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THE CANADIAN

RECORD OF SCIENCE

INCLUDING THE PROCEEDINGS OF

THE NATURAL HISTORY SOCIETY OF MONTREAL,

AND REPLACING

THE CANADIAN NATURALIST.

VOL. VII. (1896-1897.)

MONTREAL:

PUBLISHED BY THE NATURAL HISTORY SOCIETY.

1897.

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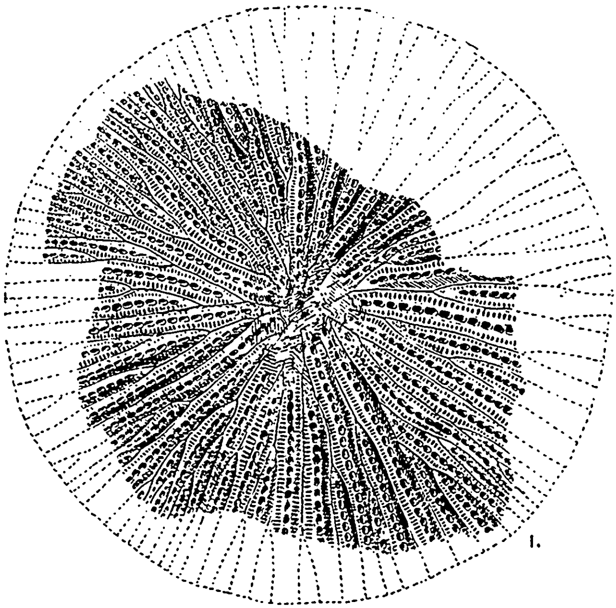

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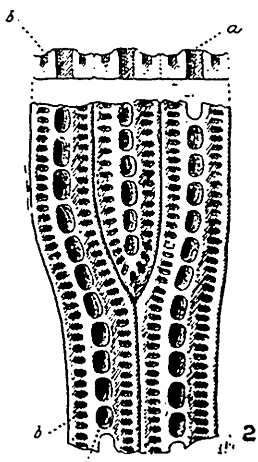

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L. M. LAMBE, DEL.

ASTROPORITES OTTAWAENSIS.

THE

CANADIAN RECORD

OF SCIENCE.

VOL. VII. JANUARY AND APRIL, 1896. Nos. 1 and 2.

Description of a supposed new genus of Polyzoa from the Trenton limestone at Ottawa.[1]

By Lawrence M. Lambe, F.G.S.

(With Plate I.)

Astroporites. (Gen. nov.)

Zoarium flat or slightly infundibuliform, circular, thin, composed of perforated and poriferous, closely connected segmentary divisions which radiate from a central point and are added to by the intercalation, at intervals, of new divisions as the distance from the nucleus increases.

Astroporites Ottawaensis. (Sp. nov.)

Zoarium forming a flat or slightly concave expansion about 80 mm. in diameter, 3 mm. thick near the centre and thinning toward the edge. It is divided radially into narrow divisions, from 3 to 4 mm. broad, which increase in breadth from their pointed proximal ends for a distance of about from 4 to 10 mm. and then remain of about the same breadth throughout their length. Fresh divisions are added by intercalation as they become necessary for the preservation of the disc-like form of the expansion.

[1] Communicated by permission of the Director of the Geological Survey of Canada.

Two keels extend the entire length of each division, and between them is a single row of perforations piercing the zoarium in a direction at right angles to the plane in which it lies; these perforations are circular, oval or oblong at the surface, from 0.5 to 1 mm. in diameter or length, and are separated by raised margins on a level with the keels. On either side of the elevated central portion of the divisions is a depressed marginal area occupied by a row of circular or oval pores which vary in diameter or length from 0.2 to nearly 1 mm., and when oval have the major axis at right angles to the direction of the divisions. From six to twelve perforations occur in a length of 1 cent, and from sixteen to forty pores in the same distance. In transverse sections the perforations are seen to extend through the thickness of the zoarium and to be of the same width throughout their length, but the pores after extending inward parallel to the direction of the perforations for a distance nearly equal to the thickness of the zoarium appear to enter the perforations from either side by an abrupt turn. The connection of the pores, however, with the perforations, if any, has not been ascertained with any degree of certainty.

The specimen figured was collected by the writer from the Trenton limestone at Hull, P.Q., near Ottawa, in 1890. It is calcareous and is preserved in a thin layer of black shale lying on a dark grey limestone. Only one side of the fossil has been seen, and at the centre of the disc the surface is abraded and the structure obliterated. At a later date Dr. H. M. Ami obtained a fossil, from the same locality, which is thought by the writer to belong to the same species; it does not show the details of structure preserved in the first mentioned specimen, but in it the thin edge of the organism is preserved showing the circular outline.

This organism appears to belong to the Polyzoa, but is different from any genus known to the writer, nor is be able to refer it without some hesitation to any particular family of this large and variable class, although in structure, it seems to approach most closely to the *Fenestellidæ*. The difficulty felt in referring it to any genus of the *Fenestellidæ* has compelled the writer to suggest a new genus for its reception in the hope that when fresh knowledge of its structure shall be obtained its position in the animal kingdom may be more clearly defined.

EXPLANATION OF PLATE I.

Fig. 1. View of a specimen of *Astroporites Ottawaensis* shewing the divergence of the divisions from the centre, the mode of intercalation of new divisions and the disposition of the openings of the pores and perforations at the surface. Natural size.

Fig. 2. Portions of three divisions showing the single rows of perforations and double rows of pores: three times the natural size.

Fig. 3. Cross section of the same divisions with the perforations (*a.*) and the pores (*b.*); the former pass through the zoarium, but the direction of the latter has not been ascertained with certainty. Enlarged three times.

Notes upon the Flora of Newfoundland.

By B. L. Robinson and H. von Schrenk.

Perhaps no region of equal size and ease of access in temperate North America has received less botanical exploration than Newfoundland. This island, although 350 miles long and 130 miles in average breadth, embracing an area nearly as large as Ohio, is settled only on or very near the coast. The only inland town is Whitbourne; and this is almost within sight of salt water, being only seven miles from Trinity Bay. The vast uninhabited interior of the island is covered in great part by sombre forests of fir and spruce, interrupted at intervals by moors or boggy places, sterile rocky hills, or desolate "burns," and studded with lakes and ponds too numerous to find place upon maps. Indeed it has been stated that more than half the surface of Newfoundland is under fresh water. Although, through the activity of the Geological Survey, the topography of the interior is known in some detail, many parts have never been visited for scientific purposes; and it is said that the island has not been traversed at its widest part since an intrepid Scotchman named William Cormack crossed from Trinity Bay to St. George's Bay, in 1822, with a Micmac Indian. Cormack was a shrewd observer, and something of a botanist, and although exposed in his perilous journey to great and almost fatal hardships he managed to make a small collection of plants, which he sent to his friend Professor Jameson, of Edinburgh. A list of these plants, which has hitherto furnished almost the only information as to the interior flora of the island, was published by Cormack in an account of his journey.[1]

The others who have collected plants upon this island have, so far as can be learned, confined their attention to the vicinity of the coast, having been unable to penetrate far inland. It is said that John Fraser collected in Newfoundland in the years 1780 to 1784, but no list of his plants from the island appears to have been published, nor are his specimens cited in systematic works. In 1816 and 1819 Newfoundland was visited by La Pylaie, but his attention was largely devoted to the cryptogams, especially the algæ. Such of his phænogamic specimens as are preserved in the Gray Herbarium are not only

1 This interesting paper, issued doubtless in small edition, is very scarce. Realizing its historic value, Dr. M. Harvey, of St. John's, had it reprinted in 1873 from Cormack's original manuscript. Unfortunately, the reprint is also scarce, and in it there are many typographical errors—due, doubtless, to the crabbed and obscure handwriting from which it was set.

rather fragmentary, but are in most cases so immature as to indicate that he was too early for the proper collecting season. The island was also visited by Banks and by Lambert, a few of whose specimens are cited by DeCandolle in the *Prodromus*, and by Torrey and Gray in their *Flora*. In more recent times, a number of collections—mostly of small extent and covering a very limited range—have been made at different points upon the coast, the most noteworthy by Henry Reeks, John Bell, Rev. Arthur C. Waghorne, Dr. Morison, Miss Brenton, Dr. Roland Thaxter, and Dr. Robert Bell. Mr. Reeks spent two years upon the island, chiefly at Cow Head upon the west coast, and although suffering from ill health, and much of the time confined to his bed, prepared the most extensive list of flowering plants of the island yet issued. Unfortunately, his determinations, while doubtless correct in the main, were made without access to extensive literature, and confessedly often from too fragmentary specimens, and under too adverse circumstances, to inspire much confidence—especially as the specimens were not preserved and verification is now impossible. John Bell, who collected upon the west coast, also published a considerable list.[1] Dr. Robert Bell made a small collection of plants upon the south-east coast, and his specimens were carefully identified by Professor John Macoun.[2] The only resident botanist who has published to any extent upon the flora of Newfoundland is the Rev. Arthur C. Waghorne, who, in his missionary work, has travelled extensively along the coast of the island and in Labrador, thus having exceptional opportunities of collecting at many different points. Mr. Waghorne has published a list of the berries of Newfoundland, and has issued several lists of mosses and lichens without habitats. He is now preparing a catalogue of the flowering plants of Newfound-

[1] Canad. Nat., New Series, IV., 256-263; V., 54-61.
[2] Ann. Rep. Geol. Surv. Canada, I., 1885, 21DD-25DD.

land, Labrador, and the French Islands,[1] the first fascicle —including the Orders from the *Ranunculaceæ* to the *Leguminosæ*—having been already issued.[2] Besides these papers, Mr. Waghorne has published a number of popular articles in the daily journals of St. John's, chiefly upon the common plants of the islands.

The phænogamic flora of Newfoundland has been scarcely represented in the leading herbaria of Europe and America, and in none better than by fragmentary sets of Banks and La Pylaie. With a hope of securing a number of uniform sets for general distribution, to form a basis for a fuller and more accurate knowledge of the flora, the writers visited the island in the summer of 1894, spending there the last days of July and nearly the whole of August. While the time was much too limited to permit anything like thorough exploration of so extensive a territory, no less than seven localities were visited, and, with the exception of the mosses, larger fleshy fungi, and fresh-water algæ, practically all species of plants seen were secured, so that the collections—which in gross amounted to nearly 8,000 specimens—are without doubt representative of the general flora, even if far from being complete.

The first week was spent in collecting about St. John's, from which it was possible to visit, by short excursions, points differing much in exposure and moisture, and of corresponding diversity of vegetation. The tourist reaching St. John's is at once struck with the rugged scenery of the coast at this point. The deep harbour is shut in by precipitous rocky hills, from five to seven hundred feet in height, whose tops are too often buried in fog.

[1] The flora of the French Islands has been carefully studied and well recorded by Bachelot de la Pylaie—Flore de l'ile de Terre-Neuve et des iles Saint Pierre et Miclon, 1829, and Ann. Sci. Nat., IV., 174-184. 1824; E. Bonnet—Florule des iles Saint Pierre et Miquelon, 1888 (Jour. de Bot., I); and E. Delamere, F. Renauld. and J. Cardot—Flora Miquelonensis, 1888.

[2] Trans. Nova Scotian Inst. Sci., Ser. 2, I.

Although these hills from a distance appear very sterile, they prove much better collecting ground than could be anticipated. Exposed and storm-swept as they are, they have frequent little springy hollows, where, in dense mats of sphagnum, a considerable number of *carices, eriophora, junci,* and even the smaller orchids are to be found. Aside from these, the hill vegetation is largely composed of a variety of shrubs, of which the most abundant are *Alnus viridis, Viburnum pauciflorum, Cornus stolonifera,* and *Ribes prostratum,* together with a number of species of *Rubus* and *Vaccinium* as well as *Empetrum nigrum* and *Potentilla tridentata.*

Back of these exposed hills the country is more protected, and covered in part by forests of fir and spruce. Here the best collecting ground was found to be the rocky banks of small streams, which, in this part of Newfoundland, flow chiefly across strongly tilted strata, giving their beds and banks much irregularity—favouring the peculiar vegetation attracted by crevices of moist rocks near running water. One of these small water-courses, called Rennie's River, about twenty minutes walk from St. John's, was most frequently visited, and, beside many other species, furnished *Triodia decumbens, Nardus stricta,* and in a neighbouring pool the natant form of *Juncus supinus,* all of which are exceptional in their American occurrence.

The chief fresh-water vegetation of the region was secured at Quiddy-Viddy Lake, near the city. Perhaps the most noteworthy plant found there was *Ranunculus hederaceus,* which carpets considerable patches of the shores. Professor Britton queries whether it may not be indigenous here, which is very possible, although evidence for such a view is not easy to furnish, and it must be remembered that the occurrence is near a prominent port. Mr. Waghorne has collected the species also, at New Harbour, far up the east coast. Virginia Water, an attractive lake several miles away, was also visited, but was chiefly interesting for the surrounding moist and mossy woods, which furnished a number of lichens and fungi. Good specimens of the Newfoundland bog vegetation were secured at what is known as Bally Haily Bog, a rich peaty swamp but a mile or so from St. John's.

The city streets and roadsides furnished, of course, their quota of introduced weeds, which also have their individuality, as no two ports seem to attract just the same class of these undesirable immigrants. Among those of St. John's, perhaps the most notable seen was *Lamium incisum*, of which only a single specimen was found. So far as learned, this species has only once been accredited to America, namely, by Bentham, in DeCandolle's *Prodromus*, who speaks of its collection in Newfoundland by La Pylaie. That the single plant now secured should be a second introduction of this unusual immigrant to just the same part of the coast seems rather improbable, but it is also difficult to conceive of the species as having persisted in the same locality for eighty years without becoming more abundant.

On leaving St. John's the writers visited Manuels, on Conception Bay, collecting for some distance along the rocky Manuels River as well as in the adjacent clearings and marshy ground. Then, through the courtesy and cordial hospitality of Messrs. W. D. and H. D. Reid, contractors for the Newfoundland Northern and Western Railway, an opportunity was afforded to visit the end of this new line. The Newfoundland Northern Railway extends up the eastern coast for a distance of about two hundred and fifty miles from St. John's and then turns inland. At the time of our visit the headquarters of construction was at the confluence of the Exploits River and Badger Brook, between thirty and forty miles from the coast. The interior region thus gained, although considerably north of St. John's, possessed a richer and heavier vegetation, showing not only a milder climate but a deeper soil, and plants of the same species were in several cases found to be in a more advanced state than at the more southern stations on the coast.

In the Exploits Valley, so far as seen, there is an alternation of woodland and moist moors. The forests are chiefly of fir and spruce, with a moderate mixture of white pine and paper birch, most of the trees being of moderate or small size. This region proved to have a flora almost identical with that of Northern New England; indeed the only plants which suggested a more boreal climate were the attractive little *Betula nana*, var. *flabellifolia*. and *Thalictrum alpinum*. The question which at once presents itself is, why such a region is entirely unused when portions of Canada of much higher latitude and similar native flora have been successfully cultivated. From a botanical standpoint the vegetation presented but little novelty, perhaps the most interesting finds being the terrestrial state of *Subularia aquatica, Litorella lacustris,* and *Carex miliaris,* with its var. (?) *aurea,* which, as now secured in mature fruit, appears specifically distinct.

The remainder of the time upon the island was divided between Whitbourne, Holyrood, Placentia, and Salmonier, in different parts of the peninsula Avalon, each place possessing a certain individuality of vegetation. In a small sphagnum bog near Holyrood a rare and poorly understood *Bartonia* (*Centaurella Moseri,* Steud. & Hochst., at least in part) was found. Few phænogams could be more inconspicuous than this, with its naked filiform stem, and one to five small pinkish-white flowers, just the colour of the surrounding sphagnum. It required nearly an hour's searching upon hands and knees to secure the desired sixty or eighty plants.

The maritime vegetation of the eastern part of the island appears to be very scanty. Although a considerable extent of coast was visited at various points, only two distinctly maritime phænogams were found, namely, *Plantago maritima* and *Ligusticum Scoticum*. This noteworthy paucity of shore vegetation is doubtless due to the generally precipitous coast. The only beaches visited (at Manuels and Placentia) were composed of coarse pebbles, and entirely sterile.

The following is a list of the phænogams and vascular cryptogams secured on the island. The plan of collection was to take all indigenous and noteworthy introduced plants in considerable quantity for some twenty sets, and these plants were regularly numbered. The commoner introduced plants were taken in small quantity, merely to show distribution, and, as well as some of the rarer plants not found in sufficient quantity to be incorporated in the regular sets, were not numbered.

Most of the plants have been determined by the staff of the Gray Herbarium, but several specialists have most obligingly rendered important assistance in their particular groups: Prof. Franz Buchenau and Mr. F. V. Coville in the *Junci*; Prof. L. H. Bailey in the *Carices*; and Prof. Lamson-Scribner in the *Gramineæ*. The cellular cryptogams have not as yet been fully determined, and cannot be included in this list.

Species and varieties marked with an asterisk appear not to have been hitherto recorded from Newfoundland, although several of them have been discovered upon the French Islands, St. Pierre and Miquelon. Plants from the Exploits River were collected within ten miles of the mouth of Badger Brook, a considerable tributary from the north.

ACONITUM NAPELLUS, L. Borders of fields, St. John's; not abundant.

COPTIS TRIFOLIA, Salisb. Common in fir woods, Whitbourne (27).

RANUNCULUS ACRIS, L. Abundant about St. John's, but occurring only on roadsides and in pastures, as though introduced there as elsewhere in America. Nothing was seen to confirm Dr. Gray's supposition that this species might be indigenous in Newfoundland.

*R. AQUATILIS, var. TRICHOPHYLLUS, Gray. In Quiddy-Viddy Lake and Exploits River.

*R. FLAMMULA, var. INTERMEDIUS, Hook. Abundant about St. John's, in moist meadows and upon the shores of Quiddy-Viddy Lake (30). More slender forms, with narrower leaves, were occasionally detected, showing transitions to the following:—

R. FLAMMULA, var. REPTANS, E. Meyer. Abundant upon the rocky banks of Rennie's River (50).

R. REPENS, L. Moist ground, Placentia (238, distributed as *R. Macounii*), also near Salmonier.

THALICTRUM ALPINUM, L. Moor near Exploits River.

T. POLYGAMUM, Muhl. St. John's (187), Colinet, Exploits River.

*NUPHAR ADVENA, var. MINUS, Morong. Whitbourne.

*NYMPHÆA ODORATA, var. MINOR, Sims. Whitbourne (114).

SARRACENIA PURPUREA, L. Whitbourne (64). The more slender green state was found on the Exploits River.

FUMARIA OFFICINALIS, L. Ploughed ground, St. John's.

CAPSELLA BURSA-PASTORIS, Mœnch. St. John's.

CARDAMINE PENNSYLVANICA, Muhl. Whitbourne; appearing introduced.

ERYSIMUM CHEIRANTHOIDES, L. St. John's (228).

*HESPERIS MATRONALIS, L. Streets of St. John's; infrequent.

NASTURTIUM OFFICINALE, R. Br. Brooksides, St. John's.

*N. TERRESTRE, R. Br. Exploits River.

*N. SYLVESTRE, R. Br. St. John's.

Raphanus Raphinastrum, L. Fields near Quiddy-Viddy.

Senebiera pinnatifida, DC. Streets of St. John's; abundant.

*Subularia aquatica, L. The terrestrial form; Exploits River (7), and around a pond near Whitbourne.

Viola blanda, Willd. Rocky banks of Rennie's River (189).

V. palmata, var. cucullata, Gray. St. John's (188), and on Exploits River.

*V. tricolor, var. arvensis, DC. Rocky hills near the harbour, St. John's.

Arenaria lateriflora, L. Bottom lands of the Salmonier River.

Cerastium vulgatum, L. St. John's.

Sagina procumbens, L. Apetalous form; abundant in low meadows, St. John's (218).

Spergula arvensis, L. Fields, St. John's; common.

*Spergularia rubra, Presl. St. John's.

Stellaria graminea, L. Borders of fields, St. John's.

S. longifolia, Muhl. Grassy bottom lands of Salmonier River.

S. media, Cyril. St. John's.

*S. uliginosa, Murr. Moist shaded cliffs, Placentia (33).

Montia fontana, L. Ditches, Holyrood (48).

Elodes campanulata, Pursh. Bally Haily Bog (149).

Hypericum Canadense, L. St. John's (185).

H. mutilum, L. St. John's (186).

*Malva rotundifolia, L. St. John's.

*Geranium Carolinianum, L. Railway ballast near Placentia Junction.

Impatiens fulva, Nutt. Whitbourne.

NEMAPANTHES FASCICULARIS, Raf. Along the banks of Badger Brook (83).

ACER RUBRUM, L. Exploits River.

A. SPICATUM, Lam. Rocky banks, Manuels River.

MEDICAGO LUPULINA, L. Roadsides, St. John's.

PISUM SP. (indeterminate state). Exploits River; probably introduced by lumbermen or campers.

*TRIFOLIUM HYBRIDUM, L. Whitbourne and Virginia Water; frequent.

T. PRATENSE, L. Whitbourne.

T. REPENS, L. St. John's, Whitbourne, etc.

VICCIA CRACCA, L. Borders of fields, St. John's.

V. SATIVA, L. Cultivated fields, St. John's; infrequent.

AMELANCHIER CANADENSIS, Medic. In two forms, growing together, in woods, St. John's:—

(1) Nearly typical; tall shrub, with leaves oblong, short-acuminate, rounded at base; fruits three or four together, in loose naked raceme, small, red (53).

(2) Arborescent shrub, fifteen feet high; leaves large and subcuneate at base; fruits axillary and solitary, or terminal in pairs, larger, greenish (237). The latter form does not fall satisfactorily in any of the described varieties.

FRAGARIA VESCA, L. Manuels and Holyrood.

GEUM RIVALE, L. Woods near Salmonier (80) and Exploits Rivers.

POTENTILLA ANSERINA, L. Placentia (42).

P. FRUTICOSA, L. Manuels (20).

P. NORVEGICA, L. Railway ballast, Whitbourne (84).

P. TRIDENTATA, Ait. Rocky hills, St. John's; common (23).

POTERIUM CANADENSE, Benth. & Hook. Along Manuels (25) and Exploits Rivers.

PRUNUS PENNSYLVANICA, L. f. Salmonier River (74).

P. VIRGINIANA, L. Salmonier River (75).

PYRUS ARBUTIFOLIA, L. f. Rocky hills, Quiddy-Viddy (51), and on Exploits River.

*P. SAMBUCIFOLIA, Cham. & Schlecht. Whitbourne.

*ROSA HUMILIS, Marsh. St. John's.

R. NITIDA, Willd. St. John's.

RUBUS CANADENSIS, L. Whitbourne (235).

R. CHAMÆMORUS, L. Whitbourne, etc.

R. STRIGOSUS, Michx. Very abundant, especially on recently burned land, said to be the first growth after forest fires. Whitbourne (66).

R. STRIGOSUS, var. CAUDATUS, n. var. Leaves more divided; leaflets narrow, lanceolate, caudate-attenuate; those of the sterile shoots cleft nearly or quite to the base. Rocky hills south of harbour, St. John's, August 1.

R. TRIFLORUS, Richards. Along Manuels and Exploits Rivers.

SPIRÆA SALICIFOLIA, L. Abundant about St. John's (22).

MITELLA NUDA, L. Exploits River.

RIBES PROSTRATUM, l'Her. Rocky hills, St. John's (113).

DROSERA ROTUNDIFOLIA, L. Quiddy-Viddy (144).

*D. INTERMEDIA, var. AMERICANA, DC. Sphagnum bogs, Manuels (145) and Exploits Rivers.

*CALLITRICHE VERNA, L. Muddy shores of Quiddy-Viddy Lake (229).

*C. HETEROPHYLLA, Pursh. Whitbourne (215) and Exploits River.

HIPPURIS VULGARIS, L. Exploits River (119).

*MYRIOPHYLLUM ALTERNIFLORUM, DC. Whitbourne (169.)

M. TENELLUM, Bigel. Quiddy-Viddy Lake (16). There is scarcely a doubt that this is the *M. denudatum* which

La Pylaie mentions, without any proper description, in Ann. Sci. Nat., Ser. 1, IV., 176.

CIRCÆA ALPINA, L. Manuels (6).

*EPILOBIUM ADENOCAULON, Haussk. Near streams, St. John's (195) and Holyrood.

E. ANGUSTIFOLIUM, L. Burned regions, etc.; abundant; St. John's (143).

E. PALUSTRE, L. St. John's.

*E. PALUSTRE, forma LABRADORICA, Haussk. Moist places on rocky hills, St. John's (194).

ARCHANGELICA ATROPURPUREA, Hoffm. Exploits River.

*CARUM CARUI, L. Chance escape, St. John's.

*CONIOSELINUM CANADENSE, Torr. & Gray. Exploits River; infrequent.

LIGUSTICUM SCOTICUM, L. Cliffs of Placentia Bay.

SANICULA MARILANDICA, L. Exploits River.

*SIUM CICUTÆFOLIUM, Gmelin. Whitbourne.

ARALIA HISPIDA, Vent. Frequent about Manuels and on barrens near Exploits River (183).

A. NUDICAULIS, L. Rocky hills, St. John's.

CORNUS CANADENSIS, L. Very common, St. John's, Whitbourne (49), and Salmonier, showing great variability in foliage, especially in woodland forms, which differ greatly in the number and arrangement of the leaves, the sterile shoots being often branched and having opposite, not whorled, leaves upon the branches. A striking anomalous form was seen several times in which a second whorl of leaves formed above the main whorl was connate in a cup.

C. STOLONIFERA, Michx. Common, and widely distributed upon the island; St. John's (217).

DIERVILLA TRIFIDA, Moench. St. John's (10); common.

LINNÆA BOREALIS, L. St. John's (55).

LONICERA CÆRULEA, L. Whitbourne (11).

VIBURNUM CASSINOIDES, L. St. John's (191); very abundant.

V. OPULUS, L. Exploits River; much less frequent than the other species.

V. PAUCIFLORUM, La Pylaie. Common about St. John's, Manuels (192), etc. The fruit is collected and made into an excellent preserve under the name of "squash-berry," a designation said to allude to the flat seeds, which are thought to resemble those of the squash.

GALIUM ASPRELLUM, Michx. Whitbourne (179).

*G. MOLLUGO, L. Ploughed ground, St. John's (38).

*G. TRIFIDUM, var. LATIFOLIUM, Torr. Open woods, St. John's (214).

*G. TRIFIDUM, var. PUSILLUM, Gray. Sunny banks of lake, Whitbourne (213).

*G. TRIFLORUM, Michx. Exploits River (32).

ACHILLEA MILLEFOLIUM, L. St. John's.

ANAPHALIS MARGARITACEA, Benth. & Hook. St. John's and Holyrood; especially abundant in burned ground.

ANTENNARIA PLANTAGINIFOLIA, Hook. Holyrood.

*ANTHEMIS COTULA, DC. Clode's Sound.

*ARCTIUM LAPPA, L. In leaf only, but probably var. MINUS. Holyrood.

ASTER NEMORALIS, Ait. St. John's (177).

A. NOVI-BELGII, L. Exploits River.

A. PUNICEUS, L. River banks; common; Salmonier (73).

A. RADULA, Ait. Salmonier and Manuels Rivers (175). Forms passing into the following were collected near St. John's:—

A. RADULA, var. STRICTUS, Gray. Exploits River (176).

A. UMBELLATUS, Mill. Common, especially along streams; Manuels, Holyrood (54).

CENTAUREA NIGRA, L. Fields, St. John's.

CHRYSANTHEMUM LEUCANTHEMUM, L. Common; St. John's.

*CICHORIUM INTYBUS, L. St. John's; infrequent.

CNICUS ARVENSIS, L. St. John's.

*C. LANCEOLATUS, L. Recent clearings, Manuels.

C. MUTICUS, Pursh. Marshy ground, Exploits River (69).

EUPATORIUM PURPUREUM, L. Salmonier River (40). A form passing to var. AMŒNUM, Gray, was collected on the Manuels River.

GNAPHALIUM ULIGINOSUM, L. In the slender uliginous form in marshy meadows near Quiddy-Viddy Lake (181) and in the bushy branched form very abundant in burned regions, Holyrood (108).

HERACLEUM LANATUM, Michx. Banks of the Salmonier River.

*HIERACIUM CANADENSE, Michx. Rocky river banks, Manuels, etc. (173).

*H. VULGATUM, Fries. Less frequent than the preceding, and occurring in crevices of rocks by swift streams and waterfalls: Holyrood, and the cataracts of the Rocky River (227). To all appearances indigenous. The leaves are nearly always mottled.

LEONTODON AUTUMNALIS, L. St. John's; a common weed.

MATRICARIA INODORA, L. Only on rubbish heaps, St. John's.

*PRENANTHES SERPENTARIA, var. NANA, Gray. St. John's (47) and Holyrood. Six inches to 2½ feet high.

*RUDBECKIA HIRTA, L. Fields, Holyrood (178) and St. John's; not yet abundant.

SENECIO AUREUS, L. Salmonier, and near Placentia Junction.

S. AUREUS, var. BALSAMITÆ, Torr. & Gray. Exploits River and Holyrood.

*S. JACOBÆA, L. Roadsides, St. John's. Noticed to be very abundant in Northern Nova Scotia.

*S. SYLVATICUS, L. Railway ballast, Whitbourne; abundant.

S. VULGARIS, L. St. John's.

*SOLIDAGO MACROPHYLLA, Pursh. St. John's (52).

*S. RUGOSA, Mill. Holyrood (172). A smoothish form was collected in open wood near St. John's.

S. TERRÆ-NOVÆ, Torr. & Gray. Whitbourne. Clearly a more corymbosely branched form of *S. uliginosa*, toward which intergradations were found near the Exploits River.

S. ULIGINOSA, Nutt. Exploits River-(210), etc.

SONCHUS ARVENSIS, L. Gravel banks in Salmonier River (164). Exclusively with native plants, as if indigenous.

S. OLERACEUS, L. Fields, Placentia.

TARAXACUM OFFICINALE, Weber. St. John's, etc.

CAMPANULA ROTUNDIFOLIA, L. Cliffs on the north side of the harbour, St. John's (71).

LOBELIA DORTMANNA, L. Quiddy-Viddy Lake (56).

ANDROMEDA POLIFOLIA, L. Exploits River and near Whitbourne (8).

CASSANDRA CALYCULATA, Don. Low, peaty ground, St. John's (58), and Exploits River.

CHIOGENES SERPYLLIFOLIA, Salisb. Moist places upon rocky hillsides, abundant; St. John's (28), etc. The fruit, under the name of "capillaire-berry," is collected in sufficient quantity to make a preserve, which is justly esteemed a special delicacy. It is said that the crops of this, to us, rare berry vary much, being often good and poor in alternate seasons. The reason assigned was, the difficulty of picking the fruit without tearing and injuring the plants, which require a year or so to recover from the rough treatment.

GAYLUSSACIA DUMOSA, Torr. & Gray. Whitbourne (201).

KALMIA ANGUSTIFOLIA, L. St. John's (41); common.

K. GLAUCA, Ait. St. John's (9), Whitbourne, etc.; common.

LEDUM LATIFOLIUM, Ait. St. John's (13).

MONESES GRANDIFLORA, Salisb. Whitbourne; rare.

MONOTROPA HYPOPITYS, L. Fir woods near Exploits River.

M. UNIFLORA, L. Virginia Water. In woods near the Exploits River a small form was found, which, although agreeing as to anthers and stigma with *M. uniflora*, had flowers in size just intermediate between this and *M. Hypopitys*. In drying, also, these plants have assumed an intermediate color between the black of the former species and the tawny color of the latter.

PYROLA CHLORANTHA, Swartz. St. John's.

P. ROTUNDIFOLIA, L. Manuels.

P. SECUNDA, L. Near St. John's (37).

RHODODENDRON RHODORA, Don. St. John's (14) and Exploits River; abundant.

VACCINIUM OXYCOCCUS, L. St. John's (12).

V. PENNSYLVANICUM, Lam. Very abundant, especially upon burned tracts.

V. PENNSYLVANICUM, var. ANGUSTIFOLIUM, Gray. Rocky hills, Placentia; infrequent.

V. ULIGINOSUM, L. St. John's and Holyrood; less plentiful than the other species.

V. VITIS-IDÆA, L. Exposed hills, abundant, St. John's (15), etc.; locally called "partridge-berry."

LYSIMACHIA STRICTA, Ait. Whitbourne (118).

TRIENTALIS AMERICANA, Pursh. St. John's (17).

*APOCYNUM ANDROSÆMIFOLIUM, L. Exploits River (96).

