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.

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LIST OF PRIZES OFFERED BY THE ROYAL SCOTTISH SOCIETY OF ARTS FOR SESSION 1846-47.

The ROYAL SCOTTISH SOCIETY OF ARTS proposes to award Prizes of different values (none to exceed Thirty Sovereigns), either in Gold or Silver Medals, Silver Plate, or Money, for approved Communications relative to Inventions, Discoveries, and Improvements in the *Mechanical* and *Chemical* Arts in General, and also to means by which the *Natural Productions* of the Country may be made more available; and, in particular, to—

I. Inventions, Processes, or Practices from Foreign Countries, not generally known or adopted in Great Britain—such as the Manufacture of Glass Pipes for conveying Water, Gas, &c.

II. Notices of Processes in the Useful Arts practised in this Country, but not generally known.

III. Experiments applicable to the Useful Arts.

IV. Practical Details of Public or other Undertakings of National Importance, not previously published.

V. Discovery of Substitutes for Hemp and Flax, &c.

VI. Inventions, Discoveries, or Improvements in the Useful Arts, including the *Mechanical* and *Chemical;* and in the Mechanical Branch of the *Fine Arts;* such as the following, viz.:—

1. *Mechanical Arts.*

1. Methods of rendering large supplies of Water available, for the purpose of extinguishing Fires; and the best application of Manual, or other Power,

to the working of Fire-Engines—of Filtering Water in large quantities—of Economising Fuel, Gas, &c.—of Preparing Superior Fuel from Peat—of Preventing Smoke and Noxious Vapours from Manufactories—of Warming and Ventilating Public Edifices, Private Dwellings, &c.—of Constructing Economical and Salubrious Dwellings for the Working Classes, especially in Towns—of Making Cheap and Wholesome Bread from Maize, or Buckwheat, or from Mixtures of these with other Substances.

2. Inventions or Improvements in the Manufacture of Iron and other Metals, simple or alloyed—in the Manufacture of Writing and Printing Paper—in Tuyeres for Blast Furnaces—in the Making and Tempering of Steel—in Gilding Brass equal in Colour to the French—in Artificial Pavement—in Balance, Pendulum, or Electro-Magnetic Time-Keepers—in Screw-cutting—in Printing-Presses—in Stereotyping, and in cleaning the plaster from the Types—in Furnaces and other Apparatus used in Stereotyping—in Type-Founding—in the Composition of Printers' Rollers—in Ship-Building, with regard to Ventilation, both for the Crew and the Timbers—in Currying and Tawing of Leather—in Preparing Black Polished Leather equal to the French—in Stationary and Locomotive Engines—in Railway Wheels and Axles—in Railway Telegraphs and Signals—in Smith-Work and Carpentry—in Tools, Implements, and Apparatus for the various trades—in Electric, Voltaic, and Magnetic Apparatus.

2. *Chemical Arts.*

Improvements in Fine Glass for Optical Purposes, free from Veins, and of a Dense and Transparent quality, equal or superior to the best Continental Glass—also in hard Infusible Glass for Chemical Purposes—in the Annealing of Glass—in the Manufacture of Writing Inks, both Common and Copying, so as to flow freely from Metallic Pens—in the Dissolving of Caoutchouc, and applying it to useful purposes.

3. *Relative to the Fine Arts.*

Improvements in Patterns of Porcelain, Common Clay or Metal, of Domestic Articles of simple and beautiful Forms, without much Ornament, and of one Colour—in the Preparation of Lime and Plaster for Fresco Painting, and in appropriate Tools for laying the Plaster with precision—in Calotype, Daguerreotype, and Electrotype—in the Production of Artificial Light as nearly of the quality of Day-Light as possible—in Engraving on Stone—in the application of Daguerreotype and Calotype to the Stone for Lithographic Printing—in Die-sinking—in Wood-cutting and other methods of illustrating Books to be printed with the Letter-Press—in Printing from Wood-cuts, &c.—in Ornamentel Metallic Casting—in Constructing Buildings on the most correct Acoustic Principles.

The SOCIETY also proposes to award the KEITH PRIZE, value Thirty Sovereigns,

For some important " Invention, Improvement, or Discovery, in the Useful Arts, which shall be primarily submitted to the Society," betwixt and 1st April 1847.

By order of the Society,

James Tod, *Secretary.*

Edinburgh, 13*th April* 1846.

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Is it possible, in the present state of our knowledge, to foretel what Weather it will be at a given time and place? Have we reason, at all events, to expect that this problem will one day be solved? By M. ARAGO, Perpetual Secretary of the French Academy of Sciences, &c. &c.

Engaged as I am, both from inclination and duty, in meteorological studies, I have often asked myself if we should ever be able, by a reference to astronomical considerations, to determine, a year in advance, what shall be the state, in a given place, of the annual temperature, the temperature of each month, the quantities of rain compared with the ordinary mean, the prevailing winds, &c.

I have already laid before the readers of the *Annuaire* the results of the investigations undertaken by natural philosophers and astronomers, regarding the influence of the moon and of comets on the changes of the weather. These results clearly shew, in my opinion, that the influences of both these bodies are almost insensible, and, therefore, that the prediction of the weather can never be a branch of *astronomy, properly so called.* And yet our satellite and comets have, at all periods, been considered as preponderating stars in meteorology.

Since the publication of these opinions, I have regarded the problem in another aspect. I have considered whether the operations of man, and occurrences which will always remain beyond the range of our foresight, might not be of such a nature as to modify climates accidentally, and in a very sensible manner, in particular with regard to temperature. I already perceive that facts will answer in the affirmative. I should have wished, however, not to publish this result till after I had finished my investigations; but I must frankly own, that I wished to have an opportunity of *protesting decidedly against the predictions which have every year been attributed to me, both in France and in other countries.* Never has a word escaped my lips, either in private or in the course which I have delivered for upwards of thirty years; never has a line published with my consent, authorised any one to imagine it to be my opinion that it is possible, in the present state of our knowledge, to announce, with any degree of certainty, what weather it will be a year, a month, a week, I shall even add, a single day, in advance. May the indignation I have felt at seeing a multitude of *ridiculous predictions* appear under my name, not constrain me, by the force of reaction, to give an exaggerated degree of importance to the disturbing causes I have enumerated! At present, I believe that I am in a condition to deduce from my investigations the important result which I now announce; *Whatever may be the progress of the sciences,* NEVER *will observers who are trustworthy, and careful of their reputation, venture to foretel the state of the weather.**

* This explicit declaration may give me a right to expect that I shall no longer be compelled to play the part of Nostradamus or Mathew Lænsberg; but I am far from indulging in any illusion on this subject. Hundreds of persons who have gone through a regular course of university studies, will not fail, in 1846, as they had done on former occasions, to ply me with such questions as the following, which it is truly pitiable to hear in the present day: Will the winter be severe? Think you that we shall have a warm summer, a humid autumn? This is a very long and destructive drought; do you think it is near an end? People think that the April moon will produce great mischief this season—what is your opinion? &c. &c. In spite of the little confidence I have in predictions, I affirm that in this case the event will not deceive me. Nay, for some years past have I not been put to a still severer proof? Has not a work been published, entitled "*Lectures on Astronomy, delivered at the Observatory by M. Arago, collected by one of his Pupils?*" I have protested a dozen times against this work; I have shewn that it swarms with inconceivable errors; that it is beneath all criticism whenever the author ceases to employ his scissors on the notices of the *Annuaire,* and is reduced to the necessity of

I repeat, that the readers of the *Annuaire* ought not to expect to find here a complete investigation of the problem which I have taken up. My sole intention is to lay before them *a few facts*, which, taken in connection with those which I shall analyse in a second notice, appear to me to lead to this conclusion.

Between what limits the mean temperatures of years and months vary in our climates.

The meteorological state of a given place, is much less variable than those would be led to believe who judge of it by their personal sensations, by vague recollections, or the condition of the crops. Thus, at Paris, the mean temperature of years ranges within very narrow limits.

The annual mean temperature of Paris, from 1806 to 1826 inclusive, has been + 10°·8 centigrade (54°·4 Fahr.) The *greatest* of 21 annual means does not exceed the general mean by more than 1°·3 (2°·3 F.); the *lowest* of the mean annual temperatures has been found below the general mean only by 1°·4. (2°·5 F.) As far as relates to *mean annual temperatures*, systematic meteorologists have, therefore, no need of foresight to predict only slight perturbations. The causes of disturbance will satisfy all the phenomena, if they can produce, more or less, 1°·5 of centigrade variation (2°·7 F.)

It is not the same with regard to the months. The differences between the general means and the partial means extend, in January and December, to 4 and 5 centigrade degrees (7° to 9° F.)

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drawing a few lines from his own resources. Vain efforts! These pretended Lectures on Astronomy at the Observatory have, however, reached no less than a fourth edition. The laws have made no provision against what I shall call this *scientific calumny*. What must be done when the law is silent? Submit with resignation? A sensitiveness which will not appear surprising to any who have seen the book in question, will not allow me to be satisfied with resignation. My position having become intolerable, I have made up my mind to publish myself the Lectures which have been so outrageously disfigured. Since it has become necessary, I shall abandon for a time the plans for original investigations which I had formed, and devote the time I wished to employ in delicate experiments, fitted to illustrate points of the science still enveloped in great obscurity, to the preparation of a work intended to popularise astronomy. May this work be in some degree useful.

In consequence of these variations, if we compare the extreme temperatures of each month with the mean or normal temperatures of all the rest, we shall find :—

That the month of *January* is sometimes as temperate as *the mean of the month of March.*

That the month of *February* sometimes resembles the mean second fortnight of April, or the mean first fortnight of January.

That the month of *March* sometimes resembles the mean of the month of April, or the mean of the second fortnight of January.

That the month of *April* never reaches the temperature of the month of May.

That the month of *May* is pretty frequently, in the mean, warmer than certain months of June.

That the month of *June* is sometimes, in the mean, warmer than certain months of July.

That the month of *July* is sometimes, in the mean, warmer than certain months of August.

That the month of *August* is sometimes, in the mean, slightly colder than certain months of September.

That the month of *September* is sometimes, in the mean, colder than certain months of October.

That the month of *October* may be, in the mean, nearly 3° (5°·4 F.) colder than certain months of November.

That the month of *November* may be, in the mean, about 5°·5 (about 10° F.) colder than the warmest months of December.

That the month of *December* may be, in the mean, 7° (12°·6 F.) colder than the month of January.

Disturbing causes of Terrestrial Temperature which cannot be foreseen.

The atmosphere which, on a given day, rests upon the sea, becomes in a short time, in mean latitudes, the atmosphere of continents, chiefly from the prevalence of westerly winds. The atmosphere derives its temperature, in a great measure, from that of the solid or liquid bodies which it envelops. Every thing, therefore, which modifies the normal temperature of the sea, produces, sooner or later, perturbations in the temperature of continental atmospheres. Are those causes, which may sensibly modify the temperature of a considerable portion of the ocean, placed for ever beyond the foresight of man? This problem is closely connected with the meteorological question I have undertaken to consider. Let us endeavour to find the solution of it.

No one can doubt that the *ice-fields* of the Arctic pole—the immense frozen seas—exert a marked influence on the climates of Europe. In order to appreciate in numbers the importance of this influence, it would be necessary to take into account at once the extent and position of these fields; but these two elements are so variable that they cannot be brought under any certain rule.

The eastern coast of Greenland was in former times accessible and well peopled. All of a sudden an impenetrable barrier of ice interposed itself between it and Europe. For many ages Greenland could not be visited. About the year 1815 this ice underwent an extraordinary breaking up, became scattered in a southerly direction, and left the coast free for many degrees of latitude. Who could ever *predict* that such a dislocation of the fields of ice would take place in such a year rather than in another?

The floating ice which ought to act most on our climates, is that known by the English name of *icebergs*. These mountains of ice come from the *glaciers*, properly so called, of Spitzbergen or the shores of Baffin's Bay. They detach themselves from the general mass, with a noise like that of thunder, when the waves have undermined their base, and when the rapid congelation of rain-water in their fissures produces a sufficient expansion to move these huge masses and push them forward. Such causes, and such effects, will always remain beyond the range of human foresight.

Those who remember the recommendations which the guides never fail to give upon approaching certain walls of ice, and the huge masses of snow placed upon the inclined ridges of the Alps; those who have not forgotten that, according to the affirmations of these experienced men, the report of a pistol, or even a mere shout, may produce frightful catastrophes, will agree in the opinion I have just expressed.

Icebergs often descend without melting, even to pretty low latitudes. They sometimes cover immense spaces; we may therefore suppose that they sensibly disturb the temperature of certain zones of the oceanic temperature, and then, by means of communication, the temperature of islands and continents. A few instances of this will not be out of place.

On the 4th October 1817, in the Atlantic Ocean, 46° 30′ north latitude, Captain Beaufort fell in with icebergs advancing southwards.

On the 19th January 1818, on the west of Greenspond, in Newfoundland, Captain Daymont met with floating islands. On the following day, the vessel was so beset with ice that no outlet could be seen even from the top-masts. The ice, for the most part, rose about 14 English feet above the water. The vessel was carried southwards in this manner for twenty-nine days. It disengaged itself in 44° 37′ latitude, 120 leagues east of Cape Race. During this singular imprisonment, Captain Daymont noticed upwards of a hundred icebergs.

On the 28th March 1818, in 41° 50′ north latitude, 53° 13′ longitude west of Paris, Captain Vivian felt, during the whole day, an excessively cold wind blowing from the north, which led him to suppose that ice was approaching. And, in fact, on the following day, he saw a *multitude* of floating islands, which occupied a space of upwards of seven leagues. "Many of these islands," says he, "were from 200 to 250 English feet high above the water."

The brig *Funchal*, from Greenock, met with *fields of ice* on two different occasions, in her passage from St John's, Newfoundland, to Scotland; first on the 17th January 1818, at the distance of six leagues from the port she had left; and afterwards, in the same month, in latitude 47° 30′. The first field was upwards of three leagues broad, and its limit in a northern direction could not be seen. The second, likewise very extensive, had an immense iceberg in its centre.

On the 30th March 1818, a sloop of war, *The Fly*, passed between two large islands of floating ice in 42 degrees of north latitude.

On 2d April 1818, Lieutenant Parry met with icebergs in 42° 20′ of north latitude.

This year (1845) the English vessel *Rochefort* continued enclosed, at the end of April and beginning of May, for twenty-one consecutive days, in a mass of floating ice, which ran along the bank of Newfoundland, advancing to the south.

The sea is much less easily heated than the land, and that, in a great measure, because the water is diaphanous. Every thing, therefore, which causes this diaphaneity to vary considerably, will produce sensible changes in the temperature of the sea, immediately after in the temperature of the oceanic atmosphere, and, somewhat later, in the temperature of the continental atmosphere. Do causes exist, independently of what science discovers to us, which may interfere with the transparency of the sea to a great extent? Let the following be my answer :—

Mr Scoresby has shewn, that, in northern regions, the sea sometimes assumes a very decided *olive-green* colour; that this tint is owing to medusæ and other minute animalculæ; and that wherever the green colour prevails the water possesses very little diaphaneity.

Mr Scoresby occasionally met with green bands, which were from two to three degrees of latitude (60 to 80 leagues) in length, and from 10 to 15 leagues broad. The currents convey these bands from one region to another. We must suppose that these do not always exist; for Captain Phipps, in the account of his voyage to Spitzbergen, makes no mention of them.

As I have just stated, the green and opaque portions of the sea must become heated in a manner different from the diaphanous parts. This is a cause of variation in the temperature which can never be subjected to calculation. We can never know beforehand whether, in such and such a year, these countless myriads of animalculæ will be more or less prolific, and what will be the direction of their migration southwards.

The phosphorescence of the sea is owing to minute animals of the medusa kind. The phosphorescent regions occupy very large spaces—sometimes in one latitude, sometimes in another. Now, as the water of the phosphorescent spaces is quite turbid, and as its diaphaneity is almost entirely destroyed, it may become, by its abnormal heating, a cause of notable disturbance in the temperature of the oceanic and continental atmospheres. Who can foresee the intensity of this cause of thermic variation? who can ever know beforehand the place which it occupies?

Let us suppose the atmosphere immobile and perfectly clear. Let us suppose, moreover, that the soil has everywhere, in an equal degree, absorbing and emissive properties, and the same capacity for heat; we should then observe throughout the year, as the effect of solar action, a regular and uninterrupted series of increasing temperatures, and a corresponding series of decreasing temperatures. Each day would have its invariable temperature. *Under every determined parallel*, the days of the maximum and minimum of heat would be respectively the same.

This regular and hypothetical order is disturbed by the mobility of the atmosphere; by clouds more or less extensive, and more or less permanent; and by the diverse properties of the ground. Hence the elevations or depressions of the normal heat of days, months, and years. As disturbing causes do not act in the same way in every place, we may expect to see the primitive figures differently modified; to find comparative inequalities of temperature where, from the nature of things, the most perfect equality might have been looked for.

Nothing is better calculated to shew the extent of these combined disturbing causes, than the comparison of *mean* *epochs*, indicating the maxima and minima temperatures in different places. The following are some of these results :—

	Maximum.	Minimum.	
St Gothard, (10 years.)	11th August.	24th December.	51 and 3 days after the solstice.
Rome, (10 years.)	6th August.	8th January.	46 and 18 days after the solstice.
Jena, (18 years.)	1st August.	3d January.	41 and 14 days after the solstice.
Petersburg, (10 years.)	22d July.	8th January.	31 and 18 days after the solstice.
Paris, (21 years.)	15th July.	14th January.	25 and 25 days after the solstice.

These differences belong to the localities. But when concealed local circumstances exert so much influence, is it not natural to think that the modifications which they receive from the hand of man may sensibly alter, in the interval of a few years, the meteorological type of every town in Europe ?

I have shewn that local circumstances which are latent, or at least faintly characterized, may exert sensible and constant influences on the manner in which the maxima and minima of temperature are distributed in the year. When science shall be put in possession of exact and comparable meteorological observations, made *simultaneously* in different places; when these observations shall be scrupulously and judiciously digested, we shall very probably find that circumstances of locality will occupy a much more prominent place in science than natural philosophers seem now disposed to attribute to them. It would not be difficult for me, at this moment, to mention circumscribed districts which have completely escaped the severe colds to which the surrounding countries were subjected. The *Sables d' Olonne*, for example, and the neighbouring districts, six leagues in circuit, formed, during the winter of 1763 and 1764, a kind of *thermal oasis.* The Loire was frozen near its mouth; an intense cold of—10 degrees centigrade (14° F.), interrupted all agricultural operations in the districts which the river traverses. In the *Sables* the weather was mild : this little canton escaped the frost.

The following is a still more extraordinary fact than the preceding, for it takes place every year.

There is in Siberia, M. Erman has informed us, *an entire district*, in which, during the winter, the sky is constantly clear, and where a single particle of snow never falls.

I am willing to overlook the perturbations of the terrestrial temperatures which may be connected with *a greater or less abundant emission of light or solar heat*, whether these variations of emission depend on the number of spots which are found *accidentally* scattered over the sun's surface, or whether they originate in some other unknown cause; but it is impossible for me not to draw the reader's attention to the obscurations to which our atmosphere is from time to time subject, without any assignable rule. These obscurations, by preventing the light and solar heat from reaching the earth, must disturb considerably the course of the seasons.

Our atmosphere is often occupied, over spaces of considerable extent, by substances which materially interfere with its transparency. These matters sometimes proceed from volcanoes in a state of eruption. Witness the immense column of ashes which, in the year 1812, after having been projected from the crater of the island St Vincent to a great height, caused at mid-day a darkness like that of night in the island of Barbadoes.

These clouds of dust appear, from time to time, in regions where no volcano exists. Canada, in particular, is subject to such phenomena. In that country recourse has been had, for an explanation, to the burning of forests. The facts do not always appear to agree exactly with this supposition. Thus, on 16th October 1785, at Quebec, clouds of such obscurity covered the sky, that it was impossible, even at noon, to see in what direction one was going. These clouds covered a space of 120 leagues in length by 80 broad. They seemed to come from Labrador, a country very thinly wooded; and they presented none of the characters of smoke.

On the 2d July 1814, clouds similar to the above surrounded some vessels in the open sea on their way to the River St Laurence. The great obscurity lasted from the evening of the 2d till the afternoon of the 3d.

With regard to the object we have here in view, it is of little importance whether we ascribe these clouds, capable as they are of completely obstructing the solar rays, to the burning of forests and savannahs, or to emanations from the earth. Their formation, and their arrival in a given place, will remain equally beyond the predictions of science; the variations of temperature, and meteors of every kind which may be caused by these clouds, will never be pointed out beforehand in our meteorological almanacs.

The accidental darkening of the air, in 1783, embraced so extensive a space (from Lapland to Africa), that it was ascribed to the matter belonging to the tail of a comet, which, it was alleged, had mingled with our atmosphere. It is out of the question to maintain that an accidental state of the atmosphere, which enabled us, for a period of nearly two months, to look at the sun at mid-day with the naked eye, was without influence on terrestrial temperatures.

Forests cannot fail to exercise a sensible influence on the temperature of the surrounding regions; because, for example, snow remains there for a much longer time than in the open country. The destruction of forests, therefore, ought to produce a modification in our climates.

In given instances, what is the precise influence of forests, estimated by the centigrade thermometer? The question is very complicated, and *has not hitherto been solved.*

In all very mountainous regions, the valleys are traversed by periodical diurnal breezes, particularly sensible in May, June, July, August, and September. These breezes ascend the valleys, from seven or eight o'clock in the morning to three or four in the afternoon, the time when they reach their greatest force, and from four o'clock to six or seven in the evening. For the most part they blow with the force of a decided wind, and sometimes with that of a violent wind; they must, therefore, exert a sensible influence on the climates of the countries which lie around these valleys.

What is the cause of these breezes? Every thing concurs to shew that the cause is to be found in the manner in which the solar rays warm the central mass whence these valleys radiate. Suppose this mass to be naked, then you have a certain effect; substitute tufted forests for arid rocks, and the phenomenon will assume another character, at least with regard to intensity.

This is one of the twenty ways in which the clearing of woods affects climates. Before putting his hand to the task of arranging his *predictions*, the manufacturer of almanacs ought, therefore, to enter into a correspondence with all the wood-cutters of every country.

In North America, the interior of the continent does not enjoy, in the same latitudes, the same climate as the coasts. By the influence of lakes, this difference disappears with respect to all the points where the distance from these great masses of water is not considerable.

We must, therefore, expect that the drying up of a lake will modify the climate of the neighbouring region; and that a vast inundation, arising from the unexpected rupture of a barrier, will produce for a time an opposite effect.

If any one should exclaim against me on seeing me register causes, each of which, taken by itself, does not seem capable of producing a very great effect, my reply would be,—We have to consider an influence as a whole, and in every case the perturbations which it is our object to explain, are far from being so extensive as the *public supposes.*

According to Howard, the mean temperature of London *exceeds* that of the neighbouring country, about a *centigrade degree* (1°·8 F.)

The difference between the two temperatures is not the same at all seasons.

Electricity.

We could not well avoid arranging electricity among the causes which have a striking influence on climatological phenomena. Let us go farther, and inquire whether the operations of man may disturb the electrical state of an entire country.

Clearing the wood from a mountain is the destruction of a number of lightning-conductors equal to the number of trees felled; it is the modification of the electrical state of an entire country; the accumulation of one of those elements indispensable to the formation of hail, in a locality where, previously, this element was dissipated by the silent and incessant action of the trees. On this point, observations support theoretical deductions.

According to a detailed statistical account, the losses occasioned by hail in the continental states of the king of Sardinia, from 1820 to 1828 inclusively, amount to the sum of *forty-six millions* of francs. Three provinces, those of *Val d'Aoste*, the *Vallée de Suze*, and *Haute Maurienne*, do not appear in these tables; they were not visited with hail storms. *The mountains of these three provinces are the best wooded.*

Of the warmest provinces, that of Genoa, the mountains of which are well covered, is scarcely ever visited by this meteor.

Atmospheric electricity gives rise to phenomena, which are immense from their extent. They seem, however, to owe their origin to causes purely local. Their propagation likewise takes place under circumscribed influences, in particular zones, and these sometimes rather narrow.

On the 13th July 1788, in the morning, a hail-storm commenced *in the south of France*, traversed, in a few hours, the whole length of the kingdom, and thence extended to the low countries and Holland.

All the districts in France injured by the hail, were situated in two parallel bands, running south-west and north-east. One of these bands was 175 leagues long; the other about 200.

The mean breadth of the most western hail band was 4 leagues, the other only 2 leagues. On the space between these two bands, rain only fell; its mean breadth was 5 leagues. The storm moved from the south to the north with a rapidity of about 16 leagues an hour.

The damage occasioned in France, in the 1039 parishes visted by the hail, appeared, from official inquiry, to amount to twenty-five millions (one million sterling.)

This, certainly, must be regarded as a considerable atmospheric commotion, whether we regard the material devastation it produced, or the influence which the displacement of the air, and the mass of hail deposited on the surface of two long and broad bands of country, must have exercised on the normal temperature of a great number of places. Could meteorologists, however skilled, have been able to foresee it?

The origin of the two bands was in the district of Aunis, and in Saintonge. Why there, and not elsewhere? Why did not the storm commence at another point of the parallel of latitude, passing by its meridional extremities? Because, it will be answered, in Aunis and in Saintonge, on the 13th July 1788, the conditions of electricity and temperature were eminently favourable for the production of a hail-storm, and an accompanying hurricane directed from the south-south-west to the north-north-east. Admitted; but were not these thermal and electrical conditions favourable to the production of a storm, ultimately connected with agricultural operations, with the existence of such and such a mass of trees, with the state of irrigation, with circumstances varying according to the wants and caprice of men? With regard to temperature, no one can hesitate in his reply. In the other particular, the connection will appear not less evident if I bring to mind that evaporation is a fertile source of electricity, and that various natural philosophers have even included vegetation among the causes which generate this same fluid in the atmosphere.

If it be true, as has been alleged, that, *in certain cases*, the flame and smoke which issue from the mouth of a furnace, or from the chimney of a manufactory, may deprive the atmosphere of all electricity for many leagues around, the *prophets* in meteorology, will be placed in an additional difficulty. It will be necessary that they should know beforehand all the plans of the masters of forges and proprietors of manufactories.

According to all that we most certainly know respecting the physical cause of water-spouts, and according to M.

Espy's theory, sometimes no more is necessary than an ascending current produced by the chimney of a manufactory, to give rise to one of these formidable meteors.

Rain.

It is said to have been remarked in Italy, that, in proportion as rice-fields multiply, the annual quantity of rain has gradually increased, and that the number of rainy days has augmented in proportion.

Can it be imagined, that such circumstances as these can ever be taken into account, in the combinations of the almanac-manufacturers?

In the tropical regions of America, the natives regard repeated shocks of earthquake, as welcome precursors of fertilizing rains. Humboldt even relates, that violent shocks suddenly brought on the *rainy season,* a considerable time before the ordinary period.

It is not probable that the influence of earthquakes is exerted only in the vicinity of the equator. The power of predicting rain must, therefore, suppose an anticipatory knowledge of the number and strength of the shocks, which are to be felt in the region for which the *astrologer works.*

The following passage occurs in Bacon's works:—"Some historians allege that, at the time when Guyenne was still in the power of the English, the inhabitants of Bordeaux and the neighbouring cantons made a request to the king of England, to induce him to prevent his subjects of the counties of Sussex and Hampton, from burning the heaths in the end of April, as they usually did; because they thereby gave rise, it was affirmed, to a wind which proved very hurtful to their vines."

I know not how far there were grounds for this request, as the distance of Bordeaux from the county of Sussex is very considerable; but I must not fail to mention, that natural philosophers are now disposed to assign a no less extraordinary part to conflagrations. In the United States, a well known philosopher, M. Espy, adopting the opinions prevalent among the natives of the New Continent, from Canada to Paraguay, has recently proposed to produce, in times of drought, *artificial rains*, and his means of doing so is by kindling large fires.* In support of his scheme, M. Espy mentions the following:—

The opinion of the Indians of Paraguay, who, according to the report of the missionaries, set fire to vast savannahs when their crops are threatened with drought, and allege that they thus produce even *storms accompanied with thunder*;

The opinion of the colonists of Louisiana, and the *success from time immemorial of burning the prairies* in that State;

The opinion of the population of Nova Scotia, respecting the consequences of burning forests;

The opinion and practice of the colonists of the districts of Delaware and Otsego, &c., &c.

M. Espy says, that he has assured himself, in various ways, that the climate of Manchester has undergone gradual and sensible modifications, in proportion as manufacturing industry has increased. Since that city has become, so to speak, a vast furnace, *it rains there more or less every day*. Those who pretend that the deterioration of the climate is not so considerable, assure us that it does not rain at Manchester more than *six* days in the seven!

Suppose these facts to be as averred. The predictions of rain, in a given place, will often be overturned by accidental fires, and by the fires of manufactories.

Space and time will not allow me to point out the multitude of local causes which may exercise a great influence on the direction and force of the wind. I shall discuss this delicate question in another notice. At present, I shall confine myself to a remark well-fitted to enlighten those who, from want of meteorological instruments, take for their guides the

* It has long been an opinion entertained by the peasantry in the south of Scotland (we know not whether the belief prevails elsewhere), that *muir-burn*, or the burning, in the spring, of old heather and other plants, in order to produce a more tender and nutritious vegetation, a practice which was once very general, has a decided tendency to produce a change of weather, and to bring on rain.—*Ed.*

state of the crops and of vegetation. It may be expressed in the following formulary; the wind exercises a *direct action* on vegetables, often very injurious, and which ought to be carefully distinguished from climatological action. It is against this direct action, that curtains of wood, by forming a shelter, are especially useful.

The *direct* influence of the wind, on the phenomena of vegetation, is nowhere more strikingly exemplified than in the Isle of France. The south-east wind, very healthy both for man and animals, is, on the contrary, a perfect scourge to the trees. Fruit is never found on the branches directly exposed to this wind; none is to be found but on the opposite side. Other trees are modified even in their foliage; they have only half a head, the other has disappeared under the action of the wind. Orange and citron trees become superb in the woods. In the plain, and where they are without shelter, they always continue weak and crooked.*

On the Ichthyological Fossil Fauna of the Old Red Sandstone. By Professor AGASSIZ.

The greater part of zoological treatises, which embrace the natural history of the animal kingdom in its whole extent, represent animals as forming a continuous series, setting out with the Zoophytes, and terminating in Man, passing through the intermediate types of radiata, mollusca, articulata, and vertebrata. Sometimes they place the mollusca, at other times the articulata, in the second or third rank, according to the ideas their authors have formed of the superiority of these types. Others, while they admit a gradation of animals from the invertebrate to the vertebrate, do not uniformly construct an ascending scale of the former in order to reach the latter, but place the radiata in the inferior degree of organization, and, by diverging in two different directions, pass to the mollusca and articulata, which they regard as parallel groups, afterwards converging to-

* Annuaire pour l'an 1846.

wards the vertebrata, as towards the culminating type of animality. Others admit many series, whether parallel, or diverging and variously combined; each according to his own views. Finally, there are others who consider the great divisions of the animal kingdom, as well as the particular classes, as equivalent groups, which do not admit of gradation, and each of which represents a separate mode of existence, as perfect in its sphere as any other group whatever. According to this mode of viewing the subject, there can be no gradations in nature.

It is evident that if these systems are true, they ought to be confirmed by the study of fossil animals, and their mode of existence in anterior creations. Now none of these modes of considering the subject appears to me to answer to the primitive order of things, such as the study of fossils has enabled me to observe in the relations which have existed from the most ancient times between all the classes of the animal kingdom.

The first important fact opposed to these systems being regarded as a true and complete expression of the natural relations which connect organized beings with each other, is the certainty which we have acquired, for about a quarter of a century, that the animals now living on the surface of the globe constitute but a small proportion of those which formerly inhabited it. And if this be the case, must not any attempt to unite all animals in the same plan, in classifications founded only on the study of living species, be extremely arbitrary, especially since it has been demonstrated that the appearance and disappearance of extinct types correspond to determinate epochs? Accordingly, the necessity of a more complete system is felt more strongly every day, in proportion as we discover a greater number of extinct genera, families, and even entire orders. The systems which regard the animal kingdom, viewed as a whole, as produced all at the same time, as composed of contemporaneous types, and capable of being placed in the same rank, with regard to their natural value, evidently do violence to primitive relations, and to the chronological order of creation. Before proceeding to classify organized beings, it is neccessary, in our day, to form, in the first place, a correct idea of the period of their appearance. This manner of viewing biological questions has become as essential as the organization itself of living beings, taken as the basis of their systematic arrangement. In order to acquire a truly philosophical knowledge of animals in general, we ought, therefore, to endeavour, before every thing else, to determine the state of the animal kingdom at the time of its first appearance on the surface of the globe; then to study the organic changes it has undergone in the different epochs which have preceded the establishment of the present order of things; and, lastly, to specify, as far as possible, the geological limits of these intermediate changes. At no period have geologists made greater and more constant efforts than in our own day, to determine the relative ages of the different formations which constitute the stratified crust of our globe, and the rigorous limits of formations. These investigations have naturally led to a greater subdivision of the epochs hitherto admitted as distinct. As the study of fossils has been pursued with an always increasing accuracy, so it has furnished means of characterising them, always increasing in precision. To such a degree has this been the case, that the opinion which admits many distinct and independent creations, is always obtaining more and more influence in the minds of palæontologists. It is even easy to foresee that in a little we shall be obliged to circumscribe the limits of geological formations more and more, in proportion as the knowledge of characteristic fossils, peculiar to the different stages of the formations actually admitted, shall more evidently represent them to us as independent systems, differing at once from those that have preceded and followed them. We shall thus be led to admit a very considerable number of independent creations, each characterised by a particular assemblage of peculiar vegetable and animal species, imbedded in a system of strata deposited during the existence of these organized beings, or in consequence of the cataclysms which attended their destruction. Ere long we shall have to do, not merely with primary, secondary, or tertiary epochs, nor even simply with palæozoic, triassic, jurassic, or cretaceous periods, but rather with cambrian, silurian, devonian, coal, permian creations, &c., as assemblages of organized beings equivalent to the whole living beings now on the surface of the globe, or as geological epochs which, from their importance, admit of comparison with that to which we belong, and which goes back to the establishment of the order of things which prevails on the earth in our own day. Indeed, I have no doubt that the truth of what I now affirm will, in a few years, be generally admitted, and that the greater part of the subdivisions of our present classification of geological formations, will be regarded as independent formations, and the fossils which they contain as representatives of distinct creations. To be convinced of this, we have only to follow the progress of the most recent discoveries in palæontology. I need only refer to the works which have been published within the last fifteen years. The examination of genera, in countries the most remote, confirms these anticipations. I require no other proof than the beautiful discoveries of M. Lund respecting the fossil bones of Brazil, and the no less important researches of Messrs Falconer and Cautley on those of the sub-Himalayan hills. Everywhere, in the end, we discover, within very restricted vertical and horizontal limits, assemblages of fossil species as considerable as those with which we become acquainted by the study of the richest living faunas within similar geographical limits.

The study of the fishes of the old red sandstone, will furnish, I hope, a new argument in favour of the theory I advocate.

In order to point out more distinctly the ichthyological characters of the epoch during which these formations were deposited, it will not be superfluous to pass rapidly in review the phases of development in the principal types of animality at the principal epochs of their metamorphoses, and then shew in what manner these types were combined in the series of time. This will be the best introduction to the genetic study of the affinities of the presently existing families of the animal kingdom. Not wishing to bring forward a complete system in this place, I shall confine myself to laying before the reader the immediate consequences of the facts, both zoological and geological, which have of late been most carefully studied ; for the agreement between the zoological affinities and the geological division of types in the series of formations is so striking, especially in certain classes which have of late been the object of particular study, that I think it may now be laid down as a fact, that sytematic classifications which are not, at the same time, the expression of the succession of families in the order of time, can no longer be considered as expressing the real affinities existing among the animals which they embrace. The most fortunate approximations which naturalists have attempted at different epochs, have really received a striking confirmation by modern palæontological discoveries, and that often when those to whom we owe them were unconscious of it. These results are so striking, that even now, in some classes of animals, the knowledge of fossils, and their order of succession, may serve us as a guide to correct the zoological system, just as, on the other hand, the advanced state of our anatomical knowledge will lead us to a correct determination of the geological age of certain deposits, even although we should not discover in them any fossil species identical with those of well-determined formations of the same era. I shall even go further, for I can now foresee the time when these results will equally harmonize with the laws of the geographical distribution of animals on the surface of the globe; but the facts relating to this order of connection are not yet sufficiently known to induce me to enter upon the consideration of them on this occasion.

The most important result of modern palæontological researches, in reference to the present question, is the fact, no longer open to dispute, of the simultaneous appearance of particular types of all classes of invertebrate animals, from the most ancient periods of the development of life on the surface of the globe. We find, in fact, in the palæozoic formations, the fossil remains of radiata, mollusca, and articulata. We may even admit that the first representatives of all the classes of the three great branches are contemporaneous, for we find Polypes, Echinoderma, Acephala, Gasteropods, Cephalopods, and Testaceous and Crustaceous Vermes, in the most ancient fossiliferous formations; and if we have not hitherto discovered any Medusæ, it is much more natural to ascribe their absence to their extreme softness, than to suppose that they did not accompany, in ancient times, the types of the other classes of invertebrate animals, with which we always and everywhere find them associated in the presently-existing creation. Some of them, indeed, have been found at Solenhofen. With regard to insects, their existence has been already ascertained in the coal-formation, which, in my opinion, is much more intimately connected with the palæozoic than with the secondary formations, by the whole of its organic characters. It is, therefore, now demonstrated, that all the classes of invertebrate animals have appeared on the surface of the globe at the same time, and that they go back to the most ancient geological epochs; whence it follows, in a manner the most unquestionable, that we can no longer continue to regard them as forming a progressive series in their appearance, as has been so long imagined. For the detail of facts, and the nominal enumeration of species, I refer to the important works of Murchison, De Verneuil, D'Archiac, De Keyserling, and Roemer, on the palæozoic formations and their fossils; reserving for myself only a few observations on the vertebrate series, when I come to speak of the fossil fishes of the old red sandstone in particular.

Our actual knowledge of fossil Polypiers, taken as a whole, not being yet so far advanced as that of the living species, and the Acalephæ not having hitherto been observed, except in a few secondary deposits, I think I may dispense with speaking of them in this place, without any apprehension of thereby weakening the general results which flow from the particular examination of the other classes of invertebrate animals.

The interesting researches of MM. Miller, Goldfuss, D'Orbigny, Th. and Th. Austin, J. Müller, and Leop. de Buch, on living and fossil Crinoïdes; those of MM. J. E. Gray, J. Müller, and Troschel, on the Asteriæ and Comatulæ; my own, and those of MM. Valentin and Desor, on the living and fossil Echinidæ, including their anatomy; those of Professor E. Forbes, and my own, on the Echinoderms in general, and those of M. Tiedemann and many modern authors on their anatomy, have enabled us, of late years, to acquire a more complete acquaintance with these animals, than with those of any other division of the department of radiata, with the single exception of living polypes. Accordingly, the relations of the living and fossil types of the class of Echinoderms now appear in the most evident manner. The Crinoïdes are the prototype of the whole class. Not only does geology shew this, but also what we know of the first states of some species of this family (*Comatula* and *Pentacrinus Europæus*) equally confirms it. We may even say that the Crinoïdes present us with a kind of synthesis of all the families of this class, by the different forms they assume; for example, in the Cystides which remind us of the Echinidæ, or in the Melocrines, which make a near approach to the Asteriæ. It is only the Holothuriæ which seem to be exclusively confined to the present creation, and this family is precisely that which occupies the highest rank among the Echinoderms; while the Crinoïdes which occur at the lower part of this series, would appear to be the first; then come the Asteriæ, already numerous in the triassic formations; and, finally, the Echinidæ, whose greater development characterises the jurassic, cretaceous, and tertiary formations. But each of these formations has its particular forms, and even its own genera; the Crinoïdes of the palæozoic formations are not the same as those of the secondary formations, and they disappear almost entirely in the cretaceous and tertiary deposits, being no longer represented in the actual epoch, but by a few fixed species, and by Comatulæ, which go back, it is true, as far as the jurassic formations, but which approximate, in many respects, to true Asteriæ. The latter, in their turn, are represented in many formations by particular genera, which are still imperfectly known, with the exception of some types belonging to the chalk, of which well preserved specimens have been found in England. Lastly, the Echinidæ, so abundant in the superior secondary and in the tertiary formations, here everywhere appear under new forms; so that the genera of the existing creation do not go back, for the most part, beyond the tertiary formations, with the exception of the Cidaris, species of which already abound in the jurassic formations. The whole family of Spatangi, that is to say, the family which approaches nearest the Holothuriæ, does not go beyond the cretaceous formations. The plates and spines of the coal formation which have been assigned to Cidarites, do not belong to this family; they are the remains of particular genera of Crinoïdes covered with spines. Yet, in our zoological systems, all these types are placed upon the same level, and if they are arranged one above another, it is without any anxiety about the analogy which exists between their gradation and the order of succession in which they appear in the series of formations. So much is this the case, that what M. de Humboldt says, in such a picturesque manner, in his *Kosmos*, of the aspect of the sky which presents to us every evening, as a real image, the assemblage of celestial bodies, many of which have ceased to exist for myriads of years, may be applied with equal truth to the idea generally given to us by the frameworks of our zoological systems, which likewise hold up to us these witnesses of bygone times as existing realities.

The Acephala afford us a not less striking example of these relations between the organic characters of a well characterised zoological group, and the time of the appearance of its different types. In order to shew this connection more distinctly, I may be permitted to premise a few general observations on this class. Mr Owen was the first to shew that the Brachiopods ought not to be regarded as a separate class, but that they may be conveniently arranged on the same line with the Monomyaires and the Dimyaires. To prove this assertion by new arguments, I have only to bring to mind that these fundamental sections of the class of Acephala are closely allied to each other by the connection of their principal forms, and by their respective position in the midst of the ambient elements, as I have shewn in my memoir, *Sur les moules de Mollusques vivans et fossiles*, to which I refer. I shall here merely state that the Brachiopods exhibit an inverse symmetry when compared with that of the regular Dimyaires. In the former, the right and left sides are of very different conformation, and the animal is constantly lying on one of its sides, and the sides have very generally and erroneously been regarded as the dorsal and ventral regions. The anterior and posterior extremities, on the contrary, are shaped with the most perfect symmetry; that is to say, in other words, the front and the hinder part of the animal cannot be distinguished, while its sides shew a marked difference. In the Monomyaires in general, and among the Ostracea in particular, we observe a conformation intermediate between that of the Brachiopods and that of the Dimyaires; the sides are still very different, but now one of the edges appears as the anterior extremity of the body, and the animal, still adhering in the case of oysters, has no longer, in all the genera, the absolutely lateral position of the inferior types; witness the Pectens, which swim freely. Lastly, among the Dimyaires, the bilateral symmetry attains to full perfection, and, at the same time, one of the extremities of the body is sensibly characterized as the anterior. The animal then assumes a position more or less vertical, the head in advance, and the relation of its organs with the surrounding media are analogous to those of other symmetrical animals.

These connections are fully justified by the order of the succession of the Acephala in the series of formations. Of all modern palæontologists, M. de Buch is the individual who has studied the fossil Brachiopods with the greatest care; and it is to his works above all others that I refer for the detailed study of the facts, the principal results of which I am about briefly to state. In the most ancient formations, we find nothing but Brachiopods, but in such profusion, and in forms so varied, that in their abundance and diversity, they scarcely yield to the Acephala of the tertiary formations, in which the brachiopods have almost entirely disappeared, to be replaced by an innumerable quantity of species of different genera, belonging, for the most part, to the order of Dimyaires. To make up for this, the intermediate formations afford a remarkable assemblage of Brachiopods, Monomyaires, and Dimyaires, the more interesting from this, that the Dimyaires with non-symmetrical sides still exceed in number those which are perfectly regular, and thus become connected with the Monomyaires and Brachiopods which, at the era when they existed alone, gave to the acephalous faunas the singular character of want of symmetry in the sides, combined with a very remarkable symmetry before and behind. The facts of detail to which I here refer, are scattered throughout all modern works on palæontology and geology. If, however, it be objected to me, that, by recapitulating these facts, I have generalised too much, I may remark, that even though some species form exceptions to the rule, the general character and fundamental relations of these great divisions are not less of the nature I have indicated; then we must not forget that certain fortuitous or obsolete determinations, collected at hap-hazard from books, cannot from any case be taken into consideration in examining the questions with which we are now occupied.

As we have already seen in the case of the Echinoderms, the Acephala likewise present very marked modifications in their representatives, from one formation to another; and, notwithstanding assertions to the contrary, I here repeat what I have long since affirmed in regard to fishes and Echinoderms, and which the comparative study of a great number of fossil shells has likewise demonstrated to my satisfaction in reference to the mollusca, namely, that the species, viewed in the mass, differ from one geological epoch to another, in the restricted limits of the subdivisions of our great geological formations. No one has hitherto brought forward this result in a more general manner in regard to the mollusca of the cretaceous and jurassic epochs, than M. D'Orbigny, in his French palæontology. On my own part, I have pointed out results in every respect similar, in my critical studies on fossil molluscs. Even before that time Mr Williamson had announced, in a short notice of the fossils in the vicinity of Scarborough, that the species differ completely from one formation to another, in the oolitic series. I am not aware, however, that this fact led Mr Williamson to enter into a critical examination respecting these fossils. But it is above all in the tertiary formations that repeated identities in the different formations have been enumerated in the greatest number. Yet, in a memoir which I published on tertiary shells, the final result of which I had long since announced in other publications, I have demonstrated, in regard to a pretty considerable number of species, that these identifications are merely exaggerated approximations of species often very much alike, but, notwithstanding, specifically distinct.

The Gasteropods do not seem at first sight capable of affording much interest in the point of view in which we are now considering the different classes; in fact, the Gasteropods of the palæozoic formations, and even those of the secondary formations, with the exception of a portion of those belonging to the chalk, have not yet been sufficiently studied to admit of being compared, with an entire knowledge of causes, with the living species. I shall, therefore, merely remark, that the two types of shells, which we distinguish in the living state, that with the opening entire, and without canal or notch for the respiratory tube, is the most ancient, and is alone met with in the palæozoic and in the ancient secondary formations; while that which has a siphon, does not make its appearance along with the former till after the lias, when it assumes a preponderance, always becoming more marked, in the tertiary formations and in the actual creation. It is a rather singular connection that these ancient Gasteropods have a greater resemblance in certain respects to our terrestrial and fluviatile shells than to marine species; witness those numerous species belonging to the jurassic and triassic formations, which have been referred without sufficient cause to Melania or the neighbouring genera. We perceive in this fact something analogous to what I pointed out many years ago with regard to the fossil fishes of the secondary formations, which, although belonging to extinct genera, have a greater resemblance to certain fresh-water fishes of the present day than to any marine fish.

The numerous special works which have been published on the Cephalopods, living and fossil, from the monographs of MM. de Ferussac and D'Orbigny, down to the most recent productions of MM. de Buch, Münster, Voltz, Owen, D'Orbigny, Valenciennes, and others, have made this class well known, and it is one of the most carefully studied of the animal kingdom. It is not, therefore, difficult to seize the natural relations of its families along with the phases of their progressive development in the order of time. The types of the Ammonites and Nautili are the most ancient; they even appear very nearly contemporary in all their development, and in this we may find a new proof of their value as zoological groups; however, they do not possess altogether the same importance. The family of the Ammonites, more numerous and varied in the most ancient epochs, disappears also sooner; for it does not come further than the cretaceous epoch. The researches of MM. De Buch and De Münster have made us too well acquainted with the order of succession of these fossils to render it necessary to refer to it here. I shall merely remark that the genera, so curious and numerous, which M. D'Orbigny has distinguished in the chalk formations, where they appear in astonishing diversity, at the very point where this family is about to become extinct, furnish us with a very correct example, and certainly one well worthy of fixing our attention, of the irregular, and, in some degree, convulsive movements to which the ammonitigenic idea has been subjected in its expiring agony, without reaching the tertiary epoch or the existing creation.

The Sepiæ, &c. form a third type of this class, and that which occupies the highest rank in it; its existence does not appear to go beyond the lias, where the Belemnites, the Teudopsis, and Celænos have been the precursors of the Sepiæ, the Calmars, and the Onychoteuthes of our era.

The department of the Articulata, like that of the mollusca, and that of the radiata, contains only three classes, namely, Crustacea, Insects, and Vermes. The other primordial sections, which there has been an attempt to distinguish, ought to be united under these three heads. Thus, the Cirripedia can no longer be separated from the crustacea, whose organisation and mode of development they share. It is likewise to the class of crustacea that we must refer the Lerneæ, Rotiferæ, &c. The Arachnida and Myriapoda are true insects, or rather they are connected with winged insects by intermediate types, so closely united that it is impossible to separate them. We must not neglect, in these connections, the characters of the larvæ and those of the species which continue apterous. Many of the so-called *Aptera* ought to be withdrawn from this ill-digested group, in order to be placed in their respective families. With regard to the vermes, it appears to me impossible to separate, as classes, the Annelida, the Turbellariæ, and the Helminthes ; too many characters unite them, and the analogy in their embryonic development, as far as it is known, is too striking to authorise the continuance of these classes. It can no longer be a question, then, henceforth, that we ought to leave the intestinal worms in the department of the radiata, any more than that the infusoria, at least by far the greater number, connect themselves, in my opinion, with the crustacea by the rotifera.

The vermes, those of them at least covered with a solid envelope, have left too insignificant traces of their existence in the series of formations, and the fossil insects hitherto discovered are in too small numbers, and have not been sufficiently studied, to render it possible at present to form a just idea of the part they have acted in the different geological epochs which have preceded the present creation. These classes still await their monographs for the fossil species.

It is not the same with the crustacea which are found in pretty considerable numbers in the whole series of formations ; and, if they have not been the subject of such numerous researches as the fossils of the greater part of the other classes of the animal kingdom, they are still sufficiently well known to enable us to ascertain the progress of their development from the most remote geological periods.

The Trilobites, which are unquestionably the most ancient type of the class crustacea, have been the object of numerous publications and very varied researches, since M. Al. Brongniart made it the subject of a special monograph. The works of MM. Dalman, Green, Emmerich, and Burmeister, particularly deserve to be mentioned in the first rank among those which have contributed most to extend our knowledge of this curious family, and give us correct ideas of their real relations to the other articulated animals. The Trilobites appear under the strangest and most varied forms, from their first occurrence in the most ancient palæozoic formations. This type, however, does not go beyond the period of the coal formation, when it is replaced by gigantic Entomostraca, which are in some degree the precursors of the Macruri. Entomostraca of small size likewise appear in very ancient formations; they abound in certain coal formations, for example, and they are found after that in a multitude of deposits. They have not yet, however, been studied in a satisfactory manner.

The Macruri, with which MM. H. de Meyer and Count de Münster are particularly occupied, prevail from the triassic epoch to the present creation; while the Brachyura are essentially tertiary. These latter, as well as the Cirripedia, which appear to be their contemporaries everywhere, are still far from being so well known as we would desire. A monograph of the Cirripedia, both living and fossil, is in particular a pressing desideratum for zoology as well as for palæontology. The other orders of crustacea are not known except in the tertiary formations. The parasitic crustacea, soft and vermiform, appear to be exclusively confined to the present creation.

It follows, from this hasty glance, that the types whose affinities have been best studied, such as the Trilobites, Macruri, and Brachyura, succeed each other in the series of formations in the order of their organic gradation. It is even very curious to observe the intimate analogy which exists between the forms of these different types and the phases of the embryonic development of the Crustacea, which MM. Rathke and Erdl have afforded us the means of becoming acquainted with.

If I have not hitherto spoken of the Infusoria, it is not because I forget their influence in the history of the formation of our globe. On the contrary, I think that M. Ehrenberg has opened a new era for palæontological researches by his important discoveries in the world of these infinitely minute creatures; but I likewise think that the novelty of these results, as surprising as unexpected, do not yet allow us to appreciate them at their just value.

After having thus passed in review the principal classes of invertebrate animals, whose fossil remains have been most carefully studied, I may be permitted to pause for an instant, and consider the consequences which directly flow, in a theoretical point of view, from so many scrupulously examined facts. And, in the first place, it is evident that, from the most ancient times, all the classes of invertebrate animals have been represented on the surface of the globe; that they have all presented from the first a great diversity of generic and specific forms; that this variety is in no respect less, if we take into account all the conditions of their preservation, and all the difficulties of observation, than that of the species of a local fauna belonging to the present creation, circumscribed within limits corresponding to the extent of the surface of the palæozoic formations hitherto examined; that the number of these fossils is certainly as considerable as that of the lists of living species which were published, scarcely half a century ago, as complete enumerations of the animals of well known countries. I shall merely mention, as examples, the various faunas of Europe at the end of the last century, or even those of Brazil, Egypt, Arabia, and the Indies, and the lists of palæozoic fossils published by Messrs J. Phillips, De Verneuil and D'Archiac, or those which accompany M. Murchison's work on the silurian system.

These facts, now as well established as facts of this nature can be, clearly shew the impossibility of referring the first inhabitants of the earth to a small number of original stocks, which have become diversified under the modifying influence of external conditions of existence. They point out to us, as with the finger, the direct intervention of a creative Intelligence, anterior to the existence of all beings, who has ordained their relations, determined their development, and directed their successive appearance, up to the establishment of the order of things which now prevails in the world. These facts also prove the nothingness of all material and pantheistical theories, which ascribe to finite beings a self-existing power, and make them depend solely on indeterminate exterior influences.

When I commenced the publication of my researches on fossil fishes, I was acquainted with no species more ancient than those of the coal formation, and even with a very small number of these. Now, not only is the list of species, and even of genera, proper to these formations, considerably increased, but the more ancient deposits are daily increasing more and more the number of types to add to our catalogues. The strata of the devonian system, and those of the silurian system, have in their turn furnished a contingent which continually goes on increasing. And if recognisable remains of fishes below the inferior Ludlow beds, which form part of the silurian system, have not yet been discovered, I do not think that we must thence conclude that fishes do not go back to the most ancient fossiliferous formations; for their extraordinary frequency in the devonian strata and their presence, which has been well ascertained, in the silurian deposits, where they are, it is true, very ill preserved, sufficiently indicate that, in its appearance on the surface of the globe, this class of animals is contemporary with the development of the most ancient types of all the classes of invertebrate animals. With regard to the period of their first appearance, we can no longer speak of differences among the classes, but such as are of little importance, in a biological development considered as a whole; and it is henceforth demonstrated that fishes entered into the plan of the earliest organic combinations, which have been the point of departure in the development of all the living beings which have peopled our globe in the series of time. It follows from this, that the most ancient faunas are composed of representatives of all the classes of invertebrate animals, and only one class of vertebrates, namely fishes; while reptiles, birds, and mammifera, did not appear till later, and in succession. There is, then, a remarkable and important contrast to be observed between the progressive development of vertebrates and that of the radiata, mollusca, and articulata, in which all the classes are contemporary, as we have seen above.

In devoting ourselves in this manner to the study of the remains of organized beings imbedded in the most ancient geological formations, we revive, as it were, the earliest representatives of creation. These fossils, in fact, may be called the first parents of all the beings that lived afterwards. In calling them up before us, we are present, so to speak, at the earliest sports of animals, and at the first bursting forth of vegetation; we behold animated nature issuing from the hand of the Creator. And if we can hope one day to arrive at the knowledge of the general plan of creation, it is by attentively investigating even the faintest appreciable relations between ancient species, and by following step by step the modifications which organized beings, viewed as a whole, have undergone in all the series of formations, from one to another, up to our own times.

There is one kind of comparison which has been too much neglected in our attempts to estimate the importance of the stages of our globe relatively to the remains of the organized beings which they inclose, but which, I am convinced, will one day exercise a great influence on our manner of regarding fossil faunas, by enabling us to determine the value of those assemblages of strata which have been called *terrains* or geological formations. I allude to the proportions in which we find species of the different classes of the animal kingdom, in given localities, on the present surface of the globe, or in such or such a group of formations. It is evident that it is the beings which now live on the earth that we are best acquainted with, and respecting which, as a whole, we possess, in every respect, the most complete and important information. It is consequently from these beings, or rather from the knowledge we possess of them, that we ought to borrow the terms of comparison for all that relates to the distribution of fossils in the whole formations. It is true that the geographical distribution of living animals is yet but imperfectly known; it is sufficiently so, however, to make us aware that all the countries of the globe, considered in a certain extent, have their particular faunas, composed of an assemblage of peculiar species, mingled with others which extend either more to the north or south, east or west; and that, consequently, each country supports but a small proportion of the totality of species which people the surface of the globe.

When we wish, therefore, to appreciate the value of the assemblages of fossils which we discover in a formation, and seek to determine the number of species proper to the geological epoch to which they belong, it is not with living animals, as a whole, that we ought to compare them, but rather with an assemblage of species living within analogous limits, and under analogous conditions, in the existing creation. An example will explain my idea more accurately. If I sought to determine approximately the number of fossil species of the period of the deposition of the chalk or plastic clay, I believe that I should choose a very bad method of attaining my object by computing the lists of fossils of all the geological deposits considered at present as belonging to these geological horizons, and then comparing the sum obtained with the sum of living species. We should certainly approach much nearer the truth, by studying as completely as possible the fossil fauna of some well explored localities, as, for example, the deposits of chalk around Paris, or the plastic clay of the Thames basin, and then comparing these lists of fossils with the living animals of some gulf or some shore in the present creation, which shall present most analogy with the extent and conditions in which we may suppose these deposits to have been formed. We shall thus obtain true foundations to fix the numerical relations of the whole of these creations compared with the actual creation.

By following this process, and comparing successively the ichthyological faunas of different formations, in which I have recognized different assemblages of fishes, with the ichthyological faunas of the present creation, confined to analogous limits, I have arrived at the result (a distressing one for the actual state of our palæontological knowledge, if it be admitted to be correct), that the strata which constitute the crust of our globe, considered as a whole, ought to contain at least twenty-five thousand species of fossil fishes. In this calculation, the grounds of which I think it unnecessary to specify in this place, I have carefully taken into account the greatest uniformity which ancient contemporary faunas present. Similar calculations, made with the same precautions, raise the number of mammifera we may yet expect to discover to about 3000; that of reptiles to about 4000; and that of shells to at least 40,000. I am even of opinion, that very few years will elapse before we shall have acquired the certainty that these calculations are much below the reality. With regard to birds, crustacea, insects, echinoderms, and polypes, particular difficulties at this moment stand in the way of all kinds of comparison of this nature. In relation to fossil infusoria, it would be premature at present to make use of the labours of one man, continued only for eight or nine years, in order to estimate the profusion with which animalculæ, whose ordinary dimensions necessarily conceal them from our view, are disseminated through the strata of the earth, especially now that we know the great mass of these formations to be entirely composed of microscopic animalculæ. Besides, M. Ehrenberg has successively revealed to us such unexpected facts, that we require to ponder them a while before we can appreciate all their importance.

The ichthyological fauna of the old red sandstone appears in such extraordinary and fantastical forms, that the most trifling remains of the beings which lived at that epoch cannot fail to arrest the attention of the naturalist. In no other formation do we find an assemblage of fishes deviating so strikingly from all that we are acquainted with in our own day. The study of no other fauna requires so many years before we become sufficiently familiarised with its types to venture to classify them, and fix their relations to those of other creations. The difficulties these researches presented were quite of a peculiar nature, for it was necessary to solve them, so to speak, without a term of comparison, or at least to have recourse to remote approximations. In fact, comparisons with the remains of anterior formations would have been impossible; because it is in the old red sandstone that we meet, for the first time, with a complete ichthyological fauna. The Silurian formations, it is true, contain some remains of fishes; but hitherto they have been so rare, and the number of species so limited, that it may be safely affirmed that it is only with the Devonian formation that fishes have really acquired some importance among other fossils, or, at least, that the part they performed in nature becomes appreciable. What first strikes one, on studying the ancient deposits is, that fishes are the only representatives of the branch vertebrata which exist in the old red sandstone, or even in the coal formation, insomuch that we have a good right to call the epoch when these formations were deposited *the reign of fishes.* This fact, to which I have already often called the attention of palæontologists, is confirmed, in the most absolute manner, by all researches which have of late been undertaken in reference to the fossils of the old red sandstone. In a few years, the investigations of geologists have increased the number of known species tenfold; and the zeal with which the study is pursued, in the two countries where this system of strata appears in its greatest development, that is to say, in England and Russia, will undoubtedly still lead to numerous and important discoveries. But it is easy, even now, to foresee that these discoveries will come within the laws which the species already known have revealed to us; that is, they will be confined to the class of fishes as regards the vertebrate department; and that neither reptiles nor mammifera will be found in the strata of the old red sandstone.

I am well aware that a recent author has imagined that he has found bones of all the classes of vertebrata in this formation. But the erroneous determinations on which such conclusions are founded, are easily estimated at their true value, and the tortoises, lizards, crocodiles, and pachyderms, with which he has chosen to people these ancient deposits, have successively been arranged in their proper place; that is, in the lowest class of vertebrata, from which a rash hand had removed them. In treating of the families and species which characterize the system in question, I have shewn the falsity of the notion which makes all the classes of vertebrata go back to the most remote antiquity; so that it now remains well proved that all we know of the remains of vertebrata in the formations anterior to the Zechstein, belong exclusively to the class of fishes.

I shall not insist further on the importance of this fact, when it is viewed in relation to the organic characters of the creations which have successively peopled the earth. I have already laid before the public, through another channel, my views on the development which the different creations have undergone during the history of our planet. But what I wish to prove in this place, by a careful discussion of facts, is the truth of the law, now so clearly demonstrable in the series of vertebrata, that the successive creations have undergone phases of development analogous to those which the embryo undergoes during its growth, and similar to the gradations which the present création shews us in the ascending series it presents when viewed as a whole. We may at least consider it henceforth as proved, that *the embryo of a fish during its development, the class of living fishes in its numerous families, and the fish type in its planetary history, in every respect go through analogous phases, throughout which we can always trace the same creative idea* (*pensée créatrice*), like a thread which guides us everywhere in searching out the connection of living beings. The consideration that the fishes of the old red sandstone really represent the embryonic age of the reign of fishes, has even been with me a powerful motive to undertake the examination of these ancient animal remains, as my first *Monograph*, forming a continuation of my *Researches;* since it was here there existed evident facts to prove the truth of this great law of the development of all living beings.

Let us first take a rapid glance at the families, the species of which I have determined. Of these there are at least five distinct ones,—the Cephalaspides, the Acanthodians, the Dipterian Sauroïdes, the Celacanthes, and the Plagiostomes, if so be that we may consider this great type as a single family. The first four belong to the order Ganoïdes, and the last to that of Placoïdes.

The first remark which occurs to the attentive observer is, that among the numerous species scattered throughout these families, we have not yet found any trace of vertebræ, and, in some, only the apophyses to protect the spinal marrow and the large vessels, though they were equally deprived of the bodies of vertebræ. Assuredly, if these fishes had possessed vertebræ, some of them would have been found among the numerous remains of skeletons which abound in the old red sandstone, in those specimens of the Coccosteus from Orkney, in which the tails are so well preserved with their spiny apophyses, their small interapophysiary bones, and fin-rays.

But there appears no trace of them, and even in the specimens of the Coccosteus referred to, we see distinctly that the apophyses rested upon an undivided and continuous axis. Now this incomplete development of the osseous system of the trunk is found among all embryos, and, in particular, among those of fishes; it is likewise found in the last gradations of the class of fishes, among the Cyclostomes. This series of vertebral bodies, which follow each other throughout the whole length of the trunk of vertebrates, is replaced in the inferior forms of this department, and also in embryos, by a cylindrical cord of a gelatinous consistence, which is called the dorsal cord. It is not till some time after the appearance of the cord, that the apophyses and the bodies of the vertebræ are developed in embryo. In the Branchiostoma (*Amphyoxus*), there is only one cord, without any other piece of skeleton, as among embryos not far advanced. It is among the Cyclostomes that the formation of apophyses commences, and among the Plagiostomes that of the bodies of the vertebræ. In this respect the fishes of the old red sandstone have remained at a degree of development altogether embryonic; for they have a cord and apophyses, but they have no vertebral bodies.

This disposition of the osseous system of the trunk, almost necessarily determines that of another,—the incomplete development of the cranium. We find, indeed, in the fishes of the old red sandstone, the exterior bones of the cranium well formed; the jaws, the thoracic girdle, the opercular and branchiostegous bones, and those of the upper part of the cranium, are well developed, strong, and evidently of a bony structure; but all that I have observed respecting the formation of the head, leads me to think that the internal case of the cranium, that which immediately surrounded the brain, was not consolidated, but rather cartilaginous. We likewise find this structure in embryos, where the protective plates which cover the top and base of the cranium are developed in an insulated manner, while the cranial case is still cartilaginous. The same conformation appears in the sturgeon, the osteology of which I have described in my *Recherches sur les Poissons Fossiles* (vol. ii., 2d part, p. 277); and it is, in fact, with the latter that we can best compare the state of the skeleton of the cranium in the fishes of the old red sandstone.

The osseous and mailed plates which cover the head of the sturgeon, and which are a continuation of the mailed plates of the neck and sides, evidently do not belong to the same system as the frontals and parietals of ordinary fishes. They are cutaneous bones, developed by replacing ordinary bones, which are wholly wanting in the great part of the fishes of the old red sandstone, and particularly in the family of the Cephalaspides, where we find the same arrangement as in sturgeons. It would be vain to seek in the cephalar plates of a Coccosteus or a Pterichthys, analogues of the frontals, parietals, and nasals, of our osseous fishes. We find in their place only carapaces, often singularly composed, and which, nevertheless, form, by their union, coverings for the cranium altogether as complete as those of ordinary fishes.

This is the place to notice the extraordinary development presented by the cutaneous system of the fishes of the old red sandstone. Enormous bony plates often cover not only the head, but likewise a great part of the body. An entire family, that of the Cephalaspides, has its essential character in the cuirass of the trunk, and the scales and plates of the greater part of the Celacanthes of the old red sandstone, greatly exceed what we witness in fishes belonging to more recent formations. Unfortunately, we have not yet terms of comparison in relation to the fishes of the present creation, sufficiently numerous to appreciate the value of these characters; because we are entirely without data respecting the development of scales in general, and particularly that of the scales of the Ganoïdes; we have not even information on the embryology of a single cuirassed fish of our epoch; but it may be presumed from the extraordinary development of the cutaneous system in our ancient fishes, that these plates and cuirasses are developed at a very early period in the embryos.

Another fact, from which we may well call the fishes of the old red sandstone the embryonic age of the reign of fishes, is the development of their fins. We know that in all the embryos of fishes hitherto examined, the vertical fins spring from a single fin running along the hinder part of the body, nearly like the fin of an eel. This continuous fin undergoes a complete transformation in certain places; in others, it disappears little by little; and where it remains stationary, the rays are gradually enlarged. The spaces which separate the different fins are, therefore, smaller, and so much the less strongly marked the younger the embryo is. To such a degree is this the case, that certain fishes which at a later period would possess very distinct fins, have them very close to each other at an early age, and sometimes scarcely separated by a shallow notch. In the fishes of the old red sandstone, the vertical fins enter completely into these primitive conditions of development. The whole of the important family of Sauroïdes, which at a later period appear provided with well separated and insulated fins, is represented in the old red sandstone only by the Dipterians, which are all provided with two anals and two dorsals, very near each other, and but a short way from the caudal. In the Celacanthes of the old red sandstone, we likewise find many genera, as the Glyptolepis, and probably also the Platygnathes, which had double vertical fins, and so closely placed that there was scarcely an intermediate space between them. Even among the Acanthodians there is one genus, that of the Diplacanthes, which is furnished with double vertical fins. It is true that this arrangement does not occur in all the genera, but it is at the same time curious that the families which are destined to run through a long series of formations, such as the Sauroïdes and Celacanthes, commence with forms having double fins, thus approaching the embryonic type.

The fact, that among all the fishes of the old red sandstone which possess a caudal, that fin is composed of unequal lobes, and inserted on an elevated extremity of the dorsal cord, is another point of approximation to the embryo of ordinary fishes. We know that, in the latter, the extremity of the tail begins to rise upwards at a certain period of life, approaching in this to the disposition observed in the sturgeon, and that at this epoch the caudal of the embryo is *heterocerque*. On the other hand, I have often called the attention of naturalists to a fact in every respect similar, which appears so strikingly in the geological series: namely, that all the fishes belonging to formations more ancient than that of the Jura, have the extremity of the caudal raised, and the caudal itself *heterocerque.*

There is, lastly, another point to which I would solicit the attention of naturalists; that is, the form of the head and position of the mouth and eyes in fishes of the old red sandstone. All, without exception, have the head large and flattened, rounded, and as it were truncated, similar to that of a Lotta or Silurus. This character preponderates to such a degree, that it is very rare to see a fish of the old red sandstone which presents the head in profile; in the majority of cases, it rests on the upper or lower surface, even when the body is lying in such a manner as to present one of the sides. The mouth of the greater part of the genera is widely open, semicircular, placed either at the extremity of the rounded head, or even under it. The eyes, in the majority of the genera, are widely apart, and thrown to the flattened sides of the head, in such a way that it is often very difficult to determine their position. Analogous forms are found in embryos. Even among fishes which, at a later period, are distinguished by a long snout in the form of a beak, the embryos have at first a broad rounded head, truncated in front, with the mouth below, and the eyes lateral, and it is not till later that the jaws become elongated and project before the eyes, forming at last a head of an entirely different form from what it exhibited at first.

I believe that it would not be easy to find more numerous approximations between the embryos of our fishes and fossil fishes, since no part of their bodies is preserved to us but the osseous system which alone has furnished all these analogies; and I think observers will generally agree with me when I affirm that *the fishes of the old red sandstone represent, in the whole of their particular structure, the embryonic age of the reign of fishes.* In no instance, in fact, in any other formation, do we find so great a number of fishes in which the internal skeleton is so imperfectly developed, and so inferior to the cutaneous system; nowhere else do we find the great majority of fishes having the embryonic forms of the fins and of the head so strongly marked.

These facts evidently afford us the key to the rank which these families ought to occupy in an ichthyological system, and a judicious application of embryology to the classification of animals, cannot fail to be attended with the most beneficial results, in bringing our zoological systems to perfection. If, indeed, after having pointed out the anatomical affinities of the fishes of the old red sandstone, we then examine the zoological relations in which they are found in regard to the succeeding creations, we perceive, that of the five families occurring in the old red sandstone, there is one, that of the Cephalaspides, which is wholly confined to that formation; that there is another, the Sauroïdes, which is represented only by a particular group, the Dipterians, likewise limited to the old red; that a third, that of the Acanthodians, is not continued beyond the coal formation, and that only the Celacanthes and the Cestraciontes reach more recent formations.

Of all these families, it is likewise that of the *Cephalaspides* which recedes most from the ordinary forms of other fishes, to such a degree that one might easily, at the time of their first discovery, misunderstand their nature, and take them for animals belonging to other classes of the animal kingdom. It is in this family that we have found the type of fishes with winged appendages, represented by the genera Pterichthys, Pamphractus, and Polyphractus, which, owing to the cuirass of their bodies, formed of many pieces closely soldered, and from their pectoral fins being transformed into recurved stylets, have passed sometimes for tortoises, sometimes for enormous aquatic Coleoptera. It is among the Cephalaspides that we have found the curious genus Cephalaspis, whose broad cephalar shield, with two eyes almost united in a single orbit, had caused it be taken for a crustacean allied to the Limulæ or Trilobites, before becoming acquainted with its scaly body and tail provided with vertical fins; it is among the Cephalaspides, finally, that we must place the Coccostei, with their powerful cuirass and long flexible tail, which must have given them the strangest aspect imaginable, and have caused them successively to be taken for fossil Trionyces and fossil Rays. I have already spoken, in treating of this family, of the affinities, remote it is true, which it presents to the cuirassed fishes of our epoch, the Loricarias and Siluroïdes. I have nothing further to add on this subject; but what I should wish to point out, is the truth of this fact, that the different genera of the Cephalaspides already shew a gradation, although faintly marked, in their conformation becoming more and more perfect. It is thus that, on the one hand, the winged appendages of the Pterichthys and Pamphractus are lost in the Coccostei and Cephalaspis, where they are replaced by ordinary fins; while, on the other hand, there is an evident approximation between the Coccostei and the broadly cuirassed genera of the family of Celacanthes, such as Asterolepis and Bothriolepis. The thick and short form of the Pterichthys, and the very incomplete development of their fins, evidently shew that they were fishes of little agility, living in shoals in mud, moving sluggishly and destined to become the prey of others. Among the Cephalaspides, the broad shield with which they are covered, and their eyes situate on the upper side, indicate the same mode of life; but in them the trunk becomes more moveable, and the tail, the most powerful instrument of motion, is furnished with fins, and becomes fit to execute the most rapid motions. The Coccostei, finally, were evidently, even at this step in the gradation, voracious fishes, as is shewn by their conical sharp teeth, and their long flat and flexible tail. There is, no doubt, a wide interval between this and the formidable armature of the Bothriolepis, and the needle-like teeth of the Dendrodes (Asterolepis); but it will be admitted that there is an advance towards the rapacious character in the family of Cephalaspides, and if we join to this the structure of the plates, the resemblance of the granulated scattered points of the Coccostei to the asterisks of the plates of Asterolepis, we will soon be convinced that it is not necessary to take a long step to advance from the Coccostei to the cuirassed Celacanthes. This resemblance will be much greater still if ulterior researches prove that the mailed Celacanthes had not true scales imbricated on the body, but only large plates covering the head and nape. There is nothing hitherto, it is true, to prove this supposition, but the fact is nevertheless curious, that along with the great quantity of large slabs of Asterolepis and Bothriolepis which characterize certain formations, we have never found true scales which can be assigned to them. I point out this fact to the attention of geologists; for nothing is often more instructive than the mode in which fossils are associated, particularly when the remains belong to animals whose size and the softness of the skeleton have prevented them being preserved entire. But it is necessary to employ the greatest circumspection in appropriations of this nature before drawing conclusions from them: for too frequently these results are transmitted from one author to another, and sometimes still continue to pass for truths, when the state of the facts has been modified. The beds of the old red sandstone, it is true, are not very favourable to researches of this nature, for the fossils not forming in them the nuclei of rounded masses, the remains are dispersed and mingled in such a manner, that we often find in the same morsel of indurated matter the remains of many genera entirely different.

The family of the *Dipterians*, like that of the Cephalaspides, is entirely confined to the strata of the old red sandstone. Here the affinities to the Sauroïdes are so evident, that I have thought it necessary to give up the opinion to which I for some time adhered, of regarding them as a separate family. The scales are the same, and the teeth approximate in every respect, in the genera Osteolepis and Diplopterus, to the eminently carnivorous type of the Sauroïdes with insulated incisive teeth. I have provisionally placed in this family the genus Glyptopomes, which, in the sculpture of its scales, makes a near approach to the Platygnathes of the family Celacanthes, but recedes from it, on the other hand, in the form and arrangement of its scales, which are evidently only in juxtaposition and cut lozenge-shape. It would be very interesting to know how the position of this genus will be ultimately fixed; whether it be necessary, from the arrangement of its fins, to place it definitively among the

Dipterians, or rather, whether it indicate, by its simple fins, the first degree of approach to the type of the Sauroïdes properly so called. In the latter case, we should have, in the Sauroïdes of the old red sandstone, a gradation similar to that which exists in the Cephalaspides.

The *Acanthodians* embrace in their history only two formations, the old red sandstone and the coal measures; more recent formations furnish no traces of them. This also is a very particular type, in no manner connected with the other families of the Ganoïdes. It is true that the form of the body does not deviate from those with which we are familiar, but the manner in which their bodies are covered certainly presents a very decided character. Those small rhomboidal scales, scarcely visible, which make the skin look like shagreen, have nothing like them in the whole class of fishes; for the shagreen of the Plagiostomes is formed of entirely different elements. It may be remarked that in general the anomalous types, which deviate most from the normal types, are also of very brief duration, and continue only during one or two epochs of the history of the earth, after which they terminate, without our remarking afterwards the types which may be regarded as those that have replaced them. This is likewise the case with the Cephalaspides. It is the same with the Acanthodians. In the fusiform Ganoïdes of more recent epochs we find neither scales in the form of shagreen, nor large spines, in the form of prickles, which stand erect upon the fins. This type becomes entirely extinct with the coal formation.

Of all the Ganoïdes of the old red sandstone, the *Celacanthes* are the only ones which have a lengthened history; for they continue as far as the chalk formations, where they terminate in the genus Macropoma. I have already shewn, in treating of this family, what difficulties we have to encounter when we wish to limit it rigorously, and assign to it definite characters, and how probable it is that it will ultimately be divided into many distinct families. But, apart from these considerations, which are not yet founded on facts sufficiently numerous, it is certainly in the old red sandstone that the family of the Celacanthes acquires the most considerable development, and it is only by diminishing in all directions that it at last reaches its point of extinction in the chalk. If we wish to represent it graphically, it may be regarded as a cone, with a broad base, the summit of which is formed by the genus Macropoma, while at the base are found the Holoptychius, Phyllolepis, Glyptolepis, Platygnathes, Dendrodus, Lamnodus, Cricodus, Asterolepis, Bothriolepis, Psammosteus, &c., of the Devonian system; all as remarkable by their structure as by the numerous individuals whose remains are everywhere found in this formation. Indeed, if there be one fact that can prove how far it is true that ancient strata enclose types in general less different than those of the present creation, but, by way of recompense, an infinitely greater number of individuals, it is surely this, that there are strata of old red sandstone, particularly in Russia, which are nothing else than true breccias, almost solely composed of scales and plates of Asterolepis or Bothriolepis. If the Pterichthys are so abundant in the nodules of Lethen-Bar that they are collected in cartfuls, there is in this nothing surprising, because they were small fishes, living probably in shoals in the mud, feeding, from all that we can gather from what is known of their organization, on shell-less molluscs, vermes, and other unprotected animals. But when we remember that the Bothriolepis and Asterolepis were fishes of very considerable size, eminently rapacious, and feeding, to judge from their dentition, on living prey, we will consider it very surprising that these voracious species, whose analogues of our own day are always found widely scattered, should be assembled in such great numbers as is the case in certain localities.

What is very curious in the Celacanthes of the old red sandstone is, that we already encounter in its numerous genera many pretty distinct types. These are, on the one hand, the Glyptolepis, which, by their double fins, make so near an approach to the Dipterian Sauroïdes that one may believe in a certain parallelism between the two families; on the other hand, the Asterolepis (Dendrodus), the Bothriolepis, and the Psammosteus, the characteristic scales of which have not yet been found, but which were provided with broad cutaneous plates, and which in their dentition nearly approach the true type of the family of Celacanthes, that is to say, of that of Holoptychius, Platygnathes, and Phyllolepis. The species of these two groups were evidently the absolute sovereigns of the seas which they inhabited; the gigantic dimensions of the bodies of some of them and their sharp cutting teeth gave them, there can be no doubt, an indisputable superiority. Already in the following strata, in the coal formation, these tyrants of the primitive ocean are accompanied by true Sauroïdes of remarkable size, the Megalichthys, for example, as well as others, although the Holoptychius, Phyllolepis, &c., still exist along with them; in the succeeding formations, however, the Sauroïdes evidently take the lead. The dentition of the Celacanthes of the old red sandstone is very remarkable; all these fishes, save Glyptolepis, which likewise form a distinct group by their fins, have needle-shaped, insulated teeth, placed at distances, and formed of folded *dentine;* and in no other group of the animal kingdom does this folding of the dentine go so far as among our Celacanthes; witness the genera Dendrodus, Lamnodus, &c.

The *Placoïdes* of the old red sandstone are not yet sufficiently known, in their organization, to enable us at present to fix their relations to those of the following formations and to those of the present creation. The fact which has struck me most, in regard to them, is the small size of the Ichthyodorulites of this formation compared with those of the coal epoch and of the lias; and, on the other hand, the rarity of the teeth of these animals, relatively to the abundance of their spiny rays, the very reverse of what we witness in the cretaceous and tertiary formations, as well as among living species. I conclude from this, that, in the early times of the development of life, it was not so much the Placoïdes as certain Ganoïdes, Celacanthes, and Sauroïdes in particular, which were the terror of the seas, and which traversed it everywhere as masters, like the sharks of our own days, under all latitudes. The approximations I have afterwards made between the Placoïdes of the old red sandstone and the sharks of the Mediterranean shew, that, in their numbers and diversity, the fossil species of this formation are in nothing inferior to that of a very extensive fauna belonging to the actual creation.

From the whole of the facts above noticed, it appears to me to follow, that not only do the fishes of the old red sandstone constitute a distinct fauna, independent of those belonging to other formations, but that they also present, in their organization, the most remarkable analogy to the earliest phases of the embryonic development of the osseous fishes of our own epoch, and a not less obvious parallelism with the lower degrees of certain types of the class, as they now exist on the surface of the globe. What is most curious in these connections is, that it is not with the corresponding types of the actual creation that these ancient fishes can be considered as parallel; for example, the osseous fishes of that period had nothing in common with the osseous fishes of this period, nor did the Placoïdes of the most ancient formations in general resemble those of the present creation. Neither do the Ganoïdes exhibit more than remote resemblances to the existing Ganoïdes; but these same Ganoïdes approach, in a multitude of characters, the Placoïdes of our own period, and even the inferior types of this order. And yet, along with this, they have also certain relations to reptiles, although this class of animals did not actually appear till later. These relations I would call prospective analogies, so frequent is it to meet with prophetic resemblances, in the series of formations, among types succeeding each other, and which, after having for a long time presented the combined characters of many groups, do not become distinct till a later period. These facts appear to me deserving of our most serious attention; for they shew us, always with increasing urgency, the necessity of renouncing serial classifications, in order to express the real relations of living beings. If, in effect, the most ancient fossil fishes of the order Ganoïdes shew striking resemblances to the Cyclostomes and Plagiostomes of our era—if these same Ganöides have, besides, certain analogies to reptiles, and, in particular, to the Labyrinthodontes—if these relations disappear in more recent eras—if these families themselves become progressively extinct and are replaced by others—can it ever be possible to express all these relations by a linear arrangement in our zoological systems? And, if what I have remarked in regard to fishes be equally true in respect to all the classes of the animal kingdom, ought we not eagerly to borrow from embryology and palæontology all the information they can furnish, in order to enable us to appreciate more correctly the whole of relations so varied, which connect all created beings with each other?

Far from believing that this object can be completely attained at present, I leave, in the mean time, these questions regarding system, the solution of which will no doubt require immense labour, to confine myself to the consideration of this assemblage of fossil fishes, which constitute one of the most interesting parts of the fauna of the old red sandstone, in a last point of view, that is to say, as a simple group of diverse, but contemporary, species. Viewing it in this manner, apart from all systematic considerations, we are nevertheless struck with the great diversity which the species really present. Who would have expected that we should ever find, in spaces so limited as those which have hitherto been explored, above a hundred species of fossil fishes, in the devonian system alone, that is to say, in a stage of our formations which was believed, a few years ago, to be confined to the British islands, and to which in consequence only a local value was assigned? And yet, all other things remaining equal, the ichthyological fauna which this formation contains, is as considerable as that which inhabits the coasts of Europe; and, even although the species of the old red sandstone do not belong to so great a number of families as the living species, they are not less varied in their forms and general aspect, nor less curious in their external characters and organization, nor less different from each other in size and the degree of locomotive power with which they were doubtless endowed.*

* From Professor Agassiz' *Monographie des poissons fossiles du vieux grès rouge.*

On the Classification of Birds, and particularly of the Genera of European Birds. By JOHN HOGG, Esq., M.A., F.R.S., F.L.S., &c. Communicated by the Author.

The principal part of this paper was originally incorporated in my "Catalogue of *Birds,* observed in South-Eastern Durham, and in North-Western Cleveland," which I read before the zoological section of the British Association for the advancement of Science, at York, on the 26th September 1844; but, being desirous of extending the classification therein proposed, I thought it advisable to delay the publication of this part, until another opportunity had permitted me to examine the noble collection of birds in the British Museum, for the purpose of rendering it as perfect as my leisure would allow. That catalogue, exclusive of any remarks on arrangement, has already appeared in the "Zoologist" for August, October, November, and December, 1845. Now, with regard to the classification adopted for the same catalogue, and of which a sketch is published in the "Report of the fourteenth meeting of the British Association," it is here necessary to enter into some short explanation.

On forming that catalogue, I, in a great degree, followed *Mr Yarrell's* arrangement and nomenclature. Although I principally adopted the former, with certain exceptions, for the *land-birds;* yet, for the *water-birds,* I made considerable alterations, and chiefly assumed *Cuvier's* classification. Having twenty years ago written a "catalogue of most of the birds which are known to frequent the country near Stockton," that was afterwards published in the appendix to *Brewster's* "History of Stockton-upon-Tees," I chose for it the *Cuvierian* system, which had then been given to the world only seven years before in the *first* edition of the "Règne Animal." Being still much prejudiced in favour of that natural arrangement (which I believe I was one of the first to adopt in this country), it appeared to me to be more advisable to incorporate it in my recent Memoir with that classification subsequently instituted by some of our English ornithologists,—making, at the same time, certain modifications in both,—than to use the latter alone, as *Mr Yarrell* had done. For, I must confess that it struck me as very anomalous to select *Cuvier's* Dentirostres, Conirostres, and Fissirostres, and then to reject, without any sufficient reason, the equally natural groups of his Longirostres, Cultrirostres, Lamellirostres, &c., as those distinguished authors thought proper to do. Also, I introduced three families, namely, Upupidæ, Recurvirostridæ, and Procellariadæ, from the "New Systematic Arrangement of Vertebrated Animals," by *C. L. Bonaparte* (the Prince of *Musignano*, now of *Canino*), published in the Transactions of the Linnean Society, vol. xviii., 1840.

There are likewise several new tribes that I myself characterised from variations in the structure or form of the *bill*, and so tending to complete, in the steps of *Linnæus*, a Rostral classification. And it seemed to me quite clear, that not only such was the view of the illustrious Swede, as a reference to the "Systema Naturæ" will shew; but, also, that the *bill* generally presents the most obvious and natural characters for the chief arrangement of birds. Thus, in continuance of this plan, and in its extension to the *genera* of the birds which have been discovered in *Europe*, I have uniformly taken the characters of all the *tribes* from those of the *bill;* whilst those of the *feet* and *toes* present the distinctions of the subclasses, of the orders, and likewise of many of the subtribes. Further and more careful examinations of certain birds have induced me to make some alterations in my classification, as published in the beforementioned report of the British Association, and my "Catalogue of Birds, observed in South-Eastern Durham, and in North-Western Cleveland; with an appendix, containing the classification and nomenclature of all the species included therein." London, 1845.

Moreover, I have omitted to give the *subfamilies,* because I am at present inclined to consider them as superfluous, and as unnecessarily lengthening the classification; but those ornithologists who differ from me, can readily insert them in their proper places. I have paid some attention to the selection of the genera, and have been obliged, in order to do away with the inconvenience of *subgenera*, to increase the number of the *genera* themselves; although I trust this has only been done where real and sufficient differences have confirmed such a necessity. But I must observe that a great many of the new genera, constituted by Messrs *C. L. Bonaparte* and *G. R. Gray*, appear to be unnecessary, and depending on far too minute distinctions. The former author, in his "Geographical and Comparative List of the Birds of Europe and North America," Edit. 1838, makes the genera then found in Europe to amount to the vast number of 246; but, in his later Memoir, "Catalogo Metodico degli Uccelli Europei," published in the "Nuovi Annali delle Scienze Naturali di Bologna, Anno 1842," he has injudiciously increased this number to 265. *Mr Gould*, in his splendid work on the "Birds of Europe," gives only 168 genera; whilst *M. Temminck* in his *second* edition, with the supplementary parts, of "Manuel d'Ornithologie," comprises all the European species in 97 genera; and 113 are the total number of genera mentioned in *M. H. Schlegel's* "Revue Critique des Oiseaux d'Europe." *Leide*, 1844.

Now, the entire number of genera, as selected by myself, for the birds of Europe, will be seen to be 205. Again, the Prince of *Canino*, in addition to his immense number of genera, has included in his very recent "Methodical Catalogue," many *subgenera*; to the latter, in truth, I cannot help expressing an insuperable objection, because by a frequent introduction of *subgenera*, a universal departure from the vast utility experienced in the *Binomial* method would soon take place, and which, in time, would most assuredly be followed by the intrusion of *subspecies* (as has already been effected by *M. Brehm*), and even of *subvarieties*.

In the classification of birds, the maxim—"*Exceptio probat regulam*," certainly prevails to a great extent; for there is scarcely a division, a tribe, or a family, in which some bird does not occur that departs from the *regular* or normal form of that division, and becomes in one or more of its characters an *exception* to, or assumes some *irregularity*, or wandering from the rest, and so constitutes what is usually termed an "*aberrant*" form. Hence arises the especial difficulty of classifying birds with such correctness and minute accuracy, as every careful ornithologist would desire to do. So then, in my present arrangement, I earnestly hope that the zoologist, after making due allowance for certain *exceptions* or *aberrant* forms, will find the general divisions and leading characters of the tribes, subtribes, and other sections, not hastily designed, but uniformly carried out with a sufficient degree of exactness and regularity for all practical purposes, and in strict conformity with Nature.

The following is a *Synopsis* of my classification :—

Class II.—AVES.

Subclass I.—AVES CONSTRICTIPEDES.

Division I.—Terrestres.

Order I. Raptores.

Tribe I. Planicerirostres.
Subtribe 1. Diurni.
Family 1. Sarcoramphidæ.
Genus. Neophron.
Family 2. Vulturidæ.
Genera. Gyps, *Vultur.**
Family 3. Gypaëtidæ.
Genus Gypaëtus.
Family 4. Aquilidæ.
Genera. Haliäetus, Aquila, Pandion, *Circäetus.*
Family 5. Falconidæ.
Genera. Falco, Accipiter, Astur, Milvus, Nauclerus, *Elanus.*
Family 6. Buteonidæ.
Genera. Buteo, Pernis, Circus, Strigiceps.
Tribe II. Tecticerirostres.
Subtribe 2. Nocturni.
Family 1. Strigidæ.
Genera. Surnia, Nyctea, Strix, *Ulula*, Syrnium, Athene.
Family 2. Bubonidæ.
Genera. Bubo, Otus, Scops.

Order II. *Prehensores.*

Tribe. Rotundirostres.
Subtribe 1. Lævilingues.
Families 1. Plyctolophidæ. 2. Psittacidæ. 3. Macrocercidæ. 4. Pezoporidæ. 5. Psittaculidæ.
Subtribe 2. Hirtilingues.
Family 6. Loriadæ.
Subtribe 3. Tubilingues.
Family 7. Microglossidæ.

Order III. Insessores.

Tribe I. Curvirostres.
Subtribe 1. Scansores.
Family. Cuculidæ.
Genera. Cuculus, Oxylophus, Coccyzus.
Tribe II. Cuneirostres.
Family 1. Picidæ.
Genera. Dryotomus, Picus, Jynx.
Family 2. Apternidæ
Genus. Apternus.
Family 3. Sittidæ.
Genus Sitta.
Tribe III. Conirostres.
Subtribe 2. Clamatores.
Family 1. Coraciadidæ.
Genus. Coracias.
Family 2. Corvidæ.
Genera. Garrulus, Pica, Nucifraga, Corvus, *Pyrrhocorax*, Fregilus.
Subtribe 3. Cantatores.
Family 3. Sturnidæ.
Genera. Sturnus, Pastor, Agelaius.

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* The Order and Genera in italics signify the *Extra-Britannic* Birds, or those which are *foreign* to the British Islands.

Family 4. Loxiadæ.
Genera. Loxia, Pyrrhula, Corythus. *Erythrospiza*, Coccothraustes.
Family 5. Fringillidæ.
Genera. *Petronia*, Passer, Linota, *Serinus*, Carduelis, Fringilla.
Family 6. Emberizidæ.
Genera. Emberiza, Plectrophanes.
Family 7. Alaudidæ.
Genera. Phileremus, Alauda, Galerida.
Tribe IV. Dentirostres.
Family 1. Anthidæ.
Genera. *Certhilauda*, Anthus.
Family 2. Motacillidæ.
Genera. Budytes, Motacilla.
Family 3. Paridæ.
Genera. *Ægithalus*, Calamophilus, Mecistura, Parus.
Family 4. Aëdonidæ.
Genera. Regulus, Melizophilus, Sylvia, Curruca, Aëdon, Salicaria, Accentor, *Calliope*.
Family 5. Saxicolidæ.
Genera. Phœnicura, Erithacus, Saxicola, Vitiflora.
Family 6. Ampelididæ.
Genus. Bombycilla.
Family 7. Merulidæ.
Genera. Oriolus, Hæmatornis, Turdus, Petrocincla, Merula, Cinclus.
Subtribe. 4. Latrones.
Family 8. Laniadæ.
Genera. Lanius, Collurio.
Family 9. Muscicapidæ.
Genus. Muscicapa.
Tribe V. Tenuirostres.
Subtribe 5. Anisodactyli.
Family 1. Certhiadæ.
Genera. Troglodytes, Certhia, *Tichodroma*.
Family 2. Upupidæ.
Genus. Upupa.
Tribe VI. Fissirostres.
Subtribe 6. Syndactyli.
Family 1. Halcyonidæ.
Genus. Alcedo.
Family 2. Meropidæ.
Genus. Merops.
Subtribe 7. Allodactyli.
Family 3. Hirundinidæ.
Genera. Cypselus, Progne, Hirundo, Chelidon.
Family 4. Caprimulgidæ.
Genera. Caprimulgus, *Scotornis*.
Tribe VII. Cutinarirostres.
Subtribe 8. Gyratores.
Family. Columbidæ.
Genera. Columba, Turtur, Ectopistes.

Subclass II.—AVES INCONSTRICTIPEDES.

Order IV. Rasores.

Tribe. Convexirostres.
Subtribe 1. Podarcees.
Family 1. Phasianidæ.
Genus. Phasianus.
Family 2. Tetraonidæ.
Genera. Tetrao, Lagopus, *Bonasia*.
Family 3. Pteroclidæ.
Genus. *Pterocles*.
Family 4. Perdicidæ.
Genera. *Francolinus*, Perdix, Ortyx, Coturnix.
Family 5. Hemipodiadæ.
Genus. Hemipodius.
Subtribe 2. Podenemi.
Family 6. Otididæ.
Genus. Otis.

Division II. Aquaticæ.

Order V. Grallatores.

Tribe I. Pressirostres.
Subtribe 1. Cursores.
Family 1. Charadriadæ.
Genera. Œdicnemus, Cursorius, Charadrius, *Hoplopterus*.
Family 2. Vanellidæ.
Genera. Squatarola, Vanellus, Glareola, Strepsilas.
Family 3. Hæmatopodidæ.
Genus. Hæmatopus.
Tribe II. Cultrirostres.
Subtribe 2. Ambulatores.
Family 1. Gruidæ.
Genera. *Balearica*, *Anthropoides*, Grus.
Family 2. Ardeidæ.
Genera. Ciconia, Ardea, Ardeola, Erogas, Nycticorax.
Tribe III. Pyxidirostres.
Family. Phænicopteridæ.

Genus. Phœnicopterus.
Tribe IV. Spathulirostres.
Family. Plataleidæ.
Genus. Platalea.
Tribe V. Longirostres.
Family 1. Tantalidæ.
Genera. Tantalus, Ibis.
Family 2. Recurvirostridæ.
Genus. Recurvirostra
Family 3. Numeniadæ.
Genera. Terekia, Limosa, Numenius.
Family 4. Scolopacidæ.
Genera. Totanus, Machetes, Rusticola, Scolopax, Macrorhamphus, *Erolia,* Tringa.
Family 5. Phalaropodidæ.
Genera. Phalaropus, Lobipes.
Family 6. Calidridæ.
Genera. Himantopus, Calidris.
Tribe VI. Diversirostres.
Subtribe 3. Macrodactyli.
Family. Rallidæ.
Genera. Rallus, Crex, Zapornia.
Tribe VII. Frontiscutirostres.
Family Fulicidæ.
Genera. Gallinula, *Porphyrio,* Fulica.

ORDER VI. NATATORES.

Tribe I. Lamellirostres.
Subtribe 1. Simplicipollices.
Family 1. Anseridæ.
Genera. Bernicla, Anser, *Chen.,* Cygnus, *Olor,* Plectropterus, Chenalopex.
Family 2. Anatidæ.
Genera. Tadorna, *Cairina,* Rhynchaspis, Chauliodus, Dafila, Anas, Mareca.
Subtribe 2. Membranipollices.
Family 3. Fuligulidæ.
Genera. Clangula, *Undina,* Harelda, Fuligula, Œdemia, Somateria.
Tribe II. Serrirostres.
Family 1. Mergidæ.
Genera. Mergus, Merganser.
Subtribe 3. Totipalmæ.
Family 2. Fregatidæ.
Genus Fregata.
Family 3. Carbonidæ.
Genera. Carbo, Sula.
Tribe III. Sacculirostres.
Family Pelecanidæ.
Genus Pelecanus.
Tribe IV. Tubinarirostres.
Subtribe 4. Longipennes.
Family. Procellariadæ.
Genera. Diomedea, Procellaria, Puffinus, Thalassidroma.
Tribe V. Medionarirostres.
Family. Laridæ.
Genera. Cataracta, Lestris, Larus, Rissa, Xema.
Tribe VI. Subulirostres.
Family. Sternidæ.
Genera. Anous, Viralva, Pontochelidon, Sterna.
Tribe VII. Cuspidirostres.
Subtribe 5. Brevipennes.
Family 1. Podicipidæ.
Genus. Podiceps.
Family 2. Colymbidæ.
Genera. Colymbus, Uria.
Tribe VIII. Sulcirostres.
Family 1. Mormonidæ.
Genera. Mergulus, Mormon, Utamania.
Subtribe 6. Imperfectipennes.
Family 2. Alcidæ.
Genus. Alca.

It now becomes me to explain, as briefly and as clearly as I can, the subclasses, certain of the tribes, and other groups, adopted in the preceding classification.

Subclass I. Aves *Constrictipedes,*—Birds whose *feet* are *constrictile,* or *adapted to grasping.* The birds belonging to this *subclass* make, in general, compact and well built nests, wherein they bring up their very weak, blind, and mostly naked, young, which they feed with care, by bringing food to them for many days, until they are fledged and sufficiently strong to leave the nest. They are principally monogamous, and have the feet endued with great *constrictility*, or complete power of grasping; and the thumb or hind-toe, which almost always exists, entirely rests upon the ground, and is in the same plane with the other, or fore toes.

