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THE

CANADIAN NATURALIST.

SECOND SERIES.

OUTLINES OF THE DISTRIBUTION OF ARCTIC PLANTS.

By Jos. D. Hooker, M.D., F.R.S., &c.*

I shall endeavour in the following pages to comply, as far a I can, with a desire expressed by several distinguished Arctic voyagers, that I should draw up an account of the affinities and distribution of the flowering plants of the North Polar Regions. The method I have followed has been, first to ascertain the names and localities of all plants which appear on good evidence to have been found north of the arctic circle in each continent; then to divide the polar zone longitudinally into areas characterized by differences in their vegetation; then to trace the distribution of the arctic plants, and of their varieties and very closely allied forms, into the temperate and alpine regions of both hemispheres. Having tabulated these data, I have endeavoured to show how far their present distribution may be accounted for by slow changes of climate during and since the glacial period.

The arctic flora forms a circumpolar belt of 10° to 14° latitude, north of the arctic circle. There is no abrupt break or change in the vegetation anywhere along this belt, except in the meridian of Baffin's Bay, whose opposite shores present a sudden change from an almost purely European flora on its east coast, to one with a large admixture of American plants on its west.

The number of flowering plants which have been collected within

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the arctic circle is 762 (Monocot. 214; Dicot. 548). In the present state of cryptogamic botany it is impossible to estimate accurately the number of flowerless plants found within the same area, or to define their geographical limits; but the following figures give the best approximate idea I have obtained:—

Filices	28	Characeæ	2	Fungi...........	200?
Lycopodiaceæ	7	Musci.............	250	Algæ.....	100
Equisetaceæ	8	Hepaticæ..........	80	Lichenes	250

Total Cryptogams..........................	925
" Phænogams	762
	1687

Regarded as a whole, the arctic flora is decidedly Scandinavian; for Arctic Scandinavia, or Lapland, though a very small tract of land, contains by far the richest arctic flora, amounting to three-fourths of the whole; moreover, upwards of three-fifths of the species, and almost all the genera, of Arctic Asia and America are likewise Lapponian, leaving far too small a percentage of other forms to admit of the Arctic Asiatic and American floras being ranked as anything more than subdivisions, which I shall here call districts, of one general arctic flora.

Proceeding eastwards from Baffin's Bay, there is, first, the Greenland district, whose flora is almost exclusively Lapponian, having an extremely slight admixture of American or Asiatic types: this forms the western boundary of the purely European flora. Secondly, the Arctic European district, extending eastward to the Obi river, beyond the Ural range, including Nova Zembla and Spitzbergen; Greenland would also be included in it, were it not for its large area and geographical position. Thirdly, the transition from the comparatively rich European district to the extremely poor Asiatic one is very gradual; as is that from the Asiatic to the richer fourth or West American district, which extends from Behring's Straits to the Mackenzie River. Fifthly, the transition from the West to the East American district is even less marked; for the lapse of European and West American species is trifling, and the appearance of East American ones is equally so: the transition in vegetation from this district, again, to that of Greenland is, as I have stated above, comparatively very abrupt.

The general uniformity of the arctic flora, and the special differences between its subdivisions, may be thus estimated: the arctic Phænogamic flora consists of 762 species; of these, 616 are Arctic European, many of which prevail throughout the polar area, being distributed in the following proportions through its different longitudes:—

Arctic	Europe.....	616:	Scandinavian forms	586;	Asiatic and American	30 =	1 : 19·57
"	Asia........	233	" "	189	"	44 =	1 : 4·2
"	W. America.	364	" "	254	"	110 =	1 : 2·3
"	E. America .	379	" "	269	"	110 =	1 : 2·4
"	Greenland ..	207	" "	195	"	12 =	1 : 16·2

This table places in a most striking point of view the anomalous condition of Greenland, which, though so favourably situated for harbouring an Arctic American vegetation, and so unfavourably for an Arctic European one, presents little trace of the botanical features of the great continent to which it geographically belongs, and an almost absolute identity with those of Europe. Moreover, the peculiarities of the Greenland flora are not confined to these; for a detailed examination shows that it differs from all other parts of the arctic regions in wanting many extremely common Scandinavian plants which advance far north in all the other polar districts, and that the general poverty of its flora in species is more due to an abstraction of arctic types than to a deficiency of temperature. This is proved by an examination of the temperate portion of the Greenland peninsula, which adds very few plants to the entire flora, as compared with a similar area south of any other arctic region; and these few are chiefly arctic plants and almost without exception Arctic Scandinavian species.

There is nothing in the physical features of the arctic regions, their oceanic or aerial currents, their geographical relations, nor their temperature, which, in my opinion, at all accounts for the exceptional character of the Greenland flora; nor do I see how it can be explained, except by assuming that extensive changes of climate, and of land and sea, have exerted great influence, first, in directing the migration of the Scandinavian species over the whole polar zone, and afterwards in introducing the Asiatic and American species with which the Scandinavian are so largely associated in all the arctic districts except those of Europe and Greenland. It is inconceivable to me that, under existing conditions of sea, land, and temperature, so many Scandinavian plants should have found their way westward to Greenland, by migration across the Atlantic, and stopped short on its west coast, not crossing to America;—or that so many American types should terminate as abruptly on the west coast of Baffin's Bay, and not cross to Greenland and Europe;—or that Greenland should contain actually much fewer species of European plants than have found their way eastwards from Lapland by Asia into Western and Eastern Arctic America;—or that the Scandinavian vegetation should in every longitude have migrated southward across the tropics of Asia and America, whilst the typical genera of Asia and America which have found their way into the arctic regions have remained restricted to these continents.

It appears to me difficult to account for these facts, unless we admit Mr. Darwin's* hypothesis, first, that the existing Scandinavian flora is of great antiquity, and that previous to the glacial epoch it was more uniformly distributed over the polar zone than it is now; secondly, that during the advent of the glacial period this Scandinavian vegetation was driven southward in every longitude, and even across the tropics into the south temperate zone; and that on the succeeding warmth of the present epoch, those species that survived both ascended the mountains of the warmer zones, and also returned northward, accompanied by aborigines of the countries they had invaded during their southern migration. Mr. Darwin shows how aptly such an explanation meets the difficulty of accounting for the restriction of so many American and Asiatic arctic types to their own peculiar longitudinal zones; and that far greater difficulty, the representation of the same arctic genera by most closely allied species in different longitudes. To this representation, and the complexity of its character, I shall have to allude when indicating the sources of difficulties I have encountered, whether in limiting the polar species, or in determining to what southern forms many are most directly referable. Mr. Darwin's hypothesis accounts for many varieties of one plant being found in various alpine and arctic regions of the globe, by the competition into which their common ancestor was brought with the aborigines of the countries it invaded: different races survived the struggle for life in different longitudes; and these races again, afterwards converging on the zone from which their ancestor started, present there a plexus of

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* This theory of a southern migration of northern types being due to the cold epochs preceding and during the glacial, originated, I believe, with the late Edward Forbes; the extended one, of their transtropical migration, is Mr. Darwin's, and is discussed by him in his 'Origin of Species,' chap. xi.

closely allied but more or less distinct varieties or even species, whose geographical limits overlap, and whose members very probably occasionally breed together.

Nor is the application of this hypothesis limited to this inquiry; for it offers a possible explanation of a general conclusion at which I had previously arrived * and shall have again to discuss here—viz.: that the Scandinavian flora is present in every latitude of the globe, and is the only one that is so; and it also helps to explain another class of most interesting and anomalous facts in arctic distribution, at which I have now arrived from an examination of the vegetation of the several polar districts, and especially that of Greenland.

A glance at a circumpolar chart will show how this theory bears upon the Greenland flora, explaining the identity of its existing vegetation with that of Lapland, and accounting for its paucity of species, for the rarity of American species, of peculiar species, and of marked varieties of European species. If it be granted that the polar area was once occupied by the Scandinavian flora, and that the cold of the glacial epoch did drive this vegetation southwards, it is evident that the Greenland individuals, from being confined to a peninsula, would be exposed to very different conditions to those of the great continents. In Greenland many species would, as it were, be driven into the sea, that is, exterminated; and the survivors would be confined to the southern portion of the peninsula, and not being there brought into competition with other types, there could be no struggle for life amongst their progeny, and consequently no selection of better adapted varieties. On the return of heat, these survivors would simply travel northwards, unaccompanied by the plants of any other country.

In Arctic America and Asia, on the other hand, where there was a free southern extension and dilatation of land for the same Scandinavian plants to occupy, these would multiply enormously in individuals, branching off into varieties and subspecies, and occupy a larger area the further south they were driven; and none need be altogether lost in the southern migration over plains, though many would in the struggle that ensued when they reached the mountains of those continents and were brought into competition with the alpine plants, which the same cold had caused to descend to the plains. Hence, on the return of warmth, many

* Introductory Essay to the 'Flora of Tasmania,' p. ciii.

more Scandinavian species would return to Arctic America and Asia than survived in Greenland; some would be changed in form, because only the favoured varieties could have survived the struggle; some of the species of Alpine Siberia and of the Rocky Mountains would accompany the Scandinavian in their return to the arctic zone; while many arctic species would ascend those mountains, accompanying the alpine species in their reascent.

Again, as the same species may have been destroyed in many longitudes, or at most elevations, but not at all, we should expect to find some of those Arctic Scandinavian plants of Greenland which have not returned to Arctic America still lurking in remote corners of that great continent; and we may account for *Draba aurea* being confined to Greenland and the Rocky Mountains, *Potentilla tridentata* to Greenland and some scattered localities from the Alleghanies northward, and *Arenaria Grœnlandica* to Greenland, Labrador and the Mountains of New England, by supposing that these were originally Scandinavian plants, which were driven south by the cold of the glacial epoch, but which on the return of warmth, being exterminated on the plains of the American continent, found a refuge among its mountains, where they now exist.

It appears, therefore, to be no slight confirmation of the general truth of Mr. Darwin's hypothesis, that, besides harmonizing with the distribution of arctic plants within and beyond the polar zone, it can also be made, without straining, to account for that distribution and for many anomalies of the Greenland flora, viz., i.—its identity with the Lapponian; ii.—its paucity of species; iii.—the fewness of temperate plants in temperate Greenland, and the still fewer plants that area adds to the entire flora of Greenland; iv.—the rarity of both Asiatic and American species or types in Greenland; and v.—the presence of a few of the rarest Greenland and Scandinavian species in remote and often alpine localities of West America and the United States.

I.—ON THE LOCAL DISTRIBUTION OF PLANTS WITHIN THE ARCTIC CIRCLE.

The greatest number of plants occurring in any given arctic district is found in the European, where 616 flowering plants have been collected from the verge of the circle to Spitzbergen. From this region vegetation rapidly diminishes in proceeding eastwards and westwards, especially the latter. Thus, in Arctic Asia only 233 flowering plants have been collected; in Arctic Greenland, 207 species; in the American continent east of the Mackenzie River, 379 species; and in the area westward from that river to Behring's Straits, 364 species.

A glance at the annual and monthly isothermal lines will show that there is little relation between the temperature and vegetation of the areas they intersect, beyond the general feature of the scantiness of the Siberian flora being accompanied by a great southern bend of the annual isotherm of 32° in Asia, and the greatest northern bend of the same isotherm occurring in the longitude of west Lapland, which contains the richest flora. On the other hand, the same isotherm bends northwards in passing from Eastern America to Greenland, the vegetation of which is the scantier of the two; and passes to the northward of Iceland, which is much poorer in species than those parts of Lapland to the southward of which it passes.

The June isothermals, as indicating the most effective temperatures in the arctic regions (where all vegetation is torpid for nine months, and excessively stimulated during the three others), might have been expected to indicate better the positions of the most luxuriant vegetation: but neither is this the case; for the June isothermal of 41°, which lies within the arctic zone in Asia, where the vegetation is scanty in the extreme, descends to 54° N. lat. in the meridian of Behring's Straits, where the flora is comparatively luxuriant; and the June isothermal of 32°, which traverses Greenland north of Disco, passes to the north, both of Spitzbergen and the Parry Islands. In fact, it is neither the mean annual, nor the summer (flowering), nor the autumn (fruiting) temperature that determines the abundance or scarcity of the vegetation in each district, but these combined with the ocean temperature and consequent prevalence of humidity, its geographical position, and its former conditions both climatal and geographical. The relations between the isothermals and floras in each longitude being therefore special, and not general, I shall consider them further when defining the different arctic floras.

The northern limits to which vegetation extends varies in every longitude; and its extreme limits are still unknown; it may, indeed, reach to the pole itself. Phænogamic plants, however, are probably nowhere found far north of lat. 81°. 70 flowering plants are found in Spitzbergen; and Sabine and Ross collected 9 on Walden Island, towards its northern extreme, but none on Ross's Islet, fifteen miles further to the north. Sutherland, a very careful and intelligent collector, found 23 at Melville Bay and Wolstenholme and Whale Sounds, in the extreme north of Baffin's Bay (lat. 76°, 77° N.). Parry, James Ross, Sabine, Beechey, and others, together, found 60 species on Melville Island, and Lyall 50 on the islands north of Barrow Straits and Lancaster Sound. About 80 have been detected on the west shores of Baffin's Bay and Davis' Straits, between Pond Bay and Home Bay. To the north of Eastern Asia, again, Seemann collected only 4 species on Herald Island, lat. 71½° N., the northernmost point attained in that longitude. On the east coast of Greenland, Scoresby and Sabine found only 50 between the parallels of 70° and 75° N.; whilst 150 inhabit the west coast, between the same parallels.

The differences between the vegetations of the various polar areas seem to be to a considerable extent constant up to the extreme limits of vegetation in each. Thus *Ranunculus glacialis* and *Saxifraga flagellaris*, which are all but absent in West Greenland*, advance to the extreme north in East Greenland and Spitzbergen. *Caltha palustris, Astragalus alpinus, Oxytropis Uralensis, O. nigrescens, Parrya arctica, Sieversia Rossii, Nardosmia corymbosa, Senecio palustris, Deschampsia cæspitosa, Saxifraga hieraciifolia* and *S. Hirculus*, all of which are absent in West Greenland, advance to Lancaster Sound and the polar American islands, a very few degrees to the westward of Greenland.

On the other hand, *Lychnis alpina, Arabis alpina, Stellaria cerastioides, Potentilla tridentata, Cassiopeia hypnoides, Phyllodoce taxifolia, Veronica alpina, Thymus Serphyllum, Luzula spicata*, and *Phleum alpinum*, all advance north of 70° in West Greenland, but are wholly unknown in any part of Arctic Eastern America or the polar islands.

The most arctic plants of general distribution that are found far north in all the arctic areas are the following; all inhabit the Parry Islands, or Spitzbergen, or both :—

Ranunculus nivalis.	Draba hirta.	Stellaria longipes.
—— auricomus.	—— muricella.	Cerastium alpinum.
—— pygmæus.	—— incana.	Potentilla nivea.
Papaver nudicaule.	—— rupestris.	—— frigida.
Cochlearia officinalis.	Cochlearia anglica.	Dryas octopetala.
Braya alpina.	—— officinalis.	Epilobium latifolium.
Cardamine bellidifolia.	Silene acaulis.	Sedum Rhodiola.
—— pratensis.	Lychnis apetala.	Chrysos. alternifolium.
Draba alpina.	Arenaria verna.	Saxifraga oppositifolia.
—— androsacea.	—— arctica.	—— cæspitosa.

* Both were found by Kane's Expedition, but by no previous one.

Saxifraga cernua.
—— rivularis.
—— nivalis.
—— stellaris.
—— flagellaris.
—— Hirculus (E. Greenland only.)
Antennaria alpina.
Erigeron alpinus.
Taraxacum Dens-leonis.
Cassiopeia tetragona.
Pedicularis hirsuta.
Pedicularis sudetica.
Oxyria reniformis.
Polygonum viviparum.
Empetrum nigrum.
Salix herbacea.
—— reticulata.
Luzula arcuata.
Juncus biglumis.
Carex fuliginosa (not yet found in Arctic Asia, but no doubt there.)
—— aquatilis (do.)
Eriophorum capitatum.
—— polystachyon.
Alopecurus alpinus.
Deyeuxia Lapponica.
Deschampsia cæspitosa (E. Greenland only).
Phippsia algida.
Colpodium latifolium.
Poa flexuosa.
—— pratensis.
—— nemoralis.
Festuca ovina.

Of the above, *Saxifraga oppositifolia* is probably the most ubiquitous, and may be considered the commonest and most arctic flowering plant.

The following are also inhabitants of all the five arctic areas, but do not usually attain such high latitudes as the foregoing:—

Ranunculus Lapponicus.
Draba rupestris.
Viola palustris.
Honkenya peploides.
Epilobium angustifolium.
—— alpinum.
Hippuris vulgaris.
Artemisia borealis.
Vaccinium uliginosum.
—— Vitis-idæa.
Ledum palustre.
Pyrola rotundifolia.
Polemonium cæruleum, and vars. (E. Greenland only.)
Pedicularis Lapponica.
Armeria vulgaris.
Betula nana.
Salix lanata.
—— glauca.
—— alpestris.
Luzula campestris.
Carex vesicaria.
Eriophorum vaginatum.
Atropis maritima.

The absence of *Gentiana* and *Primula* in these lists is very unaccountable; seeing how abundant and very alpine they are on the Alps and Himalaya, and *Gentiana* on the South American Cordilleras also.

The few remaining plants, which are all very northern and almost or wholly confined to the arctic zone, are the following. † indicates those species absolutely peculiar; ‡ the only peculiar genus.

Rananculus Palasii.
—— hyperboreus.
Trollius Asiaticus.
Corydalis glauca.
Cardamine purpurea.
Turritis mollis.
Cochlearia sisymbrioides.
Hesperis Pallasii.
†Braya pilosa.
Eutrema Edwardsii.
Parrya arctica.
†—— arenicola.
Odontarrhena Fischeriana.
Sagina nivalis.
Stellaria dicranoides.
Oxytropis nigrescens.
Sieversia Rossii.
—— glacialis.
Rubus arcticus.
Parnassia Kotzebuei.
Saxifraga Eschscholtzii.
—— serpyllifolia.
†—— Richardsoni.
Cœnolophium Fischeri.
†Nardosmia glacialis.
Artemisia Richardsoniana.
—— glomerata.
†—— androsacea.
Erigeron compositus.
Chrysanthemum arcticum.
Pyrethrum bipinnatum.
†Saussurea subsinuata.
Campanula uniflora.
Gentiana arctophila.
—— aurea.
Eutoca Franklinii.
Pedicularis flammea.
†Douglasia arctica.
†Monolepis Asiatica.
Betula fruticosa.
Salix speciosa.
†—— glacialis.
—— phlebophylla.
—— arctica.
Orchis cruenta.
Platanthera hyperborea.
Carex nardina.
—— glareosa.
—— rariflora.
Hierochloe pauciflora.
Deschampsia atropurpurea.
Phippsia algida.
Dupontia Fisheri.
Colpodium pendulinum.
—— fulvum.
—— latifolium.
‡Pleuropogon Sabini.
†Festuca Richardsoni.

II.—ON THE DISTRIBUTION OF ARCTIC FLOWERING PLANTS IN VARIOUS REGIONS OF THE GLOBE.

There is but one distinct genus confined to the arctic regions, the monotypic and local *Pleuropogon Sabini;* and there are but seven other peculiarly arctic species, together with one with which I am wholly unacquainted, viz., *Monolepis Asiatica.* The remaining 762 species are all of them found south of the circle; and of these all but 150 advance south of the parallel of 40° N. lat., either in the Mediterranean basin, Northern India, the United States, Oregon, or California; about 50 are natives of the mountainous regions of the tropics; and just 105 inhabit the south temperate zone.

The proportion of species which have migrated southwards in the Old and New World also bear a fair relation to the facilities for migration presented by the different continents. Thus,

Of 616 Arctic European species,	Of 233 Arctic Asiatic species,
496 inhabit the Alps, and	210 reach the Altai, Soongaria, etc.;
450 cross them;	106 reach the Himalaya;
126 cross the Mediterranean;	0 are found on the tropical mts. of Asia;
26 inhabit South Africa.	5 inhabit Australia and New Zealand.
Of 379 Arctic East American,	Of 346 Arctic West American species,
203 inhabit the United States.	274 are north temperate;
34 inhabit tropical American mountains.	24 on tropical mountains;
50 inhabit temperate South America.	37 in south temperate zone.

These tables present in a very striking point of view the fact of the Scandinavian flora being the most widely distributed over the globe. The Mediterranean, South African, Malayan, Australian, and all the floras of the New World have narrow ranges compared with the Scandinavian, and none of them form a prominent feature in any other continent than their own; but the Scandinavian not only girdles the globe in the arctic circle, and dominates over all others in the north temperate zone of the Old World, but intrudes conspicuously into every other temperate flora, whether in the northern or southern hemisphere, or on the alps of tropical countries.

The severest test to which this observation could be put is that supplied by the Arctic Scandinavian forms; for these belong to the remotest corner of the Scandinavian area, and should of all plants be the most impatient of temperate, warm, and tropical climates. The following will, approximately, express the result:—

Total Arctic Scandinavian forms	586	Cross Alps, etc.	480
In North United States, Canada, etc.	360	Reach South Africa	20
In Tropical America	40	Himalaya, etc.	300
In Temperate South America	70	Tropical Asia	20
In Alps of Middle Europe, Pyrenees, etc.	490	Australia, etc.	60

In one respect this migration is most direct in the American meridian, where more arctic species reach the highest southern latitudes. This I have accounted for (Flora Antarctica, p. 230) by the continuous chain of the Andes having favoured their southern dispersion.

But the greatest number of arctic plants are located in Central Europe, no fewer than 530 out of 762 inhabiting the Alps and Central and Southern Europe, of which 480 cross the Alps to the Mediterranean basin. Here, however, their further spread is apparently suddenly arrested; for though many, doubtless, are to be found in the Alps of Abyssinia and the western Atlas; these are few compared with what are found further east in Asia; and fewer still have found their way to South Africa.

