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CANADIAN PHOSPHATES CONSIDERED WITH REFERENCE TO THEIR USE IN AGRICULTURE.

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Among the numerous sources of wealth included within the vast thickness of the Laurentian system,—those ancient metamorphic rocks developed on such a grand scale in our Canadian geology,—few are invested with a larger amount of scientific interest than the mineral apatite, a substance already ranking among our economics, and probably destined to constitute, in the future, one of the most important of the raw materials of Canada, one of those sinews of the country, upon which her industrial advancement must ever be primarily founded.

It is, therefore, highly desirable that what is at present known of the extent and character of the apatite deposits of Canada should at once be made available; and that the attention of this and other societies in the Dominion should be, to a proper extent, directed to facts relating to a mineral, at once so interesting and so practically useful.

With this in view, we would state, first of all, what are the purposes to which the mineral is adapted; the processes by which it is rendered available; and, as far as can be ascertained, the past and present extent of its usefulness.

Apatite, although of some importance to the manufacturer of the element phosphorus, and in the preparation of certain varieties of porcelain, derives its chief interest from its power, when used in conjunction with nitrogenous substances, of restoring exhausted lands to their original fertility, and of increasing the value, for agricultural purposes, of such as have always been, more or less, sterile and unproductive.

Phosphoric acid is an essential element of all but the lowest animal structures; and the large quantities of phosphate of lime found in the chitinous tests of Lingula, as well as in the shields of the Trilobitidæ, prove that the element phosphorus possessed, from the earliest geological epochs, the same importance, in its relation to the animal kingdom, as at the present day; and, since the sole source of the phosphorus in animal organisms is from the vegetable kingdom, it is not surprizing to find that the element is equally essential to the higher orders of plants, and, more especially to those which are the most adapted to the wants of animals.

The following Table, extracted, partly from the works of S. W. Johnson, and in part derived from Emmons' Report, on the Geology of North Carolina, exhibits this relation in a very striking manner, and proves, moreover, *that not only* the most nutritious plants, but also the most valuable portions of the same species contain the highest percentages of phosphoric acid:—

TABLE I.

PHOSPHORIC ACID IN THE ASHES OF PLANTS.

Series A—Edible Substances.	$P.O._5$ per cent.		$P.O._5$ per cent.
Rice	53	Rice straw	1
Rye	50	Rye straw	4
Wheat	50	Wheat straw	3
Maize	45	Maize straw	17
Oats	44	Oat straw	3
Barley	39	Barley straw	3
Beans	38	Bean straw	7
Peas	33	Pease straw	5
Turnips	13	Turnip tops	9
Potatoes	13	Potatoe tops	8
Clover	18	Beet root	8
Cabbage	12	Meadow grass	8

Series B—Miscellaneous substances.	$P.O._5$ per cent.
1 Leaves of Catawaba Grape	18.3
2 White Oak (Quercus Alba) Twigs	12·7
3 Do. do. Wood	4.5
4 Cotton (wool of)	11.6
5 Tobacco	6.5
7 Fibre of Flax	6.2
Seaweed (average)	0.28

AUTHORITIES:
Series I. Johnson.
Series II. 1-6 inch. Emmons.
7. Way.

The phosphorus of plants appears, for the most part, to be confined to the softer and more highly organized portions of the structure: there is but little to answer to the lime and magnesia phosphates constituting the main frame-work of the hard internal skeleton of vertebrata, or to those composing the exoskeleton of crustacea and lower orders. The phosphorus of a plant would seem to correspond more closely to that of the nervous and vascular animal tissues; as, for example, to that of the brain in man,—which amounts to 0·9 per cent. of the cerebric acid,—or of the albumin and fibrin of the blood.

The following Table (II), which might be greatly amplified, has been compiled for the sake of comparison:—

TABLE II.

PHOSPHORUS IN ANIMAL SUBSTANCES.

Ox Bone	12.25	Fremy.
Human Bone	9.21	Richardson.*
Lingula ovalis (shell—recent sp.)	17.16	Sterry Hunt.†
Mastodon (fossil bone)	17.13	Pratt.‡
Casein	1.42	Mülder.
Urine (human)	1.24	Berzelius.
Cerebric Acid (human brain)	0.90	Fremy.
Milk (of cow)	0.68	Haidlen.
Fibrin (of blood)	0.58	Fownes.
Albumin (of blood)	0.40	Mülder.
Gastric Juice, Saliva, Mucus, Etc., etc.	Traces	Fownes.

From the researches of chemists and physiologists it is now fully established that the element phosphorus plays a most important part in the performance of nerve functions; that it undergoes many, at present, inexplicable changes within the bodies of vertebrate animals; and that various of its oxy-compounds, produced by such changes, as well as the phosphates resulting from the waste of the bones, are constantly rejected from the system in a soluble condition.

There is, therefore, in the history of the element phosphorus, a beautiful example of a complete circle of changes; and of a number of substances existing, at one time or

* Chemical Technology, vol. ii, Article "Soluble Phosphates."

† First discovered by Dr. T. Sterry Hunt, who, in 1854, showed the shells of Lingula to have a composition identical with the bones of vertebrates. (Silliman's Journal [2], vol. xvii., p. 235.)

‡ Report South Carolina Phosphates, 1868 About 30 per cent. organic matter lost by decomposition, while the recent Lingula examined by Dr. Hunt had previously lost 38 per cent. of organic matter by calcination.

another, in each of the three great divisions of nature, and handed on, from the world of vegetable existence to that of animal life, before being finally returned to inorganic nature, thenceforth to be subjected to a number of chemical changes, preparing them for a new round of usefulness. But, in order to enable this great principle to operate completely and effectually, one thing is necessary; for, owing to the concentration of populations in towns and cities, one link, so to speak, in the chain, becomes faulty, and the return of phosphates to the soil must be aided by artificial means.

From whatever lands vegetable matters are removed in the annual crops, there is a constant withdrawal of the necessary mineral constituents of the plant, including, of course, the phosphoric acid; and, although poor or exhausted lands do not shew the entire absence of phosphates, yet they have become deficient in such phosphorus salts as are available for the use of the growing plant; and do not, especially, contain enough to suffice for the cereals, containing, as they do, a larger proportion of phosphoric acid than any other family of plants.

The grain of wheat contains about 8-10ths per cent. of phosphoric acid, which proportion amounts to 16 lbs. of the acid to each ton (=2,000 lbs.) weight of wheat. Now the amount of phosphoric acid in soil may said to average 0·2 per cent.; although, except in clays the proportion is usually less. Taking 0·2 per cent. as the average quantity, and assuming the specific gravity of soil to be 2.5, there exists in the soil covering one acre of land, to the depth of 12 inches, about 68.6 lbs. of phosphoric acid; or only enough to supply the phosphates to 4.16 tons of wheat. The total weight of wheat, (whether as grain, or in the state of flour) exported from the port of Montreal in 1869, amounted to about 292,534.5 tons*; or a weight requiring the total abstraction of phosphoric acid from 70,320.8 acres (=109.8 square miles) of good average land. This withdrawal of phosphoric

* This information was kindly furnished by Wm. T. Patterson, Esq., Secretary to the Montreal Board of Trade.

acid, equalling 2,340 tons (292,534.5×16=4,680,552 lbs. =2,340 tons) would require, in order to counterbalance the loss, the annual employment of 5,850 tons of apatite, containing 88 per cent. of phosphate of lime; a quantity equivalent to 6,864 tons of apatite of 75 per cent., or to 13,728 tons of "super-phosphates" of good quality.

The corresponding money value, at $35 per ton, makes the total annual deficiency no less than $480,480.

The losses resulting from the exportation of wheat alone (either as grain or flour) have been here estimated; and the following table, compiled from Mr. Patterson's Statistical Report, will afford some idea of the approximate worth of all the phosphates contained in crops annually shipped from this port:—

TABLE III.

SUBSTANCES CAUSING LOSS OF PHOSPHORIC ACID.

Shipments in the year 1869 for Montreal.	Amount or Weight.	Equivalent Phosphoric Acid. Tons of 2,000 lbs.	Approximate Value of Phosphoric Acid.
Flour (barrels)	966,067	} 2,340.0	$480,480.00
Wheat (bushels)	6,595,332		
Corn do.	108,018	24.3	4,989.60
Peas do.	576,984	115.4	23,695.40
Barley do.	163,372	29.4	6,036.80
Oats do.	330,738	65.5	14,989.20
Totals	....	2,574.6	$530,191.00

Moreover, the exports of wheat from British North America are only about 7½ per cent. of the total amount received by Britain: so that the phosphoric acid, exported by foreign countries for consumption in England, in the shape of wheat alone, *amounts to no less than* 31,200 *tons, and represents a money value of about* $6,406,400 *annually.*

Adding to this the imports of mineral phosphates, we have a *grand total of* $15,156,400.

From these figures it is at once evident that, wherever no restorative agents containing available phosphoric acid are employed by agriculturalists, the exhaustion of lands by wheat crops is by no means a slow process; even if the utmost allowance be made for the action of springs, and of waters flowing from uncultivated lands, in bearing to the soil minute quantities of phosphates, which might retard, although they would be by no means sufficient to prevent a gradual impoverishment.

It becomes, therefore, absolutely necessary to follow the principles laid down by Liebig,* and to *restore to the soils the cinereal elements of which they have been despoiled.* Hence the utility of farmyard and vegetable manures, as well as of various products of the chemical manufactures applicable to this necessary work of restoration. In no country, however, can such a return of the valuable components of its soils be sufficient to counterbalance the constant drain required merely to furnish the elements of growth to its inhabitants: for, if the utilization of sewage-matter and of every other kind of organic residua were effected to the uttermost possible extent,—a condition very far from being realized,—there would still always be a great unavoidable waste, by which the essential constituents of the soils would, in process of time, be sensibly diminished; and, since there are but few countries whose entire vegetable product is applied to the use of the inhabitants, but that, on the contrary, a certain proportion is almost always exported for the benefit of other lands, there is usually a far greater deficiency than that resulting from irrecoverable waste. This further loss is especially great to those newly peopled lands, whose rich virgin soils have constituted them the granaries of the Old World.

Thus a very large proportion of the vegetable produce of North America, in the shape of cotton, wheat, sugar, and tobacco, is employed in ministering to the necessities of European countries; and the result is a stupendous annual withdrawal of their necessary constituents from all soils occupied in satisfying these ever-increasing demands, and this is especially true with regard to their limited quantities of the salts of phosphoric acid.

* Agricultural Lectures, Letters, etc., by Baron Liebig.

The annexed table (No. IV.), derived from the analyses of Dr. T. Sterry Hunt,* shows how small is the proportion of phosphoric acid usually existing in soils of even the best quality; and hence it arises that there already exist so many partially, or even wholly exhausted soils in Canada, and more especially in the Province of Quebec, which might have been still yielding large returns of wheat crops had they been, from the first, subjected to a rational system of tillage, coupled with the judicious and periodical use of phosphatic manures.

TABLE IV.

ANALYSES OF CANADIAN SOILS, SHOWING THE PROPORTIONS OF PHOSPHORIC ACID PRESENT.

Character.	Locality.	PO_5 per cent.
(1) Sandy Soil	St. Charles...........	.215
(2) Clayey Soil	St. Hilaire	.390
(3) do. do.	St. Dominique	.152
(4) Sandy Clay	St. Hyacinthe	.189
(5) Clay Soil	do.	.252
(6) Clay	Chambly	.126

It is true that attempts have been made to utilize the residua of the Newfoundland fisheries, and that Dr. Hunt called attention to the subject in an Essay on Fish Manures in 1857;† but very little success has been met with in their employment in this country, chiefly owing to a want of the necessary knowledge or spirit of enterprise amongst the farmers themselves.

On proceeding to inquire into the means adopted by various nations to prevent the impoverishment of their soils, it is somewhat surprising to find that the great principles of agriculture, in respect to manures, were understood from the earliest times, and that the practice of some, apparently less

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* Canada Geological Survey Reports, 1849 and 1851; also, in abridgement, Report of 1863, pp. 636-642.

† Geol. Survey Report, 1857, pp. 218-229; and Canadian Naturalist, vol. IV.

civilized, communities was even far in advance of that existing among European nations,—at least, until the beginning of the present century, when the more systematic research of modern agriculturists was soon rewarded by a correspondingly rapid improvement in the practice of farming. From the earliest dates in their history, the Chinese appear to have been strict economists in respect to manures, the filth of the cities being most scrupulously collected for the enrichment of surrounding lands. Several passages in the Bible prove that Eastern nations were also aware of the importance of manures, and that the Romans were in the habit of employing them, is evident from the writings of Virgil; especially where, in his first Georgic,* he recommended the use of ordure, and of ashes, to fertilize the exhausted fields.

In no place, probably, are natural manures more religiously farmed than in the Channel Islands, on the coast of Normandy, celebrated for their rich pastures and excellent breed of cattle; and on the Jersey coasts, the extensive flats, existing between high and low water-mark, are actually portioned out into lots belonging to the different farmers, who, in the autumn season,—for the law only then permits its removal,—gather in the rank sea-week (termed Vrjack) as scrupulously as they harvest the produce of their fields, which mainly owe their fertility to the rich saline ashes resulting from the combustion of the sea-weed, itself a minute fragment of the enormous waste constantly poured into the sea from the rivers upon which London and other great cities are situated.† Innumerable have been the plans proposed by engineers and men of science for the utilization of this vast waste of animal products; and the partial success already attained begins to

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* "Sed tamen alteris facilis labor, arida tantum
Ne saturare fimo pingui pudeat sola, neve
Effetos cinerem immundum jactare per agros,"
Georgicon, lib. i;, lines 79-81.

† From Horace's epithet "vilior algâ," it is probable that the Romans were not aware of the fertilizing properties of sea-weed The stigma implied can no longer apply to the source of so many valuable salts, and of so much productiveness when used as a manure.

be shown in the increased productiveness of many fields and gardens upon the confines of London.

With regard to bones, their employment as fertilizers certainly dates as far back as 1770;* and the supplies at present required in England are chiefly derived from Germany, Prussia, and the Baltic coasts.† The catacombs of Egypt have actually been ransacked for their supplies of bones; and the mummies of her kings and warriors, scrupulously preserved for a thousand years, have at length been sold by their descendants, to aid in the nourishment of far off lands.‡

Of the enormous importations of guano, nothing need here be said, except that their annual amount is said to be 200,000 tons, with a value of about $12,500,000.

The attention of English merchants was first turned to purely mineral sources of manures by the statement, made by Liebig, in 1840, that, by treatment with sulphuric acid in certain proportions, they could be converted into soluble compounds;§ and, two years later, J. B. Lawes obtained a patent for the preparation of superphosphates from the mineral apatite, instead of from bones, which had even then reached a high price.‖ The supply of mineral phosphates was at first drawn from the great deposits of Estramadura, in Spain, (*Vide* table VI., for analysis of the phosphates from that locality); but the better kinds of the mineral were soon, to a great extent, exhausted, and the attention of manufacturers was then directed to the coprolithic phosphates—or fossilized exuviæ of the tertiary strata of Suffolk, and the older rocks of Cambridgeshire and North Wales, all of which are comparatively poor in phosphates, containing only from 30 to 50 per cent. of phosphate of lime. In 1854, the value of the "*superphosphates*" manufactured from mineral sources in England

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* See the works of Arthur Young, published about 1770.

† *Vide* Richardson and Watt's Chemical Technology, vol. ii., article "Soluble Phosphates."

‡ Had Shakespeare lived in the nineteenth century, there would have been an awful significance in the words—"*Cursed be he that moves my bones!*"

§ *Vide* Liebig's Lectures on Agricultural Chemistry.

‖ *Vide* Specifications for British Patents, 1842. (No. 9,253, May 23rd.)

was as much as $8,750,000; and the demand for the cotton lands of the Southern States of the American Union is now probably fully one-third of that amount.*

The coprolites are fast becoming dearer and poorer, and, consequently, owners of works in England are becoming every year more eager to satisfy themselves from foreign scources; of which those of Canada and South Carolina only are of any considerable magnitude.

The South Carolina phosphates are very comparable in character to some of the phosphatic beds of Great Britain; their quantity is apparently very great; but they are by no means rich, and average from 25 to 60 per cent. of phosphates. Large quantities, on the other hand, of the Laurentian apatites, on the shores of L. Rideau, in Canada, can be obtained, averaging from 60 to 85 per cent.; and the only wonder is that they have not been utilized long since, comprising, as they undoubtedly do, a source of much prosperity.

It is not the object of the present paper to describe the mineralogical characters of the Canadian apatites: much information upon the subject will be found in the Reports of the Geological Survey of Canada, for 1863 and 1866 †; and as, since those dates, many new localities have been discovered, subsequent Reports will probably complete the description. In this connection, the author would desire, in an especial manner, to acknowledge his indebtedness to Dr. T. Sterry Hunt, F.R.S., who has for many years past been periodically making public, in a readily available form, the results of his systematic and admirable researches in this branch of Chemical Geology, and, more particularly, in his valuable Reports issued by the Geological Survey of Canada. Reference may especially be made to the Reports of 1848, 1863, and 1866; to an Essay written for the Exposition (Paris) of 1867, and to the Report of 1847-48‡ where he mentions the first

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* Richardson and Watt's Chemical Technology, vol, ii., Article "Soluble Phosphates."

† Vide Geol. of Canada, 1863, and Report of Dr. T. S. Hunt, for 1866.

‡ Reports of Dr. T. S. Hunt, 1848, p. ; 1863, p. ; 1866, p. .

References to other labours in this subject will be found in the above-discovery by himself, in 1847, of the Apatite of Lanark Co., Ontario, and moreover, remarks on the probable value of the deposits, and their application to the manufacture of mineral manures,—a branch of industry then but in its infancy.

A few remarks upon the geological portion of the subject will be found in a paper read by the author at the Troy meeting of the American Association for the Advancement of Science,* in August last; as well as in a note, shortly to be laid before the Geological Society of London† : but the history of these interesting deposits is by no means complete; and it is hoped to return to the subject in a future communication to this Society.

Facts upon the *modus operandi* of the phosphatic and other mineral manures are more especially desirable; and it may be well here to briefly to discuss a few points connected with their action upon arable lands.

With regard to the relation of phosphorus to plant-life, we have, first of all, the well established fact that a deficiency of that element in the parent soils produces a corresponding diminution in the weight of the crop, and renders it, moreover, very liable to various diseases; and that the addition of phosphorus compounds, in a state fit for the nourishment of the plant, always effects a great increase of fertility. But, with regard to this increase, it has been found to be out of all proportion to the actual requirements of the growing plant with respect to phosphoric acid. The waters in contact with

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mentioned Reports, but it will be desirable to quote from that of 1847–48, now, unfortunately, almost inaccessible :—

"The phosphate of lime is largely contained in wheat, and the exhaustion of this ingredient is one great cause of the sterility of our worn-out wheat lands. In a grain-growing country like Canada, therefore, the existence of such deposits as these will prove of great importance."

"Under these circumstances, the limestone just described, which contains throughout it a large supply of this important substance, is certainly well worthy of the attention of our agriculturalists."

* On Apatites of Lanark Co., Ont., by Gordon Broome, F.G S Proc. Amer. Assoc., 1870.

† Laurentian Apatites of Canada, by the same. Quar. Jour. Geol. Soc. circ. February, 1870.

the roots may, and often do, contain a sufficiency of phosphates for maintaining unchanged the composition of the plant, and yet the addition of phosphatic manures produce a vastly increased yield. The only rational explanation of these facts, and that which the researches of agricultural chemists appear to corroborate, is that the phosphates, besides forming important elements in the actual material of the plant, are also able to act as carriers of the requisite nourishment to the growing parts; and that, just as, in the animal economy, certain substances, as, for example, the salts of iron, give a tone to the system by aiding the powers of secretion and cell-formation; so, in the vegetable world, and, more especially, in the important families of Graminaceæ and Leguminœ, phosphoric acid stimulates the assimilative powers, excites an increase of vitality, and, in consequence, augments the fecundity of the germ, and enlarges the proportional rate of increase. The consideration of certain analyses of Woods, published in the first volume of Dr. Percy's Metallurgy, and also of a series in Emmons' Report on the Geology of South Carolina for 1858, pp. 59-78, (and also the second series of Table I., *ante* p. 8) has led me to this conclusion; for such analysis shew that the twigs and leaves are richer in phosphates, and other mineral elements, than the bark or the solid wood; whilst, in the cotton-plant, Crace-Calvert has shown that more soluble acid-phosphate of magnesia exists in the pod, than in the husk or stalk.*

From Table I., it will be seen that, whilst the ashes of solid oak contain 4·5 per cent. of phosphoric acid, the quantity present in those of the young twigs amounts to 12·7 per cent., or more than 2·75 times the proportion present in the wood.

Those parts, therefore, which are pre-eminently in a state of rapid development, are the most abundantly furnished with phosphates, doubtless, having their own peculiar functions to perform in assisting the developmental process.

As to the manner in which plants derive their saline con-

* Brit. Assoc. Rep. 1860.

stituents from the soil, there is still some degree of uncertainty; whether they imbibe those salts already existing in a state of solution, and thus obtain the matter required for their growth; or whether they dissolve out certain elements from the soil, by the solvent action of their own juices.

Eichhorn's results demonstrate that *pure distilled water can dissolve from the soil much more of mineral matter than would be requisite for the supply of an ordinary crop.** The solvent powers of waters are also in almost every case, much augmented by the presence of carbonic acid, and occasionally, doubtless, by the existence in them of dissolved organic acids. † These acids do not, in all probability, exert any very important influence in dissolving food for the plant, so long as they exist in growing vegetation, but only on their being eliminated by processes of natural decay. When thus released, they are probably very active in dissolving compounds of sesquioxide of iron, and alumina; as is, indeed, abundantly proved by the occurrence in nature of such minerals as beauxite, mellite, pigotite and oxalite, compounds in which sesquioxide of iron or alumina, exist, combined with water and an organic acid.‡

The utility of decaying vegetable matters as a manure, may, consequently, be due as well to the solvent action of certain products of their decomposition, as to the fertilizing properties of their several mineral constituents.

The absorptive powers of soils tend, moreover, to concentrate within their mass certain mineral constituents, derived from small proportional quantities of them existing in infiltrating waters; and this absorption is very marked between phosphoric-acid compounds and soils of a clayey character, which seem especially adapted for their retention.

For the sake of demonstrating this fact, an experiment

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* Poggendorf Annalen, No. 9, 1858, etc.; also Johnson, in Silliman's Journal, [2] xxviii., 1869.

† Vide Chemistry of Natural Waters, by Dr. T. Sterry Hunt, in Sillimans Journal, 1865.

‡ *Ibid.*

was made upon a gray, infusible fire-clay, which proved, upon analysis, to possess the following percentage composition :—

Silicic Acid	{ combined silica.........37·99 } ...... { free sand...............20·50 }	58·49
Alumina (by difference)		26·79
Iron (protox.)		traces
Lime		0·12
Magnesia		traces
Soda		1·53
Potassa		1·52
Chlorine, Ammonia, and Phosphoric Acid		traces
Organic matter		0·08
Water (Hygroscopic 1·38)		11·47
		100·00

One hundred grammes of this clay were washed upon a large filter, until the filtrate was quite free from solid matter, and a solution (containing 10 grm. to 1 litre) of phosphate of soda was then caused to filter slowly through the mass, by a syphon arrangement, in about 24 hours.

The solution extracted a quantity of humic acid, dissolved out by the action of the alkaline salt, and *contained only* 8·312 *grammes of phosphate of soda*, with a little alumina, lime, and sesquioxide of iron. Such a clay being, practically a pure silicate of alumina and water, the large absorption is in a great measure due to a reaction between the hydrated silicate of alumina, or clay, and the phosphate of soda, resulting in the formation of a phosphate of alumina, and the fixing of a portion of soda at the same time by the aluminous silicate.

This power of clay was first explained by Way and Thomson;* though it was remarked by the Dean of Westminster in 1849,† who suggests that it is shown by the concentration of phosphates occurring in certain clayey nodules, termed Septaria, common in the Lias of England.

It is probable, that the formation of many great phosphatic deposits, of marine origin, including perhaps the Canadian apatites, is most reasonably explicable by referring to these

* R. Agric. Soc. Journ. Eng. (xi. 68-74 xii. 317-380 ; xiii. 123-140.)
† Brit. Assoc. Report, 1849.

absorptive powers; and this is rendered the more likely by the fact that all of the mineral waters occurring in the Palœozoic rocks of Canada, which Dr. Hunt beautifully designates as fossil sea-waters,* contain traces of phosphoric acid, resembling in this respect the waters of modern seas.

The absorptive powers of soils are due to a combined chemical and molecular action, the completeness of which is, to a very great extent, dependent upon the mechanical condition of the mass.

Soluble phosphates of lime, when thrown over the surface of the land, are quickly converted into the insoluble tribasic salt, by the action of carbonates and basic compounds; but the product, being in a state of extreme division, is readily dissolved by water charged with carbonic acid, and also, as shown by Liebig, by solutions of ammoniacal salts, or of the chlorides and nitrates of the alkalies.

These modes of solution are exceedingly important from an agricultural point of view, since they shew the advantage of compound manures, formed by the addition of ammonia or potash salts to the ordinary "super-phosphates." In an experiment, recently made by me, for the purpose of ascertaining the solubility of apatite in carbonic-acid water, it was found that, by digestion of the finely pulverized mineral for twenty-four hours, at a temperature of 60° F., agitating frequently, a saturated solution of carbonic acid is capable of dissolving $\frac{1}{2857}$ parts of the mineral. Similarly conducted experiments with solutions of sal ammoniac, and of potassic chloride, gave respectively, the proportions $\frac{1}{1528}$ and $\frac{1}{1711}$.†

Alkaline carbonates also dissolve apatite, with the formation of carbonate of lime and a phosphate of the alkali; and these reactions explain the existence of phosphate of lime in sea-water, a fact long since demonstrated by Clemm and Forchammer.‡

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* Vide Geology of Canada, 1863, pp. 561–564.

† Portions of a fine sea-green prismatic crystal of the Burgess apatite were used in these trials. For its composition, see Analysis on p. 18.

‡ J. fur Prakt. Chim. xxxiv., 185; also Berzelius, Jahresb, xxiv., 393.

By means of sulphurous acid, also, in a state of aqueous solution, apatite may be dissolved to the extent of about $\frac{1}{1388}$ parts, under the above conditions; but this last reaction has not such an important bearing upon the theory of agriculture as those already described.

The researches of Thénard, upon the action of clays on phosphate of lime in carbonic-acid solution, show that insoluble phosphate of alumina is formed, whilst the solution contains all the lime, as carbonate*; but, as the alumina in clays is not in the free state, an acid silicate of alumina is probably at the same time produced.

Thénard also stated (*loc. cit.*) that, by the action of an aqueous solution of silicate of lime upon phosphate of alumina, silicate of alumina is precipitated, whilst tribasic phosphate of lime (separable by means of carbonic acid) is also produced. By repeating Thénard's experiment, a solution was obtained, containing .011 gm. of lime silicate to the litre of water, which was completely decomposed in the manner indicated by Thénard, by long boiling with pure artificial phosphate of alumina, or with the clay previously used, which contains some phosphoric acid. Since, however, heat is requisite to the success of this reaction, it is more probable that, in nature, double silicates of alkalies with lime or magnesia, play the part here assigned to solution of simple silicate of lime.

Dehérain † asserts that the reverse of this reaction results between phosphate of sesqui-oxyd of iron and carbonate of lime: and it is probable that the surrounding conditions, as to temperature, relative amounts, and mechanical division, determine the nature of the resulting change. This was notably the case in Eichhorn's remarkable experiments upon the solubility of chabazite and natrolite in various saline solutions; and, on the whole, it would seem that the numerous known instances of departure from a regular order of affinities in such reactions tend to show that the relations of many bodies, with regard to their mutual affinities, are disposed to vary in

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* Compt. Rend. de l'Acad. des Sciences, Feb. 1, 1863.

† Quoted by Johnson, in the paper previously cited.

obedience to changes in the physical conditions under which they may be brought together.

Finally, in concluding this branch of our enquiries, it may be stated that, reasoning from the researches of Thénard, Eichhorn, Way, and others, Johnson was led to conclude that the efficiency of mineral manures is, in most cases, to be abscribed to their indirect action, and not, as had been previously supposed, to their direct influence as sources of food to the growing plant.

We may now pass on to consider the manufacture of "superphosphates" from the mineral apatite, which is at present in progress at but one factory in the Dominion of Canada, namely, at the Brockville Chemical Works, under the management of Mr. A. Cowan, to whose kindness I am indebted for the sample of "superphosphate," the analysis of which will be found below, as well as for valuable information with regard to the process employed. An engine of about fifteen-horse power suffices for grinding the mineral, for turning the agitator during the digestion of the apatite with crude oil of vitriol, and for supplying steam to the sulphuric-acid chambers, which are adjacent to the mills. The quantity of superphosphate of lime obtained does not, at present, exceed six tons per diem, owing to the insufficient yield of the acid chambers. The quality of the product will be seen from the following complete analysis recently made upon a fresh sample:

TABLE V.

ANALYSIS OF "SUPERPHOSPHATE," OF LIME,

(From Brockville Chemical Works, Nov., 1870.)

	Per cent.
Superphosphate of Lime $= Ca\,O.\,2\,H\,O.\,P\,O_5$.	20 . 33
Tribasic Phosphate of Lime $= {}_3\,Ca\,O,\,P\,O_5$.	2 . 39
Phosphate of Iron ($Fe_2\,O_3$)	2 . 23
——— Alumina	0 . 43
——— Magnesia	tr.
Dihydrated Sulphate of Lime Gypsum $= Ca\,O.\,S\,O_3 + 2\,H\,O$.	63 . 84
Insoluble in Hydrochloric Acid, (principally Mica)	3 . 59
Chloride of Sodium	0 . 45
Water	5 . 50
Alkaline Sulphates and loss	1 . 24
Total	100 . 00

Soluble Phosphoric Acid (P_2O_5)...............	12 . 33
Insoluble (anhydrous)	2 . 12
	14 . 45

To proauce this fertilizer equal weights of crude sulphuric acid (of chamber strength,) and of the finely divided mineral, are thoroughly mixed in a suitable vat, or tub, until the conversion is deemed complete, when a trap is raised at the bottom of the vessel, and the thick, pasty mass allowed to flow over the floor, where it soon becomes sufficiently consolidated to be packed in barrels. * English manufacturers are in the habit of storing their "superphosphates" in pits or cellars built for the purpose, and they thus obtain a fertilizer containing a comparatively small quantity of water. They also employ somewhat stronger acid, and agitate the mixture in covered vessels.