BARTONIA, SP. (*Centaurella Moseri*, Steud. & Hochst., acc. to Griseb., in DC. Prodr. ix. 121.) A plant which appears to represent, at least in part, this rare and poorly understood species, was discovered in a small bog near Holyrood (5). The species was first described from specimens collected by Moser at Salzburg, Pa., and Drummond at Covington, La. In his treatment of the genus in DeCandolle's Prodromus, however, Grisebach includes in it, with the mark of affirmation, a specimen collected by La Pylaie in Newfoundland. As the present plant agrees with Grisebach's description as regards alternate leaf-scales and in having the corolla twice as long as the calyx, there can be little doubt that it is the plant of La Pylaie. It is, however, of lower growth, less branched, and less numerously flowered than Drummond's specimen—differences perhaps wholly due to the climate. The flowers, also, are mostly larger and solitary, on peduncles which are often 6 to 9 lines long. From *B. tenella*, the Newfoundland plant differs in its alternate leaf-scales, loose few-flowered raceme, and relatively larger corolla. which in the fresh state is pinkish; also in its purplish anthers. More perfect material of the United States form of *Centaurella Moseri* is much to be desired.

HALENIA DEFLEXA, var. BRENTONIANA, Gray. Hillsides and pastures, St. John's (180).

MENYANTHES TRIFOLIATA, L. Pools near Exploits River

*MYOSOTIS ARVENSIS, Hoffm. St. John's (203); appearing as if introduced.

M. LAXA, Lehm. Manuels.

SYMPHYTUM OFFICINALE, L. St. John's.

*SOLANUM DULCAMARA, L. St. John's.

CHELONE GLABRA, L. Whitbourne (211) and Exploits River.

EUPHRASIA OFFICINALIS, L. St. John's (102).

*LIMOSELLA AQUATICA, var. TENUIFOLIA, Hoffm. (?) Sterile, and accordingly doubtful, specimens collected upon precipitous cliffs of Placentia Harbour.

*LINARIA STRIATA, DC. St. John's, on Rennie's River, but near waste heaps; doubtless a waif.

*L. VULGARIS, Mill. St. John's.

*PEDICULARIS PALUSTRIS, L. Moist meadow, St. John's (82). The typical form of this does not appear to have been heretofore recorded in America. It differs from the var. WLASSOVIANA, Bunge (generally distributed in British America), conspicuously in the form of the corolla, and has also been collected in Labrador by Mr. J. A. Allen.

RHINANTHUS CRISTA-GALLI, L. St. John's (101) and Exploits River.

*VERONICA AGRESTIS, L. St. John's (151).

*V. OFFICINALIS, L. St. John's.

V. SCUTELLATA, L. Whitbourne (95).

UTRICULARIA CORNUTA, Michx. Whitbourne (90) and Exploits River.

U. INTERMEDIA, Hayne. Brooks, Placentia (19).

U. VULGARIS, L. Whitbourne and Exploits River.

BRUNELLA VULGARIS, L. Common; Salmonier River (72).

*CALAMINTHA LINOPODIUM, Benth. Rich bottoms, Salmonier River (91).

GALEOPSIS TETRAHIT, L. St. John's (104).

*LAMIUM AMPLEXICAULE, L. Ploughed ground, St. John's.

L. INCISUM, Willd. St. John's; a single specimen by roadside.

*LYCOPUS SINUATUS, Ell. Gravel beds, Salmonier River (106).

L. VIRGINICUS, L. Rennie's River (105).

*MENTHA ARVENSIS, L. Manuels (230); common along streams.

NEPETA GLECHOMA, Benth. St. John's.

SCUTELLARIA GALERICULATA, L. Manuels (103).

STACHYS PALUSTRIS, L. St. John's.

*LITORELLA LACUSTRIS, L. Exploits River (1).

PLANTAGO LANCEOLATA, L. St. John's.

P. MAJOR, L. St. John's.

P. MARITIMA, L. Placentia (70).

ATRIPLEX PATULUM, var. HASTATUM, Gray. St. John's.

CHENOPODIUM ALBUM, L. St. John's.

POLYGONUM AVICULARE, L. St. John's.

*P. CONVOLVULUS, L. Whitbourne.

P. HYDROPIPER, L. Whitbourne (36).

*P. LAPATHIFOLIUM, L. Near Quiddy-Viddy Lake.

*P. PERSICARIA, L. St. John's.

P. SAGITTATUM, L. Gravel beds, Salmonier River (92) and St. John's.

RUMEX ACETOSA. L. St. John's.

R. ACETOSELLA, L. St. John's.

*R. BRITANNICA, L. Whitbourne.

COMANDRA LIVIDA, Richards. Dry woods, St. John's (152), and Exploits River.

URTICA DIOICA, L. St. John's.

U. URENS, L. Quiddy-Viddy.

MYRICA GALE, L. St. John's (29).

ALNUS INCANA, Willd. Exploits River (35).

A. VIRIDIS, DC. St. John's (24); abundant.

*BETULA NANA, var. FLABELLIFOLIA, Hook. Moors near Exploits River (3).

B. PAPYRIFERA, Marshall. Manuels (139) and Exploits Rivers.

B. PUMILA, L. Moors near Exploits River (2).

[QUERCUS PEDUNCULATA, L. Cultivated near St. John's. Trees a foot in diameter, and evidently sixty or eighty years old, are interesting, as showing that the climate is not too severe for the genus, although it is entirely unrepresented in the native flora.]

POPULUS TREMULOIDES, Michx. Virginia Water, near St. John's.

*SALIX BALSAMIFERA, Barratt. Virginia Water (140).

*S. HUMILIS × DISCOLOR, Bebb. Manuels River.

S. LUCIDA, Muhl. Exploits River.

EMPETRUM NIGRUM, L. Abundant on rocky hills, St. John's (150).

COROLLORHIZA MULTIFLORA, Nutt. Deep mossy woods, Salmonier River.

CYPRIPEDIUM ACAULE, Ait. Near St. John's.

*GOODYERA REPENS, R. Br. Woods, Whitbourne and Salmonier.

HABENARIA BLEPHARIGLOTTIS, Torr. Holyrood (111).

H. DILATATA, Gray. Exploits River (110), Holyrood, Manuels, etc.; common.

*H. FIMBRIATA, R. Br. Exploits River.

*H. LACERA, R. Br. Holyrood.

H. OBTUSATA, Rich. Whitbourne.

H. ORBICULATA, Torr. Moist woods, Whitbourne. An unusually large-flowered form, the same as collected by Robbins on Lake Superior, but appearing to pass insensibly into smaller-flowered forms.

H. PSYCHODES, Gray. Wet meadows, Placentia (165), and on Manuels River.

H. TRIDENTATA, Hook. Manuels (167).

LISTERA CORDATA, R. Br. Whitbourne (168) and Exploits River.

MICROSTYLIS OPHIOGLOSSOIDES. Nutt. Manuels (68).

POGONIA OPHIOGLOSSOIDES, Nutt. Manuels and Whitbourne (166).

SPIRANTHES ROMANZOFFIANA, Cham. Holyrood (128), Exploits River, etc.; common.

IRIS VERSICOLOR, L. St. John's.

SISYRINCHIUM ANCEPS, Cav. Salmonier River.

*S. ANGUSTIFOLIUM, Mill. With the last, and not satisfactorily distinguishable from it. Doubtless Dr. Morong was quite right in uniting them as *S. Bermudiana*, L.

CLINTONIA BOREALIS, Raf. Virginia Water (45) and Exploits River.

MAIANTHEMUM CANADENSE, Desf. St. John's (62), etc.

SMILACINA TRIFOLIA, Desf. Whitbourne (44).

STREPTOPUS AMPLEXIFOLIUS, DC. Manuels River; infrequent.

*TOFIELDIA GLUTINOSA, Willd. Holyrood (39).

*XYRIS FLEXUOSA, var. PUSILLA, Gray. Holyrood (153).

*LUZULA CAMPESTRIS, var. MULTIFLORA, Celakovsky. Whitbourne (86) and Placentia, also in more exposed places upon rocky hills about St. John's (85) a smaller form with darker flowers (distributed as *L arcuata*, Mey).

JUNCUS ARTICULATA, L. St. John's (163).

J. BALTICUS, var. LITTORALIS, Engelm. Placentia (142).

J. BUFONIUS, L. St. John's; in two forms, one slender and erect, 6 to 8 inches high (160); the other spreading and more flexuous, 3 to 4 inches high (161).

J. CANADENSIS, J. Gay. Whitbourne and Holyrood.

J. CANADENSIS, var. COARCTATUS, Engelm. St. John's (162).

*J. EFFUSUS, in colour approaching var. BRUNNEUS, Engelm. Placentia. The true var. *brunneus* is of the far west.

*J. EFFUSUS, probably of the formal var. COMPACTUS, Lej. et Courtois (132); distributed as var. *conglomeratus*.

*J. EFFUSUS × LEERSII. Bottom lands of the Salmonier River (131). distributed as *J. effusus*.

*J. FILIFORMIS, L. Shores of Quiddy-Viddy Lake (138) and Exploits River.

*J. LEERSII, Marsson. Near the railway track, Whitbourne (133), and north of Placentia Junction. Hitherto known in America only from doubtful specimens collected in Pennsylvania by Sartwell (see Buchenau Monog. Juncac. 234).

J. PELOCARPUS, E. Mey. St. John's (141).

J. STYGIUS, var. AMERICANUS, Buchenau. Marshes, Holyrood.

*J. SUPINUS, Moench. Near St. John's, in two very different forms: one reddish, and with elongated stems, floating in shaded pools, near Rennie's River (234); the other, green, sub-erect, 2 to 4 inches high, growing upon muddy banks of small streams; heads viviparous (233). The occurrence of this species in America has until recently rested exclusively upon immature and doubtful specimens collected in Newfoundland by La Pylaie. Through Mr. Coville we learn that it was re-discovered some time ago by Mr. Waghorne.

J. TENUIS, Willd. Beaten paths, Virginia Water (130).

J. TRIFIDUS, L. Crevices of precipitous rocks, Helmet Mt., Holyrood (158).

SAGITTARIA GRAMINEA, Michx. Whitbourne; rare.

*SPARGANIUM SIMPLEX, var. ANDROCLADUM, Engelm. Virginia Water (200).

*POTAMOGETON HETEROPHYLLUS, Schreb. Whitbourne (231).

*P. HETEROPHYLLUS, var. GRAMINIFOLIUS, Wats. & Coult. Exploits River (232).

*P. PENNSYLVANICUS, Cham. Exploits River.

*P. PERFOLIATUS, L. Holyrood (207).

ERIOCAULON SEPTANGULARE, Withering. Quiddy-Viddy Lake (112) and Exploits River.

*CAREX ADUSTA, Boott. North of Placentia Junction, on railway ballast (93).

*C. RAEANA, Boott. (*C. miliaris*, var. *aurea*, Bailey.) Marshy ground by the Exploits River (236). Abundant fruiting material of this attractive sedge leaves no doubt of its distinctness from *C. miliaris*, and makes it more than probable that it represents the true *C. Raeana*, apparently a good species. Before its affinities were thoroughly traced it was distributed as *C. Baileyi.* The same plant has been collected in Maine by Prof. Porter and by Mr. Fernald, and is said to extend westward to North Michigan.

C. CANESCENS, var. VULGARIS, Bailey. St. John's (124).

C. CRINITA, var. GYNANDRA, Schweinitz & Torr. Manuels River (99) and St. John's.

*C. DEBILIS, var. RUDGEI, Bailey. St. John's (122).

C. EXILIS, Dew. Holyrood.

*C. FŒNEA, Willd. A peculiar form, resembling the *C. festiva*, Dew, at least appearing identical with specimens from Greenland generally referred to that species.

*C. FLAVA, var. GRAMINIS, Bailey. Rocky banks, Manuels River (98).

*C. FLAVA, var. VIRIDULA, Bailey. Rennie's River (97), Holyrood, and Exploits River.

C. FOLLICULATA, L. St. John's (76).

C. INTUMESCENS, Rudge. Between Placentia and Colinet (79).

*C. LAXIFLORA, var. VARIANS, Bailey. Exploits River.

*C. LIVIDA, Willd. Holyrood.

C. MAGELLANICA, Lam. Frequent in sphagnum, St. John's (88).

C. MICHAUXIANA, Bœckl. St. John's (78) and Exploits River.

*C. MILIARIS, Michx. Exploits River (87).

*C. OLIGOSPERMA, Michx. Exploits River (77) and Holyrood.

C. PAUCIFLORA, Lightf. Whitbourne.

C. POLYTRICHOIDES, Muhl. St. John's (89).

*C. RIGIDA, var. GOODENOVII, Bailey. St. John's (123).

C. SCOPARIA, Schkuhr. Whitbourne (94) and near Shoals Harbour.

C. STERILIS, Willd. Rennie's River, near St. John's (125).

*C. STERILIS, var. CEPHALANTHA, Bailey. Marsh near Exploits River.

C. STIPATA, Muhl. Rennie's River, St. John's (81), and Salmonier River.

*C. TRISPERMA, Dew. Virginia Water (100).

*C. UTRICULATA, Boott. Whitbourne (120), St. John's, and Exploits River.

*C. UTRICULATA, var. MINOR, Boott. Bally Haily Bog, St. John's (182), and Exploits River.

*DULICHIUM SPATHACEUM, Pers. Exploits River (46).

*ELEOCHARIS ACICULARIS, R. Br. Shores of Quiddy-Viddy Lake (126).

*E. PALUSTRIS, var. VIGENS, Bailey. Whitbourne (121).

E. TENUIS, Schultes. St. John's (127).

*ERIOPHORUM ALPINUM, L. Bluffs of Manuels River (59).

E. CYPERINUM, L. St. John's (65).

E. GRACILE, Koch. St. John's (60).

E. VAGINATUM, L. Bally Haily Bog, St. John's (117).

E. VIRGINICUM, L. Holyrood (61). In the same locality *E. polystachyon*, L., was seen, but through oversight was not collected.

RHYNCHOSPORA ALBA, Vahl. Manuels (116).

R. FUSCA, Roem. & Sch. Holyrood (171).

*SCIRPUS CÆSPITOSUS, L. Bally Haily Bog, St. John's (115).

*S. SUBTERMINALIS, Torr. Exploits River (208).

AGROPYRUM REPENS, Beauv. St. John's.

*AGROSTIS ALBA, var. SYLVATICA, Scribner. Field, St. John's.

A. ALBA, var. VULGARIS, Thurb. Whitbourne; in two forms, differing in breadth of leaves.

A. SCABRA, Willd. Exploits River (220).

ALOPECURUS GENICULATUS, L. St. John's (154).

A. PRATENSIS, L. St. John's.

ANTHOXANTHUM ODORATUM, L. Fir woods, St. John's.

*BRACHYELYTRUM ARISTATUM, Beauv. Exploits River (197).

BROMUS CILIATUS, L. Manuels and Exploits Rivers.

CALAMAGROSTIS CANADENSIS, Beauv. St. John's (204).

*C. PICKERINGII, Gray. Exploits River (205).

CINNA PENDULA, Trin. Placentia.

DANTHONIA SPICATA, Beauv. Quiddy-Viddy (199) and Exploits Rivers.

DESCHAMPSIA FLEXUOSA, Trin. St. John's (198).

*FESTUCA ELATOR, L. Whitbourne.

*F. RUBRA, L. Placentia (226).

GLYCERIA CANADENSIS, L. St. John's (155).

*G. FLUITANS, R. Br. St. John's (221).

*G. LAXA, Scribner. Whitbourne.

*G. NERVATA, Trin. Shoals Harbour (156), as if introduced.

*HOLCUS LANATUS, L. Whitbourne; rare.

*LOLIUM ITALICUM, A. Br. Introduced about railway station Clode's Sound; distributed as *L. temulentum*.

*MUHLENBERGIA GLOMERATA, Trin. Exploits River (196).

NARDUS STRICTA, L. Well established upon rocky banks of Rennie's River (209). Although forming a turf with native grasses and sedges, the specimens were too near the city of St. John's to argue strongly for an indigenous character. The species, however, is native in Greenland, and might not improbably extend down the north-eastern coast of America. We have been able to find only one previous record of the occurrence of this grass in America, that being by Prof. Edw. Tuckerman, who reported it as present in his lawn in Massachusetts—doubtless introduced in foreign grass-seed.

PANICUM BOREALE, Nash. (Bull. Torr. Club, xxii. 421.) Exploits River (222); distributed as a small-flowered variety of *P. commutatum*.

PHLEUM PRATENSE, L. Cultivated, and often escaping upon roadsides, St. John's.

POA ANNUA, L. St. John's.

P. COMPRESSA, L. On railway ballast, Placentia Junction (225) and Whitbourne.

P. PRATENSIS, L. St. John's (219). With this number a small quantity of another species of *Poa* was inadvertently distributed. It had larger spikelets and white-margined glumes, and is undoubtedly new to the island. Unfortunately, the material is too scanty to permit a satisfactory determination.

P. SEROTINA, Ehrh. Slender, shaded form, in woods, St. John's (224); also a more robust form in dry open ground, Whitbourne (223), and near Northern Bight.

*SPOROBOLUS SEROTINUS, Gray. Exploits River.

*TRIODIA DECUMBENS, Beauv. Rocky banks of Rennie's River (206). A grass not, to our knowledge, heretofore reported from America. Well established, and forming a turf with native grasses.

ABIES BALSAMEA, Mill. Common about St. John's, etc.

JUNIPERUS COMMUNIS, L. (Nearly typical). Rocky hills, Quiddy-Viddy, with, and less frequent than, the following:—

*J. COMMUNIS, var. ALPINA, Gaud. Quiddy-Viddy (67).

J. SABINA, var. PROCUMBENS, Pursh. Marshy moors, Exploits River (34).

LARIX AMERICANA, Michx. St. John's (157).

PICEA ALBA, Link. St. John's. The collection of *P. nigra*, Link, and its var. *rubra*, Engelm., was deferred, and finally, through shortness of time, neglected, so that they can only be reported upon the accuracy of field determinations.

PINUS STROBUS, L. Exploits River, common, and of considerable size; also on the peninsula of Avalon, at Holyrood, but there apparently very scarce.

TAXUS CANADENSIS, Willd. St. John's and Exploits River; frequent.

*EQUISETUM ARVENSE, L. Manuels River.

E. LIMOSUM, L. Exploits River.

E. SYLVATICUM, L. Badger Brook.

*ASPIDIUM CRISTATUM, Swartz. Whitbourne.

A. NOVEBORACENSE, Swartz. In alder thickets, St. John's (107).

A. SPINULOSUM, var. DILATATUM, Hook. Placentia.

*A. SPINULOSUM, var. INTERMEDIUM, D. C. Eaton. Whitbourne.

ASPLENIUM FILIX-FŒMINA, Bernh. Virginia Water and Salmonier River.

CYSTOPTERIS FRAGILIS, Bernh. Cliffs, Placentia, and bluffs of Manuels River.

ONOCLEA SENSIBILIS, L. Whitbourne (63).

OSMUNDA CINNAMOMEA, L. Whitbourne (57).

O. CLAYTONIANA, L. Holyrood (43) and Exploits River.

O. REGALIS, L. Holyrood and Exploits River.

PHEGOPTERIS DRYOPTERIS, Fée. Salmonier River (147) and Exploits River.

P. POLYPODIOIDES, Fée. Salmonier River (146).

POLYPODIUM VULGARE, L. Helmet Mountain, Holyrood (21).

*PTERIS AQUILINA, L. Holyrood (4).

*LYCOPODIUM ANNOTINUM, var. PUNGENS, Spreng. St. John's and Holyrood (216).

L. CLAVATUM, L. St. John's.

L. COMPLANATUM, L. Exploits River.

*L. INUNDATUM, L. Bally Haily Bog, St. John's (135), and Exploits River.

L. LUCIDULUM, Michx. Whitbourne (137).

L. OBSCURUM, var. DENDROIDEUM, D. C. Eaton. Helmet Mountain, Holyrood (134).

*L. SELAGO, L. Holyrood (136).

*ISOETES TUCKERMANI, Braun. In 3 to 6 inches of water, Quiddy-Viddy Lake.

Peculiar Behaviour of Charcoal in the Blast Furnace at Radnor Forges, Que.

By J. T. Donald, M.A.

In October last the Canada Iron Furnace Company sent the writer a sample of what they termed partly consumed charcoal, containing a large percentage of siliceous matter, and which they stated "had been thrown out at the cinder notch of the furnace in large quantities, unconsumed, and showing fibres, or threads, of a yellow colour, and similar to mineral wool." It was further stated that "the coal, which was made from oak, and, apparently, basswood and elm, seems unfit for furnace work." A superficial examination was sufficient to show that this charcoal was very peculiar indeed. Its unusual weight at once challenged attention; and a closer inspection showed in the specimen a framework in the form of a fibrous mass—not unlike a piece of harsh fibred asbestos. Analysis showed that this fibrous matter amounted to no less than 41.16 per cent. of the coal. The question now was, to account for this large percentage of mineral matter. The only explanation I could offer was to suggest that it might be the result of charring wood that had been partially fossilized, for it was well known that such silicified wood is not uncommon. At the same time this suggestion did not satisfy me; it did not, I thought, cover the fibrous or rod-like structure of the mineral matter—for I had never seen a similar structure in silicified wood. I therefore decided to send portions of the sample to Prof. Penhallow, of McGill, and Mr. W. F. Ferrier, of the Geological Survey. These gentlemen are authorities in their own departments—the former as a botanist, and the latter as a mineralogist and lithologist. It appeared to me that the question of the origin of the siliceous matter of this coal was one of either botany or mineralogy, and not of chemistry. Prof. Penhallow, having examined the specimens, reported that "it seems difficult to think that these rods are the result of natural processes of growth." Mr. Ferrier said he thought the siliceous matter had not been present in the original charcoal, but that it was slag that the coal had absorbed in the furnace. Then, next, word came from the furnace at Radnor that similar fibrous charcoal had again been expelled from the slag notch, and this whilst charcoal from a totally different locality was being used in the furnace. The evidence was thus strongly against the view that the siliceous matter was part of the original coal, and in favour of Mr. Ferrier's suggestion. The question was thus again, as it were, thrown back into the sphere of chemistry, and it appeared probable that an analysis of the fibrous matter would settle it. After much care and labour, a quantity of fibre sufficient for analysis—and free from the ash naturally present in the charcoal—was obtained. The difficulty of securing a satisfactory sample lay in the fact that the alkali of the true ash caused the fibres to fuse, forming little glassy globules. It was desirable to avoid these, in order that the analysis might show the composition of the fibre itself. The analysis of the fibre is stated in column 2; column 1 is the partial analysis of a sample of Radnor slag made by myself in January, 1891:—

	(1) p.c.	(2) p.c.
Alumina	13.52	18.15
Ferrous oxide	1.44	.51
Manganous oxide	3.48	Traces
Lime	23.89	25.44
Magnesia	.74	1.47
Sulphuric anhydride	1.52	Traces
Silica	54.00	42.18
Alkalies—Phosphoric anhydride, etc., by diff.	2.41	2.25

It is very evident, then, that the fibrous matter of this charcoal is simply absorbed slag. Two questions of interest then arise. What were the conditions in the furnace that caused charcoal in large quantities to absorb and retain the liquid slag? How did it happen that only on two occasions had the production of this slag-saturated coal been observed?

The following particulars regarding the furnace are data that must be taken into consideration in any theory put forth to explain the peculiar behaviour of the charcoal under consideration :—

Four 3½ inch tuyeres are used.

The average pressure of blast is about 5¾ lbs.

The average temperature of blast, 900 degrees Fahr.

The quantity of air, as a rule, is 2,638 cubic feet, but at times it has run to as high as 2,827 cubic feet to the minute.

Cubical contents of furnace, from stock-line down, is 1,264 cubic feet.

Charcoal Impregnated with Slag.

By D. P. Penhallow, M.A.Sc.

On the 8th of October last I received from Prof. J. T. Donald a sample of charcoal, together with some peculiarly fibrous silicious matter, accompanied by the statement that the coal was received from "clients who use charcoal in the production of charcoal iron," and that "when the coal is burned it leaves an ash consisting of long fibres. This material was thrown out at the cinder notch in large quantities unconsumed. The coal was made from oak and apparently bass-wood and elm."

Upon submitting the coal to examination, it became evident that it was derived from the wood of an elm—probably the common white or American elm (*Ulmus* *americana*). The texture was found to be very harsh and rough. A transverse fissure was found to be filled with a somewhat protruding mass of vitreous matter which also extended above and below wherever longitudinal fractures occurred. Upon handling the specimen, small vitreous particles, like small shot, but usually imperfectly rounded and quite glossy, would detach themselves from the mass. Running longitudinally, and clearly lying within the vessels, were to be seen numerous siliceous rods. Where these entered the transverse fissures previously referred to, they, in some cases, presented free terminations, or again were fused together into a more or less continuous mass. The transverse fracture of the coal is somewhat lustrous, and shows numerous short, black and glossy filaments with a lustrous fracture, projecting from the various vessels.

The sample of residue sent me shows that when the coal is consumed it leaves behind a rather compact, fibrous mass of stiff, greyish filaments which, when undisturbed, have the general aspect of a very poor and coarse fibred asbestos. Under a low magnifying glass, the filaments appear as glistening and chiefly transparent or translucent glass rods. They are of very variable size, and in our specimen reach a length of upwards of 30 mm., though there is no reason to suppose that they may not have a greater length. The surface shows conspicuous irregularities, which at once serve to suggest the conformation of the rods to the walls of the vessels in which they occur.

A more critical examination under a compound microscope shows that the filaments measure from 29 μ. to 72 μ. in diameter. For the most part they are perfectly transparent, glass like bodies, or again they assume a yellowish hue, or even become blackish or more or less opaque in consequence of the inclusion of numerous small air bubbles, or of black granules, apparently particles of unconsumed carbon. Chiefly solid, they rarely show a central, longitudinal channel. Sometimes they are full of minute air bubbles which, as they come to the surface, merge into minute but irregular fissures and air cavities, such as we might suppose to be formed by air enclosed in a solidifying mass.

The most interesting aspect, however, is to be found in the surface markings. These take of the form of transverse, often forking striæ, between which may be seen small round pit-like markings, and it requires no very critical inspection to convince one that all these markings are extremely faithful casts of the various structural features of the vessels within which the rods were found. So complete, indeed, are these casts that the terminal walls of the vessels in all their details may be observed.

On the 9th of December a second lot of coal from another furnace, was received from Prof. Donald. This proved, upon investigation, to have been derived from some species of oak. It was very light, but showed numerous rods of silica, completely filling the various vessels. In this, as in the former case, when the rods projected into fissures, they were commonly fused into bead-like terminations, or the whole were joined into a more or less continuous mass. These masses were sometimes transparent, but more often of a greenish color, strongly suggestive of slag. They commonly assumed a nodular form and usually had the aspect of being formed *in situ* by fusion of the extremities where these latter projected into fissures.

The rods themselves were found to be white or glossy, and transparent, rarely green, but often dark from the inclusion of air or of particles of unconsumed charcoal. They were found to measure from 37 μ. to 249 μ. in diameter, and thus to vary much more widely than those from the elm, a fact which is quite in accord with the different dimensions of the vessels in these two woods

—elm and oak. As in the first case, the rods exhibit in a remarkably well defined manner all the structural features of the vessels from which they were derived or within which they were formed.

In the facts thus obtained from a direct examination of the material itself, we have conclusive evidence that

1st. Siliceous matter, either in a molten or a soluble condition, was taken into the vessels of oak and elm wood, or into the charcoal derived therefrom, and eventually deposited there.

2nd. That the volume of material was sufficient to completely fill all the vessels in large pieces of coal or wood, and thus to form complete casts of these structures.

It thus becomes necessary to obtain answers to the following questions :—

1st. Was the silica taken up by the living plants or by the charcoal derived therefrom.

2nd. In what form was the silica taken up ?

3rd. In what way was entrance into the tissues of the coal effected ?

1st. The evidence of the specimens themselves shows beyond question that the silica must have been taken up before the structure of the tissues was destroyed by combustion. It must, therefore, have been taken up by the living plant or by the charcoal before the latter was subjected to a destructive oxidation.

With respect to the first of these alternatives, we fortunately have important guiding data in the known processes of silicification in plants. So far as we know, silica can enter the living plant only through its roots in the form of a soluble silicate. Its final disposition leads not to the filling up of vessels, but to such a distribution within the substance of the walls of tissues as to give to these latter a marked element of mechanical strength. Instances of this kind are familiar in highly silicified hairs of the nettle and squash, as also in the very highly silicified and strongly resistant epidermis of the grasses and Equiseti. The formation of tabashir in the hollow joints of certain bamboos might be held to offer a fair basis for comparison, but all analogy fails when it is recalled that the often large masses of silica thus met with are altogether amorphous and deposited as the residuum of the fluids originally present. In the known deposition of silica in plants, there are, in fact, no grounds for comparison, and, from a botanical point of view, there is no way of reaching an adequate explanation of the presence of such rods of silica in charcoal. It is, in fact, quite within the limits of safety to assert that it would be altogether contrary to normal processes of growth for such deposits to occur in living tissues.

We are thus confronted with the alternative that the silica must have been taken up by the charcoal itself. It is a well known fact that charcoal often retains all the prominent structural features of the original tissues in a remarkable degree, and it thus becomes possible to see how the casts could so completely represent the structure of the vessels.

In whatever form the silica entered the coal, the fact that it later appears as complete casts shows that it solidified within the vessels before the latter were destroyed by combustion.

2nd. The rods have been shown to present a diversity of appearances. They are clear and glass like; opaque through the inclusion of air or of what seem to be particles of unconsumed carbon; or they again appear—but more particularly in the massive form—of a greenish white color like slag. Collectively, these appearances point to the view that the infiltrated matter must have entered the coal in a molten state, and that it is in reality slag in which the coal was immersed, a conclusion which is greatly strengthened by Prof. Donald's statement that an analysis of this residue shows it to have the composition of ordinary slag.

3rd. The question as to how such infiltration was accomplished cannot be answered with a full measure of satisfaction. The results of our examination would seem to imply the operation of capillarity as the only process which will offer an adequate explanation of the case. This would certainly account for the entrance of even a dense fluid into the vessels of the coal, and it would find its parallel in the formation of the Kootanie Cannel coals by the infiltration of fluid hydro-carbons into plant tissues.[1] This view, however, does not take account of the special conditions existing in the furnace and under which this infiltration took place, and of such conditions we have no knowledge. Under what peculiar circumstances it is possible for conditions, such as are implied by the facts before us, to exist, it is not within my province to say, but upon a knowledge of them, appears to depend the solution of what must otherwise remain an obscure problem.

Contributions to Canadian Botany.

By James M. Macoun.

IX.

Delphinium simplex, Dougl.

About two miles above the mouth of the Kootanie River, B.C., 1889. (*John Macoun*, Herb. No. 10,597.) New to Canada.

Alyssum calycinum, L.; Macoun, Cat. Can. Plants, Vol. I., p. 53.

Near Blackwell Station, Lambton Co., Ont. (*T. C. Wheatley.*)

[1] Trans. R. Soc. Can. XII. iii. 30.

POLYGALA INCARNATA, L.

Walpole Island, Lambton Co., Ont., 1894. (*C. K. Dodge.*) New to Canada.

POLYGALA SENEGA, L., var. LATIFOLIA, T. & G.

Georgian Bay, Lake Huron, 1889. (*J. M. Dickson.*) New to Canada.

SAGINA DECUMBENS, Torr. & Gray; Macoun, Cat. Can. Plants. Vol. I., p. 79.

Hillsides, Farewell Creek, Cypress Hills, Assa. Herb. No. 11,710.[1] (*John Macoun.*)

DESMODIUM MARILANDICUM, F. Boott.

Near Blackwell Station, Lambton Co., Ont., 1893. (*T. C. Wheatley.*) New to Canada.

DESMODIUM ROTUNDIFOLIUM, DC.; Macoun, Cat. Can. Plants, Vol. I., p. 118.

Niagara Falls, Ont. (*R. Cameron.*) Near Blackwell Station, Lambton Co., Ont. (*C. K. Dodge.*)

VICIA SEPIUM, L.

In ditches in a ravine west of Hamilton, Ont. (*J. M Dickson.*) New to Canada. Introduced.

LUDWIGIA POLYCARPA, Short & Peter.

Since recording in Part I. of these papers the occurrence of this species, at Amherstburg, it has been reported from the vicinity of Sarnia by Mr. Chas. K. Dodge.

EPILOBIUM WATSONI, Barbey.

New Westminster, B.C. (*A. J. Hill. Rev. H. H. Gowen.*) New to Canada.

[1] Whenever herbarium numbers are given, they are the numbers under which specimens have been distributed from the herbarium of the Geological Survey of Canada.

LYTHRUM SALICARIA L.

In No. VII. of these papers, it was stated that this species had not been recorded from Eastern Ontario until found at Ottawa, in 1895, by Mr. Tourchat. This was a mistake. It had been before collected at Ottawa by Mr. William Scott, and was recorded in *Flora Ottawaensis*, p. 32.