The most continuous extension of Scandinavian forms is in the direction of the greatest continental extension; namely that from the North Cape in Lapland to Tasmania*; for no less than 350 Scandinavian plants have been found in the Himalaya, and 53 in Australia and New Zealand; whereas there are scarcely any Himalayan and no Australian or Antarctic forms in Arctic Europe. Now that Mr. Darwin's hypotheses are so far accepted by many botanists, in that these concede many species of each genus to have had in most cases a common origin, it may be well to tabulate the generic distribution of arctic plants as I have done the specific; and this places the prevalence of the Scandinavian types of vegetation in a much stronger light:—

Scandinavian Arctic Genera in Europe..	280	Cross Alps (approximately)	260
Found in N. U. S. (approximately)...	270	Found in South Africa (approximately)	110
" Tropical American Mts. " ...	100	" Himalaya, etc.	270
" Temperate South America " ...	120	" Tropical Asia	80
" Alps " ...	280	" Australia, etc.	100

The most remarkable anomaly is the absence of *Primula* in Tropical America, that genus being found in Extra-tropical South

* The line which joins these points passes through Siberia, Eastern China, the Celebes Islands, and Australia, but the glacial migration has no doubt been due south from the arctic and north temperate regions in various longitudes to the Pyrenees, Alps, Carpathians, Caucasus, Asia Minor, Persian and North Indian mountains, etc. The further migration south to the distant and scattered alpine heights of the tropics, and thence to South Australia, Tasmania, and New Zealand, is, in the present state of our knowledge, to me quite unaccounted for. Mr. Darwin assumes for this purpose a cooled condition of the globe that must have been fatal to all such purely tropical vegetation as we are now familiar with.

America; and its absence in the whole southern temperate zone of the Old World, except the Alps of Java.

Thalictrum, *Delphinium*, *Impatiens*, *Prunus*, *Circæa*, *Chrysosplenium*, *Parnassia*, *Bupleurum*, *Heracleum*, *Viburnum*, *Valeriana*, *Artemisia*, *Vaccinium*, *Rhododendron*, *Pedicularis*, and *Salix*, are all arctic genera found on the tropical mountains of Asia (Nilghiri, Ceylon, Java, etc.), but not yet in the south temperate zones of Asia, and very few of them in Temperate South Africa.

There are, however, a considerable number of Scandinavian plants which are not found in the Alps of Middle Europe, though found in the Caucasus, Himalaya, etc.; and conversely there are several Arctic Asiatic and American plants found in the Alps of Central Europe, but nowhere in Arctic Europe. In other words, certain species extend from Arctic America through Central Asia and North India to Central Europe, which do not extend from Arctic America westward to Arctic Europe; and there are certain other species which extend from Arctic Europe to the Caucasus and Central Asia, which do neither exist on the Alps of Central Europe nor extend eastward to Arctic America: thus,

Common to Arctic Europe and Temperate Asia, etc., but not to Alps of Europe.

Ranunculus nivalis.
——— hyperboreus.
Trollius Asiaticus.
Cardamine bellidifolia?
Parrya macrocarpa.
——— arctica.
Draba alpina.
——— muricella.
——— hirta.
——— rupestris.
Eutrema Edwardsii.
Silene turgida.
Lychnis apetala.
Sagina nivalis.
Arenaria lateriflora.
——— arctica.
Stellaria borealis.
——— humifusa.
——— longipes.
——— crassifolia.
Rubus arcticus.
——— chamæmorus.
Rosa blanda.
Saxifraga rivularis.
——— nivalis.
——— flagellaris.
——— bronchialis.
Cœnolophium Fischeri.
Conioselinum Fischeri.
Ligusticum Scoticum.
Chærophyllum bulbosum.
Cornus suecica.
Galium triflorum.
Valeriana capitata.
Nardosmia frigida.
——— palmata.
Chrysanthemum arcticum.
Pyrethrum bipinnatum.
Artemisia borealis.
Antennaria alpina.
Senecio frigidus.
Ligularia Sibirica.
Aster Sibiricus.
——— Tataricus.
Mulgedium Sibiricum.
Campanula uniflora.
Cassiopeia hypnoides.
Cassandra calyculata.
Diapensia Lapponica.
Rhododendron Lapponicum.
Ledum palustre.
Gentiana detonsa.
Pleurogyne rotata.
Myosotis sparsiflora.
Eritrichium villosum.
Gymnandra borealis.
Castilleja pallida.
Veronica macrostemon.
Pedicularis Lapponica.
——— hirsuta.
——— Sudetica.
Pinguicula villosa.
Primula stricta.
——— Sibirica.
Koenigia Islandica.
Betula alpestris.
Salix lanata.
——— polaris.
Picea orientalis.
Larix Ledebourii.
Platanthera obtusata.
Calypso borealis.
Sparganium natans.
Luzula arcuata.
Juncus biglumis.
Carex glareosa.
——— Norvegica.
——— festiva.
——— loliacea.
——— rariflora.
——— livida.

Carex laxa.
——— salina.
——— aquatilis.
——— globularis.
Blysmus rufus.
Alopecurus alpinus.
Deyeuxia deschampsioides.
——— Lapponica.
,——— strigosa.
——— Langsdorffii.
Hierochloe alpina.
Colpodium latifolium.
——— pendulinum.
——— fulvum.
Dupontia Fisheri.*

It is curious to remark how many of these boreal European plants, which are absentees in the Alps, have a very wide range, not only extending to the Himalaya and North China, but many of them all over Temperate North America; only one is found in the south temperate zone. In the present state of our knowledge we cannot account for the absence of these in the Alps; either they were not natives of Arctic Europe immediately previous to the glacial period, or if so, and they were then driven south to the Alps, they were afterwards there exterminated; or, lastly, they still inhabit the Alps under disguised forms, which pass for different species. Probably some belong to each of these categories. I need hardly remark that none inhabit Europe south of the Alps, or any part of the African continent.

The list of Arctic American and Asiatic species which do inhabit the Alps of Europe, but not Arctic Europe, is much smaller. Those marked † are Scandinavian, but do not there enter the arctic circle.

Anemone patens.
——— alpina.
——— narcissiflora.
†Ranunculus sceleratus.
†Aconitum Napellus.
†Arabis petræa.
†Cardamine hirsuta.
Draba stellata.
†Thlaspi montanum.
†Lepidium ruderale.
†Sagina nodosa.
†Linum perenne.
Phaca alpina.
†Astragalus hypoglottis.
†Spiræa salicifolia.
†Potentilla fruticosa.
——— sericea.
†Ceratophyllum demersum.
Bupleurum ranunculoides.
†Viburnum Opulus.
Galium rubioides.
†——— saxatile.
Ptarmica alpina.
Aster alpinus.
Gentiana prostrata.
Polygonum polymorphum.
Corispermum hyssopifolium.
Alnus viridis.
Pinus cembra.
†Sparganium simplex.
†Typha latifolia.
Carex ferruginea.
——— supina.
——— stricta.
†——— pilulifera.
†Scirpus triqueter.
Deyeuxia varia.
Spartina cynosuroides.
†Glyceria fluitans.
Hordeum jubatum.

III.—BOTANICAL DISTRICTS WITHIN THE ARCTIC CIRCLE.

The following are the prominent features, botanical, geographical, and climatal, of the five districts of the arctic zone:—

1. Arctic Europe.—The majority of its plants are included

* The following species were included in this list as first published, but have since been found in Switzerland:—

Naumbergia thyrsiflora.
Salix myrtilloides.
Calla palustris.
Carex fuliginosa.
——— capillaris.
Carex vulgaris.
——— cæspitosa.

[Cardamine bellidifolia has been found on the Pyrenees by Lange!—Ed.]

in the Lapland and Finland floras; and, owing to the temperature of the Gulf Stream, which washes its coasts, Lapland is by far the richest province in the arctic regions. The mean annual temperature at the polar circle, where it cuts the coast-line, is about 37°, and the June and September temperatures throughout Lapland are 40° and 37° respectively; thus rendering the climate favourable both to flowering and fruiting. Spitzbergen belongs to this flora, as do Nova Zembla and the arctic countries west of the river Obi, which forms its eastern boundary; for the Ural Mountains do not limit the vegetation, any more than do the Rocky Mountains in America. Gmelin observed more than a century ago that the river Obi in lower latitudes indicates the transition longitude from the European to the Asiatic flora.

Even in this small area, however, there are two floras, corresponding to the Arctic Norwegian and Arctic Russian. The latter, commencing at the White Sea, though comparatively excessively poor in species, contains nearly twenty that are not Lapponian, including *Braya rosea*, *Dianthus alpinus*, *D. Seguieri*, *Spiræa chamædrifolia*, *Saxifraga hieraciifolia*, *Heracleum Sibiricum*, *Ligularia Sibirica*, *Ptarmica alpina*, *Gentiana verna*, *Pleurogyne rotata*, and *Larix Sibirica*.

There are further several Scandinavian plants which cross the arctic circle on the east shores of the White Sea, but do not do so in Lapland, as *Athamanta Libanotis*, *Chrysanthemum Leucanthemum*, *Bidens tripartita*, and others.

Iceland and Greenland also botanically belong to the Arctic Lapland province, but I have here excluded both: the former because it lies to the south of the arctic circle; the latter because both its magnitude, position, and other circumstances, require that it should be treated of separately.

As far as I can ascertain, 616 species (Monocotyledons, 183; Diocotyledons, 433 = 1 : 2·3) enter the arctic circle in this region, of which 70 advance into Spitzbergen; but no phænogamic plant is found in Ross's Islet, which lies to the north of Spitsbergen. The proportion of genera to species 266 : 616=1 : 2·3. Of these Arctic European plants, 453 cross the Alps or Pyrenees to the Mediterranean basin, a few occur on the mountains of Tropical Africa, (including *Luzula campestris* and *Deschampsia cæspitosa*), and 23 are found in South Africa.

No fewer than 264 species do not enter the arctic circle in any other longitude, and 184 are almost exclusively natives of the

Old World, or of this and of Greenland; not being found in any part of North America; 24 are confined to Arctic Europe and Greenland.

The following Arctic European plants are of sporadic occurrence in North America:—

Ranunculus acris, (Rocky Mountains).
Arabis alpina, (Greenland and Labrador).
Lychnis alpina, (Greenland and Labrador).
Arenaria arctica, (Greenland and Rocky Mountains).
——— verna, (Greenland, Arctic Islands, and Rocky Mountains).
Alchemilla vulgaris, (Greenland and Labrador).
Gnaphalium sylvaticum, (Greenland and Labrador).
——— supinum, (Greenland, Labrador, and White Mountains).
Vaccinium myrtillus, (Rocky Mountains and shores of great lakes).
Cassiopeia hypnoides, (Greenland, U. States Mountains, Canada, and Labrador).
Phyllodoce taxifolia, (Greenland, New England Mountains, and Labrador).
Gentiana nivalis, (Greenland and Labrador).
Veronica alpina, (Greenland and White Mountains).
Bartsia alpina, (Greenland and Labrador).
Pedicularis palustris, (Lab'r & Newfoundl'd).
Primula farinosa, (Labrador, Canada, Maine and shores of the Great Lakes).
Salix phylicifolia, (U. States Mountains).
——— herbacea, (Greenland, Labrador, and White Mountains, etc.).
Juncus trifidus, (do. do.).
Carex capitata, (Greenland and White Mountains).
Phleum alpinum, (Greenland, White Mountains, Canada, and Labrador).
Calamagrostis lanceolata, (Labrador).

There are besides a considerable number of Arctic European plants, which, in the New World, are confined to Greenland, being nowhere found in East America: these will be enumerated when treating of the Greenland flora.

The plants which are widely distributed in Temperate America or Asia, but almost exclusively Arctic in Europe, are the following:—

Ranunculus Pallasii, (Asia and America).
Trollius Asiaticus, (Asia).
Parrya macrocarpa, (Asia and America).
——— arctica, (Asia and America).
Stellaria longipes, (Asia and America).
Potentilla emarginata, (America).
Epilobium latifolium, (Asia and America).
Sedum quadrifidum, (Asia).
Saxifraga bronchialis, (Asia and America).
Senecio resedæfolius, (Asia and America).
Ligularia Sibirica, (Asia).
Mulgedium Sibiricum, (Asia)
Cassiopeia tetragona, (Asia and America).
Gentiana detonsa, (Asia and America).
Pleurogyne rotata, (Asia and America).
Eritrichium aretioides, (Asia and America).
Gymnandra Pallasii, (Asia).
Castilleja pallida, (Asia and America).
Veronica macrostemon, (Asia).
Pedicularis flammea, (America).
Pinguicula villosa, (Asia and America).
Koenigia Islandica, (Asia and America).
Salix polaris, (Asia and America).
Picea orientalis, (Asia).
Larix Ledebourii, (Asia).
Platanthera hyperborea, (America).
——— obtusata, (America).
Deyeuxia deschampsioides, (Asia and N. W. America).
Dupontia Fisheri, (America).

The works upon which I have mainly depended for the habitats of the Arctic European plants are Wahlenberg's 'Flora Lapponica,' Ledebour's 'Flora Rossica,' Fries's 'Summa Vegetabilium Scandinaviæ,' and 'Mantissæ,' and various admirable treatises by

Andersson, Nylander, Hartmann, Lindblöm, Wahlberg, Blytt, C. Martins, Ruprecht, and Schrenk.

For Spitzbergen plants I have depended on Hooker's enumeration of the Spitzbergen collections made during Parry's attempt to reach the north pole, Capt. Sabine's collection made in the same island, and on Lindblöm and Beilschmied's 'Flora von Spitzbergen' (Regensburg, Flora, 1842).

For the southern distribution of the Arctic European plants, I have further consulted Nyman's excellent 'Sylloge,' Ledebour's 'Flora Rossica,' Grisebach's 'Flora Rumelica,' Grenier and Godron's 'Flore de France,' Parlatore's 'Flora Italiana,' Koch's 'Synopsis Floræ Germaniæ,' Munby's 'Catalogue of Algerian Plants,' A. Richard's of those of Abyssinia, Visiani's 'Flora Dalmatica,' Delile's 'Flora Ægyptiaca,' Boissier's noble 'Voyage Botanique dans l'Espagne,' and Tchihatcheff's 'Asia Minor,' besides numerous local floras of the Mediterranean region, Madeira, the Azores, and Canaries.

2. Arctic Asia.—This, which for its extent, contains by far the poorest flora of any on the globe, reaches from the Gulf of Obi eastwards to Behring's Straits, where it merges into the West American. The climate is marked by excessive mean cold; at the Obi the isotherm of 18° cuts the arctic circle in its S.E. course, and at the eastern extremity of the province the isotherm of 20° cuts the same circle, while the centre part of the district is all north of the isotherm of 9°. The whole of the district is hence far north of the isotherm of 32°, which descends to 52° N. lat. in its middle longitude. The extremes of temperature are also very great; the June isotherm of 41° ascending eastward through its western half to the Polar Sea, whilst the September isotherm of 41° descends nearly to 6° N. lat.; whence the low autumn temperature must present an almost insuperable obstacle to the ripening of seeds within this segment of the polar circle.

The warming influence of the Atlantic currents being felt no further east than the Obi, and the summer desiccation of the vast Asiatic continent, combine to render the climate of this region one of excessive drought as well as cold; whence it is in all ways most unfavourable to every kind of vegetation.

The total number of species hitherto recorded from this area is 233 (Monocotyledons, 42; Dicotyledons, 191 = 1 : 4·5.) The proportion of genera to species is 1 : 2. Of the 233 species, 217 inhabit Siberia as far south as the Altai, or Japan, etc.; 104

extend southwards to the Himalaya or mountains of Persia; none are found on the mountains of the two Indian peninsulas, but 5 are found on those of Australia and New Zealand. All but the following 37 are European. Those marked with a † are almost exclusively arctic:—

Delphinium Menziesii (West America).
†Cochlearia sisymbrioides (Boreal ditto).
Hesperis Pallasii (East and West America).
Odontharrena Fischeriana.
Cardamine macrophylla.
†Arenaria macrocarpa (West America).
—— laricina.
†—— Rossii (Rocky Mountains).
Cerastium maximum (West America).
†Oxytropis nigrescens (Boreal E. and W. America).
Hedysarum Sibiricum.
†Sieversia glacialis (Boreal W. America).
Potentilla stipularis.
—— fragiformis.
Claytonia lanceolata.
†Sedum euphorbioides (Arctic Asia only).
Saxifraga Escholtzii (Boreal W. America).
—— punctata (West America).
Saxifraga serpyllifolia (W. America).
†Nardosmia glacialis (Arctic Asia only).
—— Gmelini.
†Artemisia Steveniana (Arctic Asia only).
—— glomerata (West America).
—— biennis (E. and W. America).
Osmothamnus fragrans.
Pedicularis capitata (E. and W. America).
—— euphrasioides (E. and W. America).
†Monolepis Asiatica (Arctic Asia only).
Rumex salicifolius (E. and W. America).
—— graminifolius.
Salix ovalifolia (West America).
Abies alba (E. and W. America).
Larix Americana (E. and W. America).
Tofieldea coccinea (E. and W. America).
Fritillaria Kamtchatkensis (West America).
Carex concinna (West America).
Elymus mollis (E and W. America).

Thus out of 37 non-European species, only 12 are confined to Asia, the remaining 25 being American. On the other hand, there are only 22 European species in Arctic Asia which are not also American; which scarcely establishes a nearer relationship between Arctic Asia with Europe than with America. These are:—

Dianthus Seguieri.
—— superbus.
Silene inflata.
Arenaria uliginosa.
Phaca alpina.
Hedysarum obscurum.
Rubus Idæus.
Sedum quadrifidum.
Gaya simplex.
Leontodon autumnalis.
Hieracium alpinum.
Veronica longifolia.
Pedicularis Sceptrum.
Pinguicula alpina.
Polygonum Sibiricum.
Salix Lapponum.
—— nigricans.
—— hastata.
Picea orientalis.
Larix Ledebourii.
Cypripedium Calceolus.
Carex ferruginea.

In other words, of the 233 Asiatic species, 196 are common to Asia and Europe, 22 are confined to Asia and Europe, 25 are confined to Asia and America, and 12 are confined to Asia (three of which are peculiar to the arctic circle).

The rarity of Gramineæ and especially of Cyperaceæ in this region is its most exceptional feature; only 21 of the 138 arctic species of these orders having hitherto been detected in it. Cryptogamic plants seem to be even more rare; *Woodsia Ilvensis* and *Lastrea fragrans* being the only Filices hitherto enumerated.

Further researches along the edge of the arctic circle would, doubtless, add more Siberian species to this flora, as the examination of the north-east extreme would add American species, and possibly lead to the flora of the country of the Tchutchis being ranked with that of West America.

The works which have yielded me most information regarding this flora, are Ledebour's 'Flora Rossica,' and the valuable memoirs of Bunge, C. A. Meyer, and Trautvetter, on the vegetation of the Taimyr and Boganida rivers; and on the plants of Jenissei River in Von Middendorff's Siberian 'Travels'. For their southern extension Trautvetter and Meyer's 'Flora Ochotensis,' also in Middendorff's 'Travels;' Bunge's enumeration of North China and Mongolian plants; Maximovicz's 'Flora Amurensis;' Asa Gray's paper on the botany of Japan (Mem. Amer. Acad. N.S. vi.); Karelin and Kiriloff's enumeration of Soongarian plants: Regel, Bach, and Herder on the East Siberian and Jakutsk collections of Paullowsky and Von Stubendorff. For the Persian and Indian distribution, I have almost entirely depended on the herbarium at Kew, and on Boissier's and Bunge's numerous works.

3. Arctic West America.—The district thus designated is analogous in position, and to a considerable extent in climate, to the Arctic European, but is much colder; as is indicated both by the mean temperature, and by the position of the June isotherm of 41°, which makes an extraordinary bend to the south, nearly to 52° N. lat., in the longitude of Behring's Straits.

It extends from Cape Prince of Wales, on the east shore of Behring's Straits, to the estuary of the Mackenzie river, and as a whole it differs from the flora of the province to the eastward of it by its far greater number both of European and Asiatic species, by containing various Altai and Siberian plants which do not reach so high a latitude in more western meridians, and by some temperate plants peculiar to West America. This eastern boundary is, however, quite an artificial one; for a good many eastern plants cross the Mackenzie and advance westwards to Point Barrow, but which do not extend to Kotzebue Sound; and a small colony of Rocky Mountain plants also spread eastwards and westwards along the shores of the Arctic Sea, which further tend to connect the floras; such are *Aquilegia brevistylis*, *Sisymbrium humile*, *Hutchinsia calycina*, *Heuchera Richardsonii*, *Crepis nana*, *Gentiana arctophila*, *Salix speciosa;* none of which are generally diffused arctic plants, or natives of any other parts of Temperate America but the Rocky Mountains.

The arctic circle at Kotzbue Sound is crossed by the isotherm of 23°, and at the longitude of the Mackenzie by that of 12° 5′; whilst the June isotherm of 41° ascends obliquely from S.W. to N.E., from the Aleutian Island to the mouth of the Mackenzie, and passes south of this province; the June and the September isotherms of 41° and 32° both traverse it obliquely, ascending to the N.E.

The vast extent of the Pacific Ocean and its warm northerly currents greatly modify the climate of West Arctic America, causing dense fogs to prevail, especially throughout the summer months, whilst the currents keep the ice to the north of Behring's Straits. The shallowness of the ocean between America and Asia, north of lat. 60°, together with the identity of the vegetation in the higher latitudes of these continents, suggests the probability of the land having been continuous at no remote epoch.