The Order I. *Raptores*, I have distinguished by *two* tribes, *viz.*, 1st, *Planicerirostres;* and, 2d, *Tecticerirostres.* The *first* comprehends those genera which possess the *cere* of the bill *plain*, or conspicuous, and it is in general large, indeed often very extensive. But in the present *rostral* classification, the birds of prey might form a natural tribe,—*Aduncirostres*, on account of their strong and *hooked beak*, as in the words of Pliny — " *rostra*—rapto viventibus *adunca*." Still I must add, that I much prefer the two first mentioned tribes, derived from the important characters of the *cere*.

Family 1. *Sarcoramphidæ;*—considering the *power* of *flight* as the chief characteristic of birds, I would commence this class by the *condor*. That magnificent monarch of the feathered race is, I believe, the largest of those species that are endued with the strongest, the most extended, and perfect wings; and it also possesses the power of flying in the highest degree. And I would terminate this class by the wingless auk (*Alca impennis*), and the penguins (*Spheniscidæ*), because these remarkable birds do not at all possess the faculty of flying, and have wings which are only rudimentary, or very imperfectly formed. The *condor* receives its generic title of Sarcoramphus, or *flesh-bill*, from the large *fleshy cere*, or skin with which its bill is so conspicuously furnished.

Subtribe 2. *Nocturni:*—the nocturnal birds of prey come under my *second* tribe—*Tecticerirostres*, or those raptores which have the *cere* of their *bill hid*, or covered with feathers: *Linnæus* erroneously characterised owls as possessing, " rostrum aduncum (*absque cerâ*)." So Dr *Fleming* says, the bill of owls is " *without* cere," and the Prince of *Canino* describes them with " cera obsoleta." On the contrary, in the genus *Otus*, the cere is *large;* although in all the genera that singular wax-like membrane, situate at the base of the bill, is *concealed* by feathers.

Instead of resuming for the owls the two subdivisions of Linnæus, *Auriculatæ* and *Inauriculatæ*, I have arranged them into two families. — 1. *Strigidæ*, corresponding with the latter, or *without earets;* and, 2. *Bubonidæ*, that agrees with the former, and comprises those owls which are furnished *with earets;* or, as our old writers named them, *ears* and *horns.* Both of these families will have to be divided into *operculati* and *inoperculati*, with reference to the presence and absence of *opercula* in the ears. The diurnal birds of prey approach the owls by the genera Circus and Strigiceps; the latter, or the *owl-harrier*, in the form of the head and the facial disc, comes most nearly to an owl. So, the family of Strigidæ approximates to the hawks or falcons, by the genus Surnia, of which the species called the *hawk-owl* (Surnia funerea), ought to be placed, the *first* in the distribution of the nocturnal raptores.

Order II. *Prehensores:*—This, with the preceding, and the following orders, constitute *six* in all, in my *general* classification of birds. I was indeed desirous of retaining only *five* orders, according to the system mostly used in England; but, on mature consideration, I found that I could not do so, if I attempted to follow an arrangement in accordance with *nature:* I have, therefore, been unwillingly compelled to place the *parrot* groups in a separate order, and which I have termed "Prehensores," after M. *Blainville* and the Prince of *Canino.* But I have ventured to differ from some of the views of the last-named admirable ornithologist, and of M. *Illiger*, in making it my *second* order; and, in fact, the link which connects the *Raptores*, or birds of prey, with the true *Insessores* or perching birds; whereas they have placed the *Psittacidæ* the *first* in their systems.

The arranging of the parrots with the *Scansores* appears to me highly artificial, and, as it were, forcing them into a place in a system, where they have little except the formation (*zygodactylism*) of the toes, and perhaps the colours in some degree of the plumage, to warrant such a step. If we compare their structure with that of the *Raptores*, we shall find the parrots approaching most strongly to them. Thus, I will enumerate some of their comparative resemblances.

They have a hooked bill,—termed also "rostrum aduncum" by *Linnæus*, and a cere covering its base, through which are pierced the nostrils. These are round, like those of many of the falcons and owls. Their tarsi are reticulated; and their claws, resembling talons, are sharp, and much curved. The shape of some parrots is similar to that of a hawk; whilst that of some others with a short tail is thickset, and rather broad or squat, and resembles the shape of an owl. Again, the naked cheeks or places about the eyes of certain maccaws, represent the plumose discs, which surround the eyes of owls. These nocturnal raptores likewise further approach to the parrots, in having their external toe capable of being turned backwards, which, when reversed, resembles the zygodactyle position of the latter. Also in their internal organization they are in these respects similar, viz., the sternum of parrots is much like that of the falconidæ, while the furcula approximates to that of the owls, by being somewhat flattened. And the œsophagus is equally enlarged with that of the falcons.

So far had I written, before I had seen, or even heard of, that most singular parrot, *Strigops habroptilus*, which has recently* been placed in the British Museum. This parrot, as its generic name implies, is exceedingly like an *owl* in its general conformation, in having facial discs, and long hair-like feathers about its beak, and in its downy or soft feathers or plumage; from which latter circumstance, the name of *Habroptilus*, has been given to it. It is figured at plate 105, Part XVII., of Gray's and Mitchell's "Genera of Birds," and is classed by them in their subfamily Cacatuinæ, which corresponds with my family *Plyctolophidæ*. This bird, then, fully confirms, in the most unexpected manner, the views I had long entertained of placing the parrot families *between* the owls, and the insessorial birds: so this new genus *Strigops* must stand the first, or *nearest* to the owls, in my *first* family *Plyctolophidæ*.

* Mr *J. E. Gray* informs me that he purchased this bird at Havre in the last summer, and that it is a native of New Zealand.

But I must observe that notwithstanding these affinities to the raptores, the parrot groups are essentially distinct from both the diurnal and nocturnal subtribes of that order, and therefore compose of themselves an extremely natural order.

The term "Prehensores," or *Holders*, will be found admirably appropriate; because, the parrots, of all birds, most possess the faculty of *catching hold* of every thing; in addition to the powerful *hold* which they always take with their toes and claws,—and these, from their structure, are best adapted to that purpose—they also *hold*, when in the act of climbing, by their strong beak; and, when about to eat, they generally hold their food in one foot, and so raise it to their mouth. Since the bill of the parrots, although hooked, differs materially from that of the raptorial birds, by being *rounder* in all its parts, I have consequently named the tribe *Rotundirostres*. Indeed, in these birds the upper mandible is likewise different in its anatomical structure, for it forms quite a separate bone, and is articulated to the cranium. The *three subtribes*, Lævilingues, Hirtilingues, and Tubilingues, are distinguished by the *tongues* being *smooth*, or *rough*, sometimes even hairy, or *tubular*. I must, however, observe, that a further knowledge of several genera of the rotundirostral tribe is requisite, for the purpose of determining with greater accuracy the groups proposed in this arrangement, as well as, in all probability, of adding other new ones to it. The extra-European or foreign order of *Prehensores*, comprising the Linnæan genus *Psittacus*, I have here introduced, for the sake of completing my *general classification* of birds: *all the rest* of the *foreign* families and genera can be included in my remaining *five* orders.

Order III. *Insessores*. I commence the *perching* birds with the Scansores, or *climbers*, as being most nearly allied to those of the preceding order. Many of their habits are similar; and the division of the toes into two *pairs* or *yokes*, which has been well termed *zygodactyle*, *i. e.*, two fore-toes and two hind-toes, is very much the same. In the arrangement I have here proposed, the approximation of the genera in each succeeding order to those in the one immediately preceding it, will be distinctly apparent. In the Raptores, as I have before said, the diurnal rapacious birds are connected with the nocturnal by the genera Strigiceps (the *owl-harrier*) and Surnia (funerea or *hawk-owl*); again, the Prehensores are approximated to the latter by Strigops, or the *owl-parrot;* and the Insessores are directly allied to the Prehensores by the scansorial genera (amongst others) Oxylophus, which in some respects exhibits an affinity to Plyctolophus, and Picus, which bears no great dissimilarity of plumage from certain of the *parrots* (Psittacus). Lastly, the more ordinary division of the toes of the true Insessores is then approached through Sitta, and other genera of the Scansores that are furnished with three toes before and one behind.

My *first* tribe, *Curvirostres,* is derived from the somewhat slender and generally *curved* beak of the cuckoos; whilst my *second* tribe *Cuneirostres,* is founded on the strong *cuneated* or wedge-shaped beak of the woodpeckers, wryneck, nuthatch, &c.

Of this tribe the family 2, *Apternidæ,* is constituted for the reception of the *three-toed* woodpeckers. The genus *Apternus* of Swainson is its type, and is correctly named, for the word signifies *without* a *hind-toe,* or heel; consequently, this family forms a very rare *exception* to the groups comprised in this subclass, and to which I would also refer the foreign species *Picus shorii* and *P. tiga.* Although the hind-toe itself is absent in these birds, yet the outer fore-toe being placed behind, and in the same plane with the others, causes the want of it to be scarcely felt in the functions of walking and climbing.

Family 3, *Sittidæ.* I think there is much anomaly in placing, as the English ornithologists do, three genera with such different beaks as the *wren,* the *hoopoe,* and the *nuthatch,* in the *same* family, Certhiadæ, and in the *same* tribe, Scansores; whilst, in fact, the *hoopoe* cannot be called a *climber. Cuvier's* System places that genus, and the *nuthatch,* among the Tenuirostres, but the *wren* among the Dentirostres; to this, likewise, there are several objections. Since the genus *Sitta* differs in its structure from those genera, as well as from the two preceding families, I have, in order to assign it a station more consistent with nature, placed it in a separate family in my Cuneirostral tribe.

Subtribe 2, *Clamatores*, Criers or Screamers, I have limited to only a few groups; one of which, the Coraciadidæ, or the European *Roller* family, I prefer placing in the Conirostral tribe, and next to the jays, which in many respects it resembles, rather than among the Fissirostres, as some of our modern naturalists do. Although the wide gape, with which the *common roller* is furnished, may give it a claim to that place; still I am inclined to divide the present family *Coraciadidæ*, and station the Australian and African kinds, especially those of the latter, which are *long-tailed*, and strongly approach the *bee-eaters* in form and appearance, next after the family Meropidæ, among the Fissirostres. And this division would then constitute a new family, and stand in my subtribe *Allodactyli*, and just before the Hirundinidæ. I have observed the *common roller* in Sicily, and think it clearly more allied to the Corvidæ than to any other group. Like the *jay*, it is restless, makes a loud chattering cry, and seeks its food upon the ground, which consists of insects, caterpillars, worms, &c. But it even resembles the *woodpeckers* in breeding in decayed trees, and having eggs of a beautiful shining white colour. In fact, the eggs of the *roller* in their shape more exactly correspond with those of *Picus minor*.

Family 2. *Corvidæ*. It will be remembered that *Cuvier* classes the genus *Fregilus*, with the hoopoe, amongst his Tenuirostres, which is perhaps its proper place, if we regard the beak alone. To place it in the Conirostral tribe seems incorrect; but its general appearance and habits must decide its station to be with the Corvidæ. *Fregilus* is, consequently, an aberrant genus.

The *third* subtribe, or *Cantatores*, Singers, is very extensive, comprising, in strictness, all the *singing* birds, and especially the true *Warblers*.

Family 4. *Loxiadæ*. Considering that the family of *Fringillidæ*, as usually retained, is much too comprehensive, and ought to be divided into one or two more, I have adopted, for the larger and thicker billed genera Loxia, Pyrrhula, Coccothraustes. &c., *Vigors*' family of Loxiadæ. (See *Zool. Journ.*, vol. ii., p. 399.)

Family *Aëdonidæ.* Instead of the name Sylviadæ, which has been given to the group of true *Songsters* or *Warblers*, I have bestowed that of *Aëdonidæ,* from the Greek ἀηδων, a *nightingale,* which is derived from the verb ἀείδω, to *sing.* The word for this family will itself appropriately signify *songsters,* being also received from that chief of songsters the *nightingale,* as its type. Consequently, it appears to me to be better to assign the generic appellation of *Aëdon* to that bird, than to continue that of *Philomela.* So, then, our two European *nightingales* would be called Aëdon Philomela and Aëdon Luscinia.

Subtribe 4, *Latrones,* Robbers, are the *birds of prey* of the Insessorial order, or Perchers. They include the *Butcher-birds, Shrikes,* and *Fly-catchers.*

Subtribe 5. *Anisodactyli.* This and the two following subtribes, *Syndactyli* and *Allodactyli,* are distinguished by their *toes.*

Family 2. *Upupidæ.* As the *hoopoe* must clearly be placed in a distinct family, I have employed that previously formed by the Prince of *Canino.* But the same author having instituted the family *Cypselidæ* for the Swifts, and so entirely divided them from the Hirundinidæ, I can by no means agree with him in the necessity for this.

Tribe VII. *Cutinarirostres,* I have thus designated because of the tumid and soft skin, or *cuticle,* at the base of the bill, in which the *nostrils* are situated, being peculiar to the pigeons, doves, and turtles.

The title of *Gyratores,* bestowed upon the Columbidæ by *C. L. Bonaparte,* is strongly indicative of their movements.

Here I must remark, that those zoologists who class the *Columbidæ* with the *Rasores,* or Gallinaceous birds, evidently transgress the order of nature. No doubt, these birds approximate nearest to the latter in some respects, yet in others, and those the most important, they are totally dissimilar.

They resemble the *Rasores,* and especially the domestic poultry, in their young being hatched with much hairy down upon them, and not naked,—in some species having caruncles, narrow and long feathers on their necks,—and in several of their habits.

But they differ from them (amongst other things) in their young being mostly born blind, tender, and requiring to be fed for some time,—in being monogamous, chiefly arboreal, possessing constrictile feet, fully suited for perching; with the hind-toe quite resting on the ground; the tarsi unarmed with spurs, and in general not swift-footed.

Subclass II. Aves *Inconstrictipedes*, birds with *inconstrictile feet;* i. e., *feet little* or *not* adapted to *grasping.*

The birds in this *subclass* make either a poor and rude nest, in which they lay their eggs, or else none, depositing them on the bare ground. The young are generally born with their full sight, covered with down, strong, and capable of running or swimming immediately after they leave the egg-shell. The parent birds attend, and direct them where to find their food. They are mostly polygamous, have the feet little or not adapted to grasping, and very frequently want the thumb or hind-toe; but this, when present, is chiefly placed higher up the tarsus than the plane of the fore-toes, and usually rests, in a slight degree, or not at all, upon the ground.

The tribe *Convexirostres* points out the strongly *arched*, or *convex bill*, of the Gallinæ, gallinaceous birds or scratchers (*Rasores*); and this I have divided into *two subtribes;*—the first *Podarcees*, Ποδάρκεες, able with their feet, or *swift-footed*, —the usual characteristic of this active group, consisting chiefly of game-birds and poultry; and the second, *Podenemi* —Ποδήνεμοι, having *feet as swift as the winds.* This subtribe comprehends the bustards, which depend upon the swiftness of their powerful, long, and muscular *legs*, for safety, rather than upon the use of their short wings.

The genus Hemipodius, or *half a foot*, is so named, because it wants the hind-toe; and in this respect, as well in being polygamous, as in having the bill compressed, it approaches to the bustard. Consequently, I have stationed it in a separate family, *Hemipodiadœ*, and next before that of *Otididœ.*

The *stilters* or *waders* (Grallatores) constitute the Order V., of which my *first* subtribe marks the *coursers* or *running waders.*

The birds in this order possess almost every variety of feet, which are furnished with either *three* or *four* toes. The hind-toe or *thumb*, when it exists, is generally placed at a varying height upon the tarsus, and does not at all touch the ground, or only does so in a slight degree; rarely, however, it is attached in the same plane with the fore-toes, and rests altogether on the ground, or presses in a great degree upon it. The mode in which the fore-toes are divided, is likewise variable, and the modifications of the web or membrane are numerous, and in some examples exceedingly remarkable.

The beaks also greatly vary, but for the most part they are of considerable length, and well adapted to searching in water or wet places, for food; so are the legs, and frequently, too, the necks of the different groups.

Family 3, *Hæmatopodidæ*, is established for the reception of that singular genus *Hæmatopus*, which is of importance, as it leads directly to the following:—

Tribe II. *Cultrirostres*, signifying the *knife-bills*, an appellation very appropriately bestowed on the group by *Cuvier.* In fact, the bill of these birds, and especially of the *Ardeidæ*, is a most dangerous weapon; when used as an instrument of defence, they suddenly dart it into their enemy like a long knife or *stilétto.*

My *second* subtribe, Ambulatores, distinguishes the *stilters* or *Walking-waders*; this ought to be again divided into two or three sections, such as *Tardi*, *Veloces*, &c.

Tribe III. Pyxidirostres, *i. e.*, *box-billed*, I have taken for the family Phœnicopteridæ, from M. *Edm. de Selys-Longchamps*' Classification of Birds, published in his "Faune Belge," *Liége*, 1842.

Tribe IV. Since the *Spoonbills* cannot be correctly classed with the *dagger* or *knife-billed* birds, Cultrirostres, I have been compelled to form a new tribe for them, and which I have termed Spathulirostres, the *Spatula-billed* group. So I have necessarily added another family, *Plataleidæ*. In this and several more *new* families, I observe, on a very recent perusal of *M. De Selys-Longchamps*' work, that he has anticipated me in their institution. It is, however, gratifying to me to find, that so able a naturalist coincides in the necessity for these *new* groups.

Family 2. *Recurvirostridæ.* Agreeing with *C. L. Bonaparte*, I have placed the remarkable genus Recurvirostra in a separate family; but among *Cuvier's* Longirostres, or *Long-billed* group, which I have taken for my *fifth* tribe of Grallatores.

Family 5. *Phalaropodidæ.* On more mature consideration I prefer to follow *C. L. Bonaparte* in the name of this family. I had previously arranged it under the title of *Lobipedidæ*, as Mr *Yarrell* has done; but, since the genera Phalaropus and Lobipes belong, without any doubt, to the *Longirostral* tribe, and bear a close affinity to the genus *Tringa*, I have here necessarily assigned to them their true and natural position.

Tribe VI. *Diversirostres.* The great *diversity*, as well in the *shape*, as in the *length* and *size* of the beaks of the rails and crakes, that form the present very natural tribe, has obliged me, for the sake of perfecting this *Rostral* classification, to entitle it *Diversirostres.*

The *Rallidæ*, as well as the *Fulicidæ*, are furnished with *long toes*, unconnected by any membrane at their base, the Macrodactyli of *Cuvier*, which (although not webbed) are in some species edged with lateral membranes, that greatly assist in swimming.

Tribe VII. *Frontiscutirostres.* The singular naked *shield*, disc, or plate, upon the *forehead* of the Gallinules, Sultanas, and Coots, of the same consistency or nature as the *beak* itself, has led me to establish this tribe. Indeed, this *frontal shield* seems only to be a *portion of the beak* carried over the forehead, about as high as the crown of the head. The lobed-feet of the *Coots*, together with their habits, form, and plumage, mark them as most nearly allied to the true *web-footed* birds, Natatores or *Swimmers*, which compose my last and

VI. Order. The *feet* of the several tribes in this order are more *simple* than those of the preceding. They are all webbed, *palmipedes*, but chiefly present *three* forms of *palmature; first*, where the fore-toes are alone connected by a membrane: this is the *common palmature; secondly*, the *totipalmature*, where the hind-toe is placed at the inner side of the tarsus, and united with the fore-toes in one entire web; and, *thirdly*, where the fore-toes are edged with lateral and extended membranes: this is called the *fissopalmature*. The *tarsi* are more or less compressed, and the *claws* in some are short and blunt, whilst in others they are flat and square, or curved and sharp, resembling talons.

Tribe I. *Lamellirostres.* Cuvier has thus very properly named his fourth family of *Palmipedes*, which, with the exclusion of the genera *Mergus* and *Merganser* (also Membranipollices), I have assumed for my *first* tribe of the Natatores. In truth, the *lamellæ* or denticulations, present one of the principal characters in defining the genera of the Anatidæ. I have divided it into two subtribes, *Simplicipollices* and *Membranipollices;* and I have separated the geese and swans (*Anseridæ*) from the ducks, whilst the latter, with the remainder of the *Lamellirostral* tribe, being the Pochards, Scoters, Eiders, &c. I have divided into two more families, by restricting those genera, chiefly fluviatile and lacustrine, which have the thumb or *hind-toe simple*, or *without* a membrane, to the family *Anatidæ;* and by placing the rest possessing the *hind-toe* edged *with a membrane*, in the family *Fuligulidæ*, being the marine or oceanic kinds.

Family 1. *Anseridæ.* I have thought myself warranted in classing the geese and swans apart from the large family of *Anatidæ* of the English zoologists; because, in addition to their shape, and some other characters, their tracheæ are mostly *not* furnished with any enlargement or labyrinth, or rarely with a *single* one, as in the Egyptian goose; while the remaining male *Anatidæ*, except the common scoter, possess osseous, or cartilaginous, labyrinths, at the extremities of their tracheæ. Also, I consider that the domestic swan ought to constitute a separate genus, which might be called *Olor*, and the species *Mutus;* but the *Hooper*, with the other species, should be stationed in the restricted genus *Cygnus*, for they differ, besides some minor points, in these structural ones of importance ; *namely*, in the absence of the basal protuberance of their bill, and in the lengthened tube of their windpipe, which enters with a fold into a cavity, within the keel of the sternum. And in the distribution of the *Anseridæ* I have arranged the genera thus :—1. *Bernicla*, beginning with (*B. Brenta*) the brent bernicle, which affords considerable resemblance to the common coot, the last of the Grallatorial order, both in shape, colour, and plumage. 2. *Anser ;* 3. *Chen;* 4. *Cygnus;* 5. *Olor;* and then I have placed the spur-winged goose (*Plectropterus Gambensis*), because, in that bird, the single enlargement at the end of the trachea first presents itself, and is perforated with many holes, thereby approaching to the *Anatidæ.* And, lastly, I have added the *Chenalopex Egyptiaca*, or Egyptian goose ; for that species next offers the tracheal enlargement, which is larger and more perfect than the preceding, and thus shews its closer affinity to the family of ducks.

My restricted family 2. *Anatidæ*, answers to *Cuvier's second* divison of ducks, which is thus ably defined by that author :— " Les Canards de la *deuxième* division, dont le pouce *n'est point bordé* d'une membrane, ont la tête plus mince, les pieds moins larges, le cou plus long, le bec plus égal, le corps moins épais ; ils marchent mieux ; recherchent les plantes aquatiques et leurs graines, autant que les poissons et autres animaux. Il paraît que les renflemens de leurs trachées sont de substance homogène, osseuse et cartilagineuse." (*Règne Animal*, p. 536, tome i., edit. 1817.)

Family 3, *Fuligulidæ*, constitutes the *first* division of *Cuvier's* arrangement of the ducks (*Les Canards*), and is characterized by him as follows :—" Les espèces de la *première* division, ou celles dont le pouce *est bordé* d'une membrane, ont la tête plus grosse, le cou plus court, les pieds plus en arrière, les ailes plus petites, la queue plus roide, les tarses plus comprimés, les doigts plus longs, les palmures plus entières. Elles marchent plus mal, vivent plus exclusivement de poissons, et d'insectes, et plongent plus soûvent." (*Reg. An.*, p. 532, tome i.)

Notwithstanding that the tracheal tube and labyrinth of the golden Eye (*Clangula*), approximating to those of the

Mergidæ, would direct me to station it the last in this group, as *Mr Yarrell* has done, I have arranged it *first*, since its size, form, and appearance, clearly indicate its place to be next to the Wigeon (*Mareca*.)

Tribe II. *Serrirostres.* I considered it more correct to institute this tribe of *saw-billed* Natatores, for the Mergidæ, Carbonidæ, &c., because the mandibles of their bills are armed with sharp *teeth* like those of a *saw*, indeed, very different from the *Lamellæ* of the former tribe, than to continue them, as in the *Cuvierian* classification, among the Lamellirostres. Still I ought to remark, that some authors designate the mandibles of the Trogons and Pteroglossi as *serrated*, but these are more strictly *cut in*, or jagged, along their exterior margins; and they would, therefore, be better defined by the term *Incisirostres.* Further, relying on two or three distinctions, I have deemed it expedient to raise the genera *Mergus* and *Merganser* to the dignity of a family, of which the former is its type.

Subtribe 3. *Totipalmæ*, the *entire webs* of Baron *Cuvier.* Here we find the hind-toe, or thumb, brought forward, or rather to the inner side of the foot, and connected with the three fore-toes by a strong and *total web.*

Family 2. *Fregatidæ.* I have retained *Ray's* generic title of *Fregata* for the man-of-war bird, and have placed it in a family separated from the *Carbonidæ;* because the feet of that singular bird, although having the hind-toe brought to the side, and united with a single palmature, differ much, in the toes being only webbed for about one-third of their length, and not, as in the two following families, as far as the claws. These last, resembling the talons of the Raptores, are sharp and strongly curved. The *Fregata* is an American species; and its appearance in Europe has been accidental. The Prince of *Canino* says, it was only *once* seen at the mouth of the Weser in January 1772.

Family 3. *Carbonidæ*, or the Cormorants, have been necessarily divided by myself from the *Pelecanidæ* of authors for several important reasons; among which is the *absence* of all *serrated* denticulations on the edges of the mandibles of the latter. So likewise, the remarkable form of the entire bill, and the shape and character of the pelicans being more allied to those of the swans, have confirmed such a division.

Tribe III., *Sacculirostres* is so named from the peculiar bag, or *small sack*, affixed to the lower mandible of the *Pelicanidæ.* In fact, the *pelican* is one of the most extraordinary of the European water birds, and, like the Flamingo or Avocet, ought to constitute, *per se,* a distinct family.

Tribe IV. *Tubinarirostres.* This tribe I have derived from *M. Illiger's* "Tubinares," on account of the *tubular nostrils,* which extend along the top of the upper mandible of the different genera in this group. This, and the two following tribes, are furnished with *long wings*; and they are included in *Cuvier's* "Longipennes," or *second* family of Palmipedes.

Family *Procellariadæ.* As *C. L. Bonaparte* had previously done, so I have separated the Petrels, &c. from the *Laridæ,* and restricted to them the present family.

Tribe V. *Medionarirostres.* The *nostrils* in the skuas, gulls, and xemes, are placed about the *middle* of their *bill;* hence the term, which I have assigned to this tribe, will convey to it a proper signification.

Family *Laridæ.* From the similitude of the bill of the genus *Cataracta,* or Cascade skua, to that of *Procellariadæ,* I have selected for it the first station in this family.

Tribe VI. *Subulirostres.* This is a very natural tribe taken from the *subulate,* or awl-shaped beaks of the terns and sea swallows.

Family *Sternidæ.* I have differed from *C. L. Bonaparte, M. de Selys-Longchamps,* and others, in forming a new family *Sternidæ,* quite independent of the *Laridæ.* Also, the genus *Pontochelidon* has been instituted by me for the reception of *Sterna* Caspia, and *S.* Anglica.

Tribe VII. I have designated *Cuspidirostres,* because of the strong sharp-pointed beaks of the several genera, which much resemble the *point of a spear.* They all have *short wings*—the "Brachyptera" of *Cuvier;*—but which, for the sake of uniformity of expression adopted for my last three *subtribes,* I have called *Brevipennes,* as I find *M. de Selys-Longchamps* has likewise done.

Family 1. *Podicipidæ.* From the remarkable feet of the grebes, their want of a tail, and some other characters, I perfectly coincide with the last mentioned author in separating them from the family of *Colymbidæ.*

Tribe VIII. *Sulcirostres.* I have bestowed this title upon the present tribe, in order to point out their peculiar *bills* as well as the grooves or *furrows* (sulci) that are apparent in them.

Family I. *Mormonidæ.* This family has been established by myself for the little auk, puffin, razor-bill, &c., since they principally differ from the true auks (*Alcidæ*) in their short, but more perfectly developed wings, with which they are able to fly, notwithstanding the statement of *Cuvier* and others to the contrary.

Obs. With respect to the *subtribes,* I must here make some explanation, viz., that where *one* subtribe is intended to embrace *more* families than those comprised in a *single* tribe, for example, the *subtribe* Longipennes may include the Laridæ and Sternidæ, as well as the Procellariadæ ; and the *subtribe* Brevipennes, the Podicipidæ, Colymbidæ, and Mormonidæ, the term *suborder* might perhaps be more correctly substituted for that of *subtribe,* and in lieu of standing *after* be placed *before,* the tribe; but this I will leave to the judgment of others. And I will only add, that I have preferred, for the sake of a uniform terminology, to name *all* those sections *subtribes,* and not *some* of them " suborders," and *others* " subtribes."

Subtribe 6. *Imperfectipennes,* in consequence of the *wings* of the true auks (*Alcidæ*) being so *imperfect,* as to be useless for the purpose of flying, I have formed this subtribe for them, and for the foreign family of Penguins (*Sphenisсidæ*), which is furnished with very similar wings.

Family 2. *Alcidæ.* Herein are contained the restricted auks; and I thus station the wingless auk (*Alca impennis*) the *last* in my arrangement of the *European* birds.

As I have previously mentioned, that I would begin my *general* classification of birds by the *condor* (Sarcoramphus gryphus), and I would terminate it by the smallest species of *penguin;* so, in like manner, it will be seen, that I have commenced my distribution of the *birds of Europe* by the genus *Neophron*, a bird endued with great *vigor of flight*, and have concluded it by the *flightless Auk*. It will also be observed, how I have placed the subtribe *Brevipennes* intermediately between the *Longipennes* on the one side, and the *Imperfectipennes* on the other, and thus gradually leading from the web-footed birds, possessing considerable power and swiftness of wing, to those which have almost *no* wings, or at least are entirely deprived of the faculty of flying. For, in reality, the wings of the latter are *most imperfectly* developed; being merely rudimentary, with scale-like feathers, and useless as instruments of flight, they are alone serviceable as *fins* for the functions of swimming and diving. Thus we find the birds comprised in my last family, *Spheniscidæ*, or the Penguins, in their form, habits, and marine mode of life, approximating most closely to the Turtles, or *Amphibia*, and to the following class of Fishes.

Lastly, in the preceding classification, the great *increase* in the *number of families* may, at first sight, appear objectionable to some ornithologists. But, on a further examination of it, I trust, their objections will be removed; because I feel satisfied, that, by a more minute and extended division of the birds into such groups, we arrive at a more perfect and natural arrangement: and, at the same time, I consider it to be the only accurate method of attaining to a full knowledge of the differences presented in their organization. And I am exceedingly gratified to find, that the view of that most distinguished philosopher and observer of nature, *Alexander von Humboldt*, precisely agrees with my own; for, in his work "*Cosmos*," now publishing (vol. i., p. 388), he thus writes: "In the natural history of *birds* and fishes, the system of grouping into *many small families* is more *certain* than that into a few divisions, embracing larger masses."

Marine Deposites on the Margin of Loch Lomond. By the Rev. J. Adamson.

As to beauty or magnificence of scenery, Loch Lomond has many interesting features common to it with the other Scottish lakes which occupy the chasms of the great primitive mountainous district; it is, however, more closely connected with a different set of hollows. It is the most characteristic example of a group of long ranges which lie together, and nearly parallel to each other, but which, instead of following the direction of the mountain recesses, stretch almost perpendicular to it, generally cutting through the transition and part of the primitive rocks, together with the older members of the secondary class. All the others of those valleys are connected with the sea by means of the Frith of Clyde, and are partly filled with its salt water, and enlivened by its appropriate animals. There is reason enough to believe that this was at one time the condition of Loch Lomond; but at present we find there, along with the ocean's depth, only the remains of its inhabitants.

One of these marine deposites was about eight or ten feet above the highest level of the present waters. It lay in a small hollow, under a projecting precipice of limestone, close to the margin of the lake. The only remains of it now are some fragments of a very compact calc-tuff, containing sea-shells disseminated through it. The limestone rock is now quarried; and the calc-tuff, being the most accessible and richest limestone, was first carried off for use. The shells appear to have been accumulated in a situation exposed to the stalactite droppings from the lime rock. In the interior of the tufa, they are chiefly the *Myrtilus edulis*, or its congeners; but the surface is sprinkled with imbedded specimens belonging to the genera Planorbis and Helix, which have accidentally fallen upon it. This quarry is on the east side of the lake, about two miles north-west from the mouth of the Endrick, and on the north side of the great range of islands composed of secondary conglomerate, which stretches across the southern end of the lake. The limestone is on the lands of his Grace the Duke of Montrose, and is worked for his tenantry, but is not much esteemed for agricultural purposes. It is highly crystalline in its fracture, appearing to be irregular layers of crystals separated by quartz and clay.

There are other two places which afford shells, in very different circumstances. These points are similar in situation; both are in slight bays opening to the north, and presenting a steep gravelly beach to the water. One of them is on the island of Inch Lonach, opposite to the village of Luss; and the other on the lands of H. Macdonald Buchannan, Esq., near the south-east angle of the lake. The shells begin to appear about half-way between the highest and lowest, or the winter and summer, surfaces of the water, which varies in this respect about six feet. After removing a slight covering of coarse gravel, we find a thin bed of clay, of different shades of brown, passing into yellow colours, as we descend. In the upper, or brown clay, are found shells of the following species. Those marked ? are doubtful. *Buccinum reticulum? Nerita glaucina, Tellina tenuis? Cardium edule, Venus striatula, Venus Islandica, Nucula rostrata* young, *Pecten obsoletus, Anomia ephippium* young, *Balanus communis, Balanus rugosus, Echinus esculentus.* A skilful conchologist would discover many others, from the numerous traces of them in the clay. Those shells appear to have been deposited generally in an entire state, and many are found with both valves in their natural position. The Balanus is still slightly attached to the Venus or Pecten; and the spines of the Echinus are found clustered in the clay inclosing its fragments; so that they must have been either covered by water to a considerable depth, or thrown on a beach not much exposed to waves. Few of them, however, can be extracted entire, as several of the species are always in a state of gritty chalk; but many complete and beautiful specimens of the Pecten can easily be procured. Few of their fragments appear on the exposed part of the beach, but, during summer, many may be seen a few feet under water. Those deposites cannot be more than about twenty-two feet above the present level of the sea. It is probable that an attentive inspection of the margin of the lake would discover many others similar to them. A little attention may be necessary to an opinion which we sometimes hear expressed in conversation, " That such hollows as Loch Lomond, with a bottom so far below the level of the ocean, ought, if ever they were filled by it, still to retain its salt water." It seems to be imagined that the sea-water, on account of its greater specific gravity, is still retained in the deep pits of these chasms, and that the fresh-water glides unmixed above it, or changes by evaporation and renewal, without affecting its deeply buried mass. It does not seem difficult to demonstrate the improbability of this supposition. For the phenomena of solution can be accounted for only on some hypothesis such as this,—that where a film of pure water is applied to a film containing salt in solution, there is a tendency in them to unite, and form a compound of less saturation than the latter; which compound has a corresponding influence on the nearest, or any number of saturated films beneath it, and will, in like manner, be affected and changed by the next pure film above it, and successively by any number of films in any depth of water. The changes will cease only when an equilibrium of attractions has taken place through the whole mass, which will then be in a state of medium and uniform saturation. Whatever be the time required for the combination of two films, that time would be an element in the equation, representing the whole period necessary to produce uniformity, which must, therefore, depend on the number of films, or be a function of the depth. Changes of temperature at the surface would very much accelerate the result, by sending downward dense films, having the highest degree of attraction. until stopped among others having the same specific gravity, arising from greater saturation; so that, probably, no long time would elapse before nearly uniform saturation took place, even though the combined depths of the fluids were considerable. But the tendency towards uniform saturation is opposed in a manner which must quickly draw off the salt-water from a hollow, such as a lake, because the surface water, in general, is continually changing, and the water which has become slightly saturated flows off, and is replaced by that which is purer, and has a greater attraction for the salt; and to satisfy this augmented attraction, the progress of change downwards must be much more rapid. Consequently, however slowly the tendency to equilibrium may act in an isolated solution, —in the other case, as the progress of exhaustion goes on more rapidly, we may expect that no long period would be required to destroy all perceptible saltness. That this period has long since passed, in our Scottish lakes, can scarcely be doubted; but though we be not able to bring up sea-water from the bottom of any of them, yet all are interesting objects of observation. Loch Lomond, in particular, as the additions it receives are so uniformly distributed over the whole space of its margin, is admirably fitted for experiments on the changes or stability of temperature in deep waters.—*Memoirs of the Wernerian Society*, vol. iv., p. 334.

Address delivered at the Anniversary Meeting of the Geological Society of London, on 20th February 1846. By LEONARD HORNER, Esq., V.P.R.S., President of the Society.*

Following the example of my predecessors, I propose to notice, in the first place, in the order of formations, such particulars relating to the sedimentary rocks as have most arrested my attention during the last year, contained in the works I have had an opportunity of examining with care. But before proceeding to that systematic review, it may be useful, for the reason I have already assigned, to give an outline of the great features in the geology of Russia in Europe, and the eastern boundary of the Ural Mountains, described by Sir R. Murchison. And although he nowhere speaks in these volumes in the first person, but associates his fellow-travellers with him in all he tells us, if for the sake of brevity I more generally name him when I have occasion to refer to the authors, I hope I shall not be considered as detracting in the least degree from the merits of M. de Verneuil and Count Keyserling.

Geology of Russia.

Russia in Europe is "one huge depository basin," encircled

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* Extract from a copy sent to us by the author.

on the west and north by the granites of Sweden and Finland, and on the north-east, east, and south-east, by the chain of the Ural Mountains, which are mainly composed of plutonic and metamorphic rocks. It consists, to a very great extent, of a series of undulations, composed of incoherent clays and sands; but although in that unindurated state, not consisting of modern detritus, but being very ancient deposits that have undergone no consolidating process; for the whole of European Russia appears to have been exempted from igneous agency. No eruptions have tilted up the beds; but the elevatory forces, to which, however, it has been indubitably and repeatedly subjected, have raised the vast undulating plains *en masse*, without a break. The oscillations of the land having left the strike more or less horizontal, scarcely any traces of unconformability of strata of different ages are to be met with, and beds separated in time by vast intervals are in the same parallelism of juxtaposition as if they were the members of one group. Thus at the mouth of the Vaga, a tributary of the Dwina, about 150 miles south of Archangel, post-pliocene beds are seen resting conformably on limestones with Producti and Corals of the Permian rocks; and an observer unacquainted with fossils might view the two as parts of an unbroken series.

We have some most instructive examples of similarity of lithological characters between deposits of the most different ages, consequent, perhaps, in some degree upon that absence of consolidating processes to which I have alluded. A grit occurs in Sweden, described as a recomposed granite or granitic gneiss, which constitutes the base of the Silurian system in that country, that can scarcely be distinguished in mineral character from a tertiary grit in central France. Lower Silurian deposits charged with fossils common to the crystalline slaty rocks of other regions often occur as greensands and half-consolidated mud-like limestones. We have Silurian bituminous schists that resemble the hard beds of the Kimmeridge Clay. In one region a carboniferous limestone has all the characters of a soft tertiary deposit; in others, Devonian, Carboniferous, and Permian rocks, are not distinguishable from the younger secondary or even tertiary deposits of Western Europe; and even an oolitic rock of Mio cene age cannot be distinguished from the Great Oolite of the Jurassic period.

These facts are most valuable, as shewing that at all periods sedimentary rocks were formed, as they must now be forming, at the bottom of the sea, from the detritus of adjoining land, by the same agencies of disintegration as are now at work; and that then, as now, gravel, sand, and mud, were the forms which such detritus must have taken, to be afterwards compressed together, and consolidated by a variety of causes acting more or less intensely in different situations.

But Sir R. Murchison also observes, that the connection between the character of the fossils and the nature of the matrix in which they are imbedded, is more pointedly brought before the observer who ranges over the boundless tracts of Russia, than in any other country which he has examined. Notwithstanding the absence of violent dislocations, the various Russian formations, though horizontal, or so nearly so, that they may be all considered conformable to each other, are as distinctly separable by their included remains, as in those typical and dislocated tracts where geologists first worked out their order. And these observations hold good in the newer as well as in the older deposits; thus, in the regions of the Volga, greensand, ironsand, chalk, and chalk marl occur, in which the same groups of fossils prevail as in the rocks of Britain and France, which hold the same relative place in geological succession; and pure white chalk, containing some characteristic organic remains, extends from the British Isles to the confines of Asia.

That so vast a tract of country, unlike most other parts of Europe, has been so little broken up locally by igneous eruptive rocks, may perhaps, with great probability, be ascribed to this, that a safety-valve was opened, an enormous crack or cleft was made on the east, by a subsidence of the country on the west, through which the pent-up elastic force and the molten matter escaped, and thus the high pressure was taken off from under the broad expanse. The Ural Mountains, bounding Russia in Europe on the east, are a comparatively narrow ridge, made up of igneous rocks and sedimentary palæozoic deposits; and through fractures in the latter the igneous rocks were erupted, after having produced in them those changes of structure which we call metamorphic; that is, having caused them to change their original characters, and assume a crystalline aspect,—the force acting with such intensity as in many places to overturn the strata, and so invert the order of superposition on the flanks. But it has not been by one great fissure only that the igneous rocks have been erupted; "other parallel outbursts and upheavals have taken place along the same line at subsequent epochs;" and the authors shew grounds for belief that the present form of these mountains was the result of more than one elevatory process, and that there was a period when, as a low ridge, they formed the western shore of a great continent to the east, that now called Siberia, and even at so recent a period as when that continent was inhabited by large quadrupeds closely allied to existing species. The Urals extend from Nova Zemlia to the Caspian, through nearly thirty degrees of latitude, in a direction nearly north and south, but sending off branches to the east and west at both extremities, one of which, on the north-west, the Timan range, was first explored geologically by Count Keyserling in 1843; and in no part of this long line are they divided by any great transverse valleys, nor does their general altitude exceed from 2000 to 2500 feet. No parts of the author's descriptions are of higher geological interest than those in which they speak of the Urals; and to some of the more striking features of that chain of mountains I shall afterwards more particularly refer.

The immediate substructure of the whole area of Russia in Europe is composed of the palæozoic rocks, which, on the northern division, are covered by sand, clay, and blocks. A narrow band of Silurian deposits, the older members of that group, stretches along a great part of the shores of the Baltic, succeeded eastward by Devonian and Carboniferous formations, each occupying a vast extent of country; and, lastly, that highest member of the palæozoic order of strata to which the authors have applied the term "*Permian System*," the most widely spread of all, occupying a region more than twice the size of the whole kingdom of France. Of the whole range of the secondary deposits between the Permian and the tertiary, two only have been met with, viz., that division of the oolitic series which includes the Oxford clay and its associated rocks, and in South Russia cretaceous rocks, including a white chalk very similar in mineral characters and zoological contents to that of England. The oolitic rocks overlie the Permian, but in detached masses, and with a surprising uniformity of character from the Icy Sea to the southern extremity of the Urals. There are, besides, but in Southern Russia only, some limited tertiary districts, and of all ages, from Eocene to Pleistocene.

The most remarkable feature in the physical geography of the country described, and which may justly be said to be, in the words of the author, "one of the most singular features in the ancient condition of the surface of the globe which modern researches have brought to light," is that exhibited by the region around the Caspian; affording the most unequivocal proofs of great changes in the relative levels of the land and water, at a period geologically recent. Over a vast region a calcareo-argillaceous deposit exists in nearly horizontal stratification, abounding in freshwater shells and others analogous to, and to a great extent identical with, species now living in the Caspian, attaining, in some places, a thickness of 300 feet; which appears to prove, that, at the time it was deposited, there existed an inland sea, of brackish water, exceeding in size the present Mediterranean, and of which the present Caspian is the diminished relic. Of this remarkable deposit, designated "Steppe" and "Aralo-Caspian limestone" by the authors, I shall speak more particularly when I refer to the Tertiary formations.

This inland sea, although called by Sir R. Murchison a Mediterranean, he does not the less consider to have been entirely separated from the Western Ocean of that period, by a barrier, produced by the elevation of the marine tertiary beds of Miocene age, on which this Steppe limestone, in many places, is seen to repose. To affirm with certainty that the surface of this inland sea once stood at a higher level than that of the Caspian at the present day, and which, according to very careful measurements recently made by order of the Russian Government, is now proved to be 83·6 feet below the Black Sea, would require a most extensive series of local observations and levellings around the region occupied by the Steppe limestone, attended with very great difficulties. It is the opinion of some travellers who have carefully examined parts of this region, that, during the historic period, and within modern times, the surface of the Caspian has been diminishing, from the disproportion between the evaporation from so large a surface in that climate, and the sources of supply of water. Whatever portion of the land occupied by the Steppe limestone is now on a level with, and below the level of the Black Sea, may have been laid bare by this gradual lowering of the water of the Caspian; but whatever portion is above that level, and the greatest proportion of it is so, must, it is evident, have been upraised; and there is abundant proof of volcanic forces being in activity in that region to the present time. To endeavour to trace the direction of the vast body of water that must have been displaced by the upheaved land, as there could be no direct outlet to the ocean, would be an inquiry of great interest; for it can hardly be doubted that there must be evidence of a deluge or deluges having swept over a large portion of that part of Asia, and more especially if the elevatory forces acted suddenly.

As the leading features of the physical structure and the great geological divisions of the continent of North America are well known, I do not think it necessary to give any general outline of the country described by Mr Lyell in his lately-published "Travels;" but I shall have frequent occasion to refer to the information contained in that work on several points of great importance, in speaking of some of the additions in the past year to our knowledge of the great groups of rocks, and to our better acquaintance with questions of mineral structure, changes in the form of the land, and distribution of organic remains.

I shall now offer some remarks on the several great groups of formations, and shall begin with the lowest fossiliferous deposits.

Silurian Rocks.

It is certainly remarkable, considering the short time that has elapsed since Sir R. Murchison first proposed the separation of the lower beds of the palæozoic strata into one great series, that rocks which appear to be clearly made out to belong to the Silurian system should have been already recognised in so many regions remotely distant from each other. That they constitute a great part of Europe has been shewn by many writers. The geologists of the United States and Mr Lyell have told us how widely they are spread over the northern States of North America; and we learn from Captain Bayfield that they occur extensively all round Lake Huron; northward towards Hudson's Bay; along the northern side of the valley of the St Laurence, eastward to the Strait of Belle Isle, and on the western coast of Newfoundland from that strait to its southern extremity. M. Alcide D'Orbigny has described them as extensively developed in South America; and from Mr Darwin we learn that they probably exist in the Falkland Islands, adjoining the farthest extremity of that continent. It is also more than probable, from the information we already possess, that they exist in Australia. The rocks were known, and had been partially described, but they were not understood; they were known mineralogically, and deposits separated by great intervals of time were classified together, under the vague, uncertain, general term of graywacke, or graywacke-slate, or clay-slate, The clear development of the system, and lucid descriptions of the normal types in the Silurian region of Britain, dispelled the obscurity that hung over the history of these ancient beds; and now geologists are at work in all countries, making out the great features of resemblance, and registering those variations in mineral and fossil contents, dependent on geographical position and other local causes, which are found to prevail more or less in all formations.

It appears to be now the opinion of those geologists who have most carefully and extensively studied the sedimentar rocks which contain the oldest forms and first traces of organic life, that from the highest beds of the Lower Silurian rocks to the lowest deposit in which organic remains have been found, there had been no great variation in the circumstances under which these beds were deposited, although there is evidence of a long duration of time, in which gradual changes in animal life took place, some species diminishing in numbers, others becoming extinct, others continuing to exist throughout the whole range, and a few appearing in the lower portion of these beds, which, from a marked general change of forms, are classified as the Upper Silurian rocks. This view you will see developed in the address delivered by Sir R. Murchison from this chair four years ago,* where he states, that the conventional line that had been drawn between the Lower Silurian and the Cambrian rocks beneath them had no longer any reference to strata identified by distinguishing organic remains; for the same fossils are found in strata on each side of that demarcation. He also stated, on the same occasion, that " the zone of fossiliferous strata characterized by the Lower Silurian Orthidæ are the oldest beds in which organic life has been detected," and his belief that " many of the subjacent rocks, sometimes even when in the form of gneiss, mica-schist, talc-schist, chlorite-slate, &c., are nothing but metamorphic rocks, in less altered parts of which the same typical fossils are observable." In his recent work on Russia he asks the questions, " Can we lay open the earliest vestiges of animal life, and amid palæozoic forms trace backwards primeval history to a protozoic type? Can we separate such protozoic strata from those which went before them, and were deposited *ere life had been breathed into the waters?*"† To the latter question I am disposed to answer, that the mere negative fact that we have not yet discovered traces of organized bodies in the lowest strata, certainly does not warrant the inference that no living thing had yet existed, or our saying, that *any strata* were deposited " ere life had been breathed into the waters." If these strata contain a particle of undoubted detrital matter, a grain of rolled

* Proceedings of the Geol. Soc., vol. iii., p. 642.

† Russia and the Ural Mountains, &c., vol. i., p. 1.

sand, they afford positive proof of the pre-existence of land and water, and atmospheric destructive agency to supply the materials of these strata, and the bed of a sea to receive them. Is it not highly improbable that this sea was untenanted? There must doubtless be a lowest sedimentary stratum, the materials of which must have been derived from land composed of non-sedimentry rocks. By "non-sedimentary" I mean a rock, the formation of which may, with the greatest probability, be ascribed to igneous action. Whether it was granite, or any other form of igneous rock with which we are acquainted, we cannot tell; because of the great uncertainty as to how far the lowest sedimentary deposits have undergone changes by metamorphic action; but that silica and clay and very little lime entered into its composition is evident from the predominance of the two former earths in all the oldest strata, and the comparative rarity of lime.

But animal and vegetable life may have existed while the land that afforded the materials for the first sedimentary deposits was wholly composed of unstratified rocks. Nor is it necessary to have recourse to the obliteration by metamorphic action in all cases where there are no traces of organic remains. We have learned from the valuable report by Professor Edward Forbes of his researches in the Ægean Sea, that there are profound depths in which no animals and no vegetables seem capable of living; and thus, as there may be now, and probably are, deposits of vast thickness produced without organic bodies having ever lived in or upon them, in the profound depths of the Atlantic and Pacific Oceans, so is the absence of such remains in any stratum no proof, that when it was deposited there might not have existed above it a sea teeming with life. I cannot support this view better than by quoting what Professor Forbes says on the subject: "As in the sea there is a zero of vegetable life, so, we may fairly infer, is there one of animal life. All deposits formed below that zero will be void, or almost void, of organic contents. The greater part of the sea is far deeper than the point zero; consequently the greater part of deposits forming will be void of organic remains. Hence we have no right to infer that any sedimentary formation, in which we find few or no traces of animal life, was formed either before animals were created, or at a time when the sea was less prolific in life than it now is: it might have been formed in a very deep sea."*

The muddy waters of the Amazon stretch 300 miles into the Atlantic Ocean, and their sediment must be deposited in depths far below the zero of animal and vegetable life. Unless, therefore, portions of dead organisms be transported down steep slopes by submarine currents, from a shallower sea to those depths, and be mingled with the sediment, rocks must now be forming over the bottom of the Atlantic Ocean, which, when upraised in future ages, will exhibit as few traces of living bodies having existed when their component parts were deposited, as we can discover in the slates of Wales and of Westmoreland.

We have received as yet only a part of the results of the labours of Professor Forbes, and wait with impatience for his greater work; but what he has already made known to us of the changes that take place in organized bodies in different zones of depth, and in different states of sea-bottom, have so extensive a bearing upon many of the inferences hitherto drawn as to the age of deposits, and to changes of climate from fossil contents, that some of our most established doctrines ought to be revised, and their soundness tested by their accordance or otherwise with these conditions. Others hypothetically anticipated that rocks might have been formed in depths unsuited to animal and vegetable life; but Professor Forbes was the first, I believe, to establish, by actual observation, that such is the fact as to depth, and also the first to shew, as an element of geological reasoning, the connection that subsists between *the nature of the sea-bottom* (often changing on the same spot) and the living bodies it supports, and thus to demonstrate the existence of laws of the highest geological importance, and which must have prevailed throughout the whole range of formations.

Among the communications read before the Society since

* On the light thrown on Geology by submarine researches. Jameson's Edin. Phil. Journ., April 1844.

the last Anniversary, we have had two by Professor Sedgwick on the comparative classification of the fossiliferous strata of North Wales with the corresponding deposits of Cumberland, Westmoreland, and Lancashire, both of them in continuation of his memoir read in November 1843. I will not attempt to give any abstract of the contents of these papers, because I could not do so, to any useful purpose, without extending my observations to an inconvenient length; but I recommend all who are desirous of acquiring an accurate knowledge of the geological topography of those parts of our island, and of becoming acquainted with many facts that throw light on that obscure and difficult part of geology, to study the memoirs themselves; those of 1843 and of March 1845 are published in the first volume of our Journal, and the last of them will appear in the number of next May.

It is to Professor Sedgwick we are mainly indebted for the knowledge we possess of the geological structure of those parts of our island; it was he who first grappled with their very complicated and difficult conformation; for nearly twenty years he has been labouring to decipher their obscure and complex characters; and, since the discovery of the Silurian key, he has been enabled to make out a clear and intelligible outline of the history of these regions, which, for a long time, geologists seemed to shrink from all attempts to understand. Let us hope that the learned author will soon gather together his scattered materials, and bring out a new edition of his work, with all the corrections and illustrations which his latest observations enable him to supply. When we have that volume, and can study it with the commentaries, and the additional illustrations of accurate sections, which we in part have, and may soon look forward to receive from Sir H. de la Beche and his fellow-labourers in the Geological Survey of Great Britain, we shall possess a very full and correct knowledge of these older sedimentary deposits, and the igneous rocks with which they are associated, and therefore of the most remote periods of geological history; and we may, perhaps, then indulge in a little excusable national vanity of possessing another standard with which the structure of extensive and distant regions of the earth will be compared, in addition to what we already have of many of the palæozoic and secondary formations.

A paper by Captain Bayfield read before us last April, and published in November in our Journal, gives us much important information on the Silurian rocks that prevail to a great extent in Canada; and we are indebted for a more accurate knowledge of the same class of rocks in the Isle of Man to the Rev. J. Cumming, in the first part of a description of that island, read last June.

We learn from the "Geology of Russia," that both in that country and in Scandinavia, a series of ancient deposits cover a great tract of country, which, in all their great features, and often in their minute characters, are identical with the Silurian series of the British Isles, and that they are equally divisible into two distinct groups, and are also overlaid by a true Devonian formation. In the central and southern parts of the continent of Sweden, the lower Silurian rocks only occur, but the adjoining islands of Oesel, Dago, and Gothland are mainly composed of Upper Silurian rocks, affording better types than Wenlock or Dudley. Describing the rocks near Katchkanar, on the eastern flank of the Urals, Sir R. Murchison says, "The banks of the river Is are composed for a considerable distance of white limestone, thickly tenanted by large Pentameri, some Trilobites, and shells which we hailed as true Silurians, and worthy of the very region of Caractacus. We were enchanted when we discovered myriads of them undistinguishable from the *Pentamerus Knightii;* so that, seated on the grassy banks of the Is, we might for a moment have fancied ourselves in the meadows of the Lug at Aymestry." Of the Lower Silurian fossils of Russia a few only are absolutely identical with forms of the same age in the British Isles; but the mass of them is essentially the same as that of the mainland of Scandinavia; which region being intermediate between England and Russia, is found to contain a considerable number of forms common to deposits occupying the same position in both the other countries. In the lowest part of the Lower Silurian rocks that skirt the southern shores of the Baltic, a grit occurs so abounding in a minute shell, the Ungulite or

Obolus (which has a great affinity to the *Lingula*), as to form entire beds. Here we have a parallel to those beds in the Silurian series of the British Isles, abounding so copiously in the *Lingula attenuata.* It is also a parallel to beds occurring at a far more distant point, on the opposite side of the Atlantic. Mr Lyell, in describing the Potsdam sandstone, the lowest member of the Silurian series in North America, as it occurs on Lake Champlain, says, " In many places this most ancient of the fossiliferous rocks of New York is divided into laminæ by the remains of innumerable shells of the genus *Lingula.* They are in such profusion as to form black seams like mica, for which they were at first mistaken. It is highly interesting, that in this lowest fossiliferous bed, one of its commonest organic remains should belong to a living genus, and that its form should come very near to species now existing. Throughout so vast a series of ages has Nature worked upon the same model in the organic world !"

The Silurian system of the northern countries of Europe is, as a whole, closely analogous to that of Great Britain ; and it proves that wherever the sediments of the same age in the two regions resemble each other in lithological texture, such similarity is accompanied by a close approximation and frequent identity in the associated organic remains. When the fossils from the Silurian beds of Northern Europe were compared, Mr Lyell informs us, by M. de Verneuil with those brought by him from America, there was a great distinctness ; but the representation of generic forms, whether in the organic remains of the Upper or Lower Silurian strata, was most clear and satisfactory. The geologists of New York make three distinct groups in the Lower Silurian, and four distinct groups in the Upper Silurian series of that country, and Mr Lyell is of opinion that these divisions are based on sound principles ; that is, on mixed geographical, lithological, and palæontological considerations ; the analogy of European geology teaching us that minor subdivisions, however useful and important within certain limits, are never applicable to countries extremely remote from each other or to areas of indefinite extent. The Silurian rocks are developed in North America on a great scale, and, like those of

Russia, are little disturbed from their original horizontality, making the order of their relative positions clear and unequivocal in both countries. In lithological characters there is a considerable resemblance on both sides of the Atlantic—mudstones, sandstones, and limestones prevailing. In America, however, there is an intercalated group in the Upper Silurian system, to which nothing analogous has yet been observed in Europe, as far as I am aware. It consists of red, green, and bluish marls, with beds of gypsum and occasional salt-springs, the whole being from 800 to 1000 feet thick, and undistinguishable from parts of the Upper New Red Sandstone or Trias of Europe. A similar intercalated group of red and green argillaceous marls, with gypsum and salt-springs, is met with in the middle of the Devonian group in Russia. This occurrence of gypsum and muriate of soda associated together in the older strata, as they are in the Pliocene, as well as in many intermediate periods, is a remarkable circumstance; and it would be an investigation well deserving the joint labours of the chemist and the geologist, to endeavour to account for the origin of these chemical formations.

With regard to the fossil contents of the Silurian beds of North America, it appears that "while some of the species agree, the majority of them are not identical with those found in strata which are their equivalents in age and position on the other side of the Atlantic. Some fossils which are identical, such as *Atrypa affinis*, *Leptæna depressa* and *Leptæna euglypha*, are precisely those shells which have a great vertical and horizontal range in Europe—species which were capable of surviving many successive changes in the earth's surface, and for the same reason enjoyed, at certain periods, a wide geographical range. It has been usually affirmed that in the rocks older than the carboniferous, the fossil fauna in different parts of the globe was almost everywhere the same; but Mr Lyell adds, "that, however close the general analogy of forms may be, there is evidence in the Silurian rocks of North America of the same law of variation in space as now prevails in the living creation;" and in another place he states, that, with regard to the proportion of species common to the Silurian beds of Europe and America, whether of the upper or lower division, he can confidently affirm, that it is not greater than a naturalist would have anticipated, from the analogy of the laws governing the distribution of living invertebrate animals.

While the remains of fucoid plants are met with abundantly in the Silurian rocks of Europe, and in the lowest members of the series, I am not aware that any vestiges of land plants have yet been discovered in them. Sir R. Murchison says, that, in the older palæozoic rocks of Russia, he met with no signs of terrestrial fossil vegetables. Fucoids are plentifully distributed through every part of the series in North America; and Mr Lyell also states, that, in the Hamilton group, which corresponds in many of its fossils with the Ludlow rocks, and which, singularly enough, is met with in the neighbourhood of Ludlowville, remains of plants allied to Lepidodendron have been found associated with fossils agreeing perfectly with European Upper Silurian types; and that other plants allied to these, and ferns, have been met with in the lowest Devonian strata of New York, associated with fossil shells closely allied to the Silurian. Thus we have additional proof, if any were wanting, of the existence of dry land at the time of the deposition of these Silurian beds.

Devonian Rocks.

The Silurian rocks of Russia in Europe are covered conformably by deposits, the identity of which, with the Devonian, or old red sandstone, series of the British Isles, Sir R. Murchison and his companions clearly made out. They extend over an area of not less than 150,000 square miles, a superficies greater, by nearly one-third, than that of Great Britain and Ireland together. This monotony of feature over so vast a space is even greatly surpassed by the Permian rocks; and when it is considered that this uniformity is combined with a stratification rarely deviating from the horizontal, never thrown up into natural sections, and that the investigation of them can only be carried on where the beds are exposed in the banks of rivers, geologists can appreciate the tedium and labour of exploring such a country, and cannot too highly praise the patience and perseverance of Sir R. Murchison and his fellow-travellers.

Although recognised by a remarkable degree of identity in fossil contents, and especially in regard to ichthyolites, as a deposit of the same age as the old red sandstone in our own country, it is lithologically very different in most places. Sometimes it is made up of numerous alternations of flat-bedded, light yellowish limestones, often so impregnated with magnesia as to be scarcely distinguishable from some of the magnesian limestones of England, or the Zechstein of Thuringia; at other times it is composed of red and green flags and marls; and, on the flanks of the Urals, this series is represented by black and calcareous slaty masses. Moreover, it is comparatively rare as a red sandstone. But the fishes and shells the beds contain soon rectify the mistake as to the true position of these rocks, into which their mineral aspect alone might lead the most experienced geologist, should he not have an opportunity of seeing them reposing on true Silurian rocks, and covered by carboniferous strata. In regard to the evidence from fossil contents, it is so complete in these Russian deposits as not only to establish their own position, but to corroborate the soundness of the reasoning which unites the old red sandstone of Scotland with the slaty limestones and schists of Devonshire and the Continent; for they contain the characteristic fishes of the former, and the molluscs of the latter. The examination of Russia, Sir R. Murchison further observes, has afforded numberless proofs that the ichthyolites and molluscs which in Western Europe are separately peculiar to smaller detached basins, were there inhabitants of many parts of the same great sea. Of the known Russian ichthyolites, two-thirds are specifically the same as those of the same epoch in Great Britain.

The neighbourhood of Dörpat in Lithuania is a very remarkable locality for the ichthyolites of this age; they are there met with of so gigantic a size, that they were supposed to belong to Saurians, until the closer examinations of Professor Asmus of Dörpat, M. Agassiz, and Professor Owen, disclosed their true nature. A note by Professor Owen, in the Appendix to the "Geology of Russia," is highly instructive, as shewing the great importance of an examination of the internal structure of the substance of fossil teeth by the microscope, in determining the classes of animals to which they have belonged. He points out, by a striking illustration, how the microscopic labours of the philosopher, in his closet, may have the most important effect on questions that appear to be far remote from the subject of his inquiry. Had the teeth, under consideration, continued to be held to belong to Saurians, the matrix in which they are imbedded having a close resemblance in mineral character to magnesian limestone, or to members of the new red sandstone series, borings for coal might have been carried on in many parts of Russia, involving vast losses; but the teeth having been proved to belong to a class of fishes that are characteristic of the old red sandstone, all expectations of finding profitable seams of coal are known to be vain.

If we now cross the Atlantic with Mr Lyell, and visit the Silurian region of North America, we find that series of rocks, covered by others, having characters corresponding with those of the Devonian group in Europe. The rocks of the Appalachian chain consist of deposits of the Silurian, Devonian, and Carboniferous periods. A deposit called, by the American geologists, the Waverley sandstone, which, Mr Lyell is of opinion, corresponds with the old red sandstone of Europe, intervenes in the state of New York between the coal-beds and the Upper Silurian groups, in strata of considerable thickness. On the western side of the Alleghanies, at Portsmouth on the Ohio, the same formation also occurs, but greatly diminished in thickness, some of the subordinate beds being reduced to a very thin slate, others entirely lost, conformably with what is observed in other sandstones and associated slates and shales in that country, viz., by a gradual thinning of the beds as they extend westward, and as they become more distant from that great eastern continent, now sunk beneath the waters of the Atlantic, from which the materials composing them must have been derived.

Our knowledge of the old red sandstone or Devonian group has been much advanced by the monograph of the fishes of that series of deposits by M. Agassiz, which has just been completed; a work of the highest merit, in which the skill with which the anatomy of the singular forms of that earliest creation of fishes is worked out is quite admirable, and which also contains many highly important general views. This work was undertaken at the request, and has been carried out by the assistance, of the British Association, and is one of the many valuable gifts for which science is indebted to that body.

The history of the old red sandstone supplies a useful lesson to geologists, by shewing them the danger of coming to hasty conclusions, and founding generalizations, on negative evidence. The formation itself was long supposed to be confined to a limited portion of England; it is now known to extend over large districts in the British Isles and on the Continent of Europe. It is most extensively developed in the northern and western parts of the United States, as may be seen by inspecting Mr Lyell's Map; and we learn from Captain Bayfield, that a sandstone which prevails greatly in Upper Canada, and which may be traced all round Lake Superior, resting on granite, appears to be of the same age as the old red sandstone, or Upper Silurian; and he also observed in the district of Gaspé, at the south entrance of the river St Lawrence, a calcareous sandstone with Devonian characters. It appears, too, from the work of Mr Strzelecki on New South Wales and Van Diemen's Land, published last year, that the greater part of the palæozoic rocks he examined in Australia and Tasmania are the equivalents of the Devonian series. In like manner, this bed was long held to be barren of organic remains; Sir Henry de la Beche, in the third edition of his "Manual of Geology," published in 1833, which was no doubt brought up close to all that was known at that time, says, "Few organic remains have been discovered in that rock." When M. Agassiz, in 1833, began the publication of his "History of Fossil Fishes," he knew of none older than the coal-measures, and only a small number in them; and he tells us, that when he first learned that fishes had been discovered in the old red sandstone, during his visit to Scotland in 1834, not more than four species were known. Five years afterwards, when Mr R. Murchison published his "Silurian System," ten genera and seventeen species of fishes, and fifteen genera and twenty-three species of mollusca, are enumerated by him as belonging to the middle and lower Devonian beds. In the recent work on Russia, M. de Verneuil enumerates forty-six species of fishes and sixty-six species of mollusca, which he and his fellow-travellers found in the same group in that country. M. Agassiz, in his "Monograph of the Fishes of the Devonian System," raises the number of genera to forty-three, and of species 105, belonging to six or seven families; and he tells us that Monte Bolca itself, hitherto reported to be the locality of all others most rich in species of fossil fishes, does not contain a greater number; adding, that, as only a comparatively small portion of the rocks of this system has been examined, many additions may be expected. M. Agassiz is shortly going, it is said, to North America, where he will very likely discover many new forms. It is gratifying to find him ascribing the main success of his researches in this field "aux recherches persévérantes et au zèle infatigable des géologues Anglais."

But not only is there this great variety of genera and species, but the number of individuals found in some localities immense. Thus, in some parts of Russia there are breccias almost wholly composed of the scales and plates of the Asterolepis, and the remains of the Pterichthys are so abundant in the geodes of Lethen Bar, in Nairnshire, as to have been collected in cart-loads. But our wonder is not alone excited by the great variety and number of vertebrate animals of a high organization in strata so very low in the order of formations; there are many most remarkable features in the history of this early part of the animal creation which the researches of M. Agassiz have brought to light; for these, however, I must refer you to the work itself.

M. Agassiz, in speaking of the lowest beds in which the remains of fishes have been found, makes the following important observations on the probability of their existing in still lower beds:—"If we have not yet been able to recognize remains of fishes below the Lower Ludlow rocks, I do not think that we ought from that to conclude that fishes do not exist even in the oldest of the fossiliferous beds; for their extraordinary abundance in the Devonian series, and the distinct recognition of them in certain Silurian beds, where, it is true, they are but imperfectly preserved, sufficiently indicates, that, on its first appearance, that class of animals was contemporary with the development of the types of all the classes of invertebrate animals."

Mr Lyell states, that the lowest rock in which ichthyolites have been traced in America is the Clinton group, which may be considered the bottom of the Upper, or top of the Lower Silurian series. Ichthyolites have recently been found in the Wenlock shale; another step in descending order, and so far in support of M. Agassiz's views.

The Carboniferous Series.

Although rocks of this age cover a great extent of country in European Russia, extending over a tract equally vast in horizontal extension with that occupied by the Devonian series, there are few places, except in the coal-field of the Donetz in the south, where the coal-seams are more than a few inches in thickness; and where they are thicker, they are so poor in quality as to be rarely worth working. The great coal-fields of England, France, Belgium, and America, have no well-marked equivalents there, nearly the whole of the coal-beds in the empire being, like those of Ireland and the coal-fields on the banks of the Tweed, included in the lower members of the system; which, with the sandstones, shales and marls, are the equivalents of our mountain limestone, as is proved by the identity of a large series of fossils. From a section of the works at Lissitchia-Balka, on the river Donetz, we learn, that in a depth of 900 feet there are twelve seams of coal, the united thickness of which amounts to thirty feet; they are associated with sandstones, grits, and shales; and eight beds of sandstone are intercalated (containing, from the uppermost to the lowest, marine shells), the united thickness of which is fifty feet, three of the beds of limestone resting directly on the coal. Many of the forms of Equisetacea, Calamites, Sigillariæ, and Ferns, are of the same species as those of the west of Europe; and the carboniferous fauna of Russia contains numerous forms identical with those in the same class of rocks in the British Isles.

A glance at the geological map which accompanies Mr Lyell's "Travels," shews the enormous development of the coal series in the territory of the United States, and that it occupies no inconsiderable space in Nova Scotia and New Brunswick. We learn from the report of Mr Logan, on the Geology of Canada, which I shall presently refer to, that a great coal-field covers nearly the whole of New Brunswick, a considerable part of Nova Scotia, Cape Breton Island, and the south-west corner of Newfoundland. The greater part of the carboniferous series in North America belongs to the upper portion, and not only abounds with numerous and thick beds of coal, but, on the western side of the Alleghanies especially, they are so little disturbed, and lie so nearly horizontal, that the coal is quite easy of access; and where the strata are intersected by rivers, it can be obtained with little trouble or expense. The great coalfield of Pennsylvania, Virginia, and Ohio, extends continuously from north-east to south-west for a distance of 720 miles, its breadth being in some places 180 miles.* That extending over parts of Illinois, Indiana, and Kentucky, is not much inferior in dimensions to the whole of England, and consists of horizontal strata, with numerous rich seams of bituminous coal. Another carboniferous deposit, 170 miles by 100, lies farther to the north, between Lakes Michigan and Huron. I may give

* On the 17th of March I received a letter from Mr Lyell, dated the 16th of February, at Tusçaloosa in Alabama, containing a notice on the Alabama coal-field, and which was read at the Geological Society on the 25th of March. He states that he had been examining three coal-fields, the existence of which was unknown to him when he compiled his Map in 1844. They occur near Tusçaloosa, in the centre of Alabama, more than 100 miles farther south in a direct line than the southern limit which he had assigned to the Appalachian coal-field, and are situated on the Tombecbee, Great Warrior, and Cahawba rivers. That on the Great Warrior river has been found by Professor Brumby, of the University of Tuscaloosa, to be no less than ninety miles long from north-east to south-west, with a breadth of from thirty to forty miles. These coal-fields are portions of the great Appalachian coal-field, with the same mineral and palæontological characters. Mr Lyell promises a more detailed account of his observations.—*April* 3. 1846.

the following as an example of the almost boundless resources of fuel which this country affords. At Brownsville, on the Ohio, there is a seam, ten feet thick, of good bituminous coal, commonly called the Pittsburg seam, which may be followed the whole way to Pittsburg, fifty miles distant. "The boundaries of this seam have been determined with considerable accuracy by the Professors Rogers in Pennsylvania, Virginia, and Ohio; and they have found the elliptical area which it occupies to be 225 miles in its longest diameter, while its maximum breadth is about 100 miles, giving a superficial extent of about 14,000 square miles."

Mr Lyell states that at Blossberg in Pennsylvania he was much struck with the surprising analogy of the coal-measures to those of Europe in mineral and fossil characters. The same grits or sandstones are found as those used for building near Edinburgh and Newcastle; similar black shales occur, often bituminous, with the leaves of ferns spread out as in a herbarium, the species being for the most part identical with British fossil plants; there are seams of good bituminous coal, some a few inches, others several yards, in thickness, associated with beds and nodules of clay ironstone; and the whole series rests on a coarse grit and conglomerate, containing quartz pebbles, very like our millstone grit. The same similarity of mineral and fossil characters to European coal-measures is found to prevail throughout North America. That remarkable circumstance of the very general occurrence of a sandy clay abounding in Stigmariæ, beneath the seams of coal, observed in the Welsh and other coal-fields of Britain, is also found to prevail in those of North America. Mr Lyell saw numerous instances of this: thus, at Pottsville in Pennsylvania, there are thirteen seams of anthracitic coal (true bituminous coal supposed to be altered by metamorphic action, a subject to which I shall allude hereafter), several of them from eight to ten feet thick, and in a vertical position: on the side which had been the roof of the coal, consisting of shales, he observed numerous ferns with stems of Sigillaria, Lepidodendron, and Calamites; on the other side, that which had once been the floor, he found an underclay with numerous Stigmariæ, often several yards, and even in some cases as much as thirty feet long, with their leaves or rootlets attached.

Theories of the Formation of Coal.

It is scarcely possible to visit a coal-field, or to read the description of one, without being led to theorize on its mode of formation. The origin of coal has long been a subject of great difficulty, nor has any theory been yet advanced with which it has been possible to reconcile all the appearances which the coal-measures exhibit, all the variety of forms in which coal is found. Indeed the more closely we examine the phenomena, the more do we feel the distance we are from a satisfactory explanation of them. According to some geologists, coal-seams and their accompanying strata are accumulations of land plants and stony detritus carried down by rivers into estuaries, and deposited in the sea, where the vegetable matter undergoes changes that convert it into coal. Others are of opinion that coal is the altered residuum of trees and smaller plants that have grown on the spot where we now find them; that the forests were submerged and covered by detrital matter, which was upraised to form a foundation and a soil for another forest, to be in its turn submerged and converted into coal, and that thus the alternations which the vertical section of a coal-field exhibits are to be accounted for.

In the works of the last year to which I have chiefly referred, we find the former theory maintained by Sir R. Murchison as most generally applicable; Mr Lyell is more inclined to adopt the latter. Sir R. Murchison dwells upon the facts of the alternations of coal with limestones containing marine remains, which are so frequently met with in most countries where coal-fields prevail; and as a striking instance of this, he refers to the Donetz coal-field, which I have already alluded to. A remarkable example of a similar kind, occurring in Maryland, is mentioned by Mr Lyell. At Frostburg, a black shale, ten or twelve feet thick, full of marine shells, rests on a seam of coal about three feet thick, and 300 feet below the principal seam of coal in that place. The shells are referable to no less than seventeen species, and some of them are identical with, and almost all the rest have a near affinity to species found in the Glasgow and other coal-measures.

The theory which refers the coal to trees and plants which have grown on the spot where it now rests, is illustrated by Mr Lyell by observations he made in Nova Scotia, on the south shore of the Bay of Fundy, at a place called "The Joggins." He states that there is a range of perpendicular cliffs composed of regular coal-measures, inclined at an angle between 24 and 30 degrees, whose united thickness is between four and five miles. About nineteen seams of coal occur in the series, and they vary from two inches to four feet in thickness. The beds are quite undisturbed, save that they have been bodily moved from the horizontal position in which they must have been deposited to that inclination they now have. In these coal-beds, at more than ten distinct levels, are stems of trees, in positions at right angles to the planes of stratification, that is, which must have stood upright when the coal-measures were horizontal. No part of the original plant is preserved, except the bark, which forms a coating of bituminous coal, the interior being a solid cylinder of sand and clay, without traces of organic structure, as is usually the case with Sigillaria, and like the upright trees in the coal-measures cut through by the Bolton Railway. The trees, or rather the remains of stems of trees broken off at different heights above the root, vary in height from six to twenty-five feet, and in diameter from fourteen inches to four feet. There are no appearances of roots, but some of the trees enlarge at the bottom. They rest upon, and appear to have grown in, the mass which now constitutes the coal-seams and under-lying shale, never intersecting a superior layer of coal, and never terminating downwards out of the coal or shale from which the stem rises. The underclay or shale often contains Stigmariæ. Here then, he states, are the remains of more than ten forests, which grew the one over the other, but at distant intervals, during which each, from the lowest upwards, was successively covered by layers of great thickness of clay and solid stone, the materials of which must have been arranged and consolidated under the surface of water, and the vegetation of every layer in which the upright trees are fixed must have grown on land.

The formation of coal-measures like the above, and of all others where there is evidence that the vegetable matter was not drifted to the place it now occupies, but must have grown on the spot, is then accounted for, by supposing, that the land sank below the level of adjoining water; that gravel, sand, and mud were washed down from the land that did not sink, and formed layers of clay and sandstone over the submerged forest, either in sufficient quantity to rise to the surface of the water and form land for the next forest, which was submerged in its turn, or that a contrary internal movement took place, which again raised the submerged land; and that for every seam of coal, one above the other, a similar series of changes must have taken place. It is to this oscillatory movement that Mr Lyell ascribes the formation of the above remarkable phenomena in the Bay of Fundy, and others of a like nature.

At first sight, both theories seem well-founded, when applied to the particular coal-fields described; and it is possible that these eminent and experienced geologists may be of opinion that both are true, as applied to different situations. But I see great difficulties to the full acceptance of either, in many of the phenomena which, on a close examination, we find coal-fields generally present. As examples, I will call your attention to two sections that have very recently been published; the one a section of the western part of the South Welsh Coal-Field, included in the valuable series lately issued from the office of the Geological Survey of Great Britain, the work of W. E. Logan, Esq., a Fellow of this Society, so well known to us as an excellent observer, and as intimately acquainted with coal-fields, and who was formerly attached to that Survey; the other is entitled a "Section of the Novia Scotia Coal-Measures, as developed at the Joggins, on the Bay of Fundy, in descending order, from the neighbourhood of West Rugged Reef to Minudie, reduced to vertical thickness." It is also the work of Mr Logan, who is now employed by the Government of Canada to make a Geological Survey of that country, and is contained in his report to the late Governor Sir Charles Metcalfe, and transmitted by the Governor to the Legislative Assembly. And here I may remark, in passing, that while we, as geologists, have to thank that provincial Government for commencing so useful an undertaking, we have also the satisfaction of feeling convinced that it will be prosecuted with vigour by the present governor, Earl Cathcart, one of our own body, and, as we know, an able and active geologist. This is a section of the same series of coal-measures so carefully examined and described by Mr Lyell,* though with less minuteness of detail as to the lithological characters and dimensions of the several beds. The phenomena exhibited in the above sections are not peculiar to them; they are to a great extent common to all coal-fields, particularly in the higher parts of the carboniferous series.

Before giving the analyses I have made of these sections I wish to call to your recollection that in both theories it is assumed, that the deposition of the coal-measures took place *in the sea.* Mr Lyell speaks of the accumulations having taken place in a sea: he says, "It by no means follows that a sea four or five miles deep was filled up with sand and sediment; on the contrary, repeated subsidences may have enabled this enormous accumulation of strata to have taken place in a sea of moderate depth."

The example from South Wales is a vertical section,† representing the beds as they are known to succeed each other in descending order, the dimensions being the thickness of each bed at right angles to the plane of stratification. The coal-measures rest upon carboniferous limestone, in an inclined and somewhat waved stratification; and although these measurements would vary in different places, from the swellings and thinnings-out which all strata exhibit more or less when traced to a distance, they are probably not far from the average amount over a large area.

1. From the top of the highest bed to the limestone, the sum of the measurements amounts to nearly 7000 feet; that is, the beds must have been originally deposited over each other in horizontal or nearly horizontal stratification to that thickness.

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* "Travels in America," vol. ii., p. 198.

† No. 1 in the series, illustrating the horizontal section No. 7.

2. Reckoning only the greater divisions, when a difference of mineral character takes place, there are, besides the coal-seams, 340 beds, from a few inches to 190 feet thick, without alteration of mineral composition; involving, in the latter cases, long periods without any change in the nature of the detritus washed into the water where the deposition was going on.

3. These beds consist of sandstones, arenaceous and argilliferous slates, and clays, alternating without any apparent order of succession; sometimes one sometimes another lying upon the coal; and occasionally, but not frequently, the shale upon the coal is said to be carbonaceous.

4. Interstratified with these beds are *eighty-four* seams of coal, from one inch to nine feet thick; the highest being covered by a series of beds of sandstone, &c. 200 feet thick; the lowest seam separated from the carboniferous limestone by 1340 feet of similar sandstones and shales, making the *coal-bearing* strata 5460 feet in thickness.

5. The seams of coal occur at very unequal distances; some are separated by a few inches only of shale or sandstone, others by as much as 360 feet.

6, There are twenty-three seams, occurring in succession, most of which are not distinguished by any term indicating quality; in two instances, one a three-feet seam, they are said to be *bituminous*, and several seams are said to be *binding*, which means the same as *caking*, a quality which only richly-bituminous coals possess; the rest are merely called "Coal." These twenty-three seams, with their interstratified sandstones and shales, occupy 1840 feet.

7. Then succeed thirteen seams, in a space of 1000 feet and nine of these are described as "*not bituminous.*"

8. The thirty-seventh seam, in descending order, is said to be *anthracitic*, and fourteen seams below it are so designated: then come four seams merely called "Coal," and all very thin. Beneath the lowest of these, and separated by sixty feet of arenaceous shales and sandstones, comes a bed of coal, four feet six inches thick, called *Anthracite*, with five feet of underclay; beneath this are seven seams called *Anthracite*, and three more are intercalated called *anthracitic*.

9. Between the thirty-seventh seam, called Anthracitic, and the lowest of all, which is called Anthracite, there are twenty-two seams intercalated, without having any distinctive term affixed to them, most of them very thin ; but about midway, three occur near together, without intermediate sandstones and shales, but separated by clay containing Stigmariæ, in the following manner :—

	Ft.	In.
Coal, ...	1	0
Underclay, ...	0	4
Coal, ...	4	0
Underclay, ...	8	0
Coal, ...	1	4
Underclay, ...	8	0

10. The seams of coal, whether termed merely "Coal," or bituminous, or anthracitic, or anthracite, have, with very few exceptions, underclays, and these, generally, but not uniformly, contain Stigmariæ. The two lowest beds of anthracite have underclays of five feet each, the third from the bottom has seven feet of underclay, each with Stigmariæ. The underclay is of variable thickness ; in no part more than fourteen feet, and, except in a few instances, is always said to contain the *Stigmaria ficoides.*

11. There appears to be no relation between the thickness of the underclay with Stigmariæ, and that of the coal resting upon it. The thickest seam of coal, which is nine feet, rests on three feet of underclay; and there are instances of a seam of coal only an inch thick, with five feet of underclay stated to be *filled with Stigmariæ.*

12. A bed of clay, eight feet thick, with Stigmariæ, has no coal upon it, but a foot of carbonaceous shale ; and above that forty feet of arenaceous shale, then four feet of clay with Stigmariæ, covered by three inches of coal, and that overlaid by twenty-five feet of argillaceous shale and sandstone.

13. In no case is any difference stated in the mineral character of the sandstones or shales either *over or under* the Anthracite seams, or of any other coal-seam.

The example from Nova Scotia is a vertical section, on the same plan as that in South Wales; and the coal-measures there also rest upon limestone, containing organic remains, "among which there is, in some abundance, a bivalve shell, which Mr Logan recognised as indentical with *Producta Lyelli* of Windsor in Nova Scotia." This limestone at Windsor, Mr Lyell describes as "a lower carboniferous limestone." The total vertical thickness of the coal-measures is more than double that of the South Wales section, being 14,570 feet.

a. The number of distinct beds in the section, of which separate measurements are given, is 1114, from six inches to 138 feet thick, without change in mineral composition.

b. These beds consist of quartzose sandstones, grits and conglomerates, and of arenaceous and argillaceous shales, all of various shades of red, grey, and green, without any apparent order of succession, sometimes one sometimes another lying upon the coal, and occasionally a carbonaceous shale is associated and intermixed with the coal-seams.

c. Interstratified with these beds are *seventy-six* seams of coal, from an inch to two feet thick, the far greater proportion very thin. The aggregate thickness of the seventy-six seams is only forty-four feet, and there is about the same aggregate thickness of carbonaceous shale. The highest seam is covered by a series of beds of sandstones, conglomerates and shales, 2274 feet thick. Beneath the lowest seam of coal there are 2800 feet of sandstones and shales of the same nature as those above, but having numerous beds of grey concretionary limestone intercalated. Thus the *coal-bearing* strata have a thickness of about 9500 feet.

d. There are no terms attached to the word "Coal," indicating any change of quality throughout the section. Some of the seams are called "Coaly clay," others "Carbonaceous shale," mixed with the coal. The seams occur at very unequal distances; from a few inches apart to more than 1200 feet.

e. As in the South Wales section, the coal-seams usually rest on beds containing *Stigmariæ*, but, in a great proportion of instances, these occur not in clay but in sandstone and arenaceous shale. This under bed is from a foot to twenty-seven feet in thickness; in one place an understone with

Stigmariæ ten feet thick has a seam of coal over it only an inch thick.

f. Between the sixty-seventh and sixty-eighth coal-seams, the former with associated carbonaceous shale only fourteen inches thick, there are 170 beds of sandstone and argillaceous shale, from six inches to 132 feet thick, their aggregate thickness being 2620 feet, and the sixty-eighth coal-seam is only called coaly clay, two inches thick, with an underclay containing *Stigmaria* leaves of six feet.

g. In the 2274 feet of sandstones, &c. lying above the highest seam of coal, fragments of plants are seen in several of the beds; they first occur in a bed of sandstone 218 feet from the top, and the plants are converted into coal; they are often called "drift plants," and stated to be "coated with coal." In one bed there are "carbonized drift plants of large diameter," say one foot, the stems lying prostrate; and 1520 feet below this, there is a sandstone "fit for grindstones, with a few *Calamites* nearly at right angles to the plane of the beds, as if *in situ*, but forced over at the top;" this sandstone rests on a black carbonaceous shale two feet thick, but it is not stated whether the Calamites are fixed in this carbonaceous stratum. Between this last and the first seam of coal, which is only one inch thick, there are three feet of a "greenish-grey sandstone with *Stigmaria ficoides*," succeeded by two feet of "grey argillaceous shale, with impressions of *ferns* and other plants."

Between the seventy-fifth seam, half an inch, and the seventy-sixth, two inches thick, are eighty-four beds of sandstone from a foot to 117 feet thick, together 1223 feet; and twenty of these beds, all called greenish-grey sandstone, are said to contain carbonized drift plants; and in one of these beds there is said to be "a vast confused collection of carbonized drift plants; one lying prostrate measured twenty-five feet in length, and about one foot in diameter at the small end." So likewise in the 2800 feet of sandstones, &c. which are beneath the seventy-sixth or lowest seam of coal, ten of the beds are said to contain carbonized drift plants.

h. At a distance of 4400 feet from the surface there occurs a "bituminous limestone with shells and fish-scales," four feet thick, and lower down, in the succeeding 2000 feet, there are eighteen beds of similar bituminous limestone, one of them only half an inch thick, eleven of them under six inches, and the thickest two feet. Neither the shells nor the nature of the fish-scales are described, but that these are freshwater limestones may be inferred from this, that several of them are mixed with Stigmariæ and other plants; thus associated with the twenty-eighth seam of coal is a "bituminous limestone and carbonaceous shale in alternate layers of one to three inches, with *plants*, shells and fish-scales;" under the thirty-first, "with Stigmariæ, shells and fish-scales;" along with the thirty-sixth, "black bituminous limestone with branches and leaves of *Stigmariæ* well-marked, and very minute shells;" under the forty-fourth, "with *Stigmariæ* branches and leaves, fragments of other plants, and minute shells." Mr Lyell states, that he observed "not far above the uppermost coal-seams with vertical trees, two strata, *perhaps of freshwater or estuary origin*, composed of black calcareo-bituminous shale, chiefly made up of compressed shells, of two species of *Modiola*, and two kinds of *Cypris*." It is possible, therefore, that the "minute shells" of Mr Logan are *Cypris*. Beneath the lowest seam of coal are intercalated fourteen beds of what is called a "Concretionary limestone," and "Limestone in concretionary nodules," from one to three feet thick, one of them as much as eight feet, and in one instance the limestone is said to contain carbonized drift plants.

i. Several instances are given of stems of plants standing perpendicular to the plane of stratification; the first is 2160 feet from the top of the uppermost bed.

α. Calamites "as if *in situ*."

β. Lower down, 570 feet below *a*, two upright stems of Calamites, two inches in diameter, coated with coal, start from the top of a dark-grey argillaceous shale, and penetrate into a grey shale with sandstone above. The length of the stems is not given.

γ. Forty feet below is a foot of sandstone and then a foot of shale, and "in this shale, and running into the sandstone above, is a Calamite at an angle of 45° : it appears to start from a coal-seam below, an inch thick.

δ. Beneath this, 640 feet, a seam of coal three inches thick occurs, and from it " there springs up an erect *Sigillaria*, eighteen inches in diameter, and it penetrates the shale and sandstone above it, five feet of the plant being visible." Underneath the coal is " a grey sandstone with *Stigmaria ficoides* (*underclay*)."

ε. The next instance given is 1038 feet lower down, where, from a grey argillaceous shale, rises an upright *Sigillaria*, one foot in diameter, penetrating to a height of two feet into argillaceous shale above. There are sixteen feet of sandstone and shale below this *Sigillaria*, and *without Stigmariæ*.

ζ. The next is 270 feet lower, where, from an argillaceous shale, " springs an upright *Sigillaria* of one foot in diameter; the lower part commences to spread." There are seven feet of argillaceous shales, with ironstone balls, beneath this *Sigillaria*, *without Stigmariæ*.

η. The next is 228 feet lower, where, from a " grey, crumbly, argillaceous shale, like underclay, but no *Stigmariæ* visible, spring several upright Calamites, three of them in the distance of two feet, and eight more, the whole eleven in the distance of twenty feet."

θ. The next, 137 feet lower, in sandstone, are upright Calamites, three in the space of a foot.

ι. From a carbonaceous shale, a foot thick, sixty-two feet lower, " spring up erect Calamites, penetrating an arenaceous shale above two feet; and there are seven in the space of eight feet."

κ. The next is 254 feet lower, where, from an argillaceous shale, springs an upright *Sigillaria*, four inches in diameter; five feet of it are seen in a sandstone above. Argillaceous and carbonaceous shale beneath, six feet thick, does *not* contain *Stigmariæ*.

λ. From a grey argillaceous shale, twenty-two feet lower down, springs an upright *Sigillaria*. Its roots spread out into the shale, which is ten feet thick, and does *not* contain *Stigmariæ*; but *over* it lies a grey, crumbly, argillo-arenaceous shale or sandstone *with Stigmariæ*, in which six feet of the stem are visible. From the root of the plant proceeds a *Stigmaria* branch, which at first sight had much the appearance of being a root of the Sigillaria, but close inspection shewed that the two, although touching, were distinct.

μ. The next is 108 feet lower, where, from a grey argillaceous shale, " springs an upright *Sigillaria*, eighteen inches in diameter, penetrating an incumbent sandstone." Fourteen feet of argillaceous shale and sandstone beneath do *not* contain *Stigmariæ*.

ν. The next is 133 feet lower, where, from a thin seam of coal with carbonaceous shale beneath, " rises an upright *Sigillaria* ; the roots spread on the top of the coal ; the plant is a foot in diameter, and only one foot of the length is visible."

ξ. The next is 160 feet lower, where, from a red argillaceous shale, springs an upright *Sigillaria*. Two feet of the length is seen, but it is cut clean off at the top and at the bottom by the measures which pass both without disturbance. No *Stigmariæ* occur for many yards below.

ο. The next is 101 feet lower, where, from a grey argillaceous shale, six feet thick, without *Stigmariæ*, starts an upright *Sigillaria*, four inches in diameter ; it is planted two feet in the shale, and penetrates the sandstone above, being four feet in length altogether.

π. The next is 362 feet lower, where, from a red and dark grey variegated shale, twenty-eight feet thick, with small balls of ironstone *and Stigmariæ*, arise two upright *Sigillariæ*. The roots of these spread out just on the top of the bed, and two feet of the plant are visible. The roots of the other spread out likewise, but they sink deeper into the shale by two feet, and the plant penetrates farther into the superincumbent sandstone.

ρ. The next distinct instance is 490 feet lower, where, from a grey argillaceous shale, several upright *Calamites* from half an inch to four inches in diameter, penetrate an incumbent grey arenaceous and argillaceous shale, containing prostrate carbonized plants. The roots of a Calamite three inches in diameter, spread on the top of the shale underneath ; and twenty-one more Calamites are visible along the bank in the space of twenty yards.

This is the last instance stated of stems of plants found in the strata perpendicular to the plane of stratification; the seventeen instances thus occurring in a vertical thickness of 4515 feet.

Throughout the whole 7000 feet in the South Wales section, and, if the limestones are, as is most probable, of fresh-water origin, also throughout the 14,570 feet in the Nova Scotiá section, there appears to be no trace of any substance of a *marine* character; and from anything exhibited in the composition of the beds, all might have been deposited in fresh water. It seems infinitely improbable, had the deposition taken place in a sea, that a series of accumulations of this description, implying, be it observed, a vast duration of time, with different depths and different qualities of sea-bottoms, should have taken place without a trace being discoverable, either upon the surface of the submerged layers of vegetable matter, or in any part of the clays and sandstones that lie upon them, of a marine animal or plant. It seems no less improbable, that, in a sea skirting a shore, there should be such an absence of agitation throughout so vast a space of time, as to allow a tranquil deposit of layers of fine detritus over a wide area, a spreading out of the leaves of delicate plants in layers of clay and sand, like the specimens in a herbarium, and a gradual and insensible passage, in many instances, from one bed into another. Great as the North American lakes are, I am not prepared to say that grave objections may not be urged against the probable existence of such vast bodies of fresh water as would be of sufficient extent and depth to receive the beds of many coal-fields; but the absence of marine remains throughout vast depths of strata in coal-fields is a remarkable fact, well deserving of the most careful investigation.

That the terrestrial vegetable matter from which coal has been formed has in very many instances been deposited in the sea is unquestionable, from their alternations with limestones containing marine remains. Such deposits and alternations in an estuary at the mouth of a great river are conceivable, but whether such enormous beds of limestone, with the corals and molluscs which they contain, could be formed in an estuary, may admit of doubt. But it is not so easy to conceive the very distinct separation of the coal and the stony matter, if formed of drifted materials brought into the bay by a river. It has been said that the vegetable matter is brought down at intervals, in freshets, in masses matted together, like the rafts in the Mississippi. But there could not be masses of matted vegetable matter of uniform thickness 14,000 square miles in extent, like the Brownsville bed on the Ohio (the Pittsburg seam mentioned in page 170); and freshets bring down gravel, and sand, and mud, as well as plants and trees. They must occur several times a-year in every river; but many years must have elapsed during the gradual deposit of the sandstones and shales that separate the seams of coal. Humboldt tells us (*Kosmos*, p. 295), that, in the forest lands of the temperate zone, the carbon contained in the trees on a given surface would not, on an average of a hundred years, form a layer over that surface more than seven lines in thickness. If this be a well-ascertained fact, what an enormous accumulation of vegetable matter must be required to form a coal-seam of even moderate dimensions! It is extremely improbable that the vegetable matter brought down by rivers could fall to the bottom of the sea in clear unmixed layers; it would form a confused mass with stones, sand, and mud. Again, how difficult to conceive, how extremely improbable in such circumstances, is the preservation of delicate plants, spread out with the most perfect arrangement of their parts, uninjured by the rude action of rapid streams and currents carrying gravel and sand, and branches and trunks of trees.

In the theory which accounts for the formation of beds of coal, by supposing that they are the remains of trees and other plants that grew on the spot where the coal now exists, that the land was submerged to admit of the covering of sandstones or shales being deposited, and again elevated, so that the sandstones or shales might become the subsoil of a new growth, to be again submerged, and this process repeated as often as there are seams of coal in the series—these are demands on our assent of a most startling kind. In the sections above examined, we have eighty-four seams of coal in the one, and seventy-six in the other. In the Saarbrück coal-field there are 120 seams, without taking into account the thinner seams, those less than a foot thick.* The materials of each of these seams, however thin (and there are some not an inch thick, lying upon and covered by great depths of sandstones and shales), must, according to this theory, have grown on land, and the covering of each must have been deposited under water. There must thus have been an equal number of successive upward and downward movements, and these so gentle, such soft heavings, as not to break the continuity or disturb the parallelism of horizontal lines spread over hundreds of square miles; and the movements must, moreover, have been so nicely adjusted, that they should always be downward when a layer of vegetable matter was to be covered up; and in the upward movements, the motion must always have ceased so soon as the last layers of sand or shale had reached the surface, to be immediately covered by the fresh vegetable growth; for, otherwise, we should have found evidence, in the series of successive deposits, of some being furrowed, broken up, or covered with pebbles or other detrital matter, of land long exposed to the waves breaking on a shore, and to meteoric agencies. These conditions, which seem to be inseparable from the theory in question, it would be difficult to find any thing analogous to in any other case of changes in the relative level of sea and land with which we are acquainted.

That some seams of coal were formed of vegetable matter that grew on the spot where the coal now exists, seems to be proved in several cases (such, for instance, as that of the Bolton railway section) beyond dispute; and that some seams afford proofs of having been formed by drifted vegetable matter may be true. The coal-seams, and the beds associated with them, could be formed in no other way than under water; and the accumulation of the vegetable matter near the surface of it, and a very gradual submergence of the land, arrested at unequal intervals, appear to be the conditions most reconcileable with the phenomena. This implies, however, a de-

* Humboldt's Kosmos, p. 295.

position of the alternating sandstones and shales in very shallow water; and as we often find these rocks in regular thin stratification, forming the immediate bottom of coal-seams, the question arises, Could such a laminated arrangement of detrital matter take place in water so shallow as is here supposed?

It is held by some geologists, that *Stigmariæ* are the roots of *Sigillariæ*, and that the stems of the latter contributed largely to the formation of coal. We should therefore expect to find, that where there is the greatest accumulation of *Stigmariæ* there should be the thickest seams of coal: this is not only not the case in the above sections, but sometimes there is no coal at all (11, 12, *e*, *f*, *g*,). In a bed of sandstone, 190 feet thick, in the South Wales section, and at a depth within it of sixty feet, there is a seam of coal, four inches thick, without underclay and without *Stigmariæ*. Then again, in the Novia Scotia section, we find stems of *Sigillariæ*, standing at right angles to the plane of stratification, resting on shales that do not contain any *Stigmariæ* (*i*, ζ, ϰ, λ, μ,). Is this a proof that the stems are here, though apparently, really not in the place where they grew? or is it a proof that *Stigmariæ* are not the roots of *Sigillariæ?*

Several instances of upright stems given in the Nova Scotia section by Mr Logan, can hardly be considered as occupying the spot where they grew, certainly not that (ξ) where it is cut clean off at the bottom. It is remarkable, that, in the instances of upright stems described by Mr Lyell and Mr Logan, if occupying the spot where they grew, roots should so seldom be connected with them. Of all parts of the tree, none, we should expect, would be more likely to be preserved; being protected by their covering of soil from causes of destruction to which the stems were evidently exposed, as we find them so generally cut off at a short distance above their bases.

