THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

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EDINBURGH NEW PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

CONDUCTED BY

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ERRATUM.

For the formula on p. 379, line 11, vol. liv., substitute the following :—

$$x = \mathrm{H}\frac{\sqrt{b}}{\sqrt{\mathrm{B}}} - \frac{\left(\mathrm{H} + \mathrm{H}\frac{\sqrt{b}}{\sqrt{\mathrm{B}}}\right)\sqrt[4]{\mathrm{D}}}{50}$$

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Biography of the celebrated Geologist, Baron Leopold von Buch. By M. NOGGERATH.

HUMBOLDT, in his *Cosmos*, after giving a general description of volcanoes, proceeds as follows :—"This description is based partly on my own observations, but as a general outline it is founded upon the labours of my very old friend, Leopold von Buch, *the greatest geologist of our age*, who was the first to recognise the intimate connection of volcanic phenomena, and their mutual interdependence in regard to their effects and relations in space." It was scarcely possible for a man of science to have received a higher tribute, from the most competent of sources; and it is a tribute which has been ratified by the general consent of naturalists of every nation.

Leopold von Buch is no more. In science, no doubt, he will continue to live until the labours of the last of its present Coryphæi have been utterly forgotten; but the progress of science, by means of *his* labours, has ceased. The world-republic of science has to bewail his loss, no less than Prussia, of whom it was not one of the lesser glories to have given birth to such a son. On the 4th of March 1853, after a very few days' illness, he died at Berlin, in the 79th year of his age.

A man of such value, both for contemporaries and for posterity, will doubtless soon find a competent biographer. In this respect it is not in my power to follow him through the interesting details of his copiously varied life. I had, indeed, as a cultivator of his favourite science, the good fortune of enjoying his personal and friendly intercourse, and of making some geological journeys along with him; but still I am deficient in much information that would be requisite to enable me to present a complete sketch of his life. Penetrated, however, by a feeling of profound and affectionate regard for his memory, I will endeavour to present a very slight sketch of his eminent scientific merits, adding a few words of a more personal character.

Buch, descended of a noble family, which can count not a few eminent literati and statesmen amongst its members, was born on the 25th of April 1774, at the family seat of Stolpe, in the Uckermark, to which his remains have just been transported. Of his education in childhood and early youth I know nothing, and am therefore unable to say whether his inclination for the natural sciences was an inborn tendency, or whether it was developed by the aid of some impulse from without. At an early period of his life he was a student in the Prussian department of mines. In this technical career he never sought to attain any rank of importance, for pure science was his goddess from the very first; but not unfrequently, at a later period of his life, if he happened to be asked for his title, he used jestingly to term himself, "Royal Prussian Student of Mines"—(Königlich preussischer Berg-Elève).

In the years 1790 and 1791 we find him at the Mining Academy of Freiberg. Here he had A. von Humboldt for a fellow-student. Buch was the older pupil at Freiberg, and though Humboldt was by several years his senior, they had been youthful friends at an earlier date; they had together studied botany, which both of them cultivated with lively interest, and it is possible that Buch's residence at Freiberg may have been one of the motives which drew Humboldt thither. The two young students found a third friend of like tastes and pursuits with themselves in Johann Karl Freiesleben, well known afterwards by his works on Mineralogy and Geology, who died as Captain of Mines at Freiberg in 1846. The intimate friendship which arose amongst the three was terminated only by death.

In Freiberg flourished the then *novel* science of Mineralogy and Geognosy, which was taught in the most lively and animating manner by its genial founder, A. G. Werner, and it was in his school that the great masters grew up, who, in their services to the progress of the science, overtop perhaps those of the founder himself. In the period of a single lifetime it was impossible for Werner, notwithstanding his immortal greatness, to complete on all hands the structure of an experimental science; and our high appreciation of the merits of his pupils can nowise be regarded as detracting from the recognition of his own comprehensive labours. Unfortunately, the sphere of Werner's own personal inquiries, owing to the circumstances of his life, was confined to far too narrow a spot of the earth's surface; it scarcely extended beyond the limits of Saxony; and this was in a great measure the cause of those imperfections which clove to his science to the last. It became the business of his scholars to test the new doctrine upon other domains, and, in conformity with results, to eliminate what was untenable, to assign their fitting place to new discoveries, and to draw conclusions for the history of the earth's formation, which could not rest on the old foundation. Throughout a long lifetime this vocation was fulfilled by Buch, faithfully, and with the most speculative of minds.

We first find him opening his inquiries in the highly interesting, but then little known, mountainous districts of Silesia. Their fruit is exhibited in a small publication which appeared in the year 1797, entitled "Versuch einer mineralogischen Beschreibung von Landeck." The future perfect master of observation is, in this work, as clear to be recognised as the closeness and perspicuity of which all his writings may serve as patterns. Above the doctrines of Werner, however, even where they have since been proved to be untenable, Buch did not yet venture to place himself. Basalt was to him, in conformity with the too neptunistic views of his master, still a rock of aqueous formation. For the rejection of such a deeply-rooted dogma, more striking proofs were no doubt requisite than the observer could meet with on the soil of Silesia. Hence, along with much that is excellent, we perceive this tendency to swear *in verba magistri* in his "Versuch einer geognostischen Beschreibung von Schlesien," which shortly afterwards appeared, along with a, for the time, exceedingly advanced geognostical map of that country. If, in this work, it is still the waves which have formed the gneiss and the mica slate, and which could deposit them only in certain places and in certain directions, on the other hand, everything lying without the range of these theoretical views is expressed with such definiteness and perspicuity, that it can, with the utmost facility, be brought into harmony with the better theory which we have now attained; and this is assuredly an excellent proof of the correctness, fidelity, and impartiality of the observation.

In the year 1797, Buch met his friend and fellow-student Humboldt at Salzburg and they soon formed a plan for pursuing their observations in common. The two friends wandered about for a considerable time amongst the Salzburg Alps and in Styria, and then passed the winter together in Salzburg, where their stay was marked by the meteorological and eudiometrical inquiries instituted by Humboldt. In spring Buch proceeded alone over the Alps into Italy, and respecting all his inquiries he gave to the public the most valuable reports, which enriched science with new facts, filled up blanks, and eliminated much that was untenable. Basaltic rocks, with leucite and augite (pyroxene) in the mountains of Albano, hitherto regarded by the school of Werner as neptunistic formations, were recognised by him as lava, though he still did not venture to remove the genesis of the German basalts from the position which the then recognised dogma had assigned to them. But the general turning-point in his views with regard to the formation of basalt was already astir within him, as appears from more than one passage of a letter which, about this time, he wrote to von Moll, and which has already been printed. Complaining that he had not yet been able to get to Naples, he proceeds, "I endeavour to make the best of matters where I am (in Rome), and wander about over the country. But every day I feel more and more acutely that it is only half observations which I am making. I am perplexed with the contradictions into which Nature seems here to fall with herself, and even my very bodily health suffers under the mortifying feeling of being obliged to confess in the end that one does not know what one ought to believe,—frequently does not know if it be even admissible to believe one's very eyes." Again, "I assure you that Nature contradicts herself much more than I here seem to do." (He had been speaking of the neptunic origin of basalt.) "Make the finest and surest observations, and then go a few miles farther on, and you will find occasion, upon grounds just as certain, to maintain the very opposite of your former conclusion. You see that, in such a mess, it is somewhat venturesome to publish observations that are still so imperfectly established. It is possible that they may be altered in a day; but two days of Vesuvius would bring all this to a point." These lines afford likewise an interesting proof of the strict scientific conscientiousness of their author.

Buch arrived for the first time at Naples on the 19th of February 1799: he studied Vesuvius with the most careful attention, as might have been expected from his longing desire to visit the volcano. He was present again, along with Humboldt and Gay-Lussac, at the eruption of 12th August 1805. To these two visits we are indebted for Buch's excellent and lively descriptions of the phenomena of the volcano, and especially for the first attempt to explain the relations of these phenomena,—an attempt which has since, after more extensive experience, merely received more exact definitions upon some individual points (nur einzelene nahere Feststellungen erfahren). The whole description is a model of that lively, accurately descriptive, and, at the same time, picturesque and eloquent style by which the writings of the deceased were in general so eminently distinguished.

In the year 1802 he visited the south of France, the remarkable volcanic district of Auvergne, the great counterpart of our volcanic Eifel. Amongst various other important matters, he was the first to determine the notion of the rock termed by him trap-porphyry, or (as forming the Puy de Dome) Domite,—a rock to which Hauy afterwards gave the name of trachyte. Upon a view of the basalts which here, at the foot of the trachytic cone, break out in distinct lava streams, the notion of the volcanic origin of the basalt of this district ripened with him into conviction; but this view he did not yet venture to extend to the German basalts. The faithful disciple and reverer of Werner had no light struggle to undergo before adopting so extensive an alteration on his creed; but by degrees he assumed the volcanic origin of basalt in its most universal acceptation. The results of his extensive observations, with the valuable conclusions which he drew from them, were given to the world in his "Geognostischen Beobachtungen auf Reisen durch Deutchsland und Italien, 2 Bande 1802 and 1809."

Buch now turned his steps to Scandinavia, through which he travelled during two full years,—from July 1806 to October 1808: he penetrated to the extreme northern point of Europe: in the North Cape, upon the island of Mager-Oe, he made, in rapid succession, the greatest discoveries in regard to the structure of the earth's crust; and we can only regret that, within the limits at our disposal, it is impossible to follow his steps. Climatology and the Geography of Plants obtained the most valuable additions; and he was the first to develop and settle the very important fact, which afterwards received the most perfect confirmation, that Sweden, from Frederickshall to Abo, or perhaps till towards Petersburgh, was in the course of a very slow but continuous elevation above the level of the sea. The whole treasure of those contributions to science is contained in the "Reise durch Norwegen und Lappland, 2 Bande, Berlin, 1810.*

After this, his German fatherland formed the principal object of his wanderings and investigations; but it was especially to the gigantic Alps (which he also subsequently travelled over and studied in every direction) that he devoted his valuable leisure.

The grand phenomena of the volcanic reaction of the interior of the earth upon its surface in the Canary Islands, the

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* An English translation of this valuable work was published in London, with numerous annotations and illustrations, by Professor Jameson of Edinburgh.

mighty peak of Teneriffe, the volcanic islands of Gran Canaria, Palma, and Longerate, presented powerful attractions to his mind. Accompanied by the Norwegian botanist Christian Smith (who afterwards met with an untimely death in the unfortunate English expedition to Congo), he set sail from England for the volcanic group, and in the end of April 1815 landed in Madeira, from whence they gradually visited the other islands. The agencies—present and in progress—of the volcanoes were discovered and exhibited in the clearest manner. Never before had the relief forms of the volcanoes been so perfectly made out and placed in harmony with their genesis, and the description was illustrated by most excellent maps, such as had never before been seen,—monuments at once of the industry of the quick and faithful eye, and of the accurate hand of the illustrious geologist· In the valuable work "Physicalische Beschreibung der Canarischen Inseln, Berlin, 1825, mit Atlas." Buch went far beyond the immediate results of his voyage. With his happy gift of combination, and supported by a perfect knowledge of what had previously been observed by others, he shewed that all the numberless islands lying scattered over the broad ocean, had, like the Canary Islands, in a peculiar manner, separately emerged from the sea as "islands of upheaval" with their "crater of upheaval" in the centre; and he shewed the significant intimate connection of the volcanoes at the earth's surface in the direction of long crevices existing in its crust. Farther proofs of those, and of other cognate views, were given in two important treatises which appeared at a subsequent period, namely, "Ueberden Zusammenhang der basaltischen Inselnund über Erhebungs-Krater" and "Ueberdie Natur der Vulkanischen Erscheinungen auf den Canarischen Inseln und ihre Verbindung mit anderen Vulkanen der Erdoberfläche."

On his return from this important voyage, Buch visited the remarkable basaltic Hebrides on the coast of Scotland, and the Giant's Causeway of Antrim in Ireland.

After this he resumed his inquiries in Germany. The parallel direction of all the chains of the Alps which had already attracted the attention of Saussure, formed the subject of his genetic inquiries, and the results which he attained belong unquestionably to his most important and successful labours. They present to our convictions the doctrine that the ancient seas have nòt rolled away over the mountain chains [dass die alten meere nicht über die berg ketten weggegangen sind], but that the mountain chains have been upheaved into the atmosphere, bursting through the series of strata in long lines,—fissures, and that these upheavals have taken place at different geological epochs. A great deal more, and of much importance, attached itself to the establishment of these views, upon which undoubtedly rests the most considerable progress that has been made by modern geology. The eminent French geologist, Elie de Beaumont, has made a general and most successful application of this doctrine, which he has also contributed to perfect in a manner that deserves the most ample recognition. Buch had sketched in large and distinct traits which must be at once comprehended and recognised in their truthfulness by everybody. Those surprising new facts, with the important conclusions drawn from them, are accompanied by an excellent geological map and remarkable profile drawings, described in a series of treatises which may be found collected in Leonhard's "Taschenbuch der Mineralogie" for 1824.

To the same epoch of Buch's labours belong, amongst others, his studies and inquiries with regard to the filling up of amygdaloids by subsequent infiltration into the vesicular cavities of melaphyres. I refer to these with the more pleasure, because I have myself, within the last few years, succeeded in confirming to demonstration in every respect the correctness of the master's theory, by numerous proofs, found principally in my own neighbourhood, which I have given in detail in two printed treatises.

Another of Buch's essential services was his collection of materials for *the first* geognostic map of all Germany, which in 1824 was published in 42 sheets by Simon Schropp in Berlin. For the time in which it appeared, the map was of great value. Of course, it will gradually be surpassed in completeness and exactness by the continuous and more perfect observations of more recent works of the sort which have either appeared already or may be expected to appear in future. The Prussian government, preceded in that respect by those of regal Saxony and Austria, have, from a sense of its great utility and importance, taken into their hands the geognostic delineation of their respective territories. The impulse and pattern proceeded from the labours of Buch.

In my chronological dates of Buch's labours hitherto, I have chiefly followed the account given by the late Fr. Hoffmann, in his "Geschichte der Geognosie," 1838. In many respects, my own very limited opinion was able essentially to coincide with it; and for a great deal that I cannot comprehend in this sketch, I would refer those who may be desirous of learning more about Buch's works, to the excellent publication of Hoffmann. But even in it we find nothing like a perfect catalogue of his numerous monographs and papers. His works of this sort, included in the Transactions of the Berlin Academy alone, would fill several thick volumes, not to speak of what have appeared in various other periodicals, in the shape of articles or correspondence. But in all these prevails the same comprehensive and combining spirit, interrogating nature, giving happy interpretations to her answers, and exhibiting all the precision required by the exact sciences.

The study and progress of palæontology, by means of which modern geology has made such considerable progress, was at once comprehended by Buch, in all those relations by which alone it could preserve its real value. It was not merely the form and anatomy of the plants and animals of a former world which he endeavoured to determine by distinct and immutable characters; but he was deeply sensible how important it was to apprehend the continuous metamorphoses of these formations, through all the periods of the earth's development, to determine the limits relative to time and space, and especially to the successive deposits [Uebereinanderlagerungen] in the earth's crust, for the different forms of genus and species. The notion and term of "Pilot shells" (Leitmuscheln), which, as being easy to be recognised and determined, everywhere facilitate geognostic inquiry, were introduced by him, and found of very great advantage to science. So early as 1806 he had, almost prophetically, in a printed discourse "On the Progress of Forms in Nature" (Ueber das Fortschreiten der Bildungen in der Natur), prepared the direction on which palæontology has now entered. In the same spirit are composed his treatise on the Ammonites, which is especially distinguished by its acuteness; and, monographs on the Terebratulæ, Delthyris or Spirifer, and his Orthis, Productus, Leptænæ, &c., &c. In intimate connection with these palæontological essays, stand others on the distribution of definite formations over the surface of the earth, namely, of the Jura formation, the chalk, and the brown coal. The first-mentioned of these treatises is probably the last which was ever read by the deceased in the Berlin Academy (December 16, 1852); in its deeply pondered and combining contents it affords a striking testimony of how fresh and versatile his mind had continued down to the very latest period of his life. In his treatise on the brown coal formation there is opened to the palæontologist a new field of observation and determination in the nervures of fossil leaves; a branch of inquiry which, even in the study of living plants has, in its finer shades, been but too much neglected, and the culture of which offers every hope of a copious harvest.

Buch's comprehensive knowledge and labours extended far beyond the narrow limits of the science of *terra firma*. He was a learned physicist in the largest meaning of the word. We are indebted to him for much information regarding the atmosphere; we need only refer to his admirable treatise upon hail, regarding the temperature of springs, &c., &c., and his inquiries and publications on the geography of plants, are of the highest merit and interest.

I am not able to enumerate the whole of his various travels. He visited Scandinavia a second time; and in the latter years of his life he was always glad of an excuse for paying a visit to Switzerland. In the summer of 1852 he also again visited Auvergne.

He also exercised a benignant influence on the diffusion of science, by attending the ambulatory meetings of naturalists in Germany and abroad, especially in Switzerland, Italy, and England. He was present at the Werner festival, which was celebrated with great pomp at Freiberg in 1850, the oldest living pupil of the Mining Academy, and, as may easily be supposed, he met with the most marked attention. Where-ever he went he was sure to become the nucleus of an industrious group of givers and takers in the domain of Natural History. For the last few years Bonn has had the good fortune to see him almost every summer within her walls, engaged for a longer or shorter period in intimate intercourse with some of his fellow naturalists; with von Dechen, the now deceased Goldfuss, G. Bischof, F. Romer, O. Weber, and others, a circle from which the writer of this notice did not remain excluded. And such was the nature of his intercourse at other places likewise, which he used to stop at in the course of his pilgrimages. The latter used to comprehend not merely investigations in the field, but likewise personal intercourse with the initiated, who lived in the neighhood of the scenes he visited. He took an active part at the meetings of the scientific societies of Berlin.

From what we have said it is obvious that the deceased was a very industrious and active member of the Berlin Academy of Sciences. The French Institute had done him the honour to name him an Associé Etranger, of which, as our readers are aware, the statutes allow only eight to be elected. It is impossible for me to enumerate the other academies and learned bodies at home and abroad of which he was a member; they are certainly very numerous. He never set them forth on a title-page. For the same reason I can only state, in regard to the orders with which he may have been invested, that he was a Knight of the Civil Class of the Order *pour le Mérite,* and of the First Class of the Order of the Rother Adler. He was a Royal Chamberlain of Prussia, and his merits were always highly recognised by his sovereign.

It is no easy task to represent the personal qualities of a distinguished man, especially when, as was the case with the subject of this memoir, he possessed a number of peculiarities which place him in an anomalous relation to the common herd of God's creatures. In the present case, however, there is less necessity for dilating, because the great majority of those who will take an interest in these lines are likely to have seen the deceased once, at least, in the course of his manifold peregrinations. He is also known in his externals by the excellent likeness which has been so widely diffused, taken from the very successful portrait executed at the command of the king, by our meritorious Rhenish artist, Professor Vegas. There he sits upon a block of granite, spiritually rendered, but characteristic and true to the life; he is resting from his journeyings amongst the mountains, with his miner's crook in his hand, his broad shirt-frill not very nicely plaited, and one of the tails of his black dress-coat negligently inserted betwixt his body and his seat. The portrait is a pendant to that of Humboldt.

Buch was of middle size; his make might be described as tolerably strong. His features were distinctly marked, and he had a Roman nose. The expression of his countenance was commonly somewhat stiff, little versatile, denoting the deep earnest thinker; but withal, there would not unfrequently play over it a smile, which, in its turn, betrayed no common degree of mildness and friendliness. Another form of his physiognomy, the satirical or sarcastic, could also on occasions be displayed, and harmonised with the pungent wit of which he could be prodigal upon proper occasions. The sharpness of his eye seemed mitigated by the glasses which he constantly wore; but this organ had a most extraordinary capacity for the minute distinction of the smallest objects. His complexion was deeply tanned by sun.

His dress was commonly neither neat nor well preserved, though he was fond of elegance in his apartments. This is also exhibited in the instructive plates with which his works were, for most part, illustrated. Upon his journeys he generally wore, even in summer, a black dress-coat and great-coat, both well provided with pockets for holding his maps, note-book, hammer, and other indispensables. He always went in shoes and silk stockings. His gait was unsteady, and nobody that saw him moving along, with his head bent forward over his chest, would have dreamt that this was the man who had spent the greater part of his life in travelling about upon foot. When obliged to travel in a carriage or on a railway he was most unhappy.

He possessed a certain nervous irritability of temperament which, in his intercourse with others, and particularly when on his journeys, sometimes gave rise to somewhat odd scenes and situations ; but the inborn good nature of his character always brought him off in triumph. He had a strict sense of justice, and in this respect he would not tolerate the slightest violation. But not on this point alone but on every other, he was an extremely fine-feeling man, however little this may have been betrayed by his external appearance. Incompleteness or frivolity in the treatment of science was his aversion. His memory was exceedingly ready and retentive.

He was never married, but he rather enjoyed conversation with talented women. He never kept a male domestic. A staid elderly woman had the care of his household. When he quitted Berlin it was seldom that any mortal knew to what point of the compass he had turned his face, or when he might be expected back again. He was just the same man upon a journey ; he arrived unexpected, visited his friends, but none of them ever discovered when he meant to be off again.

He possessed a sufficient amount of worldly goods, not only for the supply of all his own wants, but also to bring considerable sacrifices to science and to general benevolence. He was always ready with his assistance to struggling youthful talent, and never withheld scientific recognition where it was due.

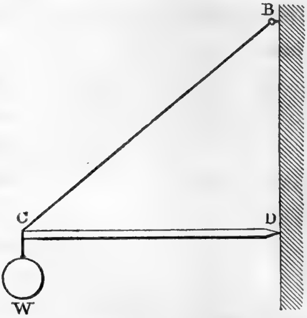
The departed will now have attained a survey of those mysteries in the structure and origin of the earth, which even his clear-seeing spirit could not compass during its abode upon its surface. This enlivening hope I dedicate to the memory of the departed illustrious naturalist and the beloved friend. Blessed be the remembrance of the man whose name (to use the expression of Snethlage at his interment) is venerated as far as civilisation has extended its empire, and whose death will create a pang in Germany, in Europe, and beyond the waves of the ocean.

On Pendulum Observations. By ALEXANDER GERARD, Esq., Aberdeen.

GORDON'S HOSPITAL,
Aberdeen, 20th April 1853.

SIR,—Having read in the last number of the Edinburgh New Philosophical Journal an account of Observations on the Pendulum in Bunker's Hill Monument, and an article respecting the Ordnance Survey, I take the liberty of sending you a description of an apparatus erected by me upwards of two years ago, which exhibited the phenomena since observed in America.

On the 12th of January 1851, a pendulum was suspended in the following manner:—The ring B was fixed near the the top of the west wall of a room. Into this was hooked a copper wire, which was brought down over the end of a beam, CD. This beam was built of four pieces of deal, in the form of a rectangular spout (with a view of obviating the effects of hygrometrical changes), and rested against the wall on a pivot at D. A block of granite, weighing about one cwt., was attached to the end of the wire. As the ring at B projected a little over the point D, the apparatus was in the condition of a gate swung upon a post not quite vertical. When set a-vibrating, it was seen to perform one oscillation in about 15 seconds, which shewed that it had the same amount of deflexibility as a pendulum hung freely from the height of 630 feet. The position of the weight was noted on a table placed near to the outer end of the beam; and, if not at rest (which it seldom was), it was either steadied by the hand, or the middle of the small vibration was taken. It was observed to be subject to a daily variation, hanging farthest south about 8 or 9 in the morning, and farthest north about 3 in the afternoon. After its movements had been watched for some weeks, the apparatus was dismounted, and fixed on the north wall of the room. The weight would thus obviously be free to move in the east and west



direction. Its position now was farthest west about 11 A.M., and farthest east about 7 P.M., so that 3 P.M. might be considered the culminating point.

The space passed over was not very accurately noted, but was greatest on days of bright sunshine, being on one occasion as much as ⅛ inch.

The room where the experiment was conducted was on the first floor of a strong granite building, and separated from the front by a large apartment and a passage. The sun at that season of the year never shone upon it, and the changes took place irrespective of the temperature of the room.

While engaged in these observations, I happened to read in a newspaper an imperfect account of M. Foucault's experiment, and erroneously identified it with my own. Under this impression, I communicated the results of my observations to Professor Airy, suggesting one or other of the two following explanations; either—1st, That, by unequal expansion, the position of the building is in some very small degree altered by the heat of the sun; or, 2d, That the solar rays produce some very minute change on the direction of gravity. The learned Professor, after a short time, favoured me with his reply, to the effect that, in his opinion, there could not be a change in the direction of gravity to the extent indicated, as this would be inconsistent with the steadiness of the zenith point in the best instruments.

Considering the Astronomer Royal as the most competent judge in this matter, I abandoned the idea of the possibility of such a change; and the subject had almost dropped from my mind, when my attention was recalled to it by the perusal of your last number. The American Professor joins with our illustrious countryman in ascribing the phenomena to unequal expansion. Yet, with all deference to so high authority, I would venture to suggest the query, Whether the suspected change of gravity may not lurk as a residuum in some of the small corrections usually made on astronomical observations, and whether the same change may not be the cause of the difficulty experienced in determining latitudes with great precision in the Trigonometrical Survey?

With respect to the Bunkers' Hill experiment, it is difficult to conceive that the sudden shower should have produced so great an effect in a few minutes, if acting merely by contracting the side of the tower exposed to it, on account of granite being a very slow conductor of heat; but, upon the hypothesis of the effect being due to a modifying influence over the whole adjoining region to windward, that difficulty is removed. And with regard to my own apparatus, so strongly sheltered from the direct action of the sun, and placed not twenty feet from the ground, the same difficulty occurs.

It is of course impossible to find a building entirely free from unequal expansion, or from tremor, occasioned by wind or other causes; but the experiment might be brought to a decisive test by hanging a pendulum down the shaft of a very deep mine which was not being wrought at the time, or by floating a powerful telescope upon mercury, after the manner of the horizontal collimator, and directing it in succession to four equidistant marks placed in the four cardinal points. The apparent position of the marks with respect to the horizontal wires of the telescope might be altered by unequal refraction at different hours of the day, but being equally distant from the observer, they would by this cause be all affected equally. If, therefore, the horizontal wires should continue to cut the marks at the same points, or at corresponding points, at all hours of the day, it would be obvious that no change had taken place in the level of the mercury; whereas, if the intersections did not correspond, a change of level, and consequently of the plumb-line, proportioned to the discordance, would be equally manifest.

The satisfactory trial of the experiment, in either of these methods, would imply a command of time, ground, and assistants, beyond the reach of most private individuals, but, if undertaken by Her Majesty's Government, might be conducted at comparatively little expense by the machinery already in operation in the Trigonometrical Survey.

Should this communication appear to you of sufficient importance, the insertion of it in your Journal may be instrumental in securing a settlement of the question in the above indicated or some other decisive manner. I have the honour to be, &c.

ALEXR. GERARD.

Synopsis of Meteorological Observations made at the Observatory, Whitehaven, Cumberland, in the year 1852. By JOHN FLETCHER MILLER, Esq., F.R.S., F.R.A.S., Assoc. Inst. C.E., &c. Communicated by the Author.

1852.	Standard Barometer, Corrected and Reduced to 32°.						Self-registering Thermometer.						Pluviometers.		Wet Days.	Evaporation Gauge.	Prevailing Winds.	
	Max.	Min.	Mean Atmospheric Pressure at 3 P.M.	Pressure of Vapour.	Mean Pressure of Dry Air.	Range.	Absolute Max.	Absolute Min.	Mean of Max.	Mean of Min.	Approximate Mean Temperature.	Range.	High Street, 90 feet above the Sea.	St James' Church Steeple, 78 feet above the Street.			Deduced from two Daily Observations.	Mean Force of Wind, 0—6.
	Inches	Inches	Inches	Inches	Inches	Inches	°	°	°	°	°	°	Inches	Inches		Inches		
Jan.	30·144	28·630	29·397	0·259	29·138	1·514	50·	31·5	44·40	39·43	41·915	18·5	8·011	4·995	23	1·284	SW.	3·5
Feb.	30·680	28·948	29·826	·247	29·579	1·732	51·	26·5	43·72	37·07	40·395	24·5	3·551	2·535	16	1·194	SW.	2·8
March	30·750	29·196	30·053	·244	29·809	1·554	59·	25·5	48·00	36·95	42·475	33·5	·258†	·158	5	2·197	Easterly	1·3
April	30·352	29·496	29·992	·262	29·730	0·856	67·	32·5	55·06	40·63	47·845	34·5	1·191	1·109	4	3·940	Easterly	1·9
May	30·260	29·492	29·819	·362	29·457	0·768	71·	36·	58·66	44·87	51·765	35·0	4·203	3·640	12	3·570	NE.	2·4
June	29·884	29·093	29·493	·412	29·081	0·791	73·	43·	63·70	51·13	57·415	30·0	3·513	2·558	19	3·172	SW.	2·3
July	30·256	29·692	29·892	·533	29·359	0·564	83·	52·	71·37	58·72	65·045	31·0	2·923	2·330	15	4·672	NE & SW	0·9
Aug.	30·326	29·158	29·624	·498	29·126	1·168	71·	50·	67·25	54·93	61·090	21·0	5·150	4·526	19	3·551	SW.	1·9
Sept.	30·390	29·180	29·809	·399	29·410	1·210	73·	40·	61·38	50·70	56·040	33·0	2·136	1·534	10	3·041	NEy.	2·3
Oct.	30·374	28·972	29·700	·313	29·387	1·402	61·	34·5	52·21	43·58	47·895	26·5	3·041	2·272	16	1·510	SW.	1·9
Nov.	30·096	28·740	29·384	·283	29·101	1·356	58·5	26·5	47·76	42·02	44·890	32·0	5·051	3·053	21	1·143	SW.	2·7
Dec.	30·142	28·220	29·391	·300	29·091	1·922	53·	32·	47·76	42·42	45·090	21·0	11·002	7·247	30	1·074	SW.	3·2
1852*	30·304	29·068	29.698	·343	29·355	1·236	64·2	35·8	55·10	45·20	50·155	57·5	50·030	35·957	190	30·348	SW.	2·3
1851	30·381	29·171	29·809	·321	29·494	1·210	62·3	35·1	53·86	44·39	49·120	55·0	43·120	32·110	195	25·340	SW.	2·2
1850	30·372	29·074	29·788	·319	29·473	1·298	63·1	33·5	54·13	44·07	49·400	62·5	40·473	28·636	189	27·349	SW.	2·1
1849	30·346	29·055	29·778	·321	29·473	1·291	62·3	33·7	53·24	44·15	48·690	56·8	38·999	28·210	190	28·699	SW.	2·1

* Max. and Min. uncorrected for temperature, except for 1849.   † Fall of Snow in 1852, 0·007 inch (measured March 1st).

Hygrometers.

1852.	3 P.M. Dry Bulb.	Wet Bulb.	Deduced Dew Point.	Complement of Dew Point.	Weight of Vapour in a Cubic Foot of Air.	Required for saturation of a Cubic Foot of Air.	Degree of Humidity, (complete Saturation 1·000).
	°	°	°	°	Grains.	Grains.	
January	42·95	41·36	39·43	3·52	3·02	0·39	0·886
February	43·03	40·79	38·16	4·87	2·88	0·53	·846
March	46·67	42·37	37·67	9·00	2·81	1·02	·733
April	54·28	47·04	39·68	14·60	3·05	1·84	·619
May	57·07	52·39	49·13	7·94	4·10	1·24	·768
June	61·69	56·53	52·86	8·83	4·62	1·58	·746
July	70·46	63·80	60·46	10·00	5·84	2·28	·721
August	66·66	61·59	58·54	8·12	5·54	1·69	·768
September	60·60	55·50	51·93	8·67	4·48	1·50	·750
October	51·36	47·85	44·35	7·01	3·51	0·95	·788
November	46·72	44·47	42·03	4·69	3·28	0·55	·855
December	46·42	45·05	43·56	2·86	3·45	0·36	·905
1852,	53.99	49·89	46·48	7·51	3·88	1·16	0·782
1851,	52·36	48·77	45·74	6·62	3·07	1·76	
1850,	52·35	48·46	45·17	7·18			
1849,	52·00	48·21	44·91	7·09	3·61	1·10	
1848,	51·93	48·23	44·98	6·95			
1847,	51·94		44·12	7·82			

Terrestrial Radiation.

1852.	Absolute Minima. Six's Thermometer, 4 feet above the Ground.	Absolute Minima. On Wool, on Grass.	Mean Nocturnal Temperature. Six's Thermometer, 4 feet above the Ground.	Mean Nocturnal Temperature. On Wool, on Grass.	Terrestrial Radiation. Max.	Terrestrial Radiation. Min.	Terrestrial Radiation. Mean.
	°	°	°	°	°	°	°
January, . .	31·5	21·2	39·43	32·84	13·	2·0	6·59
February, .	26·5	9·	37·07	28·47	17·5	1·5	8·60
March, . .	25·5	8·8	36·95	26·25	19·	4·5	10·70
April, . .	32·5	15·	40·63	26·83	19·	1·5	13·80
May, . . .	36·	21·5	44·87	36·20	17·	1·0	8·67
June, . . .	43·	32·5	51·13	42·88	16·	4·0	8·25
July, . . .	52·	42·5	58·72	53·24	12·5	1·0	5·48
August, . .	50·	36·	54·93	48·03	17·	1·0	6·90
September, .	40·	23·5	50·70	42·15	16·5	3·0	8·55
October, . .	34·5	22·5	43·58	34·50	14·	3·0	9·08
November, .	26·5	16·	42·02	36·14	10·5	0·0	5·88
December, .	32·	21·	42·42	36·43	11·5	0·0	5·99
1852, . .	35·8	22·4	45·20	36·99	15·3	1·9	8·20
1851, . .	35·1	23·3	44·39	36·86	16·3	1·8	7·53
1850, . .	33·5	20·8	44·07	36·26	15·2	1·0	7·80
1849, . .	33·7	18·8	44·15	35·05	18·4	2·2	9·09
1848, . .	32·5	20·2	43·79	35·73	15·9	1·9	8·06
1847, . .	33·7	20·5	43·50	35·95	15·1	1·1	7·45
1846, . .	36·1	23·1	45·75	38·30	14·6	1·4	7·45

Monthly Evaporation in Inches, at Whitehaven, Cumberland, in each of the Eleven Years ending with 1852.

Months.	1842.*	1843.†	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
January,	0·890	0·785	0·940	0·935	1·015	0·860	0·743	0·909	0·693	0·991	1·284
February,	1·376	1·178	1·190	·905	1·335	·843	·792	1·024	·823	·929	1·194
March,	2·542	1·620	1·835	1·862	2·085	1·821	1·397	1·558	1·690	1·544	2·197
April,	4·187	1·718	2·610	3·400	2·575	2·181	2·728	2·620	2·295	2·481	3·940
May,	4·552	3·045	6·280	3·645	4·375	2·950	4·580	3·886	3·505	3·308	3·570
June,	5·349	4·690	3·820	3·760	6·645	4·506	3·749	5·076	4·290	3·658	3·172
July,	4·888	3·125	4·495	5·455	3·450	4·726	3·935	4·156	4·278	3·415	4·672
August,	2·900	3·305	2·520	3·250	3·875	3·751	3·686	2·657	3·381	3·063	3·551
September,	4·342	3·745	3·405	3·225	2·980	2·793	2·896	3·337	2·664	2·631	3·041
October,	2·814	1·940	2·270	2·360	1·780	1·688	1·549	1·723	1·558	1·554	1·510
November,	1·625	1·030	1·554	1·760	1·360	1·107	1·129	·960	1·181	1·029	1·143
December,	1·371	·800	·800	1·875	1·025	1·005	1·019	·793	·991	·737	1·074
Evaporation,	36·836	26·981	31·719	32·432	32·500	28·231	28·203	28·699	27·349	25·340	30·348
Rain,	34·639	46·206	36·723	49·207	49·134	42·921	47·342	38·999	40·473	43·120	50·030

* The evaporation for 1842 is computed from the evaporation force, in proportion to the respective values of the estimated and measured evaporation in the corresponding months of the years 1843 and 1844. The result, calculated for the mean of the *whole* period (1843–1846) during which the evaporating force and the spontaneous evaporation were registered daily together, is 39·870 inches:—

	Grains.		Inches.		Grains.		Inches.
Thus, if	19·99	:	30·908	::	25·8	:	39·87

† The evaporation in 1843 is somewhat too small in amount, from the gauge not being sufficiently exposed to wind and sun during the first half of the year.

Remarks.

The past year is distinguished by several marked peculiarities and anomalous characteristics, of which the most prominent are,—the very large amount of rain, and its very unequal distribution over the different seasons,—the enormous and unprecedented fall in the two first and two last months, and the protracted drought of ten weeks in the spring,—the longest, though not the most severe, which has occurred within the memory of the existing generation, in the Northern Counties. The year is further remarkable for its high temperature, the large amount of surface evaporation, the great heat of July and August (especially of July, the mean temperature of which exceeded that of any other month on record)—the great quantity of free electricity in the air in these months, as manifested by the unusual number and almost tropical severity of the thunder storms,—for the small number of frosty nights and the entire absence of snow,—and, lastly, for the violent gales of wind which prevailed during the last week in December, particularly on the morning of Christmas day, when the tempest or hurricane exceeded in violence any storm which has visited the north of England since the memorable 7th of January 1839.

The abnormal conditions of climate presented by the year 1852, are so numerous and varied, that they seem worthy of something more than a mere passing notice. I therefore proceed to discuss these irregularities in the order in which they have just been enumerated. As regards the Lake District generally, the year 1852 exhibits by much the largest quantity of rain which has been recorded in any annual period since the experiments were commenced in 1844, though the falls at Wastdale Head and Seathwaite were exceeded in 1848, by 5·74 and 4·15 inches, respectively. At the coast, the depth in 1852 was exceeded in only three of the last twenty years,—viz., in 1835, 1836, and 1841, in which the atmospheric precipitation was 54·13, 58·97, and 55·97 inches, respectively.* It may be observed, that the fall of rain in 1852 has been relatively much greater in the Westmoreland than in the Cumberland portion of the Lake District. At Troutbeck, the depth exceeds the average of the eight preceding years by more than one half; at Kendal, by *nearly* one-half; and, at Ambleside, by more

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* The most extraordinary relative fall of rain in England, in 1852, occurred at North Shields,—58·21 inches, the average being only 20·37 inches. In 8 months previous to June 1852, the total quantity of rain measured was 7·94 inches; and in the last 7 months of the year, the fall was 52·41 inches;—viz., in June, 7·52 inches, in July, 5·71 inches, in August, 6·92 inches, in September, 8·65 inches, in October, 7·82 inches, in November, 9·91 inches, and in December, 5·88 inches.

than one-third; while, in Cumberland, the surplus varies from one-third, at Keswick and Bassenthwaite, to one-tenth of the mean annual quantity, at Langdale and Seathwaite. At Stonethwaite, within two miles of Seathwaite, the excess is fully one-fifth; and at Buttermere and Gatesgarth, about an equal distance apart in the same line of valley, it is one-fourth and one-sixth of the mean annual fall in the preceding eight years.

In January and February, the fall at Seathwaite was 47·70 inches, and in November and December, it amounted to 50·30 inches, so that, of 156·74 inches of water precipitated at the head of Borrowdale in 1852, exactly 98 inches descended in four months;—whilst 58·74 inches were distributed over the remaining eight months of the year. The largest quantity of rain measured in 24 hours was 5·74 inches, at Stonethwaite in Borrowdale, which fell between the mornings of the 11th and 12th of December;—the depth on the 11th and 12th (for 48 consecutive hours) was 9·11 inches.

The dry weather set in on the 18th of February, and continued till the morning of the 28th of April—exactly ten weeks. During this period, there were a few slight showers, amounting, at Whitehaven, to 0·318 inch, and, at Seathwaite, to 0·98 inch, quantities not unfrequently yielded by a smart shower of an hour's duration. From all I can learn, this appears to have been the most protracted drought which has occurred in the present century, though, from its commencing very early in the year, its effects on vegetation were not nearly so injurious as those consequent on the memorable drought which prevailed in the summer of 1826.

During the 20 years (1833-1852) over which my registers extend, there have been four remarkably dry periods, but none to compare with the present in point of duration. The first was in 1836, when *no* rain fell in the 34 days between the 30th of April and the 3d of June. The spring of 1840 was fine and dry. I have no record for that year, but, at Carlisle, the fall in March and April only amounted to 0·631, or little more than half an inch. In 1844, a drought set in on the 23d of April, and continued till the 4th of June—41 days, during which 0·262, or about a quarter of an inch of rain fell. And, there was a further absence of rain between the 25th of June and the 10th of July, in the same year.

My friend, Robert Jopson, Esq., Woodhouse, Buttermere, on the day preceding that which terminated the drought of 1826, caused a post to be firmly driven into the bed of Crummock Lake, on which a well defined notch was cut, as a permanent record of the depth of water in the Lake, at a time when it was lower than had ever been witnessed by the oldest residents in the district. On the 4th of June, 1844, the water was 5½ inches above the notch or mark. On the 19th of April, 1852, it was just three inches above zero, and on the 7th of May (when 7-10ths of an inch of rain had fallen) Mr Jopson writes, " the mark was examined this evening, when the Lake was perfectly calm,—not a ripple upon it, and the water was found to be only 3-8ths of an inch higher than in 1826; and, I have no hesitation in saying that the present season has been far drier than the summer of 1826, taking into consideration the time of the year, the dry weather of 1826 taking place in June and July."

On the 14th of June, 1824, when Derwent Lake was considered to be unusually low, a mark was cut in the rock of "Friar's Crag," by Mr Otley, of Keswick, which he calls zero. On the 5th of July, 1826, the water was six inches below the notch, but this great depression might in part be accounted for by the state of the outlet. On the 9th of June, 1830, it was $2\frac{1}{4}$ inches; June the 1st, 1836, 1 inch; and June 3d, 1844, 4 inches below zero. On the 27th of April, 1852, Derwent Lake was $2\frac{3}{4}$ inches *below* the zero mark,—and on the 2d of February last, it was 98 inches *above* the same mark. In 1826, the Lake was below zero from the 12th of June till the 12th of July, when rain came on, but the season might be called droughty from the 13th of April till the 12th of August—17 weeks. Two stooks of barley were cut at Portinscale on the 30th of June, and new oats from Underskiddaw were sold on the 5th of August in that year. In 1844, the Lake was at or below zero from May 16th to June 9th; and, in 1852, it was below zero from the 9th of April till the 9th of May. Hence, while the meteorological records kept at Whitehaven testify that no drought of equal duration to that of 1852, has happened during the last 20 years, the comparative depth of the water in Crummock and Derwent Lakes affords evidence almost equally conclusive, that so long a continuance of dry weather has not occurred since the memorable drought in 1826, or within the last 26 years.

The unusually calm state of the atmosphere during the late remarkable weather must have been striking, even to the most superficial observer; and, fortunate it is that this stillness prevailed. Had the drought been accompanied by strong easterly winds, or, had it occurred at a somewhat later period of the year, the evaporation from the ground would have been increased to an enormous extent, and the effects would, in all probability, have been most disastrous, both to the vegetable and the animal kingdoms. Thus, in 1844, during the 41 days of drought between the 23d of April and the 4th of June, with occasional strong easterly winds, the evaporation amounted to 7·825 inches; but, in the late dry period, which lasted 29 days longer, the water raised by evaporation in 70 days, is only 5·979, or barely 6 inches.

At the summit of Great Gabel, there is a vertical cavity in the rock, which, owing to the frequent presence of clouds, the high degree of humidity, and consequent feeble evaporating force at this elevation, always contains water, except in the very driest seasons. This "atmospheric spring, or well," as it is called, contained very little water at the end of March, and we may assume that it was quite dry early in April. The well was also dried up in the spring of 1844. This "atmospheric spring" is highly regarded by the simple inhabitants of the Dale, and when the "Sappers and Miners" engaged in the trigonometrical survey, accidentally covered it over in 1844, a great stir was made till it was re-opened, by order of the officers. It may not be uninteresting to note the circumstances attending the cessation of so remarkable a drought. The night preceding its termination was sufficiently fine and clear to admit of my obtaining an excellent set of measures of the binary Star, ξ Bootis, between 10 and 11 o'clock; at midnight, the sky was covered with a very thin veil of Cirro-stratus, reflecting a large, faint, lunar halo, which was followed by heavy rain at 7h. 30m. on the following morning; and, by 3 o'clock in the afternoon, 6-10ths of an inch had fallen. The writer may here remark, that the lunar halo is the most certain prognostic of speedy atmospheric deposition with which he is acquainted. A halo seen in the evening is almost invariably followed by rain in the course of the night; and, the larger the ring, the sooner does precipitation ensue. This long-continued drought ended rather suddenly, with a high state of the barometer; nor was it either preceded or succeeded by any marked fluctuations, either of pressure or temperature.

The excessive heat which prevailed throughout the greater part of the summer of 1852, will long be remembered. The month of June scarcely attained to its average temperature. Hail fell in the Lake District, on the 1st and 2d; and, on the 3d, the higher mountains were capped with snow.

At Greenwich, July was the hottest month in any year since 1778. At Whitehaven, the mean of the day extreme was 71°·37, and that of the night, 58°·72, the mean temperature (65°·04) exceeding the average of the month by 4°·88, and that of any other month on record by 1°·83. At Seathwaite, the mean of the maximum was 69°·17,—of the minimum, 58°·3,—mean temperature, 63°·76 degrees.

August was also remarkably warm, (though its mean heat was 4° less than that of July) and both months were characterised by an extremely disturbed electrical condition of the atmosphere. I certainly never remember a summer in which there occurred such numerous and awful thunder-storms. Throughout June and July, the air seem to be charged to overflowing with electricity. On several nights, electric flashes of dazzling brilliancy followed each other with scarcely a moment's intermission, from sunset till near sunrise; and many fields of the potato plant were completely blackened in a single night.

The winter of any year which passes over without snow, must be unusually mild. The only snow seen at Whitehaven in 1852, consisted of a few particles which fell on the 9th of January and on the 1st of March, scarcely deserving the name of slight showers.

November and December, in addition to their excessive wetness, were distinguished by a very high temperature, and an almost entire absence of frosty nights, which amounted to three only. At Whitehaven, the month of December was no less than 4°·5 *above* its average mean temperature. At Greenwich, it was the mildest month in the last 80 years,—and November was exceeded by only one year (1818) in the same period.

The fall of rain in December at Whitehaven, was 11·002 inches, a greater quantity than has been gauged in any one month during the last 20 years,—and exceeding the average by no less than 7·16 inches. Every day but one was more or less wet. On the 11th and 12th, an extraordinary amount of rain fell over the Lake District, and, the consequence was, the highest floods ever known at Keswick, Cockermouth, and other places. On the morning of the 13th, the height of Derwent Lake, and of the River Greta, was greater than it had ever been before, in the memory of any living individual. The water was deep on the Main Street of Keswick for upwards of 100 yards from the bridge across the Greta, and it completely inundated some of the houses, doing a considerable amount of damage. In consequence of the overflowing both of the rivers Derwent and Cocker, the principal street of Cockermouth was flooded to the depth of 2 or 3 feet, and a salmon was seen swimming opposite to the Globe Hotel in that town.

At the "Goat," at the outskirts of Cockermouth, the water covered the mantelpieces in several of the houses, and the lives of the inhabitants were placed in imminent peril. The railway between Cockermouth and Workington was under water, and one of the wooden bridges was carried away. Windermere Lake was exceedingly high, and it would have been higher than on February the 9th 1831 (or seven feet above its usual level), had not the outlet been made one or two feet deeper near Newby Bridge, for the passage of steamers. Under these circumstances, the Lake was just three inches *lower* than in February, 1831. On the 11th and 12th of December, the quantity of rain measured at Stonethwaite, for forty-eight hours, was 9·11 inches; at Seathwaite, 7·57 inches; and at Cummock Lake, 6·60 inches. In five days of this month, 15·18 inches fell at Seathwaite, and 16·36 inches at Stonethwaite.

The mean temperature of 1852, at this place, was 50°·155, which is 1°·31 above the climatic average. In the last 20 years, there have been but three which have attained to a temperature of 50°,—viz., 1834, 1846, and 1852.

The Evaporation is 30·35 inches, exceeding the annual average quantity by 0·519 inch, and the amount in 1851, by 5.008 inches. The greatest depth evaporated in any single day was 0·336 inches on the 27th of July, with a temperature of 73°·5—complement of the dew point 9°, and a bright unclouded sky.* In the almost tropically fine and dry year 1842, the evaporation amounted to 36·83 inches, exceeding the depth of water precipitated by 2·143 inches.

* The greatest depth of water raised by evaporation in 24 hours, during the 11 years last past, was 0·430 inch, on the 22d May, 1844.

Winds.—In 1852, the winds were distributed as under:—N., 17 days; NE., 77 days; E., 19½ days; SE., 34½ days; S., 65 days; SW., 93 days; W., 34 days; NW., 24½ days; and, dead calms, 1½ days. As usual, the SW. is the prevalent wind, but the easterly points are above the average number.

Weather, &c.—In the past year, there have been 50 perfectly clear days; 190 wet days; 126 more or less cloudy, without rain; 287 days on which the sun shone out more or less; 21 frosty nights;* 2 slight snow-showers; and 19 days on which hail fell. There have also been five solar and seven lunar halos, 1 parhelion, 1 lunar rainbow, 15 thunder-storms, 4 days of thunder without visible lightning, 7 days of lightning without thunder, and 10 exhibitions of the Aurora Borealis. The days of cloudless sky in 1852, exceed those in the memorably fine and luxuriant year 1842, by seven. In 1851, the perfectly clear days were 19; in 1850, 11; in 1849, 12; in 1848, 18; in 1847, 16; in 1846, 27; in 1845, 21; in 1844, 30; in 1843, 31; and, in 1842, 43; the average number in the last 11 years being twenty-five.

Atmospheric Phenomena.—Aurora Borealis.—Of the 10 appearances of aurora recorded in 1852, 3 were seen in February, 2 in April, 3 in September, 1 in November, and 1 in December. The most brilliant displays of this beautiful meteor occurred in February and in September, of which the following particulars are copied from the local register:—

February 19th, 1852.—Strong and intensely cold wind, with a nearly cloudless sky throughout the day. In the evening, there was the most magnificent and extensive aurora which has appeared for some years past. At 7h. 30m., occasional streamers rose up from E. to WSW., and at 9h., two-thirds of the sky was covered with the auroral mist and streamers, the latter converging at a point south and east of the zenith, which, at 9 P.M., was situated about 8° N., and a little E. of Castor. From W. to NW. the meteor was extremely brilliant, the bases of the streamers forming an arch, the centre or highest part of which was elevated about 25° above the horizon. The arch formed by the bases of these streamers was frequently tinted with a bright rose colour, resembling a fringe; and, below, the sky was of a deep black. From this time till past midnight, the aurora increased both in extent and intensity; and, at times, fully nine-tenths of the sky was covered by it. In the NE., the streamers were tinged with a deep rose colour. At 11h. 30m., the luminous matter was arranged round the point of convergence in a series of elliptic segments, presenting a very striking and uncommon phase of the phenomenon. The occasional minute clouds which

* Of the 21 days, or rather nights of frost, in 1852, 3 occurred in January, 7 in February, 7 in March, 1 in April, 2 in November, and 1 in December.

passed over the sky were black as ink, and they appeared to stand out in relief, conveying the impression of their being at a very much lower altitude than the aurora. The light emitted by the meteor was very considerable, and I think moderately-sized print might have been read by its aid. At 1 A.M., the aurora had diminished in extent, and was then altogether confined to the northern half of the sky, but I am told it was visible till break of day.

February 21*st.*—On coming up street, at nine o'clock this evening, there was an irregular auroral arch in the NW., and frequent vivid flashes, resembling sheet-lightning. Before 10h., the sky was overcast and the aurora concealed from view. On looking out, at 13h., *although the sky was still covered with a thin sheet of cloud*, the flashes were extremely vivid, and were repeated every few seconds, exactly resembling the playful horizontal sheet-lightning seen on fine summer evenings. I never saw the magnetic flashings so bright and frequent on any former occasion. Auroræ were seen every night between the 15th and 21st, at different places in England, during which period the Greenwich Observatory magnets were much disturbed, and the electric telegraph needles were considerably deflected. The aurora of February 19th, was visible throughout England and the continent of Europe, and in America.

September 20*th.*—Overcast, with frequent heavy showers and gusts; afternoon, gleams; at 3h., a loud peal of thunder from the northward; evening, showers. At 10h. 5m. P.M., the watery cloud then overhead partially cleared away, and disclosed a magnificent colourless arch about the width of a rainbow, extending nearly to the visible horizon at both extremities, which terminated in the ESE. and WSW. astronomical points. The arch, which was of perfectly equal width throughout its extent, divided the heavens into two not very unequal portions, its centre passing about 10° south of the zenith. In about three minutes after I first saw it, the clouds again closed in, and the phenomenon disappeared, so that I had not sufficient time to have recourse to the altitude and azimuth instrument, or even to notice its position with respect to the fixed stars, but it was observed that its eastern portion covered the star Algol. There was no other trace of aurora in the sky, except a slight blushing in the NW.

Remarkable Meteor.—*February* 22*nd.*—Light breeze; fine and sunny, very damp day; from 4 P.M., dense damp fog. A correspondent of the *Whitehaven Herald*, dating from Moresby, states that about eight o'clock this evening, he was startled by a sudden blaze of light which illuminated the whole of the surrounding country.

On looking upwards, he saw a ball of fire, apparently as large as the moon, which shot off towards the sea in a westerly direction and nearly parallel to the horizon, assuming in its course a deep and beautiful green colour. The meteor was also seen from the immediate vicinity of the town, and at the most of the adjacent villages;

also by persons leaving the church at Ennerdale. I was in the Observatory about this time, when dense fog again set in, but I did not perceive any trace of the meteor. The light from it was however perceived by those walking in the streets of the town, and was supposed to be lightning. I am told that this object was seen at many other places, both in England and Scotland.

Lunar Rainbow.—On the 20th of November, about 10 minutes past 7 o'clock in the evening, a very beautiful and perfect lunar rainbow was seen by Mr Isaac Fletcher, from the railway station at Aspatria. "The arch was bright and distinct throughout, but most so towards the extremities; its colour was milky white, but towards its edges some of the prismatic colours were perceptible. It continued visible nearly twenty minutes. Light rain was falling at the time, but the sky was quite clear towards the south, and in the north it was densely clouded."

I conclude the report with a few remarks on the relative temperature, humidity, &c., of the air, in each quarterly period, in connection with the comparative mortality in the town of Whitehaven, during the past year.

January.—A very mild, damp, and wet month. The mean temperature and fall of rain are both *above* the averages of the previous nineteen years, the former by 3°·75, and the latter 3·73 inches.

February.—Heavy rains till the 17th; afterwards, fair and fine to the end. Temperature 0°·70 *above* the average of the month. On the 23d, the barometer rose to 30·680.

March.—Very fine, mild, and remarkably dry. The temperature is 0°·92, or nearly 1° *above* the average, and the depth of rain only amounts to a quarter of an inch. The mean daily difference between the temperature of the air and of the dew-point is 9°: on the 19th and 29th, the difference was 14°; on the 20th, 20°·8; and on the 21st, 18° nearly. On the 3d, the atmospheric pressure rose to 30·750, at 90 feet above the sea. On the 7th, a Peacock Butterfly was captured, and one of the Tortoise-shell species was seen in the vicinity of Cockermouth. On the 25th, a specimen of the Sand-martin (*Hirundo Riparia*) was shot in the same neighbourhood. The earliest arrivals of this bird previously on record, are the 4th and 11th of April. On the 23d, bees were carrying burdens.

First Quarter.—The temperature of the quarter ending March 31st, is 1°·79 above the average of the last nineteen years.

The deaths in the town and suburb of Preston Quarter are 35 *under* the corrected average number, which is 153. By the Registrar-General's report, it appears, "that notwithstanding the peculiarities of the weather, the mortality over the kingdom has been considerably *below* the average for the season. The rate of mortality is 2·364 per cent., which is less by 0·111 than the mean annual rate in the ten previous winter quarters." It may be well to state the mode of correcting the average number of deaths in each quarter for increase in population. In 1841, the population of the town and suburb was 16,635; in 1848, (by a private census) 18,791; in 1845, it is assumed to have been the mean of these two periods, or 17,867; and, by the national census of March 31st, 1851, the population was 19,281. The mean of these numbers gives an average population of 18,143, for the thirteen years ending with 1851, which is very nearly one-sixteenth less than the number of inhabitants in 1852, assuming it to be the same as in the previous year; and, it is pretty certain there has been no increase in the last two years. Hence, to render the average quarterly mortality comparable with that of corresponding periods in the year 1852, one-sixteenth is added to the absolute or recorded average number of deaths for the preceding thirteen years.

April.—A memorably fine, mild, and dry month. Till the 28th, only one slight shower of rain fell, and the entire fall slightly exceeded an inch. The air was in a remarkably dry state, the mean daily difference between its temperature and that of the vapour-point being 14°·6. On the 21st and 22d, the complement of the dew-point amounted to 20°·4 and 26°, respectively.

The perfectly clear days are twelve in number, as many as were recorded throughout each of the years 1849 and 1850. In the ten consecutive days between the 7th and the 16th, there was no appearance of cloud, either by day or by night. The temperature is 1°·77 *above* the average. The Cabbage butterfly was first seen on the 12th, and the first Swallow on the 23d, both in the immediate vicinity of the town. Swallows appeared in the Lake District about the 23d, and the Cuckoo was heard at Seathwaite on the 23d, and at Langdale Head on the 24th. On the 3d, several branches of pear-tree blossom were fully expanded; and, on the 18th, the hedge-rows near St Bees were almost in full leaf. On the 16th, the maximum temperature fell 15° in the preceding twenty-four hours.

May.—A very fine, but rather cold month, the temperature being 1°·16 *below* the average. Heavy showers fell almost daily between the 7th and the 19th; the rest of the month was free from rain. On the 1st, the Corn-crake was heard at Bassenthwaite Halls, near the foot of Skiddaw; and the Cuckoo was also heard for the first time this year.

June.—Frequent showers, but the sun shone out on twenty-seven days. The temperature is 0°·78 *below* the average, and on the 2d and 3d, a large quantity of hail fell at Whitehaven. On the 21st, we had the first cast of bees at the coast.

Second Quarter.—The temperature of the quarter ending June 30th, is very nearly coincident with the mean of the corresponding period in the previous nineteen years. The deaths are one *above* the average number. In April and the early part of May, there were many deaths from Phthisis, and pulmonary complaints were unusually fatal. According to the Registrar-General "the mortality throughout England in this quarter was 2·227 per cent., which is slightly above the average of the season. The excess of deaths was chiefly in the town districts, which still maintain their fatal pre-eminence in destroying the lives of the population."

July and August.—The characters of these months have already been given. On the afternoon of the 16th of July, there was a fine prismatic solar halo, and another in the evening, which were followed at night by an awful storm of thunder, lightning, rain, and hail, *when* $1\frac{1}{4}$ *inch of rain fell in little more than an hour.* On the 14th, the thermometer rose to 83 degrees in the shade. The mean complement of the dew-point was 10°, shewing a very low degree of humidity in the air. The mean temperature of August is 1°·51 *above* its average value. Of the numerous and very frightful thunder-storms which occurred in this and the previous month, one was so remarkable in its effects, that I venture to give a few particulars respecting it.

August 10*th.*—" A dreadful storm of thunder, lightning, and rain, almost directly over the town (Whitehaven), between 8 and 11 o'clock this morning. During the height of the storm, the lightning entered the chimney of a house in Senhouse Street (attracted probably by an iron weathercock with which the chimney was surmounted), and pierced the wall, passed through an attic, descended by way of the staircase to the floor of the room beneath, passed through the floor, descended to the shop and kitchen, and finally expended its force on the cellar beneath. In its progress, it tore a beading from a door-case on the second floor, hurling a portion of it, from which two nails protruded, against another door on the opposite side of the room, *to which it became firmly attached* by the nails. The fluid also struck down a woman and child who were entering the room by the first-mentioned door, shattered the shop-door, knocked down a young man who was passing the doorway at the moment, passed through the clock-case, and communicated a severe shock to a female in the kitchen, struck a boy who was sitting in the cellar with a child on his knee, and hurled boy and child to opposite sides of the room. Thus, independently of the female who was stunned in the kitchen, five persons in the house out of nine which it contained at the time, were prostrated by the fluid, and all at the same instant,—none of whom sustained any permanent injury. The spot at which the lightning passed through the second floor is indicated by a circular orifice nearly half an inch in diameter, the edges of which indicate the action of intense heat." A few days before, the lightning descended on the gable end of a farm-house called "Gamerigg," near this town, from which several cart-loads of stones were dislodged, and projected into the interior of the building.

September.—A fine, mild, and dry month. The temperature is 0°·45 *above* its average value, and the complement of the dew-point is 0°·5 *greater* than in August. Rain fell on ten days only. Hoarfrosts occurred on the mornings of the 16th and 17th, and Auroræ were frequent during the latter half of the month.

An unusual number and great variety of the Lepidoptera were visible during the warm summer weather which was continuous during the first ten days. On the 10th, the writer noticed three butterflies, (the Admiral, Peacock, and Tortoise-shell) all located at one time on a carnation plant, in a garden within the precincts of this town.

Third Quarter.—The mean temperature of the quarter ending September 30th, is unusually high, being 2°·28 *above* its average value. The deaths are 73, being 48 *less* than the average number in thirteen years, corrected for increase in population; consequently, this quarter has been unusually healthy at this place, notwithstanding the inordinate heat of the summer months. It would appear from the Registrar-General's report for this quarter, that an equally favourable account cannot be given of the state of the *public* health, as "the deaths *exceed* the number in any of the corresponding quarters of former years, except 1846 and 1849."

October.—A pretty fine, but cold month. Temperature 2°·10 *below* the average. Thunder-storms occurred on the evenings of the 1st and 24th. On the 1st, Skiddaw and Great-End were capped with snow, the first time this autumn; and in the evening of the same day, a thunder-storm occurred in the Lake District. On the 2d, Swallows began to congregate in large flocks in this vicinity.

November.—Mild and wet. The temperature is 1°·20 *above* its average value. On the 9th, about $4^h\ 30^m$ A.M., a shock of Earthquake was felt by most of the inhabitants of this town who were awake at the time, and by many who were awoke by the convulsion. A low rumbling noise was succeeded by two slight but distinct shocks, the principal effects being the jingling of glasses, the rattling of crockery, and a kind of rocking motion communicated to the beds. In some cases, persons were awoke from a sound sleep and jumped on the floor, expecting an attack from some nocturnal marauder; and the instances are numerous in which individuals imagined that some one was hidden under their beds. The earthquake appears to have been principally confined to the two sides of the Irish Channel, though, strange to say, nothing of it was experienced at sea. It was felt as far south as Gloucester. The temperature had been unusually high for ten days previous to the shock, and it fell rapidly after its occurrence. Between the 9th and 10th, the mean temperature fell 9°, and in 48 hours, between the 8th and 10th, the mean depression was 15°·7 (14° in the maximum, and 17°·5 in the minimum or night temperature). As it is well to record all the phenomena immediately preceding or following such extraordinary physical occurrences, even though at the time they may seem to have no direct connection with the events in question, I may state, that on the day succeeding the convulsion (the 10th) I noticed a very remarkable arched cloud, extending from SE. to NW., with numerous feathery offshoots, and in this respect somewhat resembling the vertebræ of a fish. This cloud was probably of electric origin, and it may be observed that the clouds were evidently highly electric for some time previous to the occurrence of the earthquake.

There were frequent hail showers, but lightning was seen on one occasion only during the month.* On the night of the 29th, the thermometer fell to 26°·5, an unusually low temperature for the west coast at this early period of the winter. At 11 o'clock, on the morning of the 30th, the thermometer stood at 20°·5 on the summit of Sca Fell Pike, and the simultaneous temperature of evaporation was 19 degrees. The rain gauges were, of course, all frozen up. The mountains were repeatedly capped with snow, and on the 27th, the valleys were whitened for the first time this winter.

December.—In *many* respects an extraordinary month ; besides being the mildest and wettest December on record, it is marked by sudden and enormous fluctuations of the atmospheric pressure,—by the small difference between the temperature of the day and night (5°·3)—by thunder-storms, and by two of the most terrific storms of wind which have visited the British Islands for many years.

The first of the tempests or hurricanes alluded to, occurred on the morning of Christmas-day ; it was at its height from 3 to 5 o'clock A.M. ; and, during this period, it was considered to have exceeded in violence any storm we have had since the memorable 7th of January, 1839. A Parhelion was seen about noon the same day, and at 1^h 40^m : on the following morning, a dazzling flash of lightning was followed, almost instantaneously, by a terrific peal of thunder. The flash of lightning was one of the most intensely vivid the writer ever witnessed, even in a tropical climate, notwithstanding the light emitted by a full moon,—and the circumstance of his eyelids being closed at the time. The electrical discharge was immediately preceded by a heavy hail shower, and followed by a stormy night.

The storm of the 27th was much more persistent, and continued much longer than that just referred to. The moderate gale which prevailed on the 26th, increased greatly in violence during the night ; and, on the morning of the 27th, it amounted almost to a hurricane, attended by continuous heavy rain, till 3 o'clock in the afternoon, when it began to abate. At, and after noon, (about the time of high water) the sea had risen to a fearful height, the piers were completely buried by the waves, and the spray was actually driven in vast volumes over the cliffs to the north of the town, which are about 90 feet above the sea level, and considerably beyond high water

* In Bassenthwaite, thunder was heard on the 5th, and again on the 27th, accompanied by lightning.

mark at spring tides, as may be supposed from the northern line of railway intervening between the sea and the cliffs. The lighthouse keeper was imprisoned in his domicile on the West Pier (which was constantly deluged by the waves) throughout the previous night, and till 4 o'clock in the afternoon. The calculated height of the tide was 16 ft. 1 in., but about the time of high water, (11^h 56^m A.M.) it rose to 24 ft., so that the waters of the Channel were elevated 8 feet by the force of the wind alone. Although a spring tide, vessels were afloat in our harbour *at low water*. The shipbuilding yards were completely flooded, the palings were washed down, and many thousand feet of timber were floating about, no small quantity of which (including several logs of not less than 30 feet in length) was carried away by the receding tide. In one yard, the keel of a vessel which had just been laid down, was washed from the stocks, and two vessels were completely wrecked a little to the north of the harbour. The Whitehaven Junction Railway sustained damage to the amount of £3000, by the washing down of the massive masonry constituting its protecting sea-wall. About 120 yards of the wall were carried away. A striking illustration of the force of the waves is furnished by the fact, that the pigs of iron with which a small vessel, stranded lately to the north of the harbour, had been laden, were driven right up against the North Pier, a distance of several hundred yards from the portion of the beach on which they had previously been lying. When the great weight of the iron pigs in proportion to the smallness of the surface presented by them to the action of the water, is borne in mind, this fact will be deemed significant. At Maryport, the wooden pier and cast-iron lighthouse were completely carried away, and the massive logs of timber forming the piles of the pier were snapped off near the ground like so many desiccated sticks. At Flimby, near Maryport, a heavy boat was taken up by the wind, and carried completely over the railway embankment into an adjoining field. I am informed by Mr Hartnup, that the maximum horizontal force of the wind at the Liverpool Observatory, was forty-two pounds on the square foot, on the mornings both of the 25th and 27th. That faithful premonitor (when properly understood) of meteorological changes, the Barometer, gave ample and significant warning of some extraordinary atmospheric commotion, on the preceding evening or night. At 3 P.M., on the 26th, the mercury stood at 29·296. I did not again particularly attend to its movements till just before retiring to rest at 11^h 50^m, when the column was read off at 28·696, it having fallen ·074 in the previous twenty minutes; indeed, such was the rapidity with which the column fell, that the descent of the mercury was almost sensible to the visual organs; certainly, an appreciable change was perceptible in each consecutive minute of time. At 9 o'clock on the following morning, the column stood at 28·220!! at noon, at 28·382, at 3 P.M., 28·802, and at midnight, at 29·162; the column having fluctuated through a space of 2·018 inches in

33 hours. Mr Forbes of Culloden states, that the *depression* between 10 P.M. of the 26th and 9 A.M., on the 27th, was 0·923 inch. At Culloden, the mercury, at 9 A.M., stood at 27·888; at 11 A.M., 27·872 (the minimum); and, at noon, at 27·879; so that the mercury, in the north of Scotland, attained its lowest depression at least two hours later than at Whitehaven. Between 3 P.M. of the 17th, and the same hour on the 18th, the barometer at Whitehaven *rose* from 28·880 to 30·142, or through the space of 1·262 inch.

During the last two months, excessive and unprecedented floods prevailed from time to time all over the kingdom, particularly in the neighbourhood of London, at Gloucester, Lincoln, Nottingham, North Shields, Newcastle, Carlisle, and Cockermouth; and, in North Wales, they were also of a very destructive character. In the Southern and Midland Counties, the great weight of water fell in November, and, in the Northern Counties, in December. The floods visited the Lake District last of all; they were at their height from the 12th to the 17th; but the whole country was deluged with water till the close of the year. At several stations, the depth of rain in December exceeded 31 and 32 perpendicular inches, equalling the average for all England for twelve months. The greatest fall (34·60 inches) took place on the "Stye," in Borrowdale, 948 feet above the sea level, or 580 feet above the hamlet of Seathwaite and about a mile distant from it.

The mean difference between the temperature of the air and that of the dew-point is only 2°·86. Lightning was seen on five days or nights during the month, on two occasions accompanied by loud thunder; and the new year was ushered in by a storm of thunder, lightning, and hail, which continued three-quarters of an hour. Numerous shooting stars and caudated meteors were noticed during the rare and transient intervals of clear sky.

Last Quarter.—The mean temperature of the quarter ending December 31st, is 1°·19 *above* its average value, and the fall of rain is very much greater than is due to the season. The deaths in the town and suburb were 131, or four *under* the average number for the autumn quarter. Febrile diseases, the ordinary concomitants of an unnaturally high temperature conjoined with excessive humidity, were very prevalent towards the close of the year; and scarlet fever was very fatal amongst young children.

By the Registrar-General's report for this quarter, it appears, "that the rate of mortality in the last quarter of 1852, throughout England, is 2·197 per cent., which is *higher* than the average rate, or than the mortality in the corresponding quarters of 1842–45, in 1848, in 1850–51, but much lower than 2·545 and 2·389, the rates of mortality in 1846–47. It is found that the mortality in the town districts was, during the quarter, at the rate of 2·514 per cent. per annum, which is *below* the average (2·579), while the mortality in the country districts was at the rate of 1·982 per cent. per annum, or somewhat *above* the average of the corresponding quarter (1·941)."

The mean difference between the temperature of the air and of the dew-point, in 1852, (7°·51) is *greater* than in any year since 1847, indicating a more than ordinarily low hygrometrical state of the air.

The deaths in the town and suburb of Preston Quarter, in 1852, are 445, which is 85, or 16 per cent. *below* the annual average number in 13 years, corrected for increase in population. The births, (717 in number) exceed the deaths by 272, and are 43 *above* the corrected average number for the same period.

The mortality in the town and suburb, in 1852, with a population of 19,281, is exactly equivalent to 23 deaths per thousand, or one death in every 43·3 inhabitants.

The average number of deaths in the 13 years ending with 1851, is 499, which, with an assumed population of 18,143, gives 27·5 deaths per thousand, or one death in every 36·3 persons.

The sanitary condition of the town of Whitehaven has been gradually improving during the last three years. In 1846, 1847, and 1848, (assumed average population 18,329) the mean annual number of deaths is 694, being 37·8 deaths per thousand, or one in every 26·4 inhabitants in those three exceedingly fatal years.

In 1849, the mortality is equivalent to 32·2 deaths per thousand, or one in every 31 persons; in 1850, to 24·9 deaths per thousand, or one in every 40 individuals; and, in 1851, to 23·4 deaths per thousand, or one death in every 42·6 inhabitants.

The writer cannot conclude this report with satisfaction to himself, without briefly referring to the character and influence of this most remarkable year, in connection with a favourite department of scientific research. A more unfavourable year for the successful prosecution of delicate astronomical work could scarcely occur, and I question whether an epoch equally antagonistic to his pursuits will present itself to the recollection of the oldest British astrometer. Rain fell, almost uninterruptedly, from the commencement of the year 1852, till the 18th of February; dry weather then set in, and continued till the 28th of April—ten weeks; during this protracted period of drought, although there was a large proportion of clear sky, yet, from the extremely low hygrometrical condition of the air, celestial objects were generally indifferently defined, and the images unsteady, and, on many occasions, the atmosphere was in the worst possible state for determining the angles of Position and the Distances of the binary stars. On several nights, *which were perfectly clear to the eye*, stellar systems of fully 3″ central distance, such as γ Virginis and ξ Ursæ Majoris, did not shew any symptoms of duplicity; in fact, they were mere patches of diffused light, resembling single stars greatly out of focus, or imperfectly-seen irresolvable nebulosities, or masses of fine white wool. An unusual number of cloudy nights obtained in the generally clear month of October, and November and December, from their excessive wetness, militated even more strongly than did January and February against the labours of the astronomer.

On the few clear evenings in November and December, the planet Saturn presented a superb telescopic object, with his multiple rings, (now nearly at their greatest breadth) his belts, shadows, and numerous satellites. The newly discovered transparent (and consequently fluid or gaseous) inner dark ring was permanently and steadily seen where it crosses the ball, even in the twilight, and in full moonlight, and, on rare occasions, the nebulosity was also perceptible at the Ansœ, in the dark space between the inner bright ring and the ball. On some evenings, the five old satellites,

Japetus, Titan, Rhea, Dione, Tethys,

were all visible at one time in the field of the equatorial telescope at this Observatory; and the instrument being moved by a sidereal clock, enables the observer leisurely to examine the details of the truly beautiful celestial picture presented to his view. Perhaps no one ever gazed upon this magnificent orb for the first time, through a telescope of great power, without uttering a cry of admiration. And, surely, strange must be the constitution of that mind, and great the obliquity of the intellect, which could behold and study a scene so marvellously grand and unique in the Universe, without being forcibly struck with the evidence of design, and with the wonderful adaptation of means to ends therein displayed,—without feeling impressed with a deeper sense of the inconceivable vastness of the Divine attributes manifested in the creation, and ever active, ever patent to the mental and moral perception of man, in the sustentation and preservation of this, and countless other and doubtless still more majestic and stupendous globes dispersed through the unfathomable immensities of space.*

THE OBSERVATORY, WHITEHAVEN,
March 3*d*, 1853.

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* This paper has been extended to an unusual length, the writer having endeavoured to make it sufficiently comprehensive, to serve as a permanent record of the *Climate of England*, during one of the most remarkable years in the current century.

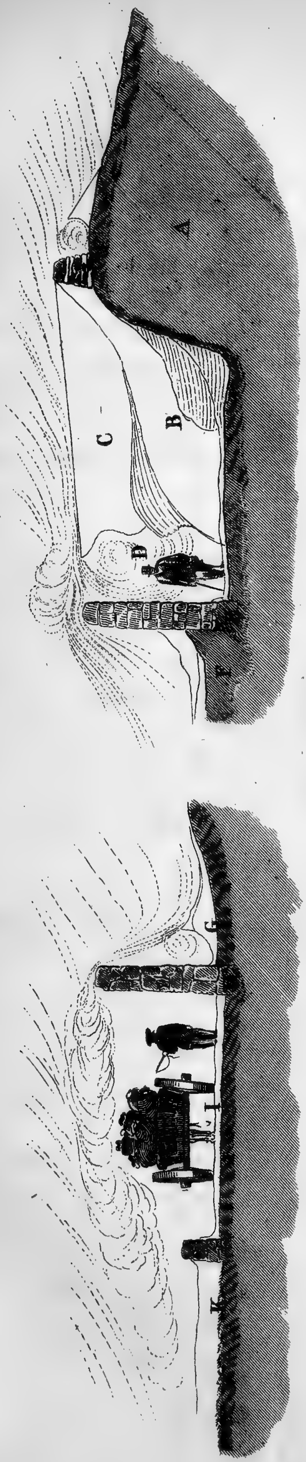
The Rain-Gauge ; the most efficient Form, Size, and Position. Deduced from Experiments with many Gauges, during several years. By Mr JAMES STRATON, Aberdeen. Communicated by the Author. (With a Plate.)

It will appear paradoxical to many, as it long did to me, but seems nevertheless to be indubitable, that the most efficient rain-gauge, the most accurate *by far*, in testing circumstances, is the smallest, the simplest, and the least expensive gauge known.

Three papers have appeared on the subject of rain and the rain-gauge during the last ten years ; (1.) by James Dalmahoy, Esq. (Philosophical Journal, Edinburgh, vol. xxxiii., pp. 8–10, 1842), shewing that the quantity of rain increases in its progress downwards ; (2.) by Thomas Stevenson, Esq., in the same volume of the Journal (pp. 10–21), on the imperfections of the gauges in use ; and (3.) by the Rev. John Fleming, D.D. (Philosophical Journal, vol. lxvii., pp. 182–187, 1849) on a simple form of rain-gauge. The following is intended as supplemental to the preceding papers ; and I wish to be understood as homologating their conclusions, except in so far as more extended experience has pointed out mistakes or suggested improvements.

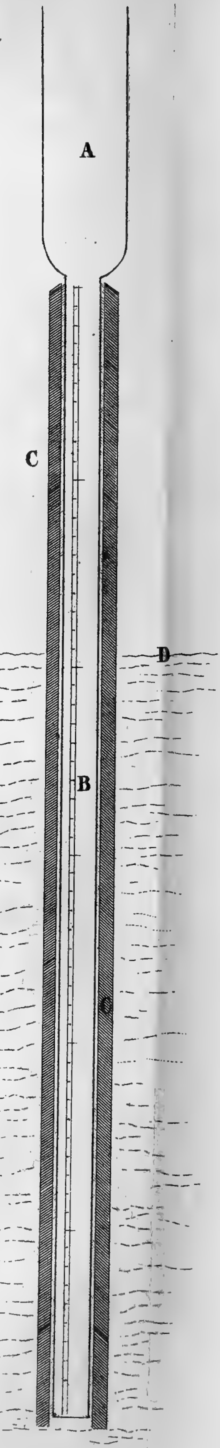
The "great flood of '29" attracted special attention to the subject of rain in the north of Scotland. Gauges were soon after planted where they had never been before, and observers kept registers in Aberdeen and other places who had not previously done so ; but so imperfectly were the essentials of size, shape, and proper position of the rain gauge understood, that, ten years afterwards, namely, at the close of 1839, there was abundant room for doubt as to whether the clouds had poured 25 inches, 34 inches, or some intermediate or other unknown quantity of water, on the granite city during said year.

Wishing to construct and use some rain-gauges, I found the subject so much involved in mystery and contradiction that the only point quite clear was, there must be much error somewhere, but we know not where. This state of knowledge



Large Rain Gauges tested in Snow

Fig. 2.



Small Gauge.

(or ignorance) was considerably more important than flattering, and the only alternative in the circumstances was to test the various points in doubt by a series of experiments. This I proceeded with as follows:—I had six sets of gauges prepared and planted in as many separate localities. Each set consisted of four gauges of the respective diameters of one, two, three, and eighteen inches. It was desirable for practical purposes to determine what is the smallest size of gauge which can be used, consistent with accurate results. This could only be determined by experiment, and hence my reason for planting gauges of one, two, and three inches diameter. A brief summary of the proceedings and conclusions attained will suffice.

Position.—As Mr Dalmahoy had demonstrated that the quantity of rain increases in its progress downward, I first planted the gauges with the mouths of the receivers level, or nearly so, with the surface of the soil, but I soon found very conflicting results; I soon found that the quantity of water registered by each gauge was influenced in some way by the state of the surrounding surface—(1.) when it was a smooth well-kept grass lawn, the gauges registered most uniformly with each other, and the smallest quantity of rain during a given week, month, or quarter; (2.) when it was soft, pulverised, uncovered earth, there was a greater quantity of water in the same period, and the gauges were less uniform with each other in the quantity registered; and (3.) When the surface was a hard smooth gravel-walk, there was the greatest quantity registered, and the least uniformity in the registrations. Another circumstance which arrested my attention was, that in all the gauges there was a quantity of earthy matter, sand, and clay, settled to the bottom and frequently adhering to the insides of the receivers. Whether this matter was blown in by the wind, or washed in by the rain, became an important question to settle. I therefore continued the experiments through several months, during which the soil was so wet that dust could not be blown by the wind. Still the earth, sand, and clay, found their way into the gauges as before. It also became obvious that the quantity of earth in the gauges at the end of each month bore a proportion (1.) to the quantity of rain which had fallen,

—the greater the quantity of the one, so was there of the other; (2.) to the state of the surrounding surface—there was least earth as well as least water from the grassy surface, more earth and most water from the hard smooth gravel, and most earth with less water from soft bare soil. It was now demonstrated, in the *first* place, that the solid matter had been driven into the gauges by the water, not the wind. The drops of rain, on striking the ground, had been spattered about, carrying particles of clay, sand, &c., with the water into the gauges. But the *second* and most important particular demonstrated was, that all the gauges so placed registered too much rain, because they received a quantity of water from the ground as well as their due proportion from the clouds. But if they are liable to fallacy in rain they are much more so when the water falls in the state of snow, and more particularly under the action of wind. This is the trying test of all gauges in every position, and of every form and size. All varieties of ground surface are soon reduced to one, that of snow, hard or soft, loose or dense, as the case may be. The ingenious device, suggested by Mr Stevenson, of a brush with the bristles pointing upwards round the mouth of the receiver, would probably be more efficient than the grass in preventing the spattering of water, but the bristles of the brush, as well as the grass, even the whin bush, and the hawthorn hedge, are often cased up in snow in a few hours; then all is smooth and level. In calm, the particles of snow and hail would dance as they fell, some leaping into the gauge, and some away from it. In wind, the gauge, whether large or small, would soon be filled by the surface drift, though it got none from the clouds.

The accompanying sketch of a scene which I passed through on the morning of the 17th February 1853, will give an idea of the difficulty of approximating accuracy with gauges, under the action of wind and snow. The sketch represents a section of a tolerably level plain, extending about a mile from north to south, and nearly as much from east to west. A public road has been formed at B, C, D, about 20 feet broad. The bank A, on the north side, is about 12 feet deep, with a stone fence on the top, about 3 feet high. On the opposite side are a retaining wall E, and fence, 10 to 12 feet high. During the four preceding days the wind was moderately strong from the NE., with showers, and the bank of snow B, was formed on the road. On the night 16–17, much snow fell, with a high wind, and the bank C was formed above B, up to the level of the stone fence on A, and extending over to within about 4 feet of the fence E, terminating in a thin crest over which the snow was blown by a strong wind. In the bottom of the ravine D, formed by the snow and the opposite wall, the snow was only a few inches deep, and the only difficulty in passing along the ravine arose from the suffocating cloud, formed of minute particles of snow, whirled by the wind in the cavity D, then tossed over the fence E, and spread on the adjoining field. From E to H is a slightly undulated surface of nearly half a mile, over which the wind and snow swept pretty freely. The wall H is about 10 feet high, running east and west. The wind being from the north, a bank of snow about two feet high, was formed at G, some three feet from the wall. From the crest of this bank a shower of snow, like the spray from the crest of a wave in a stormy sea, poured up over the wall H, crossed the road I, some 20 feet broad, and was spread over the field K. On the road I, the snow was only three or four inches deep, so that loaded carts were passing with ease, whilst the field K was covered to the depth of about two feet. Now, let us suppose for a moment that the cavity B, C, D, over the road, is the receiver of a huge rain gauge, placed on a level with the ground; we see that it gets filled with snow by a little from the clouds and a large quantity from the adjacent plain. Let the other road H, I, be a similar receiver, raised eight, ten, or twenty feet above the ground; we see that it gets almost no snow, either from above or below. The wind passes over the wall, forms a whirl in the cavity, and tosses the snow into the next field. I know not, therefore, how to place very large receivers so that they shall do their duty. We shall see what may be done with very small ones.