The number of phænogamic plants hitherto found in Arctic West America is 364 (Monocotyledons, 76; Dicotyledons, 288 = 1 : 3·7.) The proportion of genera to species is 1 : 1·7. Of these 364 species, almost all but the littoral and purely arctic species are found in West Temperate North America, or in the Rocky Mountains, 26 in the Andes of Tropical or Subtropical America, and 37 in Temperate or Antarctic South America. Comparing this flora with that of Temperate and Arctic Asia, I find that no less than 320 species are found on the north-western shores and Islands of that continent, or in Siberia, many extending to the Altai and the Himalaya. A comparison with Eastern Arctic America shows that 281 are common to it, and the following 38 are found in Temperate, but not Arctic East America:—

Anemone alpina.
——— Pennsylvanica.
Hutchinsia calycina (Rocky Mountains only and Asia.)
Sisymbrium humile (Rky. Mts. and As.).
Draba oligosperma (Rocky Mounts. only).
Lathyrus palustris (Europe, Asia, East and West America).
Spiræa salicifolia (Eu., As., E. & W. Am.).
Potentilla fruticosa (Eu., As., E. & W. Am.).
——— Pennsylvanica (E., A., E. & W. Am.).
Comarum palustre (Eu., A., E. & W. Am.).
Montia fontana (Eur., As., and W. Am.).
Saxifraga Sibirica (Asia and Labrador only).
———Dahurica (Asia and Rky. Mts. only).
Saxifraga bronchialis (Eu., As., & R. M.)
Archangelica officinalis (Eu., As., & A.).
Ligusticum Scoticum (Eu., Asia, Am.).
Cornus Suecica (Europe, Asia, Am.).
Galium rubioides (Europe, Asia, Am.).
Senecio resedæfolius (Europe, Asia, Am.).
——— Pseudo-Arnica (Asia and America.)
Cassandra calyculata (Europe, Asia, Am.).
Gentiana arctophila (Rocky Mounts. only).
——— prostrata (Europe, Asia, Am.).
——— tenella (Europe, Asia, Am.).
Veronica scutellata (Europe, Asia, Am.).
Pedicularis palustris (Europe, Asia, Am.).
Atriplex patula (Europe, Asia, Am.).
Corispermum hyssopifolium (E., A., Am.).

Corallorhiza innata (Europe, Asia, Am.).
Luzula spadicea (Europe, Asia, Am.).
—— spicata (Europe, Asia, Am.).
—— pilosa (Europe, Asia, Am.).
Juncus balticus (Europe, Asia, Am.).
Carex lagopina (Europe, Asia, Am.).
—— Gmelina (America only).
—— cryptocarpa (Europe, Asia, Am.).
—— stricta (Europe, America).
Hierochloe borealis (Europe. Asia, Am.).

These, it will be seen, are for the most part north temperate plants, common in many parts of the globe, and which are only excluded from Eastern Arctic America by the greater rigour of its climate.

The best marked European and Asiatic species that are not found further east in Temperate or Arctic America are the following :—

Anemone narcissiflora.
Ranunculus Pallasii.
Aconitum Napellus.
Parrya macrocarpa.
Dianthus alpinus.
Cerastium vulgatum.
Spiræa chamædrifolia.
Pyrethrum bipinnatum.
Gentiana prostrata.
Eritrichium aretioides.
Pedicularis verticillata.
Primula nivalis.
Atriplex littoralis.
Pinus cembra.
Carex Norvegica.
Deyeuxia strigosa.
—— Langsdorffii.
Colpodium fulvum.

Hence it appears that of the 364 species found in Arctic West America, 319 inhabit East America (arctic or temperate, or both), and 320 are natives of the Old World—a difference hardly sufficient to establish a closer affinity of this flora with one continent rather than with the other.

The species peculiar to this tract of land are :—

Braya pilosa.
Saxifraga Richardsoni.
Artemisia androsacea.
Saussurea subsinuata.
Salix glacialis.

The rarity of monocotyledons, and especially of the glumaceous orders, is almost as marked a feature of this as of the Asiatic flora : of the 138 arctic species of Glumaceæ only 54 are natives of West Arctic America.

The materials for this flora are principally the plants of Chamisso, collected during Kotzebue's voyage, and described by himself and Schlechtendahl ; Lay and Collie's collections, described in Beechey's voyage; the 'Flora Boreali-Americana ;' and Seemann's plants, described in the 'Botany of the Herald.' Most of the above collections are from Behring's Straits. For the arctic coast flora I am mainly indebted to Richardson's researches, and to Pullen's and other collections enumerated by Seemann in his account of the flora of Western Eskimo Land. For the southern extension of the flora I have had recourse to the 'Flora Boreali-Americana ;' Ledebour's 'Flora Rossica,' which includes the Sitcha plants ; the American floras of Nuttall, Pursh, Torrey, Gray, etc. ; and to the collections of Drs. Lyall and Wood formed in Vancouver Island and British Columbia; for the Californian, Mexican, and Cordillera floras generally, to the herbarium at Kew, the works above mentioned, and the various memoirs of Torrey and of Gray on the plants of the American Surveying Expeditions.

4. ARCTIC EAST AMERICA (EXCLUSIVE OF GREENLAND).—This tract of land is analogous to the Arctic Asiatic in many respects of position and climate, but is very much richer in species. It extends from the estuary of the Mackenzie River to Baffin's Bay, and its flora differs from that of the western part of the continent, both in the characters mentioned in the notice of that province, and in possessing more East American species. The western boundary of this province is an artificial one; the eastern is very natural, both botanically and geographically; for Baffin's Bay and Davis Straits (unlike Behring's Strait) have very deep water and different floras on their opposite shores.

The arctic circle is crossed in the longitude of the Mackenzie River by the isotherm of 12°, which thence trends south-eastward to the middle of Hudson Bay ; and in the longitude of Davis Straits it is crossed by the isotherm of 18½°. The June isotherm of 41° descends obliquely from the shores of the Arctic Sea, near the mouths of the Mackenzie, to the northern parts of Hudson Bay, south of the arctic circle; and the September isotherm of 41° is everywhere south of the circle. Hence, the western parts of this province are very much warmer than the eastern; so much so, that the whole west coast and islands of Baffin's Bay lie north of a southern inflection of the June isotherm of 32° which passes north of all the other polar islands; the Parry Islands have an analogous temperature of 40°. The warmth of the western portion of this tract is no doubt mainly due to the influence of the Pacific Ocean being felt across the continent of West America; though possibly also to the presence of a comparatively warm polar ocean, or to Atlantic currents crossing the pole between Nova Zembla and Spitzbergen, of which nothing certain is known*. Be this as it may, the comparative luxuriance of the flora of Melville Island is a well-known fact, and one inexplicable by considerations of temperature, if unaccompanied by a humid atmosphere. The

*It is a well-known fact that the temperature always rises rapidly with the north (as well as other) winds over all this Arctic American area.

whole region is of course far north of the isotherm of 32°, which, in the longitude of its middle district descends to Lake Winnipeg, in lat. 52°.

That portion of this province which is richest in plants is the tract which intervenes between the Coppermine and Mackenzie Rivers; east of this, vegetation rapidly diminishes, as also to the northward. The flora of the Boothian Peninsula, surrounded as it is with glacial straits, and placed centrically among the arctic islands, is perhaps the poorest of any part of the area; those of Banks Land and Melville Island to the N.W. being considerably richer, as are those of the shores of Lancaster Sound and Barrow's Strait, and the shores of Baffin's Bay to the north and east. *

The phænogamic flora of Arctic East America contains 379 species (Monocotyledons, 92; Dicotyledons, 287 = 1 : 3·1). The proportion of genera to species is 1: 2·0. Of these 379 species, 323 inhabit Temperate North America, east of the Rocky Mountains; 35 the Cordillera; and 49 Temperate or Antarctic South America. Comparing this flora with that of Europe, I find that 239 (or two-thirds) species are common to the arctic regions of both continents, whilst but little more than one-third of the Arctic European species are Arctic East American. Of 105 non-European species in Arctic East America, 32 are Asiatic; leaving 73 species confined to America, of which the following are furthermore confined to the eastward of the Rocky Mountains and Mackenzie River:—

Corydalis glauca.	Prunus Virginiana.	Urtica dioiça.
Sarracenia purpurea.	Heuchera Richardsoni.	Salix cordata.
Viola cucullata.	Cornus stolonifera.	Populus tremuloides.
Silene Pennsylvanica.	Grindelia squarrosa.	Picea nigra.
Arenaria Michauxii.	Vaccinium Canadense.	Spiranthes gracilis.
Polygala Senega.	Dracocephalum parviflorum.	Cypripedium acaule.
Lathyrus ochroleucus.	Douglasia arctica.	Carex oligosperma.
Rubus triflorus.	Elæagnus argentea.	Pleuropogon Sabini.

Of these *Douglasia* and *Pleuropogon* are the only ones absolutely peculiar to Arctic East America. It is a noticeable fact that not one of them is found in any part of Greenland. Compared with Greenland, the Arctic East American flora is rich; containing, besides those just enumerated, no less than 165 other

* Details of these florulas will be found in the volume of the 'Linnean Journal,' under the notice of Dr. Walker's Collections, made during the voyage of the *Fox*.

species not found in Greenland. The following are found on the arctic islands, and many of them on the west coast of Baffin's Bay, but not in West Greenland:—

Caltha palustris.
Parrya arctica.
Merkia physodes.
Stellaria crassifolia.
Astragalus alpinus.
Oxytropis campestris.
——— Uralensis.
——— nigrescens.
Sieuersia Rossii.
Saxifraga hieracifolia.
——— Virginiensis.
——— Hirculus (East Greenland only).
Valeriana capitata.
Nardosmia corymbosa.
Ptarmica vulgaris.
Chrysanthemum arcticum.
Artemisia vulgaris.
Senecio frigidus.
——— palustris.
——— pulchellus.
Solidago Virga-aurea
Aster salsuginosus.
Crepis nana.
Saussurea alpina.
Arctostaphylos alpina.
Kalmia glauca.
Phlox Sibirica.
Castilleja pallida.
Pedicularis capitata.
——— versicolor.
Androsace septentrionalis.
——— Chamæjasme.
Salix phlebophylla.
Lloydia serotina.
Hierochloe pauciflora.
Deschampsia cæspitosa (East Greenland only).
Glyceria fluitans.
Pleuropogon Sabini.
Bromus purgans.
Elymus mollis.*

There are thus no fewer than 184 of the 379 Arctic East American species (fully half) which are absent in West Greenland, whilst only 105 (much less than one-third) are absent in Europe. This alone would make the limitation of species in the meridian of Baffin's Bay more decided than in any other arctic longitude; and I shall show that it is rendered still more decisive by the number of Arctic Greenland plants that do not cross to Arctic East America.

Of the 379 Arctic East American species only 56 are not found in Temperate East America, of which two are absolutely confined to this area; two others (*Parrya arenicola* and *Festuca Richardsoni*) to Arctic East and West America; 25 are found in Temperate West America, and about 20 are Rocky Mountain species, and not found elsewhere in Temperate America.

For our knowledge of this flora I am principally indebted to the 'Flora Boreali-Americana,' and to Richardson's† botanical appendix to Franklin's first voyage—and his 'Boat Journey through Rupert's Land.' I have also examined the materials upon which the above works were founded, and the collections of almost every subsequent journey and voyage, up to those of Dr.

* *Andromeda polifolia* has been found in Greenland by Mr. Taylor, an intelligent surgeon of whale ships, who has spent many seasons in Baffin's Bay. He has given me a list of all the plants he knows.

† I am indebted to Sir John Richardson for some corrections to this list, which account for a few discrepancies between his lists of Arctic American plants and my own; these refer chiefly to genera and species introduced into his lists, but here excluded.

Walker in the *Fox*. To enumerate the numerous botanical appendices to voyages, and separate opuscules to which these have given rise, from Ross's first voyage to the present time, would be out of place here. I have endeavoured to embody in the essay the information gleaned from all of them. For the southern distribution of these plants in the United States, etc., I have had recourse primarily to Asa Gray's excellent 'Manual of the Botany of the Northern United States,' to Chapman's 'Flora of the Southern States,' and to the reports on the Botany of various Exploring Expeditions.

5. ARCTIC GREENLAND.—In area Arctic Greenland exceeds any other arctic district except the Asiatic, but ranks lowest of all in number of contained species. In many respects it is the most remarkable of all the provinces, containing no peculiar species whatever, scarcely any peculiarly American ones, and but a scanty selection of European. A further peculiarity is that the flora of its temperate regions is extremely poor, and adds very few species to the whole flora, and, with few exceptions, only such as are arctic in Europe also. Being the only arctic land that contracts to the southward, forming a peninsula, which terminates in the ocean in a high northern latitude, Greenland offers the key to the explanation of most of the phenomena of arctic vegetation; and as I have already made use of it for this purpose, I shall be more full in my description of its flora than of any other.

The east and west coasts of Greenland differ in many important features; the eastern is the largest in extent, the least indented by deep bays, is perennially encumbered throughout its entire length by icefields and bergs, which are carried south by a branch of the arctic current that sets between Iceland and Greenland; and is hence excessively cold, barren, and almost inaccessible. The west coast, again, is generally more or less free from pack ice from Cape Farewell (lat. 60°) to north of Upernævik in lat. 73°. It is washed by a southerly current, which is said to carry drift timber from the Siberian rivers into its fiords, and enjoys a far milder climate, and consequently has a more luxuriant vegetation. A somewhat similar contrast is exhibited between West Greenland and the opposite shores of Baffin's Bay, against which latter the northerly arctic current from Lancaster Sound drives great masses of polar ice, derived from the regions beyond that estuary, and to which the bergs that float away from the glaciers in the Greenland fiords are also drifted. It is important to bear in mind these features of the two shores of Greenland and of Baffin's Bay and Davis Straits, because they may in some degree explain their differences of vegetation. There is also another difference between the polar islands and Greenland, inasmuch as the former are for the most part low, without mountains or extensive glaciers; while the latter is exceedingly mountainous, with valleys along the shore terminating in glacier-headed fiords, and the coast is bound by glaciers of prodigious extent from Melville Bay northwards to Smith Sound.

The isothermal lines in Greenland all follow one course, from S.W. to N.E., running more parallel to one another in this meridian than in any other. The isotherm of 32° passes through the southern extremity of the peninsula, and that of 5° through its north extreme at Smith Sound. The June isotherm of 41° skirts its east coast, and that of 32° passes north of Disco; the June temperature of Disco is hence as low as that of the north of Spitzbergen, of middle Nova Zembla, and of the extreme north of Asia, and yet Disco contains quadruple their number of plants. The autumn cold is very great; the September isotherm of 32° crossing the arctic circle on the west coast; and to this the scantiness of the flora may to some extent be attributed.

The Arctic Greenland flora contains 206 species, according to Lange's catalogue (in Rincke's 'Greenland'); or 207, according to my materials (Monocot. 67, Dicot. 140=1 : 2·1); the proportion of genera to species being 1 : 2.

Of these 207 species the following 11 alone are not European:—

Anemone Richardsonii (Asiatic).
Turritis mollis (Asiatic).
Vesicaria arctica (American only).
Draba aurea (Rocky Mountains).
Hesperis Pallasii (Asia and America).
Arenaria Grœnlandica (Labr. to U. S.).
Potentilla tridentata (Labr. to Alleghanies).
Saxifraga triscuspidata (do. to L. Superior).
Erigeron compositus (American only).
Pedicularis euphrasioides (Asia).
Salix arctica (Asia).

On the other hand, no less than 57 Arctic Greenland species are absent in Arctic East America, and the following 36 Arctic Europe and Greenland species are either absent in all parts of Eastern Temperate America, or are extremely local there:—

Arabis alpina (Labrador only).
Lychnis alpina (do. and Newfoundland).
—— dioica (absent).
Spergula nivalis (do.).
Arenaria uliginosa (do.).
—— ciliata (do.).
Stellaria cerastioides (absent).
Alchemilla alpina (do.).
—— vulgaris (Labrador only).
Sibbaldia procumbens (Labr. to Wht. Mts.).
Rubus saxatilis (absent).
Potentilla verna (Labrador only).

Sedum villosum (absent,.
Saxifraga Cotyledon (Labrador and Rocky Mountains only).
Galium saxatile (absent).
Gnaphalium sylvaticum (Labrador only).
——— supinum (do. and Wht. Mounts.).
Cassiopeia hypnoides (Labr. to W. Mts.)
Phyllodoce taxifolia (Labrador to W. Mts.).
Gentiana nivalis (Labrador only).
Thymus serpyllum (absent).
Veronica alpina (White Mountains only).
——— saxatilis (absent).
Euphrasia officinalis (N. U. S. & Canada).
Bartsia alpina (Labrador only).
Rumex acetosella (absent).
Salix arbuscula (do.).
Peristylus albidus (do.).
Carex capitata (White Mountains only).
——— microglochin (absent).
——— microstachya (do.).
——— pedata (do.).
Elyna caricina (Rocky Mountains only).
Phleum alpinum (Labrador to White Mountains).
Calamagrostis lanceolata (Labrador only).
Deschampsia alpina (absent).

When it is considered how extremely common most of these plants are throughout Europe and Northern Asia, and that some of them inhabit also N. W. America, their absence in Eastern America is even more remarkable than their presence in Greenland.

A small colony of Greenland plants has been found by Mr. Taylor in Cumberland Gulf, on the West side of Baffin's Bay, where the following Arctic Greenland plants occur, viz. :—

Arabis alpina.
Gnaphalium sylvaticum.
Cassiopeia hypnoides.
Phyllodoce taxifolia.
Euphrasia officinalis.
Kœnigia Islandica.
Luzula spicata.
Carex Hebonastes.
——— vulgaris.
Agrostis vulgaris.

Another singular feature of both Arctic and Temperate Greenland is its wanting a vast number of Arctic plants which are European, and found also in America. The following is a list of most of these, excluding about 15, which are water-plants, or species whose range is limited. The letter I. placed before a species signifies that it is Icelandic, and is introduced to show not only how many are absent from this island, but also how many are present. The letter S. indicates that the species is found in the south temperate or antarctic circle. The asterisk (*) indicates that the species is arctic both in East America and Europe:—

Anemone alpina,
——— nemorosa.
——— narcissiflora.
* Ranunculus Purshii.
* I. Caltha palustris.
* Aconitum Napellus.
Actæa spicata.
Nuphar luteum.
Nasturtium amphibium.
S. Barbarea præcox.
S. Turritis glabra.
Thlaspi montanum.
Sisymbrium Sophia.
* I. Erysimum lanceolatum.
Arabis hirsuta.
I. S. Cardamine hirsuta.
* Parrya arctica.
I. Draba muralis.
I. Subularia aquatica.
* I. Drosera rotundifolia.
I. ——— longifolia.
I. Viola tricolor.
* I. Arenaria lateriflora.
* Stellaria longifolia.
I. Stellaria crassifolia.
Linum perenne.
Geranium Robertianum.
Hypericum 4-angulum.
Oxalis acetosella.
* Phaca frigida.
* Astragalus alpinus.
* ——— hypoglottis.
* Oxytropis campestris.
——— Uralensis.
Lathyrus palustris.
Spiræa salicifolia.

S. Geum urbanum.
I. —— rivale.
* Rubus arcticus.
Potentilla fructicosa.
—— Pennsylvanica.
—— argentea.
* I.S. Fragaria vesca.
I. Sanguisorba officinalis.
Rosa cinnamomea.
—— blanda.
* Circæa alpina.
* I. S. Epilobium tetragonum.
* I. S. —— alsinæfolium.
S. Lythrum salicaria.
* Ribes rubrum.
* —— alpinum.
* I. Parnassia palustris.
Saxifraga Sibirica.
* —— hieraciifolia.
—— bronchialis.
* Bupleurum ranunculoides.
Conioselinum Fischeri.
Cicuta virosa.
* I. Carum carui.
Adoxa moschatellina.
Viburnum Opulus.
Lonicera cærulea.
* Linnæa borealis.
* I. Galium boreale.
—— rubioides.
I. —— trifidum.
S. —— aparine.
* Valeriana capitata.
* Nardosmia frigida.
* Chrysanthemum arcticum.
I. Pyrethrum nodosum.
—— bipinnatum.
* Artemisia vulgaris.
S. Bidens bipartita.
Tanacetum vulgare.
Antennaria Carpatica.
* Senecio resedæfolius.
* —— frigidus.
* —— palustris.
* —— campestris.
—— aurantiacus.
* Solidago Virga-aurea.
* Aster Sibiricus.
* —— alpinus.
S. Erigeron acris.
S. Sonchus arvensis.
I. Hieracium boreale.
* Saussurea alpina.
I. Vaccinium myrtillus.
* Andromeda polifolia.
Cassandra calyculata.
* I. Arctostaphylos alpina.
* I. Pyrola secunda.
* I. Gentiana amarella.
I. —— tenella.
* Myosotis sylvatica.
—— palustris.
I. —— arvensis.
* Scutellaria galericulata.
I. S. Prunella vulgaris.
Glechoma hederaceum.
S. Stachys palustris.
* Gymnandra Pallasii.
* Castilleja pallida.
I. S. Veronica officinalis.
S —— scutellata.
I. S. —— serpylifolia.
Melampyrum pratense.
—— sylvaticum.
* I. Pedicularis palustris.
* —— versicolor.
Scrophularia nodosa.
Utricularia vulgaris.
* Pinguicula villosa.
Glaux maritima.
Trientalis Europæa.
* Androsace septentrionalis.
* —— Chamæjasme.
Naumbergia thyrsiflora.
I. S. Primula farinosa.
I. Plantago major.
—— lanceolata.
S. Chenopodium album.
I. S. Atriplex patula.
Corispermum hyssopifolium.
* Polygonum Bistorta.
I. —— amphibium.
* Myrica Gale.
I. Betula alba.
I. —— pumila.
I. Alnus incana.
I. Salix pentandra.
I. —— myrtilloides.
I. Triglochin maritimum.
Scheuzeria palustris.
Veratrum album.
* Lloydia serotina.
* Allium schænoprasum.
* Smilacina bifolia.
* Platanthera obtusata.
* Calypso borealis.
Godyera repens.
Cypripedium guttatum.
Calla palustris.
Typha latifolia.
Narthecium ossifragum.
Luzula maxima.
S. Juncus communis.
I. —— articulatus.
I. —— bulbosus.
—— stygius.
Carex pauciflora.
—— tenuiflora.
S. —— stellulata.
I. —— chordorrhiza.
—— teretiuscula.
—— paradoxa.
S. —— Buxbaumii.
I. —— limosa.
S. —— Magellanica.
—— ustulata.
—— livida.
I. —— pallescens.
—— maritima.
I. —— cæspitosa.
I. —— acuta.
—— stricta.
—— filiformis.
I. S. Eleocharis palustris.
S. —— acicularis.
S. Scirpus triqueter.
S. —— lacustris.
Eriophorum alpinum.
Rhynchospora alba.
Alopecurus pratensis.
I. Milium effusum.
S. Phalaris arundinacea.
I. S. Phragmites communis.
* I Hierochloe borealis.
* —— pauciflora.
* I. Catabrosa aquatica.
* I.S. Glyceria fluitans.
* I. Atropis distans.
I. Festuca elatior.
S. Bromus ciliaris.
I. S. Triticum caninum.
S. Hordeum jubatum.