The whole subject of the theory of coal, whether we consider its mode of deposition, the plants out of which it has been formed, or the various changes which the vegetable matter has undergone, to convert it into lignite, jet, common coal, cannel coal, blind coal, and anthracite. Two or more of these varieties often occurring in the same coal-field, is extremely obscure, and presents a wide and interesting field for future investigation. Before concluding this part of my subject, into which I shall probably be thought to have entered at disproportionate length, I would call your attention to some difficulties which the South Welch section offers to the commonly-received and, I believe, well-founded opinion, that anthracite is bituminous coal, the volatile parts of which have been driven off by heat acting gradually from below; for we see (8 and 9) that thin seams of common coal are interstratified with anthracitic seams and with anthracite. Neither do we find any signs of metamorphic action in the underclay in immediate contact with the coal, nor in the strata that lie between two seams of anthracite. We must look to the chemist to explain all this, as well as for enlightenment on the formation of the different qualities of coal; but we must be contented to receive from him only indications and resemblances; for we must never forget, that, in our experiments, we can never have the volume of materials, the amount of pressure, and above all, the duration of time with which Nature has worked; and each of these, singly and combined, must have had important influence in modifying the results.

Permian System.

The soundness of the principles on which Sir R. Murchison and M. de Verneuil first proposed to establish this great division, has been confirmed by subsequent observations both by themselves and by others, and appears to be recognised by the geologists of all countries. The name of Permian, too, has been as willingly adopted as that of Silurian was, being at once convenient and appropriate, and recalling the locality where a true type of the series can be referred to. In their first journey to Russia, only a part of the region where these rocks predominate was examined; but they saw enough then to satisfy them that some new classification was called for, and Sir R. Murchison developed his views and those of his associates at the meeting of the British Association at Glasgow in 1840, and in a paper read before this Society in the following spring. In his address as president at our anniversary in 1842, he referred to his second journey in the summer of 1841, and announced the discovery, that these newer red sand deposits, covering an enormous portion of European Russia, constitute a separate zoological system, distinct in age from the Trias, and comprehending, in ascending order, our lower new red sandstone (the *rothe-todte-liegende* of Germany), our magnesian limestone (the Zechstein of Germany), and the sandstones and conglomerates that constitute the lower member of the *bunter*, or variegated sandstone of the Germans (represented by the Grès des Vosges of France); and leaving the Trias, composed of Upper Bunter-sandstein, Muschelkalk and Keuper, as the lowest of the secondary rocks, and the commencement of new orders in various forms of life. Sir R. Murchison maintained the same views in his address of 1843; and in the spring of 1844, in a paper which he read to this Society, he gave a full confirmation of the correctness of his original conclusions, after a more careful examination of the fossils collected from the Permian series in Russia, and comparison of them with those collected in different parts of Germany and Poland, which countries he visited for the special purpose of examining *in situ* the characters of the lower members of the new red sandstone series in their long-established typical forms. The Permian system, therefore, consists of a series of conglomerates, sandstones, clays, marls, common limestones, and magnesian limestones, all under a great variety of forms, and intermediate between the Carboniferous and Triassic groups. It contains a peculiar fauna and flora, mingled, however, with a proportion of the animal and vegetable remains of the Carboniferous series, on which its beds repose, and thus connected with the palæozoic class of deposits; whereas the Triassic series, which succeeds in ascending order, has not yet been found, it is said, to contain any palæozoic form, whether animal or vegetable. The Permian system, the authors of the "Geology of Russia" observe, constitutes the remnant of the earlier creation of animals, and exhibits the last of the partial and successive alterations which those creatures underwent before their final disappearance. The dwindling away and extinction of many of the types, produced and multiplied in such profusion during the anterior epochs, and the creation of a new class of large animals, the Saurians, clearly announce the end of the long palæozoic period, and the beginning of a new order of zoological conditions.

It is remarkable, however, that palæozoic vegetable forms reappear, as I shall afterwards more particularly shew, in beds much newer than the Trias; for, in the Alps, in many parts of a series of beds, which two such experienced geologists as M. Elie de Beaumont and M. Sismonda unhesitatingly declare to belong to the Liassic period, plants have been found which so skilful a fossil botanist as M. Adolphe Brongniart has not been able to distinguish from species found in the Carboniferous series. There is, besides, this peculiarity, that while the base of the Permian rocks frequently occurs in unconformable stratification with the Carboniferous, there is no example, it is said, in any part of Europe, of the Trias being found in stratification unconformable with the upper members of the Permian system. Too much stress, however, Sir R. Murchison observes, ought not to be laid on this last circumstance, as evidence of a gradual passage in time from the Permian to the Triassic series, because sedimentary matter may be thrown down on the edges of older strata immediately after their dislocation, and that dislocation may have taken place without any great period having elapsed since the strata were deposited. On the other hand, if the sea-bottom were undisturbed, there might have been, so far as mineral structure is concerned, an immense interval of time between the deposition of two beds that are perfectly conformable, and even have a similarity in lithological character. And such, in fact, is the case. "Throughout whole regions of Russia, the older deposits are clearly separable from each other by means of their respective fossils, although they are all apparently conformable."

The different memoirs, which Sir R. Murchison had read before this Society, made us acquainted with the leading features of the Permian system; but his great work on Russia has not only given us the evidence, at full length, of his opinions, but brings conviction to our minds by a more graphic, and more impressive form of testimony than it was possible to produce in his abridged sketches. This system is developed on an enormous scale in European Russia, reposing upon carboniferous strata, throughout more than two-thirds of a basin which has a circumference of not less than 4000 English miles; that is, it occupies a space greater than twice the area of France.

The palæozoic series in North America ends with the Carboniferous rocks; for although that and the inferior groups are developed on so great a scale, a narrow zone of red sandstone on the Atlantic slope, celebrated for containing the footmarks of giant birds, which, in the opinion of Professor Rogers, belongs to the Trias, is almost the only sedimentary deposit between the Carboniferous and the Cretaceous rocks.

The Secondary Rocks.

The Trias, so largely developed in other parts of Europe, is unknown in European Russia.

It is remarkable that, except one member of the oolitic series, the whole of the secondary formations between the Permian and Cretaceous groups should be wanting in Russia; and that, with the exception of a very limited and even doubtful oolitic deposit in Virginia, not a trace of them should have been found from the Atlantic to the Mississippi, and even as far west from that river as any geologist has yet penetrated. Professor Rogers rests his determination of this deposit in Virginia as belonging to the lower part of the oolitic series, solely on the striking resemblance *as a group* of certain plants, accompanying a bed of coal which it contains, to those which are found associated with the oolite coal of Brora, Whitby, and other European localities. He says that, "judging by lithological indications alone, perhaps no more probable conclusion would have been reached on the subject than that of the able geologists Mr Maclure and Mr R. C. Taylor, the former of whom assigned this deposit, consisting of slates and of coarse grits composed of the materials of granite so little worn as to have the aspect of that rock in a decomposing state, and resting upon gneiss, and without any calcareous bed, to the period of the Old Red Sandstone; the latter to the "transition carboniferous deposits." If it be true, that, in the Alps, species of plants identical with those of the carboniferous period have been found in undoubted Jurassic beds, it becomes doubtful whether the mere "resemblance as a group" of the plants in the Virginian beds is conclusive evidence, opposed as it is by the lithological character of the deposit, and the most remarkable circumstance of the entire absence of the oolitic series in any other part of the American continent. In a letter I had from Mr Lyell, who last December passed through Virginia, he informs me that he had seen some specimens of coal plants and ichthyolites from this deposit, which throw some doubt on its being of the oolitic age, especially when he compares the list with those from Connecticut, and that he intends to return to the spot in April next, in the hope of being able to determine their true age more precisely.

The only member of the oolitic series found in Russia is a representative of our Oxford clay and the beds immediately associated with it,—that which the French geologists call the *Terrain Oxfordien.* Nor, where these Jurassic beds occur, do they occupy any great extent of surface, but are in detached spots, at remote intervals, in isolated basins, patches or stripes. They are composed of slightly coherent dark-coloured pyritous shales, sands and calcareous concretions, sandstones and marlstones, very seldom solid calcareous beds, and throughout with a surprising uniformity of character. They are besides of little vertical thickness, compared to the same series in other countries of Europe, the most considerable not exceeding 400 feet. They form low masses, which no doubt were at one time more connected, and have been subjected to powerful denuding causes. They extend from the plains of Prussia to the frontiers of Asia on the east, and to the Frozen Ocean on the north. They are moreover seen to underlie the cretaceous and tertiary deposits of Southern Russia, and appear in the steppes which lead from Europe into Asia; but in these southern regions they undergo a change in lithological characters; becoming siliceous and calcareous grits, and resembling the conglomerates and grits found at the base of the oolitic series in some parts of England; their fossil contents, however, continue the same.

Cretaceous Rocks.

These occupy a great part of Southern Russia, but are unknown to the north of 55° of latitude. In regard to mineral arrangement, there exists that sort of general parallelism between the beds in Russia and those in Western Europe, particularly with those of Eastern Germany, which we might expect to find in strata of the same epoch, separated from each other by great distances. Greensand, ironsand, chalk and chalk-marl occur, in which the same groups of fossils prevail as in rocks of Britain and France which occupy the same relative age in geological succession; and pure white chalk, containing some characteristic organic remains, occurs at intervals to the confines of Asia. In the southern steppes of the Don Cossacks, on the banks of the river Donetz, chalk, possessing all the characters of the English and French chalk, and containing some of its characteristic fossils, occurs of great thickness, Artesian wells having been sunk in it to a depth of 630 feet, without any indications of a change of rock. It contains layers of flint, and the banks of the same river exhibit a section of a greensand group, seventy feet thick, resting upon an equivalent of our coral rag, and surmounted by white chalk. A zone of true chalk, 120 miles in width, stretches through a great region about 100 miles south-west of Orenburg.

The cretaceous rocks occupy a very limited zone on the eastern side of the Alleghanies, extending about 60 miles, but having rarely a breadth of half-a-mile. They sweep round the southern extremity of these mountains, occupying a vast tract which stretches far westward of the Mississippi; and Mr Lyell saw a collection of chalk fossils brought by M. Nicollet from the higher parts of the Missouri river. It appears further, from the recent report of Captain Fremont, that cretaceous rocks occur on the eastern flanks of the Rocky Mountains. The series examined by Mr Lyell in the State of New Jersey, consist of a lower portion of greensand and green marl, and above these a pale yellow limestone with corals, both however belonging, in the opinion of Mr Lyell, who has carefully examined a large series of fossils, to the age of the white chalk, including the period from the gault to the Maestricht beds. As a detailed account of these beds and their fossil contents is given in the first volume of the Society's Journal, I need not dwell further upon them, except to give a statement of the general results. There is a remarkable generic accordance between the fossil molluscs, corals, echinoderms, fish and saurians, and those of the same series in Europe; out of sixty shells collected by Mr Lyell, five seem to be quite identical with European species, while several others approach very near to, and may be the same as, European; fifteen may be regarded as good geographical representatives of well-known cretaceous fossils, belonging for the most part to beds above the gault. This amount of correspondence is not small, when it is considered that the part of the United States where these cretaceous beds occur, is from 3000 to 4000 miles distant from the chalk of Central and Northern Europe, and that there is a difference of 10° in the latitude of the places compared on the opposite sides of the Atlantic. "Some of the species common to the opposite sides of the Atlantic are those which in Europe have the greatest vertical range, and which might therefore be expected to recur in distant parts of the globe." He concludes with the following remarks:—"We learn from the facts mentioned, that the marine fauna, whether vertebrate or invertebrate, testaceous or zoophytic, was divided at the remote period under consideration, as it is now, into distinct geographical provinces, although the geologist may everywhere recognise the cretaceous type, whether in Europe or America, and I might add India. This peculiar type exhibits the preponderating influence of a vast combination of circumstances prevailing at one period throughout the globe—circumstances dependent on the state of the physical geography, climate, and the organic world in the period immediately preceding, together with a variety of other conditions."

Tertiary Deposits.

The tertiary deposits of Russia, exclusive of a few patches of very recent age, are most expanded in the southern parts of the empire, those of Eocene and of Miocene ages both occurring. The former has, in many parts, the very same structure and contents as the London clay. Sections are seen of beds equivalent to the calcaire grossier and London clay, in connexion with strata referred to the upper part of the cretaceous system. In the neighbourhood of Saratof, on the Lower Volga, there occurs a sandy calcareous grit, subordinate to clay and sand, of a concretionary structure, undistinguishable from the Bognor rocks in Sussex, and containing the same shells. The authors appear inclined to believe, that an insensible gradation may be traced from the upper cretaceous into the tertiary beds.

The Miocene deposits are of far greater extent than the Eocene. They are the extension of the great basins of Vienna and Hungary, and are spread over Volhynia, Podolia, and Bessarabia, stretching to the Black Sea and the country north of Odessa, where they are covered by deposits of a more modern age. They have a close affinity to the deposits of the sub-Apennines and of Bordeaux, and like beds of the same age in Styria and Hungary, contain extensive oolitic beds, undistinguishable, lithologically, from many English and French varieties of the jurassic group.

Marine Pliocene deposits are wanting, but the Miocene are covered by the vast deposit of argillaceous limestone already referred to as occupying the region around the Caspian, called by Sir R. Murchison the Aralo-Caspian or Steppe limestone, in which the univalves are of fresh-water origin, associated with forms of Cardiaceæ and Mytili, which are common to partially saline or brackish water. It abounds in many places with fresh-water shells, and indeed presents the true and persistent characters of a deposit in an inland sea, and contains no vestiges of corals or other marine bodies. It was observed to be in some places between 200 and 300 feet thick, and at elevations of 700 feet above the present level of the Caspian. It possesses an uniformity of character which separates it from any tertiary deposit of Western Europe.

You are aware that Mr Lyell read before this Society four papers on the tertiary deposits of the United States, which have been published in our "Proceedings;" it is unnecessary, therefore, for me to give even a brief summary of them, and

I shall content myself with stating some of the general results. On the Atlantic side of the Alleghanies, an area about 400 miles long, from north to south, and varying in breadth from 10 to 70 miles (with some detached patches further south), is occupied at intervals by tertiary deposits, which, in the intermediate spaces, are probably concealed by the more modern deposits and alluvium which form the surface. There are extensive tracts of Eocene formations, particularly in the south. Out of 125 species of shells which Mr Lyell obtained from these deposits, he was not able to indentify more than seven with species of the same epoch in Europe. But there are a considerable number of representative species, and an equal number of forms peculiar to the older tertiary strata of America. The *Ostrea sellæformis* may be considered as representing the *Ostrea flabellula* of the Paris and London basins, and appears to be one of the most characteristic and widely disseminated Eocene shells in this North American deposit.

The Miocene deposits are of far greater extent than the Eocene; and there is in them a close affinity of many of the most abundant species with mollusca now inhabiting the American coast, the proportion being about one-sixth of the whole, or about 17 per cent., in those examined by Mr Lyell, who was able to identify 23 out of 147 with living shells. The corals also agree generically with those of the Miocene beds of Europe; the cetacea also agree generically, and the fish in many cases specifically.

Metamorphic Rocks.

The theory of metamorphism, in its more extended application, in recent times, to the explanation of the peculiar structure of certain stratified rocks, has thrown a clear light upon some of the most obscure and difficult parts of geology. No geologist will now, I presume, hesitate to admit, that there is evidence amounting to demonstration, that a permanent source of heat exists in the interior of the earth, widely spread beneath the stony envelopment, and that it has existed at all times. Whether it is local or widely spread under the surface—whether it is constantly maintained or is excited at intervals by certain combinations, are questions for the solution of which we have as yet no data to lead us beyond probable inferences. It was long ago observed, that when dykes of basalt passed through sedimentary rocks, earthy limestones were frequently changed into crystalline marble, shales into flinty slate, argillaceous sandstone into jasper, and bituminous coal into graphite or cinder. Similar changes were also often observed at the junctions of granite with sedimentary rocks. An attentive observation of these phenomena led Hutton to infer, that the strata derived from the detritus of pre-existing rocks had been consolidated into stone by the agency of subterranean heat; and although he extended his theory to all the strata, to many which subsequent observations have shewn it to be inapplicable, still the germ of the modern theory of metamorphism is clearly seen in one of the fundamental positions of the Huttonian theory of the earth. But sound as were the views of that philosopher in his leading doctrines, they were adopted by a very small number of geologists, so strongly had the theories and system of Werner got possession of men's minds, especially in Germany and France. About twenty years ago, however, some startling facts were brought to light; we heard that Belemnites had been found in micaceous schists in the Alps, and that an insensible passage could be traced from a secondary oolite full of organic remains, to the highly crystalline marble of Carrara, the old type of primary limestone, and under circumstances which afforded the strongest presumptive evidence that the oolite had been changed into the marble by the action of adjacent igneous rocks. Then there came facts on a grand scale, analogous to those that had been observed at the junction of trap dykes and granite veins, with sedimentary rocks, and not only extending to great distances from the igneous rock, but the secondary shales were changed into rocks that could not be distinguished from the so-called primitive gneiss and mica-schists, and, like them, included crystallized garnets.

Mr Lyell, in 1833, brought forward a more extended and complete development of the Huttonian hypothesis of consolidation, and first proposed the adoption of the term " metamorphic" to this peculiar altered structure of sedimentary rocks,—a term which has been since universally adopted; and every year has disclosed new facts from all parts of the world, in confirmation of the theory that the older crystalline and indurated schists, limestones, dolomites, and quartzites, and many similar beds of more modern date, were not deposited with a structure such as they now present, but were accumulations of detrital matter, *transformed* into their present condition mainly by the action of heat, accompanied by other chemical action, and the powerful agency of steam and elastic forces under enormous pressure. A very ingenious process, invented by Mr Brockedon, described in a short paper read before us last year, by which he converts, under very powerful pressure, the powder of graphite into a solid mass, having a conchoidal fracture, and undistinguishable from the most compact native black-lead, shews that pressure alone may convert fine detrital matter into solid stone.

It is not very long ago, far within our own time, since geologists spoke and wrote of chaotic fluids holding mineral matter in solution, and of precipitations of crystalline rocks from that menstruum. But these hypotheses, not only unsupported by, but at variance with, all known chemical laws, are now laid aside, and we reason more soberly, interpreting past changes in the mineral structure of the earth by our experience of the laws by which the operations in the material world are governed. Every accession to our knowledge of the older sedimentary, highly consolidated, and semi-crystalline rocks, renders the probability greater that they were formed in the same manner as those now in progress of formation in existing seas; in short, that they originated from the waste of pre-existing lands. As astronomy leads us to contemplations of immensity of distance in space, thus does geology lead us to contemplate distances in past time almost as boundless; equally difficult for us to form a conception of, but, although not capable of measurement, not less certain. We are thus brought to admit the truth of another of the fundamental doctrines of the Huttonian theory, laid down by its author more than half a century ago, and some years afterwards so eloquently illustrated by his disciple and friend Playfair, whom I am proud to call my first master in geology, "that in all the strata we discover proofs of the materials having existed as elements of bodies, which must have been destroyed before the formation of those of which these materials now actually make a part."* We learn from Professor Sedgwick, that in the north of England there are chloritic slates alternating with countless contemporaneous ribs of porphyry, as well as with trappean conglomerates and slaty beds, *derived mechanically from materials of igneous origin.* M. Abich of Dörpat considers that certain dark-green grains disseminated through the lowest beds of the Lower Silurian "Pleta," or Orthoceratite limestone of Russia, are the detritus of the ancient augitic rocks of the Finnish frontier.† The least fragment of an organic body in the lowest deposits, it is evident, must have been encased in silt or mud, and that silt or mud must have been derived from pre-existing rocks, and most probably rocks exposed on land to the destructive power of meteoric agents. We are told by Mr Lyell, that the Potsdam sandstone, the lowest of the Silurian strata of North America, at the Falls of Montmorency, near Quebec, is remarkable for containing *boulders* of enormous size—the largest he ever remembers to have seen, he says, in any ancient stratified rock. He measured some of them, which were 8 feet long. They consist of the same gneiss as that on which the sandstone rests. He also observed in the same sandstone, on the borders of Lake Champlain, ripple-marks on the surface of its flags.

Several of the works of geologists which have been published during the last year, have supplied much additional evidence of metamorphic action; none more important, I may say more conclusive, than is contained in the work of Sir R. Murchison on Russia, and of Mr Lyell on America, and in a very valuable memoir by M. Virlet. As far as my limits will allow, I will bring forward some of that evidence.

With limited exceptions, true granites are rarely found in the higher portions of the Urals, but they are of frequent oc-

* Illustrations of the Huttonian Theory, p. 5. † Murchison's Russia, i. 28.

currence in the lower regions, particularly on the Siberian side. The igneous rocks that enter into their composition are different forms of syenite, porphyry, greenstone, and felspar rocks, often graduating into each other, and associated with serpentine. These have evidently been erupted at different periods; and there are wide tracts occupied by granitoid rocks, which appear to have been erupted after the age of the carboniferous series, and posterior to the greater proportion of the greenstones and other eruptive rocks of the Urals.

It was only after Sir R. Murchison and his companions had become thoroughly acquainted with the slightly consolidated and unbroken sedimentary deposits in European Russia, that they were able to decipher the intricate characters of the indurated and crystalline strata which constitute the flanks, enter into the very body, and form lofty serrated ridges of the Ural chain; broken up and cast about in much apparent confusion. But from the presence of organic remains, traceable at intervals along both flanks, and even close to the axis of the chain, they were satisfied that some of the central ridges, although composed of chloritic, talcose, micaceous, and quartzose slates, cannot be of higher antiquity than the unconsolidated Lower Silurian rocks on the shores of the Baltic; and that others, although in a highly crystalline state, are not older than the Devonian and Carboniferous series. The same rocks, when they recede from the great lines of eruption, resume their ordinary sedimentary characters. In one place the authors expressly say, that, in proportion as they receded from the igneous zone, the sedimentary strata gradually parted with their talcose, chloritic, and quartzite characters, and assumed the appearance of ordinary argillaceous schist, with bands of grit and sandstone, all parallel to the crystalline axis of the chain. In another place they describe certain Upper Silurian beds, consisting of alternations of argillaceous slate and black encrinite limestone, passing into talc-schist, and containing great flakes of mica. Between two great parallel lines of eruption, they saw pure white saccharoid limestone containing Encrinites, and associated with other crystalline beds, which they were satisfied were once sandstones formed under the sea in the palæozoic period. In like manner, the sedimentary rocks on the northern frontier of Russia, where they approach the great granitic and trappean region that stretches southward from Russian Lapland, become so changed, that the shales are converted into Lydian stone, the limestones into marbles, and the sandstones into indurated and sometimes granular quartz. These are not partial local effects, but characterise a long line of country in a broad zone. The authors observe, that "the thorough examination of this great band of Silurian rocks, more or less metamorphic, which lies between the purely crystalline or azoic rocks of the north, and the wholly unaltered Devonian and Carboniferous deposits on the south, well merit the special attention of the geologist, mineralogist, and chemical philosopher; for the scale on which these operations of change has been conducted is gigantic. Our present acquaintance with the phenomena is, however, sufficient to convince us, that here, as in other countries, the consolidation, rupture, and alteration, of large portions of the earth's crust have been effected by the agency and eruption of igneous and gaseous matter." A limestone—ascertained, both by lithological characters and fossiliferous proofs, to belong to the Devonian age, in which copper veins occur at a point where it is intersected in a complicated manner by greenstone porphyry—is converted, for a space 350 fathoms long, and 20 wide, into a crystalline rock, in some places becoming a pure white crystalline saccharoid marble, and associated with it is a garnet rock, loaded with very beautiful and large crystals; a case somewhat analogous to that observed by Professor Henslow in Anglesea twenty-five years ago,* and to that in the neighbourhood of Christiania described by Mr Lyell.† On the east flank of the Urals, south of Ekaterinburg, there is a succession of low ridges parallel to the main crest of the chain, composed of metamorphic rocks, some of them so micaceous that they might pass, the authors say, for primary mica-schist; others resembling gneiss, which a few

* Cambridge Philosophical Transactions, vol. i.
† Elements of Geology, vol. ii. p. 403.

years ago, any geologist would have termed primary, but which are, in fact, only altered palæozoic sedimentary strata.

If we cross the Atlantic to North America, we obtain equally clear proofs of the alteration of the sand and mud of the lands of remote antiquity into crystalline schists, and of the forests that grew upon them into anthracitic coal, by this same powerful agency.

The Appalachian or Alleghany mountains, which run from north-north-east to south-south-west for 1000 miles, varying in breadth from 50 to 150, and in height from 2000 to 6000 feet, have not, like the Ural chain, the features of a great rent in the earth's crust formed by elastic forces from beneath, and into which molten rocks were injected; they are composed of Silurian, Devonian, and carboniferous rocks, in a series of nearly equal and parallel ridges formed by flexures of these rocks. The bending and fracture of the beds is greatest on the north-eastern or Atlantic side of the chain, and the strata become less and less disturbed as they extend westward, until at length they regain their original or horizontal position; thus offering between the Alleghanies and the western boundary of the basin of the Mississippi, a country very similar in conformation to that between the Urals and the Baltic, and composed, to a great extent, of similar rocks. The internal movements which caused these flexures took place, as in Russia, subsequent to the carboniferous period; and on the eastern side the igneous rocks have invaded the strata, forming dykes, some of which run for miles parallel to the main direction of the mountains. These igneous rocks are largely developed to the north-east in the States of New Hampshire, Vermont, and Maine.

Near Worcester in Massachusetts, Mr Lyell observed mica-schist containing beds of anthracite, the mica-schist including garnets and asbestus; and he states that he is strongly inclined to believe, that however crystalline they may be, they are no other than carboniferous rocks in a metamorphic state. There are many other places in Rhode Island and Massachusetts of similar transformations, especially in the neighbourhood of masses of granite and syenite.* The coal, which,

* Lyell's America, vol. i. p. 248.

westward of the Alleghanies, is highly bituminous, as it approaches the igneous rocks to the east, gradually loses its bituminous and gaseous contents, and is finally converted into anthracite.

The concluding part of the first volume of the second series of the "Bulletin de la Société Géologique de France," published last year, contains an interesting, and, in many respects, highly instructive account of the proceedings of the Society, at their meeting at Chambery, in August 1844. During the sixteen days it continued, several valuable papers were read, and interesting discussions thereon are reported. Among others, the subject of metamorphism was frequently brought forward, and it appears to be the settled opinion of the most eminent French, Swiss, and Italian geologists, who have thoroughly examined the Alpine regions, that a great proportion of the mica-schists, talc-schists, and clay-slates of the Alps, long held as types of primitive rocks, are unquestionably deposits of secondary age, metamorphosed by igneous action. The neighbourhood of the place of meeting is described by the Archbishop of Chambery,—who took an active part in the proceedings, and who, from the communications he read, seems to be a zealous geologist,—as one of the countries of Europe the most interesting in this respect, and one in which the modifications of metamorphic action may be traced from its commencement to its extreme intensity with the greatest facility. At the conclusion of the meeting, M. Virlet read a paper on the participation which veins have had in metamorphic action, and brought forward some new views on the theory of metamorphism. He states that it has generally been held to be the result only of the action of plutonic rocks on the sedimentary deposits with which they come in contact, but that it is a far more complex operation, and is probably the result of several causes acting either simultaneously, separately or successively; among these he is disposed to ascribe much to the addition of new materials, insinuating themselves in the shape of gaseous emanations from the interior of the earth. He also dwells much on the matter injected into fissures, forming veins, as having had great effect, maintaining that in all metalliferous regions, the greater the number of veins by which they are traversed, so is the degree of metamorphism increased. He insists much on the metamorphic action of quartz veins, which he holds to be of eruptive nature; refers to the growing conviction among geologists, that, in many cases, there have been eruptions of veins of calcareous spar; and even ascribes the veins and slender ramifications of gypsum, in the argillaceous beds of the lias of Burgundy and the other eastern provinces of France, to eruptions of sulphate of lime.

(To be concluded in next Number.)

On the Surface of the Moon. By Captain Rozet.

M. Elie de Beaumont has already been enabled, by means of the beautiful selenographic delineations of Lohrmann, and of Beer and Mädler, to make some very remarkable comparisons between the forms presented by certain portions of the mountainous masses of the earth, and the annular openings of the surface of our satellite.

During the summer of 1844, one of my friends having directed my attention to the circular forms of nearly the whole of the variations of the lunar surface, I have devoted myself since that time to the study of the phenomena presented by these variations of surface, having, at the same time, called in the aid of the beautiful German maps, and of various works already published on the subject.

The contours of all the great greyish spaces which, for a very long time, have been termed *Seas*, although it is known with certainty that they cannot be masses of water, are formed by arcs of circles which intersect one another. The number of arcs sometimes amounts to two, rarely to one *mare crisium*. These contours present circular escarpments which seem perpendicular, but the inclination of many of which is 45 degrees. The matter composing them appears to be swelled up, and their height often exceeds 4000 metres (upwards of 13,000 English feet). In the interior of the seas we remark annular openings or perfect rings, whose diameter amounts to 10 myriametres (upwards of 60 English miles), and the height of whose terminal ridge is 4000 metres. Several of them have a peak in the centre, which is a little less elevated than the edges of the ring.

The large grey spots cover a great portion of the northern, eastern, and western regions of the disc, and leave in its southern part a brilliant space, covered with an infinity of rings of all dimensions. These rings are simple and isolated, complex, or united together, two and two, three and three, &c. When they touch one another, the contours are always rendered imperfect; and it is generally the smaller one which encroaches on the larger. In the interior of the large rings there are almost always present smaller ones, which cut the edges when they touch them. The bottom of the rings seems to be flat, but that bottom often presents elevated portions, arranged in arcs of circles parallel to the external ridge; so that the rings would seem to have been formed at the surface of a fluid mass on which scoriæ were floating, by means of a circular undulation, whose amplitude went on diminishing.

The bottom of the great spots, such as the *mare serenitatis*, &c., exhibits the same characters. Simple spots are also to be noticed, or portions having no projection, but whose circular forms are well marked. It cannot, therefore, be called in question, that a general cause, producing these circular forms, has had an immense influence in the formation of the solid crust of our satellite. We can perfectly account for all the facts now enumerated, by supposing a number of whirlpools in the fluid matter, whose amplitude diminished with the fluidity of that matter. Nothing is to be seen on the surface of the moon which reminds us of our chains of mountains with their lateral branches, or of our great valleys with their numerous ramifications, &c. We see, indeed, many well marked fissures, as, for example, at the bottom of the *mare vaporum;* but these fissures are simple; several diverge from one centre, as in Tycho, Copernicus, Kepler, &c., and form radiating cracks, analogous to those in Von Buch's craters of *soulevement*, but much more considerable. One of the fissures of Tycho traverses the moon diametrically. A continued study of the various portions of the moon, under all inclinations of the solar rays, enables us to recognise two layers which are quite distinct, but two layers only;—the bottom of the great greyish spaces, which is also that of the rings; and a scoriaceous crust, elevated above that bottom to a height which has been measured at a great number of points. These measurements have afforded me the means of calculating the thickness of this crust, and I found that the mean is 642 metres (2106 English feet).

From all the facts I have ascertained, and from all the deductions to which these facts have led me, I think I may draw the following conclusions :—

1. The lunar globe has originally been in a state of fusion, and has been gradually cooled.

2. During the formation of the external scoriaceous pellicle, there existed in the mass whirlpools or circular movements, which, driving the scoriæ from the centre to the circumference, formed annular ridges, by the accumulation of those scoriæ at the limit of the undulation. When several whirlpools occurred in such circumstances, that the distance of the centres, taken two and two, was less than the sum of the radii, there resulted an enclosed space, bounded by arcs of circles. When the distance of two centres was greater than the sum of the radii, two complete rings were formed.

3. The amplitude of the whirlpools diminished with the fluidity of the surface, but the phenomenon continued throughout the whole duration of the process of consolidation.

4. The mode of formation which we assign to the lunar rings, altogether excludes the idea of craters resembling those of our volcanoes.

5. The surface of our satellite being thus consolidated, no solid or liquid layer coming from the exterior was subsequently deposited upon it; for, otherwise, the small rings and the fissures would have disappeared. The perfect preservation of all these variations in external configuration, shews that no liquid has ever existed in considerable quantity, either at the surface, or even in the atmosphere of the moon.

6. After the complete consolidation of the external envelope, the matter which remained fluid in the interior acted upon that envelope, and fractured it, often giving rise to large radiating cracks. At that epoch, the solid crust must have al-

ready been very thick, because the fissures are of large dimensions.

7. As no liquid, in any considerable quantity, has ever existed on the surface of the moon, or in its atmosphere, it results that no organised beings, similar to those of the earth, can ever have lived there; and if that planet, as is pretty generally admitted, has no atmosphere, it can possess no beings in whose organization liquids form a part, and we cannot conceive of organic beings without liquids.

8. Lastly, from the whole of my investigations, there results the following important fact, viz., that the surface of the moon permits us to see all the phenomena of its consolidation, and the traces of the revolutions which it has undergone. On our earth these phenomena are almost all concealed by aqueous deposits; but various regions, in which rocks resulting from fusion have remained uncovered, present forms very analogous to those exhibited by the surface of the moon. It is probable that, if the terrestrial surface were stripped of the seas, and of all the sedimentary deposits which cover it, annular forms would predominate. The same may be said in regard to all the planets of our system; for the circular undulations of matter in a state of fusion, seem to me to be a consequence of the movements inherent in the different bodies, which, by becoming agglomerated round great centres of attraction, have formed those planets.*

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* The above is an extract from a Memoir which has very lately been referred by the French Academy of Sciences to a committee, consisting of Messrs Arago, Elie de Beaumont, and Liouville.—*Comptes Rendus,* vol. xxii.

Observations on the Principle of Vital Affinity, as illustrated by recent discoveries in Organic Chemistry. By WILLIAM PULTENEY ALISON, M.D., F.R.S.E., Professor of the Practice of Medicine in the University of Edinburgh.*

PART I.

The most important steps in a science are those which lead most directly to the establishment of principles or laws peculiar to that science itself, and which constitute its claim to be regarded as a distinct branch of human knowledge. It has been long acknowledged that such is the character of many of those phenomena of living bodies which depend on mechanical movements, or changes of position in their particles, and therefore that the laws of vital contractions are to be regarded as equally elementary and distinctive principles in physiology, as the laws of motion or of gravitation in natural philosophy. But a difficulty has been long felt, as to whether a similar claim to peculiarity of the principle on which they depend, can be urged for the chemical phenomena of living bodies.

In laying down the first principles of Physiology and of Pathology, I have, however, uniformly maintained the existence of a power peculiar to living bodies, and to which the term Vital Affinity, as recommended by several authors, may be properly applied;—a power by which " the elements of nutritious matter are thrown into the combinations necessary for forming the organic compounds, and restrained from entering into other combinations, to which they are prone as soon as life is extinct;—a power which supersedes and counteracts ordinary chemical affinities in living bodies, as completely as vital contractions counteract gravitation or the inertia of matter."—(*Outlines of Human Physiology*, p. 22.) And in delivering lectures on physiology, I always expressed my

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* From " Transactions of the Royal Society of Edinburgh," nearly through the Press.

belief that a time would come, when discoveries in the chemical department of the science,—connecting the ingesta of living bodies with the nourishment of their different textures, and with the nature of the different excretions,—would elucidate the chemical changes which are continually going on in them, and are essential to their living state, as completely as the discovery of the circulation of the blood illustrated many of the conditions of the existence of living animals. It appears to me that this anticipation has been more nearly realized by recent chemical observations, than professed physiologists have yet admitted;—that not only the existence of the principle of vital affinity has been established, but its limits and mode of action, the cases in which it acts, and those in which it is unconcerned, are to a certain degree defined;—and that a short and general illustration of these points may be of some advantage, if not to the progress of the science, at least to the due appreciation, and proper generalization and expression of the knowledge which has been already acquired.

To shew the importance of this inquiry, I need do no more than quote a single sentence from Cuvier, with a statement which is nearly a commentary upon it by Professor Whewell. "It belongs to modern times to form a just classification of the vital phenomena; and upon the zeal and activity given to the task of analysing the *forces* which belong to each organic element, depends, according to my judgment, the advancement of physiology."* "As the vital functions became better understood, it was seen more and more clearly at what precise points of the process it was necessary to assume a peculiar vital energy, and what sort of properties this energy must be conceived to possess. It was perceived when, and in what manner and degree, mechanical and chemical agencies were modified, overruled, or counteracted by agencies *which must be hyper-mechanical and hyper-chemical.*" "In attempts to obtain clear and scientific ideas of the vital forces, we have first to seek to understand the cause of change and motion in each function, so as to see at what points of the process

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* Hist. des Sciences Naturelles depuis 1789, p. 218.

peculiar causes come into play; and next, to endeavour to obtain some insight into *the peculiar character and attributes of these causes.*"*

When we say that the chemical changes which take place in living bodies are elucidated, we mean, of course, that they are referred to general laws, by which the phenomena observed in this department of Nature are found, by experience, to be regulated. And when we say that these are laws of vitality or of vital action, we mean merely, that they are laws deduced from the observation of phenomena peculiar to the state of life,—taking for granted that it is always possible to describe, and practically to distinguish, those substances which we call living, from inorganic or dead matter; and that the only correct definition of vital principles or vital powers, is, that they are the laws or the powers which regulate the phenomena that are peculiar to the state of life. They are the general expression of the results of the observation, and generalization of the facts, which are observed in this department of nature, and which are ascertained to belong to this department alone.

We are not, indeed, justified in asserting the existence of laws peculiar to the state of life, merely by the *negative* observation, that the phenomena referred to them are *inexplicable* by any known laws of inorganic or dead matter; we must have the *positive* observation that they are *inconsistent with*—that they take place in despite of—the laws which regulate the changes of dead matter. It is thus that we are led to ascribe the visible movements of living bodies to vital powers; not because we do not perceive how gravitation, elasticity, or any other known causes of movement in dead matter, should produce them, but because we do perceive, that, in the circumstances in which we see these motions, all those principles, deduced from the observation of dead matter, would determine either rest, or motion in a different direction from that which really takes place.

I formerly laid before this Society the grounds of an opinion, then much disputed, but now, I think, pretty generally ad-

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* Philosophy of the Inductive Sciences, vol. ii., pp. 39 and 47.

mitted, that there are Attractions and Repulsions, as well as contractions, peculiar to the living state: chiefly, but not exclusively, observed at those parts where chemical changes are effected in living bodies, and connected with these changes; and, without reference to this general fact, I maintain that it is impossible to have a right understanding of many phenomena of essential importance in physiology and pathology.*

But the general principle is obviously equally applicable to chemical changes as to mechanical movements. It is not, indeed, so easy to ascertain, in regard to chemical changes in living bodies, that they are truly inconsistent with the chemistry of dead matter; the science must be allowed to make some progress before this can be confidently asserted in regard to any individual chemical change; but no one can doubt that, as science advances, it must become possible to say with certainty, whether the chemical changes in living bodies are consistent with those laws which regulate chemical changes elsewhere, or not; *i. e.*, whether the same chemical elements can be so brought together by the chemist, as to tend to the same combinations as are found in living bodies; or whether, in his hands, they will enter uniformly into other combinations, and form different compounds.

Farther, it appears to me that, even before any of the recent discoveries, it might be legitimately inferred from facts already known, that this last description is truly applicable, in some cases, to the chemistry of living bodies. It was known, for example, that when water, impregnated with carbonic acid and with a small proportion of ammonia, is brought into contact with vegetable substances, in a certain stage of their existence, the elements of these bodies rapidly combine so as to form starch, albumen, and oil, which are added to

* Professor Whewell, in his instructive abstract of the general principles ascertained in Physiology, regards it as established, chiefly on the authority of Mülder, in regard to the vital force concerned in assimilation and secretion, that "it has mechanical efficacy, producing motions, &c. But it exerts at the same point both an attraction and a repulsion, attracting matter on one side and repelling it on the other; and in this it differs entirely from mechanical forces."—*Philosophy of Inductive Sciences*, vol. ii., p. 51. See also Carpenter's *Manual of Physiology*, § 597, *et seq.*

the substance of the vegetable,—that under no other circumstances can water, carbonic acid, and ammonia, or their elements, be made to form these compounds,—and farther, that after a time, when brought into contact, at the same temperature with the same vegetable substance in an ulterior stage of its existence, they will form no such compounds, but will aid and participate in the successive changes to which vegetable matter is liable after the phenomena of its living state are over, and of which the ultimate result is, the resolution of that matter into its original constituents. And from these facts it seems quite reasonable to infer, that during the former, or what we call the living state of the vegetable, certain affinities peculiar to the living state—*i. e.*, certain vital affinities—actuate the elements of which it is composed.

In asserting the existence of vital affinities, we do not, in the first instance, give any opinion whether it is by the addition of certain chemical attractions, or by the suspension of others, during the living state, that the chemical changes peculiar to that state are effected; we assert nothing more than what is, as I think, correctly stated in the following sentence of Liebig:—" The chemical forces in living bodies are subject to the invisible cause by which the forms of organs are produced." " The chemical forces are subordinate to this cause of life, just as they are to electricity, heat, mechanical motion, and friction. By the influence of the latter forces, they suffer changes, in their direction, an increase or diminution of their intensity, or *a complete cessation or reversal of their action.*

" Such an influence, and no other, is exercised by the vital principle over the chemical forces."

" The equilibrium in the chemical attractions of the constituents of the food is disturbed by the vital principle, as we know it may be by many other causes. The union of its elements, so as to produce new combinations and forms, indicates the presence of *a peculiar mode of attraction*, and the existence of a power distinct from all other powers of nature, viz., the vital principle."—(*Organic Chemistry*, *&c.*, pp. 355, 357.)

In these passages I think that Liebig has expressed himself with perfect accuracy; but in other parts of his writings he uses language in regard to the nature and results of chemical changes in living bodies, which seems to me vague and speculative, and even inconsistent with what he had stated in the passages just quoted, *e. g.*, when he says that " the ultimate *causes* of the different conditions of the vital force in nutrition, reproduction, muscular motion, &c., are *chemical forces.*"—(*Organic Chemistry*, p. 10.)

The following sentence by Mülder expresses the very same idea, although it might be thought, from the manner in which this author expresses himself against any introduction of the vital principle in this department of physiology, that he considers all the chemical changes in living structures to be referable to the same laws as in inorganic matter.

" By a small organ of a plant *a force is exercised*, exciting forces which slumbered in the carbon, oxygen, and hydrogen, or rather *modifying the forces which existed in these,* so that 12 equivalents of carbon unite with 10 of hydrogen and 10 of oxygen; and from 12 equivalents of carbonic acid ($12\ C\ O_2$) and 10 of water (10 H O) starch is produced, 12 C 10 H 10 O, 24 of oxygen passing off."—(*Chemistry of Vegetable and Animal Physiology*, p. 67.)*

But it is important to fix our attention, for a short time, on the instances adduced by Mülder, of the formation of starch, or some of its allied compounds, out of carbonic acid and water, by the combination of the carbon of the acid with the elements of water, and the expulsion of the oxygen of the acid; because this is the grand and fundamental power, which must have been called into operation when organized structures were first created on earth, and on the continued exercise of which the existence of all such structures, vege-

* In the foregoing and other translations from recent German writers, the word *force* is used in a sense which I think would be much better expressed by the term *power* or *property*, merely on this account, that the English word force, in physical discussions, has usually a precise and limited meaning assigned to it, as a cause capable of producing visible motion, and of which we have a measure, either in the velocity or in the quantity of motion which it can excite; whereas the term power or property, applied to any material substance, has a more general meaning, as simply the cause of change of any kind, and is therefore applicable where the result of the property ascribed to any substance may be very different from visible motion.

table and animal, is still essentially dependent; and because the simplicity of the process makes it a fit case for considering the question, whether the power here named is strictly entitled to the epithet vital; or whether, as some eminent physiologists in this country maintained, the idea expressed by that term is incorrect and unscientific.

The opinion of those who oppose the doctrine of vital affinity, is thus distinctly stated in the Anatomy of Drs Quain and Sharpey:

"Although the products of chemical changes in living bodies for the most part differ from those appearing in the inorganic world, the difference is nevertheless to be ascribed, not to a peculiar or exclusively vital affinity different from ordinary chemical affinity, but to common chemical affinity, operating in circumstances or conditions which present themselves in living bodies only; and undoubtedly, the progress of chemistry is daily adding to the probability of this view."

I consider this to be a hasty and ill advised statement; and to shew this, I request attention, *first*, to the perfect simplicity of the apparatus by which this change is effected. "In all plants," says Mülder, "there exists a small organ, of the most simple form, although employed by nature for the most varied purposes. It is a small filmy sac, a thin membrane, which encloses a small space, which it enables to communicate with the exterior space through invisible pores. These little sacs or cells are the chief organs of plants. A countless multitude of them, grouped together, forms the whole bulk of the plant, so that if every thing except the cells be destroyed, the shape and size of the plant are not in the least changed or diminished."

Into this simple apparatus in certain parts of plants, water, impregnated with carbonic acid, is introduced, while the plants exhibit the phenomena of life; and let us next observe the intensity of the action by which the carbonic acid is there decomposed, the carbon attached to the elements of the water, and the oxygen set free. "This is done by a power," says Liebig, "to which the strongest chemical action cannot be compared. The best idea of it may be formed by considering, that it surpasses in power the strongest galvanic battery, by which we are not able to separate the oxygen from carbonic acid. The affinity of chlorine for hydrogen, and its power to decompose water, under the influence of light, and set its oxygen at liberty, cannot be considered as nearly equalling the power and energy with which a leaf, separated from a plant, decomposes the carbonic acid which it absorbs." —(*Organic Chemistry*, p. 134.)

Next let us observe the extent to which this energetic power is exercised by living plants. Perhaps the most accurate idea of it may be formed from attending to the statement of Theodore de Saussure, that on a mean of 54 observations made in a country district, the proportion of carbonic acid in the atmosphere during the night was to its proportion in the day-time as 432 to 398, *i. e.*, the carbonic acid existing in the atmosphere was found to be diminished very nearly 10 per cent. in a few hours of every day; and for this diminution we know no cause, except that this power of the green parts of vegetables, of decomposing the carbonic acid of the atmosphere, is exercised only under the influence of light.*

Now if a power of this extraordinary energy and extensive operation, and acting in so very simple a manner, were really to be regarded as depending only on ordinary chemical affinities, exerted under peculiar conditions, it might surely be expected, that the chemist might so regulate the conditions under which he might bring together carbonic acid, air, and water, as to exhibit some traces of this power, and effect some decomposition of the carbonic acid and evolution of oxygen. But we know, not only that this cannot be done, but that when air, water, and carbonic acid, are introduced into the very same vegetable cells, within half an hour after they have exhibited this phenomenon, at the same spot, under the same light, and at the same temperature, they will not only fail to exhibit the same change, but will uniformly exhibit the very reverse, *i. e.*, the absorption of oxygen and the formation and evolution of carbonic acid.

Nay, we know that it is only in certain cells of the living

* See Macaire's Memoir of Theodore de Saussure, in Jameson's Edinburgh Philosophical Journal, vol. xl., p. 31 (Jan. 1846.).

vegetable, that this peculiar chemical change, under the action of light, is effected; the same fluid, introduced into cells composed of the same material in the parts of fructification, undergoes no such change; but, on the contrary, gives occasion only to the reverse process, the absorption of oxygen and evolution of carbonic acid.*

Then it is to be remembered, that this complete inversion of ordinary chemical affinities, in the case of the living plant, is only one of several cases to be afterwards noticed, where we see chemical compounds uniformly formed in living bodies, quite distinct from any that can be formed by the chemist from the same elements, and quite distinct from those to which the same elements uniformly revert, after the phenomena of life are over.

Lastly, we must remember, when we see this apparent inversion or alteration of the ordinary chemical relations of matter, taking place in the interior of living bodies, that in that scene, by the admission of all, matter comes under the dominion of *mechanical* laws, which operate in no other department of nature; so that it is quite conformable to analogy to suppose that its chemical relations will undergo a similar modification.

When all these considerations are duly weighed, I cannot perceive what further evidence can be required in order to justify the expression which I have quoted from Liebig, viz., that the "*new combinations*," as well as the forms, assumed by that matter which goes to the composition of organized beings, "indicate the existence of a power distinct from all other powers of nature, viz., the vital principle;" *i. e.*, that the vital principle regulates the changes of chemical composition, as well as the changes of position which the particles of that matter undergo; which is more simply expressed by saying, that there are vital affinities as well as vital contractions and attractions.

But even if we are to regard it as doubtful whether or not ordinary chemical affinities can determine, under any condi-

* Theodore de Saussure, in Jameson's Edinburgh Philosophical Journal, vol. xl., pp. 22, 23.

tions, this decomposition of carbonic acid and evolution of oxygen by its contact with carbon and the elements of water, I maintain that it is sound philosophy, when we see this and other rapid and extensive and important chemical changes, essentially different from those which the same elements present under other circumstances, uniformly attending the phenomena of life in vegetables,—to investigate and generalize the laws by which these changes are regulated, as laws of living action, leaving it open to future inquirers, if they can, to resolve them into other laws of more general application. For although I acknowledge the force of the aphorism, "Frustra fit per plura quod potest fieri per pauciora," still I apprehend, that in every case to which this aphorism is applied, the *potest fieri* must be established, not by conjecture, but by experiment; otherwise we fall into the error, so strongly condemned by Bacon and others, of prematurely generalizing, and supposing the laws of nature to be fewer and more comprehensive than they really are.

Having thus, in reference to this first and simplest example, vindicated the soundness of the principle which I propose to illustrate, I think we may next shew, that the main object of inquiry in the chemical department of physiology is more simple and precise, and the extent of that inquiry, necessary to elucidate most questions in physiology, much less than might be supposed from the multiplicity of details, of which what is called the science of organic chemistry is made up. After what Liebig calls the "peculiar mode of attraction" which operates in living bodies, has led to the formation of certain organic compounds, these compounds lose their connection with living bodies, become liable to an infinite number of changes and decompositions, and thus give origin to an infinite variety of substances—generally of temporary duration only, because retained in their form by attractions of no great intensity—applicable to many useful purposes, *but foreign to the inquiries of the physiologist.* He is concerned only with the chemical changes which take place *in living bodies themselves, and during the state of life;* and the results of recent inquiries seem to me sufficient to shew, that the fundamental and peculiar arrangements of chemical elements there observed are less numerous, and the laws regulating them more simple, than they have usually been thought.

In considering this subject, we are enabled, by the results of the inquiries of geologists and physiologists, to revert to the period of the introduction of living bodies into the world, and reflect on the conditions then assigned for their existence. We are justified, by reason, in allowing the imagination to fall back on the time when this Earth rolled through space an inanimate mass; and if any minds, besides that of the Great Ruler of the universe, were connected with it, they did not hold their connection through the medium of any organized structure. For I believe we are justified in laying down these propositions as established, *first*, That the simply physical arrangements of this globe were completed before any organized beings were created; *secondly*, That vegetables were created and lived chiefly on the atmosphere, fixing large quantities of carbon from it on the earth's surface, before animals were called into existence; and, *thirdly*, That at whatever time their existence began, either the first living being of every species, vegetable and animal, or the first ovum from which that being was developed, must have been formed in a manner wholly different from that in which any living bodies, at least of the higher orders, are now reproduced; *i. e.*, that they must have been formed in a manner strictly miraculous, and, of course, beyond the limits of physical science.

But although we cannot ascend higher, in prosecuting this subject, than to inquire in what manner the first plants, or the germs of the first plants, were enabled so to act on the inorganic matter around them as to extract from it the materials, first of their own growth and sustentation, and afterwards of all other organized beings,—yet in the inquiry, thus limited, important progress has been made. From the time when these nascent organized bodies sprung into existence, we must regard it as an ultimate fact, that they were endowed with the power, which all the vegetables that have succeeded them have exercised, of so modifying the attractions existing among the particles of matter, as to cause many of these particles from the air and the water immediately surrounding them, to enter into their substance, by their roots and leaves, or by the organs which soon became their roots and leaves, and then to arrange themselves there, in those peculiar forms by which the numberless species of the vegetable world are characterized. I apprehend we must also regard it as an ultimate fact, that they were endowed with the power of so modifying the chemical relations of the elements composing those absorbed matters, as to select and retain certain of these elements, and allow others to pass away from them, to decompose the carbonic acid, fix the carbon, and invest it with those peculiar affinities for the water, the hydrogen of the water, and a few other elements, contained in the surrounding media, by which all the proximate principles, first of vegetables and then of animals, and therefore the whole substance of organized beings, are formed.

But it is important to have a precise exposition, although not an explanation, of the power thus exercised by the first plants; and it is still more important and satisfactory to be able to shew how, by the exercise of these and analogous vital powers, the atmosphere must have been gradually changed, the proportion of carbonic acid in it diminished, and the proportion of oxygen increased; how it became fitted, and is kept fitted, for the residence, first of cold-blooded and then of warm-blooded animals; how most of the other conditions of existence of these animals have been, and still are, continually prepared for them by these living actions of vegetables; how all the variety of the textures of all organized bodies, from the origin of vegetables to the death and decomposition of animals, are continually formed and maintained; and how, both divisions of organized beings, Nature has provided, not for the permanent existence, but for the development and decay of successive generations of individuals, and thus for the perpetuation of the species. These are the subjects of investigation in the chemical department of physiology; and if it can be shewn, that, by a few simple laws, regulating what we call vital attractions and affinities, *i. e.*, modifying, in organized bodies, the attractions and affinities to which matter is everywhere liable, provision is made for all this succession and continual renewal of the phenomena of life; then, although we cannot explain the introduction of living beings into the world, any more than we can explain the dissemination of the stars throughout space,—although we must always regard the appearance of organized bodies on the earth's surface as the clearest indication which human knowledge presents of the subjection of the universe, not only to general laws, but to an arbitrary Will, superior to these laws and changing them at pleasure,—yet I think it may be said that we have nearly as clear an insight into the designs and arrangements of Providence for the maintenance of living beings upon earth, and for the eternal reproduction of them there, so long as these laws shall be in force, as we have into those by which the movements of the heavenly bodies are directed and controlled.

1. Our first business is to study the facts that have been ascertained in regard to the simplest form of chemical change to which the term vital may be applied, which is merely *selection*, by a portion of living structure, of some one substance existing in a fluid, and the consequent attraction of this to a particular part of the structure, while other materials, equally presented to that living part, are excluded.

We need not here enter into the question, on which chemists and agriculturists are not yet agreed, whether the nourishment of plants, in the present condition of the earth's surface, does or does not require the pre-existence, in the soil, of organic compounds, resulting from previous living beings, which are absorbed from it. But we may justly give the name of vital attraction or affinity to that power by which certain saline matters, dissolved in the compound fluid which is absorbed, are retained in the substance of the plant, while others are returned to the soil. "The experiments of Macaire Princep," says Liebig, "have shewn that plants, made to vegetate with their roots, first in a solution of acetate of lead, and then in rain-water, give back to the latter all the salt of lead which they had previously absorbed. Again, when a plant, freely exposed to the air, rain, and light, is sprinkled with a solution of nitrate of strontian, the salt is absorbed, but is again separated by the roots, and removed farther from them every shower of rain, so that at last not a trace of it is to be found in the plant. A fir-tree, the ashes of which were analysed by a most accurate chemist, grew in Norway, on a soil to which common salt was conveyed in great quantity by rain-water. How did it happen that its ashes contained no appreciable quantity of salt, although we are certain that its roots must have absorbed it after every shower? We can explain this only by the observations above referred to, which have shewn that plants return to the soil all substances unnecessary to their own existence; and we are thus led to the conclusion that the alkaline bases, existing in the ashes of plants, must be necessary to their growth, since, if this were not the case, they would not be retained." (Ib. p., 103, 4.) Another inference is at least equally obvious, that plants have the power of fixing and retaining within them those matters which are suited or essential to their composition; and this power we regard as the simplest form of vital affinity. It may be said, that the alkaline bases are thus fixed in plants, because they enter into combination with organic acids, and that, therefore, it is the formation of these acids, not the retention of the bases which combine with them, that is truly the vital change. But this does not apply to other saline matters contained in vegetables, which must have been taken up from the soil in the same state in which they are found in the plants, *e. g.*, the phosphate of magnesia, which is "an invariable ingredient in the seeds of grasses;" or the silica which is found in certain parts of various plants.

Were it not for this selecting and appropriating power, indicating a simple attraction of some parts of the vegetable for certain earthy or saline matters only, we should find some salts of alumina, as well as of lime or magnesia, in the ashes of almost all vegetables,—that earth existing in large quantity in all fertile soils, whereas it is "very rarely found in the ashes of plants."

In the animal kindom the same power of simple selection and extraction is more fully exemplified, perhaps most strikingly in the development of many of the lower classes, of which the organization is simple, and the matters deposited from the nourishing fluid remarkably diversified, as in many of the radiata and mollusca, which have horny and earthy integuments. And in all animals, so far as any chemical change is effected in the vital actions of absorption, secretion, and even nutrition, it would appear to be chiefly of this simple kind, consisting in the selection and appropriation of compounds already existing in the fluids on which these functions are performed, not in the formation of new compounds. The chyme which is found in the intestines of an animal during digestion contains all the compounds (albuminous, fatty, and extractive matters) which are found in the chyle absorbed from it, although these are in a different state of aggregation, and associated also with other matters which are not absorbed. Since it has been ascertained that the compounds which used to be thought peculiar to the greatest secretions in the body, the bile and the urine, pre-exist in the blood, and are only evolved at the liver and kidneys,—accumulating, therefore, in the blood, when the secretive action of these organs is suspended,—it has become obvious that the main office of these organs is not *formative*, but only *attractive*, to extract from the blood compounds already existing there. And, although there is one material extensively employed in the formation of animal textures, viz., gelatin, which cannot be detected in the blood; yet, as this is the only material so employed which cannot be found there, and as a substance very closely resembling it is found there under certain circumstances, we may assert that in animals by far the greater part of the act of nutrition, numerous and diversified as the compounds forming the solid materials of animal bodies may be, is likewise of this simple kind.

(To be concluded in next Number.)

On the Constitution and Properties of Picoline, a new Organic Base from Coal-Tar. By THOMAS ANDERSON, M.D., F.R.S.E., Lecturer on Chemistry, Edinburgh. (From the forthcoming volume of Transactions of the Royal Society of Edinburgh).*

The careful study of the products of destructive distillation has enriched organic chemistry with an extensive series of

* Read to the Royal Society of Edinburgh, on 20th April 1846.

results of unexpected interest and importance. These results have affected, in no inconsiderable degree, the recent progress of the science; and their influence has been of a twofold character, both general and particular, exerted in the former case in the development of some of the more remarkable general doctrines of organic chemistry; in the latter, in the important light thrown by their investigation on the constitution of the substances from which they are derived, and the facilities they have afforded of following out connections, which the examination of the original substance either does not at all present to our view, or, at least, indicates only in an imperfect or dubious manner. Added to to this, we have the remarkable fact of the appearance among these products of substances in some cases identical with those occurring in organised beings; and in others, presenting analogies of the very closest character with the actual products of vital affinity, which, taken together, afford abundant reason for pursuing the investigation of substances which have already afforded results of so remarkable a character.

Setting aside altogether those substances, the occurrence of which is so frequent, that they may be called the general products of destructive distillation, such as carbonic acid, light carburetted hydrogen, olefiant gas, acetic acid, &c., it may be laid down as a general rule, that each individual compound produced during such a process, is formed by the destruction of a limited number of substances only, which bear to each other, and to the product, a more or less intimate connection in constitution or chemical relations. In those instances in which we have been enabled to submit to destructive distillation substances of a definite and simple constitution, in a state of chemical purity, and where an uniform temperature has been preserved, the results have been, for the most part, of an exceedingly simple and intelligible character; but in proportion as the atom becomes more complex, so also do the products of its decomposition, and the explanation of the results is found to be proportionately difficult and uncertain. These difficulties and uncertainties are increased in a still higher degree, in the case of a substance such as coal, where we have to deal not merely with one complex atom but with a congeries of several such, and where the process is performed on the large scale, and under a variety of perturbing influences. The distillation of coal is, in fact, attended by the formation of about twenty different substances, the constitution and properties of which have been examined with different degrees of accuracy, and which present among them instances of almost every species of chemical compound. The discovery of six of these substances is due to Runge,* who published, about fourteen years ago, a very interesting memoir containing an account of their general properties. Of these substances, three are possessed of acid properties, and three are bases, to the latter of which he gave the names of Kyanol, Leukol, and Pyrrol, from the peculiar colours developed by the action of certain reagents on their salts. The two former of these substances were afterwards submitted to a detailed examination and analysis by Hoffman,† who arrived at the interesting result, that both are identical with substances which had been independently obtained by the decomposition of certain well known bodies; Kyanol possessing the constitution and properties of the Aniline of Fritsche, and the Benzidam of Zinin; while Leukol is identical with the substance described by Gerhardt under the name of Chinoline, and which was obtained by him as a product of the distillation of quinine, cinchonine, and strychnia, with caustic potass. Hoffman failed, however, entirely in obtaining any evidence of the presence of pyrrol in the substance which he examined, and leaves in doubt the existence of such a compound.

Having lately had occasion to examine a quantity of the mixed bases contained in coal-tar, obtained by a method similar to that of Runge, but which, owing to a modification of the process, contained all the more volatile bases formed during the distillation of coal, I was led to try whether or not pyrrol was to be found in it, and I found immediate evidence of its existence, by the characteristic red colour which

* Poggendorf's Annalen, Band 31, u. 32.

† Annalen der Chemie und Pharmacie, vol. xlvii.

it gives to fir-wood moistened with hydrochloric acid. The attempt to separate this pyrrol proved that it was present in extremely minute quantity only, but led to the discovery of a new base different from those of Runge, for which I propose the name of Picoline, and the examination of whose properties forms the subject of the present paper.

Preparation of Picoline.

For the crude substance employed in the preparation of picoline, I am indebted to the kindness of Mr Astley of the Bonnington Chemical Works, and it was obtained by the following modification of Runge's process. In the preparation of naphtha from coal-tar, the first product of distillation is agitated with sulphuric acid for the purpose of separating any naphthaline which may be present, as well as a variety of substances in extremely minute quantity, which communicate to the crude naphtha the property of becoming dark-coloured by exposure to the air; among these substances, of course, are all the basic compounds contained in the oil. The sulphuric acid which had been used for this purpose was neutralised by impure ammonia obtained by a single distillation of the watery fluid of the gas-works. On the addition of the ammonia there was no separation of any oil in quantity appreciable to the eye; but upon distillation, the bases, which had been dissolved in the fluid, passed over with the first portions of the water, and collected in a separate layer in the receiver. This oil, when it came into my hands, possessed a very dark brown colour, a somewhat viscid consistence, and a peculiar pungent and disagreeable odour. It was heavier than water, a layer of which, containing a small proportion of oil in solution, floated on the surface. The examination of this oil proved it to consist, in addition to picoline, of a mixture of pyrrol, aniline, an oily base possessing the general properties of leukol, and a thick heavy oil destitute of basic properties.

In order to separate picoline, the oil, along with the water which floated on its surface, was introduced into a retort and carefully distilled. At first, water, accompanied by a little oil, passed over, and then an oil by itself, which dissolved completely in the watery fluid contained in the receiver. As the distillation proceeded, another oil made its appearance, which collected in a layer on the surface of the fluid which had previously distilled. When about three-fourths of the oil had passed over, the process was stopped, by which means the oil, destitute of basic properties, which requires a very high temperature for its distillation, was left behind in the retort. The fluid in the receiver was now supersaturated with sulphuric acid diluted with water, care being taken to obtain a powerfully acid reaction. The peculiar odour which the fluid possessed, was by this process entirely changed, but not destroyed; and, on distillation, the water which passed over, carried with it all the pyrrol contained in the solution, while the other bases were retained by the sulphuric acid. Caustic potass was then added to the residue in the retort until an alkaline reaction was manifest, and it was again distilled; the water which passed over carried with it the oily bases, partly dissolved, partly floating on the surface of the solution, exactly as in the first distillation. A few sticks of fused potass were introduced into the product, and the whole was left in repose; as the potass dissolved, the oil, which is entirely insoluble in solutions of the fixed alkalis, rose to the surface and there collected in the form of a pale yellow layer, still containing a considerable quantity of water, which may amount to 30 or 40 per cent. of the bulk of the oil. The oil was separated from the watery fluid by means of a pipette and pieces of fused potass added so long as they continued to become moist. The dry oil was then introduced into a retort and distilled. A transparent and colourless oil passed over, which was tested at intervals by allowing a drop of it to fall into a solution of chloride of lime. So soon as the reaction of aniline made its appearance the receiver was changed. The first portion was now picoline in a state approaching to purity; that which immediately followed consisted of a mixture of picoline and aniline. The first portion was again digested with fused potass and rectified; that which distilled at 272° was collected apart, and constituted pure picoline.

Constitution of Picoline.

The general analogy in properties which picoline bears to aniline and the other oleaginous bases, permitted the assumption that it, like these substances, was free from oxygen ; I proceeded, therefore, in its analysis, upon this hypothesis, and neglected the determination of the nitrogen. The following are the results of the analyses :—

Analysis I.	5·630	grains of	picoline gave
	15·954	...	carbonic acid,
	3·944	...	water.
... II.	5·347	grains of	picoline gave
	15·100	...	carbonic acid,
	3·670	...	water.

Which give the following results per cent. :—

	I.	II.
Carbon	77·16	77·18
Hydrogen	7·77	7·62
Nitrogen	15·20	15·20
	100·00	100·00

These results correspond closely with the formula $C_{12}\,H_7\,N$; the calculated result of which is—

		Theory.	Mean.
C_{12}	900·0	77·29	77·17
H_7	87·5	7·43	7·69
N	177·0	15·28	15·14
	1164·5	100·00	100·00

This formula is precisely the same as that of aniline, along with which picoline occurs in coal-tar. In order to ascertain whether the atomic weights of these substances were also identical, I prepared the platinum salt of picoline, and determined the amount of platinum contained in it. The salt was obtained by adding bichloride of platinum to a solution of picoline in excess of hydrochloric acid : no immediate precipitation took place unless the solutions were very concentrated, but in the course of twenty-four hours the salt was deposited in fine orange-yellow needles. When dried at 212°, it gave the following results :—

I. { 9·670 grains of chloride of picoline and platinum gave
3·147 ... platinum = 32·544 per cent.

II. { 10·844 grains of chloride of platinum and picoline gave
3·517 ... platinum = 32·522 per cent.

From these analyses are deduced the following atomic weights:—

I.	II.
1211·1	1213·7

These agree sufficiently well with the theoretical atomic weight, which is 1164·5. They correspond also precisely with the results of the analysis of the aniline salts. The identity of these results is shewn by the following table of the analyses by Fritsche, Zinin, and Hoffman, of aniline from its different sources, and of picoline, as well as of the platinum salts of these substances:—

	Aniline.*	Benzidam.*	Cyanol.	Picoline.	Theory.
C =	77·73	77·32	76·67	77·17	77·29
H =	7·60	7·50	7·72	7·69	7·43
N =	14·98	14·84	15·62	15·14	15·28
	100·31	99·66	100·00	100·00	100·00

The following are the results for the platinum salts:—

	Benzidam.	Kyanol.	Picoline.	Theory.
Mean platinum, per cent.	32·501	32·886	32·533	32·94
Atomic weight .	1216·1	1170·5	1212·4	1164·5

The results of all these analyses agree perfectly with one another; but the properties possessed by picoline differ from those of aniline, which, whether obtained from coal-tar, indigo, or nitrobenzid, presents a perfect identity in its chemical characters.

Properties of Picoline.

Picoline is a perfectly colourless, transparent, limpid fluid, extremely mobile, and destitute of viscidity. It possesses a powerful, penetrating, and somewhat aromatic smell, which, when very dilute, is replaced by a peculiar rancid odour, ad-

* Not having the original papers of Fritsche and Zinin at hand, I extract these two results from Berzelius' Arsberättelse, 1844, p. 454, where they are calculated according to C=75·12, the rest are with C=75, but the difference is so small as not to affect the comparison.

hering pertinaciously to the hands and clothes. Its taste is acrid and burning when concentrated; but when very dilute, as, for instance, when its vapour is sucked into the mouth, it is powerfully bitter, as are also the solutions of its salts. It is not changed by exposure to a cold of 0°. Picoline is extremely volatile, and evaporates rapidly in the air. It boils at the temperature of 272°, and the thermometer remains perfectly stationary during the whole period of the ebullition; it is therefore much more volatile than aniline, which, according to Hoffman, boils at 359°. It may be preserved for a long time in a bottle containing only a small quantity of it, and which is frequently opened, without becoming manifestly coloured; whereas aniline becomes rapidly brown, and, indeed, cannot easily be obtained colourless, except by distillation in a current of hydrogen. The specific gravity of picoline is less than that of water. I found it to be 0·955 at 50°, while, according to Hoffman, that of aniline is 1·020 at 68°.

Picoline mixes with water in all proportions, and forms a transparent and colourless solution. It is insoluble, however, in solution of potass, as well as in most alkaline salts, the addition of which causes its immediate separation from the water. It dissolves also readily in alcohol, ether, pyroxylic spirit, and the fixed and volatile oils. It is a powerful alkaline base: a rod dipped in hydrochloric acid, and held over it, is immediately surrounded by a copious white cloud of hydrochlorate of picoline. It restores the blue colour of reddened litmus, but does not affect the colouring matter of red cabbage. It does not coagulate the white of eggs as aniline does.

The reactions which it produces with other substances are also quite distinct from those presented by aniline. When brought in contact with the solution of chloride of lime, it does not produce, in the least degree, the violet colour which is so characteristic of aniline; on the contrary, the solution remains perfectly colourless, unless, indeed, the picoline has not been well separated from pyrrol; in which case, a slight brown makes its appearance, but no violet. Picoline is also incapable of producing the yellow colour in fir wood and the pith of the elder, which is so readily obtained with aniline.

When treated with chromic acid, even when very concentrated, and after boiling, no change takes place in the colour of the solution, and only a small quantity of a yellow powder is deposited; while aniline gives an abundant precipitate, which has, according to the degree of concentration of the fluid, a green, blue, or black colour.

Picoline precipitates from solutions of chloride of copper a portion of the oxide of copper, while the remaider forms a pale blue solution, which, when evaporated to a small bulk, deposits a congeries of prismatic crystals, which seem to be a double salt. No blackening of the solution takes place, as is the case with aniline. When an excess of hydrochloric acid is present, there is obtained, on evaporation, another double salt in large crystals, apparently derived from the rhombohedral system. Picoline produces also double compounds with the chlorides of mercury, platinum, gold, tin, and antimony. With chloride of gold it gives an exceedingly characteristic compound, in the form of a fine lemon-yellow precipitate, which is soluble in a considerable quantity of boiling water, and is deposited, on cooling, in delicate yellow needles. Aniline, under similar circumstances, gives a reddish-brown precipitate, resembling the ferrocyanide of copper. It gives, with infusion of nut-galls, a copious curdy precipitate of a pale-yellow colour, which dissolves in hot water, and is deposited again on cooling. It does not precipitate the solutions of nitrate of silver, chlorides of barium and strontium, or sulphate of magnesia.

The properties of picoline, as now detailed, are obviously different from those of aniline. They recalled, however, strongly to my mind those of a base called Odorin, obtained by Unverdorben* from Dippel's animal oil. According to this chemist, Dippel's oil, which is obtained by several successive distillations of the oleum cornu cervi, is a mixture of four different bases, to which he gives the names of Odorin, Animin, Olanin, and Ammolin. Of these, the two first constitute nineteen twentieths of the whole oil, and the odorin, which resembles picoline in its solubility in water, is obtained by simply

* Poggendorf's Annalen, vol. xi.

distilling the oil, and collecting the product as long as it dissolves. These results, however, have been called in question by subsequent observers; Reichenbach, especially, asserts that he was unable to separate any basic compounds, and considers the substances obtained by Unverdorben to be mixtures of empyreumatic oil with ammonia. As, however, the properties which Unverdorben has attributed to odorin, approximate in some respects to those of picoline, I thought it desirable to ascertain the existence of this substance, and whether or not it is identical with picoline. In order to prepare odorin, I rectified the oleum cornu cervi, and then distilled the product; but on allowing the first drops of oil to fall into water, they were not dissolved as Unverdorben has asserted, but floated unchanged upon the surface. Finding this process unsuccessful, I agitated the crude oil with dilute sulphuric acid; the acid fluid immediately acquired a very deep reddish-brown colour, and when separated from the oil, and supersaturated with potass, a semisolid viscid mass separated from the fluid. This, when distilled with water, yielded a mixture of several oily bases, while a dark-coloured resinous substance, probably Unverdorben's Fuscin, was left in the retort. The mixed bases which I thus obtained, formed an exceedingly small fraction of the oil employed. They were purified by several successive rectifications, and generally in a method similar to that employed for picoline, and the first portions of the product collected apart. It then constituted a colourless oil, which became brown in the air, dissolved readily in water, and presented an odour similar to, though not quite the same as, that of picoline. It gave, with chloride of gold, a dirty-yellow precipitate, which dissolved in hot water, and deposited, on cooling, in the pulverulent form, and with bichloride of platinum, a compound in red wart-like crystals. By an accident in the laboratory, the small quantity of this substance which I had prepared for analysis was destroyed, so that the evidence of their identity cannot be considered as sufficient. The characters of odorin, as given by Unverdorben, are not perfectly identical, either with those of picoline or the base which I obtained. Odorin, according to Unverdorben, boils at about 212°, and its salts are oleaginous compounds which distil in the form of an oily fluid, whereas those of picoline are mostly crystallizable. I am at present engaged with the examination of these substances.

It is obvious, from the observations contained in Hoffman's* paper, that picoline must have been present along with aniline and chinoline in the substance which he examined. He mentions, especially, that his aniline, as obtained by distillation only, possessed a peculiar pungent and disagreeable odour, which was got rid of only by several successive crystallizations of its oxalate from alcohol, and that the impure aniline has a specific gravity less than that of water. He observes also, that the quantity of the substance present must have been excessively minute, as it did not affect the results of the analysis, a phenomenon, the cause of which is sufficiently explained by the identity in constitution of the two substances. Hoffman did not obtain picoline in the separate state, simply because the bases employed by him were obtained from the less volatile portions of coal-tar, which necessarily contain it only in minute proportion.

(To be concluded in next Number.)

Description of a Water-Wheel, with Vertical Axle, on the plan of the Turbine of Fourneyron, erected at Balgonie Mills, Fifeshire. By JOSEPH GORDON STUART, Esq., F.R.S.S.A. (Communicated by the Royal Scottish Society of Arts.†)

My attention was first directed to the *Turbine water-wheel*, by the paper read on the subject before the British Association, at its Glasgow meeting in 1810, by my friend Professor Gordon. On that occasion the Professor introduced the Turbine of Fourneyron (the French patentee) to the notice of the Association, as a very important machine for economizing water-power, and after some discussion, the Association appointed Mr Smith (then of Deanston), and Mr Fairbairn of Manchester, along with Professor Gordon, a Com-

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* Liebig's Annalen, vol. xlvii.

† Read before the Society, on 23d March 1846.

mittee, for the purpose of investigating the comparative merits of the turbine and other water-wheels before the next meeting of the Association.

Here, however, the matter has rested, so far as that Committee is concerned, ever since; and, with a single exception, to be immediately noticed, I am not aware of the subject having been again brought before the public of this country. The exception referred to is a popular description of the turbine of Fourneyron, with a very strong recommendation in its favour, contained in the interesting volume on the "Industrial Resources of Ireland," published in the year 1844, by Dr Kane of Dublin.*

While the Committee of the British Association did not, so far as I know, follow out in any way the remit made to them, I felt so much interest on the subject (incited no doubt by suffering much annoyance and serious loss from two very inefficient breast-wheels at my works here) as to continue, with Professor Gordon, the investigations which he had already entered upon, until we became convinced that the turbine was indeed a material improvement upon any other known mode of using water-power.

Circumstances prevented us, however, from giving practical expression to our convictions, until my breast-wheels became so worn out as to threaten complete breakdown; and then, in the early part of last year, I seriously set about the task of erecting one. I may here mention that, at this time, I hesitated between the turbine and Whitelaw and Stirrat's patent water-mill; but, after consideration of their published statement, and a personal inspection of several of their mills erected on a large scale, I saw sufficient cause to confirm my impression in favour of the Turbine of Fourneyron, as the more perfect machine. I then put myself in communication with the French patentee, and offered to allow him to erect, or superintend the erection of a wheel for me, so as his invention might be introduced into this country, under the most favourable circumstances. Fourneyron, however, declined to enter into the arrangement unless he was to be per-

* Since this paper was read, Professor Kane has published a translation of Rühlman's Essay on the Construction of Turbines.

mitted to make the wheel in France, to bring it here, and to fit it up at my works, all at my sole expense; and as this, I calculated, would cost me nearly double of what it could be done for on the spot, I was under the necessity of breaking off the negotiation. I then resolved to execute the whole myself, availing myself of the valuable assistance of Professor Gordon, and his partner Mr Hill, so far as the calculations of size, speed, &c., were involved.

The fundamental principle upon which the construction of the turbine is based, is that by which the maximum of useful effect is obtained from a given fall of water, depending upon the relative velocity of the water and its recipient, which ought to be such that the water enters the wheel without shock, and quits it again without velocity. A notion of its construction may readily be formed, by supposing an ordinary water-wheel laid on its side, wrought at the bottom of the fall, and the water being made to enter from the interior of the wheel by the inner circumference of the crown, flowing along the buckets, and escaping at the outer circumference. The turbine consists essentially of, 1, *a reservoir*, the bottom of which is divided into radial compartments, by covered plates, serving to guide the water to take a particular direction of efflux; 2, a *cylindrical sluice*, capable of nicety of adjustment; 3, the *wheel* itself, a disc with covered buckets, into which, when the sluice is raised, the water enters at every point of the inner circumference, and escapes at every point of the outer circumference.

It will be readily seen, that the effective power of the wheel must depend greatly upon the curvature of the fixed partitions and buckets being such as to realize the philosophical principle of its construction, viz., that the water enters it without shock, and quits it again without velocity. This is, no doubt, a delicate problem, but practically, it has been completely solved.

My works at Balgonie are situate on the river Leven, and have right to the use of the whole water contained in it. The river issues from Lochleven; the discharge is there regulated by sluices, so as to afford, as nearly as possible, during the whole year, a regular flow of about 6000 cubic feet per minute. The fall at my works, as measured for a turbine-wheel, that is, from the surface of the water in the front lead to the surface of the water in the tail-race, is 11 ft. 8½ in. I have erected the turbine so as to take the full advantage of this fall, and calculated it for venting this 6000 feet of water per minute.

The turbine consists of six principal parts, viz.,

1 and 2, The wheel and shaft,
3 and 4, The sluice-cylinder and sluice,
5 and 6, The centre disc and pipe.

These are all made of cast-iron, and the united weight is upwards of 7 tons. Besides these, there is the reservoir, or wheel-house, as we may term it, which comes in place of the arc of the ordinary water-wheel.

I shall shortly describe each of these parts, and the description will be made more intelligible, as well as more interesting, by reference to the drawing of a vertical section, on the scale of one inch to a foot; the drawing of a quadrant of a horizontal section, full size, and the model of the whole erection, on the scale of ¾th inch to a foot,—all which I now exhibit.

The reservoir is constructed of stone, solid ashlar, hewn and jointed. It is eleven feet square within walls, and the walls all round are two feet thick, the stones being alternately headers and runners. At the depth of 11 ft. 8½ in., and the supposed depth of tail-water from the front surface, two beams of wood 12 in. square, crossing each other in the centre of the square, are bedded in the causeway of the bottom, and built into the side-walls, so as to afford a solid foundation for the step, in which stands the upright shaft of the wheel. 4 ft. 6 in. above these beams, four beams 18 × 20 in. square, cross the reservoir, placed so as to leave a square opening in their centre 6 ft. 9 in. within; and a flooring of 3 in. plank, caulked as a ship's deck, makes this opening (which it reduces to a circular form) the only communication between the upper and under parts of the reservoir. 2 ft. 6 in. from the surface of the water in front, the one side of the reservoir stops, so as to allow the ingress of the water, and the opposite side has an open arch below the floor-beams, to permit the egress of the water.

The walls are carried up two feet above the highest water-point; and there, four beams again cross, leaving an opening of about 2 feet square in the centre, in which is fixed the suspending-pipe and neck-collar of the upright shaft. I will only further remark, regarding this reservoir, that if I were erecting a turbine on a high fall, with a small supply of water, I should probably construct this of plates of cast or malleable iron.

The step is of cast-iron, about 8 cwt., and contains the brass for the bottom of the upright shaft working in. It is firmly bolted to the lower beams by strong bolts in the four paws of it.

The shaft is of cast-iron (cast on its end), about 16 feet long, 9 in. diameter at the smallest part, and swelled a little towards the centre. It is steeled at the lower end, where it works in the brass of the steps, and has a gudgeon of 8¾ in. diameter, working 18 in. from the top. Above this journal is hung the spur-wheel, from which motion is taken off by pinion in the usual way.

The wheel is a saucer-shaped disc of cast-iron, keyed on the shaft below the flooring of the wheelhouse. The saucer-shaped part is 6 ft. 8 in. diameter, and then there is a flat circumference of 1 ft. 2 in., making the whole diameter 9 feet. Upon this flat circumference are erected the curves or buckets of the wheel. They are made of the best boiler-plate, and are 9 in. high. On the top of them is fitted another circumference of cast-iron, 1 ft. 2 in. across. These circumferences are thus fastened together by means of the curves which are bolted into each, and a compact wheel thus formed, weighing in all about 45 cwt., and having 32 curved openings for venting the water through.

The pipe serves the double purpose of keeping the shaft from the water, and of sustaining in its place the centre disc. It is furnished with a square collar, with four paws, by which it is suspended from the four top-beams. It is also stayed and kept in its place by four rods from the four sides of the wheelhouse to a flange cast on it, rather more than half way down.

The centre disc is shaped so as to lie above the saucer-shaped interior of the wheel, and is about ¼ of an inch less diameter than that part. It is keyed on the bottom of the pipe just below the circular opening in the floor, and so low that its upper surface is level with the flat circumference of the wheel, and kept in its place by the stay-rods of the pipe, so as to be about ⅛ of an inch clear of that circumference all round. On this disc are erected the guide-curves, equal in number to the curves of the wheel, and in such a shape as to throw the water at the proper angle on them as it flows out.

The sluice-cylinder is bolted to the four large beams of the floor, and is of such depth that its lower end comes down to within a few inches of the top of the upper circumference of the wheel. It is bored through, so that the sluice may fit well, and be readily moved up and down in it.

The sluice itself is another cast-iron cylinder, fitted to the inside of the last mentioned one, going down as low as to rest on the outer circumference of the centre disc, and rising so high as, when fully up, to leave 9 in. of opening between that disc and it. This sluice is wrought by three rods working in screws, communicating with a triangle at the top by means of studs and levers from each rod. The triangle is wrought by bevel wheels and shaft from the outside of the wheelhouse.

The mode of working the wheel is thus:—

The water coming into the wheelhouse or reservoir from the front lead, fills it up, standing on the centre disc and flooring, to the height of the top of the water in the front lead. The sluice is then raised, when the water flows out under it, off from the curves of the centre disc, which thus remains fixed and stationary, on to the curves of the wheel, which, yielding to the pressure so exercised upon its curves, moves round in the direction of the efflux of the water from the centre disc; the sluice is raised until the necessary speed is attained, or until the water is vented by the wheel as fast as it is supplied to the reservoir from the front lead, care being taken that it is not allowed to go faster away,—that is, that the *head of the water* in the reservoir is always maintained at its full height,—the level of the front lead.

I have thus minutely described each part of the wheel, and, I trust, made the description intelligible by reference to the model and drawings, as such appears to me the best way of bringing this very important, and, in this country, novel, mode of using water-power under the notice of this Society.

As soon as the Turbine was ready, I threw out one of my old breast-wheels, and attached to it the part of my works driven thereby. The success was so encouraging, that, in January, I threw out the other breast-wheel, and the Turbine has since been driving my whole works.

My works contain

1000	spindles,	dry flax spinning.
796	,,	dry tow spinning.
160	,,	heavy jute spinning.
and 1156	,,	wet spinning.
3112		

With the necessary preparing machinery,—machinery such as, I believe, would be put upon a sixty horse-power steam-engine,—I could not get water enough to drive them with my two breast-wheels;—in fact, 500 spindles were standing altogether for two years. The turbine is driving them about 10 per cent. faster than they were before, and it is not using all the water. From the experiments I have as yet been able to make, I do not think that it is using above 5000 cubic feet per minute; and from a defect in the construction of the intake-lead, the turbine has not the full advantage of that water. The lead is too narrow, and turns an awkward corner, so that the water in the wheelhouse will not stand up to the full head, and can hardly be called above 10 ft. 3 in., instead of 11 ft. 8½ in. When I have remedied this defect, and so been enabled to give the wheel the whole water, and also maintain a steady head of 11 ft. 8½ in. in the wheelhouse, I have a very confident expectation that the wheel will prove capable of working up to 85 or 90 horses' power.*

The whole subject of water-wheels is a very interesting and important one; and I do not think that it has yet received, in this country, the attention which it merits. The

* A model of Mr Stuart's Turbine is deposited in the Museum of the Royal Scottish Society of Arts.—Ed.

French have, both theoretically and practically, arrived at much greater perfection than we have in economising water-power, and a great variety of very beautiful wheels have been introduced in that country. "Coals being abundant," Dr Kane well remarks, "the steam-engine is invented in England; coals being scarce, the water-pressure engine and the turbine are invented in France. It is thus the physical condition of each country directs its mechanical genius." Such suggestions may explain the greater practical interest taken in the subject in France, but can hardly excuse the want of theoretical inquiry which we have to complain of in this country. My complaint is surely not without reason, when I mention the fact, that no hint of any water-wheel, beyond the common old-fashioned overshot, breast, or undershot wheels, is to be found in any one of the otherwise elaborate articles on water-works, hydrodynamics, &c., in the seventh edition of the Encyclopædia Britannica, although, in the period embraced by its publication, from 1830 to 1843, many treatises by Poncelet, Morin, De Prony, and other eminent members of the Academy of Sciences, appeared in France, in which the merits of the Poncelet and the Turbine wheels are set forth. I beg to lay one of these treatises on the table, along with this paper, for the use of the Committee, to whom I hope the Society will remit the matter; and only regret that, as I have been unable to procure another copy of it for aiding me in my future experiments, I cannot present it to the Society. It is the result of experiments on the Turbine wheel, by Monsieur Morin, made under appointment of the Academy, and at the expense of the French Government, and it brings out these very interesting results:—

1. That the Turbine wheel is equally suitable to every height of fall, from the greatest to the smallest. In illustration of this, I may mention, that at St Blazien, there is one erected, by which is driven the whole machinery in a cotton-mill of 8000 spindles, with carding engines, and all necessary preparation. The available fall is 332 feet; the quantity of water 60 feet per minute; while on the Seine, in France, there is one erected with a fall of only 13 inches, and which, even in such unfavourable circumstances, economizes 55 per cent. of the theoretical power of the water.

2. That in all ordinary circumstances, the Turbine will make available—transmit a net useful effect, to use Morin's words—from 70 to 78 per cent. of the theoretical power.

3. That Turbines can be driven at speeds varying considerably from that which theoretically is their best speed, without seriously deteriorating from their practical efficiency. One great practical excellence of the turbine is the high speed at which it revolves. In the ordinary wheels, especially the overshot, which is the best of them, we cannot have great economy of power, without a very slow motion, and hence much intermediate mechanism is necessary to bring the motion up to the speed required for general use; but in the turbine, the greatest economy is accompanied by a rapid motion, and hence the connected machinery may be rendered much less complex. The one which I have erected develops its power best when at the speed of 48 turns per minute; but in consequence of the defect mentioned in the intake of the water, I have not regularly wrought it above 42 turns. Still, even at this speed, it is five times faster than my former breast-wheels; and, as my main shafting is about 200, much intermediate raising of the motion is avoided. Turbines have the farther advantage that the speed may be varied, as suitable, without materially affecting the economy of power.

4. That they may be wrought under water, that is, in back-water, without materially affecting their useful effect. This is found to be experimentally true, and may, indeed, appear from the consideration that the power is in the difference between the front and back columns of water, and that it is comparatively immaterial whether the discharge into that back column be on the surface or at the bottom. In erecting a turbine, then, the wheel ought to be placed so as to be rather under the back-water when full going; and thus the greatest possible fall is secured.

5. That they can receive very variable quantities of water, without the per-centage of useful effect being materially altered. If a turbine be working with a force of 10-horse power, and its supply of water be suddenly doubled, it becomes of 20-horse power. If the supply be reduced to one-half, it still works to 5-horse power; while such sudden and extensive changes would altogether disarrange water-wheels

of the common construction, which can only be calculated for the minimum, and allow the overplus to go to waste.

Such are the general results borne out by Morin's experiments in this treatise. Rühlman has also published a very full report on the theory and practical working of the Turbine. I have not seen it, but only extracts from it. From these I find him stating, as the general result, that 70 per cent. of the theoretical power may be depended upon in all cases. As to the choice between turbines and horizontal axle wheels, he says, that where there is a fall of a certain height which may be economized by means of an overshot-wheel, such is to be preferred to the turbine; for, when carefully arranged, the overshot-wheel economizes more than 70 per cent. of the theoretical power; but in all cases of high or very low falls, the turbine is to be preferred to all other wheels. He farther states, that their universal application, in such circumstances, can only be retarded by want of foresight or knowledge of their actual performance.

In regard to this statement I would fully coincide with it, restricting the preference for the overshot, to falls from 20 to 30 feet, in which there is no fear of back-water, and from which a quickly brought-up motion is not required. Below 20 feet, the overshot is not *economical*, and above 30 feet it becomes a very *expensive* wheel in erection. The overshot-wheel is certainly that, of all the engines hitherto in use, which most effectually economizes water-power; but the turbine has two great advantages over it, in being *adapted to any fall, whether high or low*, and *in permitting the water to be applied at the same instant to every point of the circumference.* Farther, the turbine will, in general, be less expensive in the erection than any other wheel. It is simple in its construction, and little liable to break or go out of order; and, consequently, it will suffer less than any other wheel from ordinary tear and wear.

I venture to indulge the hope that the Society will accord me some credit for having risked the experiment of introducing this wheel on a large scale; and I will only add, that if they shall think the matter worthy of being remitted to a Committee, I shall be ready to afford the gentlemen appointed all the information I am possessed of, as to the theory and practical working of the wheel, and also to exhibit the working wheel to them, if they can spare a day for the purpose, and form a deputation to Balgonie.

Report of Committee.

The Committee embraced the obliging invitation of Mr Stuart, to visit Balgonie Mills, that they might see the turbine at work, and proceeded accordingly, when they had full opportunity of examining the construction and the working of the machine, with every part of which they were much gratified. From the circumstance of the river being in a state of flood at the time of the visit, the Committee regret that they were unable to institute some intended experiments, with a view to determine the quantity of water delivered upon the turbine in its ordinary working state. But, taking the known data that prevails over the Leven, for the guaranteed delivery of 6000 cubic feet per minute as a true standard, and with the *fall* at Balgonie Mills 11 feet 8½ inches, the power given out by such water-wheels as appear to have been employed, yields, by calculation, about 67 horses' power. The received data on which this calculation is founded, has been corroborated by answers obligingly communicated to certain queries propounded to Mr Stuart by the Committee.

For the development of this power, Mr Stuart employed formerly two Breast-wheels with open float boards running in close arcs; the one was 10 feet wide, the other 7 feet, and each of them 16 feet 8½ inches diameter. With these wheels, according to Mr Stuart's own statement, his mill produced a certain quantity of yarn of certain qualities per day; but since the application of the turbine to perform the whole work, the products of the mill have been increased by 10 to 12 per cent.

The old water-wheels having been demolished, the Committee can only judge of their efficiency (in relation to the water and the fall), by comparing with the amount of work performed; and this, it appears, had been about 45 spindles per horse power with all their preparing machinery, a *duty* that approaches the average calculation.

With the application of the Turbine, there has been no increase to the number of spindles in the mill, but their velocity has been increased to the extent of the increase of production; and this is the only direct proof of the superiority of the Turbine, as yet attainable in this country.

From a careful examination of the structure of this machine, the Committee feel satisfied that it affords all the conditions of great durability, and what is of even greater importance, no peculiar liability to derangement from either internal or external causes; from the latter, indeed, it is pre-eminently free.

In absence of the means and the time requisite to make any satisfactory experiments on the actual power of the machine, the Committee can only repeat the experience of Mr Stuart himself, "that it gives out 10 or 12 per cent. more of useful effect, than the old wheels," the fall and the delivery of water being the same. This result, making allowance for defects in the old wheels, seems to agree very satisfactorily with the statements of the different Continental writers who have handled the subject experimentally; and, reasoning from a source independent of experimental results, the Committee see additional grounds for placing confidence in those statements, as well as in that of Mr Stuart. The grounds here alluded to, rest on the circumstances attending the arrangement of common bucket and breast-wheels. In all such cases, water acts by its gravity alone; hence such wheels are usually restricted to velocities of 5 to 8 feet per second, and hence also, the water must have acquired a corresponding volocity before it enters the wheel. This preparatory step takes from the *height* of the fall a quantity varying from *one* to *two* feet; at the bottom of the fall, also, there is a loss consequent upon the prevention of back-water, amounting at least to half the depth of the shrouding, or from 6 to 9 inches, making a total reduction of fall of from 2 to 2½ feet.

With the Turbine, the engineer gets free of this loss of fall, because the machine takes up, if well constructed, every inch of the height; or, according to the views of the Continental writers, it may even yield effects *beyond* the natural fall, by working the turbine under the surface of the tail-water. Upon this last point, the Committee have some misgivings; but from the grounds above stated, that of rendering every inch of the fall available, they see good reason to expect uniformly favourable results from Turbines properly constructed and regulated.

It will readily appear, that the advantage, here dwelt upon, bears with greatest effect upon *low* falls; and since the reduction of the fall (for common wheels) will be nearly the same for all heights, it follows, that the loss bears a much larger proportion to the entire height in low, than in high falls. Thus, in a fall of 6 feet, one-third may be considered as lost; but in one of 30 feet the loss would be only $\frac{1}{12}$ or $\frac{1}{15}$. It follows, from these observations, that the Turbine will be most economical, in respect to power, in falls of from 1 foot up to 10 or 12 feet. As the fall becomes higher, the advantages diminish, and it is more than probable, that, from 20 to 30 feet, a bucket-wheel is to be preferred. Upwards of 30 feet, and especially for great heights, the Turbine again becomes economical, but on other grounds; here the advantages will lie in the *comparatively small cost of erection*, compared with the power attainable from great heights.

These considerations, independently of any advantage arising from the internal mechanism of the Turbine, seem to afford still surer grounds of confidence in this machine, under the limits here specified.

In conclusion, the Committee have great pleasure in expressing their approbation of those exertions of Mr Stuart, which place him as the first in this country, to have adopted "Fourneyron's" beautiful invention; and, from the fortitude and persevering skill exhibited in the pursuit of his object, crowned as it is with a successful accomplishment, Mr Stuart is, in the opinion of the Committee, deserving of the best consideration of the Society.

JAMES SLIGHT, *Convener.*
JOHN ANDERSON.

EDINBURGH, *June* 9. 1846.

On the Indian Tribes inhabiting the North-West Coast of America. By JOHN SCOULER, M.D., F.L.S. Communicated by the Ethnological Society.*

The ethnography of the tribes inhabiting the north-west coast of America, although far from being so well known as that of the Indian races to the east of the Rocky Mountains, has of late made considerable progress. In addition to the materials scattered through the works of the older voyagers, much valuable matter is to be found in Baer's recent work on the Russian Settlements on the north-west coast; and, in the Proceedings of the Geographical Society, I have published a very extensive series of Vocabularies of Indian Languages, collected by Dr Tolmie, which have been illustrated, and made the subject of comment by Dr Latham, in two communications, read before the Ethnological Society. In the following observations it is my intention to attempt a classification of the various tribes found between Behring's Straits and the Columbia River, and included between the Rocky Mountains and the Pacific Ocean. As all our more authentic information respecting the more northern tribes of Esquimaux and Koluschians, have been derived from Wrangel's communications to Baer's work, it will not be necessary to enter minutely on that part of the subject. In attempting this synopsis of the Indian tribes of the north-westward, we have to premise that it is merely an attempt, and one which will necessarily be subject to much correction. The number and names of the tribes is very imperfectly known; and, in many cases, we have no specimens of their language to enable us to fix their place, and often the indications of travellers are so vague, and even contradictory, that their statements only produce perplexity. The following is, therefore, to be considered rather as an exhibition of what is known on the subject, than as a complete monograph. The distinction, however, between facts and probable inferences has been carefully observed.

With respect to the tribes inhabiting the Russian territory, it may be remarked, that we find there three very distinct

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families of the human race brought into intimate relationship, and each retaining its own peculiarities. We find the Esquimaux to the north and west, the Koluschians, on the sea-coast, to the south, and, in the interior, the Carriers and other tribes of the Athabascan family, extending eastward toward Hudson's Bay, and spreading southward along the western side of the Rocky Mountains to the head-waters of Frazer's River. Notwithstanding the contiguity of these three families or groups, and that they have interchanged several words of their respective vocabularies, the distinction tween them in language, manners, and modes of living, is very apparent, so that there is, in general, little difficulty in ascertaining to which of the three families a tribe belongs. Thus the Esquimaux of Greenland and Kodiac, although thousands of miles apart, have more dialectic affinities than the Kodiacs have with their neighbours, the Kenaï or Koluschians. There is nothing more remarkable than the pertinacity with which even small tribes of Indians adhere to their language, retaining it, as Mr Gallatin observes, to the last moment of their existence. The difference of customs, as, for example, between a fishing and a hunting tribe, also tends to prevent intercourse, and thus keep languages distinct. Mr Dunn informs us, when speaking of the tribes situated around Puget's Sound, that " the coast tribes and those of the plains observe a marked aversion to mutual incorporation, and confine themselves to distinct localities ; the plain tribes not approaching the Sound, and the tribes bordering on the Sound not extending their roamings into the plains." In the same manner, the Athabascan and Esquimaux races, in the northern regions, carry on a perpetual warfare. We also find, among the Indian races to the east of the Rocky Mountains, that amalgamations of dialects rarely, if ever, take place ; their organization into tribes, and the necessity of preserving the full extent of their hunting-ground causes repulsion, not union, and is favourable to perpetual hostilities. It will be seen, in the course of this paper, that a different social condition has tended to obscure the marks of dialectic distinctions in certain tribes.