Table III shows the composition of six apatites, representing the pure mineral of different districts; the first analysis being one made upon a crystal of pure translucent sea-green apatite, from the "crystal vein," on lot 5, of the fifth concession of N. Burgess, which had a specific gravity of 3.209.

TABLE VI.

COMPARATIVE ANALYSIS OF APATITES AND PHOSPHORITE.

	I.	II.	III.	IV.	V.	VI.
Phosphoric Acid.............	41 39	41.25	43.01	41.99	37.18	42.34
Lime	49 79	53 84	55.24	55.95	54.0	55.08
Alumina	—	0.38	—	—	—	—
Calcium	4.18	—	—	—	—	—
Iron (Fe_2O_3)	tr.	Alks 0.17	0.09	—	3.15	0.04
Silicic Acid	tr.	0 82	—	—	1.70	—
Chlorine	0 38	4.10	0.05	0.01	0.20	0.34
Fluorine	3 58	und.	und.	4.20	2.16	und.
Water (Air dried)	—	0.42	—	—	—	—
Totals..........	99.32	101.81	98.69	102.15	98.47	97 80

I. Burgess, Canada.--Broome.
II. Krageroë, Norway.—Volckler.
III. Faldigl, Tyrol.—Joy.
IV. Tokovaia, Ural.—Pusirevski.
V. Estramadura, Spain.–Daubeny.
VI. Hurdstown, New Jersey, U. S.—Jackson.

I., II., III., and IV., Fluor-Apatites.
II. Chlor-Apatite. V. Phosphorite

* Each of which contains 286 lbs.

Apart from all associated matters, the apatite employed at the Brockville works may be said to contain 92 per cent. of phosphate of lime, and 7.2 per cent. of fluoride of calcium. When such a mineral, commingled with its gangue of calcite, is digested with a proper proportion of sulphuric acid, three separate reactions result:—

(*a*.) The tribasic phosphate yields up two-thirds of its lime to the free acid, the remaining atom forming, with the whole of the phosphoric acid present, the super-phosphate of lime (acid phosphate of lime).

(*b*.) The calcite is wholly converted into gypsum, with evolution of carbonic acid.

(*c*.) The fluoride is decomposed, with formation of hydrofluoric acid and gypsum.*

These reactions may be represented as follows:—

(*a*.) $3\ Ca\ O, PO_5 + 2\ HO, SO_3 = 2\ Ca\ O, SO_3 + Ca\ O, HO, PO_5$.

(*b*.) $Ca\ O, CO_2 + HO, SO_3 = Ca\ O, SO_3 + HO + CO_2{}^{\dagger}$.

(*c*.) $Ca\ F + HO, SO_3 = Ca\ O, SO_3 + HF^{\dagger}$.

From the consideration of the atomic weights of these substances, it will appear that 100·00 parts of phosphate of lime (tribasic) will require 51·61 parts of anhydrous acid (SO_3), to convert it completely into the acid phosphate; that 100·00 parts of fluoride of calcium requires 99·00 parts of the same anhydrous acid (or, in round numbers, an equal amount) to produce the reaction shewn in equation (*c*); and that 100·00 parts of calcspar will require 66·00 parts of acid for its complete decomposition.

One part of apatite, of the percentage indicated as representing the pure mineral of the Brockville works, will require $\cdot 92 + (\cdot 5161 \times \cdot 07,) = \cdot 545$ parts of anhydrous sulphuric acid exactly to effect the desired changes.

The following table (Table No. VII.), compiled from these

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* This irritates the workmen's lungs so greatly that they are in the habit of using rude respirators, formed of sponge. It is much more obnoxious in foggy, still weather, than when any breeze is blowing, which soon frees the works from the most penetrating and disagreeable odour.

data, exhibits the amounts of anhydrous acid, and also of acid, of specific gravity 1.712 (*i.e.*, of the usual chamber strength), necessary for the complete conversion of one hundred parts, by weight, of mineral containing various percentages of apatite, of the above composition, with a wholly calcareous matrix :—

TABLE VII.

ACID REQUIRED TO CHANGE APATITES TO "SUPERPHOSPHATES."

100 parts of Mineral composed of		Acid	Acid
Apatite.	Calcite.	Anhydrous.	Specific Gravity 1.712=134°T.
100	0	54.5	90-8
98	2	55.0	91.7
96	4	55.5	92.5
94	6	56.0	93.3
92	8	56 5	94.2
90	10	57.0	95.0
88	12	57.5	95.8
86	14	58.0	96.7
84	16	58.5	97.5
82	18	59.0	98 3
80	20	59.5	99.1
78	22	60.0	100.0
76	24	60.5	100.9
74	26	61.0	101.7
72	28	61.5	102.5
70	30	62.0	103 3
68	32	62.5	104.2
66	34	63.0	105-0
64	36	63.5	105 9
62	38	64.0	106.7
60	40	64-5	107-5

The use of this table is that it ought to prevent any danger of having free sulphuric acid in the product, or of proceeding further than the complete conversion of apatite into soluble phosphate. By means of a table of specific gravities, the quantity of acid, of any required strength, may be easily estimated for treatment of a given mineral.

The conversion of apatite into acid phosphate of lime may may also be effected by the use of hydrochloric acid, and, under certain circumstances, this method may be preferable to the use of the oil of vitriol. For 36·5 parts of hydrochloric acid (HCl.) will convert the same amount of phosphate into a soluble form as 40·0 parts of sulphuric acid (SO_3); whilst in the case of an apatite, *a further amount of vitriol is employed in the decomposition of fluoride of calcium.* By the employment of oil of vitriol to form hydrochloric acid, by acting on common salt, and using the product for the conversion of apatite, one part of vitriol may be made to answer to 1·14 parts of vitriol applied by a direct method; and, in the decomposition of calcite, one part of hydrochloric acid will answer to 1·096 parts of sulphuric acid.*

The saving of the acid employed, by the adoption of this method, would more than counterbalance the extra expense, and the chance of further loss by a multiplication of the operations; and another advantage over the ordinary process would result from the lime salt produced being the soluble chloride, and not insoluble (comparatively) gypsum, which, by mechanically protecting a portion of the apatite from complete conversion, doubtless accounts for the presence of 2·39 per cent. of unmodified lime-phosphate in the product analysed.†

The deliquescent properties of chloride of calcium have, however, been found, by many English manufacturers, to constitute a serious objection to the employment of hydrochloric acid: the product being apt to remain in a moist unsaleable condition.

It will not, however, be difficult to understand, from the remarks already made, that combined ammoniacal, or potassic, and phosphatic manures possess many advantages over simple "superphosphates," and that such composts are likely more and more to replace the ordinary soluble phosphates. English and German manufacturers are, indeed, fast learning to produce such compounds; and numerous nitrogenous substances have been utilized for this purpose, including products

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* 40 parts of SO_3 will produce from Na. Cl. 36·5 parts of H. Cl.

† Corrosion of chambers or vessels, and accessibility of the acid must in all cases be taken into account.

obtained from blood, or animal refuse, (as for example, the waste of the enormous butcheries at Chicago); others from the refuse of tan-yards; from the ammoniacal products of gas-works; and a number of the residua resulting from various chemical manufactories. "Superphosphates," produced by the action of muriatic acid upon apatites, might readily be dried up by these materials; thus overcoming the objections arising from the pastey condition of the product, and, at the same time nearly doubling the value of the fertilizer.*

Sulphurous acid, also, produced directly from the roasting of pyrites, has been applied successfully for the formation of "superphosphates" from animal sources; but further experiments on the subject are necessary, to shew whether it would, or would not, be applicable for the conversion of apatites or other mineral phosphates.

Before concluding the subject, one very ingenious process, patented by MM. M. L. Henrionnet and L. C. Boblique, in Nov. 1860, † (see Patent Abridgements, in Appendix to Richardson and Watt's Chemical Technology) may be noticed, in which hydrochloric acid, generated during the process itself, by the reaction taking place between steam, silicic acid, and common salt, is employed in the manufacture of soluble phosphates.

The finely pulverized apatite, mixed with 2-3rds parts of common salt, and about 18 per cent. of silica, is heated, in a current of steam, upon the bed of a reverberatory furnace; when the following reactions are produced:

(a) $Si\,O_2 + Na\,Cl + H\,O = H\,Cl + Na\,O,\ Si\,O_2$
(b) $3\,Ca\,O, PO_5 + 2\,H\,Cl = Ca\,O,\ 2\,HO,\ PO_5 + 2\,Ca\,Cl.$

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* Sawdust, previously saturated with sulphuric acid, has been patented, by Messrs. Sugden and Maryatt, for the absorption of ammonia from coal-gas. When exhausted, it contains from 40 to 60 per cent. of sulphate of ammonia, and is valued at from $25 to $30 per ton of 2,240 lbs.—Vide Report on Industrial Chemistry (Paris Exposition) 1867, by J. Lawrence Smith, U. S. Commissioner.

† Berzelius Jahresbericht.

The process possesses considerable theoretical interest, and would be, if practically effective, exceedingly economical.

And here my remarks must, for the present, be drawn to a close; much that remains to be said upon this comprehensive subject being postponed for a future opportunity: but I cannot conclude without giving expression to one thought, strongly impressed upon my mind by the consideration of these topics; namely, that the comparatively dormant state of this, and many equally obvious sources of industry in Canada, arises from a great deficiency in a most important division of our national education; and that nothing, save a liberal augmentation of the ordinary courses of instruction in modern subjects, can ever prove effectual in dispelling the immense existing cloud of ignorance and prejudice. It is, therefore, sincerely to be hoped that the very able remarks, recently made by Principal Dawson upon this question, may have their desired effect; and that Canada may speedily obtain a share in the improvements that have, of late, almost revolutionized the systems of education prevailing in the universities of the mother country.

SCIENCE EDUCATION ABROAD.

(*Extracts from a Lecture by Principal Dawson, LL.D., F.R.S.*)

WHAT IS SCIENCE EDUCATION?

In speaking of science, then, I would restrict your attention to the physical sciences, or those which relate to what we call material things. In this great group of sciences we may recognize three subdivisions, distinguished by the modes in which they are pursued, though shading into each other. (1) Mathematical sciences, or those in which the methods chiefly pursued are those of mathematical reasoning and calculations, as, for instance, astronomy; (2) Experimental sciences, of which chemistry and several departments of natural philosophy may be taken as examples; (3) Observational sciences, such as zoology, botany and geology. Each of these classes of subjects must be treated according to its own methods; and unless so treated, is useless whether as a means of training or for practical application. The learning, for example, of any of the natural sciences by "getting up" a text book without actual examples and work, is not of the nature of science education; and much of the undervaluing of science studies as a means of education, on the part of practical teachers, is due to their want of acquaintance with this first truth. Natural history or experimental science taught merely from books is only an indifferent form of verbal training, and it is no wonder that those who know it only in this way should form a very low estimate of its educational value. To be usefully taught, the pupil must be familiar with the actual objects of study, and he must understand experimentally the modes of attaining to results with regard to them. He will then receive a real and valuable kind of education, the benefits of which may be summed up as follows:—(1) The student is taught to observe, compare, and reason for himself, and this in a practical manner, not so easily attainable in other subjects, and tending to give an accuracy of method and quickness of perception, and of forming conclusions most valuable in actual life. (2) Much knowledge of a useful and interesting character is acquired; and the student, while learning the uses and properties of common things, may rise to large and enlightened conceptions of the works of God, and the natural laws under which man exists. (3) Men are trained to pursue original investigations, and thus to enlarge the boundaries of science. (4) The means are afforded to utilize natural resources and improve arts and manufactures. With regard to the extent and nature of such science education, it appears to be the result of experience in all the more advanced countries; (1) That there should be special practical schools to train investigators and practical science workers in the departments most important to the welfare of the community. (2) That science study should form some part of a liberal education. (3) That the elements of some of the natural or physical sciences should be taught in all the common schools. (4) That means should be employed to train competent teachers of science. This being what I understand by science education, with reference to its nature, results and methods, let us glance at some of the efforts put forth on its behalf, more especially in the mother country.

THE ROYAL SCHOOL OF MINES, LONDON.

In London the principal institution for science education, supported directly by the Government, is the Royal School of Mines, Jermyn street, with which is associated the Royal College of Chemistry in Oxford street.

The Royal School of Mines is an outgrowth of the Geological Survey of Great Britain, whose building it shares, and whose officers are its chief directors and instructors. This association gives it great advantages in securing the influence and management of the distinguished head of the Survey, Sir R. I. Murchison, and the services of such eminent practical geologists and naturalists as Huxley, Etheridge and Smyth, as professors, in giving the students access to large and admirable collections in geology and an extensive scientific library, and in placing the young men under the immediate superintendence of those who have the best opportunities for opening up to them the paths of usefulness and success. The very atmosphere of such an institution savours of practical science, its appliances for work and study are of the most inviting description, and it has several prizes and scholarships for its more deserving stndents, and gives the title of "associate" to those who pass its final examination. Notwithstanding these advantages, though it has many occasional or partial students, the number of regular students has been much smaller than could be desired. This may in part be accounted for by its situation in a city not directly interested in mining, and remote from the great manufacturing districts; in part, perhaps, by the want of appreciation of the advantages of science training on the part of the English public. It is certain, however, that the School of Mines, though its instructing officers are second to none in the world, is inferior to the great science schools of America and the continent of Europe in its academical organization, in the completeness of its course, more especially in the direction of literary and mathematical culture, and in the standard of attainment required for entrance. Were it improved in these respects, and enabled to offer a larger number of direct prizes to students, its usefulness might be greatly increased. Still, with these limitations, the success of the school has been great. It has trained a succession of competent men for geological surveys in the United Kingdom and the colonies. Among others, the present head of the Geological Survey of Canada is one of its graduates.

It has also sent forth a number of trained men into mines and manufactures, who have been very successful, not only in introducing new improvements and inventions, but in realizing fortunes for themselves; and it is stated that the demand for these men is much greater than the supply. The course of study in the School of Mines extends over three years, and in the senior year the students are allowed options, by virtue of which they may devote themselves specially to chemistry, mining or geology.

The Royal College of Chemistry is a distinct institution, situated in a different part of the town, which is a cause of some inconvenience to the students of the School of Mines, who have to attend its lectures and classes in practical chemistry. It was established originally by a private subscription, but has been adopted by Government. Under the able management of Prof. Frankland, it is a useful institution, and always crowded with pupils. It has, however, accommodation for *only 42 practical* students, and this by no means of the airy and sumptuous character to be found in the laboratories of the continent of Europe and the United States. Crowded among the shops of a noisy business street, it has no room for extension, and its teachers and students have to submit to many inconveniences which might readily be obviated were it removed to a more central locality, and provided with a laboratory fitted up with modern improvements. It must, however, be admitted that the utmost possible use has been made of its too limited accommodation.

THE DEPARTMENT OF SCIENCE AND ART.

The Royal School of Mines, as well as the Royal College of Science, Dublin, and the Edinburgh Museum of Science and Art, are under the direction of the Government Department of Science and Art; but its largest sphere of operations is in the great South Kensington Museum, and the schools connected with it throughout the country. In its last report these schools and classes are stated at 525 in all, with an aggregate of 24,865 pupils. This represents much science teaching; all, however, of an elementary character, and of small amount relatively to the great population of Britain and Ireland. Much of the teaching is necessarily done by teachers of a very humble grade of scientific attainment; but the most effectual means are taken to ascertain that it is faithfully done, and to give it opportunities for improvement. The principle adopted is that of giving money aids to teachers, building grants, grants for apparatus, &c., scholarships and exhibitions, medals and prizes to pupils. All of these are awarded on the results of rigid examination, conducted by papers sent from London and reported on by examiners, among whom are some of the first scientific men in the country. The aids to teachers are at the rate of £2 per annum for each first-class pupil, and £1 for each second-class pupil; and the teacher, in order to receive aid, if not a University graduate, must have obtained at least a second class in the advanced grade of these examinations. Of the aids given to pupils a number are in the form of exhibitions in aid of attendance on higher science schools, and in the case of the higher Government schools the fees are remitted in favor of students taking these exhibitions. It would be difficult to imagine a system likely to do more good, and all that is wanted is that it should be further extended, and that more thorough means should be adopted for training the teachers.

SOUTH KENSINGTON MUSEUM.

The most conspicuous part of the establishment at South Kensington is its museum, embracing a vast collection of objects illustrative of industrial products, art and manufactures, and one of the most popular and useful places of instruction by the eye in London. It is proposed to remove to the extensive buildings at South Kensington the vast Natural History collections of the British Museum, and also the collections of the Geological Survey, so as to promote science study as well as that of art. Art education on an extensive scale is conducted at South Kensington itself, as well as in a multitude of affiliated art schools. More especially, young persons are trained as teachers, and with reference to practical applications to decorative art of every description. As illustrations of these, I was shown large collections of patterns for wall papers, table cloths, pottery, and coloured and engraved glass, prepared by the pupils for competition for prizes offered by manufacturers; while in a gallery of the museum, assistants were busy in arranging a vast collection of drawings and paintings sent in from affiliated schools for competition. In the Art training school I saw hundreds of pupils engaged in all kinds of work, from the elements of drawing to studies in painting and modelling from life. In addition to the study in the schools, the students, of whom there are between eight and nine hundred, have access to the Galleries of Art in the

Museum, and to an Art Library of 25,000 volumes, and a collection of 55,000 engravings and photographs. Last year 107 schools were conducted under the "Department" with 20,000 pupils; and in addition to these, elementary drawing was taught in 1,094 schools to 120,928 children. Though art is distinct from science, I think it proper, when speaking of South Kensington, to refer to its work in art as well as in science. Not only is science the handmaid of art, but art is also the handmaid of science, and both must flourish or decay together. More especially the study of art in its application to the wants of ordinary life, cannot fail to be auxiliary to the advancement of science. It is a matter of profound regret that the Boards of Art, organized in this country more than ten years ago, have been permitted to languish, and have not been enabled to establish here institutes on the plan of those of the Department of Science and Art in England.

THE LONDON UNIVERSITY.

University College, London, has no organized science school, but it trains men for the Bachelor of Science examination of the London University. This is a general science examination, implying the training necessary for matriculation, and subsequent studies in Physics, Chemistry, Animal Physiology, Geology, Logic, and Moral Philosophy. Bachelors of Science of two years standing can go up for an examination for the degree of Doctor of Science. These science degrees of the University of London do not lead directly to practical work, and this is an important defect in the system, but they are, no doubt, very important as stimuli to the general preparatory training required by every man of science. The Bachelor of Science degree, as offered by the University of London, has also undoubtedly tended to raise science to its proper status in connection with the higher education, but it is not as yet largely taken. At the graduation in May last, at which I was present, there were only eleven Bachelors in Science and seventy Bachelors in Arts. This arises in part from the want of prestige and antiquity in the degree itself, and in part from its having to compete with the honours in science which may be taken in courses in arts, and with the special science schools.

The Birkbeck laboratory of University College accommodat 24 practical students; and I was pleased with the ingenious arrangement of its theatre, by means of which 98 students can be employed simultaneously in making experiments with tests, under the direction of Professor Williamson and his assistants. This is only one among many indications which I observed of the tendency to give to examinations and instructions in science a practical character, an evidence that its true nature is being more and more appreciated.

THE ROYAL INSTITUTION.

It would be wrong to leave London without referring to the remarkable and unique establishment known as the Royal Institution, founded in 1799, at the suggestion of Count Rumford, and celebrated throughout the world as the theatre of the labours of Davy, Faraday and Tyndall, while in London itself it is known and valued as an agreeable and popular exponent of science by means of its lectures and discourses. The Royal Institution has a good building in Albemarle street, containing its theatre, laboratories, library and reading-room. Its function is two-fold. First, it sustains as its professors eminent scientific men, and provides them with the means for prosecuting original research; secondly, it provides, by its afternoon and evening lectures, the means of presenting to the more refined and educated classes information as to the latest results of scientific discovery from the lips of the actual discoverers themselves. Its lecture-room is always filled with a cultivated and attentive audience, who have the advantage of learning orally and at first hand what others must gather from reading, or from secondary sources.

The Royal Institution thus occupies a middle place between the general public and those Scientific Societies, like the Royal, Geological and Linnean, whose objects are strictly scientific or special, and whose meetings are consequently almost entirely composed of scientific men. At the same time, it promotes original research in a manner peculiar to itself, and in the highest degree successful. It undoubtedly exerts a most important influence in keeping those who move in the higher strata of society in London abreast of the science of the day, and thus in procuring moral as well as material support for scientific researches; more especially for those which, not being of direct educational or practical utility, are liable to be neglected even by the more intelligent portion of a community engrossed in the accumulation of wealth or in the still more laborious pursuit of spending it.

OWEN'S COLLEGE, MANCHESTER.

In the great manufacturing community of Manchester, academical education rears its head in an institution of no mean repute in the matter of science education. Owen's College is, like our own McGill, based on the liberality of a wealthy merchant, whose name it bears, supplemented by numerous additional benefactions. Among these I find a sum of £10,000, subscribed by 118 merchants and others, for a chemical laboratory and a library; a sum of £9,472 subscribed by the principal engineers of Manchester and neighbouring towns, for the foundation of a chair of civil and mechanical engineering, and a fund of £200 per annum to augment the endowment of the Professorship of Chemistry. These noble benefactions remind us of the liberality of some of our Montreal merchants and professional men, and should act as a stimulus to others.

I am indebted to Principal Greenwood and Professor Williamson for enabling me to learn the nature and results of the science teaching at Owen's College, which, in many essential respects, more nearly resembles one of our Canadian colleges than any other institution which I saw in England. The department of general literature and science, or, as we should say, the course in arts, extends over three years. and, like our own, includes a certain amount of modern languages, and physical, natural, and mental science. The department of theoretical and applied science, or science course proper, also extends over three years. The first is identical with the first in arts. The second and third are occupied entirely with science subjects, along with the French or German language. The students in this department are prepared for the Bachelor of Science examination at London. This course is said to be suited to prepare "for the higher departments of manufacturing art, and for pursuits and professions purely scientific." It is also said to be "adapted for such as are hereafter to be engaged in commercial pursuits," a remarkable testimony to the ideas of education on the part of business men at Manchester, who, in this respect, come up more nearly than any others in England and her colonies to the standard of the New England cities. The Principal informed me that there were, last session, 100 students taking this science course. The third department in Owen's College is that of civil and mechanical engineering, in which students are prepared for the examinations in engineering in the Indian Public Works Department, and also for entering on the higher branches of the engineering profession. The course extends over three years. It had only twenty students last year.

Another and most interesting feature of Owen's College, suited to its position in a great manufacturing town, is the provision made for evening classes. These include the subjects of the general course, and also a pharmaceutical course intended to prepare chemists and druggists for the examinations under the Pharmacy Act. Most of the students in these classes are what we would call partial students; but some study for the degree of B.A. of London University. The intention of the college is to accommodate those whose business engagements prevent them from attending lectures in the day time; and the number of students last year was no less than 400. This is a remarkable indication of the avidity for learning on the part of the young business men of Manchester, who enter on this somewhat severe course of study as an employment for their evenings, and after the toils of the day. It is further to be considered that many of these young men have to walk or drive considerable distances in order to attend these classes; but in all the cities of England distance is much less regarded than it is in this country. Prof. Roscoe delivers a separate course of lectures on chemistry to women, which, I was informed, had been successful, though I did not note the number of students. The authorities of the college have under consideration the establishment of a regular academical course for women, which will be largely of a scientific character.

Owen's College has its class rooms at present in an old building adapted to its use; but an elegant new building is now in process of erection at a cost of £90,000, and a sum of £130,000 is said to have been raised as a building fund. The foundation stone of this building was publicly laid in September last. It is to be observed that Mr. Owen wisely prohibited any portion of his endowment fund being expended in buildings, and that the Government of Great Britain has given no aid to Owen's College, so that this large sum is a product of private munificence, chiefly in the town of Manchester.

SCIENCE TEACHING AT CAMBRIDGE.

The two great English Universities of Oxford and Cambridge are obviously not content to lie under the aspersion some time ago cast on them by an eminent scientist that their "atmosphere" is *unfavourable to scientific study. Both are making rapid strides* in this direction.

At Cambridge, under the kind guidance of Prof. Stokes, himself one of the most eminent of living physicists, and of the patriarchal Sedgwick, and his able assistant Seeley, I saw the improvements which in late years have been made in the means of study in natural and physical science, and which tend, with other changes, to give greater effect to the regulations in favor of the natural science tripos. Still more recent movements in this direction are the appointment of a university professor of pure physiology, and the movement in aid of a university professorship and demonstratorship of experimental physics, towards the buildings and apparatus for which, the Chancellor, the Duke of Devonshire, has offered a contribution of £6,300.

WHAT OXFORD IS DOING.

Oxford has, however, taken the lead of its sister University in this matter, and I shall therefore notice more in detail what I had the pleasure of seeing there in the way of provision for practical science teaching.

The new museum, now of world-wide reputation, is not merely a museum in the more modern sense of the term, but a series of scientific laboratories and class-rooms, attached to a magnificent *library and museum. The museum proper* had been largely increased and improved in its collections since my last visit in 1865, and its great central glass-roofed court, more than 100 feet square, with its surrounding galleries, is now well filled with specimens in Geology and Zoology. On the south and west sides the museum is encompassed with class-rooms and laboratories in geology, chemistry and physical science. On the north side are the laboratories and class-rooms in physiology. Prof. Phillips was absent, owing to an attack of illness, and in his department I saw only assistants engaged in laboriously piecing together the huge bones of the Cetiosaurus, a gigantic reptile with thigh bones more than five feet in length, of which a magnificent skeleton has recently been discovered in a quarry not far from Oxford. I had, however, the pleasure of seeing the students at work in the laboratory of practical chemistry, under Prof. Brodie, and of examining the admirable arrangements of Prof. Rolleston for practical work in physiology. Among other things which I saw in the physiological laboratory, were excellent dissections of mollusks and worms made by students as a part of their examinations in the honour course of Natural Science.

Though the museum contains rooms for experimental physics, the University has greatly enlarged its means of instruction in this department, by the erection in the vicinity of the museum of a physical laboratory, which I believe will cost about £40,000, and which, in the perfection and completeness of its arrangements, will surpass all similar workshops of science, not only in England, but in the world. Prof. Clifton, who himself showed me the building, and explained its plan, has endeavoured to make this laboratory in itself a model of practical science, considered as the art of doing everything in the best way, by applying in the most perfect manner every known improvement and many original inventions of his own, to secure convenience and accuracy of working. The building has a central hall for apparatus, and for certain experiments requiring large space; a class-room, which is a model of acoustic perfection and mechanical arrangement; and a number of work-rooms, in which all the most delicate kinds of operations in weighing and measuring can be carried on with the best apparatus and with every precaution against error. This laboratory was to be opened in the present autumn, and I was informed by Prof. Clifton that he expected to begin with about thirty practical students. The object of the laboratory is two-fold—(1) to train observers and experimenters more thoroughly than heretofore; (2) to undertake original physical researches with more perfect appliances than those now available.

The Oxford new Museum, with the neighbouring Physical Laboratory, thus constitutes in itself a great educational institution in physical science, managed by some of the ablest instructors and original investigators of the day, and providing for studies in experimental physics, chemistry, mineralogy, geology, physiology, and zoology, botany being otherwise provided for in connection with the Botanic Garden: It has seven large class-rooms and a multitude of working-rooms and laboratories, with the scientific department of the Radcliffe Library. These appliances are as yet large in comparison with the number of students who use them; but the number of students is increasing, and this apparently not at the expense of the literary courses of study. It is to be observed, moreover, that the aim of the Oxford Science School is high. Its object is not so much to train practical workers in science as applied to the arts, as to give the education necessary to enable those who receive it to take their places as original investigators in the advancement of theoretical science, and in connection with this to bring out the true value of physical science as a means of securing the highest mental culture. Viewed with reference to these ends, Oxford is undoubtedly an excellent Science school; and a University which offers its highest honours, in courses, in which practical chemistry and physics, and dissections of invertebrate animals, constitute important parts, cannot be regarded as unfavourable to the cultivation of science. It must be admitted however that these improvements have been effected only after severe contests between the advocates of modern science and the conservative element in the University, contests in which my valued friend, Dr. Acland, well known to many of us here, has borne an influential part.

MOVEMENT IN EDINBURGH.

Edinburgh has as yet no organized Science school, and has undoubtedly been falling behind the English schools in its reputation for training in natural science. This is, however, a relative rather than an actual decadence, and there is a very strong desire on the part of many of the friends of the University to restore its ancient reputation in this respect. In evidence of this we have the recent endowment of the Baxter Chair of Engineering, and the still more recent offer of Sir Roderick I. Murchison to give £6,000 as the endowment of a Chair of Geology, which I am informed the Government is likely to supplement with a like sum. The Department of Science and Art has also attached to the University a museum on the plan of that of South Kensington, under Prof. Archer; but few lectures are delivered in connection with it. No Institution in Great Britain has a better field for science education than Edinburgh, and it possesses many excellent teachers, but their action is to some extent paralyzed by want of facility for mutual co-operation, and by the want of some professorships necessary to complete the course of study. In the meantime, there are excellent practical classes in chemistry, experimental physics and botany, and there is an academical course for a science degree. In this course the candidate is required to have the degree of B.A., M.A., or M.D., or to hold certificates of having passed the examinations in two of the departments of the University course, or to have matriculated in the University of

London. Otherwise he must pass a preliminary examination. He must then pass a general examination in mathematics, physics, chemistry, zoology, and botany; but may omit this examination if an M.A. who has taken honours in natural science, or an M.B. or M.D. who has taken honours in natural history, and has passed the examinations in physics, higher mathematics, and logic. There is then a final examination, in which the student may select one of three branches in which to pass, viz.: (1) Mathematical science; (2) physical and experimental science; (3) natural science. On passing this examination he is entitled to the Degree of Bachelor of Science; and at the end of twelve months may come up for the degree of Doctor of Science, in the examination for which he must show profound knowledge of a special scientific subject. The number of candidates for these degrees is not as yet large, but is increasing. They might obviously be rendered much more valuable and attractive by connection with special science courses, leading to applications to the arts or to definite branches of original research.