PASTINACA SATIVA, L.

Spence's Bridge, B.C.; common in old gardens and waste places on Vancouver Island. (*John Macoun.*) Not recorded west of Manitoba.[1]

PEUCEDANUM EURYCARPUM, C. & R.; Macoun, Cat. Can. Plants, Vol. I., p. 329.

From the east end of the Cypress Hills west to the Rocky Mountains, 1894, 1895. Herb. Nos. 4,963 and 10,692-3-4-5. (*John Macoun.*) Not before recorded east of Rocky Mountains.

PEUCEDANUM TRITERNATUM, Nutt.; Macoun, Cat. Can. Plants, Vol. I., pp. 187 and 536; and Vol. II., p. 329.

Milk River, Assa. Herb. No. 10,688. (*John Macoun.*) Eastern limit.

DAUCUS CAROTA, L.

Common in meadows on Vancouver Island, and apparently naturalized.

CORNUS PUBESCENS, Nutt.; Macoun, Cat. Can. Plants, Vol. I., pp. 191 and 538.

Donald, Columbia River, B.C.; north of Pass Creek, Sproat, B.C. (*John Macoun.*)

CORNUS PUBESCENS, Nutt., var. CALIFORNICA, C. & E.

Woods at Revelstoke, Columbia River, B.C., 1890. (*John Macoun.*) Only Canadian station.

[1] The geographical limits given in these papers refer to Canada only.

NYSSA AQUATICA, L.

N. multiflora, Wang.; Macoun, Cat. Can. Plants, Vol. I., p. 192.

Many fine trees of this species grow at Queenston Heights, and near Niagara-on-the-Lake, Ont., but it has apparently never been recorded from that vicinity.

ADOXA MOSCHATELLINA, L.; Macoun, Cat. Can. Plants, Vol. I., p. 193.

Athabasca River, below the Cascades. (*Miss E. Taylor.*) Athabasca River, Lat. 56°. (*Jas. M. Macoun.*)

SAMBUCUS GLAUCA, Nutt.; Macoun, Cat. Can. Plants, Vol. II., p. 331.

In woods at Deer Park, Lower Arrow Lake, Columbia River, B.C. (*John Macoun.*) Eastern limit.

VIBURNUM DENTATUM, L.; Macoun, Cat. Can. Plants, Vol. I., pp. 194 and 538.

Foster's Flats, Niagara River, Ont. (*John Macoun.*) Near Sarnia, Ont. (*C. K. Dodge.*)

VIBURNUM OPULUS, L.; Macoun, Cat. Can. Plants, Vol. I., p. 195.

Prof. Macoun, in his Catalogue, makes the Saskatchewan the western limit of this species. We have now specimens from Sproat, B.C.; Sicamous, B.C.; and Agassiz, B.C. (*John Macoun.*)

LONICERA CILIOSA, Poir.; Macoun, Cat. Can. Plants, Vol. I., p. 196.

Woods at Sproat and Deer Park, Columbia River, B.C.; Yale, B.C. (*John Macoun.*)

LONICERA UTAHENSIS, Wats.; Macoun, Cat. Can. Plants, Vol. I., p. 540.

Sheep Mountain, Waterton Lake, Rocky Mountains;

Deer Park, Lower Arrow Lake, B.C.; Revelstoke, B.C.; Sicamous, B.C. (*John Macoun.*)

Galium aparine, L.; Macoun, Cat. Can. Plants, Vol. I., p. 200.

The only western station for this plant given by Prof. Macoun is Victoria, Vancouver Island. It has since been found to be of very general distribution in British Columbia. Our specimens are from Elk River Bridge, Rocky Mountains. (*Dr. Geo. M. Dawson.*) Deer Park, Lower Arrow Lake, Columbia River, B.C.; Ainsworth, Kootanie Lake, B.C.; Kamloops, B.C.; Yale. B.C.; Agassiz, B.C.; Lulu Island, B.C.; Salt Spring Island, Gulf of Georgia; common on Vancouver Island. (*John Macoun.*) Specimens from some of the above localities have been distributed as var. *Vaillantii,* Koch, but they are true *G. Aparine.* We agree with Dr. Greene that though this species is "as much at home in our woods and thickets as any indigenous plant, it is probable that it came hither from the Old World within the last two centuries."

Sherardia arvensis, L.

In fields, Victoria, Vancouver Island, 1893. (*John Macoun.*) Not before recorded west of Ontario.

Asperula arvensis, L.

Edge of a marsh, near Hamilton, Ont. (*J. M. Dickson.*). New to Canada.

Liatris scariosa, Willd.; Macoun, Cat. Can. Plants, Vol. I., p. 208.

Near Sarnia, Lambton Co., Ont. (*C. K. Dodge.*) Not recorded from Ontario since collected by Maclagan. Not having seen Maclagan's specimens, Prof. Macoun, when preparing his Catalogue, was of the opinion that Maclagan's stations for *L. scariosa* should be referred to *L. cylindrica.*

ASTER CONCINNUS, Willd.

A specimen of this rare *Aster* was sent to our herbarium by Mr. Eugene A. Rau in December, 1890. The label reads thus: "Moraviantown (formerly called New Fairfield) near railroad station, Bothwell, Ontario, Canada. Collected by Robert Rau, Sept. 30th, 1872. Identified by Prof. Porter." Specimens collected by Jas. M. Macoun, at Point Edward, Ont., in 1884, have been doubtfully referred here. They differ very slightly from Mr. Rau's specimen, and are not referable to any other species.

ASTER CONSPICUUS, Lindl.; Macoun, Cat. Can. Plants, Vol. I., pp. 220 and 544.

In rocky thickets at Sicamous, B.C. (*John Macoun.*) Western limit.

ERIGERON ARMERIÆFOLIUS, Turcz; Macoun, Cat. Can. Plants, Vol. I., p. 235.

Additional stations for this species are: Chaplin, Old Wives Lakes, Assa., Herb. No. 10,840; Fort Walsh, Cypress Hills, Assa.; Hand Hills, Alberta; St. Mary's River, Alberta, Herb. No. 10,839; Cave Avenue, Banff, Rocky Mountains; Sicamous, B.C.; Kamloops, B.C. (*John Macoun.*) Not before recorded west of the prairie region.

ERIGERON OCHROLEUCUS, Nutt.

Summit of Sheep Mountain, Waterton Lake, Rocky Mountains. Herb. No. 10,858. (*John Macoun.*) New to Canada. Flowers purplish, turning to a dirty chrome yellow when the specimens have been badly dried. The description in Torr. & Gray, Fl. II., p. 178, is a much better one than that in Gray's Syn. Flora.

ERIGERON STRIGOSUS, Muhl.; Macoun, Cat. Can. Plants, Vol. I., p. 234.

Near Belly and St. Mary's rivers, Alberta; Griffin Lake, B.C.; Sproat, B.C.; Ainsworth, Kootanie Lake, B.C.;

Alberni, Vancouver Island. (*John Macoun.*) Not before recorded west of Assiniboia. The Sproat specimens are the var. *discoideus*, Robbins.

ERIGERON UNIFLORUS, L.; Macoun, Cat. Can. Plants, Vol. I., pp. 231 and 547.

Summit of Avalanche Mountain, Selkirk Mts., B.C.; Mt. Queest, Shuswap Lake, B.C. Alt. 6,000 feet. (*Jas. M. Macoun.*) Not recorded before from British Columbia. Specimens from Kicking Horse Lake, taken from a land-slide at the foot of a mountain, show a great divergence in habit from those collected at the summit of the same mountain, 3,000 feet higher. These latter are scarcely an inch in height, and have in some cases a barely perceptible stem; the plants from the lower levels are more than a foot high.

ANTENNARIA ALPINA, Gærtn.; Macoun, Cat. Can. Plants, Vol. I., pp. 236 and 548.

Mountains north of Griffin Lake, B.C.; Revelstoke, B.C.; Spence's Bridge, B.C.; summit of Mount Arrowsmith, Vancouver Island. (*John Macoun.*)

ANTENNARIA CARPATHICA, R.Br.; Macoun, Cat. Can. Plants, Vol. I., pp. 236 and 548.

Additional stations for this species are: mountains at Roger's Pass, Selkirk Mts., B.C., alt. 6,500 feet; near Ainsworth, Kootanie Lake, B.C.; Spence's Bridge, B.C. (*John Macoun.*) Mount Queest, Shuswap Lake, B.C.; mountains at Griffin Lake, B.C. (*Jas. M. Macoun.*) Sucker Mountain, B.C. (*Jas. McEvoy.*)

ANTENNARIA CARPATHICA, R. Br., var. PULCHERRIMA, Hook. Macoun, Cat. Can. Plants. Vol. I., pp. 237 and 548.

Guichon Creek, B.C.; mountains south of Tulameen River, B.C. (*Dr. Geo. M. Dawson.*) Spence's Bridge, B.C.; Câche Creek Mountain. B.C. (*John Macoun.*) The Câche Creek specimens were referred to *A. Carpathica* in Prof. Macoun's Catalogue. Not before recorded west of Selkirk Mountains.

ANTENNARIA DIOICA, Gaertn.; Macoun, Cat. Can. Plants, Vol. I., pp. 236 and 548.

Charlton Island. James Bay, Hudson Bay, the var. *parviflora*, T. & G. (*Jas. M. Macoun.*) Our herbarium material shows typical *A. dioica*, Gærtn., to be common from Assiniboia west through the Rocky Mountains to Kamloops, B.C., and north to Fort Smith on Great Slave River. The pink-flowered form is almost as common, but has not been found east of Belly River, Alberta.

GNAPHALIUM DECURRENS, Ives, var. CALIFORNICUM, Gray.

In open woods at Revelstoke, B.C., and at Ainsworth, Kootanie Lake, B.C., 1890. (*John Macoun.*) New to Canada.

GNAPHALIUM MICROCEPHALUM, Nutt.; Macoun, Cat. Can. Plants, Vol. I., p. 548.

Qualicum, Vancouver Island, and Protection Island, Nanaimo, V.I. Herb. No. 430. (*John Macoun.*)

XANTHIUM SPINOSUM, L.

On ballast, Nanaimo, Vancouver Island. (*John Macoun.*) Recorded before only from Ontario.

RUDBECKIA HIRTA, L.

About deserted dwellings, Kicking Horse River, Rocky Mountains. (*J. M. Macoun.*) Revelstoke, B.C.; Griffin Lake, B.C. (*John Macoun.*) Not before recorded west of the prairie region. Probably introduced by means of the railway.

HELIANTHUS DIVARICATUS, L.

Our specimens of this species show a wider range of cauline leaf forms than are included in Gray's descriptions. They vary from the ovate-lanceolate form, deeply and regularly serrate, to ovate with *obtuse* or *rounded* tips, with the serration barely apparent. Specimens collected at The Chats, Ottawa River, by Mr. Cowley, are farthest from typical *divaricatus*—the truncate, sessile, obtuse leaves, not being even divaricate.

HELIANTHUS RIGIDUS, Desf.

In thickets, Revelstoke, B.C. (*John Macoun.*) Not before recorded west of prairie region. Probably introduced from the east along the Canadian Pacific Railway.

BIDENS CERNUA, L.

New Westminster, B.C. Herb. Nos. 457 and 458. (*John Macoun.*) Not before recorded west of Rocky Mountains.

BIDENS FRONDOSA, L.

New Westminster, B.C. Herb. No. 456. (*John Macoun.*) Not before recorded west of Rocky Mountains.

MADIA FILIPES, Gray; Macoun, Cat. Can. Plants, Vol. I., p. 248.

Nanaimo, Vancouver Island, Herb. No. 461; Deer Park, Lower Arrow Lake, Columbia River, B.C. (*John Macoun.*)

ARTEMISIA ABSINTHIUM, L.

Waste places at Medicine Hat, Assa., 1895. (*John Macoun,* Herb. No. 10,980.) Not before recorded west of Ontario.

ARTEMISIA LUDOVICIANA, Nutt.

Along roadsides at Port Arthur, Ont., 1889. (*Dr. and Mrs. N. L. Britton and Miss Timmerman.*) On the Canadian Pacific Railway, near the station at Chalk River, Ont. Herb. No. 10,985. (*John Macoun.*) Doubtless introduced from the west in both cases.

SENECIO FASTIGIATUS, Nutt.

S. megacephalus, Macoun, Cat. Can. Plants, Vol. I., p. 263.

Belly River, Alberta, 1881. (*Dr. Geo. M. Dawson.*) Souris Plain, Assa. (*J. M. Macoun.*) Indian Head, Assa. (*David Macoun.*) Alkaline flats, near Twelve-mile Lake, Wood Mountain, Assa., Herb. No. 11,615. (*John Macoun.*)

SENECIO MEGACEPHALUS, Nutt.

S. amplectans, Macoun, Cat. Can. Plants, Vol. I., p. 264.

South Kootanie Pass, Rocky Mountains, 1881. (*Dr. G. M. Dawson.*) Amongst debris on mountain sides, Sheep Mountain, Waterton Lake, Lat. 49° 05′, Rocky Mountains. Herb. No. 11,631. (*John Macoun.*) New to Canada.

CICHORIUM INTYBUS, L.

Winnifred, Assa. (*W. Spreadborough.*) Sicamous, B.C. (*John Macoun.*) Not before recorded between Ontario and the Pacific Coast.

STEPHANOMERIA RUNCINATA, Nutt.

S. minor, Macoun, Cat. Can. Plants, Vol. I., p. 284, in part.

On a dry clay bank, south of Wood Mountain, Assa., 1874. (*Dr. G. M. Dawson.*) Many Berries Creek, Milk River, Assa. (*John Macoun.*) New to Canada.

ASCLEPIAS PURPURASCENS, L.; Macoun, Cat. Can. Plants, Vol. I., p. 320.

Walpole Island, Lambton County, Ont. (*C. K. Dodge.*)

ASCLEPIAS SULLIVANTII, Engelm.

Walpole Island, Lambton County, Ont. (*C. K. Dodge.*) New to Canada.

GENTIANA PUBERULA. Michx.

On the Humber Plains, near Toronto, Ont., 1895. (*Wm. Scott.*) New to Canada. All the references under *G. puberula*, Macoun, Cat. Can. Plants, go to *G. affinis*, Griseb.

LITHOSPERMUM ANGUSTIFOLIUM, Mx.

Sandy soil at the beach at Hamilton, Ont. (*J. M. Macoun.*) Not before recorded east of Manitoba.

OROBANCHE PURPUREA, Vill.

Found growing on a lawn at Wingham, Ont. (*J. A. Morton.*) Probably introduced in grass seed. New to Canada.

UTRICULARIA RESUPINATA, B. W. Green; Can. Rec. of Science, Vol. VI., p. 204.

On an island near the north shore of Parry Sound, Lake Huron, 1893. (*J. M. Dickson.*) Only authentic record for Ontario.

VERONICA VIRGINICA, L.; Macoun, Cat. Can. Plants, Vol. I., p. 360.

Found by Prof. Macoun near Savanne station on the C. P. Railway, west of Port Arthur, in 1889. Probably introduced at this particular place, but indigenous further west along the railway. Credited to the Winnipeg Valley by Gray, but on what authority is not stated. Walpole Island, Lambton Co., Ont. (*C. K. Dodge.*)

PEDICULARIS SCOPULORUM, Gray.

Summit of Saddle Mountain, Devil's Lake, Rocky

Mountains, alt. 8,000 feet. (*John Macoun.*) New to Canada.

PYCNANTHEMUM MUTICUM, Pers.

Near Hamilton, Ont. (*J. M. Dickson.*) New to Canada.

CAREX FESTIVA, Dew., var. HAYDENIANA, W. Boott.

Borders of coulees, Cypress Hills, Assa., 1894. Herb. No. 7,397. (*John Macoun.*) Not before recorded east of Rocky Mountains.

LYCOPODIUM OBSCURUM, L.; Macoun, Cat. Can. Plants, Vol. II., p. 288.

Near Fort Norman, Mackenzie River, 1892. (*Miss E. Taylor.*) Revelstoke, B.C., 1890. (*John Macoun.*) Not before recorded north or west of the Saskatchewan.

LYCOPODIUM INUNDATUM. L.

Swamp at "The Lake," Stanley Park, Vancouver, B.C., 1893. Herb. No. 527 (*John Macoun.*) Not before recorded west of Ontario.

CURRENTS AND TEMPERATURES IN THE GULF OF ST. LAWRENCE.

By ANDREW T. DRUMMOND, LL.D.

That the cold Arctic or Labrador Current which, in a broad belt, skirts the easterly coasts of Labrador and Newfoundland, sends, when passing the Straits of Belle Isle, a branch westerly into the Gulf of St. Lawrence, influencing thus, the temperature of the water on, not only its northerly coasts, but far up the estuary of the St. Lawrence, has been the hitherto received opinion. This opinion obtained confirmation not only from the presence of icebergs in the Gulf of St. Lawrence 275 miles westerly of the Straits of Belle Isle, but in the low temperature of the water, both at the surface and at the bottom, as far up the northerly side of the River St. Lawrence as at least Murray Bay, seventy miles below Quebec, the general effect of this low temperature on the vegetation of the immediate coasts being seen in the limited distribution of forest trees and the presence of high northern or semi-Arctic plants. That icebergs were not found farther into the Gulf was not an argument against the existence of a branch current, as the milder atmosphere and warmer surface waters of the land-locked gulf during summer, would, naturally, tell rapidly on the masses of ice, however large, once they were carried well into and beyond the Straits of Belle Isle.

Mr. W. Bell Dawson, who has been commissioned by the Dominion Government to make a survey of the tides and currents of the River and Gulf of St. Lawrence, has, in his report for 1894, raised the question whether there is an uniformly inward current at the Straits of Belle Isle, and whether the currents there are not, in reality, fundamentally tidal, though affected considerably by the direction of the wind in the Straits, and by barometric pressure in the Gulf as well as outside.

Apart from the great scientific interest which attaches to it, the proper settlement of this question is important on account of its bearing on the navigation of the Straits where several large steamships have in recent years been lost. Enveloped in fog as these Straits so frequently are, and their surface dotted at certain seasons with icebergs, it is essential that their currents should be carefully examined and thoroughly understood. Whilst, however, Mr. Dawson's investigations into the direction and force of the current have very great value attached to them, are not the tests made too few in number and carried over too limited an area, to, as yet, enable definite conclusions to be drawn? The nearest point in the Straits to the

Labrador coast, at which tests of the currents were made, was three miles distant, and yet the position in which we would expect to find this cold branch current, if it does exist, is comparatively close to this Labrador coast, where the water is colder and deeper.

An instance to some extent parallel to that of the Gulf St. Lawrence and the Atlantic Ocean is the Black Sea in its relations to the Mediterranean Sea. There is a great body of fresh water poured daily into the Black Sea by the Danube, the Dnieper and other rivers, but even after taking into account the enormous evaporation constantly going on over the broad area which the sea presents, there is a slight outward surface current through the Dardanelles. On the other hand, there is also a current inward which is beneath and saline, and which, Dr. Carpenter explains in the Encyclopædia Britannica, is produced by the outward surface current creating downward and therefore lateral pressure on the Mediterranean waters, causing a current inward through the Dardanelles. Dr. Carpenter adds: "We have here a pregnant instance of the slight differences in level and salinity to produce even rapid movements of considerable bodies of water, and a strong confirmation of the doctrine that differences of density produced by temperature are adequate to give rise to still larger though slower movements of the same kind in the great ocean basins."

As bearing on the subject, Mr. Dawson has taken both surface and deep water temperatures at different points on three cross sections of the Straits of Belle Isle and one cross section at Cabot Straits, between Newfoundland and the Cape Breton coast. These temperatures are very interesting and establish the conclusions that the colder waters are always deflected against the Labrador or northern side of the Straits of Belle Isle, and against the Newfoundland or northern side of Cabot's Straits, whilst the warmer waters press against the southern sides in both straits. The cold Arctic current itself, in its onward course southward along the North American coast line, is, as we know, always similarly thrown to the right hand or westward side, and exhibits this distinctive feature even where with a greatly modified temperature at the surface, it somewhat parallels the Gulf stream off the southern United States coast. The details of Mr. Dawson's notes show that on the Labrador side of the Straits of Belle Isle, just inside of Belle Isle itself, the thermometric readings at ten fathoms ranged from 35° to 38° F., whilst on the Newfoundland side of the Straits near Cape Bauld they reached as high as 51°. Again, on the south-west side of Newfoundland, near Cape Ray, at the same depth, they indicated 41° to 46° F., whilst towards the Cape Breton side they were as high as 60° to 64° F. Further, at twenty fathoms, the difference in temperature between the north and south sides of the Straits of Belle Isle was 13°, and between the Newfoundland and Cape Breton sides of Cabot Straits 4°. In some cases the variations were very marked. Proceeding from Cape North on the Cape Breton coast to near St. Paul Island, the temperature at ten fathoms fell 24°. Still further, at forty fathoms the general temperature off the Labrador coasts, in the Straits of Belle Isle, was about 30° F., whilst near Cape Bauld, on the opposite coast line, it rose to 33° F. At the same depth in Cabot's Straits variations in the readings were less marked—the range being on both sides between 33 and 34° F.

The inferences which can be drawn, generally, from these temperatures in connection with other facts is that the colder waters deflected against the northerly sides represent the Arctic Current from the Atlantic Ocean, whilst the southerly deflected warmer waters are to be attributed to the Gulf of St. Lawrence. The higher temperatures of the Gulf waters are traceable to two sources —the land-locked character of this great bay, and the enormous volume of warmer water being daily poured into it by the St. Lawrence and numerous other smaller Canadian rivers. Although the point has not been properly established on both sides of this river's great estuary by thermometric tests, yet it would appear from surface and deep sea readings taken by the writer near Murray Bay on the north coast ($46\frac{1}{2}°$ F. at surface, $38\frac{1}{4}°$ at 17 fms., and $38\frac{1}{2}°$ at 31 fms.—all on 5th August), and from the fact that whilst bathing during the summer season is somewhat exceptional on that side, it is more general on the south coast, that these warmer waters of the River St. Lawrence are also deflected to the southern coast or right hand in their progress towards the sea.

The evaporation over the broad surface of the Gulf must be very great, but does it counterbalance the enormous masses of fresh water which are being constantly poured into it from the Great Lakes and the rivers of Canada? Whether it does so or not, if there is an outward current of warmer water deflected to the southerly side of these two outlets from the Gulf, there must be some fully compensating inward flow of colder water either reversely parallel to it or underneath, just as in the case of the Black Sea. Although claiming that the current at the Straits of Belle Isle is fundamentally tidal in its nature, Mr. Dawson, nevertheless, admits that under normal conditions and when both surface current and undercurrent in the two directions are taken into account, the difference on the average is in favor of a greater inward flow from the east, and that the actual flow throughout the year appears also, on the whole, to be greater in the inward direction from the east than outward from the west. Between Newfoundland and Cape Breton he, however, finds a current running out of the Gulf on the western or Nova Scotia side, and into the Gulf on the eastern or Newfoundland side.

There are other very important considerations which have also to be taken into account. Wind, a we know, influences currents. On Lake Ontario, it will, when blowing down the lake continuously for some time even pile up the water at the lower end to a height of many inches and create underneath a reverse current. The direct effects produced by winds are, however, not relatively deep, and, therefore, probably hardly have a perceptible influence upon any cold current in the Gulf which underlies warmer waters. Thus in the Straits of Belle Isle, at a depth of thirty to forty fathoms, a high wind from the west may have but little effect on a current from the east. Again, although the great mass of water in the ocean as well as in the land-locked Gulf of St. Lawrence, is swayed backward and forward twice each day, the whole moves together, and it is quite possible to conceive of the currents in these bodies of water maintaining their directions irrespective of the motion of the whole mass, of which these currents form only a part, with different causes for their motion. The rise and fall of the surface, which is the popular notion of the tide, is, Prof. G. H. Darwin has, among other matters, pointed out to me, really the outcome of a small current in the whole fluid, the current being reversed in direction every twelve hours. The subject has an important bearing on the existence of a more or less continuous cold current inwards at the Straits of Belle Isle. The cold current, if it exists at all there, as a definite factor, is to be sought for more as a deep seated than even a surface current, and will be found clinging to the northerly side of the Straits where the deepest channel is also known to exist. How far does the effect of the tide there at forty to fifty fathoms seriously interrupt such a current? It is in this northern part of the Straits where investigations into the undercurrents are still wanted. Mr. Dawson's observations, where they were made outside of the three miles distance from the Labrador coast, show that some permanent undercurrent does exist, because "during the times that the current ran in fair correspondence with the tides, when the conditions may be considered as normal, the undercurrent was usually stronger than the surface current, when the flow was from the east, and it was always weaker than the surface current, when the flow was from the west." Whatever effect winds and tides do produce at forty fathoms or more would be exerted in favor of this inward undercurrent during a considerable part of the year, since, as a whole, between easterly and westerly influences, that from the east appears to be the stronger of the two throughout the year. As to the relative effects of high pressure areas over the Gulf and over the Atlantic Ocean, off the Labrador and Newfoundland coasts, on the passage of water through the Straits, our information is probably too meagre to enable any opinion as yet to be formed beyond the general fact that for the time a current would be formed.

Another very interesting matter brought to light by Mr. Dawson, and the further investigation of which he recognizes as necessary, is that in the deep sea temperatures, taken on the 16th August, in Cabot Straits, between St. Paul Island and Cape Ray, the temperature—especially towards the former place—which successively fell from 59° at the surface to 31° and 33° F. at fifty fathoms, appeared to rise again to 40½° F. at one hundred and fifty fathoms. Some further careful tests of the density and salinity of these waters as well as further thermometric readings appear to be needed with a view to tracing the influence here of the River St. Lawrence waters. The anomaly can hardly be altogether ascribed to areas of water of different temperatures floating oceanward. In the fresh water of the River St. Lawrence, as it leaves Lake Ontario, where the depth averages about twelve fathoms, there appear in summer to be areas of different temperature, but at any given depth, these areas as they pass the thermometer do not show differences of temperature exceeding 2° to 3°. We must look largely to other causes for such reversals of the temperature as are indicated near St. Paul's Island.

Jan., 1896.

On Certain Birds from the Moluccas, now in the Society's Museum.

By J. B. Williams, Esq., F.Z.S.

The Moluccas form, zoologically, a very peculiar and interesting group of islands. Immediately to the east of them lies the great island of New Guinea, with Australia to the south of it; while on the other side are the Celebes, with the islands of Borneo and Java in close proximity.

It was by the study, especially, of the birds and insects in this Malay archipelago that the celebrated naturalist A. R. Wallace was convinced of the necessity of some theory such as Mr. Darwin's to explain the facts connected with their variation and geographical distribution, noted during a residence of seven or eight years among the various islands.

In Borneo the fauna is altogether Indian, while the Moluccas are, zoologically, closely allied to Australia.

In Borneo some of the commonest birds are Trogons, Woodpeckers, and Barbets. These all disappear in the Moluccas. and the bird families most frequently seen there are Parrots, Kingfishers, Pigeons, and Honeysuckers.

In Borneo we find the Indian elephant and tiger, besides many smaller carnivora, and hosts of monkeys. In the Moluccas there are hardly any mammals except bats, and five or six out of the nine or ten that are there have probably been introduced by the natives. These introduced animals include one monkey and one civet cat, which are confined to two of the smaller islands, and are the only representatives of their respective orders.

This region forms, therefore, a veritable Paradise for birds: no monkeys to steal their eggs—no cats to devour the parents; no wonder that they greatly vary and increase. Of land birds there are about 200 different species (all Europe has only about 250); and of this 200 about 150 are of species *peculiar* to the Moluccas.

Three or four years ago Mr. H. J. Tiffin presented the Museum with two cases of birds, most of which came from the Malay region. These I have lately been re-arranging and naming, and find quite a number of interesting species among them.

Mr. Tiffin tells me that he purchased them at Singapore, about twenty-six years ago, at a large store where they had been taken in exchange from some of the Malay traders.

The Malays go round in their native boats to collect produce from the various islands, and many of these birds must have been procured in Gilolo—the largest of the Moluccas—as they belong to species that are peculiar to that island.

The rarest of these is a specimen of Wallace's Rail (*Habroptila Wallacei*[1]), found only in Gilolo. There are several specimens of this bird in European museums, but few, if any, on this side the Atlantic.

It is allied to the Weka Rail of New Zealand, which in its turn is allied to the Kiwi or Apteryx; so that our Rail forms one of the links that unite the winged with the almost wingless examples of bird life.

As illustrating the opposite extreme in wings, there is a specimen of the Great-winged Swift (*Macropteryx mystacea*), the largest representative of its family, and found only in this region.

The Great Black Pitta (*Pitta maxima*) is one of the

[1] The scientific names are those used in the British Museum Catalogue of Birds.

handsomest of a very beautiful family, and is peculiar to Gilolo.

This pair of dark-throated Sun-birds (*Cinnyris jugularis*) belong to a family which, in the Old World, takes the place that the Humming-birds occupy in the New. This species is found in the Philippines as well as the Moluccas.

There were several Honeysuckers in the collection, but they had been so damaged by insects that their identification was almost impossible. One, however, I recognized as *Melitograis gilolensis*.

This little Kingfisher appears to be an example of *Alcedo Floresiana*, a variety of the common English Kingfisher (*Alcedo ispida*), which only occurs in Flores and the Moluccas.

Of the Moluccan Blue Kingfisher (*Halcyon diops*) we have a young female. In this species, contrary to the usual custom, it is the female that assumes an adult plumage, and the young ones resemble the male bird.

The Racquet-tailed Kingfisher (*Tanysiptera margaritæ*) belongs to a very beautiful group found only in the neighbourhood of New Guinea. There are twenty different species of them, and eight of these are peculiar to the Moluccas. This one is only found in Gilolo and Batchian.

Of Pigeons, Mr. Tiffin's collection contained somewhat damaged specimens of the beautiful little Blue-capped Fruit Pigeon (*Ptilopus monachus*) and Superb Fruit Pigeon (*Ptilopus superbus*). The first of these is peculiar to the Moluccas, the other ranges from the Moluccas to North Australia.

Of Parrots, there are seven different species of Moluccan birds.

The Ceram Lory (*Lorius garrulus*). This specimen had lost nearly all the webs of the feathers, but, fortunately, a few spots of the yellow linings to the wings were left, so that I was enabled to identify him. It is found in Gilolo only.

Great-billed Parrot (*Tanygnathus megalorhynchus*). This handsome species is found on the west coast of New Guinea as well as the Moluccas.

Blue-necked Parrot (*Geoffroyus cyanicollis*). Found only in the Moluccas. We have a male and female.

Grand Eclectus (*Eclectus roroatus*). A male and female, but, like the two preceding species, almost ruined by insects. Found only in the Moluccas. The male has a green plumage, with a red upper and black lower bill, while the plumage of the female is red and the bill entirely black.

Variegated Lory (*Eos ricinata*) belongs to a group of Red Lories which are confined to the Moluccas; this one inhabits Gilolo.

The little Long-tailed Lorikeet (*Hypocharmosyna placens*) is one of the smallest and most elegant of a family that are very numerous in all the islands.

White-crested Cockatoo (*Cacatua alba*) is distinguished from the allied Australian birds by the broad white feathers of its crest—the Australian ones having narrow coloured crests. It is confined almost entirely to the Island of Gilolo.

We have a second specimen of this bird in the Museum, and also a Purple-capped Lory (*Lorius domicella*) which is peculiar to two of the Moluccan islands—Ceram and Amboyna. These two birds we possessed prior to Mr. Tiffin's gift, which includes also several of the Moluccan perchers (Order *Passeres*) that I have not yet identified, and a large series of birds from other parts of the Malay region, a complete list of which it may perhaps be worth publishing in some future number of the RECORD OF SCIENCE.

Anhydrite in Ontario.

By Professor W. Nicol.

Recently, while visiting the dump of the abandoned Foxton Phosphate Mine with a party of students from the Mining School at Kingston, an unfamiliar mineral was picked up. After returning, Mr. Miller, the Lecturer on Geology, subjected the specimen to an examination with the blowpipe, and determined it to be anhydrous calcium sulphate. An analysis was made with the following result:—

CaO	41.72	per cent.
SO_3	57.47	" "
CO_2	.286	" "
SiO_2	.151	" "
Fe_2O_3	.065	" "
Loss on ignition	.26	" "
	99.952	per cent.

The mine is situated in the Township of Loughborough, County of Frontenac, not far from the Village of Sydenham.

The mineral occurs in considerable quantities, closely associated with transparent selenite, gypsum, calcite, and pyroxene. In appearance the mineral somewhat resembles pink fluorite. It shows the three pinacoidal cleavages and the pearly lustre on the basal plane. Between the layers of the mineral, thin flakes of calcite occur in the same way as they do between the foliæ of mica, which is found at the same dump.