1. *Esquimaux.*—The ethnography of this race is now well

known, and requires no illustration here. Extending from Greenland to Aliaska, they speak everywhere the same language, with dialectic variations. They inhabit the most northerly parts of the new world, and even part of the icy coasts of the old. The Esquimaux tribes, inhabiting the north-west angle of America, appear to have been the most numerous portion of the race, in proportion to the extent of country which they occupy, and, at the same time, the most social and civilized. This may be accounted for by the milder climate of this region, by far the most temperate of any occupied by the Esquimaux, from its numerous islands, inlets, and peninsulas, which multiply, in a comparatively small space, an extensive line of sea-coast adapted to their mode of life. The Esquimaux of this region display much industry and ingenuity, and carry on an extensive intercourse among themselves as well as with the Koluschians, and even with the inhabitants of the Asiatic coast. In this part of America the Esquimaux are divided into numerous small communities, whose names and places of residence are to be found in Baer's work, where much information may be obtained respecting them.

2. *Athabascans.*—This family of Indians is not numerous in proportion to the extent of country which it occupies, but is interesting from its position amidst so many distinct families, and occupying very nearly the whole breadth of the American continent. The Athabascans are everywhere separated from the sea-coast by the Esquimaux; and towards the Mississippi River they become conterminous with the Algonquin race. To the west of the Rocky Mountains, the Athabascans, under the names of Tacullies or Carriers, occupy the country called New Caledonia; but have nowhere reached the sea-coast, from which they are cut off by the Esquimaux, Koluschians, and other tribes. The Athabascan tribes are separated from the Ichthyophagous tribes of the coast by repugnance arising from difference of mode of life, or by natural barriers. To the north, the Athabascans inhabit the head waters of the streams which flow into the Pacific, and thus come into hostile contact with the Esquimaux. Further south, they are cut off from the Koluschian and other

sea tribes by the range of mountains which runs parallel to the coast, and from which they extend eastward to the Rocky Mountains. It would appear, that, to the north and west, the Tacullics or Athabascans rarely approach within 100 miles of the coast. Tribes of the Athabascan family occupy the country about the sources of the Salmon River, Frazer's River, and the northern tributaries of the Columbia. The *Nagailers* or Chin Indians, who speak the same language as the Tacullies, and are consequently Athabascan, come in contact with the Bellichoola on Salmon River, and with the Atnas or Noosdalums on Frazer's River. In the interior, they descend as far as Flat Bow Lake, where their neighbours are the *Kootanie* and Flatheads.

An inspection of the vocabularies of the languages spoken on the north-west coast, will aid us in defining the limits of the Athabascan family. If we examine the languages spoken from Observatory Inlet to the Columbia, we find they possess very few Athabascan words, the mountain barrier having obstructed the intercourse between the fish-eaters of the coast and the Athabascans of the interior. On the other hand, on the north and south, where no such defined barrier separates the different races, we find in the vocabularies evidence of a more frequent intercourse. In the dialects of the northern and continental Koluschians, we find a good number of Athabascan words; and the Kenai may probably be considered as rather Athabascan than Koluschian. In like manner, we find Athabascan words in the Kleketat and Shahaptan, as tribes speaking these languages form the southern frontier of the Athabascan race.

3. *The Koluschians.*—The narrow portion of sea coast extending from Mount St Elias to the Columbia River is remarkable from being inhabited by Indians whose manners, physical features, and even intellectual and moral characters, differ considerably from those of the other Indians, whether of North or South America. The northernmost of these families may be called the Koluschian, and consist of many small tribes, of which we have attempted to give a tolerably complete enumeration.

1. *Ugalenzi.* A small tribe, dwelling in winter to the east of the Island of Kodiac, and during summer at the mouth of the Copper River.
2. *Atna.* Living on the River Atna; distinct from the Atna of M'Kenzie.
3. *Galzani*, or *Koltschani.* Living to the north and east of the Atna River.
4. *Kinai.* Inhabiting the vicinity of Cook's Inlet.
5. *Inchulukhlaites.* Inhabiting the vicinity of the River Chulitna.
6. *Inkalites.* Inhabiting the vicinity of the Rivers Kwichpack and Kuskowim.
7. *Sitkans.* Inhabiting King George the Third's Archipelago.
8. *Cheelkaats.* Inhabiting Lynn's Canal, and neighbourhood.
9. *Tako.* Inhabiting Point Salisbury and Snettisham.
10. *Stikine.* Inhabiting Prince Frederick's Sound and Stikine River.
11. *Tunghaase.* Inhabiting the island of Revilla Gigedo.

The territory occupied by the Koluschian family may be defined as including the islands and the shores of the mainland, from Cook's Inlet to the *Stikine* River. In the northern part of the Koluschian territory, the limits become undefined, from the intermixture of tribes of different languages in the same country. Thus we find an Esquimaux tribe, the Tschugassi, inhabiting the peninsula between Cook's Inlet and Prince William's Sound. The Inchuluhkaites and Inkalites, although Koluschians, live still farther north, amidst tribes of Esquimaux. Another cause of perplexity is, that in the six tribes first named in the table, we find in their vocabularies so many Athabascan words as to indicate an intimate intercourse with the Carriers. In the Kinai vocabulary, for example, the number of Athabascan words is so great, as to render it probable that they belong rather to that family of Indians than to the Koluschians, and that, to use a geological expression, they form an outlying portion of the Carriers. The more southern tribes, Nos. 7, 11, are unquestionably Koluschian, speaking dialects of the same language, which is much freer from all Athabascan or Esquimaux intermixture. The Koluschian family, as we have defined it, includes the Tunghaase of Dr Tolmie, the Sitkans of the Russians, and Tchinkitane of Marchant.

4. *Chimmesyan.*—In the present state of our knowledge, the Chemmesyans must be classed by themselves, as speaking a distinct language as peculiar as that of the Koluschians, with which it has had remote affinities.

The following table will exhibit the limits of this family and the principal tribes which speak the Chimmesyan language :—

1. *The Naaskaak.* Inhabiting Observatory Inlet.
2. *The Chemmesyan.* Inhabiting Dundas's Island and Stephen's Island.
3. *Kitchatlah.*
4. *Kethumeesh.* } Inhabiting Princess Royal Islands.

5. *Haidah.*—This well defined family comprehends the various tribes inhabiting Queen Charlotte's Island, including the *Skittegats*, *Maasets*, *Cumshewes*, *&c.* Besides the inhabitants of Queen Charlotte's Island, the Kyganie tribe, inhabiting Kyganie Bay, and the southern extremity of Prince of Wales' Archipelago, belong to the Haidah family.

6. *Haeeltsuk.*—The Haeeltsuk tribes occupy the mainland and islands from Hawkesbury Island, and Millbank Sound to Broughton's Archipelago, inclusive, with the opposite coast of the Continent, and also the northern parts of Quadra and Vancouver's Island. The geographical position of the Haeeltruk, will be best exhibited by the following table of tribes, and their places of residence.

1. *Hyshalla.* Inhabiting Hawksburg Island.
2. *Hyhysh.* Inhabiting Cascade Canal.
3. *Haeeltsuk*; 4. *Esleytuk.* Inhabiting Millbank Sound.
5. *Weekenoch.* Inhabiting Fitzhugh's Sound.
6. *Nalatsenoch.* Inhabiting Smith's Inlet.
7. *Quagheuil.* Inhabiting Broughton's Archipelago.
8. *Tlatla-Shequilla.* Including Northern extremity of Vancouver's Island.
9. *Leequeeltoch.* Inhabiting Johnston's Strait.

7. *Bellichoola.*—This family comprehends but a small number of tribes, speaking, however, a peculiar language. They live on the Salmon River and Dean's Canal, where they were visited by M'Kenzie on his journey to the Pacific Ocean. The small vocabulary collected by M'Kenzie, leaves no doubt, as Dr Tolmie and Dr Latham observes, that the Indians found by M'Kenzie at Friendly Village, belongs to the Bellichoola tribe.

We have classified the Koluschians, Haidah, Chimmesyans, Bellichoola, and Haeeltruk, as distinct families of Indians, and the distinction will hold good even if their languages should be proved to belong to one general tongue, of which they are respectively modifications. The languages of any of these tribes is unintelligible to the others; but, at the same time, the number of words common to them all induce us to suppose, that, with more copious vocabularies, many affinities might be detected and discrepancies removed,

8. *Kawitchen.*—The following tribes belong to this family:—

1. *Commagsheak.* Gulph of Georgia, Northern Part.
2. *Kawitchen.* Gulph of Georgia, Southern Part.
3. *Quaitlin.* Frazer's River.
4. *Noosdalum.* Hood's Canal.
5. *Squallyamish.* Puget's Sound.
6. *Atnas.*

The table of tribes speaking the Kawitchen, and of their habitations, indicates the extent of country over which the language prevails. It extends along the shores of the Gulf of Georgia on the mainland, opposite Vancouver's Island, and south to Puget's Sound, where it approaches the Cowlitch River. Dr Tolmie has supplied three vocabularies, those of the Kawitchen, Noosdalum, and Squallyamish, which appear to be so many dialects of the same original language; the Squallyamish, however, exhibiting the greatest amount of variation. The Atna Indians of M'Kenzie are, as Dr Latham suggests, a branch of the Kawitchen family, and have for neighbours the Athabascans.

9. *Nootkans.*

1. *Naspatle;* 2. *Nootkans;* 3. *Tlaoquatch;* 4. *Nit-*

tenat. All inhabit the western shores of Vancouver's Island.

5. *Classet.* Inhabit Cape Flattery.
6. *Queeniooll.* Inhabit Queenhithe South of Cape Flattery.
7. *Chikeelis.* Inhabit Chikeeli Bay and River.
8. *Cowlitch.* Inhabit Cowlitch River.
9. *Tilhalumma.* Inhabit sources of Chikeeli River.

The relations of this important family, as well as its geographical limits, are very difficult to ascertain, especially as there is much confusion in the vocabularies and relations of the tribes inhabiting the Lower Columbia. If all the above mentioned tribes belong to the Nootkan family, it occupies a very extensive region, including the greater part of the western and southern shores of Vancouver's Island. On the mainland it extends south to the Columbia River, and occupies the greater part of the region between Puget's Sound, the Cowlitch River, and the Pacific. As this extensive range is given to the Nootkan family for the first time, it is necessary to distinguish what is ascertained from what amounts only to a considerable degree of probability. We have many vocabularies of the Nootkan language by Cook, Mozino, Dr Tolmie, and Jewitt, who remained a captive at Nootka for several years. A comparison of these vocabularies leaves no doubt that the first four tribes in the prefixed table belong to the Nootkan family. We have, unfortunately, no vocabulary of the Classet language; but I have reason to believe that the Classets and Tlaoquatch can understand each other, and if so, the former belongs to the Nootkan family. The chief difficulty is with the last four tribes mentioned in the list. Dr Tolmie merely says, that they speak the Chikeeli, but gives no further information respecting them. The reasons for supposing that the Chikeeli tribes are allied to the Nootkan family are as follows:—At the mouth of the Columbia River, especially on the south side, we find several tribes, hereafter to be mentioned, who use the Cheenook language. Above these tribes, and ascending to the falls of the Columbia, we find the Cathlascans also speaking a peculiar language. Of the tribes on the north side of the river, between the Cowlitch, Puget's Sound, and the sea, we have apparently no vocabularies, although the country is occupied by well-known tribes of Indians. It is not, however, upon this negative argument that we place the Chikeeli tribes in the Nootkan family. While residing for several weeks among the Indians of the Lower Columbia, I collected a small vocabulary of the language, and of the phrases essential for carrying on some conversation with the natives. A comparison of this language, spoken by the Chikeelis, with the Tlaoquatch vocabulary of Dr Tolmie and the Nootkan ones of Mozino and Jewitt, prove that it has very great affinities with the Nootkan.

		COLUMBIA.
Plenty	Aya, Tlaoquatch	Haya
No	Wik, Nootkan	Wake
Water	Tchaak, Tlaoquatch	Chuck
Good	Hooleish, do.	Closh
Bad	Peishakeis, do.	Peshak
Man	Tchuckoop, do.	Tillicham
Woman	Tlootsemin, do.	Clootchamen
Child	Tanassis, do.	Tanass
Now	Tlahowieh, do.	Clahowiah
Come	Tchooqua, do.	Sacko
Slave	Mischemas, Nootka	Mischemas
What are you doing?	Akoots-ka-mamok Tlaoquatch	Ekta mammok
What are you saying?	Au-kaak-wawa Tlaoquatch	Ekta-wawa?
Let me see	Nannanitch	Nannanitch
Sun	Opeth, Nootka	Ootlach
Sky	Sieya, do.	Saya
Fruit	Chamas, do.	Camas
To sell	Makok, do.	Makok
Understand	Commatax, do.	Commatax

The vocabulary here given proves that there is a very considerable affinity between the tribes of the north part of the Lower Columbia and the Nootkans of Vancouver's Island, and is the evidence on which we have ventured to place the Chikeelis in the same group as the Nootkans.

10. *Cheenooks.*—The Cheenooks inhabit the lower part of the Columbia, near the sea, and from thence extend along the coast, probably until they reach the Umpqua tribes on the river of the same name. The chief tribes are

1. *Cheenooks.* Inhabiting the south bank of the Columbia.
2. *Cladsaps.* Inhabiting the sea-coast near Point Adams.

3. *Kellamucks.* Inhabiting the Kellamuck River, and south of the Cladsaps.
4. *Cathlamuts.* Inhabiting the south bank of the Columbia above the Cheenooks.

11. *Umpquas.*—Lewis and Clark have given the names of many Cheenook tribes which live on the bays and streams entering the Pacific, and extending towards the Umpqua river. Their names it is unnecessary to repeat. We will merely state, that beyond them, and on the Umpqua and Clamet rivers, we find the Umpqua Indians, of whom we know very little, except that they speak a very distinct language, and are therefore entitled to form a separate family.

12. *Cathlascans.*—The Cathlascans inhabit the banks of the Columbia, from the Falls down to Wappatoo Island, and also the lower part of the Multrumah or Willamud river. The Cathlascans are divided into many little tribes. Their chief place of resort is Wappatoo Island, a low but fertile tract, which resemble the Lizerias of the Tagus. The alluvial and overflown parts of the island abound in a species of Sagittaria, resembling the *S. sagittifolia,* but remarkable for producing at the root a tuber of the size of that of the artichoke, which it very much resembles in flavour, and forms an important article of food to the natives of the Lower Columbia.

As in the case of the northern tribes, the families which we have called Kawitchen, Nootkan, Cheenook, and Cathlascan, may form a group by themselves, and the recurrence of the same words in several of the vocabularies, induces us to suppose that the differences will be reduced as our knowledge of the ethnography of the Oregon improves.

13. *Shahaptan.*

1. *Kliketan.* Inhabit the tract between Fond Ner Percees, Mount Rainier, and the Falls of the Columbia.
2. *Shahaptans* or *Ner Percees.* Inhabit the southern branch of the Columbia, and spread over a great extent of country.
3. *Wallawalla.*
4. *Cayoose.* Inhabit the Snake River from its mouth to

its junction with the Salmon River, and the intermediate country.

5. *Peloose.* Inhabit sources of the Spokan River.

Of the numerous tribes inhabiting the upper tributaries of the Columbia, there are probably many who should be included in the Shahaptan family, but who, in the absence of vocabularies, cannot be placed in the table with any degree of certainty. That the Kliketat, Wallawalla, and Shahaptans, speak the same language, although with dialectic variations, is undoubted; and the vocabularies in the appendix, perhaps the most accurate we possess of any Oregon languages, exhibits both the affinities and divergences. It was drawn up by the Rev. Cornelius Rogers, who has resided as a missionary among the Nez Percees, and is thoroughly versant in their language. The Peloose and Cayoose Indians may also be referred to this family without much risk of error. The first live on the Wallawalla and Columbia at their junction, the second to the west of the Ner Percees. The Shahaptan tribes occupy a very extensive territory, extending from Mount Rainier south to Ford Ner Percees, at the junction of the great northern and southern tributaries of the Columbia, and including the extensive country included between them.

14. *Okanagan.*—This family is placed to the north and east of the Shahaptans. The language is spoken at Fort-Okanagan and in the upper part of Frazer's River. As Dr Latham conjectures, it is probable that the Salish or Flatheads belong to the Okanagans. The Rev. Mr Parker says, they are a branch of the Shahaptans, and speak the same language, but the scanty vocabulary we possess is in favour of Dr Latham's opinion. The affinities of the following tribes are uncertain, although they must be referred either to the Shahaptans or Okanagans:—the Spokans, who live on the Spokan river, the Coeur, and Alenes, and Ponderas, who are a numerous tribe living to the north of Clarke's River. The Cootanies on the M'Gillivray River, according to Mr Parker, speak a peculiar language, and beyond them we have the Athabascan Carriers.

15. *Kalapooiah.*—We possess vocabularies of two dialects, of this family, the Kalapooiah and Yamkallie. The language is spoken beyond the sources of the Willamut River, in the extensive plains in that quarter, and separated by the range from the Cheenook and Umpquas.

16. *Shossoonies.*—The Shossoonies, Snakes, or Diggers, who reside in the mountains and deserts to the south of the sources of the Columbia, are the only remaining family to be noticed, as the tribes inhabiting California, from the sources of the Rio Colorado southward, are too little known to afford materials for description. In the absence of complete vocabularies, we only know that they form a family apart, having no affinity with the Shahaptans or Kalapooiah. The Shossoonies are, perhaps, the most miserable Indians on the whole continent, except the inhabitants of Terra del Fuego; and in their arid deserts their condition, as described by Captain Fremont, is more like that of the Hottentots, or the natives of New Holland, than of American Indians. Their chief subsistence, when fish is not to be found, consists in a scanty supply of game, lizards, and small mammifers, and such roots as the country affords.

Their chief vegetable food consists, according to Captain Fremont, of the roots of a thistle, the *Circium turgenianum* of the *Anethum graveolens.* The *Camas camassia esculenta,* and a species of Valerian, *V. eduli.* It is on such scanty fare that the Shossoonies subsist amidst their rocks and deserts.

In the preceding synopsis, it has been attempted to exhibit as complete a view as possible of the various tribes inhabiting the northern coast of America, from the Polar Seas to the Columbia. The extreme difficulty of the task, and the toil of collecting information scattered in minute portions through a great variety of works, will, it is trusted, be taken as an apology for any errors which may have been fallen into. Were we to construct an ethnographical chart of the north-west part of America, and compare it with the excellent one which Mr Gallatin has given, illustrating the distribution of the Indian tribes east of the Rocky Mountains, nothing would appear more striking than the great variety of languages spoken in the narrow district included between the Rocky

Mountains and the Pacific, contrasted with the few but wide spread dialects, spoken between Hudson's Bay and the Gulf of Mexico. Unwilling to introduce premature generalizations, we have estimated the number of distinct languages at sixteen. Although the number will probably be considerably reduced by subsequent investigations; the Okanagan may be perhaps united to the Shahaptan and the Haidah, with the Koluschian; but after all such reductions, the number of distinct languages spoken to the west of the Rocky Mountains, will be far greater, in proportion to the surface of country and population, than it is to the east, between the mountains and the Atlantic. The territory occupied by the Algonquin race alone exceeds the whole extent of the Oregon territory. In the south of the United States, however, we have something analogous to the population of the west coast, for there a great number of small tribes are found speaking distinct languages, and having little affinity with each other. The creeks and the jungles of that part of country appear to have afforded an asylum to tribes expelled from their ancient abodes. On the east of the Rocky Mountains the wide diffusion of particular languages depends in part on the nature of the country. Subsisting almost exclusively by the chase, each tribe required a great extent of country; few natural barriers existed to prevent dispersion, and the sanguinary nature of Indian warfare left no resource to the vanquished but the alternative of flight or extermination. In the history of the Irriquois confederacy, we have a picture of this desolating warfare in which even the harsh mercy of slavery was refused to the vanquished.

Among the natives of the north-west coast, the features of the country, intersected by mountain ranges, or broken up into islands, rendered the tribes more sedentary; while, at the same time, it permitted, and even from the diversity of its products required, some degree of commercial intercourse. Under such physical conditions, and where the modes of obtaining food varied with the character of the country, extensive conquests were impossible; the energetic Haidah of Queen Charlotte's island could not, even if conquerors, abandon at once their mode of life as fishers, and change themselves into hunters if they penetrated across the mountains, and occupied the country of the Athabascans. This circumstance is unquestionably favourable to the production and preservation of a variety of dialects, although it is by no means a proof that they were not originally derived from a common source. When, to ascertain this, we compare the different vocabularies, we find a source of perplexity which does not occur to any thing like the same extent among the languages spoken to the east of the mountains. In the Irriquois, Cherokee, Sioux, and Algonquin, we find very few words common to all or to any two of them ; the term expressing numbers, the common objects of nature, articles of indispensable necessity, or of family relationship, are perfectly distinct. In the languages of the north-west coast, on the contrary, there seem to be an equal balance of divergences and resemblances ; the same words reappear in the most remote languages, and these frequently numerals or other terms of the first necessity. The similarity with respect to numerals, may be at once seen on inspecting the vocabularies published in the Proceedings of the Geographical Society.

The following instances will explain the same fact :—

Man, Tillicham, Columbia River ; Boy, Tchileque, Carrier.
Woman, Shewat, Koluschian ; Aiat, Shahaptan.
Water, Tchuk, Nootkan ; Tshush, Wallawalla.
Child, Munna, Bellichoola ; Mumunna, Kawitchen.
Child, Tillcoole, Chimmesyan ; Tool, Cheenook.

The source of strange confusion, so to speak, appears to depend on the following circumstances. The Indians of the northward possess a very different natural character from that of the eastern tribes ; they are more sedentary, of a milder nature, their wars are far less cruel, the prisoners are usually detained in a state of mild slavery, and ultimately incorporated into the conquering tribe ; and this circumstance alone will tend to produce an intermixture of dialects. Another modifying cause results from the extensive commercial intercourse carried on between even very remote tribes. Baron Wrangell has given an interesting account of the active trade carried on, from time immemorial, among the tribes from Behring's Straits to Queen Charlotte's Island, and even to Nootka; Dr Tolmie has given valuable information respecting the fairs held at Naas, where the Koluschians, Haidah, Chimmesyans, and Haeeltzuk, interchange commodities.

Previous to the arrival of Europeans, when the use of iron was unknown, copper was an article of great value, and the traditions concerning it prove its former importance; and also a commerce in articles constructed from this metal. Wrangell informs us that the Northern Atnas of the Copper River were famous for the fabrication and commerce in knives and daggers of copper. The tradition of the Chippewyans, recorded by M'Kenzie, that their ancestors came from the west, from a country abounding in copper, may probably refer to their intercourse, by means of the Carriers with the Atnas of the Copper River. According to Mr Dunn, the Cheelhaats of Lynn's Canal were, like the Atnas, famed for their copper, which they wrought with great dexterity. In this country, he says, great quantities of virgin copper are found, some of it is worked into a kind of shield, two feet and a-half long and one broad, with figures of men and animals expressed on it. The labour and ingenuity expended in working these shields gives them a great value. One of them is estimated as worth nine slaves, and is transmitted as a precious heirloom from father to son. The tradition of the Nootkans, as related by Meares, bears upon the same point. An old man entered the bay in a copper canoe with paddles of copper; and thus the Nootkans acquired a knowledge of the value of that metal.

Another article of commerce, or rather the circulating medium of the country, was the hyaqua shell, which was a still better substitute for money than the courie of the east. These hyaquas were sorted according to their sizes, and afterwards strung together always to the number of forty. The mode of estimating their relative values was very ingenious and simple. If the string of forty hyaquas made only a fathom they were of small value; if thirty-five made a fathom, the shells were of greater size and worth, and, of course, five remained over, and when ten remained in excess, such a string of hyaquas was worth many beaver skins. These hyaquas are obtained at Nootka and De Fucas Straits, but so much value was attached to them that they found their way to Oonalaska and the Columbia River. This shell money, both from its limited supply, its durability, and facility with which its value could be expressed in numbers, and its portability, was far superior to the *coccoa* money of the Mexicans. This commercial intercourse must have have tended to produce some assimilation among the idioms; and, accordingly, we find that most exchangeable articles have the same name in Koluschian and Haidah, although the languages are, in other respects, very different. The practice of kidnapping and selling slaves must have had a similar tendency.

Another cause of variation is the dialectic differences which grow up in distant tribes speaking the same language, leading to differences of pronunciation which the stranger cannot detect.

In the Wallawalla and Shahaptan vocabularies, appended to this paper, we see that, even in Indian languages, such variations follow certain rules. According to the excellent remarks of Mr Rogers, one form of the subjunctive ends in *tah* and *nah*, in Wallawalla it is always *tahna;* the Wallawalla substitute *sh* for the Shahaptan *k*, as in *tshusk* for *scush;* the Wallawalla substitutes *n* for Shahaptan *l*, as *wanaka* for *walasa*. Mr Rogers also adds, that the same word often varies considerably in signification; and hence another cause of difficulty in judging of affinities from imperfect vocabularies. Another observation by Mr Rogers, points out another cause of variation, of which I know of no other instance among Indian tribes. He informs us that the Cayoose Indians have an entirely distinct language of their own; but they have long since adopted the Nez Percee as their national tongue, and only a few of the old people retain a knowledge of their original language. If this circumstance be fully established, it throws much light on the causes of variation in the Oregon languages, and indicates a much more flexible disposition than is usually found among Indians. The smallest tribe, in the south of the United States, retained its language with the most obstinate tenacity; and the barbarous Otomis retained their uncouth language for centuries amidst the more polished languages of Mexico. With our present imperfect knowledge of the languages spoken in the north-west coast, all attempts at ethnological classifications will remain imperfect, more vocabularies must be constructed, and the old corrected, before we can trace the affinities and migrations of tribes, the study of whose dialects constitutes all their history.

The researches of American philologists, especially Du Ponceau and Gallatin, have shewn, that, however different the words may be in Indian languages, the same grammatical structure pervades them all. From Canada to Chili, we find similar forms under a great diversity of words. The principles of M. Du Ponceau have been found applicable, with one exception, to all the hitherto examined languages of America, and it is an interesting inquiry to ascertain whether the languages of the north-west coast afford confirmation, or exceptions, to so extensive a generalisation ; unfortunately the materials are not abundant, as it is far more difficult to obtain a grammar than a vocabulary. The only grammar of an Oregon language, which we are acquainted with, is a manuscript one of the Shahaptan or Nez Percee, drawn up by the Rev. C. Rogers, and which affords a short but perspicuous view of the peculiarities of that wide-spread tongue.

The only consonants used in Shahaptan are h k l m n p s t w. The letters b d f g r v z, so often absent in Indian languages, are only used in Shahaptan, when pronouncing foreign words. They have, however, several sounds unknown to English as *ph* aspirated *lk, tkt, shk.*

Like the other American, or in short, all barbarous languages, the Shahaptan is rich in words indicating every variety of object, but poor in general terms, like the Malayan dialects, where there may be twenty names for gold, but none for metal. It is apparently to the same poverty of general ideas, that the pronouns and verbs, with their definite and general plurals, and vast variety of inflexions, indicating every minute particular of time, place, or motion, are very unfit for the discussion of moral topics. They resemble the technical language of botanists, expressing with rigorous precision, the form and properties of bodies, but unfit for any kind of speculative discussion. The distinction of bodies into animate and inanimate, which pervades the Algonquin, and exists, although in a minor degree, in many American languages, has not been hitherto detected in dialects of the Oregon. Although not immediately connected with the subject, it may be mentioned that this distinction of bodies into animate and inanimate is not peculiar to some tribes in North America. It appears to exist in the Peruvian, where also animate objects are divided into rational and irrational. In the rational and irrational divisions, the sex is expressed by words equivalent to male and female, but these words are different in the two classes of nouns.

We have now to offer a few remarks on the physical appearance, intellectual character, and social institutions of the Indians of the north-west coast of America. Even if we exclude the Esquimaux, we find there is a considerable variety in the physical features of the north-west Indians. The Haidah and Koluschians differ greatly from the Chenooks and Cathlascans of the Columbia; and the Shahaptans and Kleketat differ from both. The northern tribes are of a pale complexion, and are not darker than the Portuguese or Italians, while the complexion of the Columbian Indian is deeper, although not so much as the Irriquois of Canada. The features also of the northern tribes are more prominent, they have broader cheek-bones. The Koluschians are of middle stature, but strong made, with broad nose and great cheekbones, and in all respects strongly marked features. The Cheenooks are of small stature, with crooked legs, from sitting so long in their canoes, with flat nose and large nostrils, but their features are less prominent than in the Haidah and Koluschians. The Kleketat and Flatheads are of a fair complexion, tall stature, well made, and active. The peculiarities in the form of the cranium have been mentioned in a paper on the Oregon Indians, published in the Transactions of the Geographical Society.

The intellectual and moral characters of the Indians on the west coast are very different from those of the Indians east of the Mountains. From the nature of their pursuits the Oregon Indians have a more extensive range of ideas, and are less inflexible in character than the other American tribes. The western Indians are imitative and docile; and instead of the hard-heartedness of the Irriquois, the ferocity of the Carib, or the implacable cruelty of the Brazilian, the Oregon Indians are comparatively humane, the custom of scalping is unknown, prisoners taken in war are rarely put to death after the excitement of the contest has subsided, and they are never exposed to lingering tortures. Those probationary tortures by which the young men were initiated into the rank of warriors, and of which, as practised by the Mandians, Mr Catlin has given so entertaining an account, are unknown to the west of the Rocky Mountains.

There is, however, a very considerable variety of psychological character among the tribes of the north-west coast. The northern tribes of Koluschians, Haidah, and Bellichoolas are, in point of skill and ingenuity, far superior to the Cheenooks and Cathlascans. The mechanical skill and imitative ingenuity of the northern Indians as displayed in the construction of their canoes, houses, fishing implements, as well as in their ornamented daggers, pipes, and masks, has attracted the notice of all civilised visitors. The elaborate carvings of the Haidahs is equal in skill to any thing we find displayed by the Mexicans, and shews how small an amount of civilisation might suffice for the construction of the monuments of Chiapa or Yucatan. A very curious instance of the imitative powers of the northern Indians is related by Mr Dunn. The Bellichoolas of Millbank Sound were struck with admiration on the first sight of a steamboat, and undertook to construct a vessel on the same model. In a short time they had felled a large tree, and were constructing the hull out of its scooped trunk. Some time after the rude steamer appeared. She was from twenty to thirty feet long, she was black with painted ports, was decked over, and the paddles painted red, and Indians under cover to turn them round. She was floated triumphantly, and went at the rate of three miles an hour. The introduction and general cultivation of the potato without the aid of European lessons or example, is a remarkable instance of the docility and industry of the Haidah, and they not unfrequently sell from five to eight hundred bushels of them at the annual fair at Naas.

The Indians of Nootka are not equal to the northern tribes, but are superior to the Cheenooks and Cathlascans of the Columbia, who are the least energetic, and at the same time the most cowardly and licentious of all the inhabitants of the north-west coast. If inferior in some degree to the northern tribes, in as far as regards dexterity and mechanical skill, the tribes of the interior, such as the Flat-Heads, Cayuse, and Shahaptans, are by far the first in moral character. The desire for religious even more than for intellectual culture, and the strong, although untutored, devotional feelings, are pleasing phenomena in the Indian race, in general so untractable. This favourable account of the Flatheads and allied tribes, does not rest on the evidence of the missionaries alone, but is the opinion of all who have travelled among them. They are described as polite and unobtrusive. Even the children are more peaceable than other children, and although hundreds may be seen together at play, there is no quarrelling among them. They have learned to observe Sunday, and will not raise their camp on that day; they also spend a part of it in prayer and religious ceremonies. The chief assembles them to prayer in which they all join in an occasional chorus. He then exhorts them to good conduct. These customs were adopted before the arrival of Christian teachers among them.

The religion, or rather superstitions, of the Indians of the north-west coast, do not appear to differ greatly from those of the tribes to the east of the Mountains. The supposed simplicity of the Indian creed, as well as their equally imaginary eloquence, have been the subject of much vague speculation, founded on inaccurate observations. As an instance of the vagueness with which the customs of the Indians are sometimes described, it may be mentioned, that a very respectable writer, in speaking of the Cheenooks, alludes to assemblies around the council fire, taking up the tomihawk, and displaying the scalps of their enemies, although such customs were unknown in the Oregon territory.

In like manner, when we hear the term Great Spirit so often used in speaking of Indian superstitions, we are ready to suppose that such an expression conveys the equivalent idea to the Indian which it does to ourselves, and that their faith was a simple natural theism. This, however, is very far from being the case. The religion of the Indian is merely a kind of fetichism, consisting in charms and incantations. In the narrative of Tanner, who lived from his childhood among the Indians, and whose faithful and detailed narrrative is so different from the speculations of certain writers, we find that the religion of the Indian is merely a system of fetichism similar to that which once prevailed among the Finns, and is found at the present day among the people of Siberia. Among the Indians east of the Mountains, the fetiche, under the name of medicine bag, is well known, and consists merely of some object supposed to be possessed of mysterious powers. Along with this, there is excitement produced by fastings, incantations, and dreams. On the north-west coast the system is similar; and in a former paper, to which allusion has been already made, there is an interesting account by Dr Tolmie of the superstitions of the Haeeltruk. In the Oregon territory, the term medicine-man is more appropriate than it is to the east of the Mountains; for, on the Columbia, the chief influence is derived from expelling diseases by means of charms snd mystic ceremonies.

Connected with the religion of these Indians, their mode of interment deserves notice. It is remarkable, that the simple and natural process of committing the body to the earth, is rarely practised by the American Indians. Among the ancient Peruvians, the body was wrapped up in mats, and interred in a sitting posture, the same posture in which the dead are represented in the picture writings of the Mexicans. On the north-west coast, the body is sometimes placed in a box, and deposited in the crevices of the rocks, or put into a canoe, and raised upon props, where it dries, and becomes a mummy, and so remains until the body and the canoe fall into decay. The custom of burning the body, although uncommon, was practised among the Carriers of New Caledonia. Mr Dunn informs us, that, like the people of

Hindostan, they used, until lately, to burn their dead, a ceremony in which the widow of the deceased, although not sacrificed, was obliged to continue beating the breast of the corpse until it was consumed on the funereal pile. Instead of being burned, she was obliged to serve as a slave the relations of her deceased husband for a series of years, during which she wore around her neck a small bag containing a portion of the ashes of her husband. At the end of the allotted time a feast was held, and she was declared at liberty to cast off the symbols of her widowhood.

Another curious custom, of which, however, we have found as yet only obscure notices of its existence on the north-west coast, is what has been called the *totem*, among the Algonquins, among whom the institution exists in perfection. According to this institution, an Indian tribe or nation is divided into various clans or families, each supposed to have a common descent, bearing, as an emblem or surname, the appellation of some animal or other object, which, among the Algonquins, is called the totem of the clan. Individuals among the Indians cannot marry within their own clan, but must seek a wife in a clan bearing another totem; and hence marriages into a close degree of consanguinity are effectually prevented. The female children in many tribes follow the totem of the mother, while the males follow that of the father. This system appears to be very general among the Indians, and even in other barbarous nations; and we find traces of it among the Indians of the north-west coast. The Cheenooks generally seek for wives among the Chiheelees, and *vice versa;* and thus Indian women may be found in places very remote from the abode of their parents. Among the Koluschians and northern tribes, there is the division of the dog and raven clans, with numerous subdivisions. This system existed in South as well as North America. Thus Piedrahita, in his History of New Grenada, notices its occurrence among the Panches, a tribe inhabiting that country. He says, "No casaban los de uno pueblo con muger alguna del, porque todos se tenian por hermanos, y era sacro sancto para ellos e impedimento de parentesco pero era tal su ignorancia, qui si la proporia hermana nacia en deferenti pueblo, no escusaba casarse con ella el hermano." The existence of this institution appears to have produced the very curious peculiarity of Indian languages noticed by Mr Gallatin, that the women use different words from the men to express family relationships. In some Indian languages this peculiarity penetrates even deeper into the language. Among the Moxas of South America, the women and the men use different pronouns in speaking to each other of things relating to each other. The Kobang of the Australians appears to be the very same institution as the totem of the Algonquins; and it would be interesting to know if similar peculiarities pervade their language.

	Shahaptan.	Wallawalla.	Kleketat.
Man	Nama	Winsh	Wins
Boy	Naswae	Tahnutshint	Aswan
Woman	Aiat	Tilahi	Aiat
Girl	Piten	Tohauat	Pitiniks
Wife	Swapna	Asham	Asham
Child	Miahs	Isht	Mianash
Father	Pishd	Pshit	Pshit
Mother	Pika	Ptsha	Ptsha
Friend	Likstiwa	Hhai	Hhai
Fire	Ala	Sluksh	Sluks
Water	Tkush	Tshush	Tshaush
Wood	Hatsin	Slukas	Slukuas
Stone	Pishwa	Pshwa	Pshwa
Ground	Watsash	Titsham	Titsham
Sun	Wishamtuksh	Au	Au
Moon	. . . . .	Ailhai	Ailhai
Stars	Witsein	Haslu	Haslo
Clouds	Spalikt	Pashst	
Rain	Wakit	Sshhauit	Tohtoha
Snow	Maka	Poi	Maka
Ice	Tahask	Tahauk	Toh
Horse	Shikam	Kusi	Kusi
Dog	Shikamkan	Kusi Kusi	Kusi Kusi
Buffalo	Kokulli	Musmussin	Musmussin
Male Elk	Wawakia	Wawakia	Winat
Female Elk	Taship	Tashipka	Winat
Grey Bear	Pahas	Wapantle	
Black Bear	Jaka	Saka	Analmi
House	Snit	Snit	Snit
Gun	Timuni	Tainpas	Tuilpas
Body	Silaks	Waunokshash	
Head	Hushus	Tilpi	Palka
Arm	Atim	Kamkas	
Eyes	Shilhu	Atshash	Atshash

	Shahaptan.	Wallawalla.	Kleketat.
Nose	Nathnu	Nathnu	Nosnu
Ears	Matsaia	Matsiu	
Mouth	Him	Em	Am
Teeth	Tit	Tit	
Hands	Spshus	Spap	Alla
Feet	Ahwa	Waha	Waha
Legs	Wainsh	Tama	
Mocassens	Ileapkat	Shkam	Shkam
Good	Tahr	Skeh	Shoeah
Bad	Kapshish	Milla	Tshailwit
Hot	Sakas	Sahwaih	Sahweah
Cold	Kenis	Kasat	Tewisha Kasat
Far	Waiat	Wiat	Wiat
Near	Keintam	Tsiwas	Tsa
High	Tashti	Hwaiam	Hweami
Low	Ahat	Smite	Niti
White	Naihaih	Koik	Olash
Black	Sunuhsimuh	Tshimuk	Tsimuk
Red	Sepilp	Sutsha	Sutsa
Here	Kina	Tshna	Stshiuak
There	Kuna	Kuna	Skone
Where ?	Minu ?	Mina ?	Mam
When ?	Mana ?	Mun ?	Mun ?
What ?	Mish ?	Mish ?	Mish ?
Why ?	Manama ?	Maui ?	
Who ?	Ishi ?	Skiu ?	Skiu ?
Which ?	Ma ?	Mam ?	
How much ?	Mas ?	Milh ?	Milh ?
So much	Kala	Kulk	Skulk
How far ?	Miwail ?	Maal ?	
So far	Kewail	Kwal	
How long ?	Mahae ?	Maalh	
So long	Kohae	Kwalk	
This	Ki	Tshi	Tshi
That	Joh	Kwa	Skwa
I	Su	Su	Suk
You	Sui	Sui	Suik
He, she, it	Ipi	Ipin	Pink
We	Nun	Nama	Nemak
Ye	Ima	Ena	Imak
They	Ema	Ema	Pamak
To go	Kusha	Winasha	Winasha
To see	Hakesha	Hoksha	
To say	Heisha	Nu	Nu
To talk	Tseksa	Siniwasa	Sinawasa
To walk	Wenasa	Winashash	
To read	Wasasha	Wasasha	Wasasha
To eat	Wipisha	Kwatashak	
To drink	Makosha	Matshushask	
To sleep	Pinimiksha	Pinusha	

	Shahaptan.	Wallawalla.	Kleketat.
To wake	Waksa	Tahshisask	Tahshasha
To love	Watanisha	Tkeshask	Tkehsha
To take	Paalsa	Apalashask	
To know	Lukuasa	Ashakuashash	Shukuasha
To forget	Titolasha	Slakshash	
To give	Inisha	Nishamash	
To seize	Inpisha	Shutshash	Wanapsha
To be cold	Iswaisa	Sweashash	Iswaiska
To be sick	Komaisa	Painshash	Painsha
To hunt	Tukuliksa	Salaitisas	Nistewasa
To lie	Mishamisha	Tshishkshash	Tshiska
To steal	Pakwasha	Pakwashash	Pakwasha

On the Winds, as influencing the Tracks sailed by Bermuda Vessels; and on the Advantage which may be derived from Sailing on Curved Courses, when meeting with Progressive Revolving Winds. By Governor REID of Bermuda.*

In high latitudes, the prevailing atmospheric currents, when undisturbed, are westerly, particularly in the winter season. As storms and gales revolve by a fixed law, and we are able by observation to distinguish revolving gales from steady-blowing winds, voyages may be shortened by taking advantage of them.

The indications of a progressive revolving gale are, a descending barometer with a regularly veering wind, or with the wind changing suddenly to the opposite point.

In the northern hemisphere, storms revolve from right to left, thus 

In the southern hemisphere, storms revolve from left to right, thus 

The indications of a steady-blowing wind which will not revolve, but blow in a straight-line direction, is a high barometer remaining stationary. When the steady wind blows from either pole, according to the side of the equator, the atmosphere will be both dry and cool. An increase of warmth

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* The above notice was communicated to us through the kindness of a friend of Governor Reid's.

and atmospheric moisture, are indications of the approach of a progressive revolving wind.

The first half of a revolving gale, is a fair wind from Bermuda to New York, because in it the wind blows from the *east;* but the last half is a fair wind from New York to Bermuda. During the winter season, most of the gales which pass along the coast of North America are revolving gales. Vessels from Bermuda bound to New York, should put to sea when the *north-west* wind, which is the conclusion of a passing gale, is becoming moderate, and the barometer is rising to its usual level. The probability is, more particularly in the winter season, that, after a short calm, the next succeeding wind will be *easterly*, the first part of a fresh revolving wind coming up from the south-west quarter.

A ship at Bermuda bound to New York or the Chesapeake, might sail whilst the wind is still *west*, and blowing hard, provided the barometer indicate that this west wind is owing to a revolving gale, which will veer to the *northward*. But as the usual track which gales follow in this hemisphere is northerly or north-easterly, such a ship should be steered to the southward. As the wind at *west* veers towards *north-west* and *north*, the vessel would come up, and at last make a course to the westward, ready to take advantage of the *east* wind at the setting in of the next revolving gale.

A vessel at New York and bound to Bermuda, at the time when a revolving wind is passing along the North American coast, should not wait in port for the westerly wind, but sail as soon as the first portion of the gale has passed by, and the NE. wind is veering towards *north;* provided it should not blow too hard. For the *north* wind will veer to the *westward*, and become every hour fairer for the voyage to Bermuda.

A great number of gales pass along the coast of North America, following nearly similar tracks, and in the winter season make the voyages between Bermuda and Halifax very boisterous. These gales, by revolving as extended whirlwinds, give a *northerly* wind along the shore of the American Continent, and a *southerly* wind on the whirlwind's opposite side far out in the Atlantic. In sailing from Halifax to Bermuda, it is desirable for this reason to keep to the westward, as affording a better chance of having a wind blowing at *north*, instead of one at *south*; as well as because the current of the Gulf Stream sets vessels to the eastward.

When vessels coming from Barbadoes or its neighbouring West India Islands, sail to Bermuda on a direct course, they sometimes fall to the eastward of it, and find it very difficult to make Bermuda when westerly winds prevail. They should therefore take advantage of the trade-wind, to make the 68° or 70° of west longitude, before they leave the 25° of latitude.

On a ship leaving England for Bermuda, instead of steering a direct course for the destined port, or following the usual practice of seeking for the trade-winds, it may be found a better course, on the setting in of an *easterly* wind to steer west, and if the wind should veer by the *south* towards the *west*, to continue on the port-tack, until by changing, the ship could lie its course. If the wind should continue to veer to *north*, and as it sometimes does even to the *eastward of north*, a ship upon the starboard-tack might be allowed to come up with her head to the westward of her direct course. On both tacks she would have sailed on *curved lines*, the object of which would be, to carry her to the westward against the prevailing wind and currents. There is reason for believing that many of the revolving winds of the winter season originate within the tropics; and that ships seeking for the steady trade-winds, even further south than the tropic, at that period of the year, will frequently be disappointed. How near to the equator the revolving winds originate in the winter season, is an important point not yet sufficiently observed. The quickest voyage from England to Bermuda therefore, may perhaps be made, by sailing on a course composed of many curved lines, which cannot be previously laid down, but which must be determined by the winds met with on the voyage. This principle of taking advantage of the changes of revolving winds, by sailing on curved lines, is applicable to high latitudes in both hemispheres when ships are sailing westerly.

GOVERNMENT HOUSE, BERMUDA,
21*st March* 1846.

Origin of the Constituent and Adventitious Minerals of Trap and the Allied Rocks. By JAMES D. DANA.

The minerals of trap and the allied rocks may be arranged in two groups:

1. Those essential to the constitution of the rock, or intimately disseminated through its texture.

2. Those which constitute nodules or occupy seams or cavities in these rocks.

Of the first group, are the several feldspars, with augite, hornblende, epidote, chrysolite, leucite, specular, magnetic and titanic iron; and occasionally Hauyne, sodalite sphene, mica, quartz, garnet, and pyrites. Of the second group are quartz, either crystallized or chalcedonic, the zeolites or hydrous silicates, Heulandite, Laumonite, stilbite, epistilbite, natrolite, scolecite, mesole, Thomsonite, Phillipsite, Brewsterite, harmotome, analcime, chabazite, dysclasite, pectolite, apophyllite, Prehnite, datholite, together with spathic iron, calcspar and chlorite. Native copper and native silver might be added to both groups, yet they belong more properly to the latter. To the same also might be added sulphur, and the various salts that are known to proceed from decompositions about active volcanoes, including the crystallizations of alum, gypsum, strontian, &c.; but these more properly form still a *third* group, and being well understood, will not come under consideration in the remarks which follow.

We observe, with regard to the minerals of the first group, that they are all anhydrous—that is, contain no water. In this respect, the essential constituents of trap and basalt are like those of granite and syenite. But in the second group, consisting of the minerals occurring in cavities or seams, all contain water except pectolite, quartz, calcspar, and spathic iron; and the last three are known to be always deposited in an *anhydrous* state from aqueous solutions.

We proceed to give a few brief hints with regard to the first group, intending only to glance at this branch of the subject, and then take up more at length the group of adventitious minerals.

Essential constituents of modern Plutonic Rocks.—It is obvious that modern igneous rocks, although in some cases derived from the original material of the globe, have proceeded to a great extent from a simple fusion of rocks previously existing, and especially of the older igneous rocks. In accordance with this view, we may with reason infer that the trachytes and porphyries, which consist essentially of feldspar, have proceeded, in many instances at least, from feldspathic granites; the basalts and trap from syenites, hornblende or augitic rocks.

A theory proposed by Von Buch supposes that the feldspathic rocks, as they are of less specific gravity, are from the earliest eruptions, or the more superficial fusings, while the heavier basalt has come from greater depths. Darwin thus accounts for the granites of the surface being intersected by basaltic dykes; the latter having originated from a deeper source, where their constituents took their place at some former period, from their superior gravity. It virtually places hornblende rocks below feldspathic granites in the interior structure of our globe. The hypothesis is ingenious, and demands consideration; but it may not be time to give it our full confidence.

But supposing these more modern rocks to have been derived from the more ancient granitic—what has become of the quartz and mica which occur so abundantly in the latter, while they are so uncommon in the former? By what changes have they disappeared?

In the fusion produced by internal fires, the elements are free to move and enter into any combinations that may be favoured by their affinities. If silica, alumina, magnesia, lime, iron, the alkalies, potash, and soda, were fused together—and these are the actual constituents of basalt—what result might we expect? From known facts, we should conclude that the silica would combine with the different bases, and these simple silicates would unite into more complex compounds. The silicates of alumina and the alkalies or lime, form thus one set of compounds, the feldspars: the silicates of magnesia and the isomorphous bases, iron and lime, another set, to which belong augite, hornblende, and chrysolite; and if much iron is present, we might have, with the lime and alumina, the mineral epidote. The experiments of Berthier, Mitscherlich, and Rose, and the facts observed among furnace slags, confirm what is here stated.

But not to go back to a resolution of the fused minerals into their elements, we may consider for a moment what changes the minerals themselves might more directly undergo in the process of fusion.

Much of the mica in granite differs from feldspar, in containing half the amount in silica in proportion to the bases—the bases in each being alumina and potash or soda. The change, then, in the conversion of the mica into feldspar, would require an addition of silica, which might be derived from the free quartz of granite. Other varieties of mica contain magnesia, which would go towards the formation of some mineral of the magnesian series. It is possible that trachytes and porphyry have thus been made from granite; but trap rocks could not have been so derived, as they contain from 10 to 25 per cent. less of silica.

Again, hornblende and augite are so nearly related, that they have been considered by Rose the same mineral, the different circumstances attending the cooling giving rise to the few peculiarities presented. There can be no difficulty, therefore, in deriving augite by fusion from hornblende rocks. This, moreover, has been actually confirmed by experiment.

Augite, by giving up half of its silica, and receiving additional magnesia in place of its lime, is reduced to chrysolite.* The Gehlenite, nepheline, anorthite, and meionite of Vesuvius, contain, like scapolite, only 40 to 45 per cent. of silica and a large proportion of lime; and it is no improbable supposition, judging from the small amount of silica, and from the lime present, that scapolite rock, or rather limestones containing scapolite, may have contributed in part towards the lavas of that region. The ejections of unaltered granular limestones, and many mineral species pertaining to such beds, strongly support this view; and it is no less sustained by the fact, that in the Vesuvian basalts, Labradorite, which

* The formula of augite is $\dot{R}^3 \dddot{Si}^2$; that of chrysolite, $\dot{R}^3 \dddot{Si}$.

includes lime instead of the alkalies, replaces common feldspar. The original feldspar seems to have given way to leucite and Labradorite.*

An important source of new combination is found in the sea-water which gains access to the fires of volcanoes. The decomposition which takes place eliminates muriatic acid, so often detected among volcanic vapour ; but the soda and other fixed constituents remain, to enter into combination with some of the ingredients in fusion. Is not this one source of the soda forming the soda feldspar, or albite, and of the muriatic acid and soda in sodalite ? Phosphates have been long known to occur occasionally in volcanic rocks, and lately phosphoric acid has been proved to be generally common in small quantities. Sea-water is also a very probable source of this ingredient, as has been shewn by late analyses of the same by Dr Jackson.

These few hints are barely sufficient to indicate something of the interest that attaches to this field of investigation, which the future developments of science will probably open fully to view. We do not attempt to explain why in these modern fusings, mica should not have remained mica, and the quartz still free uncombined quartz. The facts prove some peculiarity of condition attending the formation of the granitic rocks. Of this condition we know nothing certain, and can only suggest the common supposition of a higher heat and slower cooling, attending a greater pressure and different electrical conditions, and the same circumstances may have existed during the granites of different ages.

With these brief suggestions, I pass to the second division of the subject before us.

2. *Minerals occupying cavities and seams in amygdaloidal trap or basalt.*—These minerals have been attributed to a variety of sources, and even at the present time there are various opinions respecting their origin. According to some

* Using $\overline{R}$ for the bases and Si for silica, the formula of leucite is $\overline{R}\ Si^{\frac{4}{3}}$; that of common feldspar, $\overline{R}\ Si^{2}$; that of Labradorite, $\overline{R}\ Si$. From this, it appears that feldspar may be reduced to leucite by giving up one third of its silica, the bases being the same in the two; and with this excess, and other silica combining with the lime at hand, Labradorite might be formed.

writers, they result from the process of segregation;—that is, a separation of part of the material of the containing rock during its cooling by the segregating powers of crystallization; and in illustration of the process we are pointed to the many segregations of feldspar, quartz, and mica, in granite and other rocks, the siliceous nodules in many sandstones, the pearlstones in trachytes and obsidian. Others have thought them foreign pebbles, enclosed at the time the rock was formed. Again, they are described as proceeding from the vapours which permeated the rock while still liquid, and which condensed as the rock cooled, in cavities produced by the vapours. By a few it is urged, admitting that the cavities are inflations by vapours like those of common lava, that they may have been filled either at the time the rock cooled or at some subsequent time, either by crystallization from vapours, or from infiltrating fluids, but more generally the latter.

Of these views we believe the last to accord best with the facts. MacCulloch, in his system of Geology,—a work which anticipated many of the geological principles that have since become popular,—dwells at length on this subject, and supports the opinion here adopted with various facts and arguments. Lyell also admits the same principles. A review of the facts will enable us to judge of its correctness.

1. In the first place, the cavities occupied by the nodules are in every respect similar to the common inflations or air-bubbles in lava. These cavities are open and unoccupied in common lava, and may be no less frequently so in the ejections under water; and should they not be expected to fill in some instances by infiltration? They are the very places where an infiltrating fluid would deposit its sediment, or collect and crystallize, if capable of crystallization; and such infiltrating fluids are known to permeate all rocks, even the most solid, and especially if beneath a body of water. It is evident, therefore, that we are supporting no strange or improbable hypothesis. On some volcanic shores one variety of the process may be seen in action. The cavities of a lava may be detected in the process of being filled with lime from the sea-water washing over dead shells or coral sand, and at

times a perfect amygdaloid is formed. But the positions and characters of the minerals themselves establish clearly the view we support.

2. The mineral in these cavities sometimes only fills their lower half, as if deposited from a solution; and again, it incrusts the upper half or roof, as if solidified on infiltrating through. In the large geodes of chalcedony, stalactites depend from above like those of lime from the roof of caverns; and, as MacCulloch states, the stalactite is often found to correspond to an inferior stalagmite, the fluid silica having dripped to the bottom, and there become solid; moreover the superior pendent stalactite is sometimes found united with the stalagmite below. The same results are here observed as with lime stalactites in caverns, and often a similar laminated or banded structure, the result of deposition in successive layers. Such results can proceed only from a slow and quiet process,—a gradual infiltration of a solution from above into a ready formed cavity; they cannot be supposed to arise from ascending vapours, or gaseous emanations from below, no more than the stalactite in the limestone cavern.

Another fact is often observed. A geode of quartz crystals, sometimes amethystine,—in which every crystal is neatly and regularly formed, is found with the surface coated over with an incrustation of chalcedony, the part above hanging in small stalactites; and this chalcedonic coat sometimes scarcely adheres to the crystals it covers,—or is even loose, and may be easily separated. There can scarcely be a doubt of a subsequent infiltration in a case of this nature.

We might rest our argument here, since the fact being ascertained with regard to quartz, it is necessarily established as a general principle with reference to the zeolites and other amygdaloidal minerals: for quartz or chalcedony, when present in these cavities, is, with rare exceptions, the *lower* or *outer mineral*. We find zeolites implanted on quartz, but very seldom quartz on zeolites. I have met with no instance of the latter, while the former is the usual mode of occurrence. Any deduction, therefore, respecting quartz, holds equally for the associated minerals.

How a cavity coated with a deposit of chalcedony can still be afterwards filled up with other minerals, has been deemed a mystery in science, but the possibility of it is now not doubted. Even flint and agate, as MacCulloch states, are known to give passage to oil and sulphuric acid; and much more will this take place in the moist rocks before the agate has been hardened by exposure to the air. Silica remains in a gelatinous state for a long period after deposition, and in this condition is readily permeable by solutions. It is not necessary that the fluid which has acted the part of a solvent and filled the cavity, should yield place to another portion of fluid; for the process of crystallization having commenced, a new portion of the material is constantly drawn into the same fluid, and the necessary chemical changes are also promoted by the inductive influence of the changes in progress —the catalytic action as it is called—one of the most efficient, and at the same time one of the most universal, agencies in nature.

Other evidence with reference to amygdaloidal minerals is presented by the zeolites themselves.

3. The zeolites occupy veins or seams as well as cavities. Often the seams were opened by the contraction of the cooling rock, and at other times they were of more recent origin. In either case the minerals filling these seams must be subsequent in formation to the origin of the rock itself, and could not have proceeded from vapours attending the eruption. These seams sometimes open upward, and can be seen to have no connection with the parts below, the rock in this portion being solid. Origin from above or from either side, is the only supposition in such cases.

Messrs Jackson and Alger, in their valuable memoir on the Geology of Nova Scotia, mention the occurrence of crystals of analcime attached to the extremity of a filament of copper, the copper having been the nucleus about which the solution crystallized, and state that their formation must have been subsequent to the formation of the rock.

4. Zeolites, moreover, have been found forming stalactites in basaltic caverns, as was observed by the writer in some of the Pacific islands; and Dr Thomson has described and ana-

lyzed one (Antrimolite) from Antrim in Ireland, near the Giant's Causeway.

These facts favour throughout the view we urge, that the amygdaloidal minerals have in general resulted from infiltration, and were not necessarily formed simultaneously with the erupted rock.

5. We remark farther, that no lavas have ever been shewn to contain, at the time of ejection, any of the zeolitic minerals. The zeolites of Vesuvius are known to occur only in the older lavas, and afford no evidence against our position. The cavities in lavas, as far as observed, are empty as they come from the volcanic fires, with the exception of those containing sparingly some metallic ores which are condensed within them. Considering the fusibility of the zeolites and their easy destruction by heat and by volcanic gases, sulphureous and muriatic, we should, *a priori*, say that they could not be formed under such circumstances.

6. Besides, as we have stated, none of the proper constituents of trap or basalt—or the minerals disseminated through these rocks,—contain water. They are all anhydrous. The minerals formed accidentally in furnaces are anhydrous. The constituents of granite, syenite and porphyry are all anhydrous. It is only those minerals which are found in geodes or seams that contain water. Of equal importance is the fact, that none of the essential constituents of these rocks have ever been found in these geodes or cavities along with the zeolites, as might have been the case had they been formed together, by segregation or otherwise. Neither feldspar, although so abundant, nor augite, nor chrysolite, have been found filling, like zeolites, or with them, the cavities of amygdaloid. There is, then, a wide distinction between anhydrous constituents of these rocks, and the hydrous zeolitic minerals.

A few zeolites have been found in granite or gneiss, but they are so disseminated that they can be shewn to be of more modern origin than the rock, and to have resulted from some decompositions of true granitic minerals. They differ entirely in their mode of distribution from the feldspar, garnet, &c., of granite. Along with a decomposing feldspar, it is not unusual to find stilbite in the cavities formed by the decomposition.

Zeolites also have been found disseminated through the texture of basalt, clinkstone, &c., like the feldspar, augite, &c. But the proportion varies widely, and in some parts of the same bed they are found to be wanting; so that we have sufficient reason for classing these disseminated zeolites with those in the cavities, as formed or introduced by infiltration.

(To be continued.)

Proceedings of the Royal Society of Edinburgh.

Monday, 2d March 1846.

Sir THOMAS M. BRISBANE, Bart., President, in the Chair.

The following Communications were read:—

1. On the recent Scottish Madrepores, with Remarks on the Climatic Character of the Extinct Races. By the Rev. Dr Fleming.

The author, in this communication, referred, in the first instance, to the three species of Lamelliferous Polyparia, described in his "British Animals," Edin., 1828, exhibiting specimens of the *Caryophyllea cyathus*, and *Turbinolia borealis* of that work, together with a characteristic drawing, by the late Mrs Hibbert, of the *Pocillopora interstincta*, there alluded to as a native of the Zetland seas. He then exhibited a specimen, six pounds in weight, of the *Madrepora prolifera* of Müller, which was found last summer by fishermen, their lines having become entangled with it, in the sea between the islands of Rum and Egg. This species was known to Pontoppidan, as a native of the Norwegian seas, and is now ascertained to be a native of the Hebrides.

The author next exhibited specimens of the *Turbinolia sepulta* of the crag, together with a new and recent species from the Cape of Good Hope. In conclusion, the author observed, that while, from an acquaintance with the habits of a few *individuals*, we could safely speculate respecting the geographical and physical distribution of a species, we cannot, from our acquaintance with the history of one *species* of a genus, predicate with any confidence respecting the character of other species of the same genus. Thus, there are species of Madrepores natives of tropical seas, and there are species natives of the North seas. After illustrating his views by a reference to the species of the genera *Bos* and *Elephas*, the author closed his observations by stating, that the evidence, proving the climate, during the deposition of the mountain limestone, to have been warmer than at present, as derived from its contained organic remains, was defective, since the organisms compared did not belong to *individuals* of the same species, but to *species* of similar genera.

2. On the principle of Vital Affinity, as illustrated by recent Observations in Organic Chemistry. Part I. By Dr Alison. Published in the present Number of the Edinburgh New Philosophical Journal.

Monday, 16th March 1846.

The Right Rev. BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read :—

1. On the Personal Nomenclature of the Romans, with an especial reference to the Nomen of Caius Verres. By the Rev. J. W. Donaldson, Author of the New Cratylus. Communicated by Bishop Terrot.

2. On the appearance of the Great Comet of 1843, at the Cape of Good Hope, with illustrative Drawings. By Professor C. P. Smyth. Communicated by the Secretary.

3. On the Existence of Fluorine in the Bones from Arthur's Seat. By Dr G. Wilson.

4. On the Composition of the Bones from Arthur's Seat. By Dr Christison.

The author found that the bones of animals lately disinterred in the course of the new drive, contained $\frac{1}{8}$ of the quantity of gelatine common in recent bones.

Monday, 6th April 1846.

Sir THOMAS M. BRISBANE, Bart., President, in the Chair.

The following Communications were read :—

1. On the Description of Oval Curves, and those having a plurality of Foci. By Mr Clerk Maxwell junior; with Remarks by Professor Forbes. Communicated by Professor Forbes.

2. On the Influence of Contractions of Muscles on the Circulation of the Blood. By Dr Wardrop.

In this paper, Dr Wardrope states that he has endeavoured to shew, by a series of observations and experiments, that the muscles, besides being the active organs of motion, perform, by their contractions, an important office in the circulation of the arterial as well as venous blood; an office which has not hitherto been described by physiologists, but which appears to be capable of explaining several interesting phenomena in the living body, of which no satisfactory account has yet been given.

3. On the Solubility of Fluoride of Calcium in Water, and the relation of this property to the occurrence of that Substance in Minerals, and in recent and Fossil Plants and Animals. By Dr G. Wilson.

After a preliminary reference to the existence of fluorine in recent and fossil bones, Dr Wilson stated that he had made a series of experiments with a view to discover what solvent carried fluoride of calcium into the tissues of plants and animals. His first trials were made with carbonic acid, which was passed in a current through water containing pure fluor-spar in fine powder suspended in it. The fluor was by this treatment dissolved, yielding a solution which precipitated oxalate of ammonia, and when evaporated left a residue which, on being heated with sulphuric acid, gave off hydrofluoric acid.

The author was, in consequence, inclined to suppose that carbonic acid conferred upon water the power of dissolving fluoride of calcium. But on observing that, long after the whole of that gas had been expelled by warming the liquid, the latter remained untroubled, he became satisfied that water alone can dissolve fluoride of calcium, contrary to the universal statement of writers on chemistry.

On prosecuting the inquiry, he found that water at 212° dissolved more of the fluor than water at 60°, but he has not yet ascertained the proportion taken up by that liquid at either temperature.

The aqueous solution of fluoride of calcium was found to give, with salts of baryta, a precipitate which required a large addition of hydrochloric or nitric acid to redissolve it. The author pointed out the difficulty which must in consequence occur, in distinguishing between dissolved fluoride and sulphates, and suggested that fluorides may have been mistaken for sulphates in the analysis of mineral water.

He referred also to the objection which must now lie against the present method of determining the quantity of fluorine present in bodies, consisting, as it does, in converting that element into fluoride of calcium, which, in the course of the necessary analytical operations, is washed freely, and must be sensibly diminished in quantity; a fact which has of necessity been hitherto overlooked. Dr Wilson stated that he was not yet able to suggest an unexceptionable quantitative process; but that the fluoride of barium, being much less soluble than the fluoride of calcium, might, in the meanwhile, be substituted for it in the estimation of fluorine.

The author proceeded to state, that, in consequence of the observations he had made as to the solubility of fluoride of calcium in water, he had been led to look for that body in natural waters, and had found it in one of the wells of Edinburgh, namely, in that supplying the brewery of Mr Campbell in the Cowgate, behind Minto House. At the same time, he stated that preceding observers had already found it in other waters. He believed, however, that he was the first to detect it in sea-water, where, by using the bittern or mother-liquor of the salt-pans in which water from the Frith of Forth is evaporated, he had found it present in most notable quantity. The author referred to the presence of fluorine in sea-water, as adding another link to the chain of observed analogies between that body and chlorine, iodine, and bromine.

Dr Wilson further stated, that he had confirmed the observations of Will, as to the presence of fluorine in plants, and Berzelius' discovery that fluorine exists in the secretion from the kidneys; and had, in addition, detected fluorine in the blood and milk, in neither of which has it been hitherto suspected to occur. The paper was concluded by some observations on the presence of fluorine in fossils, and its relations to animal life.

Monday 20th April 1846.

The Right Rev. Bishop Terrot, Vice-President, in the Chair.

The following communications were read:—

1. On the Constitution and Properties of Picoline, a new organic base from Coal-Tar. By Dr T. Anderson. Inserted in the present Number of the Edinburgh New Philosophical Journal.

2. Notice of Polished and Striated Rocks recently discovered on Arthur Seat, and in some other places near Edinburgh. By David Milne, Esq.

Mr Milne stated, that, in the gully situated between Arthur Seat and Sampson's Ribs, a great extent of rock had been recently exposed (by the removal of clay and other superficial deposits) which was found to be smoothed as well as furrowed or scratched.

The gully is about 30 feet wide, at the lowest level to which it has been hollowed out, and at one part, both of its sides are composed of these smoothed furrowed rocks; but, in general, it is only on one side, viz., that next to Arthur Seat, that rock exists. There, the appearances of smoothing and rutting extend for about 80 yards.

The gully runs about NW. and SE. by compass. The highest point in it is near the north end. At both ends it is open and sinks to a level with the adjoining level country. The gully is about 200 feet above the level of Duddingston Loch, and 400 feet above the sea. Arthur Seat forms on the east side of it a precipitous cliff of about 250 feet.

The walls of the gully consist (so far as yet exposed, in the formation of the Victoria road), for about 5 feet upwards, of vertical rock.

This rock towards the north end of the gully is a compact porphyry; towards the south end, of friable porphyry. At the north end the polishing has been greatest.

The scratches are in general nearly horizontal; a few slope upwards to the south; these are at the north end of the gully, where it is narrowest.

The longest scratches are about 6 feet long, from $\frac{1}{3}$ to $\frac{1}{2}$ inch deep and an inch wide.

There are, especially towards the south end of the gully, many spots of a few inches square, where there has been neither polishing nor scratching. These all face towards the south.

The deposit immediately above those rocks, and which has completely filled up the gully, is a brown tenacious clay, full of boulders of all sizes. The boulders consist of traps (some of them of rock not existing in the neighbourhood) and sedimentary rocks. Whilst there are sandstone fragments, which are very similar to those on Salisbury Crag, there are limestones, supposed not to exist nearer than Fife.

This boulder clay is not so tenacious as the blackish-blue boulder clay generally prevalent in the Lothians. It, however, resembles in all respects a deposit of the same kind, existing at the foot of Sampson's Ribs, which is about 160 feet below the level of the gully.

Above the boulder clay in the gully there is a mass of debris, derived apparently from the crumbling of the rocks above on the face of Arthur Seat. Three species of marine shells have been found in this mass; but, as human bones and Roman remains have also been discovered in it, the probability is, that these shells have been brought by human hands.

In the cuttings for the North British Railway, between Arthur Seat and Musselburgh, the upper sides of the large boulders are generally found smoothed and scratched. The scratches seem to be from NW. to WNW. by compass. On some of the boulders there are indications of more recent scratches running W. $\frac{1}{2}$ S. by compass.

The boulders in the railway cuttings between Haddington and Dunbar exhibit scratches running from NW. to WNW.

The opinion formed by the author on these data was,—

(1.) That the agent which had polished and scratched the rocks on Arthur Seat, was the same as that which had polished and scratched the boulders.

(2.) That it had acted from the north-westward over a large and low district of country.

(3.) That the polishing and scratching had been effected by the gravel and angular blocks existing in the boulder clay and diluvial gravel.

(4.) That there had been rushes of water along the country, which bore along the mud, sand, gravel, and boulders now spread over the country, and which, in passing over the rocks and large boulders, smoothed and rutted them.

(5.) That, at this period and subsequently, water must have stood, in a comparatively tranquil state, above the level of Sampson's Ribs, to account for the beds of sand existing on the south side of Arthur Seat, and at a level of 200 feet above Duddingston Loch.

(6.) That the outline or configuration of the district, thus submerged, could not have been materially different from what it now presents.

3. Results of the Makerstoun Observations, No. II. On the Relation of the Variations of the Vertical Component of the Earth's Magnetic Intensity to the Solar and Lunar Periods. By J. Allan Broun, Esq. Communicated by General Sir T. M. Brisbane, Bart.

List of Patents granted for Scotland from 23*d March to* 22*d June* 1846.

1. To Julius Adolph Detmold, of the city of London, merchant, being a communication from abroad, "improvements in the means of applying steam as a motive power."—23d March 1846.

2. To Alexander Bain, of Hanover Street, Edinburgh, engineer, "improvements in electric clocks and telegraphs, parts of which improvements are applicable to other purposes."—25th March 1846.

3. To James Ivers, of Preston, in the county of Lancaster, machine-maker, "certain improvements in machinery, or apparatus for preparing, roving, and slubbing cotton, wool, and other fibrous substances."—30th March 1846.

4. To James Stokoe, of Newton, in the county of Northumberland, mill-wright, "improvements in purifying the vapours arising from smelting, and other furnaces, and in recovering therefrom the useful matters which may be intermixed therewith."—2d April 1846.

5. To William Mather and Colin Mather, of Salford, in the county of Lancaster, engineers, "certain improvements in boring earth, stone, and subterraneous matters, and in the machinery, tools or apparatus applicable to the same."—2d April 1846.

6. To Charles Cowan, paper manufacturer at Valleyfield, near Penicuick, in the county of Edinburgh, "improvements in the manufacture of paper, millboard, and other similar substances," which is partly his own invention, and partly the invention of a foreigner.—3d April 1846.

7. To George Daniel Bishopp, of Paddington, in the county of Middlesex, civil-engineer, "improvements in certain engines or machines

used for obtaining mechanical power, and for raising and impelling fluids."—6th April 1846.

8. To Henry Smith, of Liverpool, engineer, "improvements in the manufacture of wheels for railways, and in springs for railway and other carriages, and in axle guards for railway carriages."—6th April 1846.

9. To William Unsworth of Derby, silk manufacturer, "certain improvements in looms for weaving."—7th April 1846.

10. To Pierre Armand Lecomte de Fontainemoreau, of Skinner's Place, Size Lane, in the city of London, being a communication from abroad, "certain improvements in apparatus for raising and supporting vessels and other floating or sunken bodies, and its application for the better prevention of life and property."—8th April 1846.

11. To Henry Mandeville Meade, of the city of New York, in the United States of America, gentleman, being a communication from abroad, "improvements in distilling from Indian corn and other grain."—9th April 1846.

12. To Henry Mandeville Meade, of the city of New York, in the United States of America, gentleman, being a communication from abroad, "improvements in the manufacture of bread."—9th April 1846.

13. To Benjamin Fothergill, of Manchester, in the county of Lancaster, machine-maker, "improvements in certain parts of machinery used in the preparation for spinning, and in the spinning and doubling of cotton, wool, and other fibrous substances."—9th April 1846.

14. John Robert Johnson, of Alfred Place, Blackfriars, in the county of Surrey, chemist, "improvements in purifying gas, and in the treatment of products of gas-works."—9th April 1846.

15. Reuben Goodale Fairbanks, of Cecil Street, in the county of Middlesex, civil-engineer, being a communication from abroad, "certain improvements in machinery or apparatus for making moulding or manufacturing bricks, tiles, and other articles from earthy or plastic materials."—13th April 1846.

16. Alexander Alliott, of Lenton, in the county of Nottingham, "certain improvements in the rotatory machines employed for drying and other purposes requiring the application of centrifugal force."—14th April 1846.

17. John Ainslie, of Alperton, in the county of Middlesex, brick and tile manufacturer, "certain improvements in the arrangements for the manufacture of bricks, tiles, and other similar articles from clay and other plastic substances, and in machinery or apparatus for the manufacture of bricks."—14th April 1846.

18. James Laming, of Mark Lane, in the city of London, merchant, being a communication from abroad, "improvements in making the cyanides, and ferrocyanides, of potassium and sodium." — 15th April 1846.

19. James Allingham, of Dublin, in the kingdom of Ireland, gentleman, and James M'Gauley, of the city of Dublin aforesaid, clerk, "certain improvements in steam-engines."—16th April 1846.

20. John Lake, of Apsley, in the county of Hertford, civil engineer, "certain improvements in propelling."—16th April 1846.

21. Samuel Heseltine junior, of Bromley, in the county of Middlesex, civil-engineer, being a communication from abroad, "improvements

in machinery or apparatus for dressing stones for grinding corn, grain, and other substances."—17th April 1846.

22. William Mather, of Salford, near Manchester, in the county of Lancaster, and Colin Mather, of the same place, millwrights and engineers, " improvements in metallic pistons."—21st April 1846.

23. Edouard Auguste Desire Guichard, of Rue des Jenueurs, Paris, in the kingdom of France, " improvements in printing calico and other fabrics."—21st April 1846.

24. Bennet Woodcrofts, extension of a patent for the period of six years, of " certain improvements in the construction and adaptation of a revolving spiral paddle for propelling boats and other vessels in water." —21st April 1846.

25. William Eccles, of Blackburn, in the county of Lancaster, power-loom manufacturer, William Crook, of Livesey, hand-loom weaver, and William Lancaster, of Blackburn, in the county of Lancaster, power-loom weaver, " certain improvements in looms for weaving."—24th April 1846.

26. John Barsham, of Long Melford, in the county of Suffolk, manufacturer of bitumen, " improvements in the manufacture of mattresses, cushions, brushes, and brooms, and in machinery for preparing certain materials applicable to such purposes."—27th April 1846.

27. John Nott, of the city of York, gentleman, " certain improvements in the means of communicating intelligence from one place to another."—29th April 1846.

28. William Price Struve, of Swansea, civil-engineer, " improvements in ventilating mines."—29th April 1846.

29. Julian Van Oost, of Genbrugge, near Ghent, but now of Osnaburg Street, Regent's Park, in the county of Middlesex, gentleman, " improvements in treating seed, and in preparing materials used for fertilizing land, and for aiding vegetation."—29th April 1846.

30. George Hinton Bovill, of Millwell, and Robert Griffiths, of Havre, in the Kingdom of France, engineers, " improvements in apparatus applicable to the working of atmospheric and other railways, canals, and mines, and improvements in transmitting gas for the purpose of lighting railways and other places."—29th April 1846.

31. Peter Carmichael, manager for Baxter Brothers and Company, flax-spinners and linen manufacturers in Dundee, " improvements in hackling or dressing flax, hemp, and other fibrous substances, and improvements in machinery for rubbing, stretching, and equalizing the breadth of cloth made from flax, hemp, jute, and other fibrous substances."—6th May 1846.

32. John Lloyd Bullock, of Conduit Street, Hanover Square, chemist, being a communication from abroad, " improvements in the manufacture of quinine."—6th May 1846.

33. John Blyth, of St Anne Limehouse, in the county of Middlesex, " an improved mode of closing the orifices of bottles or other vessels applicable to inkholders."—7th May 1846.

34. Samuel Cunliffe Lister, of Manningham, near Bradford, in the county of York, gentleman, " improvements in carding and combing wool."—11th May 1846.

35. To Alexander Parkes, of Birmingham, in the county of Warwick, artist, " improvements in the preparation of certain vegetable and animal

substances, and in certain combinations of the same substances alone or with other matters."—11th May 1846.

36. To Pierre Armand le Comte de Fontainemoreau, of No. 15 New Broad Street, in the city of London, being a communication from abroad, "an improved mode of constructing certain parts of the harness of horses and other beasts of burden."—11th May 1846.

37. Thomas Hancock, of Stoke, Newington, in the county of Middlesex, Esquire, "improvements in the manufacturing and treating of articles made of caoutchouc, either alone or in combination with other substances, and in the means used or employed in their manufacture."—12th May 1846.

38. To William Garnet Taylor, of Halliwell, in the county of Lancaster, cotton-spinner, and William Taylor, of Halliwell aforesaid, labourer, "improvements in consuming smoke and economising fuel."—13th May 1846.

39. To Bryan Donkin, of the Paragon, New Kent Road, in the county of Surrey, civil-engineer, "improvements on wheels as applicable to railway carriages, and on the mechanical contrivances by which railway carriages are made to cross from one line of rails on to another line, or on to what are generally called sidings."—14th May 1846.

40. To Frederick Harlow, of Paradise Street, Rotherhithe, in the county of Surrey, carpenter, "improvements in atmospheric railways."—20th May 1846.

41. To Jean Joseph Ernest Barruell, of Rue, St Jacque's, in the city of Paris, in the kingdom of France, chemist, "improvement in working of certain sulphurets to transform them into metals or oxides, and to collect the latter, also to collect the oxides from oxidized ores equivalent to these sulphurets."—20th May 1846.

42. To George Hinton Bovill, of Millwall, in the county of Middlesex, engineer, being a communication from abroad, "improvements in manufacturing wheat and other grain into meal and flour."—25th May 1846.

43. To William Longshaw, of Manchester, in the county of Lancaster, cotton-spinner, "certain improvements in machinery or apparatus for spinning and doubling cotton and other fibrous substances."—27th May 1846.

44. To George Duncan, engineer, Edinburgh, "an improved method of making comfits, confectionary, lozenges, and all description of pan goods, the machinery and apparatus for the manufacture of the same, or for any other article to which the said apparatus or machinery may be made applicable."—28th May 1846.

45. To George Lowe, formerly of Brick Lane, Old Street, in the county of Middlesex, but now of Finsbury Circus, in the said county, civil-engineer, *extension* for *five* years, "for increasing the illuminating power of such coal-gas as is usually produced in gas-works; also for converting the refuse products from the manufacture of coal-gas into an article of commerce not heretofore produced therefrom; and also of a new mode of conducting the process of condensation in the manufacture of gas for illumination."—2d June 1846.

46. To John Webster Hale, of Fitzroy Square, in the county of Middlesex, gentleman, being a communication from abroad, "improve-

ments in machinery for clearing or freeing wool and certain other fibrous materials of burrs and other extraneous substances."—4th June 1846.

47. To Nathan Defries, of Saint Martin's Lane, in the county of Middlesex, engineer, "improvements in gas-meters."—4th June 1846.

48. To Stephen R. Parkhurst, of Liverpool, in the county of Lancaster, machinist, "a method of propelling vessels."—4th June 1846.

49. To Moses Pool, of the Patent Office, London, gentleman, being a communication from abroad, "improvements in making fabrics from fibrous materials."—4th June 1846.

50. To John Webster Cochran, of Paris, in the kingdom of France, engineer, "certain improvements in machinery for cutting and shaping wood for ship-building and other purposes."—12th June 1846.

51. To John Forrester, shawl-washer, in the town of Paisley, and county of Renfrew, in that part of Great Britain called Scotland, "certain improvements in machinery for fulling cloth manufactured of wool, cotton, silk, and other fibrous materials."—16th June 1846.

52. To Bennet Woodcroft, of Manchester, in the county of Lancaster, consulting engineer, "an improved mode of printing certain colours on calico and other fabrics."—18th June 1846.

53. To Robert Reyburn, of Brown Street, Glasgow, chemist, "improvements in making extracts from animal and vegetable substances."—18th June 1846.

54. To William Spiby, of Carrington, in the county of Nottingham, engineer, "improvements in the construction of furnaces used for heating water and other fluids."—18th June 1846.

55. Francois Stanilas Meldon de Sussex, of Millwall, in the county of Middlesex, manufacturing chemist, "improvements in the manufacture of soda potash."—18th June 1846.

56. Thomas Jones, of Salford, in the county of Lancaster, machine-maker, "certain improvements in machinery or apparatus for preparing, slubbing and roving cotton, wool, and other fibrous material."—22d June 1846.

Scientific Intelligence and Notices of New Publications in next Number.

THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

On the Site of the Ancient City of the Aurunci, and on the Volcanic Phenomena which it exhibits; with some Remarks on Craters of Elevation, on the Distinctions between Plutonic and Volcanic Rocks, and on the Theories of Volcanic Action which are at present most in repute. With Two Plates. By CHARLES DAUBENY, M.D., F.R.S., Professor of Chemistry and Botany in the University of Oxford. Communicated by the Author.*

THE lively interest, which, of all classes perhaps of physical phenomena, the operations of a volcano are best calculated to inspire, has been my principal motive for undertaking three journeys, at intervals of nearly ten years apart, to the south of Italy; on my return from each of which, I felt it a matter no less of duty than of inclination, to communicate some account of what I had observed to such members of my own University as felt any curiosity in researches of this description.

Accordingly, soon after I came back from my first visit to Italy in 1824, I submitted my views with respect to the general nature and origin of volcanoes, in some lectures delivered in this place, which have been incorporated in a work afterwards published by me, but for some time past out of print.†

In these lectures I maintained, by an appeal, more parti-

* Read to the Ashmolean Society of Oxford.

† Description of Active and Extinct Volcanoes. 1 vol. 8vo. London, 1826.

cularly, to the operations now proceeding about Vesuvius, in Sicily, and in the Lipari Islands, that hypothesis which was first propounded by Sir H. Davy, but which, towards the close of his life, that great chemist, like *an unnatural parent*, appears to have cast aside.

And although Dr John Davy, in the Life he has published of his brother, has taken me rather severely to task, for venturing to suggest, that this *cruel abandonment of his own progeny* was, on the part of Sir Humphrey, a matter of taste, rather than of deliberate judgment, as though I had almost impeached his moral conduct by attributing to him such a change of sentiment on a scientific question,* yet I am still prepared to contend, that, inasmuch as this illustrious philosopher, at the very time when he avowed his preference for a rival theory, acknowledged that the one he had originally advocated was adequate to account for all the phenomena which are known to accompany a volcanic eruption,† the opinion he expressed is not entitled quite to the same deference which it would otherwise command, nor to be regarded of sufficient weight to bias us against the reception of the evidence which may be offered in support of that hypothesis which I have ventured to espouse.

In my first visit, then, to Naples, my attention was almost exclusively directed, as that of most travellers is, to the operations of the active, or semi-active volcanoes round about this Capital; but on my second, I extended my examination to an extinct one in Apulia, situated near the eastern declivity of the Apennines, and bearing, as it would seem, the same relation to the Adriatic, which Vesuvius does to the Mediterranean.

This volcano, known to the ancients as the Mount Vultur, a name which it still retains, preserves to the present day

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* See Davy's Life, vol. ii., pp. 124, 5.

† Phil. Trans. for 1828, p. 250. "Assuming the hypothesis of the existence of such alloys of the metals of the earths as may burn into lava in the interior, the whole phenomena may be easily explained from the action of the water of the sea and air upon those metals; nor is there any fact in any of the circumstances which I have mentioned in the preceding part of this paper, which cannot be easily explained according to this hypothesis."

unimpaired the form as well as the structure of those portions of the earth's surface which have been once the theatre of igneous operations; the medium of communication, as it were, between the atmosphere and the interior of the globe.

Yet no manifestations of activity are recorded as having been exhibited by it during those periods of Roman history when such phenomena would have excited attention.

On the contrary, it appears, from the testimony of Horace, to have presented then the same luxuriant vegetation, the same wooded slopes, which we observe at present; so that the inference seems inevitable, that the grand display of volcanic activity, which must have accompanied the formation of so considerable a mountain, was limited to a period long anterior to the existence of historical records.

Of this locality, as well as of the allied phenomena exhibited in a spot on the Apennines intermediate between it and Mount Vesuvius, and in a line parallel with both, called of old the Lake Amsanctus, where, just as was the case nearly 2000 years ago, in the time of Virgil, copious volumes of carbonic acid gas are constantly given off into the atmosphere from some internal focus of volcanic operations, I gave an account on my return at one of the meetings of this Society, and the particulars are contained in a brief memoir since published in our Transactions.*

One other volcano, however, or rather, I should say, another distinct system of volcanic operations existing within the Neapolitan territory, remained to be explored; I mean that of Rocca Monfina, near Sessa, at a distance of about 30 miles to the north of Naples.

This mountain, accordingly, it was my particular object, in the third and last journey I undertook to the south of Italy, to investigate; and as it proved in some respects more interesting, and more instructive, even than any of those which I had previously examined, I conceive that a brief account of it will form a suitable appendix to the reports on volcanic

* Narrative of an Excursion to the Lake Amsanctus and to Mount Vultur in Apulia, 1835, published by the Ashmolean Society.

phenomena, which I have on former occasions presented at these meetings.*

Those who have travelled from Naples to Rome by the lower and more frequented road, which passes by Mola de Gaieta, Fondi, and Terracina, may recollect, that, after reaching Capua, they soon lose sight of the volcanic tuff or peperino, which constitutes the subsoil in all directions around Naples. They then find themselves upon a calcareous marl, which, upon examination, will appear to belong to the tertiary period, until they approach the hills which are ascended before arriving at the post-house of St Agatha. They there perceive that the rock is again a kind of tuff, but one possessing a different character, and therefore derived from another source from that surrounding Naples, and that it may be traced to a mountain called Rocca Monfina, which lies between the two towns of Sessa and Teano, one of which, Sessa, stands at a distance of about half a mile from the inn of St Agatha already noticed, whilst Teano is situated on the eastern flank of the mountain looking towards the central chain of the Apennines.

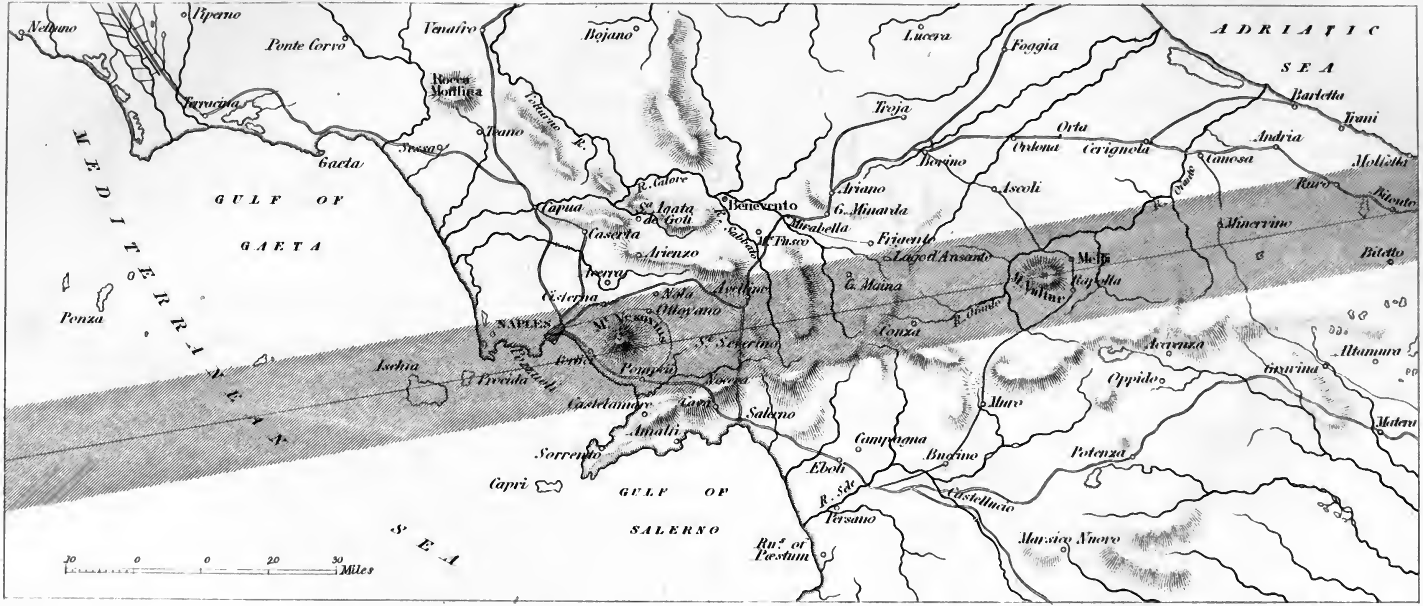
Both these cities will be familiar to the readers of Livy, the first as Suessa Auruncorum, the last hold of the nation of the Aurunci, the second as the seat of the rival state of the Sidicini.

The Aurunci, however, in the earlier periods of Roman history, had their capital at the summit, and not on the declivity, of the mountain. Though they at one time appear to have possessed themselves of a considerable tract in the level country, both of Campania and of Latium, yet their original site was the hilly country intervening. Thus they are noticed by Virgil as a hardy race of mountaineers,

——— et quos de collibus altis
Aurunci misere patres;

and those who like myself have ascended the mountain will regard it as admirably well adapted for the stronghold of a warlike and predatory clan.

* The map in Plate I., p. 216, gives the relative positions of the three volcanoes alluded to.



J. W. Lowry sculp.

MAP OF A PORTION OF THE KINGDOM OF NAPLES.

We first read of them, indeed, soon after the expulsion of the Tarquins, as having formed a confederacy against Rome with two Latin cities, Pometia and Cora, when, being defeated with great slaughter, they are said to have taken refuge within the walls of Pometia. The following year Pometia was besieged without success, and one of the consuls being severely wounded, the invading army sounded a retreat.

A second army was, however, quickly dispatched, and Roman perseverance at length triumphed, Pometia being taken by assault, after which it was so completely destroyed, that though it had ranked as the principal town in the Pontine Marshes, to which, indeed, it gave its name, no vestige of it can now be discovered, and its very position is unknown.

Still the Aurunci remained unmolested in their capital on the summit of Rocca Monfina, to which the Romans, as it would appear, did not think it prudent to pursue them; and, although a few years afterwards, when this same people, in consequence of the taking of the town of Suessa by the Romans, joined the Volscians, they were again defeated in battle, their independence was still preserved to them within the range of the mountain fastness alluded to.

For the next century and a half the Aurunci appear to have kept aloof from collision with the Roman power, but in the year A.U.C. 410, they made a predatory incursion into the Roman territory, which excited so much alarm, from the fear lest, if unchecked, the whole Latin nation might rise, and make common cause with them, that a dictator was appointed to head the army sent to oppose their march. They were indeed promptly repulsed; but nevertheless, in the great Latin war which commenced about five years afterwards, they again took part against the Romans, and shared in the defeat which attended the arms of the confederates.

At the peace which followed, they were admitted in the alliance of the Romans; but from this moment may be dated their ruin; for soon afterwards the hostile nation of the Sidicini, either by surprise or treachery, effected that which the Romans appear never to have attempted, namely, the expulsion of this people from their stronghold on the summit of Rocca Monfina, which, with its walls and fortifications, was utterly demolished, the inhabitants being compelled to seek refuge in the town of Suessa, the modern Sessa, in the plain below.

After this event, all we read of the Aurunci is, that they took part with the Samnites in their second war against the Romans, and, in consequence of their defeat, were obliged to submit to receive a Roman colony, so that their existence as a separate state was from this period destroyed.

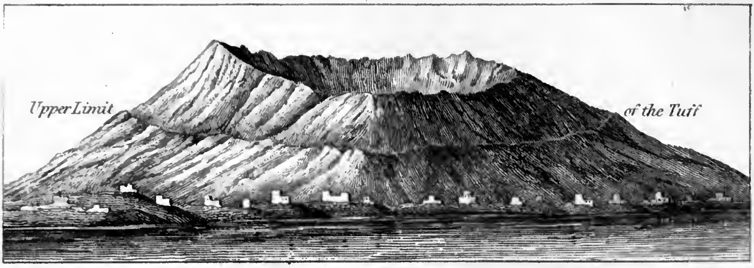
That they should so long have resisted the Roman power, and not been finally subdued, until deprived of their original fortress on the top of Rocca Monfina, will be less a matter of surprise, when I have described the structure of this remarkable mountain.

After a rather steep ascent of about 2000 feet, we find ourselves all at once within a very regular crater, the brim of which is perfect on the west, where it forms the lofty and precipitous Monte Cortinella, and may be traced in other parts throughout its entire circumference, except on the side which we enter on coming from Sessa, where it is so far broken away, that there is scarcely any sensible descent before arriving within its precincts. The circular form and extent of the crater is however better observed from some point near to its centre, than from its margin, and a remarkable conical protuberance which rises up from the midst of the crater, and reaches an elevation of 3200 feet,* considerably exceeding the highest point which the margin of the latter attains, gives us an opportunity of surveying its internal dimensions.

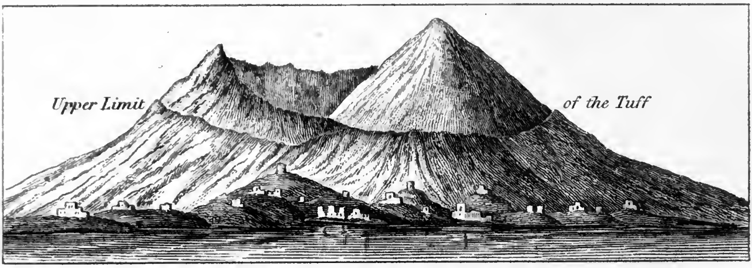
Its diameter is estimated at two and a half Italian miles, and its circumference at seven and a half; but a large portion of its interior is occupied by the conical hill above noticed, the structure of which I shall describe immediately.

It is no novelty to the traveller in Italy, to observe the country increasing in verdure and fertility, in proportion as he ascends to a higher elevation; so that, after toiling up a laborious ascent, unapproachable perhaps, except on foot, or

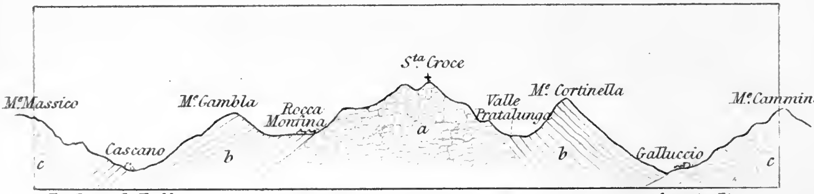
* Abich, uber die Natur, &c., der vulkanischen Bildungen. Braunschweig, 1841.



Vesuvius, or Somma, according to Strabo.

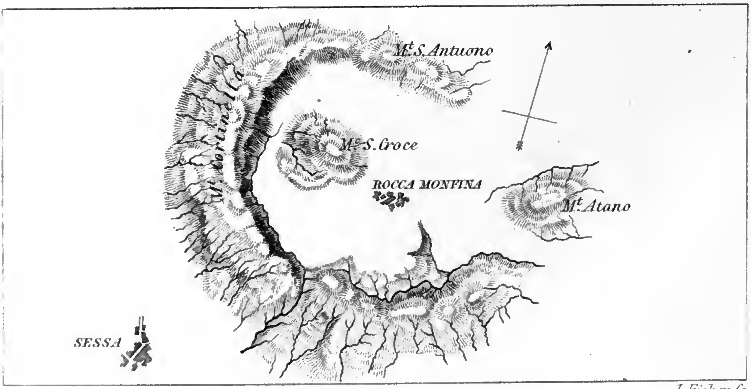


Somma and Vesuvius after the time of Pliny.



a. Trachyte. b. Tuff. c. Appenine Limestone.

Section of Rocca Monfina.



J. Fisher sc.

Ground Plan of Rocca Monfina.

by beasts of burden accustomed to mountain paths, he may often find himself all at once in a valley, exhibiting, instead of the sombre and lonely aspect which in colder countries is characteristic of mountain scenery, a display of those softer and lovelier features, which the intense heat of the sun soon banishes elsewhere from the landscape of southern latitudes, and teeming with a population, more healthy, more vigorous, and apparently more thriving, than he had left in the plain below.

Such is found to be the case in crossing the mountain chain that separates Amalfi from the towns that lie scattered along the Bay of Naples, after we have climbed up the flights of rude steps, which often form the only medium of communication between the villages situated on the slope of the hill, and the sea that flows at its base.

And in like manner, Rocca Monfina, isolated as it may appear, and remote from any great thoroughfare, comprehends within its precincts two or three populous villages, several churches, and more than one convent; whilst its surface, so far from presenting the rugged aspect which volcanic rocks usually assume, is so uniformly clothed with vegetation, and in a state of such complete culture, that, but for the amphitheatre of hills which encloses the table-land on its summit, the circular form of which betrays the origin of the mountain of which it forms the outer margin, no one could for an instant dream, from its general physiognomy, that the whole was of igneous formation.

And yet, when we look back to the accounts given by the Roman writers of the state of Vesuvius, or rather of Monte Somma, just before that mountain returned to a state of activity in the second century of the Christian æra, we may see reason to believe, that its condition must then have been nearly similar to that of Rocca Monfina at present,* if we only except the crater, which, not being composed of tuff, was entirely barren, even in the time of Strabo.†

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* See engravings in Plate II., p. 219, which represent the supposed form of the mountain in the time of Strabo, and its appearance subsequently to the time of Pliny.

† See Martial IV., Ep. 44. Strabo, V. 24.

In one respect, indeed, even here the analogy held good; for, like the crater of Rocca Monfina, that of Monte Somma seems to have been broken away on one side, by which the troops of Spartacus must have entered it when besieged by the Roman legions; and it was by climbing up the sides of that portion which continued entire, that the army alluded to contrived to escape from their dangerous position, and to take the enemy in the rear.*

If such, then, was the condition of Rocca Monfina during the early periods of the Roman Republic, we can hardly imagine a position better calculated for the stronghold of such a nation as the Aurunci are described to have been.

Their outpost Suessa, situate, as we have seen, near the bottom of the mountain, commanded the approach to it on that side where it was most accessible, and secured to them a communication with the sea, with the cities of the Pontine Marshes, and with their possessions in Campania.