Altogether there are absent in Greenland upwards of 230 Arctic European species, which are all of them American plants. The most curious feature of this list is the absence throughout Greenland of the genera *Spiræa*, *Senecio*, *Astragalus*, *Trifolium*, *Phaca*, *Oxytropis*, *Androsace*, *Aster*, *Myosotis*, *Rosa*, *Ribes*, *Thlaspi*, *Sisymbrium*, *Geranium*, *etc.*, and of such ubiquitous arctic species as *Fragaria vesca*, *Caltha palustris**, *Barbarea præcox*. It is remarkable that *Astragalineæ* are also absent from Spitzbergen and Iceland.

Iceland possesses 432 species (Monocot., 157; Dicot., 275) amongst which I find about 120 Arctic European plants that do not enter Greenland; whereas only 50 of the European plants that inhabit Greenland are absent in Iceland. The more remarkable desiderata of Iceland are *Astragalineæ*, *Anemone*, *Aconitum*, *Braya*, *Turritis*, *Artemisia* and *Androsace*; *Alopecurus alpinus*, *Luzula arcuata*, *Hierochloe alpina*, *Rubus chamæmorus*, *Cassiopeia tetragona*, *Arnica montana*, *Antennaria dioica*, and *Chrysosplenium alternifolium*. On the other hand, Iceland contains of arctic genera absent in Greenland: *Caltha* (one of the most common plants about Icelandic dwellings), *Cakile*, *Geranium*, *Trifolium*, *Spiræa*, *Senecio*, and *Orchis*.

But perhaps the most remarkable fact of all connected with the Greenland flora is that its southern and temperate districts, which present a coast of 400 miles, extending south to lat. 60° N., do not add more than 74 species to its flora, and these are almost unexceptionably Arctic European plants; and inasmuch as these additional species increase the proportion of Monocotyledons to Dicotyledons of the whole flora, Greenland as a whole is botanically more arctic in vegetation than Arctic Greenland alone is!

The only American forms which Temperate Greenland adds to its flora are, *Ranunculus Cymbalaria*, *Pyrus Americana*, a very trifling variety of the European *P. Aucuparia*, *Viola Muhlenbergii*, a mere variety of *V. canina*, *Arenaria Grœnlandica*, a plant elsewhere found only on the Mountains of New England, etc., and *Parnassia Kotzebuei*, a species which is scarcely different from *P. palustris*.

The only plants which are not members of the arctic flora elsewhere, and which are confined in Greenland to the temperate zone, besides the above American plants, are *Blitum glaucum*, *Potamogeton marinus*, *Sparganium minimum*, and *Streptopus amplexifolius*: the rest will all be found in the column of the arctic plant

* This is the more remarkable because it forms a conspicuous feature in Iceland, and is a frequent native of all the Arctic American coasts and islands.

catalogue devoted to Greenland, where S. signifies that the species is found only south of the arctic circle in that country.

On the other hand, Temperate Greenland adds very materially to the number of European Arctic species that do not enter Eastern America (Arctic or Temperate), amongst which the most remarkable are:—

Cerastium viscosum.	Galium palustre.	Betula alpestris.
Vicia cracca ?	Leontodon autumnale.	Juncus squarrosus.
Rubus saxatilis.	Hieracium murorum.	Anthoxanthum odoratum.
Sedum annuum.	——— alpinum.	Nardus stricta.
Galium uliginosum.	Gentiana aurea.	

Another anomalous feature in the Greenland flora is the presence, on the East Arctic coast, of some species not found on the west, nor in the temperate southern end of the peninsula. These are:—

Lychnis dioica (Arctic Europe).
Saxifraga Hirculus (abundant in all extreme arctic latitudes but West Greenland).
Polemonium cæruleum (all arctic longitudes, but West Greenland).
Deschampsia cæspitosa (all arctic longitudes, but also absent in Spitzbergen).

For data connected with the Greenland flora, I am mainly indebted to the collections of the various polar voyagers in search of a north-west passage, especially to Drs. Lyall's and Sutherland's; to Lange's catalogue in Rincke's 'Greenland'; and to the notices of Vahl, Greville, Sir William Hooker, etc., on the plants collected by Sabine, Scoresby, Ross, Jameson, Graah, Vahl, etc.; to Sutherland's appendix to Penny's voyage and Durand's to Kane's voyage.

There is a curious affinity between Greenland and certain localities in America, which concerns chiefly a few of the European plants common to these countries. First, there are in Labrador, or on the Rocky Mountains, or on the Mountains of New England, etc., a certain number of European plants found nowhere else in the American continent. They are:—

Ranunculus acris (Rocky Mountains).	Gentiana nivalis (Labrador).
Arabis alpina (Labrador).	Veronica alpina (White Mountains).
Lychnis alpina (do. & Newfoundland).	Bartsia alpina (Labrador).
Sibbaldia procumbens (do. & Wht. & Rky. [Mts.).	Salix herbacea (Labr. and Wht. Mts.)
Potentilla verna (Labrador).	Luzula spicata (White Mountains).
Montia fontana (Labrador).	Juncus trifidus (New England Mts.).
Gnaphalium sylvaticum (Labrador).	Carex capitata (White Mountains).
——— supinum (Labr. and N. E. Mts.).	Kobresia scirpina (Rocky Mountains).
Cassiopeia hypnoides (Labr. & U. S. Mts.).	Phleum alpinum (Labr. to White Mounts.).
Phyllodoce taxifolia (Labr. to N. E. Mts.).	Calamagrostis lanceolata (Labrador).

There are also two plants peculiar to Greenland, Labrador and the

Mountains of New England, or to Greenland and the Rocky Mountains, which have not hitherto been found elsewhere. They are:—

Draba aurea (Rocky Mountains).
Arenaria Grœnlandica (White Mountains northward to Labrador).

IV.—ON THE ARCTIC PROPORTIONS OF SPECIES TO GENERA, ORDERS, AND CLASSES.

The observations which have hitherto been made on this subject are almost exclusively based on data collected on areas too small to yield general results. Especially in determining the influence of temperature in regulating the proportions of the great groups of flowering plants, it is of the highest importance to take comprehensive areas, both because of the wider longitudinal dispersion of some orders, especially the Monocotyledons, and the effects of local conditions, such as bog land, which determine the overwhelming preponderance of Cyperaceæ in some arctic provinces compared with others.

The proportion of genera to species in the whole arctic phænogamic flora is 323 : 762, or 1 : 2·3 (Monocot., 1 : 2·8; Dicot., 1 : 2·2); and that of orders to species 1 : 10·8; in the several provinces as follows:—

	Gen.	Gen. to Sp.	Orders.	Ord. to Sp.
Arctic Europe	277	1 : 2.3	64	1 : 9.6
" Asia	117	1 : 2.0	38	1 : 6.1
" West America	172	1 : 2.1	48	1 : 7.6
" East America	193	1 : 2.5	56	1 : 6.8
" Greenland	104	1 : 2.0	38	1 : 5.5

Thus Europe presents the most continental character in its arctic flora, and West America the most insular; which may be attributable to the same cause in both; namely, the uniformity or variety of type. In West America we have, as in an oceanic island, a great mixture of types (Asiatic, European, East and West American) and paucity of species; in Europe the contrary. The proportions of species to orders are still more various; but here, again, Europe takes the lead decidedly.

The proportions of genera and orders to species of all Greenland differ but little from those of its arctic regions; whereas the contrast between Arctic Europe and this, together with Norway as far south as 60° N. lat., is very much greater. This is in accordance with the observation I have elsewhere made, that the whole of Greenland is comparatively poorer in species than Arctic Greenland is.

	Gen. Sp.	Ord. Sp.		Gen. Sp.	Ord. Sp.
Arctic Scandinavia ..	1 : 2.3 —	1 : 9·6	Arctic Greenland.....	1 : 2.0 —	1 : 5.5
All Scandinavia.....	1 : 2.8 —	1 : 11.6	All Greenland.......	1 : 2.3 —	1 : 6.6

The proportions of Monocotyledons to Dicotyledons are:—

Arctic Flora................	1 : 2.6	Arctic East America.........	1 : 3.1
" Europe..............	1 : 2.3	" Greenland............	1 : 2.1
" Asia.................	1 : 4.5	All Greenland...............	1 : 2.0
" West America........	1 : 3.8		

THE PROPORTION OF LARGEST ORDERS TO THE WHOLE FLORA.

	Gram. & Cyp.	Salicin.	Polygon.	Scroph.	Eric. & Vaccin.	Comp.
Arctic Flora........	1 : 5·6	1 : 30·5	1 : 50·2	1 : 27·1	1 : 33·1	1 : 10·0
" Europe......	1 : 5·2	1 : 38·4	1 : 56·0	1 : 23·7	1 : 30·8	1 : 12·3
" Asia	1 : 10·6	1 : 16·6	1 : 23·3	1 : 16·6	1 : 21·2	1 : 9·6
" W. America.	1 : 6·7	1 : 24·3	1 : 52·0	1 : 33·0	1 : 22·7	1 : 9·6
" E. America..	1 : 5·8	1 : 27·0	1 : 76·0	1 : 34·5	1 : 23·7	1 : 10·5
" Greenland...	1 : 3·8	1 : 29·6	1 : 51·7	1 : 23·0	1 : 17·3	1 : 20·7
All Greenland.......	1 : 3·7	1 : 34·0	1 : 42·7	1 : 24·9	1 : 21·4	1 : 15·0

	Saxif.	Ros.	Leg.	Caryop.	Crucif.	Ranun.
Arctic Flora........	1 : 26·2	1 : 17·3	1 : 24·6	1 : 15·0	1 : 14·1	1 : 17·7
" Europe......	1 : 34·2	1 : 21·2	1 : 30 8	1 : 15·4	1 : 17·7	1 : 24·6
" Asia	1 : 15·5	1 : 19·4	1 : 29·1	1 : 14·5	1 : 11·6	1 : 21·2
" W. America.	1 : 19·1	1 : 16·6	1 : 28·0	1 : 15·9	1 : 18·9	1 : 17·3
" E. America..	1 : 21·0	1 : 23·7	1 : 27·0	1 : 17·2	1 : 11·9	1 : 18·9
" Greenland...	1 : 17·2	1 : 20·7	0 : 207·0	1 : 10·3	1 : 10·9	1 : 23·0
All Greenland.......	1 : 27·2	1 : 19·8	1 : 149·6	1 : 12·4	1 : 12·0	1 : 27·2

The great differences between these proportions show how little confidence can be placed in conclusions drawn from local floras. Ericeæ is the only order which is more numerous proportionally to other plants in every province than in the entire arctic flora, and Cruciferæ is the only one that approaches it in this respect; and Leguminosæ is the only one which is less numerous proportionally in them all. East and West America agree most closely of any two provinces; then (excluding Leguminosæ) all Greenland and Europe; next Arctic Greenland and all Greenland.

The greatest differences are between Arctic Europe and Asia, and Arctic Asia and West America; they are less between Arctic Greenland and Asia (excluding Leguminosæ); they are great between Arctic Greenland and East America; and as great between all Greenland and Arctic America.

The proportion formerly deduced by Brown, etc., for the high arctic regions was a much smaller one; the Monocotyledons being in comparison with the Dicotyledons 1 : 5; and this still holds for some isolated, very arctic localities, as North-east Greenland; whereas Spitzbergen presents the same proportion as all the arctic regions, 1 : 2·7; the Parry Islands, 1 : 2·3; the west coast of Baffin's Bay, from Pond Bay to Home Bay, 1 : 3·3; and the extreme arctic plants mentioned at p. 333, 1 : 3. Of the prevalent arctic plants mentioned at p. 332, the proportion is 1 : 3·4.

I have dwelt more at length on these numerical proportions than their slight importance seems to require; my object being to show how little mutual dependence there is amongst the arctic florulas. Each has profited but little through contiguity with its coterminous districts, though all bear the impress of being members of one northern flora.

V.—ON GROUPING THE FORMS, VARIETIES, AND SPECIES OF ARCTIC PLANTS FOR PURPOSES OF COMPARATIVE STUDY.

Considering the limited extent of the arctic zone, the poverty of its flora, which is almost confined to 14° of latitude in the longitudes most favorable to vegetation, and to only 10° in the Asiatic area, and the number of able botanists who have studied it, it might be supposed that the preliminary task of identifying the species, and tracing their distribution within and beyond the arctic circle would have been short and simple; but this is not the case; for owing to the number of local floras, voyages, travels, and scientific periodicals that have to be consulted, to the variability of the species, and the consequent difficulty of settling their limits, and to the impossibility of reconciling the divergent opinions of my predecessors regarding them, I have found this a very tedious and unsatisfactory operation.

Of all these sources of doubt and error, the most perplexing has been the well-known variability of polar plants; and in the existing state of the controversy upon Mr. Darwin's hypothesis, it requires to be treated circumspectly. In several genera I have not only had to decide whether to unite for purposes of distribution dubious or spurious arctic species, but also how far I should go in examining and uniting cognate forms from other countries, which, if included, would materially affect the distribution of the species. These questions became in many instances so numerous and complicated, that I have often resorted to the plan of treating several very closely allied species and varieties as one aggregate or collective species. This appears at first sight to be an evasive course; but as it offered the only satisfactory method of solving the difficulty, I was obliged, after many futile attempts to find a better, to resort to it, and hence I feel called upon to enter more fully into my reasons for doing so; premising that all my attempts to treat each variety, form, and subspecies as a distinct plant involved the discussion of a multitude of details from which any generalization was hopeless; the results in every case defeated the object of this paper.

Of the plants found north of the arctic circle, very few are absolutely or almost exclusively confined to frigid latitudes (only about 50 out of 762 are so), the remainder, as far as their southern dispersion is concerned, may be referred to two classes; one consisting of plants widely diffused over the plains of Northern Europe, Asia, and America, of which there are upwards of 500; the other of plants more or less confined to the Alps of these countries, and still more southern regions, of which there are only about 200. *Glyceria fluitans*, *Atropis maritima*, and *Senecio campestris* are good examples of the first, as being high arctic and boreal but not alpine; while most of the species of *Saxifraga*, *Draba*, and *Androsace*, are examples of the second.* Both these classes abound in species, the limitation of which within the arctic circle, and the identification of whose varieties with those of plants of more southern countries, present great difficulties.

Those plants of the temperate plains which enter the arctic regions are often species of large, widely dispersed, and variable genera, most or all of whose species are very difficult of limitation; as *Ranunculus*, of which the arctic species *auricomus*, *aquatilis*, and *acris*, are each the centre of a nœud of allied temperate species or varieties, as to whose limits no two botanists are agreed; and the same applies to the species of *Viola*, *Stellaria*, *Arenaria*, and *Hieracium*. This has often led to the grouping of names of plants considered as synonymous by some authors, varieties by others, and good species by a third class. Furthermore, such

* Conversely the only arctic genus unknown in the Alps of the middle temperate zone is *Pleuropogon*, and the only alpine genera containing several species which inhabit the highest Alps of the north temperate zone, but not the polar regions, are *Soldanella* in Europe, *Swertia* in Europe and the Himalaya, etc.

genera are often represented in the temperate regions of two or more continents (and some of them in the south temperate zone also) by closely allied groups of intimately related species. This always complicates matters extremely; for an arctic species, being generally in a reduced or stunted state, may be equally similar to alpine or reduced forms of what in two or more of these geographically sundered groups may rank as good species, and its affinities and distribution be consequently open to doubt. Thus under the arctic *Stellaria longipes* are included five other arctic forms (*læta,Edwardsii,peduncularis, hebecalyx*, and *ciliatosepala*); but amongst these forms some specimens approach closely the American *S. Longifolio* Muhl., or slight varieties of it; while others resemble the European *S. Friesiana* Ser., others *S. graminea*, others certain Tasmanian forms, and others again Chilian. My own impression is, that some of these may prove but slight modifications of one common, very widely dispersed plant, between all whose varieties no constant definable characters will eventually be found; but in the present state of science I have abstained from including any of them, because to prove this or disprove it, the whole genus wants a far longer and closer study than it has yet received or than I can give it. *Arenaria verna* and its forms offer a very parallel case, and these I have included more largely, because I have the published opinion of many botanists to bear me out in doing so. *Viola epipsila, palustris* and *blanda*, are thus included, though they are more constant and have to a considerable extent different distributions; because I have found no differences of any moment between their normal forms, because such as exist seem to me to be too slight to attach specific value to, and because, though well distinguished by Scandinavian botanists, they have not been so carefully collected and studied in other parts of the arctic zone. *Viola canina, Fragaria vesca*, and *Sanguisorbia officinalis*, afford other examples: all these arctic plants affect the temperate plains rather than the mountains of the northern hemisphere.

Turning to those arctic plants that chiefly affect the Alps of the temperate or tropical zones, their limitation is quite as difficult; alpine plants being as proverbially variable as arctic. Many alpine plants are now considered to be only altered forms of lowland ones; and this affects the estimated distribution of every arctic species that is identified with an alpine one. As an example, *Saxifraga exilis* is a very slight variety of *S. cernua;*

both are arctic and alpine plants, but *S. cernua* is considered by some botanists to be an alpine form of the lowland *S. granulata*, whose limits and distribution are very difficult to settle, because it apparently passes into several oriental forms, which have been distinguished as species. In this case I have not included *S. granulata* with *S. cernua*; because the latter is everywhere easily distinguished as a well-marked plant, having a restricted range both in area and elevation, which *S. granulata* does not share. At the same time I am in favour of a hypothesis that would give these a common origin previous to the glacial epoch.

Other reasons for adopting the system of including very closely allied species are the following:—When species have been founded in error; this generally arises from their authors having imperfect specimens, or too limited a series of them; various species founded by Brown on the first Arctic American collections come under this category, as do Adams's Arctic Siberians pecies; the genera *Ranunculus*, *Draba*, *Arenaria*, and *Potentilla*, offer many examples: When the species, besides belonging to very variable genera, are apparently identical both in the herbarium and according to their descriptions, and present the same or a continuous distribution; of this *Trientalis*, *Senecio*, *Aster*, *Erigeron*, *Mertensia*, *Sedum*, *Claytonia*, *Turritis*, and many others, afford examples.

It may be asked what useful scientific results can be obtained from the study of a flora whose specific limits are in so vague a condition? the answer is, that though much is uncertain, all is not so; and that if the species thus treated conjointly really express affinities far closer than those which exist between those treated separately, a certain amount of definite information, useful for my purpose, is obtained; and it is a matter of secondary importance to me whether the plants in question are to be considered species or varieties. Again, if, with many botanists, we consider these closely allied varieties and species as derived by variation and natural selection from one parent form at a comparatively modern epoch, we may with advantage, for certain purposes, regard the aggregate distribution of the very closely allied species as that of one plant. When sufficient materials shall have been collected from all parts of the arctic and sub-arctic areas, we may institute afresh the inquiry into their specific identity or difference, by selecting exampies from physically differ ing distant areas, and comparing them with others from inter mediate localities. An empirical grouping of allied plants for the purpose of distribution may thus lead to a practical solution of difficulties in the classification and synonymy of species.

My thus grouping names must not therefore be regarded as a committal of myself to the opinion that the plants thus grouped are not to be held as distinct species, I simply treat of them under one name, because for the purposes of this essay it appears to me advisable to do so. Every reflecting botanist must acknowledge that there is no more equivalence amongst species than there is amongst genera; and I have elsewhere* endeavoured to show that, for all purposes of classification, species must be treated as groups analogous to genera, differing in the number of distinguishable forms they include, and of individuals to which these forms have given origin, and in the amount of affinity both between forms and individuals. My main object is to show the affinities of the polar plants, and I can best do this by keeping the specific idea comprehensive. It is always easier to indicate differences than to detect resemblances, and if I were to adopt extreme views of specific difference, I should make some of the polar areas appear to be botanically very dissimilar from others with which they are really most intimately allied, and from which I believe them to have derived almost all their species. A glance at my catalogue will show that, had I ranked as different species the few Greenland forms of European plants (called generally by the trivial name *Grœnlandica*), I should have made that flora appear not only more different from the European than it really is, but from the American also; and that the differences thus introduced would be of opposite values, and hence deceptive, in every case when the European species (of which the *Grœnlandica* is often not even a variety or distinct form) was not also common to America.

I wish it then to be clearly understood that the catalogue here appended is intended to include every species hitherto found within the arctic circle, together with those most closely allied forms which I believe to have branched off from one common parent within a comparatively recent geological epoch, and that immediately previous to the glacial period or since then. Further, I desire it to be understood that I claim no originality in bringing these closely allied forms together; from the appended notes it will

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* Essay on the Australian Flora; introductory to the Flora Tasmanica,, etc.

be seen that there is scarcely one of them that has not been treated as a synonym, variety, subspecies, form, or lusus, by one or more very able and experienced botanists, some of them by many. Furthermore, it is curious to observe how much the botanists of each country do to a considerable extent agree amongst themselves as to the specific identity or difference of the same forms—the Scandinavian agreeing with Fries, the German with Koch, and the American with Hooker's 'Flora Boreali-Americana'; also to observe, that in all these cases the authors I quote are independent observers, and not copyers or followers. I think this fact indicates that the same plant presents a different aspect (probably obliterated in drying) in each country. This observation is consonant with what we know of the tendency of all species to run into local varieties in isolated areas, which varieties are often appreciable to the eye or to the touch, but are not expressable by words.

Of the 762 species enumerated, I have compared arctic or boreal specimens of all but a few which I have indicated in the appended notes, and in most cases I have compared specimens from all the southern areas indicated; but I do not pretend to have made such a critical study of all the grouped species, or of all those belonging to difficult genera (as *Draba*, *Poa*, etc.), as to enable me to say that I have given all their distribution, or satisfied myself of all their affinities and differences. There are, on the contrary, fully 60 genera out of the 323 arctic ones enumerated, each of which requires careful monographing, and months of study before the limits, systematic and geographical, of its common European species can be ascertained. In two of the large nd most difficult of these I have been indebted to others; namely, to Dr. Boott, who has revised my list of Carices, and to Dr. Andersson of Stockholm, who has drawn up that of the Salices: each has extensively modified the conclusions of his predecessors in arctic botany; quite as much or more so than I have done in any genus, and I have every confidence in their judgment. Colonel Munro has twice revised the list of grasses with a like result. In these important genera, therefore, the groups express the opinions of these acute botanists as to the limits of the species.