The anhydrite from this locality bears a very strong resemblance to that seen in museums from Hall, Tyrol, and labelled "Muriacite."

Laboratory, School of Mining,
Kingston.

Review of the Evidence for the Animal Nature of Eozoön Canadense.

(Concluded.)

By Sir William Dawson, C.M.G., LL.D., F.R.S., Etc.[1]

II. PETROLOGICAL AND CHEMICAL.

Bearing in mind the statements made in the previous note, respecting the stratigraphical relations of the Grenville Series, and referring to the excellent account by my friend Dr. Bonney of his observations at Côte St. Pierre, and to some difficulties stated by him which merit attention, we may sum up the evidence so far, under the following statements:—

1. The limestones included in the Grenville Series and their associated quartzites and schists bear so strong a resemblance in mineral character to metamorphosed Palæozoic calcareous beds of organic origin and their associates, as to warrant at least the careful consideration of any forms apparently organic contained in these limestones.

2. The occurrence in these limestones of nodular silicates, of graphite, of pyrite, and of apatite, affords additional reason to suspect their organic origin.

3. The presence of large beds as well as of veins of graphite and of thick deposits of iron ore in the Grenville Series constitutes an additional analogy with Palæozoic formations holding organic remains.[2]

These facts were adduced by Dr. Sterry Hunt and Dr. J. D. Dana in evidence of the probability of life in the Laurentian period, even before the discovery of Eozoön. Certain particulars connected with them, however, now demand somewhat more detailed attention, in

[1] [Reprinted from the Geological Magazine, Decade IV., Vol. II., October, November, December, 1895.

[2] See papers by the author on the Graphite and Phosphates of the Laurentian Rocks, Quart. Jour. Geol. Soc. London, 1869 and 1876.

connection with that discovery, and with recent objections to the organic nature of Eozoön.

Dolomite or magnesian limestone is a not infrequent associate of Palæozoic fossiliferous limestones; and I have remarked in previous papers on the similarity of the mode of occurrence of silicified Stromatoporæ in the great dolomite of the Niagara formation with that of Eozoön in the Grenville Limestone, in which dolomite occurs in beds, in thin layers, and in disseminated crystals, in a manner to show that it was an original constituent of the deposit. Dolomite is also one of the most common minerals filling the cavities of Eozoön, and especially the finer tubuli. The mode of its occurrence on the small scale may be seen in the following description of a section of a portion of a bed of limestone from Côte St. Pierre, examined under a lens, after being treated with dilute acid. The specimen comprised about six inches of the thickness of the bed :—

Crystalline limestone with crystals of dolomite, constituting about one half (fragments of Eozoön in calcite portion).[1]

More finely crystalline limestone, with rounded granules of serpentine, some of them apparently moulded in cavities of Archæospherinæ, or of chamberlets of Eozoön.

Limestone with dolomite as above, but including a thin layer of limestone with granules of serpentine.

Limestone and dolomite, with a few grains of serpentine and fragments of Eozoön.

Crystalline dolomite with a few fragments of Eozoön, as limestone, with canals in dolomite.

Limestone with fragments of Eozoön, granules of serpentine, and groups of chamberlets filled with serpentine.

We have thus a bed of limestone in which dolomitic

[1] Distinguished by their fine granular texture and canal-systems.

and serpentinous layers appear to alternate, and occasional fragments of Eozoön occur in both, while the smaller forms resembling fossils are, so far as can be observed, limited to the serpentinous layers.

At Arnprior on the Ottawa a portion of the Grenville Limestone presents dark graphitic layers parallel to the bedding, and giving it a banded grey and white appearance which has led to its use as a marble. An analysis by Dr. Harrington shows that the graphitic layers contain 8.32 per cent. of magnesia, the lighter layers only 2.57 per cent., in the state of grains or crystals of dolomite. Associated with the marble there are also beds of brown-weathering dolomite, affording 42.10 of magnesia. The graphite in this marble, under the microscope appears as fibrils and groups of minute clots, and sometimes coats the surfaces of crystals or fragments of calcite, the appearances being not unlike those seen in carbonaceous and bituminous limestones of later date.

In both the above cases the magnesium carbonate is evidently an original ingredient of the bed, and cannot have been introduced by any metamorphic action. It must be explicable by the causes which produce dolomite in more recent limestones.

Dana has thrown light on these by his observations on the occurrence of dolomite in the elevated coral island of Matea in Polynesia,[1] under circumstances which show that it was formed in the lagoon of an ancient coral atoll, while he finds that coral and coral sands of the same elevated reef contain very little magnesia. He concludes that the introduction of magnesia into the consolidating under-water coral sand or mud has apparently taken place—"(1) In sea-water at the ordinary temperature; and (2) without the agency of any other mineral water except that of the ocean;" but the sand and mud were those of a lagoon in which the saline matter was in pro-

1 "Corals and Coral Islands," p. 356, etc.

cess of concentration by evaporation under the solar heat. Klement has more recently taken up this fact in the way of experiment, and finds that, while in the case of ordinary calcite this action is slow and imperfect, with the aragonite which constitutes the calcareous framework of certain corals, and at temperatures of 60° or over, it is very rapid and complete, producing a mixture of calcium and magnesium carbonates, from which a pure dolomite more or less mixed with calcite may subsequently result.[1]

I regard these observations as of the utmost importance in reference to the relations of dolomite with fossiliferous limestones, and especially with those of the Grenville Series. The waters of the Laurentian ocean must have been much richer in salts of magnesium than those of the present seas, and the temperature was probably higher, so that chemical changes now proceeding in limited lagoons might have occurred over much larger areas. If at that time there were, as in later periods, calcareous organisms composed of aragonite, these may have been destroyed by conversion into dolomite, while others more resisting were preserved, just as a modern *Polytrema* or *Balanus* might remain, when a coral to which it might be attached would be dolomitized. This would account for the persistence of Eozoön and its fragments, when other organisms may have perished, and also for the frequent filling of the canals and tubuli with the magnesian carbonate.

The question now arises as to the mineralization of Eozoön with serpentine, and more rarely, especially in the case of its larger and lower chambers, with pyroxene. Connected with this is the alternation, as above described, of serpentinous and dolomitic layers in the limestone, as if in successive times the conditions were alternately favourable to the deposition of magnesium in the form of carbonate and in that of silicate.

[1] Bulletin Geol. Soc. Belgium, Vol. IX. (1895, p. 3). Also noticed in Geol. Mag., July, 1895, p. 329.

We learn from the "Challenger" Reports that under certain circumstances the presence of organic matter in oceanic deposits causes an alkaline condition, tending to the solution of silica and the formation of silicates. We also learn that siliceous matter in a state of fine division (*e.g.*, volcanic dust) may afford material for the production of hydrous silicates, either directly or indirectly through the agency of organisms forming siliceous skeletons. The "Challenger" Reports also show that the silicates known under the name of glauconite, and thus deposited, contain several bases to some extent interchangeable. Of these the principal are aluminium, potash, and iron, though magnesia is also present. Some older silicates injecting fossils in the Palæozoic rocks are less complicated, and contain more magnesia: and, as Hunt has shown, there is nothing anomalous in the supposition that in the Laurentian period silicate of magnesium and iron may have acted in this capacity.[1]

It is true that serpentine is now usually regarded as a product of the hydration of olivine and pyroxene; still, even on this supposition, it might be formed from the hydration of fine volcanic dust falling into the sea. Hunt also has shown that the serpentine of the Grenville Limestone differs chemically from those supposed to be of direct igneous origin, in its comparative freedom from iron oxide, in its larger proportion of water, and in its lower specific gravity, besides being a more pure silicate of magnesium. That it can be deposited by water is shown by the chrysotile filling veins, and by my own observations, published long ago, on the serpentine replacing and filling cavities of Cambro-Silurian fossils at Melbourne in Canada, and filling the cells of Silurian corals at Lake Chebogamong.[2]

[1] See Analyses of Glauconites, etc., by Dr. Hunt in "Dawn of Life," p. 126. One tertiary example is silicate of iron and magnesia. See also Hoskins on Glauconite, Geol. Mag., July, 1895.

[2] Quart. Journ. Geol. Soc. 1864, p. 69, also 1879, p. 48, *et seq.*, Memoir on Eozoon in Peter Redpath Museum, 1888, p. 48 *et seq.*

The occurrence of pyroxene in the limestone, and filling some of the chambers of Eozoön, may also be easily explained. Dr. Bonney well remarks that it does not resemble any igneous rock known to him, and it is quite certain from its mode of occurrence that it cannot be directly igneous. Somewhat thick and continuous beds of a coarser-grained but scarcely less pure pyroxene occur in some parts of the Grenville Series, *e.g.*, at Templeton, and I have described them as probably volcanic ash-beds, though the large pyroxene crystals found in the veins of apatite traversing these beds are probably of thermo-aqueous origin.[1] But the limited and irregular masses and concretions of white pyroxene occurring in the limestones are of different texture and colour, and with less iron. They may have resulted from local showers of volcanic ashes drifted by currents into hollows of the Eozoön reefs, and sufficiently fine to fill the chambers of dead specimens, while they might also form a basis for the growth of new individuals. This is, I think, the only supposition on which they can be explained, and it would also explain the difficulty suggested by Dr. Bonney as to the association of the pyroxene with Eozoön.

There seems, however, to be no good evidence that any portion of the pyroxene has been changed into serpentine as a result of metamorphism; and it is evident that if such a change had occurred after the consolidation of the rock, serious chemical and mechanical difficulties would be involved, whereas if volcanic débris, whether of the nature of olivine or pyroxene, became hydrated while the rock was incoherent and in process of formation, this would tend greatly to promote the infiltration with hydrous silicates of any fossils present in the mass.

Assuming the serpentine and pyroxene to have been deposited as above suggested, the remaining objections

[1] In Logan's Geology of Canada, p. 467, Hunt gives the analysis of a bedded pyroxene, at High Falls, on the Madawaska, as—Silica 54.20; lime 25.65; magnesia 17.02; protoxide of iron 3.24.

stated by Dr. Bonney would at once disappear. Specimens of Eozoön or other fossils might be infiltrated or filled with these silicates, and when the latter were superabundant they might form separate concretions or grains, which might in some cases envelop the fossils or be attached to them in irregular forms, just as one finds in the case of the flints in chalk or the chert in some other limestones.[3]

It is scarcely necessary to say that no objection to the organic origin of the Eozoön can be founded on the fact that many of the specimens are fractured, crushed, bent, or faulted, by the movement of the containing rock, or on the circumstance that well-preserved specimens should be rare and found chiefly in beds containing silicates capable of injecting their cavities. On the other hand, the circumstance that fragments of Eozoön are abundant in the limestone is one of the best possible proofs that we are dealing with a calcareous organism. It would be interesting to describe and figure a number of specimens in our collections illustrating these points; but to do so would require an extensive illustrated memoir, for which neither space nor means are at present available.

I observe, in conclusion of this part of the subject, that in any highly crystalline limestone we can hope to find well-preserved fossils only when their cavities and pores have been filled with some enduring siliceous mineral; but, on the other hand, that porous fossils, once so infiltrated, become imperishable. It still remains to consider shortly new facts bearing on the structure of Eozoön and its possible biological affinities.

[3] It is a curious coincidence that Dr. Johnston-Lavis has described in the July number of this Journal, the aqueous deposition at ordinary temperature of crystals of pyroxene and hornblende, in cavities and crevices of bones included in an ash-bed of recent date, and in presence of calcite, apatite, and fluoride of calcium, as in the Grenville Series. *This is a modern instance analogous to that suggested above.*

III. STRUCTURAL AND BIOLOGICAL.

In recent years I have been disposed to attach more importance than formerly to the general form and macroscospical characters of Eozöon. The earlier examples studied were, for the most part, imbedded in the limestone in such a manner as to give little definite information as to external form; and at a later date, when Sir William Logan employed one of his assistants, Mr. Lowe, to quarry large specimens at Grenville and Côte St. Pierre, the attempt was made to secure the most massive blocks possible, in order to provide large slabs for showy museum specimens. More recently, when collections have been made from the eroded and crumbling surfaces of the limestone in its wider exposures, it was found that specimens of moderate size had been weathered out, and could, either naturally or by treatment with acid, be entirely separated from the matrix. Such specimens sometimes showed, either on the surfaces or on the sides of cavities and tubes penetrating the mass, a confluence of the laminæ, constituting a porous cortex or limiting structure. Specimens of this kind were figured in 1888,[1] and I was enabled to add to the characters of the species that the original and proper form was "broadly turbinate with a depression or cavity above, and occasionally with oscula or pits penetrating the mass." The great flattened masses thus seemed to represent confluent or overgrown individuals, often contorted by the folding of the enclosing beds. The openings or oscula penetrating some of the larger specimens of Eozoön may perhaps be compared with the central canal in the modern *Carpenteria.*

There are also in well-preserved specimens certain constant properties of the calcite and serpentine layers. The former are continuous, and connected at intervals, so that if the siliceous filling of the chambers could be

[1] Geological Magazine, and Museum Memoir.

removed, the calcareous portion would form a continuous skeleton, while the serpentine filling the chambers, when the calcareous plates are dissolved out by an acid, forms a continuous cast of the animal matter filling the chambers. This cast of the sarcodous material, when thus separated, is very uniformly and beautifully mammillated on the surfaces of the laminæ, and this tuberculation gradually passes upward into smaller chambers, having amœboid outlines, and finally into rounded chamberlets. It is also a very constant point of structure that the lower laminæ of calcite are thicker than those above, and have the canal-systems larger and coarser. There is thus in the more perfect specimens a definite plan of structure on the large scale.

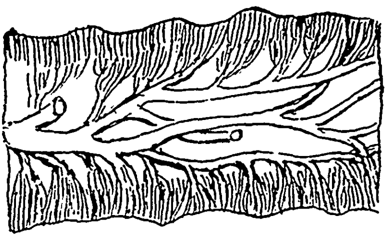


FIG. 6.—Diagram of typical mode of arrangement of canals and tubuli in a lamina of *Eozoön Canadense*. (Magnified.)

The normal mode of mineralization at Côte St. Pierre and Grenville is that the laminæ of the test remain as calcite, while the chambers and larger canals are filled with serpentine of a light green or olive color, and the finer tubuli are injected with dolomite. It may also be observed that the serpentine in the larger cavities often shows a banded structure, as if it had been deposited in successive coats, and the canals are sometimes lined with a tubular film of serpentine, with a core or axis of dolomite, which also extends into the finer tubuli of the surfaces of the laminæ. This, on the theory of animal origin, is the most perfect state of preservation, and it equals anything I have seen in calcareous organisms of later periods. This state of perfection is, however, naturally of infrequent occurrence. The finer tubuli are rarely perfect or fully infiltrated. Even the coarser canals are not infrequently imperfect, while the laminæ themselves are sometimes crumpled, crushed, faulted, or penetrated with veins of chrysotile or of calcite. In some instances the calcareous laminæ are replaced by dolomite, in which case the canal-systems are always imperfect or obsolete. The laminæ of the test itself are also in some cases replaced by serpentine in a flocculent form. At the opposite extreme are specimens or portions of specimens in which the chambers are obliterated by pressure, or occupied only with calcite. In such cases the general structure is entirely lost to view, and scarcely appears in weathering. It can be detected only by microscopic examination of slices, in parts where the granular structure or the tubulation of the calcite layers has been preserved. All palæontologists who have studied silicified fossils in the older rocks are familiar with such appearances.

It has been alleged by Möbius and others that the canal-systems and tubes present no organic regularity. This difficulty, however, arises solely from imperfect specimens or inattention to the necessary results of slicing any system of ramifying canals. In Eozoön the canals form ramifying groups in the middle planes of the laminæ, and proceed at first almost horizontally, dividing into smaller branches, which ultimately give off brushes of minute tubuli running nearly at right angles to the surfaces of the lamina, and forming the extremely fine tubulation which Dr. Carpenter regarded as the proper wall. In my earlier description I did not distinguish this from the canal-system, with which its tubuli are inwardly continuous; Dr. Carpenter, however, understood this arrangement, and has represented it in his figures[1] (see also Fig. 6). It is evident that in a structure like this a transverse or oblique section will show truncated portions of the larger tubes apparently intermixed with others much finer and not continuous with them, except very

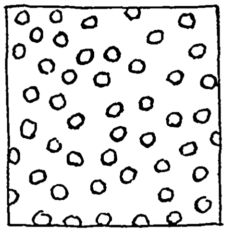


Fig. 7.—Cross section of minute tubuli, about 5 microms. in diameter. (Magnified.)

rarely. Good specimens and many slices and decalcified portions are necessary to understand the arrangement. This consideration alone I think entirely invalidates the

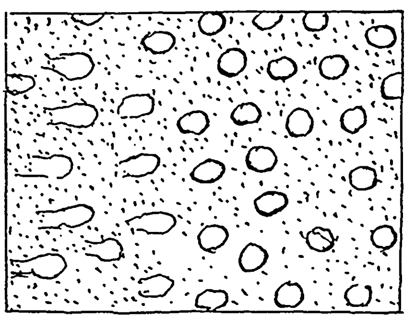


Fig. 8.—Cross section of similar tubuli, more highly magnified, and showing granular character of the test. *(From camera tracings.)*

criticisms of Möbius, and renders his large costly figures of little value, though his memoir is, as I have elsewhere shown, liable to other and fatal objections.[2]

[1] Ann. and Mag. Nat. Hist., ser. 4, xiii, p. 456, figs. 3, 4.
[2] Museum Memoir, pp. 50 *et seq.*

It has been pretended that the veins of chrysotile, when parallel to the laminæ, cannot be distinguished from the minute tubuli terminating on the surfaces of the laminæ. I feel confident, however, that no microscopist who has seen both, under proper conditions of preservation and study, could confound them. The fibres of chrysotile are closely appressed parallel prisms, with the optical properties of serpentine. The best preserved specimens of the "proper wall" contain no serpentine, but are composed of calcite with extremely minute parallel cylinders of dolomite about five to ten microms. in diameter, and separated by spaces greater than their own diameter (see my comparative figure, "Dawn of Life," p. 106; also Figs. 5. 6). In the rare cases where the cylinders are filled with serpentine they are, of course, still more distinct and beautiful. At the same time I do not doubt that observers who have not seen the true tubulation may have been misled by chrysotile veins when these fringe the laminæ. Möbius, for instance, figures the true and false structure as if they were the same.

Protest should here be made against that mode of treating ancient fossils which regards the most obscure or defaced specimens as typical, and those better preserved as mere accidents of mineral structure. In Tertiary Nummulites injected with glauconite, it is rare to find the tubuli perfectly filled, except in tufts here and there, yet no one doubts that these patches represent a continuous structure.

I have remarked on previous occasions that the calcite constituting the laminæ of Eozoöon often has a minutely granular appearance, different from that of the surrounding limestone. This is, I presume, the "dusty" appearance referred to by Dr. Bonney. Under a high power it resolves itself into extremely minute dots or flocculi, somewhat uniformly diffused. Whether these dots are particles of carbon, iron, apatite, or siliceous matter, or the remains of a porous structure, I do not know; but similar appearances occur in the calcareous fossils contained in altered limestones of later date. Wherever they occur in crystalline limestones supposed to be organic, the microscopist should examine them with care. I have sometimes by this appearance detected fragments of Eozoön which afterwards revealed their canals.

I have not space here to notice late observations on Archæospherinæ and other objects supposed to be organic found in pre-Cambrian rocks in Canada and in Europe. They afford, however, to some extent, corroborative evidence in favour of Eozoön.

Supposing a probability to be established of the animal nature of Eozoön, we should naturally expect to detect links of connection between it and fossils known to us in the succeeding geological formations. We have, however, here to make allowance for the probability that an organism so very ancient may differ materially from any of its successors, and may probably be a synthetic or generalized type, or present embryonic characters. Analogy might also justify the supposition that it might be represented in later times by smaller as well as more specialized forms. In this connection, also, the probable warmth and shallowness of the Laurentian ocean, and its abundance in calcium carbonate and in carbonaceous matter, probably organized, should be taken into account. It should also be noted that the formations next in ascending order are of a character little likely to preserve organic marine forms of the "benthos" or ground-living group. We might thus expect a gap in our record between the fauna of the Grenville Series and that of the next fossiliferous formations.

Logan naturally compared his earlier specimens with the Stromatoporæ so abundant in the Ordovician and Silurian Limestones; and in this he was justified, for, whatever may be the ultimate judgment of naturalists as to these problematical fossils, and whether they are referred to Protozoa or to Hydrozoa, or, as seems more likely, are divided between the two, they resemble Eozoön in general structure and mode of accumulation of calcareous matter, and occupied a similar place in nature. My own conclusion, in discussing the microscopic structures of the specimens of Eozoön, was that they were probably those of Protozoa allied to those Foraminifera with thick supplemental skeleton[1] which had been described by Dr. Carpenter. At the same time, I suspected that those Stromatoporoids, like Cœnostroma, which possesses thick laminæ penetrated by ramifying tubes, might be allied to the Laurentian fossil. Dr. Carpenter regarded the structures as combining in some respects those of Rotaline and Nummuline Foraminifera, and ably, and as I think conclusively, defended this view when attacked.[2] The Rotaline type of Foraminifera has since that time been traced by Cayeux and Matthew far down into the pre-Cambrian rocks. The Nummuline type is not known so early. As to the canal-bearing Stromatoporoids, none of them show the fine tubulation, though some have radiating and branching canals. Recent students of the Stromatoporæ seem disposed to refer them to Hydrozoa,[3] a conclusion probable in the case of some of the forms (especially those spinous ones incrusting shells), but doubtful in the case of others, and more particularly the oldest of all, belonging to the genus Cryptozoön of Hall, and Archæozoön of Matthew,[4] the structure of which seems, so far as known, to consist of very thin primary laminæ with a supplemental tubulated skeleton resembling that of the genus *Loftusia*, and which must, I think, be regarded as foraminiferal. In any case, whether these primitive forms are Protozoa or rudimentary Hydroids, they reach back in time nearly as far as

[1] Calcarina, etc.

[2] Ann. and Mag. Nat. Hist., *loc. cit.*

[3] Nicholson, Monographs Palæontographical Society.

[4] Bulletin Nat. Hist. Survey of New Brunswick, 1894-95.

Eozoön, and are equally massive and abundant, and may be regarded as analogous to it in magnitude, habitat, mode of growth, and function in nature.

These later discoveries are gradually widening the horizon of palæontologists in the direction of the dawn of life, and the studies of those who trace backward the history of the Invertebrates of the Palæozoic seas are demanding more and more the discovery of earlier forms than those yet known to complete the chain of life.[1] The field is a difficult one to cultivate, and demands both labour and patience, but it holds forth the prospect of great discoveries, and it has already become the duty and interest of palæontologists to extend their inquiries as far back as the Laurentian in the search for Eozoic life.

In this respect the study and discussion of Eozoön have not been without use, in directing attention to the possibility of finding organic remains in the older crystalline rocks, to the danger of confounding them in their peculiar condition with merely mineral structures, to the state of preservation of organic remains in the older formations, and to the origin and significance of the large deposits of limestone, dolomite, hydrous silicates, iron ore, graphite, and apatite, laid up in certain horizons of the Eozoic rocks. Questions of this kind have been greatly advanced toward their satisfactory solution since the discovery of Eozoön in 1858, and in some degree at least in consequence of the interest excited by that discovery. It is hoped that the present notes may tend in the same direction, and that, whether or not they succeed in removing any existing scepticism in respect to Eozoön, they may help to stimulate and guide the search for those beginnings of life, which there are now the best reasons for believing are to be found far below the base of the Cambrian.

[1] See Dr. Woodward's Address as President of the Geological Society, 1895.

[Additional facts and illustrations, and references to previous papers on the subject, will be found in "Specimens of Eozoön Canadense," pp. 106, published by the Peter Redpath Museum (Notes on Specimens, Sept. 1888), which may be obtained on application to the Museum, or through W. Foster Brown, Bookseller, Montreal. See, also, for a popular summary, Chapters V. and VI. of "Some Salient Points in the Science of the Earth," London, 1893.]

On a New Alkali Hornblende and a Titaniferous Andradite from the Nepheline-Syenite of Dungannon, Hastings County, Ontario.[1]

By Frank D. Adams and B. J. Harrington,
McGill College, Montreal.

In a paper which appeared in the American Journal of Science for July, 1894, the discovery of a large area of nepheline syenite in the township of Dungannon, in the Province of Ontario, was announced and the geological relations and mineralogical characters of the mass briefly described.

One of the many peculiarities of this rock is the absence from it of the mineral pyroxene, which is usually the chief iron-magnesia constituent in rocks of this class, its place being taken by hornblende and mica, but even these minerals are present in comparatively small amount. Of the hornblende two varieties, occurring in different parts of the mass, were distinguished. The first, from near the York river, has a large axial angle with strong pleochroism in tints varying from pale yellow to deep green and although containing a considerable amount of soda, probably approaches common green horn-

[1] [Reprinted from the American Journal of Science, March, 1896.]

blende in composition. The second variety, which occurs in a series of exposures about two miles to the east of the village of Bancroft, is quite different in character, having a small axial angle with high extinction and a much stronger pleochroism in the bluish tints suggestive of arfvedsonite.

A number of additional thin sections have been prepared and in the present paper the results of a further investigation of the optical properties and chemical composition of this second variety of hornblende are presented.

Hornblende—The mineral occurs in hypidiomorphic grains, which show the usual hornblende cleavages; it is optically negative, $\mathfrak{a}$ being the acute bisectrix, but the double refraction is weak.

It possesses, as has been mentioned, a strong pleochroism as follows:

$\mathfrak{a}$ = yellowish green. $\mathfrak{b}$ and $\mathfrak{c}$ = deep bluish green.

The absorption is $\mathfrak{c} = \mathfrak{b} > \mathfrak{a}$. $\mathfrak{b}$ and $\mathfrak{c}$, if not quite equal in absorption, are nearly so, hence sections cut at right angles to the acute bisetrix show but little pleochroism and are nearly isotropic. $\mathfrak{c}$ lies nearest the vertical axis, but whether toward the acute angle β or on the opposite side cannot be determined as the mineral does not possess a good crystalline form; it makes with the vertical axis a large angle the extinction amounting to 30°. The plane of the optic axes is the clinopinacoid, and there is a strong dispersion—red greater than violet. What drew especial attention to this hornblende in the first instance was the fact that it appeared to be nearly uniaxial. When a section, cut at right angles to the acute bisectrix, is examined between crossed nicols in convergent light, a black cross is seen somewhat thickened toward the intersection of the arms. This cross, on revolving the stage, divides into two hyperbolas, but these separate from one another but very little, and appear to separate less than they really do, on account of the fact that the low double refraction and deep color of these sections causes the hyperbolas to be ill-defined, while the whole field is very dark. The dispersion, however, makes itself evident in the varying colors on the sides of the hyperbolas. When, however, a gypsum plate giving a red of the first order is inserted above the objective the hyperbolas become a little better defined, although still not sufficiently definite to allow the axial angle to be accurately measured. The axial angle is found to be over 30°, possibly as much as 45°, which, however, is still very small for hornblende, being about one-half the usual value. Our thanks are due to Professor Rosenbusch for his assistance in working out these optical relations.

On examining a large series of thin sections of nepheline syenites representing most of the important occurrences hitherto discovered, only two rocks were found which contain a hornblende at all similar to that above described. The first of these is the nepheline syenite from the Corporation Quarry at Montreal, in which hornblende with the same small axial angle, low double refraction, intense color and pleochroism, large extinction angle and high specific gravity, occurs intergrown with the augite. The second is the hornblende described by Hackman under the name of arfvedsonite and which occurs intergrown with aegerine in the nepheline-syenite from Umptek in the Kola peninsula[1]. This mineral, however, differs from typical arfvedsonite in having an extinction of about 40° as well as in several other important respects. It possesses, moreover, a very small axial angle, although this fact is not noted by Hackman, while in true arfvedsonite the axial angle is very large. This Kola hornblende is much lighter in color than the hornblende from either of the above mentioned Canadian localities.

[1] "Petrographische Beschreibung des Nephelinsyenites vom Umptek," von Victor Hackman. Kuopio, 1894, p. 14.

In order to determine the chemical composition of this somewhat remarkable variety of hornblende from the Dungannon rock, it was decided to separate a portion for analysis. A considerable quantity of the rock was accordingly reduced to powder and passed through a sieve of 43 meshes to the inch—the rock being rather coarse in grain—and after having been freed from dust was treated with Thoulet's solution, having a specific gravity of 3·13, in a large separating funnel. In this way an almost complete separation of the colored constituents was effected. These latter, which sank in Thoulet's solution, were subjected to the action of a bar magnet and then treated with dilute hydrochloric acid, and various impurities thus removed. The purified powder was then treated first with Klein's solution, having a specific gravity of 3·22, and then with methylene iodide, having a specific gravity of 3·323. In both fluids practically everything sank, only a few composite grains floating. A microscopic examination showed the powder now to consist of grains of hornblende and of garnet with some composite grains consisting partly of nepheline. Further separation became difficult since, as was subsequently ascertained, the hornblende had a specific gravity of 3·433, and the specific gravity of the garnet was 3·739, while many composite grains consisting of garnet and nepheline had a specific gravity practically identical with that of the hornblende. As the electro-magnet was found to be useless, both minerals being readily attracted by it, Retger's silver nitrate method was employed.[1] The silver nitrate was fused in a properly arranged test tube, and after the introduction of the powder, potassium nitrate in powder was gradually added to the fused mass until the garnet fell, the whole being frequently stirred and maintained at a temperature of from 200° to 240° C. On

[1] "Ueber Schwere Flussigkeitken zur Trennung von Mineralien." Neues Jahrbuch fur Mineralogie, etc., 1889, ii, p. 190.

allowing the mass to solidify, a portion of the powder was found to have collected at the top of the mass, while the rest was at the bottom, the intervening part being quite free from mineral grains. The solid mass was then cut in two and the salts dissolved by treatment with water. After three successive separations the hornblende was obtained quite free from grains of garnet—the only impurities present being some composite grains consisting of garnet and nepheline. This powder was then placed under a lens and all the composite grains picked out by means of a fine needle. In this way a quantity of pure hornblende sufficient for purposes of analysis was obtained, while the garnet was obtained directly in a state of purity without the necessity of a final separation by hand.

Both minerals were found to be quite fresh and bright and quite unacted upon by the fused salts.

The hornblende[1] was then analyzed by Dr. Harrington with the following results:—

Silica	34·184
Titanium dioxide	1·527
Alumina	11·517
Ferric oxide	12·621
Ferrous oxide	21·979
Manganous oxide	·629
Lime	9·867
Magnesia	1·353
Potash	2·286
Soda	3·290
Water[2]	·348
	99·601
Specific gravity	3·433

[1] We would suggest Hastingsite as a varietal name for this hornblende, connecting it with the region where it occurs.

[2] Loss after igniting for about fifteen minutes. On further ignition the powder gained in weight owing to oxidation of the ferrous oxide.

The atomic and quantivalent ratios deducible from the above analysis are as follows:—

	Atomic.		Quantivalent.	
Si	$570 \times 4 = 2280$		2356	2356
Ti	$19 \times 4 = 76$			
Al	$226 \times 3 = 678$		1152	2354
Fe^{III}	$158 \times 3 = 474$			
Fe^{II}	$305 \times 2 = 610$		1202	
Mn	$9 \times 2 = 18$			
Ca	$176 \times 2 = 352$			
Mg	$34 \times 2 = 68$			
K	48	48		
Na	106	106		

The ratio of $(R_2O+RO):R_2O_3:SiO_2$ is 601 : 192 : 589, or approximately 3 : 1 : 3,, and obviously the mineral is a true orthosilicate agreeing fairly with the formula $(\overset{I}{R}_2\overset{II}{R})_3\ \overset{III}{R}_2Si_3O_{12}$, or, more fully, $(Fe, Mn, Ca, Mg, K_2, Na_2)_3\ (Fe, Al)_2\ (Si, Ti)_3\ O_{12}$—a constitution analogous to that of garnet.