If driven from thence, they had only to retreat to the summit of the mountain, where, posted on the external margin of the crater, they would watch the movements of any invading force, long before it could gain the top of a mountain of such height, and so difficult of access. In case of an attack, they could drive their flocks and herds within the crater, where they would find ample space and good pasturage, without danger of molestation, unless, indeed, the enemy were powerful enough to dislodge them from the vantage ground which their army would occupy on the brim of the crater, itself a natural fortress, inclosing within its ample boundaries a large tract of fertile land.

Even if compelled to relinquish this stronghold, they still had it in their power to take refuge on the conical and precipitous mountain which rises up from the very centre of the crater, where a small force might easily set at defiance a host of invaders.

On this mountain, called, from a cross which, till lately, stood on its summit, the Monte de la Croce, they accordingly appear to have placed their citadel; for an Italian archæolo-

* Plutarch, in Vit. Crassi. Florus III. 20.

gist* first pointed out, on a level spot nearly at the top of this eminence, as vestiges of the ruined city, pavements of streets, corners of apartments, foundations of buildings, three cisterns for containing water, together with heaps of hewn stones, and remnants of very strong walls.

Some of these were perceived by myself in the course of my rambles over the mountain, and I found that they consisted of the same material which composes the rock on which they had been erected.

No better proof than this could be adduced of the antiquity of the volcanic operations to which the mountain owes its actual configuration; for, as Sir William Gell observed to me, when I once descanted with him on the extreme disproportion which exists between the length of period embraced within the several epochs of human and geological history, a nation like the Aurunci, to whom it was of essential importance to have near their city good pasturage for the flocks and herds on which they depended for support, would never have selected Rocca Monfina for their capital, not only if the volcano itself had been in activity, but had not the stone which constitutes the interior of the crater been already in such a state of decomposition, as to be covered with herbage, and to yield abundant crops.

With regard to the geological structure of the mountain, I may remark, that, with the exception of the conical mass of rock in its centre which constitutes the Monte della Croce, it is almost entirely composed of beds of a volcanic tuff, which differs, however, from that met with round about Naples, in the inferior degree of its compactness, in its more earthy appearance, in the more frequent presence of mica, and the rare occurrence of the darker varieties of pumice.

I remarked a red ferruginous variety, sometimes in beds alternating with the commoner kinds, and in one instance forming a kind of vein running vertically through the strata.

The tuff continues from the town of Sessa till we approach the outer brim of the crater, covered over with loose uncom-

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* Perotta, Sede degli Aurunci, as quoted by Romanelli, vol. iii., p. 444.

pacted aggregates of volcanic sand, and of stones promiscuously heaped one upon the other.

In this tuff are often imbedded, not only its usual concomitants, sand and rapilli, but also large blocks of a kind of porphyry, peculiar, as it would seem, to the products of the ancient volcanoes, of Monte Somma and of Rocca Monfina in the Neapolitan territory, and of Acquapendente and Viterbo in the Roman, characterised by crystals of leucite, which, at the spot now under consideration, are often of extraordinary dimensions, sometimes two inches and a half in diameter, and are accompanied by minute crystals of augite, both imbedded in a felspathic basis. As the felspathic portion was more readily decomposed than the imbedded crystals, these latter might often be detached from their matrix in a state of great integrity.

Near the little village of Tuoro de Sessa, which is situate very little below the external margin of the ancient crater, we observe a continuous bed of this leucitic porphyry, resting upon the tuff, and extending for some distance along a ravine which runs obliquely down the sides of the mountain. This was the only instance that occurred to me, in which the above rock appeared in any other form than that of detached blocks.

The most remarkable feature, however, in the physiognomy of this mountain, and that which distinguishes it from every other volcano I had seen, is the protrusion, from the interior of the crater, of a conical mass of rock resembling trachyte,* large enough to fill up two-thirds of the area comprehended within the walls of the crater, and so lofty as to rise considerably above the most elevated point in its margin; constituting, indeed, when observed from a distance, the most conspicuous object embraced within the compass of the mountain.

This trachytic rock is much more abrupt than the tuff

* See in Plate I. the section and ground plan of Rocca Monfina, the former reduced from a sketch taken by the artist who accompanied me on my visit to the mountain; the latter borrowed from a memoir by Professor Pilla, who, however, has represented the crater as though it were entirely effaced on the east, whereas it appeared to me there distinctly traceable, although, undoubtedly, much lower than it was on the west.

through which it appears to have been protruded. In its centre is a hollow plain, which may possibly have once been a kind of crater, as there are still on three of its sides points of rock that rise considerably above the central concavity, of which the highest was formerly marked by a cross; a circumstance which, as I have stated, served to give the name of Santa Croce to the entire mountain.

The rock is generally of a reddish-brown colour; its base sometimes gray, fine-grained, and compact, but not of very close texture, intimately interwoven with small felspathic portions, which frequently shew a glassy fracture, as if from fusion.

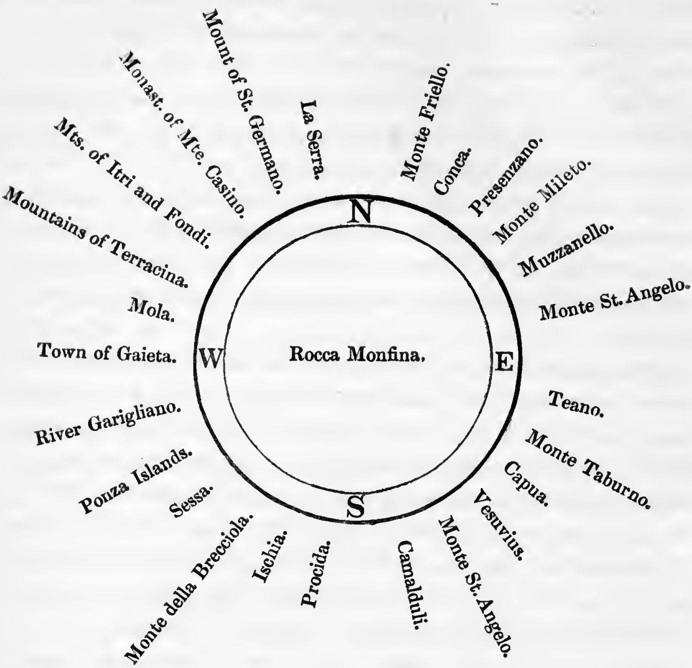
Much green augite, never, however, accompanied by even a trace of hornblende, penetrates the whole mass; and brown mica, generally in hexagonal tables, is a predominant ingredient. Abich regards the rock in the aggregate as forming a link intermediate between trachyte and greenstone.

Pilla informs us, that the summit of this cone is exactly equidistant from all parts of the crest of Monte Cortinella, the only portion of the original crater that stands absolutely intact, shewing, that it stands exactly in the centre of the inclosed area; a singular and improbable coincidence, unless it had upheaved the rest of the mountain, but one presenting no difficulty if we admit this supposition.

The rock alluded to, abrupt as it is, seems to be everywhere covered over with vegetation, and a fine chestnut forest occupies a considerable portion of its flanks.

From its summit the eye embraces, on the one hand, Mola di Gaieta, the range of mountains terminating in Cape Circello, and the whole extent of coast as far as Ischia and Vesuvius; whilst on the other, the line of the Apennines, including the monastery of Monte Casino, and other places built upon the slope of these mountains, appear conspicuous.

The artist who accompanied me executed, from this and other points of the mountain under consideration, a panoramic view of the whole circuit which the eye comprehends, of which the following ground-plan may serve to present some idea:



Now, the circumstance which, in a geological sense, attaches the highest interest to the structure of this mountain, is the support which it appears to afford to the *theory of elevation;* the view, that is, which regards volcanic mountains, as formed in the first instance by such a sudden upheavement as might have brought the masses of rock of which they consist, from a nearly horizontal position, into their present inclined one, and at the same time caused them to occupy a much higher relative level than they had done antecedently.

This view of the original formation of volcanic mountains has been maintained by some of the most distinguished of modern geologists; by Humboldt, by Von Buch, by Elie de Beaumont, by Dufrenoy, and by Abich.

But as it has met with able opponents, in Lyell and Scrope in this country, and in Mons. Prevost in France, it is satisfactory for those who adopt such a theory, to be able to justify their belief in it, by pointing out facts, which, like the *experimenta crucis* in chemistry, seem irreconcilable with any other hypothesis.

Of this description, as it appears to me, is the protrusion of a compact mass of trachytic rock through the centre of a mountain mainly consisting of materials so different from it, as leucitic porphyry and volcanic tuff; and its attaining, moreover, a height so considerable, as it has done, in the instance before us.

The first difficulty in the way of supposing it formed by the same operations as those which produced the mass of the surrounding mountain, arises from the constitution of its component parts, which is such as to imply a different origin for the two. Moreover, it may be remarked, that if the Monte della Croce had consisted of heaps of incoherent scoriæ, or of large fragments of slaggy lava piled one above the other, like the cone which is now forming in the centre of the crater of Vesuvius, its existence might then, indeed, have been explicable by an appeal to the everyday operations of which we are eyewitnesses in volcanoes now in activity.

Had it even formed part of a stream of lava, which might still be traced down the external flanks of the mountain, although we should have wondered at its ample dimensions, we might, nevertheless, have referred it to the same cause; but a conical mass of rock so considerable, and yet so completely circumscribed within the area of the crater, could only, as it would seem, have been brought into the position which it is seen to occupy, by being upheaved *all at once* from the interior of the globe, whilst in a semi-fluid or pasty state, but not in a condition of actual liquidity.

We have, therefore, before us an agent, which would not only be competent to uplift the surrounding strata of tuff, but which must necessarily have done so, if the latter had been, at the time of its eruption, in an horizontal position; and to suppose them gradually formed by successive showers of loose incoherent ejected materials, before the trachytic rock in its centre was protruded, seems to imply a forgetfulness of the height which the tuff has attained, and of the high angle at which its beds are inclined.

Alternating strata of tuff and lava may, indeed, be imagined to build up, in the course of time, a mountain of considerable elevation, but a hill consisting of tuff alone, as appears to be the case with a large part, at least, of Rocca Monfina, could only have attained its present height, which is at least 2000 feet above the sea, in consequence of some elevatory movement subsequent to its ejection ; and if this be admitted, we have before us, in the central trachytic rock of Monte della Croce, an agent calculated to cause such an upheavement, and itself hardly to be accounted for without such a supposition.*

I have not time at present to enter into the general discussion of the subject, and will, therefore, only allude to two facts relating to the volcanoes of Etna and Vesuvius, which seem to shew that even there, where analogy would most lead us to suppose that the whole of either mountain has been formed by a succession of the same ejections which are continuing to increase it, the stubborn evidence of facts compels us to adopt the elevatory theory.

The first of these facts is the circumstance so lucidly pointed out by Elie de Beaumont, and substantiated by him through a most laborious induction of particulars ; namely, that a stream of lava, having an inclination of more than six degrees, cannot form a continuous mass, and, therefore, that the upper portion of Mount Etna, which rises with an incli-

* Although Rocca Monfina presents the best instance with which I am acquainted, of a trachytic rock that has protruded through the centre of a crater, without forming a current of lava extending down the external slope of the mountain, yet we have something of the same kind in the crater of Astroni ; and on the road from Rome to Florence we may observe, near Rosciglione, in the Lake of Vico, the Lacus Cimini of antiquity, and an undoubted crater, a conical hillock rising from the centre, the real structure of which is concealed from the passing traveller by its being covered over with trees, but which may very probably be of similar formation.

Amongst extinct volcanoes, however, a still more striking parallel is presented in Auvergne by the Puy de Dome, a conical mountain consisting of that friable description of trachyte called domite, which rises from the midst of an amphitheatre of volcanic rocks of quite a different character from itself, and of a much darker colour from the intermixture of augite. See my work on Volcanoes.

nation of 29° and 30°, must have been produced in some other way.*

The second is the discovery of the same marine shells in the tuff of Monte Somma which exist in that of the Phlegrean fields;† seeming to shew that the former, as well as the latter, had once been under water, and, consequently, could only have attained its present elevation by being upheaved.

The reluctance, indeed, which certain eminent geologists in this country have evinced to the admission of this theory, seems to have proceeded from an undue reliance upon the truth of their favourite principle, that all the phenomena on the earth's surface, which geology has revealed to us, are brought about by a repetition of the same cycle of operations which we are eyewitnesses of at present—that in the natural, as well as in the moral world, there is a kind of circle of events continually reproducing each other, and bringing us back, after an interval of time, to our original starting place.

For my own part, I am inclined to think, that the analogy of the moral world might lead to more hopeful conclusions; the laws of matter, indeed, like the passions and capacities

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* See also Von Buch on Volcanoes and Craters of Elevation, Edin. Phil. Jour., vol. xxxv. for Oct. 1836.

† Professor Scacchi, in the Guida di Napoli (a valuable present made by the king of Naples to each of the Scienziati who attended the Italian Congress held at his capital in the autumn of last year), enumerates the following shells as existing amongst the erratic blocks of Monte Somma, some of which he states also to occur in the tuff of the same locality.

	Marl.	Limestone.		Marl.	Limestone.
Pecten Jacobæus, . . .	+	+	Cardium echinatum, . .	+	
——— varius, ...	+		——— tuberculatum, .	+	+
——— sanguineus, . . .	+	+	Volvaria triticea, . . .	+	
Ostrea cristata, ...	+		Buccinum mutabile, . .		+
Nucula margaritacea, . .	+		——— macula, . . .		
Mytilus, ...	+		Pleurotoma varia, . . .		
Solen legumen, ...		+	Scalaria communis, . . .	+	
Tellina donacina, . . .		+	Turritella communis, . .	+	
Tellina exigua, ...		+	Natica Valenciennerii, . .	+	
Erycina Renieri, ...		+	Dentalium dentalis, . . .	+	
Corbula nucleus, ...	+		——— coarctatum, . .	+	+
Mactra stultorum, . . .		+	Siliquaria anguina, . . .	+	
Venus exoleta, ...	+	+	Serpula cereolus, . . .		+
——— Chione, ...		+			

of man, have at all times, no doubt, continued the same; but it does not, therefore, follow, that the former may not have produced different effects in ancient times, by operating upon a different condition of the external world, and that the series of events which we witness at present must have taken place formerly, or will be repeated hereafter; any more than we need anticipate the recurrence of the same conditions of civil life which we read of in ancient history; or deny, that, in the midst of continual alternations of retrocession, as well as of advancement, the general tendency of human society is in the direction of progress.

Waiving, however, these general considerations, I will just point out certain facts, which seem to demonstrate that these geologists must, in spite of themselves, admit of processes, which, though all included under the general category of igneous operations, are, nevertheless, distinguished from those brought about by the influence of subterranean heat at the present time, and of which, therefore, they can have no actual experience.

Few of us in the present day will question the igneous origin of granite, and least of all those belonging to the school of geology to which I allude; it is impossible, indeed, to conceive in what manner the particles of silex, alumina, and alkali, composing this rock, could have been brought into such close juxtaposition as to be able to exert their mutual affinities, and to form crystals of felspar and mica, unless the mass had been in a state which admitted of a certain freedom of motion in its constituent elements, for which an approach to a state of fluidity seems absolutely requisite, whilst for this fluidity we know no other probable cause than heat.

Nevertheless, it is an undoubted fact, that, on the one hand, the igneous operations, whose effects we witness, have never been found to give rise to ejections of granite; and, on the other, that those extensive rock formations, apparently resulting from igneous processes, which, themselves destitute of all traces of organic life, lie at the base of those strata which contain the earlier manifestations of the same, and are, therefore, considered to have preceded them, never present to us the characters either of sub-aëreal or of sub-marine volcanoes, whether we regard their geological structure, and relations to other rocks, or their constitution, as determined by chemical analysis. For the first element in the consideration I would appeal to the testimony of Professor Keilhau of Norway, who, by a long series of elaborate observations, has at least succeeded in shewing the difficulties of identifying granitic rocks with modern igneous products; and I am happy to find Sir Roderick Murchison, in his recent work on Russia, adding the testimony of his extended experience to the soundness of those views with respect to the *primogeniture* of granite, which were prevalent in the earlier times of geology. For although its occurrence superimposed on secondary and even on tertiary strata cannot be denied, yet it does not therefore follow, that those extensive formations of the same kind which lie below the most ancient fossiliferous rocks are to be placed with them under the same category.

We may, therefore, appeal to the production of a granitic compound, as an example of a mode of igneous operation differing from any which we witness at present, and brought about under conditions which seem in the later periods of the earth's history to be, to say the least, but of unfrequent occurrence.

But this is not all, for by reference to the discoveries of modern chemistry we shall be enabled, if I mistake not, to trace a very beautiful series of transitions, by which the primeval granite has been converted, first into trachyte, and afterwards into the various kinds of lava, &c., which characterise modern volcanoes.

On this point I will enlarge a little, as a full explanation of it may tend to impart to you, as it has done to myself, clearer notions as to the real nature of the products which we are accustomed somewhat vaguely to designate under the names of granites, trachytes, and the like.

Ask, for instance, a geologist what he means by the term granite, and he will tell you that he understands an aggregate of three minerals, namely, quartz, mica, and felspar, in a state of intimate mixture.

But in order to learn what these several minerals really are, the chemist is the fittest person to be consulted; and from him we may collect, that quartz is nearly pure silex, coloured by indefinite, though minute, quantities of certain foreign matters, but that mica and felspar are definite compounds, formed of an acid and a base in exact atomic proportions. The same, indeed, applies to all crystallized minerals consisting of more than one ingredient, as was first laid down by the illustrious Berzelius—a generalization, by the by, which ranks, perhaps, next to the great Daltonian law of definite proportions, highest in the scale of importance amongst scientific truths of this class, and was arrived at by him at a time when so many difficulties lay in the way of its adoption, that we cannot sufficiently admire the penetration required for its discovery, as well as the boldness which he evinced in promulgating it. Indeed, until the celebrated Prussian chemist Mitscherlich had developed his original views on the subject of what he has called Isomorphism, we were stopped at the very threshold of Berzelius' theory, by finding the same mineral to contain, sometimes one base, sometimes another, without any other apparent limitation, except that the proportions they severally bore to each other should be as their atomic weights. Thus garnet might contain alumina, peroxide of iron, lime, magnesia, protoxide of iron, severally combined with silica, or any one or more of these bases might be absent, provided only there was one base with three atoms of oxygen combined with two of the negative element, and another with one atom of oxygen united with one of the latter, present in the compound.

The difficulty which this occasioned was, however, removed, when Mitscherlich had shewn that several bases admitted of being substituted one for the other without destroying the essential character of the crystallization, or producing any further change in it than a slight difference in the angle; the only necessary condition being, that each of the bases so replacing each other should contain an equal number of atoms of oxygen. Thus potass, soda, lime, magnesia, protoxide of iron, &c., may replace each other, as containing each an atom of oxygen to an atom of the radical present; as likewise may alumina, peroxide of iron, and peroxide of manganese, since they each contain three to two of base, so that the same mineral admits of a considerable diversity of composition, whilst still retaining its own peculiar crystalline form.*

But later researches have carried us a step further; they shew that crystallographers had often confounded several minerals which analysis proves to be distinct; thus Henry Rose of Berlin, and other chemists of the school of Berzelius, proved, that whilst one kind of mica contains a certain definite amount of potass, in another a portion of that base will be replaced by lithia, and in a third by magnesia.

In the two first, the mineral, when examined by polarized light, exhibits only one axis of double refraction, or one set of rings, whilst in the last it displays two such sets, so that the magnesian mica deserves to be distinguished as a separate species on crystallographical grounds alone.

In like manner, Henry Rose has asserted, on the faith of chemical analysis, that mineralogists had designated by the name of felspar several distinct substances, a statement which the more exact examination of their respective angles of crystallization has since shewn to be correct.

There is, indeed, such an analogy between them with respect to their chemical composition, as well as to their external characters, that they may, perhaps, be conveniently considered as merely different species of a genus to which the term felspar is applicable, the new terms which have been affixed to them by way of distinction being regarded as designating the species.

Thus the genus felspar may be defined as indicating a mineral, the primary form of which is an oblique rhombic prism, and its chemical constitution that of two compounds of silica united together; the first consisting of silica united with any base which contains only one atom of oxygen, the second compound of silica, one where that body is united to a base in which the proportion of oxygen to the radical is as three to two.

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* **Rammelsberg, a disciple of Rose, has proposed a chemical classification of siliceous minerals founded on this principle, which I shall give in the Appendix, as it seems to me the best attempt that has been made, to reduce to order the confused mass of species containing various proportions of those earths which mineralogy presents.**

But this definition gives scope for a considerable diversity of chemical composition, since silica is capable of entering into chemical union with bases in the proportion of one, two, and three atoms ; and, accordingly, I may enumerate the following species of the felspar family, as distinguished by Rose and his disciples. In this enumeration, however, I will endeavour to simplify the matter as much as possible, by pointing out, in the first place, merely the relation which the silica bears to the base which contains three atoms of oxygen to two of radical ; and, in order to avoid an inconvenient circumlocution, will speak of this base as though it were *in all cases* alumina, that being the negative element possessing the above composition, which is most commonly found in union with silica in this class of minerals.

In anorthite, then, and in labradorite, the silica is to the alumina in the proportion of atom to atom, the difference between these two minerals consisting, in the former being composed of three proportionals of this combination ; in the latter of only one.

In the andesin, or the felspar from the Andes, as well as in oligoklase, the silica is to the alumina in the proportion of two to one ; the difference between the two consisting in the proportion which the silica bears to the base with one atom of oxygen.

Lastly, in pericline, albite, glassy felspar, adularia, and orthoklase, the proportion of silica to alumina is as three to one, the largest amount in which it is capable of entering into chemical union with any base whatsoever.

The chemical differences between these four minerals consists in the nature of the base with one atom of oxygen united to silica, which it contains ; this in orthoklase is chiefly potass ; in albite wholly soda ; in pericline partly potass, but chiefly soda ; and in adularia chiefly potass, though a small amount of soda is also present.

Thus we have, in the felspar family, three several gradations in the proportion which the silica bears to the alumina with which it is combined, namely, one, two, and three atoms to one of base, as may be seen by the following table, for which I am indebted to Abich.

Tabular View of the Chemical Constitution, Specific Gravity, &c., of the Mineral Species comprehended in the Felspar Family.

Name.	Locality.	Sp. Gravity.	Principal Constituents.					Formula.
			Silica.	Alumina.	Lime.	Potass.	Soda.	
1. Anorthite	Monte Somma . . .	2·7630	43·79	35·49	18·93	0·54	0·68	$\dot{R}\,\dddot{Si} + 3\,\dddot{R}\,\dddot{Si}$
2. Labradorite	Mount Etna	2·7140	53·48	26·46	9·49	0·22	4·10	$\dot{R}\,\dddot{Si} + \underline{\dddot{R}}\,\dddot{Si}$
3. Andesin	Popayan, Andes . . .	2·7328	59·60	24·28	5·77	1·08	6·53	$\dot{R}^3\,\dddot{Si}^2 + \underline{\dddot{R}}\,\dddot{Si}^2$
4. Oligoklase	... ...	2·6680	62·61	24·11	2·74	0·75	8·99	$\dot{R}\,\dddot{Si} + \underline{\dddot{R}}\,\dddot{Si}^2$
5. Pericline	Pantellaria	2·6410	67·94 68·23	18·93 18·30	0·15 1·26	2·41 2·53	9·98 7·99	(5–7:)
6. Potass-albite	Drachenfels	2·6223	70·22	17·29	2·09	3·71	5·62	$\dot{R}\,\dddot{Si} + \underline{\dddot{R}}\,\dddot{Si}^3$
7. Albite	... ...	2·6140	69·36	19·26	0·46	?	10·50	
8. Ryacolite	Monte Somma . . .	2·6180	50·31	29·44	1·07	5·92	10·56	$\dot{R}\,\dddot{Si} + \underline{\dddot{R}}\,\dddot{Si}$
9. Glassy (or Soda) Felspar	Ischia	2·5970	66·73	17·56	1·23	8·27	4·10	(9–12:)
10. Adularia	St Gothard	2·5756	65·59	17·97	1·34	13·99	1·01	$\dot{R}\,\dddot{Si} + \underline{\dddot{R}}\,\dddot{Si}^3$
11. Orthoklase	Baveno	2·5552	65·72	18·57	0·34	14·02	1·25	
12. Artificial Felspar . .	Made at Sangershausen	2·5600	65·03	16·84	0·34	15·26	0·65	

N. B.—The first seven Species belong to the *ein und eingliedriges Krystallsystem* of Weiss, or the *anorthotype* one of Mohs, the axes of crystallization being unequal, and not mutually related: whereas the last five Species belong to the *zwei und eingliedriges System* of the former, and the *hemiorthotype* of the latter, two of the unequal axes bearing a certain relation to each other, so as to constitute a pair.

It is observable that the specific gravity of the mineral is, in these cases as well as in most other of the products of igneous action, inversely as the amount of silica, and directly as that of the other bases, so that a near approximation to their chemical composition may be often obtained by merely ascertaining their weight.

This, accordingly, is the method proposed by Abich, in order that we may appreciate the real mineralogical composition of a rock, in which the component parts are so blended together that it is impossible to separate one from the other for the purpose of examination.

In these cases the specific gravity will often give the proportion of silica, supposing iron and other of the heavier metals not to be present in quantity sufficient to affect the result; and from the proportion of silica the nature of the felspathic mineral present may be, in general, estimated with sufficient precision.*

Now, it is important to observe, that the kinds of felspar commonly found in granite are those which contain the largest proportion of silica, namely, either orthoklase, adularia, or albite. Where, as is often the case, orthoklase and albite are both present, the basis is generally composed of the latter, whilst the imbedded crystals consist of the former.

Such is the case at Carlsbad; and this fact affords, perhaps, the true solution of a question which I started in my

* Thus,

				Per Cent.
Trachytic porphyry, having a specific gravity of	2·5783	contains of silex		69·46
Trachyte,	2·6821	...	...	65·85
Domite,	2·6334	..	...	65·50
+ Clinkstone,	2·5770	...	...	57·66
Andesite,	2·7032	...	...	64·45
+ Glassy Andesite,	2·5851	...	...	66·45
Trachyte-dolerite,	2·7812	...	...	57·66
Dolerite,	2·8613	...	...	53·09

The only exceptions being clinkstone and glassy andesite, the former having the same composition as trachyte-dolerite, but an inferior specific gravity; the latter corresponding nearly with clinkstone in both these particulars. It is to be remarked, however, that clinkstone, although chemically resembling trachyte-dolerite, has a different mineral composition, for it appears to be a mixture of a zeolitic mineral with glassy felspar. Probably the same may apply to glassy andesite.

Report on Mineral Waters (British Association Reports, vol. v., 1836, p. 24), namely, why these and other thermal springs which issue from granitic chains, hold carbonate of soda in solution, but not carbonate of potass.

Now, by considering the nature of its felspathic material, it being one of those varieties of the mineral in which the silica is in the proportion of three atoms to only one of base, we may see the reason, why in granite a certain proportion of quartz, or uncombined silica, is almost universally present. Its amount, in fact, represents the excess of silica existing in the rock over and above that which could combine with the alumina; and hence it implies, that at the time, and at the place where the granite was formed, there was not a sufficient quantity present of the several bases to combine with the whole of the silica.

And if we examine the composition of the various rocks which have been produced by the operation of volcanic forces in ancient and in modern times, we shall be able to trace a gradual scale of diminution in the proportion of silica, and a corresponding increase in that of the bases present.

The first great division of them is comprehended under the name of trachyte, a general term for a class of rocks of igneous formation, characterised mineralogically by their harsh and gritty feel, together with the frequent presence of crystals of glassy felspar; and, chemically, as being trisilicates with or without an excess of silica.

They are divided by Abich, who follows in a great degree the classification of Beudant, into,

1. Trachytic porphyry, in which quartz is present, but neither hornblende, augite, nor titaniferous iron appear. It is found, not only in Hungary, but also in the Ponza, and in some of the Lipari islands.

2. Trachyte properly so called, in which no quartz occurs, but which contains crystals of hornblende and even of augite, together with mica.

3. Andesite, the trachytic rock of the Andes, described by Abich as being of various degrees of compactness and con-

sistency, possessing a coarse conchoidal fracture, and containing a large number of small white crystals, resembling albite, in a crystalline base of a darkish colour. Small crystals of glassy felspar are rare in this variety of trachyte, but those of hornblende are common, and augite is also present. It sometimes passes into greenstone or diorite.

Thus the rock composing the summit of Chimboraço, the basis of which resembles pitchstone, and which is destitute of hornblende, though rich in augite, is called by Von Buch an andesite. Antisana also, and Cotopaxi, are said to consist of the same; and it is probable that this rock, in connection with trachyte properly so called, constitutes the greater part of those volcanic mountains in South America which are destitute of craters.

4. Obsidian and pumice, which are so connected, both physically and mineralogically, that they must be placed under the same head, and regarded merely as expressions for two different conditions which the same original material has been made to assume, by the agency of volcanic forces. Both, indeed, have been regarded rather as particular states which many different minerals are capable of assuming, than as distinct species; but it is to be remarked, that simple silicates and bisilicates of alumina are incapable of assuming, either a vitreous condition, such as that of obsidian, or those cellular and filamentous forms which we observe in the different varieties of pumice.

It is necessary therefore that the rock should be rich in silica, or be a trisilicate; and hence, if with Abich we divide pumices into two groups, namely, into cellular and filamentous, the former being dark green, poorer in silica, and richer in alumina; the latter white, and containing more silica; we shall find that the former is derived from clinkstone, trachyte, and andesite, and the latter from trachytic porphyry.*

5. Pearlstone, a rock frequent in Hungary, and characterised by the presence of crystallites, or little globular concre-

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* For further remarks on the formation of obsidian and pumice, see Appendix.

tions more or less vitreous, and generally scaly, with a pearly lustre arising from the commencement of a kind of crystallization in the mass, or, where this is wanting, passing into a stony structure, or into a semivitreous one corresponding with that of pitchstone, which latter mineral seems to be nearly allied to it.

6. Trachytic tuff, the principal rock covering the Phlegrean fields, the analysis of which proves that it is, like pumice, only a metamorphosed condition of trachyte. Thus tuff, pumice, and obsidian, are all modifications of the same volcanic basis; and all, except obsidian, contain water chemically combined—yellow tuff three atoms—white tuff two atoms—pumice one.

Now lava, although commonly accompanied by abundance of steam at the time of its eruption, and containing, even for several months afterwards,* entangled within it a large quantity of aqueous vapour, holds no water in chemical combination, so that the fact stated with respect to tuff and pumice shews, that these formations have been placed under circumstances in some respects different from modern lavas.

We must, therefore, regard the three former as caused by water operating in a different manner from the steam which accompanies a flow of lava, inasmuch as the latter never contains any water in a state of chemical combination. All these varieties, then, of volcanic products, which Abich has classed under the general name of trachyte, approximate to granite, in the circumstance of containing a trisilicate of alumina or of some corresponding base, and hence may be supposed to be more immediately derived from the latter rock, than other igneous formations are. Nevertheless, in one variety of it, namely, in the species distinguished by Beudant as trachytic porphyry, quartz is present; and, accordingly, this modification would seem to present the nearest approximation to granite, the chief difference indeed between the two being the partial substitution of glassy felspar for ortho-

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* See my Memoir on the Eruption of 1834, in Ph. Trans. for 1845.

klase, minerals of analogous constitution, though of different external characters, and with different relative proportions of the two alkalies present in them.

In trachytes, properly so called, there would appear to have been such an accession of alkali and of earths, that the whole of the silica entered into combination, and consequently no quartz exists in the rock.

But when we proceed to the lava currents which have been emitted from actual volcanoes, or to the analogous trap formations which are regarded as the effects of submarine eruptions, we find a still further diminution in the proportion of silica, indicated by the substitution of labradorite for orthoklase, or, in other words, the presence of one atom of felspar instead of three, coupled with that of hornblende or augite,* in both which minerals the silica bears a still smaller proportion to the base with which it is combined.

In these last minerals two new elements also make their appearance, which are seldom or never present, except in small quantities, in granite or in trachyte—I mean lime and magnesia; thus evincing already a change, either in the nature of the igneous operations, or in the materials upon which they were exerted.

Thus the modern lavas of mount Etna have been determined by Löwe† to consist of an intimate mixture of labradorite and of augite; and a lava which had recently flowed from Stromboli was ascertained by Abich to possess the same composition.

Greenstone, or dolerite, is composed of nearly the same materials, its compactness being merely the effect of the

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* Hornblende is $\dot{R}\,\dddot{Si} + \dot{R}^3\,\dddot{Si}^2$, where $\dot{R}$ is generally lime, but sometimes protoxide of iron, or soda; and $\dot{R}^3$ is generally magnesia, but sometimes protoxide of iron. In some hornblendes the silica seems to be partially replaced by alumina. *Bonsdorff.* Augite is $\dot{R}^3$ Si², where $\dot{R}$ is either lime, magnesia, protoxide of iron, or protoxide of magnesia. The silica is sometimes replaced by alumina, as is the case also in hornblende. See Rammelsberg's Dictionary of Mineralogy, Berlin, 1841.

† Jameson's Journal, 1837.

greater pressure to which it was subjected during the act of cooling.

Abich, however, has found it necessary to distinguish a class of formations intermediate between trachytes and greenstones, which he denominates trachyte-dolerite. To this he refers the rocks which encircle the peak of Teneriffe, those of one of the volcanoes in Kamschatka, of the little cluster of islands between Lipari and Stromboli described by Hoffmann, and above all the material which constitutes the Monte della Croce, the central cone of Rocca Monfina already alluded to. Abich considers the felspar present in this rock to be oligoklase, which, by reference to the table, will be found to be a bisilicate, and the many green specks of augite which pervade it indicate a further change in the composition of the mass, and a nearer approach to greenstone. With this latter material, which, as we have seen, is a compound of augite with one of the species of felspar poorest in silica, the rock called basalt must not be confounded; as in it we may recognise a still further step in the elaboration of the constituents, this substance being composed of an intimate mixture of augite and magnetic iron with a mineral of the zeolitic family. The composition of the latter is such as to imply that it may have been formed out of labradorite with the addition of water, the presence of which in all zeolites is the cause of that bubbling up under the blowpipe which has occasioned them to be distinguished by that general appellation.

We perceive a similar change in the rock called clinkstone, which has been shewn by Gmelin to be an intimate mixture of glassy felspar with a zeolite.

Thus, as we proceed towards the more modern groups of volcanic formations, we find new ingredients successively coming into play; first, the alkalies increasing, then lime and magnesia becoming part of the constitution of the mineral mass, and, lastly, water entering into combination with the earthy materials.

The gradual increase of soda is likewise a remarkable circumstance, modern lavas appearing to contain a much larger quantity than the volcanic products of ancient periods, and hence various minerals being produced in which this alkali is predominant.*

These facts may, perhaps, suffice to shew, that the original material out of which volcanic rocks of whatever age have been elaborated, was of a granitic nature—a strong confirmation, as it appears to me, of the old opinion, that this rock stands lowest in the series of formations, and serves as the foundation upon which the rest repose.

The same circumstances may, likewise, be alleged as proofs that the igneous operations actually going on are, in many respects, different from those which produced the primeval granite; to which conclusion we shall also be led, by considering the differences that exist between the composition of the ancient volcanic products of the Monte Somma, and those resulting from the operations of Vesuvius at the present day.

Thus, if we go back to the period when the materials which constitute the tuff about Naples were ejected, we shall find that pumice was then one of the principal products; whereas it is now never found amongst the ejected masses at Vesuvius.

Now, pumice has been shewn to be merely an altered condition of trachyte, and not to be derivable from felspars so poor in silica as labradorite, or anorthite. Moreover, M. Dufrenoy has ascertained that the lavas of Monte Somma are almost unattackable by acids, whilst in those of Vesuvius the proportion of the soluble to the insoluble part is in general about as four to one. The former lavas contain a larger proportion of potass, whilst in the latter soda predominates.

It is also a well ascertained fact,† although disputed in an English work of authority, that this volcano was formerly

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* As Natrolite, Nepheline, Thomsonite, &c.

† For this I need not go further than the Guida de Napoli, already quoted, the geological portion of which was contributed by Professor Scacchi, a very accurate mineralogist, who has done a service to science, not only by the discovery of many new species at Vesuvius, but also by identifying several of those which Monticelli had created with substances previously discovered. From his enumeration of the minerals found about Vesuvius, it will be perceived, that, with the exception of felspar, augite, hornblende, and brieslakite, they all appear to be derived from the extinct volcano of Monte Somma.

much more prolific in minerals than it appears to be at present, very few, at least out of the large number of species, found within the range of Vesuvius existing in its modern lavas, whilst they abound amongst the ejected masses imbedded in the tuff of Monte Somma.

Having now endeavoured to trace the particulars in which the processes of an igneous character going on at the present day differ from those which gave rise to the rocks commonly called plutonic, I will next briefly consider which of the commonly received theories of volcanoes is most reconcilable with the phenomena which have just been pointed out.

I may remark, in the first place, that there are only two modes of explaining volcanic action, which deserve a moment's attention, when viewed by the lights of modern science.

One set of philosophers, inferring from the oblate spheroidal figure of the globe, that it was once in a state of fluidity from igneous fusion, and, again, presuming, from the increasing temperature observed as we descend deeper and deeper into its recesses, that it may retain enough of its heat at the present time to be preserved in a state of fusion below certain depths, propose a very simple mode of explaining the evolution of melted matter from volcanoes, by attributing it to the contraction of the crust of the globe upon its fluid contents, by which a portion of the latter is from time to time expressed at the points of least resistance.

Others, considering that all the matters ejected from a volcano contain an inflammable base united with oxygen—that the latter need not be supposed to have been present in the interior of the earth in quantity sufficient to combine with all the principles for which it could exert an affinity—and, therefore, that these bases may, without violence, be supposed to exist in an unoxidized state at a certain distance from the surface—have proceeded to shew, that, assuming such to be the fact, all the phenomena of volcanic action may be explained according to the received principles of chemistry, by the access, first, of sea water, and afterwards, of atmospheric air, to the interior of the globe.

For, granting that no other of the bases which enter into the composition of lava would inflame on the approach of water, the metals of the alkalies, at least, which constitute sometimes as much as one-tenth of the entire bulk of the ejected matter, would certainly do so, whence must result a considerable evolution of hydrogen, and a generation of heat sufficient to cause all the unoxidized substances in the vicinity to unite with the oxygen presented to them.

But, without entering into a complete exposition of this theory, I think it must on all hands be admitted, that if its relative merits are to be decided by its capability of explaining the phenomena, it may fairly claim the preference over the rival hypothesis.

If, indeed, we assume that the globe was once fluid, and take for granted that it still retains a sufficiently high temperature to preserve its original fluidity in the interior (although the slight depth to which we have yet penetrated hardly justifies us in speaking decisively as to the state of things which may exist below a certain depth), there is even then but one phenomenon of volcanic action, which, so far as I know, can be fairly deduced from these premises, namely, the protrusion in certain localities of melted matter from the surface. For the ejection of fragments of rocks, the evolution of steam, and the disengagement of various gaseous compounds, are phenomena of which this hypothesis seems to give no account. Nor does it seem clear, why the lines of least resistance should be found almost invariably near the sea, or why, indeed, they should occur at all underneath the bed of an ocean, where the controlling pressure must be even greater than it is in the midst of our continents.

Accordingly, most of those persons who profess to hold to the theory of central heat, in reality combine with it some hypothesis into which chemical considerations enter.

They explain, for instance, the evolution of steam, and of muriatic acid, by the access of salt water to the spots where this melted matter is supposed to exist, by the chemical action of which the muriatic acid is separated from its base, and the water converted into steam.

By this addition to the theory, we advance, indeed, one step towards the solution of the problem; but there will still, I conceive, be a difficulty in explaining other of the connected phenomena: such, for example, as the generation of ammonia, which so often is present amongst the products of a volcano; the evolution of air usually deprived of its oxygen, which bears witness to the existence of some processes of oxidation going on underneath; and, above all, the escape of inflammable gases, into which hydrogen enters as a constituent.

With regard to the first of these facts, the generation of ammonia cannot be disputed, although the amount formed by volcanic action may still remain a matter of surmise.

Those, however, who, with Baron Liebig, deny that gaseous nitrogen is capable, on the surface of the earth, of forming any direct combination with hydrogen,* may be less inclined to condemn the hypothesis, with reference to this subject, which I have thrown out in a former publication,† and which assumes, that the quantity so formed was once very considerable, as it traces to volcanic processes carried on in the interior of the globe all the ammonia which would be requisite for supplying the first plants with the nitrogen they must have contained; just as others have imagined all the carbon necessary for the primeval vegetation to have been derived from carbonic acid arising from the same internal source.

At least, however, even those who refuse to go with me up to this point, will admit, on the faith of the evidence which I have adduced, the second fact noticed, namely, the extrication of nitrogen gas, either pure, or with a small admixture of oxygen, from thermal springs in general; since, amongst

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* In confirmation of this, it may be stated, that I have vainly attempted to form ammonia by decomposing water in an atmosphere of nitrogen gas, through the agency of a metal like potassium. Yet these two elements unite readily when *both* are in a nascent state, as in the common experiment of producing ammonia by the action of diluted nitric acid on powdered tin. Hence it may be inferred, that, under a high pressure, such as may exist in the interior of the globe, a union between these two elements would take place.

† Three Lectures on Agriculture, page 97.

the whole extensive catalogue of those* cited as having been personally examined by myself, in various parts, both of the Old and New World, scarcely one could be fixed upon which does not present this phenomenon, excepting, indeed, a few in the island of Ischia, the origin of which is manifestly nothing else than the rain water, which had collected in internal reservoirs at a small depth beneath the surface, and had then become heated by the rock, still partaking of the high temperature it had acquired by recent volcanic operations.

And, with respect to the last fact mentioned, it is one so inexplicable by the mere access of water to an incandescent body, already saturated with oxygen, such as lava, that the opponents of the chemical theory have no other resource than to deny its reality.

"If inflammable gases were present," they say, "they would burn on coming into contact with the air; and hence flames would be commonly seen issuing from the orifices of an active volcano.

"But the appearances which have been taken for flames turn out to be illusory, being due merely to the light radiated from the red-hot stones ejected, and not derived from gaseous matter in a state of combustion."

Now, that flames should not be of ordinary occurrence in volcanoes, may be explained without much difficulty.

In the caverns and fissures through which the gases evolved had to pass before they reached the circumference of the earth, and escaped from the orifice of the volcano, they must often come into contact, either with oxygen, or with oxidized bodies, from which they would be able to abstract the same principle. In both these cases, the hydrogen would recombine with oxygen, and return to the focus of the volcano, as water.

But supposing oxygen gas to be absent, or not to exist in sufficient quantity to unite with all the inflammable matter evolved, the latter would, in most cases, be accompanied with

* See, for those in the Old World, Report on Mineral Waters, Br. Associat. Reports for 1836; for those in the New, my Sketch of the Geology of N. America.

such volumes of steam, as alone must prevent it from entering into combustion when it came into contact with the external air; for it is well known, from the researches of Davy, that a certain per-centage of any uninflammable gas or vapour prevents such bodies from taking fire.

It is, therefore, far more easy for the advocates of the chemical theory to account for the general *absence* of flames about the orifices of active volcanoes, than for the supporters of the contrary hypothesis to explain their occasional *presence;* and that they are sometimes observable seems to be now ascertained, not only from the testimony of Sir H. Davy himself, who states that he observed at Vesuvius, during a small eruption, the existence of a real jet of flame, and that of M. Elie de Beaumont, who assures us of the same fact, as witnessed by himself at Mount Etna, but more recently by the observations made by Professor Pilla of Pisa,* who has given us a circumstantial account of three several occurrences of this kind in the years 1833 and 1834 at Vesuvius.

My own persuasion, therefore, is, that hydrogen gas, derived from the decomposition of water, most generally in combination with sulphur, is evolved in enormous quantities from all volcanoes, but that a comparatively small proportion of it usually finds its way upwards to the surface: since, if sulphurous acid be present likewise, the two gases will decompose each other, so that only the excess of the one most abundant will remain, and if it meet with oxygen in its progress upwards, it will combine with this principle, and water will consequently result.

Nevertheless, I hold that the sulphuretted-hydrogen which impregnates the mineral waters in various ignigenous, and even in certain primary districts, is derived from some volcanic *focus;* I am inclined to believe, that the beds of sulphur met with in various parts of the world, where igneous agents have been at work, as in Sicily, owe their origin to the decom-

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* See his "Discorso sopra la produzione delle fiamme nei Vulcani, &c.," read at the Fifth Italian Scientific Congress, held in 1843, and translated in Jameson's Journal for April 1844.

position of sulphuretted-hydrogen disengaged from the same source; and conclude, therefore, that it is not unfrequently evolved from the orifices of volcanoes, although, for the most part, prevented from inflaming by the large intermixture of aqueous vapour which usually accompanies it.

But without entering at this advanced period of the evening into a general discussion of the question, I will merely point out to you, how completely this theory squares with the manner, in which I have shewn the several products of volcanic action to be successively produced from the constituents of granite.

We have seen that these changes of form and structure have been produced by the addition of lime, magnesia, potass, soda, oxide of iron, water, &c., to the mica, quartz, and felspar, present in the original material.

Now it is evident that, besides the water, only one of these bodies, namely, the soda, could have been supplied in sufficient quantities by the sea; the access of which to the focus of the volcano there are so many reasons for supposing an immediately exciting cause of the operations we witness. Is it not, therefore, reasonable to suppose the other constituents to have existed in their unoxidized state below, and thus to have contributed, by their subsequent oxidation, to the production of the high temperature, as well as to the generation of those inflammable gases which arise during the process?

Again, it is not an unimportant circumstance to remark, that the iron found in lavas and in trap is usually magnetic, or partly in the state of protoxide; whilst in granite it exists wholly as a peroxide. May not this partial change from peroxide to protoxide be brought about by the action of the hydrogen disengaged, and does not the presence of protoxide of iron sufficiently explain, why none of the more oxidizable metals are even found in lava, except saturated with oxygen? *

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* This is alleged by Dr John Davy, as a circumstance which operated on his brother's mind in inducing him, towards the close of his life, to abandon the chemical theory. I cannot, however, agree with him in thinking, that the presence of potassium, sodium, or even calcium, amongst the ejections of a volcano, ought to be expected according to the conditions of this hypothesis.

These considerations, if they do not persuade you of the truth of my hypothesis, may at least plead my excuse for having ventured to maintain it, even though it be one which seems to have been repudiated by Sir H. Davy, and which a geologist of reputation once, I think, stigmatized, by designating it as *smelling of the laboratory.*

With respect to the former ground of discouragement, I have already given my reasons for not regarding it as absolutely fatal; and with respect to the latter, as we all, I hope, in the nineteenth century, are aware, that modern chemistry is not confined within the limits of the apothecary's shop, I consider it the highest testimony in favour of any geological theory, to be able to say of it, that it has been submitted to the severe ordeal of chemical investigation, and has not been found wanting.*

In conclusion, then, I will remark, that my visits to Naples have afforded me the materials for laying before you, on this and on two former occasions, a sketch of the phenomena presented by the three great volcanic systems which exist within the compass of that territory, and thereby, as it so happens, exhibiting a picture of as many different phases or conditions of igneous action, exemplified in the localities which I have successively brought to your notice, namely, in the country immediately round about Vesuvius, at Mount Vultur, and at Rocca Monfina.

The first of these localities exhibits, no doubt, the most

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* On this subject, however, it behoves me to speak with some diffidence, when I see the contrary maintained by so eminent a chemist as Professor Bischof of Bonn. All I can say is, that the objections he had originally put forth to this hypothesis have been answered, in a manner which, to my mind at least, appeared satisfactory, in Jameson's Journal for April 1839. The Professor, however, having, in his memoir on the Natural History of Volcanoes and Earthquakes, published in the very same number of that Journal, reiterated some of these, and added a few other remarks, I will refer to the Appendix for a statement of the grounds on which I conceive my original views to remain still unshaken; although it may be suggested, that the Professor's remarks referred to must, from their date, have been written before he could have seen my reply to his original memoir. *See Appendix.*

striking, the most varied, and, perhaps, altogether the most instructive series of phenomena; inasmuch as it has constituted a permanent vent for the products of the chemical actions going on in the interior of the globe, ever since the cessation of those kindred phenomena which we read of as having been displayed formerly within the compass of the Phlegrean Fields, and which had rendered that district an object of terror to the early Greeks,—invested their inhabitants, the Cimmerians, with a kind of vague and mysterious awe,—and led the poets to place the entrance to the infernal regions amongst their caves and forests.

But our knowledge of the subject would be incomplete, if we did not extend our observation to such mountains as Mount Vultur and Rocca Monfina.

In the former of these we perceive a volcano which was extinguished, as it were, by the very throes that accompanied its birth; for the volcanic energy which heaved up the materials of which the mountain is composed, and produced a crater in the midst of it, seems to have been expended in that very effort, and never afterwards to have exhibited any signs of vitality, either by emitting streams of lava or ejections of scoriæ.

It is an example, therefore, of a simple crater of elevation, not converted, like Vesuvius, into a permanent volcano, by having become the vent for successive eruptions of igneous matter at any period subsequent to its formation.

In Rocca Monfina, on the other hand, we are enabled to observe the precise agents which Nature calls into operation, for the purpose of elevating volcanic hills in general, whether the latter be destined to remain merely as monuments of what she had accomplished at a distant period of time, or to serve likewise, in after ages, as chimneys for her subterranean laboratory—the trachytic rock of Monte della Croce being here seen actually protruding through the crater, in the centre of the mountain, which it no doubt contributed to upraise.

Rocca Monfina also appears to have given off one, if not two, streams of lava; but the volcanic processes would seem to have soon been transferred to some other quarter, as, from a period long antecedent to historical records, it has sunk into complete inactivity.

Thus we observe, in these three mountains, three successive developments of volcanic activity evinced,—

1*st*, In the elevation of an entire mountain.

2*d*, In this elevation being accompanied by the protrusion of a trachytic rock through its centre.

3*dly*, In the elevation of a mountain being followed, after a long interval of apparent tranquillity, by the establishment of a permanent vent, through which lavas, fragments of rocks, and elastic vapours, continue from time to time to be discharged.

All these, however, are derived from subaëreal volcanoes, having been formed on dry land, under no greater pressure than that of the atmosphere, and are, consequently, of later date than the beds of tuff which are spread on all sides around them, the latter being products of the action of volcanoes which existed when the country was yet under the bed of the Mediterranean, and, consequently, being modified in their characters and structure, by admixture with the sea-water in which they appear to have been deposited.

APPENDIX I.

Appendix I.

Rammelsberg's Classification

Definition of the Classes.	Symbols representing the Class.	Subclasses.
1st Class. Silica alone	$\dddot{Si}$	Without water With water
2d — Silica united with a single Base, having 1 Atom of Oxygen .	$\dddot{Si}\,\dot{R}$	Without water With water
3d — Silica united with a single Base, having 1½ Atoms of Oxygen	$\dddot{Si}\,\underline{\dddot{R}}$	Without water With water
4th — Silica united with several Bases, all with 1 Atom of Oxygen	$\dddot{Si}\,\dddot{R} + \dot{Si}\,\dot{R}$	Without water With water
5th — Silica united with several Bases, all with 1½ Atoms of Oxygen	$\dddot{Si}\,\underline{\dddot{R}} + \dddot{Si}\,\underline{\dddot{R}}$	Without water With water
*6th — Silica united with several Bases, both with 1 and 1½ Atoms of Oxygen	$\dddot{Si}\,\dddot{R} + \dddot{Si}\,\underline{\dddot{R}}$	Without water With water . Without water With water
7th — Silicates united with Aluminates	$\dddot{Si}\,\dot{R} + \underline{\dddot{Al}}\,\dot{R}$	. . . . . .
8th — Silicates united with other salts	. . . .	With Sulphates With Fluorides With Borates

* As the minerals comprehended under this class are numerous, the subclasses are again subdivided according to the proportion which the silica in each of the two binary compounds of which the mineral consists, bears to the bases with which it is united.

Thus the subclass without water is divided as follows:

1st Division. Both Silicates neutral—example, Albite.
2d — One Silicate neutral; with one ⅔—example, Spodumene.
3d — One Silicate neutral; with one ⅓—example, Ryakolite.

to page 231.

of Siliceous Minerals.

Examples of the Class and Subclass.	Symbol of the Mineral.
Quartz	$\dddot{Si}$
Opal	$\dddot{Si} + \dot{H}$
Tablespar	$\dot{Ca}^3\ \dddot{Si}^2$
Meerschaum	$\dot{Mg}\ \dddot{Si} + \dot{H}$
Cyanite	$\underline{\dddot{Al}}^2\ \dddot{Si}$
Kaolin	$\underline{\dddot{Al}}^3\ \dddot{Si}^4 + 6\dot{H}$
Augite	$\dot{R}^3$ (viz. $\dot{Ca}$; $\dot{Mg}$; $\dot{Fe}$; $\dot{Mm}$) $\dddot{Si}^2$
Apophyllite	$\dot{R}^3\ \dddot{Si}^4 + 6\dot{H}$
Beryl	$\dddot{Be}\ \dddot{Si}^4 + 2\underline{\dddot{Al}}\ \dddot{Si}^2$
Bole	$\dddot{R}^2 (\underline{\dddot{Al}}; \underline{\dddot{Fe}})\ \dddot{Si}^3 + 9\dot{H}$
Felspar	$\dot{R} (\dot{K}; \dot{Na})\ \dddot{Si} + \underline{\dddot{Al}}\ \dddot{Si}^2$
Garnet	$\dot{R}^3 (\dot{Ca}; \dot{Mg}; \dot{Fe}; \dot{Mn})\ \dddot{Si} + \underline{\dddot{R}} (\underline{\dddot{Al}}; \underline{\dddot{Fe}}; \underline{\dddot{Mn}})\ \dddot{Si}$
Mesotype	$\dot{R} (\dot{Ca}; \dot{Na})\ \dddot{Si} + \underline{\dddot{Al}}\ \dddot{Si} + 3\dot{H}$
Cross-Stone	$2\dot{R}^3 (\dot{Ba}; \dot{K})\ \dddot{Si}^4 + 7\underline{\dddot{Al}}\ \dddot{Si}^2 + 36\dot{H}$
Grenatite	$3\underline{\dddot{Al}}\ \dddot{Si} + \dot{Fe}^3\ \dddot{Al}^2$
Hauyne	$Ca^3\ \dddot{Si}^2 + 3\underline{\dddot{Al}}\ \dddot{Si} + 2\dot{K}\ \dddot{S}$
Lepidolite	$4\underline{\dddot{Al}}\ \dddot{Si}^2 + K\ Fl^2 + 2\ Li\ Fl$
Tourmaline	$\dot{R}\ \dddot{B} + \underline{\dddot{Al}}\ \dddot{Si}$

4th	Division.	Both Silicates $\frac{2}{3}$—example, Leucite.
5th	—	One Silicate $\frac{2}{3}$; one $\frac{1}{3}$—example, Scapolite.
6th	—	Both Silicates $\frac{1}{3}$—example, Epidote.
7th	—	One Silicate $\frac{1}{3}$; one $\frac{1}{6}$—example, Lievrite.
8th	—	One Silicate $\frac{1}{2}$; one $\frac{1}{3}$—example, Nepheline.
9th	—	Both Silicates $\frac{4}{3}$—example, Petalite.
10th	—	One Silicate $\frac{4}{3}$; one $\frac{1}{3}$—example, Murchisonite.

The same is the case with the subclass containing water.

Appendix II. (Page 236.)

Abich's Observations on the formation of Obsidian and Pumice.

The mode in which pumice and obsidian have been formed, can only be cleared up, through a more exact scrutiny into the nature of the volatile materials which both these bodies, in greater or less quantity, contain. Humboldt and others have remarked upon the swelling out which certain obsidians undergo at a white heat, and have found a great difference, in this respect, to exist between specimens taken from different localities.—Abich has further ascertained, that the poorer in silica, and the richer in alkaline bases obsidian is, the more, in short, its composition approaches to clinkstone, the more readily it may be made to pass by heat into the condition of pumice.

It being admitted that the immediate cause of the change is the extrication of some volatile principle, the nature of this latter becomes the next subject for inquiry.

Abich found, that, in order that the mineral should swell out into a porous mass, it must be submitted to heat in lumps; for, if it be in powder, it does not undergo any such tumefaction by exposure to a high temperature, but only changes to a dark red or brown colour; losing, during the process, twice as much weight as the same had done in lumps; from which it would appear, that only a portion of those volatile ingredients which escape from the powder is, in the former case, disengaged.

By comparing the analysis of obsidians with that of pumices obtained from the same locality, it would appear, that although the sum of the alkaline bases is in both very nearly the same, yet that there is more potass in obsidian, more soda in pumice,—the increase in one alkali corresponding with the deficiency in the other.

This might lead one to conjecture, that, during the formation of pumice, a certain amount of potass was dissipated, and a proportionate quantity of soda introduced from without, and that, from the disengagement of the former, the cellular condition of the mineral might have resulted.

It will be readily supposed, that both obsidians and pumices are often very widely different one from the other in their constitution, and that amongst the latter the darker and more cellular varieties may arise from a predominance of earthy and alkaline bases, the white and silky-looking kind from a larger amount of silica.

When felspathic rocks, rich in alkali, pass into a state of fusion in the presence of some earthy base, the latter displaces a portion of the alkali, and thus causes the mass to swell out.

It is worthy of remark, that chlorine and water are present in all pumices and obsidians, and that, from many, certain inflammable gases are also disengaged. This latter fact, indeed, has led some chemists to imagine, that the cellularity of pumice may have been caused by a disengagement of carburetted hydrogen, derived from the bitumen which Knox discovered in certain obsidians; but this cannot be the case, as the presence of bitumen is an exception rather than the rule. It is more probable, that the formation of pumice is connected with the disengagement of chlorine, derived from sea-salt, which may be decomposed by the heat, its soda being seized upon by the mineral, and entering, as before explained, into its composition.—A portion of this chlorine, however, adheres most tenaciously to the mineral mass, which is proved by the fusion of pumice into glass, as even then it retains a portion of this volatile ingredient. With respect to obsidian, Abich conceives, that the greater and more continued the pressure to which the melted material has been subjected may be, the greater tendency will be shewn by the mass, both to assume a stony rather than a vitreous texture, and to form definite and distinct minerals, rather than one homogeneous amorphous compound. Hence from the same material lithoide lavas may be produced under pressure, vitreous ones in the open air.

Appendix III. (Page 247.)

On the Chemical Theory of Volcanoes.

Professor Bischof justly observes, " that the close connection between volcanoes and hot springs would lead us to refer both to the same cause." " But," he continues, " thermal springs are too universally distributed to be accounted for by chemical processes going on in the interior of the globe. They seem to occur everywhere where the water rises from a great depth. They must, therefore, be attributed to the high temperature which generally pervades the interior of the globe."

To this I would reply, that no one questions that the high temperature of a spring is acquired immediately from that of the rock from whence it proceeds, or supposes the rock, when it lies at a distance from any volcano, to derive its heat from chemical processes taking place within itself. From a mineral mass so circumstanced, as well as from a water simply thermal, we can collect nothing which should lead us to give the preference to either theory; it is only from analogy, that the heat either of the one or of the other can be explained. But more commonly, hot springs, like volcanic eruptions, are accompanied with other products, which seem to imply the existence of chemical action; hot springs, for instance, with carbonic acid, sulphuretted-hydrogen, and azote,—ejections of lava, with steam, muriatic acid, sulphuretted-hydrogen, and ammonia. The carbonic acid, indeed, might be evolved from limestone, owing to the mere access to it of heat; but I cannot agree with Professor Bischof in attributing the sulphuretted-hydrogen to a decomposition of sulphates by organic matter. Sulphuric salts do not occur in the majority of these springs, and the small quantity therein existing of baregine (the only organic matter which is present) appears to be generated after the water has reached the surface. Neither can the almost constant escape of azotic gas be accounted for, without supposing some process of oxygenation to be going on in the interior.

Now these springs usually make their appearance, where other evidences of volcanic action are exhibited, in the dislocation and elevation of the surrounding strata; and the latter phenomena occur so extensively over the earth's surface, that volcanic operations, if assumed to be their cause, may have been widely enough distributed to produce a general increase of temperature throughout that zone in the interior of the globe in which they are carried on. What may be the condition of the earth lower than this, we surely have no data for ascertaining; for it is evident that, if this supposed zone lie below the level which mining operations have reached, it would itself elevate the temperature of all those portions of the earth's crust of which we have any cognizance.

I am, however, unwilling to dogmatize, either with respect to the general cause of the internal heat of the globe, or the limits to which this heat may be confined.

All that I have ever sought to prove is, that, be the existence of a central heat ever so well established, its assumption does not advance us towards the explanation of the phenomena, either of volcanoes, or of thermal springs in general, and that a process of oxidation is going on, often with intense energy, in the interior of the globe, of a different nature from that usually occurring on the surface, as being attended with an evolution of hydrogen gas, a phenomenon which can be most readily explained by the decomposition of water, through the action of the metals of the earths and alkalies upon that liquid.

I would finally remark, that Professor Bischof will find his objection to the supposed existence of these bases in the interior of the globe, arising from their low specific gravity, answered by anticipation in my Reply to his former paper, as I have there shewn that the specific gravity of one hundred parts of the metallic principles present in a mass of ordinary lava, would be quite as considerable as that of the same amount of these same bodies united with oxygen, so that the difficulty, be it small or great, which attends the fact of the high specific gravity of the globe, as compared with that of the materials composing its surface, is the same to those who reject my hypothesis, as to those who embrace it.

Lest, however, it should be imagined that I have attached an undue weight to this theory, or have done more than to advocate it as the most plausible account that can at present be given of the facts before us, I will, in conclusion, extract the remarks which I made, nearly ten years ago, in my Report on Mineral and Thermal Springs, undertaken at the request of the British Association.

" We ought carefully to distinguish between that which appears to be a direct inference from observed facts, and what at most can 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, which establish in my mind a conviction that water finds its way to the seat of the igneous operations, almost as complete as if I were myself an eyewitness 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 to volcanoes 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 extracting oxygen from water as well as from air; and this leads us to speculate on the bases of the earths and alkalies as having caused 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 phenomena, but also known to have a real existence; which latter circumstance cannot, of course, be affirmed of the alkaline and earthy metalloids, as occurring in the interior of the earth."

Miscellaneous Observations, chiefly Chemical. By JOHN DAVY, M.D., F.R.S., Lond. and Edin., Inspector-General of Army Hospitals. Communicated by the Author.

1. In experimenting upon a siliceous sand from Mahaica, in British Guiana, coloured reddish-brown by peroxide of iron, I perceived that it was rendered almost black by the application of heat, even of a moderate degree. The effect was well shewn by heating the sand either on a thin plate of glass or in a platina capsule. The change of colour was distinct, when the temperature, it may be conjectured, was very little above the boiling point of water, and seemed to be at its maximum before it attained a dull-red heat. On placing the heated capsule suddenly in water, so as to reduce its temperature rapidly, a rapid lightening or brightening of the colour appeared, making a pretty experiment.

The peroxide of iron, colouring the sand, was in the state of impalpable powder, merely adhering to the siliceous sand, which was in the form of grains of transparent colourless quartz, most of them rounded, having been water-worn: such was their appearance under the microscope.

I did not think it necessary to make the experiment on the change of colour out of the influence of atmospheric air, taking it for granted that oxygen was in no wise concerned in producing the change; and that this is another instance (if it has not been noticed before) of change of colouring depending on change of temperature, and independent of any change in the chemical composition of the substance exhibiting it.

Trials made on soils of excellent quality,—dark mould containing very little vegetable matter,—have shewn the same change of colour from change of temperature, as the coloured sand just mentioned.

These instances seem deserving of being kept in mind in conducting the examination of a soil containing iron,—a common ingredient of soils, and in the state of peroxide. Mere blackening of such a soil should not be considered a satisfactory proof of the presence of vegetable matter. More decisive proof should be required, afforded by the smell on the first application of heat, and by comparison of colour before and after a sufficient application to destroy any vegetable matter which may be present.

2. When iron is precipitated by ferrocyanide of potassium in a solution containing alumina, and the latter, without separation of the precipitate by filtration, is thrown down by ammonia, the colour of the first from blue becomes brown, as if originally precipitated by ammonia. Now, after having been well washed, after having been collected in a filter, if sulphuric or any other mineral acid be added, the mixed precipitate will acquire a blue colour; and it is surprising how long after repeated washings it retains this property, gradually, however, diminishing in intensity of colour.

Other instances might be given of the power of precipitates to retain a portion of another matter, existing in the solution from which they have been thrown down. I shall mention one only in particular. It occurred in examining cane-ashes obtained by burning the dried sugar-cane (after the expression of its saccharine juice), under the copper-pans in which the juice is evaporated, in the common process in use in the West Indies of making Muscovado sugar. After the ash had been acted on by an acid, ammonia was added to the solution formed. Owing to the presence of a little oxide of copper derived from the pans, the copious precipitate produced, consisting chiefly of phosphate of lime, was coloured bright-blue, as was also the solution after the addition of the volatile alkali. Repeated washings of the precipitate, as in the former example, only very slowly diminished the intensity of its colour; and after such washing, and standing covered with water at least a fortnight, the precipitate continued coloured faintly blue, the supernatant incumbent water being colourless.

Do not such facts as the preceding, of the retention of colouring matter by certain precipitates, help to explain how particular minerals are coloured, as opalite blue, imbedded in colourless dolomite, and the various colours of quartz and of the oriental aluminous gems, some, at least, of which we know to be formed contemporaneously with the colourless rock above mentioned? In accordance with this, I may mention, that carbonate of lime, when precipitated, as in the instance brought forward of phosphate of lime, from a solution containing a little copper, does not attach to it the colouring matter,—a single washing on a filter is sufficient to render it colourless.

The same facts regarding the retention of one substance adhering to the particles of another, shews the necessity of great caution in deciding that a precipitate is pure, and free from any of the fluid medium in which it has been thrown down. In the instances noticed of the adhesion of one to another, the precipitates were not only washed repeatedly in a filter, but were also taken from the filter repeatedly, and agitated in large quantities of water.

3. So delicate is the sense of touch, that it may be employed advantageously as an aid in chemical research. There are fine clays and sandstones, very compound, and formed of minute particles derived from disintegrated rocks. In the

examination of these, even with the aid of acids and the microscope, it is sometimes difficult to determine whether they contain silica or not. In such instances, the aid above mentioned may be had recourse to with advantage. If a little of the clay or sandstone, in fine powder, as abraded by a knife, be placed on a slip of glass, and gently touched—slightly rubbed with a rod of glass, its end somewhat rounded and perfectly smooth—a peculiar harsh sensation will be imparted to the fingers holding the rod, very characteristic, and, after a little experience, not to be mistaken. This test of silica, in a state of fine division, or of minerals as hard, in a finely divided state, may be useful to the inquiring traveller, a slip of glass and a small glass rod being, with water, all that is required. Provided thus, the geologist may in an instant determine, with tolerable accuracy, whether such finely-divided silica or hard mineral enter into the composition of the matter examined, even though in the form of delicate silicified infusoria, microscopic objects, such as occur in chalk in some situations, and which, to be distinctly seen, require to be exposed to a high magnifying power.

4. Tin, when precipitated from a saline solution by means of a carbonated alkali in the state of carbonate of lime, adheres in part to the sides of the glass vessel in which the precipitation is made. If minutely observed, it will often be found that the precipitate adheres more firmly in some places than in others; and if a slip of glass be immersed when the precipitation is taking place, it will be found that one of its sides is more coated than the other, and that on the side on which there is most precipitate, there it adheres much more firmly than to the others; from one side the carbonate is easily removed, from the other with difficulty. On both sides the precipitate, when examined by the microscope, is found in the form of crystals, and most generally rhomboidal.

Do not the facts mentioned tend to shew, that in this instance an influence is exercised analogous to that of electrical polarity? And, is not the property thus displayed of carbonate of lime so adhering to glass, that quality on which its efficacy as a cement depends? Precipitated from seawater by the separation of the carbonic acid by which it was held in solution in the sea, owing to the higher temperature of the shores, and the agitation of the breaking waves, it constitutes the cementing principle of all the sandstones now in the act of forming at the sea-margin in various regions. Absorbing carbonic acid slowly from the atmosphere when lime is mixed with siliceous or shell sand, and properly moistened, it appears to operate in the same manner in forming in time a mass of stony firmness. When a foreign substance is not present, and hydrate of lime is converted into carbonate by the absorption of carbonic acid, then it appears to form a soft little cohering mass of granular particles resembling chalk. I have found instances of the kind in the pure lime-mortar used in the Coliseum, and in the walls of ancient Thebes in Egypt. Whilst the mortar, a mixture of lime and sand, employed in the rubble work, of which the Coliseum —a combination of arches consists—is now hard as stone, this pure mortar, consisting only of carbonate of lime, used as a cement for the facing stones of the building, is as soft as chalk; and the same remark applies to the pure mortar similarly used at Thebes.

5. In examining specimens of manures offered for sale as guano, it is desirable to have a ready test of sulphate of lime by which it may be distinguished from the phosphate. The insolubility of the latter in water, and the moderate degree of solubility of the former, are certain criteria. Some time, however, is necessary to witness the effect in a satisfactory manner. To obviate delay, I find the following process to answer well. After well washing the sample under examination, to remove the more soluble salts, distilled or rain water is to be poured on the residue, and a minute or two after a few drops of the solution of oxalate of ammonia are to be added; if sulphate of lime is present, a cloudiness will be perceived apparently rising from the bottom, the cause of which requires no explanation.

6. Ammonia, as it is well known, precipitates from an acid solution several substances, as alumine, magnesia, phosphate of lime, phosphate of magnesia. The appearance of the precipitate indicates tolerably its nature, and, consequently, is deserving of attention. The precipitate of alumine alone is

almost transparent,—jelly-like,—owing to the excessive minuteness of its particles, individually out of the limits of distinct vision, using the best microscopes at present constructed. The precipitate of phosphate of lime is less transparent, consisting as it does of granules of a larger size, and within the limits of microscopic observation. The precipitate of phosphate of magnesia in the form of the double salt; the ammoniaco-magnesian phosphate, is almost of an opaque white, being thrown down in crystals which reflect a good deal of light. Though a tolerable conjecture may thus be formed of the nature of a precipitate by ammonia, and that whether pure or mixed, it will be right in most instances, and of course always when perfect accuracy is aimed at, to trust only to the appearances as a guide to the use of appropriate distinctive tests.

7. If the pulp of the tamarind, including the seed, be exposed to the air, it remains moist for a considerable time. It is not attacked by insects, nor does mildew soon form on it. If it be digested in water, and the solution formed be separated by filtration and evaporated, an extract is obtained possessing similar properties. It deliquesces in a moist atmosphere, probably owing to the presence of magnesia in combination with one or more vegetable acids, for I have found this earth in a notable quantity, in the pulp which I have examined. Whilst the entire pulp, and the residue from it, are so little liable to change, the residue is otherwise. If exposed to the air, it soon loses all excess of moisture, and is rendered dry. If kept in water and exposed to the air, it soon becomes covered with mildew. Does not this show that the acid and saline matter of the pulp have a preservative quality, and are designed for the purpose of preservation? The instance adduced appears to me a striking one. Very many more might be pointed out of similar significancy; indeed, it would be more difficult to find an example of the contrary. The preservative materials in the vegetable kingdom, especially in the instance of seeds, appear to be chiefly woody fibre, forming husks and shells; oils, as in the instance of certain kernels or nuts, and sugar and acid salts in the instance of certain fruits; and, as in the example of the tama-

rind, collected chiefly in the pulp enveloping the seeds. These means of preservation, we too well know from experience, have not an unlimited power. After a while they all, when exposed to the influences of the elements, yield and undergo change; designed, no doubt, to promote the end for which they are intended—the multiplication of their kind. The tamarind is not an exception. After many weeks exposure, I found the pulp enveloping its seeds dry and in part mildewed, and the acid-extract covered with thick mildew.

8. When Indian corn (maize) is exposed to the fire, it is easily charred, but it is reduced to ashes with extreme difficulty; indeed, it may be said that the charcoal of this grain is almost incombustible. It owes this property to the large proportion of phosphate of magnesia it contains in conjunction with a little phosphate of lime. This is proved by digesting it with dilute nitric acid. The acid dissolves these salts, and after their removal, the charcoal is incinerated without difficulty.

Owing to its property of resisting the fire, it has occurred to me, that this glazed charcoal may be advantageously employed as a varnish for pottery. It has the properties, in the most essential respects, of the admired black varnish of the pottery of Ancient Greece and Etruria; and I apprehend its effect would be as pleasing to the eye as a red ground, and that it would be equally durable. I hope it may have a trial.

9. When Indian corn is digested with dilute nitric acid for a considerable time, the saline matters above mentioned are extracted,—a bright yellow solution is formed. If a solution of ammonia be added to it, a precipitate is obtained like that of phosphate of lime, consisting, as seen under the microscope, of granules, and without any distinct crystals, as if entirely destitute of the ammonian or magnesian phosphate. If this precipitate is collected and heated before the blowpipe, it fuses, shewing thereby that it is not chiefly phosphate of lime; and, if it be redissolved in dilute nitric acid and reprecipitated by ammonia, the precipitate, as seen under the microscope, has not the character of phosphate of lime, but of the double magnesian salt, appearing chiefly in

crystals, and not distinctly in granules. The obvious difference of circumstances in the two instances is, that, in the first instance, the salt was precipitated from a solution containing some vegetable matter derived from the corn; and that, in the latter, it was without, and I may say, unimpeded, by that matter. In the mixed "fusible calculus," as it has been called, consisting of a mixture of phosphate of lime and of the ammoniaco-magnesian phosphate, we often see an earthy chalky texture, the stone being formed in part, or altogether, of loosely adhering granules. Reasoning from analogy, may not this peculiarity be owing to a cause such as has been supposed to have had an effect in the instance above described, viz., being deposited from a fluid containing an organized matter in solution, and some of which enters into the composition of the calculus? And may not the same circumstance be connected with the fact, that the urinary calculi generally are little crystalline?

10. Ammonia, as it is well known, occasions a precipitate of magnesia when added to a solution of sulphate of magnesia. But, however much in excess it be added, it does not precipitate the whole of the magnesia; a definite portion remains; a new salt is formed—a double salt, consisting of the whole of the acid in union with the unprecipitated earth, and a portion of alkali equivalent to the portion of earth thrown down. That this is the case, may be inferred from the following results. The precipitate obtained by the addition of a solution of ammonia to one of sulphate of magnesia, after having been well washed in a filter, yields no smell of the volatile alkali when mixed with quicklime, nor, when dissolved by means of nitric acid, any indication of sulphuric acid in union with it by the test of nitrate of baryta, proving that this precipitate is pure magnesia. If the solution from whence a portion of magnesia has been thrown down by the volatile alkali be evaporated, a salt in a crystalline form, deliquescent in a moist atmosphere, will be obtained, which appears to have the same properties as the double salt of sulphate of ammonia and sulphate of magnesia. When carefully heated, it first enters into the watery fusion; and when the greater part of the water is expelled, on slowly raising the heat,

keeping it below a dull red heat, a slight ammoniacal odour is first exhaled, and next fumes of sulphate of ammonia. If the heating process is stopped before the whole of the volatile salt is sublimed, the residue is entirely soluble in the water, seeming to prove that the proportions of the acid and bases are the same as in the neutral salts.

Some paradoxical appearances are connected with the formation of this double salt. Thus, as is well known, when magnesia is mixed with a solution of sulphate of ammonia, a strong smell of the volatile alkali is evolved; the magnesia separating a portion of the alkali to combine with the remainder of the acid. Thus again, even when the carbonate of magnesia is similarly added, the same odour is produced in a less degree, and there is a slight effervescence. Another instance of paradox may be mentioned. If a certain portion of sulphuric acid is added to a solution of sulphate of magnesia, ammonia, however largely added, will occasion no precipitate. The explanation of this is obvious. The same remark applies to the following:—When a precipitate has been obtained by ammonia from sulphate of magnesia, the volatile alkali being in great excess, if sulphuric acid is added, and yet not in sufficient quantity to neutralize the excess, the precipitate will be redissolved. The phenomena are the same, substituting the nitrate or muriate of magnesia for the sulphate, and using the nitric or muriatic acid for the sulphuric, and owing to the same cause, viz., the formation of soluble double salts. For purposes of analysis, it may be worth keeping in mind, that these last mentioned double salts are remarkably deliquescent.

BARBADOES, *May* 1. 1846.

Origin of the Constituent and Adventitious Minerals of Trap and the Allied Rocks. By JAMES D. DANA.

(Concluded from p. 203.)

7. Bearing upon this subject, it should be observed, that the constituents of amygdaloidal minerals are, in general, those of the containing rock. Silica, potash, soda, alumina,

are found in the felspars; lime, magnesia, and iron, in augite or hornblende; iron and magnesia in chrysolite. These are all the constituents needed, except a little baryta for one species. The felspar decomposes readily and gives up its ingredients, its potash or soda, silica and alumina, The same is true of augite and chrysolite, which afford magnesia, lime, silica, and iron. With water to infiltrate, we should, therefore, have all the necessary ingredients at hand for the required compounds. The fact already stated, that zeolites have been found as stalactites in caverns, seems to prove that they *do* actually result from decompositions and recompositions, such as have been supposed. Thus, we have all the conditions at hand necessary for producing, by infiltration, the zeolite and the chlorite nodules of these rocks. The alumina, alkalies, and lime, contribute, along with a portion of the silica, to the zeolites; and the magnesia, iron, and another portion of the silica, to the chlorite,* often as abundant as the former. The amygdaloidal nodules frequently have a green coating, which further indicate the probable truth of these views; for it appears evidently to be a precipitate from the solution before a crystallization of the zeolites took place —a settling, perhaps, of the insoluble impurities taken up by the filtrating fluid in its passage through the rock, or of the formed chlorite, less soluble than the zeolites. Occasionally, when the rock contains copper, these nodules have an earthy coating of green carbonate of copper—the carbonate having proceeded, apparently, from the native copper of the rock, by the same process as explained.

The hypothesis of filtration seems, then, to be at least the principal source of these minerals. In some instances the filtrating fluid may have derived its ingredients from distant sources. The salts of sea-water may act an important part in these changes. Silica is dissolved on a grand scale during submarine eruptions, as we have elsewhere urged, and is thence distributed to the rocks around. Lime, also, is

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* Chlorite consists of the same elements as augite or hornblende, except that the lime is excluded and water added. They are, silica, alumina, magnesia, oxide of iron, with 12 per cent. of water.

taken up in a similar manner. But the rock itself has often afforded the ingredients for the forming minerals, during the passage of the filtrating fluid through it. By the same means, the adjoining walls of a seam or dyke, which receive the drainings from the rock of the dyke, are often penetrated by zeolitic minerals.

It may be thought that I am giving undue influence to a favourite theory, and in the minds of some, these conclusions may be set down among mere speculations in science. But the circumstances attending submarine igneous action, I am persuaded, is not generally apprehended. What is the condition of the deep bed of an ocean? Even at a depth of three miles, the waters press upon the bottom with a force equivalent to a million of pounds to the square foot; and with such a forcing power above, can we set limits to the depth to which these sea-waters—magnesia and soda solutions—will penetrate? Will not every cavern, every pore, far down, be filled, under such an enormous pressure? Let a fissure open by an earthquake effort, and can we conceive of the tremendous violence with which the ocean will rush into the opened fissure? Let lava ascend, can we have an adequate idea of the effect of this conflict of fire and water? The rock rises, blown up with cavities like amygdaloid, and will a long interval elapse before every air-cell will be occupied from the incumbent water? Suppose an Hawaii to be situated beneath the waves, pouring forth its torrents of liquid rock;—this island contains about five thousand square miles, which is less than the probable extent of many a region of submarine eruption;—suppose, I say, the fires were opened and active over an area of some thousands of square miles—are there no effects to be discovered of this action? There is no geologist that pretends to deny the premises—the fact of such submarine eruptions, the ocean's pressure, the effect of fire in heating water, and in giving it increased solvent power; and why should they not reason upon the admitted facts, and study out the necessary consequences? Surely, if there have been effects, we might expect to see some of them manifested in the cavities of the ejected rocks, which were opened at the time to receive the waters and any depositions they might be fitted under the circumstances to make.

We are led by these considerations to another point in connection with this subject—the probable condition under which the different amygdaloidal minerals have been formed. Have they all proceeded from heated solutions, or all from cold solutions ? or can we distinguish some which are indubitably of one or the other mode of formation ?

Bearing on these questions, we notice such facts as are afforded by the condition and relative positions of the minerals in geodes. And I would here acknowledge my obligations to the valuable memoir, before alluded to, by Messrs Jackson and Alger. The paucity of information on this subject to be found in the various accounts of similar rocks by other writers, is surprising. Even where special pains have been taken to describe the mineral species, the relative positions of the minerals is very seldom noted. It has been altogether too common among geologists to treat mineral information with a degree of neglect almost amounting to contempt, although, as facts will probably hereafter shew, they lie at the basis of an important branch of geological science.

But to proceed with the subject before us. We find that

Quartz or *chalcedony*, and *datholite*, very seldom overlie other mineral species in geodes or amygdaloidal cavities, while the latter often overlie them.*

Prehnite is usually lowermost with reference to all the species except the two just mentioned. Occasionally it is found upon analcime, as at the Kilpatrick hills.

Analcime is commonly situated below all, except quartz, datholite, and Prehnite.

Of the remaining species, chabazite, stilbite, harmotome, Heulandite, scolecite, mesole, Laumonite, and apophyllite, it is more difficult to distinguish an order of arrangement. My

* The writer has observed stilbite, apophyllite, calc-spar, and Prehnite, overlying datholite, and various species over Prehnite.

investigations only enable me to state that chabazite is usually covered by the rest (when associated with them), yet it is sometimes superimposed on stilbite; and apophyllite is almost uniformly above all with which it may be associated; calc-spar is at different times above and below. We thus arrive at the following, as the usual order of superposition:—

1. Quartz.
2. Datholite.
3. Prehnite.
4. Analcime.
5. Chabazite, harmotome.
6. Stilbite, Heulandite, scolecite, natrolite, mesole, Laumonite, apophyllite.

It is a reasonable inference that the species which covers the bottom of a cavity was first deposited, and, as a general rule, that the others above were formed, either simultaneously, or in succession upon the lowermost, as their order may indicate. Each is usually perfect in its most delicate crystallizations, so that we cannot suppose that the minerals first deposited often underwent change after their deposition, though instances of this may no doubt be detected.

It is also evident, that if there were any species formed previous to the complete cooling of the rock, or if any require for their formation an elevated temperature, they are those first deposited—the first in the above series. A few considerations will place this, if possible, in a clearer light.

Quartz, as we have stated in a preceding page, and fully remarked upon elsewhere, enters largely into solution during submarine eruptions. This solution has been shewn, by actual experiment, to be a necessary consequence of such action. This fact corresponds most completely with the above deductions. Quartz usually forms the first lining of the geode or amygdaloidal cavity, when it is found at all, and, moreover, it is the most abundant of all amygdaloidal minerals.

Quartz may also proceed from decompositions of the rock in the cold, and incrustations of this kind are known to occur; but such an explanation does not account for its generally preceding all other species in filling cavities and seams in trap rocks, and is insufficient to produce the large deposites of silica, sometimes amounting to many tons in a single geode.

It should not be understood that the quartz is supposed to be derived always from the same heated waters that attended the formation of the containing rock; for later eruptions in the same region might, at a subsequent period, produce a like result; yet, as its place in the series proves it to be the earliest in formation, it has probably been generally deposited from the water heated during the eruption of the rock. Leaving quartz, we pass to the other minerals.

It is a striking fact, that the minerals next to quartz in the table given—*datholite*, *Prehnite*, and *analcime*—contain less water than either of the following species. While the others include from 10 to 20 per cent., the first, datholite, has but 5 per cent., Prehnite about 4¼ per cent., and analcime 8 per cent.* This fact certainly leans towards the view of their having originated at a somewhat more elevated temperature than the other species—the same conclusion that is drawn from their lower position in geodes.

The fact, also, that Prehnite has been found forming pseudomorphs, bears the same way; for heat would be necessary, in all probability, to aid in removing the original mineral. The vast extent of some Prehnite veins—occasionally, as Dr Jackson has observed, three or four feet wide—refers to an origin like that of the quartz in similar rocks. Indeed, there seems little doubt that Prehnite is often derived from that portion of the silica in solution which entered into combinations at the time with the alumina and lime which the sili-

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* The following table shews the per-centage of water, and gives at the same time a general view of the composition of the zeolites.

Silica, boracic acid, lime.—Datholite (5 Aq.)

Silica, alumina, lime.—Prehnite (4¼ Aq.) Heulandite (14 Aq.) Scolecite (13½ Aq.) Epistilbite (14 Aq.) Stilbite (17 Aq.) Laumonite (17 Aq.)

Silica, alumina, lime, and potash or soda.—Mesole (12 Aq.) Thomsonite (13 Aq.) Phillipsite (17 Aq.) Chabazite (21 Aq.)

Silica, alumina, and either soda, baryta, or strontia.—Analcime (8 Aq.) Natrolite (9½ Aq.) Harmotome (15 Aq.) Brewsterite (13 Aq.)

Silica, lime, and potash.—Apophyllite (16 Aq.)

Silica, lime.—Dysclasite (16½ Aq.)

ceous waters contained; and probably the lime as well as silica was derived in part from an external source. The pseudomorphs prove that Prehnite may have been the result also of subsequent eruptions, at the same time that they shew the probable necessity of heat for its formation.

Datholite is a compound of silica, lime, and boracic acid, with about 5 per cent. of water. Besides the small per-centage of water, and its being, next to quartz, the lowermost mineral in geodes, we find an additional fact, alone almost decisive with regard to its origin, in its containing boracic acid. Boracic acid is often evolved about volcanoes or in volcanic regions. The hot lagoons of Tuscany, and the volcano of Lipari, are the most noted examples.

Although boracic acid has never been detected in sea-water, there can be little doubt of its occurring in it. The usual modes of analysis by evaporation would dissipate it, and, of course, it could not thus be detected, except with special care, and by operating on a large quantity of water. Borate of soda (boracite) is found only in beds of salt and gypsum,—both sea-water products. Moreover, borate of lime has been lately found on the dry plains in the northern part of Chili, along with common salt, iodic salts, gypsum, and other marine salts; and all are so distributed over the arid country, that the region has been lately described as having been beyond doubt once the bed of the sea. These facts render it altogether probable that sea-water which gains access to volcanic fires is the source of the boracic acid in volcanic regions.*

If this be its origin, the necessity of heat and pressure must be admitted, in order to produce the chemical combinations in datholite. Its elements are not those of the felspar or other trap minerals, like the zeolites superimposed on it; but they have come from an extraneous source, and none is more probable than the sea-waters, which were heated at the

* The only other known source is the mineral tourmaline, quite an improbable one in the case before us. It is possible that tourmaline may have received its boracic acid from the sea during granitic eruptions, and the occurrence of this mineral in the vicinity of trap-dykes is explained in the same manner.

submarine eruption, and permeated the bed of molten rock shortly after ejection. Thus placed in circumstances of pressure and confinement, along with silica in solution, the volatile boracic acid might enter into the combination presented in datholite.

An interesting fact bearing upon the history of datholite, was observed by Dr Jackson at Keweena Point, Lake Superior. The datholite is often formed there in veins with native copper, and is associated in some places with a curious slag of boro-silicate of iron and copper. Sometimes the crystals of datholite, as well as the Prehnite and calc-spar, contain scales or filaments of native copper. These very important observations seem to establish the same origin for the three minerals—for Dr Jackson states that they appear to be contemporaneous; and if calc-spar has been deposited from a solution, the same holds true of the others. They have all been formed subsequent to the copper filaments of the cavities, for they were deposited around them; yet may have been the next to form during the cooling of the rock. The boro-silicate of iron and copper has resulted from the same causes.

Analcime approaches the zeolites in composition, but like the Prehnite and datholite, it contains less water, and is very different in its crystallization. We have less evidence as to the heat necessary for its formation; yet it was probably formed at a somewhat elevated temperature.

With regard to the other amygdaloidal minerals, we are in still greater doubt as to the necessity of heat. We cannot at present fully appreciate the efficiency of chemical agents in a nascent state, acting slowly without heat through long periods. Many of them may require heat, and some may be the last depositions from the filtering waters, after they have nearly or quite attained their reduced temperature. But the formation of zeolitic stalactites in caverns favours the view that some at least may form at the ordinary temperature, by the slow decomposition of the containing rock after it had emerged from the waves.* Kersten has lately described a modern stellated zeolite forming incrustations on the pump-wells of the Him-

* Annales des Mines, ii. (4th Ser.) 465, 1842.

melsfurst mine near Freyberg. It consisted of silica, oxides of iron, and manganese and water. Further examination will probably bring more of these modern products to light.*

The formation of particular minerals in certain regions depends, of course, upon the supply of the necessary ingredients. Where the supply of lime has been large, we should expect to find some of the minerals, Prehnite, Heulandite, Laumonite, stilbite, scolecite, dysclasite, chabazite, for carbonate of lime decomposes the silicates of potash or soda. Instances of this association of the lime-zeolites, with a large supply of lime in the vicinity, are common. When there is little or no lime, or only the results proceeding from the decomposing rock, the other zeolites are formed—the hydrous silicates of alumina and potash or soda, occasionally with some lime. But if a salt of baryta or strontia is present, the decomposition of the silicates of the alkalies takes place as by the lime, and the mineral harmotome or Brewsterite is produced.

In the above explanations we have scarcely appealed to one source of amygdaloidal minerals admitted in the outset—their proceeding from vapours rising with the erupted rock; for it seems to be of but limited influence. Besides the arguments already brought forward, we state that the vapours which rise at the moment of eruption are insufficient. They inflate the rock, or blow up the cavities; but the little vapour required to open the cavities most assuredly could not afford, by condensation, the mineral matter necessary to fill them,—to produce stalactites, stalagmite, and successive layers of minerals. The vapours, then, if the source, must have continued to rise for some time afterward. But is it possible that vapours should rise up through the solid rock? Such does not happen about recent volcanoes; for fissures are first opened, and then the vapours escape. And could it happen with the water above pressing down into the rock with the force of an ocean even a mile deep?

* Carbonate of iron seems never to form from water at the surface, its solutions depositing a hydrated peroxide of iron instead of the carbonate: it may therefore require a submerged condition of the rock, although not necessarily a raised temperature.

There may be instances of this mode of formation; but that it should be the usual mode is irreconcilable with the many facts stated. The form and condition of quartz or chalcedony in geodes, as well as the vast amount of this mineral in some cases,—the relative positions of the zeolites, and their occurrence as incrustations on rocks, or as fillings of cavities or seams, and never in disseminated crystals through the texture of the rock,—the green coating of the nodules, which is sometimes a carbonate of copper, when there is a native copper in the rock to undergo alteration,—the correspondence between the elements of the minerals and the composition of the including rock, and at the same time their contrast in being hydrous, while the constituents of the latter are anhydrous,—and the known formation of zeolites in caverns,—these various facts appear to establish infiltration as the principal means by which amygdaloidal minerals have been produced.

Observations on the Principle of Vital Affinity, as illustrated by recent discoveries in Organic Chemistry. By WILLIAM PULTENEY ALISON, M.D., F.R.S.E., Professor of the Practice of Medicine in the University of Edinburgh.

(Concluded from p. 146.)

We may consider, then, the selection and extraction, from a previously existing compound fluid, by the agency of a previously existing compound solid, of certain portions of that fluid already elaborated, as a chemical action, essential to all living beings, and so peculiar to them that it may be, at least with high probability, termed an exercise of a vital affinity. And, in regard to this simplest kind of such action, the following points may be considered as ascertained:—

1. It seems to be always performed, in the perfect vegetable or animal, by an agency, not of vessels, as was formerly supposed, capable of a vital contraction, and of changing the nature of their contents by the degrees of that contraction, but of *cells*, either pre-existing in the solid structure, or carried about in the nourishing fluid, and having the name of the

globules or corpuscules of that fluid. Most of the textures seem to be formed by the gradual transformation, elongation, or flattening of cells, which have sprung from nuclei attached to previously existing cells; and it seems to be only by the successive formation, distension, rupture, and disappearance of cells, that secretions make their way into the excreting ducts of glands, or on the surface of membranes.

The dependence of all living structures, and of all secretions, not simply on vascular action, by which nourishing fluids are circulated through them, but on *cellular action*, by which this nourishing fluid is changed, appropriated, and retained, or restored to the circulation, is the great step which has been recently gained in physiology by the use of the microscope; and seems to me to be one of the clearest proofs of the dependence of all vital phenomena on peculiar attractions and repulsions, actuating both solids and fluids, and causing motions in the latter,—not on any vital powers residing exclusively in solids. When it is stated, *e.g.* by Mr Paget, that "the purpose to which the capillaries are habitually subservient, is only the passive one of conveying blood close to those parts of the body which either grow or secrete, and that it is proved that if a part be only able to imbibe the fluid portion of the blood from an adjacent vessel, it nourishes itself as completely, and after the same method, as one whose substance is traversed by numerous capillaries,"*—it becomes obvious that the movements of the fluid portion of the blood, whereby they are applied to growth and secretion, must be determined by causes quite distinct from the contractions of vessels.

2. Living and growing cells, therefore, whether acting on the nourishing fluid just taken into the system (as in the case of the intestinal villi, or the tufts of the placenta), or on the blood brought to them by the capillaries (as in the nutrition of the different textures), appear always to have two functions to perform,—to extract from the nourishing fluid the matter of which they are themselves composed, and to extract from

* Report in Forbes's Medical Review, July 1843.

it, likewise, the matter which is contained within them,—*i. e.*, in the organs of secretion, the secreted fluids, and in the different solid textures, that additional matter which is always found, whether lignin, oil or fat, fibrinous, cartilaginous, or bony substance, in a granular or less definite form, incrusting the walls of the cells. It does not appear possible to explain what is distinctly seen in all these cases, without supposing that the pre-existing cells exert a peculiar attraction or affinity, both for the matter by which they are themselves to be nourished, and their successors to be reproduced,—and likewise for another matter, different in the different parts of the structure, by which they are to be filled or distended. And in the case of vegetables, there seems to be this general distinction between the two,—that the former is a matter destitute of azote, and the latter one containing that element.

3. The cell, growing always by attracting to itself a compound matter, existing in the fluid state, and giving it a simple increase of aggregation, the nature of the change which takes place as this matter becomes solid, is simply *consolidation*, not *precipitation*, just as the fibrin of the blood, differing from the albumen only in its stronger (vital) tendency to aggregation, is consolidated in its compound form from the liquor sanguinis in the act of coagulation. And thus it happens that these organic solids possess (as was particularly noticed by Dr Prout) that peculiarity which, in the inorganic world, is observed only in fluids, that even the minutest portion of them contains the very same ingredients (whether earthy or saline, animal or vegetable matters) as is found in the whole mass.

The absence of all crystalline arrangement, and the complex nature even of the smallest particle of an organized body, are the characteristics of matter which has assumed the solid from the fluid form,—not by a chemical precipitation, or separation from matter formerly united to it, but by a vital attraction, subjecting it to " the invisible cause by which the forms of organs are produced."

4. In the next place, we may inquire what difference exists among the cells in different parts of the same structure, to explain the great difference of the compounds which are

deposited in them from the same nourishing fluid; and I apprehend, that, on this point, we must come to the same conclusion which Cuvier drew from examining, throughout the animal kingdom, the structure of the different glands, the vessels entering them, and the ducts passing out of them, viz., that *there is no difference* of structure or of composition, corresponding, in the slighest degree, to the great difference of the products which appear. All cells in the vegetable kingdom appear to consist of the same matter, cellulose, and in the animal kingdom of the same matter, protein; and in the first instance they are quite similar to one another. When we attend to the early stages of the existence of a living body, when the difference of textures is only beginning to appear, we find only that a fluid passing through similar capillary vessels, and effused into similar cells, in different *parts of the structure*, acquires different properties. And when we carry our inquiries farther back, and observe the first development of cells themselves out of the granular matter inclosed within the sac of the yolk, it appears obvious that the particles of this matter are attracted, not into cells already existing, but *to points where cells are about to be formed.* The facts known as to the evolution of the chick in ovo from the matter that lies in contact with the germinal membrane, sufficiently indicate that the powers which effect the separation of the different component parts of that matter, so as to form the beginning of the different textures and organs, reside, not in pre-existing cells of different composition or structure, but simply in different points of a pre-existing membrane, which, in the first instance, is homogeneous. The expression of Liebig, that "the chemical forces in living bodies are subject to the invisible cause by which the forms of organs are produced," when the action of that cause is duly considered, implies, that they are subject to a cause which undoubtedly acts differently at different points of the same matter; but the difference of the action of which, at these points, is determined by no other condition, that we can see, than their *position.*

This mode of limitation of the vital affinities, by which the selection and appropriation of living matter is effected, is only a statement of fact, and the most general fact that has been ascertained; and it seems highly probable, that it will be found an ultimate fact, in this department of science. It may serve to familiarize our minds with this principle to observe, *first*, that it is precisely analogous to the principle which is now well established as a first truth in the physiology of the nervous system, that portions of nervous matter, precisely similar in structure and composition, have perfectly different endowments according to the anatomical position which they occupy; and, *secondly*, that the same principle seems distinctly exemplified in various cases of diseased action. The phenomena of inflammation, and especially the easy recurrence of inflammation once excited at any one spot in a living animal, indicate that certain vital attractions and affinities existing among the particles of the blood, and between them and the surrounding textures, are peculiarly modified, not merely in a particular manner, but exclusively at a particular spot. From the spot where it commences (*e. g.*, on a serous membrane), this alteration of vital actions extends, as from a centre, to parts that are contiguous to, although having no vascular connection with, that where it commenced, as we see in tracing it from one fold of the peritoneum to another. And when we examine the results of the inflammation in the dead body, we see what clearly shews the operation of a force, producing chemical changes of the kind we are now considering, but acting only at one part, and in one direction. "The capillaries which have taken on the appearance of inflammation are all on one side of the fine membrane, and the serum and lymph, effusions from these vessels," by which the diseased state is essentially characterized, "are all on the other."—(Goodsir, *Anatomical and Pathological Observations*, p. 43.)

In saying that the fundamental property of chemical selection, essential to the growth of all living bodies, is strictly a vital property, we do not overlook the fact that various substances, composed of inanimate or inorganic matter, have likewise different powers of attraction for different elements or compounds brought into contact with them. It appears to be only by reference to this property, that we can explain the well-known phenomena of *endosmose* and *exosmose*, in which different fluids, brought in contact with a solid body, are attracted into its pores with very different degrees of force. It is not the nature of the process by which the selection, in the case of the living body, is effected; but the peculiarities of the selections themselves, their great force, and yet uniformly temporary existence, that entitle us to regard them as indicating a vital property.

