p. 253. Note.

33. *Meteoric Phenomenon called the Lantern of Maracaybo.*—This luminous phenomenon is seen every night on a mountainous and uninhabited spot on the borders of the river Catatumbo, near its junction with the Sulia. Being nearly in the meridian of the opening of the Lake of Maracaybo, navigators are guided by it as by a lighthouse. This light is distinguished at a greater distance than 40 leagues. Some have ascribed it to the effects of a thunder-storm, or of electrical explosions, which might take place daily in a pass in the mountains; while others pretend that it is an air-volcano. M. Palacios observed it for two years at Merida. Hydrogen gas is disengaged from the ground in the same district: this gas is constantly accumulated in the upper part of the cavern *Del Serrito de Monai*, where it is generally set on fire to surprise travellers.—See Humboldt's *Personal Narrative*, vol. iv. p. 254.

34. *Hot Springs of La Trinchera.*—The hot springs of La Trinchera are situated three leagues from Valencia, and form a rivulet, which, in seasons of the greatest drought, is two feet deep and eighteen feet wide. Their temperature is 90.3 centigrade, from which it appears that they are the hottest in the world, excepting only those of Urijino in Japan, which are asserted to be pure water at the temperature of 100°. Eggs plunged in the Trinchera springs were boiled in four minutes. At the distance of forty feet from them, other springs are found entirely cold. The hot and the cold streams run parallel to each other; and the natives obtain baths of any given temperature, by digging a hole between the two currents.—*Id.*

35. *Excavations of Ants at Valencia.*—M. Humboldt informs us, that ants abound to such a degree near Valencia, that their excavations resemble subterraneous canals, which are filled with water in the time of the rains, and become very dangerous to the buildings.

36. *Bottle thrown out from the Alexander.*—One of the bottles thrown out from the Alexander, (one of the ships lately sent

under Captain Ross to the Arctic Regions), on the 24th of May 1818, in north lat. 57° 52′, and west long. 44° 36′, was picked up on the Island of Bartragh, in the Bay of Killala, on the coast of Ireland, on the 17th of March 1819, having floated across the Atlantic at the rate of about four miles a day, by the influence, no doubt, of one of the deflected branches of the Gulf Stream.—See *Quarterly Review*, N° xli. p. 255.

37. *Atmospherical or Meteoric Dust.*—Professor Rafinesque of New York, in a paper on atmospheric dust, maintains, that an imperceptible dust falls at all times from the atmosphere, and that he has seen it on Mount Ætna, on the Alps, on the Alleghany and Catskill Mountains in America, and also on the Ocean. This is the same dust which accumulates in our apartments, and renders itself peculiarly visible in the beams of the sun. He has found it to accumulate at the rate of from one-fourth of an inch to one inch in a year, but in such a fleecy state, that it could be compressed to one-third of its height. Hence, he takes the average of the yearly deposit at about one-sixth of an inch.—*American Journal of Science*, N° iv. p. 397.

38. *Nicojack Cave, in which a River has its origin.*—This singular cave, which has been only recently described by the Reverend E. Cornelius, is situated in the Cherokee country, at Nicojack, the N.W. angle in the map of Georgia. It is 20 miles S.W. of the Look-out Mountains, and half a mile from the south bank of the Tenessee River. It is situated in the Racoon Mountain, which here fronts to the north-east. The mouth of the cave, which is about 160 feet wide, and 50 feet high, is in a precipice formed of immense layers of horizontal limestone. Its roof is formed by a solid and regular layer of limestone, having no support but the sides of the cave, and as level as the floor of a house. This cave is traversed by a stream of cool and limpid water, which is 6 feet deep and 60 feet wide at the mouth of the cave. A few years ago, Colonel James Ore followed the course of it up the cave for three miles in a curve, but was stopped by a fall of water. The first direction of the cave was S.W., then S., and then S.E. by S. Great quantities of nitre are found in this cave. Mr Cornelius found

100 human skulls in the cave in the space of twenty feet square. —*Id.* N° iv. p. 330.

39. *New Weights and Measures.*—The following note contains the substance of the report of the Commissioners appointed by the Prince Regent for considering the subject of weights and measures.

1. With respect to the actual magnitude of the standards of length, the Commissioners are of opinion that there is no sufficient reason for altering those generally employed, as "there is no practical advantage in having a quantity commensurable to any original quantity existing, or which may be imagined to exist, in nature, except as affording some little encouragement to its common adoption by neighbouring nations."