So far as we are aware no other hornblende containing so small a proportion of silica has been analyzed; but the small percentage of silica is explained by the large proportions of ferrous and ferric oxides. This is made plain by the following formulæ and the corresponding percentages of silica deduced from them:

Formula.	P.C. of SiO_2.
$3FeO,\ Fe_2O_3,\ 3SiO_2$	32·19
$3CaO,\ Fe_2O_3,\ 3SiO_2$	35·43
$3FeO,\ Al_2O_3,\ 3SiO_3$	36·14
$3Na_2O,\ Al_2O_3,\ 3SiO_2$	38·38
$3CaO,\ Al_2O_3,\ 3SiO_2$	40·00

The Dungannon hornblende is interesting in connection with the views of Scharizer, who suggested in 1884[1] that many of the aluminous hornblendes might be regarded as molecular compounds of the metasilicate actinolite,

1 N. Jahrb. f. Min., 1884, ii, p. 143.

Ca (Mg, Fe)$_3$ Si$_4$O$_{12}$, and the orthosilicate $(\overset{I}{R}_2\overset{II}{R})_3\overset{III}{R}_2Si_3O_{12}$, for which he employed the name syntagmatite, originally given by Breithaupt to a black hornblende from Vesuvius. The hornblende from the Island of Jan Meyen, analyzed by Scharizer,[1] and that from Bohemia, analyzed by Schmidt,[2] agree closely with the so-called "syntagmatite molecule." The Stenzelberg mineral, analyzed by Rammelsberg,[3] also approximatee to it; but these three and the Dungannon hornblende are the only ones yet examined, so far as we are aware, that give at all closely the syntagmatite ratios. The following table gives the analyses of these four minerals and the molecular ratios deducible from them:

	Jan Mayen.	Molec. R.		Bohemia.	Mol. R.		berg.	Mol. R.		Dungan-non.	Mol. R.	
SiO_2	39·167	653	653	39·66	661	672	39·62	660	662	34·184	570	589
TiO_2	....	....		0·89	11		0·19	2		1·527	19	
Al_2O_3	14·370	140	218	14·83	145	222	14·92	146	210	11·517	113	192
Fe_2O_3	12·423	78		12·37	77		10·28	64		12.621	79	
FeO	5·856	81	648	1·97	27	663	7·67	106	685	21·979	305	620
MnO	1·505	21		....	..		0·24	3		0·629	9	
MgO	10·521	263		14·25	356		11·32	283		1·353	34	
CaO	11·183	200		12·74	227		12·65	226		9·867	176	
K_2O	2·013	21		1·25	13		2·18	23		2·286	24	
Na_2O	2·478	40		2·47	40		1·12	18		3·290	53	
H_2O	·396	22		....	..		0·48	26		0·348	19	
	99·912			100·43			100·67			99·601		

In all four analyses the ratios for $(R_2O+RO):R_2O_3:SiO_2$ (including TiO_2 when present) are practically 3 : 1 : 3, or, to give the exact figures (excluding water):

	(R_2O+RO)	:	R_2O_3	:	SiO_2
Jan Mayen......	2·87	:	1	:	2·99
Bohemia.........	2·99	:	1	:	3·02
Stenzelberg......	3·14	;	1	:	3·15
Dungannon	3·12	:	1	:	3·07

1 loc. cit. 2 Min. Mitth., iv, 23, 1881. 3 Pogg. Ann., 1858, ciii. 454.

The ratio (R_2O+CaO) : (Mg, Mn, Fe)O is, as observed by Scharizer in the case of the Jan Meyen and Bohemian hornblendes, approximately 3 : 4, thus:

	Including Water.			Excluding Water.		
	(R_2O+CaO)	:	(Mg, Mn, Fe)O.	(R_2O+CaO)	:	Mg, Mn, Fe)O.
Jan Meyen.....	3	:	3·87	3	:	4·17
Bohemia	3	:	4·10	3	:	4·10
Stenzelberg	3	:	4·02	3	:	4·38
Dungannon.....	3	:	3·84	3	:	4·11

Scharizer adopts the following ratios (3 : 1 : 3 and 3 : 4) as those of syntagmatite in calculating the composition of hornblendes intermediate between $(\overset{I}{R}_2\overset{II}{R})_3\ \overset{III}{R}_2Si_3O_{12}$ and actinolite. He assumes in the first place that all the alumina and ferric oxide belong to the syntagmatite molecule (Σ). The sum of the Al_2O_3 and Fe_2O_3 molecules (from the molecular ratio) multipled by *three*, gives $(SiO_2)^{\Sigma}$ on the one hand and $(R_2O+RO)\Sigma$ on the other. The sum of $(R_2O+RO)\Sigma$ divided in the proportion of 3 : 4 gives $(R_2O+CaO)\Sigma$ and $MgO+FeO)\Sigma$. Subtracting $(MgO+FeO)\Sigma$ from the sum of the corresponding molecules deduced from the analyses gives $(MgO+FeO)_A$—that is the number of molecules of magnesia and ferrous oxide belonging *to the actinolite* molecule (A)—and $MgO+FeO)_A$ divided by three (see actinolite formula) gives the lime molecules of the actinolite $(CaO)_A$. This value subtracted from the total number of lime molecules gives $(CaO)\Sigma$, and $(CaO)\Sigma$ subtracted from $(R_2O+CaO)\Sigma$ gives the alkali molecules (in some cases including H_2O). Finally $(MgO+CaO)_A$ gives $(SiO_2)_A$. These statements will be made clearer by the following example, one of those selected by Scharizer.

HORNBLENDE FROM EDENVILLE, ANALYZED BY RAMMELSBERG.

Original analysis.	Molec. R. deduced from analysis.	Syntagmatite.	Actinolite.	Calculated composition.	Original analysis calc to 100.
SiO_2 ....51·67	861	222	609	51·97	52·66
Al_2O_3 .... 5·75	56	56 } 74	...	5·99	5·86
Fe_2O_3 .... 2·86	18	18 }	...	3·00	2·91
MgO ....23·37	584	127 }	457	24·35	23·82
CaO ....12·42	222	70 }	152	12·96	12·66
Na_2O .... 0·75	12	12 } 222	...	0·78	0·78
K_2O .... 0·84	9	9 }	...	0·88	9.86
H_2O .... 0·46	25	4 }	...	0·07	0·47
98·12				100·00	100·00

Here $(SiO_2)\Sigma = 3(56+18) = 222$

$$(R_2O+RO)\Sigma = 3(56+18) = 222$$

$$(R_2O+CaO)\Sigma = 3\,\frac{(R_2O+RO)}{7}\Sigma = \frac{222\times 3}{7} = 95$$

$$(MgO)\Sigma = 4\frac{(R_2O+RO)}{7}\Sigma = \frac{222\times 4}{7} = 127$$

$$(MgO)_A = 584-(MgO)\Sigma = 584-127 = 457$$

$$(CaO)_A = \frac{(MgO)_A}{3} = \frac{457}{3} = 152$$

$$(CaO)\Sigma = 222-(CaO)_A = 222-152 = 70$$

$(Na_2O+K_2O+H_2O)\Sigma = (R_2O+CaO)\Sigma - (CaO)\Sigma = 95 - 70 = 25.$ But $(Na_2O+K_2O)^{\Sigma} = 12+9 = 21$

$$\therefore\ (H_2O)\Sigma = 4$$

Finally $(SiO_2)_A = (MgO+CaO)_A = 457+152 = 609$

Having thus deduced the molecular ratios of the syntagmatite and actinolite, the numbers for each constituent are multiplied by the corresponding molecular weights, in order to obtain the theoretical relative weights of the constituents of the mixed hornblende.

Syntagmatite.		Actinolite.	
222 × 60	= 13320	609 × 60	= 36540
56 × 102·6	= 5745	....	....
18 × 160	= 2880	....	....
127 × 40	= 5080	457 × 40	= 18280
70 × 56	= 3920	152 × 56	= 8512
12 × 62	= 744	....	....
9 × 94	= 846	....	....
3 × 18	= 72	....	....
	32607		63332

Then,

$$(32607+63332):(13320+36540) :: 100 : x$$

and $x = 51{\cdot}97$ = p.c. of SiO_2 in the mixed hornblende. And in like manner the percentages of the other constituents are calculated.

But 32607 : 63332 practically as 1 : 2, and therefore the formula of the Edenville hornblende might be regarded as

$$\overset{\text{II}}{R}_3\overset{\text{III}}{R}_2Si_3O_{12}+2(Mg_3CaSi_4O_{12})$$

or as Scharizer gives it

$$10(\overset{\text{II}}{R}_3\overset{\text{III}}{R}_2Si_3O_{12})+20(Mg_2CaSi_4O_{12})$$

The analyses selected by Scharizer agree remarkably well with this theory, but there are aluminous hornblendes whose constitution cannot be readily explained in this way and which at the same time cannot be referred to the pargasite orthosilicate.[1]

Garnet.—In the hand specimens the garnet is seen to possess a deep reddish-brown color. In the thin sections it is a paler brown although still deeply colored. It is not found in all parts of the mass and where it does occur is usually present only in small amount. It possesses the usual high index of refraction and is quite isotropic, occurring usually in irregular shaped grains but in some few cases showing distinct crystalline form. It frequently holds a few large inclusions which usually consist of calcite in single individuals, although the garnet

[1] See Scharizer's paper, loc. cit., p. 156.

is perfectly fresh and the calcite shows no distinct evidence of a secondary origin. It moreover sometimes holds inclusions of the hornblende above described, of pyrite, iron ore and even of nepheline. A garnet resembling this occurs in small amount associated with a similar hornblende, as above mentioned, in the nepheline-syenite of the Corporation Quarry at Montreal, and it also contains as inclusions most of the other constituents of the rock. The same is also true of the melanite in the nepheline-syenite of Alnö.[1]

Before analysis the garnet was purified by several separations with fused silver nitrate, and on careful examination with the microscope the grains appeared to be entirely free from foreign matter. With the pycnometer their specific gravity at 16° C. was found to be 3·739. Chemical analysis gave the following results:

Silica	36·604
Titanium dioxide	1·078
Alumina	9·771
Ferric oxide	15·996
Ferrous oxide	3·852
Manganous oxide	1·301
Lime	29·306
Magnesia	1·384
Loss on ignition	·285
	99·577

The atomic and quantivalent ratios deduced from the above analysis are as follows:

	Atomic.		Quantivalent.
Si	610 × 4 = 2440	2492	2492
Ti	13 × 4 = 52		
Al	192 × 3 = 576	1176	2466
Fe^{III}	200 × 3 = 600		
Fe^{II}	53 × 2 = 106	1290	
Mn	18 × 2 − 36		
Ca	523 × 2 = 1046		
Mg	35 × 2 = 70		
H	32 32		

[1] "Ueber das Nephelinsyenitgebiet auf der Insel Alnö," von A. G. Högbom. Geol. Fören. i. Stockholm Förh., 1895, p. 144.

The ratio for $RO : R_2O_2 : (SiTi)O_2$ is 629 : 196 : 623, or, calculating the titanium as Ti_2O_3, 629 : 203 : 610 = 3 : 1 : 3. *The analysis therefore accords well with the ordinary* garnet formula $3RO, R_2O_3, 3SiO_2$ or $\overset{II}{R}_3\overset{III}{R}_2Si_3O_{12}$, and the mineral may be regarded as a titaniferous andradite, with a considerable proportion of the ferric oxide replaced by alumina. In composition it resembles somewhat the brown garnet from the Island of Stokö, analyzed by Lindström.[1]

By way of comparison the analysis of the Stokö garnet and also one of a garnet from the nepheline-syenite of the Island of Alnö[2] are included in the following table.

	Stokö.	Molec.	R	Alnö.	Molec.	R.	Dungannon.	Molec.	R.
SiO_2	36·63	610	610	31·15	519	603	36·604	610	623
TiO_2	....	...	..	6·73	84		1·078	13	
Al_2O_3	9·97	98	182	3·14	31	180	9·771	96	196
Fe_2O_3	13·45	84		23·83	180		15·996	100	
FeO	2·28	32	698	....	...	616	3·852	53	645
MnO	·63	9		·58	8		1·301	18	
CaO	35·90	641		33·44	597		29·306	523	
MgO	·28	7		....	...		1·384	35	
Na_2O	....	...		·68	11		....	...	
Ign	·16	9					·285	16	
	99·30			99·55			99·577		

A Lecture upon Acetylene.[3]

By Prof. J. M. Crafts.

A year and a-half ago, if a chemist had been told that a new illuminating gas could be obtained from the evil-smelling product with which he was only too well acquainted in the laboratory, namely, the acetylene which

1 Zeit. für Kryst. u. Min., xvi, 160, 1890.
2 Sahlbom, in the paper by Högbom already cited.
3 Delivered before the Society of Arts at Boston, January 23, 1896.

forms whenever a Bunsen burner strikes down, he would have said that the idea was absurd. If a physicist had been told that the electric furnace was to be used to produce illuminating gas on a commercial scale he would have said it was quite impossible. But distinguished electricians were explaining that the telephone was impossible, while Graham Bell was inventing that instrument. So that scientific men will be well advised not to utter general opinions about the possibilities of the success of any new enterprise, and I shall endeavour to confine myself to the statement of certain facts and to the description of laboratory experiments, which constitute some new data which can be used to form an opinion regarding at least one side of this subject.

The chemistry of the manufacture of acetylene is very simple. Quicklime is reduced by carbon in an electric furnace to carbide of calcium, and enough carbon is taken not only to combine with the calcium to form carbide of calcium, but also to burn with the oxygen of the quicklime and to remove it as carbonic oxide. The process is represented by the equation: $CaO + 3C = CaC_2 + CO$. The carbide is obtained as a melted mass with crystalline structure, which when brought in contact with water is transformed to slacked lime, and to acetylene which is given off as a gas. The formula for this transformation is: $CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$. All the alkaline earths and alumina have been subjected to the same treatment, and it has been found that the carbides of barium, strontium and calcium have similar formulæ, and give off acetylene when treated with water. The carbide of aluminum has the formula: Al_4C_3, and evolves marsh gas when treated with water. It may be added that a mixture of silica and carbon yields the carbide of silicon, SiC. The compound is formed when the two boches meet as vapours in the intense heat of the electric furnace and combine as a sublimate of beautiful crystals, now sold under the name of Carborudum. The powdered crystals have sharp cutting edges, hard enough to scratch rubies, and consequently make an excellent polishing and grinding material.

It is to be noticed that this formation of carbides affects the elements which make up by far the larger part of the earth's crust, so that from a geological as well as a chemical point of view these newly discovered transformations are of the utmost importance.

The reduction of these oxides to carbides is only possible at the high temperature of the electric furnace, and it is very interesting to note that at three very different stages of temperature we have such different conditions presiding over the union of the elements that each temperature corresponds to a new chemistry.

The temperature of the electric furnace, which has been estimated to be from 3,500° to 4,000° Cent., may be considered as intermediate between the sun's temperature, estimated by different physicists at 5,000° to 8,000°, and the temperatures of our smelting furnaces, which range from 1,200° to 1,500°. Now, in the sun's atmosphere, spectroscopic observations tell us that the elements exist uncombined, and we can even observe great masses of free oxygen in the presence of heated hydrogen and of metals so transformed in the properties which we are accustomed to recognize that they do not combine, but rise as vapours from the hottest part of the sun, condense and fall back in metallic clouds, which we know as sun spots. Here, then, is a temperature which is too hot for chemistry, if we define chemistry as the science of the combination of bodies.

The next temperature on a descending scale that we have access to is that of the electric furnace; here a partial combination only is possible; much of the oxygen remains free; carbon only burns to the monoxide of carbon, and the carbides and not the oxides of the alkaline earths are the stable forms of combination.

Then, at a lower temperature, the bright red heat of our smelting furnaces, the same carbides formed in the electric furnace, when exposed to free oxygen or to air, burn to oxides and to carbonic acid, and at a still lower temperature these two unite to form carbonates represented by the chalk and magnesian limestone which make so large a part of the earth's crust. Nature has so adjusted her processes that a small residue of oxygen remains, which, mixed with nitrogen, constitutes the vital air of our atmosphere. The carbides of aluminum and silicon burn in a similar way with oxygen, and the stable condition at any temperature lower than a bright-red heat is that of silicates and carbonates which make the chief strata of the earth.

The oxidation of carbides, which became possible when our globe cooled down to a red heat and solidified, has perhaps been a superficial one, and the denser material below the crust may consist of carbides of the alkaline earths and carbides of the heavy metals like iron, and finally the metals themselves.

It is only within the past two years that experiments with the electric furnace have enabled us to study these new transformations at a high temperature, and have given us the means of estimating what must have been the primitive condition of the earth during long geological periods.

Berthelot, Moissan and others have pointed out that the evolution of marsh gas from volcanoes may be an indication of the existence of Plutonic remnants of carbides, dating from a period of higher temperature, and which we now know may give off gas when brought in contact with moisture.

The most important and original experiments made with the electric furnace have been published in the

Comptes Rendus of the French Academy of Sciences by a young chemist, Henri Moissan, who had already distinguished himself by the discovery of fluorine. One of the first results which this new instrument gave in his hands was the artificial production of diamonds made by dissolving carbon in iron, and he then undertook a complete study of the formation of the carbides of the metals. Moissan's paper which interests us most directly was published on the 5th of March, 1894. It contains a full account of the formation of pure crystallized carbide of calcium and of its reactions with oxygen, sulphur, chlorine, etc., and a complete account of the formation of acetylene by the action of water upon the carbide, and nothing of scientific interest has since been added to the chemistry of acetylene, except some few experiments in European laboratories, notably upon its silver compounds.

French physicists have, however, made some very important measures of the thermic conditions which preside over the formation and decomposition of acetylene. They are a continuation of the admirable study of this singular gas, which was begun by Berthelot in 1859, and we shall find them of great value for explaining the properties which make acetylene useful or dangerous as an illuminant. The lecture will be confined strictly to the statement of facts which bear upon the proposed new gas industry, and no place can be given to the long-known laboratory process for making acetylene, and to many experiments which display its general properties.

The idea of using this laboratory product upon a commercial scale originated in the United States, and the merit of it is due to Mr. T. L. Willson and Messrs. Dickerson and Suckert, who have secured patents; but it is important to insist upon the fact that they are not the discoverers of the crystalline carbide of calcium, nor of its transformation to acetylene and to hydrate of calcium. Moissan's publication of March 5, 1894, antedates their patents by many months, and describes completely the whole chemistry of the manufacture of acetylene.

No mention is made of Moissan's work in the reports published by the acetylene company in a lecture by Willson and Suckert before the Franklin Institute, and in a lecture before the London Society of Arts by Prof. Lewes. In these reports Mr. Willson is represented as having discovered the mode of formation of calcium carbide in the electric furnace by the reducing action of carbon upon refractory oxides. It is stated that the experiments were begun by Mr. Willson in 1888.

In such matters dates of discovery can only be established by publications, which in this case are found to be in the Patent Office reports. Mr. Willson took out four patents in 1889–92 for electric smelting processes, and in several of them the use of carbon with refractory oxides is specified. The design seems to have been to make aluminum and its alloys and perhaps other metals. No mention is made in the reports of carbide of calcium nor of acetylene. Dickerson and Suckert, December 31, 1894, nine months after Moissan's publication, patented a process for evolving and condensing acetyline made from the carbide of calcium. And June 18, 1895, is the date of the first patent by T. L. Willson in which the report specifies the production of carbide of calcium.

Many statements have been published concerning commercial aspects of the new enterprise, but it will suffice to say here that it has not yet reached a stage at which the vital question of the cost to the consumer of the carbide of calcium can be fixed by the quotation of a market price. Small quantities can be purchased for experimental purposes in New York at a price of $5 per 100 lbs. But the manufacture in the United States does not exceed one ton per diem and is carried on at Spray, in North Carolina, a somewhat inaccessible place, and no complete account of the process has yet appeared in the best-known scientific periodicals. The commercial carbide, unlike that made by Moissan, probably contains compounds of calcium with the ash of coke, but no complete analysis has been published. Some of the statements made about the number of cubic feet of acetylene are obviously inaccurate, because the figures 5.89 to 6.35 cu. ft. acetylene per 1 lb. carbide are as high or higher than could be obtained if the carbide contained no ash and were absolutely pure.

The accurate measure of the gas given off by the carbide is not easy and requires the construction of a special apparatus. The writer has examined a number of samples of commercial carbide, and found that 70 to 92 per cent. of the theoretical quantity of acetylene could be obtained from them. It appears that the product which can be made to the best advantage is one which contains 84.6 per cent. of pure carbide, and which gives 5 cu. ft. of gas per pound; or, for a ton of carbide, 10,000 cu. ft. acetylene, two-thirds saturated with moisture, and measured at 60° Fahr. and 30 inches barometer. Summer and winter variations of temperature, together with barometric variations, would cause a difference of more than 15 per cent. in the uncorrected measure of the gas, and gas measured in a mountainous region, without correction for the low barometer, would differ far more from the standard amount.

If the acetylene industry shall succeed, the cost of the carbide will have to be adjusted to the price that the consumer may be willing to pay for gas, and it is preferable to treat the subject from this side and to show, as far as laboratory experiments with materials at hand will permit, what will be the probable value to the consumer of acetylene gas.

A very simple experiment illustrates in a beautiful way the ease with which acetylene can be made from the carbide. Direct a small stream of water on a half-pound lump of carbide, ignite the gas and show that the more water is poured on, the more flame is obtained. Various forms of generators can be used for the gas. The simplest one is a bell glass floating on water and containing a few lumps of carbide in a sieve. As soon as the bell glass descends so that the sieve touches the water, a shower of fine sediment of slaked lime can be seen to separate from the carbide and fall to the bottom of the jar, while the gas generated soon causes the bell to rise and removes the carbide from contact with the water. Thus the apparatus can be made to work automatically, generating gas only as fast as it is used; but it is not fitted for permanent use, because the moisture from the water generates gas, even when the contact has ceased, and the bell gradually rises, so that after twenty-four hours gas would escape if it were not used during the interval.

It is in every way preferable to separate the generator and the gas holder, and such arrangements can easily be made automatic.

The acetylene company has patented a tank for generating the gas under sufficient pressure to liquefy itself, and proposes to distribute liquid acetylene in cylinders under a pressure of 600 to 700 pounds to the inch; of this project more is to be said later.

It is certain that a company purchasing the carbide of calcium and using an existing gas plant could generate acetylene and distribute it through mains at a very small expense, and with little skilled labour, so that when a price for the carbide had been established by contract the cost of the gas could be easily estimated; let us see what price such a company could expect to obtain from a consumer.

Value of Acetylene as an Illuminant.

Suppose we take the case of a competition with the gas companies of a large town. At first sight it would seem fair to say we pay for the light gas gives, and if a new gas gives ten times more light we are willing to pay ten times more, particularly if it possesses any other advantages; our gas bill will remain the same.

Here we come upon ground where the facts can be tested by experiments. I have made a large number of measures of illuminating power and find that with a new burner particularly suited to it 5 cu. ft. of acetylene per hour will give 200 candle power; 5 cu. ft. of Boston gas will give a little more than 25 candle power. The Brookline gas is a little brighter. From this point of view alone then we can pay in Boston about $8 per 1000 cu. ft. for acetylene when we pay $1 per 1,000 cu. ft. common gas. But will the gas bills remain the same at this ratio? More light will probably be used and the householder will be led into a more extravagant consumption, and he must decide what he is willing to pay for the new luxury. We must count then with the tastes of the consumer, and these can only be translated into money values after long trial of the new light in many houses.

Besides the question of meeting the desire of the consumer for more or less light is another, which must be taken into consideration depending upon his expertness in burning gas and the care he is willing to take in getting economical results.

No. 1. A Sugg-table fishtail burner is shown, burning just 5 cu. ft. per hour and giving the light of 25 candles. If more or less than 5 cu. ft. of gas is passed through it per hour it gives a lower efficiency and the light costs more. The law in Massachusetts, 1882, requires that the candle power should be tested with the most efficient burners, and I have used the best one for water gas. Coal gas would have given more candle power in an Argand burner. Burning gas economically is an art which is only understood by experts, and here again the habits of consumers disturb calculations; they are not usually willing to take the pains to get the best burners, as the following experiment will show.

No. 2 is a gas burner taken off the pipes in the Technology building and represents the average condition of burners in dwellings. About one-half the illuminating power of the gas is lost in this burner, and few people think of having the burners changed when they become inefficient.

If I put a globe over the burner, about half the light is absorbed, so that with a bad burner and with a milk-glass globe we pay about four times as much as need be for light; but the use of a globe is often necessary for comfort. The acetylene gas gives a different colored light, and I thought it might pass through the globe in larger proportion, but on measuring the candle power I found this was not the case. Perhaps a globe can be found that will especially suit acetylene light.

An important question then is to be answered before we can compare the lighting power of gas and acetylene. Is an acetylene light more tolerant of lack of care in the burners and of variations in the pressure than is the case with common gas? The most superficial observation shows that the two gases must be burnt in a very different way.

Gas burnt in an acetylene jet gives less than one-tenth of its true lighting power, and acetylene burnt in a common gas burner gives a yellow, smoky flame, and when turned down to a small flame it deposits soot on the jet, clogging the burner, if the opening consists of a straight slit. Even the very fine fishtail burners with a straight slit intended for oil gas suffer from this defect when the acetylene flame is turned down.

It appears then from the last experiments that the choice of burner and the mode of using it are very important factors in determining the value of any kind of illuminant, and hundreds of pages have been published on this subject with reference to oil and gas light, and it may be added that the results are not yet concordant.

Acetylene can not well be burnt in an Argand burner nor with the devices that succeed with petroleum lamps. A fishtail flame with a good exposure to the air must be used, and the best form of burner is that which throws the swiftest stream of acetylene into the air in the form of a very thin sheet.

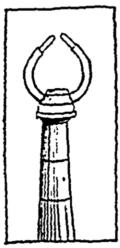
A lava-tip burner has long been used for gas in which the opening is not a slit, but two small holes. The construction of these burners can be well shown by passing gas through two blowpipe jets, and when the two long jets of flame are made to impinge on each other at nearly a right angle they spread out into a fishtail form. Acetylene can be burnt in very small lava tip jets of this class, and gives about 30-candle power, but the light can not be turned low without losing its efficiency and smoking.

An experiment can easily be made which shows how large a quantity of air is required to render acetylene flames smokeless. Mix acetylene gas with measured quantities of air up to 1½ volumes of air and burn the mixtures in a slit fishtail burner. It will be found that the acetylene does not diminish notably in illuminating power. Larger proportions of air begin to destroy the brilliancy of the flame. The same trials with common gas show that a very small proportion of air renders the flame less luminous. Suitable burners must be chosen in each case.

Acetylene can even be burnt mixed with one-third its volume of oxygen, giving a very brilliant flame. These experiments are only of practical value in indicating the kind of burner which should be chosen for acetylene. Another quality of the flame is very instructive from the same point of view. The acetylene flame clings to the burner in an extraordinary way, so that it is difficult to blow it out, and the luminous part of the fishtail flame almost touches the jet, while in a gas flame a large blue zone separates the luminous part from the jet.

By exploring the flame with a bit of platinum wire, it is easy to see, by the intensity with which it glows, which is the hottest part, and also to recognize that the luminous part deposits soot on any cold object.

These experiments led to the idea of constructing a new form of burner for acetylene gas, in which the jets should be very fine and very perfect in form, and which should give the best probable access of air, and which should bring a very small section of metal in contact with the flame in order to avoid smoke and the deposit of soot.



The form eventually chosen is shown by the sketch. The burner is made of brass with nickel or steel tips. The extreme points in contact with the flame may be tipped with platinum or silver, but steel answers the purpose quite well. The most essential feature is that the tips should not be larger than $\frac{1}{16}$ inch in diameter. These burners abstract very little heat from the flame and consequently give more light than the usual form for the same candle power. They do not smoke with any height of flame. They burn acetylene advantageously with the 10- to 20-candle-power light to which we are accustomed. Lava tips are not well suited to such small flames, because the section in contact with the flame is about 20 times larger and abstracts so much heat that the metal setting for several inches in length becomes very hot. Loss of heat occasions loss of light.

It is particularly important in burning acetylene that a large supply of air should be drawn into the flame by the suction of the gas jets which issue from the two orifices of the burner. The steel jets described above provide for this by their perfection of form, as they are bored from their base and have the same proportions, which have been found to throw the swiftest stream under a given pressure with a hose nozzle.

It seems probable, in view of the careless use of burners in the ordinary consumption of gas, that one quality of acetylene will tell in its favor. With a suitable burner acetylene will tolerate greater variations of pressure than common gas. This point was determined by more than 100 measures of the candle power taken with the two gases burning under different pressures.

The smallness of the acetylene flame required to give off a brilliant light is a point in its favour, allowing the use of a great variety of globes and shades for tempering or reflecting the light.

The same quality will be found of advantage when a strong light is to be concentrated as nearly as possible at the focus of a mirror or of a lens, as in locomotive headlights or in lanterns for projections.

It was hoped that the quantity of light given off by duplex or triplex acetylene flames would show a particularly economical consumption, but the results of measures of the candle power of such flames with or without chimneys were disappointing. It appears that defect of air supply with such flames more than counterbalances the effect of the heat which one flame communicates to the other.

It might be desirable to use the existing gas plants and to deliver, as heretofore, a gas of 20-candle power suitable for heating or lighting. Such a project seemed very easy of fulfilment, since it was at first supposed that acetylene could be used to enrich common gas, and in that case no changes would be required in the mode of distribution nor in the form of burners. Experiments have shown that it can be employed to enrich coal gas, but that water gas, which is so largely used in this country, cannot be enriched by acetylene. Water gas has little illuminating power and requires to be enriched by passing petroleum oil into the retorts during the manufacture, and it is only when water gas has already been brought up to a certain candle power that acetylene gas can be mixed with it without losing its effectiveness as an illuminant; so that it cannot be used as a substitute for petroleum to enrich crude water gas.

There is no apparent reason *a priori* why an admixture of a combustible gas should deprive acetylene of its illuminating power, and it is interesting to examine separately the effect of each one of the constituents of water gas to see which one has this property.

Brookline gas, besides 16°/ₒ of illuminants derived from oil, contains equal quantities (about 26°/ₒ) of hydrogen, marsh gas and carbonic oxide. If each one of these is burnt separately with acetylene it appears immediately that it is the carbonic oxide which renders the acetylene non-luminous. Ammonia also has a singular effect upon common gas and upon acetylene, nearly destroying the lighting power and giving a beautiful faint purple flame with curious marked fringes, but ordinarily only traces of ammonia are contained in gas. Nitrogen has much less effect than ammonia or carbonic oxide in destroying the illuminating power of acetylene.

The preceding statements tend to show that a summary of the qualities of acetylene gas, as compared with common gas, must comprise other data beside the measures of candle power, and I have endeavoured to point out some of the peculiar properties of the new light which are advantageous. The price and the taste of the consumers must decide the question of competition.

The gas of small towns is usually poorer in quality and higher in price than in large towns, and perhaps the opportunities for the introduction of acetylene are greatest in this direction. Consumers may be willing to pay

$15 per thousand for acetylene gas where they pay $1.50 for 16-candle water gas or coal gas.

I should expect to see it first introduced to replace the very expensive oil gas used in railroad carriages, and also for special purposes where great brilliancy and concentration are required, like the headlights of locomotives. For such purposes the Welsbach light cannot be used, because it is destroyed by jarring. The adherence of the flame to the burner is an advantage for railroad use, making the flame hard to blow out. For shop-window illumination the Welsbach light, which is very much cheaper than gas burnt in any other way, seems to be beyond the reach of competition; and the Auer burner, which is similar, is now used for street lighting in Paris, and these incandescent lights work well wherever the light is not shaken, and where the disagreeable green tint is not an objection.

For country houses acetylene light seems well fitted and might replace the very bad illumination of gasolene light.

Much skill and special knowledge are required to run gas works, while the making of acetylene from the carbide or its distribution as a liquid is so simple that acetylene stations could be established in many villages too small to make gas works pay. Moreover the winter consumption of gas is two or three times that of the summer, when the gas plant lies idle in part. With acetylene there is an advantage in this direction, because the value of the plant would be much less.

The whiteness of acetylene light renders it useful for displaying or sorting colours, and some experiments made with Mr. C. R. Walker show that, for photographic purposes, when equal quantities of acetylene light and of water-gas light, measured by candle-power, are compared, the acetylene light has two and one-half the actinic value of the other.

Poisonous Qualities of Gas and Acetylene.

Continuing the comparison of common gas and acetylene, let us see how the case stands from a sanitary point of view. We see reports in the newspapers of deaths and attacks of illness from gas poisoning, the dropping out during the night of the core of a gas cock or a break in a pipe, would often be an accident fatal for the inmate of a small, close bedchamber. Recently persons have been poisoned by a defect in the gas main outside of their houses. Workmen are frequently made ill by a leak in the gas mains while working in a trench, but the officers of the gas companies state that such accidents are very seldom fatal.

There is no question then about the poisonous qualities of common gas and particularly of water gas. Is the new illuminant likely to be less dangerous?

The poisonous constituent of common gas is carbonic oxide. London gas contains 3.2 to 7%; Paris gas 7%; Berlin gas 8%; Boston gas 26%.

Formerly there was a legal limit of 10%, which is now removed, and the introduction of water gas has raised the percentage to this very high and dangerous amount.

Carbonic oxide is not irritating or corrosive, and it seems strange that a compound so nearly allied to carbonic acid, which is innocuous, should act as a rapid poison.