When I was studying this part of the subject some ten years ago, I frequently went into the fields during rain to notice the action of the falling drops on the mineral and vegetable surfaces;' and I found that, on placing the eye near the level of the tops of the plants,—of growing corn for example,—beyond which was a dark background, such as a ploughed field or brown heather moor; that there was a gray mist over the green surface, to the height of eight, ten, and sometimes twelve inches, above which it could not be seen.

This mist, I inferred, was partly, at least, if not wholly, formed of the particles of water impinged from the vegetable surfaces, when the drops of rain were broken to pieces by the force with which they fell. Hence, I farther inferred that every gauge must necessarily register too much rain if the mouth of the receiver be not raised above the mist or spray which I had seen. From that time I continued to raise all the gauges in the bare soil and gravel-walks, little by little, month after month, and had the satisfaction to find, as I did so, that the excess of water registered, compared with those in the grass lawn, gradually diminished, and that the registration of all the gauges became more and more uniform with each other, until it was frequently impossible to detect the hundredth part of an inch of difference in the quantities registered from the first to the last day of the month. The most frequent exceptions to the rule of uniformity were the largest gauges (18 inches diameter), which generally registered *less* than the smaller ones;—an important fact to be kept in view for notice farther on. After they were elevated 13, 14, and 15 inches, the earthy matters were not again found in the water, nor adhering to the *insides* of the receivers, although the outsides of the gauges were generally bespattered from the ground upwards to some distance. The following examples shew the registrations of gauges of various sizes and in different positions, during the two months' greatest quantity of rain which occurred during the experiments:—

	At surface-level in Grass. Nov. 1842.	At surface-level in Gravel.	Raised 15 inches. Oct. 1846.
1 inch diam.	5·33	5·81	6·1
2 ...	5·26	5·75	6·08
3 ...	5·18	5·9	6·11
7 ...	5·37	...	...
18 ...	...	56·8	4·9

From what has been said, it appears that from 14 to 18 inches above the snrface of the soil is a proper position for the mouth of the receiver of the rain-gauge, (1.) because there the rain-drops have received their proper additions from the atmosphere; (2.) because there they have received no addition from the surface of the ground; but (3.), and chiefly, because the most suitable form of gauge, for accuracy in practice, has, when so planted, about 20 inches of its cistern or stem below the surface of the ground, and being thereby placed beyond the influence of all the ordinary, and most of the extraordinary vicissitudes of temperature, is protected from evaporation by heat in summer, and destruction by frost in winter. Mr Thom's rain-gauge, used and described by Dr Fleming, is a cylinder immersed to the surface-level of the ground; and he frequently told me that, during the warmest and least rainy months of summer, he never detected any perceptible diminution of the water in the gauge from evaporation. As this is quite consistent with my own experience, I leave the point as settled; but the *frost* in winter is the inveterate enemy, *the insuperable barrier*, indeed, to the general and constant use of the rain-gauge as it is usually made and planted.

Few observers are willing to empty their gauges habitually more frequently than once or twice a month. During the course of my experiments, some eight or nine instruments were planted by different observers in and about the locality but one after another they have all disappeared. They were made, some of copper, some of zinc, others of iron or tinplate. They were each enclosed in a wooden case, and the whole instrument was above ground, from three to five feet being the favourite height for the mouth of the receiver. Almost every night that a smart frost set in after rain, when the gauge contained water, it was frozen, and the metal generally burst, as a matter of course. The observers persevered in repairs day after day, winter after winter, till wearied out, sooner or later, the repair was left undone, the gauge was useless, neglected, and became a wreck.

I have never yet seen or heard of an instance of freezing in one of my gauges, some of which have been in constant use for six, seven, and eight years. It is quite possible to happen, however, but only on those rare occasions, once in ten, fifteen, or twenty years perhaps, when intense frost, continued for many days, penetrates deep into the soil, attracts the attention of all, and would of course warn and remind the observer to have his gauge empty.

Size.—I began experimenting under impressions regarding the size of gauges similar to those stated by Mr Stevenson, thus:—"But it seems probable that the larger they are made the better, and for ordinary use they could be conveniently enough constructed of from two to four feet diameter." I had no very definite notions, however, as to the why or wherefore a large should be superior in any particular to a small gauge. I close the experiments, convinced that instruments from four or five inches to as many yards in diameter are far, very far inferior in point of accuracy, in our climate, to those of one, two, and three inches wide. The want of uniformity of registration, which I always regarded as proof of want of accuracy also, noticeable from the beginning of the experiments, I was never able to trace to the difference of size of the gauges forming the sets. But when I ultimately obtained a very near approach to uniformity by raising them beyond the reach of the spray from the ground, which was so clearly a disturbing cause, I was then surprised to find that, while the small gauges of one, two, and three inches were remarkably uniform with each other in the quantities registered, the large gauges of eighteen inches diameter were in general considerably below, and in no instance did they exceed the small gauges in the quantity registered. At first I suspected error in the measurement or graduation of the instruments, but on examination found them all equally accurate. The question now came to be, did the small register too much, or the large gauges too little rain? The very close and habitual uniformity of the small gauges, I could not but regard as presumptive proof, at least, of their accuracy also; but how the large gauges recorded too little rain was not at all obvious at first sight. The sagacious remark of the keeper of the Buchanness lighthouse, quoted by Mr Stevenson, and verified, as it is, by most of his intelligent co-labourers at the stations round the coast, gave me the right clue to the mystery, "When there is no wind it (the gauge) is very near the truth; the more wind the farther from the truth." Yes; I have stood by the gauges in rain and in snow, in calm and in storm, and seen the truth of the statement demonstrated many, many times. Indeed, all are familiar with facts which demonstrate the proposition, though they may not have drawn the important inference from what they saw. When we witness the action of the driving gale, as, loaded with the feathery flakes, it sweeps over the crested ridge of the bank or wave of snow, we see the particles just when they pass the crest, make a somersault, as it were, and fly off, over the adjoining wall, some ten or twelve feet high, perhaps to some distance, where they fall, and form a second bank. We see also that the lee or lithe side of the bank is generally scooped out in a kind of circular hollow, beyond which the ground is for some distance cleared of snow. (Plate I., D and I, fig. 1.) Now, the mouth or orifice of the receiver is always in the lee-side of the run or lip, on passing over which the wind, when strong enough, makes a whirl, and away it flies over the opposite lip, carrying the particles of rain or snow with it. It is in such circumstances that the efficiency of gauges is put to the severest test. If they fail, they are worthless; and the most ample, elaborate, and expensive instruments I have seen do fail in such circumstances. All the "eye-traps or gimcracks, usually set up as *rain-gauges*" as Dr Fleming expresses it, are worthless, yea, worse than worthless, because they mislead, compared with a plain piece of tube an inch or two wide, by three or four long, which may be purchased in any town for a penny or two.

The one, two, and three inches diameter gauges, particularly the first and second, always register the most uniformly and the greatest quantity, not a trifling or unimportant quantity, but to the almost incredible extent of a third and a fourth part more than the large gauges, during gales of wind. Now, I can only account for this by the fact, which I have often observed, that in small or narrow openings the wind does not form a whirl sufficiently powerful, excepting perhaps in some extremely rare instances, to carry the particles of rain or snow out of the small, and away as it does out of the larger gauges. But the shape has also much to do in the matter as well as the size of the receiver; and this is the next particular we will glance at.

Shape or Form.—If we take a number of vessels of different shapes and sizes—say a soup plate and a flat one, a tea cup and saucer, a wash-hand basin, a washing-tub of the largest size, a strong ale-glass, and a lady's thimble—if we take these and arrange them level, a foot or two from the ground, in the field or open plain where wind has free scope every way, we may test the question of efficient size and shape of the rain-gauge to any extent. When the drops of rain and the snow float gently down in the calm, all are equally efficient, all register quantity in proportion to the area or surface expansion; but when the wind, "blowing great guns," drives the dry snow over the plain, all are equally useless, excepting the ale-glass and thimble.

This needs only to be considered for a little to be assented to and appreciated. The plates will remain empty, and the saucer nearly so (the particles being blown out as fast as they are blown in), the basin will not be so full as the cup, and the washing-tub will have little more in proportion to its size than either the basin or saucer. The whirl which carries the particles from the crested bank to the next one, some 50 or 100 yards off, is about as efficient in emptying the tub as the plate, but the limited opening of the glass or the thimble annihilates the whirl of the wind as effectually as the cage arrests the gambols of the imprisoned elephant; all the particles that enter the orifice drop quietly down, and render their account when called on.

Of the various shapes of gauges in use—square, round, and oblong—I much prefer the round. I have not indeed tested the square forms in every variety to be able to pronounce definitely on their merits, but all of them seem to be peculiarly objectionable, from the amount of commotion or deflection caused in the passing stream of air, compared with that caused by a round, or cylinder of the same diameter.

I have already shewn the noxious effects of commotion in and about the gauge so fully as to have demonstrated, I presume, that the form and size of instrument which creates commotion to the least possible extent, must necessarily be the best in constant efficiency and accuracy. All the square form of gauges which I have seen used, seem to me to combine the defects of the worst round ones, in an exaggerated degree, but experiment only can settle the question. This much I consider certain, however, that the round is not inferior in efficient accuracy, and is decidedly superior in strength and facility of construction. Of the round form of gauges, some are conical, like the common tin funnel used in filling bottles—some are oval like the egg-shell from which we cut off the broader end at breakfast, and others are cylindrical like a piece of plain tube. If they are narrow, and deep in proportion to their diameter, all are about equally useful. If they are broad and shallow, about as deep as they are wide, they are all about equally useless. Of the three I prefer the cylinder, about an inch and half in diameter, and three to four times as deep—say 6 inches—as it is wide.

I have not selected the inch and half receiver, because it is superior to either the one or the two inch diameter, but because it is not inferior to these, and is also large enough for strength of material, and facility for accurate construction.

The following readings during the past year (quite consistent with preceding years) are given to shew the registration of an instrument of the form and size just described in comparison with an oval (egg-shell shape) receiver of 6½ inches diameter by 5½ deep. The latter is an elaborate and complicated instrument of copper, glass and brass, planted at the Girdleness lighthouse; it is one of many similar belonging to the Northern Lights Commission. The two gauges are situate but a short distance apart, and under precisely similar circumstances.

		1852.										1853.		
Gauges.	Diam.	Mar.	Apl.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	
1.	1½	0·53	0·6	1·91	2·37	1·7	2·2	3·3	4·31	3·3	5·2	3·1	3·88	Monthly depths of water in inches & decimals
2.	6½	0·2	0·6	1·75	2·1	1·54	2·14	3.0	3·14	2·38	3·81	2·64	2·1*	

* Dry snow with strong gales of wind throughout the month.

In the summer months, we have gentle showers, with little wind, and the records are almost identical; but in the winter months, when heavy rains, snow, and strong winds prevail, then the difference is quite enormous, being fully a fourth part of the quantity registered. Like the flat plate and the saucer—equally useful in calm, equally useless in storm—with this all-important difference, however, that the elaborate and expensive gauge is not simply useless, but positively pernicious, because it is trusted in as truthful, yet is really false. It is much to be regretted that the enlightened and liberal intentions of the Commissioners to serve science and humanity are so completely frustrated in this respect.

Materials.—Gauges are sometimes made of zinc, tin, and iron, but copper is most generally preferred. Most of those which are considered the best in use, have the receiver and part of the cistern of copper, the other part of the cistern of glass, and a brass plate attached, on which the scale is engraved. This form of the instrument is simple enough in use, but it is the most complicated and costly in construction, and decidedly the most liable to destruction, from alternations of temperature, particularly from frost in winter, by the unequal contraction and expansion of the different substances.

As glass is found suitable for part, it must be much more suitable for the whole of the cistern, being much less liable to injury from change of temperature when alone than combined with any of the common metals; and being suitable for the cistern, it is equally so for the receiver,—for the whole instrument, in a word.

I consider glass a peculiarly suitable material for the rain-gauge; because (1.) the workmanship is so simple that the price is trifling, whilst it can be accurately measured and graduated, and consequently it will be as efficient in use as any other material. (2.) It is also the most simple in use. The scale can be engraved on the cistern; the quantity can be seen at any moment, without measuring, adjustment, or calculation: the readings can be taken and the record kept by any boy or girl who can read and write inches and decimals. (3.) There is least error from evaporation. Every gauge, even the most perfect, registers too litle rain, because the quantity required to wet the inside of the receiver is dried up, evaporated between showers three or four hundred times every year. Now, water passes off glass very much as it does from a cabbage leaf or a duck's back, so that the loss from evaporation is reduced to the least quantity. (4.) The strength is ample for every purpose of fair wear. The glass gauge is as safe as our windows—much more safe than our roof-lights, our cupolas, our greenhouses, and conservatories. A heavy knock, or severe frost, is destruction to the copper and iron gauge as certainly as the glass. In the form of gauge which I propose, the risk from frost (the implacable enemy of the rain-gauge, as I have said) is avoided by the position of the cistern in the ground. Lastly, Glass is not liable to rust and corrode like iron by constant exposure in all weathers; it requires neither paint nor varnish at any time, and, except broken by accident, it continues sound and efficient from age to age.

The gauge I refer to (fig. 2) may be described as a small bottle turned upside down, and the bottom cut off. The body of the bottle forms the receiver A, one and a half inches wide by six deep; the neck, extended to 30 inches long by ¾ wide, forms the cistern B, on which the scale is engraved, and the instrument is complete. The quantity of water which would fill one inch of the receiver fills about five inches of the cistern; consequently, each inch of the scale is about five inches, and each tenth about half an inch long. The tenth may be easily subdivided into five or ten parts, and the readings taken to the hundredth part of an inch. A frame, C, formed of four slips of oak deal, is firmly planted in the ground; into this frame the gauge is passed down easily, but without room to shake, and the whole is ready for use. The line D represents the level of the ground, above which the mouth of the receiver should be 15 or 16 inches elevated, and quite level. The observer can draw up the gauge at any moment, read the depth of water, empty it as often as he thinks proper, and replace the gauge in its position.

This, the most accurate and efficient form and size of the rain-gauge—an instrument so essential to science and the first arts of life, to the meteorologist, the agriculturist, the engineer, the farmer, and the gardener—is so simple, and can be produced at a price so trifling, that it may find a place in the garden-plot of every respectable cottager, as well as in the lawn of the landed proprietor. The extended use of the rain-gauge thus permitted, may form a powerful means of leading the advancing intelligence and activity of the rural population to habits of correct observation, scientific reasoning, and more rational views of weather and climate, than the prognostications contained in the pages of "Belfast Almanacs," and publications of similar "respectability."

One of the most important conclusions resulting from the foregoing facts,—a conclusion as painful as it is important,—is, that all the data yet collected, all the rain-registers of this and other countries, are vitiated to some unknown extent in consequence of the imperfections of the instruments used. The larger gauge, of which the registration is given in comparison with the smaller one, page 37, is superior in size and form of receiver (elliptical, $6\frac{1}{2}$ inches wide by $5\frac{1}{2}$ deep) to most of those which I have seen in use. Nevertheless, it will be observed that the record of the smaller during the six months preceding this date is fully six inches more than that of the larger gauge; being less and in error nearly a *fourth part* of the annual average depth of rain on the spot. It becomes necessary, therefore, in order to give scientific value to the past labours of meteorologists in this department of their work, to plant more efficient instruments beside those hitherto used, and by years of comparison discover the probable amount of error in recorded observations. Registers of the rain fallen have, for example, been kept here during the past thirty years, and these give twenty-six inches as the yearly average depth of water, but my investigations shew that, though the records for the summer months may be near the truth, they are not so during the heavy rains and snow with strong wind in the winter months. The amount of error is so great that the yearly average must be at least thirty instead of twenty-six inches depth of rain.

3 Kingsland Place, George Street, Aberdeen,
1st *March* 1853.

The Royal Observatory of Scotland.

From the annual Report presented by the Astronomer to the Board of Visitors, approved of by them, and since published, we find that much has been done, but that more still remains to do.

All the old observations have been computed and printed, as testified by the recent appearance of the tenth volume of the "Edinburgh Astronomical Observations;" but their importance is much diminished by the poverty of the establishment in instrumental means, and in the manual resources absolutely necessary to complete the scientific investigations which have been commenced.

The Astronomer has clearly pointed out in his report what these desiderata are; and they appear to be generally such as have already been granted to other Observatories and rival establishments; and that, not only in this country, but in others also where science is not generally supposed to flourish. Thus one of the observatories in Rome has just obtained from the Government there, one of the very additions to its means, which has for several years past been annually applied for by the Edinburgh Observatory, but in vain. Scotland, which justly considers itself in so many points to be better circumstanced than Rome, has not in its scientific department the same attention from her rulers.

We trust, however, that this neglect will not last long, and then, from the programme of proceedings laid down in this report, we may expect a greatly increased importance to attach to the Edinburgh observations.

The use, indeed, which the astronomer proposes to make of the proposed addition to his instrumental means, appears so novel in its character, as well as promising and effective in its results, that we subjoin here the concluding part of his report.

"The previous headings, together with an actual inspection of the instruments and books at the Observatory, will give the Board a fair idea of what has been accomplished during the past year; but looking also, and more wisely, beyond the mere details of office work, to the general results on the cultivation of science and the development of discovery, the Visitors will perhaps hardly rest satisfied with the completion merely of an accustomed annual task, when that is shewn to be insufficient for the advancing knowledge and requirements of the times. When other observatories are progressing, the Board has shewn, by its recommendations to the Government in past years, that it will not consent to this one alone being retarded for want of any necessary mechanical means, which a small sum of money could easily provide; and their late chairman laid it down that the astronomer was in duty bound to be ever on the watch for instrumental improvements on every side, abroad as well as at home, and that the fame of the visitors, the astronomer, and the observatory, would depend on the success with, and the extent to which these improvements should be introduced from time to time.

"No one acquainted with the history of Astronomy, or with that of the other sciences, but knows the propriety, nay, even the necessity of these views. In proportion always as observation was cultivated, so did the science improve. As sure as it was neglected for theory alone, so certainly did men run into confusion and error. In these days we have, it is true, a theory, arrived at by means of a vast amount of observation, and, therefore, generally right, nay, even absolutely right in principle; yet the application of that theory to the phenomena of the heavens, must in every instance depend upon observation. In proportion as these are still improved, theory can be applied with more exactness and success; while a long vista of discovery opens before us, when we find that the art of observing is still very improvable. We only require, then, to go forward in the path pointed out by theory, and rendered possible by practice; and we shall be enabled thereby to mark our own age in the history of science as one in which new facts of nature have been discovered, and new truths developed; and which will have shewn itself a worthy successor to that of the Greeks, and of the highest minds of all nations, by taking up the sum of knowledge handed down to us by them, and transmitting it, with increase of lustre and substance, for the instruction and the emulation of posterity.

"In this spirit, and remembering well that the first duty of Observatories is to procure observations, and those of the utmost attainable accuracy, the Greenwich Observatory has been furnished, amongst other recent additions, with a magnificent meridian instrument, of greater power than the world ever saw before; and the results are already so promising, that a similar instrument has been ordered for the Observatory at the Cape of Good Hope.

"I cannot refuse my meed of admiration to the inventor of that instrument, or to allow that such a construction would be a notable improvement upon our meridian instruments here; but having always restricted myself in my public demands to the most urgent necessities; having rather waited until the case itself impelled something to be done; and having, moreover, distinct ideas on the separate path which should be pursued by each observatory; I can freely leave these more fortunate establishments to pursue their glorious future; and would only re-urge again upon the attention of the visitors, the great importance of the speedy acquisition of a proper equatorial instrument; together with the various items which formed the subject of their recommendation last winter.

"Our Meridian Instruments, though now less powerful than those at Greenwich, may do much good work; and if aided to the utmost by an efficient Equatorial, will, I feel confident, satisfy the expectations of the friends of this Institution. I have nothing then to *alter* on my reports of former years, for nothing therein requested can be spared; and I will now merely add, that, when once procured, these new means and appliances would enable us to carry out, with hardly any increase of time and labour, one of the most important and comprehensive improvements in Practical Astronomy, that has ever fallen to the lot of any observatory, in these advanced times in which we live.

"I have already remarked that the healthy progress of Astronomy depending upon observation,—the whole question of the true and the false hypothesis often hanging upon the closeness with which a very small quantity may be measured to,—the improvement of the exactness of observations has always been the great cynosure of practical astronomers. But much more is it the case now, as in addition to such motives, there is the further one, that so many observations of long discovered bodies having been already accumulated in the world, there is little advantage to be obtained by re-observing those same objects again, unless it can be done *better* than on former occasions. Accuracy, therefore, still accuracy, and accuracy above all things, must be the ruling idea of modern practical astronomy.

" This being confessed, it will be found that the greatest impediment to the desired accuracy is the atmosphere; an ever present obstacle, and producing, with well-made modern instruments, far more untoward effects than all other sources of error whatever. Putting out of the question actual clouds preventing any view of the sky, and even not stopping to consider the effect of the diffusion of general day-light, though that is a consequence of the atmosphere, and very prejudicial, too, in eclipsing the fainter objects in the sky,—yet if we only take account of the smaller undulations shewn by the telescope to exist in the medium, when apparently to the naked eye it is very clear and tranquil,—we yet find them there so excessive and so lawless, that seldom or never can the highest, or even anything like the highest, magnifying power be applied, which the object-glass is actually provided with, and would otherwise bear with advantage. Thus, telescopes may be increased in size and accuracy, but, when under such drawbacks, without any benefit resulting therefrom; while the bad effects of the atmosphere are even more hopelessly obstructive in a large than a small apparatus.

" The atmosphere, then, being so determined an opponent, every effort should be made to eliminate its effects as far as possible; and this can only be accomplished by rising above its grosser parts, as when placing the telescope on a high mountain. Such was Newton's recommendation more than a century ago, when trying the first little reflecting telescope that had ever been made. And yet, though *he* recommended it, though his recommendation has been long before the world, though telescopes have been since so greatly augmented in number and in size, though the atmosphere forms an increasingly larger per-centage of loss upon every successive instrument, and though so many Observatories have been built expressly for the purpose of procuring the most accurate observations; yet, not a single one has been built in the place best calculated, according to Nature and Newton, for procuring in the most perfect manner the ends for which it was really established. For witness that our Observatories, instead of being built on the highest mountains in the clearest climates, have always been erected at the bottoms of the lowest valleys, hardly elevated in any sensible, certainly not in any useful degree, above the level of the sea; and that, worse still, they are generally immersed in the smoke of our largest towns.

"In justice it must be allowed that many other duties have often been demanded of Observatories, besides making observations,—duties, too, that compelled their proximity to the haunts of men; but even allowing for such compulsion in many cases, it is strange that men have been content, in every instance, to work under this excessive disadvantage, and these ungrateful difficulties. So much the more fortunate, however, for the Edinburgh Observatory, if the means should at last be afforded for its occupying the vacant but promising field for the promotion of Astronomy. Not but what this Institution has more than sufficient of secular business and social duties to keep it close to the city; and I am far from recommending the removal of this Observatory, or the establishment of any new one, *permanently*, on a high mountain: the expense of building in such a situation, for a *constant* residence, would be very large, on account of the strength necessary to withstand the severities of winter; while there would be great difficulty in carrying on the printing, &c. of the observations.

"What I propose is, merely to establish a temporary observing station for the summer months; as in this way the greater part of the good harvest which a mountain is capable of affording, would be reaped at the least possible outlay: for nearly the whole of the fine weather period of the station might thus be utilised in procuring measures; which in the autumn would be brought home, computed, and printed, with all the resources of a civilised country.

"This notable advantage, too, would be gained, without the loss of anything important that could have been secured by remaining in Edinburgh, or rather it would be the means of avoiding a positive loss. For when the College Session closes in April, and the Astronomer has more time to attend to his duties at the Observatory; exactly then, unhappily, not only does the summer in Scotland prove itself more cloudy than the winter; but even in clear weather, the nights, owing to the prolonged twilight of a high northern latitude, continue for some months so bright, that little can be done or even attempted, especially with that smaller class of objects, and that more exact observation, in which, as detailed last year, the Director considered himself peculiarly called upon to engage with the Equatorial. Just, then, at that season of the year in which the Edinburgh Astronomer has most time at his disposal, clouds and twilight combine to prevent his making good use of it.

"Were he, however, enabled to convey the equatorial alone, by a quick journey to a high southern mountain, merely taking with him, be it remembered, his Edinburgh work, neither less nor more, to be executed with greater efficiency, he might reach a country of clearer skies, and darker nights, and be raised high above most of the disturbing influences of the atmosphere. He would, in fact, be able in three months to make more observations there, and each of them of surpassing excellence, than in a whole year in Edinburgh. Nor does this result depend solely on the theoretical ideas of Newton, for I myself have had unusual opportunity of observing, during some years, on mountains of various heights up to 6700 feet, in a southern country. From which experience, too, I feel justified in concluding, that there would be no difficulty in selecting a station, which should be free, for a given period of the year, from the usual mountain clouds; and that the degree of increase in the visibility and "steadiness" of the images of the stars in the telescope would be so great, as to leave far behind all attempts to observe the same objects on the surface of the earth with instruments of equal calibre.

"To give a first idea of the practical details, I may mention that the mountain which I propose is the Peak of Teneriffe; of all high mountains the most quickly accessible from England, the most easily climbed, and having the very considerable elevation of 12,500 feet. Its whole distance from England lies almost due south, most effective therefore for taking one, during the summer, into the darkness of tropical nights; and for raising the zodiacal region of the sky, always so low at home, high towards the zenith. It is moreover in the direct line of the Cape steamers, hardly more than a week's voyage; and from the landing-place in the harbour, there is one continued slope to the top of the mountain; instead of the usual long winding and undulating ascents and descents which must generally be overcome, before any very lofty station can be gained in most other parts of the world. Abundance of labourers and mules appear to be procurable: a sufficiently large plateau for the necessary erections exists at the height of 12,000 feet, and is stated to be clear of cloud throughout the summer; while, if one observation of Humboldt's can be depended on, the air is there more transparent than at the same height on either the Alps or the Andes. Moreover, as to the instrument itself, I have devised a new construction of the equatorial stand which will allow of its being taken to pieces, and transported with great facility: and all the observations, when made, being brought home each autumn, the computation and the printing thereof would be managed without difficulty, as a part of the usual Observatory volume, the permanent astronomical value of which would be thereby very greatly increased."

Facts respecting the Laws which regulate the Distribution of Rivers, and the Principal Watersheds of the Earth. By WILLIAM RHIND, Esq. *

In the investigation of the hydrology of the globe, we shall find that there are certain limits of latitude within which the great majority of rivers have their origin. Thus all the rivers of the first magnitude have their sources within the tropical or sub-tropical zones. The greater proportion rise within the fortieth or fiftieth parallel of latitude; and no river, of even fourth or fifth rate magnitude, derives its origin beyond the sixtieth degree of latitude.

The following table of the principal rivers of the globe, with the latitudes in which their extreme sources originate, will serve to illustrate this fact:—

Rivers of Asia flowing North and North-West.

OBI, rises in lat. 48° N., flows into Arctic Ocean in lat. 65° N.

YENESEI, rises in lat. 50° N., flows into Arctic Ocean in lat. 71° N.

LENA, rises about 50° N., flows into Arctic Ocean in lat. 73° N.

AMOUR or SAGALIEN, rises in lat. 48° N., flows into Sangalin Gulf in lat. 53° N.

JAXARTES, OXUS, } rise in Pamir, lat. 36° N., elevation 15,000 feet, flow into Arabian Sea.

Rivers of Asia flowing South and South-East.

INDUS, rises in Kailas, M. Himalaya, lat. 31° 30′ N., elevation 18,000 feet, flows into Indian Ocean, lat. 24° N.

GANGES, rises in Himalaya, lat. 31° N., elevation 13,000 feet, flows into Bay of Bengal.

BRAHMAPOOTRA, rises in Tibetan Mountains, about lat. 30° 3′ N., flows into Bay of Bengal.

IRRAWADI, rises in East Tibet, about lat. 28° N., flows into Bay of Bengal.

HOANG-HO, YANG-TSE KIANG, } rise in East Tibet, flow into Yellow Sea.

HONG KIANG, rises in South China, flows into China Sea.

MENAM KONG, rises in Tibet, about lat. 33° N., flows into Gulf of Siam.

GODAVERY, KISHNA, } rise in West Ghauts, Hindostan, about lat. 20° N.

EUPHRATES, rises in Armenia, lat. 40° N., flows into Persian Gulf.

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* Read before the Royal Physical Society, Edinburgh, March 1853.

Rivers of Europe flowing North and North-West.

PETCHORA, rises in Ural Mountains, lat. 61° 30′ N., flows into Arctic Ocean.

DVINA, rises in lat. 59° N., flows into White Sea.

VISTULA, rises in lat. 49° N., flows into Gulf of Dantzic.

ELBE, rises in the Riesengebirge, Bohemia, lat. 50° N., elevation 4500 feet, flows into German Ocean.

RHINE, rises in Rhinewald, lat. 46° 33′ N., elevation 7650 feet, flows into North Sea.

LOIRE, rises in lat. 45° N., elevation 3940 feet, flows into Bay of Biscay.

GARONNE, rises in Pyrenees, lat. 43° N., flows into Bay of Biscay.

Rivers of Europe flowing South-East.

VOLGA, rises in Tver, Russia, lat. 57° N., elevation 550 feet, flows into Caspian Sea.

URAL, rises in Ural Mountains, lat. 54° N., flows into Caspian Sea.

DON, rises in lat. 54° N., flows into Sea of Azov.

DNIEPER, rises in lat. 54° N., flows into Black Sea.

DNIESTER, rises in Carpathian Mountains, lat. 49° N., flows into Black Sea.

DANUBE, rises in Berge Mountains, lat. 47° N., elevation 2850 feet, flows into Black Sea.

PO, rises in North Italy, lat. 44° 38′ N., flows into Adriatic.

RHONE, rises in Mount St Gothard, lat. 46° N., flows into Gulf of Lyons.

Rivers of Africa.

NILE, rises in Central Arica, from lat. 2° to 11° N., flows into Mediterranean.

SENEGAL, rises about lat. 10° 30′ N., flows into the Atlantic.

NIGER, rises about lat. 9° 25′ N., elevation 1600 feet, flows into Gulf of Guinea.

ORANGE, rises in South-east Africa, lat. 26° S., flows into South Atlantic.

ZAMBEZE, rises about lat. 17° S., flows into Indian Ocean.

Rivers of America flowing North.

MACKENZIE, rises in lat. 48° to 62° N., flows into Arctic Sea.

CHURCHILL, rises about lat. 55° N., flows into Hudson Bay.

SASKATCHEVAN, NELSON, ALBANY, } rise in Rocky Mountains, lat. 48° to 53°, flow into Hudson Bay.

ST LAWRENCE, rises from several Lakes, lat. 42° to 48°, flows into Gulf of St Lawrence.

Rivers of America flowing South and South-East.

COLUMBIA, or OREGON, rises in Rocky Mountains, lat. 54° N., flows into North Pacific.

COLORADO, rises in lat. 40°, flows into Gulf of California.

MISSISSIPPI, rises in lat. 47° N. (Missouri in lat. 42° and 48° N.), elevation 1500 feet, flows into Gulf of Mexico, lat. 29° N.

RIO BRAVO DEL NORTE, rises about lat. 38° N., flows into Gulf of Mexico.
ORINOCO, rises in lat. 2° to 10° N., flows into North Atlantic.
AMAZON, rises in Peruvian Andes and Parime mountains, from lat. 4° N. to lat. 20° S., flows into Atlantic at the equator.
TOCANTINS, PARANAHYBA, SAN FRANCISCO, } rise in Brazilian mountains, flow into South Atlantic.
LA PLATA, rises in Chilian Andes and north-east mountains of Brazil, lat. 13° to 15° S.
MENDOZA, NEGRO or CUSU LEBU, } rise in Chilian Andes, flow into South Atlantic.

From this table it will be apparent that the great rivers of Central Asia, the Ganges, the Brahmapootra, the Hoang-Ho, have their origins about the parallel of thirty-one north; while the large rivers of Northern Asia, the Obi, Yenesei and Lena have their sources about the forty-eight and fiftieth degrees of latitude. The great rivers of South America—the Amazon, the Orinoco, and La Plata—rise within the tropics; and there is no river of any consequence in the southern hemisphere which derives its origin beyond latitude 40° south.

In North America, the Mississippi rises in latitude 47°, the Missouri in 42° north, while their numerous tributaries have their origin and courses in much lower latitudes. This is the case, too, with the principal rivers of Europe. The extreme northerly sources of the Volga, Ural, Don, and Dnieper, lie between the parallels of fifty-seven and fifty-four; but they are fed chiefly by tributaries which traverse the parallels of forty and forty-five degrees. The Danube, the Rhone, and the Rhine, have their origins in lat. 46° to 47° north.

The primary cause of this arrangement of river sources seems to be very obvious, and evidently has a relation to the regions of the greatest and most constant deposition of moisture on the earth's surface. Thus the greatest amount of annual precipitation occurs within the tropical and sub-tropical regions, while the fall of rain decreases in a rapid ratio towards the frigid zones. While 100 to 300 inches of rain fall annually in the tropics, from 30 to 25 inches is the average of the temperate zones, and from 16 to 10 inches of the sub-frigid and frigid zones.

This law of the deposition of moisture, then, necessarily regulates the existence of rivers, so that as a general rule the number and size of these decrease from the equator to the poles.

Where local circumstances tend to increase or diminish the fall of rain, we there find a corresponding effect produced on the rivers. Thus the Torneo, a considerable stream in North Lapland, though ranking but as a fifth or sixth rate river, derives its origin in a very high latitude, about the parallel of 69° north, and is perhaps the largest stream on the earth's surface, to be found within this range of latitude. It owes its origin to the unusual quantity of rain which falls along the range of the Scandinavian Alps, and this unusual deposition of moisture appears to be due to the influence of the warm Gulf Stream which flows northwards along the western base of the Norwegian mountains; the annual fall of rain here being on an average 82 inches.

But besides this primary cause, which naturally arises from the thermal condition of the earth's surface, there are secondary and concurrent arrangements which mainly regulate the existing distribution and diffusion of rivers, and these arrangements will be found in the position of the principal watersheds.

In the continents of Asia and Europe there are two great leading watersheds,—one, which may be called the northern, extends from east to west in about the parallel of 50° to 55°. In Asia, it consists of the high table-lands formed by the Aldan, Altai, and Ural ranges of mountains. All the rivers which flow north into the Arctic Ocean have their origins in this great table land, as the Obi, Yenesei, Lena, Amoor, and others. A marked peculiarity in these rivers is, that their tributaries take their rise in much the same parallel of latitude as the originals; and that, as they flow northward through a comparatively rainless district, they are joined by no affluents of any importance or permanency. This is very different from the tropical rivers,—the Amazon, the Mississippi,—and even the Danube, in a sub-tropical locality, which continue to be supplied by ample tributaries onward to their mouths. The different aspects of these rivers may be compared on the map. The rivers of North Asia look like certain trees, such as palms, with a long single stem, and a few fronds at the top, from whence they derive nourishment from the air; the Amazon or the Danube resembles those mighty trees of the forest that send out boughs from every part of the trunk, the more completely to nourish their stately forms.

After passing the Ural Mountains, the watershed of Northern Europe becomes very low. It is nothing more than a dome-shaped elevation of the great northern plain of Russia, with a height of 550 feet; but towards the centre of Europe it curves more southward, and rises into the mountain ridges of the Carpathians and Alps, and finally terminates in the Pyrenees and the table-land of Spain. The rivers of Europe are by this means separated into two great divisions,—those that flow north into the Atlantic and Arctic Oceans, and those which discharge their waters into the Mediterranean, the Black Sea, and the Caspian. Into the vast hollow basin of Central Asia other rivers from the eastern slopes also empty their waters, as the Oxus, Jaxartes, Helmund.

The great southern watershed is formed by the Kouen-lun range, forming the north boundary of Tibet and the Himalaya, Hindoo Koosh, and Taurus and Iranian chains, which stretch in a direction from east to west, between the parallels of 30° and 40° north. The Euphrates, Indus, Ganges, Brahmapootra, and Chinese rivers, flow south and south-east from this, the most elevated watershed of the globe. The elevated range of the Himalaya intercepts the south-west and south-east winds blowing from the Indian Ocean, and loaded with its moisture; and this moisture is deposited at the different seasons of the year, partly in copious rain, and partly in snow, which latter accumulating in numerous glaciers, affords the summer supply of the great rivers which have their sources in these elevated regions. So extensive and almost complete is this interception of the moisture coming from the south, that, on the table-lands of Tibet to the north, rain is almost unknown, and snow is only sparingly deposited at elevations of 16,000 and 18,000 feet.*

In North America we find the great northern watershed of the old world extending to the new in about the same parallel of 50°. The elevation of the eastern part of this watershed is only about 600 feet, but it rises on the west into the range of the Rocky Mountains. To the north and west of this watershed lie the numerous lakes and rivers of New Britain, or Hudson Bay territory, the surplus waters of which are carried chiefly by the Mackenzie and the Churchill rivers into the Arctic Ocean; while on the east, the St Lawrence carries off the surplus of the five large Canadian lakes. On the south slope of this watershed the Mississippi rises, as well as some of its tributaries, and so low is the elevation, and so contiguous are the sources of the southern and northern systems of those rivers, that in great floods, from excessive rains, the waters of both divisions intermingle. The great watershed of South America, the Andes, assumes a south and north direction, in conformity with the general bearing of the continent. And here, too, there may be observed a singular propriety in the arrangement of the surface in relation to the deposition of moisture. The lofty ridges of the Andes run across the western edge of the continent, and thus form a screen by which the moisture of the south-east and north-east trade winds, blowing over the surface of the Atlantic, is completely condensed, and which, flowing down their eastern slopes, waters the wide and extensive plains, and again returns the surplus into the ocean source from which it was originally derived. The tropical region to the west of these high mountains is almost destitute of moisture and of rivers.

We are as yet but imperfectly acquainted with the structure of Africa, yet the Nile evidently derives its principal source from some elevated and snow-clad mountains near the equator, and then flowing northward, refreshes the arid deserts of the centre and north with its cooling waters. Like the rivers of North Asia, the Nile carries almost its whole supplies from its two original sources, for it is joined by only one tri-

* Dr Thomson's Western Himalaya.

butary, the Atbera, in its long course of about 2000 miles over a dry and rainless desert. The other known rivers of Africa, the Niger, the Senegal, the Gariep, and the Zambeze, all rise within the limits of the tropical and sub-tropical zones. We may suppose that the great watershed of Africa exists near the centre, and extends from west to east. The most recent discoveries on this continent indicate high mountains near the equator; and north and south of these are lakes and rivers, in all likelihood derived from those snow-peaked summits.

The Hydrology of Australia presents anomalies apparently more connected with the formation of the land-surface than the condition of the atmosphere. The absence of mountain ranges, especially in the northern half, prevents the formation of rivers, by being unfavourable to the condensation of atmospheric moisture, while the evaporation from the low, level, and arid surface of the interior carries off all the rain that falls, so that the only river system of the country is in the mountain range of the south-east shores.

It would appear that, in the lower or tropical and sub-tropical latitudes, the presence of snow-capped mountains is essential to the full and permanent supply of rivers; and it is thus that the Andes and Rocky Mountains in America, the Tibetan and Himalaya ranges in Asia, the Alps and their connected ranges in Europe, the Pyrenees and other peaked summits of the Iberian Peninsula, and the Urals, intermediate between Europe and Asia,—which latter contribute largely to the Volga and other streams of the great central basin—constitute the main centres of supply for the principal rivers of the world.

We accordingly find that the most celebrated mountain peaks, as well as the greatest amount of elevated land on the earth's surface, lie within 40° degrees of the equator, both on the north and south. The highest summits within this range of latitude are from 25,000 to 28,000 feet. A few peaks beyond the latitude of 40° attain elevations of 10,000 to 17,000 feet; but the general tendency of the mountain ranges and table-lands is to decline towards the poles; and the vast Russian plains in the northern hemisphere, and those of the Pampas and of Patagonia in the southern, are evidences of the very low elevation of the general surface. Within the Arctic regions there is no mountain range exceeding 5000 feet in elevation, while the general surface is only a few hundred feet above the sea level. In the Antarctic lands, volcanic cones, apparently isolated, attain an elevation of 12,000 feet.

That there exists, therefore, a designed harmony of arrangement between the zone of the greatest and most permanent deposition of moisture, and the distribution of watersheds, which regulate the river courses, we think may be rendered forcibly evident by supposing, for a moment, a reverse arrangement to have existed. Suppose that the most elevated parts of the earth had been towards the Arctic and Antarctic circles, instead of being in the tropical and subtropical zones, as they now are, we then would have had probably the same, or nearly the same, deposition of moisture, but it would have accumulated in the equatorial regions, and formed immense morasses or numerous lakes. Suppose, for instance, that the north watershed of Asia had been placed in latitude 70° instead of 50° north, then we should have had no rivers throughout all that vast region, the cold of Siberia would have been doubled, and animal or vegetable existence would have been barely possible. The same desolation would have followed in the north of Europe had the watershed been moved 20° degrees farther north. That the greatest deposition of rain should take place within a limited range of the equator seems a necessary consequence of the other thermal arrangements of the globe; but by the existing arrangements of the elevations and slopes on the earth's surface, this moisture is by means of rivers diffused on all sides to the utmost points of the habitable land. Are we not then, on the whole, entitled to conclude, that however irregular and unsystematic may appear the distribution of the mountain ranges on the globe, the same adjustment of means to ends is as manifest in them as in the more minute and elaborate, though not more important, structures of organised beings?

There are some other circumstances in the distribution of rivers which may be cursorily glanced at. With the exception of those rivers on the north side of the great northern watershed, a large majority of the rivers of the earth flow in a south or south-easterly direction. This is the case with the Danube, Volga, Euphrates, Indus, Ganges, of the old world, and all the great rivers of America south of lat. 50° N. The Nile in Africa is almost the only exception. This evidently arises from the continents being more elevated to the north and west, and sloping gradually south and south-east. This arrangement of continents seems also to extend to the majority of islands. It is the case in Scotland and England, and many other islands. By attending to the river-courses on a well-constructed map, we may thus obtain a pretty accurate idea of the elevations and depressions of the surface, as well as the general declination of the land. By tracing the intricate windings of rivers in this way, we shall also be able to mark where the great obstructions and obstacles to their direct courses lie, and how ingeniously, if we may so express it, their currents—impelled by the law common to all fluids—seek incessantly the lowest surface of the earth; yet, knowing well their own limited powers of force and pressure, they wisely seek, by a yielding circuitous path, what they could not gain by main force.

Another circumstance may be alluded to, which bears somewhat on a geological subject. In several of the larger rivers of the globe, their tributaries have origins many hundred miles apart; whereas other rivers, which rise within a very short distance of each other, empty their waters into seas very far asunder. Some of the chief feeders of the Amazon and of the La Plata take their rise in the same mountain declivities, yet the mouth of the Amazon is 2000 miles distant from that of the Plata. Three of the large rivers of Europe—the Rhine, the Rhone, and the Danube—have their origin in contiguous mountains, but they all assume opposite directions in their future courses. The feeders of the Mackenzie river and the Mississippi rise within a few miles of each other, but the Mackenzie empties its waters into the Arctic Ocean, some 2000 miles distant from the mouth of the Mississippi in the Gulf of Mexico. The contiguous origins of the Clyde and Tweed, while the one flows west and the other east, is another familiar example.

An observant traveller in North America, Featherstonehaugh,* when tracing the country along the banks of the Arkansas river, came to a deep and lonely gorge where the main stream of that river had once flowed. In the alluvium there he remarked alternate layers of a red ferruginous clay, and of a whitish sand, frequently repeated. His previous experience of the tributaries of this river enabled him thus to account satisfactorily for this appearance. He says, "What exceedingly interested me here were the curious party-coloured deposits of clay and sand which had been left by the various inundations of the river that had taken place since this channel was abandoned. These inundations could almost be enumerated by the thin strata they had produced. There was a layer of red clay, then one of white sand, then again a mixture of both, and occasionally large blotches or masses of whitish clay, enclosed in a regular deposit of red argillaceous earth. The last deposit consisted of about an inch of dull red argillaceous matter, most probably brought from the country where the river Canadian flows. Appearances of this kind are often met with in indurated rocks, where they can only be accounted for conjecturally. This alluvial deposit is, however, undoubtedly owing to the extraordinary character of the river Arkansas, a mighty flood, which, deriving its most remote sources from the melted snows of peaks of the Rocky Mountains, from 10,000 to 15,000 feet high, and holding its course among the mountain chains for at least 200 miles, pursues its way nearly 2000 miles before it joins the Mississippi. But the sources of this stream are numerous, and some of them are six or seven hundred miles apart from west to east. The southernmost sources flow through an ancient deposit of red argillaceous matter for several hundred miles, which gives the red muddy character to the Canadian and its branches. The western and northern sources bring down mineral matter of various kinds and colours; but, to the east, some of the branches take their rise in the petrosilicious country through which I had lately passed, and the white arenaceous deposits are sufficiently indicative of their eastern origin. The branches thus referred to being of un-

* Excursions through the Slave States of America.

equal length, and separated by great geographical distances, and the melting of the snow and the rainy seasons being governed by differences in their latitude and elevation, they are consequently subject to overflow at different periods."

Something of the same has been observed by other travellers on the lower banks of the Amazon, where there is a greater distance between the tributaries, and greater varieties in the periods of flood of the various affluents,—a layer of deep tenacious clay, alternating with various coloured sands and gravels, being here a common occurrence.

This may so far tend to explain appearances in the diluvium of our own neighbourhood, around Edinburgh, where alternations of clay, sand, and gravel, are by no means uncommon. A good example of this we have at the clay deposit of Portobello, especially in the section on the north or left hand of the road, and which is now being wrought as a brick-work. There may be seen a series of layers of silicious sand, of about six inches in depth, alternating at regular intervals with a depth of one to two feet of stiff tenacious clay. The only fossil I have ever been able to detect in this clay was a specimen which I now exhibit, and which appears to be a *cyclas*. Three casts of the same species of shell were also found, but no traces of the fragile shells remained. This shell was found in the bed to the right of the road, and in a solid mass of clay, about six feet from the surface.

On the Discovery of a Frog in New Zealand. By Arthur Saunders Thomson, M.D., Surgeon 58th Regiment. Communicated by the Author for the Edinburgh New Philosophical Journal.

In the Fauna of New Zealand, compiled by J. E. Gray, Esq., of the British Museum, and appended to Dieffenbach's Travels in New Zealand, published in 1842, it is stated, on the authority of Mr Polack, that "toads and frogs are not uncommon, especially near the mountain districts, but he believes they do not differ from the species in Europe." With this remark before his eyes Dieffenbach states, "they have never been seen by me," and he doubts their existence in New Zealand. The Rev. Mr Taylor, who has been long resident as a missionary in the country, in his "Leaf from the Natural History of New Zealand," (1848), makes no mention of frogs. Dr Sinclair, Colonial Secretary, who has contributed so much to the Fauna of New Zealand, informs me that he never saw or heard of a frog in the country. I have asked missionaries who have been upwards of twenty years in different parts of the island, and natives who have resided all their life in the country, and all of them declare that they never either saw a frog or heard the croak of one, and from these circumstances I, with many others, believed that frogs did not exist in New Zealand.

In October 1852, indications of gold were found in the hills around the harbour of Coromandel, in the Gulf of Houraki or Frith of Thames. In November, I visited the diggings and procured the frog which is herewith sent.* It was got in this way. The gold-diggers were washing the soil of a mountain-stream in the machine called "Long Tom." In excavating the banks they displaced several large boulders of quartz rock, underneath which was discovered the living frog. The gold-diggers, who voluntarily submit to the evils and miseries of such a gambling trade, and can rarely be excited by any thing unless a "great nugget," were so much astonished at the sight of a frog, that one of them desisted from the seductive occupation he was at, and took the frog, and put it into a bottle of water. As the bottle was tightly corked, the animal soon died, but so anxious were the diggers to preserve it, that they stuck the dead frog on the trunk of a kauri pine to dry, and when they saw me they gave me the animal. I took it to the place where Lieutenant-Governor Wynyard was holding a conference with the tribes for the purpose of making a treaty to enable Europeans to dig the gold. The frog was shewn to many of the natives, and was carefully examined by several intelligent old men, one of whom was Taniwha, a celebrated chief, who

* This specimen is now in the possession of James Thomson, Esq., of Glendoman.

recollects the last visit Captain Cook paid to this country. None of these individuals had ever seen the animal before, nor could they give any name to it. All the New Zealanders present were much struck with its appearance, and they said it must be the Atua, the spirit or god of the gold, which had appeared upon the earth; many of them shrunk back from it in horror, and some of them were inclined to draw unfavourable omens from its discovery at such a particular time. At Auckland I met natives from all parts of the island to whom I shewed the frog, but none of them had ever seen it before. Three other frogs were caught by the gold-diggers in a different stream from the one in which the specimen was found,—one of these was lost, and the natives insisted that the other two should be set at liberty, lest evil should come on the party who caught them. The country where the frogs were found is made up of plutonic and metamorphic rocks, which rise in some places to the height of nearly 1500 feet. It forms a peninsula from Cape Colville to the mouth of the Thames. The rivulets in which the frogs were found run down the western side of the range into the harbour of Coromandel. The hills are thickly covered with fine timber, and the streams beautifully shaded from the heat of the sun.

Description of the Frog, as taken from the specimen discovered.—Length of body one inch; head more round and less pointed than that of the *Rana Palustris* of Europe; mouth large, with teeth in the upper jaw; skin smooth and shining, with several small rounded tubercles or papillæ on the sides; posterior extremities long and muscular, with five toes palmated, and partially webbed; anterior extremities short, with four toes; eyes prominent, colour olive-brown, a white spot between them; the colour of grayish-white, back brown, the belly of a lighter brown, which extends round and forms a border on either side of the brown on the back. The extremities are marked across with lines of brown and greyish-white alternately.

Remarks.—Bory St Vincent states,* that frogs and toads

* Voyages aux Quatri Iles d'Afrique.

are not found in any of the volcanic islands of the great oceans. But this idea is not now correct as regards the north island of New Zealand; though the statement is still apparently correct as regards the other islands in the Pacific Ocean. In the Sandwich group of islands there are neither frogs nor toads.* In the Galapagos Archipelago† there are no frogs or toads, and I have examined men who have lived at Tahiti, the Navigator's Group, the Friendly Islands, Chatham Island, Norfolk Island, and many of the other islands in the great ocean which surround New Zealand; and they all agree that no frogs have ever been found in any of these islands. Perhaps, however, more careful inquiries may detect frogs in the hilly rivulets of these countries, as they have been discovered in New Zealand.

When the character of the now almost extinct native rat in New Zealand became known, it furnished a link in the chain of evidence regarding the countries from whence the New Zealand race originally came; and the discovery of the frog may throw a ray of light on some obscure geological questions in New Zealand.

ARTHUR S. THOMSON.

AUCKLAND, NEW ZEALAND,
29th November 1852.

Professor Edward Forbes on the Mollusca of the British Seas.

The mollusca of the British seas are numerous and abundant. The varied conformation of the coasts of Great Britain and Ireland, and of the sea-bed surrounding these islands, is peculiarly favourable for the nourishment of a multiplicity of kinds of these animals. The climatal conditions of our area are such as to encourage the presence and perpetuation of both northern and southern temperate types, and the influence of very different ancient conditions is manifested by the presence among them of not a few shell-fish of boreal

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* History of the Hawaiian Islands, by James Jackson. Jerves, London, 1843.
† Darwin's Voyages.

or arctic origin. Our mollusca are, when taken collectively not remarkable for brilliancy of painting, magnitude of dimensions, or singularity of contour; although, in all these respects, we can boast of striking exceptions, and among our minute species can shew many of exquisite elegance and curious sculpture. By far the larger part of our marine mollusks are tiny species. Our nudibranches are, however, distinguished for the beauty of their colouring, and even among the despised ascidians there are some whose coats are tinged with the brightest or else the most delicate hues. The cuttle-fishes that live around us, are too excursive and oceanic in their habits to be claimed as exclusively, or even chiefly, our own. Those that frequent our sea bed, are mostly animals of considerable size for mollusca, and certainly among the most astonishing and beautiful of the inhabitants of the sea. They are, however, seldom seen by the casual observer, whose knowledge of our molluscan treasures is mainly derived from sorry specimens of shells cast upon the sea-beach by the waves.

The land-shells of the British Islands are still less striking than the testacea of the surrounding seas. Their hues are dull when compared with those of more southern countries, and their shapes but seldom attractive for eccentricity of outline or ornament. They exhibit but few peculiarities, and reckon among their number but few rarities. This is not the case with our marine species, among which are numerous sorts that have either not been noticed elsewhere, or are rarely to be met with, and which, even when of pigmy dimensions, are among the most prized gems of a good conchological cabinet. In the grand system of nature, size is of small account, and elephants and mites, however different in bigness, reckon of equal value as links in the chain of organisation. God's works are never left unfinished. None is too minute for the display of infinite perfection. The microscope has exhibited to our wondering eyes beauties of structure that have been concealed from mortal sight for long ages. It would almost seem as if only glimpses of those excellencies of creation are permitted to man to behold, whilst the full contemplation of such wondrous charms is reserved for immortal and invisible admirers.

Although, in consequence of the great number of mollusks that are common to all parts of the British seas, provided we compare localities where conditions of sea-bottom and depth are similar, it might seem that there is little evidence of a peculiar distribution within the limits of our area, if we regard its shell-fish either in mass, or analyse the relations of the several species to foreign and surrounding regions, we shall find very distinct manifestations of peculiarities within the boundaries of our own. Were a conchologist desirous of accumulating personally and rapidly a complete collection of British shells, he would fail in his object if he confined his researches to any one locality, even though it embraced a considerable reach of coast and variety of sea-bottom. Four districts, at least, would have to be visited. To the Channel Islands he would have to go for several forms that are almost extra British. On the south-west coasts of England he would find a few shells that he would seek for in vain in more northern or eastern seas. Only on the west coasts of Scotland, many species of great interest and peculiarity could be readily obtained. In the extreme province of the Zetland Isles he would gather some of our most remarkable rarities; and possibly, after all, he would have to visit as much of the northern half of the German Ocean as may be claimed for our natural history province, and the west coasts of Ireland, before his cabinets could be fairly filled.

In reality, our molluscan fauna is a composite assemblage, in which immigrants from the north and from the south intermingle with the aboriginal inhabitants, and descendants of a pre-adamite fauna survive amongst them. Those forms that have travelled northwards, and those that have journeyed southwards, have not all made their way with equal speed. Consequently, as we proceed either way, we find a number of species gradually disappear, and differences instituted, both positive by the presence of peculiar types, and negative by the absence of others, that serve to mark a sub-division of provinces within our area. Even among many of the species that are widely and almost universally spread throughout our seas, we find the frequency of their occurrence diminishing one way or other according to their origin. As a general rule, the northern influence prevails over the southern in the British fauna, and gives greater peculiarities to the zoology of the Scottish than to that of the English seas. The central portion of our area, the Irish Sea, is a sort of neutral ground, from which several forms are absent that are to be found both to the south and to the north of it. But such types, mostly of southern origin, can be traced in the course of their migration along the Atlantic coasts of Ireland, where their progress northwards has been favoured by the genial influence of warm currents. The most unproductive district is the southern half of the eastern coast.—(*Forbes and Hanley's History of the British Mollusca. Introduction,* p. xiv.)

An Account of the Fish River Bush, South Africa; with a Description of the Quadrupeds that inhabit it. By Mr W. Black, Staff Assistant-Surgeon. Communicated by the Author.

The Great Fish River Bush would be better understood if denominated Jungle, according to Indian nomenclature, the meaning of which is well appreciated, from the numerous descriptions we possess of that country. The word Bush is, as it were, conventional only in this colony; and what is generally taken as its meaning at home is inapplicable here. A sheep refers to a single member of the sheep, so a bush signifies a part of the Bush. The extent of the colonial Bush cannot be estimated by any conception of one who is a stranger to its features. A small clump of bush gives one no criterion to judge of its interminable extent, just as finity can give almost no conception of infinity. A distinguished military officer, at the commencement of the '35 war, even on his arrival at Graham's Town, could not understand the meaning of the report, that "the Caffres were in the Fish River Bush," and expressed himself in very strong terms of disbelief that a nation of savages could be concealed in it so as to defy observation, and render themselves nearly impregnable in it. It was only on viewing the expansive scene presented of the Bush country from Driver's Hill on the road to Fort Peddie, that he began to have some idea of the difficulties attendant on a warfare with a people possessing such a natural fastness. He at first exclaimed, when he was told, that was the Bush he disbelieved in, "It cannot be; what, all that greenish covering of the hills and valleys, bush! no, it must be only grass." Such was the deception given of its nature by distance. Conviction to the full extent, however, overcame him on descending into the Fish River Valley; and on traversing for miles through its tangled thickets, his idea of the obstacles he had to contend with in the war underwent, of course, considerable modification.

The *Great Fish River Bush* begins principally about Junction Drift, where the Little Fish River enters, and covers the valley thence to the sea. It traverses all the numerous tributary valleys that pass into the Great Valley, as those of the Botha's River, Kowie, Ecca River, and Blaauwe Kran's River, Sheshago, Clusie, and Kap Rivers, to a certain distance up the course of the Koonap river, and a considerable way up the Kat River, nearly as far as Howse's Post. To the south-west, it may be said to cover a large triangle of country—formed by the Fish River, north and east, and the course of the Kap River, along the summit of Governor's Kop, Botha's Hills, and the Fish River Berg on the south-west. The Kat River Bush is connected with the Great Fish River Bush, lying south of Graham's Town, which last covers the passage of Caffre commandos into Lower Albany and Oliphant's Hoeck. About Junction Drift it becomes connected with the Bushman's River Bush and the fastnesses of the Zuureberg, across the Commadaga—another covered way for Caffres into the Uitenhage district. Both these routes have been much used by Caffres this war, and act the part of covered ways and sally-ports from the citadel of the Great Fish River Bush. By various large kloofs east between Trumpeter's and Victoria Post, as Foonah's and Doda's Kloofs, it becomes connected with the

Keiskamma Bush, of similar character, extending from Kaisa's Station to the mouth of that river, and these connections establish the covered transit for Caffres from Caffraria into the great rendezvous of the Fish River Bush. This Bush, last war, was the *scene* of the capture of a train of forty government waggons on the Trumpeter's Hill road; and this war, it lodged two large camps of Caffres and rebel Hottentots, several thousands strong, in the bushy kloofs east of the river, in the neighbourhood of Committee's Drift, from whence issued frequent numerous commandos to devastate the colony. The attack and dispersion of these in August and September 1851, occasioned protracted operations, harassing work, and great loss of life amongst the troops. The Ecca Bush was the scene of the exploits of the notorious rebel Hottentot, Jan Pockbaas, who waylaid and murdered many of our men, and plundered several waggons. The Koonap Hill road through the Bush, near the Koonap Post, has also witnessed roadside robbery and slaughter, and, June last, the capture and plunder of a train of ammunition waggons, with other military stores, and the loss of a considerable number of the escort of Royal Sappers. Various affairs in the neighbourhood of Fort Brown, which is in the centre of a large bushy country, also attest the advantage taken of this cover by the enemy.

The course of the *Fish River*, after leaving Somerset, is one of the most tortuous in the whole colony, and doubles upon itself so frequently, as to completely puzzle a stranger to estimate its true course at first sight. The bends it takes amongst the hills may be, some of them, four miles at right angles to the course; and if following the stream, increasing its length by about ten miles. The river runs in a vast *valley*, bounded by grass-covered hills, which are in numerous places from twelve to sixteen miles or more apart, and it is this entire valley that is covered with bush. The boundaries of that part running due east, are the Fish River, Berg and Botha's Hill on the south, and the Fish River Rand or Caffre Berg on the north. Those of the valley running southerly are formed more by its profundity than by the rise of the neighbouring country. The Bush country above the Kat River junction is habitable for sheep-farmers, during peace time, but totally abandoned from its untenableness during the war. That part below has seldom been occupied at all, except by the military posts here and there. The Fish River Valley in ordinary seasons is almost entirely destitute of any water, except what the river itself contains, so that the *soil* is universally very dry, and in consequence almost totally unfit for agricultural purposes. In fact no good soil of any depth exists, except in the flats along the margin of the river, and that is of a sandy, reddish clay. The rest of the ground is of a stony, sandy character, the surface-stratum in large areas composed of a dark, loose, broken-up clayey slate, under which lies the substratum of hard quartzose sandstone, which forms in horizontal layers the perpendicular faces of the krantzes. Some undulating parts of the valley have ground of loose sandstone rock, with clay, and are of a yellowish colour in appearance.

Some few small tributary *streams* have their channels through the valley to the river, rising in the neighbouring high country; but the water, though running only a few miles from its sources, soon loses itself by evaporation, or sinking ere it traverses the confines of the great valley, or else begins to stagnate in pools which, in dry seasons, contain brackish water. Such is the case with the Botha's River, the Kingo, and nearly all the others. These streams, however, in a very rainy season, become torrents, and rush with impetuous velocity over their stony bottoms, coloured white with mud and debris; but this surface-water soon expends itself, the fountains not being strong. The *Fish River* itself is often stagnant, and sometimes stinking with animal refuse and vegetable remains, in long dry seasons, especially about March or October. The heavy rains in the upper country, usually falling about April and December, bring down enormous volumes of water, coloured with the red clay washed from its banks, and as thick nearly as mud itself, so that even horses and cattle will scarcely drink it. Its rise on these yearly occasions amounts to from 15 to 30 feet, in particular places flooding over its deep clayey banks, and carrying down a great quantity of bush and dead timber torn away from its banks. On such occasions the sea at its mouth is tinged and dirtied reddish for miles out and on each side along the coast, and the floated debris is deposited in banks along the contiguous beach. The rise of the river often takes place suddenly in a volume of water, which presents an elevation above the level in front; and persons disappointed of a passage across some drift now flooded, may by hard riding overtake the stream, and cross at a drift lower down. These *drifts* or fords are the intervening shallow places in the deep bed of the river, formed by banks or rocks between the several pools into which the stream is divided, when at a low standard, and are used by the farmers and cattle to pass from one part of the country to another. Passages across can be made at these spots, even when the river is up to the saddle-flaps, as the bed of the river is there known and safe. No roads lead to these drifts, which are only known to frequenters of the country: in the path leading through the bush to the brink of the river, the bush is so high that in many places one may ride under the branches, but more frequently the rider must dismount and lead his horse through. In wet seasons *vleys* or ponds of water may be found here and there in the flatter parts of the valley, or on the level ground on the summit of the eminences, but these soon become dried up in the course of a long drought. During these dry seasons the *game* of the larger kind repair to the banks of the river for water, and its margins are everywhere imprinted with the spoor of numbers of animals of various descriptions, as bucks, wild pigs, koodoos, aardvarks, &c.; and here the sportsman may, by patiently waiting in the evenings and mornings, have a chance of surprising and shooting some of these game, taking his station among the bushes on the opposite side of the river to where he observes the recent footprints. It is a circumstance of astonishment that such vast areas of land should support such quantities of bush without any visible signs of running water anywhere, which one would also imagine necessary for its numerous animate inhabitants. Deep kloofs and shady ravines are in numbers everywhere without this source of vegetation and alleviation of thirst, and where one would expect a cool rill of water to be springing out to moisten the arid ground. The succulent nature of some of the vegetation of the Bush is said to supply this deficiency to some extent to its herbivorous frequenters.

The *valley country*, when viewed from the ridge of its boundaries, presents a chaos of hills, kloofs, and krantzes, with intervening patches of more level ground, and strikes one with something like a feeling of silent sublimity at its deserted repose, its sombre dark green or brownish green appearance, according to the season, its interminable extent, and the absence of any cultivated spot of ground, or even of a house. As a part of the whole, the *valley of the Ecca*, looking east from a favourable height, presents a gradually diverging valley entirely covered with bush, some eight or ten miles long by six broad, at the termination of the view, which is closed in by the bushy hills and kloofs of the east side of the Fish River Valley at Committee's Drift. Forming the south boundary of the valley is a range of disrupted bushy hills, with intervening deep and rugged kloofs and ravines, which constituted the retreat of Jan Pockbaas and his rebel banditti. The north side of the valley is filled up by the high lands about the Grass-Kop, the sides of which are deeply broken by dark kloofs and bushy ridges. In the extreme distance at the left, and situated on the bank of the Great Fish River, may be discerned a yellow spot, Committee's Post, now untenanted since the last war.

Some undefined feelings become impressed from the reflection, that within these recesses hordes of savages have lived, and that underneath the foliage, impenetrable and insensible to the burning rays of a noonday sun, and unmoved by a breath of air, repose the leopard in his lair, and the poisonous snake in his coil, and that once stalked through it the stately elephant and the headstrong rhinoceros. One can scarcely survey it as you would a battle-field, and point out such and such spots as marked by hairbreadth escapes from, and conflicts with, savage foes, as such events here all transpire under the surface of this gloomy mantle, the personification of lifeless, perennial repose. One cannot survey it as you would a map, and point out the streams, the roads, the boundaries of property, and the habitations of men; all these, if they exist at all, are shrouded from view by the same impenetrable winding-sheet, which conceals the action of the savage passions of men and brutes, as well as any signs of the former's industrial activity. Unseen by the glaring sun has the savage butchered the unwary farmer, or tortured his captive comrade to death; unseen have his waggons been captured and plundered; and daylight in vain essayed to discern the perhaps drunken orgies of the horrid crew revelling in wanton destruction and cruelty. The spectator from a height hears the reports of fire-arms, at first sharp, and sees the eddies of blue vaporous smoke rising out of the Bush; both are now gradually dying away, and savage yells and the growling bark of dogs are taking their place; not a leaf moves, nor a living creature to be seen, and soon these signs of animate existence fail to be appreciated; and yet this is all that a spectator could record of the surprise and slaughter of a company of British soldiers by the Caffres in the Committee's Kloofs in the first September of the war. Underneath these impassive leaves, and entangled amidst impenetrable thickets, the dismayed soldiers fell rapid victims to the savage barbarity of the Caffres, and the brutal ferocity of the bloodhound (not strictly so, but a large kind of Caffre dog). There, no friendly aid, if near, could have discerned the deadly struggle or the torturing death, and have carried assistance or sought revenge. The darkness of night cannot afford a deeper screen for deeds of blood than the tangled thickets and dense foliage of the Fish River Bush. As the soldier or frontier colonist can tell you of the vicissitudes of human life that have transpired in its obscurities, so the hunter can relate his incidents of sport carried on in its recesses. He can call up to mind the herds of elephants that once quietly browsed amidst the thickets in yonder valley; can shew you the paths they had formed by their ponderous power, which led from the heights to the cool vley or pool of water in the still bed of the stream; can recal to you the huge bulk of the rhinoceros or sea-cow, reposing in listlessness in the heat of the day on the shady side of the kloof, and point out to you the path he took, and his heavy footprints in the mud on the banks of the Fish River, when he repaired to the stagnant water of the stream for his drink or his bath. He can shew you where the ostriches used in former years to pick the grass in the open glades on that flat spot of ground below. He can shew you the hill ranges in the distance, where the koodoo came out to graze in the morning, and can take you on his track through the kloof and the bush to the bank of the river, where he had drunk in the evening. He can tell you of the krantze to which he followed the leopard by his spoor from his sheep-kraal, whither the brute had carried a ewe; and recount to you the desperate struggle that resulted between his dogs and the despoiler, ere he fell to the stroke of the knife or the bullet of his roer. He can tell you of the hand-to-hand conflict that took place in yonder dark kloof between his comrade and a bush tiger, in which his friend was saved by timely assistance, but to die in a week after of his lacerating wounds.

The bush covering to this part of the country does not add variety of scenery to the confused assemblage of hills, valleys, flats, and krantzes, as it covers over all inequalities of ground with a sameness of appearance, and makes almost every kloof and koppie exactly resemble each other except in size. Its impenetrability is so great that no person is able to make any way through it, except through passages made formerly by the gigantic elephant, which are well adapted for bridle-paths, and were the only roads existing in an early state of the colony. Smaller footpaths, made by the present denizens of its cover, as the larger bucks, &c., are also available means of access to the interior of its recesses. The knowledge of these various elephant-paths forms the resource of the marauding Caffre, by which he can effect a secure escape from the pursuit of those unacquainted with the locality into the far depths of the jungle, and by which he can readily drive the plundered colonial cattle, through an apparently impenetrable country, into places of concealment in the stupendous kloofs that intersect the hilly regions of the bush belt. Even should the pursuer be close on the heels of his enemy, and the guidance of the spoor should fail in such a dry country, no means could enable him to detect cattle concealed in the kloof he looks down into except that of their lowing. Should he reach them, and capture them, he will doubtless find the plunderers missing, and nowhere to be seen; yet the Caffres, and numerous too, may still be concealed in the same kloof, secure from observation, while they are aided by the black colour of their skins affording no contrast to the gloom of the recesses they have taken refuge in. The only use of the more accessible parts of this impracticable country is the more open and level parts constituting fine pasturage for sheep—the bushes affording them abundance of food, even should the grass fail in dry seasons, but then the flavour of the mutton distinctly alters, though not by any means to a disagreeable taste. Whether fossil coal will ever be discovered in sufficiently large beds in the country as to make it available for general use as fuel, remains to be seen; but no fear need be entertained of the failure of firewood, for which the majority of this bush is only serviceable, as we have here a living coal-field unmerged as yet by a deluge. The Bush is denser and more tree-like in the kloofs, and opener on the more level and elevated grounds, where the koodoo and the buck graze, and the wild pig ploughs the ground for its food, as the open glades abound after rains with abundance of sweet grass, and other such fresh vegetable productions. This jungle is never seen to have grown, either more extended or higher, in the memory of the inhabitants of this part of the country; and no encroachments are made on it except when grass fires on the hills burn away its borders, which remain for a long time scarred and black. It is composed of numerous kinds of plants, shrubs, and trees, mostly partaking of the thorny prickly character, entangled by their own branches, and by various creepers, and rendered more impassable by thick underwood. Few trees, however, are of such a size, or of such a kind, as to furnish good timber, which is chiefly procured, for the use of the eastern districts, from the forest kloofs of the Kat River district, and those of the Cowie forest in the Mancazuna and Kaja districts, but a good proportion of building timber, as deals, is imported from England. Stunted Euphorbias grow in abundance in every direction, as well in the kloofs as on the koppies and flats, and the stately giant Candelabra Euphorbia rears its hydra-headed form above its neighbours in the deep hollows, or on the sides of the kloofs—the refuge for the hunted baboon, or the perch for the far-sighted aspvogel or hawk. Abundance of milky juice distils from incisions in its trunk, or the rupture of a branch from the stem, which very probably would furnish India-rubber or caoutchouc if the proper means were taken to obtain it, and, if successful, the material would be in abundance. The sweet-scented jasmine entwines and decorates, with numberless white flowers, the different shrubs and trees, whence the wild bee gathers its honey. Numerous bulb-like Amaryllides and Narcissus shoot up their leaves, and single-stemmed crown of flowers, after rains in the spring, from the arid ground of the lower parts of the valley. The Speckboom abundantly relieves the monotonous evergreen colour of the bush, with its lilac clustered flowers; and its succulent subacid gummy leaves, formerly afforded the principal food for the elephant, and are now partaken of by the thirsty traveller with relish, and often cooked by the native inhabitants into a kind of stew. The tops and sides of the koppies and ridges are garrisoned by stumpy aloes, with their thin bristling head of leaves, often giving the appearance of a picket or party of Caffres to patrols traversing the country during war time. The prickly Acacia covers the level lands, throwing out, when its yellow clustered flowers are in bloom, a delicious fragrance. The spear-shaped, the scentless flowers of the Strelitzia may be seen shooting up amidst their dark green elongated leaves, enlivening with their bright colours the sombre hue of the sides and heads of the kloofs. The River Bush is of a different nature to that covering the rest of the country, and marks the course of the stream distinctly to the spectator from some height overlooking the valley; it is greener and loftier, and completely overhangs the water in most places, so that one scarcely can obtain a view of the stream itself till after passing through to the bank of the river. Coarse willow trees constitute its largest bush, which is tenanted by numerous and various kinds of small birds, some remarkable for their shape, others for the beauty of their plumage; some few have notes, but the majority are destitute of any. The yellow and green *finks* may be seen disporting in multitudes amongst its branches, and entering every now and then into their grass-woven nests, hanging from the extreme twigs of the waving willow, over the surface of a still pool of the river. Clumps of the prickly pear, with their leaf-like succulent branches, studded with golden yellow flowers, into the cups of which the pretty *sugarbichi* may be seen dipping his slender subulate beak, grow here and there luxuriantly, affording rich food for the wild pigs, and giving the name of Vyge Kraal to a locality on the Fish River.

The traveller through this jungle may afar witness the heavy-winged vultures gathering from different quarters of the sky, attracted by the carcase of an ox that has been knocked up and died on the road, on which some are already eagerly gorging themselves, having the eyes picked out, and they are commencing at the entrails. At another quarter in the valley, flying in circles in the air, may be seen a crowd of eager longsighted aspvogels, scared from the carcase of a sheep by the arrival of a troop of wild dogs to snatch up the excavated remains. From that lofty time-worn krantze overhanging the river, may be heard the chattering of the huge ungainly baboon, especially in the evenings—the noise elevating itself now and then in united chorus, or interrupted by discordant shrieks, perhaps indicating the neighbourhood of the stealthy tiger, or his seizure of some unlucky member of the community for his evening's repast. The saw-filing cry of the guinea-fowl may be heard echoing from the bushy krantze near the river in the evenings, when the flock are collecting to roost. The crowing concert of the black pheasants arises from the bushy thickets along the Fish River here and there, as each covey welcomes the rising sun, and the steaming dew. The pretty notes of the *michi* and *diedrick* further enliven the growing day, and the hoopoe's voice, and the cooing of the ringdove, may be distinguished from the depths of some kloof or river thicket. That white smoky line advancing along the undulations of the bush-covered valley like the progressing margin of a grass fire, is a squadron of winged locust sin line, the hindmost of which are constantly flying over their comrades ahead, to take up the unconsumed vegetation, while they leave behind them a desert. On nearer inspection, the bushes are seen completely covered by their brownish grey bodies, heaps of which may be knocked off like snow-wreaths by the stroke of a stick, while your horse may be seen with avidity clearing another bush of its devastators. The still moonlight nights bring one familiar with the lively scream of flocks of the white and black plumaged plover, and the softer and more prolonged note of the *dickop*, which seem to emerge from their daylight concealment, and enjoy the security of searching for their food by night. The prowling wolf notifies its proximity to the sheep-kraal in rainy dark nights, by its lengthened hollow howl awakening the dogs, which answer with their frequent bark. In the season nearly every night, either on the road or at home, the jackals may be heard raising a concert of shrill cries, in answer to each other in the distant bush. Fire makes no deep impression on the everlasting verdure of the bush; and if a grass fire stretches to its margin, it merely consumes the little at its edge that is of a more open character, but never penetrates into the recesses of a kloof. In every respect there seems the character of eternity implanted on it. No one knows how, or where, or when, it began to grow; no one has witnessed its increase in any way, no one its decay; no fall of the leaf takes place to any appreciable extent, the foliage only undergoing in the winter season a brownish shade of colour. Inconsumable by fire, waveless by the wind, unharmed by the torrents, unchangeable in every vicissitude of season, having neither youth nor age imprinted on it, it partakes more of the character of a stratum of the surface of the earth than anything proper to organic life.

(*To be continued in our next.*)

Singular Irridescent Phenomenon seen on Windermere Lake, October 24, 1851. By J. F. MILLER, Esq. Communicated by the Author.

On the 24th inst. (October) a very remarkable irridescent appearance was seen on Windermere Lake by a gentleman,

(J. C. Mounsey, Sunderland) from whose written description I have gathered the following particulars:—

"The morning was very misty, and the barometer high (30·35 Whitehaven); between 10 and 11 A.M., the mist cleared off, the sky became cloudless, and the air calm, the Lake being of a glassy smoothness. At 11^h we went on the lake, and, in about half an hour I observed brilliant prismatic colours on the water near the shore, say half a mile or more distant, but no appearance of a bow. I rowed towards the spot, and, in doing so, the colours increased in extent and brilliancy.

"There were two bows, which resembled ordinary rainbows inverted; both were exceedingly brilliant at the extremities, and became gradually fainter as they receded from the shore.

"The outer bow came completely down to the boat, which appeared to prevent our seeing the crown of the arch; its extremities also proceeded from the shore, and its centre was apparently under the feet of the spectator. In both bows, the red was on the outside and the violet on the inside, and, in both, the light and colours were most brilliant and distinct at the extremities, or points of conveyance at the water's edge. I am certain there was no rainbow in the sky at the time, neither was there any solar halo or any other phenomenon in the air that I observed, of which this could be the reflection. I observed that, wherever the prismatic phenomenon shewed itself, there was a sort of scum on the water, as though there was some fine dust or bubbles on the surface. I put my finger into the water, and found it so dirty as to leave a distinct mark behind, which leads me to think that what I at first took to be small bubbles must have been some sort of dust. Whatever it was, it appeared to me to be the cause of the irridescence, as, wherever it was lost, the bows disappeared.

"The bows were visible about an hour, and, in looking at them, the sun was, of course, directly behind the spectator.

"The boatmen say, they have sometimes (though very rarely) seen a similar phenomenon after the disappearance of a mist from the surface of the water." At Whitehaven, the sky was also cloudless, but in the evening the air was misty.

Dr Davy considers that the carbonaceous deposit or soot-like film occasionally observed on the lakes of Westmoreland, is really of the nature of soot, derived from the adjoining manufacturing districts, wafted thither by the wind, and falling with the mist or light rain. The film burns in the same manner as soot, sinks when wet in water, imparts a brownish hue to transmitted light, and, under the microscope, appears to be composed of particles more or less irregular in form, varying in size from $\frac{1}{4000}$th to $\frac{1}{1000}$th of an inch. Dr D. further thinks that the precipitation is an ordinary rather than an uncommon occurrence here, as is shewn by the discoloration of the sheep of the country, especially after exposure of many months on the higher fells. Seen on the mountain pastures, or, when driven into the lower meadows in the early spring, their coats are of so dark a hue, as to resemble closely those of their fellows fed in the most smoky precincts of our great towns; and, on examination, the colouring matter staining the fleece is found to be similar to that of the black film of the lakes and tarns, and, in brief, it is essentially soot.*

J. F. MILLER.

OBSERVATORY, WHITEHAVEN,
April 1853.

On the Paragenetic Relations of Minerals.

(Continued from page 323 of vol. liv.)

Although with regard to the majority of minerals and rocks which present a porphyritic structure, the inference to be drawn from the before-mentioned facts is, that the formation of the imbedded substances has been subsequent to that of the entire mass, and probably even to the perfect solidification of the matrices, it is undoubtedly necessary to take a different

* Edinburgh Philosophical Journal for January 1852, p. 64, and private letter from Dr Davy.

view of the origin of conglomerates generally, and likewise of some porphyritic masses.

The formation of ice upon ploughed land, and at the bottoms of rivers, appears to furnish a very instructive illustration of the mode in which conglomerates are produced. When after long-continued rain a frost sets in, ice is rapidly formed between the lumps of earth which are thus gradually separated from each other. The formation of ground ice in rivers commences in a similar manner between the pebbles, and in both cases a kind of conglomerate is produced in which the cementing substance is ice. At the present time a conglomerate is gradually forming in the bed of the Neckar in a precisely analogous manner. The water of this river contains carbonates of magnesia and lime in solution, and these substances are deposited in the form of dolomite between the pebbles, separating them from each other, and cementing them together.

Immediately above the brown coal at Klein Augesd, near Teflitz, there is a bed of quartz pebbles cemented together by iron pyrites. There can be no doubt that this bed is more recent than the underlying coal, and that the iron pyrites is more recent than the overlying bed of clay. The pyrites has here been formed by the reducing action of the coal upon ferruginous solutions filtering through the clay, and being deposited between the quartz pebbles, has gradually pushed them apart, and cemented the whole into one mass.

In the neighbourhood of Freiberg, a sandstone is now being formed from the sandy refuse of the ore washing. This refuse contains iron pyrites, and the oxide of iron resulting from its decomposition cements together the siliceous particles in such a way that hand specimens of the mass cannot be distinguished from an ordinary ferruginous sandstone.

In the alluvium of Meronitz (Bohemia), iron pyrites has been deposited between fragments of pyrope, forming a conglomerate on a small scale. The cementing matter of the pyrope is sometimes green opal, and more rarely gypsum.

Judging from the phenomena of imbedded nodules, it appears, as Fournet has very justly remarked, that many stratified rocks cannot always have possessed the same state of cohesion and density which they now present. Where the geognostic characters of rocks put their sedimentary origin beyond all question, it must not be supposed that their formation consisted solely in mere mechanical deposition; on the contrary, it seems that in such cases chemical action has not commenced until this has ceased. If, then, this is true of the secondary and tertiary rocks, it is still more probable with regard to those of more ancient date, which, there is good reason to suppose, remained for long periods in a softened condition.

The conglomerates occurring in lodes, although not essentially different, have been produced under somewhat modified conditions. In this case, it is generally fragments of the adjoining rock which are imbedded in one or more crystallised minerals. In the lodes near Freiberg, fragments of mica-slate are found entirely imbedded in crystalline quartz, and large masses of gneiss, perfectly detached from the adjoining rock, are found, especially near the roofs, covered with the various minerals composing the lode, and arranged in the same order as at the true saalbands. In the lodes of Schlottwitz, near Dresden, which have suffered repeated dislocations, very sharp-edged fragments of band agate are cemented together, and as it were imbedded in amethyst. The lodes of red hæmatite in the upper Erzgebirge have suffered similar dislocations, and fragments of this mineral are now found imbedded in quartz.

In all these instances, it appears obvious that the imbedded substances are older than the matrices, and it is probable that the same view must be adopted with regard to that class of agates which are surrounded by a crust of porphyry sometimes of essentially different character to the mass in which they are imbedded. These porphyry-agate balls were perhaps originally adventitious fragments of another rock. Hot aqueous vapour or other gases may have removed some of their constituents, and left the silica in a hydrated opaline state. There are some facts which greatly favour the opinion that quartz has been formed by the contraction and dehydration of opal. For example, in the lodes at Johanngeorgenstadt (Saxony), small masses of white opal occur imbedded in hornstone, close to somewhat larger quartz druses in the same hornstone. These quartz druses are perfectly closed, and sometimes covered with an exterior crust of opal, and, when broken, are found to contain water. It is therefore highly probable that these agates, which differ widely from those formed by infiltration, have been formed by the contraction of opal.

The occurrence in eruptive rocks of imbedded masses, undoubtedly adventitious, and whose original condition may in some instances be recognised, is very frequent. The so-called basalt jasper consists of fragments of some foreign rock. The sandstone of the "Blauen Kuppe" (Hesse Cassel) is more or less altered at its contact with basalt approximating in character to basalt jasper. The basalt jasper of Johanngeorgenstadt, and that near Eisenach, are more homogeneous, but streaks resembling those of the gneiss from which they have originated are still perceptible. At Hohen Borkenstein (Bavaria), the fragments of basalt jasper contain crystals of felsite which communicate to it a porphyritic appearance. It is, however, very probable that the alteration of rocks, consisting chiefly of silica and alumina, into basalt jasper, has not been caused by volcanic heat alone, but perhaps more essentially by the introduction of substances from the basalt.

These facts will sufficiently shew, that with regard to the phenomena of adventitious admixtures no definite mode of association can be recognised, it being entirely a matter of chance that an eruptive rock tears away and encloses fragments of those through which it penetrates, nor have these phenomena any further connection with the present subject, than as serving to prove that the substances imbedded in mixed rocks or simple minerals may be of very different origin, and that any exterior resemblance, especially of form, is insufficient by itself to justify the inference of a similar mode of formation. Thus, the nodules of olivine and basalt jasper occurring in basalt, and alike both in shape and size, have certainly originated by very different processes.