It may be well to mention here that the Principal of Edinburgh University, in his inaugural address, has suggested the omission of Greek from the University course for M.A., to make room for science culture, and that the chairman of the endowed Schools Committee has, as already mentioned, put this idea in a practical shape before the English Universities, in an official letter to the Vice-Chancellors, in which he intimates the design of the Commissioners to establish schools in which Latin alone shall be taught, in addition to science and modern languages and literature, and invites them to open their examinations for degrees and honours to the pupils of such schools. While it is to be doubted whether any such change is required here, where classics have not been so exclusively insisted on in the schools as in England, the arguments adduced by Lord Lyttleton in his circular are well deserving of study, as indicating the strong feeling among parents and educated persons in England that science education for their children is a matter of absolute necessity, and that, if it cannot otherwise be obtained, some portion even of their cherished literary culture must be sacrificed to a want, on the supply of which even national existence may depend.

GERMANY AND SWITZERLAND.

But though much is being done in England and the United

States, science and technical education are carried to a still higher point in Germany and Switzerland, which perhaps excel all other countries in this respect. In the former country, while every one is educated, general education is made to lead to technical education in a great variety of schools, suited topersons in all conditions of life, and culminating in the great technical Universities, a kind of institution as yet unknown in the English-speaking world, unless Cornell University can be regarded as a step in this direction. In Germany there are now no less than six technical Universities, and a large number of technical colleges or higher schools to train students for these Universities, or for directly entering into employments in arts and manufactures.

TECHNICAL UNIVERSITIES.

Mr. Scott Russell, in his work on Technical Education, takes the Polytechnicon, or Technical University of Switzerland, as an example of the most perfect organization of this kind; and I may abridge from his notes the following facts as to its scope and organization. Its courses of study are arranged under 145 subjects, divided among 31 professors, 10 assistant professors, and 16 private teachers and lecturers. They consist entirely of science, applications of science to the arts, and modern languages, literature and history. Among the few subjects not included under these heads are the Swiss federal consititution and rights, and the Biblical History of Creation, a subject scarcely thought of in the English world, even in the education of theological students. The students are either regular or "free," the latter taking selected courses; but of 762 students only 173 are free or occasional. In the regular programme of study the 145 subjects above referred to are divided into eight groups: (1) Preparatory subjects necessary for those who come imperfectly prepared; (2) subjects relating to architecture and building; (3) civil engineering; (4) mechanical engineering; (5) practical chemistry; (6) agriculture and forestry; (7) subjects necessary for scientific workers, professors and teachers; (8) a general course of philosophy, statemanship, literature, art, and political economy. In aid of these courses of study the University possesses an astronomical observatory, arranged for teaching observers; a chemical and mechanical laboratory, for experiments in new inventions, &c.; a chemical laboratory, for ordinary practical teaching, which Mr. Scott Russell calls a palace of science in comparison with similar places in England; collections of drawings, models and machines; a collection of architectural models and sculpture; collections in zoology, geology, and antiquities; and a botanical garden. To the foundation of the University the Federal Government of Switzerland contributed £20,000, and the canton of Zurich £136,000. Its annual expense is very moderate, being only £13,459 sterling. From such institutions in Germany and Switzerland annually proceed numbers of educated young men who are prepared to advance every branch of art by the applications of science, who are distancing England in so many manufactures, and who are now contributing so largely to the wonderful success of the German armies. It is well for us to remember that the Technical University of Zurich ministers to the wants of a population of only two millions and a half, or considerably less than that of Canada, and that even the little state of Wurtemburg, with a population of less than two millions, has its Technical University at Stuttgardt, with no fewer than 57 professors and teachers. It is further to be observed that these Universities are but the higher principles of a complete system of technical education, descending from them to the humblest schools of practical science, for the children of labourers. It is scarcely necessary to add that they do not detract from or interfere with the great general Universities of Germany, in which scholarship and philosophy have reached so high a pitch of development.

A recent English writer thus eulogizes the Prussian system:—

"The Prussians, whatever their other qualities, are emphatically a scientific people, and to that predominating characteristic first and foremost are their recent military triumphs due. We do not mean that because they are great chemists, astronomers, and physicists, therefore are they necessarily great soldiers; so narrow a proposition would hardly be tenable. What we mean is that the spirit of science possesses the entire nation, and shows itself, not only by the encouragement given throughout Germany to physical research, but above all by the scientific method conspicuous in all their arrangements. What does the word Science, used in its wider sense, imply? Simply the employment of means adequate to the attainment of a desired end. Whether that end be the constitution of a government, the organization of an army or navy, the spread of learning, or the repression of crime, if the means adopted have attained the object, then science has been at work. The method is the same, to whatever purpose applied. The same method is necessary to raise, organize, and equip a battalion, as to perform a chemical experiment. It is this great truth that the Germans, above all other nations, if not alone amongst nations, have thoroughly realized and applied, In all the vast combinations and enterprises with which they have astonished the world, no one has been able to point to a single deficiency in any one essential element. Every post has been adequately filled and every want provided for; from the monarch, the statesman, and the strategist, to the lowest grade in the army. This is the method of science, literally the same method which teaches the chemist to prepare his retort, his furnace, and his re-agents, before commencing his experiment."

WANT OF SCIENCE TEACHING IN CANADA.

Let us now turn to our own country, and study its means and appliances for the pursuit of practical science. The task is an easy one, for with the exception of two or three small and poorly supported agricultural schools, this Dominion does not possess a school of practical science. With mining resources second to those of no country in the world, we have not a school where a young Canadian can thoroughly learn mining or metallurgy; and, as a consequence, our mines are undeveloped or go to waste under ruinous and unskilful experiments. With immense public works, and constant surveys of new territories, we have not a school fitted to train a competent civil engineer or surveyor. Attempting a great variety of manufactures, we have not schools wherein young men and young women can learn mechanical engineering, practical chemistry, or the art of design, or we are very feebly beginning such schools. We have scarcely begun to train scientific agriculturists or agricultural analysts. Our means for giving the necessary education to original scientific workers in any department, or of training teachers of science are very defective. Hitherto we have been obliged to limit ourselves to the provision of general academical courses of study, and of the schools necessary for training men in medicine, law and theology. Other avenues of higher professional life are, to a great extent, shut against our young men, while we are importing from abroad the second-rate men of other countries to do work which our own men, if trained here, could do better. Let us enquire then what we are doing in aid of science education, more especially in this commercial and manufacturing metropolis of Canada, which we may surely venture to regard as at least a Canadian Manchester, and something more important than a Canadian Zurich.

WHAT IS BEING DONE IN MONTREAL.

(1) We have at least advanced so far as to regard physical science as a necessary part of a liberal education. In McGill University some part of natural or physical science is studied in each year of the College course, and we provide for honour studies in these subjects, which are at least sufficient to enable any one who has faithfully pursued them to enter on original research in some department of the natural productions and resources of the country, and to receive some considerable portion of the training which such studies can give. We have provided in our apparatus, museum, and observatory, the means of obtaining a practical acquaintance with several important departments of science. But in a general academical course of study too many other subjects require attention to allow science to take a leading place; and it is not the proper course of educational reform to endeavour to intrude science in the place of other subjects at least quite as necessary for general culture. We require to add to our general course of instruction special courses of practical science, presided over by their proper professors, and attended by their own technical students.

(2) The lower departments of science education are to some small extent provided for by the teaching of elementary science in the schools. This, imperfect though it is, is of value, and I attribute to the partial awakening of the thirst for scientific knowledge by the small amount of science teaching in the ordinary schools in the United States and in this country much of that quickness of apprehension and ready adaptation to new conditions, and inventive ingenuity which we find in the more educated portions of the common people. The Provincial Board of Arts and Manufactures also deserves credit for the attempts which it has made, under many discouragements, to provide science and art classes for the children of artisans. Proposals are also before the Local Legislature for Schools of Agriculture. The Local Government has procured reports on this subject from the Principals of the Normal Schools, and has also sent a special agent to study and report on the Agricultural Schools of France and Belgium, which are well worthy of imitation. A still more important sug-

gestion has been made to the Dominion Government by the Director of the Geological Survey for the erection of a School of Mining.

These arrangements and proposals are valuable as far as they extend; but they fall short of providing the full measure of the higher science education, whether with reference to the training of original investigators, or of the various kinds of professional men required for the developement of the resources of the country. Let us enquire how this wider and higher science culture can be secured.

SUGGESTIONS FOR HIGHER SCIENCE TEACHING.

The higher technical and science education may be provided for in either of the following ways. (1.) We may have special schools of mining, engineering, &c., each pursuing its own course, and not connected with any general institution. The objections to this are, that it is not economical, that it cannot provide the necessary literary and general training, that the pupils of such schools are very likely to be of various degrees of excellence and very partially trained. Such objections are applicable to schools like the Royal School of Mines in London, and I think they would prove fatal to the influence of such schools in this country. (2.) We might imitate the German technical universities. This would be the most thorough course possible; and were the means forthcoming, I cannot conceive of any greater educational benefit to this country than the institution of such an University. But it may be long before we shall find in our Legislatures, general and local, the wisdom and patriotism which actuated those of Switzerland in establishing the Zurich School; and we may have to wait quite as long for the appearance of a Canadian Cornell to give and to stimulate legislative liberality by his giving. (3.) The last, and, it appears to me, the only practicable course at present, is to ask for endowments similar to those of Lawrence and Sheffield, and thus to establish special courses of Science in connection with academical institutions, on the plan so well carried out in Owens' College, Manchester, and in the Sheffield School of Yale. This has proved the course most successful in the United States and in the Mother Country, and I have no doubt will prove so here. It is to be observed in this connection that I would not propose merely the institution of a Science degree. We have in this University the means to do this now, but I doubt its expediency, more especially as our honour course in Mathematical and Natural Science is equivalent to that for such a degree and something more, and can be as readily and easily pursued. Nor could I follow the advice above referred to as given by the Principal of Edinburgh University and the chairman of the Endowed Schools Commission, to curtail the classical part of the ordinary course in favor of science studies. Such an arrangement would, I have little doubt, injure the literary part of the academical course more than it would benefit science. I would prefer a regular and definite science school, with a course extending over three or four years—the first year to be identical with or similar to that of the ordinary course, or an equivalent examination to be exacted, at least, in modern literature and science; and the remaining years to be occupied with mathematical, physical and natural science, and modern languages, branching in the closing two years into special studies leading to particular scientific professions. The staff and appliances of such an institution would depend on the extent of its range; and this, to ensure success, should not be small.

It may be asked, would students be forthcoming? I may with confidence answer the question in the affirmative. From the applications made to me on the part of young men for whom I can do little or nothing, I believe that one central well-appointed technical university in this Dominion, would be well sustained, in so far as the number of students is concerned; and that the extension of population, of mines, manufactures, railroads, and other works, would afford an ample outlet for all the men it could train, while the professional work of such men would itself tend to increase the demand.

It is certain, however, that if the Government of this country could be induced to sustain a system of elementary technical schools similar to those of the Department of Science and Art in England, or similar to those of Prussia, a double benefit would be secured, in so far as the higher science education is concerned, in finding occupation as teachers of science for some of the graduates, and in giving the necessary preliminary training to students. At the same time the effects of such schools would be of incalculable importance to the working classes of this country. Local benefactors might do something for such schools; but for a proper system the Legislature must intervene, and it can secure the end only by payment for results on the English system, under proper arrangements for examination and inspection.

THE EARTHQUAKE OF OCTOBER 20th, 1870.

By PRINCIPAL DAWSON, LL.D., F.R.S., &c.

One of the uses of this Journal is to record, in a permanent manner, any rare or unusual natural phenomena, the notices of which, in the daily and weekly press, would soon perish. This function the *Naturalist* has hitherto performed with respect to Earthquakes. In our number for October, 1860, a detailed account was given of the Earthquake of the 17th of that month, which, in many respects, resembled that of this year.

In connection with that event, a general notice of the received theories of Earthquakes was given, and also a catalogue of all the previously recorded Earthquakes felt in Eastern America, about 87 in number, of which at last 29 were felt in Canada, more or less severely—by far the most violent having apparently been that of February 5th, 1663.* The next earthquake of any importance was that of April, 1864, a detailed notice of which will be found in the *Naturalist*, Vol. 1., N.S,. p. 156.

The following extracts from newspapers show the intensity of the shock, and, approximately, its time at different places, arranged in the order of their longitudes.

FREDERICKTON, N. B. — Shock felt at 11.45.

BIC. — An earthquake was sensibly felt here at 11.30 this morning, lasting half a minute. The direction seems to be from West to East.

RIVER DU LOUP, *en bas*, 11.13. — The shock commenced and lasted 45 seconds; appeared to come from N. W.; accompanied by rather heavy rumbling.

POINT LEVI, 11.15. — A dreadful shock of earthquake was felt here at 11.15.

QUEBEC.—At 11.17 a.m. a severe shock of earthquake was felt here. Buildings shook and bells rang; several chimneys were knocked down in Desfosses street, and two persons nearly killed.

BOSTON.—A shock of earthquake was felt here and all along the line from Montreal.

THE EARTHQUAKE.—INVERNESS, P. Q., Oct. 20th. — A severe shock of earthquake was felt here to day at about 11.25 a.m., which lasted for over a minute. The course of the undulation seemed to be in an easterly direction. It caused great alarm in this vicinity.

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*Canadian Naturalist, 1st Series, Vol. V. p. 363.

SHERBOOKE.—Felt earthquake here at 11.25. Shook the office books off the table, and the clock down.

RICHMOND, 11.17 a.m.—A severe shock just felt here. Buildings at station rocked a good deal.

DURHAM, P. Q., Oct. 20.—A slight shock of an earthquake passed here about 11.15 a.m., moving north. It shook the houses quite perceptibly, and lasted several moments.

THREE RIVERS, 11.25.—A very severe earthquake has been experienced in this city. The vibrations were very severe, lasting several minutes. The people ran out of their houses.

NICOLET.—A violent earthquake was felt here at 11.19. The whole building tottered, as if about falling. It lasted about 20 seconds.

BERTHIER.—We had an earthquake very strong in Berthier at half-past eleven to-day.

SOREL, 11.14 a.m.—A shock of earthquake was distinctly felt here, of nearly a minute duration.

ST. HYACINTHE.—A strong shock of earthquake was felt here at 11.15, lasting about thirty seconds.

WATERLOO VILLAGE, P. Q., Oct. 20th.—The shock of an earthquake was felt here at 11.30 to-day; duration about fifty seconds. It commenced with a low rumbling noise. Buildings shook and trembled, and people rushed out of their houses terrified.

ROUSE'S POINT, 11.20.—Severe shock of earthquake here. The Railroad depot shook very much.

ST. JOHN'S P. Q.—Quite a severe shock of earthquake at 11.15.

MONTREAL.—The shock was felt at Quebec about 30 seconds before it reached here. The operator at Quebec was just in the act of asking his *confrere* of Montreal if any shock was felt, when wall and instrument began to rock and shake.

ALBANY.—Not felt within 16 miles from here. Felt in Schenectady, N. Y., Cambridge, N. Y., and Cooper's Town, N. Y.

NEW YORK.—A severe shock of earthquake was felt in this city this morning about 11 o'clock. Shocks were also felt in Schenectady, N. Y., Cleveland, O., Boston, Burlington, Vt., Portland, Me., Troy, Saratoga, Warrensburg and Warsaw, N. Y.

ST. ANDREWS.—Shock of earthquake this morning; lasted 30 seconds.

L'ORIGNAL, 11.15.—We felt a very severe shock of earthquake, which lasted about half a minute. It shook the Court House in which the telegraph office is.

COTEAU LANDING.—Severe shock of earthquake this morning; shook buildings.

OTTAWA, Oct. 20. — A strong shock of earthquake here this forenoon. Drizzling rain and cold.

ST. CATHERINES.—A shock of earthquake felt here.

OWEN SOUND, Oct. 20.— A shock of earthquake was felt here this morning, commencing at 10.52, and lasted about 3 minutes.

In several places it is noticed that the shock was much more severe on sandy and loose ground than on solid rock. This is an ordinary occurrence, depending on the rapid and unobstructed passage of the vibrations through solid rock. This same cause no doubt accounts for the circumstance that at some places the shock was not felt at all, while in others not far distant it was felt severely.

The following notice sent to one of the newspapers by Mr. Bennetts, of the Capel Mine, is curious, as in other cases such shocks are often felt severely in mines; but the rapid or vertical transmission of the shock may account for it in connection, perhaps, with the direction of the vein and of the workings.—"At this mine the shock of the earthquake was very plainly felt at the surface; but at the time of its occurence I was some 200 feet underground and neither the miners, of whom there were about twenty, nor myself, felt the shock or noticed anything unusual. Could it be ascertained, it would be interesting to know to what extent other mines were affected by such an unusual occurrence."

On the other hand I am informed by Mr. James Douglas, of Quebec, that in the Harvey Hill Mine, in rock not dissimilar from that at the Capel Mine, and in the same region, though more to the eastward, the shock was sufficiently violent to throw down masses of rock, and greatly to terrify the miners, then at work in the mine.

In a notice contributed to Silliman's Journal, for November, by Prof. Newton, it is stated that the first shock began at New Haven, at 11h. 19.m 45s. A.M., New Haven mean time. "It lasted 10 seconds, and its individual vibrations were about two thirds of a second in duration, or one and one third of a second for a complete double vibration. The second series of vibrations occurred after an interval of 5 seconds, and lasted 11 seconds.

The direction of vibration was NNE and SSW. It was felt at Boston a minute and three quarters before reaching New Haven. At Cleveland, Ohio, it was felt at the same time as at New Haven. "Slight vibrations were felt as far south as Richmond, Va., and as far west as Dubuque, Iowa." Prof. Bell, of the Geological Survey, informs me that the shock was felt at Sault St. Marie, and on the North Shore of Lake Superior, and was accompanied by a cracking or rending sound in the rocks.

The following account of the Meteorological Phenomena, attending the earthquake at Montreal, is contributed by Dr. Smallwood of the McGill College observatory.

"Rain fell on the 13th day, followed by a rise in the Barometer, and a splendid display of the Aurora Borealis on the night of the 14th day. Numerous and very large spots were present on the solar disc, which had been the case for some considerable time, more especially during the presence of the Aurora on the nights of the 23rd, 24th, 25th, and 26th days of last month (September.)

"The maximum reading of the Barometer at 7 a. m. on the morning of the 16th day, indicated 30.215 inches, and was succeeded by a very fine, warm day, the mean temperature of which was 63.9 degrees, wind S. W. Showers of rain fell on the 17th from 10 a. m. till 3 p. m., with a west wind and with a falling Barometer, which at 9 p. m. of that day stood at 30.000 inches. From 1 a. m. of the 18th (Tuesday) a very rapid and sudden fall was observed, viz: 0.639 of an inch in six hours, and it attained its minimum, 29.361 inches, at 7 a. m. on that day.

"From that hour a gradual and somewhat sudden rise took place accompanied by a very heavy gale of wind. The clouds were passing from the West, but the wind veered to all points of the compass. The register of the Anemometer at the Observatory shows a complete disc of concentric circles, with a velocity varying from 35 to 15 miles per hour.

"There was also a rise of 0.507 of an inch in the Barometer, with a falling temperature. Frost occurred during the night, and a good breeze continued from the West. The Thermometer at 7 a. m. showed 33.1 degrees, and the Barometer 30.070 inches.

"From this time the temperature rose and the Barometer fell, and this morning at 7 a. m., stood at 29.499 inches. Rain set in during the night, and at 7 o'clock 0.214 of an inch had fallen. Thermometer 42 degrees. Wind S. W. Mean velocity, 3.14 miles per hour.

"At 11 h. 17 m. Montreal mean time, a very considerable shock of an earthquake was felt generally throughout the city; the first series of vibrations lasted for from 10 to 15 seconds, and was succeeded by a slight interval of a few seconds, when a second shock occurred, of less duration and of less intensity, lasting from 5 to 8 seconds. No wave of sound was perceptible, and the wave of motion was undulating and in a straight line (rectilinear) and of considerable relaxation. Domestic articles rocked to and fro, but no damage to buildings has resulted.

"The magnets were very seriously affected at 10.30.

"The barometer continued to fall after the first shock. At 2 p. m. it stood at 29.299 inches; thermometer 44.8 degrees; wind S. W., with rain. Professor Kingston telegraphed me that the magnets at the Toronto Observatory showed slight shocks at 10 minutes to 11."

"As usual with Canadian earthquakes, this was felt most severely on the Lower St. Lawrence, more especially at the junction of the Lower Silurian and Laurentian formations in the vicinity of Bay St. Paul, Murray Bay, and the Saguenay. The following graphic account is given by Rev. Mr. Plamondon, Parish Priest of Bay St. Paul, in a letter to "*L'Evenement.*"

"Un mot à la hâte pour vous faire connaître les désastres causés, tout à coup ici et dans les environs, par le tremblement de terre le plus étrange qui soit arrivé de mémoire d'hommes. Environ une demi-heure avant midi, un coup de foudre (c'est la seule dénomination que je puisse lui donner) une énorme détonation a jeté tout le monde dans la stupeur et la terre s'est mise non à trembler, mais à bouillonner de manière à donner le vertige, non-seulement à tous ceux qui étaient dans les maisons, mais encore à ceux qui étaient en plein air. Toutes les habitations semblaient être sur un volcan, et la terre se fendillant en cinq ou six endroits, lançait des colonnes d'eau à six, huit et peut-être quinze pieds en l'air, entraînant après elles une quantité de sable qui s'est étendu sur le sol. Presque toutes les cheminées se sont écroulées, de sorte que je ne pense pas qu'il en soit resté six debout dans tout le village. Des pans de maisons se sont abattus, et ici et là les poêles, meubles et autres objets ont été renversés, emportant avec eux les ustensiles, la vaisselle, etc.

" Notre couvent, qui était sous la direction des bonnes sœurs de la Congrégation est inhabitable pour le moment, trois cheminées et le plafond des mansardes étant démolis en partie. Trois élèves et une servante de cet établissement on été blessées par des pierres provenant de l'éboulement des cheminées: cependant aucune d'elles n'est gravement atteinte.

" L'église a beaucoup souffert ; une partie de son portail s'est écroulée, emportant un morçeau de la voûte, et le reste des murs est tellement lésardé qu'il est douteux qu'on puisse les réparer.

" La stupeur a été telle que pendant les trois ou quatre minutes qu'a duré la secousse, tout le monde pensait que c'en était fini, et que nous allions tous périr. Nous sommes encore sur le qui vive; car de temps en temps de légères secousses se font encore sentir. Chacun redoute la nuit prochaine et se demande où il sera demain matin. Il est certain que si cette catastrophe fut arrivée pendant la nuit, nous aurions à déplorer la perte d'un grand nombre de vies.

" Il nous est venu des gens de diverses concessions, de sorte que nous avons des nouvelles d'un circuit d'environ quatre lieues et nulle part il n'est resté une habitation intacte, partout la secousse a été aussi violente. A l'heure où j'écris ces lignes, la terre tremble encore, et qui sait si je pourrai terminer. Aussi veuillez excuser le décousu de ces quelques détails que je vous donne à la hâte, ainsi que les fautes qui peuvent s'y être glissées."

Other correspondents mention the opening of chasms in the ground, from which streams of water and sand burst forth. This phenomenon arises from the landslips produced in the terraces of Post-pliocene clay which in that part of the country rest against the steep sides of the Laurentian hills. These are ready to slide downward with any slight movement of the earth, and to press the water out of the sandy layers associated with them, or give outlet to hidden springs and streams.

It is also stated, that a mass of rock 400 feet in length fell from the face of the cliff, at Cape Trinity, in the Saguenay. Cape Trinity is a cliff of Laurentian gneiss, presenting to the river a vertical front about 1500 feet high.

It will be observed that the earthquake of Oct. 20th extended over 25 degrees of longitude, from the Bay of Fundy westward, and over at least 12 degrees of latitude from the North Shore of the St. Lawrence, southward. Its extension to the northward into Rupert's Land, is not yet known.

The general direction of the vibration, as shown by the times at the different places mentioned above, and by observations of Prof. Winslow, at Cambridge, and by Mr. Douglas, at Quebec, was from north east to south west. The shock must therefore have been propagated from the Laurentian regions north of the St. Lawrence, into the Silurian and later formations to the southward. This is of interest in connection with the facts already related as to its severity at the edge of the Laurentian formation at Bay St. Paul, and elsewhere.

It is also deserving of notice, that at Bay St. Paul and Les Eboulements several shocks are recorded; and that additional shocks are stated to have occurred at the latter place on the 26th October, six days after the principal shock.

It has been observed on previous occasions that the Barometer is low at the time of the occurrence of earthquakes, in Eastern America. Dr. Smallwood, has kindly furnished the following table in illustration of this. It gives the state of the Barometer at Montreal, on the days of eleven of the most recent earthquakes felt here.

Date of Earthquake.		Barometer.
1855.	Feb. 8	29.806
—	— 19	29.800
1856.	Jan. 1	30.163
1857.	Oct. 16	29.308
1858.	Jan. 15	30.292
—	May 10	29.800
—	June 27	29.800
1860.	Oct. 17	29.964
1864.	Apr. 20	29.900
1870.	Mar. 4	30.300
1870.	Oct. 20	29.299

It will be observed that the Barometer was unusually low on the day of the late earthquake, and according to information kindly sent to Dr. Smallwood from the observatory at Washington, this was very general over the continent.

It is thus extremely probable, that, whatever the primary cause of the movement, its occurrence on the particular day in question, may have been determined by this removal of pressure from the surface of the land. It is further to be observed, that this would place the phenomena in harmony with that general cause to which the frequent small earthquakes on the Eastern Coast of America, were formerly assigned by the writer, namely the removal of material from the land, and its accumulation on the banks off the American Coast, producing unequal pressure and consequent tension of the earth's crust, and this connected with the ascertained slow subsidence of the coast, and perhaps with slight elevation of the interior of the continent.

In a notice of the earthquake in *Silliman's Journal*, for January, 1871, by Mr. A. C. Twining, the following statement occurs with reference to the intensity of the shocks at Bay St. Paul and Les Eboulements—"They are in general conformity to what has long been known to British geologists, respecting the volcanic character of the region specified," with some other remarks based on this strange statement, which has actually no foundation in fact, other than the junction, at those places, of the Laurentian and Lower Silurian rocks, and the occurrence of thick beds of Post-pliocene clay, resting on inclined rock surfaces, and therefore very liable to slip. Captain Bonnycastle's ideas on the subject, referred to by Mr. Twining, were probably founded merely on the irregular contour of the surface, the occurrence of crystalline Laurentian rocks, and the exaggerated accounts of land-slips in previous earthquakes, contained in the memoirs of the Jesuits.

NOTE.—A slight shock of Earthquake was felt at Hawkesbury on the Ottawa, on the 3rd January. Dr. Smallwood states that, though not appreciable at Montreal, it was indicated by the Seismometer.

NOTES ON THE BIRDS OF NEWFOUNDLAND.

By HENRY REEKS, F.L.S., &c.

(Continued from page 159.)

TETRAONIDÆ.

Canada Grouse, or *Spruce Partridge*, Tetrao canadensis, *Linn.* —A very rare and uncertain visitor from the mainland: two killed, and two others seen by the settlers during my residence at Cow Head.

Willow Grouse, Lagopus albus (*Gmelin*).—Common throughout the year, and the only lowland or subalpine species indigenous to Newfoundland. From my own experience I think the willow grouse invariably roost on the ground, although I have frequently shot them when feeding in the tops of birch and alder trees, more especially when the ground is covered with deep and light snow. Their food consists chiefly of the buds and tender shoots of birch, alder, black spruce (*Abies nigra*), juniper (*Larix americana*), &c., but they seem partial at other seasons to the partridge berry (*Mitchella repens*) and cranberry (*Oxycoccus palustris*). I do not possess specimens of willow grouse from Europe or northern North America (Hudson's Bay, &c.), but Professor Baird says, "I find a considerable difference in different specimens of the large ptarmigan [L. albus] before me. Those from eastern Labrador and Newfoundland appear to have decidedly broader, stouter and more convex bills than those from the Hudson's Bay and more northern countries. I think it not improbable that there may be two species. . . . ." Professor Newton, however, informs me that "none of Professor Baird's later writings have gone to strengthen the suspicion expressed by him formerly as to the existence of a second species of willow grouse," and adds, "I have compared a pretty good series of skins from many parts of North America, extending from Alaska to Newfoundland, and so far as I can judge I have no doubt they are all of one and the same species, which is further identical with the willow grouse of Europe (*Tetrao saliceti*, Temminck; *T. subalpinus*, Nilsson)." I have never succeeded in driving the willow grouse into a bank of snow, as Sir John Richardson states in 'Fauna Boreali Americana,' vol. ii., p. 352, as being a habit peculiar to the species, nor had the settlers observed anything of the kind. They are sometimes so tame that they may be killed with a stick; at other times so wild that they will not allow you to approach within gunshot, and such is generally the case in winter when the snow is hard and crusty, and the noise of your rackets (snow-shoes) alarms them. They are shot at all seasons by the settlers, and generally when sitting on the ground although there is every excuse for doing so, especially in thick woods, for if once flushed there is rarely a chance of coming up with the covey again, and this an important consideration where food and powder and shot are not too plentiful among the poorer population. In one of my walks soon after I landed on the island I came up with a small covey of willow grouse and killed a brace, but owing to my dog— a borrowed one, which was evidently more used to rushing into the water for wounded seals and ducks, than retrieving grouse,— I was unable to get another shot at the birds. Upon showing the brace I had killed to the owner of the dog, on my return, the following conversation ensued:—"Got two *pattridges* then, sir?" "Yes." "All there was there, I 'spose?" "Oh, no; there were ten in all, I think." "Then they was wild I 'spose, sir?" "No, they allowed me to get sufficiently near to kill one with each barrel as they rose." "What, sir, you never fired at 'em to wing!" "Of course I did; how would you have me shoot at them?" "Why, sir, if I had been there I should have walked round and round them *pattridges* till I had got 'em all in a heap, and then I should have killed nearly all at a shot: I never heard of nobody firing at a *pattridge* to wing." If the settlers could be induced to observe a close time for these and other valuable game birds, the practice of shooting them in this apparently wholesale manner would not greatly diminish their numbers. The willow grouse is called *the* "partridge" by the settlers, and frequents beds of alder and dwarf birch in swampy places, especially on the borders of lakes and rivers. It breeds on the ground among stunted black spruce, in rather drier situations. One peculiarity in the Newfoundland bird is, that I have *very rarely* found the middle, or incumbent pair of tail-coverts "entirely white" in winter, as they are stated to be in 'Birds of North America,' p. 634.