The mode of action is this: Carbonic oxide is absorbed and retained by the blood in a way quite different from other gases. It combines with the red corpuscles, and the compound shows under the spectroscope special absorption bands, which make the recognition of its presence easy.

Blood which has taken up a certain quantity of carbonic oxide no longer is capable of taking up oxygen in the lungs and conveying it through the circulation, and death by suffocation ensues, just as if there were not enough oxygen to breathe.

The blood is so sensitive to carbonic oxide that so little as 0.03% in the air can be shown (Bull. Soc. chem. (6) 663) when a solution of blood is brought thoroughly in contact with a mixture containing carbonic oxide.

The best way to bring a liquid in contact with a large body of air or gas would be to have it circulate by means of minute canals, using a pump to keep the current in motion through the cell walls of a sponge, while the air was continually changed by squeezing and relaxing the sponge. We can find such a little machine in a very perfect form in the body of a small animal, the veins and arteries constituting the canals, the pump being represented by the heart, and the sponge by the lungs.

If we sacrifice a mouse as a martyr to science and enclose him in a tight box containing air with a known percentage of carbonic oxide, and kill him after 3 or 4 hours, we can detect the carbonic oxide absorbed by his blood.

A similar method is best suited to discovering whether acetylene is absorbed by the blood. We might suspect that this would be the case since the two gases have in common the peculiar property of being absorbable by solutions of subchloride of copper.

Grehant (Comptes Rendus, 1895, II., 565) made a careful comparison of carbonic oxide and acetylene in respect to their poisonous qualities upon dogs. He took care to have 20% oxygen always in his mixtures, so as to give it the vital quality of air and not to kill his animals by suffocation. He added 1% carbonic oxide (*i.e.*, enough Paris gas (containing 7% CO) to give 1% carbonic oxide). After 3 minutes the animal suffered; after 10 minutes the dog was very sick and his blood contained 27 volumes per 100 of carbonic oxide. The dog would have soon died if the experiment had been prolonged.

In a mixture containing 20% oxygen and 20% acetylene a dog breathed without inconvenience for 35 minutes.

His blood contained 10°/$_0$ acetylene, less than $\frac{1}{10}$ the rate of absorption of carbonic oxide and not a larger percentage of acetylene than would have been absorbed by water. The mixture contained much more acetylene than could ever get into the air of a room, and in fact in a dwelling house a much smaller quantity would produce an explosion.

A dog was killed by breathing 40°/$_0$ acetylene and 20°/$_0$ oxygen in 51 minutes; another in about 30 minutes by 80°/$_0$ acetylene and 20°/$_0$ oxygen. A guinea pig was *not* killed in 39 minutes by the same mixture.

L. Brociner (Comptes Rendus, 1895, II., 773) had made similar experiments in 1887, and concluded that acetylene was not poisonous. It is not more absorbed by blood than by water. It has *no* specific action on blood. Sulphide of ammonium reduces such blood normally. It has no special absorption band.

Berthelot and Claude Bernard 30 years ago found acetylene not poisonous.

Moissan (Comptes Rendus, 1895, II., 566) says pure acetylene only has an ætheric agreeable odor.

Bistrow and Liebreich in 1868 (Ber. I., 220) pronounced acetylene poisonous, but this opinion is contrary to that of Berthelot and of Claude Bernard, and Berthelot has recently stated anew that pure acetylene is not poisonous, and has pointed out that the old method of preparation of acetylene by means of the acetylide of copper may contaminate the gas with prussic acid (Comptes Rendus, 1895, II., 566). It may be concluded then on the best authority that *pure* acetylene is not poisonous.

The smell of freshly prepared acetylene made with commercial carbide of calcium would lead one to suspect that the gas contained phosphoretted hydrogen and Wellgerodt (Ber. 1895, 2107, 2115) detected its presence in acetylene by passing the gas through nitrate of silver solution. I also got by another method a good molybdate test for phosphoric acid, before I knew of the above publication.

The phosphorus is probably derived from phosphates in the quicklime and in the ash of the coke used for making the carbide of calcium. Moissan used a pure carbon obtained by charring sugar, and his carbide gave pure acetylene free from disagreeable odor. The previous statements that acetylene is innocuous may only apply to pure acetylene, and it is important then to make a special examination of commercial acetylene to see if it contains dangerous constituents. I have only found one statement on this subject, contained in the Electrical Engineer, New York, November 13, 1895, p. 469.

Dr. W. H. Birchmore says that 1 cu. ft. of acetylene in 10,000 cu. ft. of air produces headache in twenty minutes, and that so small a quantity of acetylene is not perceptible to smell.

I have frequently breathed air containing enough acetylene to be very plainly noticeable from its smell, and have not suffered the slightest inconvenience. It seems probable that individuals differ greatly in their susceptibility to poisons of the class to which phosphoretted hydrogen belongs. It is also quite possible that other poisonous gases in very small quantity may constitute impurities of acetylene. Dr. Birchmore performed a single experiment upon an animal and states that one part of acetylene in 10,000 parts of air killed a guinea pig in six hours; sickness came on in ten minutes. The blood lost its power of absorbing oxygen, as in a case of poisoning by cyanhydric acid. He did not examine the blood for acetylene. Experiments of this kind should be repeated by competent physiologists, and the blood should be carefully tested. It is quite certain that in this case the death was caused by some other body present and not by the pure acetylene.

If it is found that phosphoretted hydrogen or some similar impurity is present in dangerous quantity, they can probably be removed by a proper treatment of the gas.

Arsenuretted hydrogen might also be present, but I have failed to find any trace of it in commercial acetylene.

It has been said that acetylene gas could never act as a poison, because an escape from a leaky pipe would attract the attention of a person, even while asleep, by its irritating action upon the throat, producing coughing. The statement is contrary to all my observations.

Further experiments upon this subject are required, but the evidence already accumulated seems to be favourable to acetylene as compared with water gas, and if the new illuminant can be made for a reasonable price and can be quite freed from poisonous impurities it should become a formidable competitor with water gas. On the other side, however, we shall find that the danger from explosion will call for special precautions in the use of acetylene gas.

Danger in Use of Liquefied Acetylene.

There will be an evident advantage, if acetylene gas lighting succeeds, to begin by introducing it without putting down mains and setting down generating houses; this can be done by supplying customers with liquefied gas. A cylinder holding say 1,000 cu. ft. gas compressed in a space of less than 2 cu. ft. can be attached to the gas pipes of a house in place of a meter.

This new gas service is, however, not so simple as would at first appear. Two cylinders must be used at once, or at least a second one must be brought before the first is exhausted to make the supply continuous, otherwise we should have the disagreeable surprise of finding the gas extinguished. A gauge on the cylinders must be watched to see when No. 1 must be cut off and No. 2 turned on.

Neglect in care of this will cause extinction of the gas and discredit of the system. The gas companies have accustomed us to a constant supply through mains at an even pressure and have set a high standard of convenience.

The cylinders contain gas at a pressure of 6 to 700 lbs. A reducing valve, always kept in order, must reduce this pressure to 1 oz. = 2 inches water. The Pintch valve employed on railroad lines is used, but we must ask the question: Will it always keep in order with the care it would get in a private house or tenement house? Then an escape valve is required in case a fault of the Pintch valve throws the whole pressure on the pipes. A mercury seal would answer to empty the gas into the air, and it could be counted on to work satisfactorily, but the gas would be lost each time that the valves got out of order. All this apparatus makes the use of liquefied acetylene somewhat complicated, and in addition to this disadvantage it would present a serious danger in case of fire. The cylinders when strongly heated would be liable to explosion, and it is proposed to guard against this danger by employing a mercury seal to empty them when the pressure exceeds safe limits. This arrangement, even supposing that it always performed its office during a fire, would be open to a serious objection, for if the fire took place in a large building in a town containing, say, 10 cylinders with 5,000 cu. ft. of gas in the 10, this quantity of gas thrown in the air would make an explosive mixture with 20 times its volume of air, or about 100,000 cu. ft. in all, and whether disengaged on the roof or in the street would expose the firemen to a new danger.

If we add to the small annoyances arising from the care of a gas supply which is not constant like that of gas delivered in mains, the danger of explosion of a cylinder weakened by rust or neglect, the danger in case of fire and the very doubtful economy of the systems, the summary seems unfavourable to use of liquefied acetylene, except in places where sufficient space can be had to isolate the cylinders as gasoline tanks are now isolated.

It will be seen later that these cylinders may be exposed to a special danger, although a very improbable one, from the explosive decomposition of acetylene under the impulse of a certain kind of shock.

The Temperature of the Acetylene Flame.

When we compare acetylene and common gas illumination from the point of view of the products of combustion which vitiate the air of a room, or of the heat which is given off, the conclusions are very favourable to acetylene lighting, because ten times as much common gas has to be burnt to obtain the same amount of light as would be given by a unit measure of acetylene. The heating effect, however, is not in the ratio of ten to one. Ten cu. ft. of Boston gas give 2.42 times as much heat as 1 cu. ft. of acetylene.

Prof. Lewes[1] has calculated the amount of carbonic acid given off by different illuminants, and finds, for an equal amount of light,, that coal gas gives off six times as much as acetylene, and he estimates that the heat from acetylene would not be much greater than from the ordinary incandescent lamp.

The true relations are for the same amount of light:—Heat from incandescent light, 1; acetylene, 3; water gas, 9.

Prof. Lewes says, in the same connection:—"The flame of acetylene, in spite of its illuminating value, is a distinctly cool flame, and in experiments which I have made by means of the Lechatelier thermo-couple, the highest temperature in any part of the flame is a trace under 1,000° Cent. While coal gas, burning in the same way

[1] A paper read before the Society of Arts, London.

in a flat-flame burner, the temperature rises as high as 1,360 Cent."

It is not an advantage, but a disadvantage, that the fishtail acetylene flame should be cool. Its temperature is lowered by the excessive contact with air required for complete combustion, and, if the flame could be made hotter, more light could be obtained for the same quantity of heat. It is scarcely necessary to add that the temperature of a flame has nothing to do with *the heat of* combustion. Phosphorus or sodium can be burnt at the ordinary temperature, or at a red heat, and the heat of combustion is the same at either temperature, provided the products of combustion are the same.

Lechatelier,[1] one of the best authorities upon such a subject, does not appear to have measured the temperature of the acetylene flame with his pyrometer, and, in fact, such measurements are very difficult; but he has calculated that acetylene, burned with air, may reach a temperature of 2,100° to 2,400° Centigrade, and, burned with oxygen, 4,000°.

It is easy to melt platinum in a common air blowpipe flame fed with acetylene, but the platinum appears to first form a carbide.

Acetylene, notwithstanding its high cost, may find a restricted use in the laboratory in air or oxygen blast furnaces; it will undoutedly give a higher temperature than gas or hydrogen.

The preceding description has continually held in view the utilitarian side of the question, and it has been thought simpler to enumerate the items in favour of the economical use of acetylene as compared with gas and not to extend the comparison to other forms of illumination, but the following table mostly taken from the most recent book[2] on the subject gives the means of comparing other modes

[1] Comptes Rendus, December 30, 1895.

[2] Julius Swoboda: Petroleum Industrie. Tübingen, 1895.

of lighting. It is to be remarked that authorities differ widely in their estimates, and the cost of gas and electric lighting varies greatly with the locality. Electricity is particularly advantageous when it can be put to other uses during a part of the day.

100 Candle Light During One Hour.

	Quantity.	Cost. Cents.	Heat of combustion. Kilograms of water 1 degree.
Arc light	0.09—0.25E	1—2.5	57—158c
Incandescent lamp	0.46—0.85E	3—5	290—536c
Boston gas, $1 per 1000	20 cu. ft.	2.0	3380c
Acetylene, $10 per 1000	2½ to 3 cu. ft.	2.5—3	1000—1200c
Petroleum lamp	0.62lb.—1.0 lb.	2.0	3360c
Carcel oil lamp	0.9 lb.	8.0	4200c
Paraffine candle	1.7 lb.	28.0	9200c
Spermaceti candle	1.7 lb.	54.0	7960c
Wax candle	1.7 lb.	61.0	8940c
Stearine candle	2.0 lb.	33.0	9700c
Tallow candle	2.2 lb.	32.0	

The Chemical Properties of Acetylene.

A series of very simple experiments will illustrate the most important properties of acetylene.

To compare its density and its explosive force with those of common gas take two lamp chimneys closed at the top and bottom with corks, and each fitted with an inlet tube at the bottom and with a large brass tube at the top. Fill one with gas and the other with acetylene and light both gases at the upper tube; then remove the rubber tubes from the inlet tubes. The flames will continue to burn at the upper orifice, because each gas rises, floating on a layer of air, which rushes in from below, and the relative densities of the gases may be estimated from the rapidity with which each flows out. The common gas flows out more rapidly and burns with a higher flame than the acetylene, because it is lighter: (density of Boston gas = 0.607; density of acetylene = 0.91). At the last the flame strikes down into the small residue of each gas, which has become mixed with air in the lamp chimneys, and a slight explosion takes place, which is notably stronger with acetylene than with gas. The greater density of acetylene explains partly why it should have more illuminating power than common gas, since a cubic foot contains more material. As our object is only to examine the properties of acetylene which have a bearing upon its illuminating power, one test of its chemical activity will suffice. Set free a small quantity of hypochlorous acid gas in a tall glass jar and plunge into it a tube from which a stream of acetylene is issuing, this latter will immediately take fire from the great heat evolved by its chemical action upon the hypochlorous acid. If common gas, or almost any other gas, were subjected to the same test, no flame would result.

Acetylene forms peculiar salts with copper, silver and mercury; and these when dry decompose explosively when subjected to a shock or to the action of heat. The silver compound can even be exploded under water and is more dangerous than fulminate of silver.

Explosiveness of Acetylene.

What we have learned concerning the extreme chemical activity of acetylene leads us to expect that it would form more readily than other gases an explosive mixture with air, and this proves to be the case.

Experiments using a piece of two-inch gas pipe as a cannon show that 5–6% of acetylene mixed with air forms an explosive mixture; 10–12% of water gas is required to explode with air.

The heat abstracted by the walls of the iron tube prevents the mixture from obtaining its limit of explosiveness, and a still smaller percentage of either gas mixed with the air of a room would explode. Lechatelier (Comptes Rendus, 1895, II., 1145) gives 2.8°/$_c$ of acetylene mixed with air as the explosive limit, and it is to be noticed that in a dwelling house the danger from explosion is enhanced by the inequality of such mixtures. A flame spreading from a spot rich in gas would propagate itself explosively through a mixture very poor in gas.

The danger is enhanced in the case of acetylene by the low temperature at which it takes fire, 480° Cent. Most other gases must be treated to about 600° to take fire and marsh gas, the fire-damp of mines, fortunately requires a much higher temperature to ignite, so that a spark from flint and steel does not suffice to cause an explosion. Acetylene burns with greatest increase of volume when the products are carbonic oxide and hydrogen. The violence of combination of acetylene with oxygen can be well shown by igniting equal volumes of the two gases. A quantity equal to 3–4 grains makes a far louder report than the same weight of powder or of nitro-glycerine.

The dangerous properties shown by acetylene need not condemn it, but particular care must be taken to prevent leakage if acetylene gas comes into use; fortunately, small pipes can be used and the gas contains no ammonia, which, in common gas, destroys the grease on the stopcocks and promotes leakage.

If instead of igniting a mixture of air and acetylene, the latter alone is passed through a glass tube heated to dull redness, at first a slight change takes place, and liquid benzene and other products condense in the colder parts of the tube; at a little higher temperature the change goes further—carbon is deposited and hydrogen is set free. If the interior of the tube is carefully watched it will be seen that the decomposition takes place with a dull red flame, as if the acetylene were burning with an insufficient supply of air. No air, however, is in the tube: there is no combustion in the ordinary use of the word, and yet we have in the flame evidence of a sudden disengagement of heat. Here we approach the solution of the problem, regarding the extraordinary chemical activity of acetylene. Acetylene has a supply of heat stored up, which it gives off whenever it is decomposed spontaneously, burnt in air, or excited by any radical chemical change. The sudden evolution of heat manifests itself as light, quickens combustion and promotes all chemical action.

The exact quantity of heat absorbed and stored up by acetylene, when it is formed by the union of carbon and hydrogen, can be best measured by two experiments. Firstly, burn exactly one cubic foot of acetylene in a calorimetric apparatus, which is merely a device for heating a given weight of water without loss of heat, and find that nearly nine pounds of water can be heated from its freezing to its boiling point. Or, if we take the thermal unit in more general use we find that 407 kilograms of water gain one degree Centigrade in temperature from the heat given off by burning one cubic foot of acetylene gas, measured at 0° Cent. and 76 cm. barometer. Secondly, take exactly the weights of carbon and hydrogen which correspond to the weight of one cubic foot of acetylene and burn them in the same way under a weighed quantity of water. We shall find that according as we take pure amorphous carbon or diamonds we get a somewhat different quantity of heat. With amorphous carbon and hydrogen 336.5 kilograms of water are raised 1 degree Cent. in temperature. The difference of heating power then between acetylene gas and the same weight of carbon and hydrogen is 71 heat units. The surplus energy stored up in the acetylene and set free when it is burnt becomes evident and is measured, when we find that the acetylene arrangement or combination of carbon and hydrogen atoms is capable of making the elements do more work, that is to heat 71 kilograms more water than when the same elements are free in the state of amorphous carbon and of hydrogen gas.

When the carbon from carbide of calcium and hydrogen from water combine to make acetylene heat is utilized in changing the carbon from the solid and the hydrogen from the liquid form to the form of a gas. Heat is absorbed in this process which imparts a new energy of motion to the atoms, in the same way that heating water separates the particles to two thousand times wider distances from each other and gives them the energy of motion which is apparent in steam. In this case we can measure the amount of heat required for this work and which is absorbed while it takes place. Unfortunately we can not get similar measures with carbon vapour and solid carbon, and we can only measure a total absorption of heat during the generation of acetylene, and we suppose that the total, 71 heat units, may be made up by the absorption of a larger amount of heat in order to change amorphous carbon to the gaseous state, from which must be deducted the heat which is given out when two carbon and two hydrogen atoms combine to make C_2H_2. Benzene which has exactly the same percentage of carbon and hydrogen, but combined into quite a different chemical group, shows that more energy has been expended in bringing about its chemical arrangement. The signs which attest this are greater stability, smaller chemical activity, and above all the fact that when benzene is burnt it gives off much less heat than the same weight of acetylene does, and in fact only 4 heat units more than the same weight of carbon and of hydrogen.

It has seemed necessary to explain fully how quantities of energy, which can usually be measured in terms of heat, preside over the making of different chemical compounds, and how the dormant heat can be made active again when the compounds are excited to chemical change, and how each one is stamped as with a birth-mark by its special heat value.

This peculiar stamp set upon acetylene is at the same time a token of valuable and also of dangerous qualities. Heat is added to the heat of combustion and brings about more sudden changes and plaees acetylene with the class of bodies known as fulminates. These are distinguished from explosives like gunpowder by their capability of suddenly evolving stored-up heat, which causes a great expansion of gaseous products. Berthelot has calculated that fulminate of silver develops a pressure of 600,000 lbs to the square inch in the incredibly short time of one-thirty-millionth of a second. The acetylide of silver has similar properties, and the lightest shock suffices to explode it. It occurred to Berthelot to see whether acetylene gas might not decompose spontaneously into carbon and hydrogen with explosive suddenness. We have seen that it decomposes into these products, *but without explosion,* when strongly heated, and only in one way could it be made to decompose explosively. Berthelot succeeded in detonating pure acetylene by subjecting it to the shock of fulminate of silver.

The danger seems very slight that acetylide of copper or some other metal may form in an acetylene gas holder, and when exploded by friction or heat cause the whole mass of gas or liquid acetylene to explode. The subject, however, is worthy of further study.

As was said in the beginning, the problems which are suggested by this new industry touch on all sides upon some of the most important of the recent discoveries in chemistry and physics, and the ease with which acetylene can be obtained opens the door to many new experiments. Such questions, for instance, as the use of acetylene in gas engines, under special conditions, where the high price would not be prohibitive, would offer a very interesting study. It does not seem impossible that a gas so active and so easily stored might be exploded with air in a pneumatic gun to give an additional impulse to the projectile.

The laboratory experiments which have been described may perhaps serve as a guide in some directions to manufacturers, but they cannot settle the commercial details upon which the success of the new enterprise depends. Much further study and tests upon a larger scale, with the improvements suggested by prolonged trial, can alone decide whether the new illuminant is destined to supplant older industries built up slowly and surely by the persistent efforts of hard-working and skilful men.

Two Shrews of the Genus Sorex, new to New Brunswick.

By Philip Cox, A.B., B.Sc., Ph.D.

It may be of some importance to those interested in the distribution of small mammals to learn that two species of the genus *Sorex* have lately been found in New Brunswick, which are not only new to Provincial lists, but the occurrence of one of them is more than a surprise.

Sorex Richardsoni, Bachman, a boreal form of the North-West and Northern portion of the Central Plain, has not, so far as the writer can learn, been reported east of Northern Minnesota. That it should turn up on the Atlantic side of the continent could hardly have been suspected; yet the writer collected it here in the winter of 1894-95, Indeed it is by no means rare on the intervales and low forest country adjacent to the St. John River, in Maugerville, Sunbury County.

S. fumeus, Miller, *S. platyrhinus*, Dobson—not *S. platyrhinus*, Baird—another sub-boreal form frequenting to the south the upper parts of mountains, was also collected about the same time in coniferous woods by the banks of a stream in Maugerville. It seems very rare, but one specimen having been taken. Dr. C. Hart Merriam, ornithologist and mammalogist of the Department of Agriculture, Washington, to whose kindness I am indebted in connection with placing the identification of these species beyond doubt, informs me it has never been reported north or east of New Hampshire.

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY.

MONTREAL, Oct. 28th, 1895.

The first monthly meeting was held this evening, the President, Rev. Robert Campbell, in the chair.

Present: J. B. Williams, J. A. U. Beaudry, Geo. Kearley, John S. Shearer, E. T. Chambers, A. T. Winn, Walter Drake, and others—twenty-seven persons in all.

The Curator, J. B. Williams, reported the following donations to the Museum since the last meeting, in May:—

Skull of Albatross—Capt. W. Rome.
Piece of Yucca palm—H. J. Tiffin.
Nest of red-eyed Vireo—P. J. Copland.
Nest of red-eyed Vireo—G. A. Dunlop.
1 Menobranchus—J. B. Williams.
Head of a fossil Whale—Capt. W. Ross.
2 ribs of a Whale—Capt. W. Ross.
1 Rock Bass—E. D. Wintle.

And the following twelve living snakes :—

1 young garter snake—S. W. Boyd.
1 do do H. Swift.
1 red-bellied snake } J. B. Williams.
2 Dekay's brown snakes }
2 Dekay's brown snakes } H. Jackson.
1 red-bellied snake }
1 grass snake—Mrs. H. H. Austin.
1 young red-bellied snake } J. B. Williams.
1 young grass snake }

E. T. Chambers, Chairman of Library Committee, reported having received from the U. S. Geological Survey a copy of the Geological Atlas of the United States.

Moved by E. T, Chambers, and seconded by Walter Drake, That the thanks of the Society be sent to the United States authorities for their donation.—Carried.

Moved by J. A. U. Beaudry, and seconded by J. B. Williams, That the thanks of this meeting be sent to the donors of the different specimens.

The following new members were elected by acclamation on the motion of John S. Shearer, seconded by E. T. Chambers, the rules being suspended for that purpose :—David Robertson, Ald. R. Prefontaine, W. C. McKechnie, A. E. Deeks, M.D., Rev. G. Colborn Heine.

The President then requested the First Vice-President to take the chair that he might read his paper entitled "Some additional Notes on the Flora of Montreal."

Moved by Geo. Kearley, seconded by A. F. Winn, That the thanks of this meeting be extended to Dr. Campbell for his very interesting communication.—Carried.

Mr. J. B. Williams then read his communication entitled "Notes on the Canadian Stick Insect (*Diapheromera femorata*)." Moved by J. A. U. Beaudry, seconded by John S. Shearer, That the thanks of this meeting be extended to Mr. Williams for his intensely interesting and instructive paper.

MONTREAL, Nov. 25th, 1895.

The second monthly meeting of the Society was held this evening, John S. Shearer in the chair.

Present: Messrs. J. B. Williams, Geo. Kearley, Harold B. Cushing, B.A., J. A. U. Beaudry, F. W. Richards, E. T. Chambers, Hon. Mr. Justice Wurtele, A. F. Winn, C. R. Chisholm, Rev. G. Colborne Heine, H. McLaren, Prof. J. T. Donald, Dr. C. W. Wilson, and others.

The minutes of last meeting, October 28th, were read and confirmed.

The report of the Museum Committee was then read and adopted. It contains the following proposal, should the Society approve of the scheme :—To arrange for some short talks or lectures to young people on different objects in the Museum, to be given on Saturday afternoons during the winter months. Such a course of six or seven lectures, it was thought, would interest people in the museum, and help to bring in some young members to the Society.

DONATIONS.

The following donations were reported :—

Nest of Baltimore Oriole—Miss Jackson.
American Merganser—Mr. John Donavan.
5 Lake Urchins—Miss Marion B. Shearer.
Pileated Woodpecker (shot on Mount Royal)—Mr. David Denne.
The Hand-Book of the Flora of New South Wales, by the Hon. Mr. Cheoles, F.L.S., etc., etc.

A vote of thanks to the donors was moved by J. A. U. Beaudry and seconded by H. McLaren.

The following new members were elected by acclamation, the rules being suspended for that purpose :—Capt. W. Ross and Harold B. Cushing, B.A.

Prof. J. T. Donald then read a very interesting communication on "Gold Mining in California, Past and

Present," after which a vote of thanks was tendered to Prof. Donald for his able and excellent paper.

Mr. Harold B. Cushing then read his paper entitled "An Exhibit of Native Ferns of the Island of Montreal."

Moved by E. T. Chambers, and seconded by Geo. Kearley, That a vote of thanks be extended to Mr. Cushing for his very interesting and instructive communication.—Carried.

MONTREAL, Jan. 27th, 1896.

The third monthly meeting of the Society was held this evening at eight o'clock, Rev. Robt. Campbell, D.D., President, in the chair. There were present Sir J. W. Dawson, John S. Shearer, J. A. U. Beaudry, Walter Drake, Fred. W. Richards, Geo. Sumner, Prof. Adams, J. B. Williams, Geo. Kearley, David Robertson, Jas. Gardner, E. T. Chambers, F. D. Reid, M.D., H. McLaren, Hon. Mr. Justice Wurtele, Capt. W. Ross, Miss Howard O'Keefe, and others.

Dr. Campbell reported that the Street Railway Company had withdrawn its application to the City Corporation to build the road through the Mount Royal Park.

There was an informal discussion with regard to the proposed Conversazione.

The following donations were received by the Society :—

Collection of Cocoons and Chrysalides, from A. F. Winn.

Resplendent Trogon (skin), Least Bittern (male), Least Bittern (female) — from J. Manghan, jr., of Toronto.

Virginia Rail, from J. B. Williams.

Long-billed Marsh Wren, from J. B. Fleming, Toronto.

Engraving of Labrador Duck, from E. D. Wintle.

Eider Duck, from John Morris.

Piece of Bermuda Coral, from Dr. Deeks.

It was moved by John S. Shearer, and seconded by Walter Drake, and carried, that they be acknowledged by the Secretary.

On behalf of the Lecture Committee, Dr. Campbell announced that arrangements for the Somerville Course for 1896 were almost completed.

J. B. Williams, the Curator, announced that the Museum Committee had arranged for a series of Saturday afternoon talks, and submitted the programme.

The President then introduced Sir J. W. Dawson, who gave a most interesting paper, "On Some Older Rocks of the Lower St. Lawrence," illustrated by specimens of fossils, drawings, etc. At the close of the paper, Capt. W. Ross gave some facts regarding a specimen of the head of a fossil whale, and asked Sir William Dawson some questions concerning it.

Dr. Adams referred to the obligations the Society were under to Sir William, and also referred to the advantages of careful observation.

A hearty vote of thanks to Sir William was moved by Dr. Adams, seconded by Walter Drake, and carried unanimously.

The question of a petition against a new saloon in the vicinity was discussed, and it was referred to the Council.

MONTREAL, Feb. 26th, 1896.

The fourth monthly meeting of the Society was held this evening at eight o'clock in the Lecture Hall, Hon. Justice Wurtele in the chair. There were also present E. T. Chambers, J. A. U. Beaudry, F. W. Richards, Geo. Kearley, John S. Shearer, J. B. Williams, Prof. Penhallow, Rev. G. Colborne Heine, Miss Howard O'Keeffe, Albert Holden, G. A. Greene, Edgar Judge, Prof. Adams, Jos. Fortier and the Recording Secretary.

Minutes of last meeting read and adopted.

Moved by J. A. U. Beaudry, and seconded by E. T. Chambers, that the rules be suspended, and that the Chairman cast the ballot for the election of Miss Howard O'Keeffe as an ordinary member. Carried. Miss O'Keeffe was then elected.

The following highly interesting and instructive communications were read and discussed :—

"Peculiar Behavior of Charcoal in the Blast Furnace at Radnor Forges," Prof. J. T. Donald.

"Notes on the Silicified Charcoal dealt with in Prof. Donald's Paper" (illustrated by means of the lantern), Prof. D. P. Penhallow.

"The Ornithorhyncus Paradoxus, or Duck-Billed Platypus," Miss Howard O'Keeffe.

A vote of thanks was moved by Edgar Judge, and seconded by Prof. Adams, and carried. The Chairman, in presenting the vote of thanks, expressed the great pleasure the meeting had in seeing Prof. Penhallow present. The following donations were presented to the Society :—

21 specimens of fossil sponges, shells, etc., from the Quebec Group of the Siluro-Cambrian Rocks, from Sir Wm. Dawson.

1 King Eider (female) .... } from W. J. Drayner.
1 King Eider (young male) ...... }

MONTREAL, March 30th, 1896.

The fifth monthly meeting of the Society was held at eight o'clock this evening in the Library, the President, Rev. Robt. Campbell, D.D., in the chair. There were present J. A. U. Beaudry, J. B. Williams, Geo. Kearley, John S. Shearer, E. L. Bond, Miss Howard O'Keefe, the Recording Secretary, and others.

Minutes of last meeting were read and confirmed.

Minutes of Council meeting of March 23rd were read.

The following donations were reported as made to the Museum :—

About 75 eggs of Canadian Birds, by G. A. Dunlop.

16 specimens of Gold, Silver and Lead Ore, from Kootenay Mines, B.C., by Richard Conway, 64 Victoria street, Montreal.

One Kea Parrot, one Owl Parrot, received in exchange from C. Spanner & Co., Toronto.

A vote of thanks to the donors was proposed by John S. Shearer, and seconded by J. A. U. Beaudry. Carried.

On motion the rules were suspended, and the following were elected as ordinary members of the Society :—J. G. Veith and G. E. Drummond.

John S. Shearer then took the chair, and Rev. Robt. Campbell read Mr. A. T. Drummond's paper on "Currents and Temperatures in the Gulf of St. Lawrence."

E. L. Bond, Geo. Kearley and others made remarks on this very interesting paper, and hoped that the Government would take action in the matter of a more thorough survey.

A vote of thanks to Mr. Drummond for his excellent paper was moved by Major E. L. Bond, and seconded by Dr. Campbell.

Mr. Williams then read his communication "On Certain Birds from the Moluccas now in the Society's Museum." A hearty vote of thanks was tendered to Mr. Williams for his paper and also for his care of and arrangement of the birds in the Museum.

MONTREAL, April 27th, 1896.

The sixth monthly meeting of the Society was held in the Library this evening at eight o'clock, the President, Rev. Robert Campbell, D.D., in the chair.

Present: J. Stevenson Brown, Hon. Justice Wurtele, J. B. Williams, C. J. Williams, Jos. Fortier, John S. Shearer, Geo. Sumner, E. T. Chambers, James Gardner, Geo. Kearley, J. A. U. Beaudry, Wm. Jackson, Dr. Stirling, Albert Holden, Prof. Donald, H. B. Cushing, and others.

Minutes of last meeting read and confirmed.

Mr. Shearer, on behalf of the Field-Day Committee, reported progress, and recommended St. Jovite as the objective point.

On motion of J. A. U. Beaudry, seconded by Jos. Fortier, the rules were suspended and Mr. Joseph Haynes was elected, one ballot being cast.

Prof. Adams then read two very interesting papers, entitled "A Visit to the Lake Dwellings at Robenhausen, Switzerland," and "Notes on a Remarkable Deposit of Stalagmite from Gold Hill, Nevada."

A very hearty vote of thanks was tendered to Prof. Adams, on motion of J. Stevenson Brown seconded by J. A. U. Beaudry.