In some rare instances the matrix of a porphyritic rock would appear to be the most recent. Both Darwin and Credner mention the occurrence of broken felsite crystals in granite, and Nöggerath has observed them in trachyte. In a lava at Etna, crystals of pyroxene have been found collected together at the under surface, as if they had sunk. However, it is probable that these facts will not admit of any other inference than that there was some interval between the soldification of the matrix and that of the imbedded substances. On the other hand, there are mixtures of minerals presenting a porphyritic appearance, of which the matrix is undoubtedly of much later date than the minerals it contains. Quartz very frequently contains tourmaline, sometimes in crystals, though never perfect ones. The terminal planes at one end of the crystal may be perfect, but the other end is always broken. It is most frequently found in fragments, sometimes even curved and cracked, and the quartz is found to adhere more strongly to the electro-negative pole of the fragments. When there is a preponderance of tourmaline in this mixture, it is called tourmaline rock or schorl. It often contains cassiterite very finely disseminated throughout its mass; and, besids other localities, it occurs in Cornwall. In this mixture, the quartz must be the more recently formed, for whenever definite crystals of quartz and tourmaline are associated in druses, the quartz is always implanted upon the tourmaline. It is therefore extremely probable that this rock was formed by a deposition of silica in an opaline condition around tourmaline crystals, and that on its subsequent conversion into quartz, the crystals were broken by the contraction of the siliceous mass.

Fragments of some species of epidote occur imbedded in quartz in a precisely similar manner. The contortions and fractures of these fragments are sometimes very marked, as in the magnesian epidote of St Marcel, the zoisite of the Tyrol and Carinthia, &c. It is further probable that the so-called epidote rock is precisely analogous in point of formation to the above-mentioned tourmaline rock. Quartz, when associated with epidote in crystals, is always implanted upon it. The epidote and quartz veins in the diorite of Neustadt (Saxony), of the Labyrinth Berge (Bavaria), the druses from Arendal (Norway), Bourg d'Oisans, Pitkarand

(Russian Finland), and all other localities, without any exception, furnish evidence of the more recent formation of the quartz.

The same remarks apply to beryl, fragments of it occurring imbedded in quartz (America and Siberia), while it appears of anterior formation to the quartz with which it is associated in druses. When definite crystals of topaz and quartz are associated together in druses, as in Siberia and Saxony, the latter always appears as the more recently-formed mineral; but there is in the collection of Prince Lobkowitz a large crystal of quartz from Capo di Villa Rica (Brazil), containing an imbedded fragment of topaz.

Near Krageroe (Norway), fragments of amphibole occur imbedded in a reddish white felsite, which is probably pegmatolite.

Wherever wolframite and scheelspar are associated, the latter must be regarded as a product of the decomposition of the former, which is always the older mineral. When they form twins, the wolframite is never in a perfect state at the points of contact. However, a large mass of scheelite from Schlaggenwald (Bohemia), contains imbedded fragments of ferro-wolframite crystals, the edges of which are somewhat broken. This mineral has recently been met with in a similar manner in iron pyrites at Schneeberg; while, in other places, iron pyrites appears as the more recent mineral, being implanted upon the wolframites.

The following table comprises the most important instances of porphyritic structure, either in simple minerals or in those rocks which, like basalt clay-slate, appear to the naked eye to be homogeneous. Among the sedimentary rocks are some which, like astrite-slate, talc-slate, &c., cannot be regarded as such in their present state :—

I. Porphyritic Minerals which do not occur as rocks :—

	Substances imbedded.
Calcite, . . .	Mica.
Apatite, . . .	Cryptolite.
Chlorite, . . .	Garnet, scheelite.
Lepidomelan, . .	Black amphibole.
Sanidine, . . .	Apatite, hauyne, nosean, nepheline, meionite, melanite, zirkon, titanite, ilmenite.

Labrador, . . .	An astrite, corundum.
Lode quartz, . .	Pyrophylite, iron pyrites, and a great number of the metalliferous minerals occurring in lodes.
Garnet (aplome), .	Scapolite (Arendal.)
Garnet (rimosus), .	Ilmenite.
Agalmatolite, . .	Diaspore.
Iron pyrites, . .	Glassy actinolite, quartz with a fatty lustre and in rounded crystals (Bodenmais, Bavaria), gelbnickelkies (Dillenburg, Nassau).
Copper pyrites, . .	Aplome, iron pyrites, tesseral pyrites, heavy cobalt glance.
Magnetic pyrites, .	An amphibole, iron pyrites, copper pyrites.
Copper glance, . .	Iron pyrites.

II. Sedimentary Rocks:—

Rock salt, . . .	Glauberite, anhydrite.
Gypsum, . . .	Rock salt, crystals of gypsum, tharandite, arragonite, boracite, quartz, iron pyrites, sulphur.
Crystalline limestone, exclusive of the primitive limestones,	Calcite, meroxene, wollastonite, couzeranite, glassy actinolite, pyreneit, magnetite, iron pyrites, heavy cobalt glance.
Compact limestone without lustre, likewise as marl, . .	Calcite, coccolite, quartz, iron pyrites, sulphur.
Dolomite, . . .	Dolomite, tremolite, tourmaline, corundum (Airolo, Switzerland), iron pyrites.
Anhydrite, . .	Rock salt, boracite, sulphur.
Astrite* slate, . .	Dolomite, breunerite, apatite, talc, glassy actinolite and other amphiboles, pistacite, diopsid, garnet, beryl, several tourmalines, titanite, magnetite, iron pyrites, mispickel.
Talc-slate—the absence of quartz is here likewise remarkable,	Dolomite, breunerite, glassy actinolite, disthene, galenite, dichroite, and pseudomorpus derived from it, as fahlunite, magnetite, iron pyrites, arsenical pyrites.
Hornblende slate (quartz absent),	Garnet, magnetite.
Clay slate, . .	Amphibole altered to substances resembling serpentine and alusite, generally in the altered varieties called chiartolite, iron pyrites, mispickel, leucopyrite, gold.

* Breithaupt applies this term to the astrite or mica, with one optical axis, which occurs as a rock without being in all cases chlorite. The chlorite slate is included. Quartz is usually altogether absent.

Serpentine is in all cases a product of the alteration of either eruptive or sedimentary rocks. The minerals imbedded in it are usually pseudomorphous, as, for instance, phastine, which has undoubtedly originated from bronzite.

III. Eruptive Rocks. In these the absence of quartz and phengite is very remarkable :—

Basalt, . . .	Astrite, hauyne, sanidine, oligoclase (near Predazzo, Tyrol), basaltic amphibole, bronzite, augite, zirkon, corundum, olivine, ilmenite, magnetic pyrites.
Phonolite, . .	Nepheline, sanidine, basaltic amphibole, semeline, ilmenite.
Compact felsite (the most frequent porphyry), . .	Astrite (rare), liebenerite, pegmatolite, oligoclase, pistacite, quartz, iron pyrites, gold.
Pitchstone, . .	Astrite, sanidine, quartz.
Obsidian, . . .	Sanidine.
Pyroxene (augitic) lava	Astrite, sodalite, leucite, sanidine, Labrador pyroxene, olivine, hyalosiderite.

The last two rocks, which have undoubtedly been formed at a very high temperature, are free from either amphibole or quartz.

Although clay-slate was considered above as a relatively homogeneous rock, it is, with the exception of that which lies above graywacke, undoubtedly in the greater number of instances, a very intimately mixed crystalline mass, probably identical in most respects with mica-slate and gneiss, and as such to be included among the mixed rocks.

There can be no doubt that granite is chiefly eruptive, both on account of its geognostic position and frequent penetration of schistose rocks. However, the assumption that it has been in a state of igneous liquidity, is attended with great difficulties, although it is true that felsite may be formed at a very high temperature. The temperatures at which the mineralogical constituents of granite fuse, differ too widely to admit of the supposition that they were formed from a melted mass. Again silica, when heated with basic silicates, readily enters into combination, forming neutral or acid salts ; thus the slags from iron furnaces consist of bi- or tri-silicates, and contain uncombined silica only when there is a great excess in proportion to the bases. The slags of the Freiberg furnaces, formed at a much lower temperature, consist only of neutral and basic silicates, or, if there is a large quantity of silica, of bisilicates. It is further remarkable that quartz is never met with in rocks which have undoubtedly been formed by igneous fusion. However, the mica in granite is not only fusible at a comparatively low temperature, but is likewise in most cases a neutral silicate.

While, then, there is little difficulty in regarding rocks, consisting solely of silicates, as products of melted masses, the case is very different with rocks containing both quartz and neutral silicates. Some kind of hydrated pasty condition is perhaps more easily conceivable with regard to them, and at the same time their geognostic relations and transition into gneiss, mica-slate, &c., must not be overlooked. Granite is most frequently found to penetrate these rocks. More rarely it forms beds conformable with mica-slate; and although these are declared to be the result of injection, there is sometimes difficulty in perceiving from whence the granite has been derived,—as, for instance, between Penig and Wolkenburg (Saxony), where there is no granite in the immediate vicinity of the mica-slate. Further, lavas and basalt contain no quartz, and the felsites met with in them are seldom or ever of the same species as in granite. Pegmatolite has never been found in basalt phonolite or lava, nor sanidine or ryacolite in gneiss.

It must likewise be remembered, that it still remains problematical whether the rocks possessing a schistose structure are to be considered as the most ancient. There is, indeed, some considerable probability that they are not of sedimentary origin, for it may be supposed they were formed by the solidification and scaling of the primitive liquid or pasty mass of the earth at the surface, and that granite was formed more slowly in the less agitated layers at a greater depth. Durocher, however, says that it is in Scandinavia that we might expect to find among the rocks of the greatest antiquity the true primitive granite, which perhaps formed the original solid surface of our planet. But gneiss is nowhere found resting upon granite which we can venture to regard as more ancient than itself.

The rocks in contact with granite are not in all cases disturbed or penetrated by it. There can be no doubt that the perfectly undisturbed strata surrounding the granitic mass at Aue, near Schneeberg, were formerly continuous. Their place, however, is now occupied by granite. The fact, that at the surfaces of contact of these strata with the granite, there is a great preponderance of quartz crystals, those seated upon the slate being remarkably large, and projecting into the granite, as from the saalbands of a lodes, is a sufficient proof that this change consisted, not in any actual fusion of the rock, but merely in a softening which permitted a new chemical adjustment of the elements. It is not at all improbable that the primitive mass from which this group of rocks was formed was still liquid at some depth, and that when, from some cause, the gneiss was again softened or rendered pasty, it assumed, upon after solidification, the form, not of gneiss, but of granite; for, during this second solidification, at a depth below the surface, the mass would have been beyond the influence of those disturbing causes which have already been alluded to as probably inducing the stratification of gneiss.

All the members of this group probably resemble each other as much in regard to the temperatures at which they were formed as they do in date. From the analogy, in all essential points, between granite and granulite, granite and gneiss, granite and mica-slate, there is no ground for assuming that one was of igneous and another of aqueous origin.

The differences presented by the individual rocks of this group is but a very slight obstacle to the opinion that they have originated from the same primitive mass, especially when it is remembered how greatly the petrographic character of granite or gneiss varies, even in the same mass; that the occurrence of certain accessory constituents is confined to particular spots; and that they all pass into each other according to the presence or absence of one or other of these constituents.

The views entertained with regard to the sedimentary members of the group of crystalline rocks are very different, and even opposite. That which regards them as altered metamorphic rocks, has recently gained ground, although without being in itself very definite; for, while some geologists assume that erupted rocks originated from the agglutination, and even fusion, of sedimentary deposits, others consider that erupted masses have effected the metamorphism of sedimentary rocks. Taking into consideration the contact phenomena so abundantly made known by Murchison, the latter appears to be most probable; but it is not applicable to all kinds of gneiss, mica, and clay-slates, which are so frequently in contact with granite, syenite, &c.; and in those cases are most probably primitive, as their mineralogical analogy with those rocks is very close.

The accessory constituents occurring in the principal rocks of this group are the following:—

Rocks.	Accessory Constituents.
Gneiss, .	Oligoclase, disthene, garnet, tourmaline, dichroite (only in certain conditions, such as contact with granite), rutile, allanite.
Mica-slate, .	Chlorite (associated with the usual mixture of quartz and phengite,* forming a quite peculiar kind of mica-slate (between Falkenau and Schellenberg, Erzgebirge), amphibole, disthene, garnet, tourmaline, and alusite (it is remarkable that this mineral is almost always accompanied by fibriolite), staurotide, magnetite, allanite, iron pyrites, gadolinite, gold, graphite.

According to Durocher, the occurrence of many crystallized minerals imbedded in the gneiss and mica-slate of the Scandinavian peninsula is limited to the granite and amphibole dikes penetrating these rocks. The principal minerals contained in these rocks, and apparently connected with the phenomena of metamorphism, are amphiboles, pyroxenes, garnets, epidotes, disthene, dichroite, tourmaline, beryl, topaz, apatite, titanite, rutile, and graphite. He excludes gadolinite and orthite, which are undoubtedly quite independent of gneiss, and occur only in coarse-grained granite dikes.

Granite, .	Apatite, monazite, astrite, nepheline, petalite, pegmatolite (in crystals), amazonite, oligo-

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* It is, however, very rare to find astrite and phengite associated in the same rock.

clase* (perhaps always accompanied by pegmatolite, and surrounding it in a wreathlike manner), tetartine, labrador, spodumene, epidote, disthene, garnet, zirkon, beryl, tourmaline, topaz, chrysoberyl, titanite (when this mineral occurs, the granite is always very poor in mica), pyrochlor, magnetite, cassiterite, ilmenite, spessartite, specular iron, iytteroilmenite, mengite, columbite, tantalite (always accompanied by the prior formed beryl), æschynite, orthite, gadolinite, euxenite, iron pyrites, graphite.

The occurrence of molybdanum glance has also been recorded, although it probably occurs only in fissures. No kind of rock presents such an abundance of accessory minerals as granite. Some which, like corundum, arsenical pyrites, gold, &c., are questionable, have not been enumerated.

Syenite.—This rock, consisting essentially of felsite-mikroline, pegmatolite or labrador, and black amphibole, has been frequently confounded with gabbro and hypersthene rock, when the amphibole was regarded as pyroxene. Syenite has probably been formed at a somewhat lower temperature than dolerite, diabase, nepheline rock, basalt, &c., as the formation of amphiboles does not require so high a temperature as the pyroxenes, with the exception of spodumene. Most of the accessory minerals contained in syenite occur also in granite, and these rocks are sometimes seen to pass into each other.

Besides those modes of occurrence of minerals already spoken of, as indicating, in the greater number of instances, some sort of segregative formation, there are others which resemble them in this particular, although presenting different petrographic features. Among these are the masses of a mineral, or most frequently of several minerals, which may be essential constituents, or accidental admixtures, of the rock in which they are imbedded. The outlines of these masses are not very well defined, but they are remarkable for the perfect character of the minerals which compose them. Some few present a considerable resemblance in one particular,—the mineral species—occurring with masses of primitive limestone (Kalkstöcken); and, notwithstanding other

* Apparently a much more frequent mineral than was hitherto supposed.

differences, it is possible that their modes of formation were analogous.

It can scarcely be doubted that these minerals have crystallised out from the mass of the rocks; they have even formed druses in which a definite succession of species may be recognised. It is moreover probable that they were originally in a viscous state, and that the drusy cavities were formed in consequence of the contraction on cooling and crystallising.

These masses of minerals are in every respect connected with porphyritic rocks and those nodular masses which may be regarded as the result of contraction. There are, however, such masses of minerals which from their magnitude cannot be examined on all sides,—in Scandinavia for instance;—and it is a question of some difficulty whether these are not plutonic injections.

In the schistose rocks, masses of crystallised minerals sometimes present a similarity to beds, and perhaps many of the deposits of minerals which are regarded as beds of small extent are in reality the result of a segregation of chemical constituents subsequent to the formation of the true strata. The facts which have been observed in connection with these masses of minerals, afford additional evidence in favour of the view already expressed, that in the formation of rocks mechanical accumulation has been followed at some period by a chemical re-adjustment of the constituent molecules, giving rise to those physical and mineralogical characters which they now present.

Another mode of occurrence of minerals, connected, as regards their origin, with the porphyritic structure, is presented by the so-called divergent zones—accumulations of minerals which are so situated as to intersect at an acute angle the planes of stratification of the schistose rocks. Some of the most remarkable mineral deposits of Scandinavia belong to this class. Their origin is obscure, but Professor Breithaupt is of opinion that they were formerly lodes, which, together with the rocks in which they are situated, have suffered metamorphism,* thereby losing their sharp lines of demarcation,—the saalbands.

* With regard to the metamorphism of rocks there appear to be good grounds

These divergent zones frequently contain the same minerals as the above-mentioned masses and the primitive limestone. In the divergent zones of cobalt glance in very quartzy gneiss at Skutterud (Norway), a brown phengite mica occurs in a very characteristic manner. It is, however, less abundant in those parts of the zone containing amphibole, which is chiefly associated with arsenical pyrites. It is not an improbable conjecture that these deposits of cobalt glance were formerly lodes containing spathic iron, spies cobalt, iron and arsenical pyrites, which in the general metamorphism were converted into magnetite, cobalt glance, and tesseral pyrites. A number of instances prove that in metamorphic rocks amphibole is very abundantly associated with the more ferruginous minerals—a circumstance to which Durocher has specially drawn attention.*

These zones are sometimes interrupted apparently as though the substance of the pre-existing lodes had collected together in masses during the metamorphism. The deposits of magnetite in Scandinavia present these characters, and at Arendal they contain phrenite and datolite minerals, which otherwise occur only in lodes and vesicular cavities. It is likewise probable that the deposits of copper pyrites and galena in Scandinavia belong to this class, as well as deposits of pyrites, blende, and garnet, in the Upper Erzgebirge, the Banat Servia, &c., which present great analogies to those of Scandinavia.

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for the opinion that there are two kinds, the one giving rise to the production of definite minerals, the other consisting in an alteration, more or less complete, of such minerals into substances which are not strictly speaking mineral species. In the former process, although thermic agency may occupy an important place, it is perhaps more advisable to apply to it the term plutonic, which admits of a wider signification. The latter process, in which water appears to be a principal agent, takes place chiefly in limestone rocks; those consisting essentially of amphibole and felsite (dioritic), and those consisting of pyroxene and felsite (greenstones) producing pseudomorphous hydrated silicates, among which, as regards frequency, serpentine takes the first place; then follow pyrallolite, praslite, gigantolite, aspasiolite, phastine, and all the ophitic substances. Most of the asbestus occurring in veins in serpentine and diorite, was most probably at some period amphibole or pyroxene.

* Etudes sur le metamorphisme des roches. Bulletin de la Societé Geol. de France, 2^{e} ser., tom. iii.

The same remark applies to the beds of brown iron ore in the zechstone of Thuringia, which consist chiefly of altered spathic iron—accompanied, when this was manganiferous, by the usual varieties of wad,—tile ore, and copper pecherz, malachite and copper lazure, resulting from the alteration of copper pyrites, and even unaltered copper pyrites and fahlerz. The only difference is, that the metamorphism in this instance would have been aqueous. If this is really the case, these Thuringian deposits would correspond with the very frequent lode formation bearing spathic iron, heavy spar, copper pyrites, &c.

The so-called primitive limestone and dolomite occurring as true beds in the older rocks, are objects of particular interest to the geologist, and their origin has not yet been satisfactorily explained. They differ from the ordinary limestones and dolomites, in containing imbedded in their mass silicates and aluminates, as for instance the Teufelstein (Saxony), in which even garnets and epidotes occur. But the same kind of white crystalline limestone, sometimes passing into granular calcite, occurs in enormous masses, generally without any very definite outlines, and in their general characteristics somewhat resembling lodes, as well as in smaller masses which differ still less from true lodes. They moreover present a remarkable abundance of imbedded minerals. Various opinions have been entertained as to their real nature and origin. Their analogy to lodes is in many instances indisputable, as for example at Wünschendorf, Lengefeld, Boden, Miltitz, Tharand, &c. (Saxony), at the Bergstrasse on the right bank of the Rhine, and the Cipollino-stock at the Kaiserstuhl (Baden), in the centre of a volcanic cone. This perhaps applies equally to the similar masses of limestone in Scandinavia, Finnland, the Banat, Servia, the Alps and the Pyrenees, as well as to the red limestone of the island Tyrie. It is indeed probable that the masses ejected from Vesuvius are derived from such a mass of limestone. Finally, the crystalline limestones of North America, so rich in beautiful minerals, must be included in the same class.

In these lode-like masses there are no layers parallel to the saalbands, but the entire mass is granular, almost always pure white, with the various minerals distributed irregularly throughout. Druses are sometimes met with, and in those instances definite successions of mineral species are recognisable. Sometimes relations of age may be detected in the groups of minerals surrounded by limestone. Upon the whole, however, it would appear as though the minerals had been formed almost simultaneously.

It may be inferred from these circumstances, that the entire space occupied by such a mass was at once filled with a chaotic mixture, from which the various minerals gradually separated. The conjecture is therefore natural that the lime and magnesia were not erupted as carbonates, but as a caustic, and probably pasty mass, which, acting upon the adjoining siliceous rocks, gave rise to the formation of new silicates, aluminates, titanites, together with such other minerals as fluor spar, apatite, anhydrous iron ores, magnetic pyrites, and graphite. With regard to these masses it is impossible to assume that the formation of these minerals has taken place by a gradual infiltration of solutions. Many of the minerals have suffered subsequent alteration,—amphiboles, pyroxenes, &c., have been converted into serpentine and other ophitic substances.

Professor Breithaupt regards as untenable the view put forward by Mr Dana* of the formation of these primitive limestones from coral beds by a metamorphic action of hot sea-water. The circumstance which appears to be most strongly opposed to that view is, that in Europe at least the primitive limestone occurs in rocks which are much older than the coralline limestones. In many instances, moreover, their eruptive origin cannot be doubted, and this cannot be reconciled with their formation from coral beds.

Quartz occurs in these limestones but very rarely, a circumstance which appears to follow naturally from the presence of lime and magnesia with which it was capable of combining.

While the interpretation of the last two classes of phenomena presented very serious difficulties, those which now come under consideration—vesicular cavities, and the minerals they contain—are far more intelligible.

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* Silliman's Journal 844, p. 135.

The artificial substances which most resemble rocks are undoubtedly the slags of smelting furnaces and glasses. Many of the former are incorrectly regarded as uncrystalline, and those which are sub- or mono-silicates, although in large pieces their fracture is conchoidal, almost always possess a granular crystalline structure. The higher silicates are generally true glasses. Both in the one and the other, vesicular cavities occur very commonly, which are considered to have been caused by the disengagement of gas during their formation.

Many lavas, especially those of active volcanoes, are closely analogous to these slags and glasses, and are quite as vesicular as the crystalline slags of the Freiberg and other silver works. Obsidian, a true natural glass, is almost always vesicular.

In the lavas belonging to more remote, although historic periods, minerals are now and then found, whose chemical nature does not admit of their being regarded as original constituents. Thus, for instance, gypsum and vivianite, $Fe\ O\ 3\ Po_5\ 8\ H\ O$, which it cannot for a moment be doubted are relatively of very recent formation. Crystals of gypsum are likewise met with in the vesicles of the slags from the Muldner Hütten (Freiberg). Moreover, the greater part of those rocks in which interesting associations of minerals in vesicular cavities are met with, are eruptive rocks. It may therefore be fairly inferred that the formation of these cavities is owing to a disengagement of gas. These vesicular rocks, at the same time, almost always possess a porphyritic structure; but, what is still more remarkable, they are seldom met with in the state in which it is probable they formerly existed. They are frequently disintegrated, the fracture generally dull, they present no distinctive mineralogical characters, and may have been basalt, melaphyr, trachyte, diorite, or perhaps lava, dolorite, &c. Amygdaloids likewise are very rarely fresh rocks. Even furnace slags are altered when not piled up in heaps, from which the meteoric water can readily run off. The originally sharp-cornered fragments break down and cohere, forming in the course of time a compact mass, which frequently does not resemble the original substance in any single character. The atmospheric influence is here evident in the course of from 50 to 200 years, and Professor Breithaupt considers that this long-continued influence may have converted many rocks into substances quite different from what they were at their original solidification.

Generally speaking, fresh unaltered phonolite is not vesicular, but only slightly porous, and scattered blocks of it are then only superficially weathered ; vesicular phonolite, on the contrary, is scarcely anywhere met with in a fresh state, but is decomposed throughout. Struve shewed that the weathered crust of phonolite had lost its potash and soda. E. G. Gmelin's investigation of phonolite shewed that it consisted of a zeolitic substance, soluble in acids, and a silicate having the composition of felsite, insoluble in acids, and further, that in the vesicles and veins the former was more or less wanting, sometimes entirely so, while these vesicles and veins contained natrolite, which cannot be regarded as of simultaneous formation with the phonolite, but has probably been formed by the extraction of the rock by water. Walterhausen states that the zeolites of Iceland generally occur in a crumbled earthy bed of decomposed rock, and that the calcite occurs there in the same manner.

It is probable that the vesicular cavities in rocks have not in all instances been produced at the original formation of the rock. Pearlstone, pitchstone, and some felsites, become vesicular when heated.

Cavities resembling vesicles have likewise sometimes been formed by the decomposition and removal of imbedded nodules,—as for instance in basalt,—by the decomposition of the olivine.

The substances which are contained in these vesicular cavities are generally of subsequent date, and have most probably been formed by an extraction of the rock. In some agates, this mode of production is almost obviously indicated by the structure. The vesicular cavities containing zeolites, heavy spar, calcite, phrenite, and copper and quartz, differ from those containing agate, in not presenting the point of infiltration so characteristic of the latter. This would appear to indicate that the substances have been introduced in a different manner in the two cases. They could not have been poured into the cavities at one point, but must have been as it were secreted into them. Where the vesicular rocks are traversed by lodes, it is probable that mineral substances have been transferred from them into the vesicles; thus, at Annaberg (Saxony), metallic bismuth occurs in the vesicles of a rock near to a lode bearing cobalt, nickel, and bismuth minerals.

It is, moreover, probable that the segregative attraction of homogeneous particles—which has already been alluded to in speaking of the formation of pyrites,—may have contributed to the formation of minerals in vesicular cavities.

The green earth so frequently met with in vesicular cavities is most likely a product of decomposition, apparently of a mica, rich in protoxide of iron.

When aluminous and non-aluminous zeolites occur together, the latter are always the more recent. When non-aluminous zeolites are accompanied by calcite, this is the more recent.

Although the varieties of felsite, especially sanidine, occur so frequently as essential constituents of amygdaloid rocks, no kind of felsite has ever been met with in a vesicular cavity. But the most frequent aluminous zeolites contain the constituents of felsite *plus* water, consequently there is great probability that they have been formed, in many instances at least, by the decomposition of felsites. Indeed, desmin, decidedly the most recent of these zeolites, has a great crystallographic analogy to felsite.

Zeolites have never been found imbedded in a porphyritic manner in any undecomposed rock, and this circumstance agrees with the view that they have been formed by an extraction of the rock by water; for in such case, the new products could only be deposited in the vesicles or fissures.

The definite successions of minerals in vesicular cavities are the same as those observed upon lodes; there are, indeed, instances of lodes and vesicular cavities occurring in the same rock, both containing the same minerals and in the same order of succession.

Among geological phenomena, those presented by lodes are probably second to none in interest, both in a scientific and practical point of view. As the form and origin of lode fissures are treated of in all elementary works on Geognosy, they may here be considered as already known.

The crystallisation of the minerals in lodes has not always commenced from the saalbands, but, in some few instances, from the middle of the fissure.

It is a remarkable circumstance that some lodes have no out-crop; and although sometimes this may be owing to a subsequent formation of rock above them, there are instances in which this view is inadmissible. Moreover, many lodes which do crop out gradually increase in thickness downwards.

It is a well-known fact, that the lodes in one particular district have a more or less parallel direction, and those which intersect at any angle either do not correspond at all in their contents, or less than those which are parallel.

Upon inquiring into the probable causes by which lode fissures have been filled with minerals, it is at the outset evident that they must have been very various. When a lode contains only the same series of minerals constituting the rock traversed by it, this rock is, with few exceptions,* the source from which the substance of the lode has been derived,—for instance, veins of calcite in limestone. When veins of one rock traverse another—basalt in sandstone—they are of eruptive origin. However, these are less frequent than those which traverse only one kind of rock, in which the minerals of the vein or lode either do not occur at all, or only in very small proportion.

The greater number of lodes, and those of the greatest interest, occur in the older crystalline rocks, and especially in those possessing a schistose structure, and consisting of silicates, generally mixed with quartz. These anhydrous silicates are, however, very rare in lodes themselves, while quartz is a very frequent and abundant constituent of them.

Among the anhydrous silicates occurring in lodes bearing species of the usual ores, the felsites are most rare. A few, such as pegmatolite, oligoclase, tetartine, have here and there been met with. On the contrary, epidotes, especially

* The occurrence of granite veins in gneiss is such an exceptional instance.

the green varieties called pistacite, are probably more frequent in lodes than in rocks. It is likewise remarkable, that some anhydrous silicates which occur in the form of lodes are never met with as constituents of rocks. Among these are axinite (strictly speaking, a silico-borate), the very rare mineral zygadite. The former has been found forming a lode, together with an arsenical pyrites, rich in cobalt, cobalt glance, &c., in Chili, Saxony, and Sweden.

The other anhydrous silicates occurring in lodes are,—some garnets, pyroxenes, amphiboles, titanites, lievrite, epidote, beryl, and topaz.

Certain hydrated silicates are more frequent; for instance, phrenite, datolite (a silico-borate); most of the zeolites, many of which occur likewise in vesicular cavities; some micas, and a few amorphous mineral substances.

Silico-borates certainly never occur as constituents of rocks. Datolite is the only one which occurs in vesicular cavities.

The chief part of the mineral species which occur in lodes comprises such as are unknown as constituents of rocks, and they consist, moreover, of chemical elements which are not present in rocks. These remarkable and important facts unquestionably indicate: 1. That the minerals contained in lodes have not been formed by the extraction of the adjoining rock; 2. That such substances are chiefly present in veins, which, at the time of the formation of the rocks, were retained in the interior of the earth. We are unacquainted with any rocks from which it is probable that the sometimes enormous lodes of lead, silver, copper, antimony, zinc, arsenic, bismuth, cobalt, and nickel minerals, or even those of iron or barium, and the sulphur of the sulphurets, could have been derived by such a process of extraction by water. Indeed, heavy spar occurs in the Erzgebirge in such frequent and large veins that it may constitute no inconsiderable part of the entire mountain range, while we are unacquainted with any single mineral in these rocks, which are generally in an undecomposed state, containing baryta. Admitting the hypothesis of an original chaotic admixture of the elements, it may be conjectured that the alkaline minerals were first formed, on account of the more ready oxidation of their metals, while the heavier metals, existing perhaps chiefly as sulphurets, sunk towards the centre. This opinion gains some amount of probability, from the high specific gravity of the earth (according to Reich, 5·45; Baily, 5·66), while the mean specific gravity of all rocks is only 2·75. When, at subsequent periods, fissures were formed in the superficial parts of the earth, they might have been filled by eruptive sulphurets, &c. Most of the metalliferous minerals are or have been in the state of sulphurets; and the old belief of miners, that in general lodes are richer the deeper they are worked, which has now gained considerable probability upon scientific grounds, likewise favours the above view.

There can be no doubt that sometimes, although rarely, the substances present in lodes have at least partly been introduced from above. Instances are known in which some of the chemical constituents of the minerals must have come from the surface. For example, the phosphoric acid in pyromorphite, wavellite, kaelaite, &c. There are, however, very serious objections to Werner's theory, that all the substances present in lodes were introduced from the surface.

The study of mineral lodes has led to the assumption of four different modes of formation:—

(A.) Congeneration.
(B.) Lateral Secretion.
(C.) Ascension; and
(D.) Descension.

The two latter have, however, been the most frequent. It is also probable that, in some instances, two or more of these modes of action have gone on together.

Many lodes have, since their formation, suffered alteration to such an extent that the substances they contain are all products of the decomposition of the original minerals; and sometimes these products demand a special attention.

B. H. PAUL.

(To be continued.)

On the Eyeless Animals of the Mammoth Cave of Kentucky. (Read before the Royal Physical Society, on exhibiting Specimens of the Animals.) By ROBERT CHAMBERS, Esq., F.R.S.E. (Communicated by the Author.)

The Mammoth Cave of Kentucky is situated on the Green River, an affluent of the Ohio, midway between the towns of Louisville and Nashville. The country is here composed of an elevated plain of the mountain limestone, resting on Devonian and Silurian rocks. The rivers form trenches in the country about 350 feet deep, and the Mammoth Cave is nearly the same depth below the surface. It is, as is well known, of very great extent, not less, it is said, than ten miles, and is composed of a great *flexus* of galleries—"branching, crossing, inosculating in all directions, and at all levels,"—all affording a dry footing, and all pervaded by perfectly sweet air. Though it is believed that there is but one passage into the cave, there is constantly a stream of air coming outwards when the temperature of the outer air is above 60° Fahrenheit, and a stream going inwards when the outer temperature is below that point, apparently a consequence of the call for the establishment of an equilibrium between the air-contents of the cave, which are invariably at 60°, and the outer air; from which Professor B. Silliman junior draws the inference that the space of the excavations must be immense.

Throughout the cave, even at the distance of several miles from the mouth, are rivers and pools of water, which evidently have some connection with the waters of the outer world, as they are clear and palatable, and rise and fall with the neighbouring rivers of the outer country, according to the drought or wetness of the season. Mr Silliman is clearly of opinion that the excavations are the effect of moving water, and of no other cause.

The Mammoth Cave affords a hybernating retreat for vast numbers of bats; but its constant inhabitants are alone entitled to notice. There is a rat of furry coat, bluish in the body and white in the throat, possessed of large black eyes. Mr Silliman caught two specimens, a male and female, and he says of the former that he is satisfied it was entirely blind when first caught, though after being kept some time in light, it appeared gradually to attain some power of vision. There are also some insects, "the largest of which is a sort of cricket, with enormously long antennæ." "Of spiders Dr Tellkampf found two eyeless, small, white species, which he calls *Phalangodes armata* and *Anthrobia monmouthia;* flies of the genus *Anthomia,* and two blind beetles, *Anophthalmus Tellkampfii* of Erickson, and *Adelops hirtus.*" There are also some infusoria.

But the most remarkable animals peculiar to the Mammoth Cave are—a crustacean, *Astacus pellucidus,* and a small fish, *Amblyopsis Spelæus.*

These are the species of which specimens are now before the Society, having been sent to me by John Purves, Esq. of Kinaldy, Fifeshire, who visited the Mammoth Cave during the summer of 1850.

The signal peculiarity of these animals is their want of fully developed organs of vision. Dr Tellkampf and Mr Thomson, president of the National History Society of Belfast, who were among the first to notice the animals of the cave, speak of eyes in the crustacea. Agassiz, on the other hand, asserts that this is a mistake. He says: "I have examined several species, and satisfied myself that the peduncle of the eye only exists, but there are no visible facets at its extremity, as in other craw-fish." * These observations appear to be fully justified by the specimens now submitted to the Society; for scarcely the faintest trace of an eye can be detected in the two crustacea. M. Agassiz asserts respecting the fish, that it has not even rudimentary eyes, and appears to want even the orbital cavity.—(*Agassiz's and Gould's Principles of Zoology.*) From the circumstance of its being viviparous, from the character of its scales, and from the forward structure of its head, he considers it an aberrant type of his family of Cyprimodonts. There is also, however, a second species of fish, "not colourless like the first," and having external eyes, but quite blind. Mr Silliman, moreover, mentions an important fact, that the "larger eyed and coloured craw-fish which are abundant without the

* American Journal of Science, &c., vol. ix. No. 31. (Reprinted in Jameson's.)

cave, are also common in some seasons in the subterranean rivers, and so also it is said the fish of the Green River are to be found in times of flood in the rivers of the cave."

In reply to a letter of inquiry from Professor Silliman senior, Mr Agassiz made a few remarks on the presumable primitive condition of the eyeless animals of the Mammoth Cave. He says—"This is one of the most important questions to settle in natural history, and I have several years ago proposed a plan for investigation, which if well considered, would lead to as important results as any series of investigations which can be conceived, for it might settle once and for ever the question, in what condition and when the animals now living on the earth were first called into existence."—(*Silliman's American Journal,* ix., No. 51.)

Analyses of Fossil Bones of Nebraska.

The results of the chemical examinations of the bones of some of the fossil Mammalia from the tertiary formation of the Mauvaises Terres of Nebraska, are interesting and remarkable, as shewing the change which they have undergone during the long period of interment.

Part of Leg-Bone of Oreodon.

Water of absorption, ...	H =	2·70
Organic Matter burned off by ignition, ...	=	2·50
Phosphoric Acid, ...	$\overset{\cdot\cdot\cdot\cdot\cdot}{P}$ =	36·77
Carbonic Acid, ...	$\ddot{C}$ =	3·00
Fluorine, ...	F =	3·20
Lime, ...	Ca =	48·93
Silica, ...	$\dddot{Si}$ =	3·40
Trace of $\dddot{Fe}$ and $\dot{Mn}$, ...		
		100·50

Part of Scapula of Palæotherium.

....		2·50
....		3·20
....		32·00
....		4·20
....		3·40
Combined with $\overset{\cdot\cdot\cdot\cdot\cdot}{P}$, ...	=	34·00
$\dot{Ca}$ „ „ $\ddot{C}$, ...	=	5·35
$\dot{Ca}$ „ „ F, ...	=	3·66
$\dot{Ca}$ „ „ $\dddot{Si}$ (?).........	=	0·30
$\dddot{Fe}$, ...		4·50
$\dddot{Al}$, ...		0·70
$\dot{Mg}$, ...		0·90
$\dot{Mn}$, ...		0·80
$\dot{Na}$, ...		2·04
$\dddot{Fe}\,\dddot{Si}$, insoluble, ...		1·64
Si dissolved by HC l, ...		0·30
Loss, ...		0·51
		100·00

It is to be regretted that time did not permit me to repeat these analyses on different varieties of specimens, and by different methods. However, I am able to furnish another analysis, of a compact portion of the tibia of archæotherium, carefully freed from all extraneous matter, made with great care in Dr Genth's laboratory, and under his immediate inspection, by Dr Francis V. Greene, which has resulted very satisfactorily, and in which the fluorine was estimated by precipitation.

Water, $\dot{\text{H}}$ = 1·97; Organic matter, = 4·09; Phosphoric acid, $\overset{\cdot\cdot\cdot\cdot\cdot}{\text{P}}$ = 31·19; Silicic acid, $\dddot{\text{Si}}$ = 0·26; Carbonic acid, $\ddot{\text{C}}$ = 2·77; Sulphuric acid, $\ddot{\text{S}}$ = 2·19; Fluorine, F = 2·46; Chlorine, Cl = 0·02; Lime, $\dot{\text{Ca}}$ = 50·83; Magnesia (with a trace of Mn), $\dot{\text{Mg}}$ = 1·14; Baryta, $\dot{\text{Ba}}$ = 1·10; Potash, $\dot{\text{K}}$ = 0·28; Soda, $\dot{\text{Na}}$ = 1·57; Iron and Alumina, a trace. Total, 99·87.

These analyses are remarkable: first, in shewing the existence of a notable quantity of fluorine amounting to from 2 to 3 per cent., sufficient to etch glass very distinctly, when the bones are treated with strong sulphuric acid, and gently heated: second, in proving the existence of from 2 to 4 per cent. of the original organic matter, and from 31 to 37 per cent. of the phosphate of lime in the bones of animals, which have been entombed in these early tertiary deposits ever since the Alps first began to lift their heads out of the ocean, and in which they have been enclosed the almost inconceivable length of time that has elapsed during a vast geological epoch: in which that great mountain chain of Europe has been gradually thrusting its peaks to ten or twelve thousand feet above the ocean; and while the Andes of South America, during the same period, have attained probably even a greater elevation.

Reflecting on the origin of the fluorine discovered in these Nebraska fossil bones, it becomes a question whether it is an original constituent of the bones of the living animal, or has been introduced into their composition after death. Since the analysis of the bones of existing animals indicates but a mere trace of fluorine, it seems more probable that that element has been introduced as fluoride of calcium by infiltration during the gradual process of fossilization, after the manner of pseudomorphism in minerals, the fluoride of calcium gradually replacing the organic matter, as transformation proceeded, than that it should have been an original constituent of the bones of the living animal. Still, the subjoined analyses of the enclosing matrix gives no evidence whatever of the existence of fluorine in these deposits now.

If the fluorine has really been derived from these deposits, we are forced to the conclusion that it has all been removed by the powers of pseudomorphism. May we not, however, rather look to the saline waters, now common in that country, as the source of the fluorine; or perhaps, to the waters of the lake, bay, or estuary, in which the bones may have lain macerating, previous to their long interment?

It is worthy also of note that Greene's analysis shews the presence of sulphate of baryta in the compact portion of the bone he analysed; and Dr Genth discovered minute crystals of sulphate of baryta in the cavities of some of the bones by the aid of a stronger magnifier.—(*Owen's Geological Survey of Wisconsin, Iowa, and Minnesota.*)

Note on the Eruption of Mauna Loa. By James D. Dana. (Communicated by the Author.)

The account of Mauna Loa, by Rev. Titus Coan, together with the additional information from letters appended to this paper, suggests a few thoughts confirmatory of views mentioned in another place by the writer.

1. The eruption described, although so vast in its extent, commenced with no earthquake—no internal thunderings—no premonitions whatever, that were perceptible at the base of the mountain. In almost all descriptions of volcanoes, these phenomena are set down as essential to the result, especially if the eruption be of much extent. Some force is supposed, in one way or another, to get beneath the column of lava, and by sudden action to eject the lavas with violence, amid terrific exhibitions of volcanic power. But in the majestic dome of Mauna Loa, where the lavas are carried to

a height of 14,000 feet, the outbreak is quiet and noiseless; the mountain opens, the lavas flow. The vivid description of Mr Coan, marked as it is with the actual terrors of the scene, strikingly sustains these statements. For how unlike Vesuvius in her great outbreaks is the Hawaian volcano, when the crater, in its intensest eruption, could be approached "within forty or fifty yards on the windward side," or "within two miles on the leeward," and the traveller need retire but to the distance of "a mile" from the very scene of eruption for his "night vigils."

2. The mobility of the Hawaian lavas is most remarkably exemplified in this eruption. The fiery rock at the crater formed literally an open boiling fountain, instead of appearing in eruptive discharges through a narrow-necked funnel. A *jet* of clear liquid lava shot up in ceaseless flow to a height of 300 feet or more, and, with its surrounding jets and falling spray, produced, as Mr Fuller says, the effect of a Gothic structure of molten metal, with its shafts and pinnacles and buttresses, in quick incessant change—now rising into a tall spire 700 feet in height, now spreading into more massy forms, and ever dazzling the sight with its brilliancy. The scene of this display, according to Mr Coan, was 5000 feet below the summit outbreak,* and it would actually appear, as he implies, that the hydrostatic pressure of the central column of lavas in the mountain was the power that kept the jet in action. Such a fountain of molten rock is majestic beyond conception; and the more wonderful, the more majestic, viewed as the effect of simple pressure, with none of the convulsive heavings common in other volcanoes. The terrible roar of the crater was the sound of the ponderous mass agitated to its depths, by the tossing and falling jets and the escape of the imprisoned vapours; it was not enhanced even by the occasional shocks of an earthquake.

3. Kilauea, a crater on the flanks of Mauna Loa, but 4000 feet above the sea, having its larger diameter 18,000 feet, or 3½ miles, exhibited at this time no signs of sympathy with the summit action. If ever a region had its *safety-*

* Seven thousand feet, or half way to the base, according to Mr Fuller.

valve, we should say that this immense crater would be such to Hawaii. But the lavas rise in the centre of the mountain 10,000 feet above this vast pit (or nearly 11,000 feet above its bottom), without producing the slightest fluctuation in its boiling lakes.

4. From the eruptions of Kilauea in 1823, 1832, and 1840, the writer, in tracing out its history, stated that the course of changes leading to a new outbreak required eight or nine years, this being the interval between the known eruptions. The process was shewn to consist in a gradual filling up of the great pit for 400 or 500 feet of its depth, attended with an increased activity when at this height, and followed by a discharge from some fissure or fissures opened through the slopes toward the sea.

But since 1840 thirteen years have passed, and still no eruption has been observed. The process has, however, been essentially as indicated by the author, although under a new modification of its action. The crater did go on filling up at its usual rate, so that in 1846 it had already risen to a height of 400 feet above the level it had after the eruption of 1840. The crater, moreover, was then in violent activity, and the black ledge was nearly obliterated; the bottom continued still to rise, and an eruption was speedily expected. But instead of an eruption, we learn that in 1848 and 1849, all was nearly quiet, excepting a single convulsive heaving in the latter year. The lower pit was filled with solid lavas, and the great lake became finally the site of a solid dome or cone.

It is however altogether probable, from the retreat of the liquid lavas and the disappearance of the fires, that a discharge actually took place at the time expected, but beneath the sea. Such a discharge occurring in the usual quiet way, might be unperceived by the inhabitants of the island. The outflow of lavas, however, must have been but a partial one; and, consequently, the bottom of Kilauea, instead of subsiding, as the lavas retreated, 400 feet (as commonly happens), retained its place.

Five years have now passed, and the fires, as Mr Coan states, are again breaking out. This is a further confirmation of our view. The process of elevation in the liquid internal lavas has evidently been going on, as after previous eruptions, although out of sight, deep beneath the solid rock that forms the bottom of Kilauea; and they have again reached a height that enables them to be distinguished. The mode of progress and of eruption may therefore correspond throughout with the views presented by the author in his Exploring Expedition, Geological Report, and American Journal, vol. ix., 347. Yet it is also possible that the fires of Kilauea are dying out, and that thus the change of condition is to be explained.

Although the discharges at the summit of Mauna Loa produce no oscillations in the lavas of Kilauea, it may still be possible that the increased activity at the summit, and the diminished action of the flank crater, during the past few years, may be connected with the same changes below. These changes may consist in some variations in the distribution of the heat, or, more probably, in a variation of size or direction in the openings or channels that serve to supply the water which feeds the fires.

5. If Kilauea were to become extinct in its present condition, no evidence would exist of its former depth, or of the black ledge or shelf which has been so remarkable a feature in this crater. The present depth does not exceed 600 feet —400 feet less than after the eruption of 1840.* Moreover, as the precipitous rocky walls are wholly free from scoriæ and all other signs of recent fires (looking much like bluffs of ordinary stratified rock), there is no evidence as to the great eruptions that have taken place, and only signs of a sort of Solfatara action, without flows of lava over the bottom of the confined area. These facts bear on the conclusions that might be deduced from the existing features of extinct volcanoes.

6. Mr Coan speaks of the lavas as flowing from an orifice in a broad stream down the mountain. It is probable that fissures opening to the fires below were continued at intervals along the course of the eruption, and that these afforded accessions to the fiery flood. Such was the case in 1840, and the three tufa hills at Nanawale, on the sea-coast, mark

* The central portions of the crater are much more raised than the lateral, and over them the depth cannot exceed 500 feet.

the positions where these opened fissures reached the sea. Any internal force sufficient to break through the sides of a mountain like Mauna Loa, must necessarily produce a linear fissure, or a series of fissures, and not a single tunnel-like opening.

7. We have yet received no definite facts as to the angle of slope down which the lavas descended. Yet we do know that in this and in a former eruption the stream continued over the declivities for thirty miles, and these declivities have an *average* angle of six or seven degrees, though made up of subordinate slopes varying probably between one and twenty degrees, as Mr Coan mentions, when describing the descent of the lavas in the summit eruptions of 1843. The slopes of Mauna Loa, although the mountain is over 14,000 feet high, are therefore not too steep to receive accessions from top to bottom, from eruptions of vast extent over its sides. With such facts, in connection with others brought forward by the writer, we are assuredly sustained in not admitting the universal application of the so-called *elevation* theory. But in rejecting this theory, we do not go to the opposite extreme, and adopt in its full extent the *overflow* theory. The truth, as usual, lies between the two extremes, as the writer has elsewhere urged. Both causes have acted in the history of all volcanoes; both act from the very commencement of the germ-cone. There is elevation from the central action, from the opening and filling of fissures about the centre, and also from the outflow of lavas. The first of these operations may be most effective in the earlier periods of the rising mountain; but each continues to act till the fires die out; and in the later periods, especially, there is often a *flattening* process, arising from the spread of lavas ejected from fissures about the base of the mountain, which extend the shores, and diminish the angle of slope.

8. The interval of time between the last three eruptions of the central crater of Mauna Loa is from nine to ten and a half years. The *first* of these three took place in June 1832; the *second* in January 1843; the *third* in February 1852. The recorded eruptions of Kilauea have occurred as follows, leaving out that of 1789: the first in 1823, the

second in 1832, the third in 1840, probably a fourth through a submarine or subterranean vent in 1847 or 1848, and the fires are now increasing again in activity. In 1832 there were thus eruptions from both of these extensive craters of Mauna Loa.

We annex additional notes on the eruption, from different sources. The account of the *whirlwinds* produced by the crater are of much meteorological interest.

1. *From a Letter of H. Kinney, dated Waiohinu, Hawaii, April* 19, 1852 (published in "The Pacific," San Francisco, of June 18).

The light of the volcano at night was very great—illuminating the surrounding country for many miles distant, and giving to the overhanging clouds the appearance of an immense body of fire. After witnessing this for several nights, my desire to visit it became so strong, that I resolved to make the long and tedious journey, to take a near view of this grand display of the Almighty's power. Accompanied by Mr Fuller, I set out on the 1st day of March. After travelling through woods and over wide districts of naked lava, we arrived at the vicinity of the eruption on the forenoon of the third day. Its deep, unearthly roar, which we began to hear early on the day before, "waxed louder and louder," as we drew nearer and nearer the action, until it resembled the roar of the ocean's billows when driven by the force of a hurricane against a rock-bound coast, or like the deafening roar of Niagara.

We first reached the deep channel, through which a wide stream of liquid lava had flowed down the mountain, desolating an area of vast extent; it had ceased to flow in this direction, but was flowing still at a little distance, where we gazed with delight. The main stream was still beyond, which we could not approach, on account of the great heat; but at night we had a fine view of the fiery river, at no great distance from our encampment. Though the lava gushed out in several places like water-springs, yet the main fountain was one of indescribable grandeur. In the midst of a forming cone, with a base of 200 or 300 feet, there shot up a jet of clear liquid lava to the height of from 400 to 800 feet, combining in its ascent and descent all the beauties of the finest water fountains—jet after jet ascended in constant and regular succession, day after day; descending, it mostly fell back into the crater, but sometimes it fell spattering on its sides, and flowed down, uniting with the main stream. The outer portions cooled to a blackened mass while in the air; the upper and lighter portions were carried by the propelling force to the regions of the clouds, and fell in showers over the surrounding country.

The intense heat of the fountain and stream of lava, caused an influx of cool air from every quarter; this created *terrific whirlwinds*, which constantly stalking about, like so many sentinels, bade defiance to the daring visitor. These were the most dangerous of any thing about the volcano. Sometimes we were compelled to prostrate ourselves for safety. Once we ventured within about a quarter of a mile of the great jet; soon one of the most terrific whirlwinds formed at the crater, and advanced straight towards us, threatening us with instant ruin; but fortunately for us, it spent its force and turned to the right, leaving us to make a rapid retreat.

We saw a similar one whirling around the jet, and concealing it with a dense cloud of ashes, as if engaged in a furious combat. The two contending elements presented a most wonderful spectacle. When the strife ceased, the fountain appeared in constant action, as though nothing had occurred. Clouds approaching the volcano were driven back, and set, moving in wild confusion.

The glare of the liquid fountain was very great, even when the sun was shining; but at night it was vastly more so, casting the light of nearly a full moon in the shade, and turning night into day.

2. *From a Letter by Mr Fuller, dated Waiohinu, March* 28.

There played a *fountain of liquid fire* of such dimensions and such awful sublimity, shaking the earth with such a constant and deafening roar, that no picture of the classic realms of Pluto, drawn by Grecian or Roman hand, can give you any adequate conception of its grandeur, A few figures may assist your imagination in its attempts to paint the scene. I made the following calculations, after careful observations during nearly twenty-four hours, from different points within a mile of the crater, and, after deliberate discussion with Mr Kinney and companion, with different objects around us. Some of these calculations have been confirmed by a somewhat accurate measurement by Mr Lyman, of Hilo.

The diameter of the crater, which has been entirely formed by this eruption is about 1000 feet, its height from 100 to 150 feet. One part of the crater was raised 50 feet during our presence on the spot. The height of the column of red-hot liquid lava, constantly sustained above the crater, varies from 200 to 700 feet, seldom falling below 300. Its diameter is from 100 to 300 feet, and rarely perhaps reaching 400 feet. The motions of this immense jet of fire were beautiful in the extreme, far surpassing all the possible beauties of any water fountain which can be conceived; constantly varying in form, in dimensions, in colour and intensity; sometimes shooting up and tapering off like a symmetrical Gothic spire, 700 feet high; then rising in one grand mass, 300 feet in diameter, and varied on the top and sides by points and jets, like the ornaments of Gothic architecture. The New Yorker, who, as he gazes on the beautiful spire of Trinity Church, can imagine its dimensions increased three-fold, and its substance converted into red-hot lava, in constant agitation, may obtain a tolerable idea of one aspect of this terrific fire fountain. But he should stand at the foot of the Niagara Falls, or on the rocky shore of the Atlantic when the sea is lashed by a tempest, in order to get the most terrific element in this sublime composition of the Great Artist. For you may easily conjecture that the dynamical force necessary to raise 200,000 to 500,000 tons of lava at once into the air would not be silent in its operation.

The eruption of which I have written broke out on the morning of the 18th February, at about 3 o'clock, and continued twenty days. The crater is situated on the base of Mauna Loa, about 35 miles from Hilo, and 25 from the old crater of Kilauea. Its height above the sea is about 7000 feet. It has formed a stream, winding down the mountain side, with several branches 30 or 40 miles long, from one-fourth to two miles broad, having a depth, in some places, of 200 or 300 feet.

Mammoth Cave of Kentucky.

[We extract the following graphic account of the Mammoth Cave of Kentucky from Professor J. D. B. De Bow's "Industrial Resources, &c. of the Southern and Western American States."]

In Edmonson County is that extraordinary curiosity, the Mammoth Cave. It is situated midway between Louisville and Nashville, and is a fashionable place of resort. The cave is approached through a romantic shade. At the entrance is a rush of cold air. A descent of thirty feet by stone steps, and an advance of one hundred feet inwards, brings the visitor to the door, in a solid stone wall which blocks up the entrance of the cave. A narrow passage leads to the great vestibule or antechamber, an oval hall, 200 by 150 feet, and 50 feet high. Two passages of 100 feet width open into it, and the whole is supported without a single column. This chamber was used by the races of yore as a cemetery, judging from the bones of gigantic size which are discovered.

"Far up, a hundred feet above your head, you catch a fitful glimpse of a dark gray ceiling rolling dimly away like a cloud, and heavy buttresses, apparently bending under the superincumbent weight, project their enormous masses from the shadowy wall. The scene is vast, solemn, and awful. A profound silence, gloomy, still, and breathless, reigns unbroken by even a sigh of air, or the echo of a drop of water falling from the roof. You can hear the throbbings of your heart, and the mind is oppressed with a sense of vastness, and solitude, and grandeur undescribable." In *Audubon Avenue*, leading from the hall, is a deep well of pure spring water. It is surrounded by stalagmite columns from the floor to the roof. The *Little Bat Room* contains a pit 280 feet deep, and is the resort of myriads of bats. The *Grand Gallery* is a vast tunnel many miles long, and fifty feet high, and as wide. At the end of the first quarter of a mile is found the *Kentucky Cliffs* and the *Church*, 100 feet in diameter, and 63 feet high. A natural pulpit and organ-loft are not wanting. " In this great high temple of nature, religious service has been frequently performed, and it requires but a slight effort to make the speaker heard." The *Gothic Avenue* is reached by a flight of stairs, and is forty feet wide, fifteen high, and two miles long. The ceiling is smooth and white. Mummies have been discovered here, which have been a subject of curious study to science. In the Gothic Avenue are stalagmites, stalactites, also *Louisa's Bower* and *Vulcan's Furnace*. On the walls of the *Register Rooms* are inscribed thousands of names. The *Gothic Chapel* is " one of surprising grandeur and magnificence: and when brilliantly lighted up by the lamps, presents a scene inspiring the beholder with feelings of solemnity and awe." At the foot of the *Devil's Arm Chair* is a small basin of sulphur water. Here we have Napoleon's Breastwork, the Elephant's Head, Lover's Leap, Gatewood's Dining Table, and the Cooling Tub —a basin six feet wide and three deep of the purest water, Napoleon's Dome, &c.

The *Ball Room* contains an orchestra fifteen feet high; near by is a row of cabins for consumptive patients, the atmosphere being always temperate and pure. The Star Chamber presents an optical illusion. " In looking up to the ceiling, the spectator seems to see the firmament itself studded with stars, and afar off a comet with bright tail." We pass over the *Salts Rooms, Black Chambers, Fairy Grotto, &c.*, and come to the Temple.

" The temple is an immense vault, covering an area of two acres, and covered by a single dome of solid rock, one hundred and twenty feet high. It exceeds in size the cave of Staffa, and rivals the celebrated vault in the grotto of Antiparos, which is said to be the largest in the world. In passing through, from one end to the other, the dome appears to follow the sky, as in passing from place to place on the earth. In the middle of the dome there is a large mound of rocks rising on one side nearly to the top, very steep, and forming what is called the *mountain.* When I first ascended this mound from the cave below, I was struck with a feeling of awe more intense and deep than any thing I had ever before experienced. I could only observe the narrow circle which was illuminated immediately around me ; above and beyond was apparently an unlimited space, in which the ear could not catch the slightest sound, nor the eye find an object to fasten upon. It was filled with silence and darkness ; and yet I knew that I was beneath the earth, and that this space, however large it might be, was externally bounded by solid walls. My curiosity was rather excited than gratified. In order that I might see the whole in one connected view, I built my fires in many places of cane, which I found scattered among the rocks. Then, taking my stand upon the mountain, a scene was presented of surprising magnificence. On the opposite side, the strata of gray limestone breaking up by steps from the bottom, could scarcely be discerned in the distance by the glimmering. Above was the lofty dome, closed at the top by a smooth oval slab, beautifully defined in the outline, from which the walls slope away on the right and left into thick darkness. Every one has heard of the dome of the Mosque of St Sophia, of St Peter's, and St Paul's ; they are never spoken of but in terms of admiration as the chief works of architecture, and among the noblest and most stupendous examples of what men can can do when aided by science ; and yet when compared with the dome of this temple, they sink into comparative insignificance."

The *River Hall* descends like the slope of a mountain ; the ceiling stretches away, away before you, vast and grand as the firmament at midnight. Proceeding a short distance, there is on the left a steep precipice, over which you can look down by the aid of blazing missiles upon a broad, black sheet of water, eighty feet below, called the Dead Sea. This is an awfully impressive place, the sights and sounds of which do not easily pass from memory. He who has seen it, will have it vividly brought before him by Alfieri's description of Filippo. Only a transient word or act gives us a short and dubious glimmer that reveals to us the abysses of his being—

daring, lurid, and terrific as the throat of the infernal pool. Descending from the eminence by a ladder of about twenty feet, we find ourselves among piles of gigantic rocks; and one of the most picturesque sights in the world is to see a file of men and women passing along these wild and scraggy paths, moving slowly—slowly, that their lamps may have time to illuminate their sky-like ceiling and gigantic walls, disappearing behind high cliffs—sinking into ravines—their lights shining upward through fissures in the rocks—then, suddenly emerging from some abrupt angle, standing in the bright gleam of their lights, relieved by the towering black masses around them. As you pass along, you hear the roar of invisible waterfalls; and at the foot of the slope, the *River Styx* lies before you, deep and black, overarched with rocks. Across, or rather down, these unearthly waters, the guide can convey but four passengers at once. The lamps are fastened to the prow, the images of which are reflected in the dismal pool. If you are impatient of delay or eager for new adventure, you can leave your companions lingering about the shore, and cross the Styx by a dangerous bridge of precipices overhead. In order to do this, you must ascend a steep cliff and enter a cave above, over three hundred yards long, from the egress of which you find yourself on the bank of the river, eighty feet above its surface, commanding a view of those in the boat, and those waiting on the shore. Seen from the heights, the lamps in the canoe glare like fiery eyeballs; and the passengers sitting there, so hushed and motionless, look like shadows. The scene is so strangely funereal and spectral, that it seems as if the Greeks must have witnessed it before they imagined Charon conveying ghosts to the dim regions of Pluto.

The Mammoth Cave is said to be explored to the distance of ten miles, without reaching its termination, whilst the aggregate width of all the branches is over forty miles! Next to Niagara, it is the wonder of nature in the Western World, or perhaps throughout all her domains.

On the Annual Variation of the Atmospheric Pressure in different parts of the Globe. By Professor H. W. DOVE of Berlin.* Communicated by Colonel SABINE.

The establishment of meteorological stations in distant parts of the globe had, generally speaking, for its immediate object, so to complete the partial knowledge we already possessed of the phenomena over a considerable portion of its surface, as to enable us to take a general view of their course over the whole globe. The result of those endeavours has even exceeded what was hoped for, as besides the information obtained respecting regions where our knowledge was most defective, fresh light has been thrown on those with which we had supposed ourselves already completely acquainted.

Meteorology commenced with us by the study of European phenomena, and its next principal extension was to phenomena observed in the tropical parts of America. If what is true of Europe were equally true of the temperate and cold zones of the earth in all longitudes, and if tropical America in like manner afforded a perfect example of the tropical zone generally, it would be of little consequence where the science of Meteorology had been first cultivated; but this is not the case, and a too hasty generalisation has led to the neglect of important problems, while others less important have been regarded as essential and placed in the foremost rank. It was necessary that the science should be freed from these youthful trammels, and this needful enfranchisement has been effected by the Russian and by the English system of observations. Russia has done her part in freeing the meteorology of the temperate and cold zones from impressions derived exclusively from the limited European type; and England, which by its Indian stations had undertaken for the torrid zone the same task of enlarging and rectifying the views previously entertained, has besides, by its African and Australian stations (Cape of Good Hope and Hobarton), opened to us the southern hemisphere, and first

* From the Introduction to the 3d vol. of the Magnetical and Meteorological Observations at Hobarton, in Van Diemen's Island.

rendered it possible to treat of the atmosphere as a whole. I will now endeavour to shew the importance of being enabled to take such general views, selecting as an example the annual variation of the barometer.

The study of the *annual* barometric variation had long been singularly neglected, while the *diurnal* barometric variation had had devoted to it an attention quite disproportioned to its subordinate interest in reference to the general movements of the atmosphere. This otherwise incomprehensible mistake is excused by the localities where nature had been first interrogated. As the diurnal variation had manifested itself with great distinctness and regularity in tropical America, it naturally presented itself as an object of interest in Europe also. The annual variation, on the other hand, is inconsiderable, both in Europe and the tropical parts of America; and thus, while atmospheric phenomena were treated simply as facts of which the periodicity alone was to be investigated, without seeking for physical causes, it was natural that a phenomenon, in which opposite effects resulting from two different causes counterbalance each other, should altogether escape notice. It is, perhaps, more remarkable that no surprise should have been excited when the atmospheric pressure was not found to diminish from winter to summer with increasing heat.

When, by the labours of Prinsep more particularly, the phenomena of the tropical atmosphere in Hindostan became more known, there was seen to be a great difference between the barometric variation there and in tropical America; inasmuch as the Indian observations shewed a decidedly well-marked annual variation. A new error was now fallen into, and it was supposed that the phenomenon did not extend beyond the torrid zone, and that it was an immediate consequence of the periodical change of wind, *i.e.* of the monsoons. This erroneous view was completely refuted when the barometric relations at the Siberian stations became known; for it was then found that, north of the Himalaya (which in the supposed hypothesis must have formed the limit of the phenomenon), the annual barometric variation was exhibited on a large scale, and over a region so extensive that the shores of the Icy Sea itself could hardly be assumed as its boundary. A greatly diminished atmospheric pressure taking place in summer over the whole continent of Asia must produce an influx from all surrounding parts; and thus we have west winds in Europe, north winds in the Icy Sea, east winds on the east coasts of Asia, and south winds in India. The monsoon itself becomes, as we see, in this point of view, only a secondary or subordinate phenomenon.

I have endeavoured to establish the reality of the above phenomenon and its climatological bearings, in several memoirs; and I must refer for the numerical values to Poggendorff's "Annalen," lviii., p. 117; lxxvii., p. 309; and to the "Berichte" of the Berlin Academy, 1852, p. 285. I will here embody the results in distinct propositions, in order to shew, in connection therewith, the importance of the bearing of the Hobarton observations.

1. At all stations of observation in the torrid and temperate zones, the elasticity of the aqueous vapour contained in the atmosphere increases with increasing temperature. In the region of the monsoons this increase from the colder to the warmer months is greatest near their northern limit. Hindostan and China present in this respect the most excessive climate. No differences of similar magnitude are found in the southern hemisphere. The form of the curve of elasticity of the aqueous vapour shews, however, a less decidedly convex summit in the region of the monsoons than beyond it, having in that region rather the character of a flattened summit or table-land, the elasticity continuing nearly the same throughout the period of the rainy monsoon. Near the equator the convex curve of the northern hemisphere becomes gradually, first flattened, and then transformed into the concave curve of the southern hemisphere. In the Atlantic this transition takes place in a rather more northerly parallel. In regard to the magnitude of the annual variation, the following rule appears generally applicable in the torrid zone; the annual variation is considerable at all places where equatorial currents prevail when the sun's altitude is greatest, and polar currents when the sun's altitude is least; and inconsiderable, wherever the direction of the

wind is either comparatively constant throughout the year, or where it changes in the contrary sense to that above described. At the last-named class of places the rate of decrease in the mean annual tension of the aqueous vapour with increasing distance from the equator is more rapid than in the first class.

2. At all stations in Europe and Asia, the pressure of the dry air decreases from the colder to the warmer months, and everywhere in the temperate zone has its minimum in the warmest month.

3. If we compare the annual variation of the pressure of the dry air in Northern Asia and Hindostan with the variation in Australia and the Indian Ocean, we shall be satisfied that something more takes place than a simple periodical exchange of the same mass of air in the direction of the meridian, between the northern and southern hemispheres. From the magnitude of the variation in the northern hemisphere, and the extent of the region over which it prevails, we must infer that at the time of diminished pressure a *lateral* overflow probably takes place; that it actually does so may be considered as proved for the northern part of the region, by the fact that at Sitka, on the north-west coast of America, the pressure of the dry air *increases* from winter to summer. It is not probable that the overflow takes place exclusively to the east, it probably occurs also to the west; and on this supposition the small amount of the diminution of the pressure of the dry air from winter to summer in Europe would be caused, not solely by the moderate amount of the difference of temperature in the hotter and colder seasons, but also by the lateral afflux of air in the upper regions of the atmosphere tending to compensate the pressure lost by thermic expansion. As at the northern limit of the monsoon, at Chusan and Pekin, the annual variation of the pressure of the dry air is most considerable, while at the northern limit of the trade-wind in the Atlantic Ocean, *i. e.* at Madeira and the Azores, it is very small, it is probable that there is in the torrid zone also a lateral overflow in the upper strata of the atmosphere, from the region of the monsoons to that of the trades.

4. From the combined action of the variations of the aqueous vapour and of the dry air, we now derive immediately the periodical variations of the whole atmospheric pressure. As the dry air and the aqueous vapour mixed with it press in common on the barometer, so that the upborne column of mercury consists of two parts, one borne by the dry air, the other by the aqueous vapour, we may well understand that as with increasing temperature the air expands, and by reason of its augmented volume rises higher, and at its upper portion overflows laterally,—while, at the same time, the increased temperature causes increasing evaporation, and thus augments the quantity of aqueous vapour in the atmosphere,—so it naturally follows that the composite result in the periodical variations of the barometric pressure should not everywhere bear a simple and immediately obvious relation to the periodical changes of temperature. It is only when we know the relative preportions of the two variations which take place in opposite directions, that we can determine whether their joint effect will be an increase or a decrease with increasing temperature,—whether in part of the period the one variation may preponderate, and in other parts the other variation. The following are the results which we are enabled to derive from observation.

5. Throughout Asia the increase in the elasticity of the aqueous vapour with increasing heat is never sufficient to compensate the diminished pressure of the dry air; and the annual variation of barometric pressure is therefore everywhere represented, in accordance with the variation of the pressure of the dry air, by a simple concave curve having its lowest part or minimum in July. The observations in Taimyr Land, at Iakoutsk, Udskoi, and Aiansk, shew that this is true up to the Icy Sea on the north, and to the sea of Ochotsk on the east. On the west a tendency towards these conditions begins to be perceived in European Russia in the meridian of St Petersburg, and becomes more marked as the range of the Ural is approached. On the Caspian and in the Caucasus the phenomenon is already very distinctly marked; its limit runs south from the western shore of the Black Sea, so that Syria, Egypt, and Abyssinia, fall within the region over

which it prevails. Towards the confines of Europe there is almost everywhere a maximum in September or October, the barometric pressure increasing rapidly from July to the autumn. This maximum is followed towards the latter part of the autumn by a slighter inflection or secondary minimum; it is only beyond the Ural that the curves become uniformly concave, with a single summer minimum and winter maximum, which character they retain throughout the rest of the Asiatic continent, even to its eastern coast. In winter, the absolute height of the barometer at the northern limit of the monsoon is very great. The still considerable amount of the annual variation at Nangasaki, and the little difference between the curve of Manilla and that of Madras, shew that the region in question extends beyond the eastern coast of Asia into the Pacific Ocean; in higher latitudes, hewever, its limits appear to be reached in Kamtschatka. As the annual variation which is greater at Madras than at Manilla is found greater at Aden than at Madras, the western limit of the region would appear to extend far on the African side.

6. In middle and western Europe the barometric pressure appears to decrease everywhere from the month of January to the spring, usually attaining a minimum in April; it then rises slowly but steadily to September, and sinks rapidly to November, when it usually reaches a second minimum. In summer, therefore, the whole atmospheric pressure gains more by increased evaporation than it loses by expansion. This over-compensation is probably, as we have seen above, to be explained by the lateral overflow received in the upper regions from Asia. In Sitka the whole annual curve is convex, a result only found in Europe at considerable mountain elevations, where it is a consequence of the expansion, and extension upwards, of the whole mass of the atmosphere in summer.

7. The region of great annual barometric variation, on the Asiatic side of the globe, where *monsoons* prevail, extends much farther to the north in the northern hemisphere, than it does to the south in the southern hemisphere; for the variation reaches its maximum at Pekin, while at Hobarton, in nearly a corresponding latitude, it has already become in-

considerable; and it is generally greater in the northern than in the corresponding southern latitudes. The exact contrary is the case on the Atlantic side and in the region of the *Trades;* for here the annual variation, though nowhere very considerable, is decidedly greater in the southern than in the northern hemisphere, as is shewn by the results of observation at the Cape, Ascension, St Helena, Rio Janeiro, and Pernambuco, compared with the West Indian Islands and the southern parts of the United States. Hence it follows that, if we compare places in the same latitude, we find but little difference between the annual variation in the southern Atlantic and southern Indian oceans, while in the northern hemisphere we have in the same latitude the very large annual variation in the north part of the Indian and in the Chinese seas, and the almost entire absence of annual variation in the Atlantic (compare Chusan with the Azores and Madeira). The explanation of the last-named phenomenon, *i.e.* that of the northern hemisphere, by a lateral overflow in the upper parts of the atmosphere, seems so direct, that I think we may pronounce the irregular form of the annual barometric curve in the West Indies to be a secondary phenomenon, the primary causes of which must be looked for on the east.

8. It is known that in the eruption of the Coseguina on the 20th of January 1835, when the isthmus of Central America was shaken by an earthquake, not only were the volcanic ashes carried to Kingston in Jamaica, a distance of 800 English miles in the opposite direction to the trade-wind, but some of the same ashes fell 700 miles to the *westward*, on board the Conway, in the Pacific Ocean. We infer, therefore, that in the higher regions of the atmosphere in the tropics the air is not always flowing regularly from SW. to NE., but that this usual and regular direction is sometimes interrupted by currents from east to west. I think I have indicated the probable cause of such anomalous currents in the above described barometric relations of the region of the monsoons compared with that of the trades. If we suppose the upper portions of the air ascending over Asia and Africa to flow off laterally, and if this takes place suddenly, it checks the

course of the upper or counter current above the trade-wind, and breaks into the lower current. An east wind coming into a SW. current must necessarily occasion a rotatory movement, turning in the opposite direction to the hands of a watch. A rotatory storm moving from SE. to NW. in the lower current or trade would, in this view, be the result of the encounter of two masses of air impelled towards each other at many places in succession, the further course of the rotation (originating primarily in this manner) being that described by me in detail in a memoir on "the Law of Storms," translated in the Scientific Memoirs, vol. iii., art. viii. Thus it happens that the West India hurricanes and the Chinese typhoons occur near lateral confines on either side of the great region of atmospheric expansion; the typhoons being probably occasioned by the direct pressure of the air from the region of the trade-winds over the Pacific into the more expanded air of the monsoons region, and being distinct from the storms appropriately called by the Portuguese "Temporals," which accompany the outburst of the monsoon when the direction of the wind is reserved. The fact of the rotatory storms being of much more rare occurrence in the South Atlantic Ocean arises from the more equal distribution of the periodically diminished atmospheric pressure in the southern as compared with the northern hemisphere. Here, therefore, the rotatory storms take place principally in the monsoon itself.

9. It is evident that the unsymmetrical distribution of land and sea, which gives rise to the abnormal variations in the forms of the isothermal lines, is at the same time the principal cause of the movements of the atmosphere. Thus the monsoon is but a modification of the trade-wind, of which the cause is to be sought in part beyond the tropic. The region of great thermic expansion of the air in summer in the interior of the continent of the Old World presents all the characteristic marks of the region of calms, being a centre towards which all adjacent masses of air are drawn. Hence there is no complete sub-tropical zone, in the sense of a zone encompassing the globe. The region over which the heated air ascends does not therefore move up and down, or north

and south, parallel with the sun's change of declination, but has rather a kind of oscillatory movement, in which the West Indies represent the fixed point; and the greatest amplitude of oscillation is on the side of India. The northern excursion is much greater in the northern hemisphere than is the southern excursion on the side of the southern hemisphere. The European atmospheric relations, especially in summer, are therefore essentially of a secondary nature; and we must regard the little alteration in the atmospheric pressure in the course of the year in Europe as a secondary result, of which the explanation would not have been possible without the observations from Asia and Australia.

H. W. DOVE.

BERLIN, *January* 5, 1853.

On the Determination of Copper and Nickel in quantitative analysis. By DAVID FORBES, F.G.S., Ass. Inst. C.E., Espedalen, Norway. Communicated by the Author through Dr GEORGE WILSON, F.R.S.E., &c.

Although the determination of these metals by the present methods, when properly conducted, must be considered quite accurate, still they are tedious, and are likewise attended with several sources of error, so as to render it desirable to endeavour by some simpler process to shorten the manipulation generally employed, as well as, if possible, to diminish the chances of incorrectness.

Both copper and nickel are usually weighed in the state of oxide procured by precipitating their respective solutions by potash. This precipitation, if not conducted with great care, is liable to errors so considerable as completely to vitiate the results obtained, from the tendency which potash has to precipitate basic salts; so that the precipitate produced is not the oxide itself, but a compound of the oxide with potash, generally retaining in addition some of the solvent acid.

This compound, in the case of nickel and copper, is however decomposable by boiling water, and this property affords the means of obtaining the oxides in a pure state previous to ignition; it is however evident that some risk always exists of a portion not being perfectly decomposed by this washing, which should be conducted at a boiling temperature, and carried on without intermission until concluded. In cases where even a very small amount of organic matter* is present, either in the solution, or, as frequently happens, in the potash employed, the precipitation is not complete, or rather a portion of the oxide is retained, dissolved in the solution, and is not precipitated by the further addition of potash.

Another objection also is, that when igniting the oxide a portion of it may be reduced by the carbonaceous matter of the filter; this can, however, be readily obviated, either by prolonged ignition, or by moistening the oxide with nitric acid, and again igniting, but the operation is then necessarily more tedious.

When we likewise consider that copper and nickel are generally separated in the course of analysis, by precipitation as sulphuret, we shall at once see the desirability of endeavouring to determine their quantities as directly as possible from that compound; and the following experiments were made with this object in view.

The first point inquired into was, whether the precipitated sulphurets of prolonged ignition, or rather calcination, could not be completely deprived of all their sulphur, and converted into oxides. The results obtained were, however, not at all satisfactory, as the sulphurets were never completely decomposed and invariably yielded too high results, as may be seen from the following experiments:—

(*a*) 3·75 gr. metallic copper, equivalent to 4·70 gr. oxide, yielded 5·47 gr. incinerated sulphuret; being an excess of 0·77 gr., or equal to 16·38 per cent. too much oxide.

(*b*) 3·63 gr. metallic copper, yielded 5·10 gr., instead of 4·55 gr. Cu O; equal to excess of 0·55 gr., or 12·08 per cent.

(*c*) 1·76 gr. copper = 2·20 Cu O, gave 2·24 gr., an excess of 0·04 gr., or 1·81 per cent. too much.

(*d*) 25·00 gr. of a mineral, containing by a previous examination 45·31 per cent. copper, afforded 17·64 gr.

* This is particularly apt to take place if great care is not taken to incinerate the filter perfectly on which these metals had been precipitated previous to solution.

calcined sulphuret, equivalent, if reckoned as CuO, to 14·08 gr. metallic copper, or 56·32 per cent. This oxide dissolved in nitric acid, and determined in the usual manner by precipitation by potash, with all precautions, gave 14·10 gr. CuO = to 11·25 gr. metallic copper, or 45·04 per cent.; so that in this case, if the ignited sulphuret had been considered as oxide, the quantity of copper present would have been overestimated by more than ten per cent.

The copper in all these cases was thrown down from its solution in nitric or hydrochloric acid, by a stream of sulphuretted hydrogen, and worked with water impregnated with that gas.

Again, in repeating these experiments with nickel, equally unsatisfactory results were obtained; thus—

4·98 gr. nickel, equivalent to 6·34 gr. NiO, afforded 6·96 gr. incinerated sulphuret; or an excess of 0·62 gr., equal to 9·79 per cent. too much.

10·35 gr. nickel, equal to 13·16 NiO, gave 13·27; equal to 0·11 gr. too much, or 0·82 per cent.

The nickel being in these cases precipitated from its solution by hydrosulphuret of ammonium.

It will also be noticed, that neither in the case of nickel or copper does the excess appear constant, but perfectly uncertain in amount. With the hopes that the pure oxide would remain, on treating the ignited sulphuret with nitric acid, in the same porcelain crucible in which it had been incinerated, evaporating to dryness, and again igniting, so as to drive off the sulphuric acid formed,—this was tried, and

11·72 gr. of an alloy, containing by calculation 49·49 per cent. copper was dissolved, the copper precipitated by sulphuretted hydrogen, washed and treated as above, yielded 7·74 gr. impure oxide, equal, if considered as CuO, to 6·179 metallic copper, or 52·72 per cent.; shewing an excess of above three per cent., arising from undecomposed sulphate of copper.

Further trials in which the oxides thus obtained were very strongly ignited, with a view to decompose thoroughly all sulphate present, afforded much better, and nearly if not quite accurate results; but the heat required was found inconveniently great, and considerable difficulty was found in decomposing the last traces of sulphate; in consequence, therefore, the method now about to be noticed was tried and found much more convenient in practice, and to afford very accurate results.

Upon analysing the residue left after incinerating the sulphurets produced by precipitating these metals, it was found to consist of a mixture of the disulphuret and oxide of the metal, and containing a small amount of sulphate;—this will be seen from the following results:—

(*a*) 13·27 gr incinerated sulphuret of nickel (precipitated by hydrosulphuret of ammonium), yielded on analysis,

Nickel, . . .	10·35
Sulphur, . . .	0·60
Oxygen, . . .	2·21
Sulphuric acid, . .	0·11
	13·27

which by calculation will be equivalent to—

Nickel, . . .	2·21		
Sulphur, . . .	0·60		
		2·81	Ni_2S
Nickel, . . .	8·08		
Oxygen, . . .	2·20		
		10·28	NiO
Oxide of nickel, . .	0·09		
Sulphuric acid, . .	0·11		
		0·20	$NiO\,SO_3$
		13·29	

which shews a difference of only 0·02 gr. from the obtained results. Again, in case of copper,

(*b*) 2·24 gr. incinerated sulphuret of copper (precipitated by a stream of sulphuretted hydrogen), afforded—

Copper, . . .	1·760
Sulphur, . . .	0·058
Oxygen, . . .	0·392
Sulphuric acid, . .	0·030
	2·240

which, upon calculation, is equivalent to—

Copper, ...	0·229		
Sulphur, ...	0·058		
		0·287	Cu_2S
Copper, . . .	1·537		
Oxygen, . . .	0·387		
		1·924	CuO
Oxide of copper, .	0·029		
Sulphuric acid, . .	0·030		
		0·059	$CuO\ SO_3$
		2·270	

or an excess of ·03 gr. above the quantities experimentally found.*

As now the atomic equivalent of sulphur is exactly double that of oxygen, that of the disulphuret of a metal will of course be precisely the same as of its corresponding protoxide; and this fact consequently enables us at once to calculate the amount of copper or nickel contained in a mixture of the disulphuret and oxide, however variable the relative proportions of these compounds may be, and it becomes only necessary to remove the small amount of sulphuric acid present in the incinerated sulphurets, in order to determine the amount of the one or other metal present.

The addition of a small amount of pulverised carbonate of ammonia to the incinerated sulphuret (as soon as cold), and then carefully heating until all ammoniacal salts are expelled, seems completely to effect this object, as will be seen from the following results obtained experimentally:—

(*a*) 4·30 gr. metallic copper, precipitated by the electrotype, were dissolved, precipitated by sulphuretted hydrogen, and treated as above with all precautions. The mixture of $CuO + Cu_2S$ obtained, amounted to 5·37 gr., whereas by calculation it should have been 5·38 gr.

(*b*) 1·76 gr. same copper, similarly treated, yielded 2·21 gr. $CuO + Cu_2S$, whereas by calculation it should have afforded 2·204 gr.

* The equivalents for nickel and copper employed in the preceding calculations have been Ni = 29·57, Cu = 31·66, O = 8, S = 16.

(*c*) 17·89 gr. of an alloy containing by calculation 49·49 per cent. copper, treated as above, yielded 11·12 gr. $CuO + Cu_2S$, equivalent to 8·878 Cu or 49·62 per cent. copper.

(*d*) 7·61 gr. pure metallic nickel, precipitated from its solution by hydrosulphuret of ammonium, and treated as above, yielded 9·665 gr. $NiO + Ni_2S$, or equivalent to 7·607 gr. nickel.

(*e*) A solution of 4·99 gr. nickel and 3·73 gr. copper was treated with sulphuretted hydrogen to separate the copper; the nickel afterwards thrown down by hydro-sulphuret of ammonium, and both determined as above, gave

6·34 gr. $NiO + Ni_2S = 4·98$ gr. metallic nickel,
and 4·70 gr. $CuO + Cu_2S = 3·75$ gr. ... copper.

As these results appeared extremely satisfactory, it seemed not unlikely that this process could also be extended to the determination of cobalt; and in consequence, 5·25 gr. pure metallic cobalt were dissolved in nitric acid, and neutralised by ammonia, then precipitated by hydrosulphuret of ammonium. The precipitated sulphuret, after washing, incineration, and ignition with carbonate of ammonia, weighed 8·98 gr., and even after being several times successively heated with carbonate of ammonia, it weighed 8·68 gr., whereas by calculation it should only have yielded 6·67 gr. The residue, which was expected to have consisted of oxide and disulphuret, appeared quite pink, and aggregated together on each ignition, evidently containing a large amount of sulphate of cobalt, which seemed most strongly to resist decomposition, and therefore it does not appear probable that this method could be employed in the determination of cobalt.

From the results obtained with copper and nickel, it may be concluded that the process here described may safely be used in estimating these two metals; and, in a very large number of determinations of nickel, it has been found to afford the most accurate and satisfactory results.