II. But when we attend to the peculiar changes effected by living solids on the fluid matters which are brought in contact with them, we find that these are by no means confined to the *selection* and appropriation, at particular points, of compounds pre-existing in that fluid; but that, under the influence of the living solid, *transformations* or new arrangements of the chemical elements take place, and new compounds are formed.

In regard to the precise nature, or seat, of some of these transformations, there is considerable difficulty, but we are at present concerned only with the principle; and may state in illustration of it, two cases of transformation, of which there is no doubt, the change from carbonic acid and water to starch in the cells of plants (oxygen escaping), and the change from starch to fat in the cells of animals (carbonic acid and water escaping). And that I am correct in asserting that the organ which exercises this and other chemical powers in living plants is not only of the simplest construction, but of uniform construction, while the products of its action are very various, will appear from the following statement by Mülder.

"Pure cellulose is easily obtained from the pith of the elder-tree, from very young roots, and from other young parts of plants. From these parts it is prepared by digesting them, after being minutely divided, with alcohol, ether, diluted potash, hydrochloric acid, and water. In this manner, the starch, gum, fats, resins, vegetable alkalies, salts, sugar,—and at the same time the peculiar woody matter, are separated."

"After the action of these solvents, and especially of the alkali, the cellulose, which was formerly solid and dense, appears in a spongy form. We may state as a fact, that the proper tissue *of all plants* which have been previously exposed to the influence of these solvents, leaves *a substance which is identical in all of them,* a substance which contains carbon and the elements of water."—(*Chemistry of Vegetable and Animal Physiology*, pp. 188–195.)

Mülder annexes to this statement a speculation in regard to the influence of *forms* in organized bodies, as affecting their chemical powers or properties, which, so far as I can understand it, I think fitted to convey an erroneous impression.

"One of the first and chief laws visible in organic nature is that the form has as much influence on the character of the phenomena as the substance of which that form consists. The effects of the primary forces existing in the molecules, have become, by the combination of elements into hollow globules, altogether peculiar."

"In organic nature, besides all the peculiarities existing in the carbon, hydrogen, and oxygen, we must suppose, as a chief consequence of this, a tendency to form membranaceous, concave, spherical little bodies, in which, *because of this form*, new peculiar properties manifest themselves, which cannot be brought out by other forms. Thus, by matter and form, all that we observe in nature is, to a great extent determined." —(*Ibid.*, p. 189.) If by this it is meant that the acquisition of the form is the physical cause of the existence of the properties which cells, or any other organized structures present in the living state, two questions immediately present themselves, *first*, How are the cells themselves formed (*e.g.* on the germinal membrane of the ovum) out of a matter which is originally without form, otherwise than by those very properties which are here ascribed to their existence? and, *secondly*, If the properties are dependent only on forms, why do they not exist in the dead state, when the forms are, in many instances, still perfect? The enunciation of these questions seems to me sufficient to shew, that the correct expression of the state of our knowledge on this point is that already quoted from Liebig, that the chemical forces in living bodies are subject, not simply to an influence of forms, but to "*the invisible cause by which the forms of organs are produced*," *i. e.*, that we must include under the head of vital properties, both the mechanical, or simply attractive power, by which cells or other organs are formed out of amorphous matter, and likewise the chemical powers with which these cells are endowed.

It is no objection to what has been stated, of the strictly vital nature of these chemical powers, to admit that their action is very often *analogous* to the principle to which the name *catalysis* is given by chemists, and which is exemplified likewise in the chemistry of inorganic compounds, where the combination of two substances is determined by the presence of a third, which nevertheless takes no part in the combination itself; or that it is analogous to that disturbance of the equilibrium of chemical compounds, by which the fermentation of an organic compound is transferred to another in contact with it, although the changes in the two go on separately, and the compounds formed are different. It is quite true, that these modes of chemical action resemble and illustrate the manner in which living solids, themselves undergoing continual changes of composition, determine new arrangements of the elements of the compound fluids which are brought in contact with them. But this analogy is far from being an explanation or resolution of the one phenomenon into the other. In the first place, the analogy is essentially defective; because although it is true that in any living being, already existing, different chemical compounds already exist in different parts of the structure, which may act in these modes on the nourishing fluid, and determine distinct transformations of these at different parts; yet this does not apply, as already observed, to the first formation of each of the textures, at its appropriate point, from a homogeneous semifluid matter. But farther, although we were to admit the *analogy* of all the chemical processes going on in living beings, to these forms of simply chemical action, we should not thereby be authorised to conclude that the vital processes have not that peculiarity which makes it incumbent on us to regard them as a separate class. We say that the decomposition of carbonic acid, the combination of the carbon with the elements of water to form starch, and the evolution of the oxygen, is a vital action,—not because it is a change different in kind from the decomposition of water and evolution of the hydrogen by iron and acid,—but simply because it indicates an affinity peculiar to the state of life;—because in no other circumstances, when the elements of water are brought into contact with carbonic acid, is any such decomposition effected. So also, although it is true that the presence of spongy platinum enables oxygen and hydrogen to unite and form water, or the presence of fermenting yeast enables sugar to undergo transformation into carbonic acid and alcohol, still these facts do not interfere with those essential peculiarities on which the doctrine of vital affinity depends, viz., that the presence of living cells composed of carbon and the elements of water, determines both the addition of new matter, from a compound fluid, to those cells, and likewise the formation of other compounds within the cells, varying in different parts of the same structure,—all these compounds being different from any which the chemist can form out of the same elements, and different from those to which the same elements inevitably return, after the phenomena of life are over. The physical principle of catalysis may be said to *illustrate* the transformations in living bodies, as that of endosmose illustrates the selection and appropriation of chemical elements or compounds in living structures; but these principles, as exemplified in dead matter, include none of the peculiarities of the vital chemical actions, and therefore furnish no *explanation* of them.

The materials of which animal bodies are composed, have been now so generally found to have been prepared for them by vegetables, that it has been reasonably doubted whether any such power of decomposing the fluids presented to them, and forming new compounds, exists in animals. There are some cases, however, in which it appears certain that an action of this kind goes on in living animals, and that it is effected, as in vegetables, by an agency of cells. Thus, there is good evidence that, in the natural state, much of the bile which is discharged into the intestines from the liver is reabsorbed in its passage along the Primæ Viæ; yet it never appears in the chyle, nor, in the natural state, in the blood;

which seems to imply that it is decomposed, and its elements thrown into other combinations, in the course of the *cellular action* which attends the absorption of chyle.

In like manner, the formation of fatty compounds out of starch, or its kindred principles, as illustrated by the recent precise observations on the formation of wax by bees, and the formation of gelatine in the living animal, are undoubted instances of chemical transformations thus effected. The precise scene of these transformations is not yet ascertained, but we have strong reason, from analogy, to suppose that they are effected in the course of the circulation. And as we are certain that the greatest of all the chemical changes which are peculiar to living beings are effected within the cells of vegetables, it seems in the highest degree probable, that the corpuscles or cells (both red and white) which form so large a part of the blood of animals, are concerned in the chemical transformations which take place in blood; and therefore, that we are to regard organized and living cells as the agents or instruments employed by nature in effecting all those chemical changes which are peculiar to the state of life. And if we consider this principle as established, it goes far to explain several facts, long regarded as obscure, in regard to the structure and position of the lymphatic and lacteal vessels. We know that the mode of origin of these vessels gives *time* and opportunity for cellular action (*i. e.*, the development, growth, and rupture of cells), and consequent chemical changes, at their extremities; we know that such cellular action does in fact go on there, particularly in the lacteals; and we know that the substances absorbed there, and probably elsewhere, by these vessels, are in fact altered, and so far assimilated, in the act of absorption; as in the case, already mentioned, of bile absorbed from the intestines. Thus we are led to see the importance of these vessels being placed at all points where substances are to be absorbed, which are foreign to the animal economy, or require chemical change, in order that they may be introduced with safety or good effect. Hence, also, we see the use of the lymphatic glands, at which another opportunity for cellular action, for chemical changes and assimilation, according to the observations of Mr Goodsir, is provided.* And this also enables us to understand a general fact, which, although disputed, I believe to be both true and important in pathology,—that a substance destined for excretion, but retained in the blood by reason of disease of its excreting gland (particularly the bile or urine), is more injurious than the same matter when secreted by the gland, but re-absorbed from a mucous surface, and consequently subjected to cellular action, and thereby to chemical change.

III. Another general fact appears to be sufficiently illustrated by observations on the chemical changes in living bodies,—viz., That the vital properties by which these are effected are *transferred* from the portions of matter already possessing them, to those other portions of matter which are either taken into their substance, or deposited in their immediate neighbourhood. It is, indeed, obvious, that if we are right in saying that living matter possesses these peculiar vital properties, the act of assimilation which we know to be continually going on in living bodies, is not merely the attraction and addition of new matter, but must include this transference of vital properties to the matter which is continually added to the existing solids.

"The force with which life is kept up," says Professor Whewell, "not only produces motion and chemical change, but also *vitalizes* the matter on which it acts, giving it the power of producing the same changes in other matter, and so on indefinitely. It not only circulates the particles of matter, but puts them in a stream, of which the flow is development as well as movement."—(*Philosophy of Inductive Sciences*, vol. ii., p. 52.)

Several facts which are known in physiology and pathology, may be noticed as more special exemplifications of this principle. Thus, we know that vessels in any part of the body communicate certain properties to the whole mass of blood which lies in contact with them, so as to modify or suspend for a long time the coagulation of such blood;—that the

* See Carpenter's Manual of Physiology, § 493.

blood which enters the vessels of any part where inflammation has been excited, has peculiar properties impressed on it, and even changes on its composition effected, merely by coming in contact with the portions of vessels where that process is going on, and with the portions of blood previously subjected to it;—that the exudation from inflamed vessels acquires peculiar properties from the contact with the living surface on which it lies, first arranging itself as an organized structure, and then selecting and appropriating, from the neighbouring bloodvessels, those materials by which it is assimilated to the texture with which it is connected;—again, that, in the sound state, every portion of matter which is deposited from the bloodvessels, to form part of a muscle or of a nerve, immediately acquires the peculiar vital properties of the part which it nourishes; and, in the case of muscles, even, that the change produced in a portion of a fibre by the application of a stimulus, is instantly communicated to the whole length of that fibre, and to many adjoining fibres. It appears to be nearly in the same manner that every portion of carbon and water which enters into the composition of any living vegetable cell, acquires the power of exerting the same vital affinities as actuated the matter which it replaces, or to which it is added.

IV. Another principle, at least equally important and characteristic, may be stated in regard to this communication of vital properties to the materials which are added to living bodies, viz., That such powers are imparted only for a brief period of time, and that long before the time of the death of the structure to which they belong, all those materials lose the vital properties which have been given to them; perhaps, as has been lately stated, as a consequence of the exercise of their peculiar vital powers, perhaps merely as a general law of vitality; but equally, whether the peculiar properties which they acquire in living bodies are of the nature of nervous actions, vital contractions or attractions, or vital affinities. But as this principle is best illustrated by reference to the phenomena of excretions, we delay doing more than merely enunciating it at present.

Having so far considered the general nature of the chemical changes which are peculiar to living bodies, and the kind of apparatus provided by nature for carrying on these changes, we may next take a more special view of the different chemical changes themselves, beginning with the greatest and most fundamental of all, the formation of the amylaceous matters by vegetables, acting on the water and carbonic acid with which they are supplied, both in the liquid form by their roots, and in the gaseous form by their leaves,—and the consequent evolution of oxygen. In regard to this grand function of living plants, the following facts seem the most important that have been ascertained.

1. We see this change effected, in the present order of things, only by the agency of one of the amylaceous principles themselves, although the quantity of that pre-existent matter, in the case of the seeds of many vegetables, is exceedingly minute. We need not enter on the question how far, besides the pre-existence of matter capable of forming cells, in the textures of the plant itself, previously existing organized matter, in the dead state, is essential as part of the nutriment of vegetables,—farther than to observe, that, as the seed of every plant contains a store of organic compounds already formed, there is certainly a strong presumption that a certain quantity of such compounds, formed by previous living processes, is highly useful, if not necessary, to the nourishment of vegetables, as well as animals. This, however, appears most important in the early period of the existence of plants, when their power of decomposing the carbonic acid has not yet attained its full intensity. The evidence of the greater part of the nourishment of vegetables being from carbonic acid, water, and ammonia, applied to their leaves, or absorbed by their roots, is quite conclusive; and when we consider that vegetables preceded the appearance of animals on earth, that the first vegetables (as is well observed by Liebig) were of the kind which depend least on their roots and most on their leaves for subsistence, and that the kind of animals which first inhabited the earth, were those which consumed the smallest quantity of oxygen, and can live, therefore, in air highly charged with carbonic acid,

it appears in the highest degree probable, that a gradual purification of the atmosphere by the agency of vegetables abstracting carbon, was a necessary prelude to the introduction of animals, especially of warm-blooded animals, into the world: and that the greater part of the carbon now existing in the soil on the earth's surface, originally existed in the form of carbonic acid in the atmosphere, and has been gradually fixed, and enabled to become the chief support of all living beings, by this vital affinity of vegetables, and of those tribes of the lowest marine animals, which have been found to possess the same property, whereby carbon is separated from oxygen, and combined with the elements of water, to form the amylaceous matters.

2. The dependence of the exercise of this property on the presence of light, and its connection (according to the statements of Dr Draper), not with the heating portion of the rays, nor with those which effect other chemical changes, but simply with the luminous portion of the rays, shews distinctly that all living action on this globe is equally dependent on light as on heat, although it is, and may long be doubtful, in what manner the influence of light is exerted in producing this change; whether the theory long ago proposed by Sir H. Davy is admissible, that light enters into the composition of oxygen gas, when disengaged from any solid or liquid compound containing it, or whether the agency of light may be better expressed by saying, that it is the necessary stimulus to that kind of vital action which leads to this primary transformation of the elements of which organized beings are composed.

3. It is unnecessary to enter here on the varieties of this amylaceous matter which are formed in different vegetables or parts of the same, the *cellulose* of which the cells are formed, the *starch*, the *dextrin*, the *gum*, the *inuline*, which are deposited in different species and in different parts. All these appear to have the same simple fundamental composition, consisting almost entirely of carbon with the elements of water, and all are formed out of the same compounds, and by a vital affinity essentially the same; it may be partly owing to some imperceptible difference in the relative position of the

ultimate atoms, partly to differences in the minute quantities of inorganic matter, and of other organic compounds not yet mentioned, which enter into their composition, that so many varieties are found, not only in these compounds themselves, but in the qualities which they present as found in different species of plants, and even in different individuals of the same species. In the case of a graft inserted on the stem of an individual, or even of a species, different from that which furnishes the shoot, we see that the vital affinities of the particles composing the shoot are capable, not only of extracting from the nourishing fluid of the stock all the compounds required for its development, but of imparting to the living textures formed of those compounds which they extract, all those peculiar properties of form, of colour, of smell, of roughness, smoothness, &c., by which species, and even individuals of the same species, are characterized. And when we consider these facts, I apprehend we must admit that, under the influence of the vital affinities which operate in the cells of living vegetables, much more minute differences of compounds are produced, than can be detected and explained by any chemical analysis.

4. An important question here is, Whether the carbonic acid of the air is decomposed in the leaves where it is chiefly taken in, the amylaceous compounds immediately formed with the help of water, and the oxygen set at liberty, or whether that acid is taken into the juices of the plant, as we now know that oxygen is into the blood at the lungs, and gradually decomposed there, letting its oxygen escape gradually, and aiding in the formation of different compounds, besides the varieties of starch ? That the latter is the more probable supposition may be inferred, partly from the analogy of the action at the lungs of animals, but chiefly from the fact, that a separation of oxygen is equally required for the elaboration, which certainly takes place in vegetables, of other compounds, of the varieties of oil, and of protein, which are chiefly deposited in other parts of their structures.

5. The relations of compounds of this class to sugar, demand more special notice. It seems doubtful whether this is ever the first compound formed; it appears in the sap of

various plants when the fluids from the soil are ascending and dissolving the starch which had been formed and stored up by the living actions of the preceding year; it appears in almost exactly the same circumstances during the germination of seeds, and in both these cases is useful, as giving a greater degree of solubility to the starch whence it is formed. In both cases it disappears, and probably is converted into some of the varieties of starch, as the vital actions of the plant become more vigorous. Its composition, in its different varieties, as given by most analysts, $C_{12}\ H_{11}\ O_{11}$, $C_{10}\ H_{10}\ O_{10}$, or even $C_{12}\ H_{14}\ O_{14}$, denotes that if it be formed from the starch, $C_{12}\ H_{10}\ O_{10}$, it must be either by the addition of the elements of water, or by the abstraction of carbon; and as its formation, during the germination of seeds, is attended with evolution of carbonic acid, it seems most probable that, in that case at least, it is formed in this last way, under the influence of the oxygen of the air. It appears again in the nectaries of flowers, and in the ripening of fruits, as one of the latest results of the vital action of plants, in those parts of them which are fully exposed to air and light, but at a time when we may reasonably suppose that the vital affinities are becoming comparatively ineffective, and when carbonic acid is again evolved. It may be formed by the chemist from some of the varieties of starch by a kind of fermentation, excited by diastase, as in malting; or by a catalytic action of sulphuric acid; and it is formed from starch merely by the agency of cold, as in frozen potatoes, and from inuline merely by continued boiling in water; so that its formation from starch in vegetables seems to be most probably a simple chemical change, not the effect of a vital affinity. Farther, it is a compound which takes the crystalline form, essentially different from any form assumed by those parts of organized structures which exhibit truly vital phenomena, and retains its properties when exposed to air and water better than any of the matters of which organized forms are composed. From all these facts it may be inferred, with great probability, that sugar, as it appears in the living vegetable, is generally to be regarded as a first product of decomposition of starch, by the agency of water, and of the oxygen of the air, which appears to be the great agent in the resolution of those compounds, which the vital affinities have built up.

6. On the other hand, the relation of starch and cellulose to the lignin, which forms the greater part of the solid matters of dicotyledonous plants, seems to be nearly the reverse of their relation to sugar. This matter is always found incrusting, or incorporated with, the cells of vegetable textures; it gives them their solidity and strength, which all decompositions by chemical agents impair; it cannot be formed from the compounds of starch by artificial means, but is formed from them in greatest quantity when the vital actions of plants are strongest; and its composition is always stated as differing from the amylaceous compounds, by containing more carbon, and less oxygen, in proportion to the hydrogen, than exists in the composition of water; its formula being stated as $C_{40}\ H_{23}\ O_{18}$. This, therefore, would appear to be clearly the result of truly vital affinities, continuing to actuate the elements of starch, after the formation of the starch from carbonic acid and water has been completed, and effecting a decomposition of part of the water, as well as of the carbonic acid, presented to the living vegetable.

In studying this first and most striking of all the changes which are to be ascribed to vital affinities, it is especially necessary to understand the parts assigned to carbon and oxygen; and, in taking this general view, we must regard vegetables and animals as inseparably linked together, and look to the whole series of chemical changes which intervene between the origin of vegetables and the death and composition of animals. We must regard the carbon, originally existing in combination with oxygen in the atmosphere, in the proportion of one equivalent to two, as the great agent employed by Nature in the formation of the whole organized creation, insomuch that all organic chemistry may be said to be the chemistry of compounds of carbon.—(*Gregory's Chemistry*, p. 241.) That it may fulfil this office, it is invested with peculiar but temporary powers; it is separated at particular points, and under certain conditions, from the oxygen, and attaches itself to the elements of water, always present where vegetables grow, and so forms various compounds, beginning with the varieties of starch; in all which it is the principal ingredient. The compounds thus formed next attack and partially decompose the water, and appropriate the hydrogen, thus causing a farther evolution of oxygen, and forming oil; and afterwards nitrogen, in small quantity, is introduced, and fresh transformations take place, by which the protein compounds are formed. All the solid structures of vegetables, and indeed of organized beings generally, are made up of these compounds of carbon, in which oxygen exists, either in the proportion to hydrogen, which forms water, or in a less proportion than that; and the formation of these may be confidently ascribed to vital affinities. But it is easy to conceive, that other compounds of carbon, with hydrogen and oxygen, will exist in plants in which the oxygen will be in larger proportion than this, without supposing oxygen from the air to be added; because the vital affinities may not have been in sufficient force to separate the oxygen completely from its original union with carbon, and these, therefore, may be regarded as compounds of carbon, water, and undecomposed carbonic acid. Such are the different organic acids (the citric 12 C 8 H 14 O $=$ 9 C + 8 HO + 3 CO_2, the malic 8 C 6 H 10 O $=$ 6 C + 6 HO + 2 CO_2, the tartaric 8 C 4 H 10 O $=$ 5 C + 4 HO + 3 CO_2, the oxalic 4 C 2 H 8 O $=$ C + 2 HO + 3 CO_2) which are found in the juices of many vegetables, particularly in the immature state.

Again, it is always to be observed, not only that all organized bodies are destined ultimately to revert to the water, carbonic acid, and ammonia, from which they were originally formed, but that, in the case of animals at least, there is a process always going on during the state of life, by which these same inorganic matters are continually evolved from the living frames. Therefore, we cannot be surprised to find that the fluids of all living animal bodies contain other compounds, in which the characteristic predominance of carbon is not perceived; because they are those which are formed in circumstances where the vital affinities are losing their power, and where a step has been made towards that final dissolution of organic compounds, when the oxygen is to resume its power over the carbon, and this is to revert, directly or indirectly, to the condition of carbonic acid. This general principle as to the respective offices of carbon and oxygen in living bodies,—the one the main agent in nourishing and supporting living structures, the other in maintaining the excretions by which these structures are continually restored to the inorganic world,—we shall find to be applicable, not only to the excretion of carbonic acid and water by the skin and lungs, as compared with the amylaceous compounds taken into animal bodies, but likewise to the excretions by the liver and kidneys, as compared with the two other great constituents of the food of animals, viz., the oily and the albuminous substances.

Oxygen, in its elementary state, although indispensable to all living action,—although a condition of vitality equally universal as heat,—yet hardly enters, if it enters at all, into any of the combinations which are due to the vital affinities. Although taken into the interior of every living being, it appears to comport itself there almost, if not entirely, as it does in acting on dead matter. The expression of Liebig, that the action of the oxygen of the air in living bodies is *destructive*, is perhaps fitted to convey an erroneous idea, but we are certain that its chief, if not its sole, action in the animal economy, is on those portions of matter which have no vital properties; either because they are redundant,—not required for the nourishment of the tissues,—or because they have been re-absorbed from them, having lost their vital affinities; and with these it unites, only to carry them off in the excretions, particularly in the great excretion by the lungs. We now know that the speculation as to the connection of the oxygen of the air with vital action, long and ably maintained by the late Mr Ellis, viz., that its sole use is to dissolve and carry off excreted carbon, and therefore that in the bodies of animals it goes no farther than the lungs, was erroneous; but we may assert with much confidence, that it goes no farther than the circulating blood; and that, although its action there is essential to all the metamorphoses which are there accomplished, yet all the combinations into which it actually enters, are destined to immediate separation from the living body,—being, in fact, the media by which all living bodies, at all periods of their existence, are continually resolving themselves into the inanimate elements from which they sprung. This principle will be better illustrated, however, by a review of the leading facts lately ascertained as to the formation of the other compounds peculiar to organized bodies, and the excretions of animals.

On the Constitution and Properties of Picoline, a new Organic Base from Coal-Tar. By Thomas Anderson, M.D., F.R.S.E., Lecturer on Chemistry, Edinburgh.

(Concluded from p. 156.)

Combinations of Picoline.

Picoline forms a series of compounds which are generally closely analogous to those of aniline, but present in a less marked degree the regularity and facility of crystallization which are so characteristic of the salts of the latter base. It forms, however, with the greater number of acids, salts which can be obtained in a crystalline form. These are all highly soluble in water, and some of them are even deliquescent; they are also for the most part readily soluble in alcohol, even in the cold. They are most readily obtained by evaporating their aqueous solutions at 212°, and not by adding an acid to the etherial solution of the base; as in the latter case the presence of even a minute proportion of water causes them to precipitate in the form of a semifluid mass. Picoline forms a number of acid salts, in which respect it differs from aniline. Its salts are less readily decomposed in the air than the corresponding aniline compounds, but they do eventually become brown, although without presenting any of the rose-red colour which the latter salts assume.

Sulphate of Picoline.—I obtained this salt by supersaturating sulphuric acid with picoline. The solution obtained was perfectly colourless, and when evaporated in the water-bath, it evolved picoline in abundance, and formed a thick oily fluid, which, on cooling, concreted into a tough mass of transparent and colourless crystals, apparently of a tabular form. Exposed to the air, it deliquesces rapidly into a transparent and colourless oil, which, after a time, acquires a slight brownish colour. It is insoluble in ether, but readily in alcohol, both hot and cold. It is not deposited in crystals by allowing the hot alcoholic solution to cool. I analysed this salt by evaporating to dryness in the water-bath, in a weighed platinum crucible, and allowing it to cool under an exsiccator. It was then rapidly weighed, dissolved in water, and precipitated by chloride of barium :—

4·364 grains of sulphate of picoline gave
5·230 ... sulphate of baryta=41·20 per cent. of anhydrous sulphuric acid.

This result corresponds with the formula $C_{12} H_7 N + 2 H O, S O_3$, as is shewn by the following calculation :—

		Theory.	Experiment.
2 Eq. Sulphuric acid .	1000·0	41·84	41·20
1 ... Picoline . .	1164·5	48·74	...
2 ... Water . .	225·0	9 42	...
	2389·5	100·00	

The sulphate of aniline dried at 212° has a different constitution ; it gives 28·67 per cent. of sulphuric acid, which corresponds to the formula $C_{12} H_7 N, H O, S O_3$.

Oxalate of Picoline.—This salt is obtained by mixing oxalic acid and picoline in excess, and evaporating the solution over quicklime. When the solution is reduced to a very small bulk, it is deposited in the form of short prisms radiating from a centre; and on further evaporation, the whole concretes into a solid mass. The crystals evolve the odour of picoline in the air; they are highly soluble in water and alcohol, both absolute and hydrated. When heated to 212° it fuses and evolves abundance of picoline vapours, and on cooling it forms a thick fluid which slowly deposits crystals in the form of fine needles.

These are probably an acid salt. I did not obtain the oxalate in a state of sufficient purity for analysis.

Nitrate of Picoline is obtained as a white crystalline mass, when a mixture of picoline and dilute nitric acid is evaporated to dryness at a moderate heat. At a higher temperature it sublimes in white feathery crystals.

Hydrochlorate of Picoline may be prepared by mixing picoline and hydrochloric acid, and evaporating on the water-bath. On cooling, the thick fluid which remains consolidates into a mass of prismatic crystals. When heated to a high temperature, it sublimes easily, and deposits itself on the sides of the vessel in transparent crystals, which deliquesce rapidly in the air.

Chloride of Platinum and Picoline.—This salt is easily obtained by adding picoline to a solution of bichloride of platinum, containing an excess of hydrochloric acid; it deposits itself immediately, if the solution be concentrated, but when moderately diluted, it makes its appearance only after the lapse of some time. The crystals which are deposited are rather liable to retain an excess of picoline, which renders it advisable to redissolve them in a dilute solution of chloride of platinum with a little hydrochloric acid. From this solution it is deposited pure, on cooling, in the form of fine orange-yellow needles, which can easily be obtained half an inch long even when operating on very small quantities. It is much more soluble both in water and alcohol than the aniline salt, and indeed than the platinum salts of the organic bases generally. It requires only about four times its weight of boiling water for solution.

The crystals of this salt, after washing with alcohol and ether, and drying at 212°, gave the following results of analysis:—

10·032 grains of chloride of platinum and picoline gave
8·862 ... carbonic acid, and
2·760 ... water.

The determination of the platinum, as formerly mentioned, gave in two different trials 32·544 and 32·522 per cent., the mean of which is 32·533. The analysis corresponds with the formula C_{12} H_7 N, H Cl, Pt Cl_2.

		Theory.		Experiment.
C_{12}	= 900·0	24·07	.	24·09
H_8	= 100·0	2·67	.	3·05
N	= 177·0	4·73	.	...
Cl_3	= 1330·4	35·59	.	...
Pt	= 1232·0	32·94	.	32·533
	3739·4	100·00		

Chloride of Picoline and Mercury.—When picoline is added to a concentrated solution of bichloride of mercury, a white curdy precipitate immediately falls. If, however, the solution be dilute, it is not precipitated for some time, and then appears in the form of radiated silky needles. It is sparingly soluble in cold water, more readily in hot. It dissolves pretty abundantly in boiling alcohol, and the solution, on cooling, deposits it, sometimes in prismatic, sometimes in feathery crystals. It dissolves readily in dilute hydrochloric acid, with the formation of a peculiar compound which I have not particularly examined. Boiled with water it is decomposed, picoline being evolved, and a white powder being deposited.

In the analysis of this compound I interposed, between the combustion tube and the chloride of calcium apparatus, a small tube in which the mercury and water were condensed, and at the conclusion of the process, a current of dry air, heated to 212°, was drawn through the tube, by means of which the water was conveyed into the chloride of calcium apparatus. The salt was dried simply by exposure to the air, as it loses picoline when heated; when analysed it still smelt of picoline, which accounts for the excess of carbon obtained.

The following are the results of the analysis:—

10·962 grains chloride of mercury and picoline gave
8·245 ... carbonic acid,
2·168 ... water.

This corresponds to the formula $C_{12}\,H_7\,N + Hg\,Cl_2$, which gives the following results:—

		Theory.		Experiment.
C_{12}	= 900·0	19·63	.	20.51
H_7	= 87·5	1·90	.	2·19
N	= 177·0	3·86	.	...
Cl_2	= 887·0	19·35	.	...
Hg	= 2531·6	55·26	.	...
	4583·1	100·00		

This salt differs in constitution from the aniline salt, which is represented by the formula 2 (C_{12} H_7 N) + 3 Hg Cl_2; it tallies, however, perfectly with the compound of chinoline and bichloride of mercury, which is C_{18} H_8 N + Hg Cl_2.

I have not particularly examined the other compounds of picoline.

Products of Decomposition of Picoline.

The small quantity of picoline at my disposal has hitherto prevented my examining particularly the products of its decomposition, a branch of the subject which presents numerous points of interest. Such results, however, as I have obtained, indicate a striking difference between the products afforded by it and aniline.

When treated with nitric acid of specific gravity 1·5, picoline is immediately dissolved, but without communicating to the fluid the fine indigo-blue colour which aniline produces under similar circumstances. On the application of heat there is produced an extremely slow evolution of nitrous fumes, which contrasts strikingly with the tumultuous action which aniline produces. After very long-continued treatment with nitric acid, the fluid was evaporated to a very small bulk, when it deposited large crystals in the form of rhomboidal tables. These crystals, on being treated with potass, evolved picoline unchanged. The potass solution was red, but it contained no carbazotic acid, at least no carbazotate of potass was deposited on evaporation.

An excess of bromine water added to picoline causes an immediate and abundant precipitate of a reddish colour, which, on standing during the night, deposited itself in the form of a transparent reddish oil. This substance is destitute of basic properties, and is readily soluble in alcohol and ether, but not in water. Aniline, when treated in the same manner, gives, as is well known, the bromaniloid of Fritsche, which is solid, and crystallises in silky needles, fusible at 232°. It seems probable that the oily fluid obtained from picoline may possess a constitution similar to that of bromaniloid, in which case it would have the formula $C_{12}(H_4Br_3)N$, and would receive the name of bromopicoloid. I had not enough of it for analysis.

The action of chlorine on picoline is remarkably analogous to that which it produces on aniline. When passed into anhydrous picoline it is rapidly absorbed, and colourless crystals, apparently of hydrochlorate of picoline, are deposited. In a short time, however, the fluid becomes dark brown, and is finally converted into a resin. This resin was mixed with water, and a current of chlorine passed through it for some hours. The fluid was then introduced into a retort, and distilled, a crystalline substance passed over along with the water, and after all the water had passed, another substance made its appearance, while a large quantity of carbon was left in the retort. The quantity in which I obtained these substances was far too small to admit of their particular examination, but it appeared to me that the odour of the latter substance was different from that of chlorophenesic acid, which is produced by the action of chlorine on aniline.

The preceding investigation is sufficient to establish the identity, in constitution and difference, in properties of picoline and aniline. These substances are then isomeric, in the strict sense of the term, possessing the same composition per cent., and the same atomic weight.

Although isomerism has been recognised in a great variety of different classes of compounds, I believe the present to be the first instance in which it has been satisfactorily proved among organic bases. Two instances, indeed, have been previously described, but in neither can the evidence be considered absolutely conclusive. One of these cases is that of two bases discovered by Pelletier and Couerbe* in the husks of the Cocculus Indicus, to which they have given the names of Menispermin and Paramenispermin. The characters which they have assigned to these substances are sufficiently distinct, but their analyses of both lead to the formula $C_{18}H_{12}NO_2$. This result, however, is unsupported by any

* Annales de Chimie et de Physique, vol. liv.

determination of their atomic weights, without which the isomerism cannot be admitted as proved. The other instance is that of bebeerine, which, according to the analyses of Dr D. Maclagan,* is isomeric with morphia, both being represented by the formula $C_{35} H_{20} N O_6$; and as this result is supported by the analysis of the platinum compound, the probability of their isomerism is much higher than in the former case. Unfortunately, however, another source of fallacy enters into the question in the amorphous condition of bebeerine, which renders it impossible to determine with certainty its freedom from impurity; even the constitution of morphia, by far the most definite of the two substances, can scarcely be considered as fixed, Gerhardt, for instance, representing it by the formula $C_{36} H_{19} N O_6$, and not by that formerly given.

With aniline and picoline, however, these uncertainties disappear. Both substances are possessed of definite boiling points widely different from one another, and of all the other physical characters of pure substances. The lowness of their atomic weight also precludes any possibility of doubt regarding the true formula, and enables us to speak with certainty as to the identity of their constitution. The isomerism of these substances is, moreover, of much higher interest in a theoretical point of view. Menispermin and morphia are isolated substances, entirely unconnected, in constitution or general relations, with any other substance. Aniline, on the other hand, is a member of one of the most extensive, widely distributed, and interesting groups of substances, with which the recent discoveries of organic chemistry have made us acquainted, the Indigo Salicyl and Benzoil series. The members of this large group already present a variety of instances both of isomeric and polymeric compounds, a few of which I have here brought together in the form of a table, which does not pretend to any scientific arrangement, its sole object being to point out the remarkable relations of aniline and picoline to the group.

* Proceedings of the Royal Society of Edinburgh, No. 26.

Indigogene, . .	$C_{16} H_6 N O_2$	Indine.
Indigo, . . .	$C_{16} H_5 N O_2$	...
Isatine, . .	$C_{16} H_5 N O_4$	...
Anthranilic acid, .	$C_{14} H_7 N O_4$	...
Salicylic acid, .	$C_{14} H_6 O_6$	?*
Nitrosalicylic acid, .	$C_{14} H_5 (N O_4) O_6$	...
Benzoic acid, . .	$C_{14} H_6 O_4$	Salicylous acid.
Nitrobenzoic acid, .	$C_{14} H_5 (N O_4) O_4$	Nitrosalicylous acid.
Chlorobenzoic acid, .	$C_{14} H_5 Cl O_4$	Chlorosalicylous acid.
Hydruret of benzoil	$C_{14} H_6 O_2$	Benzoine.
Benzonitril, . .	$C_{14} H_5 N$	Azotide of Benzoil.
Stilbene, . .	$C_{14} H_6$	...
Phenol, . . .	$C_{12} H_6 O_2$	...
Aniline, . .	$C_{12} H_7 N$	Picoline.
Tribromaniline, .	$C_{12} H_4 Br_3 N$	Tribromopicoline ?
Benzin, . . .	$C_{12} H_6$	?
Nitrobenzid, . .	$C_{12} H_5 (N O_4)$	...

The facility with which aniline can be obtained by the decomposition of different members of this group, renders it by no means impossible to anticipate the artificial production of picoline also.

As we can start from benzoic acid, and convert it into benzin, benzin into nitrobenzid, and that finally into aniline, by the action of sulphuretted hydrogen, it seems by no means improbable that salicylous acid, the isomeric of benzoic acid, may be made to undergo a similar series of changes, the final result of which would be the formation either of picoline, or of some other compound isomeric with it and aniline. In oder to subject this hypothesis to the test of experiment, I mixed salicylous acid with equal weights of slaked lime and caustic baryta, and distilled in the oil bath, with the view of obtaining a substance which should be isomeric with benzin. The greater part of the salicylous acid, however, passed over unchanged; but by agitation with solution of potass, there was left undissolved an excessively minute quantity of a solid crystalline substance. Finding this mode of operating unsuccessful, I passed salicylous acid over spongy platinum heated

* Gerhardt has observed (Precis de Chimie Organique, tom. ii., p. 21), that benzoic acid, when fused with hydrate of potass, evolves hydrogen, and gives the potass salt of a new acid. This may possibly be isomeric with salicylic acid.

to a very low red heat in a glass-tube. A dark viscid oily fluid passed over into the recipient, of which the greater quantity dissolved in caustic potass, but left behind a larger quantity of the solid substance than was yielded by the first experiment. By distillation with water this substance passed into the receiver in the form of oily drops, which solidified on cooling, and formed a crystalline mass in which minute needles could be detected. It had a peculiar pleasant smell which resembled that of benzin; but the quantity which I obtained was much too minute to admit of its analysis, or of any attempt to convert it into picoline.

Postscript.

Although the analogy existing between picoline and the other oleaginous bases is perfectly sufficient to warrant the assumption of the absence of oxygen in that substance, I have thought it advisable to append here an experimental determination of the nitrogen. As the volatile bases cannot be readily analysed by Varrentrap and Will's method, I made a combustion of the platinum salt, and determined the proportion by volume of the carbonic acid and nitrogen in four tubes, which gave the following results:—

I.	94	volumes gave	8·	nitrogen.
II.	240	...	18·	...
III.	84	...	6·5	...
IV.	421	...	35·	...
	839		67·5	

These results give the gases in the proportion of $11\frac{1}{2}$ to 1; in other words, they shew a slight excess over the theoretical result, according to which they should be in the proportion of 12 to 1. They confirm perfectly, however, the absence of oxygen.

On the Cause of Induration of some Siliceous Sandstones. By JOHN DAVY, M.D., F.R.S., London and Edinburgh, Inspector-General of Army Hospitals. Communicated by the Author.

There is a remarkable contrast between the sandstones of the neighbourhood of Edinburgh and Glasgow and those of "Scotland,"—a hilly district so called in Barbadoes. Whilst many indications denote that they belong to an analogous formation, their character, as to induration, is widely different. The siliceous sandstones of the neighbourhood of Edinburgh and Glasgow, owing to their firmness, and the moderate degree of cohesion of their particles, are, as it is well known, excellent building stones; but most of those of the district of this island mentioned, are unfit for such a purpose, from the looseness of their texture, some of them actually falling to pieces when immersed in water. When chemically examined, however, no well-marked difference is discovered in their composition. In a crumbly siliceous sandstone, the strata of which are nearly vertical, constituting the seaward face of a singular hill in this island, called "Chalky Mount," I have detected minute portions of alumine, lime, fixed alkali, and phosphate of lime. In the fine-grained compact sandstone of Craigleith quarry, near Edinburgh, I have detected, also, a very little carbonate of lime, and magnesia, and oxide of iron, with a trace of phosphate of lime and organic matter. The one stone, that of this island, disintegrates in water, rendering it slightly turbid, falling to pieces, reduced to sand, as the water penetrates between the grains; and more rapidly so when acted on by an acid. The other stone, after the action of an acid, retains its original firmness unaltered. I speak of the pure siliceous kind, such as I examined.

On what does this difference depend?

When the two sandstones are reduced to powder or sand (the more compact one is easily so reduced by gentle attrition under water), and they are placed under the microscope, the sand of the loose sandstone is found to have a different character when compared with the sand of the compact stone; one is seen to be water-worn, even the minute crystals of quartz which may be occasionally observed; the other is found without marks of being water-worn, the grains with sharp edges and angles, and many of them crystalline. When fragments of the two different sandstones are similarly examined, the loosely-cohering one exhibits the water-worn grains separated by matter in a much finer state, of chalk-like appearance; whilst the compact one displays the angular sharp-edged crystalline grains in contact, and as it were entangled, without any finer granular matter intervening.

Does not, then, the cause of the difference under consideration, exist in the circumstances which the microscope brings to light? Is not the compactness of the Edinburgh stone owing to its being crystalline, the crystalline grains adhering together? Is not the looseness and want of cohesion, under water, of the Barbadoes stone, owing to its grains having been all deposited water-worn, without any crystalline cement, and having interposed a finer granular matter, a kind of clay, absorbent of and yielding to water?

I have said that these two sandstones belong apparently to analogous formations. Perhaps, farther inquiry may prove that whilst the crystalline rock is of the group of the old red sandstones, the other, without a crystalline siliceous cement, belongs to one of more recent origin,—or the group of new red sandstones.

Though most of the sandstones of this island are of the character pointed out, there are exceptions,—indeed in the district referred to, as regards the equality of firmness, a complete gradation is often observable from loose uncohering sand to compact sandstone, and that in contiguous strata. A hill near "Chalky Mount" consists of such strata; here may be seen a layer of loose siliceous sand, resting on a thin stratum of loose sandstone, and covered by one that is compact, and this to the extent of many alternations. Where there is any compactness in these strata, they are found to owe it either to carbonate of lime, or to peroxide of iron, or to both; which are, I believe, the common cementing principles of the generality of sandstones, whether siliceous or calcareous.

I may mention incidentally, as tending to shew the analogy alluded to between these strata of sandstone in the hilly part of Barbadoes, and those occurring in the Lowlands of North Britain, that the former are associated with, or succeeded by, beds or strata of various clays,—by beds of siliceous matter composed almost entirely of the remains of infusoria, and by beds of chalk abounding in similar infusoria, with seams or deposits of bituminous coal interspersed,—in one instance mixed with anthracite, and with strata having the character of volcanic ashes,—besides others. Thus exhibiting, in a small space, an extraordinary variety, and this the more remarkable from the contrast as to geological structure of by far the larger portion of Barbadoes, remarkable for its uniformity. Its prevailing rock is an aggregate or fragmentary one, consisting chiefly of shell and coral limestone, and freestone, in many places abounding in species of shells and corals identical with species existing at present in the adjoining seas.

It has been supposed by those who have hitherto written on the geology of Barbadoes, that the shell and coral limestone is lower in the series of rocks than sandstone, and the other strata mentioned. But this is clearly a mistake. The shell limestone may be seen resting on clay in some of the sea-cliffs; and some of the summits of the hills in the lesser district are capped with freestone or shell limestone, in which, in one instance, I have found the teeth of two different species of shark.

BARBADOES, 29*th May* 1846.

Address delivered at the Anniversary Meeting of the Geological Society of London, on 20*th February* 1846. By LEONARD HORNER, Esq., V.P.R.S., President of the Society.

(Concluded from p. 128.)

Metallic Products.

The protrusions of igneous rocks along the line of the Urals were accompanied throughout a great part of the chain by the formation of numerous and extensive metallic veins, particularly on the eastern flanks, the chief seat of the metallic riches of Russia, especially in copper and iron. The geological details connected with these metalliferous rocks constitute a large and interesting part of Sir R. Murchison's work. One of the most important geological features connected with them, and it is one which appears to be well established, is the comparatively recent date of the eruptions which brought these metallic products of nature's crucibles within the reach of man. The accounts of the rich gold deposites are curious, and the ejection of the rock in which that metal is contained appears to have been very modern—little, if at all, anterior to the destruction of the mammoths, whose remains are entombed in the gravel which is found everywhere in the depressions of the Ural chain, and which covers vast regions of Siberia. The matrix appears to be quartz in the form of veins; but to find the gold in that state is extremely rare. It is found in lumps and grains that have been rolled, mixed with other detrital matter. A lump weighing about seventy-eight pounds English, found in 1843, is now in the Museum of the Imperial School of Mines at St Petersburg.

Several curious facts are adduced to shew that some of the ores of copper, particularly the green carbonate or malachite, are aqueous productions, derived from pre-existing ores, as calcareous stalagmites are derived from limestone rocks. In the copper mine of Nijny Tagilsk, at a depth of 280 feet from the surface, an immense irregularly-shaped botryoidal mass of solid pure malachite was found, of a bulk estimated at upwards of half a million of pounds weight, presenting in its interior the wavy radiations and silky structure of that beautiful mineral; almost identical in structure with many calcareous semi-crystalline minerals, of whose aqueous origin no doubt exists.

All the best iron of Russia is brought from the Ural chain and its flanks. It is found in veins in greenstones, and intermixed with the mass of erupted rocks of that class, often in great abundance at the junction of the igneous and stratified rocks, these last being in a metamorphic state. Magnetic iron ore is the chief form in which the metal is found, and it constitutes vast masses, sometimes worked in an open quarry.

Changes in the Relative Level of Sea and Land.

You are well aware that proofs of changes in the relative level of the sea and land along certain shores, particularly in the Baltic and Mediterranean, since our continents and adjacent islands were bounded by their present lines of coast, had attracted the attention of some of the earlier geologists; but it is only within a comparatively recent period that the discovery, in numerous instances, of the action of the sea at elevations far above its present level, in what have been termed *raised beaches*, has excited due attention to this most important class of geological phenomena; changes which may almost be said to come within the range of our experience, and which appear to afford a key to the right solution of many analogous changes during periods long antecedent. We have for some time known that eroded rocks, and long lines of level beds or terraces of shingle, sand and clay, mixed with broken shells like what we now find at the seashore, are met with along the coasts of Sweden, and in Norway and the islands adjacent, from the Naze to the North Cape, and even to Spitzbergen. These beds of detritus, which have been found at elevations of 600 feet, and are sometimes above 160 feet in thickness, usually rest on the solid rock, and frequently contain shells in a perfect state of preservation as to freshness and colour, the bivalves, which are identical with species now living near the shore of the adjoining sea, retaining their uniting ligament; indicating that the changes have occurred, either during the latter part of the tertiary period, or at the commencement of the existing geological period. These facts are described in the writings of Playfair, Von Buch, Keilhau, Sefström, Lyell, and others, and some very remarkable cases have recently been given in a memoir by M. Bravais,* who resided a year in Finmark, between the seventieth and seventy-first degrees of latitude, and who has measured with great care a series of terraces or raised beaches in the Alten Fiord, which extend over a line of coast from fifty to sixty miles.

The western coast of our own island has also, as you know, afforded some most remarkable instances of these changes of relative level of sea and land, from the north of Scotland to Cornwall, and in some cases at a much greater elevation than in Norway, as at Moel Tryfane in Caernarvonshire, more than 1000 feet above the sea. That they have not been found in as continuous extent in Britain as in Norway is perhaps owing to this, that the shores of our island being cultivated, these banks of loose materials would gradually become obliterated.

But it is not the shores of Europe alone that have afforded proofs of these changes; the continents of North and South America exhibit them on a far grander scale, both on the Atlantic and Pacific coasts. We are indebted to Mr Darwin for descriptions of many remarkable instances; and some of these which have recently come again under our notice, in the second edition of his "Journal," published within the last few months, I will draw your attention to. I know no geologist whose observations, and the inferences he draws from them, are more to be relied upon; for he examined the country he describes evidently uninfluenced by any preconceived opinions. They have, besides, a bearing upon some

* A translation of this valuable memoir is given in the fourth number of the Quarterly Journal of the Geological Society.

fresh accessions to our knowledge of facts of this description, both in Europe and North America, during the past year.

At Coquimbo, in northern Chile, five narrow, gently sloping, fringe-like terraces, rise one behind the other, and, where best developed, are formed of shingle. At Guasco, farther north, the terraces are much broader, and may be called plains, and they run up the valley for 37 miles from the coast. Shells of many existing species not only lie on the surface of the terraces, to a height of 250 feet, but are imbedded in a friable calcareous rock, which is in some places as much as from 20 to 30 feet in thickness; and these modern beds rest on an ancient tertiary formation, containing shells apparently all extinct. "The explanation of the formation of these terraces must be sought for, no doubt, in the fact, that the whole southern part of the continent has been for a long time slowly rising, and, therefore, that all matter deposited along shore in shallow water must have been soon brought up and slowly exposed to the wearing action of the sea-beach." * He describes a great valley near Copiapo, reaching far inland, the bottom of which, consisting of shingle, is smooth and level; and states that he has little doubt that this valley was left, in the state in which it is now seen, by the waves of the sea, as the land slowly rose.† He then goes on to state, "I have convincing proofs that this part of the continent of South America has been elevated near the coast at least from 400 to 500, and in some parts from 1000 to 1300 feet, since the epoch of existing shells."‡ Speaking of the neighbourhood of Valparaiso he says,—"The proofs of the elevation of this whole line of coast are unequivocal; at the height of a few hundred feet old-looking shells are numerous, and I found some at 1300 feet. These shells either lie loose on the surface, or are imbedded in a reddish-black vegetable mould. I was much surprised to find, under the microscope, that this vegetable mould is really marine mud, full of minute particles of organic bodies."§

So far for instances of changes in the relative level of sea

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* Journal of a Voyage round the World, 2d edit., p. 344. † Ibid., 355.
‡ Ibid., 357. § Ibid., 254.

and land on the western shores of the continent; they are no less conspicuous on the Atlantic side. "The land from the Rio Plata to Tierra del Fuego, a distance of 1200 miles, has been raised in mass (and in Patagonia to a height of between 300 and 400 feet) within the period of now existing sea-shells. The old and weathered shells left on the surface of the upraised plain still partially retain their colours. The uprising movement has been interrupted by at least eight long periods of rest, during which the sea ate deeply back into the land, forming at successive levels the long lines of cliffs or escarpments which separate the different plains, as they rise like steps one behind the other."*

Now it is important to observe, that in some of the above instances, and also in others which Mr Darwin gives, the proofs of change are not in terraces or raised beaches only, but that there are broad expanses of land far from the sea-coast, where marine shells of existing species lie near the surface and upon it; in other words, that we have that which recently was a sea-bottom now forming an elevated part of the continent.

The authors of the "Geology of Russia" have described a sea-bottom, extending nearly 200 miles inland from the shores of the Arctic Ocean, which they were the first to discover. In ascending the Dwina, which flows into a bay of the Icy Sea at Archangel, they discovered at about 150 miles from that city, near where the Vaga, a tributary, falls into the Dwina, a profusion of shells having a very modern aspect, regularly imbedded in clay and sand of about ten feet in thickness, which, covered by about twenty feet of the coarse gravel and detritus of the country, reposed on red and white gypsum, subordinate to red marls of the Permian system of rocks. They traced these shelly beds to a distance of about 8 miles. Some of the shells preserved in the blue clay or marine sand, and thereby excluded from atmospheric influence, have restrained all the freshness of their original colour, with their valves often united; and the whole, even when blanched, are generally in a good state of preservation. What they col-

* Journal of a Voyage round the World, 2d edit., p. 171.

lected were carefully examined by skilful conchologists. Dr Beck of Copenhagen considered all he examined to be identical with those now existing in northern seas which range from 42° to 84° south latitude. Mr Smith of Jordan Hill was of opinion, that, though many of these species are recent, some are of peculiar varieties, now found in desiccated and elevated sea-beaches only. Mr Lyell recognised the group as identical with that which he had described from Uddevalla in Sweden, a distance of a thousand miles from the Dwina; and Mr G. Sowerby stated, that the shells, though on the whole an association of existing species, have yet among them forms seldom, if ever, found except in raised sea-bottoms of a subfossil character. The authors estimate the place where these shelly beds occur to be about 150 feet above the sea at Archangel, and consider them to afford undoubted evidence, that the land, from the Vaga to Archangel, was a sea-bottom during the period of existing species. A similar estuary appears to have existed about 300 miles eastward, in the valley of the Petchora; for Count Keyserling found fragments of sea-shells, apparently of existing arctic forms, at a distance of 180 miles from the present embouchure of that river, strewed upon argillaceous slopes in the depression of the valley. He further observed, that they do not occur in the adjoining plateaux; and that these higher grounds are occupied by sand, gravel, and clay, containing here and there bones of the mammoth, from which he infers, that the shelly deposites were formed in a bay of the sea that extended far into low lands, which were then inhabited by great extinct mammalia.

In the sketch given by the same authors of the structure of Siberia, they adduce a body of very satisfactory evidence to justify the inference they draw, that the vast region in which the bones of mammoth, rhinoceros, and *bos urus*, are so abundantly dispersed, and especially the wide and low tract of northern Siberia, and all the low promontories between the Obe, the Yenessei, and the Lena, were elevated at a period long subsequent to the time when large herds of these animals for many successive generations inhabited that region. Following up the views first propounded by Mr Lyell, to whom they do full justice, they infer that the change of climate, the diminished temperature, occasioned by the increase of land when the sea-bottoms of these estuaries and shores were upraised, caused the extinction of these great quadrupeds.

Although the great tract of country from the Baltic to the elevated region westward of the Ural Mountains has not been locally broken up by eruptive rocks, there is ample evidence to prove that it has been subjected to the action of subterranean forces, which elevated the whole region, after the deposition of Miocene tertiary beds, and after the land, while submarine, had assumed its present form. "From the German Ocean and Hamburgh on the west to the White Sea on the east, a vast zone of country, having a length of near 2000 miles, and a width varying from 400 to 800 miles, is more or less covered with loose detritus, including erratic crystalline blocks of colossal size, the whole of which blocks have been derived from the Scandinavian chain." The eastern and south-eastern boundary of these erratic blocks mark the line of coast westward of which all the land as far the shores of the Baltic was then submerged. Between that line of coast and the Urals is the region that constitutes the Government of Perm, Viatka, and Orenburg; and for a considerable space to the west of the Ural, there is not a vestige of any superficial deposite which can be referred to the influence of the sea. "We believe, therefore," says the authors, "that the region so characterised was really above the waters, and inhabited by mammoths, when the erratic blocks were transported over the adjacent north-western sea." The amount of this elevation, subsequent to the covering of the sea-bottom by the northern drift, must have been at least from 800 to 1000 feet; for the tops of the Valdai Hills, a range on the eastern borders of Lithuania, and to the south of the Government of St Petersburg, which rise in some places to that height, are covered with these blocks on their southern slopes.

Mr Lyell, speaking of the country near Savannah in North America, says, "It is evident that at a comparatively recent period, since the Atlantic was inhabited by the existing species of marine testacea, there was an upheaval and laying dry of the bed of the ocean in this region. The flat country of marshes was bounded on its inland side by a steep bank or ancient cliff, cut in the sandy tertiary strata; and there are other inland cliffs of the same kind, at different heights, implying the successive elevation above the sea of the whole tertiary region." In a letter which I received from him a few days ago, dated from Savannah, Mr Lyell tells me "that he had seen on the coast of Georgia quite a counterpart of the terraces, or successive cliffs of Patagonia, cut out of the tertiary deposites." But there are also evidences on that coast of a downward movement at the present time. Mr Lyell says, "there have also been subsidences on the coast, and perhaps far inland; for in many places near the sea there are signs of a forest having become submerged, the remains of erect trees being seen enveloped in stratified sand and mud. I even suspect that this coast is now sinking down at a slow and insensible rate, for the sea is encroaching and gaining at many parts on the freshwater marshes....Everywhere there are proofs of the coast having sunk, and the subsidence seems to have gone on in very modern times." Speaking of some phenomena connected with a boulder formation at Brooklyn near New York, he says that he had come to the conclusion, "that the drift was deposited during the successive submergence of a region which had previously been elevated and denuded, and which had already acquired its present leading geographical features and superficial configuration." In the region near the Falls of Niagara, on Lake Ontario, and in the valley of the St Lawrence, he enumerates many unequivocal proofs of emergence and submergence during the modern period now under consideration. He states, that in the valley of the St Lawrence he seemed to have got back to Norway and Sweden, passing over enormous spaces covered by deposites so modern as to contain exclusively shells of recent species, resting on the oldest palæozoic and older non-fossiliferous rocks. Wide areas are covered with marine shells of *recent* species, at the height of 500 feet above the sea, and where all the rocks can be shewn both to have sunk and to have been again uplifted bodily, for a height and depth of many hundred feet, since the deposition of these shells. At the village of Beauport, three miles below Quebec, he made a collection of shells from a cliff consisting of a series of beds of clay, sand, gravel and boulders; and he states that when they arrived in London, Dr Beck of Copenhagen happened to be with him; and "great was our surprise," he adds, "on opening the box, to find that nearly all the shells agreed specifically with fossils which, in the summer of the preceding year, I had obtained at Uddevalla in Sweden, and figured in my paper 'On the Rise of Land,' &c. in the 'Philosophical Transactions' for 1835. Among the species most abundant in these remote regions (Scandinavia and Canada) were *Saxicava rugosa, Mya truncata, M. arenaria, Tellina calcarea, T. Grœnlandica, Natica clausa,* and *Balanus Uddevallensis.* All of them are species now living in the northern seas; and whereas I had found them fossil in latitudes 58° and 60° N., in Sweden, Captain Bayfield sent them to me from a part of Canada, situated in latitude 47° N."

Ascending the St Lawrence, he found near Montreal, at a height of about sixty feet above the river, great numbers of the *Mytilus edulis,* retaining both valves and their purple colour, associated with *Tellina Grœnlandica* and *Saxicava rugosa,* in horizontal beds of loam and marly clay. He found the same shells at ninety feet associated with boulders of gneiss and syenite three feet in diameter, characteristic of the Canadian drift; and he was afterwards conducted to a hollow between the two eminences which form the Montreal mountain, where he found a bed of gravel six feet thick, containing numerous valves of *Saxicava rugosa* and *Tellina Grœnlandica.* This bed he estimates at 540 feet above the sea, 306 feet above Lake Ontario, and only 25 feet below the level of Lake Erie.

Such comparatively modern changes in the relative level of the land and sea, were ascribed by the earlier geologists, and are by some still ascribed, to a rising or sinking *of the sea.* Playfair, nearly half a century ago, combating this opinion maintained by the Swedish naturalist Celsius, demonstrated the untenable nature of such an hypothesis; it was he who first shewed that these changes of relative level are alone explicable by the movements *of the land*, and that a permanent change of level of the sea, in detached regions of the earth's surface, is physically impossible. "The imagination," he says, "naturally feels less difficulty in conceiving that an unstable fluid like the sea, which changes its level twice every day, has undergone a permanent depression in its surface, than that the land, the *terra firma* itself, has admitted of an equal elevation. In all this, however, we are guided much more by fancy than by reason; for, in order to depress or elevate the absolute level of the sea, by a given quantity, in any one place, we must depress or elevate it by the same quantity over the whole surface of the earth; whereas no such necessity exists with respect to the elevation or depression of the land. To make the sea subside thirty feet all around the coast of Great Britain, it is necessary to displace a body of water thirty feet deep over the whole surface of the ocean. It is evident that the simplest hypothesis for explaining those changes of level, is, that they proceed from the motion, upwards or downwards, of the land itself, and not from that of the sea. As no elevation or depression of the sea can take place but over the whole, its level cannot be affected by local causes, and is probably as little subject to variation as anything to be met with on the surface of the globe."*

Notwithstanding that this unanswerable doctrine was thus clearly laid down so far back as 1802, we still find geologists of authority speaking *of the sea* having risen or fallen, in their endeavours to explain certain phenomena. I have within the last year heard this said repeatedly in this room; and in a recent excellent paper of my friend Mr Maclaren of Edinburgh, on boulders and grooved and striated rocks observed by him on the shores of the Gare Loch in Dumbartonshire, an excellent observer, and in general a sound reasoner, I find such expressions as the following:—"The anomalous presence of granite boulders at Gare Loch seems best explained, by assuming that they were floated on icebergs from Ben Cruachan, Ben Nevis, or some other of the lofty granite mountains of the north . . . *The sea must then have stood perhaps* 1500

* Illustrations of the Huttonian Theory, p. 446.

feet above its present level, to permit the rafts of ice to pass over the lowest part of the barrier . . . . An iceberg starting from the West or North Highlands, *and floating in a sea* 1500 *or* 2000 *feet above the present level of the Atlantic*, is an agent perfectly capable of effecting the transportation of the stone, and offers, I think, the only conceivable solution of the difficulty . . . . *When the sea stood, as it certainly once did stand,* 1000 *feet or more above its present level*, a current would set eastward through the gulf then occupying the low lands, of which the estuaries of the Forth and Clyde form the extremities." Speaking of an ancient beach 32 feet above the present high water line on the shore of Gare Loch, he says, "We may infer that, when the glacier occupied the valley of Gare Loch, *the sea stood higher than it does now by at* least 30 feet, and probably a great deal more."* It is possible that these may be mere inaccuracies of expression in describing changes of relative level of sea and land; but if they are so, they ought to be guarded against, for they may be very easily misapprehended; and they tend to perpetuate an error that leads to the most false reasoning on many changes on the earth's surface.

If the land of Norway had been immovable, if the sea had fallen from a higher level, the lines of its former shores, as it sank at intervals, would have been continuous and parallel; but the raised beaches are, within short distances, at different elevations. Other observers had marked this; but it is to M. Bravais that we are indebted for the first exact measurements of the relative positions of the successive terraces, and these have demonstrated that their parallelism is only apparent. During his residence on the Alten Fiord, near North Cape, he extended his levellings over a space of from 9 to 10 myriametres, that is, from about 55 to 62 English miles; and he ascertained, that the two great lines of ancient level there, which are on a slope rising from the sea, come nearer and nearer to each other as they approach the present shore; their greatest elevation is in the upper part

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* Jameson's Edin. Phil. Journal, Jan. 1846.

of the Fiord, and they are there widest apart. It is evident, therefore, that the movement of the land has been different in different parts of the Fiord. It seems as if the continental mass had been elevated with an inclination seaward, the axis of motion corresponding nearly to that of the great chain of the mountains of Norway. It is most desirable, that measurements similar to those of M. Bravais should be made in all places where there are terraces or raised beaches, one above another, along our coasts. Mr Darwin's explanation of the parallel roads of Glen Roy, that they are ancient sea-beaches, appears to be now generally accepted; and it would be most interesting, if it were ascertained by exact levellings, such as those of M. Bravais in the Alten Fiord, whether they are really parallel; because, as M. Bravais well remarks, they may seem so to the eye, which can take in only a small part of the space they occupy, while exact measurements might prove that the appearances are deceptive.

That land, in various parts of the earth, has undergone movements of elevation and depression, and that it has been subject to such oscillations at all times, up to the present day, admits, I think, of no doubt. Without, therefore, going quite so far as my friend Mr Darwin, who tells us, that "daily it is forced home on the mind of the geologist, that nothing, not even the wind that blows, is so unstable as the level of the crust of this earth;" still, I believe, it may be safely affirmed, that the stability of the sea, and the mobility of the land, must be acknowledged to be demonstrated truths in Geology.

Boulder Formations and Erratic Blocks.

The geologically modern changes in the relative level of sea and land, are intimately connected with the history of the vast accumulations over Northern Europe and North America of detrital matter, in the form of sand, clay, gravel, boulders, and huge erratic blocks, and of the grooved, striated, and polished surfaces of hard rocks, which usually accompany them. This great problem, complicated in its nature, and full of difficulties, has of late years more particularly arrested the attention of geologists; and it must long continue to do so, before a sufficient mass of observations can be collected on which a satisfactory solution of it can be founded. Although, as regards Europe, many important local facts, exhibited in limited districts, have been well described by several geologists, both of this country and of the continent, we are indebted, for the most extended observations and the most comprehensive views of the subject, to the labours of Keilhau, Sefström, Durocher, Murchison, De Verneuil, and Forchhammer. The geologists of the United States, and Lyell, have brought together a great body of evidence respecting the same phenomena in North America. There is reason to infer, from the limited observations that have been made along the shores of Siberia, that the boulder formation extends also over Northern Asia.

Many new observations have been made known to us during the last year, by the authors of the "Geology of Russia," by Mr Lyell, in his "Travels in the United States, Canada, and Nova Scotia," and by M. Durocher, in an additional memoir which he read last December before the Geological Society of France, describing observations made by him in Norway during the preceding summer.

You are aware that Agassiz and Charpentier have attempted to explain the phenomena, by supposing that, at a very recent geological period, since the time when the land had assumed its present form, Northern Europe was covered with a vast mantle of ice; and that the detritus and erratic blocks have been formed and transported by the agency of sub-aërial glaciers, in the same manner as moraines have been accumulated, blocks transported, and rocks furrowed, striated, rounded, and polished, by the glaciers descending from the Alps. Abundant evidence has been brought forward to demonstrate, that by no such action can the phenomena be explained; and all the geologists mentioned above, who have carefully investigated them, reject the theory as inapplicable to Northern Europe and America, except in a very limited sense.

The Boulder Formation, or Northern Drift, and The Erratic Blocks, are shewn, by the authors of the "Geology of Russia," to be two distinct classes of phenomena; the latter being usually angular, the materials of the former being rounded and worn by attrition. It appears to me to have been clearly proved, that the boulder formation is not the work of a sudden transient action of short duration, but the result of operations that were going on during the middle tertiary deposites, and, in Europe, extended at least to the Pleistocene period; that the greater part of the accumulations took place since existing species of testacea inhabited the adjoining seas; and that the transport of erratic blocks took place at a later period. It seems to be no less clearly established, that the boulder and drift accumulations and the erratic blocks now covering the dry land, were deposited upon a sea-bottom, which has been since upraised. Where the smaller detritus and rounded boulders came from, and how they were drifted into their present situations, are branches of the subject involved in great obscurity. That fragments of hard rock were the tools which grooved the furrows and striæ, and polished the surfaces of hard rocks they passed over, is pretty evident; but what held and guided the tool, what force applied it, to what extent ice, and to what extent water, was the agent, is not so clear: that both have acted, there can be no doubt. It is, I think, very satisfactorily shewn, that the erratic blocks must have been brought down from lofty mountains, to the open sea that washed their bases, by glaciers; that they were floated to great distances by masses of ice breaking off from these glaciers, to form icebergs, in different directions from central points, and stranded on elevated parts of the sea-bottom, without having been subject to much attrition; and, moreover, that these erratic blocks can, in a great number of instances, be traced to their parent rock, though now separated some hundred miles. Some of the evidence in support of these positions, supplied during the last year, I will now bring forward. I regret that my limits will not allow me to do greater justice to the authors to whom we are indebted for it, either as regards their facts, or their deductions from these facts.

The boulder formation and erratic blocks cover an enormous area, from the Arctic Sea over a great part of Northern Europe; not continuously, but often uninterruptedly over vast regions. The masses of clay, sand, and gravel, are sometimes of so great thickness that it is impossible to detect a trace of the subjacent solid rock, over very wide tracts, even in the beds of the Volga and the deepest cutting rivers. M. Durocher, in his first memoir,* did not trace the erratic blocks farther east than the forty-second degree of longitude, nor farther south than the fifty-fifth degree of north latitude; but the authors of the "Geology of Russia" have described them as extending 500 miles farther east, and above 200 miles farther south. As the parent rocks of most of these huge fragments are in Scandinavia and Finland, they have been, in some intances, transported to a distance of 800 miles in a direct line.† It is possible that the *boulder formation* may extend somewhat farther, but probably not much; for there is reason to believe that land on the east and south was above the level of the sea, as has been already stated, at the time the country to the west and north was submerged, which would stop the advance of the boulder formation and erratic blocks, but in an irregular line. No erratic blocks of northern origin have been seen for a considerable distance westward of the Ural Mountains.

There is a feature in the character of this superficial covering of detritus which is very important to attend to in tracing its history, viz., that the materials are not always the same; that the principal mass in each district is of local origin, and very clearly bespeaks its derivation to be in the subjacent rocks; and that the great northern drift is distributed in the form of long sand-banks, "*trainées*," or "*osar*," as they are called in Sweden, often of great length and breadth, and rising sometimes more than 100 feet above the depressions between them, which last are occasionally of great width. These trainées are often composed of finely laminated sand and clay, containing shells identical in species with those now living in the Baltic or in the northern seas; they traverse, from the shores of the Baltic, the Silurian, Devonian, and carboniferous regions in succession, deriving new materials from each zone

* Comptes Rendus, Janvier 1842.

† Map accompanying "Geology of Russia."

of rocks crossed, but always indicating a southerly direction of the drift, the Devonian detritus never being found in the Silurian zone, nor the carboniferous in the Devonian zone.

Mr Forchhammer describes the boulder formation of Denmark as being of different ages. The oldest which affords any distinct evidence to mark its age, consists of a congeries of clays, marls, and sands, which have been traced to a depth of several hundred feet, and contain boulders throughout the entire mass, extending to the deepest part of the series. The boulders, sometimes several hundred cubic feet in size, are of granite, gneiss, porphyry, greenstone, and quartz rock, and also of transition (Silurian) sedimentary rocks ; none of these occurring nearer than Norway and Sweden. Besides these travelled blocks, there are many parts of the formation composed of chalk, identical with rocks upon or near to which the boulder formation occurs. In the duchy of Schleswig, this boulder formation *alternates* with beds of brown coal, a deposite which exends over the greater part of Denmark, and which, besides brown coal, consists of clays, limestones, and sandstones, containing fossils, that, in the opinion of Mr Forchhammer, mark it to be identical with the sub-Appenine group. The causes which produced this boulder formation, in part at least, were therefore in operation as early as the Miocene tertiary period (if, as some maintain, the sub-Appenines are of that age), during which the sea, overspread at its bottom by this detritus, was inhabited by Mediterranean species. There is clear evidence in the works of the authors I have quoted, of the operation of the same causes long after the northern seas were inhabited by existing species ; and throughout the whole of this period, how long we have no means of determining, all the land in Northern Europe overspread by the boulder formation must have been under the sea. Thus the authors of the " Geology of Russia" describe the deposite of recent shells in the valley of the Dwina, 150 miles inland from Archangel, as covered by sand and gravel, which, they say, they would have great difficulty in separating from the superficial northern drift ; and they add, that " a recent excursion through Sweden has convinced them that in the neighbourhood of Upsala, marine post-pliocene deposites, containing the *Tellina Baltica*, are there covered by coarse gravel and large erratic blocks, as stated by Mr Lyell."

The ingenious and ardent naturalists of Switzerland, who have held that the boulder formations of Northern Europe were produced by sub-aërial glaciers, never could have advanced so extravagant a theory had they visited that region, and been even moderately acquainted with the facts above stated, and others which as indisputably prove a submarine origin. But there is every reason to conclude that glaciers in high lands in Scandinavia, Finland, and Lapland, in very remote times, had much to do with the origin of *the erratic blocks*, in separating them from their parent rocks, and transporting them to the coast. Sir R. Murchison informs us, that he was assured by Dr Wörth, a distinguished mineralogist of St Petersburg, that, after a careful examination of the numerous blocks scattered around that capital, there was not among them a single example which could not be paralleled with its parent rock in Finland. Speaking of the observations of himself and his companions, he states, that, near Jurievitz, on the Volga, they found erratic blocks of a quartz rock associated with others of a trap breccia peculiar to the north-western side of Lake Onega, affording clear evidence that they had been transported in a south-eastern direction, 500 miles from their parent rocks.

If the blocks were encased in and transported by icebergs, they would be accumulated chiefly on the ridges and higher parts of the sea-bottom, by which the progress of the icebergs would be arrested, and where the icebergs would be fixed until they gradually melted, leaving their stony cargo on the spot. Such we find to be the fact. The great accumulations of the blocks are not in the valleys, but on the high grounds. The summits of the cliffs on the south shores of the Gulf of Finland, at an elevation of 150 feet above the sea, are covered with angular blocks of the granite, gneiss, and porphyry of Finland; they are found on the hills adjoining Lake Onega, at elevations from 400 to 600 feet above the lake; the Valdai Hills, which are in some places 1000 feet above the level of the Baltic, have arrested large quantities of blocks from Finland, which are profusely spread over their southern slopes. In the sandy plains east of Posen, not a block is to be seen for several miles, until the elevations towards the Polish frontier are reached, and they again become numerous. In the sandy plain the blocks are usually small, but on the hills between Konin and Kolo, vast numbers of large blocks are buried in and mixed with sand, at heights of 300 or 400 feet above the sea.

A very important circumstance in the history of these erratic blocks is pointed out by the authors of the "Geology of Russia," viz., that they have not travelled from north to south only, but in all directions from certain centres in Scandinavia and Lapland. In Denmark they have come from north by east; in most parts of Prussia almost direct from north; opposite the coasts of Finnish Lapland, where the granitic and other crystalline boundary sweeps round to the north-east, the direction of the blocks changes accordingly. Near Nijni Novogorod they must have travelled from north-west to south east; and in the Government of Vologda they have nearly an eastern course. By the observations of Böhtlingk, we learn that the erratic blocks of Scandinavia have been shed off from the coast of Kemi into the Bay of Onega, and from Russian Lapland into the Icy Sea, in north-eastern, northern, and north-western directions; and Norwegian detritus has been transported westward to the coasts of Norfolk and Yorkshire.

Russia in Europe, from the nature of its surface, cannot be supposed to afford many proofs of furrows, grooves, and striæ, on hard rocks; but on Lake Onega a hard greenstone and siliceous breccia are rounded off, grooved, and striated, on the northern face of a small promontory, the direction of the grooves and striæ being north and south, and the striæ are to be seen, through the transparency of the water, eight feet below its surface; they are also to be traced near the summit of a low hill. On the south side of that hill, however, no such traces of wearing or friction can be seen, "and thus," the authors say, "we had before us, on the edges of Russian Lapland, the very phenomenon so extensively observed by Sefström over Sweden, viz., a rounded, worn, and striated surface of the northern sides of promontories, whose southern faces are natural and unaffected by any mechanical agency."

M. Durocher visited the coasts of Sweden and Norway, in the neighbourhood of Christiania, last year, and discovered there many most remarkable instances of these furrows and striæ, detailed accounts of which he has given in the paper read before the Geological Society of France in December, which I have already alluded to. He, indeed, describes effects of erosion on a much greater scale than I remember to have read of before; furrows so deep, that channels are a more appropriate term, as he himself has thought, for he calls them *canaux*. Both on the east and west coasts of the bay at the head of which Christiania is situated, from Gothenborg on the Swedish shore, and from Arendal on the Norwegian, to Christiania, distances of 160 and 170 miles respectively, and especially among the islands that skirt the Norwegian coast, he observed the rocks worn into deep channels and furrows, or striated, in directions from north-west to south-east, and having their surfaces rounded and polished. These channels or furrows are of various dimensions; some from twenty-five to fifty centimetres (ten to twenty inches) in width, with a depth of from one and a half to two and three metres (five to ten feet). In a great number of instances, the sides of the interior of these channels are grooved and striated in the direction of their longer axis. Sometimes they divide into two or more branches, which afterwards reunite into one. Many are rectilinear, but many are undulating, and bent in short waves. The axes of the channels and the striæ, in their interior, have the same general direction as the depressions of the neighbouring country. The north-western extremity of these channels, that is, the openings made where the eroding instrument entered, are somewhat wider than the rest of the channel, and are rounded off, polished and striated.

Another very curious, and, as far as I know, a new class of facts has been described by M. Durocher. These furrows, he states, are frequently met with in horizontal lines *on the under side of overhanging rocks*, and he has met with instances of this description along the Norwegian coast to beyond Drontheim, a distance from Gothenborg of more than 500 miles. One remarkable case he gives, that occurs to the north of Drontheim, where the furrows are cut horizontally in a pudding-stone rock of pebbles of granite and quartz, the hardest of which are cut through as clean as the softer argillaceous cement. The eroding tool has acted to the length of forty-five metres (about fifty yards), on a surface inclined from 45° to 50°, and with a breadth of from four to five metres (thirteen to sixteen feet). But my limits oblige me to refer you to the memoir itself, and to the report of the discussion to which it gave rise, for many most interesting facts, and some important views as to the causes of these remarkable phenomena.* For the same reason, I can only very briefly allude to the descriptions contained in several parts of Mr Lyell's "Travels," of the boulder formation, the erratic blocks, and the furrowed surfaces, that are met with over a great part of the northern regions of North America, presenting many features identical with those of Northern Europe.

In Europe the boulder formation has not been traced farther south than 52° north latitude, but a similar kind of detritus, sand, clay, gravel, and rounded blocks of great size, cover a considerable extent of country in the neighbourhood of Boston, which is ten degrees farther south, or about the latitude of Valencia in Spain. It is not found within the range of the Alleghany mountains; but blocks again appear on their western side, near the Ohio river, in latitude 40°, and some scattered blocks have reached Kentucky, the northern boundary of that state, in lat. 38½°. How far a boulder formation, erratic blocks, and furrowed rocks, extend beyond the valley of the St Lawrence, we have yet to learn; but the scanty information we do possess leads us to infer, that they exist on the shore of the Arctic Sea.

Near Boston the boulder formation has been pierced to a depth of more than 200 feet without the solid rock having been reached; and although mainly composed of the materials of neighbouring rocks, huge rounded blocks brought from a great distance rest upon them or are buried in them. Here, as in Russia and Denmark, we have a boulder formation composed of materials that have not been far travelled, intermixed in some degree with, but more frequently covered by, that of

* Bulletin de la Soc. Géol. de France, tome iii., p. 65.

northern origin. An instance of this last occurs at Brooklyn, near New York.

In the United States, Canada, and Nova Scotia, where the gravel or drift has been removed, the rock immediately subjacent is very frequently furrowed and striated, and here and there flattened domes of smoothed rock (*roches moutonnées*) are met with. The furrows have been found in the New England hills at all heights, even to as much as 2000 feet. In one place, on the summit of a high hill of sandstone, Mr Lyell saw an erratic block of greenstone 100 feet in circumference. The erratic blocks and boulder formation have been transported southwards along the same lines as are marked out by the direction of the furrows: in New England, from NNW. to SSE.; in the valley of the St Lawrence, from north-east to south-west.

With regard to evidence of the age of the boulder formation of North America, I am not aware of any having been met with that connects it with a period so early as in Denmark; it contains, in many places, shells identical in species with those now living in the adjoining seas. The detritus in which the bones of Mastodon are buried at Big-Bone-Lick, in Kentucky, Mr Lyell is inclined to believe to be more modern than the northern drift.

In a late number of Jameson's Edinburgh New Philosophical Journal are two valuable papers relating to erratic blocks, grooved surfaces, and the action of glaciers; the one by Mr Maclaren, to which I have already referred, the other by Professor James D. Forbes. The paper of Mr Maclaren describes grooves and striæ which he observed last summer on the rocks on each side of the Gare Loch, in Dumbartonshire, and these, together with blocks and an accumulation of loose materials resembling a terminal moraine, appear to indicate very clearly the former existence of a glacier in the space inclosed between the hills that bound the loch. He also observed numerous rounded blocks in the same locality, which could not have been produced by the same glacier, for they consist of granite, some of great size, as much as five feet in diameter, at various heights on the hills—one on the top of a hillock, 320 feet above the loch; and no granite, no parent rock to which they can be traced, is nearer than forty miles to the north. But between the localities where they now exist and that parent rock, there are ridges, over which they must have travelled, that are 1500 feet above the present sea-level. This, then, is a case analogous to that of the Valdai Hills in Russia, on the southern flanks of which blocks of Scandinavian granite are scattered, indicating that these hills, and, in like manner, the summits of the barrier north of Gare Loch, were a sea-bottom, upon which the blocks were dropped from floating icebergs; that sea-bottom being subsequently raised to form the existing land.

The principal object of Professor Forbes's paper is to describe the topography and geological structure of the Cuchullin Hills in Skye. He gives us much new and interesting information respecting the igneous rocks, of which they are composed, particularly that comparatively rare variety, hypersthene rock: but he also describes these same rocks as being furrowed and polished in several of the valleys, but especially in the valley of Coruisk, the furrows there radiating from a centre to the sea-shore; and, in his opinion, they demonstrate in as clear a manner as the subject admits of, the former existence of a glacier in that locality. All will admit that the opinion of Professor Forbes on this subject is one in which we may place entire confidence. The hypersthene rocks "are smoothed and shaven in a direction parallel to the length of the valley wherever their prominent parts are presented towards the head of the valley; but towards the sea, they are often abruptly terminated by craggy surfaces, shewing the usual ruggedness of the natural fracture of the rock, and exhibiting the phenomenon of *Stoss Seite* and *Lee Seite*, so often described in the Scandinavian rocks."

"When the same rock is traversed by claystone veins, or by veins of crystallized hypersthene and magnetic iron, these various parts of such different hardness are all uniformly shaven over, in conformity with the general form of the mass to which they belong. This presents a striking analogy to the phenomena of polished rocks in the Alps, where the quartz veins are cut off parallel to the surface of the bounding felspar. . . . The furrows are not confined to the entrance of the valley, but extend to the upper part of it, and to a great height above its level, particularly on the west side, where the faces of these almost vertical cliffs of adamantine hardness are scored horizontally, as potter's clay might be by the pressure of the fingers, or like the moulding of a cornice by the plasterer's tool."

The question naturally arises, at what period were these valleys in Dumbartonshire and in Skye occupied by glaciers? That they were so after the land had been formed into the present mountains and valleys is obvious; but that defines no particular period. We have in the Gare Loch two distinct classes of phenomena, which could not have been produced either by the same agents or at the same time. We have proof of the action of sub-aërial glaciers; we have also proof that there are erratic blocks that could not have been brought into their present position unless the ground on which they rest had been submerged: they were dropped, it is most reasonable to suppose, from icebergs floating in a sea, and arrested by elevations in the sea-bottom. During such submergence there could be no glaciers in the valleys of Gare Loch or Coruisk. Are we to suppose that after these valleys had been occupied by a glacier, and the erosions had been made, the land sank down, continued for a long interval as a sea-bottom, during which time the glaciers melted away, and that the land again emerged, bearing the erratic blocks upon it? The subject is one of vast difficulty; but the phenomena evidently involve great changes in the condition of the land, and consequently, perhaps, in the climate of that region.

It is an important feature in the history of the boulder formation, that the mode of its accumulation, and the direction of the channels, furrows and striæ worn in the rocks, indicate a force coming from the north, between NW. and NE. The worn and polished surfaces of so many rocks facing the north, while their rugged unworn surfaces point to the opposite direction, are farther proofs of the same movement. The travelled rounded boulders and detritus from the middle of Sweden and Norway southward, must therefore have been derived from land existing north of that latitude.

Submarine currents are by many geologists supposed to have been the moving power; and it is also said, that the detrital matter they hurried along smoothed and polished the rocks they met with in their progress, and graved the furrows and striæ. We as yet know little of the existence, at great depths, of submarine currents, or of their power of transporting heavy materials. Sir R. Murchison, referring to the generation and power of what Mr Scott Russell calls a wave of the first order, or "the wave of translation," and to the application of Mr Russell's researches and theory by Mr Hopkins, in his paper "On the Elevation and Denudation of the district of the Lakes of Cumberland and Westmoreland,"* considers that all the phenomena of the boulder formation and drift of Northern Europe (not including the erratic blocks) may be accounted for by the action of such waves. But a sudden paroxysmal movement of the bed of the sea is a necessary condition for the production of a wave of translation. Mr Hopkins says, "If the elevation were sufficiently gradual, no sensible wave would result from it; but if it were *sudden*, the surface of the water above the uplifted area would be elevated very nearly as much as the area itself, and a *diverging* wave would be the consequence;" and that "there is no difficulty in accounting for a current of twenty-five or thirty miles an hour, if we allow of *paroxysmal elevations* of from 100 to 200 feet;" and he adds, that "if the extent of country be considerable, the elevation might occupy *several minutes*, and still produce the great wave above described." It is to be observed that the wave would be *diverging*, and therefore the currents would not be limited to one direction. But however great the power of transport of the sudden wave might be, its action would be transient, and we must therefore suppose, either that the whole phenomena were produced by one sudden elevation, or that there was a succession of paroxysms. Whether such sudden violent transport, such tumultuous hurrying along of the blocks, gravel, and sand, be consistent with the forms and arrangements of the detrital matter, the long "trainées," "the widely spread and finely laminated sands," and the included fragile shells, can only be determined by special observations directed to such an inquiry. It does not appear at all consistent with the formation of the detritus of local origin, that which constitutes

* Proc. Geol. Soc., vol. iii., p. 757.

so great a part of the boulder formation over the whole northern region, and which seems to indicate a long-continued action over the same ground. We ought, besides, to have some independent evidence of paroxysmal action in the same region; whereas there is the strongest proof of gradual upheavals: take, for example, the whole continent of European Russia, which exhibits scarcely any disruption, and which, Sir R. Murchison is of opinion was elevated *en masse*.

But we must go further back in our inquiry, before the wave of translation was generated. Whence the detrital matter which the wave transported? Are we to suppose that the same paroxysmal movement broke up and shattered to fragments the bottom of the sea, and that it was these fragments which the transient wave transported and rounded into boulders? Or is it more reasonable to suppose, that the materials of the detritus must have been derived from pre-existent land, the rocks of which were broken by glacial and atmospheric action, as rocks now are, to be afterwards rolled, rounded, and polished by currents of water; as they unquestionably must have been, however the currents may have been produced? Then as to the power of such currents, transporting hard bodies, to produce the furrows and striæ, I should be disposed to refer to the *physicien*, to him conversant with the laws of mechanical philosophy, the questions whether rounded blocks and gravel, *moving in water*, passing over rocks, would be capable of producing on them these deep furrows and striæ; or whether it is not more probable that they were worn by angular fragments of rock held fast in ice, and pressed, as the current floated the iceberg, against the opposing rock, with a vast force derived from the weight of the mass?

We learn from the "Magazine of Natural History" of last September, that letters had been received the preceding month from Mr Harry Goodsir, attached, as Naturalist, to the Arctic Expedition under the command of Sir John Franklin, dated from Disco, in Baffin's Bay, the 7th of July last; and it is stated that "Mr Goodsir is making minute observations upon the ice of the bergs, and as he purposes continuing them throughout the voyage, there can be little doubt of his arriving at valuable conclusions." It is added, "We also find some observations upon the action of floating ice upon the *granitic* shores of the islands. *All the rocks below high-water mark, and some considerably above it, are rounded off into long irregular ridges, with intervening hollows, by the half-floating masses of ice.*"

Palæontology.

This great department of Geology is now cultivated with so much industry by so many naturalists in Europe and America, that scarcely a month elapses without some valuable additions to our knowledge. It is not possible for me to do more than briefly refer to some of the more important of those which I have had an opportunity of becoming acquainted with.

At the last meeting of the British Association at Cambridge, Professor Edward Forbes made an interesting and important communication to the Natural History section, in which he pointed out a connexion of the present distribution of plants with geological changes which took place during the later tertiary periods. He maintains, for example, that the existing flora of Britain belongs, not to the present epoch only, but is composed in part of the remains of the floras of the pliocene and post-pliocene periods. He considers that certain peculiarities of the vegetation of the west of Ireland depend on an ancient geological connexion with the Asturias; those of the Scottish and Welsh mountains on the migration of plants from Scandinavia during the glacial period, and the subsequent upheaval of the land, and consequent change of climate; whilst the great mass of the British flora migrated across the upheaved bed of the Pleistocene sea. He further holds, that the determination of the date of the migrations of terrestrial plants and animals will eventually aid in fixing the periods of many geological events.

In the year 1828, M. Elie de Beaumont published in the "Annales des Sciences Naturelles" an account of some observations he had recently made at Petit-Cœur, a village in the Tarentaise, east of Chambery; where he had seen resting on talcose gneiss and hornblende schist, a series of sedimentary beds, which prevail over a great extent of that country, the lowest of which, a micaceous sandstone alternating with a black slaty rock, is surmounted by a bed of fissile argillaceous limestone containing belemnites, and this last passes insensibly into a black slaty clay, containing impressions of plants identical in species with some of those belonging to the true coal formation. M. de Beaumont concludes his detailed description in these words:—"Il me parait donc incontestable que le système de couches qui, à Petit-Cœur, contient les Belemnites et les impressions végétables, et qui s'enfonce sous toutes les autres couches non-primitives de cette partie des Alpes, *appartient à la formation du lias.*" The plants were carefully examined by M. Adolphe Brongniart, and in an accompanying memoir, descriptive of them, he states, "que l'identité le plus parfaite existe entre ces plantes et celles du terrain houiller, tandis qu'il n'y a aucun rapport entre elles et celles qui se trouvent habituellement dans le lias, ou dans les terrains oolitiques." He enumerates among others of Petit-Cœur, *Neuropteris tenuifolia*, found at Liege and Newcastle; and *Pecopteris polymorpha*, one of the most common in the coal-fields of France.

At the meeting of the Geological Society of France at Chambery in autumn 1844, an account of which we have received since our last Anniversary,* the attention of the members was directed to this most remarkable fact, in a memoir by M. Rozet; and afterwards, several who attended the meeting visited Petit-Cœur. The observations of M. Elie de Beaumont and M. Adolphe Brongniart were confirmed in every particular; they found abundance of the vegetable remains, and of belemnites below them. The report farther states:—"Il a été évident aussi, pour tous les membres de la Société, que l'on ne peut aucunement admettre l'explication d'un plissement qui aurait raproché les fossiles de deux formations et produit une alternance apparente entre les couches à Belemnites et les couches á empreintes. Ce sont les mêmes schistes et la même formation qui renferment ces deux genres de fossiles que l'on avait cru pendant longtemps appartenir à des époques géologiques très éloignées l'une de l'autre." M. Sismonda, who was present, stated, that in another locality he had found

* Bulletin de la Soc. Geol. de France, vol. i., new series, p. 601.

Ammonites in a prolongation of the same bed; and in reply to M. Agassiz, also present, affirmed, that he had found this bed containing belemnites and coal plants over an extent of from 25 to 30 leagues. We have thus the same species of plants continuing to exist throughout the whole Carboniferous, Permian, and Triassic periods, and into that of the lower portion of the oolite age. I need not say how important a bearing this remarkable fact has on the theories of climate, and of the prevalence of an atmosphere loaded with carbonic acid gas during the Carboniferous period.

M. Adolphe Brongniart, in his memoir above cited, thus accounts for the anomalous position of these coal plants:—A l'époque où la formation du lias se déposait en Europe, notre globe présentait très-probablement deux regions très-diverses par leur climat et par les végétaux qui y croissaient. L'une comprenait l'Europe et peutêtre toute la zône tempérée, et était habitée par des végétaux fort différens de ceux qui y croissaient à une époque plus reculée, et qui avaint donné naissance aux couches de houille; l'autre s'étendant sans doute sur les parties plus chaudes du globe, était encore couverte des mêmes végétaux qui, dans des temps plus anciens, avaient habité la région européene, et formé les dépôts houillers. Les végétaux de cette partie du globe pouvant dans certaines circonstances, être transportés dans les régions plus tempérées, auraient donné lieu à ces anomalies apparentes que présentent les terrains d'anthracite des Alpes qui, d'après les observations géologiques et zoologiques, appartiennent à l'epoque de formation du lias, et dont les végétaux sont cependant les mêmes que ceux du terrain houiller." This theory therefore admits that the same species of plants existed through the whole series of ages that passed from the time of the deposition of the carboniferous series to that of the lias; that they and belemnites were coexisting, but in different regions. It is not very easy to conceive how such delicate vegetable bodies should be drifted the vast distance between a tropical and temperate zone, to form parts of thin continuous strata thousands of square miles in extent, in successive layers of great thickness on the same spot, in the depths of the sea.

It is extremely improbable that this case in the Tarentaise is a solitary one; future researches will probably bring to light other instances of a similar kind. May not these facts be an extension to plants of the recently advanced doctrine regarding animals, that species which have had a wide range in space have also had a long duration in time? or, as it is expressed by those who first brought it forward,—"That the species which are found in a greater number of localities, and in very distant countries, are almost always those which have lived during the formation of several successive systems." The attention of geologists, I believe, was first directed to this highly important observation by Viscount d'Archiac and M. de Verneuil, in their joint paper "On the Fossils of the older Deposites of the Rhenish Provinces," read before this Society in December 1841; and while these distinguished geologists announced the law as applicable to the oldest fossiliferous beds, Professor Edward Forbes has shewn the extension of it to existing species. He found "that such of the Mediterranean testacea as occur both in the existing sea and in the neighbouring tertiaries, were such as had the power of living in several of the zones in depth, or else had a wide geographical distribution, frequently both." He adds, "the same holds true of the testacea in the tertiary strata of Great Britain. The cause is obvious: such species as had the widest horizontal and vertical ranges in space, are exactly such as would live longest in time, since they would be much more likely to be independent of catastrophes and destroying influences than such as had a more limited distribution." Now we know that the same species of plants are found in the coal-fields belonging to the palæozoic carboniferous rocks of Europe and of North America, and in regions with differences of more than thirty degrees of latitude; and, therefore, they may have been able to live through the many vicissitudes of condition of the earth's surface that must have occurred between the Carboniferous and Liassic periods.

The plants from the Permian system of Russia, collected by Sir R. Murchison and his fellow-travellers, have been described by Mr Morris, and further illustrated by the remarks of M. Adolphe Brongniart. The species are few, not exceeding sixteen in number. Three of these—*Neuropteris tenuifolia*, *Lepidodendron elongatum* and *Calamites Suckowii*—are pronounced by M. Brongniart to be identical with plants of the coal formation. The remainder are peculiar (as far as is hitherto known) to the Permian system. All the *genera* are common to this and to the carboniferous series; the genera *Odontopteris*, *Noeggerathia*, and *Lepidodendron*, had been hitherto supposed peculiar to the coal-measures. Altogether, the Permian flora is evidently much more similar to that of the carboniferous system than to any other: it has no affinity to that of the Grès bigarré, or of the Jurassic system.

Mr Morris has likewise described the fossil plants brought by Count Strzelecki from the coal-fields of New South Wales and Van Diemen's Land. Unfortunately the materials were very scanty, the number of species being only eight; and it is singular, that of this number four are from the coal-field of New South Wales, and four from that of Van Diemen's Land, no one species having been found common to the two. Both these Australian coal-fields are very remarkably distinguished from those of Europe and North America by the entire absence of *Stigmariæ*, *Sigillariæ*, *Lepidodendra*, and *Calamites*. In this respect they agree with the coal formation of Burdwan in Northern India, to which, indeed, they have other points of striking similarity in the character of their vegetable remains. The *Glossopteris Browniana* is actually common to the coal formations of New South Wales and of India, and the *Pecopteris australis* of the former country comes very near to the Indian *P. Lindleyana*. The flora of the coal-fields of Australia has likewise a striking similarity to that of our Yorkshire oolites. *Glossopteris Browniana* is nearly allied to *Glos. Phillipsii*, *Pecopteris australis* to *P. Whitbiensis*, and *Pecopteris alata* to *P. Murrayana*. It is possible that the coal of Australia and of Northern India may really belong to the Jurassic system.

In the "Geology of Russia," a work I have already so often referred to, there is an immense mass of valuable contributions to palæontology, by different distinguished naturalists. The following are the parts which relate to the Invertebrata:—

1. A very elaborate and important essay by Mr Lonsdale on the palæozoic Corals of Russia, abounding in minute details of

structure, deserving the attention of every one engaged in the study of that class of organic bodies.

2. A full synopsis of the palæozoic Radiata, Articulata, and Mollusca, by M. de Verneuil. The species are all admirably described, and full details of great interest are given respecting their affinities, synonyms, and distribution. A great number of new and curious forms are made known for the first time. In that part which treats of the Brachiopoda, M. de Verneuil has given the results of a critical investigation of the genera, accompanied by tables of characters of the greatest value. He has constituted a new genus, *Siphonetreta*, for the reception of certain very curious fossils, which, while presenting much of the form of *Terebratulæ*, are really allied to *Orbiculæ*, and have the same corneous texture of shell. Among the palæozoic *Acephala*, he has described a well-marked species of *Astrea*, a genus hitherto having only doubtful claims to such high antiquity. Among the *Gasteropoda*, *Ianthina*, for the first time, appears as a palæozoic genus.

In the account of the *Radiata* are interesting descriptions and comments on the Russian species of *Cystideæ*. Among the *Articulata* is the genus *Fusulina*, a foraminiferous animal abounding in certain beds of carboniferous limestone in Russia. Hitherto, traces of such animals in such ancient beds have been few and imperfect.

3. The Jurassic, cretaceous, and tertiary mollusca are described in full detail by M. D'Orbigny, and their synonyms carefully elaborated,—a service for the rendering of which we cannot be too thankful, since duplicate names have accumulated to a most confusing extent. As an instance, it may be mentioned that M. D'Orbigny enumerates as synonyms of the *Ammonites Jason* of Zieten, no less than fourteen distinct names.

The plates throughout are admirable.

The history of fossil radiate animals has received one of the most important additions ever made to it, in the memoir of M. von Buch on the *Cystideæ;* a memoir of the greatest value to the naturalist, since it furnishes him with an elaborate and philosophical exposition of the organization and affinities of a group of fossil animals hitherto misunderstood, and which fill up a blank in the series of Radiata. As these fossils are now known to be by no means unfrequent in the British palæozoic strata, though they have hitherto attracted but little attention, the study of the paper, itself a model of palæontological description, will well repay the attention of geologists. They will find it at full length, translated by Professor Ansted, in the last number of our Journal; and I may adduce it as an instance of the valuable assistance which we afford to the geologists of this country, by devoting a portion of our quarterly publication to original foreign memoirs; for how few there are who can have an opportunity of seeing the "Transactions of the Berlin Academy," to say nothing of those who do not read German!

M. Agassiz, that most indefatigable of living naturalists, besides his important contributions during the last year in that department in which he is universally acknowledged to occupy the highest rank, has commenced a new series of essays under the title of "*Iconographie des Coquilles Tertiaires reputés identiques avec les espèces vivantes, ou dans différens terrains de l'époque tertiaire.*" In the preface to the first part he announces his views and object. He says that he has been long convinced that the greater number of identifications of tertiary shells with those of other tertiary epochs, or with recent species, are incorrect. From his investigations he is led to maintain, 1*st*, That notable differences exist between living and tertiary species; and, 2*dly*, That in the tertiary formations the different stages present distinct faunæ. He opposes classification founded on *per-centages*, as purely artificial, and attributes the errors to the mistaking analogues for true identifications. He holds that each geological epoch is characterized by a distinct system of created beings (the results of a new intervention of creative power), including not only different species from those of the preceding system, but also new types. At the same time he admits that the "reiterated intervention of the created power" does not necessarily and absolutely imply a specific difference between the beings of different deposites. He holds, however, the probability of such a difference existing; and his object in this

" Iconographie" is to prove that such difference has been overlooked. He goes the length of saying, that, even when species are, so far as the eye can judge, identical, they may not be so. " Perhaps," he says, " there may exist species so nearly allied, as to render it impossible to distinguish them ; yet even that would not be to my eyes a proof of their identity; it would only prove the insufficiency of our means of observation :" and further, " the animals might differ though the shells are alike."