Rock Ptarmigan, L. rupestris (*Gmelin*).—A truly alpine species in Newfoundland; rarely found below the line of stunted black spruce, except in the depth of winter, when they descend to the low land and feed on the buds of dwarf trees, sometimes in company with the willow grouse, but I never saw this species perch on trees: it is called by the settlers the "mountain partridge."

GRUIDÆ.

I was informed by one of the settlers that a "brown crane" was killed a few years since at Codroy, Newfoundland, and some others seen. I am of opinion that they must have been "stragglers," and it is therefore hard to determine the species. Did they really belong to the genus *Grus*?

ARDEIDÆ.

American Bittern, Botaurus lentiginosus, (*Montagu*).—A summer migrant to Newfoundland, and the only species of the heron family that I met with. A pair of bitterns are generally found frequenting the margins of wooded lakes and ponds in the lowlands throughout the summer, arriving early in May and departing again about the last of September. Yarrell describes the legs and feet as "greenish brown;" they are, however, of a pretty yellow-green, but soon lose this colour after death. The American bittern makes a curious thumping noise, very much resembling the noise made by fishermen when driving oakum into the seams of their boats; hence probably arose its popular name of "stake-driver" in the United States, and "corker" (? caulker) in Newfoundland.

CHARADRIDÆ.

American Golden Plover, Charadrius virginicus (*Borck*).—Visits Newfoundland abundantly in the autumnal migration, but very rarely, if at all, in the vernal.

Killdeer, Ægialitis vociferus (*Linn.*)—Not so common as the preceding, otherwise the remarks on that species are equally applicable here.

Ring Plover, or *Semipalmated Plover*, A. semipalmatus (*Bon.*)—A summer migrant and breeds on the coast: this and the following species are called "beach birds."

Piping Plover, A. melodus (*Ord.*)—Appeared to be a common autumn migrant, congregating in large flocks.

Grey Plover, or *Blackbellied Plover*, Squatarola helvetica (*Linn.*)—Very common in the fall of the year, but I did not meet with it in spring: the plovers evidently take some other, and probably more direct route than *viâ* Newfoundland to their breeding grounds in the far north.

HÆMATOPODIDÆ.

Turnstone, Strepsilas interpres (*Linn.*)—Abundant on the sea-shore in the fall of the year, and generally so fat that the settlers have bestowed on it the appropriate name of "fat oxen."

Of the Recurvirostridæ I did not meet with either Recurvirostra americana, Gmelin, or Himantopus nigricollis, Vieillot, although both, but more especially the former, may reasonably be expected to occur periodically.

PHALAROPODIDÆ.

Red Phalarope, Phalaropus fulicarius (*Linn.*)—Visits Newfoundland generally in the month of June, and is sometimes tolerably common, but I doubt whether it breeds on the island. This is undoubtedly our old friend Phalaropus lobatus in its nuptial dress, and the American authors have done well in restoring to it the Linnean name of fulicarius, because it is yet a matter of doubt whether the Tringa Lobata of Linnæus in Systemæ Naturæ ever applied, or was intended to apply, to this species. It is the only species of phalarope I got in Newfoundland, and was called by the settlers the "gale bird." It is wonderful to watch these pretty and delicate-looking little birds swimming and taking their tiny food from the crests of waves that would "swamp" any boat and many schooners. They are very tame, and swim almost within arm's length of the rocks, giving one the idea that the next immense wave which is fast approaching will cast them on shore, or smash them against the rocks: at such times it takes a quick shot to kill them on the water.

SCOLOPACIDÆ.

European Woodcock, Scolopax rusticola, *Linn.*—A single specimen is said to have been killed in the neighbourhood of St. Johns, in January, 1862 (See "Ibis," 1862, pp. 284, 285). If no deception has been practised here, it is certainly a very extraordinary capture, as is also that of another specimen since taken near New York. To those who have spent any length of time on the coast of North America, the problem of the occurrence of so many American birds in Europe is soon solved: it is undoubtedly caused by the prevalence, especially in the fall, of great gales of westerly winds, which probably take most of our American stragglers off the east coast of Newfoundland; but how to account for the appearance of two stray specimens of S. rusticola being killed in America—far apart, but in each case near a populous city, and by those so well up in ornithological literature as to be aware of the value of such captures, presents a difficulty by no means so easily disposed of. Of course it is probable that land birds may occasionally get blown off our west coasts by rough easterly winds, but it is equally probable that before they had gone one-third across the Atlantic they would take the wind dead ahead, which would cause them to 'bout ship and be thankful for a fair breeze home. It does not require a great stretch of the imagination to account for the appearance of an Icelandic species in Greenland, or the northern parts of the American continent, or even in Newfoundland, but if I remember right the European woodcock is not found in Iceland.

American Woodcock, Philohela minor (*Gmelin*).—Probably occurs on the island, but my accident prevented my thoroughly searching situations likely to produce this species. It would only occur as a summer migrant.

Wilson's Snipe, Gallinago Wilsoni (*Temm.*)—A common summer migrant, arriving generally about the last week in April, and soon commences breeding. When the female is sitting on her nest the male frequently rises in the air, drumming and making a peculiar rushing noise with its tail, which may be heard a considerable distance.

Gray Snipe, Macrorhamphus griseus (*Gmelin*).—A summer migrant. The remarks appended to the proceeding species appear equally applicable to this.

Gray Back; Robin Snipe, or *Knot*, Tringa canutus (*Linn.*)—Visits Newfoundland only in its periodical migrations.

Purple Sandpiper, Tringa, maritina, *Brunnich.*—A summer migrant, but rather rare at Cow Head; probably more common on the southern shores of the island.

American Dunlin, T. alpina. var. americana, *Cassin.*—A summer migrant, but much more abundant in the fall of the year.

American Jack Snipe, T. maculata, *Vieill.*—A summer migrant, and tolerably common.

Least Sandpiper, T. wilsonii, *Nuttall.*—A common summer migrant.

Bonaparte's Sandpiper, T. bonapartii, *Schlegel.*—A common summer migrant, collecting in flocks in the fall of the year at the seaside, and generally so tame that a dozen to twenty may often be killed at a shot. This remark applies also to some other allied species of sandpipers and small ringed plovers which congregate on the coast every autumn, from some flocks of which upwards of sixty have been killed at a shot; giving some idea of the immense quantities of these little birds. The pretty little pigeon hawk (*Falco columbarius*) is a cruel attendant on these flocks of small Tringæ. Professor Newton informs me that "Tringa bonapartii is the Schinz's Sandpiper of Yarrell and other English authors, though not the true T. schinzi."

Sanderling, Calidris arenaria (*Linn.*)—Visits Newfoundland periodically: abundantly in the fall, but very sparingly, if at all, in the spring.

Semipalmated Sandpiper, Ereunetes petrificatus, *Illiger.*—Another common species on the coast in the fall.

Stilt Sandpiper, Macropalama himantopus (*Bon.*)—Not common at Cow Head. I killed one specimen in September, 1867, and saw a few others which appeared of the same species.

Willet, Symphemia semipalmata (*Gmelin*).—Common in the fall of the year, especially in the spotted or immature plumage.

Tell Tale, or, *Stone Snipe*, Gambetta melanoleuca (*Gmelin*).—A summer migrant, but not so common as the following species.

Yellow Legs, or *Yellowshanked Sandpiper*, G. flavipes (*Gmelin*).—A summer migrant, arriving in May and departing again in October. A great many pairs breed in the marshes, but I think the majority pass on to more northern regions, and return in August and September in increased numbers, generally at that season very fat and much appreciated for the table, but being small birds they are not usually shot at by the settlers unless four or five can be killed at a shot. Sometimes they are very tame and take little notice of men or dogs: at other times they are so wild that I know no bird more difficult of approach, and then they are a perfect nuisance to the sportsman, as they not only keep out of range themselves, but alarm every other bird by their incessant cry of "twillick," "twillick." Many a blessing (?) have I bestowed on these birds when, after crawling on my hands and knees a quarter of a mile through long wet grass on boggy soil to get a shot at a flock of black ducks (*Anas obscura*), I have heard the everlasting "twillick" and seen the ducks take wing instantly, perhaps not eighty yards from me. I fear, since my visit, many a skeleton of poor "twillick" lies bleaching in the marshes by the sea-coast near Cow Head. Provincial names of this bird are "twillick," "twillet" and "nansary"—the latter name more frequently in the south of the island.

Solitary Sandpiper, Rhyacophilus solitarius (*Wilson.*)—Not uncommon in summer, generally towards autumn.

Spotted Sandpiper, Tringoides macularius (*Linn.*)—A common summer migrant, arriving early in May: breeds on the coast, and lays its four eggs sometimes in a hollow on the bare shingle; at other times in short grass, but always just above high-water mark. Provincial name "wagtail."

Bartram's Sandpiper, Actiturus bartramius (*Wilson*).—Visits Newfoundland periodically, but it is rarely met with during the vernal migration. I doubt if it breeds in Newfoundland, although known to do so on the mainland both north and south of that island. Like the peewit at home this species prefers inland and cultivated districts.

Buffbreasted Sandpiper, Tryngites rufescens (*Vieill*).—A summer migrant, but not very common. I did not succeed in taking eggs of this species, but I think it breeds on some of the drier spots in marshes in Newfoundland.

Marbled Godwit, Limosa fedoa (*Linn*).—Only a periodical visitor; most common in the fall. This and the following species are called "dotterels" by the settlers.

Hudsonian Godwit, L. hudsonica (*Latham*).—Visits Newfoundland in its periodical migrations, but is most common in the fall of the year, when it is generally very fat and much appreciated for the table.

Longbilled Curlew, Numenius longirostris, *Wilson*.—A periodical migrant much sought after by the settlers, who are great adepts in imitating its whistle, by which means they kill many that would otherwise pass a long distance out of range. It is a fat, good-eating bird in the fall.

Hudsonian Curlew, N. hudsonicus, *Latham*.—Frequently confounded by the settlers, under the name of "Jack Curlew," with the preceding species, with which it is about equally common, and like that visits Newfoundland in its migrations, but does not breed there.

Esquimaux Curlew, N. borealis (*Forster*).—By far the most common species of curlew, but like the preceding species is only a periodical visitor; coming by thousands in the fall, but very rarely in the spring; in fact, I think they take some other and more direct route at that season. They feed on the berries of *Empetrum nigrum*, which stain the feathers posteriorly a rich dark purple. These birds arrive in Newfoundland on their migration about the last week in August, and remain until the end of September, when they are always very fat, and delicious eating. I was told by one of the old English settlers that they were so abundant some seasons that he had himself shot fifty in one morning before sunrise.

Virginia Rail, Rallus virginianus, *Linn*.—A summer migrant, and apparently rare—I saw only one specimen; but the well known habits of the *Rallidæ*—that of concealment among reeds in marshy places—may account for a seeming paucity in individuals.

Common American Rail, Porzana carolina, *Vieill*.—A summer migrant, and, although not common, is probably more so than the preceding.

American Coot, Fulica americana, *Gmelin*.—Although this bird is perhaps a regular summer migrant to Newfoundland I never met with it, neither do I think it is *the* "Coot" of the settlers; if so, I know it is frequently confounded with *Pelionetta perspicillata* (*Linn.*), the surf scoter.

ANATIDÆ.

American Swan, Cygnus americanus? *Sharpless.*—Apparently a rare and accidental visitor to the western coast of Newfoundland: I saw only one specimen, which was an adult bird flying south in the fall of 1867.

Snow Goose, Anser hyperboreus, *Pallas.*—Very rare: I heard of one or two being obtained in the north of the island, and an equal number on the west coast.

American Whitefronted Goose, A. gambeli, *Hartlaub.*—Equally rare with the preceding, or perhaps more so. It seems extraordinary that these two common species of American geese should be so rare when we consider that Newfoundland, in one place, is only, separated by twelve or fifteen miles of water from the mainland.

Canada Goose, Bernicla canadensis (*Linn.*)—A regular summer migrant, and by far the most abundant species, arriving in April and in May by "countless thousands." The majority pass on to more northern regions to breed, although a great many remain for that purpose in Newfoundland; but, besides a general discrepancy in size, I have almost invariably found the northern migrants of this species much darker on the breast; in fact, so much so, that we used to call them the "little blackbreasted northerners." The colour of the "down" appears a good distinction between the sexes; on the male it is light gray, and on the female dark gray, almost black. This was pointed out to me by the settlers, who, however, know how to separate the sexes by the shorter bill and head of the goose. The Canada goose is greatly prized for the table, and the settlers are adepts in "toling" them within gunshot in the spring of the year, but it cannot be done in the fall, or during the autumnal migration: a dog is generally used for this purpose. The sportsman secretes himself in the bushes or long grass by the sides of any water on which geese are seen, and keeps throwing a glove or stick in the direction of the geese, each time making his dog retrieve the object thrown: this has to be repeated until the curiosity of the geese is aroused, and they commence swimming towards the moving object. If the geese are a considerable distance from the land, the dog is sent into the water, but as the birds approach nearer and nearer the dog is allowed to show himself less and less: in this manner they are easily toled within gunshot. When the sportsman has no dog with him he has to act the part of one by crawling in and out of the long grass on his hands and knees, and sometimes this has to be repeated continuously for nearly an hour, making it rather a laborious undertaking, but I have frequently known this device succeed when others have failed. The stuffed skin of a yellow fox (*Vulpes fulvus*) is sometimes used for toling geese, and answers the purpose remarkably well, especially when the geese are near the shore, by tying it to a long stick and imitating the motions of a dog retrieving the glove or stick. Foxes have frequently been observed to practice the same device in a state of nature, and the settlers who prize fur more than feathers commence toling poor Reynard within range of the fatal shot, which, strange to say, considering the general craftiness of the animal, is very easily done. The Canada goose may often be toled from a long distance when on wing, by "cronking" or imitating its cry. When these geese fly, either in pairs or in flocks, a gander invariably leads: this fact is so well known to the settlers that when firing at a pair of geese they invariably shoot at the hinder bird, not only because the goose is the fattest (in the spring), but because the gander will generally fly round and round its dead mate for some little time: such affection but too often proves fatal, especially when the shooter has the use of two barrels, but such is not generally the case among the settlers, who chiefly use the old-fashioned long duck guns, single barrelled, of ten or twelve bore. Ice-gazes and false geese are also employed on the ice for killing these beautiful birds in the spring of the year. Like the domestic goose, which has been known to live upwards of a hundred years, these birds are supposed by the settlers to live to a great age. A few years ago a specimen of the Canada goose was shot at Grasswater Bay, on the Labrador, which had a thin brass collar on its leg initialed and dated just thirty years previous to its capture. This species does not commence laying until three years old, and from examining the ovaries of several evidently young females I found them to contain from 180 to 190 eggs, which, averaging six per annum, would limit the laying period to some thirty or thirty-one years; so that, bar accidents, the birds would not probably live more than forty or forty-five years.

Brent Goose, B. brenta, *Stephens.*—Very common on the southern and western parts of Newfoundland, in its periodical migrations, but very rare farther north than St. George's Bay, in 48½ North latitude, or occasionally Port au Port, whence it crosses to Anticosti, and thence up the Labrador shore. Two specimens were said to have been seen on wing at Cow Head last spring (1868,) but the double-crested cormorant (*Graculus dilophus*) flies much like a small goose, and I fancy the birds thought to be Brents were of this species.

Mallard, or *Common Wild Duck*, Anas boschas, *Linn.*—Very rare; I only examined one normal specimen of this species, also one of the supposed hybrids, between this species and the Muscovy, (*Cairina moschata*,) which had been shot and skinned by two of the settlers a few years since, and preserved as curiosities. The larger bird was considered by them a drake of the domesticated variety, and I have certainly seen some of the descendants of the "Lincolnshire". breed much resembling it; but as I was informed no ducks, except eiders (*S. mollissima*,) were kept domesticated on the island, the bird had probably wandered north in company with a flock of some other species.

Black Duck, A. obscura, *Gmelin.*—This is the common wild duck of the island, and is abundant throughout the summer. It breeds among rushes and long grass on the borders of lakes and rivers, and lays from ten to fifteen eggs, which much resemble those of the preceding species. The black duck is much esteemed for the table, but is usually a very shy bird, and not easily approached, except from the leeward, as it will "wind you like a deer."

Pintail Duck, Dafila acuta (*Linn.*)—Very rare, but known to some of the settlers as the "long-tailed duck."

N. B. — The true "long-tailed duck" (*Harelda glacialis*) is called a "hound" in Newfoundland.

Green-winged Teal, Nettion carolinensis (*Gmelin.*)—A summer migrant, and appears to be the "common teal" of the island.

Blue-winged Teal, Querquedula discors (*Linn.*)—Rare in the neighbourhood of Cow Head, and probably nowhere on the island so common as the preceding species.

Shoveller, Spatula clypeata (*Linn.*)—A summer migrant, and generally distributed over the island, but is by no means common. It is called "Pond diver" by the settlers.

Gadwall, or *Gray Duck*, Chaulelasmus streperus (*Linn.*)—Rare: does not breed on the island, but is occasionally killed during its periodical migration.

Baldpate, or *American Widgeon*,* Mareca americana (*Gmelin.*)—A common summer migrant, and when fat one of the best flavoured of American ducks. The adult male of this species, which is called a "Cock Widgeon" by the settlers, is, in summer plumage and fresh killed, one of the handsomest ducks in Newfoundland.

English Widgeon, M. Penelope? (*Linn.*)—Although only a straggler to the continent of North America, it is not improbable that this species occasionally occurs in Newfoundland, especially *en route* from Greenland to the United States, whence most of the captures are recorded.

Scaup Duck, or *Big Blackhead*, Fulix marila (*Linn.*)—A very rare struggler to the N. W. coast.

American Scaup Duck, F. affinis, (*Eyton*).—Occasionally shot in spring or fall, but rarely seen at Cow Head.

Ring-necked Duck, F. collaris (*Donovan*).—Equally rare with the preceding species.

Aythya americana (*Eyton*) and A. vallisneria (*Wilson*) may reasonably be expected to occur in Newfoundland.

American Golden Eye, Bucephala americana (*Bon.*)—A very common summer migrant; one of the first to arrive in spring and remains until frozen out in the fall. Breeds in holes in trees, sometimes near the ground, but very frequently fifteen or twenty feet high, and often a considerable distance from water. The hole is generally made in a rotten tree, and I think always by the bird itself: it is called the "pie duck" by the settlers, and the young birds are considered good eating.

Buffel-headed Duck, or Butter Ball, B. albeola (*Linn.*)—Rare; at least at Cow Head, where it is called the "Spirit Duck."

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* A male *Mareca* which I obtained in Newfoundland differs from type specimens in being of an uniform dark brown on the back, without the ordinary traverse bars; in its smaller size (*barely* 19 inches; wing 10; tarsus 1.10); legs and feet blue; irides WHITE; culmen less convex; and by having a broad conspicuous white band on the wings. Mr. G. R. Gray and Professor Newton are unable to refer the specimen to any other species than *M. americana.*—H. R.

Harlequin Duck, Histrionicus torquatus (*Linn.*)—A common summer migrant, and breeds on the borders of lakes and rivers flowing into the sea, frequently many miles in the country, whence it brings its young in July. The male of this species, which is called a "lord" in Newfoundland, is decidedly the handsomest little duck inhabiting those cold regions, and is a most expert diver. It seems extraordinary that any bird when quietly settled on the water, and within twenty yards of you, should escape by diving from the shot of a percussion gun; but how far more astonishing is it that birds on the wing, and within easy range, should employ the same device, and yet the little "lords" and "ladies" (females) frequently escape by doing so! The amateur sportsman, unacquainted with this fact, is amazed at his own prowess, when, having shot at eight or ten of these birds on the wing, he sees the whole flock drop apparently "stone dead" into the water; but his vexation perhaps exceeds his amazement when, in a few seconds, he again sees his little flock of harlequins on wing, and that too just out of range for his second barrel. The harlequin duck is frequently found sitting on rocks many feet above the water, but, from its small size and resemblance to the parti-coloured rocks, is very difficult to see in time to get a shot by stalking. Adult males are generally distinguished as "old lords," and females as "jennies."

Long-tailed Duck, Harelda glacialis (*Linn.*)—This handsome species is very common all along the coast in fall and spring,—in fact, as long there is any open water throughout the winter; but I think does not breed anywhere in Newfoundland, although I have an adult male, in summer plumage, which was shot at Cow Head on the 13th of June, 1868.

To the naturalist and sportsman there can be few more interesting sights than seeing several hundreds of "hounds," as these birds are called by the settlers, in a flock, and hearing their clamorous cry of "Cow-cow-wit;" "Cow-cow-wit," which, when borne on the breeze from a distance, has a fancied resemblance to a pack of hounds in full cry, and, however fanciful the comparison, it always proved sufficiently obvious to recall many pleasant reminiscences of bygone days. The longtailed ducks usually frequent shoals and beds of "killup" (kelp) in one to five fathoms of water, but I have seen them diving for food in thirty fathoms of water. Like many other oceanic birds they are expert divers, and it is sometimes almost impossible to kill them when sitting on the water; and I really think the nearer you are to them the more likely are they to evade the shot, but, of course, everything depends on the day; if dull and cloudy, or with snow on the ground, they dive at the flash with the rapidity of lightning, while on bright sunny days they are shot as easily as any non-diving birds. On the 12th of October, 1867, I killed two males of this species at a shot. It was a lovely day, frosty in the morning but the thermometer marked 50 degrees Fahr. at noon, and the ducks which were fishing side by side, at the distance of about forty yards, made no attempt to dive. "Old Wife" is another provincial name for this species.

Labrador Duck. Camptolæmus labradorius (*Gmelin*).—Probably occurs on some parts of the coast, but I did not meet with it during my stay at Cow Head.

Velvet Duck, Melanetta velvetina (*Cassin*).—Common, and probably breeds on the island, as individuals may be seen throughout the summer; although supposing the birds to assume the adult plumage the *second* year, which I have reason to doubt they may be non-breeding birds, as they certainly do not breed until the *third* year. Provincial name "Whitewinged diver."

Surf Duck, Pelionetta perspicillata (*Linn.*)—Common, especially during the migratory season. The remarks on the plumage and breeding habits of the preceding species applies equally to this and the following species. Provincial names "Bottle-nosed diver" and "Bald coot."

American Scoter, Œdemia americana (*Swainson*).—Very common throughout the year; at least until driven from the coast by drift ice, which is not usual until the first week in January. It is called the "sleepy diver" and "little black diver" when adult, by the settlers.

*American Eider Duck,** Somateria mollissima? (*Linn*).—By far the most abundant species of duck in Newfoundland, but not so plentiful now as a few years since, owing in a measure to an increase in population, but more particularly to a wholesale robbery of eggs which is carried on with impunity from the islands along the coast, and others in the straits of Labrador and Belle Isle.

* Professor Newton is of opinion that the American eider differs from the European far more strikingly than do some other so-called American species of ducks (especially the genus *Œdemia*), and I quite agree with him.—H. R.

Several hundreds of these beautiful ducks breed on some islands in the Bay of St. Paul, about five miles west of Cow Head, and are strictly preserved by an old Englishman, the only human resident in the bay. So abundant were these birds in Newfoundland a few years ago that a man living at Cow Head killed *one hundred and ten* eiders at *two* shots in one day, and on another occasion *fifty-three* at *one* shot: forty, also, had frequently been killed at a shot, and I saw a youth, seventeen years of age, knock down twenty at a shot in January, 1868, but even this last number is now rarely obtained so easily. To the sportsman who is content with a duck to each barrel this comparative scarcity is of small import, but to the poor settlers it is a matter of great consideration. The common eider does not breed or assume the adult plumage until the third year: it is called the "sea duck" by the settlers. The young males resemble the females, but lack the tinge of reddish brown which is characteristic of adult females of this and the following species.

King Eider, S. spectabilis (*Linn.*)—The adult male of this species is a large handsome bird and much sought for by ornithologists, especially those who go to the trouble and expense of visiting either its summer or winter haunts. The king eider, which is called "king bird" in Newfoundland, is tolerably common during its periodical migrations, and is frequently shot in company with the preceding species. On the 17th of December, 1867, I obtained an adult male "king bird;" and on the 19th an immature male: the latter was one of two killed at a shot with eight of the common eider. King eiders are more abundant some seasons than others: in 1865 twenty of these birds were killed at a double shot by one of the settlers at Cow Head. Young males the first year resemble the females, but in the second year have the throat and neck copiously spotted with white. The adult female of this species is easily separated from its congener, (*S. mollissima*) by its much smaller size, its shorter bill, and by having a more decided rufous tinge on the upper plumage.

Ruddy Duck, Erismatura rubida (*Wilson*).—A rare and uncertain visitor on the north-west coast.

Goosander, Mergus americanus, *Cassin.*—A summer migrant and tolerably common: it breeds on the margins of lakes and rivers, and is called the "gozzard" by the settlers.

Redbreasted Merganser, M. serrator, *Linn.*—A very common summer migrant, remaining in Newfoundland as long as any open water can be found. At early morning the redbreasted mergansers fly out to sea in large flocks, but return to fresh water in the evening: its provincial name is "shell bird."

Hooded Merganser, Lophodytes cucullatus (*Linn.*) Apparently rare on the north-west coast, and generally obtained in the immature plumage.

(*To be Continued.*)

ON THE ORIGIN AND CLASSIFICATION OF ORIGINAL OR CRYSTALLINE ROCKS.

By Thomas Macfarlane.

(*Continued from June Number.*)

IV.—CHEMICAL COMPOSITION.

Crystalline or original rocks have been hitherto regarded and described as aggregates of minerals. No doubt the larger number of them may be correctly enough thus characterised, but it is doubtful whether the description applies to all the original rocks. For instance, obsidian has always been classed among these, and, on all hands, it is admitted that no minerals are discernable in it, that it is perfectly vitreous, as much so as bottle or window glass. A similar vitreous substance, unresolvable by the microscope, forms, according to Vogelgesang, part of the matrix of all true porphyries. Then we have many instances of rocks, almost impalpable in texture, belonging to various families, in which the microscope certainly reveals the presence of separate minerals, but, frequently, leave their nature and, always, their composition undetermined. Besides the uncertainty which thus very frequently surrounds our knowledge of the mineralogical constitution of fine-grained rocks, there are other considerations which tend to shew that the composition of a rock is not ascertained even after its constituent minerals have been determined. In the first place, the relative quantities of these present cannot be ascertained, and, secondly, even when this is done approximatively, the uncertain composition of the mineral species renders the chemical composition of the rock almost as doubtful as before. It would therefore appear simpler and tend to a juster view of the nature of original rocks, to regard them not so much as aggregates of minerals, as mixtures of their chemical components, alkaline and earthy silicates, which, during crystallisation. arranged themselves into compounds of more definite atomic composition, namely, into minerals.

As has been already remarked, the primary source of all original rocks must have been the original fluid globe, and also that part of it, which, until the present day, has remained in a state of igneous fluidity. The elements which originally composed the fluid-globe must have been the same as those which enter into the composition of the earth at the present day. If, however, we leave out of consideration those volatile and gaseous elements which, from their nature, must have gone to form the primitive atmosphere, and also the greater bulk of the metals, which, from their gravity, must have accumulated at the centre of the earth, we have the following list of substances, which in all likelihood, constituted the upper zone of the original fluid-globe:—Silicic, boracic, phosphoric, stannic, titanic, niobic, tungstic, and tantalic acids: among bases, potash, soda, lithia, lime, magnesia, alumina, ferric oxide, zirconia, manganic oxide, manganous oxide, ferrous oxide, glucina, ceria, yttia, oxides of zinc, lanthanum and uranium. All of these substances make their appearance in original rocks, many of them however in comparatively minute quantity and entering only into the composition of their so-called accessorial constituents. If we, for the sake of clearness, leave these rarer substances aside for the present, we have the following, which may be regarded as the essential chemical constituents of original rocks:

Silicic Acid, ...Alumina..................Protoxide of Iron,
Magnesia,........Lime,........Soda,........Potash.

These substances, we may suppose, were, in the original fluid magmas from which original rocks crystallised, present in the same manner in which we see them combined together in furnace slags or glass. Each of these constituents, the alkalies excepted, is of a most refractory nature by itself, but, when several of the earths unite with the silica, compounds result of various degrees of fusibility. In this there is merely a repetition of the well-known phenomena of chemical combination, where elements the most antagonistic combine to form a substance innocent of any of the properties of its constituents. The silica or quartz, infusible and chemically indifferent as it may appear under ordinary circumstances, acts in this case as an acid, and, with the aid of heat, combines with the equally refractory bases, forming readily fusible compounds. The simple silicates, formed by the union of silica or silicic acid with one base, are not always fusible. Those of the alkalies and iron oxides are, but the silicates of alumina (clay), magnesia (serpentine), and lime (wollastonite), are almost or completely infusible. Nevertheless, the three latter combined form the scoriae of most frequent occurrence in the arts, namely, those of iron furnaces. In these slags the proportion of silica present often mounts as high as 75 per cent., while those from puddling furnaces do not contain more than 35. The former are termed very acid or siliceous, and the latter very basic slags. Such variations in the silica contents of these compounds are accompanied by corresponding changes in their chemical and physical properties. Basic slags are more easily fused than siliceous slags, although the latter do not solidify as rapidly as the former.