In the case of copper, however, more attention must be paid to the details of the operation, as the protosulphuret of copper, especially in cases where free sulphur has been precipitated along with it, is very apt to aggregate together, or even fuse during the incineration (if this is not very carefully conducted), and, consequently, is less easily acted upon by the air during incineration; this must be avoided, and the oxide should also not be allowed to absorb hygrometric moisture before or during weighing.

It will be found most convenient to add the carbonate of ammonia to the incinerated sulphuret in the same crucible in which it had been ignited, or rather to cover the ignited sulphuret with four or five times its volume of this salt, and then by means of a small agate pestle or glass rod to break up all grains and mix it well together by trituration, which can be easily effected without any loss whatever, as the super-stratum of carbonate of ammonia effectually prevents any particles flying over the side of the crucible. This, with its cover loosely placed upon it, is now very gently heated, until nearly all ammoniacal salts are expelled; then the heat is increased for an instant, and the whole, after cooling over sulphuric acid, is weighed and estimated as usual.

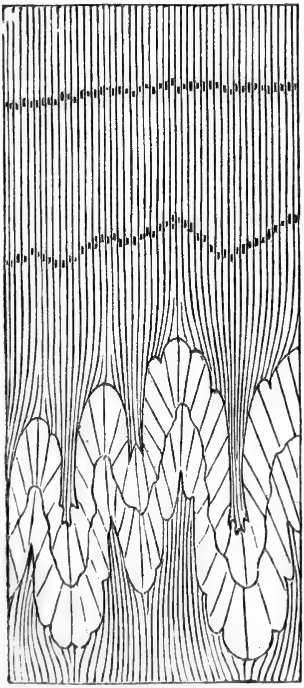
On the Origin of Slaty Cleavage. By HENRY CLIFTON SORBY, F.G.S. Communicated by the Author.

For several years I have devoted myself almost entirely to investigating the physical structure of rocks, both on a large scale, as seen in the field, and by preparing sections of extreme thinness, capable of being examined with the highest powers of the microscope. This latter subject has hitherto attracted little or no attention, though the inspection of two or three thin sections will sometimes solve most important geological problems. Amongst other branches of the study, I have applied this method of research to ascertain the origin of slaty cleavage, which, being obviously due to some peculiarity of structure, I thought might, in all probability, be solved by that means. The examination of thin sections of slate rocks with high powers, and a comparison with those of similar mineral composition not possessing cleavage, have led me to form a theory to account for their difference of structure, materially different from any yet propounded, and which, in my opinion, not only does so most satisfactorily, but also explains perfectly every fact that I am acquainted with, connected with the subject. To enter fully into the whole would require a long treatise, and I shall therefore, on the present occasion, merely give a short outline of my general conclusions.

Professor Phillips and Mr Daniel Sharpe have shewn that the organic remains found in slate rocks indicate a change of their dimensions; and it was their observations which first led me to test the mechanical theory, as applied to explain the microscopical structure. I am fully prepared to substantiate their observations, and have also ascertained a number of other facts, proving, in an equally conclusive manner, that slate rocks have undergone a great change in their mechanical dimensions, which change is invariably related to the direction and intensity of the cleavage, and is such that the cleavage lies in the line of greatest elongation, and in a plane perpendicular to that of greatest compression.

A most careful examination of very numerous contortions of the beds in slate rocks, in North Wales and Devonshire, has led me to conclude that they indicate a very considerable amount of lateral pressure, the thickness of the contorted beds being very different in one part to what it is in another. The accompanying figure will illustrate my meaning, where it will be seen that the thickness of the contorted sandy bed is about four times greater in those parts lying in the mean direction of cleavage than in those perpendicular to it.

Vertical section seen in the Cliffs near Ilfracombe, North Devon.
Scale, 1 *inch to* 1 *foot.*



Fine-grained, dark coloured, shaly slate; the bedding shewn by bands of coarser grain and lighter colour, which, in the upper part, are not contorted. The cleavage is well developed, and dips about 60° to S. by E.

Much contorted bed of coarser-grained light coloured sandy slate, with less perfect cleavage.

Fine-grained slate, as at the upper part.

The difference in thickness of the beds in different parts of the contortions, and the doubling of the beds, which are necessarily related to one another, give rise to what may be called an axis for each contortion; which, from the nature of the case, must lie in the line of greatest thickening of the beds, and therefore shews the direction of the greatest elongation of the mass of deposit, and is usually perpendicular to that of maximum pressure. Now I find that, though contiguous contortions may have their axes inclined at very various angles, even within a distance of not many yards varying by a right angle, yet the dip of the cleavage invariably agrees with them; that is to say, it does not pass through them dipping at a regular angle, as would most probably be the case if it was not due to a mechanical cause, but, in each part, coincides with the line of greatest elongation. In the example figured, the axes of the various contortions are nearly parallel; but it will be seen that the cleavage coincides with them.

In districts where the cleavage dips at a high angle, the contortions have also their axes similarly inclined; whereas, when it is nearly horizontal, so also are their axes.

In slaty rocks of very mixed structure,—as for instance some in the north of Devonshire,—the greatly contorted beds are those which have only an indistinct or imperfect cleavage, and are of such a nature as not to have so readily undergone a change of dimensions as beds above and below them. I have frequently seen cases where such beds are contorted, so as to indicate a very great amount of lateral pressure and change of dimensions, whilst the finer beds just above and below them are most distinctly seen not to have been contorted at all. The case figured illustrates this in a very satisfactory manner. It would seem that a sandy bed had been forced into sharply curved contortions, and its dimensions altered in different parts by the pressure, as previously mentioned. The distance from the lower ends of the two principal contortions was, in a direct line, nine inches, whereas, measured in the line of the bed, it was thirty-eight; and therefore these two points must at first have been about that distance apart, but were forced towards one another, so as to be now at a distance of only one-fourth that amount. Above and below the contorted sandy portion, the beds of fine-grained shaly slate are somewhat disturbed, but in a distance of a few feet are not at all so; the thin bands of more sandy deposit being, as usual, only broken up into small detached portions, which appear as spots in a section perpendicular to cleavage in the line of dip, but as bands in its plane. This is only shewn in the upper side of the contorted bed, but it was the same below it. Hence it appears to be proved, as clearly as possible, that the finer beds have been squeezed to about one fourth of their original thickness, partly no doubt by absolute forcing together of their ultimate particles, but also by elongation in the line of dip of cleavage; the general direction of which is seen to be perpendicular to that of the pressure. I have observed numerous suchlike cases, and in fact nearly all the greatly contorted coarser-grained beds in North Devonshire present similar appearances. They are, in fact, analogous to what would occur if a strip of paper, for instance, was included in a mass of some soft plastic material, which would readily change its dimensions. If the whole was then compressed in the direction of the length of the strip of paper, it would be bent and puckered up into contortions, whilst the plastic material would readily change its dimensions, without such being the case; and the difference in distance of the ends of the paper, as measured in a direct line, or along it, would indicate the change in dimensions of the plastic material.

The green spots so often seen in slate, do also most distinctly indicate a similar change of dimensions. I am persuaded that they have been concretions of a peculiar kind, formed round bodies lying in the plane of bedding. In rocks without cleavage, such green spots are almost perfect spheres, or are elongated in the plane of bedding. The facts seen in those in slate rocks, prove, I think, most clearly that they were exactly similar before the cleavage was developed. Now, however, they are greatly compressed in a line perpendicular to cleavage, and somewhat elongated in the line of its dip. When they have been originally spherical, their long axis agrees with the dip of cleavage, both in its plane and perpendicular to it; whereas, if they have been originally more elongated in the line of bedding, their longer axis is inclined in such a manner as would then occur if they had been subsequently elongated in the direction of dip of cleavage; that is to say, it does not now coincide with it, but deviates towards the plane of bedding. If, however, the stratification is perpendicular or parallel to the cleavage, the longer axis of the spots does agree with the dip; or, if it cuts the plane of cleavage in the line of true strike, then also, in the plane of cleavage, the longer axis of the spots coincides with the line of dip. On the whole, all the facts agree most perfectly with what would occur if the spots had originally been similar to those in non-cleaved rocks, and the mass of slate had been greatly compressed in a line perpendicular to cleavage, and somewhat elongated in the line of dip.

Many of the finer-grained slates used for roofing, contain minute rounded grains of mica, seldom so much as $\frac{1}{100}$th of an inch in diameter, and usually much less, which are of nearly the same thickness as width, and not merely flakes. When these are cut through in the thin sections used for microscopical examination, they are seen to be composed of many laminæ. When the line of lamination,—that of the crystalline cleavage of the mica,—coincides with the cleavage of the slate, these rounded grains retain their form unaltered. If the lamination is perpendicular to the cleavage, the rounded form still remains, but the laminæ are generally not straight, being irregularly bent in just such a manner as if they had been compressed in the direction perpendicular to the cleavage of the slate. Those, however, which lie with their lamination at intermediate angles, as for instance at 30° or 40° to the cleavage of the slate, do not retain their original form, but are broken up and extended out in the plane of their lamination, in just such a manner as would occur if the dimensions of the slate had been changed, as previously mentioned. If carefully drawn with a camera lucida, these broken-up grains can be, as it were, restored to their original form, and the amount of change of dimensions calculated with great accuracy.

Hence, therefore, in cleaved rocks, whether we examine the diminution in the distance between any two points lying in the line of pressure in contorted beds, the dimensions of the beds in different parts of contortions, the organic remains, the green spots, or the very minute rounded grains of mica, we find most conclusive evidence of an elongation in the line of dip of cleavage, and of a great compression, invariably in a line perpendicular to the cleavage.

The relation between the compression and elongation varies in different rocks, as would necessarily follow from their different composition. The examination of the spots on fine-grained, good roofing slate furnishes the best evidence of the absolute condensation in a direction perpendicular to cleavage. If they had originally been spheres, and if there had been no condensation of the rock, but only a change in its dimensions, so that, though its thickness was reduced, it was elongated to a corresponding extent in the line of dip of cleavage, it would necessarily follow that their area would not be changed in the plane perpendicular to cleavage in the line of its dip. Therefore, if, in the plane of cleavage, the length of the spot in the line of dip bore a certain proportion to that in the line of strike, in the plane just mentioned, the ratio of the length of the spot, in the direction of cleavage, to that perpendicular to it, would be as the square of that in the former case. Very numerous and accurate measurements, in the very perfectly cleaved slate near Penrhyn and Llanberis, shew that, in the plane of cleavage, the length of the spots in the line of dip exceeds that in the line of strike in the proportion of 1·6 : 1; whilst in the plane perpendicular to cleavage, in the line of dip, their length in the line of cleavage is six times greater than perpendicular to it. In the plane perpendicular to cleavage, in the line of strike, the ratio between the length of the spots in the line of cleavage to that perpendicular to it, would be 6 : 1·6 = 3·75 : 1. These results are obtained from so many and various cases, that the effects of bedding, in such regular spots as I chose, would be so slight as not to be of any material consequence. If no condensation had occurred, the ratio of the axes in the plane perpendicular to cleavage would have been as 2·56 : 1, instead of 6 : 1; and hence there must have been an absolute compression from 100 to about 43. From the nature of the facts, the chances are that it is, if anything, rather too great; and hence, probably, the true average absolute condensation in such rocks, has been to about one-half of the original volume. This must have resulted chiefly from the forcing of the particles more closely together, so as to fill up the spaces left between them, when only touching each other; and their very close packing, as seen in thin sections, agrees well with this supposition.

These amounts of change of dimensions vary considerably in different cases, but they agree most perfectly with that indicated by the contortions of the beds in their immediate vicinity, and also most closely correspond with that deduced from the breaking up of the rounded grains of mica.

The power most generally useful in examining slate rocks, is about 400 linear; but higher and lower are of course valuable for particular purposes. It is almost indispensable to use a polarizing microscope, and there should be such contrivances as to give a good, bright, polarized light with high powers. The physical structure and optical properties of the minerals found in them, are such that they can be identified with great certainty, even when in grains less than $\frac{1}{1000}$th of an inch in diameter.

Some slate rocks, as for instance the pencil slate of Shap, consist almost entirely of rounded grains and minute flakes and granules of mica, varying from about $\frac{1}{100}$th to $\frac{1}{10,000}$th of an inch in diameter, but chiefly under $\frac{1}{1000}$th. I do not believe that this is in the least due to metamorphism, but has been a deposit of micaceous mud, for the rounded grains have every character of being water-worn; and in the limestone of Rhiwlas near Bala, which consists almost entirely of such grains and flakes of mica, and fragments of encrinites, their organic structure is as perfect, or even more so, than in any limestone with which I am acquainted, though I have prepared and examined thin sections of several hundred specimens of every geological period; and so much so, that any material amount of metamorphism is wholly out of question. When deposits of decomposed felspar have been acted on by great heat, they are, as it were, baked into a natural porcelain, but no such grains of mica are formed. Usually, besides mica, there is found in good roofing slate, like that at Penrhyn, a certain proportion of decomposed felspar, a few minute grains of quartz sand, and granules of phosphate of iron. The red tint is produced by the presence of very numerous minute crystals of peroxide of iron, and the dark by those of pyrites. From such slate there is every gradation to those containing little or no mica, but made up of more or less fine quartz sand, and decomposed felspar, in very variable proportion; but these have only an imperfect cleavage. Other slates, as is well known, contain much chlorite and other minerals. On the present occasion I shall chiefly confine myself to the consideration of such slate as has a perfect cleavage.

If a thin section of a rock not having cleavage be examined, which has a similar mineral composition to those which, when having it, form good slates, it will be seen that the arrangement of the particles is very different. For instance, the well-known Water of Ayr stone has no cleavage, but shews more or less of bedding. It consists of mica and a very few grains of quartz sand, imbedded in a large proportion of decomposed felspar; the peroxide of iron being collected to certain centres, and having the characters of peroxidised pyrites. The flakes of mica do not lie in the plane of bedding, but are inclined tolerably evenly at all angles, so that there is no definite line of structural weakness, independent of that due to bedding; which results chiefly from alternations of layers of somewhat different composition, and not from the arrangement of the ultimate particles. This is however totally different in a rock of similar composition having cleavage. If a section be examined, cut perpendicular to cleavage, in the line of its dip, it will be seen that though some of the minute flakes of mica lie perpendicular to the cleavage or at high angles to it, by far the larger part are inclined at low, so that the majority lie within 20° on each side of it. In fact they are most numerous nearly in the plane of cleavage, and gradually but rapidly diminish in quantity in passing to higher angles, so that there are twenty times as many nearly in the plane of cleavage as at 45° to it, and very few at 90°. Where a section is examined, cut perpendicular to cleavage, in the line of the strike, it is seen that the arrangement is similar, but there is not near so rapid a diminution of the members in passing from the line of cleavage, so that there are comparatively several times as many more inclined at about 45° to it, than when the section is in the line of dip, and those at still higher angles are also much more numerous. In a section in the plane of cleavage, but few flakes are cut through so as to have a greatly unequiaxed form; but they are similarly arranged with respect to the line of dip, though not in so marked a manner. It is not merely the larger flakes of mica that are thus arranged, but the whole of those unequiaxed particles which existed in the rock before the cleavage was developed.

When a cleavage crack in the thin sections is examined, it is clearly seen that the cleavage is due to the above described arrangement of the particles, which it follows most perfectly; not passing straight forwards, but turning about according to the manner in which the ultimate particles lie in every part. It therefore appears that the fissile character of slate is due to a line of structural weakness, brought about by the manner of arrangement of the ultimate, unequiaxed particles. The natural cleavage cracks, of course, bear the same relation to this arrangement as those so often seen in many crystalline bodies do to that of their ultimate atoms. They appear, in general, to have been mainly due to meteoric agencies; their position having been determined by the structural weakness. In accounting, then, for so-called slaty cleavage, it is only requisite to shew how such particles could have had their position so changed that their arrangement should be altered from that found in rocks not having cleavage to that in those having it; which explanation must of course be such as would agree with every other fact connected with the subject.

Now I trust I have already shewn that there is abundance of evidence to prove that rocks having slaty cleavage have been greatly compressed in a line perpendicular to cleavage, and elongated to a certain extent in the line of its dip. Taking for the amount of these changes those I have already mentioned for the slate of Penrhyn and Llanberis, it is easy to calculate mathematically what would be the arrangement of the unequiaxed particles in such a rock as Water of Ayr stone, if its dimensions were so changed. Supposing that A = the angle of inclination of the longer axis of any unequiaxed particle to the line along which the maximum elongation would occur, and that a = this angle after it had taken place, we should have, perpendicular to cleavage in the line of dip, $\tan a = \frac{\tan A}{6}$; in that of strike $\tan a = \frac{\tan A}{3{\cdot}75}$; and, in the plane of cleavage, $\tan a = \frac{\tan A}{1{\cdot}6}$. From these relations it necessarily follows that the particles would then be arranged in precisely such a manner as is seen to be the case in such a rock having cleavage, the agreement being most perfect in every particular, both in kind and amount, as seen in sections cut in each direction.

Though such calculations may be fully relied on, yet, to satisfy myself that they were correct, I have tested them by actual experiment. Having mixed some scales of oxide of iron with soft pipe-clay, in such a manner that they would be inclined evenly in all directions, like the flakes of mica in Water of Ayr stone, I changed its dimensions artificially to a similar extent to what has occurred in slate rocks. Having then dried and baked it, I rubbed it to a perfect flat surface, in a direction perpendicular to pressure and in the line of elongation, which would correspond to that of dip of cleavage, and also, as it were, in its strike, and in the plane of cleavage. The particles were then seen to have become arranged in precisely the same manner as theory indicates that they would, and as is the case in natural slate; so much so, that, so far as their arrangement is concerned, a drawing of one could not be distinguished from that of the other. Moreover, it then admitted of easy fracture into thin flat pieces in the plane corresponding to the cleavage of slate, whereas it could not in that perpendicular to it. Even in clay which has but few very unequiaxed particles, a most distinct lamination is produced by changing its dimensions, as described above, but it would not cleave perfectly, no more than will natural slate of similar mineral composition, and moreover one cannot obtain their firm, uniform structure.

It is a fact well worthy of remark, that, on each side of the larger rounded grains of mica, in the line of cleavage, in well-cleaved slates, the particles are arranged evenly at all angles, over small triangular spaces, having their bases towards the grain. This is just the part which would be protected from change of dimensions by its presence; and this fact is therefore very good evidence of the slate having had originally such a structure as would be changed into its present, if its dimensions had been altered in the manner and to the extent indicated by the breaking up of other rounded grains of mica seen in the same thin section.

What I therefore contend is, that there is abundance of proof that slate rocks have suffered such a change of dimensions, as would necessarily alter the arrangement of their ultimate particles from what is found in rocks not having cleavage to that in those which have, and hence develop a line of structural weakness in the direction in which it really does occur.

Some slates have a very poor cleavage, although their mineral composition is similar to that of such as often have a most perfect. In these the green spots indicate a comparatively small change of dimensions; and in others having no cleavage, the contortions and spots shew that little or none has occurred. Whence it should appear that the perfection of cleavage depends both upon the ultimate mineral composition, and the amount of change of dimensions of the rock.

When slates are composed of alternating beds of different character, the cleavage almost always does not pass straight through them, but lies nearer to the plane of bedding in the finer-grained and more perfectly cleaved varieties. When the cleavage cuts the beds at a moderate angle, this difference is often very considerable; but where the bedding is perpendicular or parallel to it, there is little or no variation. When the change in mineral structure of the beds is sudden, the inclination of their respective cleavages is sharp and angular; but if it be gradual, it passes from one to the other in a curve. These facts are most easily explained by this theory. When such a mass of rocks was compressed, certain beds would yield much more readily than others, both to absolute compression and elongation. In such contortions of coarse-grained beds interstratified with fine, as that figured, the fact of them being so whilst the fine are not, and the spreading-out arrangement of the cleavage planes in the finer, at the vertices of the contortions of the coarser, as shewn in the figure, prove that they did not admit of so much absolute compression as the fine. In uncontorted alternating beds of such characters the amount of elongation in the line of dip could not vary, and, therefore, it would necessarily follow that the more compressible would be more compressed in the plane of bedding than the others. Hence, the line of cleavage would lie more towards that plane in the fine than in the coarser, the junction being angular or curved, according as the nature of the beds changed suddenly or gradually, as is really found to be the case.

The inequalities at the junctions of different kinds of beds, and the peculiar wrinkling of their surface, agree perfectly with this mechanical theory. I have examined sections cut in the plane of bedding perpendicular to the cleavage, and find that the arrangement of the particles corresponds to the wrinkles, and is just such as would necessarily occur if there had been an irregular giving way of the rock so as to form them.

If the direction of the cleavage be examined in the various parts of the case figured in this memoir, I cannot conceive how they could possibly be explained, except by such a theory as I am now advocating. In the coarser-grained sandy bed it coincides with the axes of all the contortions, and is in the line of greatest elongation of the thickness of the bed, and perpendicular to the line of pressure. It is arranged in fan-shape in all the contortions, as though they had been squeezed together after the sandy bed had suffered as much compression as it admitted of. The cleavage in the fine-grained beds at some distance from the contorted one, is perpendicular to the line of squeezing, as indicated by its puckering up, and the increase and diminution of its thickness, in passing round the contortions; but when approaching their rounded ends, though the cleavage passes straight forward in the line of their axes, it spreads out on each side, and curves down into the sharp-ended spaces between them, in just such a manner as would necessarily occur if the coarser-grained bed had been less compressed than the other. It would also follow, that the above-mentioned fan-shaped arrangement would be of greatest amount in such beds as offered much resistance to change of dimensions, whereas in fine-cleaved slates it would be very small, or even not occur at all; and such is the fact observed in the rocks themselves. It would also necessarily follow from this theory, that the strike of the cleavage would usually coincide with the general strike of the beds, and be parallel to the main axis of elevation of the district, as has been found to be so commonly the case. The dip of the cleavage planes over any extensive district would likewise be as has been observed. The structure of the so-called double-cleaved slate admits of most easy explanation, as do a number of other facts connected with the subject; and, so far as I am aware, there are none which cannot be explained by this theory, or by suppositions most perfectly reconcilable with it.

It may perhaps be objected that the cleavage of slate is too regular and parallel in its range over a given district, to agree with the supposition of its being due to the cause I have suggested; but I think there is abundance of evidence to shew that such a physical change of dimensions has really occurred with the kind of regularity observed in respect to the cleavage planes. Such metamorphic schists as those of the north-east of Anglesea, have a peculiar linear graining on the surface of their beds, but no true cleavage. This linear graining is due to small puckerings of the beds, and may be called "plications of the first order." They are not parallel to other sets of plications which have occurred after their formation. I have carefully examined their direction over a considerable area, and laid them down on a map, and find that they trend parallel, or turn gradually about, in precisely the same manner as the strike of the cleavage planes in slate rocks. Similar facts have been often observed with respect to larger contortions. There can be no doubt of the mechanical origin of both these kinds of plications, and hence we have evidence to shew that wide districts have been compressed laterally in just such a manner as would produce a similar arrangement of the strike of the cleavage planes in rocks of such a character as have had cleavage developed, when they have suffered similar compression under somewhat different circumstances. It has also been urged against this theory, that if masses of rock of different kinds had been compressed, they would not have given way uniformly. This, however, must have arisen from some misapprehension of the real arrangement of the cleavage in such rocks; for, as I have shewn, the facts prove that they have not given way uniformly, and this very circumstance explains many of its irregularities.

Perhaps it may be said, How is it possible that hard rocks could have had their dimensions changed to the extent described? To this I would reply, If the rocks be examined, it will be seen that it really has occurred, and I would suggest that solidity is but a comparative property, and that the intensity of the forces in action during the elevation of a range of mountains, could gradually change the dimensions of rocks; for it is well known that many hard and brittle substances will admit of such movements, as for instance the ice of glaciers, and hard and brittle pitch.

I would now ask, How is it possible to reconcile all the mechanical facts I have described, which are so clearly related to the cleavage, with the supposition of its being due to electrical action, or any other non-mechanical cause? If I be not greatly deceived, they all form a most complete whole, if viewed in the light I have placed them; whereas, so far as I can see, they are quite incomprehensible on the latter supposition; nor, so far as I can learn, have its most zealous supporters ever given any satisfactory reason for the manner of distribution of the cleavage planes, even assuming them to be as regular and uniform as some authors appear to describe them. Mr Sharpe's theory, of course, only differs from mine in his assuming that the particles have been really *compressed;* whereas I am persuaded, that in general they have only suffered a *change of position.* This, however, no doubt resulted from the different method of research I have adopted. It would however, cause me to extend this communication to too great a length, to enter fully into all these questions, or describe many other facts I have observed connected with the subject. My object, in the present memoir, is to give a rough outline of my observations and theories; and though I have greatly exceeded my proposed limits, yet I fear that many points will have been far from clearly understood; for to explain them all thoroughly would require much detail and numerous illustrations.

Colonel Sabine on the Determination of the Figure and Dimensions of the Globe.

The determination of the figure and dimensions of the globe which we inhabit may justly be regarded as possessing a very high degree of scientific interest and value; and the measurements necessary for a correct knowledge thereof have long been looked upon as proper subjects for public undertakings, and as highly honourable to the nations which have taken part in them. Inquiries in which I was formerly engaged, led me fully to concur with a remark of Laplace, to the effect that it is extremely probable that the first attempts were made at a period much anterior to those of which history has preserved the record; the relation which many measures of the most remote antiquity have to each other and to the terrestrial circumference strengthens this conjecture, and seems to indicate, not only that the earth's circumference was known with a great degree of accuracy at an extremely ancient period, but that it has served as the base of a complete system of measures, the vestiges of which have been found in Egypt and Asia. In modern times the merit of resuming these investigations belongs to the French nation, by whom the arc of the meridian between Formentera and Dunkirk was measured towards the close of the last century. The Trigonometrical Survey of Great Britain, commenced in 1783, for the specific object of connecting the Observatories of Greenwich and Paris, was speedily expanded by the able men to whom its direction was then confided, into an undertaking of far greater scientific as well as topographical importance, having for its objects, on the one hand the formation of correct maps of Great Britain, and on the other the measurement of an arc of the meridian, having the extreme northern and southern points of the Island for its terminations. A portion of this arc, amounting to 2° 50′, viz. from Dunnose in the Isle of Wight to Clifton in Yorkshire, was published in the Phil. Trans. in 1803. As the whole arc, extending from Dunnose to Unst and Balta, the most northern of the Shetland Islands, would comprise more than 10°, and as nearly half a century had elapsed since the publication of the earlier part of the survey, it is not surprising that some degree of impatience should have been felt, both by those who desired the results for scientific use, and by those who were interested for the scientific character of the nation, that the general results of the survey applicable to scientific purposes should at length be given to the world. Accordingly, at the Birmingham Meeting of the British Association in 1849, a resolution was passed appointing a deputation to confer with the Master-General of the Ordnance, and a similar resolution was passed about the same time by the President and Council of the Royal Society. On communicating with the Master-General, it appeared that the want of special funds for the requisite calculations formed the only obstacle, a difficulty which was happily immediately surmounted by an application of the President and Council of the Royal Society, to Lord John Russell, then First Lord of the Treasury. The report of the Council of the British Association to the General Committee at the meeting of the last year at Ipswich, contained an official statement from the Inspector-General of Fortifications of the progress of the reduction and examination of the observations preparatory to the desired publication, and concluded with expressing the expectation of the director of the survey, that he "should be able to furnish for communication to the British Association that would probably assemble in 1852, the principal results obtainable from the geodetic operations in Great Britain and Ireland." By a recent letter to my predecessor from Captain Yolland of the Royal Engineers, who is intrusted with the direction of the publication, I am enabled to have the pleasure of announcing that the "printing of the observations made with the zenith sector, for the determination of the latitudes of stations between the years 1842 and 1850, is finished, and will be presented in time for the meeting of the British Association, and that the calculations connected with the triangulation are rapidly advancing towards their completion."

In the meantime, the great arc of Eastern Europe has been advancing with unexampled rapidity, and to an extent hitherto unparalleled. Originating in topographical surveys in Esthonia and Livonia, and commenced in 1816, the operations, both geodesical and astronomical, have been completed between Izmaïl on the Danube and Fugleness in Finnmarken, an extent of $25\frac{1}{3}$ meridional degrees. Next to this in extent is the Indian arc of 21° 21′ between Cape Comorin and Kaliana; and the third is the French arc already referred to, of 12° 22′. It appears by a note presented to the Imperial Academy of Sciences at St Petersburg by M. Struve, that a provisional calculation has been made of a large part of the great arc of Eastern Europe, and that it has been found to indicate for the figure of the earth a greater compression than that derived by Bessel in 1837 and 1841, from all the arcs then at his command,—Bessel's compression having also been greater than Laplace's previous deduction. It is naturally with great pleasure that I perceive that the figure of the earth derived by means of the measurement of arcs of the meridian, approximates more and more nearly, as the arcs are extended in dimension, to the compression which I published in 1825 as the result of a series of Pendulum Experiments, which, by the means placed by Government at my disposal, I was enabled to make from the equator to within ten degrees of the pole, thus giving to that method its greatest practicable extension.—*Address to the British Association at Belfast.*

On the Distribution of Heat at the Surface of the Sun. By Professor SECCHI.

1. The heat of the solar image is at the centre almost twice as great as at the borders. This is found to be true, examining the diameters both in right ascension and declination. 2. The maximum of temperature did not appear to be at the centre, but above it, in a point distant from it about 3′ of geocentric declination. Constructing graphically the

curve of the intensity of heat, taking as abscissæ the parts of the sun's diameter, and as ordinatæ the intensities themselves, it appears that this curve (a kind of inverted parabola) is not symmetrically disposed about the axis of the ordinates, but a good deal inclined towards the upper edge. I subjoin some numbers which represent the intensity of heat in the parts of the diameter of the sun, taken in minutes, + above, and – below the centre of the image.

Positions on the diameter of the sun in declination,	+14′·96	+11′·32	+3′·00	+1′·32	–10′·9	–14′·88
Relative intensity of heat,	57·39	88·81	100·00	99·48	81·32	54·34

These are the results of eight series of experiments, none of which is found in contradiction with the others, and their separate numbers are very nearly the same, so that the fact seems to me completely ascertained. It is certainly curious that the maximum of heat corresponds with the position of the solar equator, as visible from the earth at the epoch of the experiment (20th, 21st, 22d March). This leads naturally to the conclusion that the solar equatorial regions must be hotter than the polar regions, as was suspected already from the more frequent appearance of the spots there. The conclusion seems perfectly accurate, even admitting a solar atmosphere, since the effect of this last should be to diminish symmetrically the radiation around the centre of the image; on the contrary, if the polar regions are less hot than the equatorial, the intensity of heat should have been less in the lower part of the image, where the south pole of the sun was visible; and consequently, the parts having equal distance from the centre of the image, had a very different heliographical latitude, on account of the inclination of the solar axis to the ecliptic. From these principles only, the non-symmetry of the curve is accounted for. If *this alone* is the cause, the curve will be found symmetrical in the months of June and December, and reversed in September, since in the two former the equator passes through the centre of the image, and in the last is below it. But it is not impossible that the two solar hemispheres should possess different temperatures, as seems to be the case on the earth, and is suspected in *Mars*. If this is the case, these researches will throw some light on the climatology of the earth itself; since the heat of the sun must be different, according as one or other of its poles is turned towards the earth. Future experiments will resolve this question. With respect to the poles of the sun, I shall add here a conjecture on a fact recently discovered by Colonel Sabine. The journal *Institut* relates that this gentleman has found that the deviation of the magnet from its mean position at the Cape of Good Hope is found to be in opposite directions at the epochs of the two equinoxes. Might this not be an effect of the solar magnetical polarity on the terrestrial magnetism. The fact deserves to be examined, if it takes place in our hemisphere, and in opposite directions. Coming again to the solar heat, I have found that spots seemed less hot than the rest; but as only small groups of them were visible, no singular fact or law can be stated from these observations. I shall conclude this account by noticing an odd historical coincidence, namely, that these observations were made in the same room where it is said F. Scherner, the first who used a telescope mounted equatorially, made his observations of the sun. This room has been this year added to the observatory.—*Proceedings of the Royal Astronomical Society, November* 1852.

On the Mean Density of the Superficial Crust of the Earth. By M. PLANA.

The researches of geometers have established, beyond doubt, that the density of the earth increases towards the centre. Assuming the densities of the successive strata to increase in arithmetical progression, Laplace has investigated the constant amount of increase for each successive stratum, and has hence deduced the mean density of the terrestrial spheroid (Méc. Cél., tome v., liv. xi.) In his researches on this subject, he supposes the density of the superficial stratum (ϱ) to be three times the density of the sea, considered equal to unity. He remarks that this assumption agrees very nearly with the density of granite. His expression for the density of any stratum is,

$$\varrho = (\varrho)\,(1 + e - e\,a),$$

in which a denotes the radius of the stratum (the mean radius of the superficial stratum being supposed equal to unity), and e the constant quantity by which the depth of each successive stratum; $1 - a$ is to be multiplied conformably to the assumed law of density. Admitting the ellipticity of the earth to be equal to 0·00326, Laplace found the value of e to be 2·349, and hence determined the mean density to be 4·764. This value differs considerably from the results which Reich and Baily have deduced from their experiments with the balance of torsion; the former having obtained 5·44, and the latter 5·6604, for the mean density of the terrestrial spheroid, the density of pure water being supposed equal to unity.

The remarks of Humboldt on the density of the superficial stratum of the earth, contained in the first volume of his *Kosmos*, would seem to imply that the value of this element assumed by Laplace is erroneous. He states, that from the nature of the rocks which constitute the superficial strata of the solid parts of the globe, the density of continents is hardly 2·7; and he hence infers, that the mean density of continents and seas taken together does not amount to 1·6. The researches of Plana, contained in the note above referred to, serve to confirm this conclusion. Supposing the ellipticity of the earth to be represented by 0·00326 (1 − 0·008479), he has found that the mean density 5·44, and the initial density 1·6, may be satisfactorily accounted for. The ellipticity derived either from actual measurement or from researches on the lunar theory, cannot be regarded as sufficiently trustworthy to render the value here assumed inadmissible. On the other hand, if the ellipticity be supposed equal to 0·00326, the mean density deducible is 4·76; a result which is incompatible with the precision of the experiments made for the purpose of determining this element.—*Proceedings Astron. Soc., Dec.* 1852.

Lieutenant Maury's Plan for Improving Navigation; with Remarks on the Advantages arising from the Pursuit of Abstract Science. Extracted from Lord Wrottesley's Speech in the House of Lords, on 26th April 1853.

"It is time that I should now explain how these charts are constructed and routes discovered. The whole ocean is divided into squares the sides of which represent 5° of longitude and 5° of latitude; in the midst of these squares the figure of a compass is drawn, with lines representing sixteen of the compass points, the intermediate points being omitted; the log-books are then searched for observations of the directions of winds and of the proportion of calms in each of these squares. In the centre of each compass so drawn are placed two numbers, one representing the total number of observations obtained in the square, the other the per-centage of calm days. By the side of each of the lines representing the sixteen points of the compass, are written numbers which denote the per-centage of the winds that have been found to blow from that quarter, and at the extremity of each line are numbers, which shew the per-centage of miles a ship will lose if she attempt to sail 100 miles through that particular square, in the particular direction indicated by the line in question. Now that number is obtained as follows:—

"By the resolution of simple problems in sailing, it is known that if the wind will not allow a ship to lie within six points of her course, that is, if it be a head wind, she will lose 62 miles (omitting fractions) in every 100 that she sails, or, in other words, after sailing 100 she will only have made 38 good in the wished-for direction; in like manner, if she can sail within four points, she loses 29 miles, and if within two points, only eight. Having therefore the per-centage of winds that will make such deviation from the desired course necessary, it is easy by a common proportion to calculate the total amount of space lost or *detour* (as Maury calls it) for every given direction, for every 100 miles sailed within the square. When a course has to be traced, therefore, all the squares are carefully examined, and by a very laborious system of trial and error, the combination of squares is found which gives the route most likely to succeed, by ascertaining those through which the loss is a minimum. I say *most likely*, for of course this is only a problem of chances, and the event *may* be adverse, as in the case of insurances, but is less likely to be so as observations are multiplied. I should explain that in performing this process, currents and calms are taken into account, and that there are separate compasses drawn, and separate routes traced for each of the twelve months of the year; for though the winds are assumed to be so far constant for individual months as to give an average on which some reliance may be placed, when the number of observations is sufficiently large, this is by no means the case thoughout the whole year. When the twelve compasses have been delineated and filled up, they are combined, by a peculiar and neat arrangement of the numbers within concentric circles, into one, and a chart of the ocean, containing these combinations, is termed a *pilot chart.*

"Lieutenant Maury is anxious to obtain at least 100 observations per month in each square, which will be more than a million and a half for the whole ocean, and a less number seems certainly not sufficient to give a result in which confidence can be placed. As might be expected, in some squares he has obtained a great many more than this, and in some none at all; in the square *e. g.* which adjoins New York, he has obtained 4,387 observations; but there is a large space of ocean seldom traversed by ships, that *e. g.* between the southern extremities of Africa and America, in which the squares are all blank. Now, my Lords, I think those blank squares are a reproach to the civilisation of the present age, and I say so on this principle, that it is our duty not to rest satisfied till we know all that can be known about the globe we inhabit, that can be rendered in any way profitable to our common species; and therefore I think that the principal maritime nations should share the labour of exploring these vacant spaces, for no doubt shorter routes might be discovered through them, and others matters ascertained, to which I shall presently allude. However, it is no part of Lieutenant Maury's plan, as such, to send out surveying expeditions.

"Now, your Lordships will of course understand that other things besides the directions of the winds are contained in these log-books, and *these* matters not contained in ordinary records of this kind; but I thought it better to keep that division quite distinct, as it is the winds that form the chief guide in devising the new course. Hydrography is of two kinds,—that which consists in accurate surveys of harbours and coasts, which may be called more properly 'maritime surveying,' and that which consists in recording all the phenomena of a scientific character which are observed at sea, in what sailors call 'the blue water,' *i. e.* out of ordinary soundings. Among these the most important, exclusive of astronomical and meterological observations, properly so called, are the force and set of currents, and the temperature and depth of the water. The American masters are instructed to immerse a thermometer in the water, and take the temperature of the ocean at least once a day, and to examine, as often as convenient, the force and set of currents, and also to try for deep sea soundings."

Report of the Royal Society on Lieutenant Maury's Scheme.

"Short as is the time that this system has been in operation, the results to which it has led have proved of very great importance to the interests of navigation and commerce. The routes to many of the most frequented ports in different parts of the globe have been materially shortened, that to St Francisco in California by nearly one-third: a system of southwardly monsoons in the equatorial regions of the Atlantic and on the west coast of America has been discovered; a vibratory motion of the trade-wind zones, and with their belts of calms and their limits for every month of the year, has been determined: the course, bifurcations, limits, and other phenomena of the great Gulf-stream have been more accurately defined, and the existence of almost equally remarkable systems of currents in the Indian Ocean, on the coast of China, and on the north-western coast of America and elsewhere, has been ascertained. There are, in fact, very few departments of the science of meteorology and hydrography which have not received very valuable additions; whilst the more accurate determination of the parts of the Pacific Ocean where the sperm-whale is found (which are very limited in extent), as well as the limits of the range of those of other species, has contributed very materially to the success of the American whale fishery, one of the most extensive and productive of all their fields of enterprise and industry."

Lieutenant Maury is enthusiastic in the cause. He sees the benefits that must arise from the extension of this system of observation, and he invites the co-operation of all maritime nations; but to which does he look with the most longing eyes and the best hopes of success? Of course to the nation of whom the poet sings—

> "Their path is on the mountain wave,
> Their home is on the deep;"—

To his brethren at this side of the Atlantic. What do the Royal Society say on this point?

"But it is to the government of this country that the demand for co-operation, and for the interchange of observations, is most earnestly addressed by the government of the United States; and the President and Council of the Royal Society express their hope that it will not be addressed in vain. We possess in our ships of war, in our packet service, and in our vast commercial navy, better means of making such observations, and a greater interest in the results to which they lead, than any other nation. For this purpose, every ship which is under the control of the Admiralty should be furnished with instruments properly constructed and compared, and with proper instructions for using them: similar instructions for making and recording observations, as far as their means will allow, should be sent to every ship that sails, with a request that the results of them be transmitted to the Hydrographer's Office of the Admiralty, where an adequate staff of officers or others should be provided for their prompt examination, and the publication of the improved charts and sailing directions to which they would lead. Above all, it seems desirable to establish a prompt communication with the Hydrographer's Office of the United

States, so that the united labours of the two greatest naval and commercial nations of the world may be combined, with the least practicable delay, in promoting the interests of navigation."

However, the Dutch have in this instance been beforehand with us; they have already adopted Maury's plan. The expenses will be really trifling in comparison to the great results to be obtained. Some thermometers must be bought and supplied to ships, and officers must be placed in charge of a separate department of hydrography, whose constant duty it will be to collate all the materials sent in, and construct new charts, and that department must be placed in communication with the hydrographical department of the United States. But if I do not take too sanguine a view of the matter, it really seems to me that this expenditure will bear an almost indefinitely small ratio to the benefits likely to be realised to navigation alone. But this is a small part of the total amount of advantages—the benefits that are likely to flow from having a numerous host of observers making meteorological observations continually night and day, over all the parts of the globe covered with water, which are nearly three-fourths of its surface, and which before supplied no materials to the common stock of science, can scarcely be over-estimated. There is no subject which is more perplexing than the science of the weather; the phenomena are so various and so complex that at one time philosophers despaired of eliminating any general laws; but the prospect is now brighter; a vast step has been made by the invention of self-registering instruments, the beautiful applications of electricity to that object, and by the establishment of numerous magnetic observatories, at all of which meteorological observations are made. But the sea may be described as the spot on which all the phenomena are in their most regular and normal state, uninterrupted by casual causes, such as unduly heated surfaces, mountain ranges, and so forth. "The sea," says Maury, "is the field for observing the operations of the general laws which govern the circulation of the atmosphere. Observations on land enable us to discover the exceptions, but from the sea we get the rule." Thus the addition of near three-fourths of the globe to the field of meteorological observation, and that three-fourths covered by water, will be an accession to science of great importance.

Observations by Augustus Petermann, Esq., on the Arctic Relief Expeditions.

Noble efforts have been made to rescue Sir John Franklin and his companions. But now that nearly eight years have elapsed without tidings of them, even the most sanguine must begin to feel anxiety about their safety. If, as is very probable, they have not perished from the want of food, but have been eking out an existence by means of certain Arctic animals, their number must have greatly diminished, and those who may still be alive would doubtless, from their long confinement and severe trials, have their strength so reduced as to be unable to extricate themselves from their prison, or make much locomotive progress. In any efforts, therefore, that may yet be made for their relief, *time* should form a chief point of consideration, as every week may cut off some from the number yet living. It is now satisfactorily established that they must be looked for far beyond the American shores,—indeed, far beyond Melville Island,—namely, opposite the shores of Siberia, in a region extending from the land discovered by Captain Kellett to the eightieth parallel, and from the meridian of Point Barrow on the American side, to that of the Kolyma on the Asiatic. This is just the region which has been, and is still, altogether unprovided for in the search, except by the Assistance and her tender under Sir Edward Belcher, who has gone up Wellington Channel, where most probably the missing expedition has preceded him. But although Sir Edward Belcher found an unusually open season, enabling him to push his way up that channel, it is not very likely, considering the time that would be lost in looking for traces, that he would overtake Franklin in less than three years, by following him on a route which has occupied the latter six years. For it must be remembered that Sir John Franklin, in 1846, was in exactly the same position as Sir Edward Belcher now is, if he then did get up Wellington Channel; and surely his expedition was as effective as that of the latter, and his crew not inferior.

While it is evident that the relief expeditions hitherto have been too much concentrated on one side of the Arctic regions,—in summer 1850 no less than eleven vessels were accumulated in one spot,—it is not too much to say that the search on the track of the missing vessels has only now commenced, by Sir Edward Belcher's having sailed up Wellington Channel.

The rest of the searching vessels at present in the Arctic regions, the Investigator and Enterprise, as well as those under Captain Kellett, are only directed to Banks Land and Melville Island, a region probably far away from Sir John Franklin's position. "The fearlessness and tameness of the animals in Melville Island," says Lieutenant M'Clintock,—the best authority on this point,—"was almost in itself a convincing proof that our countrymen had not been there;" and indeed, it may be added, not anywhere within five hundred miles. If Sir John Franklin had wished to retreat to any known region on the American side, nothing could surely have hindered him from doing so. It is well known that sledge parties have travelled distances of nearly one thousand miles during one winter; and Sir John Ross, after four years' imprisonment in the ice, and with a force of only twenty-four men, greatly reduced by hardships and trials, travelled at least five hundred miles, partly by land and partly by water, from the point where he abandoned his vessel to that where he was released.

The fact that no less than fifteen expeditions, consisting of thirty vessels, besides the boats, had failed in their main object, prompted me a short time back to draw attention to a portion of the Arctic regions which has remained entirely neglected, and to suggest a plan of search through the Spitzbergen Sea, that great ocean between Spitzbergen and Novaya Zemlya. I adduced reasons to shew that that sea would probably offer the best route, and demonstrated that its exploration was a most important desideratum in a commercial and geographical point of view. If the searching operations are to be based on a comprehensive and exhaustive system, my scheme cannot possibly be left unconsidered and neglected. The commercial interests of the country likewise demand an early exploration of the region to which I have drawn attention, and science looks eagerly forward to the solution of one of the most interesting of geographical problems. Moreover, when it is considered that five years' increasing efforts from one side have hitherto proved complete failures, the other side, so promising as regards an easy and speedy access with the aid of steam, should no longer be neglected. As yet the missing voyagers may not all have perished, but a further delay of one or two years may not leave one of them to tell the woeful tale of their sufferings, and may repeat the fearful case of Sir Hugh Willoughby's Expedition, where the stiff and frozen corpses only were found on the dreary shores of the Arctic regions.

A Description of Lunar Volcanoes. By Professor SECCHI.

Professor Secchi divides the Lunar Volcanic Formations into three classes, and he says, " a fourth may be added, analogous to our Plutonian Formations.

" The *first* class of the lunar volcanoes possesses a distinctive character ; that the edges of the craters are almost completely obliterated, so that their border now is a continuation of the plane ground, in which they seem excavated, and a deep well only remains in the place of the ancient mouth of the volcano. Instances of this kind are very frequent near the south pole of the moon, and around the large spot Tycho; but Tycho itself does not belong to this class. The physiognomy of these craters nearly resembles our submarine volcanoes of the Monti Ciminii to the north-west of Rome. The country around the craters of Bracciano, Bolsena di Vico, is almost flat, and the old openings of the craters are now deep lakes. On this ground we are led to believe that even in the moon many subaqueous volcanoes existed.

Another distinct character of these volcanoes of the first class is, that they are in a line, as if they burst from the cracks of the solid body of the crust produced by earlier formations: this is most striking in Arzahel, Purbach, Alphonsus, and many others, and they seem to follow the cracks made by the *soulèvement* which raised Tycho, the lunar Appennines, &c. Some of the higher chains of lunar mountains are seen visibly parallel to the alignement of the craters: this fact also is like that which we observe on the earth; indeed, the large Italian volcanic chain follows the line of the Apennines along this country.

"The *second* class of lunar volcanoes are those which have their outside edges elevated above the surrounding plain; their form is generally regular, and not broken, as those of the preceding class, and the ground around them is elevated in a radiating disposition, as is visible around Tycho, Copernicus, Aristotle, &c. The regularity of their forms suggests that the ejected matter was not disturbed by the motion of waves, and, consequently, that they were atmospherical volcanoes, like those of the Monti Laziali, Albani, and Tusculani, at the south-east of Rome; the want of breach in the craters seems to indicate that no lava, but only scoriæ and loose matters have been ejected. The disposition of the soil around them suggests the opinion that they are of a comparatively later epoch, and formed after the crust of the satellite was pretty resistant, and was capable of being elevated all round by a great effort. It is singular, indeed, that this *radiation* of the soil around is found proportional to the magnitude of the central crater. The effect of this *soulèvement* extended sometimes to a prodigious distance, comparable to that of the Cordilleras of the Andes on the earth. The greater part of the craters of both the classes now described possesses an insulated rock inside, very seldom appearing (at least in commonly good telescopes) perforated. This bears great analogy with what we see in more than one place in the ancient volcanoes of the earth, where the erupting mouth has been stopped by a dome of trachytic matter as by a stump. Monte Venere, near Rome, is of this formation, and lies in the centre of an immense old crater.

"The *third* class of lunar craters is very small, and bears a great likeness with those called by geologists adventitious craters, and seems to be of a very late formation, the last efforts of the expiring volcanic force. They are irregularly scattered through all the moon, but occur more frequently at the borders or inside of the old demolished craters, although not concentric with them, and seem to have been produced after the large ones were completely closed, either by trachytic ejection or by becoming lakes. These small craters have very seldom rocks inside, or a flat bottom; but their cavity is conical, and does not exceed in dimension our common volcanoes which are yet active on the earth. From these facts and observations it appears, that volcanic action has gone on in the moon through all the same stages which it has gone and is going on in the earth, and is there, probably, completely extinguished, on account of the smaller mass of the moon, which has been cooled very rapidly. This rapidity of cooling, joined with the smaller gravity, may account for the great development of volcanism there, and comparatively fewer Plutonian formations. But extensive instances of this kind are not wanting; the lunar Alps, the Apennines, the Ripheæ, &c., may represent thi formation, surrounding vast basins, and having modern volcanoes following the direction of the higher edges of their chains. Professor Ponzi seems to think it unquestionable that water existed at the surface of the moon; the fierce glare of the sunshine is not able to melt the ice there, which is, probably, at the temperature of the planetary spaces; just as the sun at the surface of the earth is not able to melt our glaciers, which yet possess a certainly higher temperature. Cold, and other unknown causes, may have absorbed and fixed all the atmosphere which anciently existed, as we see that the immense atmosphere which anciently surrounded the earth has been fixed by several chemical processes and reduced to its actual composition; and it might be possible that this actually existing atmosphere of ours should be all solidified, either by cold or chemical processes, if the earth arrives at the same degree of cold which seems to have place on the moon."

Livingston's Researches in South Africa.

At a late meeting of the New York Geographical Society, Mr Leavitt read a paper from Rev. Mr Livingston, English missionary in South Africa. Mr L. had made two excursions, in company with Capt. Oswald and another officer of the British Army. Passing the lake Ngami and the river Zonga, in latitude 20° south, they passed in their journey due north across the dry bed of the Zonga. Here they found numerous salt-pans or ponds. The Bushmen abound near the springs. They are a merry and honest race. For three days Mr Livingston was without water; travelling by night to avoid the heat. On the fourth day they struck a rhinoceros trail, and followed it to the river Mataba, a small stream. They reached the Chobe on the next day. This is a deep and very crooked river. Here they found a famous old chief, Sabatoae. His tribe is a very savage one. This old chief died while the travellers were there. They then went on to the Sesheke or Skiota, on horseback, a distance of 100 miles. This is an immense stream; 300 to 500 yards across in the driest season. Ten days up the river is the seat of the Barotsi, once the most powerful tribe in that region. The river has many tributaries and some rapids. In this region there are many large rivers; the country is flat, and in the rainy season is flooded for many miles from the streams. The people here are very black, very large, and strongly developed, but peaceful. They are more ingenious than the Cape people. The Baloe tribes melt large quantities of iron, and are very good smiths.

From an examination of the recently constructed maps of this country, it is seen that the Zambesi (which is a very large river emptying into the Mozambique Channel, by innumerable mouths, in latitude 18° and 19° south), seems to divide into two great branches some 350 miles up; that these branches run west, and then for several hundred miles north; that the branches are something like 200 miles apart, and that the country between is a rich delta, since junction streams constantly run from one branch to the other, thus forming large islands inhabited each by a different tribe : that 700 or 800 miles from the ocean, the western branch of the Zambesi receives the Chobe, which is also a large river, the Ohio to this African Mississippi; that the sources of none of these rivers are as yet known ; that south and west of the Chobe runs the Zonga, another very large river, neither end of which has been found, but it is supposed to empty into the Zambesi; that one or two hundred miles further south is the Limpopo River, also unexplored either way. It seems probable, from these documents, that there is a large and fertile region well watered, wooded, and peopled, on the spot generally set down as the lower part of a great desert, lying within a space bounded by longitude 20° and 35°, and latitude 10° and 20°.—(*American Annual of Scientific Discovery in* 1853, p. 383.)

On the Crystalline Form of the Globe. By M. de Hauslab.

M. de Hauslab, in a recent publication, after discussing the direction of mountains, and of dikes and of cleavages among rocks, deduces some general principles with regard to their direction, and then explains his hypothesis that the surface of the globe presents approximately the faces of the great octahedron. In an octahedron there are three axial planes intersecting one another at right angles; and the positions of the circles on the earth's surface, which he lays down as the limits of these planes (or their intersection with the surface), are as follows. The first circle is that of *Himalaya and Chimborazo*, passing from Cape Finesterre to the Himalaya, Borneo, eastern chain of New Holland (leaving on its sides a parallel line in Malacca, Java, and Sumatra), to New Zealand, thence to South America, near Chimborazo, the chain of Caracas, the Azores to Cape Finesterre. The *second* passes along the South American coast, and the north and south ranges of the Andes, the mountains of Mexico, the Rocky Mountains, Behring's Straits, the eastern Siberian chains, going to the south of Lake Baikel, the Altai, Himalaya, the mountains of Bombay in Hindostan, a point in the north-east of Madagascar (where the summits are 12,000 feet high), the mountains of Nieuwedfeld, 10,000 feet high, Cape Caffres, to Brazil, the rapids of La Plata, Paraguay, Panama, the elevated basin of Titicaca, the Andes, Illimani, and the defile of Maranova. The *third* circle cuts the two preceding at right angles, and passes by the Alps, the islands of Corsica and Sardinia, along the basin of the Mediterranean, the mountains of Fezzan, Lake Tchad, the Caffre mountains of Nieuwedfeld, the Southern Ocean, near Kerguelen's Land, the eastern or Blue Mountains of New Holland, Straits of Behring, Spitsbergen, Scandinavia, Jutland, &c.

These three great circles point out the limits of the faces of the great hypothetical octahedron. Each of the faces may be divided into eight others by means of line of accidents of minor importance, so as to make in all forty-eight irregular triangles, a form of the diamond. At the intersections, M. de Hauslab observes that there are nodes of dikes, and along the lines, or near them, all the mountains of the globe occur. The author gives an extended illustration of his subject, and afterwards considers the particular history of the configuration of the earth's surface in accordance with his hypothesis.

M. Boue, who adopts similar views, adds as a note, that we should remember in this connection that the metals crystallise either in the tesseral or rhombohedral system, and that native iron, the most common constituent of meteorites, is octahedral in its crystals.

On the Classification of Mammalia. By CHARLES GIRARD, of Washington.

I. The limits of the class of Mammalia were not clearly understood by the earlier naturalists. Some groups, which in former times were referred to other classes (as Cetacea and Bats), have successively been brought into it. None, however, originally placed in this class have ever required removal elsewhere. Thus the progressive investigations has always increased the number of the representatives of this class.

At the present day, we may safely say that we know all the essential groups of the class of Mammalia, the actual limits of which are acknowledged by every naturalist. Indeed, we must expect many additional species and genera which time and labour will bring to light, either in a fossil state from various depths in the strata which constitute the solid crust of our globe, or else from its actual surface, and belonging to the living fauna contemporary with the human races. Such additions are not expected to change or modify the boundaries of the class, though they may have some importance in the subdivisions and methodical arrangement of the minor groups.

The division of the class into secondary or minor groups, the relationship and subordination of the latter, have attracted the attention of all general writers on zoology. Almost every one has attempted a classification in accordance with the value attributed to one series of characters, rather than to another.

The most ancient authors seem to have occupied themselves but little with zoological characters: hence the subdivisions which they establish among Mammalia are based upon their mode of life, or the elements in which they live.

Next we see the subdivisons based upon external characters, the most striking being selected, such as the locomotive members.

All this prior to the eighteenth century.

Towards the end of that very century, however, comparative anatomy started as a science; and at the beginning of the nineteenth, it introduced an entirely new method of classification. Systematic zoology underwent a metamorphosis.

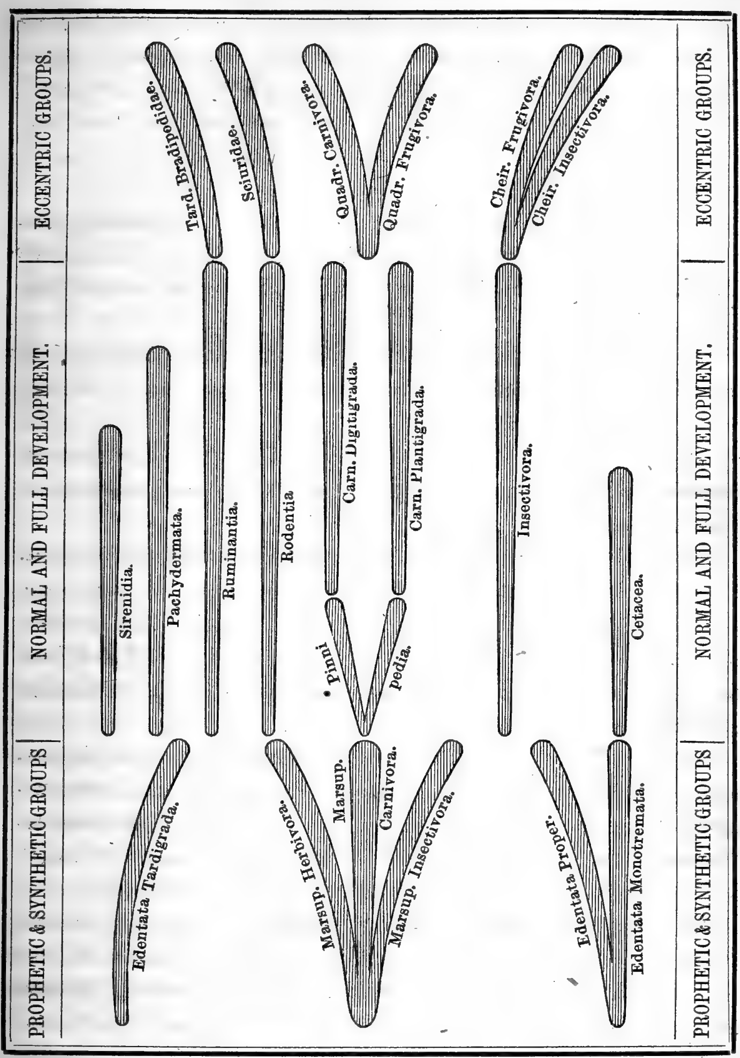
The first half of the present century had not yet elapsed, when another science grew up with rapid steps, claiming her share in the question of the natural classification of the animal kingdom: we allude to embryology. The formation of the young mammal, its genesis, its development prior to the period when it makes its first appearance in the world, if not entirely unveiled yet, are no longer mysterious, and their bearing upon systematic zoology is universally felt.

Palæontological data are not less important in arriving at a natural classification, than those derived from either comparative anatomy or embryology; and indeed palæontology, comparative anatomy, and embryology, hold an equal rank in respect to zoology.

As investigations progress in these fields of researches, new light is daily thrown on some obscure points, and difficult questions are thus elucidated; but as yet, no methodical arrangement of the class of Mammalia has been universally adopted: there is still as much diversity of opinion, and perhaps even more at the present time than in the two past centuries, although, as a whole, our views on the subject have been improved upon those of our ancestors.

II. In order to render more tangible our thoughts on the subordination of the various groups which constitute the class of Mammalia, we have prepared the accompanying plate, which we shall now examine.

The orders *Edentata* and *Marsupialia* are considered as the trunks of the class: these two groups, we place on the same level. They constitute the foundation, the bottom of the class, and accordingly are the lowest of all.



IDEAL GRADATION OF THE CLASS OF MAMMALIA.

The trunk of Edentata sends out three diverging stems, the *Monotremata*, the *Edentata* proper, and the *Tardigrada*:* an herbivorous stem (*Tardigrada* s. *Gravigrada*),

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* The graphic representation on a plane surface has caused the stem of Tardigrada to be separated from its trunk; but in bringing into contact both edges of the plate, we would obtain a figure similar to that of Marsupialia. Instead of a flattened surface, we want an ideal cone for both trunks.

an insectivorous stem (*Edentata* proper), and a carnivorous stem (*Monotremata.*) The carnivorism in the trunk of Edentata is of the lowest grade, and subordinated; as the carnivorous propensities only attack invertebrates, that is to say, animals of a much inferior rank, comparatively very weak and defenceless.

Above Monotremata we place *Cetacea* (whales and dolphins); Edentata proper, above the *Insectivora;* and above Tardigrada, the *Sirenidia*, or so-called herbivorous cetaceans, the *Pachydermata* and *Ruminantia.*

The trunk of Marsupialia exhibits likewise three stems, an *herbivorous*, an *insectivorous* and a *carnivorous.* Above which we have, the *Rodentia*, containing the herbivorous stem; the *Insectivora*, continuing the insectivorous stem in common with Edentata proper; and *Carnivora*, continuing the carnivorous stem.

Thus above Edentata and Marsupialia, we have, on another level, *Cetacea*, *Sirenidia* and *Walrus*, *Pachydermata*, *Ruminantia*, *Rodentia*, *Insectivora*, and *Carnivora;* that is to say, all the normal types which represent the full development of the class as synthetically combined in Edentata and Marsupialia below.

The fact that Insectivora are foreshadowed both by Edentata and Marsupialia, shews that there exists a close connection between the two trunks of the class. The insectivorism is intermediate in rank between herbivorism and carnivorism; it is of a higher grade than the former, and of a lower than the latter. The predominating feature of the trunk of Edentata consists in the vegetable diet, and in the want of a complete set of teeth; the predominating feature of the trunk of Marsupialia, on the contrary, consists in the animal diet, and the possession of a complete set of teeth. Accordingly there can be no doubt that Edentata are lower in grade than Marsupialia: they are the lowest grade in their class.

It will be obvious, also, that here Edentata rank the lowest in grade amongst the normal groups of the class; still shewing that Edentata are inferior to Marsupialia, the latter foreshadowing groups of a marked superiority.

Now there are other groups which we place on still another level above the normal types, although not of an absolute superiority. Their place can be nowhere else; their history must follow that of the normal types from which they proceed: the *Bradipodidæ* (or sloths), arising from the herbivorous stem of Edentata; the *Sciuridæ* (or squirrels), arising from the stem of Rodentia; the *Cheiroptera* (or bats), arising from the stem of Insectivora; and the *Quadrumana* (or monkeys), arising from the stem of Carnivora.

We consider these as so many shoots of the mammalian tree, which went beyond the vital sphere of activity of the class; in other words, deviations from the normal development of the class.

III. § 1. Let us return now to some of the groups mapped down on our chart of the ideal gradation, and state in a very brief manner their most striking zoological features and relationships.

To begin with *Edentata*, which we concluded were the lowest of the class: when looking at those creatures amidst the other groups, we cannot help being strangely struck by their singular physiognomy, and the still more astonishing association of characters, which appear sometimes rather borrowed from other classes, than as belonging to that of Mammalia. We need only call to mind the water-mole (*Ornithorhyncus*) of New Holland, the pangolins (*Manis*) of Asia and Africa, the anteater (*Myrmecophaga*) and armadillos (*Dasypus*) of South America, the aard-vark (*Orcyteropus*) of the Cape of Good Hope, and the sloths of tropical America, which constitute the three orders *Monotremata*, *Edentata* proper, and *Tardigrada*; the one as strange as the other.

The Monotremata exhibit the lowest grade of mammalian organization. They are ovoviviparous; the young are without uterian connection with the mother, but they are suckled by the latter. In that respect they approach nearest to birds and reptiles; the structure of their sternum and shoulder, also, presents a great resemblance to the same parts in lizards and ichthyosauri. Their position at the bottom of the order of Edentata is justified by the fact that one genus (*Echidna*) is completely deprived of teeth, whilst the other (*Ornithorhynchus*) possesses but a few insignificant ones. These two genera, which constitute by themselves the whole order, may just as well constitute two families, so wide are the differences in their general appearance and structure.

The Edentata proper constitute a group exceedingly remarkable, composed of a few genera likewise very strange in their characters, strange in their external features, strange in all their relations. The differences amongst these genera are so great that they have been made the types of as many families by systematic writers, and we believe with great propriety. The absence of teeth is the only character by which they are united, although this character is not absolute, inasmuch as grinding teeth in a very rudimentary state are observed in some few: the front teeth or incisors—those never exist in Edentata. Edentata moreover are provided with strong nails or claws to the four locomotory extremities.

Each of the types in Edentata, by its strange appearance, recals to mind another order of things, another physical period in the earth's history, of which they are mere reminiscences.

The Tardigrada divide into two groups, one completely extinct, the remains of which are found in the tertiary deposits of South America chiefly, the *Tardigrada gravigrada*, or *Megatheridæ;* and another exclusively composed of living representatives, the *Tardigrada bradipodida*, or sloths of Central and South America.

§ 2. The order *Marsupialia* is another combination into one group of strange forms and strange characters, quite as diversified and heterogeneous as in the Edentata, although Marsupialia seem cast upon a more uniform external mould. The great diversity resides in the physiognomy, and in the structure of the teeth.

In Edentata, we have seen the dentition so defective, than in several cases teeth were entirely absent. Here in Marsupialia the dentition is greatly developed, becomes a permanent character, and requires a contrasting importance. The incisors, it is true, are nowhere six in each jaw, which is the normal number; shewing that at the outset the number was of a subordinate value, as well as the relative signification of the different kind of teeth. Nevertheless it can be distinctly shewn that the three orders following, Rodentia, Insectivora, and Carnivora, are synthetically combined and foreshadowed in the group of Marsupialia, which, when considered zoologically in itself, cannot but strike any one as an odd group standing isolated in the actual creation.

§ 3. The order of *Cetacea*, the lowest amongst the normal groups, may be subdivided into three families. The first and lowest, the family of *Balænidæ*, is characterised by the absence of teeth, or, if not entirely absent, they have no function. These are the *toothless* or *edentated cetaceans*, reminding us of the order of Edentata proper, our second prophetic type. The second family, that of *Physeteridæ*, exhibits well-developed teeth on the lower jaw, and rudimentary ones on the upper: the *subdentated cetaceans* of the authors.* The third family, that of *Delphinidæ*, seems to complete the progressive series in the development of teeth; for the latter exist here on both jaws, whence the name of *ambidentated cetaceans*. The fourth family, that of *Heterodontidæ*, includes the narwhal or *predentated cetaceans*, and some other types in which the dentition is losing both its shape and its function. The *Monodon* (narwhal) is closely allied to *Phocæna* (porpoise), whilst *Hyperoodon* comes nearer to *Delphinus*. The other genera are deviations or reminiscences of the other families. Heterodonts, then, must follow the dolphins in a natural and serial classification. The order of Cetacea begins with the whales, and closes with heterodonts; the real superior groups are those placed in the middle, the Delphinidæ, which represent the normal cetacean type. They

* Physeteridæ, or sperm-whales, are more nearly allied to dolphins than to whales, if we take into consideration the structure of the whole skeleton. We might even say that Physeteridæ are gigantic dolphins in which the development of teeth has stopped, and the body increased beyond all proportion. That colossal mass which sperm-whales partake with the whales proper, is of an incontestable inferiority, as it is unfit for graceful movements; but, on the other hand, the material strength is developed, and the muscular power increased to harmonize with the immensity of the element in which they live. Balænidæ, the lowest of the order, are likewise amongst the largest.

are the smallest of the order, and possess two fresh-water representatives, one closely allied to dolphins proper, the second bearing some far relations to Physeteridæ (sperm-whale), and to the genus Hyperoodon of the heterodonts family.

The morphology of the teeth in Cetacea is very interesting, and instructive in a philosophic point of view, when the relationships of this order with the Edentata are well understood. In the lowest type, teeth remain undeveloped; in the highest, they cover the whole surface of both jaws, but are of one kind: incisors, canines, and grinding teeth are not known amongst cetaceans. This fact alone would ascribe to them an inferior rank amongst the normal groups of the class.

§ 4. The affinities of the so-called herbivorous cetaceans, or Sirenidæ, with pachyderms, have been alluded to by several authors. In 1834 Fred. Cuvier* wrote the following remarkable sentence: "The group of herbivorous cetaceans, composed of genera intimately connected together, are related to the pachyderms by the manati." And farther on (page 6) he remarks that they come nearer to pachyderms than to cetaceans. In 1838 they were definitively removed from the Cetacea, and actually placed amongst Pachydermata.† Upon this point, every naturalist now agrees. Sirenidæ are the lowest grade among pachyderms; even if considered as parallel to pachyderms, they still must rank lower in a natural classification. They are aquatic, provided only with the anterior limbs constructed for swimming. Unlike the cetacea, they live near the land, and may occasionally creep along a beach; undoubtedly representing a higher step in the class, and an approximation towards the subaquatic Hippopotamus, which, together with the tapir, shew intimate relation with the manati and dugong. The Dinotherium, and other fossil representatives of the group of Sirenidia, seem to synthetise the living genera of their groups, together with both the proboscidian pachyderms and the ruminants. This synthesis, however, cannot yet be fully understood. The earth's crust

* Histoire Naturelle des Cétacés, p. 34.

† Owen, in Proceed. Zool. Soc., London.

has not yet yielded all the data by which alone we delineate the history of the pachyderms and allied groups from their cradle up to our days.

Amongst the living genera, we observe the following particulars: The *Manati*, when young, have on the lower jaw two small incisors directed forwards and downwards, reminding us of the tusks in Dinotherium. The presence of tusks, therefore, assigns to the latter a lower position. In *Halicore*, tusks exist on the upper jaw, as in the elephant, with which the genus *Rytina* seems also related by its teeth, although completely deprived of tusk of any kind.

§ 5. The position of the *Walrus* is between Sirenidia and Pachydermata; they belong to the pachydermic order by structural evidences, and bear only analogies to the seals. They constitute a small group whose distinctive features from Manati consist in the presence of four locomotive members; and from the other pachyderms, in having these four locomotive members adapted for aquatic habits.

§ 6. The order of *Pachydermata* is the least understood of all, on the very ground that its history belongs chiefly to the past; and since Sirenidia and Trichechidæ (walrus) are referred to the same group, it becomes difficult to determine the relationships between the living and the extinct representatives in order to establish a graduated series.

We are satisfied of the existence of two progressive series in the pachydermic groups, in the following way:

WITHOUT PROBOSCIS.	PROBOSCIDIANS.
EQUIDÆ,	ELEPHANTIDÆ,
SUIDÆ,	MASTODONTIDÆ,
HYRACIDÆ,	RYTINIDÆ,
RHINOCEROTIDÆ,	HALICHORIDÆ,
HIPPOPOTAMIDÆ,	MANATIDÆ,
TRICHECHIDÆ,	DINOTHERIDÆ,

ANOPLOTHERIDÆ,
PALÆOTHERIDÆ.

At the bottom of the order, the extinct Palæotherium and Anoplotherium: on one side the proboscidians, and on the other the families which have no proboscis. The proboscidians are relatively inferior to nonproboscidians, inasmuch as they are *edentata* in the general sense of the word: grinding teeth and tusks alone exist. In the nonproboscidians the dental system acquires a great development, the greatest to be observed in the edentated trunk; but as this development is an excessive effort, and thus brought the group beyond its circle of activity, it had only a temporary existence, and became almost extinct in the present era.

The history of pachyderms will form a contrasting episode compared to that of Cetacea, when it shall once be written out fully. Our hypothetical views on the subject, for fear that they should appear too premature, we abstain from giving now.

§ 7. As to the limits of the order of *Ruminantia*, every one is agreed; but not so with regard to its systematic position. Considering its imperfect dental system, we see that it belongs to the great division of edentated mammals. That ruminants are inferior in rank to rodents, we derive first from their appertaining to the edentated division, which we have seen is inferior to the division of marsupials. Their dentition and herbaceous diet is a second very important feature which assigns to them a lower rank than to the rodents, which feed chiefly on bark and fruits, a food superior to grass and leaves.

§ 8. Now the position of the order *Rodentia* is clearly defined by what has just been said of the ruminants. Their complete system of dentition, and the similarity in the insertion of the incisors in herbivorous marsupials, are the reasons which have guided us in this arrangement.

§ 9. The place which we assign to the order of *Insectivora* is based upon a similar principle: the affinity of their dentition and mode of life with the insectivorous marsupials and edentata.

§ 10. *Pinnipedia* have always been placed below Carnivora, and Carnivora have always been divided into *digitigrada* and *plantigrada*. We find both plantigrada and digitigrada synthetically indicated in Pinnipedia; not in the structure of the locomotive members, but in the profile of the face.

§ 11. In the eccentric groups of *Bradipodidæ*, *Sciuridæ*, *Cheiroptera* and *Quadrumana*, we observe the remarkable fact that they assume a general external resemblance to each other, that they become monkey-like in features and habits. They live above the ground, in trees and in the air; they are chiefly nocturnal, and their diet has a general tendency to becoming frugivorous. That Cheiroptera proceed from the insectivorous stem, the Quadrumana from the carnivorous stem, the Bradipodidæ from the tardigrade stem, a thorough comparison of these types will convince every one.

We give now the following Mammalian System :—

I. QUADRUMANA.
- SIMIADÆ.
- CEBIDÆ.
- LEMURIDÆ.
- GALEOPITHECIDÆ.
- CHIROMYIDÆ.

II. CARNIVORA.
- *a.* UNGUICULATA,
  - 1. DIGITIGRADA.
    - FELIDÆ.
    - HYÆNIDÆ.
    - CANIDÆ.
    - VIVERRIDÆ.
    - MUSTELLIDÆ.
  - 2. PLANTIGRADA.
    - CERCOLEPTIDÆ.
    - PROCYONIDÆ.
    - URSIDÆ.
- *b.* PINNIPEDIA.
  - PHOCIDÆ.

III. CHEIROPTERA.
- *a.* FRUGIVORA.
  - PTEROPODIDÆ.
- *b.* CARNIVORA.
  - VESPERTILIONIDÆ.
  - VAMPYRIDÆ.

IV. INSECTIVORA.
- ERINACEIDÆ.
- SORICIDÆ.
- TALPIDÆ.

V. HERBIVORA.
- *a.* RODENTIA.
  - SCIURIDÆ.
  - CASTORIDÆ.
  - MURIDÆ.
    - Myoxina.
    - Dipodina.
    - Ctenodactylina.
    - Murina.
    - Spalacina.
    - Arvicolina.
    - Bathyergina.
    - Saccomyina.
  - HYSTRICIDÆ.
    - Hystricina.
    - Dasyproctina.
    - Echymyina.
    - Octodontina.
    - Chinchillina.
    - Caviina.
  - LEPORIDÆ.
- *b.* RUMINANTIA.
  - CAMELEOPARDALIDÆ.
  - CAMELIDÆ.
  - ANTELOPIDÆ.
  - CERVIIDÆ
  - MOSCHIDÆ.
  - BOVIDÆ.
- *c.* PACHYDERMATA.

EQUIDÆ.	ELEPHANTIDÆ.
SUIDÆ.	MASTODONTIDÆ.
HYRACIDÆ.	RYTINIDÆ.
RHINOCEROTIDÆ.	HALICHORIDÆ.
HIPPOPOTAMIDÆ.	MANATIDÆ.
TRICHECHIDÆ.	DINOTHERIDÆ.

  - ANOPLOTHERIDÆ.
  - PALÆOTHERIDÆ.

VI. CETACEA.
- HETERODONTIDÆ.
- DELPHINIDÆ.
- PHYSETERIDÆ.
- BALÆNIDÆ.

VII. MARSUPIALIA.

a. CARNIVORA.

Thylacinidæ.

Didelphidæ.

Dasyuridæ.

b. INSECTIVORA.

Peramelidæ.

c. HERBIVORA.

Phalangistidæ.

Phascolomyidæ.

Macropodidæ (*Halmaturidæ*)

VIII. EDENTATA.

a. TARDIGRADA.

Bradipodidæ.

Megatheridæ.

b. EDENTATA proper.

Dasypodidæ.

Orycteropodidæ.

Myrmecophagidæ.

Manidæ.

c. MONOTREMATA.

Echidnidæ.

Ornithorhynchidæ.

IV. § 1. The data relating to the earliest appearance of the class of Mammalia lead us as far back in the earth's history as the period of the oolite. There we find it displaying but a small number of forms under the shape of marsupials, more intimately allied, however, to our opossum than to any of the Australian types. These first representatives of the class inhabited that geographical portion of the globe now called the British Islands.

The conclusions to which Cuvier had arrived, viz. that the epoch of the appearance of mammals was the tertiary in the series; his beautiful researches, his remarkable discourses on the revolutions of the globe, were present to the mind of every one. Now came that fossil jaw of an opossum-like animal, which seemed to contradict these philosophical deductions. The mammalian nature of the jaw was denied by some, exaggerated by others: its geological position in the oolite was considered as accidental; but all attempts at rejecting these remains from the class of mammalia have proved unsuccessful; time and repeated investigations have concurred in shewing that they were true mammals, and that they truly belonged to the oolitic period. And instead of contradicting the formerly ascertained results, these facts now complete the palæo-history of the class, and illustrate most beautifully the gradual introduction of the different groups of the animal kingdom upon the surface of our globe. For it remains true that the class of mammalia acquired a full development during the tertiary epoch only; the tertiary types were preceded in the secondary epoch by these marsupials, and in some sort foreshadowed, predicted by them.

The marsupials being zoologically inferior, they are geologically the first created. Their abnormal forms, the disproportions of some of their limbs, illustrate the first evolution of the mammalian activity. Their bringing forth their young in an imperfect state of development, and the existence of an external pouch to protect that progeny, assign to them an inferior rank. The fact that there are among them carnivorous, insectivorous, and herbivorous types, indicates clearly that they combine these groups of which they are the prototype in the Creator's thought, and their precursors in time.

As the development of the class went on, and the foreshadowed groups appeared as distinct and independent manifestations of the mammalian organization, the marsupialian group was preserved within the limits of its original conception up to our epoch, in which it stands as an odd group which reminds us of a past order of things. In the actual fauna, Marsupialia are an isolated type which has deceived and misled all the systematic writers; still combining characters of several other types, if it is not understood that they are prototypic, and the lowest, they will give rise to contests as to their position in the system.

No facts illustrate better the immateriality of the relations which exist between the various groups of this class: they may foreshadow, they may prophetize, but they will continue to exist. There are no material transformations, no material permutations, from one group to another; for if such was the case, those first created groups, combining those of a later appearance, would not be found possessing the same material attributes, the same circle of vital activity as before. On the other hand, when the foreshadowed groups appear, they lose their zoological importance, and accordingly are confined to a geographical province physically lower, to remind us of their low position in the system.

§ 2. But if Edentata are zoologically the lowest of the class, they should have been created the first in time, or at least be contemporaneous with Marsupialia. As far as our present knowledge respecting the fossil remains of mammals goes, Edentata are not known prior to the miocene strata of the tertiary epoch; but in those very strata, their remains are so numerous, and exhibit such a diversity of generic forms, that we must conclude from these facts that Edentata have acquired, if not the maximum of their development, at least a large portion of it, during the first period of their creation.

This great development of Edentata, at the presumed dawn of their existence, is in contradiction with the general law which has presided over the development of all other groups of the animal kingdom: each group, each natural order or family, the history of which has been investigated in past times, has manifestly shewn a development parallel to that of the individual life: 1*st*, An early period,—corresponding to that of youth,—during which the group has but a small number of representatives; 2*d*, A period of full development,—corresponding to that of the adult,—during which the group exhibits the greatest diversity which was in its power to assume; 3*d*, Finally, there is a period of decline,—corresponding to old age and fall,—during which period the individuals are less numerous. In the class of Mammalia there are comparatively few groups which have thus reached the third period of their history, and passed away from the surface of our earth. The majority have just attained their period of fullest development at the beginning of the human era, and are actually in existence upon the external surrounding crust of our planet.

According to these facts, and satisfied that the systematic position which we have assigned to Edentata is natural, and in accordance with the general plan of the creation, we predict that remains of Edentata will be found in the strata below the miocene; that they will be found in secondary beds at least as low as the oolite, if not further down. If they prove to be of a decidedly lower zoological grade than Marsupialia, they must have been introduced on earth before the latter; and if parallel with them, they must have been contemporaneous. In the actual era, the order of Edentata is in its period of decline: its representatives now living are much less numerous than the extinct ones already known.

§ 3. The Pachydermata constitute another group, whose history chiefly belongs to past times. They are known to have existed as early as the eocene period; the miocene is the period of their greatest development; they diminish in number in the pliocene, and finally the living representatives are still less numerous. So that pachydermata are in the period of their decline, as well as the edentata.

Now as far as is known, these two groups, Pachydermata and Edentata, are the only ones in the class of Mammalia whose circle of activity has been exhausted in geological ages.

The two series which we have established among pachyderms will have to be carefully studied geologically.

The oldest remains known of Sirenidia have been discovered in the lowest beds of the miocene period.

The oldest remains of ruminants known, belong to the middle strata of the miocene period.

Cetaceans are contemporaneous with the ruminants; it being always understood that we speak of the actual state of our knowledge.

Rodentia, which we consider the highest amongst Herbivora, are foreshadowed by Marsupialia, the second synthetical type. Rodentia make their first appearance at the beginning of the eocene period, the first of the tertiary epoch.

And so do the Carnivora proper and Pinnipedia, parallel in their genetical development; although zoologically speaking, Pinnipedia are lower, and synthetise the two groups of carnivorous digitigrades and plantigrades.

Insectivora, which are shadowed by both Edentata and Marsupialia, are not known in the eocene: their remains, hitherto found, belong to the miocene and strata above.

Quadrumana and Cheiroptera have left some of their remains in the middle strata of the eocene period.

The annexed diagram is intended to sketch out the history of the class of Mammalia, prior to the epoch of mankind.

§ 4. If we look now at the geographical distribution of Mammalia, which is regulated by laws, we may point out some facts of a very striking interest, and which corroborate the foundation of our classification.

The globe and the animal kingdom were created for one another; the globe, however, was made for the kingdom, matter being subordinate to life. During each of the geological ages, and even during each period or era, the physical features of the globe have assumed a peculiar character. The animal creation has likewise assumed a peculiar zoological character, always in a direct relation with the physical characters of the time and the special physical wants of the globe.

There are two points of view to be taken into consideration when investigating the introduction of life upon the surface of our globe, but these we cannot discuss at length here: we must limit ourselves merely to the signalizing of them.

1. Life, from its first manifestation upon the globe, may have undergone a gradual, slow, and continuous development; in which case a single and unique creation, passing through divers metamorphoses to suit the wants of the globe, renewing itself without the necessity of a special creation at the beginning of each period, would seem the real doctrine.

2. Life, after its first introduction on earth, might have ceased at the end of each period, and at the beginning of each one, a new creation called forth, purposely made to suit the physical wants of the new era. Thus numerous creations would have succeeded each other without any material connection, or any genetic relationship, but physically independent of each other.

Both of these views have their defenders and opponents. The choice of one or the other is of no consequence in regard to the fact which we are now tracing, as soon as we can admit that *at each period the animal kingdom was in a direct relation with the physical wants of the globe.*

The physical wants of our planet went on increasing with time, both in number and importance; and the same may be said of animal life. The relations of these two worlds are so intimate, that the zoological subordination of the groups will give us the relative physical superiority of the continents above one another; and, *vice versa,* the relative physical superiority of the continents will point to the zoological gradation of the groups composing the class of mammalia.

Now let us look at the facts. The lowest Mammalia, the Monotremata, belong exclusively to Australia. Australia is physically the lowest continent. Marsupialia are also limited to the same continent.

The next in grade after Monotremata are the Edentata proper, which belong chiefly to South America; the Manidæ and Orycteropodidæ alone being African. South America and Africa rank above Australia; and although Marsupialia are placed by us above Edentata generally, the consequence of their occurring in Australia does not contradict the assumption that Australia is physically lower than Africa and South America. The fact that the lowest among Edentata are Australian, and the highest among Marsupialia (the Didelphidæ) are South American, is very conclusive.