With regard to the probable completeness of our knowledge of the flowering plants of the arctic zone, I think it is pretty certain that there are few or no new species to be discovered. The collectors in the numerous voyages undertaken since 1847 in search of the Franklin expedition have not added one species to the flora of the Arctic American islands, and but one to that of Arctic Greenland. The Lapponian region is, of course, as well known as any on the globe; but further east, and especially in Arctic Siberia, much remains to be done; not perhaps in the discovery of new plants, but in ascertaining the southern limits of various Siberian ones that probably cross the arctic circle. Of Arctic Continental America the same may be said.

The method which I adopted in finally arranging the materials for geographical purposes was the following. I took Wahlenberg's 'Flora Lapponica,' Fries's 'Summa Vegetabilium Scandinaviæ,' Ledebour's 'Flora Rossica,' Hooker's 'Flora Boreali-Americani,' and Lange's 'Plants of East Greenland,' which together embrace in outline almost everything we know of arctic botany, geographical, systematic, and descriptive. I put together from these all the matter they contained, and arranged it both botanically and geographically into a 'Systema,' which I studied with an Admiralty north circumpolar chart; and by this means arrived at a general idea of the position and extent of the centres of vegetation within the polar circle. I then again went through the catalogue with the herbarium, with every work treating on arctic plants that was accessible to me, and lastly revised it, verifying the habitats, comparing specimens from each province, adding new localities from more recent floras, catalogues, and voyages; tracing the extra-arctic distribution of the species, and noting all points requiring further investigation.

(*To be continued,*)

NOTICES OF SOME REMARKABLE GENERA OF PLANTS OF THE COAL FORMATION.

By J. W. DAWSON, LL.D., F.R.S., etc.*

GENUS SIGILLARIA.—The Sigillariæ, so named from the seal-like scars of fallen leaves stamped on their bark, were the most important of all the trees of the coal-swamps, and those which contributed most largely to the production of coal. Let us take as an example of them a species very common at the Joggins, and which I have named *S. Brownii*, in honour of my friend, Mr. R.

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* From "Acadian Geology," 2nd edition, with specimens of the illustrations.

Brown, of Sydney. Imagine a tall cylindrical trunk spreading at the base, and marked by perpendicular rounded ribs, giving it the appearance of a, clustered or fluted column. These ribs are marked by rows of spots or pits left by fallen leaves, and toward the base they disappear, and the bark becomes rough and uneven, but still retains obscure indications of the leaf-scars, widened transversely by the expansion of the stem. At the base the trunk spreads into roots, but with a regular bifurcation quite unexampled in modern trees, and the thick cylindrical roots are marked with round sunken pits or areoles, from which spread long cylindrical rootlets. These roots are the so-called Stigmariæ, at one time regarded as independent plants, and, as the reader may have already observed, remarkable for their constant presence in the underclays of the coal-beds. Casting our eyes upward, we find the pillar-like trunk, either quite simple or spreading by regular bifurcation into a few thick branches, covered with long narrow leaves looking like grass, or, more exactly, like pine leaves greatly increased in size, or, more exactly still, like the single leaflets of the leaves of Cycads. Near the top, if the plant were in fruit, we might observe long catkins of obscure flowers or strings of large nut-like seeds, borne in rings or whirls encircling the stem. If we could apply the woodman's axe to a Sigillaria, we should find it very different in structure from that of our ordinary trees, but not unlike that of the Cycads, or false sago-plants of the tropics. A lumber-man would probably regard it as a tree nearly all bark, with only a slender core of wood in the middle; and, botanically, he would be very near the truth. The outer rind or bark of the tree was very hard. Within this was a very thick inner bark, partly composed of a soft corky cellular tissue, and partly of long tough fibrous cells like those of the bark of the cedar. This occupied the greater part of the stem even in old trees four or five feet in diameter. Within this we would find a comparatively small cylinder of wood, not unlike pine in appearance, and even in its microscopic structure; and in the centre a large pith, often divided, by the tension caused in the growth of the stem, into a series of horizontal tables or partitions. Such a stem would have been of little use for timber, and of comparatively small strength. Still the central axis of wood gave it rigidity, the surrounding fibres, like cordage, gave the axis support, and the outer shell of hard bark must have contributed very materially to the strength of the whole. Growing as these trees did in swampy flats close together, and the bark of which they were chiefly composed being less susceptible of rapid decay than most kinds of wood, and too impervious to fluids to be readily penetrated by mineral matter, they were admirably fitted for the production of the raw material of coal. (Fig. 161.)

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I include under Sigillariæ the remarkable fossils known as Stigmaria, being fully convinced that all the varieties of these plants known to me are merely roots of Sigillaria; I have verified this fact in a great many instances, in addition to those so well described by Mr. Binney and Mr. Brown. The different varieties or species of Stigmaria are no doubt characteristic of different species of Sigillaria, though in very few cases has it proved possible to ascertain the varieties proper to the particular species of stem. The old view, that the Stigmariæ were independent aquatic plants, still apparently maintained by Goldenberg and some other palæobotanists, evidently proceeds from imperfect information. Independently of their ascertained connexion with Sigillaria, the organs attached to the branches are not leaves, but rootlets. This was made evident long ago by the microscopic sections published by Goeppert, and I have ascertained that the structure is quite similar to that of the thick fleshy rootlets of Cycas. The lumps or tubercles on these roots have been mistaken for fructification; and the rounded tops of stumps, truncated by the falling in of the bark or the compression of the empty shell left by the decay of the wood, have been mistaken for the natural termination of the stem.* The only question remaining in regard to these organs is that of their precise morphological place. Their large pith and regular areoles render them unlike true roots; and hence Lesquereux has proposed to regard them as rhizomes. But they certainly radiate from a central stem, and are not known to produce any true buds or secondary stems. In short, while their function is that of roots, they may be regarded, in a morphological point of view, as a peculiar sort of underground branches. They all ramify very regularly in a dichotomous

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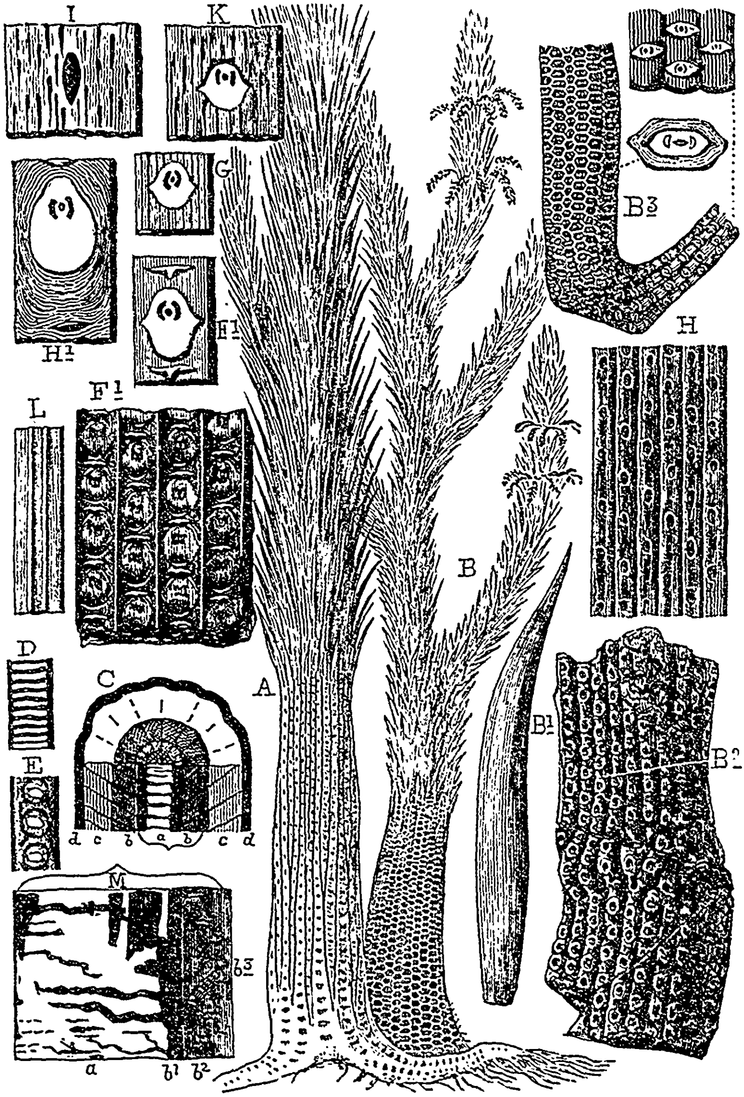
* For examples of the manner in which a natural termination may be simulated by the collapse of bark or by constriction owing to lateral pressure, see my papers, Quart. Jour. Geol. Soc., vol. x. p. 35, and vol. vii. p. 194.

Fig. 161.—*Sigillariæ.*



A, *Sigallaria Brownii*, restored. B, *S. elegans*, restored. B1, Leaf of S. elegans.
B2, Portion of decorticated stem, showing one of the transverse bands of fruit-scars.
B3, Portion of stem and branch reduced, and scars nat. size.
C, Cross section of *Sigillaria Brownii* (?), reduced, and portion at (M) natural size. (*a*) Sternbergia pith. (*b*1) Inner cylinder of scalariform vessels. (*b*2) Outer cylinder of discigerous cells, with medullary rays and bundles of scalariform vessels going to the leaves at (*b*3). (*c*) Inner bark. (*d*) Outer bark.
D, Scalariform vessel magnified.
E, Discigerous woody fibre, magnified.
F, *Sigillaria Bretonensis*, ⅔. (*f*1) Areole n. size.
G, *S. striata*, nat. size.
H, *S. eminens*, reduced. (H1) areole, half n. size.
I. *S. catenoides*, half nat. size.
K, *S. planicosta*, half nat. size.
L, Portion of leaf of *S. scutellata*.

manner, and, as Mr. Brown has shown, in some species at least, give off conical tap-roots from their underside.

In all the Stigmariæ exhibiting structure which I have examined, the axis shows only scalariform vessels. Corda, however, figures a species with wood-cells, or vessels with numerous pores, quite like those found in the stems of Sigillaria proper; and, as Hooker has pointed out, the arrangement of the tissues in Stigmaria is similar to that in Sigillaria. After making due allowance for differences of preservation, I have been able to recognize eleven species or forms of Stigmaria in Nova Scotia, corresponding, as I believe, to as many species of Sigillaria.* At the Joggins, Stigmariæ are more abundant than any other fossil plants. This arises from their preservation in the numerous fossil soils or Stigmaria underclays. Their bark, and mineral charcoal derived from their axes, also abound throughout the thickness of the coal beds, indicating the continued growth of Sigillaria in the accumulation of the coal.

Our knowledge of the fructification of Sigillaria is as yet of a very uncertain character. I am aware that Goldenberg has assigned to these plants leafy strobiles containing spore-capsules: but I do not think the evidence which he adduces conclusive as to their connexion with Sigillaria; and the organs themselves are so precisely similar to the stobiles of Lepidophloios, that I suspect they must belong to that or some allied genus. The leaves, also, with which they are associated in one of Goldenberg's figures, seem more like those of Lepidophloios than those of Sigillaria. If, however, these are really the organs of fructification of any species of Sigillaria, I think it will be found that we have included in this genus, as in the old genus Calamites, two distinct groups of plants, one cryptogamus, and the other phænogamous, or else that male strobiles bearing pollen have been mistaken for spore-bearing organs.

I cannot pretend that I have found the fruit of Sigillaria attached to the parent stem; but I think that a reasonable probability can be established that some at least of the fruits included, somewhat vaguely, by authors under the names of Trigonocarpum and Rhabdocarpus, were really fruits of Sigillaria. These fruits are excessively abundant and of many species, and they occur not only in the sandstones, but in the fine shales and

* See Paper on Accumulation of Coal, Journ. Geol. Soc., vol. xxii.

coals and in the interior of erect trees, showing that they were produced in the coal-swamps. The structures of these fruits show that they are phænogamous and probably gymnospermous. Now the only plants known to us in the Coal formation, whose structures entitle them to this rank, are the Conifers, Sigillariæ, and Calamodendra. All the others were in structure allied to cryptogams, and the fructification of most of them is known. But the Conifers were too infrequent in the Carboniferous swamps to have afforded numerous species of Carpolites; and, as I shall presently show, the Calamodendra were very closely allied to Sigillariæ, if not members of that family. Unless, therefore, these fruits belonged to Sigillaria, they must have been produced by some other trees of the coal-swamps, which, though very abundant and of numerous species, are as yet quite unknown to us. Some of the Trigonocarpa have been claimed for Conifers, and their resemblance to the fruits of Salisburya gives countenance to this claim; but the Conifers of the Coal period are much too few to afford more than a fraction of the species. One species of Rhabdocarpus has been attributed by Geinitz to the genus Næggerathia; but the leaves which he assigns to it are very like those of *Sigillaria elegans*, and may belong to some allied species. With regard to the mode of attachment of these fruits, I have shown that one species, *Trigonocarpum racemosum* of the Devonian strata,* was borne on a rhachis in the manner of a loose spike, and I am convinced that some of the groups of inflorescence named Antholithes are simply young Rhabdocarpi or Trigonocarpa borne in a pinnate manner on a broad rhachis and subtended by a few scales. Such spikes may be regarded as corresponding to a leaf with fruits borne on the edges, in the manner of the female flower of Cycas; and I believe with Goldenberg that these were borne in verticils at intervals on the stem. In this case it is possible that the strobiles described by that author may be male organs of fructification containing, not spores, but pollen. In conclusion, I would observe that I would not doubt the possibility that some of the fruits known as Cardiocarpa may have belonged to sigillarioid trees. I am aware that some so-called Cardiocarpa are spore-cases of Lepidodendron; but there are others which are manifestly winged nutlets allied to

* 'Flora of the Devonian Period,' Quart. Journ. Geol. Soc., vol. viii. p. 324.

Trigonocarpum, and which must have belonged to phænogams. It would perhaps be unwise to insist very strongly on deductions from what may be called circumstantial evidence as to the nature of the fruit of Sigillaria; but the indications pointing to the conclusions above stated are so numerous that I have much confidence that they will be vindicated by complete specimens, should these be obtained.

All of the Joggins coals, except a few shaly beds, afford unequivocal evidence of Stigmaria in their underclays; and it was obviously the normal mode of growth of a coal-bed, that, a more or less damp soil being provided, a forest of Sigillaria should overspread this, and that the Stigmarian roots, the trunks of fallen Sigillariæ, their leaves and fruits, and the smaller plants which grew in their shade, should accumulate in a bed of vegetable matter to be subsequently converted into coal—the bark of Sigillaria and allied plants affording 'bright coal,' the wood and bast tissues mineral charcoal, and the herbaceous matter and mould dull coal. The evidence of this afforded by microscopic structure I have endeavoured to illustrate in a former paper.*

The process did not commence, as some have supposed, by the growth of Stigmaria in ponds or lakes. It was indeed precisely the reverse of this, the Sigillaria growing in a soil more or less swampy but not submerged, and the formation of coal being at last arrested by submergence. I infer this from the circumstance that remains of cyprids, fishes, and other aquatic animals, are rarely found in the underclays and lower parts of the coal-beds, but very frequently in the roofs, while it is not unusual to find mineral charcoal more abundant in the lower layers of the coal. For the formation of a bed of coal, the sinking and subsequent burial of an area previously dry seems to have been required. There are a few cases at the Joggins where Calamites and even Sigillariæ seem to have grown on areas liable to frequent inundation; but in these cases coal did not accumulate. The non-laminated, slicken-sided and bleached condition of most of the underclays indicates soils of considerable permanence.

In regard to beds destitute of Stigmarian underclays, the very few cases of this kind apply only to shaly coals filled with drifted leaves, or to accumulations of vegetable mud capable of conversion

* 'On the Structures in Coal,' Quart. Journ. Geol. Soc., 1859.

into impure coal. The origin of these beds is the same with that of the carbonaceous shales and bituminous limestones already referred to. It will be observed in the section that in a few cases such beds have become sufficiently dry to constitute underclays, and that conditions of this kind have sometimes alternated with those favourable to the formation of true coal.

There are some beds at the Joggins, holding erect trees *in situ*, which show that Sigillariæ sometimes grew singly or in scattered clumps, either alone or amidst brakes of Calamites. In other instances they must have grown close together, and with a dense underground of ferns and Cordaites, forming an almost impenetrable mass of vegetation.

From the structure of Sigillariæ I infer that, like Cycads, they accumulated large quantities of starch, to be expended at intervals in more rapid growth, or in the production of abundant fructification. I adhere to the belief expressed in previous papers that Brongniart is correct in regarding the Sigillariæ as botanically allied to the Cycadaceæ, and I have recently more fully satisfied myself on this point by comparisons of their tissues with those of *Cycas revoluta*. It is probable, however, that when better known they will be found to have a wider range of structure and affinities than we now suppose.

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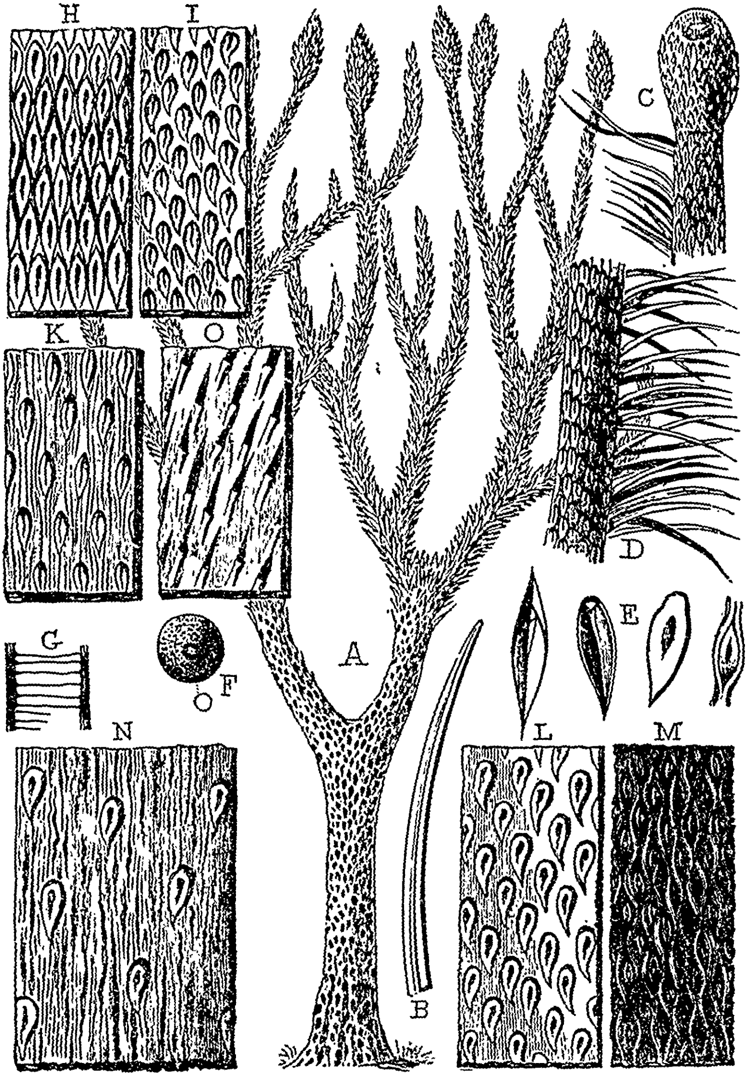
GENUS LEPIDODENDRON, Sternberg.—This genus is one of the most common in the Coal formation, and especially in its lower part. Any one who has seen the common Ground-pine or Club-moss of our woods, and who can imagine such a plant enlarged to the dimensions of a great forest tree, presenting a bark marked with rhombic or oval scars of fallen leaves, having its branches bifurcating regularly, and covered with slender pointed leaves, and the extremeties of the branches laden with cones or spikes of fructification, has before him this characteristic tree of the coal forests,—a tree remarkable as presenting a gigantic form of a tribe of plants existing in the present world only in low and humble species. Had we seen it growing, we might have first mistaken it for a pine, but the spores contained in its cones, instead of seeds, and its dichotomous ramification, would undeceive us; and if we cut into its trunk, we should find structures quite unlike those of pines. As in Sigillaria, we should perceive a large central pith, and surrounding this a ring of woody matter; but instead of finding this partly of disc-bearing wood

Fig. 168.—*Lepidodendron corrugatum.*



A, Restoration.
B. Leaf, nat. size.
C, Cone and branch.
D, branch and leaves.
E, Various forms of leaf areoles.
F, Sproangium.
G, Scalariform vessel, magnified.
H, I, K, L, M, Bark with leaf-scars.
N, Do. of old stem.
O, Decorticated stem (Knorria.)

cells, as in Sigillaria, and divided into regular wedges by medullary rays, we should find it a continuous cylinder of coarser and finer scalariform vessels. Outside of this, as in Sigillaria, we should have a thick bark, including many tough elongated bast fibres, and protected externally by a hard and durable outer rind. The Lepidodendra were large and graceful trees, and contributed not a little to the accumulation of coal. Several attempts have been made to divide this genus. My own views on the subject are given below.

Of this genus nineteen species have been recorded as occurring in the Carboniferous rocks of Nova Scotia. Of these six occur at the Joggins, where specimens of this genus are very much less abundant than those of Sigillaria. In the newer Coal formation, Lepidodendra are particularly rare, and *L. undulatum* is the most common species. In the middle Coal formation, *L. rimosum*, *L. dichotomum*, *L. elegans*, and *L. Pictoense* are probably the most common species; and *L. corrugatum* is the characteristic Lepidodendron of the Lower Carboniferous, in which plants of this species seem to be more abundant than any other vegetable remains whatever.

To the natural history of this well-known genus I have little to add, except in relation to the changes which take place in its trunk in the process of growth, and the study of which is important in order to prevent the undue multiplication of species. These are of three kinds. In some species the areoles, at first close together, become, in the process of the expansion of the stem, separated by intervening spaces of bark in a perfectly regular manner; so that in old stems, while widely separated, they still retain their arrangement, while in young stems they are quite close to one another. This is the case in *L. corrugatum*. In other species the leaf-scars or areoles increase in size in the old stems, still retaining their forms and their contiguity to each other. This is the case in *L. undulatum*, and generally in those Lepidodendra which have very large areoles. In these species the continued vitality of the bark is shown by the occasional production of lateral strobiles on large branches, in the manner of the modern Red Pine of America. In other species the areoles neither increase in size nor become regularly separated by growth of the intervening bark; but in old stems the bark splits into deep furrows, between which may be seen portions of bark still retaining the areoles in their original dimensions and arrangement. This is the case with *L. Pictoense.* The cracking of the bark no doubt occurs in very old trunks of the first two types, but not at all to the same extent.