The same variations in the quantity of silica which occur in furnace slags are also to be found in original rocks, and just as furnace scoria have been ranged under different chemical formulæ, *so, likewise, it has become possible to classify original rocks in a* similar manner. When the student of chemistry has gradually added an acid to an alkali, or other base, until the mixture neither reddens litmus nor browns turmeric paper, he has formed a neutral salt consisting of one atom of base to one of acid, such as sulphate of iron ($FeO\ S.O_3$) and nitrate of potash ($KO\ N.O_5$). The salts of the peroxides, although frequently possessing acid properties, are, nevertheless, also regarded as neutral or normal and contain, for every atom of base, three of acid, such as persulphate of iron ($Fe_2\ O_3\ 3\ SO_3$) or tersulphate of alumina ($A_2\ O_3\ 3\ SO_3$). Similarly in mineralogy those silicates are regarded as neutral which contain one atom of monoxide combined with one of silica acid or silica, or one atom of sesquioxide combined with three of silica. Thus the mineral leucite, which consists of one atom of potash, one of alumina, and four of silicic acid, may be regarded as the type of a neutral mineral. Its formula is $KO.\ Al_2\ O_3.\ 4\ Si.\ O_2$ and it will be observed that its bases contain four while its acid contains eight equivalents of oxygen. Neutral or monosilicates, therefore, are those in which the proportion of oxygen in the bases, to that in the acid, is as 1 is to 2. If we search among crystalline rocks for those in which this oxygen ratio exists, we *shall find them to be well-defined rock species* which are not usually considered from a chemical point of view at all. These rock species are syenite, melaphyre and andesite, which respectively represent the neutral development of the granular, porphyritic, and trachytic orders of original rocks. If, from among the syenites, melaphyres and andesites which have been subjected to analysis, we select those whose oxygen ratio best corresponds to neutrality, we have the following:—

	Oxygen of bases.	Oxygen of acid.	Quantity of Silica in 100 parts rock.
I. Syenite from the Steilen Stiege, in the Hartz,—Fuchs.........	1	1·818	56·36
II. Syenite from Monte Margola, near Predazzo,—Kjerulf......	1	2·229	58·05
III. Syenite from the Schonberger Thal in the Bergstrasse,—G. Bischof....................	1	2·051	58·90
IV. Syenite from Plauenschen Grund, near Dresden,—Zirkel.	1	2·288	59.83
Average............	1	2·104	58.28
I. Melaphyre from Schneidmüllersberg, in Ilmenthal, near Ilmenau,—Von Richthofen...	1	1·938	55·51
II. Rhombic porphyry of Vettakolien, classed with the melaphyres, by Naumann, Delesse Kjerulf......................	1	2·017	56·—
III. Melaphyre from Bahrethal, near Ilfeld,—Streng.........	1	2·011	56·22
IV. Melaphyre from Leuchtburg, in the Thüringian Forest,—Soechting....................	1	2·133	59·18
Average............	1	2·024	56·73
II. Augitic andesite from Lowenburg, in Siebengebirge,—Kjerulf	1	1·868	55·6[illegible]
II. Hornblendic Andesite, from Merapi, in Java,—Prolss......	1	1·975	57·60
III. Hornblendic Andesite from Stary Swietlan,—Tschermak.	1	2·091	58·92
IV. Hornblendic Andesite, from Stenzelberg, in Siebengebirge, —Rammelsberg..............	1	2·332	59·22
Average.....	1	2·066	57·85

It would seem therefore from these figures, that those rocks which, in composition, are neutral or monosilicates, contain an amount of silica averaging 57.62 per cent.

As in chemistry we have acid salts, in which one atom of base is combined with more than one atom of acid, so in lithology we have rocks in which the silica is present in much larger quantity than is required for monosilicates. A very well defined series of rocks is known in which the silica is present in such excess as to give them the composition of bi-silicates, in which two atoms of silica are present for every one of mon-oxide, and six for every two of sesqui-oxide, or in which the oxygen ratio between bases and acid is as one to four. The granular, porphyritic and trachytic developements of those rocks are respectively represented by granite, felsitic porphyry and rhyolite. Proceeding in the same manner as with the neutral rocks we find the following among this series to approach most closely in composition to bi-silicates:

	O. RATIO. Bases.	Silica.	Quantity of Silica in 100 parts rock.
I. Granite from Heidelberg,—Streng	1	3 893	72.11
II. Granite from Doochary Bridge, Donegal,—Houghton	1	3.760	72.24
III. Granite of Fox Rock, near Dublin,—Houghton...	1	4.077	73
IV. Granite of Striegan near Silesia, —Streng....................	1	4.364	73.13
V. Granite of Blackstairs Mountian, Wexford,—Houghton ...	1	3.953	73.20
Average..............	1	4 009	72.73
I. Felsitic porphyry from Mühlberg near Halle,—Laspeyres	1	4.051	72.24
I. Quartzose trachyt from Hohenburg, near Berkum, opposite the Siebengebirge, Bischof ..	1	3.824	72.25
II. Quartzose trachyte from the Island of Ponza.—Abich	1	4.152	73.46
Average.............	1	3.988	72.86

It appears, therefore, that the oxygen ratio 1 to 4 corresponds to an average silica percentage of 72.61, and to such bi-silicate rocks the name silicic might be applied.

But besides this silicic series of rocks there is found another series of very different chemical constitution, and in which the bases, and not the silica, preponderate. It is only, however, in rare instances among these rocks that the silica disappears to such an extent as to form a disilicate, *i.e.*, a compound of one equivalent of silica with two of base, or in which the quantities of oxygen contained in acid and base are equal. A very well marked series of basic rocks may, however, be pointed out in which two equivalents of silica are combined with three of base, and in which the oxygen ratio is as $1\frac{1}{3}$ to 1. The rocks which represent this basic development of the porphyritic and trachytic textures, are, respectively, augitic porphyry and nephelinite. The following are instance of these rocks in which the oxygen ratio most closely approaches 1·333=1 :—

	OXYGEN RATIO. Bases.	OXYGEN RATIO. Silica.	Quantity of Silica in 100 parts rock.
Augitic porphyry from Fassathal in Tyrol	1	1·391	45·05
Nephelinite from Wickenstein in Lower Silesia,—Lowe	1	1·347	41·87

The number of analyses of these basic rocks being somewhat limited, it is not possible to arrive at their average silica contents so closely as in the case of the neutral and silicic rocks. These instances, however, shew that the oxygen ratio 1·333:1 corresponds to a percentage of about 43.46 silica. Rocks thus constituted being two-third silicates, might be conveniently called sub-silicates, and, in contradistinction to the silicic series, might be termed the basic rocks.

Between the basic and neutral rocks, on the one hand, and the latter and the silicic rocks on the other, there exist many other rocks of intermediate composition and forming gradual transitions between each of the series, which have been more minutely referred to in the foregoing. It thus becomes possible to point out a series of rocks passing gradually from the basic extreme to that of acidity in composition, not only for each of the granular porphyritic and trachytic order of rocks, but also for every variety of texture specified in the preceding chapter. The following Table gives an arrangement of these various series of rocks and an exhibition of the distinctive characters as to texture and chemical composition possessed by each. In constructing this table, it has been found that by limiting the variations in silica contents of each family to 7 per cent. very correct lines of separation may be drawn betwixt them:—

TABLE I,

Showing the General Chemical Composition of the Families of Original Rocks.

Order of Texture.	Basic Rocks, (subsilicates), containing less than 49 per cent. Silica.	Basous Rocks containing from 49 to 55 per cent. Silica	Neutral Rocks, (monosilicates) containing from 56 to 63 per cent. Silica.	Siliceous Rocks, containing from 63 to 70 per cent. Silica	Silicic Rocks, containing more than 70 per cent. Silica
I. Coarse and small-grained..............	Anorthosite.	Greenstone.	Syenite.	Granitite.	Granite.
II Schistose	Basic schist.	Hornblende chist.	Syenite schist.	Gneiss.	Gneissite.
III. Slaty..............	....	Greenstone slate.	Clay slate.	Siliceous slate.	Silicic slate.
IV. Porphyrite	Augitic porphry.	Greenstone porphyry.	Melaphyre.	Porphyrite.	Felsitic porphyry.
V. Variolite............	....	Variolite.	Var. basaltite	....	Spherulite.
VI. Fine-grained	Basalt.	Trap.	Basaltite.	Eurite.	Felsite.
VII. Trachytic.........	Nephelinite.	Dolerite.	Andesite.	Trachyte.	Rhyolite.
VIII Volcanic	Nephelinite lava.	Dolerite lava	Andesite lava.	Trachytic lava.	Obsidian.

Before proceeding to explain the foregoing table, it may be mentioned that no new names have been used in its construction; that names to which definite ideas as to mineralogical constitution are attached, have been, as much as possible, excluded. Such names as trap, greenstone, and melaphyre, which have been, in the early history of the science, much abused and misapplied, and more recently condemned as useless for the purpose of indicating any special rock, are introduced into our table, and advantageously used in designating the families of rocks to which they were originally applied. If it were made a rule in the science to exclude from it all names which have been at one time or other misused, very few petrological terms would escape obliteration: and the fact that the names above mentioned, in spite of their condemnation by some lithologists, continue in common use, sufficiently proves that they possess a certain degree of usefulness and applicability.

It will be observed that in the table the terms basic and basous, silicic and siliceous, are used in a manner analogous to that in which the stronger and weaker bases and the stronger and weaker acids are indicated in chemical nomenclature. A bas*ic* slate always contains a larger percentage of bases than a bas*ous* one, and a sili*cic* porphyry in the same way contains more silica than a sili*ceous* one. It will next be observed that we have in the table eight different horizontal series of rocks, or rather rock families, corresponding to the eight different varieties of texture which have been before particularized. On passing in each of these series from left to right, we pass from the basic to the siliceous extremes, through rock families gradually increasing in silica contents, as the figures at the head of the vertical columns shew. With this increase in the amount of silica a corresponding change in the nature of the bases with which it is combined takes place. Towards the basic extreme these are principally magnesia, lime, and protoxide of iron; but as the silica increases these bases diminish, and alumina with the alkalies increase until, at the silicic extreme, alumina and potash become the preponderating bases. We have also in the table five different vertical series, among which the neutral, basic and silicic groups already referred to, occupy places in the middle and at the sides, while the intermediate groups, which were also mentioned above, and which have been called the basous and siliceous rocks, occupy positions immediately to the left and right of the central column. The rock families of each of these vertical series, although they may differ widely as regards their texture, all possess a similar chemical composition. The chemical nature, texture, and affinities of any original rock or rock family are seen from this table at a glance. Thus, porphyrite appears as the porphyritic developement of the siliceous group of rocks; as less siliceous than felsitic porphyry, and more so than melaphyre. Basalt is seen to be the most basic member of the fine-grained order, and to contain less than forty-nine per cent. of silica. The affinities of any rock may be ascertained by observing the names of the rocks placed next to it, for in almost every case it is into these that it is most prone to graduate.

There are other of the general relations among original rocks visible from this table than those which refer to their composition texture and affinities. Not only do the rock families mentioned in each vertical column resemble each other in chemical composition, but they also exhibit similar coincidences as regards their general colour, hardness and fusibility, and gradual transitions in each of these respects are found to exist from rock to rock along each horizontal series. The basic rocks are generally darker coloured, less hard, and more readily fusible than the rocks which correspond to them in texture but differ from them in containing a larger percentage of silica. On the other hand the more siliceous a rock is, the lighter it will generally be found to be in colour, the harder and more difficult to penetrate or excavate, and the more refractory on exposure to high temperatures.

There is yet another physical property belonging to those original rocks, in which they show a similar correspondence with their chemical composition. Still speaking generally, the more siliceous a rock the lighter it is, not only in colour, but in weight; the more basic the rock, the heavier it becomes. Thus it is the case that, in each order of texture on passing from the siliceous to the basic rocks, a gradual increase of density takes place, and, on the other hand, the transition from the basic rocks to the more siliceous exhibits a gradual diminution of specific gravity. So constant is this relation that it may be taken advantage of in determining the general composition of a rock. To take as an instance the coarsely granular series of rock families the general range of their specific gravities may be said to be as follows:—

Granite	- - - - -	2.65 and under.
Granitite	- - - -	2.65 to 2.8.
Syenite	- - - - -	2.8 to 2.875.
Greenstone	- - - -	2.875 to 3.—

This part of the subject is one of very great interest, but it would be premature at present to discuss it minutely.

(*To be continued.*)

NOTES ON THE BOTANY OF A PORTION OF THE COUNTIES OF HASTINGS AND ADDINGTON.

By B. J. Harrington, B.A.,

During a portion of the summer of 1869, I accompanied Mr. Vennor as his assistant in his exploration, among the Laurentian rocks of Ontario, and although my labours were of necessity for the most part geological, I could not resist the temptation of taking an occasional botanical stroll, and jotting down the names of a few old and familiar friends. While many other Townships were entered, it was principally in those of Elzevir, Kaladar and Barrie that attention was given to Botany. The hilly and broken character of the Laurentian country is well known, and this, together with the imperfect drainage of the crystalline rocks, and the frequently scanty and light soil arising from their disintegration, cannot well fail to exert a marked influence upon the vegetation. Thus, among the granitic hills of Elzevir, Caprifoliaceæ are exceedingly abundant, fourteen species being represented. Of the genus Viburnum there were five species, several of these being very common. In the lower ground Ericaceous shrubs, and in some places, more particularly in cedar (*Thuja occidentalis*) swamps, several species of northern Orchids were found. I say low ground; but there is much of the country having this character which is in reality elevated, the imperfect drainage, mentioned above, causing the formation of bogs, marshes and lakes in the hollows among the hills.

On the 10th June we left Belleville by stage for Bridgewater, a village about thirty miles back. The road for the first twenty miles passes through a beautiful farming country, with here and there a grove of Maples and Beech (*Fagus ferruginea*). In clumps along the fences, the Dogwood (*Cornus stolonifera*), with its red stems and newly-opened flowers, was occasionally to be seen, and just before reaching the bridge over the Moira, we saw the May-Apple (*Podophyllum peltatum*) with its umbrella-like leaf. Next morning found us among the Laurentian hills at Bridgewater, with the river Scutomatto ("turbulent water") rolling past, in the low ground near which we found two species of Crow-foot (*Ranunculus recurvatus et abortivus*): a Meadow-Rue (*Thalictrum dioicum*), the Cranberry Tree (*Viburnum Opulus*), an Elder (*Sambucus pubens*), the Choke-cherry (*Prunus Virginiana*) and Red Cherry (*P. Pennsylvanica*) were in full bloom, and a little higher up, the showy Bunch-berry (*Cornus Canadensis*), the Service-berry (*Amelanchier Canadensis*), the Barren Strawberry (*Waldsteinia fragarioides*), the Indian Turnip (*Arisaema triphyllum*) and the Wild Sarsparilla (*Aralia nudicaulis*). Close to the river the Star-Lily (*Smilacina stellata*) grew, its starry flowers looking all the whiter over the black mud, and a short distance from the bank several species of Horsetail were waving like plumes in the breeze, the most common being *Equisetum sylvaticum*. Here and there a Trillium (*T. grandiflorum*) was expanding its petals to receive the sunshine after being watered by nearly a week's rain, and two Violets (*Viola cucullata et blanda*) dotted the meadow with their tiny flowers. On the road-side some of the usual stragglers (*Cynoglossum officinale*, *Verbascum Thapsus* and *Capsella Bursa-pastoris*) were growing in abundance, as if preferring the society of man to the retirement of the forest; and hard by in a swamp I gathered the three Flowering Ferns (*Osmunda regalis, O. Claytoniana* and *O. cinnamomea*), the fertile fronds of the last standing straight as soldiers on duty. Alongside these grew the Sensitive Fern (*Onoclea sensibilis*), and, where the ground was dryer, the Bracken (*Pteris aquilina*). On a ridge of granitic gneiss to the East, we found the Fly-Honeysuckle (*Lonicera ciliata*), the Wild Gooseberry (*Ribes Cynosbati*), the Fringe-Jointed Knotweed (*Polygonum cilinode*) and the Sheep Sorrel (*Rumex Acetosella*). On the highest point of the rock, the common Polypody (*Polypodium vulgare*) seemed to find sufficient nourishment to grow quite luxuriantly, while its less aspiring brother (*P. Dryopteris*) had chosen a more congenial spot in the hollow at the base. The delicate Bladder Fern (*Cystopteris fragilis*) peeped out from crevices in the rock, while two Shield-Ferns (*Aspidium spinulosum* and *A. marginale*) and the Lady-Fern (*Asplenium Filix-fœmina*) clothed the borders of a little brook. In the dry fields the Plantain-leaved Everlasting (*Antennaria plantaginifolia*) was everywhere abundant.

Throughout the Laurentian country the soil upon limestone bands is in general much richer than that upon other kinds of rock, and its influence upon the vegetation is very marked. The Pines and other evergreens which generally accompany gneissose rocks, give place to hard-wood trees; the shrubs, and other plants, too, are those which are usually found in rich, moist woods. The following list of plants, collected on the 12th of June, while following the Bridgewater limestone southwards, makes this evident:—

Acer rubrum,
—— saccharinum,
—— spicatum,
Aquilegia Canadensis,
Sanguinaria Canadensis,
Osmorrhiza brevistylis,
Actæa spicata,
Uvularia grandiflora,
Smilacina bifolia,
—— racemosa,
Dicentra Canadensis,
Caulophyllum thalictroides,
Aralia trifolia,
Mitella diphylla,
Tiarella cordifolia.
Trillium erectum,
Trientalis Americana,
Dentaria diphylla,
Ampelopsis quinquefolia.
Viola Canadensis,
Viburnum lantanoides,
Polygonatum biflorum,
Streptopus roseus,
Adiantum pedatum,
Aspidium acrostichoides,
Polypodium Phegopteris, and
Botrychium Virginianum.

On the 13th June, we followed the limestone in the opposite direction from the day before, and found other circumstances coming in to alter the character of the vegetation. The limestone occupied a depression, bordered on either side by high ridges of gneiss, and the water accumulating in this hollow had formed a Cedar and Black Ash (*Fraxinus sambucifolia*) swamp, which would be well nigh impenetrable to any but an enthusiastic naturalist. On the borders of this swamp we found *Aspidium Thelypteris* and *A. cristatum*, and just within its dismal confines gathered *Asplenium thelypteroides*. A little further and the Clintonia (*C. borealis*) spread its broad leaves over the moss, and seemed to tinkle its bell-like flowers, and the delicate Twin-flower (*Linnæa borealis*) covered the stumps as if to conceal their rottenness, scarce leaving room for the little Goldthread (*Coptis trifolia*). Here and there might be seen the downy little Dalibarda (*D. repens*), and but a short distance beyond, the northern green Orchis (*Platanthera hyperborea*) stood as stiff and straight as an obelisk. In a spot a little more open, but still wet and mossy, I gathered a Coral-root (*Corallorhiza Macraei*) in full bloom; it was not again met with during the summer. Club-Mosses (*Lycopodium dendroideum*, *L. annotinum* and *L. clavatum*) were there very abundant.

Returning by the road, we found among the rocky hills a Sumach (*Rhus typhina*) growing in abundance, also the Blackberry (*Rubus villosus*) and Red Raspberry (*R. strigosus*). On the borders of a moist wood, the little *Hepatica triloba* grew in the shade of a Basswood (*Tilia Americana*). The long, green racemes hung like earrings from the Striped Maple (*Acer Pennsylvanicum*), contrasting strongly with the broad, white cymes of a Cornel (*Cornus alternifolia*). Within the wood we found *Pyrola secunda*, *Medeola Virginica*, *Circaea alpina* and *Gaultheria procumbens*. In the fields near the road the Crowfoot (*Ranunculus acris*), Chickweed (*Cerastium vulgatum*), and Dandelion (*Taraxacum Dens-leonis*) were growing everywhere.

On the day following, I found the first Strawberry (*Fragaria Virginiana*) of the season, and among the granitic hills on the Flinton Road, *Corydalis glauca*, *Geranium Carolinianum*, and *Diervilla trifida*, all three in flower. In the swampy depressions, before mentioned, the white blossoms of the Choke-berry (*Pyrus arbutifolia*) were now and then to be seen.

From Bridgewater to Flinton (a small settlement in Kaladar) is a distance of about twelve miles by the direct road; there is, however, another, known as the Old Flinton Road, which is more circuitous, and passes through the corner of Hungerford. Upon this road, about five miles from Bridgewater, the following plants were collected on the 16th of June:—

Mitchella repens,	Geum rivale,
Chimaphila umbellata,	Galium triflorum,
Calla palustris,	Iris versicolor,
Cicuta maculata,	Eupatorium purpureum,
Sium lineare,	Naumburgia thyrsiflora,
Sanicula Marilandica,	Senecio aureus,
Rubus odoratus,	Myosotis arvensis, and
Physalis viscosa,	Erigeron Philadelphicum.

A few days later, in crossing over to the village of Madoc, we left the road and took a short cut through the woods, where we found the Yellow Wood-Sorrel (*Oxalis stricta*). On reaching the river Moira, the Persicaria (*Polygonum amphibium*) was growing in the shallow water, its elliptical leaves floating upon the surface, and not far off the Water Plantain (*Alisma Plantago*).

The road from Bridgewater to Queensborough (a small village near the western boundary of Elzevir) follows for the most part the course of the green dioritic rocks which succeed the great granitic area of Elzevir. The soil is light and sandy nearly all the way, but there are occasional marshy spots. Along this road the following plants were collected on the 25th of June:—

Ledum latifolium,
Caltha palustris,
Eupatorium perfoliatum,
Triosteum perfoliatum,
Galium circæzans,
Viburnum nudum,
Nepeta Cataria,
Leucanthemum vulgare,
Tanacetum vulgare,
Gnaphalium polycephalum, and
Anemone Pennsylvanica.

At a place called Hasard's Corners, a few miles from Queensborough, we saw a few Butternut trees (*Juglans cinerea*). This was the only place in which this tree was met with during the summer, and the reason of its occurrence here is probably to be found in the deposits of drift, which form a richer soil than that derived from the wear of the metamorphic rocks.

Proceeding, we took the direct road across the granitic area of Elzevir, gathering by the way a number of plants. On a sandy hill, near Bridgewater, we found *Viburnum pubescens*, and on the road sides *Erigeron strigosum*, *Potentilla norvegica* and *Silene noctiflora*. In the depressions among the granitic hills, the Common Meadow-Sweet (*Spiræa salicifolia*) was exceedingly abundant, and *S. tomentosa* not uncommon. The shrubbery was composed of different species of Arrow-wood, and in addition to those already mentioned, the *Viburnum acerifolium*. The white blossoms of the Mountain-Ash (*Pyrus Americana*) were here and there to be seen, and where fire had been at work, the great Willow-herb (*Epilobium angustifolium*). Growing upon the almost bare rock, we found everywhere the Bristly Sarsparilla (*Aralia hispida*). On the borders of a little pond were growing the *Galium trifidum* and the *Sarracenia purpurea*, and in the water, *Nuphar advena*. In a moist wood on the eastern side of the granitic area, we found the Wood-Sorrel (*Oxalis Acetosella*).

the Gossamer-Fern (*Dicksonia punctilobula*) and the Moose-wood (*Dirca palustris.*)

The day following, June 29th, we started to survey the old road from Flinton towards Bridgewater. A considerable portion of this road passes through dry Pine woods (*Pinus Strobus*); here we found Honeysuckles (*Lonicera hirsuta*) in full bloom, and *L. parviflora* in fruit; also *Pyrola rotundifolia* both in flower and fruit. The Goldenrod (*Solidago squarrosa*) was seen occasionally, but had not yet spread its showy rays; but the Loosestrife (*Lysimachia quadrifolia*) grew in abundance. On the way back to Flinton, we saw in the sandy fields the common Yarrow (*Achillea millefolium*).

At the beginning of July we left for the Township of Barrie, and on the Addington Road found the following species:—

Epilobium coloratum,	Laportea Canadensis,
—— palustre,	Verbena hastata,
Apocynum androsæmifolium,	Polygonum Convolvulus, and
Thalictrum Cornuti,	Alnus incana.

Barrie is studded with numerous and beautiful lakes, and much of our time was spent in following their shores in canoes—this being the easiest way of obtaining sections across the Township. The first lake visited is known by the name of 'Mazinaw,' or, among the settlers, 'Michinog'; it is about nine miles long, varying greatly in width. On the eastern side the Mazinaw Cliff rises from the water to a height of about 200 feet perpendicular, at one part slightly overhanging. The Red-man gazes with awe upon this rock, and, if you question him, tells you that it is the abode of the Evil Spirit. In years long past he has ventured to approach the base in his birch canoe, and paint upon it figures of men and various animals. The oldest settlers say that the figures were there when they were young, but that they still retain their original brightness. Much as we had desired to see them, we only obtained a glimpse of the top of an Indian's head, since a dam had been built at the foot of the lake, raising the water several feet The settlers have much to tell about the rock; they say that it contains wealth untold, and that in days gone by the silver could be seen hanging from the face like great icicles. Some persons have spent weeks of search, but have always been obliged to come to the conclusion that the rock is nothing but a great mass of granitic gneiss, and that whatever silver may have been there in the past, the Evil Spirit has since appropriated. As we paddled along, we could not wonder at the superstitions of the savage, for we were awed to silence by the grandeur of the scene. Our tiny craft seemed to grow more and more tiny as we advanced; we felt like pigmies, and feared lest the plash of the paddle might arouse the ire of the Spirit who had chosen the rock for his abode. The summit of the rock is covered with evergreens, and on the steep sides a little Evergreen or a Birch (*Betula papyracea*) is here and there seen struggling for a foothold. By a clear spring which trickled down the rock, the Poison Ivy (*Rhus Toxicodendron*) trailed, and along the face of the rock the Harebell (*Campanula rotundifolia*) nodded in the breeze. *Pentstemon pubescens* was very abundant, and here and there we saw tufts of *Woodsia Ilvensis* and of *Cystopteris fragilis*.

In the neighbourhood of Lake Mazinaw, we found at different times during the month of July, the following plants:—

Corallorhiza multiflora,
Pinus resinosa,
Moneses uniflora,
Pyrola chlorantha,
Monotropa Hypopitys.
Platanthera orbiculata,
—— bracteata,
—— psycodes,
Sambucus Canadensis,
Cephalanthus occidentalis.
Corylus Americana,
Œnothera pumila,
—— biennis,
Aster puniceus,
—— cordifolius,
Lysimachia stricta,
Hypericum perfoliatum,
Scutellaria galericulata,
Brunella vulgaris,
Shepherdia Canadensis,
Adlumia cirrhosa,
Potentilla palustris,
Geum strictum,
Fragaria vesca,
Ribes prostratum,
Saxifraga Virginiensis,
Aralia racemosa,
Cornus circinata.
Sagittaria variabilis,
Aspidium Noveboracense,
Betula excelsa,
Quercus rubra,
Larix Americana,
Kalmia glauca,
Andromeda polifolia.
Cassandra calyculata.
Diplopappus umbellatus,
Hypericum ellipticum, and
Ulmus Americana.

On the 4th of August we crossed from Mazinaw to Buckshot Lake. If any one would test his powers of endurance, let him shoulder his pack and try this "portage," much of which passes through swamps and beaver-meadow, where the mud and water are knee deep, and the mosquitos make their onset with a ferocity beyond description. Here we found —

Potentilla fruticosa,
Pontederia cordata.
Monotropa uniflora,
Cypripedium acaule,

Campanula apariniodes,
Clematis Virginiana,
Rosa Carolina,
Goodyera pubescens, and
Lycopodium complanatum.

While spending a few days on and about the Frontenac Road, near the Mississippi River, we found the following plants:—

Lobelia inflata,
—— ardinalis,
Mimulus ringens,
Scutellaria lateriflora,
Lycopus Europæus,
Eupatorium ageratoides,
Solidago Canadensis,
—— altissima,
Agrimonia Eupatoria, and
Asclepias incarnata.

Such, then, is an imperfect account of the plants collected from the middle of June until the latter part of August, in a small portion of our Laurentian country. The lists were not intended for publication, but were kept merely for private gratification. otherwise they might and would have been more complete. Being fully aware of their imperfection, I have only been persuaded to publish them in the hope that they may be of some small service to those who are studying the distribution of plants in Canada.

MEETING OF THE BRITISH ASSOCIATION,

Held at Liverpool in September, 1870.

THE PRESIDENT'S ADDRESS.

My Lords, Ladies, and Gentlemen,—It has long been the custom for the newly-installed President of the British Association for the advancement of Science to take advantage of the elevation of the position in which the suffrages of his colleagues had, for the time, placed him, and casting his eyes around the horizon of the scientific world, to report to them what could be seen from his watch-tower; in what directions the multitudinous divisions of the noble army of the improvers of natural knowledge were marching; what important strongholds of the great enemy of us all, Ignorance, had been recently captured; and, also, with due impartiality, to mark where the advanced posts of science had been driven in, or a long-continued siege had made no progress.

I propose to endeavour to follow this ancient precedent, in a manner suited to the limitations of my knowledge and of my capacity. I shall not presume to attempt a panoramic survey of the world of Science, nor even to give a sketch of what is doing in the one great province of Biology, with some portions of which my ordinary occupations render me familar. But I shall endeavour to put before you the history of the rise and progress of a single biological doctrine; and I shall try to give some notion of the fruits, both intellectual and practical, which we owe, directly or indirectly, to the working out, by seven generations of patient and laborious investigators, of the thoughts which arose, more than two centuries ago, in the mind of a sagacious and observant Italian naturalist.

It is a matter of every-day experience that it is difficult to prevent many articles of food from becoming covered with mould; that fruit, sound enough to all appearance, often contains grubs at the core; that meat left to itself in the air, is apt to putrefy and swarm with maggots. Even ordinary water, if allowed to stand in an open vessel, sooner or later becomes turbid and full of living matter.

The philosophers of antiquity, interrogated as to the cause of these phenomena, were provided with a ready and a plausible answer. It did not enter their minds even to doubt that these low forms of life were generated in the matters in which they made their appearance. Lucretius, who had drunk deeper of the scientific spirit than any poet of ancient or modern times except Goethe, intends to speak as a philosopher, rather than as a poet, when he writes that "with good reason the earth has gotten the name of mother, since all things are produced out of the earth. And many living creatures, even, now spring out of the earth, taking form by the rains and the heat of the sun." The axiom of ancient science, "that the corruption of one thing is the birth of another," had its popular embodiment in the notion that a seed dies before the young plant springs from it; a belief so widespread and so fixed, that St. Paul appeals to it in one of the most splendid outbursts of his fervid eloquence:—"Thou fool, that which thou sowest is not quickened, except it die." (1 Corinthians, xv. 36.) The proposition that life may, and does, proceed from that which has no life, then, was held alike by the philosophers, the poets, and the people of the most enlightened nations, eighteen hundred years ago; and it remained the accepted doctrine of learned and unlearned Europe, through the Middle Ages down even to the seventeenth century.