The occurrence of the opossum in the southern part of the United States clearly indicates that this continent is physically inferior to Europe and Asia.

When comparing the relative superiority of the continents with each other, the comparison, in order to remain true, must be made independently of the influences of man. They must be taken at the dawn of their history, when in formation, during the epochs which have preceded the cradle of man kind. If America occupies a relatively low physical rank, that nation by which it has been taken possession of, by which it has been subdued and conquered, has changed its destinies by applying to its elevation the power of its intellectual aptitudes.

Although some few fossil remains of Marsupialia and Edentata occur out of the actual geographical provinces of these groups, the greatest number are found within the limits of the said provinces; shewing that the order which now prevails at the surface of our globe, takes its roots in former ages; that the same general laws which now prevail, have presided over the past.

Amongst the normal groups of the class we have Cetaceans, the lowest, all aquatic; as are likewise Sirenidia, Trichechidæ, and Pinnipedia. The Pachyderms are tropical: their actual distribution on earth is to be referred to a past order of things, in order to be understood. The Ruminants, Rodents, Insectivora, and Carnivora, are distributed all over the globe in given proportions.

A general glance at the mammalian fauna of North America strikes us by the preponderance in the number of species of the order Rodentia. The true grass-feeders, the Ruminantia and Pachydermata are in minority; although the New World has been opposed to the Old, and called the *continent of vegetation*, by contrast with that of *animalization*. The greatest

Carnivora are absent from America: Carnivora are the most numerous where ruminants are most numerous, the former feeding chiefly upon the latter.

Each group has a part to perform in the economy of nature. Carnivora, the most powerful in the animal creation, check the Ruminants, the most bulky and most clumsy of the terrestrial forms of the class, and partly the Rodents; the Rodents, in their turn, check the arborescent vegetation, whilst Ruminants check chiefly the grass. Ruminants are constructed to walk on the ground; whilst the organization of Rodents is adapted either for ascending trees, or for burrowing in the ground. Ruminants are timid, constantly in fear of becoming the prey of others, and have for their only retreat the depths of the forests, or the unbounded plains and deserts.

The Insectivora feed upon Articulata, and are intended chiefly to check the never-resting class of Insects: they are adapted to divers situations; for the aerial element, the surface of the soil, and under it, as their peculiar instinct will lead them to feed either on flying, creeping, or burrowing articulates. The Insectivora increase in number from the north to the equator, as the class of Insects does.

Amongst the eccentrical types, the majority of the species inhabit the warm zone; a very significant fact. Cheiroptera exist in both hemispheres, increasing in number from the arctic regions to the tropics. Quadrumana are chiefly tropical; and so are Bradipodidæ. Flying squirrels belong to the temperate and tropical zones.

On the Reproduction of the Toad and Frog without the intermediate stage of Tadpole. By EDWARD JOSEPH LOWE, Esq., F.G.S., F.R.A.S.

The following brief remarks on the Toad (*Bufo vulgaris*) and the Frog (*Rana temporaria*) may perhaps be received with some degree of interest, as they are, I believe, contrary to the generally received notion of the procreation of these reptiles. Ray, and most naturalists, at least, consider toads and frogs as oviparous animals, yet it is apparent that they are viviparous as well, or if they do not bring forth their young alive, have the power of reproduction in a different manner to the ova and subsequent tadpole.

Mr J. Higginbottom of Nottingham, who has paid great attention to this subject, has clearly proved the development of the tadpole to the perfect toad in situations wholly deprived of light, as I have through his kindness several times witnessed. My present remarks are intended to show that *occasionally* frogs and toads are reproduced in localities where it would be impossible for the intermediate stage of tadpole to have any existence.

1. *Toads deposit spawn in cellars and young toads are afterwards observed.*—Last summer several masses of spawn were procured from my cellar, having been found deposited amongst decaying potatoes, &c., and subsequently young toads were noticed. The cellar is free from water, and at a considerable distance from any brook.

2. *Young toads are observed about hot-beds.*—In the kitchen-garden at Highfield House (which is entirely walled round) young toads have been noticed about the cucumber and melon beds. The gardeners have been in the habit of bringing toads to these beds to destroy the insects; these have continued amongst the warm damp straw all summer. It is after these beds have remained three or four months that the young ones have been noticed. Toads would have to travel nearly half a mile to reach this garden from the brook or lake, and also to mount a steep hill, besides taking the opportunity of coming through the door. Toads so small are not seen in any other part of the gardens.

3. *Young toads and frogs observed in abundance at the summit of another hill, whilst quite small.*—During the past summer, especially in the month of July, very many young toads and frogs were seen amongst the strawberry plants, apparently from a week to a month old. These might possibly have travelled from the brook a few hundred yards distant; yet it is strange, that, with the exception of these beds, no young toads could be found elsewhere in the garden. A number of full-grown toads are mostly to be seen about these beds.

4. *Young frogs dug out of the ground in the month of January.*—In digging in the garden amongst the strawberry-beds (near where so many toads were observed last summer) in the middle of January in the present year, a nest of about a score young frogs were upturned. These were apparently three or four weeks old. This ground had been previously dug in the month of August and many strawberry plants buried; it was amongst a mass of these plants in a state of partial decomposition that these young ones were observed.

5. *Young frogs are bred in cellars where there is no water for tadpoles.*—In mentioning this subject to Mr Joseph Sidebotham of Manchester (an active botanist), he informed me that young frogs, and in fact frogs of all sizes, were to be seen in his cellar amongst decaying dahlia tubers. The smallest of them were only about half the ordinary size of the young frog when newly developed from the

tadpole. He further stated that there was no water in the cellar, and no means of young frogs entering, except by first coming into the kitchen, a mode of entry, if not impossible, highly improbable. Mr Sidebotham never found any spawn.

It seems probable from the above, that frogs are occasionally born alive in situations where no water can be found for the spawn to be deposited in, and that toads are either reproduced in the same manner, or from the egg directly. The latter mode seems most likely, owing to spawn having been found previously to the young toads.

Mr Higginbottom tells me, the same remark on the birth of the Triton, without the stage of tadpole, has been mentioned to him.

These are the facts; should the subject be deemed worthy of further investigation, I shall be glad to continue observations upon these reptiles during the present year, or to make any experiments that may be deemed advisable.—(*Phil. Magazine*, vol. v., No. 34, 4th Series, p. 466.)

SCIENTIFIC INTELLIGENCE.

ASTRONOMY.

1. *Relation between the Spots on the Sun and the Magnetic Needle.*—According to observations made by M. Rodolphe Wolf, director of the Observatory at Berne, it appears that the number of spots on the sun have their maximum and minimum at the same time as the variations of the needle. It follows from this, that the cause of these two changes on the sun and on the earth must be the same; and consequently, from this discovery, it will be possible to solve several important problems whose solution has hitherto never been attempted.

2. *On the Periodic Return of the Solar Spots.*—M. Wolf, director of the Observatory of Berne, mentions in a letter to M. Arago, that he has recently been engaged in researches on the solar spots, and has arrived at some interesting conclusions on the subject. By a comparison of all the observations of the spots made from the epoch of their discovery down to the present time, he has discovered that the number visible upon the surface of the sun in the course of a year, recurs at regular intervals of time. The mean duration of the period comprised between two maxima or minima, he finds to be $11{\cdot}111 \pm 0{\cdot}038$ years, which, he says, agrees much better with the variations in declination of the magnetic needle, than the corresponding period of $10\frac{1}{2}$ years assigned by M. Lamont. He has also ascertained that the years during which the spots have been most numerous, have been also the driest and most fertile, agreeably to a remark of Sir William Herschel.—(*Proceedings of the Royal Astronomical Society.*)

3. *Lunar Atmospheric Tide.*—The facts derived a few years since

from the barometrical observations at St Helena, shewing the existence of a lunar atmospheric tide, have been corroborated in the last year by a similar conclusion drawn by Captain Elliot of the Madras Engineers, from the barometrical observations at Singapore. The influence of the moon's attraction on the atmosphere, produces, as might be expected, a somewhat greater effect on the barometer at Singapore, in lat. 1° 19′, than at St Helena, in lat. 15° 57′. The barometer at the equator appears to stand on the average about 0,006 in. (more precisely 0,0057, in lat. 1°19′), higher at the moon's culminations than when she is six hours distant from the meridian.

METEOROLOGY.

4. *Evaporation and Condensation.*—The total quantity of dew believed to fall in England is supposed to amount to five inches annually. The average fall of rain is about twenty-five inches. Mr Glaisher states the amount of evaporation at Greenwich to have amounted to five feet annually for the past five years, and supposes three feet about the mean evaporation all over the world. On this assumption the quantity of actual moisture, raised in the shape of vapour from the surface of the sea alone, amounts to no less than 60,000 cubic miles annually, or nearly 164 miles per day. According to Mr Laidlay, the evaporation at Calcutta is about fifteen feet annually; that between the Cape of Good Hope and Calcutta averages in October and November, nearly three-quarters of an inch daily; betwixt 10° and 20° in the Bay of Bengal it was found to exceed an inch daily. Supposing this to be double the average throughout the year, we shall, instead of three, have eighteen feet of evaporation annually; or were this state of matters to prevail all over the world, an amount of three hundred and sixty thousand cubic miles of water raised in vapour from the ocean alone.—(*American Annual of Scientific Discovery*, 1853, p. 371.)

5. *The Amount of Oxygen in the World.*—"Let us for an instant contemplate," says Faraday,* "the enormous amount of oxygen employed in the function alone of respiration, which may be considered in the light of a slow combustion. For the respiration of human beings, it has been calculated that no less than one thousand millions of pounds of oxygen are daily required, and double that quantity for the respiration of animals, whilst the processes of combustion and fermentation have been calculated to require one thousand millions of pounds more. But at least double the whole preceding quantity, that is to say, twice four thousand millions of pounds of oxygen, have been calculated to be necessary altogether, including the amouut necessary in the accomplishment of the never-ceasing functions of decay.

As stated in pounds, we can hardly create to ourselves any defi-

* Faraday's Lectures on the Non-Metallic Elements.

nite idea of this enormous amount; the aggregate is too vast, too overpowering. It is scarcely to be grasped by our senses when reduced to tons, of which it corresponds with no less than 7,142,847 per day.

Amount of oxygen required daily.

Whole population, . . .	1,000,000,000
Animals, ...	2,000,000,000
Combustion and fermentation, .	1,000,000,000
	4,000,000,000
	2
Oxygen required daily, =	8,000,000,000 lb.

Tons.

7,142,857	in a day.
2,609,285,714	in a year.
260,928,571,400	in a century.
15,655,714,284,000	in 6000 years.

Whole quantity, 1,178,158,000,000,000.

Such being the daily requisition of oxygen in the economy of nature, how great must be the total quantity existing in the world! Why, between one-half and two-thirds of the crust of this globe and its inhabitants are composed of oxygen. This will be manifested to you most conveniently by inspecting a diagram wherein the demonstration is made clear.

Amount of oxygen in the world.

Principles, .	$\frac{1}{4}$	$\frac{3}{4}$	Oxygen is $\frac{1}{2}$ or $\frac{2}{3}$ of the globe.
Phos. lime, .	$\frac{3}{7}$		
Water, .	$\frac{8}{9}$		
Principles, .	$\frac{1}{3}$	$\frac{4}{5}$	
Water, . .	$\frac{8}{9}$		
Silica, . .	$\frac{1}{2}$	$\frac{1}{2}$	
Alumina, .	$\frac{1}{3}$		
Lime, . .	$\frac{2}{5}$		
Ocean and waters,	$\frac{8}{9}$		
Atmosphere, .	$\frac{1}{5}$		

MINERALOGY.

6. *Wöhler on the Passive State of Meteoric Iron.*—Wohler states that he has observed the curious fact, that the greater portion of the meteoric iron he has had an opportunity of examining, is in the so-called passive state; that is to say, it does not reduce the copper from a solution of the neutral sulphate of copper, but remains bright and uncoppered therein. But if touched in the solution with a piece

of common iron, the reduction of the copper commences immediately upon the meteoric iron. It also becomes active instantaneously on the addition of a drop of acid to the solution of copper; but if the reduced copper be filed away, the new surface is again passive. I convinced myself by experiments on meteoric iron, which had never been in contact with nitric acid, and nevertheless was passive, that this state could not have been produced by the corrosion of the surface by the acid, for the production of the Widmannstattean figures. I thought first that this deportment might be employed as a means of distinguishing true meteoric iron; but it soon appeared that some undoubtedly genuine meteoric iron was not in this state. Seven specimens, from different parts of the world, examined, were found to be passive; six reducing, or active, and four which do not become coated with copper immediately, but on which the reduction gradually commences after a longer or shorter contact with the cupreous solution, and usually from one point, or from the margins of the fluid.

These peculiarities appear to have no connection, either with the presence of nickel, or the property of forming regular figures on corrosion. I also found that an artificially-prepared alloy of iron and nickel, which on corrosion acquired a damasked surface, reduced the copper from solution in the same manner as common iron. Whether this state is proper to all meteoric iron on its reaching the earth, and, as may have happened in the case of the active kinds, have only been lost in the course of perhaps a very long period of time, and what probable opinion can be formed of these phenomena, must be settled by experiments and observations of a more extended nature.—(*Poggendorf's Annalen.*)

7. *Crystallisation of Glass.*—Some interesting experiments on this subject have been made by M. Leydolt in the course of his investigations upon the crystallisation of the silicates. He had examined agate by subjecting it to the dissolving action of fluohydric acid, and obtained a surface with projecting crystals of quartz, that were left untouched by the acid. On subjecting glass in the same manner, he was surprised to see that it was far from homogeneous in its texture. All the kinds of glass examined contain more or less perfectly distinct crystals, regular and transparent, encased in an amorphous base. The crystals were brought out by exposing it to the vapours of fluohydric acid, and vapour of water, and arresting it when the crystals appear; the amorphous part is a little the most soluble in the acid. M. Leydolt observes also, that some natural crystals pure and transparent, and apparently homogeneous, present similar deficiency in homogeneity with the glass, and he has the subject under further examination.—(*American Annual of Scientific Discovery*, 1853, p. 210.)

8. *On Diopside and Molybdate of Lead, Furnace Products;* by J. Fr. L. Hausmann (Acad. Sci. Gottingen; *L'Institut*, No. 956,

April 28, p. 131).—The crystals of diopside were from a Swedish furnace at Gammelbo in Westmannland. They are two or three lines long; translucent or transparent; grayish, pearly, to greenish or reddish gray.

G. = 3·127; H. = 6; composition—

$\dddot{Si}$	$\dddot{Al}$	$\dot{Mg}$	$\dot{Ca}$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Na}$	$\dot{K}$
54·69	1·54	15·37	23·56	0·08	1·66	1·94	1·15 = 100

corresponding to the general formula, $\dot{R}i3\ \dddot{Si}2$.

The molybdate of lead was found in a reverberatory furnace at Bleiberg in Carinthia, in crystals very much like the natural crystallisations.

9. *Formation of Arragonite, Calc-spar, Brochantite, and Malachite.*—M. Becquerel some time since shewed that calc-spar may be obtained in primary rhombohedrons, through the slow reaction of a solution of bicarbonate of soda, feeble in degree (2°), on laminæ of sulphate of lime or gypsum. On experimenting with a solution marking five or six degrees, the carbonate of lime crystallised in the trimetric system, or in other words as arragonite. It is hence not surprising that arragonite should be found in gypseous and saliferous deposits, like those of Spain, Salzburg, and elsewhere.

Calc-spar may also be obtained by the action of a solution of potash marking 10°, on gypsum, the solution being contained in a flask imperfectly closed. In this case the carbonic acid is derived from the atmosphere.

Brochantite (subsulphate of copper) is easily obtained, looking like native specimens, by putting a piece of porous limestone in contact with a saturated solution of sulphate of copper. The Brochantite is deposited upon the limestone in small crystalline tubercles along with the crystals of gypsum.

Malachite ($\dot{Cu}\ \ddot{C} + \dot{Cu}\ \dot{H}$) may be obtained by the reaction of coarse porous limestone on a solution of nitrate of copper, marking 12° or 15°, and when the action ceases, by plunging the mass into a solution of an alkaline bicarbonate marking 5° or 6°. The piece of limestone in the first case becomes covered with subacetate of copper; and this subacetate, in the next step, changes to malachite, or if prolonged, to a double carbonate of copper and soda. The malachite is in small silky globules.

10. *On the Artificial Formation of Malachite*; by M. Henri Rose (Königl. Preuss. Akad., Oct. 1851).—When a solution of sulphate of copper is precipitated in the cold by carbonate of soda or potash, the precipitate is at first voluminous, and of a blue colour; but left for a while and then washed, it becomes more dense and of a green colour. It has the composition of green malachite as found in nature.

BOTANY.

11. *The Effect of very Low Temperature on Vegetation.*—In 1838, I published, says M. A. de Candolle, in the Bulletin de la Classe d'Agriculture de Genève (No. 120, p. 171), in an article on the intense cold of January 1838, the following remarks. After first alluding to the observations of Pictet and Maurice, who found the temperature of the centre of a chestnut tree below zero, and also the experiments of M. Ch. Coindet, who after a prolonged cold had extracted from the middle of a large tree small crystals of ice. These trees are however not dead. I have myself, after a cold but little intense, seen crystals of ice in the interior of the buds of several trees which have not suffered from it. Young branches, the buds of many trees, and the leaves of the plants of our country, are in winter often penetrated, beyond doubt, with a cold several degrees below zero (centigrade); and although the viscous liquids of the slender tubes congeal with difficulty, it must frequently happen that congelation takes place, without the plant or the organ perishing. Thus cold does not kill vegetation by a mechanical action proceeding from the congelation of the liquid, as some naturalists pretend. We must recognise rather a physiological action, that the vitality of the tissue is destroyed by a certain degree of cold followed by a certain degree of heat according to the peculiar nature of each plant. The vegetable and animal kingdom, according to this view, will act alike. In the same manner as the gangrene that sets in after the thawing of a frozen part causes the death of an animal tissue, so the change or putrefaction which follows a rapid thawing will be the principal cause of the death of the vegetable tissue. It is well known in practice how to manage the transitions of temperature to preserve the organs of vegetables. Since 1838, until my connection with the Academy of Geneva ceased, I stated in my annual lectures that cold may act in two ways on vegetation, either *physically*, by the contraction or congelation of the liquids which often does not kill them; and *physiologically*, by an action upon the tissues and upon vegetable life, which the laws of physics do not account for. The most striking example of this last is the immediate death of hothouse plants when exposed to a temperature of + 1 or + 2° C., which causes no congelation. The action of the same degree of temperature is very different on two allied species, and sometimes on two varieties of the same species.

12. *Sleep of Plants in the Arctic Regions.*—Mr Seemann, the naturalist of Kellett's Arctic expedition, states a curious fact respecting the condition of the vegetable world during the long day of the Arctic summer. Although the sun never sets whilst it lasts, plants make no mistake about the time when, if it be not night, it ought to be, but regularly as the evening hours approach, and when a midnight sun is several degrees above the horizon, droop their leaves and sleep even as they do at sunset in more favoured climes. "If man," observes Mr Seemann, "should ever reach the pole and be undecided which

way to turn, when his compass has become sluggish, his timepiece out of order, the plants which he may happen to meet will shew him the way ; their sleeping leaves tell him that midnight is at hand, and that at that time the sun is standing in the north.—(*American Annual of Scientific Discovery*, p. 231.)

ZOOLOGY.

13. *Professor Agassiz on the Colour of Animals.*—Professor Agassiz is of opinion that the coloration of the lower animals living in water, depend upon the condition, and particularly upon the depth and transparency of the water in which they live : that the coloration of the higher types of animals is intimately related to their structure ; and that the change of colour which is produced by age in many animals is connected with structural changes. Coloration is valuable as an indication of structure ; and it is a law universally true of vertebrated animals, that they have the colour of the back darker than that of the sides ; and that the same system of coloration prevails in all the species of a genus, partially developed in some, but recognisable when a large number of species is examined.

14. *The Tsetse, or Zimb, of South Africa.*—The Tsetse is the name given to an insect found in the interior of South Africa. The most curious fact about this insect is, that while its sting is harmless to man and wild animals, it is certain destruction to horses, cattle, sheep, dogs, or any other domesticated brute, except goats and young calves. Several instances are known where all the cattle, horses, and dogs, of a traveller have been swept off by it. A horse was taken among them by a doubter; about fifty settled on him, and immediately he began to lose flesh ; in eleven days he was dead. When an ox is bitten, at once the countenance stares, the eyes run, he loses strength, swells under the jaw, staggers, grows blind, and becomes emaciated, which continues sometimes for months, when death ensues. Upon removing the skin, a great many air-bubbles are found on the surface of the body, under the cellular membrane. The fat is of an oily, glassy consistence, and of a greenish-yellow colour. The heart is soft and pale, lungs and liver diseased, and the gall-bladder unusually distended with bile. The muscles are flabby, the blood contains very little colouring matter, and not a pailful is found in the body. There is no such thing as becoming accustomed to them, and the natives in the localities where they abound, are unable to raise a single domestic animal. In the same districts, elephants, buffaloes, zebras, gnus, &c., live unaffected by the tsetse. A dog fed on the meat of game, lives ; one reared on milk, falls a victim to them. It is said that game meat is possessed of a peculiar acid found but sparingly in tame animals ; perhaps this may be the antiseptic. But then why do calves who subsist on milk escape ? Sometimes an entire herd of cattle is cut off, excepting the calves, and these follow likewise if kept in the region for a year or two.—(*American Geographical Society.*)

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Indications of Glacial Action in North Wales. By Sir WALTER C. TREVELYAN. In a Letter addressed to Professor JAMESON.

WALLINGTON, MORPETH, 14*th July* 1853.

MY DEAR SIR,—Several years ago, when in North Wales, I made notes of several indications I observed of glacial action; and as some of them have not, I think, been noticed by other observers, I send you a copy of some of the notes I made at the time (in September and October 1844), thinking that, if you should consider them worth a place in your Journal, they may interest some of your readers, and draw attention to localities which would, I think, repay further examination.

On Snowdon, on the west side of the small lake at the foot of the bold precipice of Clogwyn dur Arddu, is an enormous moraine of large angular fragments, derived from the peak from which it is separated by the lake; its position can only be accounted for by the deep interval having been filled with ice, over the surface of which the fragments of rock had fallen. Some of the rocks at the base of the peak above the lake, and by the side of the stream by which its waters escape, have been rounded and scratched by the action of ice.

In Cwm Llan, at the eastern foot of Snowdon, is a terminal moraine, the last probably left there by the melting glacier; it stretches across the termination of the Cwm in a semicircular form, and incloses several acres. The exterior slope is about double the height of the interior, probably owing to the accumulation against the latter of debris brought down by winter rains, for there is no stream running into the Cwm. The rocks on the side of the Cwm are rounded, scratched, and polished.

At the head of the pass of Nant Francon, near Llyn Ogwen, on rocks on the south side of the Ogwen, are curious glacial markings crossing each other at right angles. The deepest groovings, and those which appear to be the most ancient (the polish and minor scratches having disappeared), indicate, I think, the existence of a glacier ranging down the valley from Llyn Ogwen. These groovings are crossed by smaller scratches and polishing, which appear to be more recent, and to have been caused by a glacier descending from Llyn Idwal; which, originating at a higher elevation, may possibly have continued to exist for some years after the disappearance of that in Llyn Ogwen, both having previously been united in one glacier at this point.

The marks of glacial action are very frequent about Cader Idris. At the base of the north peak of the mountain is a small lake nearly filled by torrent-borne debris, and in front of it a considerable transverse moraine, and also lateral ones, as there are also near Llyn-y-Gader, at the north-west base of the principal height. These moraines are very extensive, and visible at a considerable distance, as was well shewn in Glover's Panorama of Cader Idris, and in the engraving of it, where they are described as "immense beds of lava." Great part of the moraines are quite bare, and form a very striking scene of desolation; they are formed in parts of enormous angular fragments, as of the wreck of a mountain.

In the neighbourhood of Barmouth I traced the marks of glacial action and boulders to the height of about 1450 feet above the sea. The marks indicate a glacier coming down the valley from Cader Idris; and from the great height at which they appear, and the direction of the marks after they have passed over the summit ridge, would also tend to shew that at one period of the glacial era great part of the country had been covered with ice, and that it was not merely limited to the mountain valleys.

There is hardly a valley in North Wales, as in most mountainous countries of the north of Europe, in which decided marks of glacial action may not be observed, but I think I have mentioned above some of the most remarkable cases. Yours very truly,

W. C. TREVELYAN.

To Professor JAMESON.

On the Mammalia of the Fish River Bush, South Africa, with notices of their Habits. By Mr WILLIAM BLACK, Staff Assistant-Surgeon. Communicated by the Author.

(Continued from p. 83.)

The *Elephant* and *Rhinoceros* have years ago left the retreats of the Fish River Bush. The present Colonel Armstrong recollects, when as a subaltern stationed at Fort Brown, of passing through a herd of elephants on the Koonap Hill; and it was the common practice for the men of the detachment there in his time to hunt them on the Committee's Flats in the valley of the Ecca. A solitary sea-cow, or *Hippopotamus*, here and there, still lingers in the Fish River, below Trumpeter's Drift, and there still remain several of them in the Keiskamma.

The *Buffalo* still haunts, though in few numbers, the bushy kloofs and sides of the hills between the Grass-Kop and Committee's and Double Drift, and one or two have been killed in that neighbourhood, since the last war, by some boers living between the two posts. They are hunted with dogs, which bring them to bay, so as to afford a good shot behind the shoulder, or about the ear. The forehead is impenetrable, the brain being there protected by an enormous thickness of bone, forming the standing for the horns. They are excessively savage when wounded, and sometimes they evince a cunning which will prompt them to feign death, so as to delude the unwary to venture too near, when the infuriated brute summons up his strength, and rushes on his adversary to his almost certain destruction.

The fawn-coloured *Koodoo* (*Antelope Strepsiceros*), with its spiral-twisted horns,—absent in the female,—one of the handsomest of the large bucks, may be observed in small herds or solitary about the Fish River Rand, where they graze in the open glade, on the summit of that range, but their refuge is in the bushy kloofs of the Kinga. Their spoor, horse-shoe shaped, and with the cloven mark in its axis, may often be seen leading from thence to the banks of the Fish River on one side, or the Koonap on the other, in search of water; though the gratification of this appetite does not appear to be daily necessary in any kinds of buck. They also frequent the country between Double Drift and the Grass-Kop, and that eastward of the Fish River, and some have been seen up as far as Liewfontein, on the road to Fort Beaufort. They come out to feed in the early mornings and late evenings in the open spaces of the bush, and also browse on particular kinds of delicate shrubs, while their spoor may be seen covering the ground in such spots. During the heat of the day they lie down in the recesses and cool shade of some bushy kloof, near where they had been feeding. In wet and cloudy weather they are less shy, and like most bucks seem then to dislike the shelter of the bush, it is said from the dripping of the water through the foliage. In such weather the sportsman can easily follow the spoor and need not desist from his toil during the day, as probably he may at length come upon the animal or herd feeding. In dry weather, it is rather arduous sport. Sometimes they may accidentally be discovered about sunrise out feeding, and in such a case great caution must be used in approaching them, from their acute sense of smell and hearing. Its ear is large and lobed, and well adapted for detecting the approach of danger, especially from windward. Various covers of small bush, hillocks, ant-heaps, &c., may be employed to obstruct their seeing your approach; and some people have actually taken off their shoes and crept on their hands and knees to get within gunshot. Should the animal, however, get alarmed, his bound is fine, clearing the bush to his own height, and dashing down thus by repeated leaps, deep into the hollows of some contiguous kloof, whence being in a state of alarm it would be vain to follow him. The boer proceeds to hunt him otherwise, by traversing the country on horseback, till he finds a fresh spoor, which is followed through every difficulty of ground and bush, at the imminent risk of the clothes of an unaccustomed stranger being torn into shreds by the prickly thorns of the shrubbery. When the morning's spoor is traced, or the animal has been seen unalarmed on entering a kloof, the dogs are fetched, and some of the hunting party enter and station themselves about the head of the kloof, while the dogs are led by another of the party into the bottom, and are driven up so as to turn out the animal, which flies before them, and passes, perhaps, within gunshot of some of the former party. A well-known boer was accustomed in this case to follow on the spoor alone, being stripped to the skin, and carrying merely his bandelier round his waist, and his gun in his hand, with his tobacco-pipe, which he lit every now and then to observe how the wind set. Should it be with him he rested till it took a more advantageous direction, when he carried on the track farther through the bush. As the breaking of a twig might be heard by the wakeful animal, or the rustle of the thorns on his clothes, he had stripped himself naked. So following on by cautious degrees, every now and then lighting his pipe and ascertaining the course of the wind, he would at last come right upon the koodoo, lying in repose in his cover in the bush, and have ample leisure to take a fatal aim. The flesh forms the richest venison of any of the bucks of this part of the colony, and what is not required for immediate use is cut into strips, hung up and dried in the sun, forming excellent biltung. The skin, as large and longer than an ox's, is cleaned and pegged out on the ground to dry in the sun, and is afterwards used for various farm purposes by the boer, or sold,—chiefly being useful as the best material for vorslaghts, the lash of their great waggon whips. Its value may be about £1 a skin, which further makes excellent leather when dressed, &c., for shoes.

The next largest buck frequenting this bush is the powerful *Bushbuck* (Tragelaphus, *A. sylvatica*), of a dark brown colour, having black spiral horns with a ridge, the number of twists corresponding to its age. It is further recognized by half-a-dozen white spots on the hind quarters, and one on the cheek, a short tail, white underneath. He wants the usual lachrymal sinus, like the koodoo, the large lachrymal line of the buck's head here being quite flat on its aspect to the cheek. The female has no horns, like all those of that sex of the antelope kind inhabiting the Fish River Bush, and she is seldom seen. The rump and mammary region are white. The male and female of all the smaller bucks are distinguished in the country as ram and ewe, while in the koodoo and other larger ones, they are called bull and cow. Inguinal sacs are also possessed by the male bushbuck. It frequents the deepest and thickest kloofs and bush, and is very shy, though extremely ferocious when wounded, and can inflict serious wounds with its sharp-pointed horns. The Hottentot or boer, knowing the habitat of any animal, as they are generally solitary, stations himself by dawn in some little krantze or rock under cover of a bush overlooking a kloof, and silently awaits the buck coming out to feed at sunrise at the edge of the bush, in the open space or glade, and perchance may obtain a view within gunshot. In very dry weather they come down from the higher kloofs and live in the thick lofty bush on the banks of the river, so that the water is nearer; and here the spot they frequent on the banks may become known to the hunter by the frequent spoor, which is lancet-shaped and marked with the cleft in its axis, which he takes advantage of by stationing himself within proper range on the opposite bank, and awaiting the buck's time of repairing to drink in the evenings. They may also be started by following a morning's fresh spoor to their cover in the bush, either with or without dogs; and an opportunity for a shot may be obtained as the buck rises and bounds off, which he does with remarkable power and speed, clearing much over his own height. A favourite plan of hunting bucks in Lower Albany adopted by the English farmers, where a kloof can be found separate and surrounded by open country, is in stationing the party with their guns around it at various distances, and sending in beaters up from the bottom of the kloof to scare the game, which rush out according to their number from the edge of the bush, and afford fine practice. A common plan adopted by the Hottentot in the shooting of smaller bucks of all kinds, is in discovering an open spot of ground which, from the spoor and quantity of fresh dung, he judges is a favourite feeding ground, and excavating a hollow in a close bush within range of this with his knife, wherein he conceals himself before sunrise with his gun, ready on the watch for a buck displaying himself in the open glade which he commands. These coloured people are peculiarly expert in this stealthy kind of sport, which skill their rebel brethren have turned to a too fatal use in the war; they otherwise will walk cautiously over a favourable tract of bush country, where there are clumps and open glades, and taking views every now and then from behind different shelters, till they by good fortune espy in the morning or evening some unwary buck out feeding on the edge of a clump, and are almost certain to bring back one or two on such favourable occasions. A knowledge of the habitats of the various smaller bucks can be readily acquired by observation of spoor and the presence of their dung—their freshness, or otherwise, leading one to form an opinion of the proximity of the game. During the day, when they are lying down from the shelter of the sun, they may be flushed by good dogs who understand them, when one may get a chance of a shot, as they rush out of the bush and bound off; but this mode of sport requires a great rapidity of aim to be very successful, as their speed is very great.

Showery cloudy weather is the best to follow this sport; the bucks then leave the denser, cooler kloofs, and frequent the more open bush for the fresh grass and other green food. The breaking of a fore leg does not prevent the entire escape of a wounded buck, but injury to a hinder limb cripples it much more, though not to the extent but that probably a good dog would be required to capture him. From the nature of this part of the country, it is impossible to course them, and all common dogs cannot attain the speed of the buck, nor are they able to clear obstacles which the latter do by most astonishing bounds. Next to the koodoo, perhaps, bushbuck venison may be reckoned as palatable as any; but all these smaller bucks are devoid of fatty materials, and the flesh is very dry, so that to render the meat quite acceptable, it requires to be dressed in peculiar ways. The English farmers sometimes, when sport is no object, and the mere procuring of the skins and flesh for sale or consumption their aim, adopt a more wholesale method of capturing the smaller bucks of all kinds, and one that requires no expenditure of time. The River Bush is the most frequented resort of these animals during dry seasons, and their resort in any favourable numbers is easily ascertained by the quantity of spoor. Certain narrower tracts of it are bushed in after the manner of a kraal-fence, right across from the river bank to the outside edge of the bush, say for 80 yards, except a single narrow opening through which the bucks must pass when traversing the length of the bush to or fro. At this spot a trap is set, a hole is first dug, and a long spring of bush tree fixed in the ground close by, to the upper end of which is tied a *riem* or rope, having a running noose at the lower end, which is fixed by a small easily-loosened stick, round the margin of the hole, the spring being then bent down to its utmost. The opening of the hole is covered by other smaller sticks, over which are placed loose grass and rubbish to hide its artificial appearance. The buck in passing through puts his foot on the covering, which the pressure bruises down, the noose is liberated, the leg caught, and up springs the bender, and so holds the animal in spite of all his endeavours to escape till the poacher arrives. This plan is recommended from its not injuring the skin of the animal by any wound, so that its market value is not lessened. The Caffres in this country sometimes use a nearly similar method, bushing across a space of the river bush, leaving a single opening where a deep hole is dug, in the bottom of which is fixed an upright sharp-pointed stake, and the opening of the hole is covered lightly with sticks and grass. The buck, instead of being ginned, is here staked. The skins of all these smaller bucks are valuable, being, when prepared with the panion, made into carosses, bed-covers, carpets, &c., for use in the colony, and further form very fine leather stuff. Their usual selling price in the Graham's Town market is from one shilling to one shilling and sixpence.

In all these smaller bucks the *stomach* has the four cavities of the ruminant. The paunch contains a large quantity of semifluid half-digested vegetable matter, the reticulated cavity the same, which in the *maniplus*, however, is quite dry, preparatory to the chymification effected in the true stomach. The food in the fourth cavity is similar, but more liquefied than in the first two cavities. The cæcum is large, contains no formed fæces, and the small intestine enters into it at right angles to its axis by a small constricted opening, situated about three inches from the cul-de-sac extremity. The colon is much narrower than the cæcum, and at its commencement performs two complete circular folds in a separate plane of peritoneum, before becoming a movable free viscus in the abdominal cavity. The spleen is not larger than a crown-piece, flat, and lies against the left surface of the stomach. The pancreas is also small and flat in shape. The smallness of the former organ is probably commensurate with the large circulation of the intestinal tube, affording sufficient amount of portal blood for the liver, and with this circulation being in these animals in a state of almost constant activity, and thus affording a constant supply; while the periodical state of these matters in the carnivora may afford greater ground for a larger supplementary organ to receive an unrequired influx on the stomach and intestines, and sustain a steady supply of materials for the liver to elaborate into bile for an ensuing period.

The *Dui-Ru* (*Cephalophus*), so called from its bounding mode of progression, is a species of antelope, and rather numerous in the Fish River Bush, where it inhabits the darker-coloured ground covered with clumpy patches of bush. Both its spoor and dung are peculiar from the others, and its habitats consequently become known by these means. It has beautiful shining dun-coloured hair, short erect horns, with three or four annulations at the base, and is marked by a black stripe on the forehead and nose, and an S-shaped streak beneath each eye, indicating the situation of the orifice of the lachrymal sinus. It has a short tail, white underneath. Its speed is very great; in fact swifter than any other kind of the smaller bucks of the colony, which is attained by its numerous bounds, each clearing about 30 feet of level ground. As an object of mere sport, it has very great chances in its favour for escape. Its skin forms good carosses, and its capture for this object is effected by the various means above detailed.

The *Griesbuck* or Griessteenbuck (Tragulus), rather smaller than the *dui-ru*, takes its colonial name from the reddish-gray coloured skin. Its horns are short, straight, and smooth, and it possesses no tail. Inguinal sac in the male, four teats in the female, and a lachrymal sinus, are further characteristics of its antelope species. It inhabits a part of the bush-belt where the ground is sandstone and clayey, and of a colour apparently assimilated to that of the fur. It is far inferior to the *dui-ru* in speed, being apparently only gifted with running. Its skin is scarcely so valuable as that of the *dui-ru*.

The Steenbuck or *Bleekbuck* (Tragulus) is about the size of the *dui-ru*, and frequents bush growing chiefly on sandy clay ground. Its fur is of a shining reddish-yellow colour, the belly white, and the mammary region bounded by a black border on each side. It has two black stripes on the forehead and one on the nose. The horns are erect, short and smooth, and there is no tail. It partakes in a great measure of peculiarities proper to the dui-ru and griesbuck. Lachrymal sinus also is present. Its fur is less valuable than either of the other two, from the coarse nature of the hair, and in consequence little employed for carosses, but the skin makes as good leather as the others. Its speed is intermediate between the two former, but its appearance in a natural state is prettier than either. Pairs are generally found together, or may be started by the dogs from bushes not far separate; in the totality they are not so numerous as the other two.

The excretory orifice of the *lachrymal sinus* is single in the griesbuck, and opens in a black spot beneath the eye on the check. The buccal aspect of the lachrymal bones in this and the *dui-ru* and *bleekbuck* is hollowed for the reception of the black-coloured lacrymal sinus, which appears to abound in dark pigmentary matter like sepia, but the excreted fluid when seen is colourless. This gland has no connection with the orbit or eye, and its excretory ducts are single in the *griesbuck* and *bleekbuck*, but open by many pores in the S-shaped black stripe on the cheek of the *dui-ru*. If any use is to be assigned to it as possessed by these three species of antelopes, on what grounds is it dispensed with in the bushbuck and koodoo, which inhabit this bush-belt also? It cannot be for any object connected with the lubrication of the eyeball, as it is placed underneath it, so that its anatomy throws no light apparently on its function.

The *Wild Pig* of the Fish River Bush (*Phascochœrus*) is seen in two varieties, the larger of a dirty white colour entirely, and possessing three excessively-developed cartilaginous tubercles on the face on each side, two nasal, in appearance like horns, two orbital, and two buccal, which probably serve as fenders from injury to the eyes, in its progress through the thorny dense underwood. These prominences do not exist in the sow, which has a smaller head, but is otherwise similar to the boar. This variety goes by the appelation of *witkop* amongst the Dutch farmers. The smaller variety called *rocaitkop*, is of a dirty reddish-brown colour on the body and limbs, but the hair of the head becomes gray in the older individuals. The young of this kind have a general brown colour, with two or three longitudinal reddish stripes on each side extending from the head to the tail. The nasal tuberculations seem only here to attain any size in the male, and are entirely, as in the other variety, deficient in the sow, which is also somewhat smaller than the male, but otherwise similar in appearance. The ears in both are erect. The distribution of the teeth in both varieties is as follow: incisors $\frac{2}{6}$, canines $\frac{1}{1}-\frac{1}{1}$, molars $\frac{5\text{-}5}{4\text{-}4}=30$. The upper canines rest on their sides, and, directed outwards, seem merely for the purpose of keeping the two edges of their opposites in the lower jaw sharp by their grinding action, as their fibres will act perpendicularly against those of the lower tusks longitudinally. These animals afford excellent sport during the day, when the boer hunts them with a pack containing a few strong plucky dogs which have been accustomed to the sport. They frequent the dense bush and thickets, seldom the River Bush, and during the day may be turned out of these retreats, where they repose, by dogs knowing their scent. They then immediately make off, and in difficult thick country give a long chase to the pack, but in more open country are soon run into, as they cannot keep up any lengthened speed, though rapid for short distances. When they have taken to the dense bush the hunter waits, listening from some overlooking spot to the bark of the dogs, and hearing how matters are going on, till he becomes aware by the sound that the pig is brought at length to bay, when he then endeavours to get as best he can through the bush, to the assistance of his dogs, who would in a long contest most probably lose some of their numbers. The best of the dogs, when the pig is brought to bay, run up at once, and fasten upon him by the ears, snout, lip, &c., the others assisting, and thus hold him fast, and prevent him doing much mischief, till the boer's knife between his ribs or a bullet puts a termination to a struggle, which, if not thus interfered with, most likely would end in the defeat of the pack, and death of some of the dogs. In every seizure generally one or more dogs get wounded by the formidable tusks, and some are killed altogether, either by the belly being ripped up, or the vessels of the neck in front of the chest lacerated and pierced. Hesitating dogs are liable to suffer most, as may be inferred. By moonlight the wild pigs come out of their retreats, especially during and after rainy weather, when the ground is soft, to feed on the roots, bulbs, &c., which they fancy, and large pieces of ground may sometimes be seen ploughed up by them, after a single night's ranging. They may then be hunted very successfully, and sometimes shot when discovered out alone feeding. The flesh of the young is fair pork, but not very fat, and the skins of the older seem the only valuable part, of which the boer makes his veldschoons, or covers his saddle with. The flesh of these pigs is most frequently allotted by the boer to feed his dogs, and is cut off the carcase on the spot, and devoured by them raw.

Of the common Bush *Tiger* or Leopard (*F. Leopardus*), there are generally two kinds seen, a smaller and larger, inhabiting the densest bush of the koppies, kloofs, and krantzes. They are a great nuisance to the sheep-farmer of the Bush country, preying on his flocks, and are said to be very partial to baboons' flesh ; some skins of the larger kind with the long tail reach eight or ten feet long, while the smaller average about five or four. The spoor of some attain the size of that of a horse or ox's, or larger, recognized from that of the wolf or dog by their circularity, and the absence of claw-marks. They are sometimes hunted with a pack of good dogs by the boers, and when brought to bay, despatched with the roer. Otherwise they are caught in traps placed not far from the kraals; a large wolf-trap, with teeth, is set in the ground, covered over with rubbish in a sort of small kraal of bush, at the entrance of which it is placed, and opposite to it about two feet, is staked a piece of fresh meat. The animal is obliged, in order to get at this, and tear it off its fixture, to pass over and tread upon the plate of the trap, which by the pressure instantly loosens the spring, and the animal is caught by the limb. The trap is not fixed firm, so that the tiger can, if he pleases, walk off with it attached to his leg into the cover of some neighbouring thicket or kloof, as, if not permitted to do so, he would break or eat off his own limb, and so escape entirely. The boer next morning misses the trap, collects his dogs, and goes on the spoor, and is not long in discovering the retreat of the exhausted tiger. Their skins are valuable; the larger being rated at about 30s., and the smaller 15s. to purchasers; and are used for carosses, and chair and sofa covers. A few years ago, a fine young boer met an untimely end from being attacked by one of these ferocious creatures. He went out with his dog and gun, accompanied by a Caffre servant, to look after his sheep, during the day grazing amongst the bush of the Fish River, near the Kat River junction. The dog scented and discovered a tiger in a neighbouring kloof, and the servant having ascertained that such was the case, requested his master would enter the bush with him, and kill the tiger. The boer declined at first, telling the Caffre he could not trust him in a fight, and knew that he would run away at a critical time. However, the contrary assurances of the servant at length prevailed on the boer, and both went in to attack the tiger. The dog having shewn them his whereabouts, though still under some concealment from the foliage, the boer fired, and wounded the animal, which immediately sprung out, and ere the shot could be repeated, felled his antagonist, and the gun was thrown out of reach in the fall; the boer now cried out for his servant's assistance, but the coward had fled. A long struggle now ensued for life and death, the boer had got on his feet, but the tiger kept repeatedly springing up at his throat, and was as often shaken off by the hands. So rapid was this action that had it not been for the timely courage of the dog at length seizing and biting the tiger severely on the flanks, and diverting its attention for a moment, that enabled him to reach his gun, and despatch his enemy, the boer would have been worried on the spot. Assistance from some passing people enabled him then to reach his home, but dreadfully lacerated in the shoulders, arms, and scalp, and faint from the loss of blood. Death in ten days, however, put a period to his sufferings, which continued till then intense, the wounds never having become healthily inflamed or suppurated. Other accidents of this nature have occurred in contests with this formidable savage of the forests, and are so generally fatal that a tiger's bite in the country is reckoned poisonous, for which perhaps there may be some ground in analogy with that of a rabid dog, and from a received opinion that the salivary juices of carnivorous animals in a state of passion become morbidly changed from their constitution in health.

A few individuals of the *Red Cuba Lynx* (*Felis Lynx*) are found in similar situations to the tiger, and are caught and destroyed by similar means, by either dogs or traps. They are equally a nuisance to the sheep-kraals, and like the wild cat, prey upon fowls and such domestic birds. Their fur is reddish-yellow above, rather whitish underneath; the inguinal regions have a few dark brown spots scattered on them. The tail is black at its extremity, and the nearly erect ears, of a dull lead colour, are tipped with a pencil of fine hairs. Their skins are valuable for carosses and such purposes.

The *Wild Cat* (*Felis Serval*, F. Cuv.) is found everywhere in bushy country, and is very destructive to feathered game. It sometimes attains as large a size as the small tiger, and is of great comparative length of body, and the tail becomes very bushy. Like all these feline animals, they are found amongst bushy thickets, or else may be seen ensconced in trees, awaiting to spring on their prey beneath.

Several communities of the *Bavian*, or Ursine Baboon (*Cynocephalus porcarius*), are scattered over this bushy country in different localities. Inaccessible bushy krantzes are their favourite resort, but they may be found amongst the hills and koppies here and there; but when alarmed they betake themselves to their rocky fastnesses. They are destructive in gardens and grain fields, and become an annoyance to farmers on that account. When troublesome, they are sometimes hunted when found single; as attacking a whole community, except for their dispersion, would be dangerous. A pack of dogs are employed to bring the animal to bay, and the conflict is very similar to that with the wild pig, and is obliged to be terminated with the knife or the bullet. If a baboon takes refuge in the trees from the dogs which wait barking at the foot, he is brought down by a shot, which probably only wounds him, as correct aim cannot easily be taken, from the obstruction of the leaves. Sometimes a dog is killed by the wounds inflicted by the baboon's formidable tusks, and generally one or two are wounded before the struggle is over. These tusks are quite as formidable as those of the wild pig, but the upper one, pointed downwards, is the longer and more projecting of the two, quite sharp on the hinder edge, so that what is bitten is speedily torn through by the retraction of the head of the animal. In some old individuals, from the absence of so perfect a grinding tooth opposite as the pig possesses, the upper tusks attain such a length that it becomes impossible to open the jaw wide enough, so as to permit the use of such an apparently formidable fang, and consequently the boer has less fear of having his dogs maimed when hunting such, as their bite is no longer to be dreaded. Many old baboons also are devoid of one or other upper tusk, which has probably been broken off in some former struggle. When caught young, they may be trained to a certain extent; but they very frequently become ferocious from the confinement of the chain, especially males, and dangerous to their keepers and masters, and are obliged to be shot. A serious accident of this nature happened to a commissariat officer in Graham's Town, who was much lacerated by a baboon he was keeping, but which was afterwards shot.

The more inhabited parts of the Fish River country have nearly been cleared of the *Cape Wolf* (*Hyæna capensis*), or spotted hyæna, but they still exist in that part about Committee's and Trumpeter's. As these animals are very destructive to flocks, instead of hunting them for sport, the farmers have got rid of them in a wholesale manner. Pieces of meat impregnated with strychnine are deposited here and there over a certain property, and the wolf, if it partakes of any of them, is generally found dead not further than 100 yards off. This poison is so strong, that the flesh of the poisoned animal becomes itself poisonous, and will act nearly as powerfully as the original bait, whatever animal partakes of it. Their large dog-like spoor may sometimes be seen during wet weather, when they are more daring than usual. They are sometimes seen by travellers in the Trumpeter's Hill road, and have proved such a source of obstruction to some people, as to make them retrace their steps; and on these occasions they appear in troops. They do not generally act on the offensive, but fight desperately when attacked. Their enormous jaws and powerful strong teeth enable them to crush a limb or break a very stout stick like a twig. An old boer farmer near Fort Brown retains to this day numerous traces of deep wounds inflicted on him, when, in his younger days, he attacked and fought with a wolf that had entered his sheep-kraal, and would not have escaped being worried on the spot, unless assistance had arrived in time. These wolves are sometimes caught in large wooden crate-like traps, 10 or 15 feet square, and formed of stout building timber. A bait is affixed at the end opposite to a sliding door, which falls down on the former being loosened. Almost incredible instances are told of their power in crushing and breaking sticks, bending pokers, &c., by their jaws. They live chiefly in caverns and holes in the ground, such as old abandoned antbear runs, but their paws are powerful enough to excavate for dead carcases a considerable depth, and by many they are said to burrow their own holes.

The *Jackal*, or *Cape Fox* (*Canis mesomelas*), affords good coursing in open country, and English foxhounds have been trained to scent and follow him. He betakes himself generally to holes also, made in the earth by the antbear and porcupine, which have been abandoned. They are rather handsome in appearance, with erect open ears, long flowing fur, and a fine bushy tail, black at the after-part. The back is marked by a large patch of dark gray, with long white hairs interspersed, extending from the neck to the rump, and is bounded by a different coloured stripe all round, the rest of the fur being of a tawny colour; the tip of the nose is black and sharp. They can be made a pet of when caught young, and be taught to follow and act like a dog somewhat, but are rather uncertain in temper. Their prepared furred skins are made into very handsome carosses, and are nearly equal in this respect to those made of wild-cat skin, that of the male being handsomer than the female. Jackals are generally solitary in their habits in a wild state, and are not seen in troops like the wild dog in this part of the country.

The *Mane Jackal* (*Proteles Lalandi,* Is. Geof.), a kind of striped hyæna, shares peculiarities proper to the dog and the hyæna. It is rarer than the common fox, more shy, and less fleet when pursued, and lives in holes in the earth. Its food would appear to consist chiefly of ants, beetles, roots and bulbs, &c.; for the obtaining of mere carnivorous food, neither its teeth nor its strength would seem adapted. Its knees are soil-marked, hard, and bare of fur; and its posture at times, on feeding on certain aliments, would seem similar to the goat, which goes on its knees when cropping the grass. Its fur is coarse, of a dirty gray colour, and marked with transverse black stripes on the body and limbs. A mane extends along the back from the head to the tail, which is erected when the animal is pursued or its passions aroused, but is not perceived when in a state of repose. The tail is bushy, like the jackal, black at the tip, and hangs down as far as the hock, about half as short as the jackal's. The fore feet have five toes, and the hind feet four toes, like the dog, in which it differs from the generic characters of the hyæna. The teats of the female are four, situated in the ventral region, and the tongue is spiny, or aculeated, as in the true hyæna. The teeth seem peculiar to it alone, are weak and small, the great carnivorous tooth of the dog, hyæna, and jackal, is wanting, and the only substitute for the molars are a few separate small lancet-shaped teeth, which it is stated it retains through life. These are seen in specimens of full growth, so that they are not milk teeth. It only resembles the dog in having incisors and canines in the upper and lower jaw, the former of which seem much used, being worn by the frequent act of cropping or biting. Incisors $\frac{6}{6}$, canines $\frac{1}{1}-\frac{1}{1}$, molars $\frac{5\cdot5}{4\cdot4}=34$. Its ears are long, and erect like the hyæna, and there is a anal odoriferous gland.

The *Ratel* (*Viverra mellivora*) is a common inhabitant of the bush, and may be accidentally met with, or flushed by dogs on its scent, which is strong. It feeds on honey nests, though sometimes attacking the hen-roost and domestic fowls. The ratel follows the note and leading of the honey-bird, and answers it by a low grunt; a peculiar odour it emits drives away the bees, and the ratel digs out the different pieces of comb, and piles them outside the cavity, on which it repasts, but leaves some portion for a subsequent meal, part of which, of course, is shared by the honey-bird. It is very difficult to kill by dogs, from the great thickness of its skin and the coarseness of the hair, which also afford it protection from the stings of the bees. Its skin is used by the boers for soles of shoes. A heavy blow on the nose is stated to be the most vulnerable wound, and this peculiar vulnerability is shared by the porcupine. It is characterized by the large distinctly-bounded patch of dull ash-gray fur on its back, bounded on the sides by black stripes, and extending from the head to the tail.

Two or three different kinds of *Mousehund*, or weasel (*Mustela*), are commonly seen now and then running sharply from one bush to another, or they may be turned out by dogs. One variety (*Zorilla*) has its fur variegated by longitudinal black and dirty yellowish-white stripes, extending from the nose to the tail, and emits a very strong odour, when attacked or disturbed, from its anal gland, so that many dogs refuse to attack it—also then erecting its tail, and uttering a peculiar scream. In skinning such an animal, care must be taken not to wound this gland, else its secretion pouring out will taint the skin so much that the odour never leaves it. Another kind is of an entirely grayish-brown sandy colour, and the fur is very soft; and the furred skin is used by the natives for tobacco sacs, and such uses. It does not appear to be possessed of such a powerful scent as the former kind.

The *Porcupine* (*Hystrix*) affords good sport in the moonlight nights, people going out with dogs, and on horseback, armed with spears, or instruments that will answer such a purpose, and heavy sticks. They come out of their deep burrows at that time to feed, and root in the surface of the soil for bulbs, roots, &c. The flesh of the young porcupine makes good kind of pork when dressed for the table. It is a fiction their darting their quills; but they are easily detached from the skin, and their points are very sharp, and resemble very much the blade of an assegai; and if they enter a certain depth into the body of some unfortunate dog, readily stick there till pulled out. They are very destructive amongst gardens, and burrow holes in even hard ground very rapidly, dividing the roots that cross by their strong sharp incisors. The skull of the porcupine is very slight and spongy, and easily crushed when dried, which may explain the blow on the nose being fatal to them.

A troop of *Wild Dogs* (*Lycaon picta*, Brookes) are occasionally seen crossing the Bush country in the open glades, in the pursuit of some large buck, as a koodoo or bushbuck, and the destined victim seldom or ever escapes the perseverance and avidity of its pursuers, who follow it for miles on the spoor, which is never surrendered till it terminates at the death. Fleetness and the densest thickets are of no avail against these unrelenting hunters; the leading dog on the scent when tired sinks back into the pack, and a fresher huntsman takes his place, every one working for the common service of the stomachs of the whole pack. Its appearance gives one the idea of an intermediate form between the dog and the jackal, which it resembles in its pointed nose and long erect ears.

There are a great variety of *Dogs* in use in the colony, of all sizes, shapes, and degrees of strength, &c., but few gifted with individual courage and fine discerning scent, like English blood-bred dogs, and are only useful when in numbers.

The progeny of pure blood-dogs imported into the colony soon degenerate into the usual type witnessed here; the broad, short, and square nose becoming elongated, narrow, and pointed; the ears gradually acquiring more erectness, and the tail becoming wiry if bushy, and curly and hairy if smooth and straight. The shaggy coat of the imported Skye terrier or spaniel, in the individual itself ere long becomes smooth and shorter, and the hair straight; and the next breed are more altered still. Nothing but fresh blood from England, or elsewhere, can keep up good breeds of any kinds of household or hunting dogs, and they are found always much superior to their progeny born in the country. Well-bred dogs are much thinned in numbers by the distemper, which attacks them more virulently than it does more common breeds, and with more fatal effect. This disease bears strong characters of a congestive bilious fever, the liver and lungs become loaded with blood, and the white of the eyes becomes yellow, and torpidity and total loss of appetite ensue. The most efficacious remedies would appear to be emetics and calomel purges, followed by antimony and calomel powders. I cannot call to mind any instance of canine madness in this country, or any cases of hydrophobia. Whether this exemption is due to the uncontrolled liberty here given to dogs, which are seldom or ever chained up, allowing them free access to water wherever it lies, or to the unrestrained companionship of the bitch, I am unable to say. Certain it is, dogs are here uncommonly salacious. The observation in the tendency to degeneracy of well-bred dogs would argue the influence of the climate in reducing the varieties all down to the common characteristics of the native dog of the country, the *Canis venatica*. The common standard of *Cape Horse* remains the same, though good blood has been infused into the race from other parts; yet the native-born progeny sometimes naturally decline to the lower native standard—the horizontal or *t* neck, the straight perpendicular shoulder, and the heavy under jaw and narrow chest. The same law would seem to occur in the *Ox* and *Sheep*, the straight back and short horns soon in a generation or two lapse into the hanging neck and hollow back, and long ponderous horns, sometimes six or ten feet between the tips ; and the progeny of the well-bred woolled sheep, if let alone, change the curly thick-set coat for one hairy and shaggy, and thin, and the small tail for the long pendulous and fat-laden one of the Cape sheep. This deposit of fat in the tail would seem to have some connection with the absence of the usual quantity of internal fat seen in the latter breed. *Horses* are affected in the lower districts with a congestive fever, implicating the lungs at particular times and seasons, which proves fatal to great numbers, especially such as are turned out to graze all day, whence some attribute the cause to the grass, especially with the dew on. Purging and the maintenance of profuse perspiration are the usual methods of alleviation. Some are cured, but the majority of cases are unsuccessful.

The *Common Hare* may be found and shot about the open thickets on stony clayey ground in the level parts of the Bush country, but its flesh is far inferior to that of the English hare, and very dry. It has a grayish fur, and is of considerable size. Associated with it, but in more stony places, occasionally springs up and darts off very swiftly and sharply, the mountain hare, *Klipdas*, or red hare, about half of the size of the common species, having a general silver-gray thick fur, red woolly tail and red legs, and has long hairs round the nose and cheeks. Its skin is very difficult to take off, from its thinness and slightness, and is difficult to preserve. The flesh is very similar to that of the large species.

Out feeding in the clear moonlight nights after dark, may often, in particular localities, be detected the pretty and singular *Spring Hare* (*Pedetes*), in the neighbourhood of open sandy clay soil interspersed with small bushes, which it browses on, standing on its hind legs. It has many of the peculiarities of the squirrel or sloth, in the shape of its fore paws, which seem manifestly constructed for grasping branches or holding berries or nuts. Its powerful strong sharp incisors can easily bite the small twigs or cut off the wild fruit. It does not seem adapted to climb trees, and therefore only obtains such food as is within reach of a standing posture on its long hind legs, armed with hoof-like nails on the feet. As the fore feet are made as prehensile organs, it would seem that it is chiefly enabled to progress by leaps like the kangaroo from its hind feet and tail, which is long, tolerably thick, and plentifully supplied with muscular power. When wounded it utters a peculiarly shrill, melancholy cry. It betakes itself during the day to holes of its own construction in the sandy ground, running amongst the roots of the small thickets. When in a sleeping posture, or reposing, the long hind legs are stretched out forwards, and between them it buries its head, enfolded at the sides by its fore feet, the tail either extended or sweeping round one side of the body. The tail has a knob-like termination covered with black hair, the remainder being of the usual fawn colour of the body, &c. It has a similar posture with its limbs when reposing on its side. They are destructive to garden vegetables, and eat of the young mealies as they sprout forth. Its strong rodent incisors are very similar to those of the porcupine, and the fangs extend a long way into each upper and lower maxillary bone. The fur is bright and fulvous, and the hairy tail tinged black at its extremity. There is no external appearance of the testes, a peculiarity shared in by the elephant, seal, and cetacea, according to Professor Jones, who, however, does not allude to the spring hare in the paragraph in his Comparative Anatomy. These organs are both included in the abdominal cavity, but into the inguinal canal may be observed inserted the detractor ligament, the agent of the descent of the testes in the young of other animals. Each organ is suspended by its free extremity against, but free of, the anterior walls of the abdomen. The vasa deferentia pass from each testis to the corresponding side of the base of the bladder, and the vesiculæ seminales exist as entirely separate glands, whose ducts enter the vasa deferentia.

Basking themselves on the sunny side of the krantzes in the evenings and mornings, may generally be seen several of the *Klipdas*, *Cony*, *Rock Rabbit*, or Cape Hyrax (*H. capensis*), sitting together on the stones, and when alarmed by the approach of a stranger, rapidly to dive like lizards into the cavities out of sight. They are of various sizes, from that of a rat up to a full-grown rabbit; their fur is very fine, and the skin soft.

They are classed as pachydermata, but are plantigrade, and the feet are formed similar to those of a monkey, having a cushiony leathery sole all over, extending along the lower surfaces of the fingers and toes, which are provided with little nails, evidently adapting them for their stony peregrinations. They may be seen ascending up almost perpendicular faces of rock, and they can as rapidly descend without having recourse to a fall to hasten their descent. The distribution of the teeth are as follows: Incisors $\frac{2}{6}$, canines $\frac{1}{1}-\frac{1}{1}$, molars $\frac{5\text{-}5}{4\text{-}4}=30$. The lower incisors are small, chisel-shaped, set together, and their edges indented like a saw transversely. The two upper incisors are longer, curved, triangular, pointed and set apart, and look like canines in every respect as to appearance, and no doubt as to use; for they cannot cut, and are only serviceable to tear, and in fact are suitable tusks. The molars are all tuberculated. No tail.

The *Aardvark* (*Orycteropus capensis*) is an inhabitant of the Fish River country, but a description of this animal, and its anatomy, have already been given.*

On the discovery of some Fossil Reptilian Remains and a Land-Shell in the interior of an erect Fossil-Tree in the Coal Measures of Nova Scotia; with remarks on the origin of Coal-fields, and the time required for their formation. By Sir C. Lyell, F.R.S.

The entire thickness of the carboniferous strata exhibited in one uninterrupted section on the shores of the Bay of Fundy, in Nova Scotia, at a place called the South Joggins and its neighbourhood, was ascertained by Mr Logan to be 14,570 feet. The middle part of this vast series of strata having a thickness of 1400 feet, abounds in fossil forests of erect trees, together with root-beds and thin seams of coal. These coal-bearing strata were examined in detail by Mr J. W. Dawson of Pictou, and Sir C. Lyell in September last (1852), and among other results of their investigations they obtained satisfactory proof that several Sigillariæ standing in an upright position, or at right angles to the planes of stratification, were provided with Stigmariæ as roots. Such a relation between Sigillaria and Stigmaria had, it is true, been already established by Mr Binney of Manchester, and

* *Vide* Edin. New Phil. Journal, vol. liv., No. 107, p. 168.

had been suspected some years before on botanical grounds by M. Adolphe Brongniart; but as the fact was still doubted by some geologists both in Europe and America, it was thought desirable to dig out of the cliffs, and expose to view, several large trunks with their roots attached. These were observed to bifurcate several times, and to send out rootlets in all directions into the clays of ancient soils in which they had grown. Such soils or underclays with Stigmaria afford more conclusive evidence of ancient terrestrial surfaces than even erect trees, as the latter might be conceived to have been drifted and fixed like snags in a river's bed. In the strata 1400 feet thick above mentioned, root-bearing soils were observed at sixty-eight different levels; and, like the seams of coal which usually cover them, they are at present the most destructible masses in the whole cliff, the sandstones and laminated shales being harder, and more capable of resisting the action of the waves and the weather. Originally the reverse was doubtless true, for in the existing delta of the Mississippi the clays, in which innumerable roots of swamp trees, such as the deciduous cypress, ramify in all directions, are seen to withstand far more effectually the excavating power of the river or of the sea at the base of the delta, than do beds of loose sand or layers of mud not supporting trees.

This fact may explain why seams of coal have so often escaped denudation, and have remained continuous over wide areas, since the roots, now turned to coal, which once traversed them, would enable them to resist a current of water, whilst other members of the coal formation, when in their original and unconsolidated state, consisting of sand and mud, would be readily removed.

The upright trees usually inclose in their interior pillars of sandstone or shale, or both these substances alternating, and these do not correspond in the thickness of their layers, or in their organic remains, with the external strata, or those enveloping the trunks. It is clear, therefore, that the trees were reduced while yet standing to hollow cylinders of mere bark (now changed into coal), in which the leaves of ferns and other plants, with fragments of stems and roots, were drifted together with mud and sand during river inundations. The stony contents of one of these trees, nine feet high and twenty-two inches in diameter, on being examined by Messrs Dawson and Lyell, yielded, besides numerous fossil plants, some bones and teeth which they believed were referable to a reptile; but not being competent to decide that osteological question, they submitted the specimens to Dr Jeffries Wyman of Harvard University in the United States. That eminent anatomist declared them to be allied in structure to certain perennibranchiate batrachians of the genera Menobranchus and Menopoma, species of which now inhabit the lakes and rivers of North America. This determination was soon afterwards confirmed by Professor Owen of London, who pointed out the resemblance of some of the associated flat and sculptured bones, with the cranial plates, seen in the skull of the Archegosaurus and Labyrinthodon.* In the same dark-coloured rock, Dr Wyman detected a series of nine vertebræ, which from their form and transverse processes he regards as dorsal, and believes them to have belonged to an adult individual of a much smaller species, about six inches long, whereas the jaws and bones before mentioned are those of a creature probably two-and-a-half feet in length. The microscopic structure of these small vertebræ was found by Professor Quekett to exhibit the same marked reptilian characters as that of the larger bones.

The fossil remains in question were scattered about the interior of the trunk, near its base, among fragments of wood now converted into charcoal, which may have fallen in while the tree was rotting away, having been afterwards cemented together by mud and sand stained black by carbonaceous matter. Whether the reptile crept into the hollow tree while its top was still open to the air, or whether it was washed in with mud during a flood, or in whatever other manner it entered, must be matter of conjecture. Footprints of two reptiles of different sizes have been observed Dr Harding and Dr Gesner on ripple-marked flags of the lower coal measures in Nova Scotia, evidently made by quadrupeds walking on the beach, or out of the water, just as the recent Menopoma is sometimes observed to do. Other reptilian footprints of much larger size had been previously noticed (as early as 1844) in the coal of

* Professors Wyman and Owen have named the reptile Dendrerpeton Acadianum, Acadia being the ancient Indian name for Nova Scotia.

Pennsylvania by Dr King; and in Europe three or four instances of skeletons of the same class of animals have been obtained, but the present is the first example of any of their bones having been met with in America, in rocks of higher antiquity than the trias. It is hoped, however, that other instances will soon come to light, when the contents of upright trees, so abundant in Nova Scotia, have been systematically explored; for in such situations the probability of discovering ancient air-breathing creatures seems greater than in ordinary subaqueous deposits. Nevertheless we must not indulge too sanguine expectations on this head, when we recollect that no fossil vertebrata of a higher grade than fishes, nor any land-shells, have as yet been met with in the oolitic coal-field of the James River, near Richmond, Virginia, a coal-field which has been worked extensively for three-quarters of a century. The coal alluded to is bituminous, and as a fuel resembles the best of the ancient coal of Nova Scotia and Great Britain. The associated strata of sandstone and shale contain prostrate zamites and ferns, and erect calamites and equiseta, which last evidently remain in the position where they grew in mud and sand. Whether the age of these beds be oolitic, as Messrs W. B. Rogers and Lyell have concluded, or upper triassic, as some other geologists suspect, they still belong clearly to an epoch when saurians and other reptiles flourished abundantly in Europe; and they therefore prove that the preservation of ancient terrestrial surfaces even in secondary rocks does not imply, as we might have anticipated, conditions the most favourable to our finding therein creatures of a higher organization than fishes.

In breaking up the rock in which the reptilian bones were entombed, a small fossil body resembling a land-shell of the genus Pupa, was detected. As such it was recognized by Dr Gould of Boston, and afterwards by M. Deshayes of Paris, both of whom carefully examined its form and striation. When parts of the surface were subsequently magnified 250 diameters, by Professor Quekett of the College of Surgeons, they were seen to exhibit ridges and grooves undistinguishable from those belonging to the striation of living species of land-shells. The internal tissue also of the shell displayed, under the microscope, the same prismatic and tubular arrangements which characterize the shells of living mollusca. Sections also of the same shewed what may be part of the columella and spiral whorls, somewhat broken and distorted by pressure and crystallized. The genus cannot be made out, as the mouth is wanting. If referable to a Pupa or any allied genus, it is the first example of a pulmoniferous mollusk hitherto detected in a primary or palæozoic rock.

Sir Charles next proceeded to explain his views as to the origin of coal-fields in general, observing that the force of the evidence in favour of their identity in character with the deposits of modern deltas has increased in proportion as they have been more closely studied. They usually display a vast thickness of stratified mud and fine sand without pebbles, and in them are seen countless stems, leaves, and roots of terrestrial plants, free for the most part from all intermixture of marine remains, circumstances which imply the persistency in the same region of a vast body of fresh water. This water was also charged like that of a great river with an inexhaustible supply of sediment, which had usually been transported over alluvial plains to a considerable distance from the higher grounds, so that all coarser particles and gravel were left behind. On the whole, the phenomena imply the drainage and denudation of a continent or large island, having within it one or more ranges of mountains. The partial intercalation of brackish water-beds at certain points is equally consistent with the theory of a delta, the lower parts of which are always exposed to be overflowed by the sea even where no oscillations of level are experienced.

The purity of the coal itself, or the absence in it of earthy particles and sand throughout areas of very great extent, is a fact which has naturally appeared very difficult to explain, if we attribute each coal-seam to a vegetation growing in swamps, and not to the drifting of plants. It may be asked how, during river inundations capable of sweeping away the leaves of ferns, and the stems and roots of Sigillariæ and other trees, could the waters fail to transport some fine mud into the swamps? One generation after another of tall trees grew with their roots in mud, and after they had fallen prostrate and had been turned into coal, were covered with layers of mud (now turned to shale), and yet the coal itself has remained unsoiled throughout these various changes. The lecturer thinks this enigma may be solved, by attending to what is now taking place in deltas. The dense growth of reeds and herbage which encompasses the margins of forest-covered swamps in the valley and delta of the Mississippi, is such that the fluviatile waters in passing through them are filtered and made to clear themselves entirely before they reach the areas in which vegetable matter may accumulate for centuries, forming coal if the climate be favourable. There is no possibility of the least intermixture of earthy matter in such cases. Thus in the large submerged tract called the "Sunk Country," near New Madrid, forming part of the western side of the valley of the Mississippi, erect trees have been standing ever since the year 1811-12, killed by the great earthquake of that date ; lacustrine and swamp plants have been growing there in the shallows, and several rivers have annually inundated the whole space, and yet have been unable to carry in any sediment within the outer boundaries of the morass.

In the ancient coal of the South Joggins in Nova Scotia, many of the underclays shew a network of Stigmaria roots, of which some penetrate into or quite through older roots which belonged to the trees of a preceding generation. Where trunks are seen in an erect position buried in sandstone and shale, rooted Sigillariæ or Calamites are often observed at different heights in the enveloping strata, attesting the growth of plants at several successive levels, while the process of envelopment was going on. In other cases there are proofs of the submergence of a forest under marine or brackish water, the base of the trunks of the submerged trees being covered with serpulæ or a species of spirorbis. Not unfrequently seams of coal are succeeded by beds of impure bituminous limestone, composed chiefly of compressed modiolæ with scales and teeth of fish, these being evidently deposits of brackish or salt water origin.

The lecturer exhibited a joint of the stem of a fresh-water reed (*Arundinaria macrosperma*) covered with barnacles, which he gathered at the extremity of the delta of the Mississippi or the Balize. He saw a cane-brake (as it is called in the country) of these tall reeds killed by salt water, and extending over several acres, the sea having advanced over a space where the discharge of fresh water had slackened for a season in one of the river's mouths. If such reeds when dead could still remain standing in the mud with barnacles attached to them (these crustacea having been in their turn destroyed by a return of the river to the same spot), still more easily may we conceive large and firmly-rooted Sigillariæ to have continued erect for many years in the carboniferous period, when the sea happened to gain on any tract of submerged land.

Submergence under salt water may have been caused either by a local diminution in the discharge of a river in one of its many mouths, or more probably by subsidence, as in the case of the erect columns of the Temple of Serapis, near Naples, to which serpulæ and other marine bodies are still found adhering.

Sir Charles next entered into some speculations respecting the probable volume of solid matter contained in the carboniferous formation of Nova Scotia. The data he said for such an estimate are as yet imperfect, but some advantage would be gained could we but make some slight approximation to the truth. The strata at the South Joggins are nearly three miles thick, and they are known to be also of enormous thickness in the district of the Albion Mines near Pictou, more than one hundred miles to the eastward. There appears therefore little danger of erring on the side of excess, if we take half that amount or 7500 feet as the average thickness of the whole of the coal measures. The area of the coal-field, including part of New Brunswick to the west, and Prince Edward's Island and the Magdalen Isles to the north, as well as the Cape Breton beds, together with the connecting strata which must have been denuded, or must still be concealed beneath the waters of the Gulf of St Lawrence, may comprise about 36,000 square miles, which, with the thickness of 7500 feet before assumed, will give 7,527,168,000,000,000 cubic feet (or 51,136·4 cubic miles) of solid matter as the volume of the rocks. Such an array of figures conveys no distinct idea to the mind; but is interesting when we reflect that the Mississippi would take more than two millions of years (2,033,000 years) to convey to the Gulf of Mexico, an equal quantity of solid matter in the shape of sediment, assuming the average discharge of water in the great river, to be, as calculated by Mr Forshay, 450,000 cubic feet per second, throughout the year, and the total quantity of mud to be, as estimated by Mr Riddell, 3,702,758,400 cubic feet in the year.*

We may, however, if we desire to reduce to a minimum the possible time required for such an operation (assuming it be one of fluviatile denudation and deposition), select as our agent a river flowing from a tropical country, such as the Ganges, in the basin of which the fall of rain is much heavier, and where nearly all comes down in a third part of the year, so that the river is more turbid than if it flowed in temperate latitudes. In reference to the Ganges, also, it may be well to mention, that its delta presents in one respect a striking parallel to the Nova Scotia coal-field, since at Calcutta, at the depth of eight or ten feet from the surface, buried trees and roots have been found in digging tanks, indicating an ancient soil now underground; and in boring on the same site for an artesian well to the depth of 481 feet, other signs of ancient forest-covered lands and peaty soils have been observed at several depths, even as far down as 300 feet and upwards below the level of the sea. As the strata pierced through contained fresh-water remains of recent species of plants and animals, they imply a subsidence which has been going on contemporaneously with the accumulation of fluviatile mud.

Captain Strachey of the Bengal Engineers has estimated that the Ganges must discharge $4\frac{1}{2}$ times as much water into the Bay of Bengal, as the same river carries past Ghazipore, a place 500 miles above its mouth, where experiments were made on the volume of water and proportion of mud by the Rev. Mr Everest. It is not till after it has passed Ghazipore,

* See Principles of Geology, 8th Ed., p. 219.

that the great river is joined by most of its larger tributaries. Taking the quantity of sediment at one-third less than that assigned by Mr Everest for the Ghazipore average, the volume of solid matter conveyed to the Bay of Bengal would still amount to 20,000 millions of cubic feet annually. The Ganges, therefore, might accomplish in 375,000 years the task which it would take the Mississippi, according to the data before laid down, upwards of two million years to achieve.

One inducement to call attention to such calculations is the hope of interesting engineers in making accurate measurement of the quantity of water and mud discharged by such rivers as the Ganges, Brahmapootra, Indus, and Mississippi, and to lead geologists to ascertain the number of cubic feet of solid matter which ancient fluviatile formations, such as the coal-measures, with their associated marine strata, may contain. Sir Charles anticipates that the chronological results derived from such sources will be in harmony with the conclusions to which botanical and zoological considerations alone might lead us, and that the lapse of years will be found to be so vast as to have an important bearing on our reasonings in every department of geological science.

A question may be raised, how far the co-operation of the sea in the deposition of the carboniferous series might accelerate the process above considered. The lecturer conceives that the intervention of the sea would not afford such favourable conditions for the speedy accumulation of a large body of sediment within a limited area, as would be obtained by the hypothesis before stated, namely, that of a great river entering a bay in which the waves, currents, and tides of the ocean should exert only a moderate degree of denuding and dispersing power.

An eminent writer, when criticising, in 1830, Sir Charles Lyell's work on the adequacy of existing causes, was at pains to assure his readers, that while he questioned the soundness of the doctrine, he by no means grudged any one the appropriation of as much as he pleased of that "least valuable of all things, past time." But Sir Charles believes, notwithstanding the admission so often made in the abstract of the indefinite extent of past time, that there is, practically speaking, a rooted and perhaps unconscious reluctance on the part of most geologists to follow out to their legitimate consequences the proofs, daily increasing in number, of this immensity of time. It would therefore be of no small moment could we obtain even an approach to some positive measure of the number of centuries which any great operation of nature, such as the accumulation of a delta or fluviatile deposit of great magnitude may require, inasmuch as our conceptions of the energy of aqueous or igneous causes, or of the powers of vitality in any given geological period, must depend on the quantity of time assigned for their development.

Thus, for example, geologists will not deny that a vertical subsidence of three miles took place gradually at the South Joggins during the carboniferous epoch, the lowest beds of the coal of Nova Scotia, like the middle and uppermost, consisting of shallow-water beds. If, then, this depression was brought about in the course of 375,000 years, it did not exceed the rate of four feet in a century, resembling that now experienced in certain countries where, whether the movement be upward or downward, it is quite insensible to the inhabitants, and only known by scientific inquiry. If, on the other hand, it was brought about in two millions of years according to the other standard before alluded to, the rate would be only six inches in a century. But the same movement taking place in an upward direction would be sufficient to uplift a portion of the earth's crust to the height of Mont Blanc, or to a vertical elevation of three miles above the level of the sea. In like manner, if a large shoal be rising, or attempting to rise, in mid-ocean at the rate of six inches or even four feet in a hundred years, the waves may grind down to mud and sand and readily sweep away the rocks so upraised as fast as they come within the denuding action of the waves. A mass having a vertical thickness of three miles might thus be stripped off in the course of ages, and inferior rocks laid bare. So in regard to volcanic agency a certain quantity of lava is poured out annually upon the surface, or is injected into the earth's crust below the surface, and great metamorphic changes resulting from subterranean heat accompany the injection. Whether each of these effects be multiplied by 50,000, or by half a million or by two millions of years, may entirely decide the question whether we shall or shall not be compelled to abandon the doctrine of paroxysmal violence in ancient as contrasted with modern times. Were we hastily to take for granted the paroxsymal intensity of the forces above alluded to, organic and inorganic, while the ordinary course of nature may of itself afford the requisite amount of aqueous, igneous, and vital force (if multiplied by a sufficient number of centuries), we might find ourselves embarrassed by the possession of twice as much mechanical force and vital energy as we require for the purposes of geological interpretation.

Some Observations on Fish, in relation to Diet. By JOHN DAVY, M.D., F.R.S. Lond. & Edin., Inspector-General of Army Hospitals, &c.* Communicated by the Author.

What are the nutritive qualities of fish, compared with other kinds of animal food? Do different species of fish differ materially in degree in nutritive power? Have fish, as food, any peculiar or special properties? These are questions, amongst many others, which may be asked, but which, in the present state of our knowledge, I apprehend it would be difficult to answer in a manner at all satisfactory.

On the present occasion, I shall attempt little more than an opening of the inquiry, and that directed to a few points, chiefly those alluded to in the foregoing queries.

1. *Of the Nutritive Power of Fish.*

The proposition probably will be admitted, that the nutritive power of all the ordinary articles of animal food, at least of those composed principally of muscular fibre, or of

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* Read before the Royal Society of Edinburgh, 18th April 1853.

muscle and fat, to whatever class belonging, is approximately denoted by their several specific gravities, and by the amount of solid matter which each contains, as determined by thorough drying, or the expulsion of the aqueous part at a temperature such as that of boiling water, not sufficiently high to effect any well-marked chemical change.

In the trials I have made, founded on this proposition, the specific gravity has been ascertained in the ordinary hydrostatical way;—the portions subjected to trial, in the instance of fish, have been taken from the thicker part of the back, freed from skin and bone, composed chiefly of muscle. And the same or similar portions have been used for the purpose of determining their solid contents, dried in platina or glass capsules of known weight, and exposed to the process of drying till they ceased to diminish in weight.

The trials on the other articles of diet, made for the sake of comparison, both as regards specific gravity (excepting the liquids), and the abstraction of the hygroscopic water, or water capable of being dissipated by the degree of temperature mentioned, have been conducted in a similar manner.

The balance used was one of great delicacy, at home, or a small portable one, when from home, of less delicacy, yet turning readily with one-tenth of a grain.

The results obtained are given in the following tables. In the first, on some different species of fish; in the second, on some other articles of animal food.

I have thought it right, whenever it was in my power, to notice not only the time when the fish were taken, but also the place where they were procured,—not always so precise as I could wish,—as both season and locality may have an influence on their quality individually. When the place mentioned is inland, it must be understood that, in the instance of sea-fish, they were from the nearest sea-port.

Table I.

Species of Fish.	Specific Gravity.	Solid Matter per cent.	Place where got, and Time.
Turbot, *Rhombus maximus*,	1062	20·3	March. Liverpool.
Brill, *R. vulgaris*, .	1061	20·2	October. Penzance.
Haddock, *Gadus æglefinus*, . .	1056	20·2	August. Ambleside.
Hake, *G. merlucius*,	1054	17·4	October. Penzance.
Pollack, *G. pollachius*,	1060	19·3	October. Penzance.
Whiting, *Merlangus vulgaris*, . .	1062	21·5	March. Chester.
Common Cod, *Morrhua vulgaris*, .	1059	19·2	April. Ambleside.
Red Gurnard, *Trigla cuculus*, . .	1069	23·6	October. Penzance.
Dory, *Zeus faber*, .	1070	22·9	October. Penzance.
Mackerel, *Scomber scombrus*, . .	1043	37·9	October. Penzance.
Sole, *Solea vulgaris*,	1065	23·0	February. Ambleside.
Do. do., . .	1064	21·1	February. Ambleside.
Thornback, *Raia clavata*	1061	22·2	October. Penzance.
Salmon, *Salmo salar*,	1071	29·4	March. River Boyne, Ireland. Fresh run from the sea.
Sea-Trout, *S. eriox*, .	...	41·2	June. Ambleside.
Charr, *S. umbla*, .	1056	22·2	November. Windermere.
Trout, *S. fario*, .	1053	22·5	March. Lough Corrib, Ireland. Weight about ½ lb., in good condition.
Do. do., . .	1050	18·7	Oct. River Brathay. A small fish of about 2 oz.
Smelt, *S. eperlanus*, .	1060	19·3	March. Liverpool.
Eel, *Anguilla latirostris*, .	1034	33·6	June. Ambleside.

Table II.

Kinds of Food.	Specific Gravity.	Solid Matter, per cent.	Place and Time.
Beef, sirloin, . .	1078	26·9	March. Ambleside.
Veal, loin, . .	1076	27·2	November. Ambleside.
Mutton, leg, . .	1069	26·5	November. Ambleside.
Pork, loin, . .	1080	30·5	January. Ambleside.
Pemican, composed of beef and suet,	...	86·25	Victualling-yard, Portsmouth.
Common fowl, breast,	1075	27·2	November. Ambleside.
Grey Plover, breast, .	1072	30·1	November. Ambleside.
Cow's milk, new, before the cream had separated, . .	1031	11·2	November.
White of hen's egg, .	1044	13·9	
Yolk of the same, .	1032	45·1	

These results I would wish to have considered merely as I have proposed in introducing them, viz., as approximate ones. Some of them may not be perfectly correct, owing to circumstances of a vitiating kind, especially the time of keeping. Thus, in the case of the whiting, which was brought from Chester, its specific gravity, and its proportion of solid matter may be given a little too high, owing to some loss of moisture before the trials on it were made. Casting the eye over the first table, it will be seen that the range of nutritive power, as denoted by the specific gravity, and the proportion of solid matter, is pretty equable, except in a very few instances, and chiefly those of the salmon and mackerel; the one exhibiting a high specific gravity, with a large proportion of solid matter; the other a low specific gravity, with a still larger proportion of matter, viz., muscle and oil, and, in consequence of the latter, the inferior specific gravity. A portion of the mackerel, I may remark, merely by drying and pressure between folds of blotting paper, lost 15·52 per cent. of oil. Oil also abounded in the sea-trout and eel, and hence the large amount of residue they afforded.