* * * *

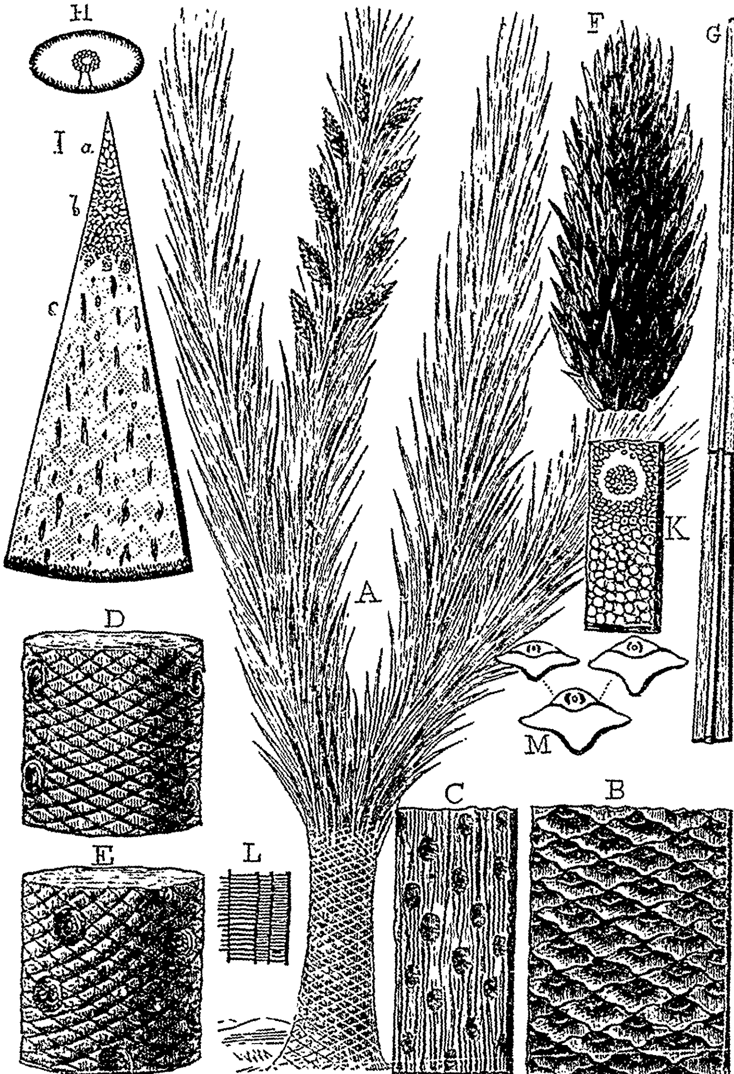
GENUS LEPIDOPHLOIOS.—Under this generic name, established by Sternberg, I propose to inclnde those Lycopodiaceous trees of the Coal measures which have thick branches, transversely elongated leaf-scars, each with three vascular points and placed on elevated or scale-like protuberances, long one-nerved leaves, and large lateral strobiles in vertical rows or spirally disposed. Their structure resembles that of Lepidodendron, consisting of a Sternbergia pith, a slender axis of large scalariform vessels, giving off from its surface bundles of smaller vessels to the leaves, a very thick cellular bark, and a thin dense outer bark, having some elongated cells or bast tissue on its inner side.

Regarding *L. Laricinum* of Sternberg as the type of the genus, and taking in connexion with this the species described by Goldenberg, and my own observations on numerous specimens found in Nova Scotia, I have no doubt that *Lomatophloios crassicaulis* of Corda and other species of that genus described by Goldenberg, *L. Ulodendron* and *L. Bothrodendron* of Lindley, *Lepidodendron ornatissimum* of Brongniart, and *Halonia punctata* of Geinitz, all belong to this genus, and differ from each other only in conditions of growth and preservation. Several of the species of Lepidostrobus and Lepidophyllum also belong to Lepidophloios.

The species of Lepidophloios are readily distinguished from Lepidodendron by the form of the areoles, and by the round scars on the stem, which usually mark the insertion of the strobiles, though in barren stems they may also have produced branches; still the fact of my finding the strobiles *in situ* in one instance, the accurate resemblance which the scars bear to those left by the cones of the Red Pine when borne on thick branches, and the actual impressions of the radiating scales in some specimens, leave no doubt in my mind that they are usually the marks of cones; and the great size of the cones of Lepidophloios accords with this conclusion.

The species of Lepidophloios are numerous, and individuals are quite abundant in the Coal formation, especially toward its upper part. Their flattened bark is frequent in the coal-beds, and their roofs, affording a thin layer of pure coal, which sometimes shows the peculiar laminated or scaly character of the bark when other

Fig. 171.—*Lepidophloios Acadianus.*



A, Restoration.
B, Portion of bark, ⅔ natural size.
C, Ligneous surface of the same.
D, Lower side of a branch, with scars of cones.
E, Upper side of the same.
F, Cone, ⅔ natural size.
G, Leaf, natural size.
H, Cross section of stem, reduced.
I, Portion of the same, nat. size, showing (*a*) pith, (*b*) cylinder of scalariform vessels, (*c*) inner bark.
K, Portion of woody cylinder, showing outer and inner series of vessels magnified.
L. Scalariform vessels, highly magnified.
M, Various forms of leaf scars, natural size.

characters are almost entirely obliterated. The leaves also are nearly as abundant as those of Sigillaria in the coal-shales. They can readily be distinguished by their strong angular midrib.

I figure, in illustration of the genus, all the parts known to me of *L. Acadianus.* (Fig. 171.)

ON OZONE.

A SOMERVILLE LECTURE IN 1866.

By CHARLES SMALLWOOD, M. D., LL.D., D.C.L.

What is Ozone? Again, and perhaps, a question of greater import—more especially at the present time—What is the peculiar action and atmospheric influence, during Cholera and some other of those diseases, usually called Epidemics? This subject has engaged the attention alike of the chemist, the physician and meteorologist; to each it has presented a prolific field for investigation and research, and the subject becomes at the present time of still greater importance from the existence of cholera on the continent of Europe. As to whether cholera may visit us or not, I shall not speculate, but content myself simply to lay before you some points of interest in relation to a powerful and subtile agent, a component of our atmosphere, and which, from numerous observations, has been found to possess a wonderful influence over some diseases, and to exert some peculiar action on the lives of animals and vegetables.

The nature and composition of the atmosphere was long involved in mystery; its properties were not ascertained until chemistry and other branches of natural science were considerably advanced.

The discovery of oxygen, by Priestly, was the first-fruits of modern chemistry; and after its properties have been investigated for so many years, and in so ample and varied a manner, we are only just now beginning to find out how utterly ignorant we are of its real nature;—a substance which is the very breath of life for all created beings, both animal and vegetable, which inhabit and propagate on our globe.

In furtherance of our views on this subject, let us notice the progress of Electrical science, one which now takes its rank among the most important branches of natural philosophy, and which has made most rapid strides within the past few years; it embraces subjects curious and interesting from their close relation to almost every other branch of natural and physical investigation. It may be true that the ancients were familiar with some of its peculiar properties—that property possessed by amber, which, when smartly rubbed on a piece of linen or cloth, attracted light substances when thus excited by friction—the shock felt on touching the electric fish—and the appearance of sparks which are seen to issue from the human body under some peculiar conditions, are among the familiar and earlier examples of electrical knowledge, and it was at this period of history, and by slow degrees, that the knowledge thus acquired was reduced to something like system. That toy—the kite—which the renowned Benjamin Franklin floated under the canopy of the American firmament in June, 1752, caught from the storm-cloud the electric sparks which are now, in our day, made subservient to man, to flash our messages of commerce and daily wants along the slender pathway of a single wire.

Recent investigations have brought to light many interesting facts in connection with the sources of atmospheric electricity, which is said to have a certain bearing on the subject under our present consideration. Some of these have their origin in evaporation, which takes place constantly from the whole surface of our globe, and from the waters of the sea, lakes, and rivers; thus furnishing a constant moisture in our atmosphere, holding therein, in solution, a number of foreign substances which plants imbibe and eliminate for their own peculiar use; and it is a well ascertained fact that no electrical action takes place unless accompanied with some chemical change. Now this constant evaporation and the chemical change that is thus going on upon the surface of the earth, in the respiration of animals and plants, and the various cosmical phenomena of our globe, are supposed to be some of the sources which give rise to the generation and frequent changes of the electrical state and tension of our atmosphere. I would just allude to a theory which has a certain reference to the supposed connection between the amount of Ozone and the electrical tension of the atmosphere. It is stated that the earth is always charged with negative electricity, or that the earth is negatively electrified, and that the vapours which rise from its surface are, like itself, of a negative character; but from a constant law observed in electrical phenomena, named induction, (which is a property it possesses of producing in bodies a state opposite to its own) these particles of aqueous vapour once having left the surface of the earth, by evaporation or any other cause, become of an opposite or positive character, and are repelled in accordance with another well-known electrical law; this action of repulsion repels the positive electricity towards the upper strata of the atmosphere, carrying with it its positive character. During the night the aqueous vapour becomes condensed into dew by cold and radiation, and by the absence of the sun's rays, the amount of positive electricity in the atmosphere is diminished, and the upper vapours possess a less amount of water; the effects of heat, furnished by the rising sun, cause the dew and water to assume again its state of elastic vapour, to be again subjected to the same laws of induction and repulsion, and again placed between the negative earth and the positive celestial space. The first particles, which change from dew to the elastic state of vapour, come off the earth at a higher negative tension, which is obtained by weakening or diminishing the tension and repulsive power of the vapour they leave behind, and which has become less negative than the earth itself, thus keeping up an everchanging amount of electricity, differing both in character and tension.

It was in the year 1785, that Van Marum first called the attention of scientific men to the existence of some anomalous body, which further investigation proved to be Ozone; for he discovered, in passing the electrical spark through atmospheric air, that there was generated a peculiar and strong odour which, says he, is certainly the smell of electrical matter. For more than fifty years this fact remained forgotten or unheeded, until Schonbien, in 1839, while conducting some experiments by passing the electric current through gases, became struck with the same thought, and wrote to M. Arago, the French Astronomer Royal, that for some years he had remarked the perfect analogy that exists between the odour which is developed when ordinary electricity passes the point of a conductor into the surrounding atmosphere, and that which takes place when water is decomposed by the galvanic current.

To Schonbien, then, must be awarded the discovery of Ozone; it was he who gave it its present name, taken from a Greek verb which signifies to give out an odour, but the name reveals nothing of its real nature.

It is not my purpose to enter into a very long and argumentative chemical reasoning on the composition of Ozone. Some difference of opinion still exists as to its present character. Schonbien looked upon it as a regular constituent of our atmosphere, forming a part of, and always present in the air we breathe. I might casually mention that Cavendish, more than half a century ago, found, what he stated was nitrous-acid, present in atmospheric air, and he attributed the beautiful green colour of plants, after a thunderstorm, to a chemical combination of ammonia and nitrous-acid, making a nitrate of ammonia. This effect upon plants, after thunderstorms, is now referred to the effects of Ozone in increased quantity.

The absolute and uniform composition of Ozone has been the subject of much controversy. Schonbien claimed it as a binoxide or peroxide of hydrogen. Faraday denied this, and considered Ozone as oxygen in an isomeric state, or as a simple modification of oxygen in an allotropic condition of that body. Williamson says that, according as Ozone is produced by a galvanic battery, developed by the electric spark, or brought forth by the action of phosphorus on atmospheric air, it is a peroxide of hydrogen and azotic-acid, or a mixture of both. Berzelius opposed this idea, and went to show that Faraday was correct. De la Rive and others stated that it was only oxygen in a peculiar condition given to it by electricity. Freney and others instituted experiments to confirm their ideas, and went on to state that the presence of Ozone would not be developed unless the oxygen was electrified,—for it was shown that in the presence of oxygen alone, or electricity singly, no development of Ozone took place, but as soon as the oxygen became electrified, Ozone became manifest; they placed a strip of test paper in a glass filled with oxygen and hermetically sealed, and by means of metallic bulbs at each end, electric sparks were made to flash across, or through the volume of oxygen; the result was, the test paper immediately became blue, indicating the presence of Ozone.

Test papers have been suspended in oxygen for ten days without any apparent change, but when electrified at the end of that time, they became blue, thereby indicating the presence of Ozone. Test papers of the same quality have been placed in a vacuum, and when the electric spark has been passed through it, no change of colour in the test papers took place, but the moment oxygen gas was introduced, and the otherwise same conditions were fulfilled, the test papers showed the presence of Ozone, thus demonstrating that neither electricity nor oxygen alone, was sufficient to cause any change in the test papers. From these facts it has received the name of electrified oxygen.

Ozone can be made artificially by taking a piece of phosphorus, about half an inch long, cleaning its surface by scraping, putting it into a clean quart bottle, and adding as much water as will cover half the surface of the phosphorous; close the bottle with a loose fitting stopper, and set it aside at a temperature of about 60° Fahrenheit; Ozone will soon then begin to form in the bottle, and in five or six hours it will be abundant. Remove the phosphorus, shake a little water in the bottle, and throw this out to remove the phósphoric acid. This washing must be repeated several times; the Ozone will not be washed away but will remain with the atmospheric air in the bottle. Oil of turpentine, exposed to the sun's rays, in a bottle, partly filled, will also generate Ozone; also some other chemical combinations. The chemical agencies of magnetism and galvanism evolve Ozone, and a current of electricity passed across the surface of water produces it. It might be stated in reference to the formation of Ozone by phosphorus, that the atmospheric air in the vessel should be of the average barometrical pressure, and of a temperature not under 50° or over 90°, for Ozone is not formed in this artificial way at zero Fahrenheit. The formation becomes very rapid at 75° Fahrenheit. It is also formed by the ordinary electrical machine in rapid motion, when the electric fluid is evolved from the conductor—which fact, as before stated, led to its discovery. It may also be formed in various other ways, but enough for our present purpose. When formed by the decomposition of water by means of the galvanic pile, Ozone is always manifest at the positive pole.

I shall now proceed briefly to state the means used to ascertain its presence, and its amount in the atmosphere. The method of detecting its presence is by means of a combination of the iodide of potassium and starch. Take one part of iodide of potassium, ten parts of starch, and 100 parts of water; boil the starch with the water, allow the water to cool, and stir intimately with it the iodide of potassium; then spread the mixture on slips of good glazed paper by means of a soft brush or a sponge. My experience is that good glazed or sized paper is preferable to bibulous or blotting paper. Cream-laid post has been used by me for years; but I have since found that strips of well washed calico, after dipping them in the solution and smoothing their surfaces, answers better than paper; the calico seems more readily to absorb any moisture present, and also to retain it better than the paper, and for experiments will be found better suited for the purpose than paper slips. The exposure of these tests, free from rain, but placed in the light, causes them to become first a pale straw colour, increasing to the tint of a dried leaf, then a deep brown or dark violet approaching to black, which being wetted with pure water resolves into a blue. The decomposition which takes place in these tests is owing to the fact that the Ozone acts similarly to an acid, uniting with the potassium forming potash, and a portion of the iodine is set free, which unites to the starch, giving the peculiar blue colour just alluded to; the starch is only used to estimate the amount present by the depth of colour, and this test is sometimes called an Ozonoscope. The amount is measured from 0 to 10, the different degrees of shade indicating its amount, 10 being the deepest shade. Dr. Moffatt advises that the test papers be placed free from light, but having a free access to air; I have followed both these methods, and the results are nearly alike. Should there be a great amount of moisture in the atmosphere, the exposed test paper attains at once its blue colour, which becomes brown as it dries, but the blue colour may be again attained by moisture or re-wetting with water. Ozone is colourless, possessing a peculiar odour. resembling chlorine, and when diluted cannot be distinguished from the electrical smell; its density is said to be four times that of oxygen; it is a most powerful oxydizing agent, converting most of the metals into peroxides; it is very slightly absorbed by water after long contact; a very high temperature destroys its properties; it possesses bleaching qualities—hence its affinity to chlorine; it combines with chlorine, bromine and iodine; it is also rapidly absorbed by albumen, fibrine, blood, and other such like solutions. It is a most powerful disinfectant, and when even largely diffused in atmospheric air causes difficult respiration, acting powerfully on the mucous membrane, and in still larger quantities may prove fatal. Its presence is easily detected in the state produced in the laboratory as well as the atmosphere; its rapid production, its peculiar smell and other marked properties, render it somewhat less difficult to investigate than many other substances.

Winds influence the amount of Ozone, the amount depending upon the quarter from which they come, and in some cases on their velocity: easterly and southerly winds may be called ozonic winds, while westerly and northerly winds barely ever indicate a trace. Rain and snow generally give indications of a large amount. A N.E. land wind does not generally indicate Ozone; whenever there is Ozone in a N. E. wind it may be attributed to the sea-breeze passing over the land, for we have very often, in this vicinity, a dry N. E. wind with a very high barometer for some days, with no indications of Ozone. Atmospheric temperature does not seem to influence the amount; I have observed its presence at some 30° to 40° below zero, and at 98° above zero, Fahrenheit.

The variation in its daily amount, has been the source of some discussion. Observations were carried on for some years at the Isle Jesus observatory, by means of a movable ozonometer, time being taken as an element; the strips of calico were by a simple contrivance passed over an opening exposed to light and air at the rate one inch per hour. From upwards of 3000 observations, tending to confirm this important point, it was found that the increase and decrease of the daily ozonic periods corresponded in a striking manner to the bi-daily variations of the atmospheric humidity. There were also some slight fluctuations corresponding in a marked degree to the bi-daily variations of the barometer. Upwards of 20,000 observations on Ozone have been taken and recorded, and I am ashamed to say, unaided, thus depriving us of any means of comparison, or confirmation; but I can but express a wish that brighter and better days will come in the future, and that observers will not be found wanting to set at rest the important problem of the effects of the absence or presence of Ozone on the health of animals and vegetables. Assuredly, a substance which has been found to exert an important bearing on the health of individuals, and upon the agricultural and commercial wealth of nations, demands from men of science a calm and patient investigation. It requiries, for its due prosecution, a systematic method of recording its amount; it is for common purposes observed twice in twenty-four hours, and a mean of the two observations is recorded, and also a register of rates of disease and mortality, and a correct register of the nature of these diseases; these of course must be simultaneous with the usual meteorological observations, of atmospheric pressure, temperature and humidity, the force and the direction of the winds, and such like conditions.

It has been stated that the higher we ascend the greater the amount of Ozone found present in the atmosphere. For many years past observations were taken at the Isle Jesus observatory, with an ozonometer hoisted nearly 80 feet high, but the observations at that altitude yielded no different results from those taken at five feet from the surface of the soil. [I might mention, the height five feet is now considered a standard one for observation; it is, probably, at that distance, removed far enough, from the earth, to prevent the action of moisture which is emitted at the surface]. At very high altitudes, as it would appear from Glaisher's balloon experiments, a very trifling difference was apparent, much of course depending upon the wind and its direction; and if it is to be received as a general law that there is always a westerly current of wind in the higher regions of the atmosphere produced by the rotation of the earth on its axis, it is not probable that any great increase in amount would be found, as westerly are not generally known as ozonic winds.

Captain Jansen, of the Dutch Navy, in a voyage to Australia, confirms the assertion as to the ozonic winds, he says:—That in the Northern hemisphere those winds which have a southing in them are more abundant in Ozone, and that in the Southern hemisphere, those winds which have a northing in them are those more abundant in Ozone; and he further says:—That the Equatorial calm belts, with their thunder and lightning, constant rain and moisture, may well be said to be its birth-place.

So far as there is any connection between the amount of Ozone coinciding with the variations in the amount and kind of atmospheric electricity, I would beg leave to state, that from some 6000 observations taken at the Isle Jesus observatory simultaneously with the various electrometers and other apparatus connected with the investigation of atmospheric electricity, no apparent connection was evident between the amount of Ozone and the changes in the tension and kind of electricity.

In passing to the next part of the subject—its influence on some epidemics—it might be observed that epidemics generally are said to be generated by miasmata, a term used for designating a highly important class of febrific agents of a gaseous form, which act on the animal system through the medium of the atmosphere. This class of agents is generally divided into two orders: First, infectious — comprehending those febrile effluvia which are generated by the decomposition of vegetable and animal matter; Second, æriform contagious, generated by the animal system in a state of disease. First, infection may result from the humid decomposition of vegetable and animal matter, contained in the filth of cities, in marshes, and some soils furnishing these materials, hence the designation marsh-miasma. Second, it may result from the decomposition and natural exhalations and excretions of the human body, under ill-conditioned circumstances; to this has been applied the term idio-miasma, expressive of the personal or private character of its source.' Marsh-miasma has also received the name of malaria. Much has been written of malaria but little of its true nature is understood, although it is supposed to be the effluvia that generates fevers, cholera, and such like diseases; many physicians of eminence have written elaborately on the subject—but after all, very little is really known of its subtile influence.

Here is a picture drawn by Dr. Macculoch:—" The fairest portions of Italy are a prey to the invisible enemy, malaria—its fragrant breezes are poison, the dews of the summer evenings are death. The banks of its refreshing streams, its rich and flowery meadows, the borders of its glassy lakes, the luxuriant plains of its overflowing agriculture, the valleys, where its aromatic shrubs regale the eye and perfume the air, these are the chosen seats of this plague—the throne of malaria. Death here walks hand-in-hand with the resources of life, sparing none. The labourer reaps his harvest but to die, or he wanders amid the luxuriance of vegetation and wealth, the ghost of man, a sufferer from his cradle to his impending grave; aged even in childhood, and laying down in misery that life which was but one disease. He is driven from some of the richest portions of this fertile, yet unhappy country; and the traveller contemplates, at a distance, deserts—but deserts of vegetable wealth—which man dares not approach, or he dies." Whatever is its composition, it may be enough for us to know that its existence in the atmosphere is incompatible with health. Now, Ozone is said to destroy this malaria; no deleterious substance is found in the atmosphere where Ozone is manifest, for one of the peculiar properties of Ozone is, its disinfecting powers; putrid meat exposed to the action of ozonized air soon becomes disinfected. Manure heaps and foul drains, where there is decomposition going on, become quite innocuous: and it has been shown that when putrid organic matter is subjected to the action of

Ozone, the bad odour is destroyed as long as the ozonometer gives evidence of thè presence of Ozone, but as soon as the ozonometer ceases its indications, the odour immediately returns. Schonbien's experiments proved that air containing one-6000th part of Ozone can disinfect 540 times its volume of air from putrid meat. Apartments are now being purified by means of Ozone; and during the visitation of cholera, last summer, in London, Ozone was extensively used as a disinfectant. Pieces of phosphorus were also suspended over the gratings of the sewers, so as to generate Ozone and neutralize the spread of the choleraic-contagion. It is here necessary to remark that the phosphorus must be luminous to produce Ozone, and the height of the barometer and the degree of temperature must be taken into account; even the direction of the wind has some influence on its development.