It is commonly counted among the many merits of our great countryman, Harvey, that he was the first to declare the opposition of fact to venerable authority in this, as in other matters; but I can discover no justification for this wide-spread notion. After careful search through the 'Exercitationes de Generatione,' the most that appears clear to me is, that Harvey believed all animals and plants to spring from what he terms a "*primordium vegetale*," a phrase which may now-a-days be rendered "a vegetative germ"; and this, he says, is "*oviforme*," or "egg-like"; not, he is careful to add, that it necessarily has the shape of an egg, but because it has the constitution and nature of one. That this "*primordium oviforme*" must needs, in all cases, proceed from a living parent is nowhere expressly maintained by Harvey, though such an opinion may be thought to be implied in one or two passages; while, on the other hand, he does, more than once, use language which is consistent only with a full belief in spontaneous or equivocal generation. In fact, the main concern of Harvey's wonderful little treatise is not with generation, in the physiological sense, at all, but with developement; and his great object is the establishment of the doctrine of Epigenesis.

The first distinct enunciation of the hypothesis that all living matter has sprung from pre-existing living matter, came from a contemporary, though a junior, of Harvey, a native of that country, fertile in men great in all departments of human activity, which was to intellectual Europe, in the sixteenth and seventeenth centuries, what Germany is in the nineteenth. It was in Italy, and from Italian teachers, that Harvey received the most important part of his scientific education. And it was a student trained in the same schools, Francesco Redi—a man of the widest knowledge and most versatile abilities, distinguished alike as scholar, poet, physician, and naturalist,—who, just 202 years ago, published his 'Esperienze intorno alla Generazione degl' Insetti,' and gave to the world the idea, the growth of which it is my purpose to trace. Redi's book went through five editions in twenty years; and the extreme simplicity of his experiments, and the clearness of his arguments, gained for his views, and for their consequences, almost universal acceptance.

Redi did not trouble himself much with speculative considerations, but attacked particular cases of what was supposed to be "spontaneous generation" experimentally. Here are dead animals, or pieces of meat, says he; I expose them to the air in hot weather, and in a few days they swarm with maggots. You tell me that these are generated in the dead flesh; but if I put similar bodies, while quite fresh, into a jar, and tie some fine gauze over the top of the jar, not a maggot makes its appearance, while the dead substances, nevertheless, putrefy just in the same way as before. It is obvious, therefore, that the maggots are not generated by the corruption of the meat; and that the cause of their formation must be a something which is kept away by gauze. But gauze will not keep away aëriform bodies, or fluids. This something must, therefore, exist in the form of solid particles too big to get through the gauze. Nor is one long left in doubt what these solid particles are; for the blow-flies, attracted by the odour of the meat, swarm round the vessel, and, urged by a powerful but, in this case misleading instinct, lay eggs, out of which maggots are immediately hatched, upon the gauze. The conclusion, therefore, is unavoidable; the maggots are not generated by the meat, but the eggs which give rise to them are brought through the air by the flies.

These experiments seem almost childishly simple, and one wonders how it was that no one ever thought of them before. Simple as they are, however, they are worthy of the most careful study, for every piece of experimental work since done, in regard to this subject, has been shaped upon the model furnished by the Italian philosopher. As the results of his experiments were the same, however varied the nature of the materials he used, it is not wonderful that there arose in Redi's mind a presumption, that in all such cases of the seeming production of life from dead matter, the real explanation was the introduction of living germs from without into that dead matter—(Redi, *Esperienze*, pp. 14–16). And thus the hypothesis that living matter always arises by the agency of pre-existing living matter, took definite shape; and had henceforward a right to be considered and a claim to be refuted, in each particular case, before the production of living matter in any other way could be admitted by careful reasoners. It will be necessary for me to refer to this hypothesis so frequently, that, to save circumlocution, I shall call it the hypothesis of *Biogenesis*; and I shall term the contrary doctrine—that living matter may be produced by not living matter—the hypothesis of *Abiogenesis*.

In the seventeenth century, as I have said, the latter was the dominant view, sanctioned alike by antiquity and by authority; and it is interesting to observe that Redi did not escape the customary tax upon a discoverer, of having to defend himself against the charge of impugning the authority of the Scriptures (Redi, *l. c.* p. 45, *Esperienze*, p. 120); for his adversaries declared that the generation of bees from the carcase of a dead lion is affirmed, in the Book of Judges, to have been the origin of the famous riddle with which Samson perplexed the Philistines:

> Out of the eater came forth meat,
> And out of the strong came forth sweetness.

Against all odds, however, Redi, strong with the strength of demonstrable fact, did splendid battle for Biogenesis; but it is remarkable that he held the doctrine in a sense which, if he had lived in these times, would have infallibly caused him to be classed among the defenders of "spontaneous generation." "Omne vivum ex vivo," "no life without antecedent life," aphoristically sums up Redi's doctrine; but he went no further. It is most remarkable evidence of the philosophic caution and impartiality of his mind, that, although he had speculatively anticipated the manner in which grubs really are deposited in fruits and in the galls of plants, he deliberately admits that the evidence is insufficient to bear him out; and he therefore prefers the supposition that they are generated by a modification of the living substance of the plants themselves. Indeed, he regards these vegetable growths as organs, by means of which the plant gives rise to an animal, and looks upon this production of specific animals as the final cause of the galls and of, at any rate, some fruits. And he proposes to explain the occurrence of parasites within the animal body in the same way.

It is of great importance to apprehend Redi's position rightly; for the lines of thought he laid down for us are those upon which naturalists have been working ever since. Clearly he held Biogenesis as against Abiogenesis; and I shall immediately proceed, in the first place, to inquire how far subsequent investigation has borne him out in so doing.

But Redi also thought that there were two modes of Biogenesis. By the one method, which is that of common and ordinary occurrence, the living parent gives rise to offspring which passes through the same cycle of changes as itself—like gives rise to like; and this has been termed Homogenesis. By the other mode, the living parent was supposed to give rise to offspring which passed through a totally different series of states from those exhibited by the parent, and did not return into the cycle of the parent: this is what ought to be called Heterogenesis, the offspring being altogether, and permanently, unlike the parent. The term Heterogenesis, however, has unfortunately been used in a different sense, and M. Milne-Edwards has therefore substituted for it Xenogenesis, which means the generation of something foreign. After discusing Redi's hypothesis of universal Biogenesis, then, I shall go on to ask how far the growth of science justifies his other hypothesis of Xenogenesis.

The progress of the hypothesis of Biogenesis was triumphant and unchecked for nearly a century. The application of the microscope to anatomy, in the hands of Crew, Leeuwenhoek, Swammerdam, Lyonet, Vallisnieri, Reaumur, and other illustrious investigators of nature of that day, displayed such a complexity of organization in the lowest and minutest forms, and everywhere revealed such a prodigality of provision for their multiplication by germs of one sort or another, that the hypothesis of Abiogenesis began to appear not only untrue, but absurd; and in the middle of the eighteenth century, when Needham and Buffon took up the question, it was almost universally discredited. ('Nouvelles Observations,' p. 169 and 176.)

But the skill of the microscope-makers of the eighteenth century soon reached its limit. A microscope magnifying 400 diameters was a *chef-d'œuvre* of the opticians of that day; and, at the same time, by no means trustworthy. But a magnifying-power of 400 diameters, even when definition reaches the exquisite perfection of our modern achromatic lenses, hardly suffices for the mere discernment of the smallest forms of life. A speck, only $\frac{1}{25}$ of an inch in diameter, has, at ten inches from the eye, the same apparent size as an object $\frac{1}{10000}$th *of an inch in diameter*, when magnified 400 times; but forms of living matter abound, the diameter of which is not more than $\frac{1}{40000}$th of an inch. A filtered infusion of hay allowed to stand for two days, will swarm with living things, among which, any which reaches the diameter of a human red blood-corpuscle, or about $\frac{1}{3200}$th of an inch, is a giant. It is only by bearing these facts in mind, that we can deal fairly with the remarkable statements and speculations put forward by Buffon and Needham in the middle of the eighteenth century.

When a portion of any animal or vegetable body is infused in water, it gradually softens and disintegrates; and as it does so, the water is found to swarm with minute active creatures, the so-called Infusorial Animalcules, none of which can be seen except by the aid of the microscope; while a large proportion belong to the category of smallest things of which I have spoken, and which must have all looked like mere dots and lines under the ordinary microscopes of the eighteenth century.

Led by various theoretical considerations, which I cannot now discuss, but which looked promising enough in the lights of that day, Buffon and Needham doubted the applicability of Redi's hypothesis to the infusorial animalcules, and Needham very properly endeavoured to put the question to an experimental test. He said to himself, if these infusorial animalcules come from germs, their germs must exist either in the substance infused, or in the water with which the infusion is made, or in the superjacent air. Now the vitality of all germs is destroyed by heat. Therefore, if I boil the infusion, cork it up carefully, cementing the cork over with mastic, and then heat the whole vessel by heaping hot ashes over it, I must needs kill whatever germs are present. Consequently, if Redi's hypothesis hold good, when the infusion is taken away and allowed to cool, no animalcules ought to be developed in it; whereas, if the animalcules are not dependent on pre-existing germs, but are generated from the infused substance, they ought, by-and-by, to make their appearance. Needham found that, under the circumstances in which he made his experiments, animalcules always did arise in the infusions, when a sufficient time had elapsed to allow for their developement.

In much of his work Needham was associated with Buffon, and the results of their experiments fitted in admirably with the great French naturalist's hypothesis of "organic molecules," according to which, life is the indefeasible property of certain indestructible molecules of matter, which exist in all living things, and have inherent activities by which they are distinguished from not living matter. Each individual living organism is formed by their temporary combination. They stand to it in the relation of the particles of water to a cascade or whirlpool; or to a mould, into which the water is poured. The form of the organism is thus determined by the reaction between external conditions and the inherent activities of the organic molecules of which it is composed; and, as the stoppage of a whirlpool destroys nothing but a form, and leaves the molecules of the water, with all their inherent activities intact, so what we call the death and putrefaction of an animal or a plant is merely the breaking up of the form, or manner of association, of its constituent organic molecules, which are then set free as infusorial animalcules.

It will be perceived that this doctrine is by no means identical with *Abiogenesis,* with which it is often confounded. On this hypothesis, a piece of beef or a handful of hay is dead only in a limited sense. The beef is dead ox, and the hay is dead grass; but the "organic molecules" of the beef or the hay are not dead, but are ready to manifest their vitality as soon as the bovine or herbaceous shrouds in which they are imprisoned are rent by the macerating action of water. The hypothesis, therefore, must be classified under Xenogenesis rather than under Abiogenesis. Such as it was, I think it will appear, to those who will be just enough to remember that it was propounded before the birth of modern chemistry and of the modern optical arts, to be a most ingenious and suggestive speculation.

But the great tragedy of science—the slaying of a beautiful hypothesis by an ugly fact—which is so constantly being enacted under the eyes of philosophers, was played almost immediately, for the benefit of Buffon and Needham.

Once more, an Italian, the Abbé Spallanzani, a worthy successor and representative of Redi in his acuteness, his ingenuity, and his learning, subjected the experiments and the conclusions of Needham to a searching criticism. It might be true that Needham's experiments yielded results such as he had described, but did they bear out his arguments? Was it not possible, in the first place, that he had not completely excluded the air by his corks and mastic? And was it not possible; in the second place, that he had not sufficiently heated his infusions and the superjacent air? Spallanzani joined issue with the English naturalist on both these pleas; and he showed that if, in the first place, the glass vessels in which the infusions were contained were hermetically sealed by fusing their necks, and if, in the second place, they were exposed to the temperature of boiling-water for three quarters of an hour (see Spallanzani, 'Opere' vi. pp. 42 and 51), no animalcules ever made their appearance within them. It must be admitted that the experiments and arguments of Spallanzani furnish a complete and a crushing reply to those of Needham. But we all too often forget that it is one thing to refute a proposition, and another to prove the truth of a doctrine which implicitly, or explicitly, contradicts the proposition; and the advance of science soon showed that though Needham might be quite wrong, it did not follow that Spallanzani was quite right.

Modern Chemistry, the birth of the latter half of the eighteenth century, grew apace, and soon found herself face to face with the great problems which Biology had vainly tried to attack without her help. The discovery of oxygen led to the laying of the foundations of a scientific theory of respiration, and to an examination of the marvellous interactions of organic substances with oxygen. The presence of free oxygen appeared to be one of the conditions of the existence of life, and of those singular changes in organic matters which are known as fermentation and putrefaction. The question of the generation of the infusorial animacules thus passed into a new phase. For what might not have happened to the organic matter of the infusions, or to the oxygen of the air, in Spallanzani's experiments? What security was there that the developement of life which ought to have taken place had not been checked, or prevented, by these changes?

The battle had to be fought again. It was needful to repeat the experiments under conditions which would make sure that neither the oxygen of the air, nor the composition of the organic matter, was altered, in such a manner as to interfere with the existence of life.

Schulze and Schwann took up the question from this point of view in 1836 and 1837. The passage of air through red-hot glass tubes, or through strong sulphuric acid, does not alter the proportion of its oxygen, while it must needs arrest, or destroy, any organic matter which may be contained in the air. These experimenters, therefore, contrived arrangements by which the only air which should come into contact with a boiled infusion should be such as had either passed through red-hot tubes or through strong sulphuric acid. The result which they obtained was that an infusion so treated developed no living things, while if the same infusion was afterwards exposed to the air such things appeared rapidly and abundantly. The accuracy of these experiments has been alternately denied and affirmed. Supposing them to be accepted, however, all that they really proved was, that the treatment to which the air was subjected destroyed *something* that was essential to the developement of life in the infusion. This "something" might be gaseous, fluid, or solid; that it consisted of germs remained only an hypothesis of greater or less probability.

Contemporaneously with these investigations a remarkable discovery was made by Cagniard de La Tour. He found that common yeast is composed of a vast accumulation of minute plants. The fermentation of must, or of wort, in the fabrication of wine and beer, is always accompanied by the rapid growth and multiplication of these Torulæ. Thus fermentation, in so far as it was accompanied by the developement of microscopical organisms in enormous numbers, became assimilated to the decomposition of an infusion of ordinary animal or vegetable matter; and it was an obvious suggestion that the organisms were, in some way or other, the causes both of fermentation and putrefaction. The chemists, with Berzelius and Liebig at their head, at first laughed this idea to scorn; but in 1843, a man then very young, who has since performed the unexampled feat of attaining to high eminence alike in Mathematics, Physics and Physiology,—I speak of the illustrious Helmholtz,—reduced the matter to a test of experiment by a method alike elegant and conclusive. Helmholtz separated a putrefying, or fermenting liquid, from one which was simply putrescible, or fermentable, by a membrane, which allowed the fluids to pass through and become intermixed, but stopped the passage of solids. The result was, that while the putrescible, or the fermentable, liquids became impregnated with the results of the putrescence, or fermentation, which was going on on the other side of the membrane, they neither putrefied (in the ordinary way) nor fermented; nor were any of the organisms which abounded in the fermenting, or putrefying, liquid generated in them. Therefore the cause of the developement of these organisms must lie in something which cannot pass through membrane; and as Helmholtz's investigations were long antecedent to Graham's researches upon colloids, his natural conclusion was, that the agent thus intercepted must be a solid material. In point of fact Helmholtz's experiments narrowed the issue to this: that which excites fermentation and putrefaction, and at the same time gives rise to living forms in a fermentable, or putrescible fluid, is not a gas and is not a diffusible fluid; therefore it is either a colloid, or it is matter divided into very minute solid particles.

The researches of Schroeder and Dusch in 1854, and of Schroeder alone, in 1859, cleared up this point by experiments which are simply refinements upon those of Redi. A lump of cotton-wool is, physically speaking, a pile of many thicknesses of very fine gauze, the fineness of the meshes of which depends upon the closeness of the compression of the wool. Now, Schroeder and Dusch found, that, in the case of all the putrefiable materials which they used (except milk and yolk of egg), an infusion boiled, and then allowed to come in contact with no air but such as had been filtered through cotton-wool, neither putrified nor fermented, nor developed living forms. It is hard to imagine what the fine sieve formed by the cotton-wool could have stopped except minute solid particles. Still the evidence was incomplete until it had been positively shown, first, that ordinary air does contain such particles; and, secondly, that filteration through cotton-wool arrests these particles and allows only physically pure air to pass. This demonstration has been furnished within the last year by the remarkable experiments of Prof. Tyndall. It has been a common objection of Abiogenists that, if the doctrine of Biogeny is true, the air must be thick with germs; and they regard this as the height of absurdity. But nature occasionally is exceedingly unreasonable, and Prof. Tyndall has proved that this particular absurdity may nevertheless be a reality. He has demonstrated that ordinary air is no better than a sort of stirabout of excessively minute solid particles; that these particles are almost wholly destructible by heat; and that they are strained off, and the air rendered optically pure, by being passed through cotton-wool.

But it remains yet in the order of logic though not of history, to show that, among these solid destructible particles, there really do exist germs capable of giving rise to the developement of living forms in suitable menstrua. This piece of work was done by M. Pasteur in those beautiful researches which will ever render his name famous, and which, in spite of all attacks upon them, appear to me now, as they did seven years ago ('Lectures to Working Men on the Causes of the Phenomena of Organic Nature,' 1863, to be models of acurate experimentation and logical reasoning. He strained air through cotton-wool, and found, as Schroederand Dusch had done, that it contained nothing competent to give rise to the developement of life in fluids highly fitted for that purpose. But the important further links in the chain of evidence added by Pasteur are three. In the first place, he submitted to microscopic examination the cotton-wool which had served as strainer, and found that sundry bodies, clearly recognizable as germs, were among the solid particles strained off. Secondly, he proved that these germs were competent to give rise to living forms by simply sowing them in a solution fitted for their developement. And, thirdly, he showed that the incapacity of air strained through cotton-wool to give rise to life was not due to any occult change effected in constituents of the air by the wool, by proving that the cotton-wool might be dispensed with altogether, and perfectly free access left between the exterior air and that in the experimental flask. If the neck of the flask is drawn out into a tube and bent downwards, and if, after the contained fluid has been carefully boiled, the tube is heated sufficiently to destroy any germs which may be present in the air which enters as the fluid cools, the apparatus may be left to itself for any time, and no life will appear in the fluid. The reason is plain. Although there is free communication between the atmosphere laden with germs and the germless air in the flask, contact between the two takes place only in the tube; and as the germs cannot fall upwards, and there are no currents, they never reach the interior of the flask. But if the tube be broken short off where it proceeds from the flask, and free access be thus given to germs falling vertically out of the air, the fluid, which has remained clear and desert for months, becomes, in a few days, turbid and full of life.

These experiments have been repeated over and over again by independent observers with entire success; and there is one very simple mode of seeing the fact for oneself, which I may as well describe.

Prepare a solution (much used by M. Pasteur, and often called "Pasteur's solution") composed of water with tartrate of ammonia, sugar, and yeast-ash dissolved therein. Infusion of hay treated in the same way, yields similar results; but as it contains organic matter, the argument which follows cannot be based upon it. Divide it into three portions in as many flasks; boil all three for a quarter of an hour; and, while the steam is passing out, stop the neck of one with a large plug of cotton-wool, so that this also may be thoroughly steamed. Now set the flasks aside to cool, and when their contents are cold, add to one of the open ones a drop of filtered infusion of hay which has stood for twenty-four hours, and is consequently full of the active and excessively minute organisms known as Bacteria. In a couple of days of ordinary warm weather, the contents of this flask will be milky, from the enormous multiplication of Bacteria. The other flasks, open and exposed to the air, will, sooner or later, become milky with Bacteria, and patches of mould may appear in it; while the liquid in the flask, the neck of which is plugged with cotton-wool, will remain clear for an indefinite time. I have sought in vain for any explanation of these facts, except the obvious one, that the air contains germs competent to give rise to Bacteria, such as those with which the first solution has been knowingly and purposely inoculated, and to the mould Fungi. And I have not yet been able to meet any advocate of Abiogenesis who seriously maintains that the atoms of sugar, tartrate of amonia, yeast-ash and water, under no influence but that of free access of air and the ordinary temperature, re-arrange themselves and give rise to the protoplasm of Bacterium. But the alternative is to admit that these Bacteria arise from germs in the air; and, if they are thus propagated, the burden of proof, that other like forms are generated in a different manner, must rest with the asserter of that proposition.

To sum up the effect of this long chain of evidence:—

It is demonstrable, that a fluid eminently fit for the developement of the lowest forms of life, but which contains neither germs nor any protein compound, gives rise to living things in great abundance, if it is exposed to ordinary air; while no such developement takes place if the air with which it is in contact is mechanically freed from the solid particles, which ordinary float in it, and which may be made visible by appropriate means.

It is demonstrable, that the great majority of these particles are destructible by heat, and that some of them are germs, or living particles, capable of giving rise to the same form of life as those which appear when the fluid is exposed to unpurified air.

It is demonstrable, that inoculation of the experimental fluid with a drop of liquid known to contain living particles, gives rise to the same phenomena as exposure to unpurified air.

And it is further certain that these living particles are so minute that the assumption of their suspension in ordinary air present not the slightest difficulty. On the contrary, considering their lightness and the wide diffusion of the organisms which produce them, it is impossible to conceive that they should not be suspended in the atmosphere in myriads.

Thus the evidence, direct and indirect, in favour of Biogenesis for all known forms of life must, I think, be admitted to be of great weight.

On the other side, the sole assertions worthy of attention are, that hermetically sealed fluids, which have been exposed to great and long-continued heat, have sometimes exhibited living forms of low organization when they have been opened.

The first reply that suggests itself is the probability that there must be some error about these experiments, because they are performed on an enormous scale every day, with quite contrary results. Meat, fruits, vegetables, the very materials of the most fermentable and putrescible infusions, are preserved to the extent I suppose I may say, of thousands of tons every year, by a method which is a mere application of Spallanzani's experiment. The matters to be preserved are well boiled in a tin case provided with a small hole, and this hole is soldered up when all the air in the case has been replaced by steam. By this method they may be kept for years, without putrefying, fermenting, or getting mouldy. Now this is not because oxygen is excluded, inasmuch as it is now proved that free oxygen is not necessary for either fermentation or putrefaction. It is not because the tins are exhausted of air, for Vibriones and Bacteria live, as Pasteur has shown, without air or free oxygen. It is not because the boiled meats or vegetables are not putrescible or fermentable, as those who have had the misfortune to be in a ship supplied with unskillfully closed tins well know. What is it, therefore, but the exclusion of the germs? I think that Abiogenists are bound to answer this question before they ask us to consider new experiments of precisely the same order.

And in the next place, if the results of the experiments I refer to are really trustworthy, it by no means follows that Abiogenesis has taken place. The resistance of living matter to heat is known to vary within considerable limits, and to depend, to some extent, upon the chemical and physical qualities of the surrounding medium. But if, in the present state of science, the alternative is offered us, either germs can stand a greater heat than has been supposed, or the molecules of dead matter, for no valid or intelligible reason that is assigned, are able to re-arrange themselves into living bodies, exactly such as can be demonstrated to be frequently produced in another way, I cannot understand how choice can be, even for a moment, doubtful.

But though I cannot express this conviction of mine too strongly, I must carefully guard myself against the supposition that I intend to suggest that no such thing as Abiogenesis ever has taken place in the past, or ever will take place in the future. With organic chemistry, molecular physics, and physiology yet in their infancy, and every day making prodigious strides, I think it would be the height of presumption for any man to say that the conditions under which matter assumes the properties we call "vital" may not, some day, be artificially brought together. All I feel justified in affirming is, that I see no reason for believing that the feat has been performed yet.

And, looking back through the prodigious vista of the past, I find no record of the commencement of life, and therefore I am devoid of any means of forming a definite conclusion as to the conditions of its appearance. Belief, in the scientific sense of the word, is a serious matter and needs strong foundations. To say, therefore, in the admitted absence of evidence, that I have any belief as to the mode in which the existing forms of life have originated, would be using words in a wrong sense. But expectation is permissible where belief is not; and if it were given to me to look beyond the abyss of geologically recorded time to the still more remote period when the earth was passing through physical and chemical conditions, which it can no more see again than a man may recall his infancy, I should expect to be a witness of the evolution of living protoplasm from not living matter. I should expect to see it appear under forms of great simplicity, endowed, like existing Fungi, with the power of determining the formation of new protoplasm from such matters as ammonium carbonates, oxalates and tartrates, alkaline and earthy phosphates, and water, without the aid of light. That is the expectation to which analogical reasoning leads me; but I beg you once more to recollect that I have no right to call my opinion anything but an act of philosophical faith.

So much for the history of the progress of Redi's great doctrine of Biogenesis, which appears to me, with the limitations I have expressed, to be victorious along the whole line at the present day.

As regards the second problem offered to us by Redi, whether Xenogenesis obtains, side by side with Homogenesis; whether, that is, there exist not only the ordinary living things, giving rise to offspring which run through the same cycle as themselves, but also others, producing offspring which are of a totally different character from themselves, the researches of two centuries have led to a different result. That the grubs found in galls are no product of the plants on which the galls grow, but are the result of the introduction of the eggs of insects into the substance of these plants, was made out by Vallisnieri, Reaumur, and others, before the end of the first half of the eighteenth century.

The tapeworms, bladderworms and flukes continued to be a stronghold of the advocates of Xenogenesis for a much longer period. Indeed, it is only within the last thirty years that the splendid patience of Von Siebold, Van Beneden, Leuckart, Kuchenmeister, and other helminthologists, has succeeded in tracing every such parasite, often through the strangest wanderings and metamorphoses, to an egg derived from a parent actually or potentially like itself; and the tendency of inquiries elsewhere has all been in the same direction. A plant may throw off bulbs, but these, sooner or later, give rise to seeds or spores, which develope into the original form.

A polype may give rise to Medusæ, or a pluteus to an Echinoderm, but the Medusa and the Echinoderm give rise to eggs which produce polypes or plutei, and they are therefore only stages in the cycle of life of the species.

But if we turn to Pathology, it offers us some remarkable approximations to true Xenogenesis.

As I have already mentioned, it has been known since the time of Vallisnieri and of Reaumur that galls in plants and tumours in cattle are caused by insects, which lay their eggs in those parts of the animal or vegetable frame of which these morbid structures are outgrowths. Again, it is a matter of familiar experience to everybody that mere pressure on the skin will give rise to a corn. Now the gall, the tumour, and the corn are parts of the living body, which have become, to a certain degree, independent and distinct organisms. Under the influence of certain external conditions, elements of the body, which should have developed in due subordination to its general plan, set up for themselves, and apply the nourishment which they receive to their own purposes.

From such innocent productions as corns and warts there are all gradations to the serious tumours which, by their mere size and the mechanical obstruction they cause, destroy the organism out of which they are developed; while, finally, in those terrible structures known as cancers, the abnormal growth has acquired powers of reproduction and multiplication, and is only morphologically distinguishable from the parasitic worm, the life of which is neither more nor less closely bound up with that of the infested organism.

If there were a kind of diseased structure, the histological elements of which were capable of maintaining a separate and independent existence out of the body, it seems to me that the shadowy boundary between morbid growth and Xenogenesis would be effaced. And I am inclined to think that the progress of discovery has almost brought us to this point already. I have been favoured by Mr. Simon with an early copy of the last published of the valuable 'Reports on the Public Health,' which, in his capacity of their Medical Officer, he annually presents to the Lords of the Privy Council. The Appendix to this Report contains an introductory essay 'On the intimate Pathology of Contagion,' by Dr. Burdon Sanderson, which is one of the clearest, most comprehensive, and well-reasoned discussions of a great question which has come under my notice for a long time. I refer you to it for details and for the authorities for the statements I am about to make.

You are familiar with what happens in vaccination. A minute cut is made in the skin, and an infinitesimal quantity of vaccine matter is inserted into the wound. Within a certain time, a vesicle appears in the place of the wound, and the fluid which distends this vesicle is vaccine matter, in quantity a hundred or a thousand-fold that which was originally inserted. Now what has taken place in the course of this operation? Has the vaccine matter by its irritative property produced a mere blister, the fluid of which has the same irritative porperty? Or does the vaccine matter contain living particles, which have grown and multiplied where they have been planted? The observations of M. Chauveau, extended and confirmed by Dr. Sanderson himself, appear to leave no doubt upon this head. Experiments, similar in principle to those of Helmholtz on fermentation and putrefaction, have proved that the active element in the vaccine lymph is non-diffusible, and consists of minute particles not exceeding $\frac{1}{20000}$ of an inch in diameter, which are made visible in the lymph by the microscope. Similar experiments have proved that two of the most destructive of epizootic diseases, sheep-pox and glanders, are also dependent for their existence and their propagation upon extremely small living solid particles, to which the title of *microzymes* is applied. An animal suffering under either of these terrible diseases is a source of infection and contagion to others, for precisely the same reason as a tub of fermenting beer is capable of propagating its fermentation "by infection," or "contagion," to fresh wort. In both cases it is the solid living particles which are efficient; the liquid in which they float, and at the expense of which they live, being altogether passive.

Now arises the question, are these microzymes the results of *Homogenesis* or of *Xenogenesis;* are they capable, like the *Torulæ* of yeast, of arising only by the developement of pre-existing germs; or may they be, like the constituents of a nut-gall, the results of a modification and individualization of the tissues of the body in which they are found, resulting from the operation of certain conditions? Are they parasites in the zoological sense, or are they merely, what Virchow has called "heterologous growths"? It is obvious that this question has the most profound importance, whether we look at it from a practical, or from a theoretical, point of view. A parasite may be stamped out by destroying its germs, but a pathological product can only be annihilated by removing the conditions which give rise to it.

It appears to me that this great problem will have to be solved for each zymotic disease separately, for analogy cuts two ways. I have dwelt upon the analogy of pathological modification, which is in favour of the xenogenetic origin of microzymes; but I must now speak of the equally strong analogies in favour of the origin of such pestiferous particles by the ordinary process of the generation of like from like.