Comparing *seriatim* the first table with the second, the degree of difference of nutritive power of those articles standing highest in each, appears to be inconsiderable, and not great in the majority of the others, exclusive of the liquids,—hardly in accordance with popular and long-received notions.

2. *Of the Peculiar Qualities of Fish, as Articles of Diet.*

I am not prepared to enter into any minute detail on this important subject, from want of sufficient data.

That fish generally are easy of digestion, excepting such as have oil interfused in their muscular tissue, appears to be commonly admitted, as the result of experience,—a result that agrees well with the greater degree of softness of their muscular fibre, comparing it with that either of birds or of the mammalia, such as are used for food.

A more interesting consideration is, whether fish, as a diet, is more conducive to health than the flesh of the animals just mentioned, and especially to the prevention of scrofulous and tubercular disease.

From such information as I have been able to collect, I am disposed to think that they are. It is well known that fishermen and their families, living principally on fish, are commonly healthy, and may I not say above the average ; and I think it is pretty certain, that they are less subject to the diseases referred to than any other class, without exception. At Plymouth, at the public dispensary, a good opportunity is afforded of arriving at some positive conclusion,—some exact knowledge of the comparative prevalency of these diseases in the several classes of the community. The able physician of that institution, my friend Dr Cookworthy, at my request, has had the goodness to consult its records, and from a communication with which he has favoured me, it appears that of 654 cases of "confirmed phthisis and of hæmoptysis, the probable result of tuberculosis," entered in the register of the dispensary, 234 males, 376 females, whose ages and occupations are given individually, the small number of four only were of fishermen's families,—one male and three females,—which is in the ratio of one to 163·2 ; and of watermen "who fish with hook and line, when other work is scarce, generally very poor, and of habits generally by no means temperate or regular," the number, including their families, did not exceed eleven, of whom ten were males, one a female, which is in the ratio of one to 58·8. The entries from which the 654 cases are extracted, Dr Cookworthy states, exceed 20,000. He assures me, that had he taken scrofula in all its forms, the result would, he believes, have been more conclusive.

Such a degree of exemption as this return indicates in the instances of fishermen and boatmen, is certainly very remarkable, and deserving of attention, especially considering the prevalency of tubercular consumption, not only in the working classes generally throughout the United Kingdom, but also amongst the regular troops, whether serving at home or abroad, and having an allowance of meat daily, but rarely tasting fish.*

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* In 1205 fatal cases, not selected, in which the lungs were examined at the General Hospital, Fort Pitt, Chatham, tubercles were found to exist in 734 (61·7 per cent.) See the author's "Notes on the Ionian Islands and Malta," vol. ii., p. 312, for details.

If the exemption be mainly owing to diet, and that a fish diet, it may be presumed that there enters into the composition of fish, some element not common to other kinds of food, whether animal or vegetable. This I believe is the case, and that the peculiar element is iodine.

I may briefly mention, that in every instance in which I have sought for this substance in sea-fish, I have found distinct traces of it, and also, though not so strongly marked, in the migratory fish, but not in fresh-water fish. The trials I have hitherto made have been limited to the following, viz., the Red Gurnet, Mackerel, Haddock, Common Cod, Whiting, Sole, Ling, Herring, Pilchard, Salmon, Sea-Trout, Smelt, and Trout. In each instance, from about a quarter-a-pound to a pound of fish was dried and charred, lixiviated, and reduced to ashes, which were again washed. From the sea-fish, the washings of the charcoal afforded a good deal of saline matter on evaporation; the washings of the ash less. The saline matter from both consisted principally of common salt, had a pretty strong alkaline reaction, and with starch and aqua regia afforded, by the blue hue produced, clear proof of the presence of iodine. In the instance of the fresh-run Salmon, Sea-Trout, and Smelt, a slight trace of iodine was thus detected; in the spent Salmon descending to the sea, only a just perceptible trace of it was observable, and not a trace of it either in the Parr or in the Trout.

That iodine should enter into the composition of sea-fish, is no more perhaps than might be expected, considering that it forms a part of so many of the inhabitants of the sea on which fish feed;—to mention only what I have ascertained myself,—in the common Shrimp I have detected it in an unmistakeable manner, and also in the Lobster and Crab, and likewise in the common Cockle, Mussel, and Oyster.

The medicinal effects of cod-liver oil, in mitigating if not in curing pulmonary consumption, appear to be well established. And as this oil contains iodine, the analogy seems to strengthen the inference that sea-fish generally may be alike beneficial.

Should further inquiry confirm this conclusion, the practical application of it is obvious; and fortunately, should fish ever come into greater request as articles of food, the facility with which they may be preserved, even without salt, by thorough drying, would be much in favour of their use. I lay stress on thorough drying, as that seems essential,—for preservation, I believe even hygroscopic water should be excluded. Even in the instance of those articles of food which can be preserved in their ordinary dry state, the expulsion of this water would be advantageous under certain circumstances, were it merely on account of diminution of weight. Thus, referring to the second table, it will be seen that the Pemican, carefully prepared in the Portsmouth Victualling-Office, lost by thorough drying 13·75 per cent., so much being the water it contained in a hygroscopic state,—a lightening of weight that, to the Arctic land explorer, could not fail to be welcome and useful.

The inference regarding the salutary effects of fish depending on the presence of iodine, in the prevention of tubercular disease, might be extended to some other diseases, especially to that formidable malady goître, the mitigation or cure of which has, in so many instances, been effected by iodine; and which, so far as I am aware, is entirely unknown amongst the inhabitants of sea-ports and sea-coasts, who, from their situation, cannot fail to make more or less use of fish.

Amongst the many questions that may be asked in addition to those I have proposed, I shall notice one more only, and that in conclusion. It is, whether the different parts of the same fish are likely to be equally beneficial in the manner inferred,—the beneficial effect, it is presumed, depending on the presence of iodine. From the few experiments I have yet made, I am led to infer, reasoning as before, that the effects of different parts will not be the same, inasmuch as their inorganic elements are not the same. I may instance liver, muscle, and roe or milt. In the ash of the liver and muscle of sea-fish, I have always found a large proportion of saline matter, common salt abounding, with a minute portion of iodine,—rather more in the liver than in the muscle,—and free alkali, or alkali in a state to occasion an alkaline reaction, as denoted by test paper; whilst in their roe and milt I have detected very little saline matter, no trace of iodine, or of free alkali; on the contrary, a free acid, the phosphoric, analogous to what occurs in the ash of the yolk of the domestic fowl,—and in consequence of which, the complete incineration of the roe of the fish and its milt, like that of the yolk of the egg, is very difficult.

The same conclusion, on the same ground, viz., the absence of iodine, is applicable to fresh-water fish,—a conclusion that can hardly be tested by experience, nor is it of practical importance, since fish of this kind enters so sparingly into the ordinary diet of the people.

LESKETH HOW, AMBLESIDE,
April 14, 1853.

P.S.—I have mentioned briefly the test employed to detect iodine. To prevent obscurity, may I be permitted to add a few particulars relative to the mode of proceeding? On a portion of starch in fine powder, that is, in its granular state, aqua regia is poured, or about equal parts of nitric and muriatic acid, in a platina capsule, and then well mixed, using a glass rod. The salt to be tested, either in solution or solid, is then added. The blue tint due to the presence of iodine is immediately produced, if any of this substance, or a sufficiency of it to take effect, be present. The delicacy of this test is, I believe, well known. I have by means of it detected iodine, when one-tenth of a grain of the iodide of potassium was dissolved in 16,775 grains of water. Relative to this method, I may further remark, that by well mixing the acid and starch, not only is the starch reduced to a gelatinous state favourable for being acted on by the iodine, as liberated by the action of the chlorine, but also that the excess of chlorine is, to a great extent, got rid of. The platina capsule has appeared preferable to one of glass, as shewing the effect of colour by reflected light more readily and distinctly; and also, I am disposed to think, from some peculiar influence which the metal exercises, favouring the combination of the starch and iodine, similar, it may be, to that of spongy platinum, in effecting the union of oxygen and hydrogen.

In seeking for iodine in animal substances by incineration, it may be well to keep in mind, that, experimentally considered, the liability to error lies in underrating, rather than in overrating the result by the methods employed, and that mainly in consequence of more or less of loss of iodine being sustained in the process of combustion, incineration, and evaporation used. To illustrate this by a simple experiment, I may mention that a portion of water, equivalent to about 1525 grains, in which were dissolved 10 grains of common salt, and ·09 grain of iodide of potassium, was quickly evaporated to dryness by boiling. Previously, the iodine could be detected in the mixture by the test I have used; but not afterwards, when the residual salt was dissolved in the same quantity of water; proving how there had been a loss of the iodine in the operation of boiling; a loss chemists are familiar with, of substances in themselves not volatile, carried off suspended in aqueous vapour.

In stating the comparative exemption of fishermen and their families from pulmonary consumption, as indicated by the Plymouth Dispensary return, I have not given the total number of this class of persons. This deficiency I am now able to supply. From information which I have received, for which I am indebted to the Registrar-General, it would appear, that of the total male population of Plymouth (24,605), the number of fishermen is 726, exclusive of 37 pilots. This large proportional number renders the fact of their exemption the more remarkable, and especially comparing them with a class of the population, altogether different in their habits, and, it may be presumed in their diet, using fish only occasionally when abundant and cheap,—these are the cordwainers or shoemakers, whose number altogether (males) is 608. Now, on consulting the Dispensary return, I find, that the total number of this class that have died of the disease under consideration, has been 37, viz., 19 males and 18 females!

Reflecting on the fact, that iodine has been detected in all the trials I have hitherto made on sea-fish, it seemed probable that guano, considering its origin, would not be destitute of this substance; and the result of experiments has been confirmatory; using the test-method noticed above, a distinct indication of its presence was obtained, both in the instance of the Peruvian and African guano, the only two I have yet tried.

Lesketh How, *June* 1, 1853.

On the Identity of Structure of Plants and Animals. By Thomas H. Huxley, Esq., F.R.S. Read before the Royal Institution.

The lecturer commenced by referring to his endeavours last year to shew that the distinction between living creatures and those which do not live, consists in the fact, that while the latter tend to remain as they are, unless the operation of some external cause effect a change in their condition, the former have no such inertia, but pass spontaneously through a definite succession of states—different in kind and order of succession for different species, but always identical in the members of the same species.

There is however another character of living bodies, *Organization*—which is usually supposed to be their most striking peculiarity, as contrasted with beings which do not live; and it was to the essential nature of organization that the lecturer on the present occasion desired to direct attention.

An organized body, does not necessarily possess organs in the physiological sense—parts, that is, which discharge some function necessary to the maintenance of the whole. Neither the germ nor the lowest animals and plants possess organs in this sense, and yet they are organized.

It is not mere external form, again, which constitutes organization. On the table there was a lead-tree (as it is called), which, a mere product of crystallization, possessed the complicated and graceful form of a delicate fern. If a section were made of one of the leaflets of this tree, it would be found to possess a structure optically and chemically homogeneous throughout.

Make a section of any young portion of a true plant, and the result will be very different. It will be found to be neither chemically nor optically homogeneous, but to be composed of small definite masses containing a large quantity of nitrogen, imbedded in a homogeneous matrix having a very different chemical composition; containing in fact abundance of a peculiar substance, *Cellulose.*

The nitrogenous bodies may be more or less solid or vesicular, and they may or may not be distinguished into a central mass (*nucleus* of authors) and a peripheral portion (*contents, Primordial utricle* of authors.) On account of the confusion in the existing nomenclature, the lecturer proposed the term *Endoplasts* for them.

The cellulose matrix, though at first unquestionably a homogeneous continuous substance, readily breaks up into definite portions surrounding each endoplast:—and these portions have therefore conveniently, though, as the lecturer considered, erroneously, been considered to be independent entities under the name of cells—these, by their union, and by the excretion of a hypothetical intercellular substance, being supposed to build up the matrix. On the other hand, the lecturer endeavoured to shew that the existence of separate cells is purely imaginary, and that the possibility of breaking up the tissue of a plant into such bodies, depends simply upon the mode in which certain chemical and physical differences have arisen in the primarily homogeneous matrix, to which, in contradistinction to the endoplast, he proposed to give the name of *Periplast* or *periplastic substance.*

In all young animal tissues the structure is essentially the same, consisting of a homogeneous periplastic substance with imbedded endoplasts (*nuclei* of authors); as the lecturer illustrated by reference to diagrams of young cartilage, connective tissue, muscle, epithelium, &c. &c.; and he therefore drew the conclusion that the common structural character of living bodies, as opposed to those which do not live, is the existence in the former of a local physico-chemical differentiation; while the latter are physically and chemically homogeneous throughout.

These facts, in their general outlines, have been well known since the promulgation, in 1838, of the celebrated cell-theory of Schwann. Admitting to the fullest extent the service which this theory had done in anatomy and physiology, the lecturer endeavoured to shew that it was nevertheless infected by a fundamental error, which had introduced confusion into all later attempts to compare the vegetable with the animal tissues. This error arose from the circumstance that when Schwann wrote, the primordial utricle in the vegetable cell was unknown. Schwann, therefore, who started in his comparison of animal and vegetable tissues from the structure of cartilage, supposed that the corpuscle of the cartilage cavity was homologous with the "nucleus" of the vegetable cell, and that therefore all bodies in animal tissues, homologous with the cartilage corpuscles, were "nuclei." The latter conclusion is a necessary result of the premises, and therefore the lecturer stated that he had carefully re-examined the structure of cartilage, in order to determine which of its elements corresponded with the primordial utricle of the plant,—the important missing structure of which Schwann had given no account—working subsequently from cartilage to the different tissues with which it may be traced into direct or indirect continuity, and thus ascertaining the same point for them.

The general result of these investigations may be thus expressed:—*In all the animal tissues the so-called nucleus* (endoplasts) *is the homologue of the primordial utricle* (*with nucleus and contents*) (endoplast) *of the plant, the other histological elements being invariably modifications of the periplastic substance.*

Upon this view we find that all the discrepancies which had appeared to exist between the animal and vegetable structures disappear, and it becomes easy to trace the *absolute identity* of plan in the two,—the differences between them being produced merely by the nature and form of the deposits in, or modifications of, the periplastic substance.

Thus in the plant, the endoplast of the young tissue becomes a "primordial utricle," in which a central mass, the "nucleus," may or may not arise; persisting for a longer or for a shorter time, it may grow, divide and subdivide, but it never (?) becomes metamorphosed into any kind of tissue.

The periplastic substance follows to some extent the changes of the endoplast, inasmuch as it generally, though not always, grows in when the latter has divided, so as to separate the two newly-formed portions from one another; but it must be carefully borne in mind, though it is a point which has been greatly overlooked, that it undergoes its own peculiar metamorphoses quite independently of the endoplast. This the lecturer illustrated by the striking case of the sphagnum leaf, in which the peculiarly thickened cells can be shewn to acquire their thickening fibre *after the total disappearance of the primordial utricle*; and he further quoted M. von Mohl's observations as to the early disappearance of the primordial utricle in woody cells in general, in confirmation of the same views.

Now, these metamorphorses of the periplastic substance are twofold: 1. Chemical; 2. Morphological.

The chemical changes may consist in the conversion of the cellulose into xylogen, &c. &c., or in the deposit of salts, silica, &c., in the periplastic substance. Again the periplastic substance around each endoplast may remain of one chemical composition, or it may be different in the outer part (so-called intercellular substance) from what it is in the inner (so-called cell-wall).

As to morphological changes in the periplastic substance, they consist either in the development of cavities in its substance—*vacuolation* (development of so-called intercellular passages), or in *fibrillation* (spiral fibres, &c.)

It is precisely the same in the animal.

The endoplast may here become differentiated into a nucleus and a primordial utricle (as sometimes in cartilage), or more usually it does not,—one or two small solid particles merely arising or existing from the first, as the so-called "*nucleoli*;"—it persists for a longer or shorter time; it divides and subdivides, but it never (except perhaps in the case of the spermatozoa and the thread-cells of Medusæ, &c.) becomes metamorphosed into any tissue.

The periplastic substance, on the other hand, undergoes quite independent modifications. By chemical change or deposit it acquires horn, collagen, chondrin, syntonin, fats, calcareous salts, according as it becomes epithelium, connective tissue, cartilage, muscle, nerve, or bone; and in some cases the chemical change in the immediate neighbourhood of the endoplast is different from that which has taken place exteriorly,—so that the one portion becomes separable from the other by chemical or mechanical means; whence, for instance, has arisen the assumption of distinct walls for the bone-lacunæ and cartilage cavities; of cell contents and of intercellular substance as distinct histological elements.

The morphological changes in the periplastic substance of the animal, again, are of the same nature as in the plant:—vacuolation and fibrillation (by which latter term is understood, not only the actual breaking up of a tissue in definite lines, but the tendency to do so). *Vacuolation* of the periplastic substance is seen to its greatest extent in the "areolar" connective tissue; *Fibrillation* in tendons, fibro-cartilages, and muscles.

In both plants and animals, then, there is one histological element, the endoplast, which does nothing but grow and vegetatively repeat itself; the other element, the periplastic substance, being the subject of all the chemical and morphological metamorphoses, in consequence of which specific tissues arise. The differences between the two kingdoms are mainly, 1. That in the plant the endoplast grows, and as the primordial utricle, attains a large comparative size—while in the animal the endoplast remains small, the principal bulk of its tissues being formed by the periplastic substance; and 2; in the nature of the chemical changes which take place in the periplastic substance in each case. This distinction, however, does not always hold good, the Ascidians furnishing examples of animals whose periplastic substance contains cellulose.

"The plant, then, is an animal confined in a wooden case; and Nature, like Sycorax, holds thousands of 'delicate Ariels' imprisoned within every oak. She is jealous of letting us know this, and among the higher and more conspicuous forms of plants, reveals it only by such obscure manifestations as the shrinking of the Sensitive Plant, the sudden clasp of the Dionœa, or, still more slightly, by the phenomena of the Cyclosis. But among the immense variety of creatures which belong to the invisible world, she allows more liberty to her Dryads; and the Protococci, the Volvox, and indeed all the Algæ, are, during one period of their existence, as active as animals of a like grade in the scale. True, they are doomed eventually to shut themselves up within their wooden cages and remain quiescent, but in this respect they are no worse off than the polype, or the oyster even."

In conclusion, the lecturer stated his opinion that the cell-theory of Schwann consists of two portions of very unequal value, the one anatomical, the other physiological. So far as it was based upon an ultimate analysis of living beings, and was an exhaustive expression of their anatomy, so far will it take its place among the great advances in science. But its value is purely anatomical, and the attempts which have been made by its author, and by others, to base upon it some explanation of the physiological phenomena of living beings by the assumption of cell-force, metabolic-force, &c. &c., cannot be said to be much more philosophical than the old notions of "the actions of the vessels," of which physiologists have lately taken so much pains to rid themselves.

"The living body has often, and justly, been called, 'the house we live in.' Suppose that one, ignorant of the mode in which a house is built, were to pull it to pieces, and find it to be composed of bricks and mortar,—would it be very philosophical on his part to suppose that the house was built by *brick-force?* But this is just what has been done with the human body; we have broken it up into 'cells,' and now we account for its genesis by cell-force."

On Changes of Level in the Pacific Ocean.
By J. D. Dana, Esq.

Evidences of change of level in the Pacific are to be looked for in the height or condition of the coral-reef formations or deposits, in the character of the igneous rocks, and in the features of the surface. The points of evidence are as follow :—

A. *Evidences of Elevation.*

1. *Patches of coral reef, or deposits of shells and mud from the reefs, above the level where they are at present forming.*—The coral-reef rock has been shewn occasionally to increase by growth of coral to a height of four to six inches above low-tide level, when the tide is but three feet, and to twice this height with a tide of six feet. It may therefore be stated as a general fact, that the limit to which coral *may grow* above ordinary low tide, is about one sixth the height of the tide, though it seldom attains this height.

Beach accumulations of large masses seldom exceed eight feet above high tide, and the finer fragments and sand may raise the deposit to ten feet. But with the wind and waves combined, or on prominent points where these agents may act from opposite directions, such accumulations may be *thirty* to *forty* feet in height. These are drift deposits, finely laminated, generally with a sandy texture, and commonly without a distinguishable fragment of coral or shell; and in most of these particulars they are distinct from reef rocks. (Pp. 369, 370, vol. xi.)

2. *Sedimentary deposits or layers of rolled stones interstratified among the igneous layers.*

3. *Compactness of the igneous rocks.*—The great uncertainty of this kind of evidence has been shewn in another place.

B. *Evidences of Subsidence.*

1. *The existence of wide and deep channels between an island and any of its coral reefs; or, in other words, the existence of barrier reefs.*

2. *Lagoon islands or atolls.*

3. *Submerged atolls.*

4. *Deep bay indentations in coasts, as the terminations of valleys.*—In the remarks upon the valleys of the Pacific Islands, it has been shewn that they were in general formed by the waters of the land, unaided by the sea; that the sea tends only to level off the coast, or give it an even outline. When, therefore, we find the several valleys continued on beneath the sea, and inclosing ridges standing out in long narrow points, there is reason to suspect that the island has subsided after the formation of its valleys. For such an island as Tahiti could not subside even a few scores of feet without changing the even outline into one of deep coves or bays, the ridges projecting out to sea on every side, like the spread legs of a spider. The absence of such coves, on the contrary, is evidence that any subsidence which has taken place, has been comparatively smaller in amount.

5. *Sea-shore alluvial flats or deposits.*

6. *The lava surface of a volcanic island, sloping without interruption beneath the water, instead of terminating in a shore cliff of a hundred feet or so.*

C. *Probable evidence of Subsidence now in progress.*

1. *An atoll reef without green islets, or with but few small spots of verdure.*—The accumulation requisite to keep the reef at the surface-level, during a slow subsidence, renders it impossible for the reef to rise above the waves, unless the subsidence is extremely slow.

From the above review of evidences of change of level, it appears that when there are no *barrier* reefs, and only fringing reefs, the corals afford no evidence of subsidence. But it does not follow that the existence of only fringing reefs, or of no reefs at all, is proof *against* a subsidence having taken place. For we have elsewhere shewn that through volcanic action, and at times other causes, corals may not have begun to grow till a recent period, and therefore we learn nothing from them as to what may previously have taken place. While, therefore, a distant barrier is evidence of change of level, we can draw no conclusion either one way or the other, as is done by Darwin, from the fact that the reefs are small or wholly wanting, until the possible operation of the several causes limiting their distribution has been duly considered.

The influence of volcanoes in preventing the growth of zoophytes extends only so far as the submarine action may heat the water; and it may therefore be confined within a few miles of a volcanic island, or to certain parts only of its shores.

There are three epochs of changes in elevation which may be distinguished and separately considered: 1. The subsidence indicated by atolls and barrier reefs; 2. Elevations during more recent periods, and also during the same epoch of subsidence; 3. Changes of level anterior to the atoll subsidence, and the growth of recent corals. On this last point we have few facts.

1. *Subsidence indicated by atolls and barrier reefs.*

In a survey of the ocean, the eye observing its numerous atolls, sees in each, literally as well as poetically, a coral urn upon a rocky island that lies buried beneath the waves. Through the equatorial latitudes such marks of subsidence abound, from the eastern Paumotu to the western Carolines, a distance of about 6000 geographical miles. In the Paumotu Archipelago there are about eighty of these atolls. Going westward, a little to the north of west, they are found to dot the ocean at irregular intervals; and at the Tarawan Group the Carolines commence, which consist of seventy or eighty atolls.

If a line be drawn from Pitcairn's Island, the southernmost of the Paumotus, by the Gambier Group, the north of the Society Group, Samoa, and the Salomon Islands, to the Pelews, it will form nearly a straight boundary trending N. 70° W., running between the atolls on one side, and the high islands of the Pacific on the other, the former lying to the north of the line, and the latter to the south.

Between this boundary line and the Hawaiian Islands, an area nearly two thousand miles wide and six thousand long, there are two hundred and four islands, of which *only three are high*, exclusive of the eight Marquesas. These three are Ualan, Banabe (Ascension or Pounypet), and Hogoleu, all in the Caroline Archipelago. South of the same line, within three degrees of it, there is an occasional atoll; but beyond this distance there are none excepting the few in the Friendly Group, and one or two in the Feejees.

If each coral island scattered over this wide area indicates a subsidence of an island, we may believe that the subsidence was general throughout the area. Moreover, each atoll, could we measure the thickness of the coral constituting it, would inform us nearly of the extent of the subsidence where it stands; for they are actually so many registers placed over the ocean, marking out not only the site of a buried island, but also the depth at which it lies covered. We have not the means of applying the evidence; but there are facts at hand which may give, at least, comparative results.

a. We observe, *first,* that barrier reefs are, in general, evidence of less subsidence than atoll reefs (xiii. 186), consequently the great preponderance of the former just below the southern boundary line of the coral island area, and farther south the entire absence of atolls, while atolls prevail so universally north of this line, are evidence of little depression just below the line; of less further south; and of the greatest amount north of the line, or over the coral area.

b. The subsidence producing an atoll, when continued, gradually reduces its size, until finally it becomes so small that the lagoon is obliterated; and consequently a prevalence of these small islands is presumptive evidence of the greater subsidence. We observe, in application of this principle, that the coral islands about the equator, five or ten degrees south between the Paumotus and the Tarawan Islands, are the smallest of the ocean: several of them are without lagoons, and some not a mile in diameter. At the same time, in the Paumotus, and among the Tarawan and Marshall Islands, there are atolls twenty to fifty miles in length, and rarely one less than three miles. It is probable, therefore, that the subsidence indicated was greatest at some distance north of the boundary line, over the region of small equatorial islands between the meridian of 150° W. and 180°.

c. When, after thus reducing the size of the atoll, the subsidence continues its progress, or when it is too rapid for the growing reef, it finally sinks the coral island, which, therefore, disappears from the ocean. Now it is a remarkable fact that while the islands about the equator above alluded to indicate greater subsidence than farther south, north of these islands, that is, between them and the Hawaiian Group, there is a wide blank of ocean without an island, which is near twenty degrees in breadth. This area lies betweeen the Hawaiian, the Fanning, and the Marshall Islands, and stretches off between the first and last of those groups, far to the north-west.

Is it not, then, a legitimate conclusion that the subsidence which was least to the south beyond the boundary line, and increased northward, was still greater or more rapid over this open area; that the subsidence which reduced the size of the islands about the equator to mere patches of reef, was farther continued, and caused the total disappearance of islands that once covered this part of the ocean?

d. That the subsidence gradually diminished south-westwardly from some point of greatest depression situated to the northward and eastward, is apparent from the Feejee Group alone. Its north-east portion, as the chart shews (see vol. xiv.), consists of immense barriers, with barely a single point of rock remaining of the submerged land; while in the west and south-west there are basaltic islands of great magnitude. Again, along to the north side of the Vanikoro Group, the Salomon Islands, and New Ireland, there are coral atolls, though scarcely one to the south.

In view of this combination of evidence, we cannot doubt that the subsidence increased from the south to the northward or north-eastward, and was greatest between the Samoan and Hawaiian Islands near the centre of the area destitute of islands, about longitude 170° to 175° W., and 8° to 10° N.

But we may derive some additional knowledge respecting this area of subsidence from other facts.

Hawaiian Range.—We observe that the western islands in the Hawaiian Range beyond Bird Island, are coral islands, and all indicate some participation in this subsidence. To the eastward in the range, Kauai and Oahu have only fringing reefs, yet in some places these reefs are half-a-mile to three-fourths in width. They indicate a long period since they began to grow, which is borne out by the features of Kauai shewing a long respite from volcanic action. We consequently detect proof of but little subsidence of the islands. Moreover, there are no deep bays; and, besides, Kauai has a gently sloping coast plain of great extent, with a steep shore acclivity of one to three hundred feet, all tending to prove the smallness of the subsidence. We should therefore conclude that these islands lie near the limits of the subsiding area, and that the change of level was greatest at the western extremity of the range beyond Kauai.

Marquesas.—The Marquesas are remarkable for their abrupt shores, often inaccessible cliffs, and deep bays. The absence of gentle slopes along the shores, their angular features, abrupt soundings close alongside the islands, and deep indentations, all bear evidence of subsidence to some extent; for their features are very similar to those which Kauai, or Tahiti, would present, if buried half its height in the sea, leaving only the sharper ridges and peaks out of water. They are situated but five degrees north of the Paumotus, where eighty islands or more have disappeared, including one at least fifty miles in length. There is sufficient evidence that they participated in the subsidence of the latter, but not to the same extent. They are nearly destitute of coral.

Gambier or Mangareva Group.—In the southern limits of the Paumotu Archipelago, where, in accordance with the foregoing views, the least depression in that region should have taken place, there are actually, as we have stated, two high islands, *Pitcairn's* and *Gambier's*. There is evidence, however, in the extensive barrier about the *Gambier's*, that this subsidence, although less than further north, was by no means of small amount. On page 371, vol. xi., we have estimated it at 1150 feet. These islands, therefore, although towards the limits of the subsiding area, were still far within it. The valley-bays of the Mangareva islets are of great depth, and afford additional evidence of the subsidence.

Tahitian Islands.—The Tahitian Islands, along with Samoa and the Feejees, are near the northern limits of the area pointed out. Twenty-five miles to the north of Tahiti, within sight from its peaks, lies the coral island Tetuaroa, a register of subsidence. Tahiti itself, by its barrier reefs, gives evidence of the same kind of change; amounting, however, as we have estimated, to a depression of but two hundred and fifty or three hundred feet. The north-western islands of the group lie more within the coral area, and correspondingly, they have wider reefs and channels, and deep bays, indicating a greater amount of subsidence.

Samoa.—The island of Upolu has extensive reefs, which in many parts are three-fourths of a mile wide, but no inner channel. We have estimated the subsidence at one or two hundred feet. The volcanic land west of Apia declines with an unbroken gradual slope of one to three degrees beneath the sea. The absence of a low cliff is probable evidence of a depression, as has been elsewhere shewn. The island of Tutuila has abrupt shores, deep bays, and little coral. It appears probable, therefore, that it has experienced a greater subsidence than Upolu. Yet the central part of Upolu has very similar bays on the north, which would afford apparently the same evidence; and it is quite possible that the facts indicate a sinking which either preceded the ejections that now cover the eastern and western extremities of Upolu, or accompanied this change of level. Sovaii has small reefs, from which we gather no certain facts bearing on this subject. East of Tutuila is the coral island, Rose. It may be, therefore, that the greatest subsidence in the group was at its eastern extremity.

Feejee Islands.—We have already remarked upon this group. A large amount of subsidence is indicated by the reefs in every portion of the group, but it was greatest beyond doubt in the north-eastern part.

Ladrones.—The Ladrones appear to have undergone their greatest subsidence at the north extremity of the range, the part nearest the centre of the coral area; for although the fires at the north have continued longest to burn, the islands are the smallest of the group, the whole having disappeared except the summits, which still eject cinders. The southern islands of the group have wide reefs, but they afford no good evidence of any great extent of subsidence since the reefs began to form.

We have thus surveyed the borders of the coral area, and besides proving the reality of the limits, have ascertained some facts with reference to a gradual diminution of the subsidence towards and beyond these limits. A line from Pitcairn's to Bird in the Hawaiian Group appears to have a corresponding position on the north-east with the southern boundary line of the coral area; the two include a large triangular area. An axis nearly bisecting this triangular space, drawn from Pitcairn's toward Japan, actually passes through the region of greatest subsidence, as we have before determined it, and may be considered the *axial line*, or *line of greatest depression* for the great area of subsidence.

It is worthy of special note, *that this axial line, or line of greatest depression, coincides in direction with the mean trend of the great ranges of islands, it having the course* N. 52° W.

The southern boundary line of the coral area, as we have laid it down, lies within the area of subsidence, although near its limits.

There are places along this line where this area has been prolonged further than elsewhere. One of these regions lies between Samoa and Rotuma, and extends down to the Feejees and Tonga Group; another is east of Samoa, reaching towards the Hervey Group. Each of these extensions trends parallel with the groups of islands, and with the part of the line east of Tahiti. It would seem, therefore, that the Society and Samoa Islands were regions of less change of level than the deep seas about them.

What may be the extent of the coral subsidence?—It is very evident that the sinking of the Society, Samoan, and Hawaiian Islands, has been small compared with that required to submerge all the lands on which the Paumotus and the other Pacific atolls rest. One, two, or five hundred feet could not have buried all the many peaks of these islands. Even the 1500 feet of depression at the Gambier Group is shewn to be at a distance from the axis of the subsiding area. The groups of high islands above mentioned contain summits from 4000 to

10,400 feet above the sea; and can we believe it possible that throughout this large area, when the two hundred islands now sunk were above the waves, there were none equal in altitude to the mean of these heights? That all should have been within nine thousand feet in elevation, is by no means probable. However moderate our estimate, there must still be allowed a sinking of several thousand feet; and however much we increase it within probable bounds, we shall not arrive at a more surprising change of level than our continents shew that they have undergone.

Between the New Hebrides and Australia, the reefs and islands mark out another area of depression, which may have been simultaneously in progress. The long reef of one hundred and fifty miles from the north cape of New Caledonia, and the wide barrier on the west, cannot be explained without supposing a subsidence of one or two thousand feet at the least. The distant barrier of New Holland is proof of as great, if not greater, subsidence.

Effect of the subsidence.—The facts surveyed give us a long insight into the past, and exhibit to us the Pacific scattered over with lofty lands, where there are now only humble monumental atolls. Had there been no growing coral the whole would have passed without a record. These permanent registers, planted ages past in various parts of the tropics, exhibit, in enduring characters, the oscillations which the "stable" earth has since undergone. Thus Divine wisdom creates, and makes the creations inscribe their own history; and there is a noble pleasure in deciphering even one sentence in this Book of Nature.

From the actual extent of the coral reefs and islands, we know that the whole amount of high land lost to the Pacific by the subsidence, was at least fifty thousand square miles. But since atolls are necessarily smaller than the land they cover, and the more so, the farther subsidence has proceeded; since many lands from their abrupt shores, or through volcanic agency, must have had no reefs about them, and have disappeared without a mark, and others may have subsided too rapidly for the corals to retain themselves at the surface,—it is obvious that this estimate is far below the truth. It is apparent that in many cases islands now disjoined have been once connected, and thus several atolls may have been made about the heights of a single subsiding land of large size. Such facts shew farther error in the above estimate, evincing that the scattered atolls and reefs do not tell half the story. Why is it, also, that the Pacific Islands are confined to the tropics, if not that beyond thirty degrees the zoophyte could not plant its growing registers?

Yet we should beware of hastening to the conclusion that a continent once occupied the place of the ocean, or a large part of it, which is without proof. To establish the former existence of a Pacific continent is an easy matter for the fancy; but geology knows nothing of it, nor even of its probability.

The island of Banabe, in the Caroline Archipelago, affords evidence of a subsidence *in progress*, as my friend, Mr Horatio Hale, the philologist of the expedition, gathered from a foreigner who had been for a while a resident on this island. Mr Hale remarks, after explaining the character of certain sacred structures of stone, "It seems evident that the constructions at Ualan and Banabe are of the same kind, and were built for the same purpose. It is also clear that when the latter were raised, the islet on which they stand was in a different condition from what it now is. For at present they are actually in the water; what were once paths are now passages for canoes, and as O'Connell (his informant) says, 'when the walls are broken down the water enters the enclosures.'" Mr Hale hence infers, "that the land, or the whole group of Banabe, and perhaps all the neighbouring groups, have undergone a slight depression." He also states respecting a small islet near Ualan, "from the description given of Leilei, a change of level of one or two feet would render it uninhabitable, and reduce it, in a short time, to the same state as the isle of ruins at Banabe."

Period of the subsidence.—The period during which these changes were in progress, was probably since the tertiary epoch. In the island of Metia, elevated over two hundred feet, the corals below were the same as those now existing, as far as we could judge from the fossilized specimens. At the inner margin of shore reefs, there is the same identity with existing genera. We do not claim to have examined the basement of the coral islands, and offer these facts as the only evidence on this point that is within reach. We cannot know with absolute certainty that the present races of zoophytes may not be the successors of others of the secondary epoch: but we do know that we have little reason in facts observed for even the suspicion. For a long time volcanic action was too general and constant for the growth of corals; and this may have continued to interfere till a comparatively late period, if we may judge from the appearance of the rocks even on Tahiti.

The evidence of subsidence from coral islands might be pursued to other regions in other seas; but we here only refer to the facts on this point presented in our review of the geographical distribution of corals (xiii. 338), since we cannot speak from personal observation.

The subsidence has probably for a considerable period ceased in most, if not all, parts of the ocean, and subsequent elevations of many islands and groups have taken place, which we shall soon consider. In some of the Northern Carolines, the Pescadores, and perhaps some of the Marshall Islands, the proportion of dry land is so very small, compared with the great extent of the atoll, that there is reason to suspect a slow sinking even at the present time; and it, is a fact of special interest in connection with it that this region is near the axial line of greatest depression, where, if in any part, the action should be longest continued.

Among the Kingsmills and Paumotus, there is no reason whatever for supposing that a general subsidence is still in progress; the changes indicated are of a contrary character.

The results to which we have here been led obviously differ, in many particulars, from the deductions of Mr Darwin.

2. *Elevations of modern eras in the Pacific.*

Since the period of subsidence, the history of which has occupied us in the preceding pages, there has been no equally general elevation. Yet various parts of the ocean bear evidence of changes confined to particular islands or groups of islands. While the former exemplify one of the grander events in the earth's history, in which a large segment of the globe was concerned, the latter exhibit its minor changes over limited areas. The instances of these changes are so numerous and so widely scattered, that they convince us of a cessation in the previous general subsidence.

The most convenient mode of reviewing the subject is to state in order the facts relating to each group.

a. Paumotu Archipelago.—The islands of this archipelago appear in general to have that height which the ocean may give to the materials. Nothing was detected which satisfied us of any *general* elevation in progress through the archipelago. The large extent of wooded land shows only that the islands have been long at their present level: and on this point our own observations confirm those of Mr Darwin. There are examples of elevation in particular islands however, some of which are of unusual interest. The instances examined by the Expedition, were Honden (or Henuake), Dean's Island (or Nairsa), Aurora (or Metia), and Clermont Tonnerre. Beside these, Elizabeth Island has been described by Beechey, and the same author mentions certain facts relating to Ducie's Island and Osnaburgh, which afford some suspicions of a rise.

Honden or Dog Island.—This island is wooded on its different sides, and has a shallow lagoon. The beach is eight feet high and the land about eleven. There are three entrances to the lagoons, all of which were dry at low water, and one only was filled at high water. Around the lagoon, near the level of high tide, there were numerous shells of Tridacna lying in cavities in the coral rock, precisely as they occur alive on the shore reef. As these Tridacnas evidently lived where the shells remain, and do not occur alive more than six or eight inches, or a foot at the most, above low tide, they prove, in connection with the other facts, an elevation of *twenty inches* or *two feet.*

Nairsa or Dean's Island.—The south side of Dean's Island, the largest of the Paumotus, was coasted along by the Peacock, and from the vessel we observed that the rim of land consisted for miles of an even wall of coral rock, apparently six or eight feet above high tide. This wall was broken into rude columns, or excavated with arches and caverns; in some places the sea had carried it away from fifty to one hundred rods, and then there followed again a line of columns and walls, with occasional arches as before. The reef, formerly lying at the level of low tide, had been raised above the sea, and subsequently had undergone degradation from the waves. The standing columns had some resemblance in certain parts to the masses seen here and there on the shore platforms of other islands; but the latter are only distantly scattered masses, while on this island, for the greater part of the course, there were long walls of reef-rock. The height moreover was greater, and they occurred too on the *leeward* side of the island, ranging along nearly it whole course.

The elevation here indicated was at least *six feet;* but it may have been larger, as the observations were made from ship-board. Thirty miles to the southward of Dean's Island, we came to Metia, one of the most remarkable examples of elevation in the Pacific.

Metia.—This island has already been described, and its elevation stated at *two hundred and fifty feet*. (See xii. 40.)

*Clermont Tonnerre,** according to Mr Couthouy, shews the same evidence of elevation from Tridacnas as Honden Island. Clermont Tonnerre and Honden are in the north-eastern limits of the Paumotus.

Elizabeth Island was early shewn to be an elevated coral island by Beechey. This distinguished voyager represents it as having perpendicular cliffs fifty feet in height. From his description, it is obviously of the same character as Metia; the elevation is *eighty* feet.

Ducie's Island is described by Beechey as twelve feet high, which would indicate an elevation of at least *one* or *two* feet.

Osnaburgh Island, according to the same author, affords evidence of having increased its height since the wreck of the

* This island was not visited by the writer, as only the officers of the Vincennes attempted to land on it.

Matilda in 1792. He contrasts the change from "a reef of rocks," as reported by the crew, to "a conspicuously wooded island," the condition when he visited it; and states further, that the anchor, iron-works, and a large gun (4-pounder) of this vessel were two hundred yards inside of the line of breakers. Captain Beechey suggests that the coral had grown, and thus increased the height. But this process might have buried the anchor if the reef were covered with growing corals (which is improbable), and could not have raised its level. If there has been any increase of height (which we do not say is certain), it must have arisen from subterranean action.

b. Tahitian Group.—The island of Tahiti presented us no conclusive evidence of elevation. The shore plains are said to rest on coral, which the mountain debris has covered; but they do not appear to indicate a rise of the land. The descriptions by different authors of the other islands of this group, do not give sufficient reason for confidently believing that any of them have been elevated. The change, however, of the barrier reef around Bolabola into a verdant islet encircling the island, may be evidence that a long period has elapsed since the subsidence ceased; and as such a change is not common in the Pacific, we may suspect that it has been furthered by at least a small amount of elevation. The observation by the Rev. D. Tyerman with regard to the shells found at Huahine high above the sea, may be proof of elevation; but the earlier erroneous conclusions with regard to Tahiti, teach us to be cautious in admitting it without a more particular examination of the deposit.

c. Hervey and Rurutu Groups.—These groups lie to the south-west and south of Tahiti.

Atiu (Wateoo of Cook) is a raised coral island. Cook observes that it is "nearly like Mangaia." The land near the sea is only a bank of coral ten or twelve feet high, and steep and rugged. The surface of the island is covered with verdant hills and plains, with no streams.*

* Cook's Voyage, vol. i., pp. 180, 197. Williams's Miss. Enterprizes, i., pp. 47, 48, first Am. edit., Appleton.

Mauke is a low elevated coral island.*

Mitiaro resembles Mauke.†

Okatutaia is a low coral island, not more than six or seven feet high above the beach, which is coral sand. It has a light-reddish soil.

Mangaia is girted by an elevated coral reef *three hundred* feet in height. Mr Williams speaks of it as coral, with a small quantity of fine-grained basalt in the interior of the island; he states again that a broad ridge (the reef) girts the hills.‡

Rurutu has an elevated coral reef *one hundred and fifty* feet in height.§

With regard to the other islands of these groups, *Manuai*, *Aitutaki*, *Rarotonga*, *Remetera*, *Tubuai*, and *Raivavai*, the descriptions by Williams and Ellis appear to shew that they have undergone no recent elevation.

d. Scattered Islands in the latitudes between the Society and Samoan Groups.—These coral islands, as far as we can ascertain, are low like the Paumotus, excepting some of the Fanning Group north of the equator, and possibly Jarvis and Malden.

Of the *Fanning Group* (situated near the equator, south of the Hawaiian Group),—

Washington Island is three miles in diameter, without a proper lagoon; the whole surface, as seen by us, was covered densely with cocoa-nut trees. This unusual size for an island without a lagoon indicates an elevation, which the height of the island, estimated at twelve feet, confirms. The elevation may have been *two* or *three* feet.

Palmyra Island, just north-west of Washington, is described by Fanning as having two lagoons; the westernmost contains twenty fathoms water. *Fanning's Island*, to the

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* Williams's Miss. Ent., pp. 39, 47, 264. † Ibid., pp. 39, 264.

‡ Ibid., pp. 48, 50, 249. See also Mr Darwin, p. 132.

§ Ibid., p. 50.—Stutchbury describes the coral rock as one hundred and fifty feet high (West of England Journal, i.)—Tyerman and Bennet describe the island as having a high central peak with lower eminences, and speak of the coral rock as two hundred feet high on one side of the bay and three hundred on the other (ii., 102.)—Ellis says that the rocks of the interior are in part basaltic, and in part vesicular lava, iii., 393.

south-east of Washington, is described by the same voyager as lower than that island. The accounts give no evidence of elevation.

Christmas Island, still farther to the south-east, according to the description of Cook, its discoverer, had the rim of land in some parts three miles wide. He mentions narrow ridges lying parallel with the sea-coast, which "must have been thrown up by the sea, though it does not reach within a mile of some of these places." The proof of a small elevation is decided, but its amount cannot be determined from the description. The account of F. D. Bennet (Geographical Jour., vii., 226), represents it as a low coral island.

Jarvis Island, as seen from the Peacock, appeared to be eighteen or twenty feet in height, which, if not exaggerated by refraction (we think it not probable), would shew an elevation of six or eight feet. This island is a sand flat, with little vegetation, and is but two hundred miles south of Christmas Island.

Malden, two hundred and fifty miles south-east of Jarvis, near latitude 4° S., and longitude 155° W., visited by Lord Byron, is described as not over forty feet high; but this may be the whole height, including the height of the trees.

e. Tonga Islands and others in their vicinity.

All the islands of the Tonga Group about which there are reefs, give evidence of elevation: *Tongatabu* and the *Hapai* Islands consist solely of coral, and are elevated atolls.

Eua, at the south extremity of the line, has an undulated, mostly grassy surface, in some parts eight hundred feet in height. Around the shores, as was seen by us from shipboard, there is an elevated layer of coral-reef rock, twenty feet thick, worn out into caverns, and with many spout-holes. Between the southern shores and the highest part of the island, we observed three distinct terraces. Coral is said to occur at a height of three hundred feet. From the appearance of the land, we judged that the interior was basaltic; but nothing positive was ascertained with regard to it.

Tongatabu (an island visited by us) lies near Eua, and is in some parts fifty or sixty feet high, though in general but twenty feet. It has a shallow lagoon, into which there are two entrances; some hummocks of coral-reef rock stand eight feet out of the water.

Namuka and most of the *Hapaii* cluster, are stated by Cook to have abrupt limestone shores, ten to twenty feet in height. Namuka has a lagoon or salt lake at centre, one and a half-mile broad; and there is a coral rock in one part twenty-five feet high.*

Vavau, the northernmost of the group, according to Williams, is a cluster of elevated islands of coral limestone, thirty to one hundred feet in height, having precipitous cliffs, with many excavations along the coast.†

Pylstaart's Island, south of Tongatabu, is a small rocky islet without coral. Tafua and Proby are volcanic cones, and the former is still active.

Savage Island, a little to the east of the Tonga Group, resembles Vavau in its coral constitution and cavernous cliffs. It is elevated *one hundred feet*.‡

Beveridge Reef, a hundred miles south-east of Savage, is low coral.

f. Samoan Islands.—No satisfactory evidences of elevation were detected about these islands.

g. Scattered islands north of Samoa.

These islands are all of coral, and several indicate an elevation of one to six feet. On account of the high tides (4 to 6 feet), the sea may give a height of ten or twelve feet to the land.

Swain's, near latitude 11° S., is fifteen to eighteen feet above the sea, where highest, and the beach is ten to twelve feet high. It is a small island, with a depression at centre, but no lagoon. The height proves an elevation of *three to six* feet.

Fakaafo, ninety miles to the north, is fifteen feet high. The coral-reef rock is raised in some places three feet above the present level of the platform. Elevation at least *three* feet.

* Cook's Voyage; Williams, p. 296. † Williams, p. 427.

‡ Williams, pp. 275, 276. Foster estimates the height at fifty feet, and speaks of a depression about the centre.

Nukonono, or Duke of Clarence, near Fakaafo, was seen only from shipboard.

Oatafu, or Duke of York's, is in some parts fourteen feet high. Elevation *two* or *three* feet.

Enderby's and *Birnie's*, still farther north, are twelve feet high. Judging from the double slope of the beach on Enderby, this island may have undergone an elevation of *two* feet, the height of the upper slope; yet we think it doubtful.

Gardner's, *Hull*, *Sydney*, and *Newmarket*, were visited by the Expedition, but no satisfactory evidences of elevation on the first three were observed. The last is stated by Captain Wilkes to be *twenty-five* feet in height.

h. Feejee Islands.—The proofs of an elevation of four to six feet about the larger Feejee Islands, Viti Lebu and Vanua Lebu, and also Ovalau, are given in our report on this group. How far this rise affected other parts of the group, I have been unable definitely to determine; but as the extensive barrier reefs in the eastern part of the group rarely support a green islet, they rather indicate a subsidence in those parts than an elevation.

i. Islands north of the Feejees.—Horne Island, Wallis, Ellice, Depeyster, and four islands on the track towards the Kingsmills, were passed by the Peacock; but from the vessel no evidences of elevation could be distinguished. The first two are high islands, with barriers, and the others are low coral. *Rotuma* (177° 15′ E., and 12° 30′ N.), is another high island, to the west of Wallis's. It has encircling reefs, but we know nothing as to its changes of level.

k. Sandwich Islands.—*Oahu* affords decided proof of an elevation of twenty-five or thirty feet. There is an impression at Honolulu, derived from a supposed increasing height in the reef off the harbour, that the island is slowly rising. Upon this point I can offer nothing decisive. The present height of the reef is not sufficiently above the level to which it might be raised by the tides, to render it certain, from this kind of evidence, that the suspected elevation is in progress.

Kauai presents us with no evidence that the island, at the present time, is at a higher level than when the coral reefs begun; or at the most, no elevation is indicated beyond a foot or two. The drift-sand rock of Koloa appears to be a proof of elevation, from its resemblance to those of Northern Oahu; but if so, there must have been a subsidence since, as it now forms a cliff on the shore that is gradually wearing away.

Molokai, according to information from the Rev. Mr Andrews, has coral upon its declivities three hundred feet above the sea. The same gentleman informed us, that on the western peninsula of *Maui*, coral occurs in some places eight hundred feet above the sea; and specimens of well-defined coral were obtained at a height of five hundred feet. These islands were not visited by the writer.

With regard to *Molokai*, Mr Andrews informed the author that the coral occurs "upon the acclivity of the eastern or highest part of the island, over a surface of more than twenty or thirty acres, and extends almost to the sea. We had no means of accurately measuring the height; but the specimens were obtained at least three hundred feet above the level of the sea, and probably four hundred. The specimens have distinctly the structure of coral. The distance from the sea was two to three miles."

Mr Andrews, who appears to doubt the connection of the supposed coral on *Maui* with reefs, writes to the author as follows:—"In no case have I seen the coral in a rocky ledge; it is generally mixed with the lava rock, to which it adheres. It has usually the appearance of burnt lime; and thus, large stones and rocks seem as though they had been whitewashed several times over, and sometimes it amounts to an inch in thickness, or an inch and a half. At other times the whitewash has found its way into cracks in the stones. Sometimes only one side of a stone is whitened by it, or only a corner of it. It is sometimes soft and crumbly, and at other times quite hard; and again it is mixed with the earth." From this description it appears to resemble the line in crustations and seams of Diamond Hill, Punchbowl, and Koko Head, Oahu, which occur at the same height, but most certainly give no evidence of elevation, as they have proceeded beyond doubt from aqueous eruptions carrying lime in solution. Fragments of coral, it will be remembered, occur in the tufa of these hills. This evidence from Maui, should therefore be received with great hesitation until farther examined.

Besides the above, there are large masses of coral rock, according to Mr Andrews, along the shores of Maui, from two to twelve feet above high water. From his descriptions, this rock appears to be the reef-rock, like the raised reef of Oahu, and is probably proof of an elevation of at least twelve feet.

l. Kingsmill or Tarawan Group.

Taputeouea or Drummond.—This is the southern island of the group. The reef-rock, near the village of Utiroa, is a foot above low-tide level, and consists of large massive Astreas and Meandrinas. The tide in the Kingsmill seas is seven feet; and consequently this evidence of a rise might be doubted, as some corals may grow to this height where the tide is so high. But these Astreas and Meandrinas, as far as observed by the writer, are not among the species that may undergo exposure at low tide, except it be to the amount of three or four inches; and it is probable that an elevation of at least ten or twelve inches has taken place.

Apia or *Charlotte's Island*, one of the northernmost of the group, has the reef-rock in some parts raised bodily to a height of six or seven feet above low-water level, evidencing this amount of elevation. This elevated reef was observed for long distances between the several wooded islets; it resembled the south reef of Nairsa in the Paumotu Archipelago, in its bare, even top, and bluff worn front. An islet of the atoll, where we landed, was twelve feet high, and the coral-reef rock was five or six feet above middle tide. A wall of this rock, having the same height, extends along the reef from the islet. There was no doubt that it was due to an actual uplifting of the reef to a height of full six feet.

Nanouki, *Kuria*, *Maiana*, and *Tarawa*, lying between the two islands above mentioned, were seen only from the ship, and nothing decisive bearing on the subject of elevation was observed. On the north-east side of Nanouki there was a hill twenty or thirty feet in height covered with trees; but we had no means of learning that it was not artificial.

We were, however, informed by Kirby, a sailor taken from Kuria, that the reef of *Apamama* was elevated precisely like that of Apia, to a height of *five* feet; and this was confirmed by Lieutenant Dehaven, who was engaged in the survey of the reef. We were told, also, that Kuria and Nanouki were similar in having the reef elevated, though to a less extent. It would hence appear that the elevations in the group increase to the northward.

Maraki, to the north of Apia, is wooded throughout. We sailed around it without landing, and can only say that it has probably been uplifted like the islands south. *Makin*, the northernmost island, presented in the distant view no certain evidence of elevation.

The elevation of the Kingsmills accounts for the long continuity of the wooded lines of land, an unusual fact considering the size of the islands. The amount of fresh water obtained from springs is also uncommon (xii., 48). The wear from storms would also be greater on islands which have been elevated.

m. Radack, Ralick, and Caroline Islands.—No evidences of elevation in these groups are yet known. The very small amount of wooded land on the Pescadores inclines us to suspect rather a subsidence than an elevation; and the same fact might be gathered with regard to some of the islands south, from the charts of Kotzebue and Kruesenstern.

n. Ladrones.—The seventeen islands which constitute this group, may all have undergone elevations within a recent period, but owing to the absence of coral from the northern, we have evidence only with regard to the more southern.

Guam, according to Quoy and Gaymard, has coral rock upon its hills more than six hundred feet (one hundred toises) above the sea.

Rota, the next island north, afforded these authors similar facts, indicating the same amount of elevation.

o. Pelews and neighbouring Islands.—The island *Feis*, three hundred miles south-west of Guam, is stated by Darwin, on the authority of Lutke, to be of coral, and ninety feet high. *Mackenzie Island*, seventy-five miles south of Feis, is a low atoll, as ascertained by the Expedition. No evidences of elevation are known to occur at the Pelews.

Melanesian Islands.—Among the New Hebrides, New Caledonia, Salomon Islands, the evidences of elevation have not yet been examined.

The details given on the preceding pages may be presented in the following tabular form:—

		FEET.
Paumotu Archipelago,	Honden,	1½ or 2
... ...	Clermont Tonnere,	2
... ...	Nairsa or Deans's,	6
... ...	Elizabeth,	80
... ...	Metia or Aurora,	250
... ...	Ducie's,	1 or 2
Tahitian Group,	Tahiti,	0 ?
... ...	Bolabola,	?
Hervey and Rurutu Groups,	Atiu,	12 ?
... ...	Mauke,	Somewhat elevated
... ...	Mitiaro,	do.
... ...	Mangaia,	300
... ...	Rurutu,	150
... ...	Remaining Islands,	0 ?
North of the Tahitian,	Washington Island,	2 or 3
... ...	Christmas,	2 ?
... ...	Malden,	?
... ...	Jarvis,	6 or 8 ?
Tongan Group,	Eua,	300 ?
... ...	Tongatabu,	60
... ...	Namuka and the Hapai,	25
... ...	Vavau,	100
Savage Island,		100
Samoan Islands,		0
North of Samoa,	Swain's,	3 to 6
... ...	Fakaafo or Bowditch,	3 ?
... ...	Oatafu or Duke of York's,	2 or 3
... ...	Enderby's,	2 ?
... ...	Gardner, Hull, Sidney, Newmarket,	0 ?
Feejee Islands,	Viti Levu and Vanua Levu, Ovalua,	5 or 6
	Eastern Islands,	0 ?
North of Feejees,	Horne, Wallis, Ellice, Depeyster,	0 ?
Sandwich Islands,	Kauai,	1 or 2
... ...	Oahu,	25 or 30
... ...	Molokai,	300
... ...	Maui,	12
Tarawan Islands,	Taputeouea,	1 or 2
... ...	Nanouki, Kuria, Maiana, and Tarawa,	2 or more
... ...	Apamama,	5
... ...	Apia or Charlotte,	6 or 7
... ...	Maraki,	2 or 3
... ...	Makin,	0

		FEET.
Carolines,		None ascertained.
Ladrones,	Guam,	600
...	Rota,	600
Feis,		90
Pelews,		0 ?
New Hebrides, New Caledonia,	Salomon Islands,	None ascertained.

Several deductions are at once obvious :—

1. That the elevations have taken place in all parts of the ocean.

2. That they have in some instances affected single islands, and not those adjoining.

3. That the amount is often very unequal in adjacent islands.

4. That in a few instances the change has been experienced by a whole group or chain of islands. The Tarawan Group is an instance, and the rise appears to increase from the southernmost island to Apia, and then to diminish again to the other extremity.

The Feejees may be an example of a rise at the west side of a group, and possibly a subsidence on the east; while a little farther east, the Tonga Islands constitute another extended area of elevation. We observe that while the Samoan Islands afford no evidences of elevation, the Tonga Islands on the south have been raised, and also the Fakaafo Group, and others on the north.

We cannot, therefore, distinguish any evidence that a general rise is or has been in progress ; yet some large areas appear to have been simultaneously affected, although the action has often been isolated. Metia and Elizabeth Island may have risen abruptly ; but the changes of level in the Feejees and the Friendly Islands appear to have taken place by a gradual action.

On some New Points in British Geology. By Professor EDWARD FORBES, President of the Geological Society. Communicated by the Author.

Not many years ago it used to be said that the geology of England was done, and yet the best investigated localities are constantly affording fresh discoveries. When the lecturer last year exhibited Captain Ibbetson's beautiful and accurate model of Whitecliff Bay in the Isle of Wight, in illustration of his views respecting the distribution of species in time, he had not the slightest suspicion that this particular locality, so often and apparently so thoroughly explored, could yield new results and new interpretations. Nevertheless, having had occasion, at the suggestion of Sir Henry De la Beche, to examine the tertiary strata of the Isle of Wight for the purposes of the Geological Survey of Great Britain, this very bay of Whitecliff proved to be a rich source of novel geological information. Moreover, a great portion of the Isle of Wight, on further examination, turned out to belong to a division of the older tertiaries that had never been demonstrated to exist within the British Islands. As a general statement of these results and of their bearings may be more intelligible to non-professional lovers of geology than the detailed memoirs about to be published on the subject, Professor Forbes has taken this opportunity of communicating them to the Members of the Royal Institution.

The Isle of Wight is divided into two portions by a great chalk ridge running east and west. This is the ridge of vertical chalk beds. To the north of it, the country is composed of tertiary, to the south, of older strata, as far down in the geological scale as the Wealden. The lower Greensand or Neocomian beds occupy the greater part of the surface of the southern division, and fresh-water tertiaries that of the northern. At Alum Bay on the west, and Whitecliff Bay on the east, the ends of the older tertiary strata, as they rise above the chalk, are seen truncated and upturned, being all affected by the movement which caused the verticality of the chalk. These tertiaries constitute the following groups, successively enumerated in ascending order, the Plastic clay, the Bognor series (equivalents of the true London clay), the Bracklesham series, and the Barton series, upon which lie the Headon Hill sands, and those fresh-water strata that, spreading out, form the gently undulating country, extending from near the base of the chalk ridge to the sea.

Owing to the section at Headon Hill, near Alum Bay, being so clear and conspicuous, and their position being in the loftiest tertiary hill that exhibits its internal structure in the island, the fresh-water and fluvio-marine beds which compose that elevation have long attracted attention, and have been described by many observers, the first of whom was the late Professor Webster. The apparent slight inclination of these beds, as seen in the Headon section, except at the point where they are suddenly curved in conformity with the verticality of the chalk and the beds immediately above it, appear to have led geologists to the notion that the fluvio-marine portion of the Isle of Wight was composed entirely of continuations of the beds forming Headon Hill. Two observers only suspected a discrepancy, viz., Mr Prestwich, who in a short communication to the British Association at Southampton, expressed his belief that Hempstead Hill, near Yarmouth, would prove to be composed of strata higher than those of Headon; and the Marchioness of Hastings, who, having given much time to the search for the remains of fossil vertebrata in the tertiaries of the Isle of Wight and Hordwell, declared her conviction that these remains belonged to distinct species, according as they were collected at Hordwell, Hempstead, and Ryde, and that these three localities could not, as was usually understood, belong to the same set of strata. The recently published monograph of the pulmoniferous molluscs of the English eocene tertiaries, by Mr Frederic Edwards, afforded also indications of the shells therein so well described and figured having been collected in strata of more than one age.

A few days' labour at the west end of the island convinced Professor Forbes that the surmises alluded to were likely to prove true, and that the structure of the north end of the island had been in the main misunderstood. After four months' constant work at both extremities, and along the intermediate country, he succeeded in making out the true succession of beds, with most novel and gratifying results. During this work he was greatly aided by his colleague, Mr Bristow, and by Mr Gibbs, an indefatigable and able collector attached to the Geological Survey.

The fresh-water strata of Whitecliff Bay proved to be entirely misinterpreted. Instead of being constituted out of the Headon Hill strata only, more than a hundred feet thickness of them are additional beds characterized by peculiar fossils, and resting upon a marine stratum that overlies the Bembridge limestone, the equivalent of which at Headon is a soft concretionary calcareous marl, scarcely visible except in holes among the grass immediately under the gravel on the summit of the hill.

The beds of the true Headon series, in fact, are all included in the sub-vertical portion of the Whitecliff sections, and are there present in their full thickness. They are succeeded by peculiar strata of intermediate character, for which the name of St Helen's beds is proposed, and which become so important near Ryde that they constitute a valuable building stone. The Bembridge limestone that lies above is the same with the Binstead limestone near Ryde, out of which were procured the remains of quadrupeds of the genera Anoplotherium, Palæotherium, &c., identical with those found in the gypsiferous beds of Montmartre. The Sconce limestone near Yarmouth is also the same, and none of these limestones are identical with any of those conspicuous among the fluvio-marine strata at Headon Hill, and with which they have hitherto been confounded. They are far above them, and are distinguished by distinct and peculiar fossils.

Almost all the country north of the chalk ridge, exclusive of the small strip occupied by the marine eocenes, is composed of marls higher in the series than any of the Headon Hill beds, and hitherto wholly undistinguished, except in the Whitecliff section, where the age and relative position had been entirely mistaken. These are the Bembridge marls of Professor Forbes. Above them are still higher beds preserved only in two localities, viz., at Hempstead Hill, to the west of Yarmouth, and in the high ground at Parkhurst. For these the name of Hempstead series is proposed. Their characteristic fossils are very distinct, and the highest bed of the series is marine. These beds prove to be identical with the Limburg or Tongrien beds of Belgium and with the Gres de Fontainebleau series in France. We thus get a definite horizon for comparison with the Continent, and are enabled to shew, that instead of our English series of eocene tertiaries being incomplete in its upper stages, as compared with those of France and Belgium, it is really the most complete section in Europe, probably in the world. We are enabled by it to correct the nomenclature used on the Continent, and to prove that the so-called lower Miocene formations of France and Germany are in true sequence with the Eocene strata, and are linked with them both stratagraphically and by their organic contents. We are also enabled to refer, with great probability, the so-called Miocene tertiaries of the Mediterranean basin, of Spain and Portugal,—those of the well-known Maltese type—to their true position in the series, and to place them on a horizon with the Tongrien division of the Eocenes. As these Maltese beds are unconformable, and evidently long subsequent to the deposition of the great nummulitic formation, we are enabled to assign an approximate limit to the estimate of the latest age of that important series. From well-marked analogies we get at a probable date even for the Australian Tertiaries. Thus the deciphering of the true structure of a small portion of the British Islands can throw fresh light upon the conformation of vast and far apart regions.

The peculiar undulatory contour of the surface of the fluvio-marine portion of the Isle of Wight is due to the gentle rolling of these beds in two directions, one parallel with the strata of the chalk ridge, and the other at right angles to it. The valleys and hills running northwards to the sea depend upon the synclinal and anteclinal curves of the latter system of rolls, a fact hitherto unnoticed, and the non-recognition of which has probably been one cause of the erroneous interpretation of the structure of the Isle of Wight hitherto received. The truncations of these curves along the coast of the Solent exhibit at intervals beautiful and much neglected sections, well worthy of careful study. There is one of these sections near Osborne. Her Majesty's residence stands upon a geological formation hitherto unrecognized in Britain. Near

West Cowes there are several fine sections along the shore. The total thickness of unclassified strata in the Isle of Wight is four hundred feet, if not more, and within this range are at least two distinct sets of organic remains. The fluvio-marine beds in all, including the Headon series, are very nearly six-hundred feet thick.

On the question whether Temperature determines the distribution of Marine Species of Animals in depth. By JAMES D. DANA, Esq.

It is a question of much interest, how far temperature influences the range of zoological species in depth. From a survey of the facts relating to coral zoophytes, the author arrived at the conclusion that this cause is of but secondary importance.* After determining the limiting temperature bounding the coral-reef seas, and ascertaining the distribution of reefs, it was easy to compare this temperature with that of the greatest depths at which the proper reef corals occur. This depth is about 100 feet, now the limiting temperature, 68°, is reached under the equator at a depth of 500 feet, and under the parallel of 10° at a depth of at least 300 feet. There must therefore be some other cause besides temperature; and this may be amount of pressure, of light, or atmospheric air dissolved in the waters.

Professor Forbes has remarked that the deep sea species in the Ægeanh ave a boreal character ;† and Lieut. Spratt has ascertained the temperature at different depths,‡ and shewn that the deep-sea species are those which have the widest range of distribution, most of them occurring north about the British shores, or north of France. Yet is it true, that the species which occur in deep water in the Ægean are found in shallow waters of like temperature about the more northern coasts? If so, Lieut. Spratt's conclusion, that temperature is the principal influence which governs the distribution

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* Exped. Report on Zoophytes, 1846, p. 103 ; and on Geology, p. 97 ; this tour. xii, 180.

† Report on the Ægean Invertebrata, Rep. Brit. Assoc. 1843, p. 130.

‡ Rep. Brit. Assoc. 1848, p. 81.

of marine fauna in depth as well as in latitudinal distribution, will stand as true. But we believe that facts do not bear out this conclusion; deep-sea species live in deep seas in both regions, with but little difference in the depth to which they extend. They are boreal in character, when of Mediterranean origin, because they are cold-water species; and their wide distribution is because of the wide range of temperature for which they are fitted, rather than their fitness to endure a given temperature which they find at considerable depths to the south, and near the surface to the north.

As this point is one of much importance, we have run over the recent tables of dredging by Professor E. Forbes, in the Ægean and about the British Islands,* to see how far it is borne out; and we add other results by R. Macandrew, Esq., at Vigo Bay, Portugal, Gibraltar, Malta, Pantellaria, Algiers, and Tunis.†

	North of Scotland and Shetlands.	South of England and Isle of Man.	Vigo Bay.	Gibraltar.	Ægean.	Malta and Pantellaria.	Algiers and Tunis.
Corbula nucleus . .	3·80	5·50	5·25	8·20	7·80	6·50	8·35
Neæra cuspidata .	10·80	·50	·20	·45‡	12·185		
Thracia phaseolina .	·80	3·30	...	...	7·30		
Solen pellucidus . .	7·100	5·50	...	·40	...	...	·35
Psammobia ferroensis	3·90	5·50	...	·8‡	20·40	...	10·
Tellina donacina . .	1·80	5·40	...	...	7·45	...	10·
Mactra subtruncata .	0·12	·20 ?	5·10	...	...	...	6·
Lutraria elliptica .	0·10	·20	Low water				
Cytherea chione . .	...	10·20 ?	...	·8	7·10	6·15	
Venus ovata . . .	5·100	7·50	·8	6·40	29·135	6·40	6·35
Venus fasciata . .	5·90	7·50	·8	·8	27·40	6·50	6·35
Venus verrucosa . .	...	·10	·5	·6	2·40	6·15	6·
Artemis lincta . .	0·80	5·50	Low water	·6	...	6·15	6·8
Cardium echinatum	5·100	5·50	Littoral	...	7·50		
Lucina flexuosa . .	3·100	5·50	·4	...	7·11		
Lucina spinifera . .	10·100	15·30 ?	10·12	15·25	4·30	6·40	·35
Kellia suborbicularis	0.90	10·40	·8	...	29·45	35·50	
Modiola tulipa . .	10·50	5·25	·12	10·25	2·50	...	·35
Modiola barbata . .	...	2·15	...	...	7·95	6·15	6·8
Arca tetragona . .	10·60	20·30	·8‡	·30	20.80	35·50	·35
Arca lactea . . .	...	10·50	...	12·20	0·150	...	6·35
Pectunculus glycimeris	5·80	5·50	8·12	·30	6·24	...	·35
Nucula nitida . .	5·60	5·30	20·25	12·40	...	6·15	6·8
Nucula nucleus . .	5·100	5·50	5·25	6·20	2·10	6·40	6·35
Lima subauriculata .	4·100	15·30	...	·35	15·30	...	·35
Pecten similis . .	2·80	20·50	·20‡	...	27·185	...	·35
Pecten maximus . .	2·40	10·30	·8	4·25	...	35·50	6·8
Pecten opercularis .	2·100	5·50	8·20	20·40	10·70	...	·35
Pecten varius . . .	3·20	3·30	·8	·8	7·55	6·15	·35
Anomia ephippium .	0·80	·50	·10	...	20·40	35·50	6·35

* Rep. Brit. Assoc. 1843; and On British Marine Zoology, *Ibid.*, 1850, p 192.

† *Ibid.*, p. 264. ‡ Not found living at the depth stated.

The great care and thoroughness of Professor Forbes's researches, and those also of Macandrew, give peculiar weight to the conclusions. Those species are taken from the tables which are common to these several regions, and with regard to which the observations are free from doubt; and we have confined the list to the *Acephalous Molluscs*, as these appear to be sufficient to test the law under discussion. The depth is given in *fathoms*.

It should be observed that, to carry out the theory, the species should be confined to *shallower* waters to the north than to the south.

To compare fairly this table, it should be noted that the dredging at the Shetlands, Orkneys, and north of Scotland, was carried to a greater depth than about southern England, fifty fathoms being the limit in the latter region, as the waters are shallow. Making this allowance, we are still struck with the *great depth* to which the species penetrate at the most northern locality, instead of the *small* depth. Out of the twenty-one species which are here mentioned as occurring in northern Scotland or the Shetlands, and the Ægean, fourteen or fifteen descend to a *greater* depth in the former than in the latter; and nearly all the species common to the north and south extremities of the British Islands, are reported from the deepest waters at the north. Of the observations made at Vigo Bay, Malta, Pantellaria, Tunis, Algiers, and Gibraltar, there is but a single example among the above species of a greater range in depth than occurs in the northernmost locality examined. The dredging in the Mediterranean by Macandrew was not carried to as great depths; yet even allowing for this, the facts are not a little remarkable.

Now, the temperature in the Ægean during the warmer months, according to Lieut. Spratt, is as follows.

At the surface, 76° to 84°.
10 fathoms, seldom below 74° in the summer.

20	...	68	...
35	...	62	...
75	...	56	...
100 to 300	...	55 to 55½	...

The temperature of the waters near southern England in summer is 62°, and near the Shetlands 55°, or less. Consequently the surface summer temperature of the British Channel is not found in the Ægean at a less depth than thirty-five fathoms, and the surface summer temperature of the Shetlands is the temperature at one to three hundred fathoms in the Ægean; and still species that range to a depth of one hundred fathoms about northern Scotland, are found within thirty fathoms of the surface in the Ægean; that is, where the summer temperature is 74° or more. Such facts shew the hardiness of the species in enduring great ranges in temperature. We must therefore conclude that it is not temperature alone, or mainly, which determines the depth to which species may live. It exerts an influence, and species fitted for cold waters may be found in the deeper seas where such waters occur. But the limit of descent depends on other influences.

Looking at this table in another way, we see, as recognized by Professor Forbes, that species which occur at or near the surface in northern Scotland, are generally met with only at greater depths in the Mediterranean; that is, the minimum depth is less in the former case than in the latter. Thus *Corbula nucleus* has for its minimum depth in the Mediterranean six fathoms, and in the northern regions three fathoms. *Psammobia ferroensis* has ten fathoms for the former, and three for the latter. Other examples will be found in the above table, sufficient to illustrate the principle, although many exceptions exist. Thus species that have a range of one hundred fathoms beyond Scotland may have the same in the Mediterranean, except that in many cases they do not reach as near the surface, where the waters are warm.

The crustacea of the same seas illustrate this subject in a similar way; but the observations upon them have been made with less thoroughness, and we have therefore confined our discussions to Molluscs.—(*American Journal of Science and Arts*, vol. xv., 2d series, No. 44, p. 204.)

On the identity of a Colouring Matter present in several Animals with the Chlorophyle of Plants. By M. MAX. SCHULTZE of Greifswald.

The author enumerates several animals of a green colour which are common in ditches and marshes—such as *Hydra viridis,* several green *Turbellariœ, Vortex viridis, Mesostomum viridatum,* and *Derostomum cœcum;* and also several green infusoria, such as *Stentor polymorphus, Ophrydium versatile, Bursaria vernalis,* &c. The colour in these animals is afforded by minute green globules, about 0·016 inch in diameter, which are situated under the integument in the parenchyma of the animals. They are perfectly spherical, and exhibit within the green substance an extremely minute, colourless, and homogeneous nucleus; or they may consist of several minute green globules, grouped together in a mulberry form; in this latter case they arise from the division of a homogeneous vesicle.

This green colouring substance is not altered by dilute acids or alkaline solutions; by which it is distinguished from the green colouring matter of several Algæ, which, according to Nägeli, is changed into a yellow, orange, or red by the same re-agents. Concentrated sulphuric and muriatic acids dissolve the colouring matter; the solution is of a beautiful green or bluish-green colour, unchanged by the action of heat; it is also dissolved by a concentrated solution of potass, by ammonia, alcohol, and ether, the colour precisely resembling that of a solution of chlorophyle.

Its development, also, is influenced in the same way as that of a vegetable chlorophyle by light; but animals containing it do not evolve oxygen, and the author thence concludes that the evolution of that gas is not solely dependent upon the chlorophyle in plants.

In *Vortex viridis,* the minute green globules, owing to their mutual compression, assume an hexagonal form—the green compartments thus formed are separated by an interstitial colourless substance. The existence of a colourless membrane around each green vesicle may thence be deduced.

This fact is further demonstrated in vesicles, the green matter of which only partially fills the globular cavity.

With respect to the chemical composition of the membrane and of the nucleus of the vesicles in *Vortex viridis*, the results of the author's researches are limited to the following facts:—The solutions of potass and of ammonia, and sulphuric acid, after the extraction of the colouring matter, cause the membrane to swell out, in which the nucleus can no longer be recognized. The membrane becomes pale and finally disappears entirely, but especially so long after boiling. Acetic and chromic acids and alcohol do not affect the membrane and the nucleus. By solution of iodine the vesicle is coloured brown, the nucleus becomes more distinct, but its colour is unaltered. It cannot, consequently, be assimilated to the nucleus of the vegetable chlorophyle vesicle, which mostly consists of amylum.—(*The Quarterly Journal of Microscopical Science*, No. iv., July, p. 278.)

On the Classification of Rocks. By M. Dumont.

In this communication M. Dumont proposes a distribution of rocks and mineral deposits generally into three classes, according to the mode of their formation, and the use of the word *Geyserian* as a designation for the third of these classes.

The chemical, as well as the physical, study of the crust of the earth, is now beginning to engage a portion of that attention which for some years has been almost exclusively devoted to palæontology; nor can it be doubted that inquiries which may hereafter enable the geologist to explain both the physical and chemical condition of the earth's crust, are necessary to a right understanding of the past history of its successive changes. M. Dumont appears to feel this, when he suggests the threefold division of the rocks and strata of the earth above mentioned, and the adoption of a new designation for one of them. He observes that the terms Neptunian and Plutonian cannot embrace all the forms of mineral deposits. The term Neptunian naturally comprises all stratified deposits which have been formed under the action of external causes, and have therefore been called by Humboldt *exogenes.* They have been produced generally under the influence of water, exhibiting phenomena of a mechanical, chemical, or physical nature, and often containing the relics of organic bodies. Such strata, which are quartzose, slaty, clayey, calcareous, dolomitic, or carbonaceous, and are either laminated, compact, sandy, conglomeratic, or organic, sometimes appear nearly in the condition of their original deposit, and sometimes in a state of great alteration consequent upon the action of internal causes subsequent to their deposition, a change in consequence of which they have been designated Metamorphic. The term Plutonian comprises those rocks which have been produced by igneous action from internal causes, and have been therefore called by Humboldt *endogenes.* Such rocks are crystalline, and sometimes cellular, are feldspathic, and appear either in masses or have been erupted, like lavas, in streams.

By the term "Geyserian" M. Dumont proposes to designate those rocks which, though, like the Plutonian, they have been produced by causes acting from within, have not, like them, been fused by heat, but have been formed by either aqueous or gaseous emanations. The Plutonian, in fact, have been formed like lavas, the Geyserian like sublimed sulphur. Geyserian rocks are metalliferous, rarely feldspathic, are confusedly crystalline, concretionary, or cellular, and exhibit a very different aspect to that of the Plutonian. On the other hand, though sometimes conglomeratic or composed of transported materials, and formed under the influence of water, they are distinguished from the Neptunian by their want of stratification, by the metallic and mineral substances they contain, by the absence of organic remains, by a crystalline or concretionary structure, and especially by their mode of formation.

Such are the views of M. Dumont; and although, as he states, it may be sometimes difficult to draw the line of limitation between rocks of these various modes of formation, and the Geyserian may appear involved in, and subsidiary, sometimes to the Plutonian, sometimes to the Neptunian, it is certainly desirable that the geologist should feel and admit that igneous fusion alone, as supposed to be recognized in Plutonic rocks, or the ordinary action, whether mechanical or chemical, of water, as recognized in Neptunian rocks, cannot explain all the phenomena of rock formations and of mineral veins; whilst the term "*Geyserian*" sufficiently explains the nature of the other actions, M. Dumont considers to have shared in the production of the general effects observed.—(*Quarterly Journal of the Geological Society*, vol. ix., No. 35, p. 25.)

Causes of Phosphorescence.

It is well known that the waters of the sea, in some latitudes and under certain circumstances, are phosphorescent, producing a light more or less brilliant. This remarkable phenomenon has always attracted the attention of travellers, and various have been the explanations they have offered.

Ehrenberg sums up, in the following manner, the important results of his labours:—

1. The phosphorescence of the sea appears to be owing solely to organized beings.

2. A very great number of organic and inorganic bodies shine in the water and out of the water in different ways.

3. There is also a light from organized bodies, which is probably owing to vital action.

4. The active organic light shews itself frequently under the form of a simple flash, repeated from time to time, spontaneous or provoked. Often also it appears under the form of repeated sparks, following each other in quick successions, under the influence of the will, and very similar to electric sparks. Often, but not always, there is formed by this production of sparks, a mucilaginous humour, gelatinous or aqueous, which is diffused around in great abundance, and is evidently placed in a secondary or passive state of phosphorescence, which continues a long time without requiring any new influence from the organic being, and even lasts after that has been divided or destroyed.

A light which, to the naked eye, appears uniform and tranquil, shews itself scintillating under the microscope.

5. The viscous humour which envelopes and penetrates the ovaries, seems to be especially susceptible of acquiring this communicated light, which is constantly reinforced by friction, and reappears even when it seems to have ceased.

May not the light emitted by living fishes, by Actinias, and by many other animals covered with mucosity, be sometimes merely communicated.

6. The relations which exist between the production of light and the sexual functions are evident in the Coleoptera, although the connection of the small luminous sacs with the reproductive organs may remain concealed. With many marine hermaphrodite animals, phosphorescence appears to be a means of defence and protection analogous to those of another kind which exist in the *Brachinus crepitans*, the cuttle fish, the frog, or to the discharges of the torpedo. Whatever it may be, the air and the sea have their phosphorescence.

7. As yet it is only among the Annelids, and of them only in the Photocharis, that a peculiar phosphorescent organ has been discovered ; it is external, tufted, frequently giving out light, similar to a thick cirrus, shewing a largely cellular structure, and formed within of a mucilaginous substance. The expanded base of the marginal cirri in the Thaumantias (Acalephs) may be regarded as phosphorescent organs of an unusual kind. The ovaries are more probably luminous, passively, and in a secondary manner, although their minuteness and transparency have prevented our ascertaining whether the organs of phosphorescence are placed near them, as for instance in the *Polynöe* and *Pyrosomas*.

8. The production of light is evidently a vital act, very similar to the development of electricity; an act which, being completely individual, becomes more feeble, and ceases on too frequent repetition, which reappears after a short interval of repose, to the production of which, absolute integrity of the organism is not necessary, but which sometimes manifests direct connections only with the nervous system.

The memoir of Meyen is less extended, but it contains some important facts.* The author admits three kinds of phosphorescence ; 1. The phenomenon is owing to a mucosity diffused in water. In that case, the water seen in the day has a uniform tint of bluish-white. It is often observed in tropical parts, but rarely out on the open sea. This mode of phosphorescence may be produced artificially by washing or by crushing certain molluscs and acalephs either in sea-water or in fresh ; 2. Phosphorescence results from the presence of certain living animals, endowed with a luminous mucus. This continues even after the death of the animal ; it arises from a superficial oxydation of the mucous coating, and it can be reproduced after it seems extinct by passing the finger over the animal. The animals which owe their luminous property to a secretion are, according to the author, Infusoria, Rotifera, Biphoræ, Medusæ, Asteria, Cuttle fish, Sertulariæ, Pennatulæ, Planariæ, Crustacea, and Annelids : 3. The third cause of phosphorescence is in some animals from the presence of one or more special organs. Of this number are the Pyrosoma, and especially P. Atlantica, whose light of a greenish blue is very brilliant. Each individual carries behind its mouth a soft opaque substance of a reddish brown colour. This body is slightly conical, and under the microscope thirty or forty red points my be seen ; it is this substance which produces the light.—(*American Journal of Science and Arts,* vol. xv., No. 44, 2d Series, p. 202.

Dr Daubeny and Professor Bunsen of Heidelberg on Volcanoes.

Those who have taken the trouble of perusing my work on Volcanoes, and especially the second edition of it, published in 1848, will recollect, that in bringing forward that theory which may be regarded as a revival, or perhaps a development, of the original hypothesis of Sir Humphry Davy,

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* Beitræge zur Zoologie, von J. F. Meyen, fünfte Abhandlung. Ueber das Leuchten des Meeres. (Nov. Act. Nat. Ar., t. xvi., Suppl., 1834.)

my professed object principally was that of enlisting the services of chemists in an attempt to elucidate a series of phenomena, which, although essentially chemical, had been hitherto, in a great degree, abandoned to geologists.

Indeed, since the time when Gay-Lussac published his "Remarks on Vesuvius," and that at which Sir Humphry Davy paid a cursory visit to the same spot, no chemist of European reputation appears to have made volcanoes a subject of study, excepting Abich, to whom we owe the first lucid sketch of the chemical relations which volcanic and plutonic rocks bear to each other; and Professor Bischoff of Bonn, whose researches were, however, confined to extinct volcanoes, such as those of the Rhine and Eyfel.