The thanks of the Society were tendered to Sir William Dawson for his kindness in exhibiting the specimen of stalagmite referred to in Dr. Adams' paper, as well as to Mr. Higbich, by whom the specimen was sent to the Peter Redpath Museum.

The meeting then adjourned.

Book Notices.

The History of Mount Mica of Maine, U.S.A., and its Wonderful Deposits of Matchless Tourmalines.—By Augustus Choate Hamlin. Published by the Author; Bangor, Maine, 1895, pp. 72, forty-three colored plates, etc.

This is a memorial volume, dedicated by the author to his father, Hon. Elijah Livermore Hamlin, and his son, Frederick Cutting Hamlin. It gives a history of the development of the locality from the time of its discovery down to the present day, describes the deposits and the mode of occurrence of the tourmalines with a chapter (VII.), giving explanations of a plan of the workings and of the beautiful colored plates. The book is attractive in appearance, and that it is pleasantly written the following extract will suffice to show :—" It (Mount Mica) was discovered in 1820 by two students who had become interested in the study of mineralogy, and who spent much of their leisure time in searching for minerals among the exposed ledges and the mountains around the village. Late in the autumn of 1820, and on one of its clear, calm days, they started out to explore the range of hills which form the eastern boundary of the town, and stretch away to the north-west until lost among the mountains around Molly Ocket. The names of these two students were Elijah L. Hamlin and Ezekiel Holmes. Hamlin was a resident of the village, but Holmes was a visitor, and temporarily a student in the place. They had spent most of the day along the mountain ridge to the southward, and were descending the western declivity on their way home, just as the sun was setting behind the great White Mountain range, fifty miles or more away on the western horizon. At this moment the view of the intervening country, diversified in color and in shade, together with the gorgeous masses of changing clouds in the western sky, formed a picture of great beauty, and young Hamlin, fascinated with the entrancing picture spread before him, halted for a moment on the crest of a little knoll to enjoy the scene. On turning to the eastward for an instant for a final look at the woods and mountains in his rear, a vivid gleam of green flashed from an object on the roots of a tree, upturned by the wind, and caught his eye." Such was the discovery of the first of the matchless tourmalines of Mount Mica. A heavy fall of snow prevented the students from continuing their investigations on the following day, but when the winter's snow had melted they returned to the spot and soon discovered the source from whence the tree-borne fragment had been derived.

The plates are from original drawings by the author, and have been produced in color by the Coloritype Company of New York.

B. J. Harrington.

GEOLOGICAL BIOLOGY, AN INTRODUCTION TO THE GEOLOGICAL HISTORY OF ORGANISMS.—By Henry S. Williams. 8vo. pp. 395. Henry Holt & Co., New York, 1895.

Professor H. S. Williams, of Yale University, has written this book with the view of presenting to college students as well as to the general reader a clear and succinct account of the chief problems in the geological history of plants and animals and of pointing out what progress has been made in solving them by the investigations of Palæontologists in recent years.

The late Professor Huxley once said: "That the primary and direct evidence in favor of evolution can be furnished only by palæontology. The geological record, so soon as it approaches completeness, must, when properly questioned, yield either an affirmative or a negative answer: if evolution has taken place there will be its mark left; if it has not taken place, there will lie its refutation." Dr. Williams, in this book, points out how the study of the geological record shows that evolution has taken place and what the chief facts and factors of this evolution are.

The means of estimating the approximate length of time during which life has existed on the earth are first explained, and the way in which this great length of time may be divided into geological periods is referred to. The teaching of the fossil remains of animals which lived upon the earth during these enormously long periods, and its bearing upon the subject of evolution is then taken up, certain genera of fossils being selected for especial treatment, and the question: "What is a species?" considered and answered. Dr. Williams shows from these studies that the actual facts of the geological history of organisms points unmistakably to a course of evolution by descent in which the progress attained by each succeeding form was a paramount condition of the origin of the next member of the race. Dr. Williams' own investigations have added many important facts to the daily accumulating body of evidence going to establish this important conclusion. He is, however, a firm believer in the divine origin of things. "It has been supposed by many," he writes, "that evolution is intrinsically antagonistic to, and has, in fact, replaced the creational conception of the origin of things in the world. In one respect this is partly true; the new view has fundamentally changed the conception of creation. Evolution has given us another notion of God. In the old conception God was an artificer making organisms out of inorganic matter directly, as one might build up a vessel of clay and then vivify it. The new conception of God, as creator, finds its concrete empirical representation in the act of expressing a thought or purpose into the spoken word. Creation is the phenomenalizing of will, so sublimely described in that ancient formula—*In the beginning God spoke and it* (the whole phenomenal universe) *became*. . . . And the increment to organic structure, expressed by the final bursting into morphological reality, after travelling unobserved, but potential, through the organic matter of countless generations, is as much a result of creative energy as if a new species were to arise out of the dust of the earth."

The book is an excellent one, well printed and fully illustrated, and will prove of great value, especially to University teachers.

FRANK D. ADAMS.

ABSTRACT FOR THE MONTH OF NOVEMBER, 1895.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER.				BAROMETER.				†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND.		SKY CLOUDED IN TENTHS.			Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
	Mean.	Max.	Min.	Range.	Mean.	Max.	Min.	Range.				General direction.	Mean velocity in miles per hour	Mean.	Max.	Min.					
1	33.87	39.6	30.3	9.3	29.9017	30.176	29.720	.456	.1673	70.3	29.5	W.	22.46	8.5	10	4	23	0.40	....	0.40	1
2	30.32	32.3	27.8	4.5	30.2423	30.292	30.212	.080	.1372	81.3	25.2	N.	7.17	9.5	10	7	00	....	....	....	2
SUNDAY........3	.....	37.5	26.5	11.0	....	......	......	....	.....	....	....	S.E.	7.46	....	....	..	59	....	....	....	3..........SUNDAY
4	35.07	45.4	27.3	18.1	30.5177	30.594	30.441	.153	.1773	87.0	31.5	S.E.	9.75	4.7	10	0	61	....	....	....	4
5	46.35	57.3	34.1	23.2	30.3960	30.450	30.356	.094	.2263	74.0	37.7	S.W.	17.46	1.0	5	0	96	....	....	....	5
6	47.22	56.4	37.5	18.9	30.3213	30.390	30.247	.143	.2682	82.3	41.8	S.W.	13.83	3.2	10	0	82	....	....	....	6
7	52.43	56.4	47.0	9.4	30.1327	30.247	29.956	.291	.3575	90.0	49.5	S.W.	13.79	9.7	10	2	00	0.09	....	0.09	7
8	53.33	61.3	41.2	20.1	29.9198	30.023	29.872	.151	.3845	92.3	51.0	S.W.	18.08	10.0	10	10	00	0.38	....	0.38	8
9	33.78	41.2	31.2	10.0	29.9340	30.089	29.717	.372	.1862	95.8	32.8	N.E.	28.67	10.0	10	10	00	0.80	....	0.80	9
SUNDAY........10	.....	34.5	31.1	3.4	....	......	......	....	.....	....	....	W.	12.42	....	......	..	06	0.02	1.0	0.12	10..........SUNDAY
11	28.28	30.1	27.0	3.1	30.3760	30.430	30.292	.138	.1318	84.7	24.2	N.E.	12.46	6.3	10	0	21	....	0.0	0.00	11
12	33.30	35.8	27.5	8.3	30.4128	30.436	30.392	.044	.1612	84.5	29.0	N.E.	4.83	8.3	10	0	00	....	....	....	12
13	35.93	37.8	35.0	2.8	30.4737	30.518	30.411	.107	.1825	86.5	32.2	W.	5.58	8.3	10	0	00	....	....	....	13
14	39.43	45.6	32.4	13.2	30.3430	30.463	30.175	.288	.2075	85.2	35.0	S.E.	14.37	7.7	10	0	06	0.00	....	0.00	14
15	44.08	45.5	41.6	3.9	29.8177	30.060	29.655	.405	.2785	96.0	43.0	S.	14.50	10.0	10	10	00	0.14	....	0.14	15
16	39.93	43.9	36.3	7.6	29.8800	29.951	29.783	.163	.1847	75.2	32.5	S.W.	18.25	4.2	10	0	50	....	....	....	16
SUNDAY........17	.....	47.3	35.7	11.6	....	......	......	....	.....	.	....	S.	14.04	....	....	..	32	....	....	....	17..........SUNDAY
18	42.45	45.9	40.5	5.4	29.7662	29.894	29.677	.217	.2443	90.2	39.8	N.	15.29	8.3	10	0	00	0.21	....	0.21	18
19	38.23	41.6	37.0	4.6	29.7755	29.902	29.519	.383	.2303	99.7	38.0	N.E.	9.33	10.0	10	10	00	....	....	....	19
20	36.27	46.2	21.7	24.5	29.2880	29.377	29.248	.129	.2108	94.5	34.7	S.W.	20.87	10.0	10	10	00	0.12	0.0	0.12	20
21	13.25	21.7	10.5	11.2	29.7123	30.244	29.277	.967	0657	82.5	9.0	W.	32.83	7.7	10	0	45	....	3.7	0.37	21
22	15.92	21.5	7.5	14.0	30.5035	30.568	30.391	.177	.8117	89.0	13.0	S.E.	9.71	7.8	10	0	00	....	....	....	22
23	19.78	23.2	16.3	6.9	30.2307	30.550	30.026	.524	.1037	81.5	19.0	N.E.	16.42	8.8	10	3	00	....	5.6	0.56	23
SUNDAY........24	.....	30.4	19.7	10.7	....	......	......	....	.....	....	....	S.	9.08	....	...	.	13	....	0.5	0.05	24..........SUNDAY
25	18.40	35.8	7.8	28.0	30.2327	30.448	29.931	.517	.9867	92.3	16.5	N.E.	14.46	7.5	10	0	00	0.41	1.9	0.60	25
26	40.80	55.6	34.8	20.8	29.6043	29.842	29.401	.441	.2507	96.0	39.8	S.	30.92	10.0	10	10	00	1.23	....	1.23	26
27	28.27	34.8	22.8	12.0	30.3332	30.482	30.060	.422	.1238	79.8	22.8	S.W.	18.65	3.7	10	0	86	...	....	....	27
28	33.37	40.2	27.1	13.1	30.4887	30.555	30.406	.149	.1483	77.2	26.8	W.	17.16	0.2	1	0	91	....	....	....	28
29	35.65	42.2	31.8	10.4	30.1502	30.318	30.033	.285	.1608	77.3	29.2	W.	10.83	6.7	10	0	34	....	....	....	29
30	17.22	37.1	11.2	25.9	30.3598	30.481	30.097	.384	.0785	75.2	10.8	N.	15.12	1.8	10	0	97	....	0.0	0.00	30
....Means	34.34	40.80	28.61	12.19	30.1198	30.2608	29.9731	.2977	.2487	85.40	30.59	S. 45½° W.	15.19	7.07	9.46	2.92	26.7	3.80	12.7	5.07	Sums ....
21 Years means for and including this month......	32.42	38.86	26.49	12.37	30.0124	.....	......	.2644	.1597	79.68	....	......	ꟷ16.49	7.37	..	..	¶29.09	2.35	12.78	3.62	21 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	1143	1762	198	933	1598	3353	1861	96	
Duration in hrs..	83	123	20	85	123	162	111	9	4
Mean velocity....	13.77	14.32	9.90	10.97	12.99	20.69	16.77	10.67	

Greatest mileage in one hour was 47 on the 26th.

Greatest velocity in gusts, 60 miles per hour on the 26th.

Resultant mileage, 3,090.
Resultant direction, S. 45½° W.
Total mileage, 10,944.
Average velocity 15.20 m. p. h.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 14 years only. ꟷ Ten years only.

The greatest heat was 61.3° on the 8th; the greatest cold was 7.5° on the 22nd, giving a range of temperature of 53.8 degrees.

Warmest day was the 8th. Coldest day was the 21st. Highest barometer reading was 30.594 on the 4th. Lowest barometer was 29.248 on the 20th, giving a range of 1.346 inches. Maximum relative humidity was 100 on the 1st, 15th, 19th, 25th and 26th. Minimum relative humidity was 51 on the 5th.

Rain fell on 11 days.
Snow fell on 8 days.
Rain or snow fell on 16 days.
Lunar halos on 3 nights, 4th, 6th and 30th.
Lunar coronas on 1 night, 1st.
Hoar frost on 2 days, 4th and 29th.
Thunder and lightning on 9th.

ABSTRACT FOR THE MONTH OF DECEMBER, 1895.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	THERMOMETER. Max.	THERMOMETER. Min.	THERMOMETER. Range.	BAROMETER. Mean.	BAROMETER. Max.	BAROMETER. Min.	BAROMETER. Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	SKY CLOUDED IN TENTHS. Max.	SKY CLOUDED IN TENTHS. Min.	Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY
SUNDAY. 1	.....	23.9	9.2	14.7	......	......	......	....	.....	....	....	N.E.	7.42	....	....	..	43	....	....	....	1... ....SUNDAY
2	24.23	27.6	18.3	9.3	29.6845	29.863	29.582	.281	.1298	99.2	23.8	N.	8.54	10.0	10	10	00	inap.	4.6	0.46	2
3	7.58	18.3	3.7	14.6	29.9520	30.108	29.768	.340	.0558	90.5	5.3	S.W.	11.37	3.7	10	0	70	....	1.0	0.10	3
4	6.32	10.7	0.6	10.1	30.2060	30.244	30.148	.051	.0573	98.5	6.0	S.E.	7.37	5.8	8	0	37	....	....	....	4
5	10.67	14.8	5.6	9.2	30.1188	30.202	29.996	.306	.0678	95.7	9.5	N.	7.75	9 3	10	8	18	....	....	....	5
6	13.33	17.8	9.0	8.8	29.9965	30.090	29.927	.063	.0678	85.2	9.8	S.W.	19.79	1.8	8	0	75	....	....	....	6
7	20.47	27.4	10.0	17.4	29.8620	30.093	29.723	.370	.1082	95.2	19 3	S.E.	9.96	10.0	10	10	00	....	5.3	0.53	7
SUNDAY....... 8	.....	21.8	1.2	20.6	....	......	......	....	.....	....	....	N.	10 71	....	......	..	87	....	0.4	0.04	8..........SUNDAY
9	2.08	7.2	—4.9	12.1	30.2793	30.330	30.202	.128	.0453	93.3	0.5	S.	15.00	1.8	10	0	53	....	inap.	inap.	9
10	19.22	26.6	6.0	20.6	30.1010	30.177	30.053	.124	.0927	87.5	16.0	S.	16.12	6.8	10	0	05	....	0.3	0.03	10
11	1.35	8.5	—1.7	10.2	30.1960	30.293	30.137	.156	.0425	93 0	—0.7	N.	28.37	0.5	..	0	92	....	....	....	11
12	—5.02	—0.2	—9.9	9.7	30.4248	30.471	30.338	.133	.0307	89.8	—7.5	N.	18.46	2.5	8	0	65	....	....	....	12
13	—4.25	1.2	—10.3	11.5	30.4162	30.467	30.356	.111	.0387	96 5	—5.0	N.	12.87	0 0	0	0	61	....	....	....	13
14	3.03	9.3	—4.7	14.0	30.2275	30.342	30.120	.222	.0483	94.0	—1.8	N.	9.79	0.2	2	0	67	....	....	....	14
SUNDAY.......15	.....	28.4	2.8	25.6	......	......	......	...	.....	....	....	E.	11.54	....	..	..	00	....	....	....	15..........SUNDAY
16	17.98	23.5	11.4	12 1	30.6078	30.749	30.390	.359	.0820	83.2	13.8	W.	13.08	0.0	0	0	81	...	....	....	16
17	13.95	29.5	1.4	28.1	30.5665	30.772	30.374	.388	.0742	86.7	10.5	E.	16.00	6.5	10	0	13	inap.	inap.	inap.	17
18	35.40	39.0	29.5	9.5	30.2125	30.353	30.013	.340	.1807	86.3	31.7	S.	21.92	10.0	10	10	00	0.05	inap.	0.05	18
19	38.90	41.8	35.5	6.3	30.1883	30.255	30.130	.119	.2350	99.0	38.5	S.W.	14.50	10.0	10	10	00	0.05	....	0.05	19
20	45.65	48.3	39.5	8.8	30.2162	30.311	30.152	.159	.2775	90.7	42.8	S.	20.67	9.2	10	5	01	....	....	....	20
21	47.07	54.4	39.4	15.5	30.2830	30.395	30.136	.249	.2752	85.2	42.8	S.	16.50	5.5	10	0	79	....	....	....	21
SUNDAY.......22	.....	40.4	35.8	4.6	....	......	......	....	.....	....	....	W.	23.37	....	...		00	0.63	....	0.63	22..........SUNDAY
23	37.02	38.5	34.3	4.2	29.9455	30.056	29.816	.240	.2027	91.8	34.8	S.W.	11.29	10.0	10	10	00	0.18	....	0.18	23
24	34.37	38.0	32.2	5.8	30.1167	30.210	29.959	.251	.1663	84 0	29.8	W.	10.92	3.7	10	0	73	....	.	....	24
25	38.32	43.9	31.7	12.2	30.0475	30.174	29.982	.192	.2000	85.5	34.2	S.E.	11 12	9.7	10	8	23	0.03	....	0.03	25
26	48.10	53.2	41.5	11.7	29.7155	29.958	29.374	.584	.3050	90.2	45.2	S.	21.04	10.0	10	10	00	0.32	....	0.32	26
27	31.85	51.2	23 5	27.7	29.6995	29.928	29.109	.819	.1667	85.8	28.2	W.	27.50	7 7	10	0	25	...	0.1	0.01	27
28	30.47	34.8	24.2	10.6	29.9362	29.987	29.834	.153	.1605	94.0	28.8	S.	9.75	7.5	10	2	15	....	0.2	0.02	28
SUNDAY.......29	....	37.7	29.6	8.1	....	......	......	....	... .	....	....	S.	15.33	...	....	..	65	....	....	....	29..........SUNDAY
30	34.42	37.0	30.0	7.0	29.8820	30.043	29.498	.545	.1820	90.8	32.0	S.	13.42	7.7	10	0	05	0.66	....	0 66	30
31	31.30	40.6	26.0	14.6	29.1812	29.353	28 924	.429	.1568	87.3	27.8	N.	44.71	9.3	10	8	27	0.20	0.1	0.21	31
Means	22.46	28.87	16.14	12.73	30.0793	30.201	29.925	.274	.1327	90.7	19.8	S. 33° W.	15.68	6.1	8.4	3.5	34.8	2.12	12.0	3.32	... . Sums
21 Years means for and including this month......	14.87	....	... .	.... ..	30.0294	.....	......	.295	.0996	82.6	....	......	§16.71	6.96	..	..	¶29.65	1.33	23.4	3.62	21 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	2579	648	525	1103	3066	1635	1524	589	
Duration in hrs..	145	58	49	95	193	94	84	25	1
Mean velocity....	17.79	11.17	10.71	11.61	15.89	17.39	18.14	23.56	

Greatest mileage in one hour was 67 on the 31st.
Greatest velocity in gusts, 80 miles per hour on the 31st.

Resultant mileage, 2,425.
Resultant direction, S. 33° W.
Total mileage, 11,669.
Average velocity 15.68 m. p. h.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 14 years only. § Ten years only.

The greatest heat was 54.4° on the 21st; the greatest cold was —10.3° on the 13th, giving a range of temperature of 64.7 degrees.

Warmest day was the 26th. Coldest day was the 12th. Highest barometer reading was 30.772 on the 17th. Lowest barometer was 28.924 on the 31st, giving a range of 1.848 inches. Maximum relative humidity was 100 on the 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 12th, 13th, 14th, 17th, 19th, 22nd, 26th, 28th, 30th and 31st. Minimum relative humidity was 65 on the 12th.

Rain fell on 10 days.
Snow fell on 11 days.
Rain or snow fell on 17 days.
Auroras were observed on 1 night, 8th.
Lunar halos on 1 night, 4th.
Lunar coronas on 3 nights, 24th, 25th and 27th.
Hoar frost on 4 days, 9th, 14th, 24th and 30th.
Earthquake shock at 12.25 a.m. on 9th.
Very heavy wind storm on 31st.

Meteorological Abstract for the Year 1895.

Observations made at McGill College Observatory, Montreal, Canada.—Height above sea level 187 ft. Latitude N. 45° 30′ 17″. Longitude $4^h\ 54^m\ 18{\cdot}55^s$ W.

C. H. McLEOD, *Superintendent.*

Month.	Thermometer. Mean.	¶ Deviation from 21 years means.	Max.	Min.	Mean daily range.	* Barometer. Mean.	Max.	Min.	Mean daily range.	† Mean pressure of vapour.	‡ Mean relative humidity.	Mean dew point.	Wind. Resultant direction.	Mean velocity in miles per hour.	Sky clouded per cent.	Per cent. possible bright sunshine.	Inches of rain.	Number of days on which rain fell.	Inches of snow.	Number of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain *and* snow fell.	No. of days on which rain *or* snow fell.
January	14.89	+ 2.96	37.2	—12.7	15.31	29.9346	30.637	29.200	241	.0789	82.8	10.6	S. 70° W.	14.6	59	40	1.36	4	24.9	18	3.76	2	20
February	14.20	— 1.64	37.2	—19.8	14.26	29.8003	30.347	28.832	.255	.0853	87.5	11.1	S. 64° W.	20.6	60	47	0.00	2	24.7	15	2.45	1	16
March	22.13	— 2.15	40.7	— 6.0	15.29	29.9327	30.496	29.381	.247	.1093	84.0	18.2	S. 67° W.	16.1	51	59	0.45	4	5.6	15	1.01	2	17
April	41 17	+ 1.17	68.6	16.0	16.06	29.9984	30.656	29.236	.222	.1934	73.4	32.7	N. 34° W.	13 7	54	46	3.76	12	0.0	1	3.76	..	13
May	58.27	+ 3.66	87.1	32.8	19.96	29.9663	30.498	29.429	.155	.3537	67.8	46.9	S. 59° W.	14.6	54	53	3.31	17	0.0	1	3.31	1	17
June	69.54	+ 4.51	86.4	52.8	17.14	29.9877	30.428	29.603	.148	.5489	79.2	61.0	S. 51° W.	13.4	55	63	3.74	12	....	..	3.74	..	12
July	67.21	— 1.54	87.5	51.2	16.84	29 8944	30.189	29.471	.138	.4632	69.0	56.1	S. 56° W.	12 3	56	58	2.38	12	....	..	2.38	..	12
August	65.84	— 0.87	82.2	47.7	15.10	29.8658	30.242	29.539	.148	.4916	77.2	58.0	S. 54° W.	15.7	53	58	6.92	23	...	..	6.92	..	23
September	60.30	+ 1.70	86.3	36.5	16.88	29.9508	30.313	29.587	.172	.4211	76.1	52.3	S. 44° W.	14.5	47	63	3.40	10	....	..	3.40	.	10
October	41.22	— 4.13	61.1	23.8	15.09	29.9812	30.571	29.462	.272	.1993	74.2	33.2	S. 25° W.	15.4	63	43	0.64	14	0.8	2	0.71	.	16
November	34.34	+ 1.92	61.3	7.5	12.19	30.1198	30.594	29.248	.298	.2487	85.4	30.6	S. 45° W.	15.2	71	27	3.80	11	12.7	8	5.07	3	16
December	22.46	+ 3.51	54.4	—10.3	12.73	30.0793	30.772	28.924	.274	.1327	90.7	19.8	S. 33° W.	15.7	61	35	2.12	10	12.0	11	3.32	4	17
Sums for 1895	...	...	....	....	....	...	....	....	....	....	...	....		....	....	....	31.88	131	80.7	71	39.83	13	189
Means for 1895	42.63	+ 0.76	....	....	15.57	29.9634	....	....	.214	.2772	78.9	35.9	S. 52° W.	15.15	57.0	49.2	....	....	....	..	3.32	..	16
Means for 21 years ending Dec. 31, 1895.	41.82	....	....	....	...	29.9783	....	....	....	.2519	74.7	....	....	α 15.18	61.0	§ 45.6	28.17	133	118.1	78	39.67	16	200

Ten years (1885-94) Means of bi-hourly temperatures at Montreal.

Month.	1h	3h	5h	7h	9h	11h	13h	15h	17h	19h	21h	23h	Means.	Month.
January	11.34	10 59	9 76	9 53	10.41	12 88	14.37	14.95	13.92	13.50	12.69	12.13	12.17	January
February	12.21	11.45	10.49	9.95	11.82	14.60	16.24	17.01	15.85	14.86	14.16	13.45	13.51	February
March	22.39	21.41	20.09	20.36	23.08	25.98	27.76	28.42	27.55	25.83	24.68	23 81	24.28	March
April	36.78	35.46	34.14	36.38	39.86	43.32	45.47	46.27	45.65	42.31	40.25	38.73	40.39	April
May	50.66	49.12	47.73	51.08	55 29	58.76	61.41	62.33	61.22	57.55	54.77	52.81	55.23	May
June	60.69	59.40	58.64	62.26	65.82	69.18	71.21	71.80	70.31	66.86	63.89	62.23	65 19	June
July	64.25	62 82	62.11	65.69	69.65	73.17	75.04	75.75	74.02	70.25	67.42	65.83	68.83	July
August	61.44	61.32	59 44	62 02	66.22	69.75	71.78	72.09	70.39	66.30	63.90	62.53	65.52	August
September	51.48	53.46	52.77	54 01	58.25	61 91	63.78	64.29	62.53	58.68	56.93	55.52	58.05	September
October	43.00	42 16	41 65	41 69	44 98	48.20	49.72	49.94	48.10	45.77	44.43	43.50	45.26	October
November	31.95	31.49	31.03	30.77	32 44	34.64	35.64	35.56	34.28	33.37	32.54	31.88	32.97	November
December	18.64	18.31	17.37	16 83	17 73	19.71	20.73	21.02	19 96	19.61	19.12	18.77	18.98	December
Sums for 1895	.....	.....	.	.....	.	.....	....	.....	.....	.....	.....	.....	500.38	Sums for 1895
Means for 1895	38.99	38.00	37.10	38.38	41 30	44.34	46.10	46.12	45.31	42.91	41.23	40.10	41.70	Means for 1895
Means for 21 years ending Dec. 31, 1895.	. ...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.. .	Means for 21 years ending Dec. 31, 1895.

* Barometer readings reduced to 32° Fah. and to sea level. † Inches of mercury. ‡ Saturation 100. § For 14 years only. ¶ "+" indicates that the temperature has been *higher*: "—" that it has been *lower* than the average for 21 years inclusive of 1895. The monthly means are derived from readings taken every 4th hour, beginning with 3 h. 0 m. Eastern Standard time. The anemometer and wind vane are on the summit of Mount Royal, 57 feet above the ground and 810 feet above the sea level. α For 9 years only.

The greatest heat was 87.5° on July 8: the greatest cold was 19.8° below zero on February 6. The extreme range of temperature was therefore 107.3. Greatest range of the thermometer in one day was 31.8° on Januuary 4: least range was 2.8° on November 13. The warmest day was July 8, when the mean temperature was 78.55°. The coldest day was February 6, when the mean temperature was 13.33° below zero. The highest barometer reading was 30.772 on December 17. Lowest barometer reading was 28.832 on February 8, giving a range of 1.940 for the year. The lowest relative humidity was 29 on May 18. The greatest mileage of wind recorded in one hour was 67 on December 31, and the greatest velocity in gusts was at the rate of 80 miles p. h. on December 31. The total mileage of wind was 129,326. The resultant direction of the wind for the year is S.52° W., and the resultant mileage was 62 856. Auroras were observed on 15 nights. Fogs on 11 days. Thunder storms on 9 days. Lunar halos on 14 nights. Lunar coronas on 7 nights. Solar halos on 20 days. Earthquakes were felt on 2 days, April 17th and December 9th. The sleighing of the winter commenced in the city on November 21. The first appreciable snowfall of the autumn was on October 20.

NOTE.—The yearly means of the above, are the averages of the monthly means, except for the velocity of the wind.

ABSTRACT FOR THE MONTH OF JANUARY, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER.				BAROMETER.				†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND.		SKY CLOUDED IN TENTHS			Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY
	Mean.	Max.	Min.	Range.	Mean.	Max.	Min.	Range.				General direction.	Mean velocity in miles perhour	Mean.	Max.	Min.					
1	26.13	29.2	24.2	5.0	29.6668	29.912	29.461	.451	.1035	73.3	19.0	N.W.	37.75	8.3	10	0	00	....	Inap.	Inap.	1
2	27.50	31.8	20.6	11.2	29.8643	30.024	29.597	.427	.1275	84.7	23.7	S.	14.42	8.3	10	4	51	....	1.4	0.14	2
3	23.52	35.3	6.3	29.0	29.5475	29.728	29.431	.297	1053	78.3	17.7	N.	30.08	6.5	10	0	68	....	0.4	0.04	3
4	—5.80	6.3	—13.0	19.3	30.0698	30.235	29.885	.350	.0312	94.5	—7.3	N.	23.62	5.2	10	0	18	....	....	....	4
SUNDAY........5	.....	—13.1	—19.7	6.6	......	......	......	....	.....		....	N.	11.83	....	.....	..	67	....	....	....	5..........SUNDAY
6	—15.45	—11.4	—21.2	9.8	30.6507	30.675	30.591	.084	.0203	98.3	—16.0	N.	6.58	0.0	0	0	95	....	....	....	6
7	—6.23	—0.2	—13.0	12.8	30.4145	30.619	30.272	.347	0312	95.8	—7 3	N.	16.00	4.5	10	0	00	....	Inap.	Inap.	7
8	2.42	6.4	—3.0	9.4	30.2613	30.345	30.170	.175	.0373	78.2	—3 2	N.	1.96	1.2	7	0	87	....	....	....	8
9	8.27	10.8	4.3	6.5	30.0830	30.110	30.048	.062	.0575	90.3	6.0	N.	15.04	7.0	10	0	00	....	1.0	0.10	9
10	11.07	15.4	7.8	7.6	30.2392	30.298	30.172	.126	0670	94.0	9.3	N.	15.54	3.7	10	0	74	....	0.1	0.01	10
11	9.70	14.7	4.6	10.1	30.2642	30.327	30.178	.149	.0640	94 7	8.5	N.	7.29	0.0	0	0	76	....	....	....	11
SUNDAY........12	.....	26.7	2.2	24.5	....	.....	......	...	.....	....	....	E.	9.46	....	...	..	04	....	2.0	0.20	12..........SUNDAY
13	21.33	23.8	17.9	5.9	29.9730	30.108	29.887	.221	.0982	85.5	17.7	W.	17.39	9.3	10	8	36	....	Inap.	Inap.	13
14	18.58	22.8	15.2	7.6	30.1027	30.235	30.012	.223	.0925	91 5	16.5	N.W.	15 17	8.5	10	5	41	....	1.1	0.11	14
15	11.05	17.3	6.6	10 7	30.4358	30.517	30.309	.208	.0615	86.0	7.7	N.W.	19.83	3.3	10	0	51	....	....	....	15
16	13.93	20.0	5.4	14.6	30.2870	30.508	30.123	.385	.0788	94.0	12.3	S.	7.83	8.3	10	0	00	...	0.9	0.9	16
17	14.58	21.8	11.6	10.2	30.3300	30.419	30.244	.175	.0728	85.8	11.3	N.W.	11.04	4.3	10	0	72	....	....	....	17
18	17.68	20.9	13.0	7.9	30.1958	30.258	30.145	.113	0863	88.8	15.0	N.W.	9.62	7.5	10	0	48	....	0.1	0.1	18
SUNDAY........19	.....	20.2	10.8	9.4	.... .	......	......	....	....	....	....	N.W.	19.21	....	...	.	67	....	....	....	19..........SUNDAY
20	13.93	18.6	8.0	10.6	30.2638	30.370	30.124	.246	.0748	90 8	11.5	N.W.	12.21	7.3	10	0	28	....	0.3	0.03	20
21	20.45	24.2	17.2	7.0	30.1377	30.222	30 091	.131	.1023	93.2	18.7	S.	4.92	10.0	10	10	00	....	1.6	0.14	21
22	19.23	23.6	14.8	8.8	30.3837	30.472	30 258	.214	.0918	88.3	16.3	N.W.	7.50	6.0	10	0	65	....	....	....	22
23	15.03	18.1	12.6	5.5	30.4528	30.519	30.385	.134	.0817	94.2	13.7	N.	9.29	7.0	10	0	43	...	....	....	23
24	19.72	26.2	11.4	14.8	30.1162	30.298	29.922	.376	.1030	94.2	18.2	N.	19.29	8.3	10	0	00	....	6.6	0.66	24
25	27.42	30.6	23.8	6.8	30.0000	30.070	29.916	.154	.1425	95.2	26.0	N.	16 67	10.0	10	10	00	....	2.9	0.30	25
SUNDAY........26	.....	28.6	24.0	4.6	....	. ....	......	....	... .	....	....	N.W.	6.12	...	....	..	00	....	2.3	0.28	26..........SUNDAY
27	15.18	26.3	10 3	16.0	30.0640	30.114	30.025	.089	.0780	87.8	12.2	N.W.	22.33	7 0	10	0	55	...	....	....	27
28	1.83	10.3	—2 6	12.9	30.2687	30.345	30.157	.188	.0403	85.5	—1.7	N.W.	16.92	1.0	6	0	100	....	....	....	28
29	2.15	4.8	—2 0	6.8	30.3175	30.384	30.232	.152	.0417	87.2	—1.2	N.	10.42	8.0	10	0	00	....	....	....	29
30	13.45	18.8	6.0	12.8	30.3098	30.464	30.223	.241	.0062	80.8	8.5	N.W.	14.18	5.0	10	0	48	....	Inap.	Inap.	30
31	7.07	15.0	4.0	11.0	30.4468	30.547	30 260	.287	.0475	80.0	1.8	N.E.	10.71	6.2	10	0	49	...	....	....	31
Means	12.36	17.54	6.71	10.83	30.1906	30.300	30.078	.222	.0742	88.5	9.4	N.20°W.	14.52	6.0	9.0	1.4	40.1	....	20.7	2.11	.... Sums
22 Years means for and including this month......	11.94	20.32	4 11	16.21	30.0596	.....	......	.324	.0726	81.5	....	......	ꞩ16.68	6.3	..	..	¶30.9	....	23.8	3.54	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	4379	484	456	32	487	69	304	4352	
Duration in hrs..	311	26	59	3	46	4	15	260	20
Mean velocity....	14.08	18.62	7.75	10.67	10.59	17.25	20.27	16.74	

Greatest mileage in one hour was 52 on the 1st.