In the special part of his essay, M. Agassiz proceeds on the position that the law of variation is not the same in all classes, families, and genera ; and selects his examples from certain genera of Acephalous Mollusca in which the characters are very constant, viz. *Artemis*, *Venus*, *Cytherea*, *Cyprina*, and *Lucina*, on thirty-one forms of which genera, considered by him as distinct species, he gives full comments and valuable details. One species only among them, the *Cyprina islandica*, he admits to be at the same time recent and fossil.

M. Agassiz introduces the same doctrine in his Monograph of the Fishes of the Old Red Sandstone. Thus he says, at page xi., that the characteristic fossils of each well-marked geological epoch are the representatives of so many distinct creations, and affirms that he has demonstrated " *pour un nombre assez considérable d'espèces*," that the presumed identifications are exaggerated approximations of species resembling one another, but nevertheless specifically distinct.

Whether species of Mollusca hitherto deemed common to two or more of the tertiary periods be really, as M. Agassiz affirms, distinct, is a doctrine that must await the concurrence of experienced conchologists before it can be made the means of overthrowing present generalizations, and the basis of new ones. With regard to the Mammalia, certain eocene forms have been repeatedly recognised in miocene strata, and the continental miocene Mastodon has been satisfactorily determined as a fossil of our older pliocene (Norwich Crag). But M. Agassiz is peculiarly unfortunate in citing Dr Falconer and Major Cautley (p. xi.) as supporting, by their discoveries of fossil animals in the Sub-Himalayan Mountains, his views as to marked distinctions of the tertiary fauna, since they have done more than any other palæontologists to prove the progressive and undistinguishable blending of eocene into miocene, and this into pliocene, by the mammalian fossils, and have shewn that some species of reptiles actually exist at the present day which were coeval with the Himalayan Anoplothere, Mastodon, and Hippopotamus.

The attention of several distinguished naturalists has lately been directed to the investigation of the structure and classification of Trilobites. A valuable work on these singular extinct crustacea has been lately given to the world by Professor Burmeister, who is now revising an English translation of it, to be published by the Ray Society. In this work there is a systematic arrangement of all the species known to the author, and there are dissertations of great value on their organization. M. Emmerich has also published a very important memoir on the structure of Trilobites, a translation of which has lately appeared in Mr Taylor's "Scientific Memoirs." In Sweden, Professor Löven, a naturalist distinguished for his researches among the invertebrate animals, has commenced the investigation of the Trilobites of that country with great success. His papers may be found in the Proceedings of the Swedish Academy for 1844 and 1845. All the memoirs now enumerated are illustrated by excellent plates. Lastly, in the "Geology of Russia" will be found an interesting note on the affinities of Trilobites, by Professor Milne Edwards.

In what I have said of the accession during the last year to our knowledge of the Devonian rocks, I have referred to the Monograph by M. Agassiz of the Fishes of the Old Red Sandstone, which those most capable of appreciating its value consider as one of his most important works; and I have reason to know that he himself views it in that light. I again refer to it in this place on account of some peculiar views there developed, which I do not find altogether assented to by those whose judgments on this subject are much looked up to.

M. Agassiz states, p. xxx., "que les poissons de l'Old Red représentent, *par leur structure toute particulière*, l'age embryonique du règne des poissons." A part of the peculiar structure which he especially dwells upon is, "le développement extraordinaire que présente le système cutané;" but he acknowledges that "malheureusement nous n'avons pas encore des termes de comparaison avec les poissons de la création actuelle assez nombreux pour apprécier la valeur de ces caractères." Another feature of the peculiar structure which he points out is the continuity of the vertical fins. This character, however, Sir Philip Egerton and Professor Owen inform me, is only of partial application; the family of *Cephalaspides* he does not cite, but in *Coccosteus*, the sole form of Old Red fishes in which vertical fins have been observed, the distance between them is considerable. In the *Dipterians*, *Dipterus* has these organs very close, but in *Diplopterus* and *Osteolepis* they have considerable intervals between them. *Diplopterus*, moreover, occurs in the coal measures. In the *Cœlacanths* the fins of *Glyptolepis* are very near each other, but this family runs into the chalk. In the *Acanthodians* the fins are quite distinct, and *Acanthodes* is found in the coal measures. There are also recent fishes with their vertical fins quite as little distinct as in the most exaggerated of the Old Red. Neither is the heterocerque tail a character peculiar to the fishes of the Old Red, for all the fishes older than the lias have this form, as have the Sturgeons of the present day; and it is perhaps more important to find, that certain highly characteristic genera of the Old Red, for example, *Pterichthys*, *Pamphractus* and *Coccosteus*, did not possess the heterocercal tail.

Another character, viz., the flattened form of head, is not peculiar to the Old Red, for the *Siluridæ* and other recent fishes have this character equally prominent. Then the non-development of the vertebral column is found in the Sturgeon, Lamprey, and other recent fishes. Persons seeking for support to the theory of progressive development might, on a hasty perusal of this work, find sentences in favour of their views; but the above facts are irreconcilable with the theory as ordinarily promulgated, and it would be a perversion of M. Agassiz's undoubted opinions to quote detached sentences from his writings in support of that doctrine. They will find for instance, at p. 23, a rectification of the error committed by the ingenious Hugh Miller, in describing the jaws of the *Coccosteus* as being vertical, like those of crustacea, and thence inferring that "it seems to form a connecting link between two orders of existences;" M. Agassiz having proved that they are horizontal, and move vertically, as in other true fishes. Then there are four species of Sharks of the Cestracion division in the Devonian rocks of Russia, and the squaloid fishes of the present day offer the highest organization of the brain and of the generative organs, and make in these respects the nearest approach to the higher vertebrate classes.

The work of Professor Owen on the fossil remains of Mammalia and Birds found in the British Islands, which has been for some time in course of publication, is now completed, the concluding part having been published within the last few days. This valuable contribution to palæontology, in which it is the purpose of the author "to deduce from these remains, by physiological comparisons, the living habits of the extinct species, to trace out their zoological affinities, and to indicate their geological relations," is another gift in the last year for which geologists are indebted to the British Association. Professor Owen, in his preface states, that the special researches which have enabled him to fulfil in any degree the above-mentioned design, were begun by the desire, and have been carried on chiefly by the liberal aid of that body.

The concluding part contains a very interesting and instructive introduction, which will enable the reader to follow with far greater pleasure, and more fully to appreciate the value of the special details which follow. He begins by pointing out that first trace of the creation of mammalian quadrupeds which was discovered in the Stonesfield slate of the oolitic series; and it was certainly a most fortunate accident which brought these minute bones within the sight of a geologist. It is a very remarkable circumstance, that all the researches of geologists, multiplied as they have been since that discovery was made, have not yet brought to light another fragment of the same order of animals, throughout the vast series of deposites, the immense duration of time that intervened between the Stonesfield slate and the eocene tertiary deposites; notwithstanding that there are indubitable proofs of the existence during that interval of extensive continents, of forests growing on that land, of its being tenanted by other races of animals, and that birds and pterodactyls spread out their wings in the air above it.

The land that supported the mammalia whose remains are found in the eocene deposites of our island must have been submerged, and must to a great extent have remained so during the miocene period, when the adjoining continent was inhabited by the animals whose remains have been disinterred there from the deposites of the miocene age; for it is in pliocene and post-pliocene deposites that the mammalian remains in the British Islands next present themselves. There is the most conclusive proof that the animals lived and died, generation after generation, for a long succession of years, in the land where their remains are now found; evidence which completely "refutes the hypothesis of their having been borne hither by a diluvial current, from regions of the earth where the same genera of quadrupeds are now limited. The very abundance of their fossil remains in our island is incompatible with the notion of their forming its share of one generation of tropical beasts drowned and dispersed by a single catastrophe."

The author ably discusses the question how the various members of that ancient fauna came into this island. Other and independent geological proofs shew that the British Islands were united with the continent when it received its pliocene mammalia, and the zoologist finds the known habits and powers of these mammalia to be in accordance with that configuration of the land. He then considers the no less important question,—although it is one more difficult of solution,—by what processes they became extinct? The subterranean movements which separated our islands from the continent, and submerged other parts of these islands, must have produced such changes in the means of subsistence, and powers of migration of these animals, as must have been one great cause of their diminution and eventual extinction; the loss of a sufficient supply of vegetable food for the greater herbivorous quadrupeds, and, by their diminished numbers, the want of support for the larger carnivora which preyed upon them. He enumerates other causes, which must have operated for a long period before the agency of man aided the work of extinction. He adduces many most curious and interesting particulars in illustration of the laws by which the geographical distribution of the mammalia of the pliocene and post-pliocene periods generally appear to have been determined; shewing that, "with extinct as with existing mammalia, particular forms were assigned to particular provinces, and, what is still more interesting and suggestive, that the same forms were restricted to the same provinces at the pliocene period as they are at the present day."

In this work, eighty species of British fossil Mammalia are described, of which the following (forty-two in number) were either originally determined by the author as new species, or were first recognised by him as occurring in a fossil state. They were, for the most part, described in the publications of this Society.

Amphitherium Broderipii.
Arvicola agrestis.
——— pratensis.
Balæna affinis.
——— definita.
——— emarginata.
——— gibbosa.
Balænodon physaloides.
Bison minor.
Bos longifrons.
Cervus Bucklandi.
——— Tarandus.
Chæropotamus Cuvieri.
Coryphodon eocenus.
Dichobune cervinum.
Equus plicidens.
Felis pardoides.
Hyracotherium leporinum.
——— cuniculus.
Lagomys spelæus.
Lophiodon magnus.
Lophiodon minimus.
Lutra vulgaris.
Macacus eocenus.
——— pliocenus.
Machairodus latidens.
Meles taxus.
Palæotherium magnum.
——— crassum.
——— minus.
Palæospalax magnus.
Phascolotherium Bucklandi.
Phocæna crassidens.
Physeter macrocephalus.
Rhinolophus ferrum equinum.
Sorex vulgaris.
Strongyloceros spelæus.
Talpa vulgaris.
Trogontherium Cuvieri.
Ursus priscus.
Vespertilio vulgaris.

Of the eighty species described in this work,—

Three are of Oolite antiquity;
Twenty from Eocene tertiary strata;
Five from the Miocene Red Crag;
Fifty-two from the older and newer Pliocene freshwater and drift formations.

Of the newer Pliocene species of fossil Mammalia, seventeen became extinct before the historic period, viz.—

Macacus pliocenus.
Palæospalax magnus.
Ursus priscus.
—— spelæus.
Lagomys spelæus.
Elephas primigenius.
Rhinoceros tichorhinus.
———— leptorhinus.
Equus plicidens.
Hyæna spelæa.
Felis spelæa.
Machairodus latidens.
Trogontherium Cuvieri.
Hippopotamus major.
Megaceros Hibernicus.
Strongyloceros spelæus.
Cervus Bucklandi.

Five species came down to the age of tradition or history, and have been extirpated in England, viz.—

Canis lupus, Wolf.
Castor Europæus, Beaver.
Cervus Tarandus, Reindeer.
Bison priscus, Aurochs.
Bos primigenius, or Great Urus. This species is also extinct on the continent.

Twenty-six of the Mammalia, whose fossil remains testify to their co-antiquity with the Mammoth, still exist in England, as well as on the continent of Europe, viz.—

Vespertilio noctula, } Bats.
Rhinolophus ferrum-equinum, } Bats.
Sorex, Shrew, three species.
Meles taxus, Badger.
Putorius vulgaris, Polecat.
——— ermineus, Stoat.
Lutra vulgaris, Otter.
Canis vulpes, Fox.
Felis Catus, Wild Cat.
Mus rattus, Black Rat.
—— musculus, Mouse.
Arvicola, Vole, three species.
Lepus timidus, Hare.
Lepus cuniculus, Rabbit.
Equus caballus, Horse.
—— asinus, Ass.
Sus scrofa, Hog.
Cervus elaphus, Red Deer.
—— capreolus, Roe.
Capra hircus, Goat.
Bos longifrons (probable source of the Highland Cattle).
Physeter, Sperm Whale.
Balænoptera.
Balæna mysticetus, Whalebone Whale.

You cannot but remember the great interest that was excited when Dr Royle, in March 1836, communicated to this Society a paper by his friends, Captain Cautley and Dr Falconer, then resident in India, on the remains of Mammalia found in the Tertiary formations of the Sewalik Mountains, at the southern foot of the Himalayas, between the Sutlej and the Ganges; discoveries deemed so important, that the Council, at the following anniversary, awarded a Wollaston Medal to each of these gentlemen. Besides the paper by Captain Cautley, published in the fifth volume of our "Transactions," numerous details respecting these discoveries are contained in the "Asiatic Researches," and in the "Journal of the Asiatic Society of Bengal." A magnificent donation of these remains, contained in more than two hundred chests, was made by Captain Cautley to the British Museum, and a work of immense labour and research has been undertaken by Dr Falconer, to describe, in conjunction with his friend, now Major Cautley, these very interesting remains. Her Majesty's Government and the Directors of the East India Company have supplied funds in aid of the successful progress of the work. The first part has just appeared; it bears the title of "*Fauna Antiqua Sivalensis*," and consists of twelve folio plates, and sixty-four pages of octavo letter-press. Nothing has ever appeared in lithography in this country at all comparable to these plates; and as regards the representations of minute osseous texture by Mr Ford, they are perhaps the most perfect that have yet been produced in any country.

The work has commenced with the Elephant group, in which, they say, "is most signally displayed the numerical richness of forms which characterizes the Fossil Fauna of India," and the first chapter relates to the PROBOSCIDEA—Elephant and Mastodon. The authors have not restricted themselves to a description of the Sewalik fossil forms, but they propose to trace the affinities, and institute an arrangement of all the well-determined species in the family. They give a brief historical sketch of the leading opinions which have been entertained by palæontologists respecting the relations of the Mastodon and the Elephant to each other, and of the successive steps in the discovery of new forms which have led to the modifications of these opinions. They state, that the results to which they themselves have been conducted, lead them to differ on certain points from the opinions most commonly entertained at the present day respecting the fossil species of Elephant and Mastodon. As they differ in their conclusions from those of Cuvier, De Blainville, and Owen, as to specific differences, you will readily conclude that the proof they adduce rests upon nice distinctions in anatomical structure; to enter upon which would be quite unsuitable on the present occasion, by even the most competent to judge of questions in which such high authorities disagree.

Conclusion.

Although this Address has extended to so great a length, those who are actively alive to what is going on in the several departments of Geology, will have found many important works of the past year unnoticed, many topics of interest left untouched. This would not have been the case to so great an extent, if I had had more time at my disposal. Even with the opportunities I have had, I might have briefly noticed a greater number of books published in our own and in foreign countries, and memoirs contained in journals and transactions; but I confess to yielding to an inclination to dwell upon topics that have more particularly attracted me in my past geological studies.

It is highly gratifying to see so much activity in the cultivation of our science in almost every part of the civilized world; and still more satisfactory to observe, that it has been for some time past pursued in a better spirit, with a disposition to greater accuracy and rigour in investigation, and with a more strict adherence to the rules of philosophical inquiry. When we contrast the state of Geology now with what it was when this Society was established, or compare the then limited extent of our knowledge of Palæontology with the wide range it now takes, and when we think of the crude hypotheses and hasty generalizations, founded on the most scanty and imperfect observations, which were then misnamed science, we may well look back with satisfaction to the work of the last thirty years, to which this Society has contributed no inconsiderable share.

It has hitherto too frequently happened, that geologists have dealt with important questions of physics, chemistry, comparative anatomy, zoology, or botany, without an adequate acquaintance with the principles and known laws of the science essentially involved in the question. Now, unless our conclusions will bear the test of the most strict examination by those who are acknowledged authorities in the particular science, it is obvious that we cannot make any secure progress. The study of Geology, more perhaps than that of any other branch of natural science, has a tendency to create a disposition to theorize; this disposition, however, if kept within due bounds, is rather to be encouraged than repressed, for it has often proved a stimulus to accurate observation; and to arrive at a knowledge of a true theory of the earth, is, in truth, the great aim of our inquiries. But we must carefully guard against the error which the earlier geologists too frequently fell into, of quitting the sober path of inductive philosophy, and wandering into the regions of imagination. We must indulge in no theory that is not in accordance with laws of nature of which we have had experience, or which may be fairly inferred from that experience, although the operations we seek to explain may have been on a greater scale than any of which we have certain knowledge. The cautious and accurate Playfair was wont to inculcate upon those who studied in the school of Hutton, the warning of the noble aphorism with which Bacon opens his great work, the "Novum Organum,"—an aphorism which every geologist will do well to bear in mind when he ventures to theorize on causes:—"*Homo, naturæ minister et interpres, tantum facit et intelligit, quantum, de naturæ ordine, re vel mente observaverit; nec amplius scit, aut potest.*"

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*On certain Phenomena presented by the Glaciers of Switzerland.** By M. Escher de la Linth. (With a Plate.)

I have just read, with much interest, the memoir of M. Durocher on the erratic phenomena of Scandinavia, and am glad to perceive that M. Durocher is of opinion, that the agent which has produced furrows on the surface of Scandi-

* In this article there is some obscurity, probably owing to a bad manuscript.

navia, has been the same as that which produced them among the Alps. In fact, the detailed descriptions and figures given by M. Durocher, correspond so well to the furrowed surfaces of our Alps, that I cannot perceive any important differences, the contrast between the sides that have been abraded and the sides that have been preserved, existing also among us, a circumstance of which M. Durocher himself mentions instances. I likewise share with him the opinion, that the agents which produced the furrows must have been flexible. M. Durocher is of opinion, that, among the agents that have been proposed to explain this phenomenon, water alone possesses this character, and he, consequently rejects ice. It is worth while, however, to examine whether the ice of glaciers is really destitute of the degree of flexibility necessary to produce this effect.

Now, without taking into account the results obtained of late years by Messrs Agassiz and Forbes, relative to the movements of glaciers, results which cannot well be explained without attributing to the ice of glaciers the property of bending and becoming flexible, I am persuaded, that, if we observe the curves and folds described by the blue and white bands (elsewhere rectilinear and parallel to the length of the glacier) in the neighbourhood of rents, and, in general, wherever the movement of the glacier has been interfered with by some obstacle, no one can refuse to admit that the ice of glaciers is flexible, and *sufficiently* flexible to enter, under an adequate pressure, into all the anfractuosities of the ground and of the walls of glaciers : in short, that it is sufficiently flexible to accommodate itself to all the movements M. Durocher requires in the grooving agent. If the ice of glaciers is not very flexible in certain circumstances, how can we explain the very sharp folds, and the insensible passage to fainter curves, represented in Figs. 1, 2, 3, 4, Plate III.,—curves which, as has been already stated, are never found but when crevasses, more or less frequent, intimate that the glacier is interrupted in its movement, and has obstacles to overcome? I ought to add, that, in nature, the curves are much more regular, and better marked, than they are in the figures. They are also much nearer each other, the breadth of the blue and white bands varying from nearly 1 millimetre to 4 centimetres. The figures merely give an idea of the form of the curves.

Starting with the supposition that ice is rigid, M. Durocher says that the glacier can exercise its grooving power only at its bottom. Fig. 5, Plate III., representing the end of the western arm of the glacier of Viesch, and its western wall overhanging and furrowed, shews, in my opinion, with all the evidence desirable, that the assertion alluded to is not correct. In fact, we there see, from a height of nearly 2 metres above the ground, the glacier resting immediately upon and against the granitic wall, whose rounded and polished surface exhibits large furrows a little inclined towards the horizon, and which extend to a distance in a direction parallel to that of the glacier. In the concave and convex parts of the granitic surface we see, moreover, smaller and shallower furrows, from 2 to 5 centimetres broad, sensibly parallel to the great furrows; besides, we remark, principally in the furrows, a multitude of extremely fine, scarcely visible, striæ, parallel to the furrows. Stones* were set in the ice, so firmly cemented with it (evidently by the pressure of the superior mass of the glacier, which rose 100 feet above the ground), that I had much difficulty to detach some of them with a hammer. These stones, a little rubbed on the side of the rock, were covered on the same side by an extremely fine mud, almost unctuous to the touch, owing to the fineness of its grain. This mud, mingled with fine sand, likewise covered the accessible part of the overhanging rock, separated from the glacier at the base by an empty space, evidently produced by the influence of the summer heat. This cavern continued to get narrower up the glacier in such a manner that it was scarcely 20 paces long. Some weeks earlier, one would, no doubt, have seen the glacier skirting the rock to the base; but then one could not have seen the large furrows extending beneath the glacier, as was then the case.†

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* These stones had, no doubt, originally fallen from the higher parts of the wall, or the surface of the glacier, in the interval which, on the surface of glaciers, is so often found between the ice and the walls of its bed; they were then enclosed by the ice.

† There is considerable obscurity in this page, owing, probably, to a bad manuscript.

It is clear that the stones imbedded in the ice must advance simultaneously with the glacier, and that they cannot advance without being rubbed, and, according to the degree of their own hardness, and that of the walls, produce furrows and striæ in the latter, or receive such themselves (detached stones, polished, furrowed, and striated). The mud mentioned appears as the necessary produce of the friction of the stones against the rock; accordingly, we observe it everywhere in the rivulets which issue from beneath glaciers.

The mode of producing polish, furrows, and striæ, is thus exhibited so distinctly to the eye, that every one, I should imagine, ought to yield to the evidence of facts, and admit that glaciers have the power of producing the phenomena mentioned in all parts of their bed.

With regard to the deep and undulated canals, I confess that in such canals, which are very frequent in the bottom of our glacier beds, but rarely accessible to minute examination, I have not hitherto remarked the striated appearances mentioned by M. Durocher. But, the flexibility of the ice once admitted, there is not the least difficulty in conceiving their production in such a canal, as soon as it is left by the water and filled again by the ice. The frequent change of water-courses under the glaciers is a phenomenon too well known to render it necessary to enter into details on this subject.

It appears to me, therefore, that M. Durocher's objections to the theory of M. de Charpentier, which ascribes the furrowing to glaciers, are refuted by the examination of what we witness taking place in glaciers still existing.

Let us now see if facts are not to be found which require properties in the furrowing agent, which are opposed to those of a current of water or mud. It appears to me that there are several.

1*st*, The large furrows, as well as the fine striæ we see in countries now destitute of glaciers, are by no means, in general, rectilinear; on the contrary, they follow, in lines generally almost horizontal, exactly the irregular circumference, often very sinuous, and even almost at a right angle with the walls. The instrument by which these furrows have been produced, has therefore followed exactly, in its progress, this tortuous circumference. Now, of whatever density we may suppose a current of water or mud to be, it will always be less than that of stones, if it must possess a considerable quickness. Stones, moving nearly in the direction of the current, will no doubt here and there go along the walls of the bed; but all those which reach the side-walls, under whatever angle that may be, will be thrown back towards the middle of the current, and it appears to me altogether impossible that they can turn the least salient angle.*

Admitting, for an instant, that a current may produce fine striæ, it is then necessary to suppose, with regard to such as are not rectilinear, that, commencing with one stone, they have been continued by a second, a third, &c., which, by an accident the most improbable, should have continued the striæ exactly from the point where it had been left by the preceding stone.

Again, when we consider that nearly horizontal furrows shew themselves in the upper valley of the Aar, in a space of many thousand feet in height, we must suppose, in order to account for a simultaneous origin throughout the whole height, a current, at least, of equal power, a current of a den-

* No one, as far as I know, has ever pretended to have observed striæ of the nature in question, produced by actual currents. Stones set in motion by a torrent have neither the power to produce nor to receive striæ, because in rolling along they only rub others, and are rubbed themselves. In fact, we never find striæ either in the beds of torrents or on the borders of lakes, not even in eboulements, such as those of the Deut-du-Midi, and Combe-Mauvoisin, near St Maurice. It is true that the stones in the latter sometimes exhibit white spots, a little elongated (the longest I have seen did not exceed an inch and a-half), produced by the rubbing of the stones against each other; but these spots appear to enable us expressly to distinguish between what can be produced in this way by debacles and glaciers. We find not one of these horizontal striæ on the surface of the walls, exceeding six inches in length, the edges well defined; in short, striæ cut as with a graving tool. We will seek for them in vain on the surface of detached stones, while they are very frequent, and sometimes of astonishing perfection, on the surface of the calcareous pebbles of the moraines of existing glaciers (glacier of Sustenhorn, at the foot of the Meyenthal), and in the erratic formations of all Switzerland.

sity exactly similar to that of the stones, in order that, from their primitive position, they may advance almost horizontally. Besides, it is necessary not only to make the stones fly like an arrow, but we must assign a tortuous path to those situate near the margin of the bed, without, however, making them lose their speed. In order to account for a successive origin, we must necessarily suppose that the valleys are excavated by the effect of currents, in order that the furrows from above could be formed before those of the middle and at the foot of the slopes.

I confess that the view of the labyrinth which either of these suppositions opens up, alarms me much more than the idea of countries covered with glaciers.

By admitting, on the contrary, that the polish in question, the furrows and striæ of countries destitute of glaciers, are the produce of glacial action, we only apply the effects of existing glaciers to forms exactly similar to those which the glaciers continue, under our own observation, to give to their walls; their ice is sufficiently flexible to ply around the contours of their bed, and sufficiently compact to press the grooving body constantly against the wall. The action takes place simultaneously over the whole circumference of the glacier, where the gravel or stones are found at its edge, and where it is not separated from the walls of the bed by some void space; a space, however, which will disappear sooner or later in its turn, and be again filled with ice and stones.

2d, It is not rare to find erratic blocks, especially of a calcareous nature, but likewise, also, of a granite, having one of the faces (to the extent of a metre square) flat as a table, and rayed with furrows and striæ more or less numerous. These flat surfaces are found in blocks which have travelled upwards of fifteen leagues, and the circumstance appears to me incompatible with transportation by currents, as much in theory as in practice, since the blocks of currents never shew us anything similar.

3d, In some places, for instance on the western side of the valley of the Rhine, near Oberried (Canton of St Gall), and a league beyond the baths of Pfeffers, in the valley of Tamina, we find on the surface of a polished calcareous rock, for a great extent, rays very nearly horizontal, and from one and a half to four millimetres broad. In the very wide hollows of these rays, small and transverse notches may be seen, almost always more or less curved, usually about 0^{m} 3 distant from each other, their convexity constantly turned up the valley. These notches have all the appearance of the trace of an instrument like a chisel, which, moved by a slow mechanism, and somewhat tremulous action, presses against the substance submitted to its action, sometimes more and sometimes less strongly. I believe that no one, on seeing this appearance, would hesitate to ascribe it to a *very slow* movement, similar to that of glaciers, and to consider it altogether incompatible with a rapid movement.

The polished rock near Pfeffers, cleared a little while since by a rivulet from the detritus which covered it and protected it hitherto against the influence of the atmosphere (fig. 6, Plate III.), presents still another peculiarity. Very nearly perpendicular to the furrows which follow the general direction of the valley, we perceive numerous striæ all very fine, of a depth more appreciable, sensibly parallel to each other, and running in the direction of the greatest acclivity. These striæ cross the longitudinal furrows in some places in so distinct a manner, that we perceive they are of newer formation. I know not what explanation the advocates of currents would give of this circumstance. In the theory of glaciers, it presents itself as the result of the slow movement which the detritus of the surface of the glacier has been subjected to, during the sinking and melting of the glacier, that is to say, during its transport from *a b* to *c d*, fig. 7, Plate III.

In short, it appears to me that M. Durocher's objection to the production of furrows and striæ by the action of glaciers are by no means plausible, and that the circumstances mentioned above prove, on the contrary, that it is glaciers which have produced them, or, if such a view of the matter be preferred, an agent still altogether unknown, which gave rise to effects absolutely identical with those of glaciers.

I refrain from entering into a comparison of mounds and erratic deposits with the deposits of glaciers, and from shewing that the transverse erratic mounds most distant from the

Alps—for example, those which surround the openings of the lakes of Zurich, Greifensee, and Sempach, are connected more or less intimately with the moraines of existing glaciers, and that the mode of production in the one case is absolutely the same as in the other. In general, it may be said, that the more we study the erratic formation of the Alps the more we find in it analogies with the deposits of glaciers, and the more do the difficulties of the theory of currents multiply and gather strength.

With regard to the *lapias*, of which M. Desnoyers has spoken in discussing M. Durocher's Memoir (p. 85 of the *Bulletin*), I may be permitted to add, that this phenomenon appears to me to be completely independent of the action of glaciers. The prevailing character of the latter is to make all the natural asperities of the ground disappear, and to produce forms more or less rounded and flat. The characteristic property of the lapias is, on the contrary, to increase the inequalities of the ground, to have a surface excessively rough and covered with projecting points, hollows between the prominences, and even the smallest intervals bearing pointed projections and plates as sharp as a knife, &c. In it the furrows are, in general, in the direction of the steepest slope, and frequently terminate below in funnels sensibly vertical, very deep, often corresponding to the tributaries of the great springs, spouting out on the slopes, and at the bottom of mountains (Hundsloch in Wæggithal, sources at Engelberg, at Bisithal, &c.) The formation of lapias, in my opinion, depends on the want of perfect uniformity of substance in the rock, taken in connection with its being of a certain consistency, a consistency which admits of the parts not destroyed to remain standing, and increase in size in proportion as the channels become deeper by the mechanical and chemical action of what falls from the atmosphere. In fact, it is only, as far as I know, calcareous rocks which exhibit lapias; they never appear in sandstone and crystalline rocks. Among the calcareous rocks of the Swiss Alps, it is that at *Caprotina*, and the compact, bluish-black, brittle limestone (representing the middle oolite), which are most favourable to the development of this form of surface, principally in elevated regions, or where there is no vegetation to protect the surface against the influence of atmospheric agents.

Explanation of the Figures in Plate III.

Fig. 1. Contorsions of the icy masses near the north edge of the glacier of the Oberaar, 5th August 1842.
Fig. 2. Contorsions in the glacier of the Unteraar, near M. Agassiz's gallery, 1st August 1842.
Fig. 3. Contorsions in the glacier of Aletsch, near Lake Moriel, 17th July 1841.
Fig. 4. Contorsions in the glacier of Aletsch, half a league above Lake Moriel, 14th August 1841.
Fig. 5. Lower extremity of the western arm of the glacier of Viesch, 30th June 1841.
Fig. 6. Limestone rock, polished, furrowed, and striated, in the valley of Tamina, a league beyond the Baths of Pfeffers.

—*Geological Society of France. Seance* 19*th Janvier* 1846.

An Account of Thermo-Electrical Experiments. By Mr R. Adie, Liverpool. Communicated by the Author.

In the present communication, I propose to resume the consideration of some of those thermo-electrical experiments, which were published in Nos. 70 and 71 of this Journal, chiefly for the purpose of shewing that, in the joints of thermo-electric couples, *molecular action has no power to develop a current of electricity, unless the bars are unequally heated.*

Referring to the above mentioned papers for several facts which go to shew that there is a molecular change in a joint, which has been long engaged developing a thermo-electric current, I have since endeavoured to find a similar change in a joint which has been long equally heated at a temperature a few degrees below boiling water. One series of experiments extended through a period of sixteen months, yet in no case have I met with a molecular change in the joints of equally heated thermo-electric couples. From this we should infer that unequal heating is necessary to produce the molecular change; then, reasoning from analogy, we should expect to find that molecular change, without unequal heating, should, in like manner, fail to throw an electrical current into circulation, a result which I shall endeavour to establish, by briefly running over a few experiments.

In No. 74, p. 298, I have stated that I could produce no effect on the galvanometer by the slow mechanical fracture of the soldering of a thermo joint. The following is a much more satisfactory method of testing this point. A couple of bismuth and lead were connected in the usual manner with the galvanometer, and their

PHENOMENA OF THE GLACIERS
by Escher de la Linth.

Fig. 1.

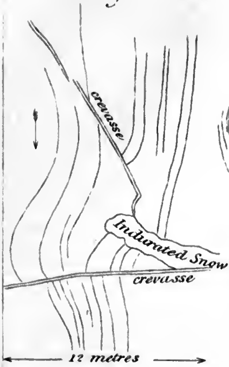

Fig. 2.

Fig. 6.

Plan

Fig. 3.

Fig. 4.

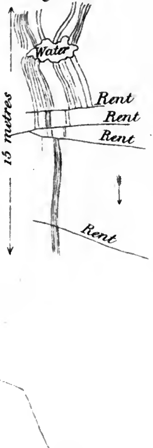

Fig. 5.

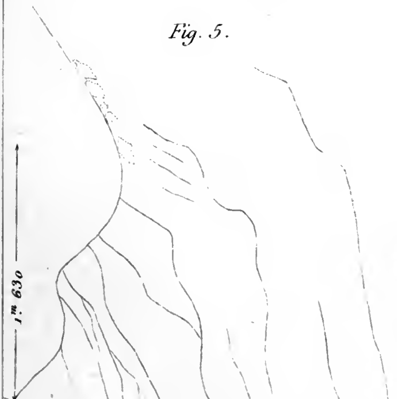

Fig. 7.

joint, together with a portion of the bismuth bar, was placed betwixt the chops of a strong vice; on pincing the vice, the bismuth was crushed together, emitting a crackling sound like tin, when bent backwards and forwards; there was no decided action on the galvanometer. Repeating this experiment with another similar in the vice-joint placed between two cards in the vice, in order to prevent the mass of iron in the vice from quickly withdrawing any heat which the violent crushing developed, at the moment of compression the galvanometer made a swing of 10° in the same direction, as if the joint had been very slightly heated. Had molecular change been alone able to develop an electrical current, the galvanometer should have in both cases moved, and, if I apprehend rightly, the extent of the action should have been very great.

In forming mercurial amalgams, abundant molecular change can be produced without any perceptible variation in temperature. To use mercury like a bar of metal in a thermo couple, a glass-tube, open at one end, and fused at the other around a piece of platina wire, was filled with mercury; the platina wire was connected to one end of the galvanometer wire, and a bar of bismuth, connected to the other extremity, was made to dip into the mercury at the open end of the tube. In this arrangement, the bismuth was slowly combining with the mercury, yet there was no effect on the galvanometer so long as care was taken to preserve equality of temperature throughout the couple. The same was found for lead and tin. When unequal temperatures existed, then the well-known thermo-electric effects were noticed, where bismuth is the generating metal to mercury, and mercury the generating element to lead or tin. From some unseen cause, most probably connected with the circumstance of one of the elements in these couples being a fluid, the density of the amalgams forming has no influence on the direction of the electrical current developed; for, when one equivalent of tin and mercury are amalgamated, the specific gravity by experiment is 11·05, by calculation 12·15; and for one equivalent of bismuth and mercury, the specific gravity by experiment is 12·08, by calculation 12·55:* the calculated specific gravity is on the supposition that the metals unite without change of volume. Lead and mercury give exactly the same density as calculation shews, but from the above numbers it is seen, that the amalgam of tin undergoes a greater change in volume than that of bismuth, yet the thermo-electric relation of tin to mercury is nearly like that of lead, and quite different from bismuth.

I have formerly mentioned cases of other metals where the influence of the molecular change is distinctly seen on the thermo-electrical current generated. The two best examples of this kind may be

* The proportion of mercury was tried for half an equivalent and for two equivalents, which only varied in degree the changes noticed.

briefly recapitulated. A piece of soft steel with a portion hardened and reduced in density, by heating and plunging in water, gives a thermo current passing from the hard or changing side to the soft or more stationary side. A similar experiment with the part hardened and made dense by hammering, gives the current passing from the soft part to the hard. Bars of hard steel change their dimensions by annealing at temperatures 20° above the weather. This I have carefully observed by reading off their length with delicate micrometer microscopes. Further, I am informed, on excellent authority, that the steel balance-springs of chronometers are subject to a change extending over years ; it is by the rates at different temperatures that this slow change is found out,—a truly beautiful method of detecting minute alterations.

Antimony, when cast in a cold metal mould, has a low specific gravity which rises by annealing ; when cast in the same mould heated, the specific gravity is high, and reduces slightly by annealing at high temperatures. When an annealed bar of antimony was connected with a soft bar of iron and the joint heated, the iron was the generating metal ; but when a quickly cooled bar of antimony was substituted for the annealed piece, then the antimony became the generating metal, being a reversal of the natural relation, and continued so until the temperature reached 160°, where, although there was unequal heating, and molecular change in so far as regards the density of the bars, there was still no electrical current, most probably from the change in the two elements exactly counterbalancing ; for higher temperatures the usual relation of iron to antimony was established. These experiments with iron and antimony have always appeared to me to be valuable for reconciling the action of a pair of thermo-electric elements with an ordinary galvanic couple ; where the molecular action corresponds to the chemical action, and the unequal heating in the thermo couple has to perform the same office which the fluid has in those batteries excited by active chemical agents, namely, to produce the electricity in a form that will circulate in a current. The facts shewn by the couples, where mercury forms one of the elements, present difficulties which may serve to stimulate more able inquirers to endeavour to explain.

The results which I formerly gave of metallic silver, precipitated by astral and solar influence, acting on the thermo-electric batteries described No. 70, fig. 1, I have since repeatedly verified ; but for this climate the quantities of metal obtained are much too small to serve any purpose, beyond proving that silver may be so precipitated. The experience of three years now makes me prefer the arrangement described (No. 70, p. 348), as a sensitive instrument for telling at all times the rate of radiation to or from the earth.

There are molecular changes in metals, either immersed in water or exposed to the moisture of the weather, which are very rapid. A piece of thin brass wire exposed to the weather soon becomes brittle, and cannot be bent without breaking; while its original pliability may be restored by annealing at a dull red heat. The same fact has, I believe, been observed for pieces of copper immersed in battery cells for electrotype purposes. That these changes are connected with the water surrounding the metals is at once shewn by the fact, that portions of the metals kept dry, but engaged conducting an electrical current like the wet parts, remain unaltered. They are evidently of a quite different character from the slow change in thermo-electric joints at high temperatures, where the heated metal surfaces are always in a very dry state. To detect a similar action in joints at lower temperatures I have experiments of now near three years' duration; but from all I can observe, this space of time falls far short of what will be required.

Account of a remarkable Cave in the Island of Barbadoes, commonly called "Cole's Cave." By JOHN DAVY, M.D., F.R.S. Lond. and Edin., Inspector-General of Army Hospitals, &c. Communicated by the Author.

It is not my intention, in the present communication, to enter into any minute account of this well-known cave;—it is my wish, chiefly, to point out some of its peculiarities, and, most of all, certain appearances which seem to me interesting in relation to geology.

I may premise, that Cole's Cave is nearly in the central part of the island, on an estate called "the Spring,"—a name derived, it is said, from a spring in the cave, the source of a subterraneous rivulet. It is distant about six miles from the principal town, Bridge-town; and may be about five or six hundred feet above the level of the sea, and about thirty feet deep, measuring from the surface above. The descent to it is steep, but not difficult. The entrance is narrow, and, consequently, the descending rays of light are soon lost, and the interior of the cave is dark within a few feet of its mouth. The cavern may be briefly described as a subterraneous chasm or rent, of variable dimensions, and varying in the most irregular manner, with branches from it. That of greatest extent has never been followed to its termination; and it is yet a problem whether its termination is in the direction of the low coast to the southward, or the contrary, inland towards the hilly part of the island, in a northerly direction. There is a stream on each side, which may be adduced in favour of either hypothesis; but the course the chasm takes, so far as it has been penetrated, favours most the latter. The cavern occurs in a calcareous rock,—an aggregate exceedingly various in different situations,—often abounding in shells and coral, often having the character of freestone. This applies to the formation generally.

Water is plentiful in the cavern; there are few places where there is not a dropping of it from the roof, and, as already mentioned, a spring of water rises in it. This occurs, it may be, about fifty yards from the mouth. It is copious. Its temperature, when I tried it about noon on the 11th July, was 77° Fahr., which, probably, is about the mean annual temperature of the spot. It gushes from the rock with force, and immediately forms a pretty and clear rivulet, which, after flowing some way, is lost, and a little farther reappears, and continues sometimes running sluggishly, forming pools, sometimes rapidly, as far as this the main chasm has been traced. It may be mentioned, that another chasm, communicating with this, is without a running stream. In its bed, however, are some pools of water, and large deposits of clay, which also occur in the first mentioned at intervals; clearly indicating that during floods, the consequence of heavy rains, the cave is liable to be inundated, the clay suspended in the water subsiding on rest; and thus farther indicating, that the outlet of these chasms is very narrow, so as to admit of a small stream only flowing out, and, consequently, of accumulation and rising of the water and of a partial rest within. The clay or mud traces on the walls of the cavern shew that the depth of the collected water, when highest, is many feet.

Though so moist, and though all the other circumstances of the cavern seem favourable to vegetation, excepting one—the exclusion of light,—there is a total absence in it of vegetation, even of the lowest kind; not even a mucor is to be detected, at least I sought for such in vain. The only living things known to be found in its recesses are a few of the fresh-water crayfish of Barbadoes in the stream, some insects of the cricket kind on the walls, and numerous bats, which make its drier parts their roosting-places. I have not been able to learn that any lizard, analogous to the Proteus, has been found in its pools.

Where water is always flowing, and commonly dropping, it is not surprising, especially considering the nature of the rock-formation, that deposited carbonate of lime should abound. Its character seems to me the most interesting circumstance connected with this cave. I have specimens now before me, which I broke off myself, evidently formed from deposition in water, exhibiting a very remarkable variety, not only as regards forms, but also structure; in brief, there is a tolerably complete series, from a kind resembling mountain limestone, to another very little different in appearance from Parian marble. Even in the strata of the smaller stalactites and stalagmites, such and other differences are observable; thus, one part may be very fine-grained in thin concentric layers, another confusedly crystalline, and a third more regularly so. In one specimen, and that a stalactite, the general structure is radiated, shewing a tendency to the prismatic form of crystallization, accompanied by transverse lines, as it were, of cleavage, denoting the rhomboidal form; the one approximating to arragonite, the other to calc-spar. Moreover, there are, in particular situations, strata formed on the bank of the rivulet very like tufa, or a porous freestone, and somewhat similarly constituted, being formed of carbonate of lime in crystalline grains, acting the part of a cement, and of a portion of sand or a little clay.

I have thought it worth while to examine chemically some of these specimens exhibiting the greatest variety of character; and I shall briefly notice the results of the trials.

The pure white crystalline specimen resembling Parian marble appeared to consist of carbonate of lime alone; nothing else could be detected in it.

That resembling mountain limestone, of a fawn colour, finely granular, and in part minutely crystalline, besides carbonate of lime, contained a minute quantity of alumine, with a trace of peroxide of iron, and a small quantity of matter in a finely divided state, not soluble in an acid, which, under the microscope, had the granular appearance of particles of clay, with which were intermixed a few grains of excessively fine quartzose sand.

The tufa-like specimen, or that resembling porous sandstone, it has been already mentioned, consisted of crystalline grains of carbonate of lime, and of a little clay or sand. With this carbonate of lime a minute portion of phosphate of lime was detected. The sand that remained undissolved by an acid mixed with a little clay, consisted partly of water-worn particles of quartz, and partly of particles like those of volcanic ashes, being angular with sharp edges;—such was the appearance of both, as seen under the microscope with a high power.

Lastly, the clay was found to be very compounded, and to contain carbonate of lime in small quantity, a little carbonate of magnesia, a minute portion of alumine soluble in an acid, and a minute portion of phosphate of lime, besides a portion of sand, and a large proportion of clay not readily soluble in dilute muriatic acid. Its compound nature was also indicated by its fusibility before the blow-pipe. Amongst the specimens I brought with me from the cavern, there were two kinds I have not yet noticed. One was a fragment broken from the wall of the cave: it consisted of incrustation of carbonate of lime, coloured brown, and in part almost black. Its colouring matter I found to be peroxide of magnesia, mixed with some peroxide of iron. The other were small masses, either spherical or oval, the largest not exceeding an almond in size. They were numerous in one part of the bank of the stream. When taken up they were soft and most easily broken; after exposure to the drier open air (the air in the cavern tried by the moistened bulbed thermometer, was found saturated with moisture) they increased in firmness. Many of them when broken were found to have an ochry nucleus, giving the idea that they might be embryo concretions of clay ironstone, that in process of time the proportion of oxide of iron might increase, and that ultimately they might become included in a bed of clay.

What are the influences which are to be drawn from the other specimens? That the material of them, so various, was either deposited from water from a state of solution, in consequence of the separation of carbonic acid, or was a subsidence from water, having been mechanically suspended in it, in a very finely divided state, seems to be unquestionable. The main inference then is, that so many varieties of rock as those mentioned may be formed by deposition and subsidence from water; the pure white crystalline-like marble by deposition of carbonate of lime alone from a state of solution; that like mountain limestone, by a like deposition, with an admixture of a little sediment of foreign matter; and the tufa-like kind, or sandstone, from a greater admixture of sediment, and that sediment composed partly of quartz sand, and partly of what I believe to be volcanic ashes.

Now, as the calcareous deposition and the other deposits are constantly increasing in this cavern, judging from what is now to be witnessed, it requires no great stretch of the imagination to conceive a time, and that not very remotely distant in the future, when the fissure may be completely filled up, and its contents be like the contents of a vein, according to the old Wernerian hypothesis; and which, if broken into and quarried, may exhibit irregular beds of marble in connection with rock having the character of mountain limestone, and other rock having the character of freestone. In parts of the island where excavations have been made, or natural sections occur, phenomena of the kind are to be witnessed at present. The one seem to elucidate the other.

As regards the materials entering into the composition of the rocks now forming in the cavern, it is not difficult to find their source. It is unnecessary to point out whence the carbonate of lime is derived; the worn honey-comb appearance of the calcareous rocks on the higher grounds, at the surface exposed to the action of rain-water holding carbonic acid in solution, obviously explains it. The clay of the cavern is very like the finest portion of the surface soil; and, doubtless, has been washed out of the soil. The particles contained in the tufa-like deposit resembling volcanic ashes, have also probably been washed out of the soil, and are a portion of the shower which fell on the island at the time of the last volcanic eruption which took place in St Vincent, and of which a thin layer is often now to be seen a few inches below the surface, in spots where the soil has not since been disturbed. Of the manner in which the different varieties have formed, I shall not here speculate. Composition probably will be found to be the most important governing circumstance; and that one kind has the character of marble, because formed of pure carbonate of lime; another, the character of tufa, because composed of carbonate of lime, mixed with foreign matter. Nor shall I speculate on the question whether the crystalline stalactites acquired their peculiar structure immediately as they formed, or subsequently after the deposition of the material, in consequence of an internal molecular action and movement, favoured with the presence of water. In alluding to this last, I would express the hope that it may have the attention paid to it which it seems to deserve.

In conclusion, I would remark, that as there are few, if any, objects in this interesting island more deserving of being seen by the casual visitor than "Cole's Cave," if he has any curiosity in such scenes, it is easily gratified. A good carriage road through a pleasant country will bring him to within a hundred yards of the mouth of the cavern; and of a deep ravine contiguous, itself worthy of a visit. In an hour he may reach it from Bridgetown. He will have no difficulty in finding a guide on the spot. If he intends to explore the recesses of the cavern, he should come provided with a change of clothes, and of shoes, and with two or three wax candles. No lantern is necessary, as there is not any strong current of air below. And, however far he penetrate, he need have no apprehension of suffering from the state of the air, which, so far I went, and we were three hours in the cavern, wading and wandering, appeared to be as pure and as respirable as the open atmosphere. This, I specially mention, because the Rev. M. Hughes, in his "Natural History of Barbadoes," published nearly a century ago, states in his account of an excursion he made to this cave, that "near a quarter of a mile from the entrance was his *ne plus ultra*, being so much fatigued, and wanting air so much, that he durst not, without presumption, proceed any farther." I have recommended wax-lights, because they are greatly preferable to lighted bundles of dried, or partially dried, cane stalks, which, when parties are formed for descending into the cave, are often used to the great discomfort of the company, heating the otherwise cool air, and filling it, otherwise pure, with oppressive and obscuring smoke.

BARBADOES, 21*st July* 1846.

On the Natives of Guiana. (With a Plate.) By Sir ROBERT SCHOMBURGK. Communicated to the Edinburgh New Philosophical Journal by the Ethnological Society of London.*

So great is the similarity in appearance of the aborigines of America, in provinces far removed from each other, and differing in climate and productions, that accurate observers have been struck with the surprising resemblance in figure and aspect. Pedro de Cicca de Leon, who had an extensive knowledge of the American Indians, writes,—"The people, men and women, although they are divided into many nations, inhabiting different climates, appear, nevertheless, like the children of one family."

Though the inhabitants of the northern, compared with the southern parts of America, are tall and robust, a national resemblance may be easily traced, especially in women. In both men and women the head is large in comparison with the body, and the trunk with the limbs. The hair, though occasionally of a red colour, is in general black, straight, coarse, and of luxuriant growth. The iris of the eye is black, the eyelash long, and the eyebrow finely arched and slender.

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* Read before the Ethnological Society of London, 27th November 1844.

Thus the Guianese, with the advantage of a fine proportioned figure, may vie with the European. In some individuals an obliquity of the eye is very apparent, the external canthus being raised towards the temple. The distance between the eyes is perhaps a peculiarity which the American shares with the Mongolian. The greatest difference of the long to the short diameter of the osseous cavity of the eye is $\frac{7}{10}$, and the least difference $\frac{2}{10}$ of an inch. The nose is, generally speaking, prominent, long, and thick towards the nostrils, the openings being directed downwards, as in the Caucasian. The mouth is rather large, the lips protuberant, without approaching the thrown-up lip of the African. The teeth, which are seldom good, are destroyed at an early age owing to the practice of chewing the cassada bread, for the purpose of making it into an intoxicating drink; and thus, without any farther examination, the skull of a native Guiana woman may be recognised. The pelvis is well covered, and apparently of a capacity equal to the Caucasian. The hand is small and slender. The inferior extremities are well proportioned. The foot is, if anything, somewhat broad compared with the Caucasian, and in proportion to the difference, strength and solidity appear to be the result; for the Indian of Guiana, in walking, far surpasses the African,—children from six to eight years of age having been known to march sixteen miles in a day without complaining of fatigue. The skin of the female is of a soft texture, notwithstanding the pores are much larger than in the European.

The South Americans are generally short, and differ in this respect from their brethren of the North. Indeed, the average height of the Indians I have seen, amounts to no more than five feet four inches ; the tallest was five feet eight and a quarter inches. Hearne, the north polar traveller, saw among the Indians in Canada, individuals who measured six feet four inches, and the Muscogulges and Cherokees of North America are taller than Europeans, many being above six feet, and few under five feet eight inches. In this particular the following measurements are interesting,—

	Wapisianas.			Tarumas.	Mawackas.		Atorais.		Macusis.	
Supposed age,	Years. 12	Years. 15	Years. 16	Years. 14	Years. 15	Years. 16 to 17	Years. 35	Years. 15	Years. 14 to 15	Years. 14
	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.	f. in. 10ths.
Height of figure,	4 8 5	4 6 0	5 1 1	4 11 3	4 10 0	4 9 5	5 1 5	5 1 0	4 8 0	5 0 0
Circumference of pelvis,	2 6 7	2 8 0	2 11 5	2 10 0	2 10 5	2 11 3	2 9 2	2 11 2	2 7 0	2 6 8
Length of hand,	0 6 7	0 6 0	0 6 6	0 6 2	0 6 1	0 6 3	0 6 6	0 6 6	0 6 3	0 6 9
Breadth of do.	0 3 0	0 2 8	0 3 6	0 3 0	0 3 1	0 3 6	0 3 2	0 3 4	0 3 2	0 3 4

Casts of the face of individuals of the Macusi, Arecuna, Wapisiana, Carib, and Paravilhana tribes, and portraits taken by Mr Goodall the artist, exhibit the similarity of feature that prevails in Guiana; and if we extend our observations to the extremities of America, the same law will be found to exist.

From the skulls of the Carib, Wapisiana, Taruma, Arawaak, and Macusi Indians, which I collected, Professor Owen has made the following observations:—

"Dr Prichard, in his general observations on the shape of the head among the South American aborigines, states, that 'no constant observation can be laid down: the form of the cranium varies in every tribe.'

"The Peruvians have most generally heads of an oblong form, somewhat compressed laterally, the forehead a little prominent, short, and falling somewhat backward. In the people of the Pampas the head is generally rounded, nearly ellipsoid, contracted in length, and but little compressed laterally, with a forehead moderately prominent, and not falling back. In the Chiquitos the same character is exaggerated, and the head is nearly circular, while in the Moxos it is more oblong: this last form is very nearly that of the Guarani or Paraguay Indians."* Dr Prichard also cites the observation by Dr Morton, 'that the heads of the Caribs, as well of the Antillas as of Terra Firma, are naturally rounded.'"†

"The skulls of the Indians, which Sir Robert Schomburgk has done me the honour to submit to my examination, include specimens of the Carib, of continental South America, of the Taruma, the Wapisiana, the Arawaak, and the Macusi Indians, all natives of Guiana, and belonging to the Caribée division of the great Basilio-guarani group of M. D'Orbigny's classification of the South American Aborigines."

"The tribe which still retains the name of 'Carib' in Guiana, has long ceased the practice of artificially flattening the head, which characterised the Caribs inhabiting the neighbouring Caribean Islands. The skull of the individual of the continental tribe, a female, is ovate, viewed from above: the occiput is not flattened as in the Peruvian and Californian Indians, but is moderately prominent, rounded, and rather narrow. The forehead is narrow, and slopes with a gentle curve directly from the interorbital space, which is more prominent than the superciliary ridges, and has no medium vertical impression. The alæ of the sphenoid present a margin of half an inch in length to join the parietal. The cheek-bones and lower border of the orbit are moderately prominent. The nasal bones are continued with a very slight depression from the interorbital prominence. The superior maxillary bones are slightly protruded. The lower border of the malar process of the maxillary bone is slightly concave. The lower border of the orbit is a little more concave than the upper one: the spheno-orbital fissure widely open anteriorly. The length of the skull is 6½ inches: its greatest breadth 5½: its height from the vertex to the lined margin of the foramen magnum 5 inches."

"Of the three skulls of the Taruma Indians, all of which are

* History of Man, 8vo., 1843. † Ib., p. 364.

female, two have rather more prominent foreheads than the Carib: in the third it curves backward in the same degree from the interorbital prominence; the nasal bones are broader and flatter; in other respects they closely agree with the Carib skull: one of them, a young female about 14, presents an abnormal elevation of the upper and right side of the frontal bone."

"The Wapisiana skull presents the ovate form, but the occiput is rather more prominent, and the prominent part more circumscribed: the interorbital space is slightly depressed, owing to the projection of the supraorbital ridges: the forehead is a little more convex than in the Carib; but the general resemblance is as close as that which usually obtains between the skulls of two individuals of the same race.

"The cranium of the Macusi Indian is more oblong and ellipsoid viewed from above: the forehead is broader, the parietal region narrower, or at least not broader than it is in the shorter crania of the Carib and Taruma tribes. The frontal sinuses cause the supraorbital ridges to project beyond the interorbital space: the nasal bones are more prominent than in the Carib and Taruma Indians; the malar bones are equally prominent: the outer angle of the malar process of the maxillary bones overhangs the concave line leading thence to the alveolar processes. The general character of the facial part of the skull resembles that of the Patagonian Indian; but the prominent convex occiput, and general form of the cranium approaches nearer to the Carib form."

"In one Macusi skull, the spheno-orbital fissure is as much dilated anteriorly as in the other Caribeans; but in a second specimen, it was as narrow as in the Patagonian. The nasal bones are flatter in the second than in the first specimen of Macusi cranium."

"All the Indian skulls manifest the same inferiority in the size of the true molar teeth, as compared with the teeth of Negroes and Australians; the incisors, canines, and premolars, or bicuspides, are not smaller than in the Black races."

"They all agree in the roundness or convexity of the occipital region, and differ in this respect, as well as in their more symmetrical figure, from the skulls of the Peruvian, Chilian, and Patagonian Indians."

Although a difference in language is not an argument against the descent from a common stock, where similarity in form and structure exists, it may safely be concluded that tribes speaking allied languages were earlier or later related. In the language of the Northern and Southern Indians, the greatest uniformity prevails, which is particularly exemplified in that of the Wapisiana and Delaware, or Lenapé tribes. M. Du Ponceau has called attention to the compound words in the North American languages, by which means they can be increased to any extent. The same remark may be applied to the Wapisiana language. The language of the Northern Indian is remarkably copious; so is that of the Wapisiana. The words for brother and sister are manifold; and their signification shews whether the brother or sister is older or younger than the speaker, whether married, and in possession of one child or children. For every case in this respect the Wapisiana have a word, the abstract of which is brother or sister, but which points out the comparative age and domestic history of the individual spoken of. The adjective in the language of the European becomes a verb in that of the Delaware and Wapisiana, and passes through moods and tenses. The verbs *to have* and *to be* do not exist; they are compound with the possession and existence of a thing, and expressed according as the noun is animate or inanimate. An example of this peculiarity in the Cherokee language is recorded in the Massachusetts Historical Collection. Examples of the analogous, and frequently identical structure of the Delaware and Wapisiana languages might be proved point for point, according to the peculiarities which Du Ponceau, Pickering, and other philologists have remarked.*

I now come to the question of origin. To guide the inquirer through the intricacies of this labyrinth, to give him a notion from whence came the nation of America, there is not a

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* Blumenbach, Prichard, and Morton, are of opinion, that the Aborigines of North and South America have descended from a common stock. In the faithful portrait, remarks Humboldt, which an excellent observer, Mr Volney, has drawn of the Canada Indians, we undoubtedly recognise the tribes scattered over the meadows of the Rioapure, and the Coroni.

vestige of history, not a thread of tradition ; our knowledge on the subject depends wholly upon hypothetical reasoning.

The opinions which at present have been promulgated with regard to this subject may be divided into three heads.

I. They are indigenous, or coeval with the continent which they inhabit.

II. They are of Asiatic origin, and, emigrating from that continent, peopled first the South Sea Islands, and spread thence over the American continent.

III. They arrived across Behring's Straits and the Aleutian Islands, and spread thence over the New World.

It has been attempted to establish the hypothesis, that the first germs of the development of the human race in America can be sought for nowhere but in the so-called New World. But unless it can be proved, that the laws of nature are in direct violation of the Inspired record, which expressly says, that "God has made of one blood all the nations of men to dwell on all the face of the earth," we must still appeal to that Holy Book for interpretation, and reject the hypothesis.

The Bible and profane history corroborate the narrative, that ancient Egypt and Hindostan were invaded by a powerful tribe who introduced their peculiar customs into the conquered country, built temples and pyramids, and covered them with hieroglyphics. Historians here allude to the Cushites, who, after having erected a splendid empire, were dispersed by the Almighty. They are traced chiefly by the ruins of their mural defences in a north-easterly direction to Palestine ; by the relics found in their tumuli, and their peculiar zodiacal signs, to the north of Siberia, where all further traces of them are lost. Similar tumuli, mural defences, hieroglyphic inscriptions, astronomical divisions of time, and zodiacal signs, were used by the civilized aboriginal race of America ; and as the geographical position of Behring's Straits and the Aleutian Islands admit the possibility of emigration from Asia to America, we are led to believe that the Toltecans and Aztecs arrived that way. They were, however, expelled by succeeding hordes, and during the struggle for occupancy, the earthen ramparts may have been constructed ; but the frequent attacks and the arrival of new hordes rendered their destruction inevitable, if they obstinately persisted in remaining; they, therefore, abandoned the country to the conquerors, emigrated southward, and became ultimately extinct. The descendants of the latter savage tribes, the conquerors of the ancient Mexicans, constitute at present the aboriginal inhabitants of North and South America; tribes, whose language, though dissimilar, possess philological affinities, and who are distinguished by the same predilections for a nomadic or roving and savage life, and are given alike to war and to the chase.

The Mongolian races of Northern Asia possess a similar disposition; but we may infer a still stronger affinity between the Indians of North America and the nomadic tribes of Northern Asia, from anatomical coincidences. Indeed, Dr Prichard, in alluding to the Mongolian races and the North American Indians, observes, "we do not find that any clearly defined difference has been generally proved between the two classes of nations."

The present American race, if we do not enter into specialties, blended with the Mongolian to the north, spreads over the greater part of the New World; and, however feeble their intellect may be, they surpass the more civilized, but now extinct, races of Mexico, in their full belief of the existence of one Good Spirit and a future state.

The religious belief of a nation ought to be kept strictly in view in tracing affinities and relationship. The absence of all idolatry among the aborigines has struck the inquirer as very remarkable.

The numerous instances of strong resemblance in manners and customs of the Samoiedes and Yakutes in Erman's Reisè, struck me as very remarkable; and I have no doubt that further investigation will lead to remarkable results as to the origin of the Guiana Indians.

The Samoiedes believe in the existence of a Supreme Being, the creator and preserver of all things; but they offer him no worship, because they suppose that he takes no notice of them, and requires nothing of them. To another being, inferior to the Supreme, but yet very powerful, eternal and invisible, but inclined to evil, they ascribe all misfortunes.

They believe also in a future state, or that the soul wanders forth from the grave, in which they accordingly inter the clothes and the bows and arrows of the deceased, in order that they may be ready for the use of their owner when he stands in need of them.

If we substitute for the word Samoiedes, "Guiana aborigines," we have a statement of their religious belief. The Macusis name their good spirit Makunaima, the evil one Immawari; of the latter there are legions. The soul, which leaves the body when man dies, is called Teckétong.

The religious rites of the Yakutes are similar to those of the Samoiedes; both tribes have priests or Biuhns, who are reputed mediators between men and the gods, and connect magical performances with their incantations.

The Piatzas or Piais of the Guiana Indians exercise similar functions, and constitute a powerful priesthood. The Piatzas, when performing their superstitious customs, use rattles and bells; others, chiefly the Caribs and Wapisianas, avail themselves of drums. A similar custom prevails among the Yakutes and Samoiedes. There is another custom of the ancient Yakutes, which is followed by the Warraus and other Indian tribes in Guiana in a somewhat similar manner, namely, the custom of burying alive or killing the oldest servants or favourites of a prince at his funeral, which, however, is now abolished. At the funeral of one of their chieftains or principal men, the Warraus place the favourite hunting-dog of the deceased, alive, with his former master, into the grave; or, as is now more frequently the case, the dog is killed and buried with him.

When the Yakutes meet with a fine tree, they presently hang up all manner of nick-nacks about it; a custom which is followed generally by the Indians of Guiana.

The pyramidal huts of the Indians in the interior of Guiana, chiefly the Macusis, Wapisianas, and Tarumas, are remarkable for their size, and the walls are sometimes made of clay, sometimes of bark of trees, covered with palm-leaves, which are rendered impervious to the rain, by clay being thrown upon them.

In the winter the Yakutes inhabit jurte or yourds, which are pyramidal huts made of boards, and covered with grass and mud.

The tents of the Samoiedes are made of pieces of bark, covered with reindeer skin, and are made of a pyramidal form.

The description which the author of the Neue Nackrichten gives of the appearance of the Samoiedes holds good in many respects, if compared with the Guiana Indians; but nothing has struck me more forcibly than the observation, that the females are often mothers at the age of ten or twelve years, and cease to bear children at thirty.

The Indians of Guiana obtain their wives by purchase, or by a three or four years' labour, if they do not possess the required purchase-money. Early engagements, therefore, take place, and the boy or young man is permitted to pay visits to his intended in the interval till marriage takes place.

Erman was told by an old Yakuti, that among the northern families of his tribe, who were not converted to Christianity, polygamy was still prevailing, and that the men purchase their brides, for a sum of money which is called Kolûim; but as frequently the family of the young man was not able to pay the whole sum at once, they were betrothed at an early period, to afford time to pay the sum by instalments, and during which period the young man was permitted to visit his bride.

According to Erman, the language of the Yakutes preserves the inflection of adjectives through case and gender, a peculiarity which is worthy of consideration. This traveller's observations with regard to their national songs and music, refer likewise to the Indians of Guiana; their song consists only of a few notes, and the theme is constantly repeated in short phrases, inspired at the moment, or caused by events known to the singers. These songs are plaintive, and more like a dirge than the effusion of a joyful spirit.

The similarity in manners and customs between the Yakutes and Samoiedes and the Indians of Guiana, cannot be called accidental coincidences, and urge us to inquire, whether additional confirmatory proofs can be discovered of these tribes being of a common origin.

But this similarity in manners, &c., does not refer solely to the Yakutes and Samoiedes; it may be traced through all those tribes with which the two Asiatic races are connected. Erman relates some festivities of the Chinese Mongoles, during which he was present at Mai-ma-tshen,—his description of their song and dance will equally apply to that practised by the Indians in the interior of Guiana.

Like many of the Indian tribes, and chiefly the Caribs, the inhabitants of Mai-ma-tshen constantly change the *l* for *r*, and *vice versa*, in the pronunciation of words. But what most astonished me, was his observation, that the Maadjus, who, form the higher classes of the Chinese subjects, wear a knob made of a whitish rock, as a sign of the high caste to which they belonged; and cylindrical pieces of white rock, more or less perforated, according to the descent of the individual, and executed by manual labour, are worn by the Indians at the banks of the Uaupès, in the province of Rio Negro, as a token of high birth and chieftainship. Their religion acknowledges a god of horses, of cows, &c. The Indians of Guiana do not call these fancied spirits gods, but masters or lords of the horses, cows, &c., and consider them to possess eternal life and supernatural powers.

Notwithstanding the greatest similarity is traced in manners and customs, I confess I have not been able as yet to discover any analogy, by comparing the vocabularies of the northern Asiatic languages with those of Guiana. I do not despair yet, that, with more time and more resources at my hand, I may succeed in finding that similarity which is still required to add the concluding link to the chain.

It has not been proved as yet whence the languages of the Yakutes and Samoiedes originated; and may not one rather expect that a race like the ancestors of the Guianese, emigrating to regions, under the sky of which nature exhibited herself in such various forms, and where life and the means to sustain it obliged them to use different means, should, in the lapse of centuries, operate upon a language which, not being written, depended upon oral delivery? History informs us of the rapidity with which tribes in adversity forget their language; and the Holy Bible instances the Jews in captivity, who, in so short a period as seventy years, had forgotten the Hebrew language.

From these general remarks, I turn to an enumeration of the tribes, and some of the most striking characteristics of the Indians who inhabit those parts of Guiana which I have visited.

It is difficult, if not impossible, to form a close approximation to truth in calculating the number of aborigines within the boundaries of British Guiana. Our imperfect knowledge of the country and still more their wandering life increase this difficulty. In 1840 I estimated the tribes who inhabit the British territory at seven thousand. I fear much that since that period they have materially decreased. Smallpox was introduced among the Macusis, Wapisianas, and Atorais in 1842, and has brought many to an untimely grave, so that I think scarcely six thousand are left, in a territory which comprises about 100,000 square miles.

The different tribes who inhabit Guiana consist of—

Arawaaks.
Warraus.
Caribs or Caribisi.
Accawais or Waccawaios.
Macusis.
Arĕcŭnăs.
Wapisianas.
Atorāis or Atōrias.
Tarumas.
Woyavais.
Maopityans.
Pianaghotto.
Drios.

The Arawaaks and Warraus live in the coast regions, and their small settlements extend scarcely one hundred miles inland. They number about three thousand. The Caribs inhabit the lower Mazaruni and Cuyuni. The settlements at the Guidaru have been abandoned, and the population, once the lords of the soil, does not at present exceed three hundred.

The Accawais or Waccawaios inhabit the upper Demerara, the Mazaruni, and Pataro. The two subtribes, the Waicas and Sœrikongs, inhabit, the former the regions between the river Cuyuni and the Barima, the latter the upper river Mazaruni, and unitedly amount to six hundred. The Macusis live in the open country or savannahs of the Rupununi Parima, and the mountain chains Packaraima and Canuku.

Those who inhabit the British territory amount probably to twelve hundred; the whole tribe is probably not less than two thousand five hundred. They are bounded to the north by the Arècunas, who dwell in the mountainous regions and savannahs at the springs of the rivers Caroni, Cuyuni, and Mazaruni. They are a powerful tribe, and in manners and language closely connected with the Macusis. This does not, however, prevent enmities and wars from breaking out among them, and the Arècunas are accused of being poisoners and night murderers. The number inhabiting British Guiana is perhaps five hundred. The Wapisianas or Mauxinians are a tribe belonging to the savannahs of the upper Rupununi and the banks of the Parima. They have been reduced by smallpox to four hundred. The Atorais are nearly extinct. The same refers to the Dauris, a subtribe of the former; and to the Amaripas. Of the latter, Miaha, an old woman of seventy or eighty years of age, whom I saw in 1843 in Watu Ticaba, was the last of her tribe. The Atorais and Dauris scarcely number one hundred individuals, of whom only thirty-five or forty are pure Atorais and Dauris. The Tarumas, four hundred strong, inhabit the tributaries of the upper Essequibo. The Woyawais, a race who live in the regions between the sources of the Essequibo and confluence of the Amazon, number about three hundred and fifty.

The Maopityans, Mawackos or Frog Indians, are rapidly approaching extinction. They are now restricted to a single settlement near the river Caphewin. Their whole number amounted in July 1843, to thirty-nine individuals, viz., fourteen men, eleven women, eight boys, and six girls. They were formerly divided into two small settlements, but latterly they have united, and are now living in one great circular hut, eighty-six feet in diameter, and of a proportionate height, isolated from other Indians by thick forests and high mountains, their nearest neighbours being the Woyawais to the south, and the Tarumas of the Essequibo to the west. The Wapisianas call them Maopityan, from "Mao," a frog, and "Pityan," people or tribe, but they call themselves Mawakwa. I have not been able, upon the most minute inquiries, to learn that the flatness of head is the result of artificial means. The average height of the men is five feet six inches, that of the women four feet ten inches. The bows of the Maopityans are longer than those of the Macusis and Wapisianas, being generally from six feet ten inches to seven feet in length. The arrows are pointed with bone, and when required, are poisoned with a preparation made from a plant. It is not strong, nor does it preserve its quality so long as the Macusi Urari. They are a very ingenious people. The combs which they manufacture are really beautiful. The teeth are made of hard palmwood, and fastened into a piece of bone. At the distance of an inch and a half below this bone are fixed two pieces of palmwood, one on each side of the teeth, and the space between the two pieces and the bone is plaited with red and white cotton, which serves for ornament, and gives the teeth a firm fixture.

The Pianoghotto and Drios inhabit the upper Corentyne; but from the uncertainty of the boundaries of British Guiana, I cannot form an estimate of the number which belong to the British territory; therefore, not including the three last tribes, I estimate them at six thousand eight hundred and fifty.

The Indian tribes of Guiana paint their faces and bodies with lines, sometimes straight, sometimes in imitation of the Etruscan or Grecian patterns. A few, and among them the Warraus, Arawaaks, and Macusis, slightly tatoo their faces. The tatooing generally consists of a few curved lines at the corners of the mouth, and over the eyebrows, giving to the faces of the females, among whom it is more customary than the men, a characteristic and not uninteresting expression.

They wear glass beads about their arms, neck, and ankles, and when these cannot be procured, they substitute the teeth of monkeys, peccaris, and divers seeds or shells. The dress of the men is restricted to a piece of cloth covering the loins, and of the women to a small apron formed of glass beads. When they are able to procure a kind of blue cotton cloth, which in the colony is called salempor, they give it the preference to their own manufacture, although inferior in durability. The way in which the cloth is worn, or a difference in its size, in a great measure designates the tribe. The Kirishanas, Œwakus, and some of the Maionkongs, dispense with all clothes, and paint their bodies black and red with pigment.

The form of hut is sometimes characteristic of the tribe; and while the hut of the Warrau, Arawaak, and Carib is a mere shed, that of the Macusi and Wapisiana is frequently built of mud, surmounted by a roof of a pointed form, of almost eastern character. These roofs are neatly thatched with palm-leaves; and whatever may be the form of the house, this substance is generally used. The inner structure is simple, and answers all the purposes for which it is intended. The absence of nails and bolts is replaced by lianas or withes.

The hut of the Wapisiana is dome-shaped, and displays considerable architectural skill. These houses, for the most part, have only a ground floor; I noticed, however, among the Caribs, huts having one story, the communication being effected by a ladder on the outside.

Several families will occupy a single hut, which is in no way partitioned off. In every village there is a house exclusively dedicated to the reception of strangers. It is usually situated in the midst of the community, and is furnished and provisioned by the chieftain and his family. This house is called Tapoi by the Macusis and Wapisianas.

The Œwakus and Kirishanas on the rivers Parima and Orinoco, and the Muras on the Amazon, have no fixed habitations. Like the gipsies, they hold little intercourse with foreigners, wander from place to place, and build a temporary shed. No girdle surrounds their loins, no perizoma hides their nakedness.

Although the same hut may be occupied by more families than one, there is no community of utensils. These, as may be presumed, are very simple, consisting of many sorts of earthenware vessels of different shapes and sizes, resembling in form the Etruscan vases. The women principally fabricate the pottery, and mould with the hand the largest vases, containing from twenty-five to thirty gallons. These are frequently ornamented with Greek and arabesque designs. A few low stools carved out of a solid piece of wood, and resembling the wooden pillows or head stools of the Egyptians, the necessary utensils for the preparation of the cassada bread, and the implements of the chase and of war, form the furniture of the hut. The inmates usually sit on their stools, or rest in their hammocks. Each tribe has its own hunting ground, and each family its own plantations, which, after the trees have been felled by the husband and grown-up sons, are cultivated by the women.

Members of the same tribe frequently form small villages of from six to ten houses; over which communities a chieftain presides, called in the Carib language Yuputorikung, and in the Macusi Toyeputori, whose authority is only acknowledged to its full extent during feuds and wars. His power and influence depend upon his personal superiority in strength and enterprise. The hereditary dignity is derived from the mother; but it is rendered easy for any one who has talent and courage to assume the command on the death of his predecessor, without the advantage of relationship, and his authority is more frequently retained by his undisputed superiority than by any formal election.

It is customary among some nations, before a child is born, for its parents to subject themselves to a rigid fasting. The day after its birth it is carried into the air without a covering on its head, or, as among the Macusis, the head is daubed over with arnotte or rucu. Their heads are generally more covered with hair than those of European children, and they learn to speak and to walk at an earlier period. They are frequently nursed until they are five or six years of age. At the birth of the child the husband receives the congratulations of his friends, and the women of the village are attentive to the wants of the mother, who is restored in a few days to her wonted strength and occupation. Twins are seldom born to them; but I have nowhere found any reason to suppose that one is always destroyed. As a direct contradiction to this assertion, I have seen the Carib and Macusi mother with twins in her arms. The child is named by the piaiman, piatsang, paché, or conjuror, who receives an offering of considerable value, and the strength of the incantations, which he pronounces on that occasion in a dark hut, corresponds with that of the fee. An Indian who has been named is supposed to be less subject to disease and misfortune. The appellations are generally patronymic. The borings of the lips, ears, and septum of the nose, take place at an early age, and are kept open by pieces of wood. The parents are exceedingly affectionate to their children, and, with one or two exceptions, I have never seen them administer personal correction ; they will bear any inconvenience, or even insult, rather than inflict punishment.

The first delight of the boy is a bow and arrow. His little hand grasps the light bow, and with the greatest self-satisfaction and infantine prowess depicted on his face, he tries his skill, and takes small lizards and locusts as his mark. The girl assists her mother in the preparation of bread, of the favourite drink, or, by means of a primitive spindle, of thread from the indigenous cotton, for the manufacture of the hammock. They accompany their mothers to the provision fields, and help to cultivate the ground, and are accustomed at an early age to carry the heavy cassada roots to their homes. These wild children of the forest and savannahs are modest, and, without being tutored by their mothers, are reserved towards strangers.

I have not observed many games among the children, but wrestling is frequently practised, and a kind of tennis, for which purpose they use balls made of indigenous caoutchouc, or the ears of maize or Indian corn. When the boys verge into manhood, they have to subject themselves to severe lacerations on their breasts, made with the teeth of the wild hog, or the beak of the toucan. There are several other ceremonies which appear symbolical of courage, fearlessness, and endurance of pain, such as being put into a bag where there are stinging ants ; and if they endure these without shrieking, they are accepted as the companions of men. When a Warrau girl arrives at womanhood, she is merely deprived of her long hair ; but the young Mauhe, Mundrucu, and Mura women, at the Rio Negro and Amazon, at this interesting period have to undergo a most severe trial. Their hammocks are slung under the roof of the hut, where they are exposed to incessant smoke, besides being subjected to strict fasting. There are many instances where they have paid for the ordeal with their lives. The Arawaaks and Warraus celebrate this period with a feast and dance, at which the young girl appears, ornamented with beads, and the white down of birds, the latter of which, by means of a gummy substance, is fixed to her head, shoulders, and legs.

Marriage is not accompanied by any religious rite. Although it is customary to hold a courtship, the parents not unfrequently arrange matters for their children in their infancy; in which case, the young man is bound to assist the family of his wife till she arrives at womanhood. In the intermediate time, he is very particular in his attention to her, presents her with beads, and brings her the best of what he has been able to procure at the chase. At the time of marriage, he leads her where he pleases, and establishes his own household.

When the marriage takes place, the husband clears a sufficient space of ground for raising provisions. When cleared, it is made over to the care of the woman, who, from that time, has the whole management of it.

The generality of husbands have only one wife, but polygamy is allowed and practised by all those who possess the means. I recollect an Arawaak chief in the river Berbice, who had five, the youngest of whom was a handsome girl of only thirteen years of age. The first generally pretends to superiority in domestic affairs over the rest; but it is frequently necessary for the husband to exercise his authority in order to restore tranquillity in his harem.

On the husband's return from hunting or fishing, his wife prepares his meal, which usually consists of flesh or game; the latter is frequently boiled in the blood of the animal, and well seasoned with capsicums or cayenne pepper. The male part of the family all eat together, and, if the weather permit, before the door, in the open air. Squatted on the ground, the Indian dips his cassada bread into the pot which contains the food, and helps himself with his fingers to that piece of meat for which he has the greatest fancy. Their meals last but a short time, and every one rises as soon as he has done. The females do not eat with the men, but wait till they have finished. It frequently happens, however, that a favourite dish is put aside by them for a period of undisturbed enjoyment.

The hog, cow, and fish of large size, are forbidden food. The Caribs are very particular in this respect. The delicious fish, the Sudis gigas, or pirarucu, one of the largest which swims in fresh water, and which abounds in the Rupununi, and different species of Siluridæ, are considered unclean by the Macusis and Caribs. In their native woods and savannahs, where they are not degenerated through intercourse with Europeans, the meat of the domestic hog is held in horror. I could never induce Irai, a Carib chieftain, who was otherwise a sensible man, to taste the smallest slice of ham. The herds of wild cattle on the savannahs of Rupununi and Rio Branco, are unmolested by the Macusi Indians who inhabit these regions, as the flesh is considered unclean. They, however, eat their native hogs, the peccari and cairuni. The cassada affords their chief sustenance. The root of this plant (Janipha manihot), which, in its natural state, is so poisonous, is, by a simple process, converted into nutritious food. After it has been washed and scraped, it is grated and pressed into an elastic tube, which is called a matappi, and has been made of the plaited stems of a calathea. The tube being filled, its upper end is tied to one of the beams in the hut, so that its opposite end, which possesses a loop hole, remains a few feet from the ground; a long pole is pushed through the loop-hole, the shorter end of which is fixed, while the longer being pressed down, serves as a powerful lever, and the elasticity of the tube presses the grated cassada forcibly together, and the poisonous juice escapes through the interstices of the plaits. The mass, deprived of its juice, is then gradually dried, and, if required, some of the flour, after it has been sifted, is put upon a pan over a fire, and in a few minutes a cake, resembling an oatmeal cake in appearance, is ready. Violent as the poisonous juice of the cassada root proves to be, its narcotic principle is so volatile, that it escapes by being exposed to fire; the Indian forms, therefore, a sauce of the juice, which resembles ketchup or soy.

Yams, bananas, and Indian corn, form the other articles of food which they cultivate in their fields. They are particularly fond of the half-ripe ears of the Indian corn, which they parch; this custom equally prevails in Egypt. In the morning the women rise first, and, after having taken the customary bath, they prepare their husband's breakfast. The Indian eats little at one time, but he eats often; the general hours are sunrise, ten, noon, three, and sunset. The chief meals are breakfast and supper.

The Indians prepare different beverages of divers fruits and Indian corn; but the favourite drink is paiwori, which is prepared from cassada bread. The bread is for that purpose made thicker, and is carbonized on its surface; it is then broken into pieces, and, after boiling water has been poured over it, the women begin to turn it about with their hands, the large lumps being taken out and chewed, and then put into the pot again. This process, they say, increases the fermentation of the decoction, and renders it intoxicating. Cassiri, which is a fermented liquor from the sweet potato or yam, is made in a similar way.

The preparation of this beverage for a drinking feast will occupy the women several days. A large trough, in the form of a canoe, is an indispensable piece of furniture in a chief's hut. Although it may contain from a hundred to a hundred and twenty gallons, I have seen it emptied in the course of the day by forty or fifty individuals.

The scenes incident to a feast of this description do not present much variety. The invitations having been given several days before, the young men of the village from whence the invitation emanated, repair the preceding night to the neighbouring settlements to repeat the summons. The guests assemble the next day, their faces and figures being much painted and decorated with feathers, necklaces of monkey and peccari teeth, and seeds. The dancers arrange themselves round the trough which contains the intoxicating drink, with their bodies bent forwards; the one who follows the leader has a calabash in his right hand, and in the left a maraca or rattle; the others seize upon any object which falls first in their way, the men a war-club, a gun, or a cutlass; the females, a baby, a puppy, or a monkey; and, with eyes bent to the ground, the dance commences, the measure of which is in triple time. It is accompanied by a monotonous song, which is strongly marked by stamping with the foot, or knocking the ground with a hollow cylinder of bamboo, surrounded with the seed vessels of a species of cerbera, which make a rattling noise. The words of the dancers, which are extemporaneous, are frequently repeated. They continue moving round and round, first one way and then the other, or they follow each other in single file. After this measured dance, which is intended to keep away evil spirits, the leader of the column approaches the trough of paiwori, and, taking the calabash from the hand of his neighbour, dips it gravely into the trough, and takes a sip; this is announced by the recommencement of the song, and the rattling of the maraca. The calabash is then presented to the others, who help themselves at pleasure. Several other dances follow, which are monotonous in song and movement.

The paiwori resembles in taste our malt liquor, and when taken in large quantities is intoxicating; it has not, however, the injurious effects of spiritous liquors, but the scenes which accompany such a drinking bout beggar all description. Unpalatable as this beverage must prove to a European, when presented to him as a pledge by his host it is necessary that he should drink it; the contrary would offend the Indian and awaken distrust.

Dancing appears to be a practice which belongs as much to the civilized nations of the world, as to those whom we have termed savages; and all the Indian tribes whom I have had the opportunity of becoming acquainted with, delight in this amusement.

They possess several instruments, chiefly flutes, made upon primitive principles, some of reeds or bamboo, others of the thigh bones of animals. The Warrau Indians have, in large settlements, the band-master or hohohit, whose duty it is to train his pupils to blow upon flutes made of reeds and bamboo, in which a small reed, on the principle of the clarionet, is introduced, and, according to the size of the opening, it causes a higher or deeper sound, and this is in some instances powerfully increased by a hollow bamboo, often five feet long, which is called wauawalli. These rude musicians are taught, according as their band-master makes a sign, to fall in with their instruments, and thus produce an effect similar to the Russian horn-bands. The effect, chiefly at a short distance, resembles strikingly that peculiar music of the Russians, and the favourite melody of the Warraus has something musical in its composition surpassing all others.

The quamah is a hollow flute of bamboo, of peculiar construction, and mostly in use among the Caribs. The Carib sounds it as he approaches his home in token of his arrival; and, as in the silent woods, or among the mountains, it is heard at a considerable distance, preparations for his reception are immediately made. The music is peculiar, and, probably descended for ages, is characteristic of that wildness which has rendered the Carib so formidable. (Plate IV. fig. 1.)

The Macusi Indians amuse themselves for hours, singing a monotonous song, the words of which, Hai-a, hai-a, have no farther signification. I add a copy, in Plate IV. fig. 2, of this musical *morceau*, which is quite "sui generis."

The Indians are not without poetical feeling. Irai, the chieftain of the Caribs, before he was converted, lost his child in 1835 at the Rupununi. I became about this time acquainted with him, and as we sojourned for some weeks at his settlement, I heard him generally singing words in a melancholy strain. I asked him the signification, and he told me he bewailed his child. The words were addressed to the child in the grave :—

"Come, dear child, to me. Come out a little; let us speak together. Why do you not speak to-day? I hear the flute of Donkaba Waehra. It is your uncle's flute which sounds; come out a little before your uncle comes."

The strophe and antistrophe were frequently repeated.

The Arecunas, who live in the neighbourhood of the re-

PLATE IV.

GUIANA NATIVE MUSIC.

Fig. 1.

Carib quamah.

Fig. 2.

MACUSI SONG "HYA, HYA".

markable sandstone mountains, Roraima, always more or less wrapped in clouds, sing, "Of Roraima, the red-rocked, I sing, where with day-break night still prevails."

Generally speaking, the voices of the Indians are mellow, but not strong; and I have heard it repeatedly remarked from such as are able to form a judgment, that the hymns which they heard sung by the converted Indians, at the Protestant mission at Bartika Grove, surpassed in sweetness any congregation they had heard in the civilized part of the colony.

The funeral ceremonies of the Indians of Guiana differ in some respects according to the tribe to which the deceased belonged. If a man of consequence dies among the Warraus, he is put into a canoe in lieu of a coffin, and all which he possessed when alive, such as bows, arrows, clothes, and beads, are buried with him; over his heart they place a looking-glass. They frequently kill the favourite dog of the deceased, and put it with him into the grave. He is buried in the house which he inhabited, and a fire is kept burning on the spot for many nights. His relations assemble to bewail his loss with excessive and outrageous lamentations; and this is renewed at different times, and continues for many months. The widow and children of the Warrau become the property of his brother or next male relation. However, should the widow refuse him, the incensed relations frequently satisfy themselves by subjecting her to a violent whipping, after which she may live with whom she pleases.

If the individual be an influential man the hut is burnt down, sometimes the whole village. The Macusis follow the custom of the Warraus in burying the property of the dead. His dog is buried alive, not only to assist him in hunting in the other world, but likewise to watch over his body. The Atorais are, as far as I am aware, the only nation who put the dead body upon a heap of wood, and burn it.

The ceremonies of the Arawaaks are similar. Upon the demise of a man of some standing, the relations plant a provision field with cassada roots, and bewail him with sudden outbursts of lamentation. After the period of twelve moons, the relations and friends of the deceased are called together, and the cassada which was planted at the time of his death being now ripe, the guests are feasted with paiwori and game. A dance is performed over his grave, and the dancers flog each other with whips prepared for that purpose, which they hang up in the hut of the deceased when the ceremony is over. About six moons later another dance follows, when these whips are buried, and with them the remembrance of the dead, as well as any resentment which may have been felt in consequence of the severe flogging which has been inflicted upon each other.

The Caribs put the body into a hammock, where it is daily washed by the wives or nearest female relatives, and watched, that it be not molested by beasts of prey or insects. After it has become putrid, the bones are cleansed, painted, and put into a pacal or basket, and carefully preserved. If they abandon this settlement, the bones are consumed with fire, and the ashes collected and taken with them. The women who cleanse the bones are considered unclean for several moons.

The Indians undoubtedly possess some religious principle, and believe in the immortality of the soul. They acknowledge the existence of a Superior Being; but say, that the urgent business of keeping the world in order prevents him from paying that attention to man which he would wish, and numerous evil spirits are thus permitted to exercise a pernicious influence, thereby causing sickness and death. With a view to counteract this influence, recourse is had to the sorcerer, piaiman, or piatra, who, by incantations or magical ceremonies, pretends to restore health, or to turn the evil from such of his dupes who pay him well for his supernatural agency. It is therefore evident, that this individual exercises the greatest power over the community, and is regarded with awe and respect.

On the Limits of the Atmosphere, and on Compensation Pendulums. By HENRY MEIKLE, Esq. Communicated by the Author.

1. *On the Limits of the Atmosphere.*—Various attempts have at different times been made to prove that the atmosphere of the earth is not only finite, but of comparatively small extent; and there are some methods of reasoning which have been long regarded as quite conclusive, in assigning limits beyond which the atmosphere could not possibly extend. None of these, however, though they afford considerable probability, can be said completely to demonstrate the thing. But without at all meaning to contend for the indefinite extent of the atmosphere, I shall briefly state some doubts regarding one or two of the most usual modes of assigning its limits.

As to any evidence which the refraction may be supposed to afford, I need only observe that such an idea, in a great measure, assumes the thing to be proved. It assumes that a limit exists, and thence infers where the limit is. For, did the density of the air decrease till at a certain distance, and then become uniform, the refraction could at best point out where the uniform density commences; because the refraction would have nothing to do with the air, which was uniform.

Neither does any proof, derived from the centrifugal force of the rotation of the atmosphere, seem more to the purpose; because it depends entirely on the assumption that the earth and its atmosphere revolve together in one rigid mass in the space of a sidereal day: whereas, there is reason to think that the higher parts of the atmosphere, especially about the equator, revolve more slowly than the lower, or than the earth's surface does. For if, as is generally admitted, the principal motions of the air between the tropics, are from the south-east and north-east towards the equator, where they unite in one current whose particles move both westward and upward, the case will be very different; because the angular motion of such particles round the earth's centre, or compared with the earth's motion of rotation, would continually decrease; and therefore their centrifugal force, instead of increasing with their distance from the earth's centre, must, on account of the westward motion over the earth's surface, decrease something like the centrifugal force of a comet while receding from the sun. Indeed, if it observed the same law in respect of the earth as the centrifugal force of a comet does in respect of the sun, it could never become equal to the attraction of the earth—being at first less, and always decreasing in the same ratio as that attraction does. But, without pretending to assign the precise law of such decrease, or of that of the centrifugal force of a current of air which probably soon spreads again towards the poles in the upper regions, enough of it has just been noticed to set aside any proof of a limit to the atmosphere, deduced either from the refraction or the centrifugal force.

Some plausible arguments of a very different kind were advanced in the Philosophical Transactions for 1822, by the late distinguished Dr Wollaston, to assign a limit; but these it will be unnecessary to discuss here, because they have been completely disposed of by Dr Wilson, in the Transactions of the Royal Society of Edinburgh, vol. xvi., p. 79.

As to any solid shell which the late eminent mathematician, M. Poisson, and others, have imagined to be frozen upon the top of the atmosphere, and which is seriously referred to as a reality, in various publications, it could scarcely fail to be perceptible by its refracting and reflecting the rays of light; if, indeed, the dust which had been collecting on it for thousands of years, would allow any light to reach us. None of the other planets shew the least appearance of being enclosed in any such shell. Nor would it better consist with the free motion of aëroliths and meteorites; some of which are believed to come from very remote regions, and could hardly be expected to treat such tender ware with sufficient delicacy.

2. *On Compensation Pendulums.*—At the Manchester meeting of the British Association, the late lamented Professor Bessel brought forward some speculations regarding pendulums, and called attention to certain circumstances which he

thought had till then been overlooked. As, for instance, the defects of various compensations arising from the different parts of a pendulum not being all at the same temperature, and, in particular, the imperfections of the mercurial pendulum on this account. But whoever will take the trouble of looking into the article *Pendulum* of the Encyclopædia Britannica, will find that such ideas are by no means so new; because I had there pointed out the same things, and they were published more than four years before the illustrious astronomer of Königsberg took up the subject.

There is, however, I suspect, another defect in the mercurial pendulum; and which, so far as I am aware, has not yet been attended to. The performance of that pendulum is always assumed to be exactly the same as if the mercury in it were a perfectly rigid mass. But, since mercury is allowed to be one of the most perfect of fluids, there can be no doubt, that, when the pendulum is in motion, the surface of the mercury, which is of considerable extent, must be in a state of perpetual undulation. The precise amount and effect of this, it will be no easy matter to determine; but there is reason to think that it must tend to retard the pendulum, and to add to the inequality of the times of the greater and less vibrations. One way of nearly obviating it would be to use a less mass of mercury, and put it in a bottle with a narrow neck, the upper surface of the mercury being half way up the neck. But this would not necessarily do anything towards giving the same temperature to the whole pendulum rod, or the mean temperature to the compensation, unless the centre of gravity of the mass of mercury were near the middle of the rod. In that form, however, the mercury could not conveniently serve as the principal mass of the pendulum.

Analysis of the American Mineral Nemalite. By ARTHUR CONNELL, Esq., F.R.S.E., Professor of Chemistry, University of St Andrews. Communicated by the Author.

This mineral bears a striking resemblance to asbestus, so that by the eye it can hardly be distinguished from it. It was first chemically examined by Mr Nuttal, who ascertained that it differs entirely in constitution from asbestus; and concluded from his experiments that it consists essentially of magnesia and water, with a little oxide of iron and lime. It was subsequently examined by Dr Thomson, according to whom, it also contains 12½ per cent. of silica. The constituents the latter found to be :—

Magnesia, . . .	51·721
Silica, ...	12·568
Peroxide of Iron. . .	5·874
Water, ...	29·666
	99·829*

Having lately obtained small specimens of this mineral from the locality of Hoboken, in America, I subjected them to analysis, and obtained a result differing in some respects from both the previous.

The specimens examined by me had the ordinary external characters of nemalite, consisting of adhering fibres of a fine silky lustre, and white colour, with a shade of yellow and partial slight blue or green tinge. Their matrix was serpentine, and in the analysis, any adhering particles of the matrix were carefully removed. According to Mr Nuttal and Dr Thomson, the mineral is soluble in acids, without effervescence, at least in its fresh state. But on very careful examination of what appeared to be perfectly fresh portions of my specimens, there was sensible effervescence on solution in acids, and this was still more manifest when the experiment was performed in a tube, and a lens employed in the observation. It appears to me, therefore, that carbonic acid, although in much smaller quantity than in the native carbonate of magnesia, is a constituent of the mineral, at least of those specimens of it which I have obtained. Of silica I found only a minute proportion, the mineral being soluble in acids, with only an insignificant residue, particularly when the acid is left some time on it. Mr Nuttal states that it is soluble without any residue. The solution, when made in a close tube, shewed protoxide of iron, with red prus-

* Transactions Royal Society, Edinburgh, vol. xi.

siate of potash. By ignition, the mineral assumed a light brownish cast.

As the quantity of mineral in my possession was small, I could only employ small portions in the analysis.

To ascertain the amount of the water, 7·51 grains of the mineral were introduced into a weighed tube of German glass, closed at one end. It was then twice bent, and a quantity of fused chloride of calcium introduced into it, the weight of which was ascertained. The open end was then drawn off, so as to leave a capillary termination, and the closed end strongly ignited, for a quarter of an hour, over a powerful spirit-lamp, with a double draft. The tube was then cut asunder, between the mineral and the collected water, and all the apertures immediately closed with pieces of lute. By the necessary weighings, the loss of weight of the mineral, and the weight of the collected water, were ascertained. The water collected amounted to 27·96 per cent., and the loss of the mineral to 32·62 per cent., the difference being carbonic acid. This would only have given 4·66 per cent. of carbonic acid; but the following experiments shewed that the heat had not been sufficient nor long enough continued to drive off all the carbonic acid.

Five grains of the mineral were treated with diluted muriatic acid in a little bottle having a tube containing chloride of calcium connected with it, to retain moisture. The loss of weight, from escaping carbonic acid, was ten per cent.

2·43 grains of the mineral were ignited during an hour in a small open platinum crucible. The loss of weight was 39·27 per cent. The ignition was continued for a quarter of an hour longer, but no farther loss of weight ensued. This result shews, that the estimate of 27·96 per cent. of water, and ten per cent. of carbonic acid, is not far from the truth. If the carbonic acid were computed as the difference between the quantity of water and the total loss by ignition, it would amount to 11·31 per cent.

To ascertain the proportions of the other constituents, the before-mentioned solution of five grains of the mineral was employed. Ammonia threw down a precipitate which, by solution in acid, left 0·03 of silica, in which was included all that the acid used in dissolving the mineral, had left undissolved. The rest of the ammoniacal precipitate consisted of 0·16 peroxide of iron, and 0·29 of magnesia, which were separated by benzoate of ammonia. The solution which had been precipitated by ammonia was evaporated to dryness, and ignited after excess of sulphuric acid had been added. From the sulphate of magnesia thus obtained, solution in water separated 0·01 more of silica. The sulphate weighed, deducting the silica, 7·6 grains, equivalent to 2·585 of magnesia. In five grains of the mineral, there thus were, of solid constituents,—

Magnesia,	0·308	
	2·585	
		2·893
Protoxide of iron,		0·142
Silica,	0·03	
	0·01	
		0·04
		3·075

And in 100 parts,—

Magnesia,	57·86
Protoxide of iron,	2·84
Silica,	0·80
Water,	27·96
Carbonic acid,	10·00
	99·46

Considering the protoxide of iron as replacing a little magnesia, it appears that the mineral is a combination of hydrate of magnesia with a little hydrated carbonate of magnesia. The formula, $5\,MgO \cdot HO + MgO \cdot CO^2 \cdot HO$, will nearly express its constitution, on that view, giving,

Magnesia,	61·67
Water,	27·24
Carbonic acid,	11·09
	100·00

We have an example of a mineral having an analogous constitution, in the native hydrated carbonate of zinc (zinkblüthe), for which M. Rammelsberg gives the formula, $2\,ZnO \cdot HO + ZnO \cdot CO^2 \cdot HO$.

General Considerations on the Organic Remains, and in particular on the Insects, which have been found in Amber. By Professor F. J. Pictet.

The history of the animals and vegetables which have lived in epochs anterior to our own, presents a connected series of remarkable facts, from which palæontologists endeavour to derive a knowledge of the laws which have regulated the development of life, and the succession of organized beings in the series of geological eras. The greater part of these laws have, as yet, been established merely from the study of a small number of classes; and we may, therefore, entertain some doubts as to their generality, the more so, as each of these divisions exhibits numerous special features in its palæontological history. Animals are better known, in this respect, than vegetables; at the same time, the laws which refer to this kingdom cannot be sufficiently established until all the groups which compose it shall have been better studied in their successive faunas, and more accurately compared. Until then, we run the risk of deducing general rules from special facts, and of transferring to animals in general, results which are true only in reference to a portion of them.

Unfortunately, it is still required that the fossil remains of all the classes should be equally well observed, and that we could dare to expect for all that we should be able to complete their history, which is often long and complicated. While some animals have transmitted to us, as a proof of their existence, solid and well characterized remains, others, on the contrary, softer and more delicate, have passed away, without leaving any traces, because they had no parts sufficiently hard to admit of preservation in a fossil state. The vertebrates by their bones, the mollusca by their shells, and a great number of polypes by their polypiers, furnish to the palæontologist the means of reconstructing, in his own mind, the population of the remote periods, because these hard bodies have been buried in the successive deposits left by the ancient seas. Many other animals, having neither skeleton nor hardened integuments, have certainly lived in these same seas, but their remains have not been preserved in the same formations.