Hence it is not to be wondered at, that the subject should be treated as though it were exclusively a mechanical problem, and theorized upon without any due appreciation of the interesting chemical phenomena which it presents to our notice.

It was this consideration more especially which led me, in my work on Volcanoes, to give a prominence to those points which appeared to have been unduly neglected by others; and to advocate with more zeal than I might otherwise perhaps have felt inclined to do, a theory which necessarily brought before us the nature of the gaseous, saline, and crystalline products which proceed from the internal focus of its action.

That this was my object, will appear from some remarks which I made fifteen years ago, in my "Report on Mineral and Thermal Waters," undertaken at the request of the British Association for the Advancement of Science, and published in their Transactions:

"We ought," I observed, "carefully to distinguish between that which appears to be a direct inference from observed fact, and what can at most advance no higher claim than that of being a plausible conjecture. The general occurrence of volcanoes in the neighbourhood of the sea, and the constant disengagement of aqueous vapour, and of sea-salt from their interior, are facts that establish in my mind a conviction that water finds its way to the seat of the aqueous operations, almost as complete, as if I were myself an eye-witness of another Phlegethon, discharging itself into the bowels of the earth, in every volcanic district, as in the solitary case of Cephalonia.

"Nor is the access of atmospheric air more questionable than that of water; so that the appearance of hydrogen united with sulphur, and of nitrogen either alone or combined with hydrogen at the mouth of the volcano, seems a direct proof that oxygen has been abstracted by some process or other from both.

"Having satisfied our minds with regard to the fact of internal oxidation, we naturally turn to consider what principles can have existed in the interior of the earth capable of abstracting oxygen from water, as well as from air; and this leads us to speculate on the basis of the earths and alkalies, as having been instrumental in causing it. But in ascribing the phenomena to the oxidation of these bodies, we ought not to lose sight of the Baconian maxim, that in every well-established theory, the cause assigned should be not only competent to explain the facts, but also *known to have a real existence*, which latter circumstance cannot, of course, be affirmed of the alkaline and earthy metalloids, as having a place in the interior of the earth."

I should not despair of being able to shew that such an hypothesis is still tenable; but it will be more profitable on the present occasion, as well as, I doubt not, more agreeable to my hearers, for me to point out the substantial additions which Professor Bunsen has supplied to our knowledge of this class of phenomena.

He has, in the first place, proved that the products of volcanic action—at least as they display themselves in that vast *focus* of internal energy which we observe in the island of Iceland—consist only of two kinds of material: either a trachytic rock, consisting of a trisilicate of alumina, conjoined with a similar compound of silica, with an alkali or alkaline earth; or else an augite rock, in which one atom, only, of silica, is combined with two atoms either of alumina, protoxide of iron, lime, magnesia, potass, or soda.

Bunsen has given a formula by which the proportion between these two constituents in any given rock may be readily computed; and hence concludes, that the products of volcanic action in Iceland, are derived from *two* independent *foci*.

But the most interesting part of his researches relates to the changes which have been wrought upon these materials by causes of subsequent operation.

Few of the friends I see around me are old enough to have witnessed the contests which for many years were waged with so much fury between the advocates of the igneous and aquous origin of basalt.

In this controversy much stress, I recollect, was laid by the Wernerians on the characters of trap tuff, which, it was contended, could by no means admit of being referred to the action of heat, whilst its passage into trap rocks rendered it difficult to ascribe to the one an origin which was denied to the other.

Now, Professor Bunsen has, in the first place, beautifully shewn that the species of tuff which prevails in Iceland, and which is also abundant in Sicily, as is implied by its name *Palagonite*, derived from the village of Palagonia, at the base of Etna, possesses such a chemical composition as identifies it with the pyroxenic rock of the neighbourhood.

He has also succeeded in explaining those differences in structure and in appearance, which, in spite of this correspondence in the nature of its constituents, stamp it as a distinct mineral; having traced such alterations to the operation, not indeed of water alone, but of an alkali or an alkaline earth, containing just so much water as to exist in the condition of a hydrate, formed in either case by the influence of a temperature equal to that of ignition.

The Professor states, that he has actually succeeded in converting basalt into palagonitic tuff, by mixing it in a state of fine powder with thirteen times its weight of slaked lime, or of potass.

Thus, the very alkali, which may have been sublimed from some internal *focus* of igneous action, might, if water were also present, have been instrumental in converting an ordinary pyroxenic rock into palagonite under the influence of heat.

Another difficulty which beset the Huttonian theory, arose from the existence of zeolites in the midst of rocks of supposed igneous formation, as the readiness with which these minerals part with their water, seemed inconsistent with the supposition of their originating at a high temperature.

This was got over by supposing such minerals to have been formed under a pressure sufficient to prevent the water from escaping, and hence the Vulcanists were in some cases driven to assume pressure where none could be shewn to have existed.

But Bunsen has relieved them from this embarrassment by demonstrating that zeolites may be generated by fusing lime and silica with an excess of caustic potass, without any pressure at all; and that by this method crystals may be produced at a red heat containing water, of which, however, the greater part is disengaged at a temperature not exceeding 228°, when the substance is detached from the crucible in which it had been formed.

Professor Bunsen has also, by a series of decisive experiments, removed all doubts as to the nature of the aëriform bodies which are disengaged from volcanoes, and has fully substantiated what my own observations, and those which I had collected from various other sources, led me to infer, namely, that inflammable gases, made up either wholly or in part of hydrogen, are amongst the most constant concomitants of volcanic action in all its various phases. Nitrogen also, often unaccompanied with oxygen, seems to be as common in the fumaroles of Iceland, as I have found it to be in the thermal springs of other volcanic regions.

And with respect to the origin of these gases, Bunsen most satisfactorily refutes the idea of his countryman Bischoff, who refers them to the spontaneous decomposition or dry distillation of organic matters, shewing that when this process takes place, nitrogen is invariably accompanied with marsh gas and other hydrocarbons which are never present in volcanoes.

He accordingly expresses his decided opinion that the objections which have been supposed to be fatal to the old volcanic theory of Davy, entirely lose their value after these results. "For if," he remarks, "in the spirit of this theory it is assumed that the lavas, and the phenomena of ignition accompanying them, result from an oxidation of alkaline and earthy metals, determined by a decomposition of water, it admits of being proved, that the quantity of the hydrogen evolved from volcanoes, bears a perfect relation to the magnitude of the streams of lava formed."

A single one of the vapour springs of Krisuvik yields, according to Bunsen's own calculations, about twelve cubic metres of hydrogen in twenty-four hours.

"Assuming, then, that the remaining innumerable springs, together with the large fumaroles occurring there, yield together a quantity only 100 times as great, which may safely be regarded as far less than the quantity of this gas which is actually evolved, we may, by means of this assumption and simple calculation, shew that the formation of lava, which would be equivalent to such an evolution of gas within the period which elapses between two great eruptions, is sufficient to produce immense streams of lava."

"Nor is it any longer possible to attach importance to the second of the principal objections which have been made to Davy's hypothesis, namely, that it is unusual to observe any sensible appearance of flames during great volcanic eruptions. For if, from the known composition of the first-mentioned fumarole gas, we estimate the temperature of its flame, we find it to be 305° 6′; consequently a temperature which is far below the point of ignition of hydrogen. These gases are, therefore, combustible only at a red heat, and even under the most favourable circumstances can only produce by such a combustion an increase of temperature amounting to 305° 6′, which in a red heat must necessarily altogether escape observation by the eye."

Satisfied with having obtained the weighty testimony of Professor Bunsen in favour of the facts which I had alleged in confirmation of the theory to which I had given my adhesion, I shall the less regard the opposition that exists between my views and his with respect to the source of the hydrogen evolved.

Professor Bunsen derives this gas from the process in which pyroxenic lava is converted into palagonite through the agency of the hydrates of the alkalies or alkaline earths, assisted by a high temperature, during which, as he has shewn, hydrogen is evolved; and he even shews that if sulphur in vapour be brought into contact with basalt at a high temperature, and afterwards steam be passed over the rock so treated, sulphurous acid is disengaged in the first instance by the union of the sulphur with the oxygen of the peroxide of iron, which metal forms, with another portion of the same body, sulphuret of iron; and that sulphuretted hydrogen will be emitted in the second instance, owing to the decomposition of water, and the union of its hydrogen with the sulphur of the pyrites, whilst its oxygen forms, with the metallic portion, magnetic oxide of iron.

Supposing the formation of palagonite to be going on at all times when sulphuretted hydrogen and pure hydrogen can be shewn to be concomitants of the volcanic action, and on a scale commensurate to the amount of gas generated, the explanation of Professor Bunsen will probably be accepted by chemists in general, in preference to that which refers it to the decomposition of water by alkaline and earthy metalloids, or their yet unoxidized sulphurets; but I cannot admit, as a valid objection to this latter hypothesis, the absence of carbonic oxide from volcanic exhalations, of which carbonic acid constitutes so large a proportion. No doubt the latter would, as Bunsen remarks, be partially converted into carbonic oxide by hydrogen at the high temperature which probably exists around the *focus* of the volcanic action; but I have always been accustomed to refer the carbonic acid given off by volcanoes to the diffusion of heat over contiguous limestone rocks, and not to processes going on at the point where the temperature was most intense.

Nor do I feel quite satisfied with the explanation offered by the Professor, of the presence of sal-ammoniac in the lava, which he refers to the vegetable matter existing in meadowland overflowed by the molten current. If such were the origin of the volatile alkali, we ought not to find it exhaled round the orifices of the crater, or from any of the fumaroles proceeding directly from the same internal *focus* of action.

It is not my purpose, however, especially on such an occasion as the present, to criticise the labours of this eminent chemist, or to dwell upon those points in which the results of my own humbler inquiries in the same field of research may clash with his. It is sufficient for me to have pointed out to you his memoirs on the subject of the Iceland Volcanoes, as an important present rendered by chemistry to the sister science of geology; and as a service, too, which those who turn away with indifference from researches of a more refined nature, lying strictly within the domain of pure chemistry, would be likely to accept as an undeniable evidence of the extensive utility of our pursuits.

It is, indeed, a fortunate circumstance, in more respects than one, when such happy applications of chemical principles to other departments of natural knowledge are carried out by those of our brethren who had before established their reputation amongst ourselves by researches which chemists, and chemists only, are capable of appreciating.

No geologist, at least, can feel that he has a right to impugn as visionary, conclusions which have been deduced by a philosopher, who had before attained the first rank amongst experimentalists by his profound and intricate investigations into the members of the Cacodyle series; just as for the same reason no candid mind can fail to pay deference to the suggestions of another of our foreign associates, on questions relating to physiology, agriculture, and the like; knowing that before that eminent philosopher had turned his attention to these subjects, he had already earned a great name amongst chemists, by the success with which he had grappled with the most difficult problems in organic chemistry; and by the flood of light which he had shed over a class of bodies before comparatively unattractive, owing to the obscurity which enveloped their real nature, and the absence of those connecting links, the discovery of which by himself, more than perhaps by any other single individual, has shewn that they constitute the parts of one harmonious and unbroken series.—(*Dr Daubeny's Anniversary Address to the Chemical Society of London.*)

On the Discovery and Analysis of a Medicinal Mineral Water at Helwân, near Cairo. (In a Letter to Professor JAMESON, from LEONARD HORNER, Esq., F.R.S.L. & E., and F.G.S.)

I have been for a considerable time in correspondence with the Honourable Charles Augustus Murray, H.M. Consul-General and Diplomatic Agent in Egypt,* on the subject of some geological researches instituted by me respecting the alluvial deposits in the Nile Valley which are now in progress. In the following letter, dated the 2d of May 1852, he announced to me his discovery of a mineral water, which he believed might prove of great value to the inhabitants of Cairo and the vicinity.

"Having heard from my friend, Dr Abbott of Cairo, that some Arabs had told him of the existence of mineral springs near the edge of the desert, on the east bank of the Nile, nearly opposite to Memphis, I crossed over thither to a village called Helwân, and having obtained a confirmation of the report from the Scheik of the village, I went out with him, accompanied by two men with spades. Not more than two miles from the village, in an easterly direction, and about one mile beyond the cultivable soil, we came to a small green oasis in the desert, betokening the presence of water. On approaching it, a strong sulphurous effluvium tainted the air, and at the upper edge of the little oasis, I came to the spring, bubbling up into a natural basin in the sand, about 5 feet long, 4 feet broad, and 3½ feet deep. Its temperature, at the time of my visit, was 90° Fahr., but the Arabs told me it was sometimes much warmer. Judging from the appearance and smell, I conceive that the principal mineral ingredients of the water must be sulphur and iron ; but there is a gray-blue film upon the surface, which leads me to imagine the possible presence of iodine.

"Filling a bottle which I had carefully cleaned, I proceeded in my search in a southerly direction, and found four more

* Mr Murray has recently been appointed our Minister Plenipotentiary to the Swiss Confederation.

springs, two of them saline, and two sulphureous; none of them, however, so abundant as the first. At one of the latter springs I filled a second bottle, and both of them I have sent to you by this steamer, in order that you may have them analysed. Bottle A is the central spring, B a spring to the south, the last but one, a mile and a half from A.

"About a mile north of A, I came to a small spring very much choked with sand, so much so, that in half-an-hour's work with our two spades, I could only get up a kind of black mud, of which I have sent you a specimen, in a third bottle C.

"Is it not marvellous that the existence of these mineral springs, not more than four hours ride from Cairo, should hitherto have been unknown, not only to the numerous scientific travellers who have visited Egypt, but also to the Egyptian government? Only two months ago, the viceroy sent an officer to inspect a mineral spring on the *eastern* shore of the Red Sea, with the view of establishing baths there. I anticipate the most beneficial results to invalids from the discovery of these springs, and I hope the report of your analysing chemist will confirm my anticipation."

On receiving this letter, I wrote to Mr Murray, requesting him to obtain some details of the geological structure of the country in the immediate vicinity of the springs. "I presume, I said, from the short distance they are from Cairo, that they must lie near the foot of a range of hills that are a continuation of the nummulite limestone of Gebel Mokattam, behind Cairo; and as that limestone contains gypsum, it is desirable to know whether that mineral is found near the springs, and also whether there exist any veins or nodules of sulphuret of iron, not an unfrequent accompaniment of that limestone." Mr Murray afterwards informed me, that he had requested M. Hekekyan Bey, the engineer in the service of the viceroy, who is conducting the geological researches for me above referred to, and whose field of operations is just opposite to the Helwân springs, to go to the spot and make out a detailed report of the nature of the soil, and collect specimens of the adjacent rocks; and he forwarded to me the report of M. Hekekyan Bey, from which I extract the following particulars:—

"The lowest strata of the Mokattam run parallel to the valley of the Nile as far as Massara. These lower strata are capped by layers of limestone, calcareous grit, and argillaceous sandstone containing iron, separated from each other by sands, marls, and bituminous shales, containing, all of them, sulphate of lime. Near Helwân, the argillaceous layers and softer limestones prevail. The summit-level of the desert between the Nile and the Red Sea is about thirty miles to the N.E. of Helwân. It frequently rains there in winter, and torrents precipitate themselves into the Nile by channels having beds of clay covered by sand. A large portion of the water may be detained in basins, natural and artificial, and from thence passing between the layers of impervious clays, through ferruginous and sulphurous shales and sands containing also crystallized gypsum, come out at Helwân, and at several other places above the Helwân springs on this side of the Mokattam, and at Aine el Moussa on the Red Sea, where there is a warm spring, similar in quality to that at Helwân. The elevation of the springs above the valley is about 40 feet. From the highest level of the Nile inundations, the ground rises very gently, and for the first mile is sand mixed with clay; this is succeeded by a zone of flat ground, covered at first with a slight crust of saline clay, the salt increasing in quantity towards the springs. The plain ends at the foot of a very slightly elevated plateau of loose dry shales and marls, running nearly horizontally from north to south. M. Hekekyan Bey adds,—'I think there is only one spring. The temperature of the water felt warm to our hands after an exposure of several hours to the burning rays of an Egyptian sun in the month of June. Sulphurous hydrogen gas rises from the limpid water of the spring. It is rather bitter to the taste, and there is something peculiarly unctuous to the touch in its deposits, which I may compare to the white of a raw egg. I perceived no thin plates on the water. The supply is considerable, for it is made to water about three or four acres of sedge, used for matting. I presume that the water of the springs, having filled up the line of hollows that serve as a reservoir for it, running over, oozes down in a westerly direction through a surface-layer of sand

and clay, which it is continually impregnating with salt under the evaporating influence of the sun. Mr Erben, who accompanied me, bathed in the spring, and experienced sensations of a slight prickly heat all over his body, which lasted about half a minute, and his hands retained the odour of violets for about ten minutes."

The analyses were kindly undertaken by my friend Dr Hofmann, Professor at the Royal College of Chemistry, who gave me the following results of his examination of the contents of the three bottles, and of a specimen of a rock sent along with them.

1. *The bottle marked "Southern Spring."* (B.)

Amount of fixed constituents in the gallon (70,000 grains), 352 grs.

Mineral Oxides.		*Mineral Acids.*	
Lime, Magnesia, Soda,	in large quantity.	Sulphuric acid, Carbonic acid,	in large quantity.
Iron, Alumina,	traces.	Hydrochloric acid—trace.	

The water contained free sulphuretted hydrogen.

The water was especially examined for iodine, but none was found. However, in order to decide this question in a positive manner, a much larger quantity of water would be required.

No definite statement can be made as to the mode in which the bases are combined with the acids, without a full quantitative analysis. From the fact, however, that the water, when boiled, furnished a deposit of carbonate of lime, it may be inferred that it probably contains the following salts :—

Carbonate of lime,
Carbonate of iron, } held in solution by free carbonic acid.
Sulphate of lime.
Sulphate of magnesia.
Sulphate of soda.
Chloride of sodium.
Sesquichloride of aluminum—traces.

2. *The bottle marked "Central Spring."* (A.)

Amount of fixed constituents in the gallon (mean of two experiments), 444 grains.

The constituents of this water were exactly the same as those in the other water. In addition, a small quantity of silicic acid was found. The water likewise contained free sulphuretted hydrogen. No iodine could be found in it.

In the case of the two waters, it was impossible to perform a quantitative analysis, owing to the small amount of water at my disposal.

3. *The bottle with Sand.* (C.)

This specimen chiefly consisted of common siliceous sand, mixed with a small quantity of sulphur, arising from the decomposition of the sulphuretted hydrogen by contact with the air, and lastly, of a very small quantity of sulphuret of iron, which, together with some finely divided coloured sand, imparts the dark colour to the water with which the sand is mixed.

4. *The Rock.*

This substance is soluble in hydrochloric acid, with evolution of carbonic acid. Only a very trifling proportion of silica is left behind. The solution contains chiefly lime and magnesia. The rock is therefore a dolomite limestone, in which, moreover, traces of sulphate of lime, together with common salt, are present.

A quantitative analysis of the sand and of the rock would not have afforded much interest.

A. W. Hofmann.

For the purpose of obtaining a quantitative analysis of the solid constituents of the water, I addressed a letter, in the absence of Mr Murray from Cairo, to Alfred S. Walne, Esq., Her Britannic Majesty's Consul at Cairo, requesting him to send me a concentrated solution, by the evaporation of a considerable quantity of the water. This he kindly undertook to do, but the medical officer of the viceroy, to whom the task was confided, unfortunately evaporated the water to dryness. Mr Walne, however, sent me the residuum of the evaporation of $6\frac{1}{4}$ lb. of the water, weighing $58\frac{1}{2}$ grammes. This I placed for analysis in the hands of Mr James S. Brazier, who had long worked under Dr Hofmann in the Royal College of Chemistry, and on whose skill and accuracy in such analyses

Dr Hofmann places great reliance. Mr Brazier is now assistant to the Professor of Chemistry in Marischal College, Aberdeen. The results of his examination are contained in the following letter :—

"ABERDEEN, *July* 25, 1853.

"DEAR SIR,—Inclosed are the results of my analysis of the residue of the Helwân mineral water. This I have just arranged according to its per-centage composition, and if this residue corresponds to the same water as that in which Dr Hofmann found 352 grains per gallon, the constituents of a gallon may be easily arrived at by multiplying by $3\frac{1}{2}$. I have not made this calculation, as another water appears to have yielded 444 grains.

"My analysis indicates much the same as was found by Dr Hofmann's qualitative analysis, only that I find a very considerable amount of hydrochloric acid.

"Hydrosulphuric acid must have been driven off by the evaporation, if in the free state, or converted into sulphuric acid. Iodine was specially looked for, but no traces of it could be found.

"100 parts were found to consist of the following constituents :—

Chlorine,	41·420
Sodium,	23·920
Magnesia,	3·393
Lime,	7·350
Sulphuric acid,	7·783
Carbonic acid,	2·420
Moisture,	12·423
Organic matter,	1·205
Silica,	0·600
Precipitate by ammonia, consisting of alumina and phosphates, with iron,	0·506

"These constituents may probably be arranged in the following manner :—

Chloride of sodium,	60·820
Chloride of magnesium,	6·050
Sulphate of magnesia,	2·536
Sulphate of lime,	10·360

Carbonate of lime, . .	5·500
Moisture (dried at 230° F.), .	12·423
Organic matter, . .	1·205
Silica, . . .	0·600
Alumina and iron in combination with sulphuric and carbonic acids and phosphates,	0·506
	100·000

"J. S. Brazier."

I was desirous that the quantity of sulphuretted hydrogen in the water should be measured, which could only be properly done on the spot, but I suppose it was an experiment difficult to get made in that country, especially at such a distance from Cairo.

An eminent physician in London has compared this last analysis, with reference to the probable medicinal virtues of the water, with the published analyses of seventeen of the principal mineral waters of Germany, by Berzelius, Struve, Schweitzer, Steinmann, Bauer, and Bischof, but cannot compare the Helwân springs with any one of these, in respect either of similarity of saline ingredients or of the proportions of those that co-exist. It may be described, he thinks, as a strong water, and is of opinion, from the small amount of purgative salts, that it is more likely to prove beneficial if used as a bath, than if taken internally.

The Transition from Animals to Plants.

It has been long asserted by Bory de St Vincent and others, that there exist in nature organized bodies which are animal at one period of their lives, and vegetable at another! This, if true, would for ever put an end to the possibility of distinguishing the two kingdoms when they shall each have arrived at their lowest forms. Its truth has, however, been denied. On the contrary, Kützing, in his recent magnificent work on Algæ, insists that it happens in his *Ulothrix zonata*. He asserts that in the cells of that plant there are found minute animalcules, with a red eye point, and a transparent mouth place; that they are not in fact distinguishable from Ehrenberg's *Microglena monadina;* these bodies, however, are animals only for a time. At least they grow into vegetable threads, the lowest joint of which still exhibits the red eye point. This phenomenon, which Kützing assures us he has ascertained beyond all possibility of doubt, puts an end to the question of whether animals and plants can be distinguished at the limits of their two kingdoms, and sufficiently accounts for the conflicting opinions that naturalists entertain as to the nature of many of the simpler forms of organization.

Such being the case, it is not worth attempting to decide whether the lowest forms of structure belong to the one kingdom or the other; it will be sufficient that they have been regarded as plants by many eminent naturalists.

It is in this microscopical cellular state of existence that the Animal kingdom ends and the Vegetable commences. It is from this point that the naturalist who would learn how to classify the kingdom of plants must take his departure. He perceives that those species which consist of cells either independent of each other (*Protococcus uredo*), or united into simple threads (*Conferva monilia*), are succeeded by others in which the threads collect into nets (*Hydrodictyon*), or plates (*Ulva*), or the cells into masses (*Laminaria agaricus*); peculiar organs make their appearance, and, at last, as the complication of structure increases, a leaf and stem unfold as distinctly limited organic parts. Kützing cut to pieces the marine animal called *Medusa aurita*, washed the pieces carefully in distilled water, put them into a bottle of distilled water, corked it close, and placed it in a window facing the east. The bits of Medusa soon decomposed, and emitted a very offensive odour, during which time no trace of infusoria was discoverable. After a few days, the putrid smell disappeared, and myriads of Monads came forth. Shortly after, the surface of the liquid swarmed with extremely small green points, which eventually covered the whole surface; similar points attached themselves to the sides of the bottle. Seen under a microscope, they appeared to be formed of numberless monads, united by a slimy mass, and, at last, after some weeks, the *Conferva fugacissima* of Lyngbye developed itself in perfection.

Late observations on the reproductive bodies of some Algæ shew that their motion is produced by vibratile cilia, exactly in the same way as in certain animals. But it is exceedingly difficult to imagine the transformation of one real species into another. The same species may assume a variety of forms, according to varying circumstances, and it is highly instructive to observe these changes; but that the same spore should, under different circumstances, be capable of producing beings of an almost entirely different nature, each capable of reproducing its species, is a matter which ought not to be admitted generally without the strictest proof.—(*Lindley*.)

A few Remarks on Currents in the Arctic Seas. By P. C. Sutherland, M.D.

The author states, that, during a voyage lately made in the Arctic seas, his attention was arrested by the power exerted by refrigeration and congelation, in separating from water any saline ingredients it may contain, and of thus causing disturbances in the mean density of the waters of the ocean, which, after being influenced by currents, can be overcome only by subsequent intermixture with water from other localities where the disturbance in the equilibrium is of an opposite character. He considers that evaporation, which is so active within the tropical and temperate zones, obviously renders the sea more dense by depressing its surface, and thus gives rise to the necessity for currents from the two poles of the earth, where deposition of vapour predominates to a considerable extent over evaporation. This he illustrates by referring to the constant current from the Atlantic into the Mediterranean, caused by the evaporation in this sea preponderating over the supply of fresh water. He then points out the necessity also of a current out of this sea, in order that its waters, by the constant influx of saline matters may not become a saturated solution of the salts of the ocean; and infers that counter currents into the polar seas must also exist to obviate the contrary tendency which the waters of these seas have to become fresh. He calls attention to the importance of ascertaining the differences that occur in many parts of the surface of the ocean in respect to its saline contents, that we may be enabled to determine to what extent the currents and counter-currents may be influenced by the comparative freshness of the iced water of the northern and southern regions, and the necessary saltness of the equatorial and other over-heated basins. On this point, with respect to the Arctic seas, he refers to observations by Dr Scoresby, Sir Edward Parry, and those recorded in tables appended to his paper, which have been extracted from the Meteorological Journal kept in the North Atlantic and Davis's Straits during the late voyage in the Isabel.

The author next refers to the remarkable difference occurring in the climate of the east and west sides of Davis's Straits, that of the latter being much the colder. In the absence of thermometric registers for the west, to compare with those on the east side, he points out how the appearance of the land, and development of plants and land animals on the two coasts, enable us to determine which has the warmer climate. Looking from the top of Baffin's Bay, which commands a good view of both shores, the east side at the sea-coast has many portions of land free from snow; whereas the opposite, by its snowy and icy covering, presents an appearance altogether uncongenial. On the former are found a tolerably abundant flora, hares, and deer; on the latter there scarce appears to be a spot to receive the roots of plants or the feet of these animals; and in the productions of the sea, both vegetable and animal, the same disproportion is met with. Upon the whole, he considers complete the analogy that exists between the North Atlantic and Davis's Straits, both with respect to the climate of their shores, and to their inhabitants of the animal and vegetable kingdoms. With reference to the question how this analogy is brought about, the author considers it difficult to decide whether the increase in the temperature of the water, and the consequent improvement of the climate, on the east side of the strait, arise from the disposition the ice has to leave the coast, by which means the water becomes exposed to the influence of the sun; or from currents of heated water from a more southern region. He further remarks that its density here cannot be restored, if once disturbed, without admixture with a large volume of water somewhat above the mean density.

Again referring to the observations of Sir Edward Parry and those recorded in the tables, the author remarks, that from these it will be seen that refrigeration has the effect of precipitating the salts of sea-water; and further, that it appears to him very probable that the temperature at which water begins to expand by the continued application of cold, is that at which saline and earthy matter begins to be precipitated in solutions of the density of sea-water.

From the immense depth to which icebergs extend in Davis's Straits, and also from their vast number, the author infers that the temperature of the water will be kept pretty uniformly the same throughout a considerable part of its depth, rarely exceeding + 32°, except at the surface, where the action of the sun comes into operation, in which case the water of greatest density from saline contents would always occupy the lowest position. In illustration of his views, he describes experiments on the freezing of sea-water of the density 1·025, in glass tubes; and from these he infers that, not only does congelation precipitate the saline matter in water, but refrigeration also, at temperatures from 40° down to 32°. With reference to the influence of the density of the sea-water on currents, he remarks, that after the warm season has fairly set in in the Arctic seas, nothing is more common than to observe the surface-water, in hollowed-out lanes or fissures of the land-ice, moving slowly towards the open water at the edge of the fixed ice; and this seaward motion is altogether independent of tidal motion or oceanic current, depending entirely upon the diminished density of the surface-water.

In conclusion, the author states that he does not know that we are yet in a position to demonstrate the actual existence of currents *into* the icy seas as well as *out* of them, but that the necessity for them is obvious. It is not necessary, he remarks, that these currents, as in other parts, should occupy the surface, and probably also the bottom of one of the sides of the basins whose waters require to be renewed, as the Gulf Stream occupies the east side of the North Atlantic. It is plain that the cold and hot waters of two regions can be exchanged by the latter passing underneath the former; and although the Arctic current from the Greenland Sea does not contain much ice to the southward of Cape Farewell, it is more than probable its chilly waters pass over a fork of the Gulf Stream, which ultimately sweeps along the shores of West Greenland.—(*Proceedings of the Royal Society of London.*)

Recent Researches of Professor Agassiz.

Prof. Agassiz has recently made a rapid tour from Charlestown, South Carolina, through Alabama, Mississippi, and Louisiana, thence up the Mississippi to St Louis, Chicago, and along by the great lakes to New York and Massachusetts. In a recent letter from him, addressed to J. D. Dana, dated Cambridge, 9th June, he mentions the following as some of of the results of his tour.

"I have been successful in collecting specimens, especially fishes, of which I have brought home not less than *sixty* new species, mostly from the great southern and western rivers. Some of these are particularly interesting. I would mention foremost a new genus, which I shall call *Chologaster*, very similar in general appearance to the blind fish of the Mammoth Cave, though provided with eyes; it has, like Amblyopsis, *the anal aperture* far advanced *under the throat,* but is *entirely deprived of ventral fins;* a very strange and unexpected combination of characters. I know but one species, *Ch. cornutus*, Ag. It is a small fish, scarcely three inches long, living in the ditches of the rice fields in South Carolina. I derive its specific name from the singular form of the snout, which has two hornlike projections above.

The family of Cyprinodonts has received the most numerous additions, and among them there are again new combinations of characters. Several years ago I noticed two species of new genus which I would call *Heterandria*, from the great difference observed between the two sexes, the males having the ventral fins near the pectorals in about the same position as in the *Thoracic* fishes, while the females have those fins in the middle of the belly as in the *Abdominals.* Of this genus I have observed several new species. They all live in dense shoals in shallow waters. Another type *Zygonectes*, presents no such sexual differences, and differs also in its habits. These fishes are constantly seen swimming on the top of the water *in pairs*, whence their name. I have found half a dozen new species of this genus.

You may remember the remarkable genus Mollinesia described by Lesueur from specimens obtained from Lake Ponchartrain and from Florida. If you do not, pray look for the figures in the Journal of the Acad. of Nat. Sci., vol. ii., to appreciate the facts here mentioned. From its structure and from the sexual differences observed among other Cyprinodonts, I have long entertained the opinion that this genus had been established upon the males of Pœcilia mutilineata also described by Lesueur (same Journal), and both are admitted as distinct in the great Natural History of Fishes by Cuvier and Valenciennes. Having found both together in all the Gulf states, I have watched them carefully, and in Mobile as well as in New Orleans, I have seen them day after day in copulation during the months of April and May; so that their specific identity is now an established fact. I have caught hundreds of them and found all the Pœcilias to be females and all the Mollinesias males; and what is further very interestiug, the females are viviparous. I have been able to trace their whole embyronic development in the body of the mother, in selecting specimens in different stages of gestation.

I do not remember whether I have already mentioned to you the existence in the United States of two families of fishes not before observed in our waters, one of the *Myxinoids*, with one species from Eastport in Maine, collected by W. Stimpson, the other the *Erythrinoids* of Valenciennes, or *Charaxini* without adipose fin of T. Müller, of which a new genus occurs in the fresh waters of our northern and middle as well as western states, with half a dozen species, some of which have been unfortunately described as Leuciscus, Fundulus, and Hydrargyra, with which genera they have no affinity, while other new ones have been discovered by Professor Baird and myself. I shall call this genus *Melanura*, from the singular black mark which all species shew upon the tail. But I would tire you were I to go on with my ichthyological remarks, even if I should limit myself to enumerating new genera, for I have many more of these.

I will close this long letter with one observation upon Crustacea, which may have a more immediate interest for you, if you have not yet noticed the fact yourself. On my return from Florida two years ago, I noticed among many specimens of Lupa dicantha, one in which the tail presented a triangular form intermediate between that of the male and that of the female. Unable to ascertain from a single specimen whether it was a mere variety, or perhaps an improperly developed female, I awaited another opportunity for a fuller investigation, which the market of Charlestown, S. C., afforded largely during the latter part of February last, when I ascertained that that form was at times as common in the market as either the males or the females, and upon careful anatomical examination, I satisfied myself farther, that these specimens *are entirely deprived of internal sexual organs*, though slight indications of the openings of the sexual organs entirely closed up by calcareous matter, clearly indicated that they are imperfectly developed females, a kind of neuters among crabs, the great number of which leads to the supposition that they are not without function in the general economy of these animals. The tail is soldered to the carapace, the last joints only at which the alimentary canal terminates being movable. At the same time males and females were dissected, and shewed the sexual organs in that fulness which precedes copulation. Looking afterwards for similar conditions in other species, I found in the collection of Professor L. Gibbes, specimens of Lupa cribraria, and of L. Sayi, with the same conformation of their tail. * * * *

I cannot help returning to my fishes to say, that I have now *twenty species* of Lepidosteus from the United States in my collection, a good foundation upon which to base a revision of the fossil fishes. I could not say how many other new things I have collected, for I have not yet unpacked half my packages.—(*American Journal of Science and Arts*, vol. xvi., No. 46.)

On the Palæohydrography and Orography of the Earth's Surface, or the probable position of Waters and Continents, as well as the probable Depths of Seas, and the absolute Heights of the Continents and their Mountain-Chains during the different geological periods. By M. Ami Boue'. Communicated by the Author.

The Palæohydrography is an old principle in geology, and is even still considered so by geographers and theoretical geologists who have not a correct knowledge of all the facts upon which this doctrine is founded. Water having covered the surface of the earth from the time that temperature permitted it, its abrading effects must have been in action during all periods of time. During each of these periods there were sea-shores, sea-cliffs, river-beds, and the like. Many of the sea water-marks have, in all probability, been destroyed by the length of these various operations, but here and there some still exist; and it now remains for the expert geologist to arrive at the date of the origin of each of these. We will then be able to draw general geognetic conclusions from such a mass of well-established facts. We have an able essay on this interesting subject by Mr Robert Chambers (*vid. Ancient Sea-Margins*, 1848). It is necessary to proceed in this inquiry from the most recent phenomena to the oldest, as I have already shewn in a memoir on the subject (*Proceedings of the Vienna Academy*, January 1850). From the water-marks of a fresh-water lake that is now empty, we come to those of interior seas, of Mediterraneans, and last of Oceans. From these, we proceed to the water-marks of Tertiary and Secondary seas, and combine these facts with those given by the theory of elevation and subsidence of the earth's surface. Palæontology is highly useful in this inquiry, for instance, in the determination of ancient deltas, the course of ancient rivers, and the depth of seas, as ascertained by lithophagi. Still geodesy, and a knowledge of the bottom of seas, are two things which would forward our views of these mighty changes. It would enable us to trace over the whole of the earth's surface, not only the abrading and upfilling action of water, but also the extent of subsidences, and of volcanic effects. At present we have only very small indications of these ; for instance, one seems warranted to admit to the west of Europe an old large continent or island,—not only till the middle Tertiary period, but probably to the old Alluvial time. The proofs of it are the state of destruction and steepness of the western shores, their islands, the submarine forests, the direction of sea currents, the elevation of neighbouring continents, the geographical distribution of certain plants and animals in the now isolated western parts of Europe.

To the east of North and South America old land seems also to have subsided in the sea, and some summits of the hills form now only islands. In the Pacific, Darwin shews us an extensive subsidence in quite an opposite direction, viz., from east to west, where now so many coral islands exist, or are in formation. Along Western America, on the contrary, is a deep sea, the bottom of which has a tendency to elevation. The greatness of this action is proved by the high chains along the sea-shores which run like the meridian. It is apparently the mightiest on the earth's surface, and it is probable that it gave rise also to the greatest subsidences in the Pacific. If we pass to Asia, we find between Hindostan and Australia, with its satellites, New Guinea, New Brittany, the Solomon's Isles, New Caledonia, the New Hebrides, and New Zealand, the best indications of considerable subsidences, namely, many islands or divided continents, steep shores, rugged cliffs, and volcanoes, as well as a very particular distribution of vegetable and animal life. During the same time, probably, subsidences took place around the Hindostan triangular peninsula, and especially to the south of it. The same may be said for the neighbourhood of South Africa and on both sides of it ; for we find to the east fragments of continents under the form of islands. In the Atlantic similar indications of older islands exist. At last at the poles great subsidences may have been produced by the force which tended to flatten these; the many Polar islands may also have been derived from it. But the Arctic lands possess a more powerful agent of change than the Antarctic; many large rivers flow into the Arctic, and produce every year great motions in the ice-fields; in the Antarctic, snow and ice alone exercise their powers, and the temperature is not so low as at the opposite pole, but the winter is eternal. The particular external form of the Austral Polar continent, with its two points and re-entering angles, have been adduced by Hombron as proofs of their ancient separation from the southern continents (*Compt. Ac. d. Sc., Paris,* 1844, v. 18, p. 2). When we arrive at the following interesting conclusions, we unite to the preceding great subsidences in the oceans, the greatest continental elevations, not only as chains but also as vaults of whole continents; and take besides as true, and probably founded on physico-magnetical laws, the well-known doctrine of M. Leblanc, that each direction of elevation cuts the preceding under a right angle, or at least under a very great one (*Bull. Soc. Geol. de Fr.*, 1840, v. 12, p. 140). Without going through all the elevation periods either of MM. Leblanc or Beaumont, we may remain satisfied with shewing that the active and extinct volcanoes of South-Eastern Asia, as well as those of Mexico, Guatemala, and Oregon, cut transversely the older chains of those countries. Elie de Beaumont remarked, besides, that the various elevations in America have changed invariably their positions from east to west; but quite the contrary happened in Asia and Europe, where this change took place from north to south (*Compt. R. Ac. d. Sc. Paris,* 1843, vol. 17, p. 415).

We have thrown some light on the nature of Polar countries, where ice and snow have nearly stopped every formation newer than the old coal formation, and have preserved us a picture of the state of land and water in that remote period. On the other hand, the great subsidences in the Atlantic to the west of Europe and Africa, are inclined from north to south, and seem to have taken place chiefly after the old alluvial period, at the same time that the central parts of Europe and Africa were raised into the E.W. direction. In Asia it would seem also that the great central elevation of this continent preceded the end of the alluvial time, and the direction of the eastern part of both Indian Peninsulas was changed to N.S.

The elevations and vault of the American meridian chains were later events than the motions in the Old World; but these phenomena were similar, in as far as regards the transverse crossing of the great E.W. subsidence of the Pacific.

We ought not to forget that in every see-saw motion there takes place a subsidence as well as an elevation, a principle which is well exemplified in the plastic form of the earth's surface.

When the heights of central Europe, Africa, and Asia, with some parts of the countries of the Mexican Gulf, were raised during the alluvial period, in an equatorial direction, some extensive parts of the low and flat countries of Northern Europe, Siberia, and even North America, were depressed in the same direction, and this gave rise to the erratic phenomena. Similar subsidences took place in that direction in the south of Europe, Africa, and Asia, for instance in the Mediterranean, the Gulf of Mexico, &c.

On the contrary, when the meridian chains of North America were elevated, those of Eastern America were depressed, especially in South America, where older islands disappeared entirely under the Atlantic. Again the contrary took place:—with the indications of elevation of the western coast of America, we see a part of Greenland, and of Arctic America subside. In the Old World the Siberian shores of the Icy Sea, as well as the bosom of the Baltic and Scandinavia, were elevated. All these see-saw-like motions took place in quite contrary directions. In the recent Tertiary period, we find some elevations in the meridian direction in the Old as well as in the New World, but these were preceded by equatorial subsidences. About the same time, facts shew, on the contrary, immense equatorial elevations in Central Europe and Asia. Let us go back to the secondary periods, and we find connected with Europe, Africa, Asia, and America, great oceans with islands, and we also find that these become more free the further we go back to the primitive times of the earth.

These oceans seem, according to the forms of the actual continents and to their geognosy, to have extended in an equatorial direction, exactly the contrary of our present oceans, which are in the meridian direction.

The islands and continents of those remote times extended, on the other hand, especially N.S., such as the partly-destroyed islands of Western Europe, Scandinavia, Arctic America, Eastern and Southern Asia, Southern Africa, the Eastern partly-destroyed America, the Western America, the Eastern New Holland.

If we go still further back in the primary period, we find many continents or islands which extend parallel to the equator, viz., around both the poles, between the tropics, and probably, also, in the warmer parts of the temperate zones, but the seas or the subsidences were then exactly in a contrary direction.

Under the great causes of changes of the earth's surface, we must next mention the dynamic motions, and also reckon the destruction produced by the eternal tendency of the water to turn round the middle of the earth as much as possible after the astronomical laws.

When we are forced to admit the mentioned cruciform alternation of the dynamic relations, *it is only what we would expect to find in a spheroidal body which has an igneous fluidity in the interior, a rigid surface partly covered* with water, and turning round itself. Every one admits that the centrifugal force in the course of time has given rise to a flattening of the poles, as well as to an elevation against the equator; but this change in the spheroid must have produced rents and subsidences in both equatorial and meridian-like directions. According to mathematical laws, the equatorial subsidences were contemporaneous with the elevations, but not with the meridian-like subsidences, because these appeared later, and owing to new elevated parts of the earth's surface, resulting from the subsidence of the rigid parts upon the molten mass, and these parts appear to have been so much forced from their former position between the new vaults, as to have preserved a compression upon them. Those meridian-like subsidences must have had a tendency to produce only in N.S. direction, long and oval basins, and not circular ones, in E.W. direction; which, on the contrary, was always the case between two equatorial elevations. The Mediterranean is an example of the last. Finally, we must add the fact which concords with the rotation of a body whose interior is igneous, viz., the arches or higher parts of the earth's body, formed in consequence of the centrifugal force, are parallel to each other, but no one of these goes entirely round the earth as a continued line. The Alps, Taurus, Himalaya, and the chains of Central Africa, are examples of this kind.

Is it not possible to estimate the value of the various elevations and subsidences on the earth's surface, at different periods of time?

It is possible,—but our knowledge in astronomy, physics, and geology is still too imperfect to allow of more than an approach to the answer.

Let us take the simplest case of an island composed of horizontal marine beds. We would measure the depth of the sea and the height of the highest mountain of the island, add these together, and then endeavour to ascertain whether the sea subsided, or the land elevated. As to the last conclusion there remains the question, Does the sea bottom still preserve its original height? This shews us the necessity of having a knowledge of the normal depth of all seas in the primitive time, so that, according to our knowledge of Bathography, and the whole quantity of water on the earth, we might then limit per maxima and minima the same value for the various periods. This done, we could then calculate each elevation.

Let us now take the case of an island of a roof-like form, where we shall have the elevation of the summit of the roof, we could also obtain the elevation of each isolated parts of its inclined phases.

If the island is long, with a steep inclination on one side, and a very slightly inclined plane on the other, as for instance, in the North American point, we can estimate the value of the low shore, when we know the elevation of the high and steep chain, but the sea should have on both sides the same depth, which is frequently not the case. The sea can be deep on one side, and shallow on the other, or deep or shallow on both. For this reason, the normal depth of the sea will always better suit for the calculations.

When a rigid part of the earth was elevated, vaults were produced, or in other words, elevations and subsidences, according to the principle of the see-saw motion. If the value of such an elevation above the level of the sea is found, it is easy to obtain that of the subsidences under water, because both values are determined by an equal angle around a fixed point. A country might have been subjected to a simple see-saw like motion, as England for instance, where one shore is high and hilly, and the other flat, with subsidences in the Northern sea.

The middle of an island can have been vaulted with a kind of double see-saw motion, of which the two elevated extremities represent the middle of the vault. The subsidences of both sides under the sea-level would equal the height of the vault above the sea-level.

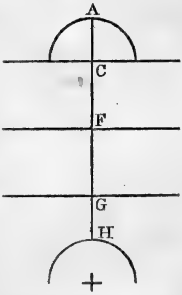
The variation in the position of the highest part of the elevation changes nothing in the results, the triangles which are to be constructed on both sides, above and below the sea-level, will only become more and more unequal the more the greatest elevation is placed further from the middle part of the observed land on one or other side.

If two triangles represent the vault above the sea-level, and their base be that level, and if we lengthen these lines on both sides of their relative value in the triangles, and if we do the same with the two lines which descend from the middle of the vault, till the sea-shore on both sides become, through this construction on each side under the sea, similar triangles with angles of equal value as the vault above the sea. This result remains the same whatever irregularity the vault

may have; but in the last case the values of the triangles and angles on both sides are unequal. In this way we arrive knowledge of the approximate places of the subsidences, which are never far from that of the elevations, because the value of the elevations known, the length of the lines between the sea-level and the highest point of the vault remains equal to the length of the lines of the subsidences in the triangles.

As many protuberances of the chains suffered diminutions, we should include them in our calculations; and should construct the triangle by tangents to the two arches of the vaults, and the lost summit would be restored approximately by this construction. This method seems also to give us a mean to determine in the interior of the earth the place where the elevation began, because the causes of it are lower.

It is only necessary to add to the height of the highest point of the elevated vault above the sea-level, the normal covering of the compact part of the earth under the normal depth of the sea, and then to lengthen these lines in its entire value in the interior of the earth. This way of proceeding is the same, whether the elevation be a primitive one, or may have taken place where others already were formed. The normal depth of sea being necessarily a value equal to the normal thickness of the last compact and rigid covering of the earth's surface, and, on the other hand, the elevated parts of the earth's surface having had their place in the interior of the earth before this motion, we have A C = G H, and C F = F G; or, in other words, the depth of the cause of elevation, + = 2 Ac + 2 C F. Now if Ac = 26,000 feet, as in the Himalayas, and C F = 2000 feet, we would already have for the depth + = 56,000 feet, which is not far from that to which calculations on the temperature of the earth have conducted M. Cordier; at least it will be so when we correct the now acknowledged errors in some facts on which Cordier's calculations rest, and also take into consideration the destruction of the summit of the chains.



In this way we should obtain an idea of the true site of volcanic action; or of the very unequal limits where there is in the earthy mass already complete rigidity on one side and igneous fluidity on the other. If, according to this, the depth of volcanic action is pretty great, still it is not so, as some people would conclude, from the extent of the vibrations of earthquakes. As that depth must be in extensive relation with our highest chains, and as the height of our highest hills even surpasses the value of their parts in the earth which lie below the sea-level, it is not at all certain that this may be everywhere the case. On the contrary, the wrinkles and low parts of the earth's surface, and the depth of the volcanic action, or the fluid focus, must have various values according to the different places of the earth. This also clears up the different scales of temperature which have been established for different places by the observations on the increase of heat according to the depth in the earth.

We find, next to elevated points, subsidences of equal value in the contrary way. Considering in this way the different elevations in different periods, we find that the greatest appeared latest. But it must be observed that the latest elevations must frequently have taken place upon already vaulted places, or even on those which have been more than once elevated. Besides the actually highest chains are those the least destroyed, and in uniting them with the first formed, may possibly not have been elevated more, or may have changed entirely their aspect by frequent subsequent elevations. If the latest elevations have produced the greatest protuberances, a similar complicated relation must have taken place for the subsidences. In the primitive time the sea was not so deep as now; this depth increased gradually till our times, when the hydrographic value equalled those got by the hypsometry of our highest hills.

Can we calculate the numeric value of the vaults of a country and its relative subsidences?

It becomes much more difficult to determine the subsidences which may be produced by the inversion of beds. If one had only one series of beds, elevated in a straight line, we should determine the angle of inclination, the thickness, and the extent of these, and perhaps arrive at the possibility of calculating the space left, as well as the space occupied. This simple case is more seldom than the others. Similar considerations may be applied to elevations of beds around a profound central point, a crater or a long rent. Yet, in most cases of elevation with upright standing beds, there are convolutions, divisions, various inclinations, fallings in, and later destructions; besides, one period of elevation may complicate itself frequently with another, and make the problem still more difficult to be resolved. We can only resolve these by an approximative calculation by maxima and minima. One can calculate nearly the surface of a chain with the value of the space of its valley, and then estimate the value of the space of the hills, and on the whole as a compact mass of certain geometrical form, as for instance as a triangular division with two truncatures at the ends. One would consider the whole as pushed out of the soil. One should also reckon what such a chain was once, and what it probably lost by subsequent destructions. In that way one sees the possibility at least of arriving at an approximate result for the value of subsidences produced by such elevations of chains.

Great elevations of the earth's crust have left subterranean vacuities, and their number increases with the height of chains. I do not believe that there now exists voids equal to our chains; that would destroy naturally all our calculations. If they do really exist, earthquakes would indicate them, from the sea-water entering into such spaces. These are not necessary to explain the extent of earthquakes, for they are in a great measure the extent of vibrations of all dense bodies.

To enlighten the solution of the former problem in question, we should put to ourselves the following question:—Is it possible to determine a normal depth of the sea during different times, in certain limits; and would it be quite impossible *to find out, if not the value of each individual elevation, at least the general value of all elevations in each period?* This question is rendered soluble by what has been already obtained by calculations upon the solution, the refrigeration and contraction of the earth, and by other facts given by geography and geology. If we had already only an approximative estimation of the value of each period of elevation, we could answer the question about the elevations and subsidences for each period in every country of the globe.

It is not now sufficient to trace the presence of the sea everywhere; but we must determine also *its depth.* If we knew how much, and in what quantity, a land or chain has been elevated or depressed, we could determine the depth of the sea-water by the height of the marine beds, which are still horizontal. But we should be very prudent in such determinations, and especially not to draw conclusions from individual countries. When the obtained halves are found applicable to the chief known parts of the earth, we can come to rational conclusions, for we can learn by comparison how much nearly a given country is elevated or subsided. And we can hope to arrive at the maxima and minima of elevations and subsidences in a given period of time, because many formations in the earth give at least a maximum of height and subsidence.

As I conceive the solution of the problem, it would be found if the two following facts are admitted as sufficiently proved:—

1*st*, What the globe always was; and if it has remained the same, nothing can be lost except the heat, which is of no value to us in this consideration. Yet many things have been changed on earth, for instance a part of the water has been turned into ice, and a greater quantity of fresh-water currents, and of subterranean water, have taken the place of the former much greater humidity in the atmosphere. Perhaps the salt formations may be in some relation with this difference between the quantity of fresh and salt water in the primitive times, and in later periods.

2*d*, The protuberances and low places of the earth's surface are in equal relations to the rigid and fluid parts of the globe; or, in other words, all the values of the heights of the earth are found to differ when related with cavities. The protuberances lessen the place of the fluid in the same measure as the corresponding cavities do make.

When the geographical value of the extent of land and water is known, it is possible then to determine by bathography and geodesy the extent of the waters of all seas, as well as that of the protuberances of our earth spheroid.

These numbers got, we could establish with them a normal medium for the thickness of the last covering of the rigid part of the globe, which forms especially now the continents and heights; in the meantime, one would deduce from the extent of the fluid, the medial height with which this water once surrounded the rigid part. On this base all the changes known would have followed, and we could estimate all the values of subsidences and elevations.

Afterwards one would determine exactly the geographical surface and space of the continents in each great geological period, to get the value of the place and space occupied during the same times by the water. To replace the surface of the land which probably was lost by subsidence in some geological periods, one should employ the probability of calculations which may be based on what remained from each period, on the mode of distribution of continents from the beginning till now. But an absolute necessity would always remain, viz., the knowledge of the greatness of each series of elevations in each period. To get this, it is only necessary to make the following reasoning. As we know now the mutual relation of the surface of the actual seas to that of land, as well as to what these were in the alluvial period, we can then conclude what surface the sea covered in the tertiary time; we must subtract from the value of the surface of land in the alluvial period, that which it had in the tertiary, and add this difference to the sum of the surface value of the sea in the old alluvial period.

But when two seas of the kind have not the same surface value, the smaller must replace the want of space by the greater depth. This necessity is the best proof that the seas have gained in depth from the oldest time till now, and that in exact proportion as the land became always greater and greater in extent. First there existed only islands, and for that reason a shallow sea; the more this extended, the deeper the sea became.

On the other hand, as the cavities of the earth's surface are in time in relation with their chains and protuberances, we ascertain by this *a mean to determine for each geological period the greatness at least of the median value of the elevations; not only for the general one as vaults, but also for the more particular as chains, and that through the median value not only of the greatest subsidences, but also through that of the deepest rents in the sea bottom.*

We can say the following:—When we find for a sea a certain medium of depth, which has a determined value of surface, and a determined quantity of water, what medium of depth will another sea have with another value of surface and quantity of water? When we have got this medium depth or medium value of subsidences, we can positively deduce from it the medium value of the elevations.

But the medial value and the place of the greater protuberances of the earth's surface are in constant relation with the height of the greatest chains and their places on the earth's surface; so that we have a mean to conclude something approximatively for the chains, which may possibly surpass the medium value of the elevations in each period. This is enough to shew how important are such determinations of orographical medium value, as they were traced by Humboldt, Strantz, Berghaus, and others.

Some may object that we shall never either know the true place of lands and seas, nor the greatest elevations and subsidences in the various geological periods, notwithstanding we may arrive at the knowledge of the medium value of the elevations and subsidences, as well as at that of the sea depth. Our physical and astronomical knowledge is truly not yet sufficient for it, but geology seems to give hope for the solution of the problem. I would, for instance, expect a natural result when one remembers that subsidences are always in the neighbourhood of the elevations, or *vice versa*, as in the see-saw; one would determine the rest by traces left of the one or other of these events. Secondly, one must employ Leblanc's doctrine of the constant opposition in the directions of two events of the kind, which follow one another, and apply this to all the events of the kind, from the actual state and place of the protuberances, chains, and cavities now existing, to those in the remotest times. A third important document is furnished by the palæontological geography. The countries where identical petrifactions lie in a formation, may be distributed in countries very distant from one another, yet they were covered by the same sea, or even one same channel of salt water, notwithstanding now large chains intervene between them. The certainty of such palæontological indications increases with the more recent age of the formations, and diminishes the more one considers an older formation. The following are some examples.

A great similarity is known between the miocene beds of Italy, of the Adriatic, of European Turkey, as well as of Austria and Switzerland. This proves the old free communication of the Miocene sea on both sides of the Alps, notwithstanding the differences of climate and the chains interspersed. In the Eocene period, the extent of the nummulitic beds indicates the free union of the basins of the Euphrates and Tigris with the Mediterranean and the old eocene sea round the Alps. On the contrary, the difference between the tertiary fossils in Chili and the Pampas (*Compt. R. Ac. d. Sc.*, Paris, 1843, v. 17, p. 392), shews that these two neighbouring countries, notwithstanding under the same latitude, were already separated in the tertiary period by a mighty dike composed mostly of trachytes; a circumstance which explains also the great mass of agates and of red argil amongst the inferior tertiary beds of the Pampas. In a similar way D'Archiac has been able to prove that the tertiary basin of northern France was hardly connected with Belgium and England, because at the place of the present British Channel there extended a chain in NES. direction; for that reason the shells of the red crag of Suffolk, and the crag of Belgium, are not those of the faluns of the middle of France (*Compt. R. Ac. d. Sc.*, Paris, 1845, v. xx., p. 314).

On the other hand, the differences in the chalk formation around the Mediterranean, and in the NW. of Europe, compel us to believe that in that period there was a great difference of climate as well as a separation of the two seas.

The comparison of the Jura in the Alps and Mediterranean countries with that in Central Europe, has often induced geologists to acknowledge in that time two seas of very different depth as well as very divided seas. Lastly, the peculiarities of the Muschelkalk in the German Alps, in Superior Italy, and in Superior Silesia, give proofs of the existence then of a sea channel where now the Alps partly raise their heads. (*Zeitsch. d. Deutsch Geol. Gesch.*, Berlin, 1849, vi. p. 246).

In taking another view of the subject, one finds still another mode of coming to conclusions. I mean, to make use of all that we know of the *various thickness of the formations, and the variation in the same formation, as well as of the absolute height they attain in different countries.* But on this our information is still very small.

I must remark, 1*st*, That the fresh-water formations, like the alluvial and Travertine deposits, are to be found at very different heights and in very different thickness; 2*d*, That the various heights of actual seas shew the former existence of a sea in the same way at different altitudes. Besides, we have proofs that seas were formerly much more numerous, and sometimes placed on levels one above the other. This gives an idea how a part of the water has found room in older times on the earth. The salt-water sea has been converted into fresh-water before it became empty, or after having become partly empty. If we had, for instance, the medium value of the depth of sea in the old alluvial period, we could say how deep that sea was in Northern Europe when the erratic phenomena took place, because the boulders indicated its height in the southern part of this basin, where they came upon the ice floating, and not by glaciers, as in Scandinavia.

On the other hand, one could fall into error if one would, from the results gained in this way, conclude about the depth and absolute height of the sea at the foot of the Alps during these times, or during the tertiary period, because probably a sea was there on a higher level than that of Northern Europe.

3*d*, *The difference in the thickness and absolute height of* *each formation furnishes us the means to know the depth of each sea upon its shores, as well as at a distance from them,* notwithstanding that certain places, or frequently the deepest, may have received no deposit at all; but it must not be forgotten to subtract always from the absolute height the possible value of the elevation to which the whole country or basin has been subjected. For that reason, we attain a much more certain conclusion upon the depth of the sea, when we measure the height of a formation only above that of the basin in which it lies. The bed must be then horizontal, and contain shells of which the animals were littoral, or lived in waters of a certain depth. If the rocks are, on the contrary, only alluvial, or conglomerates without fossils, then their height gives no certain indications for the depth of the sea, because the bottom of the basin may have been upraised.

4th, One should always attempt to determine by the fossils if a formation was littoral or formed in lagunes of salt water, or in a deep sea. Such being the case, the study of malcology and actinology, or, in other words, the study of the life of molluscs and zoophytes, becomes daily more important to geologists.

The Tertiary Sea appears to have been between 2000 and 3000 feet deep along its shores, but not more than 900 or 2000 in its channels and straits. The greatest heights of these formations have been produced by the elevation of their bottoms, or by the inversions of their beds. For example, they are in Switzerland 4000 feet, in Bolivia 16,000 feet and the like. These limits are confirmed by the heights of tertiary beds which have been deposited in Mediterranean Seas on a higher level than the ocean. The greatest absolute height of the bottom of these former interior seas varies from a few feet to 500 in Europe at least; but we still want information on this subject.

As the Tertiary beds were deposited in basins and on shores, and as such deposits did not occur in the deepest places, the Tertiary period must have had depths in their seas that reached from 3000 to 4000 feet.

The chalk formation consists of marine formations in deep water, and of a littoral one. The seas during that time must have been very similar to the tertiary period, having a depth of from 600 to 800 feet; but the chalk itself was deposited in water of a depth varying from 1200 or 1300 to 3000 feet.

The Jura Sea, or at least that part of it where the Jurassic beds were formed, was a sea of more than 3000 feet in depth. The littoral deposits of the seas were formed under a sea of 1300 or 1500 feet in depth,—the coral rag, similar shallow sea. In Western Europe we find for it the latter, a sea of nearly 800 feet deep, or even less.

The Trias formation shews by its thickness that its sea had a depth of at least 3000 feet, with occasional places more shallow.

The Zechstein and the red secondary sandstone were deposited upon shores in water less than 1000 feet deep. This is confirmed by coralline formations and plutonic eruptions.

In the primary periods the seas were deep and shallow; the deep about 2000 or 3000 feet in depth, the shallow indicated by the many coral deposits found in the formations.

In taking a general glance of the value of these depths in the various periods of time, we learn that the marine formation never covered the whole sea bottom. Besides the deposits on shores and in sea channels or straits, and from currents that now accumulate in our deeper seas, we have a great part of the sea bottom that remains now as formerly uncovered by aqueous deposits. It is difficult to calculate the present extent of plutonic eruption that takes place; but it appears that volcanic matters are accumulating now in deep seas, as must have been the case formerly. But this will seldom occur in the deepest places where the pressure is very great.

These values of the deep and deepest places can be established still for each period, if we admit that the scale of subsidences from the older times to the newer is an ascending one like that of elevations and vaultings. In this case we can use the height which some formations attain through elevation; by which events the exact time is given by the geognostical relations of position. The inclination or immersion of beds, and the repetition of elevation on the same spots, do not render this more difficult, because the same took place for the subsidences.

In the old *alluvial and recent tertiary* periods, the great Sea Depths and their middle depths were nearly those of our present seas, which we can prove especially by the height of volcanic mountains and chains. In the tertiary times the elevations of the chalk and eocene formations indicate sea depths of 8000, 9000, 10,000, to 24,000 feet, which was the case immediately after the chalk period. The middle sea depth of the ocean may have been then from 4000 to 5000 feet.

In the *chalk period*, the height of the elevated Jurassic beds indicates seas of from 6000 to 11,000 feet, and probably still more in depth when we consider the Himalaya. Their middle depth may have varied between 2000 and 3000 feet. In the Jura period the heights of the elevated Trias seem not favourable to the existence of sea depths of that greatness. The *middle depth* may probably have been 3500 feet, and the deepest places may have measured 5000 to 6000 feet.

In the *Trias period* the well-known elevations of old formations, as well as the great plutonic deposits, appear to indicate for the *deepest places of the seas* between 4000 and 5000 feet, and the *middle depth* may not be far from 2500 feet. The greatest known height of the Trias exists in Bolivia, where it is preserved still partly on both sides of the eastern Cordillera, and reaches sometimes, according to D'Orbigny, the height of 2000 feet (*Compt. R. Acad. d. Sc.*, Paris, 1843, v. 17, p. 388), a circumstance only to be explained by elevation.

Lastly, in *olden times* the sea may have had no deep places, and only a middle depth of from 2000 to 3000 feet; for all the high summits of older rocks are only the consequence of later elevations, but, on the contrary, all the rest of the oldest islands or continents do present themselves only as very low hills or even plains.

When we construct a table of the values of the probable depths of the sea at different times on its shores, as well as in the middle, we come to the following interesting results :—

1*st*, When the *deepest places* of the primary sea were about 2000 to 3000 feet, the middle value of the deepest places in the Trias and Jura periods was about 4000 feet; in the chalk 8000 feet; in the tertiary 16,000 feet, and in the older alluvial and actual periods 18,000 feet. This furnishes us with a kind of scale of value like that given by the subsidences in the seas during the alluvial period. I shewed (*Proceed. Vienna Acad.*, 1850–51) that this last scale, expressed by the numbers 5, 10, 20, 30, 40, and others, corresponds to the number of feet of the subsidences.

2*d*, The possibility and impossibility of animal life under certain depths of water, conduce to the belief that the seas and their shores must have had always the same depths as now. Molluscs and zoophytes live, the first to a depth of 600 feet, the latter to a depth of about 976 or even 1000 feet, but their most common habitation is of far less depth. For example, the ostrea lives only at the depth of from 40 to 60 feet. In looking over the value of sea depths at the time of deposition of the various formations, we find *for all times a depth of the sea on its shores only of* 100, 200, *to* 600 *feet in value.*

3*d*, *Between these shores and the deepest places of the sea.*—Our table shews that this sea depth was always more than 1000 feet, and from the time of Trias till later it may have measured already 3000 feet. In the meantime, in the chalk and more recent periods, other values of depth may have added themselves to the former, because deeper valleys at the bottom of the sea shew more extensive inclined planes. According to this, we find that the sea had depths in the Jura period of 4000 to 5000 feet; in the chalk period, depths of 4000 to 6000 or even 8000 feet; in the tertiary times, depths of 4000 to 20,000 feet; and in the actual period, depths of from 4000 to 24,000 feet.

4*th*, We arrive, lastly, at the final result, that the value of 1500 to 2000 feet expressed nearly the middle value of the depth of the sea at all times, and that this depth must have been about that of the sea, if not in the primary, in the oldest geological periods.

(To be continued.)

On Animal and Vegetable Fibre, as originally composed of Twin Spiral Filaments, in which every other structure has its origin: a Note, shewing the confirmation by Agardh, in 1852, *of Observations recorded in the Philosophical Transactions for* 1842. By MARTIN BARRY, M.D., F.R.S., F.R.S.E.* Communicated by the Author.

When, in a paper "On Fibre," in the *Philosophical Transactions* for 1842, I published drawings of the cells of cartilage and the cells of coagulating blood, the walls of which were represented as made up of fibre, it was said that I must have formed the fibre with chemical re-agents. My announcement at the same time, that this, as well as all other organic fibre, is originally composed of spiral filaments, numbering invariably two, was considered as denoting "contorted views, not worth a moment's disputation." And my conclusion, from what I had seen in large spirals, that the spirals of fibre, however small, contain the elements of future structures to be formed by division and subdivision, to which no limits can be assigned, was ridiculed as "moonshine," and "a myth." Even Hervey's announcement of the circulation of the blood can scarcely have been held in more absolute derision.

Before venturing to publish observations so opposed to existing views, I had of course extended my researches very widely; so widely, that the paper in which they were made known contains the enumeration of more than fifty distinct structures of the animal body in which I had found fibre still presenting the compound form in question, and upwards of 150 delineations of it, as seen in animals and plants, from the substance of the brain to the mould of cheese.

It was soon said and published: "Dr Barry might as well have entitled his paper 'On the Spiral Structure of the Organic World.'"† To such a title, though suggested in

* The substance of a Communication read before the Royal Society of London, March 17, 1853.

† Bowman, Cyclopædia of Anatomy and Physiology, p. 511.

derision, I have elsewhere stated that I had no objection. Indeed, so far from this, I have published my thanks for it to the proposer, as nothing could have been more descriptive of the results at which I had arrived.

I knew that nature had been faithfully represented in my drawings, unassisted by the imagination, and that I had published no more than a simple record of observations. It therefore could not be doubted that the day would come when others would see what I had seen.

That day has at length arrived. And it seems due to the Royal Society, in whose *Transactions* the paper in question was published, as well as to myself, that I should thus publicly state the observations just mentioned, so long ridiculed as "moonshine," and "a myth," to have been fully confirmed. In a paper, "*De cellula vegetabili fibrillis tenuissimis contexta* (*Lundæ*, 1852), it is shewn by Agardh, from researches in *Conferva Melagonium*, *Griffithsia equisetifolia*, and *Polysiphonia complanata*, not only that vegetable membrane is formed by fibre, but that the fibre forming vegetable membrane has the very structure that has been so much ridiculed in my drawings, being composed of spirals, which in number he delineates as *two*.* Farther, he delineates each of these two spirals as dividing into a spiral fasciculus, so that each fibre becomes converted into two fasciculi of spirals;† thus demonstrating the truth of what I had said ten years before, that the spirals of fibre, however small, contain the elements of future structures to be formed by division and subdivision, to which no limits can be assigned.

But my paper of 1842 contains a record of other observations made in a field beyond the region of Agardh's researches; observations which I think explain *how* it is that fibre forms the membrane of the cell, and what I deem of more importance still—the mode of origin of *fibre*. I must here refer to the drawings in that paper, from which, in connection with facts that I had previously recorded in the *Philo-*

* Agardh, *loc. cit.*, Tab. I., fig. 8.

† As in *Conferva Melagonium, loc. cit.*, Tab. I., fig. 8.

sophical Transactions, it appears—1. That fibre has its origin in the so-called "cytoblast," the outer part of which always passes into a ring or coil of fibre; 2. That when a cell is to arise, its primary membrane is formed out of this ring or coil of fibre; 3. That then the nucleolus of the "cytoblast" becomes the nucleus of the cell; 4. That the outer part of the nucleus of the cell also passes into a ring or coil of fibre, wherewith to form deposits such as the annular and spiral, or to weave the secondary membranes; 5. That the term "cytoblast" is unsuitable, as the body so called does not always become a cell; 6. That fibre is thus more universal as well as more primitive even than the cell, for fibre not only forms the cell, but it forms other structures without having first to form a cell; 7. That the prime mover in both the "cytoblast" and the nucleus is the *nucleolus*, which is the organ of absorption, assimilation, and secretion; 8. That the nucleolus is continually giving off its substance and continually renewing it, continually passing from the state of nucleolus into that of "cytoblast" or nucleus,—so that the "cytoblast" and the nucleus are each of them but the nucleolus enlarged; 9. That it is therefore the nucleolus enlarged that passes into fibre; 10. That the nucleolus always passes into fibre, and directly into no other form than that of fibre; 11. That thus the whole organism arises out of nucleoli, for fibre is but the nucleolus in another shape, and every structure arises out of fibre; 12. That the nucleolus is reproduced by self-division, and that subsequently, when it has passed into the form of fibre, the mode in which the nucleolus gives origin to other structures is such as to imply even here the continued reproduction of its own substance—that mode being self-division.

Primary Membrane of the Cell, its mode of Origin—Secondary Membranes of the Cell, their mode of Origin—Division of the Cell.

With the exception of some from cartilage, there are no drawings in my paper "On Fibre" of 1842 that contribute so largely towards the solution of these three questions, as those of the "cytoblast" and cells of coagulating blood.* That paper will be found to contain drawings which afford examples—1. Of the blood-disc or "cytoblast" giving origin to a ring or coil of fibre for the formation, in some instances, of the primary membrane of the blood-cell, into which primary membrane it is actually seen passing; 2. Of the nucleus of the blood-cell giving off fibre to form secondary membranes or other deposits; and 3. Of division of the cell. The following appears to be the process effecting these three changes.

The "cytoblast," so called, is at first an exceedingly minute particle of the substance which, from its appearance, I have been accustomed to term hyaline. It enlarges, and at the outer part becomes finely granular. (There occurs no deposition of granules *around* it, as many have imagined.) It is soon seen to be flat and *elliptical*. *At first it is never round*, a fact of which my drawings in the *Philosophical Transactions* for 1841 afford countless examples, though I believe I have never mentioned it before.† It becomes round, and is now in essentially the same state as a circulating mammiferous blood-disc (which also in all the Mammalia, as I long since shewed, is elliptical at the first). Its finely granular outer part corresponds to that which is red in these blood-discs. When destined to form a cell it becomes invested by a membrane. In order to the formation of this membrane, there occur the following changes:—The pellucid centre, called the nucleolus, gives off globules. These globules appropriate and assimilate the finely granular substance of the outer part of the "cytoblast" into which they were cast, and furnish the material out of which there is formed a ring or coil of fibre. This ring or coil of fibre passes into

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* In all vertebrated animals the *young* blood-corpuscle is a mere disc ("cytoblast"). In Mammalia it circulates in this form, while in the other Vertebrata it becomes and circulates as a nucleated cell. (This was stated in my paper "On Fibre," *loc. cit.*, 1842.)—The evolution of red colouring matter forms one of the most remarkable changes in coagulation of the blood, and of this coagulation the formation of fibre constitutes the leading part.—The arrangement of themselves by the mammiferous blood-discs in rolls like rolls of coin, seems to denote the tendency, not merely to *form* fibres, but to *arrange* them.

† Others have described it merely as "sometimes oval, and sometimes round."

membrane. The membrane thus formed, or rather forming, expands into the *primary* membrane of a cell, leaving the nucleolus of the "cytoblast" to become the nucleus of the cell.*

The nucleus of the cell, too, has its pellucid centre or nucleolus, performing an office just the same as that of the nucleolus in the "cytoblast." The nucleolus gives off globules. These globules appropriate and assimilate the finely granular substance of the outer part of the nucleus into which they were cast, and furnish the material out of which there is formed a ring or coil of fibre. I saw the nucleus of the cell actually *unwinding itself as fibre*; and the fibre thus given off I followed from the nucleus to the cell-wall, were it was either weaving the *secondary* membranes,† or forming other deposits.

Division of the cell is initiated by self-division of the nucleolus. The nucleus, which had been the nucleolus, is found divided into halves.‡ These two halves become two "cytoblasts," which undergo the same changes as the parent "cytoblast." They become in the outer part coils of fibre. These coils of fibre form the membranes of two young cells; and the walls of these two young cells where in contact with one another produce a septum, dividing the parent cell into two compartments; and thus explaining division of the cell.§

The much disputed questions in vegetable physiology of the mode of origin of secondary membranes, and division of the cell, would have found a solution long before, had physiologists paid due attention to the nucleus of the cell, first recommended to especial notice by our illustrious fellow-countryman, Robert Brown. One conclusion regarding the nucleus they certainly did arrive at, but this was not until after it had disappeared; and then they agreed in concluding

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* For illustrative drawings in my paper "On Fibre," see those of many blood-corpuscles; for instance fig. 5, and other figures in Plate V. Some figures of nervous substance in that paper also exhibit "cytoblasts," passing into coils of fibre.

† *Loc. cit.*, Plate X., Fig. 133, from cartilage of the ear.

‡ *Loc. cit.*, Plate X., Fig. 134, from a neighbouring cell of the same cartilage.

§ *Loc. cit.*, Plate XI., Fig. 150.

the nucleus to have been—" absorbed." Nothing, as I have shewn, could have been further from the truth. The nucleus had *exhausted itself* in the formation of fibre for secondary membranes (or other deposits) and division of the cell.

Thus there occurs no folding inwards of a "primordial utricle" for division of the cell, as maintained by Von Mohl; nor does there take place for this purpose a division of the *contents* of a parent cell into two parts, *around which contents* are formed the walls of two young cells, as supposed by Nägeli and Hofmeister.*

Annular, Spiral, and other Fibrous Deposits in the Vessels of Plants;—their mode of Origin.

Each of these I find to be originally a fibre of the twin spiral form in question. Their mode of origin is therefore almost implied by what has just been said regarding the nucleus of the cell. Thus, when the nucleus becomes a ring, the deposit is annular; when the nucleus becomes an incipient coil, many of these unite end to end to form a long one; which sometimes remains single, and sometimes divides and subdivides; and if the divisions of such deposits, whether annular or spiral, be not continued but partial and irregular, we have the reticular form as well as an explanation of the supposed tendency in vegetable fibre to anastomosis.

Importance of the Nucleolus.

The *nucleolus* is thus the essential part of both the "cytoblast" and nucleus. However inappreciable, it is never altogether wanting. This nucleolus it is which, where cells are reproducing cells, descends by fission from cell to cell. It is the organ of absorption, assimilation, and secretion; secreting, for instance, the red colouring matter of the blood in the outer part of the blood-disc. It is continually passing from the state of nucleolus into that of nucleus; continually giving

* "Principles of the Anatomy and Physiology of the Vegetable Cell." By Hugo von Mohl. Translated by Arthur Henfrey, F.R.S., pp. 50–57.

off its substance, and continually renewing it.* In the so-called cytoblast as well as in the nucleus of the cell, the nucleolus is the prime mover. It is more than the prime mover, for it passes into fibre. The "cytoblast" that forms a coil, and the nucleus that unwinds itself like a ball of twine, really represent the nucleolus enlarged. The nucleolus thus enlarged passes into fibre; and it passes into nothing else, it always passes into fibre. It is therefore not enough to say that the nucleolus is the prime mover. It is far more than this. The whole organism arises out of nucleoli. For fibre is but the nucleolus in another shape, and every structure arises out of fibre.

This reproduction of the nucleolus by *self-division*,—its continually giving off its substance, and continually renewing it,—and its passing into fibre, which by the *self-division* of its filaments forms the whole organism,—are facts which it was impossible to become aware of, without being reminded of another fact, made known by my "Researches in Embryology,"† that the point of fecundation in the ovum is also a nucleolus, which after fecundation is likewise, and continues to be, reproduced by *self-division*. For in this continued *self-division* of nucleoli endowed with the properties in question,—this descent, as it were, of properties from one nucleolus to another,—there is to be recognized a fact, I think, not undeserving of notice in connection with the subject of resemblance between the offspring and its parents.

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* This is an important point, essential to an understanding of the physiology of cells. When describing the "cytoblast" in a former paragraph as at first a minute particle, I stated that there occurred no deposition of granules around it, as many had imagined. They were right in supposing a smaller body to exist before the larger one, but wrong in imagining the larger body to arise from deposition of a substance *around* the smaller. Observers thought that their nucleolus in the "cytoblast" was identical with the previously existing smaller body. It is not so. The previously existing smaller body *absorbs* and assimilates new matter and *becomes* the "cytoblast." To some this difference may seem small. It is far otherwise, and essential to an understanding of the properties of the nucleolus. (See my "Researches in Embryology, third series; a Contribution to the Physiology of Cells," *Phil. Trans.* 1840.)

† *Phil. Trans.* 1840.

Fibre is thus more primitive even than the cell; for fibre forms the cell. It is more universal too; for fibre, which I have just stated to be but the nucleolus in another shape, does not always pass into the membrane of a cell,—it forms other structures without having first to form a cell.* Hence, in this communication, when speaking of the "cytoblast," I have frequently mentioned it as the "cytoblast" *so-called;* for the term is inappropriate,—this body does not always become a cell.

The two spiral filaments composing fibre, at first appeared to me to run in opposite directions, which I subsequently saw was not the case,—their direction is *the same.* This error I corrected in Müller's *Archiv* for 1853, in a paper On Muscle, which Professor Purkinje, Foreign Member of the Royal Society, translated into German, and communicated to that Journal, after I had convinced him of the twin spiral structure of the muscular fibril; an observation first announced in my paper "On Fibre," *Phil. Trans.* 1842. For I found the muscular fibril to have a structure exactly the same as that of other fibre, and to be distinguished from it mainly by permanently retaining the twin spiral structure as an attribute of its function,† and presenting stages of contraction

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* If all that we are in the habit of calling cells be entitled to the term, the difference in these respects, however, can be but small. For if the existence of the membrane of the cell implies the previous existence of fibre, it is equally certain that the existence of fibre implies the existence of the *elements* of cells; fibre being made up of these. (See an observation of mine recorded in my paper "On Fibre" of 1842, shewing large spirals in a certain state to be made up of cells; from which it follows that the spirals of fibre, however small, are composed of the elements of cells.) Yet in the order of formation fibre does to a certain extent, precede the cell. For fibre may be considered fully-formed, though composed of only the *elements* of cells; but the formation of the cell is not complete, until its membrane has arisen out of *fully-formed* fibre. Again, although the elements of the cell are not less general than fibre (fibre being composed of the elements of cells,) yet some structures are seen to consist almost entirely of fibre in which those elements have not formed cells.

† Like all other organic fibre, however, the muscular fibril shews a tendency to pass into membrane. In some instances this tendency is seen in muscle still endowed with contractile power, as in the Echinodermata, where the fibrils be-

and relaxation. That announcement of the spiral structure of muscle has, of course, had its full share of the derision in which the paper in question has been held.

Embryonic states of the Muscular Fibril mistaken by observers for the fully-formed Fibril.

In their endeavours to reach the *ultimate* structure of the muscular fibril, observers have actually gone too far, and reached the elements of a later generation. They passed over what really admits of examination—the mature fibril, and arrived at what almost defies the microscope—the embryo; mistaking and delineating for the fibril itself, a row of quadrilateral particles, the mere elements thereof; mistaking for the chain, as it were, a row of half-formed links destined to compose the chain. I cannot wonder that in a row of quadrilateral particles, no one could discern my twin spirals! These particles are known to be light and dark in alternate order. They give origin to the twin spirals. And for this purpose the dark particles undergo what observers have entirely overlooked,—division and subdivision, changes which I figured in Müller's *Archiv* for 1850,* as seen with a microscope of Plössl. And I have lately confirmed the observation when examining muscle with one of Smith and Beck's microscopes along with Professor Allen Thomson, to whom I refer, as having seen and delineated the divisions and subdivisions in question. As the quadrilateral bodies divide and subdivide, the resulting minute particles become so far dislocated, that they slide into positions for producing by their union the spiral form.

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come smooth flat threads, with only here and there a trace of the crenate edge derived from their originally twin spiral structure; though this twin spiral structure is distinct enough at earlier periods even here.

* Taf. XVII., Fig. 29, *c*, *f*, *d*.

On the Penetration of Spermatozoa into the Interior of the Ovum; a Note, shewing this to have been recorded as an Established Fact, in the Philosophical Transactions for 1843. By Martin Barry, M.D., F.R.S., F.R.S.E. (Read before the Royal Society of London, March 17, 1853.)

A paper on "*The Reproduction of Ascaris mystax*, by Henry Nelson, M.D.," published in the *Philosophical Transactions* for 1852, contains the following remark:—"Dr Martin Barry says, 'On one occasion, in an ovum of $5\frac{1}{4}$ hours, I saw in the orifice of the membrane' (the external membrane of the ovum) 'an object very much resembling a spermatozoon which had increased in size. . . . . I am not prepared to say that this was certainly a spermatozoon, but it seems proper to record the observation.'"

Dr Nelson then adds: "Now, whether we believe Dr Barry to have really seen the penetration of the spermatozoon into the mammiferous ovum, or whether we agree with Bischoff and most other distinguished authors, and deny the correctness of Dr Barry's observation, as well as the possibility of any such occurrence, the present investigations appear to be the first in which the fact of the penetration of spermatozoa into the ovum has been distinctly seen and clearly established, in one of the most highly organized of the Entozoa."*

When he made this statement, Dr Nelson was evidently not aware of what had been published on the subject. A reference to the *Philosophical Transactions* for 1843, Part I., p. 33, will shew him that my announcement in 1840, which he quotes, that I had seen "an object very much resembling a spermatozoon" entering the ovum of the rabbit, was followed three years afterwards by a communication to the Royal Society, entitled "*Spermatozoa observed within the Mammiferous Ovum*," and recording as an established fact, that I had met with ova of the same animal, containing a number of spermatozoa *in their interior*; a fact established not only by my own observations, but by those of others.

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* *Phil. Trans.*, 1852, p. 578.

For it will be found stated in that communication: "These ova were submitted to the inspection of Professor Owen, and I afterwards shewed one of them to Professors Sharpey and Grainger, all of whom agreed that the spermatozoa were *contained within the ovum.*" Dr Nelson will also find it recorded in a note added to that communication in the *Philosophical Transactions* for 1843, while it was passing through the press, that I had seen the same thing a second time; having met with several ova containing spermatozoa *in their interior* in another rabbit. An account of this second observation he will also find in the *Lancet* of April 8, 1843, p. 53. And the *Edinburgh New Philosophical Journal* for October 1843, contains a drawing (Plate V., fig. 1.) in which seven spermatozoa are represented *in the interior* of an ovum, besides the statement (p. 212), that in one instance I had counted more than twenty spermatozoa in a single ovum.*

Dr Nelson therefore was mistaken in supposing "the fact of the penetration of spermatozoa into the ovum" to have been first "distinctly seen and clearly established" by his own observations. He merely added a further confirmation in ova of an Entozoon, to what my researches on mammiferous ova had enabled me to record as an established fact nine years before.

Researches in Embryology: a Note supplementary to Papers published in the Philosophical Transactions for 1838, 1839, *and* 1840, *shewing the confirmation of the principal facts there recorded, and pointing out a correspondence between certain Structures connected with the Mammiferous Ovum and other Ova.* By MARTIN BARRY, M.D., F.R.S., F.R.S.E.†

Referring to his account of the process of fecundation of the mammalian ovum and the immediately succeeding phenomena, published in various papers in the *Philosophical Transactions*, the author calls attention to the confirmation

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* "On Fissiparous Generation," *Edin. New. Phil. Jour.*, Oct. 1843, p. 212.