It is a matter of history that, in 1854, cholera visited many cities of the old world and of the new. It has been asserted, and that by numerous observers, that during this visitation, there was always indicated a deficiency of Ozone in the air; and further, that the increase or decrease of cholera coincided strictly with the development or absence of this mysterious substance.

Below is a table shewing for seven years the comparative day of precipitation (rain or snow) each year, and the amount of Ozone indicated, in quantity more than five-tenths of the scale.

1850	there were	106	days of precipitation and	110	days of ozone in more than $\frac{5}{10}$
1851	do.	123	do.	136	do.
1852	do.	136	do.	135	do.
1853	do.	156	do.	114	do.
1854	do.	133	do.	73	do.
1855	do.	140	do.	110	do.
1856	do.	144	do.	126	do.

Shewing the comparatively small amount of ozone in the year 1854, the year this cholera was prevalent.

A commission of the members of the Medical Society of Strasburgh, during the visitation of cholera in 1854, was named for testing the subject, and their united report was:—That during the days that Ozone was deficient in the atmosphere, cholera was at its greatest rate of mortality. From observations taken at Isle Jesus observatory and carefully compared with the death rates in Montreal, and the country parts visited by the epidemic in 1854, this opinion was certainly confirmed. At Newcastle, in England, during the prevalence of cholera, in 1854, Ozone was at its minimum; in London, in the same year, from the 24th of August until the 11th of September, Ozone was only present once, and then in a minute quantity, and cholera was at its height during that period. On the 11th of September, a southerly breeze set in, with indications of Ozone, and from day to day the number of cases diminished. In a paper, read by me in Montreal, before the American Association for the Advancement of Science at their meeting in 1857, I stated that moisture in the atmosphere was necessary for the development of Ozone; this opinion has been opposed by the only American observer, Captain Pope, during some journeys that he made across the great plains in 1856 and 1857. He says:—" Ozone increases in quality, rapidly and regularly, in receding from the low lands which border the Gulf of Mexico, and is greatest on the table lands of the interior"; he goes on further to state that on the low lands animal and vegetable decomposition is very rapid, and on the table lands very slow and with little escape of offensive gases—therefore, on account of the moisture in the low lands, there should be more Ozone developed than in the table lands. But another cause must, with all deference, be brought to bear on the observations of Captain Pope, and it is a very important one: for as already shown, there is a considerable amount of fever and malaria in these wet, low lands, hence the deduction that Ozone has been partially destroyed by the malaria, consequently a less amount was indicated by the ozonometer on the low lands than on the higher table lands. These reasons will account for Captain Pope's observations, without in the least disparaging the theory, that moisture is necessary for the development of Ozone. The fact, that a humid state of the atmosphere better developes Ozone, is confirmed by the observation of Dr. Moffatt, Mr. Lowe, and other Europeans, who have paid attention to the subject. I shall read a short extract from my 1857 paper, showing the amount of precipitation as a test for determining its presence in the atmosphere, and the amount of Ozone corresponding to the days of precipitation; and showing, also, the diminished quantity of Ozone during the months of July, August, and September, 1854, which were the months of the greatest mortality during that visitation of cholera in this neighbourhood. During the visitation of cholera, in most places there were high readings of the barometer. In 1854, here, the mean reading for the month of July was 29.961; for August, 29.910; and for September, 30.201 inches—the lowest reading during the period was 29.619. The thermometer also ranged high—the mean temperature for July being 76.2, and for August 68.31; the dryness of the atmosphere for July was .709, and for August, .714—taking saluration as 1.000—with which number at 9 P.M. on the 11th of August, the thermometer even stood at 76°. There was a haze in the atmosphere, which led to the supposition of fires in the woods being the cause; the weather was calm, and the wind north-westerly, but very light. There was a great thunderstorm at Isle Jesus on the 6th of September, from 6 to 8 P.M., and a slight frost occurred on the morning of the 11th, and snow fell at Quebec on the 21st. The ozonometer, soon after these meteorological events, indicated its usual amount. On the other hand, influenza and pulmonary diseases, when prevalent, are accompanied by a high amount of Ozone, while all gastric diseases, diarrhœa and its allies are accompanied by a decrease in the average amount. The air coming from the sea shows a high amount of Ozone, and it is presumed that it is this property that makes the sea-breeze so beneficial to health. It is a direct stimulant to animal and vegetable life, and it must be borne in mind, that a 2000th part of Ozone in the atmosphere would make it fatal to small animals, and a little more than this would be fatal to man in an atmosphere which gives the maximum number 10 in the ozonoscope or ozonometer; Ozone only exists in the proportion of 1 to 10,000 parts of atmospheric air. When considering the source of Ozone it would seem reasonable to suppose that there should be but little of this agent manifested in the atmospheres of large and crowded cities; repeated experiments have proved this to be the case. In such cities there is always a large consumption of Ozone going on; on the contrary, in the pure air of the country, and at the sea-side, Ozone is generally abundant, and the consumption is manifestly less. There is, indeed, a marked difference between the amount observed at my own residence, which is not in a crowded part of the city, and at the observatory in McGill College grounds. Ozonometers placed in the wards and halls of hospitals give no trace of Ozone, while at the exterior of these buildings a reasonable amount is indicated, shewing that the atmosphere of a city, where large numbers are dwelling together, tells largely on the consumption of this peculiar body, and it must be self-evident that any thing tending to its conservation, such as good and efficient drainage, free currents of air and plenty of ventilation, will directly contribute to the health of cities; and the removing of the causes of its consumption, if not destruction, is the paramount duty of every citizen; and it is thus to the interest of the rich to aid the poor by a cheerful submission to such taxes as may be necessary for the proper cleansing and scavengering our city. It has been beautifully put by one of England's favourite writers:—"That the universal diffusion of common means of decency and health is as much the right of the poorest of the poor, as it is indispensable to the safety of the rich, and of the State; that a few petty boards and corporate bodies—less than drops in the great ocean of humanity around them—are not for ever to let loose fever, malaria, and consumption on God's creatures at their will, or always to keep their jobbing little fiddles going, for a Dance of Death."

Chemical and physical agents produce Ozone, while the decay of vegetable and animal matter consumes it, and when the balance is destroyed between its production and consumtion, disease is the consequence. Ozone is apparent in large quantities in the pine-forests of America, and but few of the diseases arising from malaria exist in their neighbourhood, except where marshes are numerous—their exhalations, under a tropical sun, producing what is termed marsh-miasma. Ozone is generally found to exist in larger quantities in the winter than in summer—more particularly in Montreal, because there then is a much less decomposition of animal and vegetable matter.

Ozone in excess has been found to prevail when disease of the lungs and catarrh are in the ascendant; it has been frequently remarked that easterly winds aggravate these diseases. Dr. Beckel, jr., of Strasburgh, selected cases suffering from pulmonary, bronchial, and heart diseases, carefully comparing the numbers admitted into hospital through a long period of time, and by the fluctuation of the ozonometer, and the variation of the temperature, he came to the conclusion that pulmonary diseases are in adverse relation to the quantity of Ozone and in reverse relation with the degree of temperature. When there is much Ozone with a low temperature, such diseases increase, and death often ensues; whereas, when there is little Ozone with a high temperature, the contrary occurs. Scoutetten's tables show similar results. Schonbein states, that in Berlin a diminution of atmospheric Ozone coincides with the production of gastric disorders, and that there was a complete absence of Ozone in that city, during the invasion of the cholera, and that indications of Ozone in large quantities give rise to pulmonic affections.

Persons interested in the bleaching of linen fabrics have of late directed attention to the amount of Ozone in the atmosphere, and have been induced to keep daily registers of its amount, so that it would seem that it has an important bearing upon our economic wants. Experience shows that upon days when Ozone was present in large quantities, the bleaching was better accomplished; and from experiments carried on in this department, it has been proved that our test papers rather underrate the amount of Ozone absolutely present. The bleaching properties of Ozone have been carried out, still further, for restoring books and prints that have become brown by age and exposure to the light, or have been soiled or smeared with colouring matter—a short time only being required to render them perfectly white, as if just issued from the press, and this without the slightest injury to the blackness of the printer's ink, or the lines of a pen and ink sketch or crayon drawing.

Writing ink may readily be discharged by Ozone, if the paper be subsequently treated with chlorohydric acid to remove the oxide of iron. Vegetable colouring matters are completely removed by it; but it does not act so readily on metallic colouring matters or on grease spots.

Much still remains to be said on this interesting subject. I trust the day is not far distant when it will receive from the scientific world the attention which is due to its great importance as bearing on the health and welfare of the whole community, and that observers will not be wanting to aid in carrying out the important objects embraced in its study.

ON THE AZOIC AND PALÆOZOIC ROCKS OF SOUTHERN NEW BRUNSWICK.

By F. G. Matthew.*

While exploring with my brother, Mr. R. Matthew, the Manganese district of King's County, in the summer of 1866, we made some observations on the geology of this County, having an important bearing on the subject of the article above named.

Huronian.—A more extended examination than had pre-

* Supplementary note to my paper in the Journal of Geol. Society of London, vol. xxi., p. 422.

viously been given to the Cambrian rocks in the Quaco Hills, led to the discovery of an important part of this series not previously recognized as sedimentary; it consists of shales, grits, and conglomerates, usually highly metamorphic, so much so, as in general to have lost all traces of stratification. In this condition they appear to be syenites, granulites and felsites, all highly coloured by the bright red felspar of which they are chiefly composed. Masses of these rocks were observed by our party, in 1864, on the Hammond River, and in the adjacent hills, but their sedimentary character was not at that time recognized.

With this addition the grand lithological features of the older supra-Laurentian rocks in the Southern Hills of New Brunswick appear to be:—

LOWER SILURIAN.—The lingula bearing flags and shales of St. John, etc., at the base of which the primordial fauna occurs.

HURONIAN.—Red sediments of comparatively small volume, perhaps not recognizable in other parts of Acadia. (No. 5. in article on Azoic Rocks.)

Dark coloured trap-slate rocks (Nos. 2 and 4, art. cit.) of great thickness; parted about midway by a rusty-colored calcareo-arenaceous zone charged with iron and manganese. (No. 3, art. cit.).

Red sediment, usually converted into red felspar rocks, also of great thickness, resting upon the Laurentian series (No. 1 of article on Azoic Rocks is here included). The felsites referred to (No. 3, in my article,) may be of this lower horizon, but I have not been able to verify this point. The succession throughout this immense series of beds is greatly obscured by faults. An instance is given at page 28, of Mr. Bailey's Report.

It is noteworthy that the core of the Northern Highlands of New Brunswick consists, in a great degree, of red felspathic rocks (*vide* Bailey's Notes on Geology and Botany of N. B., *Can. Nat.*), and that these are flanked by metalliferous slates, frequently of a dark brown colour, which may be of the same age as the main portion, of the Huronian in the south (Nos. 2—4) above noticed.

The resemblance of the Lower Silurian of Saint John to the gold and antimony bearing slates of the central part of the Province has been already noticed in the article cited above. Thus the Northern metamorphic region may present a full representation of the older Palæozoic series in the Southern Hills.

There is a large area of red felspar rocks in northern Cape Breton, and masses of a similar character in Charlotte Co., N. B., both of which may prove to be Lower Cambrian.

It will be seen that these views are partially at variance with conjectures offered in the last paragraph of page 428, and on page 427; the latter should be applied to the southern band of Cambrian slates (yielding gold and antimony) only.*

LOWER CARBONIFEROUS.—There is a great development of this formation in the area N. and N. E. of the Quaco Hills, drained by the Kennebeckasis and Petticodiac Rivers. The following succession (see wood-cut,) observed on the slopes of these hills, and in the lower valleys parallel to them, are beds, collectively, of very considerable thickness, but some of them vary much in bulk in other parts of this tract. They represent, as nearly as can be judged without actual measurement, the thickness of the formation in eastern Kings County.

Nos. 1 to 5 are much attenuated in the western part of this L. C. district, and have not been detected west of Hammond River valley. In this western quarter also the upper members, especially 6, 7, and 8 have a more considerable thickness than elsewhere. The first of these (6) is much reduced in bulk about the middle of the area; and 7 changes its character or disappears entirely in the east.

The limestone and gypsum beds are but a small part of this voluminous series, in which we were unable to find more than one calcareous horizon; the other outcrops of these rocks in the valley appearing to be merely repetitions of the same beds thrown up by faults.

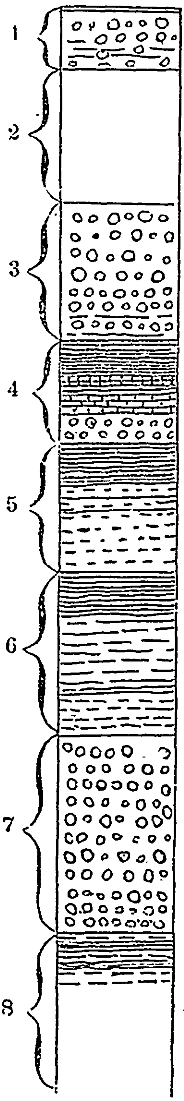
In No. 6 the salt springs of Sussex and Upham occur. No. 4 is rich in manganese derived from the Cambrian rocks, upon and against which much of the lower carboniferous sediments of this tract rest.

Nos. 6 and 8 have complimentary characters in different parts of it; thus, the first towards the east has much bright-red sandstone, but on the Lower Kennebeckasis it is mostly chocolate coloured, and largely made up of thick shale beds, while the converse holds in regard to No. 8. The general prevalence of

* Observations made for the Canadian Survey during the past summer indicate that much of the slate country of the interior may be of Upper Silurian or Lower Devonian age.—Oct. 1868.

chocolate coloured rocks appears to be due to the presence of oxides of iron and manganese, derived from the Huronian system in the adjacent hills.

LOWER CARBONIFEROUS SERIES IN KINGS CO.



1. Basal Conglomerate resting on the Cambrian or Huronian slates.

2. Break in the section (probably shales).

3. Lower Conglomerate, hard heavy beds.

4. Limestone and Gypsum—covered by Conglomerate and underlaid by dark grey shales, somewhat bitumenous. Fossils—*Terebratula sacculus*, Productus, etc., in the limestones; *Cyclopteris Acadica, Lepidodendron corrugatum* and Fish remains in the shales.

5. Grey sandstones and dark-gray shales, somewhat bitumenous. Fossils—*Lepidodendron corrugatum, Cyclopteris Acadica*, etc.

6. Bright-red sandstones, and brown-red shales and sandstones. Fossils—several species of fucoids and fragments of land plants. (Brine springs rise from these beds).

7. Upper Conglomerate (or "Kennebeckasis Conglomerate") hard massive beds.

8. Red-brown arinaceous shales and Red sandstones.

Nos. 4, 5, and 6, which are comparatively soft, are frequently seen on the slopes and at the bottom of valleys of erosion, formed between the hard conglomerates of Nos. 3 and 7. These softer members also yield the elements of the fertile loamy soils, for which the valleys of Kings County are famous.

Along the margin of the great central coalfield, these "Lower Coal-measures"* are much reduced in bulk; and volcanic outbursts have left traces of their presence in that quarter, at epochs corresponding to those marked by the spread of conglomerate beds (Nos. 3 and 7) among the Southern Hills. See Prof. Bailey's Report, page 98.

The following changes in that part of my article which relate to this formation, will bring it into accord with the preceding remarks† :—

Page 431, line 11, for "which may represent" read "of later origin than"

" " 29, for "at or near" read "not far from".

SEA-WEEDS IN MEDICINE.—The genus *Laminaria* consists chiefly of large plants growing abundantly in deep water. They are very rich in iodine, chlorine, sulphur, silica, lime, potash, and soda. They are burnt in large quantities on the French shores of the British Channel and Atlantic, and produce the best raw soda from which iodine is afterwards extracted. There are three species: —*Laminaria digitata, L. saccharina,* and *L. bulbosa ;* and these almost exclusively yield the 70,000 kilogr. of iodine annually brought into the market. There are also other algæ such as *Fucus vesiculosus, F. nodosus, F. serratus,* etc., which generally yield bromine. The inhabitants of the Cordilleras of the Andes were in the habit of using the decoctions of sea-weeds, in cases of scrofula, wens, and lymphatic tendencies. These liquids are, however, very unpalatable, to avoid which M. Moride proceeds as follows:—The plants are slightly rinsed in fresh water, then dried and exposed to the sun, whereby they lose their smell and taste of wrack; after which they are pounded in a mortar and macerated in strongly alcoholized water at a somewhat high temperature. The iodized tincture thus obtained is found useful in all affections for which iodine is prescribed.—*Ex.*

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* Dawson.—Synopsis of the Flora of the Carboniferous period in Nova Scotia.

† Journal of Geological Society of London, Vol. xxi.

NATURAL HISTORY SOCIETY.

REOPRT OF THE COUNCIL TO THE ANNUAL MEETING OF THE NATURAL HISTORY SOCIETY, MAY 18, 1867.

The Council begs to congratulate the members on the more hopeful condition of the Society in many of its aspects.

MEMBERSHIP.

During the last year, twenty additional ordinary members have been elected; but as ten of these have been proposed as life members, the real addition from this source only amounts to ten.

In order to meet the increased expenses of the Society, it has been agreed, after mature and frequent deliberation, to raise the subscription from four dollars to five dollars per annum. It will be an important branch of the labours of the incoming Council to endeavour to increase the list of ordinary members, as the working revenue of the Society depends principally on this source.

Two new life members have been added to the Society; but they regret to record the decease of one, Mr. W. H. A. Davies, who was also a Vice-President. The number of life members is now forty-one, which will shortly be increased by ten of the ordinary members, as above noted. The payments received from life members will now be $50 instead of $40 as before.

A new bye-law has lately been passed admitting ladies to the privileges of the Society as Associate Members, on payment of two dollars per annum. Thirty names have already been proposed; and if members will exert themselves to add to this good beginning, the income will not only be increased, but the attendance at the meetings, the visits to the Museum, and the general interest felt in the concerns of the Society will receive a very healthy augmentation. It is hoped that this new source of income may more than counterbalance the loss incurred by the transference of many names from the list of ordinary to that of life members,—a change which otherwise would be of questionable benefit to the Society.

FINANCE.

The present income from ordinary and associate members may be stated at $800. The Society is still under great obligations to Mr. Ferrier for his valuable services as Treasurer. The financial position during the past year is set forth in the balance sheet herewith presented.

DR. THE NATURAL HISTORY SOCIETY OF MONTREAL, IN ACCOUNT WITH JAMES FERRIER, JR., TREASURER. CR.

1866, May 1.	
To Balance due the Treasurer	$188 51
1867.	
Cash paid, J. F. Whiteaves, salary	300 00
" " Wm. Hunter, do.	200 00
" " Commission for collecting	31 70
" " Interest	243 75
" " for Wood and Coal	166 86
" " Gas Accounts	42 72
" " Water Rent	40 65
" " City Taxes	40 00
" " Insurance	39 00
" " Repairs, and petty expenses	107 12
" " Post Office Accounts	14 50
" " Printing	17 15
" " Advertising	11 58
" " for Specimen Cases	110 00
" " Specimens purchased by Mr. Whiteaves	24 75
May 1.	
To Balance in Treasurer's hands	128 97
	$1707 26

1867.		
By Cash, Government Grant		$750 00
" Donations towards liquidation of debt:—		
Wm. Molson, Esq	$100	
Thos. Rimmer, Esq	50	
		150 00
" Members' yearly subscriptions		640 00
" Museum entrance fees		18 00
" Rent of Lecture Room		52 50
" Proceeds of Conversazione		96 76
		$1707 26

JAMES FERRIER, JR., *Treasurer, N. H. S.*

STATEMENT OF LIABILITIES, MAY 1ST, 1867.

Open Accounts	$ 159 45
Mortgage on Society's Building, favour Royal Institution	2000 00
Do do do do Wm. Watson, Esq	400 00
	$2559 45

E. & O. E.,

Montreal, May 1, 1867.

After considerable discussion on the liabilities of the Society, it was determined, by an appeal to the public, to raise a special fund to defray the debt incurred by the Building Committee, now amounting to $2,400; and, if possible, to increase the Library and Museum. The object was announced by the President at the Conversazione; the appeal has been printed and circulated, and a special Collecting Committee appointed. It was decided that all subscribers of $50 or upwards to this fund should be recommended as life members, or be able to nominate a friend if they were themselves qualified. The Council earnestly recommend that this most important committee be re-appointed. The subscriptions already promised amount to $1,430, of which the following is a list:—

SUBSCRIPTIONS for the Liquidation of debt owed by the Natural History Society of Montreal, and thereafter for the improvement of its Museum and Library.

Mr. John Frothingam	$100	Mr. T. Macfarlane	$50
— William Molson	100	— Champion Brown	50
— Thomas Workman, M.P.	50	— John Swanston	50
— William Workman	50	— Alexander McGibbon	50
— Thomas Morland	50	— Jas. Ferrier, Jr.	50
— Peter Redpath	50	— T. J. Claxton	50
— John W. Molson	50	— F. J. Claxton	50
— George Barnston	50	Rev. A. DeSola, LL.D.	50
— J. Henry Joseph	50	Rev. Canon Balch, D.D.	20
— Thomas Rimmer	50	Sir W. E. Logan, LL.D., F.R.S.	50
— G. A. Drummond	50	Mr. E. Billings, F.G.S.	25
— William Muir	50	— J. F. Whiteaves	25
— William Ewan	50	— A. S. Ritchie	20
— John Leeming	50	— Jas. Ewan	20
— W. Fred. Kay	50	— Jno. Lovell	20

PUBLIC LECTURES.