The articulata are not sufficiently solid to have been preserved in all deposits, nor so delicate as to have been always destroyed; accordingly, we find them in a fossil state only in some special localities, where the formations are composed of very fine-grained rocks, rather soft, and which, by decomposing into thin plates, permit us to observe the impressions upon them. These deposits have, in general, been produced by sudden cataclysms, and the beautiful manner in which the organic remains are preserved, is partly owing to the animals having been fossilized immediately after their death. These localities, so valuable for the palæontological study of this class, are too rare not to leave immense blanks in its history. Besides, it too often happens that the most essential characters of the animals are altogether concealed, and that, consequently, we can form only very imperfect notions of the true zoological relations of many species.

Yellow amber, or *Succin* (the *Electrum* of the ancients, *Bernstein* of the Germans), often incloses the remains of insects and vegetables, and the examination of it appears destined to furnish materials of the highest importance, and to complete, in an essential department, the palæontological history of the articulata, the difficulties of which I have just glanced at. The great number of species which have been already found in this substance, the admirable preservation of the greater part of the individual specimens, the transparency of the material, which enables us to see sometimes the most delicate organs almost as well as in living nature, are so many circumstances which impart interest to the study of the fauna and flora of amber. We may, indeed, by a suitable examination, hope to arrive at the knowledge of a numerous population, animal and vegetable, whose natural relations may be fixed with a precision which it is impossible to obtain in regard to the other deposits in which they are found.

It is, at the same time, only a short while since the importance of this study has been fully felt. It was necessary that palæontological systems should have been advanced to the point they have now reached, and that theoretical questions should have been determined as they have been of late years, before we could perceive the advantage that would result to palæontology from a perfect acquaintance with the remains inclosed in amber. We find, it is true, among the old naturalists, some works relating to this substance, and some incomplete attempts to make us acquainted with the organic remains contained in it. But it is M. Berendt who has first attempted to develop this subject fully. After some special works, he has conceived the plan of a great general work, in which all the species should be described in a manner worthy of the actual state of the science. An undertaking of this importance cannot be completed by one man; accordingly, M. Berendt has obtained several individuals to assist him. M. Gœppert has undertaken the botany; M. Koch the crustacea, myriapodes, arachnides, and apterous insects; M. Loew the diptera; M. Germar the hemiptera and orthoptera, &c.; and M. Berendt has connected me with the work, by entrusting to my care the study of the neuropterous insects. The publication has commenced under the auspices of the Queen of Prussia; and there is every reason to expect that in a few years this great project will be completed. We shall lay before our readers some of the principal facts which the successive parts of the work will disclose. I shall, for the present, avail myself of what has already appeared, and of what my own observations have taught me, in order to give a general idea of the nature of amber, its formation, and the principal features of the fauna and flora whose remains are inclosed in it.

Yellow amber, as every one knows, is a transparent or slightly opaque substance, varying from pale yellow to brown, susceptible of becoming charged with electricity by friction, diffusing a resinous odour when burnt, and containing a peculiar acid known by the name of succinic acid. Amber resembles the resin named *copal*, which flows from the trunk of certain leguminous trees of warm countries, and also the resin named *animée*, which comes from the *Vateria Indica* and *Trachylobium Gaertnerianum;* and as these two substances frequently contain insects also, it is of consequence to be able to distinguish them readily, for they belong to the existing epoch. We shall find, in some authors who were unable to make the distinction, catalogues of truly fossil species found in amber, mingled with existing species occurring in these modern resins. M. Berendt, in the first number of his work, has given some details as to the characters which enable us to distinguish true amber. We may consider the presence of succinic acid among the most certain, for it is wanting in the modern resins. The colour, besides, is pretty constant in the latter, while amber presents great varieties in this point of view.

Amber is found in many countries. It is particularly abundant on the shores of the Baltic; but is also found in Sicily, the Indian seas, China, Siberia, North America, Madagascar, &c. M. Berendt's work is more particularly devoted to the study of the amber occurring on the coasts of Prussia. We shall not here enter upon the question, whether amber has been formed in all these countries at the same epoch, and in the same manner? Precise examinations of the composition of this substance, taken from different localities, are necessary for the solution of this question. Certain facts even appear to indicate that amber is sometimes found in formations much anterior to those in which it is usually inclosed.

Prussian amber is gathered more particularly on the shores of the Baltic Sea, when it is cast out by the waves; but it is likewise found by digging into the soil. It is probable that the greater part of the fragments have suffered from attrition, for they are usually rounded, and found in many different stages. If, therefore, it is not collected now, we may afterwards find it buried in the arenaceous deposits at present forming on the shores of the Baltic; and many beds of sand and gravel inclose fragments of it, which have been conveyed thither by similar causes. The presence of amber in these recently formed beds, proves nothing, therefore, against the antiquity of this substance; and it is probably through error that some authors have concluded, from these deposits, that it was of more modern origin than the tertiary epoch. Sometimes amber has been found even mingled with the remains of human industry. Thus Steinbeck says, that a small metal bell was discovered, near Brandenburg, under a bed, containing amber; and instances are mentioned of nails, wire, &c., having been found in veins of amber. All these facts cannot be explained but by admitting, as we have said, that fragments of amber have been, at different periods, displaced by the sea, as happens in the present day, and deposited in formations posterior to the tertiary period. We cannot, therefore, deduce from them any argument for bringing the period when this resin was formed nearer to our own day.

Other more important facts shew that the origin of amber goes back to the tertiary epoch, and that it is to be assigned to a resin which flowed from the trunk of certain trees belonging to that era. The following are the proofs in favour of this view: 1*st*, We find amber in beds of tertiary lignites, in the form of numerous fragments lying between the trunks of amber trees. It is true that this substance has never been found adhering directly to any of the trunks; but the position of the fragments seems to admit of no doubt. 2*d*, The analogy between copal and amber evidently indicates a similar origin. Their consistency, their colour, their nature, and the fact that they both inclose organic remains, prove this resemblance, and concur in shewing that amber, like copal, and many modern resins and gums, has flowed from the trunk and branches of a vegetable. It is probable that the large and irregular masses are the produce of the trunk, that the smaller ones have come from the branches, and that those which have a slaty structure have been formed by a series of layers. The roots probably produced none. The great quantity thrown up by the Baltic Sea, is probably owing to the existence of a considerable bed, situate in the south-west quarter of the present basin of that sea, towards 55° north latitude, whence the winds convey it by diverging to the different points of the coasts of Prussia. This must have been the principal place where Baltic amber was formed, and the site of the forest which produced it. This forest probably flourished on a low island, which marine currents issuing from the north subsequently submerged and destroyed.

The lignites where amber is found belong to the period of the Prussian *molasse*, or the deposits of this epoch are immediately above the saline formation of Galicia, and inferior to the argillaceous schists, to the cerithean limestones and arenaceous deposits which, in this country, compose a series of tertiary stages. The forests, whose trunks have furnished amber, have therefore lived during the earliest ages of this period. It remains, at the same time, doubtful, whether the commencement of the tertiary epoch in Germany corresponds exactly to the time during which the eocene formations of Paris were formed. Ought the fragments of this substance, found in the coarse limestone of Passy, to be regarded as demonstrating that they are contemporaneous? New geological researches can alone teach us this.

The animal and vegetable population of Prussia, during the period when these forests flourished, is probably, then, contemporaneous with the tertiary pachyderms; and the organic remains inclosed in amber ought, consequently, to furnish materials to complete the fauna and flora of this remarkable epoch. While this resin was still viscous and semifluid, it has enveloped as it flowed fragments of vegetables; and insects, rashly lighting upon it, must often have been entrapped. In many of them we notice positions indicating that they have struggled, and vainly tried to escape. After assuming a solid consistency, amber does not appear to have undergone any important chemical modifications. It sometimes contains small empty cells, which have been originally formed by drops of water.

The amber-producing forests were principally composed of Coniferæ, and more especially of numerous species of Pine. The most common of these species, that consequently to which we most probably ascribe the amber, has been named by M. Göeppert *Pinites succinifer*. (I know not why this skilful botanist has not used the name *Pinus*, for the trees whose wood, cones, and leaves, he describes, cannot, according to him, be separated generically from existing pines.) This tree has a great resemblance, in its wood, to the pines and firs of our own countries; but, for the abundant production of resin, we can compare it with none of the coniferæ of the present world but the *Dammara australis* of New Zealand, and, among the other families, the leguminæ that produce copal. Along with these pines we likewise find some trees whose foliage is not that of the coniferæ, and in particular shrubs of the family ericaceæ.

It is impossible, at present, to give a perfectly complete idea of the fauna of amber, because there are still some orders of insects which have not been studied. However, the results I have obtained by the study of the Neuroptera having appeared to be confirmed, in a general manner, by what we know of the other divisions, I shall here indicate the principal points. It is necessary to remark, before entering into these details, that the insects preserved in amber cannot represent the totality of the entomological fauna of this epoch; for many of them, from their very nature, could not be preserved in this manner. Aquatic insects, for example, would rarely come in contact with this resin; accordingly, neither the cases of phryganiæ, nor any larva or insect, whose habitation is exclusively aquatic, has ever been found in amber. It must be remarked, moreover, that large insects, as well as strong ones, and such as have a powerful flight, would most frequently make their escape from the viscous matter which was sufficient to arrest weaker and smaller insects. In these two points of view, then, and probably in others besides, blanks exist, which we must take into account in many comparisons. If we overlook this consideration, we shall erroneously conclude, for example, that the size of amber-insects is less than that of the present race; and, in the comparison of the number of representatives of each family, we may fancy that some of them were very rare, while the real fact may be, that the insects which compose it have been able to make their escape from the resin.

The small number of known species, is still another circumstance which ought to make us cautious in our generalisations. We know about 800 fossil species in amber, a number certainly considerable relatively to that of the species which have been described of late years, but very small, if we compare it with the total number of insects of the present European fauna, and consequently with the probable number of those composing the fauna of which they are the representatives. It is probable that, when their number shall increase, the general results will remain nearly the same, for there is no reason to believe that new discoveries will weaken, in any considerable degree, the consequences that may be drawn from the facts already known.

The first and most important of the results which the study of the fauna of amber has furnished, is a complete confirmation of the law of the specialty of species. No neuropterous insect sufficiently well preserved has presented to me specific characters identical with those of a living species. M. Koch, on his part, has come to precisely the same result with respect to the crustacea, arachnides, and aptera; and what we know of the yet unfinished labours of our associates, leads us to believe that it will be the same in all the orders. This confirmation of a law so important, and so much controverted, is of great interest; for we have had to compare animals of the tertiary epoch with those of the modern epoch, that is to say, beings belonging to two creations, between which, it has been believed, analogues have most frequently been discovered. Our observations, besides, refer to a class which could not hitherto be studied under this point of view. We may likewise affirm that there is some interest in establishing these complete differences between the aërial animals of the two faunas. With respect to aquatic animals, these differences have often, in fact, been attributed (erroneously, in my opinion) to simple organic modifications, produced by changes in the nature of the waters. It is difficult to extend this meaning regarding the subject to aërial animals, and to suppose that the modifications of the atmosphere could be so sensible as to exercise a very powerful action. It is necessary, besides, to remark, that, in what relates to the discussion of this law regarding the specialty of fossils, the mode in which the organic remains are preserved is of great importance. The insects of amber are known to us by the whole of their body, and, as I have said above, their essential organs may often be observed with great precision; we may, therefore, place certain confidence in the results furnished by the study of them. The molluscs, on the contrary, are preserved only by the shell, that is to say, by an accessory part of their organism, and their vital organs are known to us only by a more or less questionable analogy with the existing world. Now, it is principally from the molluscs that those who believe in the preservation of species in many successive epochs, derive their arguments. Is it not reasonable to attach more importance to results furnished by animals most completely preserved, and consequently to consider the insects in amber as furnishing a strong proof in favour of the law of specialty of fossils?

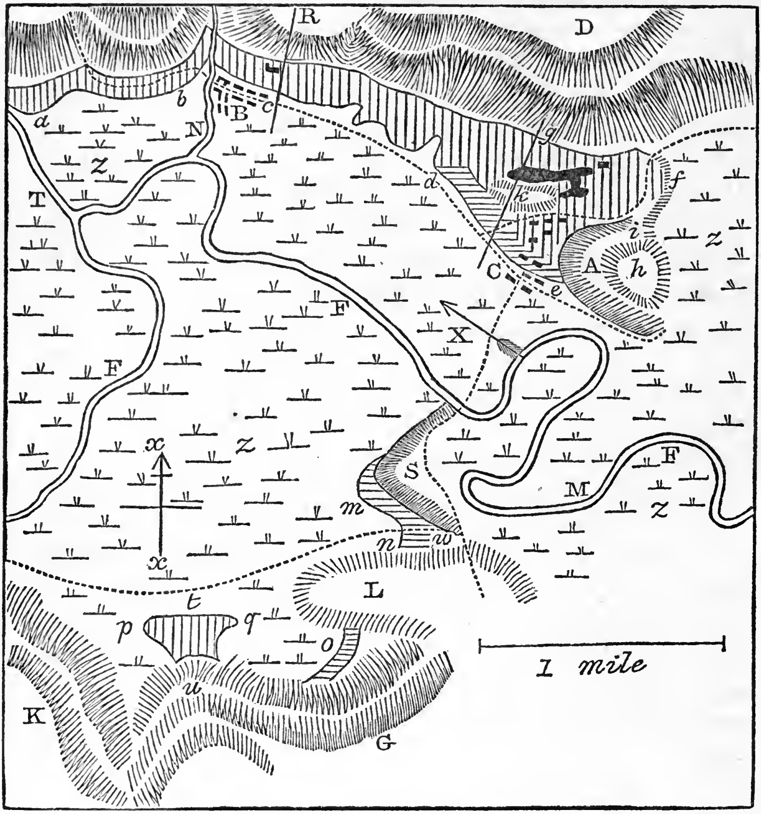
But if the species of amber are all different from those now existing, it is not necessary to conclude that the fauna of these two epochs present very great differences in their general physiognomy. A great number of the insects of amber belong to genera now living. For some of them, it has been necessary to establish new genera, and the number of such as could not be classified in existing families is very limited. The investigations undertaken for Mr Berendt's great work have hitherto detected, in the insects of this fauna, only two types which are sufficiently distinct from living insects to require the formation of new families. These are, 1*st*, The family of *Archœides* in the class of Arachnides, which has been established by M. Koch, and which is characterised by a head united to a spherical thorax, by four lozenge-shaped eyes placed on each side, by mandibles longer than the head, prolonged like teeth, and forming long pincers. *2dly*, The family of *Pseudo-perlides*, which I have been called upon to establish for very remarkable insects, which had at first been considered by M. Berendt as the larva of Nemoura, and which have some relation in their forms with this genus, and the wings wanting, or rudimentary; but the number of joints in the tarsi, the form of the antennæ and that of the abdominal appendages, approach nearer to the order Orthoptera, and in particular to the family of the Phasmides. The Pseudo-perlides are probably, therefore, a family which forms a kind of transition between the Orthoptera and Neuroptera. Some doubts remain as to the question, whether the specimens we possess are the larvæ and nymphs, or whether they are perfect insects with rudimentary wings, as often happens among the Orthoptera.

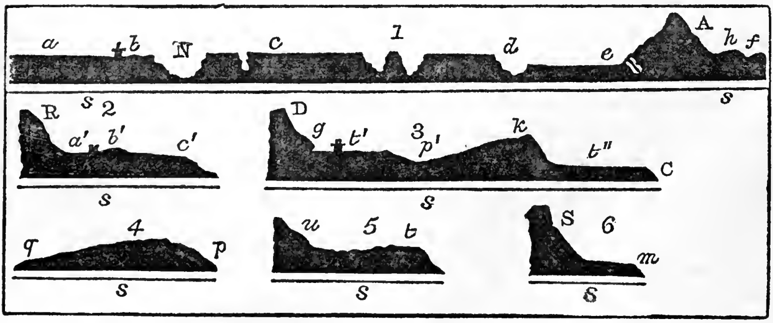
The new genera are a little more numerous. I have, however, found only three among the Neuroptera; but some of my fellow-labourers have distinguished a greater number, and, on consulting the parts of the general catalogue already drawn up, we shall find that the number of genera special to the fauna of amber, represents nearly one-fifth of the entire number. Besides these new genera, there are some which are found in the presently existing fauna, but which contain species strangers to Prussia, and even to Europe. Thus, among the Neuroptera, I have mentioned a *Chauloides*, a genus at present confined to North America, an *Embia*, whose congeners now live in warm zones, &c. One of the most remarkable genera in this point of view is that of Termes, which are very abundant in amber, both in species and individuals. By supposing that the specimens we have it in our power to examine are in the same proportion as the insects were themselves when alive, we shall find that this genus has furnished 0·17 of the population of the Neuroptera of amber! At present we are acquainted with none of them in Europe, save some small southern species, which maritime commerce has naturalized a little farther to the north than their native country: the size of the fossil species greatly exceeds that of the latter, and it is only in the Termes of the warmest quarters of the globe that we now find their analogues in this point of view.

If we attempt, by means of these facts, still in a very incomplete state, to draw some conclusions respecting the climate of Europe during the epoch when amber was formed, we can advance only very hypothetical conjectures. The great number of Termes, and the presence of some species belonging to the warm zones of the globe, would seem to indicate that the temperature has been higher than it now is, and that the north of Prussia must have been placed in conditions intermediate between those which now characterise it and those of the basin of the Mediterranean. I ought, at the same time, to observe that considerations of this nature have an element of uncertainty evidently attached to them. In fact, we compare lost species with species which are not identical with them, and we conclude, in general, that such as resemble each other must have lived in similar climates, which is far from being constantly demonstrated. But, while we acknowledge that we must not assign too much importance to these comparisons, we are of opinion that it would be passing the limits of a judicious caution to refuse altogether to take them into account, the more so since the results they furnish agree with what the study of other classes of animals establishes.

The Articulata appears, moreover, to be the only division of the animal kingdom of which amber has preserved sufficiently numerous remains to throw some light on their history. With regard to the Mammifera, nothing else has been found in amber connected with them than tufts of hair, one of which, examined by a microscope, appears to have belonged to a bat. The feather of a bird has likewise been found. Among the Mollusca nothing further is mentioned than a few small shells imperfectly preserved.—(*Bibliotheque Universelle.*)

Remarks on Ancient Beaches near Stirling. By Charles Maclaren, Esq., F.R.S.E. Communicated by the Author.*





* This paper was read before the Royal Society of Edinburgh in December 1844, but has since received various corrections and additions.

Explanation of Map.

z, z, z, z. The Carse, an alluvial plain, composed of stratified sand, clay, and gravel, whose surface has the aspect of a dead level. Its general elevation above the high water line at Cambuskenneth Abbey, M, may be about 25 feet, but considerably less at a few places, where the rivers overflow their banks, or have changed their beds. At the head of the Carse, fifteen miles westward, it is nearly 40 feet.

F, F, F. The river Forth.

T. The river Teith, the largest tributary of the Forth.

N. The river Allan, a considerable stream.

A. Abbey Crag, an isolated hill, capped with greenstone, whose summit is about 350 feet above the sea.

B. The village of Bridge of Allan.

C. The village of Causeyhead.

S. The hill on which Stirling stands, capped with greenstone, the summit of which is about 350 feet above the sea.

R. Airthrey hill, whose summit is 500 feet above the sea.

D. A higher hill, which forms the western prolongation of Demyat.

L, G, K. Hills bounding the plain on the south. The first is low, the other two are elevated.

The dotted lines represent the two principal roads on the south and north sides of the Carse.

The terraces are distinguished on the map by parallel shading lines, the higher by vertical lines, the lower by horizontal.

The black figures below are sections of the terraces, with portions of the contiguous hills. In these sections the line *s s* represents the level of the sea at Cambuskenneth Abbey (M, in the map); the white space above it, the elevation of the surface of the Carse above that level; and the depth of the black horizontal bands represents the elevation of the terraces above the Carse. For the sake of distinctness, this depth has been made three times greater than it ought to be in proportion to the length. In section 3, the length or horizontal extent has been exaggerated for a similar reason.

x, *x*. A figure shewing the cardinal points.

About a mile northward from Stirling is the isolated rock of Abbey Crag, which presents a steep acclivity on its western side, covered with debris. From the foot of this acclivity a terrace of considerable height extends westward to the river Allan, and beyond it, forming the northern boundary of the Carse. This terrace seems to me to present very distinctly the characters of an ancient sea-beach, or rather of two ancient beaches, a higher and a lower; and there are remnants of corresponding beaches at other parts of the Carse.

The position of the terraces will be understood from the map prefixed, which represents a small portion of the Carse or plain of Stirling, with the hills bounding it on the south and north.

The village called the Bridge of Allan, B, now much resorted to for the Airthrey mineral waters, lies at the foot of the terrace, the south side of which is very steep, and covered with growing wood. Footpaths are cut in various directions on the acclivity. In passing along these we discover sand or gravel at every step, and where a foot or two of the sand happens to be exposed, we observe traces of stratification. On ascending to the top of the acclivity, we do not see what is usually seen on the flanks of mountains, a series of knolls or rounded undulations, rising towards the chain. On the contrary, we find ourselves on a plateau or terrace (*a*, *b*, *c*, *d*, *f*, section 1, and map), with a surface remarkably uniform and level, and terminating abruptly at the foot of the steep hills R, D, which tower over the Carse here to a height varying from 500 to 800 feet. Looking eastward, we see several hollows running across the terrace, cut by the action of small streams or other agents, but the eye easily discovers that the separate portions of the terrace rise to the same apparent level. Looking westward, we see a great breach (N in section 1) made across it by the river Allan, but beyond the river, at the distance of a quarter of a mile, the terrace reappears, *a*, *b*, and as nearly as the eye, assisted by a pocket-level, can judge, at precisely the same elevation.

The well-marked part of the terrace ends on the west at Lecropt Church near *b*; on the east, at Lord Abercromby's east gate near *f*, and at the foot of Abbey Crag *e*, where the village of Causeyhead is built on it. The distance between these points is two miles. Beds of sandstone rising from beneath Abbey Crag, and dipping eastward at a high angle (*e* in section 1), are seen in the village; they are seen again in the bed of the river Allan (N, section 1), two or three yards below the level of the Carse, and again at the level of the Carse near Lecropt Church *b*. Except at these points, and in the hill above, rock is nowhere visible.

The terrace reappears nearly a mile west from Lecropt Church at *a*, but in a different form; for here it rests on 30 or 40 feet of rock. Above the rock there is a deposit of sand and gravel to the depth of perhaps 30 or 40 feet, and the surface exactly resembles that of the eastern part of the terrace. There are distinct terraces also within the grounds of Blair-Drummond. I was able to distinguish three, with pretty well marked cliffs behind them; but I cannot speak positively as to their height.

I measured the height of the terrace at Lecropt Church, and at the mineral well, by means of a pocket-level, fitted with a reflector; and at both places I found it to be about 92 feet above the Carse. If we add 25 feet for the elevation of the Carse above the surface of the Forth at Stirling, the height of the terrace above the water will be 115 feet. But there is a slight swell to be afterwards noticed, for which 15 feet must be added, raising the entire height to 132 feet. My measurements, however, being roughly executed, and with no pretension to minute accuracy, I prefer giving them in fathoms, and shall call this the "22 fathom terrace."

The internal structure of the terrace is shewn at several places, and bears unequivocally the character of a deposit from water. In a quarry near Lecropt Church, the materials are seen to be sand and gravel rudely deposited in strata. At the River Allan sandstone is seen under the bridge, in the water-course, above which all is gravel and clay to the top; but the gravel is coarse, such as a river subject to floods brings down, and in which stratification is often not apparent. A furlong east from this there is a quarry on the summit, about 5 or 6 yards deep, where three or four beds of gravel alternate with as many of sand, all pretty correctly horizontal. The sand and fine gravel shew stratification; the coarse gravel does not. Half a mile eastward there is a small opening in the wood only four or five yards above the Carse level, where again we find sand and gravel in layers, and there are other openings presenting similar appearances. At the cut made for the railway under the road at Bridge of Allan, the bottom of the terrace was found to consist of the blue boulder clay, inclosing a few rolled and *striated* boulders from 2 to 3 feet in diameter. This clay, which rose to at least 30 feet above the Carse, and was covered with sand, probably forms the lowest stratum of the terrace along a considerable part of its extent, and by its compactness and tenacity may have contributed essentially to its preservation.

The breadth of the terrace at Lecropt Church may be about 200 feet. At the mineral well, I found it to be about 900 feet, and towards the east end, within Lord Abercromby's grounds, it must be nearly half a mile.

That the terrace does not owe its elevation to a nucleus of rock is evident; for, from Lecropt Church to Causeyhead, a distance of 2 miles, though various breaches and openings, 50 or 60 feet deep, exist in it, no vestige of rock *in situ* is visible, except at the bridge over the Allan, where the sandstone is seen many feet under the level of the Carse.

Like our present beaches, the terrace, though nearly level, is not rigidly so at every point. In the cross section at the mineral well (section 2), the lowest part of the surface is that at a' next the hill. Beyond this is a slight swell (b') rising 15 or 20 above a', and melting gradually into the outer portion, which scarcely deviates from a dead level. This outer portion terminates in an escarpment at c', precisely such as we find in a bank of earth, exposed to the action of a river or the tide. When the sea which deposited this terrace, had sunk to a lower level, and merely washed its foot, the tides had eaten away, in the course of ages, all that portion which was towards the centre of the valley, leaving this remnant as a witness of the higher level at which the water once stood.

It is scarcely necessary to say that, in speaking of *the sea rising so many feet or yards above its present level, or subsiding so many feet or yards below it*, the expression is put in this form merely to avoid circumlocution. In common with nearly all living geologists, I hold that the change of level is solely in the land—that the subsidence of the sea is merely apparent, and is the effect of a real rise in the land; and *vice versa*, that an apparent rise of the sea is the effect of a subsidence of the land.

An elevation like *b′* is seen at several parts of the terrace, near the foot of the steep acclivity R, but not everywhere. It may be a storm beach, or bank of shingle thrown up in a storm; or it may have been produced in some cases by torrents from the hill R, sweeping away the portion of sand and gravel nearest the strand. It is enough that such banks are found within the high water mark on the shores of the present sea.

The evidence furnished by these details, to shew that the terrace was an ancient beach, may be thus summed up: 1. It is composed of such water-worn materials as compose our present beaches. 2. These materials are arranged as we find them in our present beaches; that is, they are disposed in beds or layers, approximating to a horizontal position. 3. The upper surface of the unbroken parts of the terrace, approximates to a dead level, as in our present beaches. 4. Like these beaches, it meets the hill behind it abruptly; and it is, as nearly as the eye can judge, parallel to the surface of the Carse, which we know to have once formed the bottom of the sea.

Now water is the only agent which could have arranged the materials of the terrace, and levelled its surface, as we find them; and the water must either have been that of the sea or a lake. But the oyster, cockle, and mussel shells found in the Carse westward from Stirling, assure us that the sea once covered it; and with this evidence before us, it would be unphilosophical to explain the facts by assuming the existence of a lake.

The Airthrey whale, found in the Carse near Blair Logie, 22 feet above the present high-water level, shews that the sea once stood much higher than it now does. In the New Statistical Account of the parish of Drymen, we are told that the surface of the Carse there is nearly 40 feet above the sea. The fact is probably known from Mr Smeaton's survey; and, assuming it to be correct, the tides which covered the carse must have flowed to that height at least. Again, we have a bed of oyster-shells at the mouth of the river Avon in Linlithgowshire about 37 feet above the present strand; and as the oyster inhabits deep water, we must add 20 feet for the tide. We are thus furnished with evidence, that in a part of the Frith about 15 miles from Stirling, the sea stood at one time 57 feet *at least* above its present level. It may have been twice as much, for the oyster is known to live sometimes at the depth of one hundred feet.

If sea-shells had been found in it, the evidence of the terrace being an ancient beach would have been complete. But shells, though not observed hitherto, may yet be discovered in it; and even, if none should be found, it does not follow that they never existed. Shells, as organic substances, are liable to decomposition when exposed to the elements. Mr Darwin informs us, in his Memoir on Glenroy, that he had found shells on the coast of Peru, in a gradually increasing state of decay as he ascended from the beach, till at a certain height a mere layer of calcareous powder, without a vestige of structure, alone remained. The higher parts of the shore having been first raised above the water, the shells deposited on them had suffered most from being longest exposed to meteoric action. He farther states, on the authority of Mr Lyell, that on the coast of Forfarshire sea-shells are found in gravel-beds up to the height of 50 or 60 feet, but are wanting in similar beds which exist at greater elevations. In Norway, again, where deposits of shingle and sand exist up to the height of 600 feet, shells are found only in those which are 200 feet or less above the sea.* We can thus understand how the Airthrey terrace, though a marine deposit, may be destitute of shells, while they abound in the Carse, at a lower level by 100 feet. Much, however, may depend on the nature of the envelope. Those embedded in a clay impervious to water may remain entire for a vast length of time, while those buried in sand or gravel will decay rapidly. Fuller information as to the levels at which marine remains exist in Britain, may be found in Mr Murchison's address to the Geological Society for 1843.

The preservation of this remnant of the ancient beach or sea-bottom, while the southern portion of it has been swept away, admits of a satisfactory explanation. The sea may have subsided either by sudden starts, as on the coast of Peru in 1821; or gradually and insensibly, as on the east coast of Sweden; or gradually, but with pauses at certain intervals, as on the coast of Lapland.† Let us suppose the change to have been sudden. At each subsidence, the water would retire from the sides of the valley towards the middle; and after it had fallen through a certain space, say 10 or 20 feet or yards, and come to a state of rest, the tide, in advancing and receding, would attack those parts of the ancient bottom which were above the low-water line. An opening once made, a sea-cliff would be formed at the strand; yard after yard of the cliff would be undermined and swept away; and if the sea remained long enough at the same level, and its erosive action was not stopped or turned aside by some firm resisting body, the whole of the ancient beach would disappear, leaving no trace of its existence.

Such a resisting body we have in Abbey Crag, (A in the map and section 1) which is 350 feet in height, and two-thirds of a mile in breadth. When the sea was many fathoms above its present level, the tide setting through the channel scarcely one mile in breadth between Stirling Rock (S) and Abbey Crag (A), would act with great force in *a north-west and south-east direction*, and rapidly cut away the portion of the ancient beach in front of it, but the portion behind

* Darwin's Memoir on Glenroy. Phil. Trans., 1839. Part i., p. 63.

† Rapport sur un Memoire de M. A. Bravais. *Comptes Rendus*, Sceançe, 31st Oct. 1842.

Abbey Crag, or northward of a line passing from C to B, would be protected by that rock, which would act as a breakwater, and turn aside the current. The course of that current would correspond with the line of the valley of the Forth for ten or twelve miles below Stirling, which is S. 55 E. or SE. by E., and NW. by W. Its principal action would be in the direction indicated by the arrow X. Of course the portions of the terrace northward of a line passing from C to B would be in a great measure screened from its assaults. The portions *a b* more directly in front of the tide, have not been swept away; and the reason is, that they have a basis of rock rising many yards above the Carse.

A current would be maintained through the opening at *f* north of Abbey Crag; but from its course in reference to that hill (A), and the declivity of the hill D, which is very steep, its action would be comparatively feeble. Accordingly, though the terrace exists here, its height is a third or a fourth lower than the average, and a hollow has been scooped out in it in an east and west direction, part of which forms the ornamental pond lying southward from *g*, and indicated by a black space in the map. I have spoken only of the current of the flowing-tide; but of course it will be understood that the ebbing-tide would run in the same channels, and act in the same way, though with less energy. There are two rounded masses *h*, *i*, on the east side of Abbey Crag, apparently of clay or gravel, which the shelter of the hill had also saved from destruction.

Besides the hollow containing the pond, there are two deviations from the usual form of the terrace here, which demand attention. The one is a small specimen of a *lower terrace*, extending from *d* to *e* in the map, and from 30 to 40 feet above the Carse. This terrace (which is distinguished by horizontal shading lines) commences at Lord Abercromby's south gate, is about a furlong in breadth, and somewhat more in length, and terminates at the village of Causeyhead, C. It is level and regular in its surface (t'' section 3) and has a well marked *sea cliff* behind it at *k* as sharply cut as if it had only recently escaped from the action of the tides. The outer margin of the terrace close to the road is about 30 feet above the Carse, the inner margin at the foot of the cliff *k*, is 10 or 12 feet higher, that is about 67 feet above the sea. As the tide which formed it must have reached to this inner margin, it may be described as the "11 fathom terrace."

Every part of the cliff *k* which I examined was of gravel or sand, and I was informed by one of Lord Abercromby's labourers, that the whole was of the same materials. It rises with a steep and sharp acclivity facing the south, to the height of 90 feet above the lower terrace, 30 above the higher, and 155 above the high-water level at Cambuskenneth, according to my rough measurements. From its summit it slopes very gently northward till it reaches the pond. The form of the surface will be understood from section 3, where D is the steep flank of Demyat; t' the higher terrace on which Airthrey

Castle stands; *p'* the hollow containing the pond; *k* the top of the cliff forming a sort of ridge; and *t''* the lower terrace at its foot. The ridge *k* is interesting, as an indication of the state of the surface before the upper or "22 fathom terrace" was formed. We may regard it as a remnant of a still higher terrace, or an ancient shoal, formed when the sea stood 155 feet or more above its present level, and saved from subsequent destruction by the bulwark of Abbey Crag, which stands precisely in a position to screen it from the action of a tide setting NW. by W.

Beaches are merely the outer portions of the sea's bottom; and I inferred that if the 22 and the 11 fathom terraces were remnants of ancient beaches, something similar should be found at the opposite side of the Carse. The inference proved correct.

Behind Whitehouse Farm, about a mile SW. from Stirling, (at *t* in the map) there is a hill about a third of a mile in length, and from 70 to 80 feet in height, above the Carse, from which it rises like an island. It is connected with the hills behind it by a sort of isthmus, while the Carse surrounds it on three sides. So far as I could judge from walking over a considerable part of it, the whole consists of alluvial matter. But there were no openings in it from which I could discover whether the matter was stratified. The north side *t*, which looks to the middle of the Carse, presents an abrupt and steep acclivity, precisely like that of the terrace at the Bridge of Allan. Here, again, we are able to account for the preservation of this fragment of the ancient sea bottom, while the rest was swept away; for it will be observed, that it exists in a sheltered recess, surrounded on three sides by a high barrier of hills, K, G, L. Rivulets descending from the hills, pass near its flanks *p* and *q*, and may account for the disappearance of the other portions of it, which no doubt once occupied the low ground on its east and west sides. Section 4 represents the form of this hillock, as seen from the north. Section 5 shews its form transversely; *u* the hill behind it, *t* its north front looking to the Carse.

As Abbey Crag had protected one portion of the ancient sea-bottom from destruction, it might be inferred that Stirling Rock would protect another, Now this is actually the case. A little terrace, flat in the top, (*m*, *n*, in the map), about 200 feet in breadth, and 30 or 35 in height above the Carse, encircles the south-west foot of the rock under Stirling Castle. It commences at the village of Raploch; there is an artificial breach where the road passes through it; it terminates at a long flat hill of trap, L, and at this end has a farm-house on its summit. Here the terrace is 40 or 45 feet high, and it has a sharply cut declivity of alluvial matter facing the Carse. Section 6 shews its form near Raploch; S the steep declivity under the Castle, *m* the terrace. We can explain also why so small a portion of the ancient bottom was preserved here. On the south side of Stirling Rock (at *w* in the map), the ground is probably not more than 40 feet above the Carse, and the tides would play freely through the hollow here, as well as through the great channel between S and A, long after the passage at *f*, by the north side of Abbey Crag, was closed.

There is another small elevation at *o*, one mile south-west of Stirling behind the hill L, which looks like a terrace, but is ill defined and equivocal.

In speculating on the changes which the alluvial deposits have undergone from the action of the sea, at the different levels alluded to, it may be proper to advert to the state of things which preceded those changes. When the Forth and Clyde canal was projected, Smeaton carried a survey over the low grounds east of Loch Lomond, which separate the Carse from the basin of the Clyde. He found the summit-level at the Bog of Bollat, in the parish of Drymen, to be 222 feet above high water in the Clyde. When the sea therefore stood at a higher level than this—say 250 feet—two long narrow sounds (like the Sound of Mull) would extend across Scotland, uniting the Friths of Forth and Clyde, one by the line of Kelvin Water or the present canal (whose summit-level is 147 feet above the sea), the other along the valleys of the Rivers Endrick and Forth; the Campsie and Gargunnock hills forming an island between them. Our concern at present is only with the northern sound. While the sea had a free passage here, strong currents like those of the Pentland Frith, would set through it, and not only prevent any new deposit of matter, but sweep away much of the old alluvium. When the sea subsided below the level of the Pass of Bollat, the currents would cease, and the destruction of the ancient deposits would be arrested. The mud, sand, and gravel, poured in by the Forth, the Teith, the Allan, and other streams, would no longer be swept away, but distributed by the alternate motions of the tide, first along the shore, and ultimately over the bottom of the valley, replacing those portions of the older alluvium which had been carried off. Even when the currents held their free course across this part of Scotland, portions of the older alluvium would escape their action, and remnants of terraces formed of it, no doubt exist; but, if my argument is good, continuous well-marked terraces should not be looked for in the district alluded to, at an elevation much exceeding that of the Pass, which is 222 feet. To such causes I think the extreme rarity of ancient marine terraces, except at low elevations and in sheltered localities, may be ascribed. With regard to the ridge *k* in section 3, therefore, neither its height (155 feet), nor the absence of terraced deposits at corresponding elevations elsewhere, form any valid objection to its being considered as part of the bottom of the ancient sea. From its shape, and its evident truncation on the south side, I infer that it was once many feet higher, and that it probably formed a shoal behind the barrier of Abbey Crag. We find a similar shoal in the present Frith on both sides of Inch Colm, where the water deepens suddenly from 3 fathoms to 15.—

(See Thomas' Survey). Taking its height as its stands, I shall call it the "26 fathom terrace." Portions of others, still higher, probably exist. The village of Doune, for instance, stands upon a terrace, the elevation of which above the sea I estimated at 180 feet.

In the part of the valley of the Forth below Grangemouth, the action of currents would be greater and longer continued, the Pass by the Kelvin being 75 feet lower than by the Endrick. Terraces so distinct and continuous as the 22 fathom terrace, and at such an elevation, should not consequently be looked for there. Four successive terraces may indeed be traced on the ground extending from Corstorphine Hill to North Leith, at various elevations up to more than 100 feet above the sea; but the higher ones, instead of being level, have a considerable inclination to the east, and are, in other respects, not so well marked as that in section 1. Besides, the straight longitudinal furrows, two or three furlongs broad, on the surface of the higher ones, seem to indicate that the alluvium of which they are composed, had undergone a process of denudation, which materially altered its external form.

Returning from this digression to the terraces above Stirling, I have shewn that indications exist there of the sea having occupied successively four distinct levels, exclusive of the present one.

First, The bottom of the sea was so much below its present level, that its waters deposited the sand and gravel seen in the ridge *k*, in section 3, which I have termed "the 26 fathom terrace."

Second, The bed or bottom of the sea rose 30 or 40 feet, laying dry much of its ancient shores. The "22 fathom terrace" (*a b*, &c., in section 1, *t* in section 5, and *t'* in section 3), is a portion of its beach when it stood at this level, and it had remained here long enough to eat away nearly the whole of the older terrace or shoal *k*.

Third, The bed of the sea again rose 50 or 60 feet, when the "11 fathom terraces" (*e*, in section 1, *t''* in section 3, and *m* in section 6) were formed, and were then portions of its beach (See also *d e*, *m n*, and *o*, in the map). It remained long enough at this level to eat away all the "22 fathom terrace," except the fragment *a b c d f* on the north side of the valley, and the fragment *p q* on the south side (See the Map).

Fourth, The bed of the sea again rose 35 or 40 feet, and the water, of course, retreated into a narrower channel as before. It now merely covered the Carse, the margin of which constituted its beach, and it remained long enough here to eat away all the older beach of the "11 fathom terrace," except the portions *d e* and *m n* and *o*, in the map. Agreeably to the terminology adopted, the Carse might be called the "7 fathom terrace."

Fifth, The bottom of the sea rose 40 feet, the waters again retreated, laid the Carse dry, and settled at their present level; and the tides, as before, are renewing their depredations on the land which they formerly covered.

It must not be assumed that the surface of the Carse, when last under the sea, was as level as it now appears. The action of the streams in meandering through it for some thousands of years, and the growth of peat afterwards filling up the hollows, would contribute to equalize the surface, which, after all, is not so level as it seems.

The deepest part of the present Frith is at Queensferry, where the erosive action of the tide has been greatly increased by the contraction of the channel to a narrow gorge 1 mile in breadth. When the sea covered the Carse to the depth of 60 or 100 feet, the space between Abbey Crag and Stirling would form a gorge similar to the Ferry, and we would expect to find it equally profound. Accordingly Mr Bald informs us, that though a bore of 30 feet generally reaches the rocky bottom eastward from Abbey Crag, no bore has ever reached the bottom between Abbey Crag and Stirling. (Statistical Account of Logie Parish).

There is a terrace on the east side of the road from St Ninians to Stirling, which is probably a remnant of the "22 fathom beach;" and between Grangemouth and Falkirk there is a succession of terraces, the highest of which, I think, has nearly the same elevation.

The western part of Demyat presents many abraded surfaces of rock. They are well seen on the cart-road that passes up by Logie Church. At one spot on the road, the height of which I estimated at 500 feet, I found very distinct striæ, whose direction was WNW., and ESE., which is very nearly the bearing of the valley of the Forth from Stirling to Grangemouth.

On the Great Thunder-storms and Extraordinary Agitations of the Sea, on 5th July, and 1st August 1846. By Richard Edmonds Junr., Esq. (Read at the Penzance Natural History Society, on 11th August 1846.)

The extraordinary agitation of the sea in different parts of Mount's Bay at the commencement of the great thunder-storm which passed over Britain on the 5th ult., was noticed at the last meeting of this Society.*

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* The following is the description given of it by Mr Edmonds:—" The precise time when the oscillation of the 5th of July commenced I cannot learn, but it was observed at Marazion as early as half-past four in the morning, immediately after a terrific thunder-storm, the tide being about four hours ebb. One of the persons who witnessed the extraordinary motion and agitated state of the water said, 'the sea seemed as if it had been struck by the lightning.' It was observed at Penzance and Newlyn between six and seven A.M., when the attention of a fisherman, in the latter place, was arrested by seeing the bows of the boats, moored near the shore, not as usual facing the wind (then about N.) but turned against a current which was moving alternately N. and S. Boats

I have now to notice a similar phenomenon observed at Penzance Pier early in the morning of the 1st instant, when a still more dreadful thunder-storm visited the metropolis and other parts of England.

I would previously, however, make a few remarks on the storm of July. It must have been felt on the Atlantic on the 4th, as much distant lightning from the S. and SW. was seen in Mount's Bay before midnight, and continued until between 3 and 4 o'clock of the following morning, when the fierce lightning and thunder from every part of the heavens became truly alarming. As the storm proceeded from Mount's Bay, throughout Cornwall, towards the E. and NE., it grew still more violent and destructive. It reached Exeter between 8 and 9 A.M.; Windsor, between 2 and 3 P.M.; and London at half-past three.* In its progress towards the north it was felt throughout Somersetshire between 8 and 10 A.M.; at Leeds about 3¼ P.M.; at Penrith, Dumfries, Ayr, and Glasgow, between 3½ and 4 P.M.; at Edinburgh soon after 5; and at Dundee, and in Argyleshire, about 7 P.M. Thus the storm, as it advanced from Mount's Bay towards the east, moved at the rate of only about 20 miles per hour, whilst its progress northward was about 30.

In many places both the lightning and the thunder were incessant during most of the storm. A whirling, fitful, or "wild kind of wind," accompanied it, with heavy rain, and occasionally large hailstones. At Ayr and Maybole it was preceded by a whirlwind of remarkable violence. At Walsall a whirlwind tore up trees by the roots.

The temperature on the 5th of July was unusually high, not only in most parts of England, but on the Continent. The thermometer at Cheswick was 95°; at Boston, in Lincolnshire, 90° (the hottest day since 31st July 1826); at Manchester 87°; and at Paris 97¼°.

Before the storm commenced in Kent, one of the largest flights of butterflies ever seen in this country completed its passage from France to England. For many hundred yards it quite obscured the sun. "During the passage the weather was calm and sunny, but an hour or so after they reached *terra firma,* it came on to blow great guns from SW., the direction whence the insects came."

The storm of July was not felt in London and the eastern coasts of Britain, so severely as on the western. But the storm of 1st August, which visited the metropolis and its neighbourhood, was more terrible than any experienced there since that of the 18th of May 1809. It commenced at 3h. 20m. P.M. In the Meteorological Report from the Greenwich Observatory, it is stated that at Lewisham the hailstones "were nearly all as large as pigeons' eggs." It was felt severely the same even-

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which had been left by the tide in Penzance, St Michael's Mount, and Newlyn, were again floated and left dry—the rise and fall being between three and four feet. The interval from the commencement of one influx to that of the next was about fifteen minutes. The flux and reflux were greatest in Penzance Pier, but were observed there only once; whereas, at Marazion and Newlyn, they were noticed two or three times successively."

* In the *Journal des Debats* was the following communication from Havre, dated 6th of July:—"Yesterday, at five P.M., a violent storm suddenly rose from the west, and still continues unabated."

ing at East Walden, Leicester, and Nottingham, and before midnight at Southampton and Paris. About 4 A.M. of this day an extraordinary agitation of the sea was observed at Penzance Pier by the labourers employed there, the tide being about five hours ebb, and the sea very calm. The water suddenly returned towards the shore, rising between 1 and 2 feet, and after an apparent pause, rushed back "like a river," to its former level—the time occupied in the influx and the reflux, including the time the water appeared to be stationary, was about six minutes. The flux and reflux were observed only once.

In London the thermometer on this day was 89½° in the shade, and 116° in the sun (the latter the maximum for the year), and throughout the previous night it did not descend below 70°; at Paris it was 90° a great part of the day. At Penzance the nights of the 29th, 30th, and 31st of July, were the warmest of the year. On the 30th a terrific thunder-storm, with heavy rain and hail, occurred in Mount's Bay, and throughout Cornwall, and also in Wales and Cumberland, from which time, until after the great storm of the 1st of August, the atmosphere in Cornwall, London, and probably throughout England, was not only very sultry, but highly charged with electricity, whilst violent thunder storms were experienced in various places.

An earthquake shock was felt along the Rhine on the evening of the 29th of July—the moon's first quarter was on the 31st—and the agitation of the sea above described (the result perhaps of a submarine shock) happened on the 1st of August.

In conclusion, I may remark that, with only one exception, all the shocks of the earth and extraordinary oscillations of the sea in Cornwall during the present century, whose dates are known (and which are eight in number), have happened nearer to the moon's first change or quarter than to any other. The exception is the shock of the 20th of October 1837, the day before the moon's last quarter.

Eleventh Letter on Glaciers; Addressed to Professor Jameson. (1.) *Observations on the Depression of the Glacier Surface.* (2.) *On the Relative Velocity of the Surface and Bottom of a Glacier.* By Professor J. D. FORBES. With a Plate.

MY DEAR SIR,—In my Tenth Letter on Glaciers, which you did me the favour to publish lately, a question was discussed respecting the apparent depression of the surface of a glacier. I had already pointed out in the first edition of my Travels, that several causes combine to produce this depression, but that observations were wanting to distinguish them. The causes then enumerated were (if I mistake not) these:—1. The actual waste or melting of the ice at its surface.

Fig. 3.

Fig. 1.

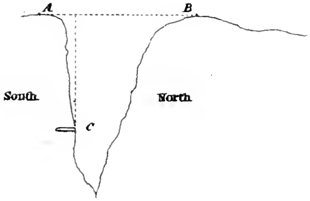


Fig. 2.

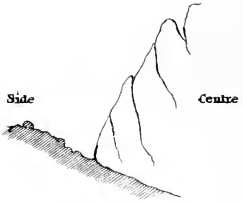
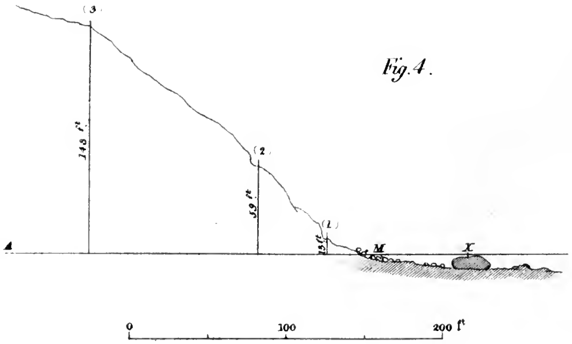


Fig. 4.



S. Leith's Lithogy. Edinr.

2. The subsidence of the glacier in its bed, owing to the melting of its inferior surface, whether by the heat of the earth, or that due to currents of water. 3. The effect of the drawing out of the glacier where it is in a state of distension, which tends to reduce the thickness of the mass of ice; (when a glacier is violently compressed the effect will be contrary, or an elevation will result); to which may be added the influence of the slope of the bed of the glacier, by which, as it moves forward, its absolute elevation is diminished, or the contrary if it ascends. I had also pointed out a method* by which the first of these effects, or the absolute *ablation* of the ice (as it has been termed by M. Agassiz), might be distinguished from the other two, namely, by driving a horizontal hole into the wall of a crevasse, and observing the diminution of the thickness of the stratum of ice above it. The partial and total effects I have observed in the following manner, during the present summer, on the Mer de Glace of Chamouni. A crevasse, nearly vertical, and of no great depth, was selected, running in a direction transverse to the glacier. The most vertical wall nearest A (Plate V., fig. 1) is always that the least exposed to the sun, and the waste of its surface is very small, unless in the case of rain. In this wall a horizontal hole C was bored, to the depth of at least a foot, and was renewed from time to time. The depth at which this hole existed below the surface of the glacier was determined by stretching a string AB across the crevasse, and measuring by a line the vertical height from C to AB. The variation of this quantity gives the actual fusion of the surface, free from the errors mentioned in my former letter. It is, of course, very variable, depending on the weather as well as on the place of experiment. Opposite the Montanvert, about 200 feet from the side of the glacier, during the hot weather of July and August 1846, the *ablation* amounted on an average to 3·62 inches per day; at a higher station between the Angle and Trelaporte (opposite station Q of the year 1844, see Eighth Letter), it was only 2·73 inches,

* Travels, 1st edition (1843), p. 154.

the ice being also remarkably clean and white, and the distance from the western bank of the glacier 553 feet.

The *subsidence* of the glacier in its bed, or the difference between the geometrical depression of the surface and the ablation, was very easily and most accurately obtained in the following manner. The theodolite being placed and levelled on the ice in the neighbourhood of the place of observation (not necessarily always on the same spot), the height of the horizontal wire of the telescope above the horizontal hole pierced in the side of the crevasse, was noted by directing the level upon a measuring tape divided into feet and inches, the ring at the extremity of which was passed over the boring instrument, which was then firmly adjusted in the horizontal hole. The reading at the telescope gave the height of the eye at the moment above the hole in question. The level was then directed against a fixed object on the moraine, where a cross had been cut in a stone as a point of departure for the vertical height. The height of the eye above or below the fixed point was measured, and the sum or the difference (as the case might be) of this measure and the last gives the difference of the level of the horizontal hole in the ice, and the mark on the moraine. The following may serve as an example :—

Station U, near Montanvert.

1846.	Aug. 1, 4½h P.M. Ft. In.	Aug. 3, 6 P.M. Ft. In.	Difference.
Horizontal hole C below A ..B,	9 3·3	8 7·0	8·3 inches=*ablation.*
C below Theodolite, . .	12 7·2	11 9·8	
Cross (+) U below Theodolite,	2 3·8	1 5·0	
C below (+) U, . . .	10 3·4	10 4·8	1·4 inches=*subsidence.*

Of course the horizontal hole may be renewed as often as convenient, all that is necessary being to ascertain the difference of level of the old and new hole.

In the preceding example (which has been selected by chance), the *subsidence* bears an unusually small porportion to the *ablation.* At the station in question, the average daily ablation in July and August was 3·62 inches, the average daily subsidence 1·63 inches. The sum of the two, or the geometrical depression of the surface 5·25 inches, whereof *seven-tenths* were produced by ablation, *three-tenths* by subsidence. These relations, together with those opposite the old station Q, are shewn in one view in the following table of

Mean Results.

	Slope of Surface.	Daily Progression.	Daily Ablation.	Daily Subsidence	Geometr. Depression	Proportion due to Ablation.	Proportion due to Subsid.
		Inches.	Inch.	Inch.	Inch.		
Station U.		18·7*	3·62	1·63	5·25	·69	·31
Station Q.	2° ¾	21·2	2·73	0·97	3·70	·74	·26

The last two columns shew the effects of the ablation and subsidence in hundredth parts of the whole depression.

As we do not know correctly the slope of the bottom or bed of the glacier, it is impossible to estimate how much of the subsidence is owing to the declivity. It is probable, however, that the greater part of it may be thus accounted for. The amount of geometrical depression agrees well with that ascertained by me in 1842, at the Angle, which is in a position intermediate between the stations U and Q, but nearest to Q. During the height of summer, *i. e.*, from the 26th June to the 28th July, the daily depression was 4·1 inches.†

Relative Velocity of the Surface and Bottom of a Glacier.

The influence of the sides or walls of a glacier in retarding its motion laterally, was demonstrated by my first observations in June 1842; and the same cause might well be presumed to influence the motion of the ice in a vertical plane. That the superficial ice should *overflow* that which presses on

* Taken from the observation of the neighbouring mark D·2.

† As some numerical or typographical errors have slipped into the Table of Depressions of the Level of the Ice at the *Angle* in 1842 (Travels, p. 154, 2d Edit.), I take this opportunity of correcting them, after a careful comparison with my note-books. The observed depression from June 26 to June 30 ought to be 1 ft. 4·5 in., instead of 1 ft. 9·0 in.; and the daily depression should be the following—

1842.	June 26—June 30.	4·1 inches.
	June 30—July 28.	4·09 ...
	July 28—Aug. 9.	3·92 ...
	Aug. 9—Sept. 17.	3·06 ...

the bottom, seems a simple corollary, from the fact that the centre of a glacier *flows past* its sides. Even admitting the irregularities of the bottom to be less than those of the lateral expansions and contractions of the valley, the enormous pressure on the bed must generate a friction proportionally great. Some persons have, however, found so much difficulty in conceiving the fact of varying velocity in a vertical plane (notwithstanding the evident analogy of a river), that I was glad to take an unexceptionable opportunity of demonstrating it.

I have already shewn, at the close of my Sixth Letter, that the effect of friction in retarding the rate of motion, must be most sensible nearly in contact with the soil; and that when the glacier is of great thickness, the upper part of it (to which alone we have access) may be expected to move uniformly, or sensibly so, which accounts for the approximate verticality of most crevasses, during the limited period of their existence. It is, therefore, near the contact of a glacier with the subjacent soil, that the most sensible effect may be looked for. The circumstances which first suggested themselves to me as the most favourable for such an observation, were where a glacier emerging from a gorge, or from between a double mound of its own formation, falls into a valley, and presents for some space lateral faces of ice, not, indeed, quite vertical, but still very highly inclined, and which repose immediately on a bed of rubbish, which, if not flat, but sloping somewhat towards the centre of the glacier, might be considered, beyond cavil, as the floor or bed on which it rests. But a careful examination of several glaciers with a view to such an experiment convinced me that, even if successful, it would not be conclusive. For it almost invariably happens, under these circumstances, that the glacier, being no longer confined laterally, tends to scale off by means of fissures parallel to its length (as in fig. 2.); and even if these fissures do not give rise to a sensible sliding of the surfaces, they indicate the direction of the twist to which the ice is exposed by the more rapid motion of the centre. To avoid misapprehension, I here repeat that such a tendency to scale by means of longitudinal fissures, occurs only where lateral compression is wanting, and there, consequently, the *veined structure* is always feebly developed.

I succeeded, however (though not without difficulty), in establishing points of observation in the *terminal face* of the Glacier des Bois, at Chamouni, whose relative position will be understood from the sketch of a front view of the glacier, fig. 3, and from the vertical section parallel to the length of the glacier in fig. 4. It will be seen by fig. 3, that whilst the lateral parts of the glacier were fissured and scaly, in consequence of the action described in the last paragraph, the central mass was exceedingly compact and uniform. The terminal face of compact ice was inclined, at the point selected for experiment, at an angle of about 40° to the horizon, and the three stations (1.), (2.), (3.), were selected one above the other, in a vertical plane passing through this face in a direction which was judged to be nearly that of the progressive motion of the ice. Any variation in the motion of these three points could only be imputed to the effect of the friction of the soil, for by the progress of the glacier each would pass in succession vertically over the same spot. The position was also unexceptionable in this respect, that the glacier is here subject to no extraordinary constraint. The sides are free, and the base rests on a bed of rubbish and debris nearly flat, therefore offering no fixed barrier to the forward motion of the ice; the retardation, if it exist, can only, therefore, be due to the ligitimate effect of friction. The glacier, too, is here seen from top to bottom, for the contact with the soil is only concealed by the trifling mound of rubbish not many feet in height, shewn at M in fig. 4, which it presses before it; the gravel between M and X being flat, and untouched by the glacier for many years. The lowest mark (1.) was estimated at not less than 4 feet, and not exceeding 12 feet from the real base or soil of the glacier. The mark (2.) was 46 feet vertically above (1.), and No. (3.) was 89 feet vertically above No. (2.) From the analogy of the lateral friction of glaciers, and from the phenomena of rivers, it was anticipated that the retardation of (1.) upon (2.), and of (2.) upon (3.), would be sensible, but that the former would be greatest, which the results confirm.

The progress of each point, as well in direction as in amount, was rigorously determined by a trigonometrical process, reference being had to two fixed stations, one of which, X, seen in fig. 4 was in the original plane of the points observed, the other was 75·525 feet distant to the right hand of fig. 3. The choice of stations was limited by the peculiar local circumstances, and was not otherwise the most desirable. The continual fall of blocks which bounded with great velocity from the terminal face of the glacier, rendered it necessary to consult the safety of the observer and the instrument; and in order to plant and maintain the wooden pins which marked the points (1.), (2.), (3.), it was necessary to commence by laboriously removing the blocks and rubbish from the surface of the glacier above, whose fall would at every instant have threatened the safety and even the lives of my assistants. Two men were laboriously employed for some hours at this task.

Circumstances prevented me from pursuing these observations for more than five days, which was to be regretted; but, in this time, ample evidence was obtained of the existence and amount of the effect of friction in retarding the lower ice. Less than 50 feet of thickness between Nos. (1.) and (2.) corresponded to an apparent acceleration of *nearly half the motion at the lower point.* The ratios of the motion at (1.) and (2.) were, by three independent sets of observations,

1 : 1·41 , 1 : 1·50 , 1 : 1·49

the acceleration of (3.) upon (2.) was (as anticipated) less considerable, and also more difficult of correct estimation, owing to the greater horizontal distance,* but the following results appear to be worthy of confidence.

	(1.) Ft.	(2.) Ft.	(3.) Ft.
Motion from 13th Aug., 11 A.M., to 18th Aug., 3 P.M., . . .	2·87	4·18	4·66
Ratios, ...	1·00	1·46	1·62
Angle (φ) made by the motion with the direction of X, . . .	5°.0	8°·3	10°·1

* The horizontal distances of the points (1.), (2.), (3.), from X were at the commencement of the observations, 95·79, 138·0, and 246·8 feet.

The three points being approximately, 8, 54, and 143 feet above the bed or floor of the glacier.

These results have been computed by the following formulæ, which may be useful to those desirous of repeating the observations :—

Let X and x be the two trigonometrical stations from which the motion of the points (1.), (2.), (3.), are observed. Let θ be the angle under which X and x are seen from one of these points. Let p be the *linear transversal* movement of the point as seen from X (deduced from the apparent angular motion and the known distance of X). Let q be the similar quantity with respect to x, which will have the same or contrary sign with p, as the apparent motion from the two stations is in the same or in contrary directions. Then the total motion of the point observed (which is assumed to be small relatively to the dimensions of the triangle, which has X, x, for two of its corners) will be

$$r = \sqrt{q + (q \text{ cotan } \theta - p \text{ cosec } \theta)^2}$$

and the angle (φ) of the direction of motion with the visual line through X, is found by this equation

$$\sin \varphi = \frac{q}{r}$$

I shall take the liberty of addressing you again, as to the farther observations which I have been able to make, in another letter.—I remain, my dear Sir, yours very truly,

JAMES D. FORBES.

LARGS, AYRSHIRE, 16*th September* 1846.

To Professor JAMESON.

SCIENTIFIC INTELLIGENCE.

METEOROLOGY AND GEOLOGY.

1. *Sulphur in the Atmosphere.*—M. Boussingault lately made a communication to the French Academy of Science on the much-disputed point of the presence of sulphur in electricity. It is generally stated that an odour of sulphur accompanies the electric fluid. This, however, has been positively denied by many natural philosophers.

M. Boussingault concludes from some experiments on metallic substances, which have been exposed to the action of electric fluid, that sulphur is always present in such cases.

2. *On Cleavage of Slate-Strata.*—Professor H. D. Rogers gave the Meeting of the Association of American Geologists, in April 1845, an oral abstract of a paper by himself, on the direction of the slaty cleavages in the strata of the south-eastern belts of the Appalachian chain, and the parallelism of the cleavage dip with the planes of maximum temperature.

He prefaced his communication by a brief sketch of the researches of Professor Sedgwick and Sir John Herschell, in relation to cleavage, which prove that it is a structural condition in rocks, irrespective of their dip, and is the result of molecular forces developed in the strata subsequent to their elevation and contortion.

He then proceeded to a description of the direction of the cleavage planes in the Appalachian chain. By the aid of a general section and a diagram, it was shewn that, throughout the south-eastern belts of the chain, and in the region of the metamorphic strata still farther towards the south-east, the strata lie in closely compressed anticlinal and synclinal folds, the medial, or axis planes of which, dip at a steep angle almost invariably to the south-east, or some point between the south and the east. Now, it is a general fact, established by his own observations and those of Professor W. B. Rogers, that, from Vermont to Alabama, the cleavage dip is likewise towards the south-east, and therefore nearly parallel in direction and steepness to the *anticlinal* and *synclinal planes.* This prevailing parallelism of the cleavage surfaces to the belts of *maximum crust and fracture* in the strata, is suspected by the author to obtain also in other countries, and is regarded by him as having an important connection with the mode in which cleavage has originated.

He called attention to the circumstance, that the anticlinal and synclinal planes constitute in these closely plicated strata, so many parallel and steeply dipping belts of fissured and dislocated rock, more readily permeable than any of the other parts of the mass, to the intensely heated steam and gas, which he supposes to have issued through the crust of the earth, while the folding of the strata was in progress, as it now does to a less extent during modern earthquakes. The hot effluent vapours would impart their temperature along the anticlinal planes; and thus the whole body of the strata would consist of a series of alternating belts of heat, or more properly of steeply dipping planes, alternately warm and cold. This symmetrical and parallel distribution of the heat seems to be precisely that which ought to impart through the new polarities it would awaken in the mass, a corresponding symmetry and parallelism in the planes of maximum and miminum cohesion, or, in other words, the planes of cleavage. The conjecture that they have been thus produced, finds confirmation in some facts mentioned by Professor Philips, in his

Treatise on Geology, in Lardner's Encyclopædia. In the coal-measures near Newcastle, the common shale loses its ordinary horizontal lamination near the vertical sides of a basaltic dyke, and over a width of a few yards, it presents numerous vertical divisional planes parallel to the faces of the dyke, not more than half an inch apart, and analogous to the cleavage planes of slate. He likewise mentions that a cleavage structure occurs parallel to the great Craven fault. Professor Philips views the cleavage of slate as a metamorphic structure, produced by heat, exerted either primarily, or through the agency of electricity, in superinducing a new polarity in the particles of the rocky mass.

The main object of Professor Rogers is to state the general fact of the approximate *parallelism* of the cleavage dip, and the anticlinal and synclinal planes of the closely folded strata; and also to point out the general law of their parallelism to the planes of maximum heat.—*Proceedings of the Sixth Annual Meeting of the Association of American Geologists and Naturalists*, April 1845, p. 49.

3. *Earthquake in Tuscany, Marseilles, 19th August.*—By the Virgile, just arrived from Naples and the Italian coast, we learn, that on Friday, the 14th instant, a most violent earthquake was felt in Tuscany. The church of St Michel, at Pisa, was greatly shaken; in the country, the earth opened at various places, and vomited forth muddy and boiling water. At Leghorn, the bells in the different church steeples rang of their own accord. The disastrous effects are not so considerable in the town as in the neighbouring villages, where many of the houses were thrown down, and the frightened inhabitants flew to the open fields. The Grand Duke, informed of the disaster, immediately ordered provisions of every description to be sent to the unfortunate sufferers. The earthquake was first felt about one o'clock in the afternoon of Friday the 14th instant. The village of Orciana, about 20 miles from Leghorn, has suffered considerably. Of 120 houses, only 2 remain standing; 59 persons were killed, and 65 wounded. Most of the houses at Leghorn have large cracks in the walls. The flags of the pavement were raised, but closed again immediately. The event caused great anxiety at Leghorn, and the people took the precaution of sleeping in the fields outside the town. At Pisa, the church of St Michel was thrown down. An hour previously, the church was crowded, and the door was scarcely closed when the roof fell in. The shock lasted for three seconds, and was followed by a muffled and awful sound, like the report of a distant cannon, and people staggered in the streets. A letter from Leghorn, of the 17th, states:—"Our town has just been thrown into great alarm by an earthquake. On the 14th, at 10 minutes to 1 P.M., the first shock was felt, preceded by a rumbling noise; the shock lasted 7 or 8 seconds; the oscillations seemed to be at first perpendicular, as if the ground was raised in a direction north-east to north-west. The inclination of the houses

was such at that moment, that it was difficult to stand upright in them, and the cracking of the walls and beams warned the inhabitants, who rushed into the streets. The women threw themselves on their knees, imploring the aid of the Madonna de Montenon, patroness of the town, and the men devoutly crossed themselves. During the night, different other shocks were felt. The earth seemed to be in a state of convulsion; the sky was cloudless, but there was a thick haze, which did not fail to make a sinister impression. In the country, the effects were more disastrous, principally in the Maremme, where ancient traces of volcanic eruptions are numerous. Whole villages were destroyed in the districts of Taulia, Laurenzana, Corciana, and Casciano. At Voltena, a state-prison fell in, burying some of the prisoners in the ruins. The number of lives lost is estimated at 38, and 140 wounded, some dangerously. Various natural phenomena occurred; near Lorenzuna, and at Treiona, muddy and boiling water issued from the earth; a lake was formed in a hollow. All the villas on the hills near Pisa have suffered considerably. For the last four days the ground has not ceased to shake at intervals. In the present shaken state of the houses, another powerful shock would be the ruin of Leghorn. Part of the population has left the town, others live in tents, or have sought refuge in boats."—*Daily News, August* 25, 1846.

PALÆONTOLOGY.

4. *Discovery of New Species of Fossil Frog in the Tertiary Formations of the neighbourhood of Osnabruck.*—M. Duuker has found small bones of frogs in the shelly and coraline gravels of Hellern, not far from Osnabruck, which belong to the tertiary epoch. M. H. de Meyer, who has examined them, has detected at least three new species, which may be distinguished from each other by the forms of the humerus. This same bone had already enabled this skilful palæontologist to establish twenty-four species of frogs found at Weisenau. None of the humeri discovered at Hellern are like those belonging to these twenty-four species. The other bones, such as those of the sacrum, the fore-arm, and pelvis, appear to indicate more analogy between the species of these two localities.—*Leonh. and Bronn, N. Jahr* 6. 1845, p. 798.

5. *Two New Species of Fossil Bat in the Tertiary Formations of Weisenau.*—The Cheiroptera have rarely been found in a fossil state in tertiary formations. We know of none belonging to this family, in deposits anterior to the diluvian epoch, except the *Vespertilio Parisiensis* of the Montmartre schists, of which only one individual is preserved in the museum at Paris; and two small teeth found in the eocene sand of Kyson, and referred, by Mr Owen, with doubt, to the genus Vespertilio.

The species mentioned by Karg, at Œningen, appears very uncertain, and the original specimen has been lost. M. Hermann de

Meyer has discovered at Weisenau, among a considerable mass of remains of bones, a few bones belonging to two cheiroptera. They consist of the half of a lower jaw, in which, although the teeth are wanting, the sockets are sufficiently preserved to give an idea of the dental system; of three humeral bones, two left and one right, which shew the existence of two species, and which render it probable that there is even a generic difference between them; lastly, of the half of a radius, which can only belong to a cheiroptera. The two species differ from that of Montmartre; and M. H. de Meyer designates them by the name of *Vespertilio præcox* and *V. insignis*, until their generic affinities be distinctly ascertained.

ZOOLOGY.

6. *The Lion, as an article of Food.*—We were anxious to know if there was any chance of another lion being found in the neighbourhood, and were informed that, doubtless, there were plenty; but such was the nature of the ground, that, unless their exact haunts were known (in which case they were generally killed), we might go out for a fortnight, and never encounter a single beast. The skins of all lions killed throughout the regency are sent to the Bey, who pays a handsome premium upon each. The flesh is eaten; and, contrary to our expectation, we found it excellent, and made a capital supper upon the ends of the ribs stewed with a little salt and red pepper; it tasted like very young beef, and was neither tough nor strong flavoured.—*A Journey through Algeria and Tunis, by Captain Clark Kennedy*, vol. ii., p. 205.

7. *On a Gigantic Stag, Cervus Euryceros*, Aldr.; *Megaceros*, Hart.; *Giganteus*, Galde, *By Dr E. Eichwald.*—Cuvier, after having described the fossil bones of the gigantic stag found in England, Lombardy, and throughout the whole of western Europe, expresses his surprise that none have hitherto been found in Russia and Siberia, where stags are at present so widely distributed. M. Eichwald records, in a memoir on the discovery of the bones of the same stag in the eastern part of European Russia, in the government of Simbirsk, where M. Sagykoff found fragments of the cranium, and the horns of two individuals. They have likewise been found in Siberia on the north-west slope of the Altai, in the caverns of the arrondisement of Kolywanowoskressenskisch to the east of Schlangenberg, and in the vicinity of the river Tscharysch. In these deposits, the bones of the stag are very abundant, as well as those of the lama, horse, rhinoceros, hyæna, dog, bear, gnawers, and bats.

The author adverts to the controverted question respecting the antiquity of this remarkable species. The beautiful cranium of the gigantic stag described by Goldfuss, had been found near Emerich along with urns and stone hatchets,—tokens of the existence of man. Another cranium was found in the peat-bogs of Lancashire in formations similar to those where a boat was found. These historical facts have led some authors to believe that this gigantic stag was the same as the stag of Ireland, which disappeared in the twelfth century, and of which ancient authors speak, being the same as the *Seg* of the ancient Britons, and the *Eurycerus* of Appianus. A magnificent antler of the gigantic stag of Bohemia, which the author has seen in the Imperial Museum of Vienna, and on which are engraved a few words in old Slavonian letters, indicate the origin of this animal; and the exploits of the chase related in ancient heroic poetry, justify the belief that the gigantic stag was then known. This animal was probably the *schelch* which the poems in question inform us was hunted along with elks, aurochs, &c. It is, therefore, very probable, that being an object of chase, the gigantic stag disappeared from Europe two or three centuries ago, as the elk has disappeared from Italy, France, and Germany, and as the Bos primigenius and aurochs have so diminished that they are no longer found, save in the great forest of Bialowesha (in the government of Grodno), where, to prevent their total destruction, immense provision of hay is made for them every winter.

All these animals which were hunted in Germany probably lived, in former times, along with the mammoth and rhinoceros, since we find their bones intermingled in the same diluvian deposits. These latter appear to have perished first, and the others, especially the Bos primigenius and the gigantic stag, to have long survived them. Ferocious animals, such as hæynas, lions, and bears, may have been destroyed before them, in consequence of the interest man had in preserving himself from their devastations, before they thought of driving away less hurtful animals. The last lion lived in Greece in the time of Aristotle, near the rivers Acheloüs and Nestus. Pliny likewise mentions this animal as inhabiting Thrace and Macedonia.

Analogous occurrences appear to have taken place in America, for it is probable that the mastodon lived in historical times; and, just as the gigantic stag survived the mammoth, it appears that the mastodon survived the latter. This is demonstrated by the discovery of a complete skeleton of the *Mastodon* or *Missourium giganteum* in the valley of the Mississippi. The point of an arrow made of flint was still under the right hip of the animal, a circumstance which completes the evidence that these gigantic animals lived at the same time as man.

It is useless to insist here on the confirmation which these facts furnish to the opinion we have elsewhere advanced (*Traité Elem. de Paleontologie*, tom. i. note A.) on the connection which exists between the diluvian and the modern epoch. These two epochs ought not perhaps to be distinguished; and they are certainly not separated by a destruction of species at the end of the first, and by a new appearance at the commencement of the second. It is very probable that all the existing species date from the origin of the diluvian epoch;

but that a part of them have been destroyed, and have not reached our times. The changes of climate, and the influence of man, have been the causes of these disappearances of species, some of which have taken place at periods too remote to have left any traces in tradition, but others of which are well known, and some are even taking place under our eyes.—*Professor Pictet.*

8. *On the Respiratory Apparatus of Birds. By M. Natalis Guillot and M. Sappey.*—It is a fact generally admitted, that in birds the air which reaches the lungs is introduced by permanent openings, in the cavity of the abdomen, in the bones, and in diverse parts of the body. M. Guillot has endeavoured to determine the position of the aërial reservoirs, and to shew that it is an error to believe that the air can be introduced into all the parts of the body of the animal.

He distinguishes the thoracic aërial reservoir and the abdominal reservoir. The latter is composed of two large spheroidal bladders, formed by a membrane of extreme tenuity, and separated by the mesentery and the mass of the intestines. Their origin is towards the base of the breast, on a level with the last rib, where we perceive an elongation of the lung pierced with many openings. The interior of these receptacles does not communicate with the peritoneum; they are bladders full of air, and nothing more; they are not cellular, like the thoracic reservoir.

When we place a living bird under water, and keep it there in such a manner that the respiration is free, we may open the peritoneum, without a single bubble of air making its escape. Neither does any appear by cutting the cellular tissue, by raising the skin, and cutting the muscular masses. The same thing does not always take place after the death of the bird, for then, according to M. Guillot, gaseous bubbles arise from the blood. This anatomist thence concludes, that the air maintained by the envelopes of the two reservoirs above mentioned, cannot enter but into the bones, and that it neither enters into the peritoneum nor the cellular tissue; in a word, that it cannot diffuse itself through all the parts of the body during the life of the animal.

In connection with this communication, M. Serres referred to the analogous investigations of M. Sappey, demonstrator in the anatomical school of the hospitals; and this latter anatomist himself read a memoir to the Academy of Sciences (9th and 23d July 1846) on the same subject. The conclusions of his memoir are the following: 1*st*, There is no pleura in birds; 2*d*, The membrane which has been described under that name, is formed by the inferior *bronchia* of the lungs; 3*d*, All the *bronchial* ramifications are periferal, and produce, by leaning against each other, a true aëriferous envelope; 4*th*, Not only does a diaphragm exist in birds, but it is an essential agent in the pulmonary dilatation; 5*th*, Observation rejects the existence of full cells, the communication of the respiratory apparatus with the muscles, the cellular tissue, and the feathers; 6*th*, The aërial reservoirs, annexed to the lung, are five in number on each side; 7*th*, These reservoirs, being of no use for respiration, are intended to secure the equilibrium of the bird during flight, and to diminish its specific gravity; 8*th*, The air which they contain becomes rarefied during inspiration, and condensed during expiration; 9*th*, The presence of air in the bones has the effect of augmenting their diameter and resistance, without increasing their weight; 10*th*, Finally, this same fluid penetrates directly into the feathers by an elliptical orifice, situate on their under side, and serves the same purpose in these organs as in the bony levers.

These researches, it will be perceived, will probably have the effect of modifying greatly the notions generally adopted respecting the air contained in the different parts of birds.

9. *On the Comparative Anatomy of the Vocal Organs of Birds. By Professor Muller.*—For the earliest investigations into the vocal apparatus of birds we are indebted to Cuvier; and it is to this celebrated anatomist that we likewise owe the greater part of the facts relative to their organization. At a later period, M. Nitzsch attempted to derive, from the study of the inferior larynx, materials for the classification of birds, which has always been, as is well known, one of the most embarrassing problems in the natural systems. M. Muller has made a long series of observations on the vocal organs of the passerine tribes. The results of his labours are as yet but partially known; a detailed description will soon be published in the Memoirs of the Academy of Berlin. Meanwhile, we shall here point out some of the general conclusions of that work, which is impatiently expected, like everything else which comes from the pen of the illustrious Berlin professor.

Professor Muller concludes, from the facts he has observed, that the passerine songsters cannot form a natural division; and, contrary to the opinion of M. Nitzsch, he affirms that the *Picariæ* cannot be separated from them. The most natural groups of the order of passerine birds contain types which differ in the organization of the larynx, and the variable nature of this apparatus renders it but little fitted for the purposes of classification. It is the less so, since song may be produced by arrangements of structure very different from each other. The passerine order ought probably to be preserved in its most extended limits, comprehending even the syndactyli and the climbers; and it ought to contain, at once, birds possessing the most perfect vocal apparatus, and others which seem reduced to the greatest degree of simplicity.

The two most common forms of the vocal organ among birds, are, 1*st*, The vocal muscular apparatus, formed on the type of that of our singing birds of Europe; 2*d*, The form of a single muscle, thick or slender. It is worthy of remark, that the first form prevails in Europe and Africa, and that the second is most common in America. Consequently, the forests of the Old World possess a greater number of birds truly songsters; those of the New World abound principally in birds with a loud and clear voice, but of little variety, and resound with cries rather than songs. Besides these two widely extended forms, there are many other laryngical organizations of a more especial nature; the most complicated is that of the parrot tribe.

M. Muller's memoir contains numerous facts of detail, and likewise plates explanatory of all the forms described.

10. *Physiological Remarks on the Statics of Fishes. By Joh. Muller.*—Like all other animals, fishes have a very delicate sense of the equilibrial position of their bodies. They endeavour to counteract all change in this position, by means of movements partly voluntary and partly instinctive. These latter appear in a very remarkable manner in the eyes; and they are so constant and evident in fishes while alive, that their absence is sufficient to indicate the death of the animal.

The equilibrium of the body of a fish in the water is independent of the swimming bladder; that organ may even be injurious to it. The equilibrium of the fish, its horizontal position, with the back upwards, depends solely on the action of the fins, and principally that of the vertical fins.

The swimming bladder may enable a fish to increase or diminish its specific gravity. By compressing the air contained in it, the fish descends in the water; it rises by relaxing the muscles which produced this compression. Besides, the fish may continue in the deep parts of the water in consequence of the mere pressure of the column of water on the air contained in the bladder.

By compressing more or less the posterior or anterior portion of the bladder, the animal, at pleasure, can make the anterior or posterior half of its body lighter; it can also assume an oblique position, which permits an ascending or descending movement in the water. The arrangement of the swimming bladder in some fishes may favour this action. The Cyprinoides and Characins have two bladders, one before the other, and communicating with each other by a narrow neck. The anterior bladder is very elastic, while the posterior is very slightly so; accordingly, in proportion as the fish ascends in the water, the anterior and more elastic bladder must increase in size considerably, and tend to keep the head upwards, while the contrary must take place when the fish descends.

11. *Red Colour of the blood in the Planorbis imbricatus. By M. de Quatrefages.*—By observing the *Planorbis imbricatus* by means of a transparency, M. de Quatrefages has ascertained that this little mollusc, which is very common in the fresh water around Paris, possesses blood of a red wine colour. Under a faint magnifier, the liquid may be seen filling the cavities of the pericardium and ventricles, and by its motions colouring pretty distinctly the whole general cavity of the body on its lower surface. M. de Quatrefages could not perceive distinct globules in this liquid. Other Planorbes,

of very small dimensions, possess white blood. M. de Quatrefages presumes that these are the young of *P. imbricatus*, the blood not acquiring its characteristic tint but by age; and he remarks, that if this conjecture is verified by the observations which he proposes to continue, the processes will go on in these molluscs exactly as among the annelides.

12. *On the Development of the Annelides. By M. Sars.*—The development of the annelides was only known, till of late years, by works on the leech; and it was erroneously concluded, from analogy, that all these animals, on issuing from the egg, had the general form of body exhibited by the adult. M. Sars has confirmed the discoveries of M. Loven respecting the metamorphoses which certain annelides undergo, by carefully describing the development of the *Polinöe cirrata*, which is common on the coasts of Norway.

It is in the months of February and March that reproduction takes place in this annelide. At first the eggs, in the body of the mother, present the usual broken appearance observable in the young, having at one period the aspect of a raspberry, and afterwards becoming smooth. They are ejected from the body by particular openings in the dorsal surface of the animal, and are then agglutinated in a mass by means of viscuous filaments, which likewise serve to fix them on the back of the animal, under the branchiæ, where they remain till the exclusion of the embryo. When the embryo issues from the egg, its form has no relation to that of the mother; it is oval, not annulated, and has only two eyes in the anterior part of its body; the middle of the animal is surrounded with a circular crown of vibratile ciliæ, which serve for locomotion, and are the only appendages of the body.

The annelides, we thus see, may undergo important metamorphoses. They thus approach the other annelides, and also the myriapodes, embryos of which quit the egg, according to Waga and Newport, in a very imperfect state, and completely destitute of articulated appendages.

13. *On the Development of the Hearing Apparatus in the Mollusca. By Dr H. Frey.*—M. Frey's observations have been made chiefly on the embryo of the *Lymnia stagnalis.* The auditory vesicle or bladder does not begin to appear in this mollusc till the period when the singular rotatory movements of the embryo have ceased, and the animal is now creeping over the interior wall of its shell. We can then notice, without difficulty, at the anterior part of the body, the rudiments of the tentacula, the eyes with their pigment, the tongue with its highly characteristic epithelium. It is on each side of the base of the tongue that the auditory vesicles are found. They are spherical, the contour simple, and the diameter about $\frac{1}{60}$ or $\frac{1}{56}$ of a line (0·038 to 0·04 millimetres). They appear at first to enclose in their interior only a transparent liquid, and are at that time, as is likewise the case with the eye, without connection with the central

parts of the nervous system. One or two small corpuscles are soon developed in this liquid, whose form, size, and oscillatory movements are in every respect similar to those of the otolithes in the perfect animal. The vesicle or bladder containing them has a double margin round the outside, resulting probably from the walls becoming thicker. The size of the otolithes is from $\frac{1}{450}$ to $\frac{1}{300}$ of a line (0·005 to 0·0075 millimetre); their number goes on gradually increasing, and reaches a score, when the lymnia quits the shell; the diameter of the vesicle or bladder, at this time, is about $\frac{1}{40}$ of a line (0·056 millimetre). Besides the otolithes, other small corpuscles are found, of smaller size, which often do not reach the dimensions of $\frac{1}{1000}$ of a line (0·0023 millimetre). The number of otolithes, and the size of the auditory vesicle or bladder, then continue to augment; at the same time the animal continues to grow. When in the adult state, we can reckon from 100 to 200 otolithes, and the diameter of the bladder varies from $\frac{1}{16}$ to $\frac{1}{10}$ of a line (0·14 to 0·23 millimetre).

The development of the auditory apparatus presents the same phenomena in the Physes, Paludines, and terrestrial Gasteropods in general (helix, limaces, &c.) There is no difference except in the size of the parts.

Among bivalves, the apparatus of the ear contains only a single otolithe of a large size, which fills the cavity of the bladder. The same disposition is found in the embryo of these molluscs before issuing from the egg; the otolithe, smaller than in the adult, exhibits very lively oscillatory movements, as it does in the latter.

NEW PUBLICATIONS RECEIVED.

1. A History of British Fossil Mammals and Birds. By Richard Owen, F.R.S., F.G.S., &c. 8vo, pp. 560, with 237 woodcuts. John Van Voorst, Paternoster Row, London. 1846. *This original, able, accurate, and important, contribution to the Palæontology of Britain, already more fully noticed in this volume of the Edinburgh New Philosophical Journal, from page* 338 *to page* 343, *is, long ere this, in the hands of every British Palæontologist.*

2. Thoughts on Animalcules, or a Glimpse of the Invisible World, revealed by the Microscope. By G. A. Mantell, LL.D., F.R.S. John Murray, Albemarle Street, London. 1846. *This beautiful and interesting volume, like most of Mr Mantell's writings, has an agreeable popular cast. It combines so much good scientific details and inferences as will render it acceptable to an extensive class of readers.*

3. A History of the Fossil Insects in the Secondary Rocks of England. By the Rev. P. B. Brodie, M.A., F.S.S. John Van Voorst, Paternoster Row, London. 1846. *The Palæontological History of Insects has hitherto been so little cultivated that naturalists will receive with pleasure Mr Brodie's valuable volume, which we recommend to the particular notice of Palæontologists.*

4. Primary and Present State of the Solar System, particularly of our own Planet. 1846.

5. The Thirteenth Annual Report of the Royal Cornwall Polytechnic Society. 1845.

6. Catalogue of Birds observed in South-Eastern Durham, and in North-Western Cleveland. By John Hogg, M.A., F.R.S., &c., London. 1845.

7. Articles 1 and 2. On three several Hurricanes of the American Seas, and their Relations to the Northers, so called, of the Gulf of Mexico and the Bay of Honduras, with charts illustrating the same. By W. C. Redfield. *Mr Redfield is still cultivating, and with great success, "The Natural History of Hurricanes," as is shewn in the work here quoted.*

8. Structure and Classification of Zoophytes. By James Dana, A.M., Geologist of the United States Exploring Expedition, during the years 1838, 1839, 1840, 1841, 1842. Philadelphia, 1846. *The Natural History of Corals, in a zoological point of view, and also as illustrative of the doctrine of Rock formations, has now assumed a character of great importance. To those engaged in the study of these beautiful departments of science, we recommend Mr Dana's interesting work.*

9. Provisional Report on the Meteorological Observations made at Colaba, Bombay, for the year 1844. By George Buist, LL.D. Cupar, printed at the St Andrews University Press, by G. S. Tullis. 1845. *This elaborate and valuable Report has been well received by British Meteorologists.*

10. Elements of Physics. By C. F. Peschel, Principal of the Military College, Dresden. Translated from the German, with notes, by E. West. Illustrated with Diagrams and Woodcuts. 3 volumes, 12mo. Longman, Brown, Green, and Longman, London. 1846. *Cultivators of Natural Philosophy in this country will prize Mr West's judicious translation of the "Elements of Physics" of the distinguished Principal of the Royal Military College at Dresden—a work very favourably known on the Continent, and which, we doubt not, will be equally well received in Britain. The numerous diagrams and woodcuts with which it is illustrated, are well selected; and, what is of importance, all the measures are reduced to English standards, and the centigrade degrees of the thermometer are adapted to Fahrenheit's scale, and those calculated for the centigrade division are likewise retained, for the convenience of any student who may have occasion to refer to foreign scientific works.*

11. Recherches sur la Systeme Nerveux de la Tete du Congre (Murcena Conger-Lacep.), Par Al. Pierre Prevost. Quarto. Geneve, 1846.

12. Essai sur la Theore de la Vision Binoculaire. Par Alexandre P. Prevost. Geneve, 1843. *These Memoirs we owe to an accomplished young Genevese Naturalist.*

13. Beckmann's History of Inventions. Tranlated from the German. Fourth edition, carefully revised and enlarged. By Dr Francis and Dr Griffith. Vol. I. Henry G. Bohn, York Street, Covent Garden, London. 1846. *The reading public will be grateful to Mr Bohn for the publication of this well got up and very cheap edition of Beckmann's celebrated work.*

14. Observations in Natural History, with an Introduction on the Ha-

bits of Observing, as connected with the Study of that Science; also a Calendar of Periodic Phenomena in Natural History, with remarks on such Registers. By the Rev. Leonard Jenyns, M.A., F.L.S., &c. 1 vol. 8vo, pp. 440. London, John Van Voorst. 1846. *This very pleasing and instructive work of the well known author of the "Manual of British Vertebrate Animals," ought to be in the hands of all young Naturalists, and may also be read and consulted with advantage by experienced observers.*

15. Experimental Investigation of the magnetic characters of Simple Metals, Metallic Alloys, and Metallic Salts. By William Sturgeon, Esq., Lecturer on Experimental Philosophy at the Hon. East India Company's Military Academy, Addiscombe. From Manchester Philosophical Society's Memoirs. 1846. Joseph Gullet, Bookseller, Manchester. 1846. *This valuable detail of experiments will be noticed on a future occasion.*

16. Wild Sports and Natural History of the Highlands (of Scotland). From the Journals of Charles St John, Esq. Published in Nos. 36 and 37 of Murray's Home and Colonial Library. London. 1846. *We have perused this very amusing volume with much pleasure. From cur acquaintance, not only with the country so well described by the author, but also with its quadrupeds, birds, &c., we can answer for the faithfulness of his details; and are convinced no true lover of wild mountain and river sports will hesitate in considering M. C. St John as an intelligent observer, and skilful sportsman.*

17. Address on the Recent Progress of Geological Research in the United States. Delivered at the Fifth Annual Meeting of the Association of American Geologists and Naturalists, held at Washington City, May, 1844. By Henry D. Rogers, Professor of Geology in the University of Pennsylvania, Foreign Member of the Geological Society of London. Philadelphia. 1844.

18. An Easy Introduction to Chemistry. By George Sparkes, Esq. 2d edition, pp. 88, 12mo. Whittaker & Co., London. 1846. *This agreeable Treatise we recommend to our Chemical readers, and also to those commencing their Chemical Studies.*

19. On the Oscillation of the Barometer, with particular reference to the Meteorological Phenomena of November 1842. By William Brown jun. Richard and John Edward Taylor, booksellers and printers, London, 1846. *A very valuable and accurate record of good observations.*

20. Jahres-Bericht uber die Fortschritte der Chemiè und Mineralogie. Von Baron Jacob Von Berzelius. Tubingin, 1846.

21. The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. July 1846.

22. Journal of the Asiatic Society of Bengal. Three numbers for the year 1846.

23. American Journal of Science and Arts. Conducted by Messrs Sillimans and James D. Dana. May 1846.

List of Patents granted for Scotland from 25th June to 21st September 1846.

1. To John Davie Morries Stirling, of Black Grange, in North Britain, Esq., " certain new alloys and metallic compounds, with a method of welding the same, and other metals."—25th June 1846.

2. To John Mercer, of Oakenshaw, in the county of Lancaster, and John Greenwood, of Church, in the same county, chemist, " certain improvements in dyeing and printing turkey red and other colours."—26th June 1846.

3. To Peter Fairbairn, of Leeds, Esq., " certain improvements in atmospheric railways," being a communication from abroad.—30th June 1846.

4. To Elijah Galloway, of 14 Buckingham Street, Strand, in the county of Middlesex, civil engineer, " improvements in locomotive engines."—2d July 1846.

5. To William Henry Burke, of Tottenham, in the county of Middlesex, gentleman, " certain improvements in the manufacture of fabrics, which may, if required, be made air and waterproof, a part of the materials employed herein, when combined with other matters, being intended to produce coverings for vessels of capacity."—3d July 1846.

6. To John Fatham, of Rochdale, in the county of Lancaster, machine-maker, David Cheetham, of the same place, machine-maker, and John Wallace Duncan, of Manchester, in the same county, gentleman, " certain improvements in machinery, or apparatus to be used in the preparation and spinning of cotton and other fibrous substances."—3d July 1846.

7. To Antoine Perpigna, of Paris, in the kingdom of France, advocate, being a communication from abroad, " improvements in regulators for qualifying the actions of mechanical powers."—6th July 1846.

8. To George Leach Ashworth, of Rochdale, in the county of Lancaster, cotton-spinner, and Wilson Crossley, of the same place, manager, " certain improvements in machinery or apparatus for preparing and spinning cotton and other fibrous substances."—7th July 1846.

9. To William Pidding, of Wigmore Street, in the county of Middlesex, gentleman, " an improved process for preserving the flavour of coffee and cocoa, or of any preparations thereof, from the effects of the atmosphere."—8th July 1846.

10. To Charles Hancock, of Grosvener Place, in the county of Middlesex, gentleman, " certain improvements in the manufacture of gutta percha, and its application alone and in combination with other substances."—10th July 1846.

11. To Michel Borgognon, of No. 15 New Broad Street, in the city of London, gentleman, being a communication from abroad, " certain improvements in producing artificial basaltic lavas."—13th July 1846.

12. To Charles Chinnock, of Seymour Place, Little Chelsea, gentleman, " improvements in the construction and methods of extending and compressing articles of furniture and domestic use, also applicable to cutlery, workmen's tools, window blinds, shutters, and similar useful purposes."—16th July 1846.

13. To Peter Taylor, of Hollinwood, near Manchester, machinist, " certain improvements in machinery for propelling vessels, carriages, and machinery, parts of which improvements are applicable to drawing

and propelling fluids, also improvements in the construction of vessels."—21st July 1846.

14. To Nicholas Francois Corbin Desboissierres, of Rue St Pierre, Montmaitre, in the kingdom of France, gentleman, " improvements in preparing and burning fuel."—21st July 1846.

15. To Gustaf Victor Gustasson, late of Sweden, but now of Warren Street, Fitzroy Square, in the county of Middlesex, engineer, " certain improvements in steam-engines."—22d July 1846.

16. To Henry Highton, of Rugby, in the county of Warwick, Master of Arts, " improvements in electric telegraphs."—23d July 1846.

17. To William Seed, of Preston, in the county of Lancaster, machine-maker, " certain improvements in machinery or apparatus for preparing, slubbing, and roving cotton and other fibrous substances."—23d July 1846.

18. Robert Hodgson, of Neckinger Road, Bermondsey, in the county of Surrey, gentleman, " certain improvements in propelling vessels, and in the machinery for working the same."—28th July 1846.

19. To Augustus William Hillary, of No. 66 Cadogan Place, Chelsea, but at present residing at No. 146 Avenue des Champs Elysees, in the city of Paris, Esquire, " improvements in the manufacture of gas."—29th July 1846.

20. To Lawrence Hill junior, of Glasgow, civil and mechanical engineer, being a communication from Henry Burden, of Troy, in the United States of America, and partly by invention of his own, " improvements in the manufacture of iron for building ships and boats, and other vessels, and in instruments, machinery, and apparatus to be used in the said construction."—29th July 1846.

21. To Hugh Greaves, of Hulme, in the parish of Manchester, in the county of Lancaster, engineer, " improvements in the construction of railways, and in the vehicles to be used thereon."—3d August 1846.

22. To David Yoolon Stewart, of Montrose, in the kingdom of Scotland, iron-founder, " implements in moulding iron and brass."—5th August 1846.

23. To John Augustin Alexis Sauvage, of the Rue Richen, Paris, in the kingdom of France, mechanist, " improvements in condensing the steam of steam-engines, and in supplying water to steam-engine boilers."—5th August 1846.

24. To Christopher Binks, of Friars Goose House, in the county of Durham, chemist, " improvements in the manufacture, and in the application to useful purposes, of certain compounds of nitrogen and of carbon, more particularly cyanogen, ammonia, and their compounds."—6th August 1846.

25. To John Simson, of Riche's Court, Lime Street, in the city of London, merchant, being a communication from abroad, " certain improvements in machinery for preparing and spinning flax and other fibrous materials."—10th August 1846.

36. To John Brocklehurst, of Holburn, in the county of Middlesex, lamp-manufacturer, " certain improvements in the hanging and disconnecting of window sashes and frames."—10th August 1846.

37. To Robert Robinson, of Strines, in the county of Derby, calico-printer, and Thomas Bowden, of the same place, mechanic, " certain improvements in machinery for washing and cleansing cotton, linen, or woollen fabrics."—13th August 1846.

28. To Robert William Thomson, of Adam Street, Adelphi, in the county of Middlesex, civil-engineer, "an improvement in carriage-wheels, which is also applicable to other rolling bodies."—13th August 1846.

29. To Richard Whytock (extension of a patent to), of Edinburgh, manufacturer, for the term of five years, the original patent granted on the 21st September 1832, for "an improved method or manufacture which facilitates the production of regular figures or patterns on different fabrics, particularly velvets, velvet-pile, and Brussels, Wilton, and Turkey carpets, with a saving of material."—17th August 1846.

30. To Peter Claussen, of Leicester Square, in the county of Middlesex, Esq., "certain improvements in machinery for weaving."—18th August 1846.

31. To James Montgomery, of Salisbury Street, in the county of Middlesex, engineer, "certain improvements in the construction of steam-boilers and steam-engines, and in steam-vessels and the machinery for propelling the same."—18th August 1846.

32. To William Nicholson, of Manchester, in the county of Lancaster, engineer, and George Wadsworth, of Sutton Glass-Works, in the same county, manager, "certain improvements in the manufacture of glass and other vitreous products."—2d September 1846.

33. To Moses Poole, of the Patent Office, London, gentleman, being a communication from abroad, "improvements in treating vegetable fibres to render them applicable to the manufacture of paper."—2d September 1846.

34. To James Warren, of Montague Terrace, Mile-End Road, in the county of Middlesex, gentleman, "improvements in the manufacture of cast screws."—2d September 1846.

35. To John Spenceley, of Whitstable, in the county of Kent, master blockmaker, "improvements in the construction of ships and other vessels, and also improvements in apparatus to be attached to ships and other vessels."—3d September 1846.

36. To Frank Hills, of Deptford, in the county of Kent, manufacturing chemist, "a method or methods of treating certain gases and manufacturing sulphuric acid, muriatic acid, acetic acid, and certain salts of potash."—3d September 1846.

37. To Robert Nisbet, of Lambden, in the county of Berwick, Esq., "certain improvements in locomotive engines and railways."—4th September 1846.

38. To Frederick Crace Calvert, of Paris, in the kingdom of France, chemist, "improvements in the preparation of the article called fute, rendering the same applicable for various useful purposes."—9th September 1846.

39. To Charles Dowse, of Camden Town, in the county of Middlesex, gentleman, "improvements in the manufacture and finishing of fabrics, capable of being used as substitutes for paper."—11th September 1846.

40. To James William Bowman, of Great Alie Street, Goodman's Fields, in the county of Middlesex, sugar-refiner, "improvements in reburning animal charcoal."—21st September 1846.

41. To Alfred Vincent Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, mechanical draughtsman, being a communication from abroad, "certain improvements in machinery for manufacturing screws."—21st September 1846.

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END OF VOLUME FORTY-ONE.

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