† From the Proceedings of the Royal Society of London, 16th June 1853.

which his views have received from corresponding observations made by subsequent inquirers on the ova of other animals. He more particularly adverts to a recently published memoir by Dr Keber, in which that physiologist describes the penetration of the spermatozoon into the interior of the ovum in *Unio* and *Anodonta*, through an aperture formed by dehiscence of its coats, analogous to the micropyle in plants.

Small pellucid vesicles, lined with ciliated epithelium and inclosing a revolving mulberry-like object, such as the author discovered imbedded under the mucous membrane of the Rabbit's uterus, and described in the *Philosophical Transactions* for 1839, have been likewise observed by Keber, not only under the mucous membrane, but also and most frequently in some part of the cavity of the abdomen. Keber considers these bodies to be fecundated ova. The author agrees with Keber in considering them to be ova, but he does not suppose them to be fecundated, nor does he think that their membrane is the vitellary membrane (" zona pellucida"), which he believes to have been absorbed. He considers such ova to have been detached from the ovary along with their containing ovisac, which in their new situation constitutes the ciliated capsule ; and as they present themselves in unimpregnated animals, he now believes that the formation of a mulberry-like group of cells from the germinal spot, and the process of division and subdivision of the latter, take place without fecundation ; but when this happens, the mulberry is not found to contain one cell larger than the rest, the nucleus of which, according to his observations, is the embryo. He is further of opinion, that in all cases of separation of ova, the ovisac, or internal coat of the Graafian follicle, is detached from the ovary, either entire and along with the ovum, as in the instances alluded to, or after the ovum has first escaped by rupture, as in the instance of the fecundated ovum.

The author is led to the following conclusions with reference to the structures connected with the ovum in different animals :—1. That in the Mammalia, the vesicle he described as the foundation of the Graafian follicle, and termed the ovisac, *does not remain permanently in the ovary*, but is *ex-*

pelled and absorbed. 2. That in the Bird, the ovum, when escaping from the ovary, is accompanied by the corresponding vesicle—the ovisac; and that *the ovisac becomes the shell-membrane of the Bird's egg.* 3. That the expelled and lost ovisac in the Mammalia therefore corresponds to the shell-membrane in the Bird. 4. That after the formation of the ovum, the albuminous contents of the ovisac in the Mammalia correspond to the albumen in the Bird's egg. 5. That the author's retinacula in the Mammalia, after all, find their analogue in the chalazæ of the Bird; and that both have their origin in the granular contents of the ovisac, which at an early period are in appearance just the same in both. 6. That the shell-membrane of the Bird is thus a primary cell.

He then points out the position which, from his observations, is to be assigned to the several parts of the ovum in the language of "cells;" and shews the presence of a plurality of ova in a Graafian follicle to be referable to the same cause as that producing more than one yelk (ovum) in the Bird's egg.

On the Colour of Hair. By Dr ALLEN DALZELL. Communicated by the Author.

The colour of the hair, which, according to Griffith, was long attributed to pigment accumulated in the cells of the medulla, depends upon one or more of three causes. First, on pigment granules; second, on diffused colouring matter impregnating the entire tissue; and third, on the presence of air spaces within the fibres of the shaft. To these might be added the nuclei of the cells themselves, which, however, where pigment granules are present, are so surrounded by them, as to be scarcely, if at all, discernible. But where their isolation has been effected by boiling with moderately dilute caustic potash, they are shewn as dark bodies of an elongated form.

The colour of the hair corresponds in intensity to that of the iris; as, for example, auburn with blue, and black with the darker tints. Nor are these relations at all confined to the human species, although especially remarkable in the Albino, whose choroid is destitute of pigment, and hair either very pale or entirely white.

Many observers have described the granular pigment which forms the first class of colouring matter, as if it was situated in interspaces of the fibres. I have, however, assured myself of the fact that pigment is never lodged exteriorly in the cells, but always in some part of the interior, as may be plainly seen in the hairs of some *cervi*, where the entire cells are dry and empty, except of traces of colouring matter which adhere to their walls. Changes, during the growth of hair, often take place at regular intervals in the colour and amount of these deposits. This is seen in the hairs of many of the Quadrumana and Carnivora, to which classes it is, however, by no means confined.

In many hairs, the colour is uniform or diffused. Most animals have hairs of this kind; good examples may however be found in the short hairs from the face of the Hare, in the Tapir, and yellow Bear.

Air spaces in the shaft.—These cavities, from containing air, refract light beyond the field of the microscope, and thus, like the cells of the axis, give the idea of colour; these are best seen in white hairs. Some authors have described them as fat granules. This is inaccurate, for, on boiling with ether or turpentine, they become filled with the fluid; and even when treated in a menstruum, which does not dissolve fat, they lose their refractive properties, and retain only their general outline. They are empty cavities situated in the cells of the shaft, produced, as Kölliker supposes, by the absorption of its granular pigment; for they are not found in any hair originally colourless, but only in such as have become so from some cause affecting their vitality. I examined a hair with one extremity entirely white, the other unaltered—the former part I found filled with air cells, the latter pigment cells.

Changes in the Colour of Hair.

The change of colour in the hair is well seen in the common Alpine hare, and in many of the Mustella, in which the fur becomes white on the approach of winter. With age, also, its colour disappears, and very generally, though not always, with the loss of its pigment, the vigour of this appendage declines. The hair is frequently tinged by the absorption of materials introduced along with the food. The hairs of a rat taken from a ship with a cargo of logwood were examined, and they were found to be deeply coloured with the dye. The Chinese have long enjoyed the credit of being able to alter the colour of the hair by the administration of certain drugs, either from white to coloured, or from one colour to another. At this moment, I know a gentleman in Paris who has for some years been engaged in the investigation of this curious subject, which the following incidents will sufficiently illustrate.

At one of the meetings for 1839 of the Society Philomatic of Paris, the case of M. L'Abbé Imbert was detailed. He left for China in 1823, carrying with him a luxuriant crop of carroty locks. His friends in the celestial empire fearing, on that account, his detection as a foreigner, and his consequent expulsion from the country, shut him up on his arrival, and, by an internal course of constitutional treatment, speedily turned to black the hair on every part of his body.

At the same meeting, the case of the Abbé Voisin was related by M. Roulin. He had white hair on his arrival in China, but was subjected to a treatment consisting of internal remedies only, the result of which was, that it permanently became black.

Under no less creditable an attestation than that of Velpeau, we are informed that the hair of M. Rochoux changed from white to black; in this case, however, without the aid of any medicament, merely by the re-absorption of that colouring matter which had been temporarily destroyed. I had an opportunity last autumn of observing the effect of a chronic attack of jaundice upon a relative of my own, whose hair was white, but became distinctly coloured with the yellow colour of the bile. Bush mentions the hair from the tattooed chin of a New Zealand chief being coloured with the pigment introduced into the skin.

But the most singular instances of change in colour are those rapid, almost sudden processes, by which, in the course of a few hours, the colour of the hair is destroyed. Such phenomena become more wonderful when we remember that even the strongest acid scarcely, if at all, affects the pigment of the hair; that the caustic alkalies dissolve, but do not destroy it, and that none of the organic acids (so far as I am aware), not even the formic, causes it to disappear. A stronger evidence in favour of its independent vitality can scarcely be found; nor do I understand how such facts can be accounted for on any other hypothesis than that of a permeation of fluids among the fibres of the shaft. Vauquelin attributed its disappearance to an acrid secretion from the follicle; Henle to a molecular change in the elements of the hair itself. Grief, fear, and other emotions, are well known to alter the character of the secretions, and such mental conditions are also known to have been the proximate causes of these sudden changes in the hair. The hair of a lady, in my own family connection, from some distressing circumstances which deeply affected her, became gray in a single night. A medical man in London, less than twenty years ago, under the fear of bankruptcy, had his dark hair so changed in the same period, that his friends failed to recognise him; but the colour in this instance returned as his worldly prospects revived. M. Roulin states that a friend of his, terrified by the prospect of losing his fortune, had the hair on the side on which he reposed turned to gray in a single night.—(*From an Inaugural Dissertation on the General Integuments of Animals and their Appendages*, 1853. *This Dissertation gained the gold medal in the University of Edinburgh.*)

Some account of the Proteus anguinus. By J. C. Dalton Junior, M.D.

In the Austrian province of Carniola there are a large number of grottoes, the two most remarkable of which are in the immediate vicinity of Adelsberg, a small post-town about thirty-five miles inland from Trieste. The larger of these, which is the only one usually visited by travellers, and which is justly celebrated for the extent of its passages, and for the elegance and variety of its stalactites, has its entrance on the side of a hill, about fifteen minutes' walk from the village. It is called by the inhabitants the "Grotto of Adelsberg." A small stream flows into its mouth, but disappears after a short distance through one of the numerous chasms which open into the principal passage. The grotto penetrates the hill in a nearly horizontal direction, and can easily be followed for a distance of one or two miles. It has also been explored for nearly twice that distance, but the passage is difficult and dangerous, and its termination has never yet been reached. In the waters of this cavern there are found occasionally a few crabs and fishes, of the same species as those met with outside, and which have been carried in by the stream that enters at its mouth. There is, however, another grotto, situated about a mile farther from the town, called the "Magdalena Grotto," the waters of which contain the curious species of reptile known as the "Proteus anguinus." This is the only place in the vicinity of Adelsberg where the animals are met with; and though they exist also in other parts of Carniola, they are more abundant in the Magdalena Grotto than elsewhere.

Unlike the "Adelsberg Grotto," this cavern receives no stream at its mouth, and penetrates the hill in a steep downward direction, instead of horizontally. After descending for about fifteen minutes, by an exceedingly rough and irregular passage, partly rocky and partly covered with soft mud, the visitor comes to a pool of still water, varying from 12 to 18 feet in depth, according to the season, beyond which the cavern cannot be explored. It is in this pool that the Proteus is met with. The water apparently communicates with that of the Adelsberg Grotto; as it is always turbid when the latter is so, and *vice versa.* Both caverns are, of course, perfectly dark, and can be explored only with torches. The temperature, in the latter part of August, was about 40° to 50° Fahr., and probably does not vary much throughout the year. It is certain, at least, that in winter it is much higher in the interior of the grotto than outside.

The Proteus is taken in small hand nets by the peasants, who watch for the animal as he lies almost motionless near the bottom of the pool, and capture him by a sudden motion of the net. They are not very abundant, however, and as they can be taken only when the water is perfectly clear, it is seldom that more than fifteen or twenty are obtained during the course of a year. The animals should be kept afterwards in obscurity, and at a temperature as nearly as possible resembling that of the grotto. It is necessary, also, to change the water in which they are kept regularly every day. With these precautions it is said they may be preserved alive for an indefinite length of time. I have myself kept one of them for several weeks without giving it any food, and at the end of that time it was as active, and nearly as well conditioned as ever; only the branchiæ had become somewhat smaller. I am told by M. Fitzinger, the superintendent of the department of reptiles in the Vienna Zoological Museum, that they have been kept at the museum for over six years, without any other food than the organic matter usually existing in fresh water.

It is very commonly believed that the Proteus is found only in the Magdalena Grotto. This, however, is an error, as it appears, by a report of M. Fitzinger's to the Imperial Academy of Sciences, in October 1850, that there are no less than thirty-one different localities in which the animal is said to have been found since it was first discovered in 1751. M. Fitzinger himself has seen specimens from eleven different localties. Of these the Magdalena Grotto supplied much the greater number, viz., 312 out of 479. The reporter states that, in almost every instance, the animals coming from different grottoes, present such striking peculiarities in size, colour, and shape, that they cannot be considered as belonging to the same species. Accordingly, he rejects the old name of Proteus anguinus, and adopts instead the generic name "Hypochthon." In this genus he comprises seven different species, as follows:—

Hypochthon	Zoisii.	Hypochthon	Laurentii.
...	Schreibersii.	...	Xanthostictus.
...	Freyeri.	...	Carrarae.
...	Haidingeri.		

Six of these species are found in various grottoes of Carniola, and the seventh in Dalmatia. Two different species never exist together in the same locality, though sometimes the same species is found in more than one grotto. One of the principal marks of distinction is their size, the maximum length of the different species varying from $9\frac{1}{3}$ to $11\frac{4}{5}$ inches. The tint of the skin is in some species more rosy, in others yellowish; the head is also pear-shaped, triangular, or more globular in form. The eyes also are more distinctly visible in some species than in others, and vary somewhat as to their situation.

The body of the animal is cylindrical, like that of an eel, with its posterior portion compressed laterally into a kind of vertical membranous fin. There are four extremities, the anterior three-toed, the posterior two-toed. The posterior are considerably smaller and more feeble than the anterior. The first circumstance which strikes the notice of the observer is the almost entire absence of colour, and the transparency of the tissues, which allow the cutaneous and subcutaneous vessels, and even the veins and arteries of the extremities to be perceived without difficulty. The heart can be distinctly seen through the skin at the anterior part of the neck, beating 48 or 50 times per minute. The dark colour of the liver also shews through the integument very plainly on the under surface of the abdomen. The whole aspect of the animal reminds one very strongly of the fœtal condition of the higher vertebrata, particularly about the extremities, where the transparency of the integument shews to best advantage. Notwithstanding, however, its delicacy and apparent feebleness, its motions are occasionally very rapid and energetic. They consist of swift undulating movements of the eel-like body and tail. The limbs are nearly useless during rapid progression, and remain almost motionless, applied to the sides of the body. It is only in the slow motions of crawling and turning that the extremities are used, and then only in a feeble and imperfect manner. The gills, three in number on each side of the neck, are in the form of long tufts, each principal stem being divided into six or seven branches, and these again subdivided into fine twigs. When the Proteus is in rapid motion they become distended with blood, and of a bright scarlet colour, contrasting finely with the light yellowish indefinite hue of the rest of the body. In a state of rest, however, they are often perfectly pale, like any other part of the surface. The animal occasionally lifts its head above water, and takes in air by the mouth or nostrils, which after remaining some time in the lungs, is expelled through the bronchial fissures in the sides of the neck. Notwithstanding this frequent respiration of air, however, and the large size of the lungs, the pulmonary respiration is a very imperfect one, and altogether secondary to the bronchial. It is said that in a moist and cool place, as, *e.g.*, on the floor of the Magdalena Grotto, the Proteus can live many hours, carrying on its respiration by the lungs, and through the skin only; but in a warm apartment, it expires in a few minutes after being taken out of the water, particularly if the skin is wiped dry, as I have myself ascertained by trying the experiment. Over the whole surface of the skin, from the anterior part of the head nearly to the end of the tail, there are minute punctiform openings, the orifices of cutaneous follicles, which exude an abundance of transparent colourless mucus. The peritoneal cavity is also filled with a similar exudation.

There are but few peculiarities about the skeleton. The bodies of the vertebræ are articulated to each other by concave surfaces as in the fishes, instead of one of the articulating surfaces being concave and the other convex, as is the general rule among reptiles. The anterior extremities consist of a cartilaginous clavicle and scapula, fused into a single piece, a humerus, radius and ulna, three carpal pieces, and three digits, the two inner ones of which have three phalanges each, and the outer one, which is shorter, only two. The posterior extremities are supported by a simple pelvic ring, resting against the sides of the vertebral column. They are composed of a femur, tibia and fibula, a tarsus composed of three pieces, precisely similar to those of the carpus, and two digits of three phalanges each. All those parts are entirely cartilaginous, or so slightly ossified that it is difficult to be sure whether there is any true bony formation or not. The snout is rather broad and thick. The nostrils open on the under surface of the upper lip, as in *Lepidosiren paradoxa*. They are continued into a cylindrical membranous canal, something less than a third of an inch long, situated in the thickness of the lip. There is a long row of fine sharp conical teeth in both upper and lower jaw; and in the upper there is also a second much shorter row, in front of the first. The tongue is erroneously stated by R. Wagner (*Comp. Anat.*, Vertebrata) to be wanting. It is, on the contrary, very easily seen; about one-eighth of an inch long, but consisting only of mucous membrane and adipose tissue. The animal has the vertical stomach and short intestinal canal of the allied genera. The anus is a longitudinal slit, just behind the junction of the posterior extremities with the body. The liver is a long, lobulated organ, wrapped round the stomach and upper part of the intestinal canal, and extending nearly two-thirds the whole length of the abdominal cavity. The heart, inclosed in a pericardium, is composed of a single auricle and ventricle. The arterial trunk arising from the ventricle is partially converted into a double canal by an imperfect longitudinal partition. It sends off, on each side, three branchial arteries, and the returning branchial veins unite immediately below the situation of the heart, to form a single descending aorta. The lungs are simple, elongated, thin membranous sacs, secured by a fold of peritoneum against the posterior abdominal wall, and somewhat unsymmetrically developed. The left runs down, from its opening into the œsophagus, nearly three-quarters the whole length of the abdominal cavity; the right but little over one-half the length. The blood globules of this animal have been long known to be remarkable on account of their large size. They can be easily found almost unaltered in the bloodvessels, and particularly in those of the gills, even in specimens which have been kept for a long time in spirit. They are of a flattened oval shape, like those of the frog, with a central, white, granular, roundish nucleus, also somewhat flattened. The length of the globules varied, in the specimen examined, from ·0016 to ·0023 inch. The breadth is usually ·0013, and the thickness ·0003. As this last measurement is exactly the diameter of the human blood globule, some estimate may be made of the difference between them. The muscular fibres of the body are also very large, and very distinctly striated. Their diameter varies from ·0019 to ·0036 inch. The nerve-fibres were not remarkably large, those from the facial measuring only ·00027 inch in diameter.

The two most interesting peculiarities of the animal, taken in connection with its subterranean mode of life, are the colourless condition of its skin, and the imperfect development of its visual organs. At first, the eyes seem to be altogether wanting; but, on close examination, they may be discovered, in the recent state, as two minute blackish points, situated about the junction of the anterior and middle thirds of the head. When the animal has been preserved in spirits, it is sometimes impossible to distinguish them until the integuments have been removed. They are then found lying immediately beneath the skin, imbedded in a small quantity of adipose tissue. In an individual measuring $8\frac{7}{8}$ inches in length, the eye-ball was $\frac{1}{50}$th of an inch in diameter; and the optic nerve, just before joining the globe, $\frac{1}{362}$d of an inch. Notwithstanding its minute size, however, the eye is sufficiently well developed as to its structure. The sclerotic is covered with brownish spots, mostly hexagonal in shape, and which are more thickly crowded and deeper in shade just at the margin of the cornea, where they form a blackish ring. The crystalline lens is globular, and $\frac{1}{145}$th of an inch in diameter. There were some appearances of a nearly colourless iris lying behind the cornea, but the parts were so minute that I did not succeed in ascertaining its existence by dissection. The brain is pretty well developed, though less so than in other allied genera; and notwithstanding the imperfect condition of the eyes, the lobes which, in the brain of reptiles, are usually considered as representing the Tubercular Quadrigemina, are of very considerable size. The brain of the *Triton cristatus,* another naked amphibian, with large well-developed eyes, differs from that of the Proteus simply in being rather larger in comparison with the size of the animal, and in having a somewhat greater proportional development of the hemispherical lobes. The following are the longitudinal measurements of the brain of a *Triton cris-*

tatus 6⅓ inches long, and that of a *Proteus anguinus* 8⅞ inches long:

	Triton.	Proteus.
Hemispherical lobes,	5 millimetres.	4½ millimetres.
Tubercula Quadrigemina,	2½ ,,	2½ ,,
Cerebellum,	1½ ,,	1½ ,,

The two brains could hardly be distinguished from each other, except for the fact that the olfactory nerve in the Proteus runs forward for some distance as a trunk along the inner side of the membranous olfactory canal, while in the Triton it breaks up into branches immediately on leaving the anterior extremity of the brain.

It will be seen that the suppression of the visual organs in these animals is not by any means complete. There are, however, other creatures existing in the same localities with the Proteus, in which the eyes are altogether absent. Two species of Crustaceans are found in the caves of Carniola, viz., *Palæmon anophthalmus* and *Titanethes albus*, both of which are colourless, diminutive in size (not more than one inch long), and, so far as they have been examined, entirely destitute of eyes. They are supposed by some to be the natural food of the Proteus. I am informed by Mr Kollar, of the Vienna Zoological Museum, that a species of spider, entirely blind, has also been discovered in the same caverns.

There is much resemblance, in regard to the condition of the eyes, between the Proteus and *Lepidosiren paradoxa.* In the two specimens of Lepidosiren dissected by Prof. Bischoff, and described by him in a monograph on the subject, the eyes were "hardly a line in diameter," though one of the animals measured over three feet in length. The opening of the eyelids is wanting, also, in Lepidosiren as in Proteus, and the eyeball is completely covered by the integument. So little is known, however, of the mode of life of Lepidosiren, that it is impossible to determine whether the cause of the imperfection be the same in both animals.

Very little is yet known with regard to the mode of reproduction of the Proteus; and particularly it is altogether uncertain whether the animals are oviparous or viviparous. Dr Joseph Hyrtl, Professor of Anatomy at the University of Vienna, states that he has found, at the extremity of the oviduct in the Proteus, a gland which exists elsewhere only in the oviparous species of the naked Amphibia; so that the Proteus is probably also oviparous. But nothing more definite has been discovered. One German observer (Von Schreibers) endeavoured to ascertain this point by examining specimens of Proteus, taken from their caverns at every season of the year; but, according to Herr Fitzinger, he only succeeded in finding the ovaries unusually developed in a few instances. H. Fitzinger himself has met with the ovaries in a state of active development in only one instance; and up to the present time, according to him, neither ova nor embryos have ever yet been discovered in the oviducts.

The female generative organs consist of two elongated sacciform ovaries, situated at the posterior part of the abdomen, directly in front of the kidneys. In the specimen measuring $8\frac{7}{8}$ inches total length, in which the generative organs were in a state of quiescence, the right ovary was 0·98 of an inch long, the left somewhat smaller. The cavity of the organs was lined by a mucous membrane, beneath which was to be seen the whitish, globular, nearly transparent ova, varying in diameter from $\frac{1}{70}$th of an inch downward. The oviducts were a pair of slender and perfectly straight tubes, which, commencing by a wide aperture at some distance anterior to the ovaries, and running down on the outer and posterior aspect of those organs, opened into the cloaca, just above the orifices of the ureters.

In another specimen, however, obtained at the Vienna Museum, the organs were in a high state of development. The right ovary was 1·75 inches, the left 1·64 inches long; and they contained, together, 66 roundish opaque ova, of a deep yellow colour, and evidently just ready to be discharged. Their average size was a little less than $\frac{1}{7}$th of an inch in diameter. The oviducts were much larger than in the other specimen, and exceedingly contorted, so that they must have attained two or three times their ordinary length. None of the ova, however, had yet left the ovaries, so that nothing new could be learned with regard to the question of viviparity. —(*American Journal of Science and Art*, vol. xv., No. 45, 2d Series, p. 387.)

Researches on Granite. By A. DELESSE.*

[From the special study of the granitic rocks of the Vosges Mountains, the author has made some generalizations of great interest upon the relation of the proportion of silex, and of the nature of the mica, to the age of the mass and to its circumstances of crystallization, also upon the varieties of feldspar.]

There are in the Vosges at least two types of granite, distinguishable by their mineralogical constitution and geological position.

The first is the granite of the Ballons; it forms the summits and the central part of the ridge of the Vosges; its greatest development is between Sainte Marie aux Mines and Guebwiller; it contains quartz, orthose, feldspar of the sixth system, dark mica, and sometimes hornblende.

The quartz is hyaline, and of a gray colour; it is most abundant in the highly crystalline varieties; those varieties which are porphyritic and least crystalline contain little or no quartz, the greater part of the silica having remained in combination with a feldspathic paste.

The orthose is the preponderating mineral of this granite. It is white or reddish-yellow; both kinds, containing oxide of iron, turn red by alteration; it sometimes becomes greenish, and by decomposition passes into a halloysite. The orthose is the most persistent mineral of this granite; its crystals sometimes attain a decimeter in length: the analysis of three specimens from different localities gave the following result:—

	SiO^3.	Al^2O^3.	Fe^2O^3.	CaO.	MgO.	NaO.	KO.	HO.	Sum.
I.	64·91	19·16	traces	0·78	0·65	2·49	11·07	0·30	= 96·36
II.	64·66	19·58	traces	0·70	15·18			0·58	=100·00
III.	64·00	20·55		0·68	13·49			1·28	=100.00

The proportions given in this table differ but slightly from each other or from previous determinations; orthose is then

* From the *Annales des Mines*, vol. iii. p. 369.

a mineral whose composition is very constant, and independent of that of the rock in which it is produced.

The granite of the Ballons contains also a feldspar of the sixth system ; its colour on a fresh fracture is greenish ; it is translucent, and has a greasy lustre ; its crystals shew parallel striæ, which characterize the isomorphous feldspars of the sixth system ; it becomes red by atmospheric alteration, afterwards white, and the mineral passes into kaoline. The analysis of it gave the following composition :—

			Oxygen.	Ratio.
Silica	58·55	...	30·422	8
Alumina	25·26	11·807	11·899	3
Oxide of iron	0·30	0·092		
Oxide of manganese	trace			
Lime	5·03	1·412	3·832	1
Magnesia	1·30	0·517		
Soda	6·44	1·648		
Potash	1·50	0·255		
Loss by burning	0·91			
Sum	99·29			

It contains less of silica and of alkalies, with more of lime, than oligoclase ; moreover, its atomic proportions of oxygen are very nearly that of andesite. This strengthens a remark I have made before, that all the feldspars of the sixth system are isomorphous, and that their proportions of silica may vary indefinitely between that of albite and that of anorthite. This feldspar of the sixth system occurs in the most crystalline granite, and appears also to be especially associated with hornblende.

The granite of the Ballons contains but one mica, of a dark colour, with sometimes a greenish shade. In the polariscope of Amici it shews two optic axes, forming a very small angle. Its dominant bases are magnesia and iron : it is affected by hydrochloric and sulphuric acids.

The *accidental minerals* of this granite are hornblende, sphene, zircon.

It is very little broken or veined. The mean composition of some of its varieties are—

	SiO^3.	$Al^2 O^3$.	$Fe^2 O^3$.	CaO.	Ko,NaO, MgO.	Loss by burning	Sum.
I.	70·8	15·3		0·5	12·4	1·0	100
II.	68·5	...*		1·3	...	0·9	...
III.	67·3	16·1	1·9	0·6	13·3	0·8	100
IV.	64·8	20·0		1·1	12·7	1·4	100
V.	64·8	21·1		0·7	...	...	...
VI.	63·3	20·2		1·8	11·8	2·9	100
VII.	63·8	18·7		2·3	13·8	1·4	100

The loss of silica is replaced by alumina and lime. These variations depend very much (as I have proved elsewhere, *Bull. de la Soc. Géol.*, 2d Sér., vol. ix., p. 464) upon the position in the mass, the more central and elevated being the more siliceous, and upon the nature of the rocks in junction.

The second type of granite is the *granite of the Vosges.* I group under this name the varieties which have been called common granite, leptynite, and gneiss.

Its *essential minerals* are quartz, orthose, feldspar of the sixth system, two micas—a dark and a bright.

The quartz is in grayish-white grains. The orthose is the preponderating mineral; it occurs in minute lamellæ or grains, the analysis of which gave—

Silica,	66·08
Alumina and traces of peroxide of iron,	18·70
Oxide of manganese,	trace.
Lime,	0·93
Magnesia,	0·45
Soda,	3·77
Potash,	9·11
Sum,	99·04

The large amount of silica is no doubt due to quartz mechanically mixed.

Orthose and *quartz* are found in the most degraded varieties of this granite.

* The dots indicate that the quantitative determination was not made.

The feldspar of the sixth system is rare, and only found in the most crystalline varieties.

The granite of the Vosges, although its grain is fine and its mineral generally smaller than those of the porphyritic granite, contains no feldspathic paste. Its essential character is to contain two micas, the one dark, the other bright. The first is identical with the mica of the Ballons. The second is silver-white or violet-gray; its dominant base is potash; it resists the action of sulphuric and hydrochloric acids, and is altogether the same as that I have described before as occurring in the veins of pegmatite (*Ann. des Mines*, 4th ser., vol. xvi., p. 100). The clear is less abundant than the dark mica, and is less uniformly disseminated.

The *accidental minerals* are garnet, pinite, and, in the schistose varieties, hornblende, graphite, fibrolite. Some minerals of subsequent origin are common to the two granites, as chlorite, carbonate, and oxides of iron, heavy spar, fluor-spar, &c.

The granite of the Vosges is very much fissured and cut up by veins and lodes. Its density is about that of quartz, and is less than that of the granite of the Ballons. Its average composition may be computed from the accompanying table: for each analysis a large mass of the stone was reduced to powder, and the assay taken from this.

	SiO^3.	Al^2O^3.	Fe^2O^3.	MnO.	CaO.	Mgo.	KO.	NaO.	Loss by burning.	Sum.
I.	76·3	12·8	1·5		0·8	trace	...*	...	...	
II.	75·4	12·7			0·6	...	...	...	...	
III.	73·8	15·8		trace	0·9	0·9	7·8		0·80	100·00
IV.	73·3	10·4	1·6		0·7	...	...	...	...	
V.	72·0	15·33	0·4	trace	0·98	0·60	7·70	2·00	0·40	99·50
VI.	70·4	16·6			0·6	...	...	...	...	
VII.	70·0	17·3			0·6	...	...	...	...	
VIII.	67·3	16·2			1·9	0·6	...	...	...	
IX.	66·7	...	1·8		0·9	...	...	...	...	

* The dots shew that the quantitative determination was not made.

The phenomena of the rock veins in the masses of granite are rather complicated.

These veins appear generally to have formed at the time of crystallization of the granite; their great richness in quartz favours this opinion, it being the last mineral of the rock to remain in a fluid state.

The granite of the Vosges forms smaller eminences around the bosses of the Ballons, and is itself covered by stratified rocks, into which it graduates by insensible degrees. The granite of the Ballons has evidently penetrated with violence into the granite of the Vosges; this is well seen at Mehachamp. In some places the junction of the two is not discoverable.

Of these rocks, then, that containing the smaller proportion of silica and the greater of alumina is the more recent.

The distinction of two granites in the chain of the Vosges is not of mere local interest; the remark may be extended to most granitic regions, of which I will only mention the right bank of the Rhine, Normandy, Brittany, Auvergne, Ireland, &c.

The general application of the above observations shews that the same geological phenomena are reproduced after long intervals of time and in widely separated districts. It is not then surprising that we should find in most granitic regions two granites: the one *porphyritic*, and containing but *one* mica; the other *granular* (grenu), and containing *two* micas; the former being the more recent, and generally poorer in silica.

On the Paragenetic Relations of Minerals.

(Continued from vol. lv., page 106.)

(A.) *Congeneration Lodes* are those which bear only the same kind of minerals as constitute the adjoining rock. The most remarkable are those of granite, and some quartz veins in mica and clay slates. It is very probable that such lodes or veins do not differ much in date from the rocks which they traverse. They do not possess any great importance.

(B.) *Lodes or Veins formed by Lateral Secretion.*—The substances constituting the minerals contained in these lodes have been introduced into the fissures from the adjoining rock.

Lodes which traverse different kinds of rocks are of different compositions in the parts adjoining those rocks. At the Neue Hoffrung Gottes mine, near Freiberg, the lodes are richer in ore where they traverse a very quartzy clay-slate much impregnated with carbon, while in mica-slate they are poorer in ore. At Konigsberg (Sweden) the largest quantity of metallic silver is found in the lodes where they intersect the so-called "Fallbänder" beds, impregnated with argentiferous pyrites. In the adjoining rock, close to the lodes, the silver has been found imbedded, in the form of rhombic dodecahedrons. This form has probably been derived from the deposition of the silver in cavities, from which garnets have been removed by decomposition.

Professor Breithaupt states, that it is a general opinion among experienced miners, and supported by his own observation, that lodes are generally richer in ore where the adjoining rock is more or less decomposed. The nature and state of the adjoining rock are two of the most significant among the conditions of richness of lodes. There are undoubtedly many other circumstances of a similar kind, which are, however, known only in mining districts.

It is difficult to perceive in what manner this secretive formation of minerals can have taken place, except as the result of decomposition in the rocks. It is possible, and indeed probable, that in some instances this secretive formation has been preceded by an impregnation of the rocks with mineral substances erupted or sublimed through the yet vacant fissures.

Some few rocks, especially granite, contain imbedded tin ore. The topaz rock and porphyry of Saxony both contain tin ore, as perhaps do some kinds of gneiss and mica-slate. The tin ore occurs in the rock in such extremely minute particles, as to be imperceptible to the eye. It is frequently found as a strong impregnation of the rock contiguous to lodes which are quite filled, and into which it would appear to have been segregated until the fissures were incapable of receiving any more. This phenomenon is remarkably distinct in the "bandzwittern," at Altenberg (Saxony). The pseudomorphous tin ore, after feldspar, from Cornwall, appears to be of interest in connection with this fact.

Granite ought to be more generally examined for tin ore; for not only is it probable that many granites contain enough of the finely-disseminated ore to be worked advantageously, but likewise this circumstance may serve as a clue to the discovery of lodes. Moreover, the presence of beryl, topaz, wolframite, &c., should not be overlooked, as these minerals are frequent associates of tin ore.

Professor Breithaupt is inclined to doubt the existence of beds of tin ore. The deposits of this ore in the granite of Zinnwald, which have been regarded as beds, certainly present some such appearance. But those which make but a very small angle with the horizon are intersected by a true lode, possessing in every respect similar characters. The loose fragments and the masses of fractured quartz crystals, cemented together by subsequently-formed quartz found in these deposits, render it probable that they are true lodes, which, together with the rocks, have suffered such an alteration of position as to become more or less horizontal.

It has already been stated, that many minerals occur, both imbedded in rocks and upon lodes, and they perhaps furnish the strongest evidence of lateral secretion.

The extraction of certain constituents of the lode minerals from the adjoining rocks would appear to have been more easy in schistose and stratified rocks, on account of their structure, than in the massive rocks,—granite, syenite, porphyry, &c. It is perhaps for this reason that lodes are more frequent and richer in such rocks. Tin lodes are more frequent in the schistose than in the massive rocks. Both granite and the older gneiss have probably originated from the same primitive mass, but no disseminated tin ore has ever been found in either mica or clay slates, although it may have been present in those instances where it occurs in lodes in these rocks. Lodes which do not bear tin ore are still more rare in massive rocks. However, it must not be inferred from this that all tin ore has been formed by lateral secretion. There are, indeed, circumstances which render it probable that it has been introduced into the fissures from below. And again there is no reason for assuming that tin is not one of those elements which may have remained at a considerable depth below the surface during the formation of the earlier rocks.

(C.) *Lodes formed by Eruption.*—Three different modes of eruption must be admitted in any general theory of these lodes: 1. The eruption of melted or at least pasty masses; 2. The eruption of solutions; 3. Sublimation. Lodes which have originated in the first of these modes do not present the peculiar banded structure observed in most others. Springs upon lodes are by no means uncommon, and most of the true mineral springs of any particular district are so situated, that their origin from a lode of some kind is very probable. The formation of lodes by sublimation may sometimes be observed at the present day on volcanic mountains. Thus, for instance, during an eruption of Vesuvius in 1817, a fissure of more than three feet diameter was filled within the space of ten days with specular iron ore, deposited from the vapour of chloride of iron evolved. The lodes of red hematite in the Upper Erzgebirge may have originated in a similar manner, although more slowly.

Manganese lodes are perhaps likewise deposits from superfluoride or chloride of manganese. Silica and the few silicates may have been introduced by aqueous vapour. Bischof is of opinion that metallic silver has originated from silver glance by the abstraction of sulphur by steam.

The principal grounds for the ascension theory are,—1. The minerals of lodes are chiefly such as in a chemical point of view can only have been formed in the wet way; but, to judge from their constituents, are neither products of surface-water or of the extraction of the adjoining rocks. 2. Certain minerals are not unfrequently found in druses of the lodes covering or implanted upon the underneath surfaces of crystals. Thus, for example, at Lobenstein the rhombohedrons of spathic iron have a double covering; that on the under surfaces being clear acicular quartz; that on the upper surfaces clay, and these latter, when washed, have a less brilliant lustre than the under ones. At Nagyag (Transylvania) metallic arsenic sits only upon the lower surfaces of rose spar. 3. Lodes are generally larger and richer in ore the greater the depth. 4. Lodes which do not crop out can only have been derived from the earth's interior. 5. Fragments of rock torn from the saalbands are found *above* the places from which they have been broken. 6. Sublimed substances must have come from the interior. 7. Substances have been introduced from the lodes into the adjoining rock, sometimes in considerable masses, which appear quite foreign to it. 8. Even the very frequent banded structure of lodes indicates their origin from below.

It cannot be doubted that in many instances some of the constituents of minerals in lodes have been derived from the surface. This is strikingly evident with regard to the phosphates, many of which are hydrated, and occur in the upper parts of lodes. Pyromorphite occurs only in the upper parts of galena lodes. Iu 1813, it was found, in working the Beihilfe mine (Freiberg) close under the grass in masses of several hundredweight. This mineral has in every instance originated from the alteration of galena. Wavellite and peganite, both hydrated phosphates of alumina, occur close to the surface in lodes in siliceous slate sandstone at Zbirow (Bohemia), Freiberg; the former mineral alone at Giessen, Barnstaple, St Austle, and in Tipperary. They are not known to occur at any great depth. At Langenstriegis, near Freiberg, the lode was purposely followed downwards for some distance, and the phosphates soon disappeared; while, by working along the surface, wavellite was again found, together with a conglomerate of siliceous slate fragments cemented together with wavellite. Herder likewise found peganite in a soft state, shewing that these minerals were of very recent formation. It is said that there was formerly a skin yard upon the spot.

Turquoise or kalaite—consisting essentially of phosphate of alumina—occurs in the East, and in Silesia and Saxony only at the surface. Varizite likewise occurs in the same manner. Kraurite, hydrated phosphate of iron, has been found upon quartz and brown iron ore a few feet below the surface, in the "Hoff auf mich" mine at Göritz and other places. Uranite has been found at the surface upon narrow granite dikes near Schneeberg; and other minerals containing phosphoric acid—as kakoxen, beraunite, stilpnosiderite, sordawalite, and vivianite, &c.—occur in the same manner. The same holds good with regard to the cupreous phosphates.

Taking all these circumstances together, it is hardly possible to form any other inference than that the minerals in question, or at least the phosphoric acid they contain, originates from the surface, and in all probability from the decomposition of organic substances.

It must not, at the same time, be forgotten that apatite—the most frequent of the phosphatic minerals—occurs as an original constituent of granite, syenite, nephelin rock, and in tin lodes and primitive limestone. This phosphate cannot be regarded as similar, in respect to its formation, to the above-mentioned minerals, and it is also singular that they are not found in rocks containing apatite.

It is possible that the chlorine of horn-silver has been derived from the surfaces, for this mineral is found only in the upper parts of lodes.

General and partial alteration of lode minerals, aud the products resulting therefrom.

The alterations in mineral veins, although on a smaller scale than in the rocks, are much more frequent and remarkable. It is not from the rarer pseudomorphs that these alterations must be inferred; whole generations of lode substances have disappeared. Lodes containing heavy spar, fluorspar, and calcspar, have been entirely destroyed; and their former existence is indicated only by the pseudomorphic substances bearing their form. The chemical elements of some lodes have in part remained, but the sulphurets have been converted into oxides, hydrated oxides, or oxysalts, &c. There are even regenerated minerals.

There is scarcely a single lode formation which does not present some products of alteration.

It cannot be doubted that water has in many instances stood for a long time in lodes. Its decomposition in contact with sulphurets, especially iron pyrites, gives rise to the formation of sulphuretted hydrogen, and hydrated or anhydrous peroxides of iron. Entire lodes of iron pyrites have thus been converted into brown hæmatite. Copper pyrites, and its associates, gray copper, variegated pyrites, redruthite, &c., have been converted into red copper, copper pechertz, tile ore, and, when carbonic acid had access, into malachite, copper lazure, &c.

It is not improbable that metallic silver may have been produced from argentine, as well as from polybasite, by the action of hot aqueous vapours.

Fragments of spathose iron in the refuse heaps of mines are often found to have become quite brown, and entirely converted into hydrated peroxide. The same change is shewn to take place in lodes by the pseudomorphous peroxide in rhombohedrons.

Partial abstraction of metal may frequently give rise to the formation of higher sulphurets. Some of the lodes at Freiberg not unfrequently bear pseudomorphous hepatic, pyrites, iron pyrites, and mispickel, in the form of magnetic pyrites, which is itself very rare in the same lodes. Analogous lodes, however, at Drehbach, contain large masses of magnetic pyrites, associated, as at other places, with galena and calcite. Perfect crystals of magnetic pyrites, presenting exactly the same characters as the pseudomorphs at Freiberg, occur in lodes of the same formation in Stranitza (Transylvania). When it is remembered that in some places considerable quantities of magnetic pyrites occur in lodes, it is not at all improbable that the greater part of the iron pyrites in the Freiberg lodes was formerly magnetic pyrites. Moreover, iron pyrites, when associated with magnetic pyrites, is always the more recent, and this view is likewise in accordance with the fact that iron pyrites occurs upon copper pyrites.

Exhalations of sulphuretted hydrogen have undoubtedly caused a regeneration of altered minerals. The filamentous silver is found reconverted into sulphuret of silver, and containing a nucleus of this metal. Pyromorphite formed from galena is found covered with a crust of galena, in small individuals, such as are never found elsewhere, and more frequently entirely converted into galena, while its form is retained (Blaubleiertz).

The entire removal of the minerals, such as is observed at Göpersgrün is certainly one of the most remarkable phenomena known. Steatite occurs here in the form of quartz, fluorspar, a carbonate, and a nodular mineral, perhaps kalkschwerspath, which formerly constituted the lode. Every trace of silica, carbonate, &c., has disappeared, and silicate of magnesia is found in their place. The silica of the quartz and the magnesia of the carbonate cannot have contributed much to the immense masses of steatite. This change has most probably been very gradual, and may have been caused by springs containing silica and magnesia.

There are certainly changes observable in lodes which cannot be explained on known chemical principles. Time appears almost without question to have exercised a most important influence in their production; and there can be no doubt that chemical processes are continually going on in the mineral masses which constitute our globe, so gradual in their action as to be imperceptible, and perhaps even unsuspected by the chemist, but whose results are, in point of magnitude, out of all comparison with such as he is able to observe and set in action in his laboratory.

(To be continued in our next.)

Anniversary Address to the Ethnological Society of London. By Sir BENJAMIN C. BRODIE, Bart.

Mankind, scattered as they are over the entire surface of the globe; located among the perpetual snows of the Arctic regions, and in the perpetual summer of the Equator; on mountains and in forests; in fertile valleys and in deserts; in lands of rain and tempests; and in those which are never or rarely blessed by descending showers—are presented to us under a vast variety of aspects, differing from each other, not only as to their external form, but also as to their moral qualities and intellectual capacities. The first question which presents itself to him who is entering on that extensive field of observation which Ethnology affords is, Do these beings, apparently so different from each other, really belong to one and the same family? are they descended from one common stock? or are they to be considered as different genera and species, descended from different stocks, and the result of distinct and separate creations? Those to whose opinions on the subject we may refer with the greatest confidence—among whom I may more especially mention our own countrymen, Mr Lawrence, Dr Prichard, and Dr Latham—have come to the conclusion that the different human races are but varieties of a single species; and without entering into all the arguments which have been adduced by these philosophers, I may observe that there are many facts which seem, as it were, to lie on the surface, and which are obvious to us all, that may lead us to believe that this conclusion is well founded.

Although we justly regard the intellectual faculties as of a higher order than those which belong to mere animal life; although it is as to these alone that mankind "*propius accedunt ad Deos;*" yet it must be admitted that up to a certain point, and within its own domain, instinct is a more unerring guide than human reason. And what is but instinct which leads us at once to recognise the Esquimaux, the Negro, the Hottentot, as belonging to the same order of beings with ourselves, with as little hesitation as the greyhound, the spaniel, the mastiff, mutually recognise each other as being of the same kindred?

Then be it observed, that, however different may be the external figure, the shape of the head and limbs, there is no real difference as to the more important parts of the system, namely, the brain, the organs of sense, the thoracic and abdominal viscera; and the medical student is aware that he obtains all the knowledge which he requires just as well from the dissection of the Negro or the Lascar as from that of the Anglo-Saxon or the Celt. Even as to the skeleton, the difference is more apparent than real: there is the same number, form, and arrangement of the bones; and I may add, there is the same number, form, and arrangement of the muscles.

Pursuing the inquiry further still, we find that the different sexes are mutually attracted to each other; that their union is prolific; that the period of gestation in the female is the same in all; and that—unlike what happens as to hybrid animals—instead of stopping short after one or two generations, their offspring continues to be prolific ever afterwards.

Nor is there any thing difficult to understand, nor contrary to the analogy of what happens among other animals, in the production of the different varieties of mankind. The Hottentot and the Anglo-Saxon have a closer resemblance to each other than the mastiff and the spaniel. How different is the Leicestershire from the Southdown breed of sheep; and the English dray-horse from the thorough-bred Arabian! We see these changes actually going on, nay, we actually produce them artificially among our domesticated animals; and we see them taking place, to a certain extent, even in our own species. The Negroes, taken from on board the captured slave ships and transported to Jamaica, have a different aspect from those who have been for some generations domesticated in the service of the planters. The descendants of the Anglo-Saxon race transplanted, within the last two centuries, to other regions of the globe, are already beginning to be distinguishable from those who remain in the parent country by their external appearance, and, even to a greater extent, by their characters and habits. It was observed to me by a gentleman who has served his country in important official situations in Europe and on the other side of the Atlantic occan, that if, in going from England to Italy, he was struck with the comparative passiveness of the Italians, on returning to England from America he found something still more remarkable in the passiveness of the English compared with the excitement and activity observable among the citizens of the United States. If in the present condition of the world, when there is so free an intercourse among its inhabitants, and so constant an intermixture of races, such changes are to a certain extent going on, it is easy to conceive that changes still more remarkable might have taken place when human society was in its infancy; when nations were separated by impassable seas and mountains; when there was nothing to interfere with the influence of climate, food, and mode of life on the physical and moral character; and when repeated intermarriages among individuals of the same tribe were favourable to the transmission of accidental peculiarities of structure to succeeding generations.

There was a period when a jealousy prevailed of studies such as those of the Geologist and Ethnologist, from a supposition that they in some degree tended to contradict the revelations of the earliest of our sacred volumes. The advancement of knowledge has shewn that such jealousy was without any just foundation; and those who on such narrow grounds stand aloof from the pursuits of science are now reduced to a small and almost unnoticed minority. It is, however, satisfactory to find that the inquiries of the Ethnologist, so far from being opposed to, actually offer a strong confirmation of, the Mosaic records as to the origin of mankind having been from one parent stock, and not from different creations.

"The noblest study of mankind is man."

So says one of our greatest moralists and poets; and if we estimate them according to the rule which is here laid down, it must be admitted that inquiries into the physical, intellectual, and moral character of the various human races ought to hold a high rank among the sciences which claim the attention of the philosopher. Standing, as it were, midway between the physical and the moral sciences, Ethnology is not less interesting to the Naturalist than to the Metaphysician; and not less so to the Metaphysician than to the Philologist. To trace the influence of climate, of food, of government, and of a multitude of other circumstances on the corporeal system, on the intellect, the instincts, and the moral sentiments, is the business of the Ethnologist: nor is it less in his department to trace the origin and the construction of language generally, and the relation of different languages to each other. Infused into it, Ethnology gives a more philosophical character to history; adding to the dry and often painful detail of political events occurring in a particular country another serious of facts, which present to us the whole of the human inhabitants of the globe as one large family, constituting one great system, advancing together towards the fulfilment of one great purpose of the Creator.

But in this utilitarian age there are, I doubt not, some who regard Ethnology as offering matter for curious speculation, but as being in no degree worthy of a place among those sciences which admit of a direct and practical application to the wants of society and the ordinary business of life. It is, indeed, with some among us too much the custom to measure things by this low standard, and to forget that whatever adds to our stores of knowledge, and gives us broader views of the universe, tends to the improvement of the intellect, the elevation of the moral sentiments, and thus leads to a more complete development of those qualities by which the human species is justly proud of being distinguished from the inferior parts of the animal creation. The practical genius of the English is essentially different from the genius of the ancient Greeks; but no one can hesitate to believe that the philosophers, the poets, the architects, the sculptors, who form the glory of that wonderful people, are even now exercising a most beneficial influence on the character of mankind, after the lapse of more than 2000 years. Setting aside, however, these considerations, and admitting that it affords us no assistance in the construction of steam-engines or railways; that it is of no direct use in agriculture or manufactures; still it may be truly said, that, even according to his own estimate of things, the most thorough utilitarian who looks beyond the present moment will find that there is no science more worthy of cultivation than Ethnology. Is there any thing more important than the duties of a statesman? and can there be any more mischievous error than that of applying to one variety of the human species a mode of government which is fitted only for another? Yet how often, and even in our own times, from a want of the necessary knowledge and foresight on the part of those to whom the affairs of nations are entrusted, has this error been committed. Even within the narrow limits of our own island, there are two races having each of them their peculiar character. But the British empire extends over the whole globe. It comes in contact with the descendants of the French in Canada; with the Red Indians of America; with the Negroes of Sierra Leone and Jamaica; with the Caffres and Hottentots of South Africa; with the manly, warlike, and intelligent inhabitants of New Zealand; with the rude Aborigines of Australia; with the Malays, the Hindoos, the Mussulmans, the Parsees, the Chinese in the East—races differing widely from ourselves, and not less widely from each other. Surely much advantage would arise, and many mistakes might be avoided, if those who have the superintendence and direction of the numerous colonies and dependencies of the British crown would condescend to qualify themselves for the task which they have undertaken by studying the peculiarities of these various races, and by seeking that information on these subjects which Ethnology affords.

This Society is yet in its infancy. But those who have attended its meetings will bear testimony to the value of the written communications which have been made to it during the present Session, and of the discussions to which these communications have led. Seeing how much has been already accomplished, and the zeal which exists among its members, I am, I conceive, not too sanguine in my expectations, when I anticipate that the Ethnological Society will from year to year advance in reputation and usefulness; and that the time is not far off when its labours, and the objects which it has in view, being justly appreciated by the public, it will be ranked among the most important Scientific Institutions of the age.

SCIENTIFIC INTELLIGENCE.

MINERALOGY.

1. *Native Metallic Iron.*—Dr Andrews, in an examination into the minute structure of basalt, has found evidence of the existence of iron in a native state. After pulverizing the rock, and separating with a magnet the grains that were attracted by it, he subjected these grains, which were mostly magnetic iron, to the action of an acid solution of sulphate of copper in the field of a microscope.

This salt produces no change with the oxide, but if a trace of pure iron be present, copper is deposited. In his trials there were occasional deposits of copper in crystalline bunches; the largest of which obtained was little more than one-fiftieth of an inch in diameter. He observes that with 100 grains of the rock, three or four deposits of copper can usually be obtained. The basalt of the Giant's Causeway affords this evidence of the presence of native iron, but less so than the Slievemish basalt.

The same result would be produced, if the nickel or cobalt were present in fine grains; but Dr Andrews considers this very improbable. The same basalt afforded, on microscopic examination, augite, magnetic iron, pyrites, and a colourless glassy mineral.—(*American Journal of Science and Arts*, vol. xv., No. 45, 2d Series, p. 443.)

2. *On Glauberite from South Peru;* by M. Ulex. (*Leonhard u. Bronn's N. Jahrb. f. Min. u.s.w.*, 1851, p. 204; and *Woehl. u. Lieb. Ann.*, vol. lxx., p. 51 *et seq.*)—The Brongniartin or Glauberite occurs in crystals imbedded in nodular masses of a substance called "Tizza," which the author recognised as a boracic compound. According to Frankenheim the crystals, attaining a size from 1 to 1½ inch (German), differ from those of Brongniartin previously known in their angles, but slightly however; the form also somewhat differs. Sometimes the crystals appear perfect and transparent, sometimes white and laminated, the fissures being occupied by the above-mentioned substance. Spec. grav. = 2·64; hardness = 2·5 – 3·0. Its behaviour in the alembic and before the blow-pipe, is like that of the Spanish Brongniartin. An analysis gave—

Lime,	19·6
Soda,	21·9
Sulphuric acid,	55·0
Boracic acid,	3·5

Formula: $\dot{N}\,A\,\dddot{S} + \dddot{S} + \dot{Ca}\,\dddot{S}$.

The presence of borax is no doubt due to the admixture of the mineral substance in which the crystals are imbedded.—(*Quarterly Journal of the Geol. Society*, vol. ix., No. 35, p. 24.)

3. *On the Structure of Agate;* by Theodore Gümbel. (*Leonhard u. Bronn's N. Jahrb. f. Min., u.s.w.*, 1853, pp. 152–157.)—The curious and beautiful appearances afforded by agates have long made them of primary importance in mineralogical cabinets; but until of late years particular attention does not seem to have been paid to the internal structure of these bodies. Dr J. Zimmerman is the first, of my knowledge, who observed* that the different varieties of quartz—as amethyst, calcedony, carnelian, jasper—formed the concentric layers of the nodules, which were either hollow or occupied with crystals.†

In the Jahrbuch of the Imperial Geological Institute of Vienna for 1851,‡ is a very interesting memoir on the interior structure of agates by Prof. Dr Franz Leydolt, where he states that, on being submitted to the action of fluoric acid, the amorphous portions are dissolved before the crystalline layers or bands; and the agate surface being thus prepared, it is made use of in printing an exact copy of itself. The six beautiful plates accompanying the memoir perfectly exemplify Prof. Leydolt's views, and shew,—*first*, that the parts towards the outer surface consist of several spherules variously combined, which are composed of layers of diverse character; *secondly*, that towards the centre of the nodule is a large mass of amethystine quartz, the nucleus of the latter again being formed of very small concentric spherules.

In the *Jahrbuch für Praktische Pharmazie, Sc.* 1852, is a short paper of mine on the rotatory motion of matter in the amorphous condition, in which I have shewn, that in a sphere of blown glass the material is not homogeneous, but consists of lamellæ overlying one another at varying angles and confusedly distorted. As in the thin pellicle of blown glass the intimate structure of the soap bubble is as it were fixed, so I sought to make further researches by means of experiment on molecular movement, such as can be observed in so many instances. One of the most successful experiments was the use of melted stearine with which very fine graphite had been mixed, spangles of which easily indicated the intimate motion of the mass. By this easy experiment it appears that in some parts there was a strong tendency to the formation of spheres, and which existed even in the interior of the larger spheres, giving rise to smaller spherules.—(*Quarterly Journal of the Geological Society*, vol. ix., No. 35, p. 259.)

4. *Scleretinite, a new Fossil Resin from the coal measures of Wigan, England;* by J. W. Mallet.—Occurs in small drops or tears from the size of a pea to that of a hazel nut. Brittle, with the

* In his Taschenbuch für Mineralogie.

† See also Mr Hamilton's Paper on the Agate Quarries of Oberstein, Quart. Journ. Geol. Soc., vol. iv., p. 215.—Transl.

‡ Vol. ii. No. 2, p. 124.

fracture conchoidal. Translucent in thin splinters. Colour black, but by transmitted light reddish-brown: streak cinnamon-brown, lustre between vitreous and resinous, rather brilliant—G. = 1·136, H. = 3. Heated on platinum foil it swells up, burns like pitch, with a disagreeable empyreumatic smell, and a smoky flame, leaving a coal rather difficult to burn, and finally a little gray ash. In a glass tube, yields a yellowish-brown oily product of a nauseous empyreumatic odour. Insoluble in water, alcohol, ether, caustic, and carbonated alkalies or dilute acids; and even strong nitric acid acts slowly. Composition—

	Carbon.	Hydrogen.	Oxygen.	Ash.
1.	76·74	8·86	10·72	3·68
2.	77·15	9·05	10·12	3·68

Affording the ratio C10 H 7 O = carbon 77·05, hydrogen 8·99, oxygen 10·28, ash 3·68. Taking the number of atoms of carbon at 40, which exist in so many resins, the formula becomes C 40 H 28 O 4. It is nearest in composition to amber, which contains C 40 H 32 O 4.—(*American Journal of Science and Arts*, vol. xv., p. 433.)

5. *On Pseudomorphous Crystals of Chloride of Sodium;* by G. Wareing Omerod, M.A., F.G.S.—In a paper read before this Society, on 1st December 1852, by Mr Strickland, on pseudomorphous crystals of chloride of sodium in Keuper Sandstone,* no reference is made to prior observations on the same point. In my paper "On the Principal Geological Features of the Salt-field of Cheshire,"† it is stated that "the Waterstone beds (a subdivision of the Keuper) at Holmes Chapel have the same peculiar crystal as those at Lymm, Preston on the Hill, and elsewhere;" and in a note it is added, "At this place the crystals are of silicate of protoxide of iron. This seeming crystal is probably caused by the component matter taking the places of scattered crystals of chloride of sodium, the form of which, both in Cheshire and at Slime Road in Gloucestershire, they have taken, exhibiting, if so, the lowest traces of the salt." To Mr Crace Calvert (Honorary Professor of Chemistry at the Royal Manchester Institution) I was indebted for the examination of this specimen; and to him any credit for the discovery, as far as relates to Cheshire, is due, he having, on my shewing him the specimens, stated his opinion that the crystals were Pseudomorphic Chloride of Sodium. I had omitted to ask his permission to allow me to mention his name when my paper was read, and it was therefore not then given. This paper was read before the Geological Society 8th March 1848, when specimens were exhibited and a discussion took place, when Professor Buckland mentioned many localities in which he had observed this pseudomorph, for which he had not hitherto been able to account.

* Quart. Journ. Geol. Soc. vol. ix., p. 5. † Ibid. vol. iv., p. 273.

In July 1850 the Government Reports of the Natural History of the State of New York were sent over as a donation to the Free Library and Museum of the borough of Salford; and shortly afterwards, on examining the geological division of that work, I found that the same peculiar crystal had been observed in the district lying to the south of Lake Ontario. In Part III., pages 102 and 103, Mr Lardner Vanuxem notices them thus:—"Hopper-shaped cavities, Onondaga Salt Group. These forms and cavities are of great importance, for they were produced by common salt, no other common soluble mineral presenting similar ones. They are found in the gypseous shale or marl in its more solid and slaty parts." A drawing is given of specimens (from Bull's Quarry, town of Lenox, Madison county) in which the pseudomorphs resemble those found in Cheshire and Gloucestershire which have come under my notice.

In Part IV., page 127, Mr James Hall mentions that similar crystals were found in Wayne and Monroe counties, but that he had rarely observed them in Genessee or Erie counties, the most perfect which he had seen being at Garbutt's Mill on Allen's Creek. Part III. was published in 1842, and Part IV. in 1843.

In making those observations, I must not be understood as in any way attempting to take from Mr Strickland the credit of a discovery; before he directed special notice to it, the matter was only incidentally mentioned, and he was doubtless quite as much unaware that it had been noticed before, as Professor Calvert or myself were. My object has been to direct attention to this matter as shewing the great extent of country in which this singular crystal is found. The observations of Mr Strickland and myself shew that it is found in the Keuper sandstone through a considerable portion of Gloucestershire, and I have noticed its frequent occurrence in Cheshire; Professor Phillips has found it in Worcestershire, and Dr Percy in Nottinghamshire. The observations of Messrs Vanuxem and Hall shew the existence of a similar pseudomorph in North America, in the district to the south of Lake Ontario, extending from Erie county through Genessee, Monroe, and Wayne to Madison county. There, however, these crystals are found in the Onondaga salt group, belonging to the upper Silurian division.

6. *Note on the occurrence of similar Crystals;* by W. W. Smyth, Esq., F.G.S.—The presence of pseudomorphous crystals, similar to the above mentioned, in several divisions of the trias, has long attracted notice on the Continent, and has been detected at very numerous points scattered over a large proportion of Northern Germany. In Leonhard and Bronn's Journal for 1847, Gutberlet has devoted an elaborate paper to the description and geological discussion of those more particularly which occur in beds of variegated marls between the Bunter sandstein and the Mus-

chelkalk. They have also been described by Dr Dunker as occurring in the Wealden of Germany; by Braun, in the marl-slate of the Zechstein near Frankenberg; and by others, in the tertiaries of Austria and of the south of France.

In all these different localities the "hopper-shaped" crystals (or cubes with hopper-shaped impressions) are the most frequent, and are the same forms of salt which are produced by gradual evaporation, whether in salt-pans or on a sea-shore. The materials of which these pseudomorphs are constituted vary with the composition of the adjacent rocks, and are, in different localities, marly limestone, dolomitic marl, gypsum, quartz (more or less pure), sandstones of many kinds, mica, and brown spar, the last two often disposed only round the edges. In the first-mentioned paper, and in some by Hausmann and Nöggerath on the same subject, will be found much valuable and suggestive matter connected with both the chemical and geological aspect of the subject.—(*Quarterly Journal of the Geological Society*, vol. ix., No. 35, p. 187.)

7. *On Matlockite*; by C. Rammelsberg. (*Leonhard u. Bronn's N. Jahrb. f. Min. u.s.w.*, 1853, p. 173; *Poggend. Annal.*, lxxxv., p. 141 *et seq.*)—The new mineral, Matlockite, is very similar in external appearance to Corneous lead (murio-carbonate of lead, Blei-hornerz), and, together with the latter, it has been found associated with earthy galena, at the deserted Cromford mine, near Matlock. Both are very rare.

Compact fragments of the Murio-carbonate are transparent, colourless or yellowish, lustrous, and pretty generally cleavable in three directions at right angles to each other. Brooke* and Krug von Nidda‡ describe the crystals of this mineral. Rammelsberg found its specific gravity to be 6·305. In powder it was in some degree decomposed even by cold water, chlorite of lead being set free. Its analysis is given below.

In Matlockite a single but very perfect plane of cleavage has been observed. This mineral has been recognized as a basal chloride of lead. The specific quantity of the powder is 5·3947. Its analysis is—

Matlockite.			Blei-hornerz.	
Chlorine	14·12	55·62	Carbonic acid	7·99
Lead	41·50		Oxide of lead	40·46
Lead	41·50	44·38	Chlorine	12·97
Oxygen	2·88		Lead	37·96
	100·00			99·38

—(*Quarterly Journal of the Geological Society*, vol. ix., No. 35, p. 24.)

* Poggendorf's Annalen, xlii., p. 582.

‡ Zeitschrift d. Deustch. Geol. Gesellschaft, vol ii., p. 126.

GEOLOGY.

8. *On the Structural Characters of Rocks;* by Dr Fleming.—While the condition of the mineral masses in the neighbourhood of Edinburgh furnish interesting illustrations of the structural characters of rocks, such as the columnar, the concretionary, and the fragmentary, &c., the author proposed to confine his remarks at present to what he denominated the Flawed Structure.

In the ordinary language of quarriers, the *flaws* are termed *backs*, while they are known to masons as *dries*, and to geologists, when referred to, as *slicken-sides.* This last term, independent of its provincial character, refers to one peculiar form of the flaw only, and, although explicable according to the same views entertained respecting the origin of the others, is far from being a typical form. The *flaw* of the lapidary, in reference to crystals or gems, comes sufficiently near in character to justify its adoption.

The Flaw is a crack which is confined to the stratum or bed in which it occurs, and is thus distinguished from *fault* or dislocation, since these extend through several beds. It occupies all positions in the bed, without an approach to parallelism, the flaws being variously inclined to one another, and not extending continuously throughout the thickness of the bed; thus differing from the *columnar structure.*

These flaws are sometimes isolated; in other cases two unite at angles more or less acute, and the junction edges are either sharp or rounded. The surface of the sides of the flaw is frequently crumpled or waved, and in the granularly-constituted beds, such as granite, porphyry, or sandstone, is rough, while in slate-clay, bituminous shale, and steatite, it often exhibits a specular polish.

The circumstance of the flaws exhibiting no approach to parallelism, joined to the fact that they are not prolonged into the inferior or superior beds, nay, frequently not extending throughout the bed containing them, furnish a demonstration that they were not produced by an external force. The notion, too, is untenable, that the polishing was produced by the faces of the flaw sliding backwards and forwards on one another, because their limited extent, mode of junction, and waved surfaces clearly indicate the absence of any such alternate shifting.

The author then stated his opinion that the flaws had been produced by *shrinkage*, owing to the escape of volatile matter, aided by molecular aggregation, and that the polished surfaces were produced in comparatively soft plastic matter, like bituminous shale, by the presence of water or gas in the cavity, so that the specular character was the *casting* or impression of a liquid surface. The empty vesicles of amygdaloid are occasionally found glossy on the walls, or exhibiting an apparently vitrified film, while the rock itself is dull and earthy in fracture. The smoothness in this instance is probably produced as the casting or impress of included vapour or gas. Sometimes the flaws in coarse materials, such as porphyry, have a specular aspect, owing to a film of anhydrous peroxide of iron. Illustrative examples were exhibited, and references made to various localities around Edinburgh, where the whole phenomena of *flawed* structure were well displayed.

In proceeding to consider still farther the physiology of rocks, Dr Fleming proposed in the second part of his communication to confine himself to the illustration of—

1*st*, *The Columnar Structure.*—After enumerating examples of this structure, as occurring in the neighbourhood of Edinburgh, in candle coal, sandstone, clay, ironstone, clinkstone, claystone, greenstone, and basalt, he exhibited examples of similar appearances in oven soles and fragments of the walls of vitrified forts. The ordinary explanation of this structure as the result of cooling from a state of fusion he pointed out as unsatisfactory, even in the case of basaltic pillars, and inapplicable to similar appearances as occurring in sedimentary rocks. He considered the whole phenomena explicable as connected with one cause, viz., shrinkage, arising from the escape of aqueous or volatile matter.

2*d*, *The Cone in Cone Structure.*—Examples of this structure occur in impure ferruginous limestone at Joppa, the Water of Leith, and other places, in connection with the coal measures. Dr Fleming referred the origin of this structure to shrinkage, conjoined with a certain amount of molecular aggregation or crystallizing influence.—(*Proceedings of the Royal Society, Edinburgh.*)

9. *Almaden Mine, California.*—The process of extracting the metal from the ore is very simple. The ore is placed in the furnaces, where a gentle and regular heat is applied. As it diffuses itself through the ore, the quicksilver contained in it sublimes, and is afterwards condensed, and falls by its own weight, trickles down and out at little pipes leading from the bottom of the chambers of the furnace, and empties into vessels so situated as to receive it. From these pipes we saw the quicksilver falling more or less rapidly in large drops. In one vessel there must have been from 15 to 20 gallons of quicksilver. About 1000 flasks per month are manufactured, each flask containing 75 pounds, making 75,000 pounds per month. The flasks are all of wrought iron. The time occupied in filling the furnace, and extracting all the metal from a furnace full of ore, is about one week. When this is accomplished, the furnace is opened that the mass of rock may be removed to make way for another batch of ore.—(*American Journal of Science and Arts*, vol. xvi., No. 46, 2d Series, p. 137.)

METEOROLOGY.

10. *An Account of Meteorological Observations in four Balloon Ascents made under the direction of the Kew Observatory Committee of the British Association;* by John Welsh, Esq. Communicated by Colonel Sabine, R.A., Treas. V.P.R.S., President of the British Association, on part of the Council of the Association. —The object contemplated by the Kew Committee in the balloon ascents, of which an account is given in this communication, was chiefly the investigation of the variations of temperature and humidity due to elevation above the earth's surface. Specimens of the air at different heights were also obtained for analysis.

The instruments employed were the barometer, dry and wet bulb hygrometer, and Regnault's condensing hygrometer.

The barometer was a siphon, on Gay-Lussac's construction, without verniers; the upper branch of the siphon being alone observed, corrections having been previously determined for inequality of the tube at different heights of the mercury.

Two pairs of dry and wet thermometers were used, one pair having their bulbs protected from radiation by double conical shades open at top and bottom for the circulation of the air, the surfaces being of polished silver. The second pair were so arranged, that by means of an "aspirator," a current of air was made to pass over the bulbs more rapid than they would be exposed to by the mere vertical motion of the balloon. The object of this arrangement was to enable the thermometers to assume with more rapidity the temperature of the surrounding air, and also to diminish the effect of radiation, in case the shades should not be a sufficient protection, especially when the balloon was stationary or rising very slowly. The thermometers used were very delicate, the bulbs being cylinders about half an inch long and not more than $\frac{1}{12}$th of an inch diameter. It was found on trial that when the bulbs were heated 20° above the temperature of the air in a room, they resumed their original reading in 40 or 45 seconds, when moved through the air at the rate of 5 or 6 feet in a second. It is thus probable that any error arising from want of sensibility in the thermometers will be small, and in all likelihood not more than may be expected from other accidental causes.

The observations were taken at short intervals during the *ascent*, it having been seldom practicable to obtain a regular series in the *descent*. The intervals were generally one minute, but frequently only 30 seconds, so that an observation was for the most part recorded every 200 or 300 feet. All the observations are given in detail in the tables accompanying the paper. They are also given in the graphical form in the curves.

The ascents took place on August 17, August 26, October 21, and November 10, 1852, from the Vauxhall Gardens, with Mr C. Green's large balloon.

The principal results of the observations may be briefly stated as follows:—

Each of the four series of observations shews, that the progress of the temperature is *not* regular at all heights, but that at a certain height (varying on different days) the regular diminution becomes arrested, and for the space of about 2000 feet the temperature remains constant or even increases by a small amount: it afterwards resumes its downward course, continuing for the most part to diminish regularly throughout the remainder of the height observed. There is thus, in the curves representing the progression of temperature with height, an appearance of *dislocation*, always in the same direction, but varying in amount from 7° to 12°.

In the first two series, viz. Aug. 17 and 26, this peculiar interruption of the progress of temperature is strikingly coincident with a *large* and *rapid fall* in the temperature of the *dew-point*. The same is exhibited in a less marked manner on Nov. 10. On Oct. 21 a dense cloud existed at a height of about 3000 feet; the temperature decreased uniformly from the earth up to the *lower* surface of the cloud, when a slight rise commenced, the rise continuing through the cloud, and to about 600 feet above its upper surface, when the regular descending progression was resumed. At a short distance above the cloud the dew-point fell considerably, but the rate of diminution of temperature does not appear to have been affected in this instance in the same manner as in the other series; the phenomenon so strikingly shewn in the other three cases being perhaps modified by the existence of moisture in a *condensed* or vesicular form.

It would appear on the whole that about the principal plane of condensation heat is developed in the atmosphere, which has the effect of raising the temperature of the higher air above what it would have been had the rate of decrease continued uniformly from the earth upwards.

There are several instances of a second or even a third *sudden* fall in the dew-point, but any corresponding variation in the temperature is not so clearly exhibited, probably owing to the *total* amount of moisture in the air being, at low temperatures, so very small that even a considerable change in its *relative* amount would produce but a small thermal effect.

As the existence of the disturbance in the regular progression of temperature now stated rendered it neccessary, in order to arrive at any approximate value of the normal rate of diminution with height, to make abstraction of the portion affected by the disturbing cause, each series was divided into two *sections*, the first comprising the space below the stratum in which the irregularity existed, and the second commencing from the point where the regular diminution of temperature was resumed. It was then found that the rate of diminution was nearly uniform within each *section*, but that it was somewhat greater in the lower than in the upper sections.

On taking a mean of both sections for each series, giving each section a value corresponding to its extent, it is found that the number of feet of height corresponding to a fall of one degree Fahrenheit is—

On August 17.........	292·0 feet.
August 26.........	290·7 „
October 21.........	291·4 „
November 10.....	312·0 „

The first three values being remarkably coincident, and the last differing from them by about $\frac{1}{15}$th of the whole.

The air collected in the ascents was analysed by Dr Miller; he states that "the specimens of air do not differ in any important amount from that at the earth at the same time, but contain a trifle less oxygen. All of them contained a trace of carbonic acid, but the quantity was too small for accurate measurement upon the small amount of air collected."—(*Proceedings of the Royal Society of London.*)

11. *Influence of Light upon the Colour of the Prawn.*—A few hours' captivity changes all the colours of the prawn; all the fine bands and stripes and spots become so pale as to be scarcely distinguishable from the general pellucid olive hue of the body.

I cannot tell how this loss of colour is effected, but I have reason to think that light, the great agent in *producing* colour, in most cases is the cause. I took two specimens just dipped from a deep pool, and equal in richness of their contrasted colours: one of these I placed in a large glass vase of sea-water that stood on my study table; the other in a similar vase shut up in a dark closet. In twenty-four hours the one that had been exposed to the light had taken on the pale appearance just alluded to: the one that had been in darkness had scarcely lost any of the richness of its bands and stripes, though the general olive hue of the body had become darker and of a brown tint. This individual, however, assumed the appearance of the former before it had been an hour emancipated from its dark closet. Without attempting to account for the phenomenon, I would just advert to the parallel exhibited by the sea-weed. The brilliant colours displayed by many of these exist, as is well known, in the greatest perfection, when the plants grow at considerable depths, or in the caves and holes of the rocks, where light can but dimly penetrate.

Some of these will not grow at all in shallow water, or in a full light, and those that can bear such circumstances are commonly affected by them in a very marked degree—marked by the degeneracy of their forms, and by the loss of their brilliancy of colour. The prawn, as I have already hinted, delights in the obscurity of deep holes and rocky pools; it is here alone that his fine zebra-like colours are developed. When taken in shallow pools, he is of the plain olive-yellow tint of the specimen that had spent four and twenty hours on my table.—(*A Naturalist's Rambles on the Devonshire Coast*, by P. H. Gorre, p. 42.)

12. *Coralline Light.*—The common coralline, if held to the flame of a candle, burns with a most vivid white light. If we take a shoot and let it dry, and then present the tips to the flame, just at the very edge, not putting them into the fire, the ends of the shoot will become red first, snapping and flying off with a crackling noise; some, however, will retain their integrity, and these will presently become white hot, and glow with an intensity of light most beautiful and dazzling, as long as they remain at the very edge of the flame; for the least removal of the coralline, either by pulling it away, or by pushing it in, destroys the whiteness. It will however return when again brought to the edge. The same tips will display the phenomenon as often as you please. I did not find the incrusting lamina that spreads over the rock before the shoots rise, shew the light so well as the shoots.

The brilliant light obtained by directing a stream of oxygen gas upon a piece of lime in a state of combustion occurred to my mind as a parallel fact, and I experimented with other forms of the same substance. The polypidoms of *Cellularia avicularia*, and of *Eucratea chelata*, one of the stony plates of Caryophyllia, and a fragment of oyster shell, I successively placed in the flame, and all gave out the dazzling white light exactly as the coralline had done. The horny polypidom of a *Sertularia*, on the other hand, shrivelled to a cinder.—(*A Naturalist's Rambles on the Devonshire Coast*, by P. H. Gorre, p. 226.)

13. *Aurora Borealis.*—Mr W. J. M. Rankine announces, that he has on several nights examined the light of the aurora borealis with a Nichol's prism, and has never detected any trace of polarization. The same light reflected from the surface of a river was polarized, shewing that his failing to detect polarization in the direct light of the aurora was not owing to its faintness. This fact is adverse to the idea that the light of the aurora is reflected light. —(*American Journal of Science and Arts*, vol. xvi., 2d Series, No. 46, p. 148.)

ZOOLOGY.

9. *On the Structure and Economy of Tethea, and on an undescribed species from the Spitzbergen Seas;* by Professor Goodsir.—The author, after a brief summary of the observations of Donati, M. Edwards, Forbes, Johnston, and Huxley, on various species of Tethea, described the structure, and deduced the probable economy of a large species apparently undescribed, some specimens of which he had procured from the Spitzbergen Seas.

The following peculiarities of form and structure were minutely detailed and illustrated :—

1*st*, The turbinated form of the sponge.

2*d*, The partial distribution of the rind.

3*d*, The minute pores of the rind, arranged in threes; a pore in each of the angles, formed by the primary branches of the six-radiate spicula.

4*th*, The water, instead of passing out by oscula, drains through a perforated or network membrane which lines a number of irregularly tortuous grooves on the surface of the attached hemisphere of the sponge,—the grooves being continuous with deep fissures, which extend into the rind, and are apparently the result of distension from internal growth.

5*th*, The silicious spicula are arranged according to the type of the skeleton in the other Tetheæ. Elongated, slightly bent or twisted rod-like spicula, are combined in bundles by means of fibrous substance, and a few boomerang-shaped spicula, laid cross-ways. These bundles are arranged irregularly in the centre of the sponge, so as to form a nucleus from which radiating masses extend outwards to the rind, or beyond the surface, where the rind is deficient. The spicula of the rind are large and six-radiate. Their shafts are deeply and firmly inserted into the radiating bundles. Their three primary branches are set at angles of 120° to the shaft, and to one another. The two secondary branches at the extremity of each primary branch are long-pointed, slightly concave towards the centre of the sponge, and set at an angle of 90° to one another.

6*th*, The fleshy mass which envelopes the spicular bundles in the interior of the sponge, consists of—1. Ordinary sponge particles; 2. Caudate particles, probably similar to the Spermatozoa described and figured by Mr Huxley in an Australian Tethea; 3. Ova-like masses, the largest of which envelope a radiating arrangement of anchor-like spicula; 4. Towards, and in the rind, elongated cellules, apparently fibrous and muscular, the fibrous connecting the spicula, and with the nucleated muscular cellules arranged transversely as figured by Donati.

7*th*, From the structure of Tethea, as well as from the observations of Donati and M. Edwards, this group of sponges would appear to possess considerable contractility.—(*Proceedings of the Royal Society of Edinburgh.*)

15. *Hungarian Nightingale.*—Last autumn I brought from the neighbourhood of Hungary, says Dr Martin Barry, a nightingale, *Sylvia Philomela.* It wintered in Scotland, I will venture to say the only one there; and then, after two months of powerful and most delicious song in its cage, it died.

16. *M. Quatrefages' Method for destroying Insects.*—The *Termes lucifugum* is well known for its ravages. It has been

very destructive about the villages of Saintes, Tonnay-Charente, and Rochefort. Roofs and floors are often completely riddled in these villages by these animals so feeble in appearance; and even entire houses have been so destroyed in their foundations, that they had to be abandoned or rebuilt. The danger from these depredations is the greater, that they work altogether out of sight, and respect with extreme care the surface of the bodies they attack. The archives of Rochelle for certain years have been completely devoured by the termites (excepting the outer surface, which leaves no evidence of the destruction within), and of recent years they have been inclosed in zinc. At La Rochelle the invasion has even extended to the arsenal and the prefecture, and the whole village is threatened.

M. de Quatrefages has made some experiments which solve the problem of their destruction. He has shewn that the gases which are most energetic are chlorine and nitrous vapour, NO_4; sulphurous acid is less active, and oxide of nitrogen, NO_2, acts only when it can be transformed into hyponitric acid, under the influence of a little oxygen. The gases have been made to act on fragments of wood infested with the termites, and have so penetrated into the deeper termitic cellules that none have escaped.

As the application of gas in many cases must be inconvenient, it is recommended to prepare the wood before employing it in construction. The method hitherto employed for preserving woods have had reference rather to protection against decay than insects. There is an exception in the process of Bethell, which consists in saturating the wood with a bituminous oil rich in naphthaline, a material proceeding from the distillation of the bitumen of coal. The cross timbers of the Stockton and Darlington Railway, prepared in this way ten years since, are still untouched; and the same is true of the timbers of part of the London and North-Western Railway. At the port of Lowestoft, the naphthalized tiles are wholly exempt from the attacks of insects, while wood unprepared is more or less deeply eaten. The disastrous results mentioned by M. de Quatrefages will not fail to call attention to this process, which has been sometimes objected to on account of its making the wood more combustible.—(*American Journal of Science and Arts*, vol. xvi., No. 46, p. 107, 2d Series.)

BOTANY.

17. *Experimental Researches on Vegetation;* by M. George Ville. Communicated by the Earl of Rosse, P.R.S.—After stating that it has often been asked if air, and especially azote, contributes to the nutrition of plants; and, as regards the latter, that this question has always been answered negatively, the author remarks, it is however known that plants do not draw all their

azote from the soil, the crops produced every year in manured land giving a greater proportion of azote than is contained in the soil itself. The question which he has proposed to himself for solution is, whence then comes the excess of azote which the crops contain, and in a more general manner, the azote of plants, which the soil has not furnished? He divides his inquiry into the three following parts:—

First, Inquiry into and determination of the proportion of the ammonia contained in the air of the atmosphere.

Second, Is the azote of the air absorbed by plants?

Third, Influence on vegetation of ammonia added to the air.

1*st*, The author remarks that, since the observation of M. Théodore de Saussure, that the air is mixed with ammoniacal vapours, three attempts have been made to determine the proportion of ammonia in the air: a million of kilogrammes of the air, according to M. Gräyer, contain 0·333 kil. $A2H^3$; according to Mr Kemp 3·880 kil.; according to M. Frésenius, of the air of the day, 0·098 kil., and of night air, 0·169 kil. He states that he has shewn the cause of these discrepancies, and proved that the quantity of ammonia contained in the air is 22·417 grms. for a million of kilogrammes of the air; and that the quantity oscillates between 17·14 grms. and 29·43 grms.

2*d*, The author states that though the azote of the air is absorbed by plants, the ammonia of the air contributes nothing to this absorption. Not that ammonia is not an auxiliary of vegetation, but the air contains scarcely 0·0000000224, and in this proportion its effects are inappreciable. These conclusions are founded upon a great number of experiments in which the plants lived at the expense of the air without deriving anything from the soil. For the present he confines himself to laying down these two conclusions:—1. The azote of the air is absorbed by plants, by the cereals, as by all others. 2. The ammonia of the atmosphere performs no appreciable part in the life of plants, when vegetation takes place in a limited atmosphere. After describing the apparatus by means of which he carried on his experiments on the vegetation of plants placed in a soil deprived of organic matter, and the manner in which the experiments were conducted, he adduces the results of these experiments in proof of the above conclusions.

3*d*, With reference to the influence of ammonia on vegetation, the author states, that if ammonia be added to the air, vegetation becomes remarkably active. In the proportion of 4 ten-thousandths the influence of this gas shews itself at the end of eight or ten days, and from this time it manifests itself with a continually increasing intensity. The leaves, which at first were of a pale-green, assume a deeper and deeper tint, and for a time become almost black; their petals are long and upright, and their surface wide and shining. In short, when vegetation has arrived at its proper period the crop is found far beyond that of the same plants grown in pure air; and, weight for weight, they contain twice as much azote. Besides these general effects there are others which are more variable, which depend upon particular conditions, but which are equally worthy of interest. In fact, by means of ammonia we can not only stimulate vegetation, but, further, we can modify its course, delay the action of certain functions, or enlarge the development and the modification of certain organs. The author further remarks, that if its use be ill-directed, it may cause accidents. Those which have occurred in the course of his experiments appear to him to throw an unexpected light upon the mechanism of the nutrition of plants. They have at least taught him at the expense of what care ammonia may become an auxiliary of vegetation. These experiments, which were made under the same conditions as those upon the absorption of azote, are then described, and their numerical results given.

To the conclusions already stated, the author adds that there are periods to be selected for the employment of ammonia, during which this gas produces different effects. If we commence its use when several months intervene before the flowering season of the plants, it produces no disturbance; they follow the ordinary course of their vegetation. If its use be commenced at the time of flowering, this function is stopped or delayed. The plant covers itself with leaves, and if the flowering takes places all the flowers are barren.—(*Proceedings of the Royal Society of London.*)

MISCELLANEOUS.

18. *On Extinguishing Fires by Steam.*—After the burning of the Amazon, Henry Clay, and M. Dujardin of Lille, recalled the fact that in 1837 it was proposed to employ steam for extinguishing fires; as was also mentioned by M. Fourneyron soon after the disaster of the Amazon. It may be added that the process proposed by M. Dujardin has been tried with full success during a fire that occurred in the galvano-plastic workshops of MM. Christoffe at Paris. The fire had already made great progress, and threatened a complete destruction of the buildings before aid could be had. At this crisis, some one present suggested the idea of opening the valve of the boiler which feeds the engine, and immediately the steam penetrated through the workshops, the fire was seen to diminish, and soon was reduced to so trifling an extent, that it was easily mastered when aid arrived.

This fact cannot have too great publicity; and it is especially important that manufacturers, captains of vessels, and superintendents of workshops, should be familiar with it.—(*American Journal of Science and Arts.*)

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