The yearly course of the Somerville Free Lectures was delivered last winter as follows:

1.—General Sketch of the Gasteropodous Mollusks. By P. P. Carpenter, B.A., Ph. D.

2.—On the Chemistry of the Stars. By J. B. Edwards, Ph. D., F.C.S.

3.—On the Origin of Continents. By the President.

4.—On the Anatomy of the Common Sea-Urchin. By Principal Dawson, LL.D., F.R.S.

5.—From Granite to Basalt. By Mr. T. Macfarlane.

6.—On Coleoptera. By G. P. Girdwood, M.D.

In consequence of the interest excited by the very beautiful experiments made by Dr. Edwards in illustration of the second lecture, he kindly consented to deliver a supplementary lecture on Artificial Auroras, illustrated by Rumkorff's Induction Coil and Geissler's vacua Tubes. A small charge was made for admission to this, to defray the expenses of illustration.

CONVERSAZIONE.

The annual Conversazione was held at the Museum on Feb. 18th, and was numerously attended. After an address by the President, a series of interesting experiments on Force was made by Dr. Edwards. Objects were exhibited in microscopes lent by Messrs. Ferrier, Watt, Muir, Clarke, Ritchie, Murphy, Baillie, and others. A binocular microscope was lent by Mr. F. Cundill. Principal Dawson exhibited a collection of Fossils and Canadian Pearls; Mr. Rimmer a series of Fossils; Mr. Chap man of Fictile Ivories; Mr. Stanley Bagg of Coins and Medals; Mr. Reynolds of Illustrated Works and Roman Antiquities. The rooms were tastefully ornamented by a committee of ladies; and a choice collection of flowers was exhibited from the conservatory of Mr. Donald Ross. The band of the Rifle Brigade enlivened the meeting with beautiful music. A novel feature on this occasion was the execution of permanent decorations, designed by Mr. M'Cord, which recall to mind the names of the leaders in different departments of science, emblazoned with mottoes and emblems, in a very attractive manner. It is hoped that every year permanent additions will be made of the same character.

MUSEUM.

The Council has pleasure in again expressing their high appreciation of the services of Mr. Whiteaves, whose special report to the Council has fully set forth the labours and acquisitions of the year. They have renewed the previous engagement with him, subject to due notice being given on either side. In consequence of the great additions to the collection, and especially those generously presented by the University of Oxford at the instance of Mr. Whiteaves, it has been found necessary to erect three new glass cases. A sub-committee was appointed to assist the Curator in this and other changes in the Museum. Special donations to the fund for cases were made by Mr. Rimmer of $40, and Mr. Reynolds of $45.

The two extremities of the Museum room being now fitted with permanent cases, the much greater work of fitting up the two sides on the same plan ought to be proceeded with without delay. The existing cases are not only unsightly, but they afford no room for additional specimens. Upwards of a hundred new species of birds (of which ninety-two specimens were presented by the University of Oxford), several fine and rare mammals, and specimens in every other branch of natural history, make the new cases urgently called for.

Perhaps the most important alteration introduced this year has been the throwing the Museum open to the public gratuitously on Saturdays, from 1 to 4 p.m. in winter, and from 2 to 6 p.m. in summer. This step, which was not taken without full deliberation and some difference of opinion among the members, has at any rate proved their desire to spread the knowledge and pleasure to be derived from their collections as widely as possible among the inhabitants of Montreal and the strangers visiting the city. At first considerable damage was done to the property of the Society; but, an appeal having been made to the Mayor, two policemen have been regularly placed in attendance, and the conduct of visitors has been such as to warrant the Council in recommending the present as a permanent arrangement. The visitors have varied from 30 to 130 on these occasions,—a small number for so large a population.

During the past summer one of the Vice-Presidents, Mr. Leeming, kindly made arrangements to send the Cabinet-keeper on a collecting excursion to the coast of Maine. This was not only an agreeable change from his ordinary employments, but Mr. Leeming (who defrayed all the expenses of the expedition,) generously presented the specimens obtained to the Museum. Many other places might be visited with great advantage if other gentlemen are disposed to follow this excellent example.

The Scientific Curator reports as follows:—

Mammalia.—Fourteen specimens of North American mammals, mostly Californian species, and six specimens of Australian marsupials, have been procured. These additions made it necessary to re-group and re-arrange the whole of this part of the collection. The collection of antlers has been taken down, cleaned, re-arranged, and conspicuously labelled.

Birds.—The collection of birds has largely increased, especially in the department of British and exotic species. Ninety-two specimens have been presented by the authorities of the University of Oxford and by the late Rev. F. W. Hope, through Prof. Westwood. Mr. Angas has given an Australian eagle, Mr. Jno. Molson a specimen of the "black-headed plover" of the

Nile, and six exotic species have been purchased, making a total of one hundred specimens. Twenty new Canadian birds have been added, some of which are new to our series. The new British and exotic species have been named as far as possible, and have been arranged in a temporary manner until proper cases are provided for their reception.

REPTILES.—Dr. Gunther, of the British Museum, has kindly given thirty-five species of exotic reptiles; seven have been acquired by purchase; and Mr. Vining has given two Geckos from Jamaica. This portion of the collection has more than doubled during the past year. With the exception of about half the exotic snakes, all the specimens have been labelled and arranged.

FISHES.—Mr. Leeming's donation above referred to consisted of twelve species from the Portland coast; Mr. Morland gave the head of a Tunny caught at Gaspé; Dr. Gunther seven species of exotic fishes; and other donors six specimens of Canadian fresh-water fishes. A specimen of the rare Port Jackson Shark, and four species from the Pacific Ocean have been purchased.

INVERTEBRATES.—Thirty species of shells, principally fine cones, have been presented by Mr. B. M. Wright. A collection of beetles and butterflies from Jamaica was given by Mr. Vining, and some of the rarer Canadian moths by Mr. Fowler. The insect cabinet has been re-arranged. Seventeen species of crustacea (from Dr. Dawson and Mr. Wright), three of corals and five of Echinodermata, have been received during the year.

BOTANY.—In this department a set of specimens of the woods of New Zealand has been presented by Mr. Wright, and a beautiful specimen of the fibre of the lace-bark tree of Jamaica by Mr. Vining. In the Aquarian room a space has been set apart for the illustration of structural botany and botanical economics after the plan adopted by the British Museum.

GEOLOGY.—About one hundred and thirty species of fossils have been added during the past session, mainly through the kindness of Mr. Henry Woodward, Mr. Wright and Mr. Mason. These have been mounted on tablets, labelled, and arranged in their respective places in the Museum. Sixty-six fine specimens of rare exotic minerals have been presented by Mr. Wright; these are named, and have been provisionally placed in one of the cases in the gallery.

MISCELLANEOUS.—The ethnological and miscellaneous objects in the cases and on the walls of the gallery have been re-grouped and, as far as possible, labelled. A new case has been put up in the gallery for the reception of objects of antiquarian and of general ethnological interest. A collection of medals and medallions given some years ago by Dr. Gibb, has been arranged and labelled. Want of cases has prevented the formation of a collection to illustrate the comparative anatomy of our Canadian vertebrates; still, a beginning has been made, and the few specimens we have, have been collected together and some of them cleaned.

The Council desire to renew their expression of satisfaction at the manner in which the varied duties of Janitor, Taxidermist and Cabinet-keeper have been performed by Mr. Hunter,—whose labours have been necessarily increased by the opening of the Museum to the public.

LIBRARY.

The Council regret that no funds have been at their disposal to increase the Library, or even to bind the periodicals, which at present are almost useless for reference. It is recommended that during the forthcoming year the Council take steps to render this department more attractive to members, and that gentlemen be invited to contribute books and periodicals thereto.

ORIGINAL PAPERS.

The following are among the communications laid before the Society:—

On the Mineralogy of Crystalline Limestones. By the President.

On the Classification of the genus ATHYRIS M'Coy, as determined by the laws of Zoological Nomenclature. By E. Billings, F.G.S.

On certain discoveries in regard to *Eozoon Canadense;* On Insects from the Devonian and Carboniferous Formations; and On Canadian Pearls. By Principal Dawson, LL.D., F.R.S.,

On the Distribution of Plants in Canada, as related to its physical and geological conditions. By A. T. Drummond, B.A.

On Some Mammals and Birds recently added to the Society's Museum. By the Scientific Curator.

On certain peculiarities in the Shell-structure of Chitonidæ; and on the Vital Statistics of Montreal. By P. P. Carpenter, B.A., Ph. D.

The last paper belongs rather to the unnatural than to the natural history of our species, and might therefore be regarded as somewhat foreign to the objects of the Society. As, however, it is impossible at present to organize a Society in this city for the prosecution of every branch of scientific knowledge, it is to be hoped that the subject on which it treats, which is confessedly of the greatest importance, will be fully discussed from time to time at the monthly meetings.

MISCELLANEOUS.

In consequence of the unnecessary labour caused by the appointment of sub-committees for separate but connected objects, a bye-law has been passed providing that a committee should be nominated by the Council and elected by the Society at the meetings in October, to make the necessary arrangements for both the Conversazione and the Somerville Lectures.

A new bye-law has also been adopted, changing the date of the Council meetings from the Thursday to the Tuesday preceding the monthly meetings, in order to allow more time for the issuing of the necessary circulars.

It is recommended that steps be taken by the Council now to be appointed, to codify and print these and all other new bye-laws of the Society which have been passed since 1859.

In conclusion, the Council beg to recommend that the Silver Medal of the Society be awarded to Mr. Billings. It was owing to his exertions that the *Canadian Naturalist,* which has become so valuable an organ for the Society's operations, was first established. His contributions to scientific literature and to the geology of Canada, although unobtrusive, and of a nature not to attract the general attention, have been singularly careful and exact, and have won the praises of all on this continent and in Europe, who are competent to pass judgment on their merits. And at the present time there is a special reason why this mark of appreciative respect should be no longer delayed,—the Council wishing to bear testimony to the singular ability which Mr. Billings has displayed in the volume on the Palæozoic Fossils of Canada and other publications, which have been issued by the Geological Survey during the last year.

Respectfully submitted by

PHILLIP P. CARPENTER,

Chairman.

BOOK NOTICES.

ACADIAN GEOLOGY.*

Canada has been upon the whole liberal to science. Not so liberal, it is true, as the neighbouring State of New York, whose splendid series of quartos are known the world over; not perhaps so liberal as some even of our sister colonies, who have cheerfully contributed their share of the expense necessary to publish the series of works known as the Colonial Floras, while Canada has hitherto refused hers. Yet, withal, she has been, in her own way, liberal. She has for many years back spent something like $20,000 per annum on literary and scientific societies. It might have been better if this money had been given to these several societies for some specific object—for research into some defined branch of literature or science (excluding geology), to be pursued from year to year, and the results published; nevertheless, though probably there may not be much to show for it, this money has, doubtless, been upon the whole well spent. Canada's greatest benefaction to science is, however, in the maintenance of her Geological Survey, which, under the direction of its eminent chief, has been continued for some sixteen or eighteen years, with plenty of good work to shew for the sums expended on it. Personally we are of opinion that this Survey has been too restricted,—all has been devoted to the fossil, almost nothing to the living. Had Sir William been provided with means to extend his survey so as to report on the natural productions of a district as well as on its geology, the country might have been saved the thousands it has spent in making so-called colonization roads through uncolonizable territory, and in surveying lots unfitted for settlement.

Until very recently, the Lower Provinces have not enjoyed the benefits of organized Geological Surveys, but our author, Dr. Dawson, aided to some extent by other zealous explorers, animated by a love of science for its own sake has, and that to no mean extent, in great part made up for this deficiency, though of course devoting himself to those points most likely to yield important scientific results, leaving the drudgery of details to those who

* ACADIAN GEOLOGY.—The Geological Structure, Organic Remains, and Mineral Resources of Nova Scotia, New Brunswick and Prince Edward Island, by John William Dawson, M.A., LL.D., F.R.S. Second edition, with a Geological map and numerous illustrations. London: MacMillan & Co. Montreal: Dawson Brothers. 8vo, pp. xxviii, 694.

might be officially entrusted with that part of the work. Not content with mere survey, Dr. Dawson has from time to time, and at his own expense, generously published his 'Reports of Progress,' the last and most complete of which is now before us, and in a form well entitled to take rank with official reports, while it is much more attractive to the general reader.

We do not propose giving any lengthy review of this work, as it is within easy reach of all our readers, and moreover we shall hereafter have opportunities of enriching our pages with copious extracts, one of which is given in the present issue of this journal. The following paragraphs are from the preface:—

"While the progress made in the Geology of Acadia since the publication of the first edition of this work is most satisfactory, it also suggests the fact that the present edition, probably the last which the author will be permitted to issue, merely marks a stage in that progress; and that the time will soon arrive when its imperfections will be revealed by the discovery of new facts, when many things now uncertain may have become plain, and when some things now held as certain will be proved to have been errors. When that time shall come, I trust that those who may build on the foundations which I have laid, if they shall find it necessary to remove some misplaced stone or decaying beam, will make due allowance for the difficulties of the work, and the circumstances under which it was executed." * * *

"The lovers of the lighter kind of scientific literature may be disappointed in not finding in this work any incidents of travel or illustrations of the aspects of social life in Acadia. I have been obliged by the pressure of graver and more important matter to resist all temptation to dwell on these; but may perhaps find some future occasion to introduce the public to the incidents and adventures of my geological excursions. * * *

"For myself, I confess that at an earlier period of my life it was a cherished object of ambition with me, that it might be my lot to work out in a public capacity the completion of some, at least, of the departments of geological investigation opened up to me in my native province; but it has been otherwise decreed; and however I may regret the want of that extraneous aid, which would have enabled me to devote myself more completely to original researches, by which my own reputation and the interests of my country might have been advanced, I am yet thankful that I have been enabled to do so much by my own unaided resources, and that I have also been able to assist and encourage others, who may now carry on the work more effectually in connection with an organized Geological Survey." D. A. W.

FILICES CANADENSES.

Under this title the undersigned has issued, for distribution among his foreign correspondents, a collection of our native ferns (filices exsiccatæ). The following is his catalogue: it includes all the species hitherto detected in Upper and Lower Canada, and were the Maritime Provinces included in the limits, the list would have been extended by only one species, (and that of very doubtful occurrence,) namely, *Asplenium marinum*, of which Sir William Hooker says in the Species Filicum, iii. p. 96, "I possess specimens from New Brunswick, Nova Scotia, from Capt. Kendal"—which contradictory note is corrected in the more recent Synopsis Filicum, so as to read "from Nova Scotia," while the Flora Bor. Am., had it from "New Brunswick, E. N. Kendal, Esq."—but its occurrence in either of those Provinces has not otherwise been authenticated. Three other species probably occur on the Canadian shores of Lake Superior, namely, *Cryptogramme crispa* (*acrostichoides* R. Br.), *Dryopteris Filix-mas*, and *Woodsia Oregana*, but have not been found there, the region being probably not yet botanized. The name attached to each species and variety is, in all cases, that of the author of the same; when it is placed within brackets, that author put the plant in a different genus (or in the same genus differently named) from that here assigned to it. It is noteworthy that out of forty-two species twenty-nine belong to Linnæus, and five (or if *P. gracilis* be included, six) to Michaux.

FILICES CANADENSES.

COLLECTÆ DISTRIBUTÆQUE CURA D. A. WATT.

POLYPODIUM (Linn.) Mett.

P. vulgare *Linn.*; No. 1.

PELLÆA, Link.

1. P. Stelleri (*Gmel.*)
sub *P. gracilis* (Michx.); No. 2.

2. P. atropurpurea (*Linn.*); No. 3.

PTERIS, Linn.

1. P. aquilina *Linn.*; - No. 4.

ADIANTUM, Linn.

1. A. pedatum *Linn.*; No. 5.

WOODWARDIA, Smith.

1. W. Virginica (*Linn.*); No. 6.

SCOLOPENDRIUM (Smith) Hook.

1. S. vulgare *Smith*,
[*Aspl. Scolopendrium* Linn.]; No. 7.

2. S. rhizophyllum (*Linn.*); No. 8.

ASPLENIUM, Linn.

1. A. viride *Hudson*; No. 9.

2. A. Trichomanes *Linn.*; No. 10.

3. A. ebeneum *Aiton*; No. 11.

4. A. angustifolium *Michx.*; No. 12.

ATHYRIUM, Roth.

1. A. thelypteroides (*Michx.*); No. 13.

2. A. Filix-fœmina (*Linn.*); No. 14.

PHEGOPTERIS, Feé.

1. P. Dryopteris (*Linn.*); No. 15.

2. P. connectile (*Michx.*),
[*Polyp. Phegopteris* Linn.]; No. 16.

3. P. hexagonoptera (*Michx.*); No. 17.

DRYOPTERIS (Adans,) Schott.

1. D. Thelypteris (*Linn.*); No. 18.
2. D. nov-Eboracensis (*Linn.*); No. 19.
3. D. spinulosa (*Müll.*); No. 20.
   b. dilatata (*Wahl.*); No. 21.
4. D. cristata (*Linn.*); No. 22.
5. D. Goldiana (*Hook.*); No. 23.
6. D. marginale (*Linn.*); No. 24.

POLYSTICHUM (Roth) Schott.

1. P. fragrans (*Linn.*); No. 25.
2. P. aculeatum (*Linn.*).
   a. Braunii (*Koch*); No. 26.
3. P. Lonchitis (*Linn.*); No. 27.
4. P. acrostichoides (*Michx.*); No. 28.

CYSTEA, Smith.

1. C. bulbifera (*Linn.*); No. 29.
2. C. fragilis (*Linn.*); No. 30.

WOODSIA, R. Brown.

1. W. Ilvensis (*Linn.*); No. 31.
   b. alpina
   sub *W. hyperborea* R. Br.; No. 32.
2. W. glabella *R. Brown*; No. 33.

ONOCLEA, Linn.

1. O. sensibilis *Linn.*; No. 34.
2. O. Struthiopteris (*Linn.*); No. 35.

DICKSONIA, L'Herit.

1. D. punctilobula (*Michx.*); No. 36.

OSMUNDA, Linn.

1. O. regalis B. *Linn.*; No. 37.
2. O. Claytoniana *Linn.*; No. 38.
3. O. cinnamomea *Linn.*; No. 39.

BOTRYCHIUM, Swartz.

1. B. Lunaria (*Linn.*); No. 40.
   b. simplex; No. 41.
2. B. matricariæfolium *A. Braun*; No. 42.
   b. lanceolatum; No. 43.
3. B. ternatum (*Thunb.*).
   a. lunarioides *Milde*; No. 44.
   b. obliquum *Milde*; No. 45.
4. B. Virginianum (*Linn.*); No. 46.

OPHIOGLOSSUM, Linn.

1. O. vulgatum *Linn*; No. 47.

The following supplementary species (of fern allies) are intended to be included in the collection:—

Lycopodium apodum *Linn.*; No 48.
L. rupestre *Linn.*; No. 49.
L. dendroideum *Michx.*; No. 50.
L. lucidulum *Michx*; No. 51.
Equisetum robustum *A. Braun*; No. 52.
Eq. scirpoides *Michx.*; No. 53.

A complete set will be deposited in the Herbarium of the Society.

D. A. W.

ARCHIVES DES SCIENCES PHYSIQUES.

Prof. Oswald Heer, of Zurich, has continued his researches into the Miocene Flora of Greenland, and has published the results, and his inferences therefrom, in the above named periodical. By these researches our knowledge of the distribution of vegetation in an era long prior to the present is increased, In Prof. Heer's details we find that the Arctic Fossil Flora, so far as known, now comprises 162 species, among which are eighteen cryptogams, nine being tall, handsome ferns, that probably covered the soil of forests, while on some of the others a growth of minute fungi can be detected, as in analogus species of our own day. Of phanerogams 31 species are conifers, 14 are monocotyledons, and 99 dicotyledons: and judging of these by the existing Flora, 78 were trees and 50 shrubs, which gives a total of 128 species of woody vegetables formerly distributed over the polar regions. The pines and firs come near to those now growing in America, particularly the *Pinus Maculrii*, which closely resembles the *Pinus alba* of Canada. Cones of this tree were brought from Banks Land by Capt. Maclure, who saw the stem of the tree in the hills of fossil wood in that country. And, remarkable enough, that extinct Arctic Flora includes four species of the largest trees in the world, of which two only survive--the *Sequoia sempervirens* and *S. gigantea* of California. These prodigious trees played an important part in the forests of the miocene period; they are found fossilized in Europe, Asia, and America, as well as in the polar regions.

Prof. Heer distinguishes three kinds of cypress Taxodium, Thujopsis, and Glyptostrobus, of which the last two are still living in Japan. The elegant twigs of the Thujopsis are identical with those sometimes found embedded in amber.

Among the deciduous trees are a number which resemble the beech and chestnut of the present day. The *Fagus Deucalionis*, which flourished beyond the 70th degree of north latitude, nearly resembles our common beech—*Fagus sylvatica*—the leaves being of the same forms and dimensions and the same venation, that, were they not toothed at the extremity, it would not be easy to describe the difference. The tree appears to have been widely spread in the north, for its remains are found in Iceland and Spitzbergen as well as in Greenland. There is even more variety among the oaks; eight species have been discovered in Greenland alone, most of them with large, beautifully-formed leaves. One example (*Quercus Olafsoni*,), which can be traced from the north of Canada to Greenland and Spitzbergen, is the analogue of the *Q. Prinus* of the United States. The plane and poplar were also largely represented. The willow, on the contrary, is very rare; a surprising fact, when we remember that in the present day the willow forms one fourth of the woody vegetation of the Arctic zone. The birch was abundant in Iceland; where, also, a maple and a tulip-tree have been found. The magnolia, the walnut, a species of gum and two species of vine grew in Greenland, a large-leafed lime and an alder in Spitzbergen. In short, Prof. Heer, with all the interesting fossils before him, sees in imagination the polar regions of the miocene period covered with great forests of various trees, leafy and resinous, the leaves in some instances extraordinarily large, where veins and ivy interlaced their wandering branches, while numerous shrubs and handsome ferns grew beneath their shade, and these forests extended to the lands bordering on the Pole, if not to the very Pole itself.—*The Athenæum.*

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