2. "The sub-divisions of weights and measures at present employed in this country, appear to be far more convenient for practical purposes than the decimal scale." "The power of expressing a third, a fourth, and a sixth of a foot in inches, without a fraction, is a peculiar advantage in the duodecimal scale; and for the operations of weighing, and of measuring capacities, the continual division by *two* renders it practicable to make up any given quantity with the smallest possible number of weights and measures, and is far preferable in this respect to any decimal scale." The Commissioners therefore recommend, that "all the multiples and subdivisions of the standard to be adopted should retain the same relative proportions to each other, as are at present in general use."

3. That the standard yard should be that employed by General Roy in the measurement of a base on Hounslow Heath, as a foundation of the great trigonometrical survey.

4. That in case this standard should be lost or impaired, it shall be declared, that the length of a pendulum vibrating seconds of mean solar time in London, on the level of the sea, and in a vacuum, is 39.1372 inches of the standard scale, and that the length of the French metre, as the 10 millionth part of the quadrantal arc of the meridian, has been found equal to 39.3694 inches.

5. That ten ounces troy, or 4800 grains, should be declared equal to the weight of 19 cubic inches of distilled water at the

temperature of 50°, and that one pound avoirdupois must contain 7000 of these grains.

6. That the standard ale and corn gallon should contain exactly *ten* pounds avoirdupois of distilled water, at 62° of Fahrenheit, being nearly equal to 277.2 cubic inches, and agreeing with the standard pint in the Exchequer, which is found to contain exactly 20 ounces of water. The customary ale gallon contains 282 cubic inches, and the Winchester corn gallon 269, or, according to other statutes, $272\frac{1}{4}$ cubic inches; so that no inconvenience can possibly be felt from the introduction of a new gallon of 277.2 inches.—The Commissioners have not decided upon the propriety of abolishing entirely the use of the wine gallon.

The report, of which the preceding is a brief abstract, was signed, on the 24th June 1819, by Sir Joseph Banks, Bart., Sir George Clerk, Bart., Mr D. Gilbert, Dr Wollaston, Dr Young, and Captain Kater; and we have no doubt that its conclusions will be gratefully adopted by Parliament, and by the country at large. To the Report is annexed a very able and interesting Appendix, drawn up by Dr Thomas Young.

40. *Preparation of Opium in India.*—In the article on the preparation of opium, published in this Number, the author was not aware of the changes which had been adopted in the manufacture of it after the year 1799, when, under the government of Marquis Wellesley, the plan of having it procured by agency, under the charge of a civil servant, was introduced. All the abuses that had prevailed in the preparation of the drug, adulteration, fallacious envelopes of the cakes, short weight, &c. were at that period abolished, and, ever since, the utmost care has been taken, that the opium put up at the Company's sales shall be in the utmost state of purity, that the envelopes shall be of the due degree of thickness, and the drug of the proper consistence. Dr John Fleming, M. P. then President of the Medical Board at Calcutta, had the merit of having formed and recommended this plan of providing the opium, and, on his return to England in 1803, he received on this account a remuneration from the Honourable Court of Directors, of Sicca rupees 50,000, or L.6250 Sterling.

Art. XXXIX.—*List of Patents granted in Scotland since 12th May* 1819.

10. To John Smith of Bermondsey, in the county of Surrey, wood-merchant, for "Improvements in making arms or axletrees for coaches, carts, waggons, and all other descriptions of carriages." Sealed at Edinburgh, 21st May 1819.

11. To William Bundy, of the town of Camden, in the county of Middlesex, mathematical instrument maker, for his invention of "certain machinery for breaking and preparing flax and hemp." Sealed at Edinburgh 21st May 1819.

12. To Patten Smith and Hugh Macmorran, both of Roscrea, in the county of Tipperaray in Ireland, distillers, for their invention of improvements in the construction "or formation of stills, boilers or evaporators, to be heated by steam." Sealed at Edinburgh 21st June 1819.

13. To Henry Stubbs of St James' Street, in the parish of St James, and county of Middlesex, blind-manufacturer, for his invention "of a moveable heel for boots, shoes, and other purposes." Sealed at Edinburgh 21st June 1819.

14. To Alexander Hadden of Aberdeen in Scotland, for an "improved manufacture for carpeting." Sealed at Edinburgh 21st June 1819.

15. To William Rutt of Shacklewell, in the county of Middlesex, printer and stereotype founder, for his invention of "certain improvements on printing machines." Sealed at Edinburgh 29th July 1819.

16. To John Chancellor of Sackville Street, Dublin, watchmaker, for his invention of "an instrument for turning the leaves of music-books in a simple and effective manner, with or without pedal-work attached." Sealed at Edinburgh 30th August 1819.

17. To William Brunton of Birmingham, in the county of Warwick, engineer, for his invention of "certain improvements in steam-engines, by which a saving in the consumption of fuel is effected, and the combustion of smoke is more completely attained." Sealed at Edinburgh 11th September 1819.

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