It is, at present, a well-established fact that certain diseases, both of plants and of animals, which have all the characters of contagious and infectious epidemics, are caused by minute organisms. The smut of wheat is a well-known instance of such a disease, and it cannot be doubted that the grape-disease and the potato-disease fall under the same category. Among animals, insects are wonderfully liable to the ravages of contagious and infectious diseases caused by microscopic Fungi.

In autumn, it is not uncommon to see flies, motionless, upon a window-pane, with a sort of magic circle, in white, drawn round them. On microscopic examination, the magic circle is found to consist of innumerable spores, which have been thrown off in all directions by a minute fungus called *Empusa muscæ*, the spore-forming filaments of which stand out like a pile of velvet from the body of the fly. These spore-forming filaments are connected with others, which fill the interior of the fly's body like so much fine wool, having eaten away and destroyed the creature's viscera. This is the full-grown condition of the Empusa. If traced back to its earlier stages, in flies which are still active, and to all appearance healthy, it is found to exist in the form of minute corpuscles which float in the blood of the fly. These multiply and lengthen into filaments, at the expense of the fly's substance; and when they have at last killed the patient, they grow out of its body and give off spores. Healthy flies shut up with diseased ones catch this mortal disease and perish like the others. A most competent observer, M. Cohn, who studied the development of the Empusa in the fly very carefully, was utterly unable to discover in what manner the smallest germs of the Empusa got into the fly. The spores could not be made to give rise to such germs by cultivation; nor were such germs discoverable in the air, or in the food of the fly. It looked exceedingly like a case of Abiogenesis, or, at any rate, of Xenogenesis; and it is only quite recently that the real course of events has been made out. It has been ascertained, that when one of the spores falls upon the body of a fly, it begins to germinate, and sends out a process which bores its way through the fly's skin; this, having reached the interior cavities of its body, gives off the minute floating corpuscles which are the earliest stage of the Empusa. The disease is "contagious," because a healthy fly coming in contact with a diseased one, from which the spore-bearing filaments protrude, is pretty sure to carry off a spore or two. It is "infectious" because the spores become scattered about all sorts of matter in the neighbourhood of the slain flies.

The silkworm has long been known to be subject to a very fatal contagious and infectious disease called the Muscadine. Audouin transmitted it by inoculation. This disease is entirely due to the development of a fungus, *Botrytis Bassiana*, in the body of the caterpillar; and its contagiousness and infectiousness are accounted for in the same way as those of the fly disease. But of late years a still more serious epizootic has appeared among the silk worms; and I may mention a few facts which will give you some conception of the gravity of the injury which it has inflicted on France alone.

The production of silk has been, for centuries, an important branch of industry in Southern France, and in the year 1853 it had attained such a magnitude, that the annual produce of the French sericulture was estimated to amount to a tenth of that of the whole world, and represented a money value of 117,000,000 francs, or nearly five millions sterling. What may be the sum which would represent the money-value of all the industries connected with the working up of the raw silk thus produced, is more than I can pretend to estimate. Suffice it to say, that the City of Lyons is built upon French silk, as much as Manchester was upon American cotton before the civil war.

Silkworms are liable to many diseases; and even, before 1853, a peculiar epizootic, frequently accompanied by the appearance of dark spots upon the skin (whence the name of "Pébrine" which it has received), had been noted for its mortality. But in the years following 1853 this malady broke out with such extreme violence, that, in 1856, the silk-crop was reduced to a third of the amount which it had reached in 1853; and, up till within the last year or two, it has never attained half the yield of 1853. This means not only that the great number of people engaged in silk-growing are some thirty millions sterling poorer than they might have been; it means not only that high prices have had to be paid for imported silk-worm-eggs, and that, after investing his money in them, in paying for mulberry-leaves and for attendance, the cultivator has constantly seen his silk-worms perish and himself plunged in ruin,—but it means that the looms of Lyons have lacked employment, and that, for years, enforced idleness and misery have been the portion of a vast population which, in former days, was industrious and well to do.

In 1858 the gravity of the situation caused the French Academy of Sciences to appoint Commissioners, of whom a distinguished naturalist, M. de Quatrefages, was one, to inquire into the nature of this disease, and, if possible, to devise some means of staying the plague. In reading the Report (Etudes sur les Maladies Actuelles des Vers à Soie, p. 53) made by M. de Quatrefages, in 1859, it is exceedingly interesting to observe that his elaborate study of the Pébrine forced the conviction upon his mind that, in its mode of occurrence and propagation, the disease of the silk-worm is, in every respect, comparable to the cholera among mankind. But it differs from the cholera, and, so far, is a more formidable disease, in being hereditary, and in being under some circumstances contagious, as well as infectious.

The Italian naturalist, Filippi, discovered in the blood of the silkworm affected by this strange disease, a multitude of cylindrical corpuscles, each about $\frac{1}{6000}$ of an inch long. These have been carefully studied by Lebert, and named by him Panhistophyton; for the reason that, in subjects in which the disease is strongly developed, the corpuscles swarm in every tissue and organ of the body, and even pass into the undeveloped eggs of the female moth. But are these corpuscles causes, or mere concomitants, of the disease? Some naturalists took one view and some another; and it was not until the French Government, alarmed by the continued ravages of the malady, and the inefficiency of the remedies which had been suggested, despatched M. Pasteur to study it, that the question received its final settlement; at a great sacrifice, not only of the time and peace of mind of that eminent philosopher, but, I regret to have to add, of his health.

But the sacrifice has not been in vain. It is now certain that this devastating, cholera-like, Pébrine is the effect of the growth and multiplication of the Panhistophyton in the silkworm. It is contagious and infectious because the corpuscles of the Panhistophyton pass away from the bodies of the diseased caterpillars, directly or indirectly, to the alimentary canal of healthy silkworms in their neighbourhood; it is hereditary, because the corpuscles enter into the eggs while they are being formed, and consequently are carried within them when they are laid; and for this reason, also, it presents the very singular peculiarity of being inherited only on the mother's side. There is not a single one of all the apparently capricious and unaccountable phenomena presented by the Pébrine, but has received its explanation from the fact that the disease is the result of the presence of the microscopic organism, Panhistophyton.

Such being the facts with respect to the Pébrine, what are the indications as to the method of preventing it? It is obvious that this depends upon the way in which the Panhistophyton is generated. If it may be generated by Abiogenesis, or by Xeno genesis, within the silkworm or its moth, the extirpation of the disease must depend upon the prevention of the occurrence of the conditions under which this generation takes place. But if, on the other hand, the Panhistophyton is an independent organism, which is no more generated by the silkworm than the mistletoe is generated by the oak, or the apple-tree, on which it grows, though it may need the silkworm for its developement, in the same way as the mistletoe needs the tree, then the indications are totally different. The sole thing to be done is to get rid of and keep away the germs of the Panhistophyton. As might be imagined, from the course of his previous investigations, M. Pasteur was led to believe that the latter was the right theory; and guided by that theory, he has devised a method of extirpating the disease, which has proved to be completely successful wherever it has been properly carried out.

There can be no reason, then, for doubting that, among insects, contagious and infectious diseases of great malignity are caused by minute organisms which are produced by pre-existing germs, or by Homogenesis; and there is no reason, that I know of, for believing that what happens in insects may not take place in the highest animals. Indeed, there is already strong evidence that some diseases of an extremely malignant and fatal character to which man is subject, are as much the work of minute organisms as is the Pébrine. I refer for this evidence to the very striking facts adduced by Prof. Lister in his various well-known publications on the antiseptic method of treatment. It seems to me impossible to rise from the perusal of those publications without a strong conviction that the lamentable mortality which so frequently dogs the footsteps of the most skilful operator, and those deadly consequences of wounds and injuries which seem to haunt the very walls of great hospitals, and are even now destroying more men than die of bullet or bayonet, are due to the importation of minute organisms into wounds, and their increase and multiplication; and that the surgeon who saves most lives will be he who best works out the practical consequences of the hypothesis of Redi.

I commenced this Address by asking you to follow me in an attempt to trace the path which has been followed by a scientific idea, in its long and slow progress from the position of a probable hypothesis to that of an established Law of Nature. Our survey has not taken us into very attractive regions; it has lain chiefly in a land flowing with the abominable, and peopled with mere grubs and mouldiness. And it may be imagined with what smiles and shrugs practical and serious contemporaries of Redi and of Spallanzani may have commented on the waste of their high abilities in toiling at the solution of problems which, though curious enough in themselves, could be of no conceivable utility to mankind.

Nevertheless, you will have observed that before we had travelled very far upon our road, there appeared, on the right hand and on the left, fields laden with a harvest of golden grain, immediately convertable into those things which the most sordidly practical of men will admit to have value,—namely money and life.

The direct loss to France caused by the Pébrine in seventeen years cannot be estimated at less than fifty millions sterling; and if we add to this what Redi's idea, in Pasteur's hands, has done for the wine-grower and for the vinegar-maker, and try to capitalize its value, we shall find that it will go a long way towards repairing the money losses caused by the frightful and calamitous war of this autumn.

And as to the equivalent of Redi's thought in life, how can we over-estimate the value of that knowledge of the nature of epidemic and epizootic diseases, and, consequently, of the means of checking or eradicating them, the dawn of which has assuredly commenced?

Looking back no further than ten years, it is possible to select three (1863, 1864 and 1869), in which the total number of deaths from scarlet fever alone amounted to 90,000. That is the return of killed, the maimed and disabled being left out of sight. Why, it is to be hoped that the list of killed in the present bloodiest of all wars will not amount to more than this! But the facts which I have placed before you must leave the least sanguine without a doubt that the nature and the causes of this scourge will one day be as well understood as those of the Pébrine are now; and that the long-suffered massacre of our innocents will come to an end.

And thus mankind will have one more admonition that the "people perish for lack of knowledge"; and that the alleviation of the miseries and the promotion of the welfare of men must be sought, by those who will not lose their pains, in that diligent, patient, loving study, of all the multitudinous aspects of Nature, the results of which constitute exact knowledge, or Science.

It is the justification and the glory of this great Meeting that it is gathered together for no other object than the advancement of the moiety of Science which deals with those phenomena of Nature which we call Physical. May its endeavours be crowned with a full measure of success!

GEOLOGY AND MINERALOGY.

The Student's Elements of Geology. By Sir Charles Lyell, Bart., F.R.S.—The Elements and Principles of Geology, by Sir Charles Lyell, have been probably the most successful works on that science ever published. The former has gone through six editions, and the latter is now in its tenth. A new edition of the Elements being required, Sir Charles was induced to curtail it to such dimensions as would make it a more suitable manual for students, without sacrificing any of its essential features. This he has accomplished in the present "Student's Elements," which is a perfect gem in its way. Compact in size, admirably arranged, its well filled pages beautifully illustrated, it brings up every department of geology to the latest point in regard to facts, while the discussions in regard to theoretical views are very strict, pithy and well-weighed. While the formations of Europe are, as is usual in British text-books, taken as types, those of other parts of the world are well worked in; and a fair share of attention is given to the discoveries which have recently been made on this continent.

Sir Charles notices fully the recent remarkable discoveries of fossils in the Lower Cambrian of Britain, which extend a rich fauna back into the Longmynd Group, at one time supposed to be nearly barren of fossils. He proposes, in connection with this to establish firmly the once debateable Cambrian system, and to extend it as far upward as the Tremadoc. He thus arranges these rocks:—

Upper Cambrian:

Tremadoc Slates (Primordial of Barrande in part.)
Lingula Flags (Primordial of Barrande.)

Lower Cambrian:

Menevian Beds (Primordial of Barrande.)
Longmynd Group { *a.* Harlech grits. / *b.* Llanberis slates.

He regards the Potsdam Sandstone as equivalent to the Upper Cambrian, and places the Huronian as the possible equivalent of the Lower Cambrian. He barely notices our richly fossiliferous Lower Potsdam or Acadian group, and does not include it in his table, though it would have enabled him to find an equivalent for his Menevian beds. He still regards *Histioderma* as a worm-burrow, not being, apparently, aware of Mr. Billings' more probable explanation of it as a cast of a sponge.

It would, however, be useless to follow in detail a work of this kind, which every student and amateur in geology should have in his hands as a book of reference, and which as nearly as is possible in that science whose goal to-day is its starting point to-morrow, brings up the subject to a level with the present state of knowledge, and compresses all its more important facts into the shortest possible space, while exhibiting them with the utmost clearness.

Geological Discoveries in Brazil.—The following letter to one of the Editors from Prof. Hartt, a Nova Scotian by birth and education, and now Professor in Cornell University, gives some interesting notes on his present explorations in Brazil. The letter is dated from near Mont Alegre, Rio des Amazonas:—

"I have been making some discoveries down here that I think will interest you. On the Rio Tapajos I found a large area occupied by Carboniferous (lower) strata, affording fossils in profusion. The rocks are sandstone, limestone and shale,—the two former full of fossils. The strata are horizontal. The fossils bear a very close resemblance, many of them, to Nova Scotian species. There is a Productus cora and a P. semireticulatus wonderfully like the forms found at Windsor. I have between one and two hundred species of these fossils, and most of them will admit of determination. Many of the brachiopods, &c., are perfectly free from the rock, and shew interiors, loops, &c. I have one species of Trilobite, probably *Phillipsia*. Of fishes I have teeth scales, and spines. I am in doubt whether the deposits are Sub Carboniferous or Lower Coal Measures; I think the latter the most probable. I am going to give up my little steamer, which, through the kindness of the President of the Province I have had for two months, and divide up my party. I shall then return to the Tapajos to study out carefully these carboniferous deposits and Agassiz's drift. By the bye in this last there are, at Mont Alegre and Aveiros, trap beds."

BOTANY AND ZOOLOGY.

THE GEOGRAPHICAL HANDBOOK OF FERNS; by Katharine M. Lyell, London, 1870.—Mrs. Lyell has done good service to botanical students by compiling and publishing this excellent and most laboriously prepared handbook. The labor incident to such work can be appreciated only by those who have made similar attempts at compilation and geographical distribution. The globe is divided into eighteen sections or botanical areas, and the catalogues of all the species known to occur in each of these sections occupies the bulk of the volume; an indication of the distribution of species throughout the section is given in addition to the name,— thus *Nephrodium fragrans* occurs in three of these catalogues, first in one of the sections of Asia, "Northern, Central and Western Asia, China and Japan" where its habitat is said to be "high-arctic and sub-arctic regions, Caucasus "to Kamtschatka, Manchuria, and Amur;"—and then in two of the N. A. areas. The last forty pages of the book are occupied by a systematic catalogue of all the species, with the occurrence of each throughout these eighteen areas tabulated in parallel columns. North America is botanically deemed to go no further south than the northern Mexican boundary and is divided into three areas:—1st, British America east of the Rocky mountains, and Greenland, 2nd, the United States east of the Rocky mountains and Bermuda, and 3rd, the territory west of the Rocky Mountains from Alaska to the Mexican boundary. As the two first are not botanically separable by any geographical line perhaps that chosen by Mrs. Lyell is as good as any. Of the forty-four species given as occuring in the Canadian division, four have probably been inserted without sufficient authority; *Woodsia scopulina*, *Lomaria Spicant* and *Polypodium alpestre* are known only from the west side of the Rocky Mountains, and the occurrence of *Asplenium marinum* in New Brunswick still awaits verification. On the other hand nine undoubted natives have been omitted, some of them through an inadvertence as Mrs. Lyell informs me; they are,—

Cheilanthes gracilis ("base of the Rocky Mountains, Aug. 13, 1858," Bourgeau no. 3689 in Herb. Hook.*),
Pteris aquilina,
Woodwardia Virginica,
Scolopendrium vulgare,
Woodsia Oregana (Lake Winnepeg and westward),
Aspidium Lonchitis,
Nephrodium Noveboracense,
Botrychium matricariæfolium *A. Br* (including *B. lanceolatum* and=*B. rutaceum* in Syn. Fil. of Hooker, but not of Swartz), and
Ophioglossum vulgatum.

Of these forty-nine species at least twenty are common to both sides of the Rocky Mountains, all of which (with a doubt as to

* Prof. Eaton was kind enough to trace out the exact locality for me —" Windy mountain near Lacs des Arcs, N. lat. 51° 1' 44, *vide* Dr. Hector's journal in the 'Blue Book' on Capt. Palliser's Expedition." This station is probably its northern limit. In the U.S. it occurs on both sides of the Rocky mountains and as far south as Arizona (Herb. Eaton) and New Mexico (Ch. Wright nos. 818, 2125). It is the *Ch. vestita* of Hook. Fl. Bor. Am. ii, p. 264 and Sp. Fil. ii, p. 98, the *Ch. lanuginosa* of Gray's Manual.

the two species which are marked) are also known to occur on the mountains themselves; these are,—

Woodsia Oregana,
Cystea fragilis,
Adiantum pedatum ?
Cryptogramme crispa,
Pellæa atropurpurea,
Pteris aquilina,
Asplenium viride,
——— Trichomanes ?
——— Filix-fœmina,
Aspidium Lonchitis,
Aspidium aculeatum,
Nephrodium Filix-mas,
——— fragrans,
——— spinulosum,
Polypodium vulgare,
——— Phegopteris,
——— Dryopteris,
Botrychium Lunaria,
——— ternatum, and
——— virginianum.

On the east side of the Rocky Mountains, but apparently not extending as far west as the mountains, are twenty-three species, as follows,—

Onoclea sensibilis,
——— Struthiopteris,
Woodsia glabella,
——— hyperborea,
Dicksonia punctilobula,
Cystea bulbifera,
Pellæa gracilis,
Woodwardia Virginica,
Asplenium ebeneum,
——— angustifolium,
——— thelypteroides,
Scolopendrium vulgare,
Scolopendrium rhizophyllum,
Nephrodium Thelypteris,
——— Noveboracense,
——— Goldieanum,
Polypodium hexagonopterum,
Osmunda regalis,
——— Claytoniana,
——— cinnamomea,
Botrychium simplex,
——— matricariæfolium, and
Ophioglossum vulgatum.

The remaining six species of this area are found on the Rocky mountains, all of them (except *Ch. gracilis* which is not known east of Illinois) also extending eastward to the Atlantic; they are,

Cheilanthes gracilis,
Cystea montana,
Woodsia Ilvensis,
Aspidium acrostichoides,
Nephrodium cristatum, and
——— marginale;

making forty-nine species indigenous to that portion of British America to the east of the Rocky mountains. From the mountains westward to the Pacific we have but eleven other species which may be noted here. They are,

—On the Rocky Mountains and westward,

Woodsia scopulina,
Polypodium alpestre.

—On the West Coast, but not extending as far east as the Rocky Mountains,

Woodsia obtusa,*
Cheilanthes gracillima,

* It is somewhat singular that this species which is common throughout Prof. Chapman's and Dr. Gray's limits, coming right up to our borders

Pellæa densa,
Lomaria Spicant,
Polypodium Scouleri,
——— intermedium, and
Gymnogramme triangularis,
Nephrodium rigidum, (A. argutum, *Kaulf.*),
Aspidium munitum,

thus giving British America a known fern-flora of sixty species of which twenty-eight occur on the Rocky mountains.

On another page is given a list of the ferns of Labrador which includes some species not hitherto published. Thanks to Mr. Becket (one of the staff of the Geological Survey of the Island) and to Dr. Bell (this journal vol. iv. 1869, p. 256) we have now a tolerably long list of the ferns of Newfoundland though doubtless eight or ten species more would reward any careful collector. It is as follows:—

Onoclea sensibilis,
Woodsia Ilvensis,
——— glabella (Becket—robust specimens like some of Macoun's from Lake Superior),
Cystea fragilis,
——— bulbifera,
Pellæa gracilis,
Pteris aquilina,
Asplenium viride (Becket),
——— thelypteroides (Bell),
——— Filix-fœmina,
Aspidium aculeatum (Bell—the var. Braunii),
Nephrodium fragrans (Bell),
——— Filix-mas (Kunze),
——— spinulosum (verum et dilatatum),
Polypodium Dryopteris,
——— Phegopteris,
——— vulgare,
Osmunda regalis,
——— Claytoniana,
——— cinnamomea,
Botrychium Lunaria (Lyell),
——— ternatum (Hooker),
——— virginianum (Hooker).

A list of the ferns of Greenland, an outlying province of North America but with a European flora even along its western shores, has an interest in this connection. It is copied from Prof. Lange's catalogue in Rink's "Grönland" the author's nomenclature being preserved.

Polypodium Dryopteris *L.*
——— Phegopteris *L.*
——— alpestre *Hoppe*,
Aspidium Lonchitis *Sw.*
——— fragrans *Willd.*
Lastræa Filix-mas *Presl*,
——— dilatata *Presl*,
Cystopteris fragilis *Bernh.*
Woodsia ilvensis *R. Br.*
——— hyperborea *R. Br.*
Botrychium Lunaria *Sw.*
——— rutaceum *Fries* (=B. matricariaefolium *A. Br.*)

Mrs. Lyell adds *Woodsia glabella* and *Asplenium viride* without

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in the State of New York, should be unknown on the east side of the Rocky mountains in British America and unknown on the west side in the United States. Its Br. Am. station is on the authority of Kew specimens collected in 1861 on Galton mountains by Dr. Lyall of the Oregon Boundary Survey.

giving her authority and probably in error. Not one of these twelve species is peculiar to America; none of them are likely to have come from America unless *Aspidium fragrans*, a non-European plant wide-spread in north Asia.

Turning to Mrs. Lyell's second area, the United States east of the Rocky Mountains and north of Mexico, we find that the admitted species number seventy-eight, of which these four have probably been inserted in error:—

Cystea montana (the Rocky Mountains habitat of which is north of N. lat. 49°),
Pellæa densa ("Washington" Territory being on the west side),
Cheilanthes gracillima, and
Woodsia scopulina (neither of which occur on the east side of the mountains).

A good many species should be added which may be conveniently divided into various groups:—

A. Species which occur on the Rocky Mountains, but not as far north as lat. 49°—

Cheilanthes Fendleri,
Asplenium Septentrionale,
Nethochlæna Fendleri,
——— dealbata:—

[These four species added to the twenty-eight above noted, gives thirty-two species as the fern flora of the Rocky Mountains.]

B. Species which occur on both sides of the mountains (California, Arizona or New Mexico, and Texas)—

Pellæa Wrightiana,
——— mucronata,
Nothoclæna sulphurea (Mr. Baker's species is probably too comprehensive).

C. Species which have to be removed from the third area into this—

Cheilanthes Wrightii,
——— Lindheimeri,
Pellæa aspera,
——— pulchella,
——— cordata,
Aspidium juglandifolium,
Nothochlæna sinuata,
——— ferruginea,
Gymnogramme pedata,
Aneimia Mexicana.

This division must be held to include the trans-Mississippi States east and north of the Rio Grande, some of which (as Texas, Missouri, etc.) Mrs. Lyell erroneously quotes as belonging to her third area.

D. Two Eastern species are omitted, probably in error—Woodsia glabella (New York and northward); Woodsia hyperborea (Vermont, H. Mann, and northward).

These additions bring up the number of the known species inhabiting this area, to ninety-four; to which may be added

Woodsia Peruviana, should Chas. Wright's no. 2120 prove to be that species, and a new Asplenium recently found by Prof. Bradley in Tennessee.

Mrs. Lyell's third division, embracing all North America to the west of the Rocky Mountains and north of Mexico, is well separated into a botanical area, but, considering its extent and variety of climate, its fern flora is small though in many respects peculiar. Mrs. Lyell enumerates sixty species which number must, I fear, be considerably reduced, inasmuch as a great part of the range of mountains known as Sierra Madre is in (old) Mexico, not in New Mexico, and while such States as that last named and Colorada are common to both second and third areas, others, such as Texas, Kansas, Missouri, and Nebraska, are wholly in the second. The omissions should probably be as follows:—

A. The eleven species above enumerated as belonging to the second area not being known to occur on the west side of New Mexico.

B. Eight species not known on the west coast further north than Mexico proper:—

Adiantum Capilus-veneris (which, however, occurs on the east side from Alabama southward),
Cheilanthes Seemanni
—— microphylla (there is a Kew tradition that this species occurs in Texas, but it needs confirmation),
Cheilanthes viscosa,
Polypodium Madrense,
Gymnogramme tartarea,
—— podophylla,
Acrostichum conforme.

A few species should be added, some of which I enumerate:—

Cheilanthes argentea (said to have been collected by a Russian botanist in Alaska),
—— Newberrii *Eaton* (San Diego, Dr. Newberry and Prof. Wood),
Pellæa —— (Sierras, 1869, Prof. Bolander — probably a new species),
Nephrodium fragrans (N. W. America, Seemann),
—— dilatatum, (same locality and collector).

The scanty fern flora of the west coast may be seen from the following list copied from "A Catalogue of the Plants of San Francisco," by H. N. Bolander, 1870, which is said to include all the "species found about a hundred miles north and south of "San Francisco, and as far east as Mount Diablo":—

Polypodium Scouleri,
—— Californicum,
Adiantum pedatum,
—— Chilense,

Petris aquilina,	Cystopteris fragilis,
Pellæa mucronata,	Aspidium munitum,
——— densa,	——— Californicum,
——— andromedæfolia,	Nephrodium rigidum,
Gymnogramme triangularis,	——— Filix-mas,
Woodwardia radicans,	

or only fifteen species in all. Within the same distances of Montreal we could muster nearly three times as many.

Mrs. Lyell has followed the "Synopsis Filicum" of Hooker and Baker in nomenclature and species limitation, and, in the foregoing remarks, I have more or less closely followed her example.

NOTICE OF FUCUS SERRATUS FOUND IN PICTOU HARBOUR. By Rev. A. F. Kemp, M.A.—On the 29th June, 1869, I had an opportunity of examining the shores of the harbour of Pictou, Nova Scotia, and was fortunate enough in finding very fine specimens of *Fucus serratus* Linn. This plant is very common on the rocky sea-shores of Europe, and specially so in the northern parts of the British Islands. Harvey, in his Preface to the Nereis Boreali-Americana, says that *Fucus serratus* has not yet (1851) been detected in America. In the supplement to that work (1858), he says: "I have received a small fragment of this " common European plant, stated to have been found at Newbury- " port, Mass, U.S. It is hardly probable that it is either con- " fined to one locality, or even rare, wherever it occurs; yet none " of my other correspondents have sent it, nor do I know " the circumstances under which Captain Pike obtained it. I " hope this notice may lead some one on the coast to investigate " the subject; for European botanists are yet uncertain whether " *F. serratus* be really *bona fide* native of the American coast, or " merely a stray waif accidentally cast ashore." I have myself examined several points on the eastern coast of America where, if anywhere, this plant might be expected to grow, but have never seen a fragment of it. At Portland, and along the coast of Maine, northward, the shore is highly favourable for the growth of the larger fuci. At Peak's Island I found a peculiar analogue of *F. serratus*, occupying very much its place, and having nearly the same form and habit, excepting the serratures of the margins. It was very abundant on the outer shores of the islands in Casco Bay, but seems very much to be confined to that locality. I did not find it on the northern shores of the State around Eastport. Harvey thinks the plant is *Fucus anceps*. It is as prolific and abundant as *F. serratus* is in Europe. I have also examined several localities on the northern shores of Nova Scotia and in the harbour of Halifax, and have not seen a fragment of *F. serratus*, nor have I ever found it in the collections of amateurs. It was on the western shore of the harbour of Pictou, north of the town, that I first met with this plamt. It was cast ashore along with other sea-weeds. I however found it nowhere *growing* there. *F. nodosus* and *F. vesiculosus* were abundant *in situ*, but not this one. I searched carefully for it at low water, and only found at last a few fronds of it growing on a flat stone about a foot and a half in length and six inches in breadth, and lying loose on other stones, on the shore about a mile to the south of the town. From the quantity that lay on the shores, it was obvious that it grew abundantly in the harbour, but in deep water. This is not its usual habit. Along with allied species it generally occupies the space between tide marks. From these circumstances I have been led to think that *F. serratus* is not indigenous to this continent, and has been introduced from Europe. Probably it has been brought in the ballast of British ships, which used at a former time to be discharged in to the deeper parts of the harbour. This will also account for its deep-sea habitat. The fronds which I found *growing* were, as I have noted, on a flat stone that might easily have been washed ashore by the force of the waves, floated, as it would be to some extent, by the luxuriant vegetation which covered it. I have every reason to believe that this is the first authenticated instance of the existence of this plant on the eastern coast of America; and is probably the first instance in modern times of a naturalised European alga.