Greatest velocity in gusts, 60 miles per hour on the 1st.

Resultant mileage, 7,710.

Resultant direction, N. 20° W.

Total mileage, 10,563.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ꞩ Ten years only.

The greatest heat was 35.3° on the 3rd; the greatest cold was —21.2° on the 6th, giving a range of temperature of 56.5 degrees.

Warmest day was the 2nd. Coldest day was the 5th. Highest barometer reading was 30.675 on the 6th. Lowest barometer was 29.431 on the 3rd, giving a range of 1.244 inches. Maximum relative humidity was 100 on the 4th, 5th, 6th, 7th, 9th, 10th, 11th, 12th, 16th, 23rd and 24th. Minimum relative humidity was 61 on the 1st.

Snow fell on 17 days.

Auroras were observed on 2 nights, 3rd and 9th.

Hoar frost on 2 days, 11th and 12th.

Lunar halos on 1 night, 28th.

Lunar coronas on 2 nights, 3rd and 9th.

ABSTRACT FOR THE MONTH OF FEBRUARY, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	THERMOMETER. Max.	THERMOMETER. Min.	THERMOMETER. Range.	BAROMETER. Mean.	BAROMETER. Max.	BAROMETER. Min.	BAROMETER. Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles perhour	SKY CLOUDED IN TENTHS Mean.	SKY CLOUDED IN TENTHS Max.	SKY CLOUDED IN TENTHS Min.	Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	21.12	32.8	4.6	28.2	29.7548	30.163	29.456	.707	.1168	95.8	20.0	N.	13.79	10.0	10	10	00	....	1.9	0.20	1
SUNDAY.........2	.....	29.0	13.0	16.0	......	......	......	....	.....	..	....	N.W.	22.83	....	.....	..	28	....	0.2	0.02	2...........SUNDAY
3	10.43	14.8	3.8	11.0	29.9937	30.112	29.876	.236	.0603	86.5	7.2	N.	14.00	4.8	10	0	07	....	....	....	3
4	15.52	20.8	7.6	13.2	29.8975	29.918	29.867	.051	.0817	91.3	13.5	N.W.	12.08	9.0	10	4	05	....	0.7	0.05	4
5	30.28	33.7	19.5	14.2	29.8978	29.921	29.857	.064	.1447	87.3	26.7	S.W.	11.46	10.0	10	10	00	....	0.8	0.08	5
6	32.95	34.4	31.6	2.8	29.5222	29.921	28.934	.987	.1777	94.8	31.5	N.E.	21.17	10.0	10	10	00	....	3.3	0.52	6
7	31.83	33.6	30.5	3.1	29.1032	29.424	28.786	.638	.1712	95.7	30.7	N.W.	18.58	9.5	10	7	00	....	1.0	0.25	7
8	21.92	30.5	18.8	11.7	29.8822	30.000	29.668	.332	.1082	93.0	20.0	N.W.	23.21	1.8	10	0	100	....	....	....	8
SUNDAY........9	.....	18.8	7.6	11.2	....	......	......	...	.....	....	....	N.	21.12	...	...	..	00	....	5.2	0.48	9...........SUNDAY
10	18.02	22.3	11.4	10.9	29.5820	29.644	29.464	.180	.0878	88.3	15.0	N.W.	23.21	5.8	10	0	95	....	1.0	0.10	10
11	24.40	30.3	19.6	10.7	29.4208	29.649	29.293	.356	.1165	87.3	21.3	N.W.	35.46	9.5	10	5	36	....	1.4	0.14	11
12	12.28	19.5	8.9	10.6	30.0975	30.240	29.851	.389	.0658	85.2	9.0	N.W.	29.75	2.0	10	0	100	....	....	....	12
13	11.33	14.2	8.4	5.8	29.8973	30.236	29.538	.698	.0683	94.2	10.2	N.	16.87	10.0	10	10	00	....	2.6	0.35	13
14	13.08	19.4	7.3	12.1	29.8250	30.081	29.621	.460	.0665	83.8	8.7	N.W.	26.50	4.5	10	0	76	....	0.2	0.02	14
15	0.78	7.3	−1.5	8.8	30.0235	30.141	29.914	.227	.0405	90.7	−1.5	N.	19.46	8.3	10	0	00	....	1.7	0.19	15
SUNDAY.......16	.....	2.7	−17.2	19.9	......	......	......	....	.....	....	....	N.	13.62	....	...		94	...	....	....	16...........SUNDAY
17	−16.02	−10.0	−22.6	12.6	30.5542	30.601	30.517	.084	.0192	93.3	−17.3	N.	22.08	0.0	0	0	100	....	....	....	17
18	−10.92	−3.3	−23.4	20.1	30.2185	30.499	29.890	.609	.0250	94.3	−12.2	N.E.	11.79	1.3	5	0	86	....	....	....	18
19	8.23	22.6	−7.0	29.6	29.5465	29.784	29.363	.421	.0598	90.5	5.8	E.	9.37	7.8	10	0	35	....	0.4	0.05	19
20	14.80	20.6	11.9	8.7	29.4598	29.719	29.327	.392	.0798	92.5	15.0	N.W.	18.85	6.8	10	0	00	....	3.9	0.35	20
21	1.15	12.2	−1.7	13.9	30.0530	30.189	29.853	.336	.0383	84.2	−2.7	N.W.	28.29	2.0	8	0	86	....	...	....	21
22	14.52	23.6	−2.9	26.5	30.0378	30.197	29.943	.254	.0842	90.2	12.3	N.W.	30.04	4.8	10	0	33	....	Inap.	Inap.	22
SUNDAY........23	.....	35.7	13.6	22.1	....	......	......	....	....	....	....	S.	25.92	...	....	..	00	...	1.5	0.17	23...........SUNDAY
24	25.10	35.8	11.1	24.7	29.7283	29.956	29.547	.409	.1247	88.3	22.0	N.W.	26.21	7.7	10	4	51	....	0.1	0.02	24
25	2.55	11.1	−2.6	13.7	30.0555	30.104	29.988	.116	.0418	85.8	−0.2	N.W.	20.33	0.0	0	0	100	...	....	....	25
26	2.28	9.8	−5.0	14.8	29.8390	29.945	29.760	.185	.0455	92.5	0.2	N.W.	13.33	2.3	8	0	40	....	....	....	26
27	11.07	20.6	−1.5	22.1	29.8533	29.913	29.744	.169	.0658	87.7	8.0	S.E.	7.54	4.7	10	0	56	...	....		27
28	34.92	40.5	19.4	21.1	29.6955	29.736	29.677	.059	.1758	85.0	30.7	S.	23.12	7.2	10	3	53	....	....	....	28
29	37.18	41.5	33.4	8.1	29.8437	29.899	29.774	.125	.2215	99.0	37.2	S.	20.42	10.0	10	10	00	0.35	....	....	29
30	.....	.....	.....	.....	......	......	......	....	.....	....	....	......	.....	...	...	.	..	....	....	....	30
31	.....	.....	.....	.....	......	......	......	....	.....	....	....	......	.....	....	...	..	.	...	....	....	31
Means	14.75	21.54	6.78	14.76	29.8314	29.999	29.660	.339	.0915	90.3	12.44	N. 30¾° W.	20.02	6.0	8.8	2.9	40.7	0.35	25.9	3.34	... . Sums
22 Years means for and including this month......	15.34	23.60	6.79	16.80	30.0272	.....	......	.305	.0824	79.8	....	......	ʃ18.48	5.9	..	..	¶41.6	0.765	22.6	2.96	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	2778	800	544	444	1666			7750	
Duration in hrs..	151	40	60	33	88			320	4
Mean velocity....	18.07	20.00	9.07	13.45	18.93			24.22	

Greatest mileage in one hour was 66 on the 11th.

Greatest velocity in gusts, 90 miles per hour on the 11th.

Resultant mileage, 7,930.

Resultant direction, N. 30¾° W.

Total mileage, 13,932

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ʃ Ten years only.

The greatest heat was 41.5° on the 29th; the greatest cold was −23.4° on the 18th, giving a range of temperature of 64.9 degrees.

Warmest day was the 29th. Coldest day was the 17th. Highest barometer reading was 30.601 on the 17th. Lowest barometer was 28.786 on the 7th, giving a range of 1.815 inches. Maximum relative humidity was 100 on the 6th, 15th, 17th, 18th, 19th, 28th. and 29th. Minimum relative humidity was 71 on the 19th.

Rain fell on 1 day, 29th.

Snow fell on 17 days.

Rain or snow fell on 18 days.

Auroras were observed on 2 nights, 14th & 21st.

Lunar halos on 1 night, 28th.

Lunar coronas on 2 nights, 24th and 27th.

Hail storm on the 24th.

ABSTRACT FOR THE MONTH OF MARCH, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range.	BAROMETER. Mean.	Max.	Min.	Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles per hour	SKY CLOUDED IN TENTHS Mean	Max	Min	Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
SUNDAY.........1	.....	39.0	32.0	7.0	......	......	......	....	.....	....	....	N.W.	21.46	....	.....	..	00	0.38	....	0 38	1............SUNDAY
2	19.57	32.0	14.2	17.8	29.7067	29.775	29.589	.186	.0798	89.7	12.7	S.W.	38.54	9.0	10	8	08	....	3.6	0.42	2
3	16.82	20.4	10.6	9.8	29.9262	30.041	29.771	.270	.0823	86.8	13.7	N.W.	23.83	7.5	10	0	00	....	3.9	0.44	3
4	10.07	21.4	0.9	20.5	29.9867	30.066	29.884	.182	0557	78.2	4.5	N.W.	21.33	6.5	10	0	45	....	Inap.	Inap.	4
5	15.60	23.9	7.8	16.1	30.0278	30.075	29.992	.083	.0682	77.3	9.5	S.	14.42	9.5	10	9	00	....	0.2	0.02	5
6	24.03	27.0	18 8	8.2	30.0210	30.125	29.879	.246	.1063	82.7	19.7	S.	9.47	9 3	10	7	06	....	Inap.	Inap.	6
7	30.80	35.2	24.0	11.2	29.4955	29.798	29.275	.523	.1605	93.0	28.7	S. E.	24.71	10 0	10	10	00	....	5.4	0.61	7
SUNDAY.........8	.....	29.3	15.1	14.2	....	... .	......	...	.....	....	....	N.W.	34.87	..	..	..	27	....	Inap.	Inap.	8...........SUNDAY
9	14.95	19.7	10.5	9 2	29.8042	29.866	29.732	.134	.0575	78.7	9 8	N.W.	28 50	7.8	10	0	03	....	....	....	9
10	10 58	16.6	4.5	12.1	29.8892	29.912	29.850	.062	.0537	76.3	4.3	N.W.	22.00	0 3	2	0	87	....	....	....	10
11	9.25	14.2	0.4	13.8	29.8242	30.001	29 522	.479	.0502	76.3	3.2	N.W.	21.04	5.8	10	0	62	....	Inap.	Inap.	11
12	11.22	16.4	7.8	8.6	29.4577	29.820	29.247	.573	.0643	88 3	8.5	N.W.	31.12	8.3	10	0	00	....	2 0	0.21	12
13	7.82	13.4	1.6	11.8	30.1685	30.331	29.975	.356	.0425	69 7	—0.8	N.	23.29	4 3	10	0	75	....	....	....	13
14	11.67	19.1	1.9	17.2	30.3997	30.431	30.363	.068	.0582	76.3	6.2	N.	19.33	0 0	0	0	71	....	....	....	14
SUNDAY........15	.....	21.7	6.6	15 1	....	......	......	....	....	...	....	N.	14.29	..	.		56	....	....	....	15...........SUNDAY
16	16.83	23.8	2.5	21.3	30.0598	30.173	29.898	.280	.0798	83.5	12.7	N.	11.00	6.3	10	0	21	...	1.3	0.05	16
17	26.18	32.6	20.8	11.8	29.9402	30.089	29.835	.254	.1218	86.7	22 8	N.	18.79	4.5	10	0	57	....	1.1	0.18	17
18	29.08	35.3	22.2	13.1	30.2010	30.231	30.166	.065	.1425	89.2	26.3	N.	14.58	5.0	7	0	54	....	Inap.	Inap.	18
19	30.15	31.7	28.4	3.3	29.7093	30.133	29.189	944	.1648	98.3	29.5	N.E.	19.33	10.0	10	10	00	0.08	14.5	2.04	19
20	23.12	32.1	15.5	16.6	29.3700	29.793	29 039	.754	.1147	88 7	20.5	N.	13.37	5.3	10	0	00	0.26	2.3	0.43	20
21	20.08	29 8	9.2	20.6	29.9647	30.049	29 829	.220	.0958	86.3	16.7	N.	13.75	3.2	9	0	73	....	....	....	21
SUNDAY........22	.....	39.1	9.0	30.1	....	......	......	....	... .	....	....	N.W.	20.79	...	....	..	71	0.02	....	0.02	22...........SUNDAY
23	2.65	9.0	—2.0	11.0	30.5950	30.650	30 562	.088	.0403	82.8	—1.5	S.	6.50	0.5	6	0	79	...	....	....	23
24	8.12	16.7	—3 2	19.9	30.5612	30.682	30.376	.306	.0488	76.5	2.2	S.	6.67	1.0	5	0	73	....	....	....	24
25	26.32	35.8	8.4	27.4	29.8978	30.086	29.640	.446	.1307	87.5	23.0	S.	23 87	6.5	10	0	65	..	Inap.	Inap.	25
26	33.28	38.8	22.9	15.9	29.5093	29.594	29.420	.174	.1897	97.8	32.5	S.	15.08	10.0	10	10	00	1.29	2.0	1.53	26
27	16.98	23.0	9.9	13.1	29.7410	29.940	29.540	.400	.0820	86.5	13 3	N.W.	32.54	2 3	10	0	84	...	2.0	0.16	27
28	20.70	27.3	12 5	14.8	30.1708	30.219	30.051	.168	.0945	85.0	17.0	W.	16.16	0.5	6	0	97	....	....	....	28
SUNDAY........29	.....	37.2	11.6	25.6	....	......	......	....	.....	....	....	W.	4.38	....	...	..	00	0.04	1.2	0.22	29 ....SUNDAY
30	39.83	45.6	36.3	9.3	29.7848	29.885	29.747	.138	.2152	88.3	36.2	S. W.	11.04	4.8	10	0	67	0.06	....	0.06	30
31	25.30	43.1	25.7	17.4	30.0695	30.251	29.989	.262	.1793	87.3	31.5	S. W.	18.96	1.3	6	0	90	....	....	....	31
Means	19.65	27.42	12.46	14.96	29.9339	30.078	29.783	.295	.0995	84.5	15.5	N. 51½° W.	19.23	5.5	8.5	2.1	41.0	2.13	39.5	6.97	... . Sums
22 Years means for and including this month......	24 07	31.43	16 45	14.76	29.9672	.....	.....	.263	.1083	76.3	....	......	¶18.10	6.0	..	..	¶46.8	1.00	23.6	3.38	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	3304	245	5	917	1771	1345	1063	5655	
Duration in hrs..	193	10	2	46	116	68	67	234	8
Mean velocity....	17.12	24.50	2.50	19.78	15.27	19.78	15.87	24.12	

Greatest mileage in one hour was 60 on the 7th and 12th.

Greatest velocity in gusts, 72 miles per hour on the 7th.

Resultant mileage, N. 51½° W.

Resultant direction, 6,800.

Total mileage, 14,305.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ʃ Ten years only.

The greatest heat was 45.6° on the 30th; the greatest cold was —3.2° on the 24th, giving a range of temperature of 48.8 degrees.

Warmest day was the 30th. Coldest day was the 23rd. Highest barometer reading was 30.682 on the 24th. Lowest barometer was 29.039 on the 20th, giving a range of 1.643 inches. Maximum relative humidity was 100 on the 1st, 7th, 12th, 19th, 20th, 22nd and 26th. Minimum relative humidity was 52 on the 13th.

Rain fell on 7 days.

Snow fell on 18 days.

Rain or snow fell on 21 days.

Auroras were observed on 2 nights, 14th & 22nd.

Lunar halo on 1 night, 24th.

Fog on 1 day, 23rd.

Hail fell on 4 days, 6th, 7th, 25th and 29th.

Mock Suns on 21st.

ABSTRACT FOR THE MONTH OF APRIL, 1896.

Meteorological Observations McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. Mean.	Max.	Min.	Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles per hour	SKY CLOUDED IN TENTHS Mean.	Max.	Min.	Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY
1	24.12	28.2	19.2	9.0	30.1580	30.293	29.874	0.419	.1082	83.0	19.7	N.E.	10 87	3.3	10	0	94	Inap.	....	Inap.	1
2	32.13	35 7	27.3	8.4	29.6493	29 730	29.581	0.146	.1703	93.7	30.3	S.W.	17.87	7.2	10	0	00	0.46	2 0	0.67	2
3	24.62	28.7	19.3	9.4	29.4793	29.558	29.419	0 139	.1173	88 7	22.0	S.W.	31 50	6 8	10	0	21	....	0.4	0.05	3
4	24 72	29.2	17 6	11.6	29.7987	29.987	29.640	0.347	.1202	89 0	22.2	S.W.	30.21	9.5	10	2	03	....	0.1	0.01	4
SUNDAY.........5	.....	34.1	23.3	10.8	......	......	......	.....	.....	..	....	S.W.	22.12	....	......	..	03	....	Inap.	Inap.	5.........SUNDAY
6	31.28	36.2	27.1	9 1	30.1205	30.163	30.[illegible]	0.074	.1528	87.3	27 7	S. E.	10.71	3 2	10	0	74	....	....	....	6
7	32.05	27 6	26.6	11.0	30.2795	30.424	30.143	0.281	.1557	80.0	28.3	N.E.	16.37	7.0	10	0	63	....	....	....	7
9	33.32	39.5	26.7	12.8	30.5462	30.586	30 540	0.046	.1498	80.0	27.3	N.	9.17	0 7	2	0	94	....	....	....	8
8	33.32	41.1	24.4	16.7	30 4225	30.556	30.267	0.289	.1382	74 7	25.3	N.E.	6.62	0.0	0	0	89	....	....	....	9
10	36.65	47 6	24.5	23.1	30.2655	30.323	30.215	0.108	.1505	70.5	27.2	S.E.	7.42	1.7	10	0	93	....	....	....	10
11	40.65	44.3	36.6	7.7	30.2152	30.245	30.187	0 058	.2132	84.7	36.2	S.W.	19.75	6.5	10	0	39	....	....	....	11
SUNDAY.......12§	.....	48.0	36.2	11.8	......	......	......	.....	....	....	....	N.E.	10.29	....	...	..	76	0.01	....	0.01	12...........SUNDAY
13	40.97	51.8	34.0	17.8	29 9233	29.952	29 925	0 047	.2123	81.7	35.5	W.	14.13	7 2	10	0	57	....	....	....	13
14	44 66	55.8	32.4	23.4	29.8167	29.897	29.760	0 137	.2545	84 7	40.0	S. W.	21.04	4 8	10	0	31	0.15	....	0.15	14
15	55.08	66.8	44.8	22.0	30.0008	30.036	29.963	0 073	.3310	76 7	47.5	S. W.	16 67	5 3	10	0	78	...	....	....	15
16	55.03	72.3	41.6	30.7	29.9865	30.034	29.930	0 104	.3448	77.2	47 5	S. W.	12.58	1.2	4	0	87	...	....	....	16
17	45.70	54.4	36.1	18.3	29.9957	30.091	29.911	0.180	.2818	90.7	43.0	S. W.	13.00	7.3	10	0	11	Inap.	...	Inap.	17
18	46.93	51.4	44.7	6.7	30.0180	30.063	29.918	0.145	.2818	87.3	43 3	N. E.	10 38	7.7	10	0	01	0.04	...	0.04	18
SUNDAY.......19	.....	77.0	42 3	34.7	......	....	......	.....	.....	....	...	S. W.	18 96	....	....	..	58	0.01	....	0.01	19 ....SUNDAY
20	53.87	65.8	45 6	20.2	29.9408	30.032	29.849	0.183	3015	71 3	44.5	S. W.	24.33	3.8	10	0	73	0.04	....	0.04	20
21	38.48	47.0	34.2	12.8	29.8763	29 994	29.743	0.251	.1333	56.8	24.5	E.	17.92	8.2	10	0	03	0.05	0.5	0 11	21
22	41.85	50 2	32.2	13.0	29.9588	30.025	29 796	0 229	1557	59.8	23.3	N.E.	20.29	4.5	10	0	51	...	0.2	0.02	22
23	48.58	60.8	38.2	22.6	30.0965	30.173	30 035	0 138	.1752	53.0	31.2	S. W.	16 42	0.2	1	0	91	....	...	....	23
24	44.12	54.2	35.0	19.2	30.1762	30.242	30.123	0.119	.1622	56.8	29.2	N.E.	13 03	4 7	8	0	71	....	....	...	24
25	46.57	55.8	34.3	21 5	30.0962	30.128	30.058	0.070	2005	64.8	34.0	S E.	11.58	6.5	10	0	39	0.05	...	0.05	25
SUNDAY........26	.....	61.2	44 3	16.9	....	......	.....	. ...	.....	....	....	S. W.	4.13	...	....	..	75	Inap.	....	Inap	26 ....SUNDAY
27	57.43	69.2	41 0	28.2	30.2260	30.292	30.166	0.126	.2935	62 3	43 8	S. E.	12.63	2.0	8	0	86	....	...	....	27
28	50.63	55 8	48.3	7.5	30.1915	30.249	30.158	0 091	.2922	78.8	43.8	S.	12.25	10 0	10	0	00	0.04	....	0.04	28
29	48.18	59.3	38.8	20 5	30.3308	30 360	30.249	0 111	.1722	51.7	30.7	N E.	19.00	2.3	10	0	95	....	...	....	29
30	47.42	58.6	33.3	25.3	30.2428	30 332	30.155	0.177	.1510	48.2	27.7	N.E.	12.37	0.0	0	0	94	....	....	....	30
Means	44.48	50.58	33.66	16.92	30 0685	30.1448	29.9876	.1572	.2008	74.59	33.10	S. 44¾° W.	18.23	4.68	8.19	0 08	55.3	0.85	3.2	1.20	... . Sums
22 Years means for and including this month	40.07	48.59	32 36	16.22	29.9576	....	.....	.203	.1713	66.8	....	.....	‡16.71	6.13	..	..	¶51.4	1.61	6.0	2.21	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction.... ...	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	1436	2405	442	779	378	5237	390	61	
Duration in hrs .	91	167	38	78	29	266	33	9	9
Mean velocity....	15.78	14.40	11.63	9.98	13.04	19.69	11.82	6.78	

Greatest mileage in one hour was 46 on the 3rd.

Greatest velocity in gusts, 48 miles per hour on the 3rd.

Resultant mileage, 2045.
Resultant direction, S. 44¾ W.
Total mileage, 11,128.
Average velocity, 15.45 miles per hour.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ‡ Ten years only.

The greatest heat was 77.0° on the 19th; the greatest cold was 17.6° on the 4th, giving a range of temperature of 59.4 degrees.

Warmest day was the 19th. Coldest day was the 1st. Highest barometer reading was 30.586 on the 8th. Lowest barometer was 29.419 on the 3rd, giving a range of 1.167 inches. Maximum relative humidity was 99 on the 1st, 3rd, 6th, 17th and 18th. Minimum relative humidity was 30 on the 23rd and 30th.

Rain fell on 12 days.

Snow fell on 6 days.

Rain or snow fell on 16 days.

Auroras were observed on 2 nights, 23rd & 24th

Lunar halo on 1 night, 24th.

Hail fell on 17th and 21st.

Rainbow on 19th.

ABSTRACT FOR THE MONTH OF MAY, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range.	BAROMETER. Mean.	Max.	Min.	Range.	†Mean pressure of vapor.	‡ Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles perhour	SKY CLOUDED IN TENTHS Mean.	Max.	Min.	Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	51.33	66.7	36.0	30.7	30.0960	30.183	30.021	.162	.1753	49.0	31.0	N.E.	12.75	1.7	10	0	91	....	....	....	1
2	55.02	68.2	37.1	31.1	30.0135	30.082	29.947	.135	.2645	62.3	41.5	S.E.	8.54	2.0	8	0	79	....	....	....	2
SUNDAY........3	.....	69.3	48.5	20.8	....	......	......	....	.....	..	....	S.	9.54	....	...	..	27	....	....	....	3........SUNDAY
4	60.08	70.5	52.9	17.6	29.8277	29.872	29.768	.104	.4095	79.3	53.5	S. W.	18.13	3.7	8	0	53	0.01	....	0.01	4
5	53.78	65.7	43.5	22.2	29.8742	30.104	29.759	.345	.2928	72.2	44.2	S. W.	16.92	7.7	10	2	66	Inap.	....	Inap.	5
6	47.83	57.9	41 0	16.9	30.2867	30.366	30.204	.162	.2390	71.8	38.8	N.E.	17.75	5.8	10	0	45	....	....	....	6
7	53.78	64.2	38.8	25.4	30.3177	30.408	30.211	.197	.2712	66.0	42.0	S.	2.21	5.0	10	0	73	Inap.	....	Inap.	7
9	62.10	72.1	53.3	18.8	30.1218	30.262	30.005	.257	.4223	76.5	44.2	S. W.	10.54	9.0	10	8	23	0.07	....	0.07	8
8	71.37	83.5	56.0	27.5	29.8295	30.008	29.705	.303	.4965	66.3	58.8	S. W.	23.00	3.0	5	0	71	Inap.	....	Inap.	9
SUNDAY........10	.....	88.7	57.4	31.3	....	.....	......	....	.....	....	....	S. W.	25.17	....	....	..	86	1.22	....	1.22	10..........SUNDAY
11	62.27	74.0	56.3	17.7	29.8055	29.901	29.750	.151	.4095	73.2	54.0	N.	9.75	4.3	8	0	75	0.01	....	0.01	11
12	57.35	68.6	51.0	17.6	29.9675	30.046	29.916	.130	.2472	53.5	39.7	N.W.	9.17	0.0	0	0	98	....	....	....	12
13	53.78	63.2	44 4	18.8	30.1488	30.228	30.082	.146	.2318	57 0	38.0	S.	10.17	0.7	2	0	98	....	....	....	13
14	60.42	70.1	44.5	25 6	29.9678	30.076	29.872	.204	.2675	52.0	41 8	S.	6.12	1.0	4	0	84	....	...	....	14
15	61.70	72.4	49.9	22.5	29.9117	29.961	29.886	.075	.3340	61.7	47.7	E-	8.12	4.5	10	0	55	0.19	....	0.19	15
16	59 27	67.2	52.8	14.4	29.9788	30.020	29.961	.059	.3468	69.3	49.0	S.W.	13.12	4.7	10	0	28	....	...	....	16
SUNDAY........17	.....	70.5	49.7	20.8	....	......	......	....	.....	....	....	S. W.	13.21	....	......	..	69	....	....	....	17..........SUNDAY
18	62.27	69.4	54.7	14.7	29.6317	29.757	29.493	.264	.4445	72.7	53.3	S. W.	19.96	5.0	9	0	50	0.05	....	0.05	18
19	51.85	62.0	45.2	16.8	29.9082	30.078	29.765	.313	.2478	65.0	39.7	N. W.	9.21	4.8	10	0	50	0.02	....	0.02	19
20	55.78	65.4	44.2	21.2	30.1927	30.282	30.137	.145	.2460	56.0	39.7	S.W.	4.58	1.8	6	0	91	....	....	....	20
21	59.15	69.0	47.9	21.1	30.0488	30.205	29.906	.299	.3515	70.3	49.0	S E.	13.50	1.2	7	0	80	....	....	....	21
22	60.75	72.8	54.1	18.7	29.9073	30.071	29.836	.235	.4232	79.3	54.3	N.W.	12.17	6.2	10	3	45	0.09	...	0.09	22
23	53.82	61.5	46.6	14.9	30.2907	30.338	30.202	.136	.2445	59.8	42.3	N.W.	7.79	1.7	5	0	97	...	....	....	23
SUNDAY........24	.....	69.4	45.0	24.4	....	......	......	....	... .	....	....	S. E.	6.58	....	....	..	38	....	....	....	24..........SUNDAY
25	61.40	69.6	50.4	19.2	29.9733	30.160	29.763	.397	.3395	62 2	48.2	S.E.	13.25	3 0	10	0	80	....	...	....	25
26	62.65	76.8	51.1	25.7	29.5752	29.659	29.496	.163	4097	74.0	53 3	S.E.	15.67	5 7	10	0	45	0.23	...	0.23	26
27	59.13	67.5	53.2	14.3	29.8730	30.025	29 680	.345	.3453	69.3	48.5	S W.	8.04	4.5	10	0	74	0.01	....	0.01	27
28	54.73	59.9	46.6	13.3	29.8910	30.069	29.7[illegible]2	.347	.3440	79.0	48.2	E.	11.25	8.0	10	0	16	0.47	....	0.47	28
29	54.62	60.8	51.1	9.7	29.7352	29.776	29.704	.072	.3298	77.0	47 3	S W	6.83	8.8	10	3	28	0.37	....	0.37	29
30	53.07	58.3	48.0	10.3	29.7542	29.765	29.736	.029	.2953	73.3	44.5	S.W.	8.04	9 8	10	9	07	Inap.	....	Inap	30
SUNDAY........31	.....	64.8	45 8	19.0	....	......	......	....	.....	....	....	W.	5 58	....	..		21	....	....	....	31..........SUNDAY
Means	57.66	68.39	48 29	20.10	20.9588	30.065	29.866	.199	.3319	67.2	45.9	S. 33¾° W.	11.54	4.37	8.2	1.0	59.5	2.74	....	2.74	... . Sums
22 Years means for and including this month	54.74	64.11	45.75	18.81	29.9077	.....	......	.169	.2887	65.7	....	......	ꜱ14.50	6.1	..	..	¶51.0	2.94	....	2.94	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	405	1170	315	1098	708	3810	373	705	
Duration in hrs..	31	87	47	110	71	263	47	75	13
Mean velocity....	13.07	13.45	6.70	9.98	9.97	14.49	7.94	9.40	

Greatest mileage in one hour was 43 on the 10th.
Greatest velocity in gusts, 48 miles per hour on the 10th.

Resultant mileage, 2950.
Resultant direction, S. 33¾° W.
Total mileage, 8.584.
Average velocity, 11.54 miles per hour.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ꜱ Ten years only.

The greatest heat was 88.7° on the 10th; the greatest cold was 36.0° on the 1st, giving a range of temperature of 52.7 degrees.

Warmest day was the 10th. Coldest day was the 1st. Highest barometer reading was 30.408 on the 7th. Lowest barometer was 29.493 on the 18th, giving a range of .915 inches. Maximum relative humidity was 97 on the 28th. Minimum relative humidity was 28 on the 1st.

Rain fell on 16 days.

Auroras were observed on 4 nights, 2nd, 16th, 17th and 18th.

Rain fell on the 3rd.

Rainbow on the 3rd.

Thunder and lightning on 2 days, the 10th and 15th.