LABRADOR PLANTS.—The Rev. S. R. Butler, who has recently returned from a residence extending over several years in Labrador, has been good enough to give me a list of all the plants collected by him when there, from which I have compiled the following catalogue. Mr. Butler explains his localities thus:— "The two places I have most thoroughly examined are Caribou "Island and Forteau Bay. When a plant is marked 'Caribou,' "it is meant that I found it only at that place; when 'Forteau' "is mentioned, the plant may occur all round Forteau Bay, "while 'Amour' means that I have found it only in 'L'ance "Amour,' and that it is not likely to occur elsewhere in the Bay;

" and when no locality is specified, the species may be expected to " occur at many places, if not all along the coast." Amour Point is in the Strait of Belle Isle in long. 56° 50', and is thus in Labrador proper, while Caribou, three-fourths of a degree to the westward, is in the Dominion. Mr. Butler adds that he collected neither pines, willows nor glumaceous plants, and that his more obscure species were named for him by Prof. Eaton, of New Haven. This gentleman has kindly furnished me with a list of the collections of Miss Macfarlane in and around the same localities, which contained several species not mentioned by Mr. Butler; these I have inserted in their proper places, with the collector's name attached:

Ranunculus acris *Linn.* — level grassy places, Forteau.
Anemone parviflora *Michx*— hill-sides, Forteau.
Thalictrum dioicum *Linn.*—hill-sides and along brooks, Caribou and Forteau.
——— Cornuti *Linn.*—(Miss Macfarlane No. 1).
Coptis trifolia *Salisb.*—in swamps along the coast.
Nuphar advena *Aiton*—in ponds, Caribou.
Arabis alpina *Linn.*—brook-sides, Forteau.
Draba incana *Linn.*—Caribou.
Cochlearia tridactylites *Linn.*—sea-shore, Caribou.
——— ——— ——— hill-tops, Forteau.
Viola blanda *Willd.*—moist places, common along the coast.
——— Muhlenbergii *Torrey*—hill-sides, common.
Drosera rotundifolia *Linn.*—in swamps.
Parnassia parviflora *Cand.*—hill-sides, Amour.
Silene acaulis *Linn.*—hill-tops Amour, also Old Fort Island.
Arenaria Grœnlandica *Spreng.*—hill-sides, Baie des Rochers.
——— peploides *Linn.*—in sand near the sea-shore, Caribou and Forteau.
——— verna *Linn.* — hill-sides, Amour.
——— lateriflora *Linn.* — level grassy places.
Stellaria longipes *Goldie*—near the sea-shore.
——— Edwardsii *R. Br.*—(Miss Macfarlane No. 9. Torrey & Gray very properly reduce this to a variety of the last species).
——— borealis *Bigelow*—hill-sides, Caribou.
——— crassifolia *Ehrh.*—marshy flats.
Cerastium alpinum *Linn.* }
——— arvense *Linn.* }
—abundant about Forteau.
Astragalus alpinus *Linn.* }
Hedysarum boreale *Nuttall* }
—hill-sides, Amour.
Lathyrus maritimus *Bigelow*—Caribou and Amour.
——— palustris *Linn.*—Caribou.
Oxytropis campestris *Cand.*—hill-side near Forteau light-house.
Sanguisorba Canadensis *Linn.*—abundant on hill-sides.
Alchemilla vulgaris *Linn.*—abundant on hill-sides, Amour.
Dryas octopetala *Linn.*—hill-tops, Amour.
Geum rivale *Linn.*—brook-sides.
Potentilla Norvegica *Linn.*—along the sea-shore.
——— Anserina *Linn.*—flats near shore
——— palustris *Scopoli*—marshy places, Caribou.
——— tridentata *Aiton*—abundant everywhere.
——— maculata *Pourret* — hills, Amour.

Fragaria Virginiana *Ehrh.*—sparingly on hill-sides.
Rubus Chamæmorus *Linn.*—abundant everywhere.
——— articus *Linn.* — in level grassy places.
——— triflorus *Richn*—on hill-sides.
——— strigosus *Michx*—in inland gulches.
——— castoreus *Fries?*—Forteau.
Pyrus Americana *Cand.*—in gulches and on hills.
Amelanchier Canadensis *Torrey et Gray* var. oligocarpa *Gray* —in swamps.
Epilobium augustifolium *Linn.*—on hill-sides, Caribou.
——— alpinum *Linn.*—wet places, Forteau.
——— palustre *Linn.* — marshy places, common.
——— latifolium *Linn.*—sea-shore, Amour.
Ribes lacustre *Poiret* }
——— prostratum *L'Her.* } —ravines, common in the interior.
Sedum Rhodiola *Cand.*—on rocks and hill-sides.
Saxifraga aizoides *Linn.*—on rocks, Forteau.
——— oppositifolia *Linn.* — on rocks, Amour.
——— cæspitosa *Linn.*—in level sandy places, Forteau.
Mitella nuda *Linn.* — hill-sides, Forteau.
Cornus Canadensis *Linn.*— common everywhere.
Heracleum lanatum *Michx* }
Archangelica atropurpurea *Hoffm.*? } —hill-sides and ravines.
Ligusticum Scoticum *Linn.*—Caribou.
Lonicera cærulea *Linn.* }
Linnæa borealis *Gronov.* } on hill-sides.
Viburnum pauciflorum *Pylaie*—in ravines.
Galium trifidum, var. pusillum *A. Gray*—(Miss Macfarlane No. 25).
Senecio pseudo-Arnica *Lessing*—on hill-sides.
——— aureus *Linn.* var. Balsamitæ *Gray*—in swamps.
Aster Radula *Aiton*—on the sea-shore.
Vaccinum cæspitosum *Michx*— on hill-sides.
——— uliginosum *Linn.* — in swamps.
——— Vitis-Idæa *Linn.*—on hills.
——— Oxycoccus *Linn.* — in swamps.
——— Pennsylvanicum *Lam.* var. angustifolium *Gray.*—on hill-sides.
Chiogenes hispidula *Torrey et Gray* —(Miss MacF. No. 35).
Cassandra calyculata *Don* — in marshy places.
Andromeda polifolia *Linn.* — in swamps.
Kalmia glauca *Aiton*—hill-sides and swamps.
Rhodora Canadensis *Linn.*—hill-sides, Caribou.
Ledum latifolium *Aiton*—common on hills.
Rhododendron Lapponicum *Wahl.* —on a hill-top near Amour.
Loiseleuria procumbens *Desv.*—on hills, Caribou.
Pyrola rotundifolia *Linn.* — in swamps, Amour.
Moneses uniflora *Gray*—in damp shady places.
Armeria Labradorica *Boissier*—on a hill-top, Amour.
Primula farinosa *Linn.*—along shore and on hill-sides.
——— stricta *Hornem.*—Fox Island near Caribou (P. Mistassinica *Michx.*)
Trientalis Americana *Pursh*—common on hills.
Plantago pauciflora *Pursh*—(Miss Macfarlane No. 42).
Pinguicula vulgaris *Linn.*—in moist places.
Euphrasia officinalis *Linn.*—on hill-sides, Caribou.
Rhinanthus Crista-galli *Linn.*—common on hill-sides and on flats.
Mertensia maritima *Don*—in sand on the sea-shore.
Diapensia Lapponica *Linn.*—common on hill-tops at Caribou.
Gentiana acuta *Michx*— on flats, Caribou.

——— propinqua *Richn*
Halenia deflexa *Griseb.* } —on hill-sides, Amour.
Pleurogyne rotata *Griseb.*—on flats at Caribou and shores of Esquimaux river.
Menyanthes trifoliata *Linn.*
Diapensia Lapponica *Linn.*—common on hill-tops, Caribou.
Polygonum viviparum *Linn.*—common.
Empetrum nigrum *Linn.*—everywhere common.
Myrica Gale *Linn.*—(Miss Macfarlane No. 56).
Betula nana *Linn.*
——— glandulosa *Michx* } —on hill-sides everywhere.
——— pumila *Linn.*—(Miss Macfarlane No. 57).
Larix Americana *Michx* — in swamps and ravines.
Juniperus communis *Linn.*—on hill-tops.
Sparganium simplex *Hudson*—(the vars. genuinum and angustifolium of *Gray*)—in ponds, Caribou.
Habenaria obtusata *Richn*—on hill-sides, Caribou.
——— dilatata *Gray*
——— hyperborea *R. Br.* } —in swamps and on hill-sides.
Listera cordata *R. Br.*—in ravines, Caribou.
Iris versicolor *Linn.*—common on flats and hill-sides.
Smilacina bifolia *Ker*
——— trifolia *Desf.* } —in marshy places.
——— stellata *Desf.*—on the sea-shore.
Clintonia borealis *Rafin.*—on hill-sides.
Streptopus roseus *Michx* — in ravines.
——— amplexifolius *Cand.*—(Miss Macfarlane No. 62).
Eriophorum capitatum *Host*—on hill-tops.
——— russeolum *Fries*—in swamps and on high hills.
Luzula parvifolia *Desv.*—on hills.
Poa pratensis *Linn.*—on the sea-shore.
Hierochloa borealis *Roem. et Schultes*
Elymus mollis *Trinius* } —on the sea-shore.
Lycopodium annotinum *Linn.*—ravines and hill-sides.
Polypodium Dryopteris *Linn.*—on rocks.
——— Phegopteris *Linn.* — in ravines.
Pellæa gracilis *Hook.*
Cystea fragilis *Smith* } rocks, Amour.
——— montana (*Lam.*)—Amour.
Aspidium spinulosum *Swartz* — ravines and hills, common.
Athyrium Filix-fœmina *Roth*—on hill-sides.
Botrychium Lunaria *Swartz*—hill-sides, Amour.

THE STUDENT'S FLORA OF THE BRITISH ISLANDS. By J. D. Hooker, C.B., etc. London: MacMillan & Co.—Yet another flora of Britain! is one's involuntary exclamation on opening this book—making not a fifth wheel but something like a tenth wheel to the proverbial coach. Nor is this feeling modified after a careful perusal of the book; the work is, of course, well done—remarkably well done, as is everything that Dr Hooker does—but why should one of the first botanists of the day waste such good work on a thread-bare subject? Had Dr. Hooker given us a condensed flora of north Europe, or, better still, taking in Ledebour's ground, of the northern portion of the eastern hemisphere, not merely British students, but students the world over would have thanked him; as it is, one cannot help feeling that a great deal of good work has been thrown away. Dr.

Hooker may well afford to leave the naming and describing of some twenty varieties of Ranunculus aquatilis and the thirty varieties of Rubus fruticosus to less busy pens. There are in this book some remarkably good features well worked out. Dr. Hooker gives the affinities of each family, oftentimes a note of its properties (p. 259, "a few are purgative or emetic or intensely bitter or very poisonous"), always its distribution throughout the world and the numbers of genera and species comprised in it. He gives the same details under each genus and the geographical distribution of each species. As regards our personal hobby, the ferns, his notes on such of the species as are also American are remarkably correct, much more so than in any foreign flora we have seen. I note only the following corrections: *Trichomanes radicans* occurs in Alabama which is not "trop. Am."; *Asplenium marinum* is still given as "Brit. N. America"; and *Scolopendrium vulgare* is said to occur in "N. W. America," while it is known only from Western Canada and New York. Dr. Hooker in orthodox in his mode of quoting authors; hence he writes the name of a well-known Linnean plant as "Selaginella selaginoides *Gray*," thus depriving Link of what little credit may be due to him, but giving compensation elsewhere by writing "Cystopteris montana *Link*," which species is certainly Bernhardi's in view of what he wrote in Schrader's neus Journal for 1806, part 2nd, p. 26; moreover this old blunderer's impossible genus (*loc. cit.*, table ii., fig. 9) having been accepted, he may as well get the benefit of any doubt touching one of the species. Dr. H. introduces a new name to fern honors, the *Acrostichum septentrionale* of Linneaus being referred to its proper genus Asplenium as A. septentrionale *Hull*, an author unknown to us. It would add greatly to the value of such manuals if the reference were given in addition to the name of the author of the species; Asplenium germanicum *Weis* Plantæ Crypt. p. 299, or Scolopendrium *Smith* in Turin Mem., v., p. 421, do not occupy much space, and are necessary to the proper understanding of the names quoted. Dr. Hooker writes "Nephrodium cristatum *Rich.*" probably for Richard, and referring to Michaux's Flora, of which work he was author. If this be correct some other author's name must be found to attach to this well-known Linnean plant, inasmuch as Prof. Eaton has shewn that Michaux's cristatum is spinulosum, as might have been surmised from the omission of the latter species from that work, though it is much more general than cristatum, and is one of the commonest of ferns in this country. The reference, " A. cristatum *Sw.*" under Nephrodium, Filix-mas, is probably a slip of the pen. The " var. uliginosum (Rabenhorst, no. 19) is correctly referred to this species, and is the same as our *Aspidium Boottii* of Tuckerman in Hovey's Mag. of Hort. and Bot. vol. ix. (1843), p. 145, which Dr. Hooker, however, quotes as a variety of his "sub sp. dilatatum" under " *N. spinulosum* Desv."—wherein, I think, he errs. The last-named species is divided into three sub-species: (1) "spinulosum proper"; (2) dilatatum having four varieties—glandulosum, nanum, Boottii and dumetorum, and also, as I suppose dilatatum proper,; and (3) remotum. Of dilatatum it is said that it " extends into W. Asia and E.N. America,)" but if I be correct in referring Seemann's no. 1760 and some of Dr. Lyall's British Columbia specimens to this variety, its range in North America is much more extensive. The usually noted differences between it and spinulosum, as color and shape of scales, color of the frond, and whether glandulose or otherwise, are all inconsistent; the outline of the frond I judge to be the only consistent character. The publishers have done their part well; the letter-press is remarkably clear and distinct, and the type well chosen, after the style first set by Dr. Gray. The paper, though good, is too soft to bear ink, and the fifty pages of advertisements are rather too heavy an imposition.

SAPONACEOUS PLANTS.—Many plants in different countries furnish useful substitutes for soap to the natives, where there are no conveniences or materials for manufacturing the ordinary soap of commerce. Prominent among these are the soapworts, tropical plants belonging to the genus Sapindus. The Hindoos use the pulp of the fruit of *Sapindus detergens* for washing linen. Several of the species are used for the same purpose instead of soap, owing to the presence of the vegetable principle called saponine. The root and bark also of some species are said to be saponaceous. The capsule of *Sapindus emarginatus* has a detergent quality when bruised, forming suds if agitated in hot water. The natives of India use this as a soap for washing the hair, silk, &c. The berries of *Sapindus laurifolius*, another Indian species, are also saponaceous. The name of the genus is merely altered from *Sapo-indicus*, Indian soap, the aril which surrounds the seed of *S. Saponaria* being used as soap in South America.

According to Browne, the seed-vessels are very acrid; they lather freely in water, and will cleanse more linen than thirty times their weight of soap, but in time they corrode or burn the linen. This assertion, however, requires confirmation. Humboldt tells us that proceeding along the river Carenicuar, in the Gulf of Cariaco, he saw the native Indian women washing their linen with the fruit of this tree, there called the *Para para*. Saponaceous berries are also used in Java, for washing. The fresh bark of the root *Monnina polystachia* called "Yalhoi," pounded and moulded into balls, is used by the Peruvians in place of soap. Saponine exists in many other seeds and roots—in the legumes of *Acacia concinna*, in which a considerable trade is carried on in some parts of India, and in the root of *Vaccaria vulgaris*, *Agrostemma Githago* and *Anagallis arvensis*. It also occurs in various species of Dianthus and Lychnis, and in the bark of *Silene inflata*. *Gypsopyila struthium* is used by the Spaniards for scouring instead of soap. The bruised leaves of *Saponaria officinalis*, a native of England, forms a lather which much resembles that of soap, and is similarly efficacious in removing grease spots. The bark of *Quillaia saponaria* of Central America answers the same purpose, and is used as a detergent by wool dyers. It has been even imported largely into France, Belgium, &c., and sold in the shops as a cheap substitute for soap. The fruit of the *Bromelia Pinguin* has also been found useful as a soap substitute. A vegetable soap was prepared some years ago in Jamaica from the leaves of the American aloe (*Agave Americana*), which was found as detergent as Castile soap for washing linen, and had the superior quality of mixing and forming a lather with salt water as well as fresh. Dr. Robinson, the naturalist, thus describes the process he adopted in 1767, and for which he was awarded a grant by the House of Assembly of Jamaica:—"The lower leaves of the Curaca or Coratoe (*Agave karatu*) were pressed between heavy rollers to express the juice, which, after being strained through a hair cloth, was merely inspissated by the action of the sun, or a slow fire, and cast into balls or cakes. The only precaution deemed necessary was to prevent the mixture of any unctuous materials, which destroyed the efficacy of the soap. Another vegetable soap, which has been found excellent for washing silk, &c. may be thus obtained:—To one part of the Ackee, add one and a-half parts of the before-named *Agave karatu*, macerated in one part of boiling water for twenty four hours, and with the extract from this decoction mix four per cent, of rosin." In Peru, the leaves of the *Maguey agave* are used instead of soap; the clothes are wetted, and then beaten with a leaf which has been crushed; a thick white froth is produced, and after rinsing the clothes are quite clean. The pulpy matter contained in the hard kernel of a tree called locally 'Del Jaboncillo' is also used there for the same purpose. On being mixed with water it produces a white froth. In Brazil, soap is made from the ashes of the bassena or broom plant (*Sida lanceolata*), which abounds with alkali. There are also some barks and pods of native plants used for soaps in China. The soap-plant of California, *Phalangium pomeridianum*, is stated by Mr. Edwin Bryant to be exceedingly useful. The bulbous root, which is the saponaceons portion, resembles the onion, but possesses the quality of cleansing linen equal to any olive soap manufactured. From a paper read before the Boston Society of Natural History, it appears that this soap-plant grows all over California. The leaves make their appearance about the middle of November, or about six weeks after the rainy season has fairly set in; the plants never grow more than a foot high, and the leaves and stalk drop entirely off in May, though the bulbs remain in the ground all the summer without decaying. It is used to wash with, in all parts of the country, and, by those who know its virtues, it is preferred to the best of soap. The method of using it is merely to strip off the husk, dip the clothes into the water, and rub the bulb on them. It makes a thick lather, and smells not unlike brown soap. At St. Nicholas, one of the Cape Verde Islands, they make a soap from the oil of the *Jatropha curcas* seeds, and the ashes of the papaw tree leaf. The oil and ashes are mixed in an iron pot heated over a fire, and stirred until properly blended. When cool it is rolled up into balls about the size of a six pound shot, looking much like our mottled soap, and producing a very good lather.—*P. L. S. in the Journal of Applied Science.*

THE VULTURES AND HUMMING BIRDS OF TROPICAL AMERICA. —At the recent meeting of the American Association for the Advancement of Science, held at Troy, N.Y., in August, 1870, Prof. James Orton read a paper upon the "Condor and the Humming Birds of the Equatorial Region." The following abstract of the Professor's paper is taken from the October (1870) number of the *American Naturalist*:—

"He remarked that probably no bird is so unfortunate in the hands of the curious and scientific as the Condor. Fifty years have elapsed since the first specimen reached Europe, yet to-day the exaggerated stories of its size and strength are repeated in many of our text books, and the very latest ornithological work leaves us in doubt as to its relation to the other vultures. No one credits the assertion of the old geographer, Marco Paulo, that the Condor can lift an elephant from the ground high enough to kill it by the fall; nor the story of the traveller, so late as 1830, who declared that a Condor of moderate size, just killed, was lying before him, a single quill feather of which was twenty paces long. Yet the statement continues to be published that the ordinary expanse of a full grown Condor, is from fifteen to twenty feet, whereas it is very doubtful if it ever exceeds or even equals twelve feet. I have a full grown male from the most celebrated locality in the Andes, and the stretch of its wings is nine feet. Humboldt never found one to measure over nine feet; and the largest specimen which Darwin saw, was eight and one half feet from tip to tip. An old male in the Zoological Gardens of London, measures eleven feet. It is not yet settled that this greatest of unclean birds is generically distinct from the other great vultures. My own observation of the structure and habits of the Condor, incline me to think it should stand alone. Associated with the great Condor is a smaller vulture, having brown or ash-colored plumage instead of black and white, a beak wholly black instead of black at the base and white at the tip, and no caruncle. In inhabits the high altitudes, and is rather common. This was formerly thought to be a distinct species; but lately ornithologists have with one accord pronounced it the young of the Sarcoramphus gryphus—a conclusion which the speaker did not seem wholly to endorse.

As to the royal Condor, Professor Orton offered the following observations, either new or corroborative: Its usual habitation is between the altitudes of ten thousand and sixteen thousand feet. The largest seem to make their home around the volcano of Cayambi, which stands exactly on the Equator. In the rainy season they frequently descend to the coast, where they may be seen roosting on trees; on the mountains they rarely perch, but stand on the rocks. They are most commonly seen around vertical cliffs, perhaps because their nests are there, and also because cattle are likely to fall there. Flocks are never seen except around a large carcass. It is often seen singly, soaring at a great height in vast circles. Its flight is slow. It never flaps its wings in the air, but its head is always in motion as if in search of food below. Its mouth is kept open and its tail spread. To rise from the ground it must needs run for some distance; then it flaps its wings three times and soars away. A narrow pen is therefore sufficient to imprison it. In walking the wings trail on the ground and the head takes a crouching position. Though a carrion bird it breathes the purest air, spends much of its time soaring three miles above the sea. Humboldt saw one fly over Chimborazo. I have seen them sailing at one thousand feet above the crater of Pichincha. Its gormandizing power has hardly been overstated. I have known a single Condor, not of the largest size, to make away in one week with a calf, a sheep, and a dog. It prefers carrion, but will sometimes attack live sheep, deer, dogs, etc. The eyes and tongue of a carcass are the favorite parts and first devoured; next the intestines. I never heard an authenticated case of its carrying off children, nor of it attacking adults, except in defence of its eggs. In captivity it will eat everything except pork and fried or boiled meat. When full fed it is exceedingly stupid, and can be caught by the hand; but at other times it is a match for the stoutest man. It passes the greater part of the day sleeping, searching for prey in the morning and evening. It is seldom shot (though it is not invulnerable as once thought), but is generally caught in traps. The only noise it makes, is a hiss like that of a goose—the usual tracheal muscle being absent. It lays two white eggs on an inaccessible ledge. It makes no nest proper, but places a few sticks around the eggs. By no amount of bribery could I tempt an Indian to search for Condor's eggs, and Mr. Smith, who had hunted nearly twelve years in the Quito Valley, was never able to get sight of one. Incubation occupies about seven weeks, ending in April or May (in Patagonia much earlier, or about February.) The young are scarcely covered with dirty white down, and are not able to fly until nearly two years old. D'Orbigny says they take the wing in about a month and a half after being hatched, a manifest error, for they are then as downy as goslings. It is five months moulting, and while at that stage when its wings are useless, it is fed by its companion. As may be inferred the moulting time is not uniform. Though it has neither the smelling powers of the dog (as proved by Darwin), nor the bright eyes of the eagle, somehow it distinguishes a carcass afar off. He described in full the appearance of the Condor, remarking that the female is smaller than the male, an unusual circumstance in this order, the feminine eagles and hawks being larger than their mates.

Professor Orton next spoke of the Humming Bird, of the habits and economy of which our knowledge is very meagre. The relationship between the genera is not clear, and one species is no more typical than another. The only well marked divisions we can discover, are those adopted by Gould and Gray, the Phæthornithinæ and Polytminæ. The former are dull colored and frequent the dense forests. They are more numerous on the Amazon than the other group; and I know of no specimen from the Quito Valley, or from an altitude above ten thousand feet. Their nest are long, covered with lichens, lined with silk and hung over water courses. The latter comprises the vast majority of the Humming Birds, or nearly nine-tenths. They delight in sunshine, and the males generally are remarkable for their brilliant plumage. Their head-quarters seem to be near New Granada; some species are confined to particular volcanoes, or an area of a few miles square. Of the four hundred and thirty known species of Humming Birds, thirty-five are found in and around the valley of Quito, thirty-two on the Pacific slope, and seventeen on the Oriental side of the Andes, making a total of eighty-four, or about one-fifth of the family within the Republic of Ecuador. If the wanton destruction of Humming Birds for mere decorative purposes, continues for the next decade, as it has during the last, several genera may become utterly extinct. This is evident when we consider that many a genus is represented by a single species, which species has a very circumscribed habitat, and multiplies slowly, producing but two eggs in a year. He noticed one fact in regard to the nests of Humming Birds, which he could not explain. Our northern hummer glues lichens all over the outside; so do a number of species in Brazil, Guiana, etc. But in the valley of Quito moss invariably is used, though lichens abound. A similar variation is seen in the nests of the chimney swallow—our species building of twigs glued together with saliva, while its Quito representative builds of mud and moss. The time of incubation at Quito is twelve days, and there is but one brood in a year."

MISCELLANEOUS.

On the Comparative Steadiness of the Ross and the Jackson Microscope-Stands.—In most of the older Microscopes the *Body* was a fixture, and the focal adjustment was obtained by giving motion to the Stage. This plan, however, was very soon abandoned when the improvement of the Microscope, in its mechanical as well as its Optical arrangements, was seriously taken in hand by men of real constructive ability; and the *Stage* being made a fixture, two different modes were adopted for supporting and giving motion to the Body, of one or the other of which nearly all the different patterns devised by our now numerous makers may be regarded as modifications. The one in which the Body is attached at its base only to a transverse Arm, borne on the summit of a racked stem, I have elsewhere termed the *Ross model;* not because Mr. Ross could in any sense be considered its inventor, but merely because he was among the first to employ it, and his original patterns are now in general use, with extremely little modification. The other, in which the Body, having the rack attached to it, is supported for a great part of its length on a solid Limb, to the lower part of which the Stage is fixed, may with more propriety be distinguished as the *Jackson* * *model;* since it was originally devised by Mr. Jackson, and was thenceforth almost uniformly adopted by the Firm which may be considered as the representative of his ideas.

It has always appeared to me that the Jackson model is so obviously preferable *mechanically*, that if it had been introduced before the Ross model had come into use, it would have been the one more generally adopted; and having lately had an opportunity of comparing the performance of two instruments, one constructed on the Ross and the other on the Jackson model, under peculiarly trying circumstances, and having found my previous opinion most fully confirmed, I have thought it well to bring my experience in this matter before those whom it most especially concerns, namely, Microscope-makers and practical

* In the last edition of my 'Microscope' I inadvertently designated this as the *Lister* model, having supposed it to have been devised by Mr. J. J. Lister.

Microscopists. In order that the bearing of that experience may be rightly understood, it will be desirable in the first instance to examine the conditions on which *tremor* of the Microscopic image depends.

When the building in which the Microscopist is at work is thrown into vibration as a whole, as by the passage of a heavily-laden cart in the street outside,—or the floor of the room in which he is seated is made to vibrate by the tread of a person crossing it,—the Microscope and the observer move together; and if the frame of the Microscope were *perfectly rigid*, there would be no tremor of the image. For this tremor is the result, not of the vibration of the Microscope as a whole, but either (1) of the difference between the vibration of the Body as a whole and that of the object on the Stage; or (2) of the difference between the vibration of the two extremities of the Body, the ocular and the objective.

Now it scarcely seems to me possible to conceive a method of construction which should be more favourable to this *differential* vibration, especially at the ocular end of the Body, than that which is adopted in the Ross model. The long tubular body, fixed only at its base, is peculiarly subject to it; and although the oblique stays with which it is sometimes furnished diminish the vibrations of the tube, they by no means prevent it. The transverse arm and the stem which bears it, each have a vibration of their own; and it is obvious that the nearer to the fixed point of the whole system—which, in this arrangement, is the part of the racked Stem embraced by the tube that carries the Stage—flexure takes place, the greater will be the vibration of the Eye-piece, which is at the greatest distance from that fixed point. The only mode in which this vibration can be kept in check, is the giving great solidity to the Stem, the Arm, and the Body, especially the two former; and this, while objectionable on account of the cumbrousness which it imparts to the Microscope-stand, is by no means effectual for its purpose; as every Microscopist knows to his cost, when using very high powers under any condition but that of the most perfect stillness of the support.

On the other hand, in the Jackson model, the support of the Body along a great part of its length reduces to a minimum the vibration of the tube, and the consequent differential vibration of the eye-piece; and even in those modifications of it in which the tube has but a short bearing, as the support is given to it in the middle of its length, instead of at its lower extremity; the vibration equally affects its ocular and its objective extremities. The form of the Limb makes the Body much less liable to vibration as a whole, than when supported on the transverse Arm and vertical Stem of the Ross model; and as there is no fixed point from which vibration can commence, increasing in extent with the distance from that point, the Body and Stage are much more likely to move together, such motion imparting no tremor to the image.

In the "Porcupine" Expedition for the Exploration of the Deep Sea, in which I took part last summer, microscopic inquiry had to be carried on under conditions very different from those which obtain on shore. When our ship was lying-to under sail, even if the swell was sufficient to produce considerable pitching and rolling, the motion, being imparted equally to the Microscope as a whole and to the Observer, did not produce any tremor of the image; and the only difficulty lay in the maintenance of the observer's own position, which was most effectually secured by firmly grasping the leg of the table (which was fixed to the floor of the cabin) between his knees. When the ship was going under "easy steam," with either a fair wind or a light contrary breeze, there was enough *general* vibration to produce a considerable *differential* vibration in any Microscope liable to it, and thus to occasion a decided tremor in the image even when only moderate powers were employed. But when we were steaming with full power against a head-sea, the general vibration became so great as to be the severest test of the mechanical arrangements of our Microscopes. Now, it happened that whilst my own instrument—a portable Binocular Microscope weighing *less than seven pounds*, which is my usual travelling companion—is constructed on the Jackson model, Professor Wyville Thomson was provided with an instrument of about the same scale, but heavier by some pounds, made upon the Ross model; and we thus had an opportunity of fairly testing the two plans of construction under circumstances peculiarly critical. The difference in their performance was even more remarkable than I had anticipated. I found that I could use a 1-4th-inch objective on my own Microscope, with an even greater freedom from tremor in the image than I could use a 2–3rds–inch objective on Professor Wyville Thomson's. In fact the image "danced" very perceptibly in the latter, even when the 1½–inch objective was in use.

Now I purposely abstain (for obvious reasons) from naming the Makers of these two instruments. But I think it well to say this much, in order to meet the possible objection, that the difference lay rather in the *workmanship* of the two instruments than in their *plan of construction*,—that the advantage, if any, lay on the side of the Ross model. And my own very decided conviction is, that the adoption of the principles of the Jackson model would be decidedly advantageous, alike for *first*-class Microscopes, in which the *steadiness of the image* when the highest powers are being employed ought to be a primary consideration,—for those *second*-class instruments, which are intended, at a less cost, to do as much of the work of the first-class as they can be made to perform, *portability* being hère of essential importance,—and for those *third*-class instruments in which everything has to be reduced to its simplest form, so as to permit the greatest reduction in their cost.—*Dr. W. B. Carpenter, in Transactions of the Royal Microscopic Society.*

— Mr. J. Gwyn Jeffreys, who had just returned from the south of Europe, after having accomplished his part of this year's deep-sea exploring expedition in H.M.S. *Porcupine*, stated that in this cruise he had dredged across the Bay of Biscay, and along the coasts of Spain and Portugal to Gibraltar. The weather had not been favourable; but the depth reached was 1,095 fathoms. A large collection of Mollusca, Echinoderms, Corals, Sponges, and Hydrozoa, had been made. Half a-dozen specimens of a beautiful new *Pentacrinus* (*P. wyville-thomsoni*) had been taken in 795 fathoms depth, between Vigo and Lisbon. Both Northern and Mediterranean species of shells were met with.

— Congress has granted $30,000 for the erection of a Government Winter Garden, either at New York or Washington, somewhat similar to that at Kew, but on a smaller scale. This will partake partly of the nature of an economic garden, in which useful plants can be raised and then disseminated far and wide throughout the States.

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