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THE

CANADIAN NATURALIST

SECOND SERIES.

ON THE LAURENTIAN ROCKS OF BAVARIA.

By Dr. Gumbel, Director of the Geological Survey of Bavaria; with a plate containing figures of two species of Eozoon.

*Translated from the Proceedings of the Royal Bavarian Academy for 1866, by Professor Markgraf.**

The discovery of organic remains in the crystalline limestones of the ancient gneiss of Canada, for which we are indebted to the researches of Sir William Logan and his colleagues, and to the careful microscopic investigations of Drs. Dawson and Carpenter, must be regarded as opening a new era in geological science.

This discovery overturns at once the notions hitherto commonly entertained with regard to the origin of the stratified primary limestones, and their accompanying gneissic and quartzose strata, included under the general name of primitive crystalline schists. It shows us that these crystalline stratified rocks, of the so-called primary system, are only a backward prolongation of the chain of fossiliferous strata; the elements of which were deposited as oceanic sediment, like the clay-slates, limestones and sandstones of the paleozoic formations, and under similar conditions, though at a time far more remote, and more favorable to the generation of crystalline mineral compounds.

In this discovery of organic remains in the primary rocks, we hail with joy the dawn of a new epoch in the critical history of these earlier formations. Already, in its light, the primeval geologic time is seen to be everywhere animated, and peopled with new animal forms, of whose very existence we had previously no suspicion. Life, which had hitherto been supposed to have first

*Editor's Note.—In revising and preparing this for the press, the original paper has been considerably abridged by the omission of portions, whose place is indicated in the text. Some explanatory notes have also been added.—T. S. H.

appeared in the primordial division of the Silurian period, is now seen to be immeasurably lengthened beyond its former limit, and to embrace in its domain the most ancient known portions of the earth's crust. It would almost seem as if organic life had been awakened simultaneously with the solidification of the earth's crust.

The great importance of this discovery cannot be clearly understood, unless we first consider the various and conflicting opinions and theories which had hitherto been maintained concerning the origin of these primary rocks. Thus some, who consider them as the first-formed crust of a previously molten globe, regard their apparent stratification as a kind of concentric parallel structure, developed in the progressive cooling of the mass from without. Others, while admitting a similar origin of these rocks, suppose their division into parallel layers to be due, like the lamination of clay-slates, to lateral pressure. If we admit such views, the igneous origin of schistose rocks becomes conceivable, and is in fact maintained by many.

On the other hand, we have the school which, while recognizing the sedimentary origin of these crystalline schists, supposes them to have metamorphosed at a later period; either by the internal heat, acting in the deeply buried strata; by the proximity of eruptive rocks; or finally, through the agency of permeating waters charged with certain mineral salts.

A few geologists only have hitherto inclined to the opinion that these crystalline schists, while possessing real stratification, and sedimentary in their origin, were formed at a period when the conditions were more favorable to the production of crystalline materials than at present. According to this view, the crystalline structure of these rocks is an original condition, and not one superinduced at a later period by metamorphosis. In order however to arrange and classify these ancient crystalline rocks, it becomes necessary to establish, by superposition or by other evidence, differences in age, such as are recognized in the more recent stratified deposits. The discovery of similar organic remains, occupying a determinate position in the stratification, in different and remote portions of these primitive rocks, furnishes a powerful argument in favor of the latter view, as opposed to the notion which maintains the metamorphic origin of the various minerals and rocks of these ancient formations; so that we may regard the direct formation of these mineral elements, at least so far as these fossiliferous primary limestones are concerned, as an established fact.

So early as 1853, after investigating the primitive rocks of eastern Bavaria, which are connected with those of the Bohemian forest, I expressed the opinion that, although eruptive masses of granite and similar rocks occur in that region, the gneiss was of sedimentary origin, and divisible into several formations. I at that time endeavored to separate these crystalline schists into three great divisions, the phyllades, the mica-schists, and the gneiss formation, of which the first was the youngest and the last the oldest; all these formations having essentially the same dip and strike.

These results, obtained from very detailed geological and topographical researches, were subsequently more fully set forth in the Survey of the Geology of Eastern Bavaria, (Book IV., p. 219 *et seq.*); where I endeavored to assign local names to the subdivisions of the primitive rocks of that region. Beginning with the more recent, I distinguished the following formations:

1. Hercynian primitive clay-slate.
2. Hercynian mica-slate.
3. Hercynian gneiss. } Primary gneiss system.
4. Bojian gneiss. }

In some cases, within limited regions, I even succeeded in tracing out still smaller subdivisions. It was in this way established that definite and distinct kinds of rocks, as for example hornblende-slate and mica-slate, may replace each other and, as it were, pass into each other, in different parts of the same horizon.

After Sir Roderick Murchison had established the existence of the fundamental gneiss in Scotland, and recognized its identity with that of the Laurentian system of Canada, he turned his attention to the primitive rocks of Bavaria and Bohemia. My researches and my communications to him disclosed the important fact that these rocks belong to the same series as the oldest formations of Canada and of Scotland. On one point only was there an apparent difference of opinion between Sir Roderick and myself; which was that he was disposed to look upon the whole of the gneiss of the Hercynian mountains as constituting but a single formation, corresponding to the Laurentian gneiss of Canada and of Scotland; while I had endeavored to distinguish two divisions, the newer grey or Hercynian gneiss, and the older red or variegated, which I called the Bojian gneiss. This difference of opinion is however at once removed by the remark that I did not intend to maintain in the older gneiss the existence of a formation more ancient than the fundamental gneiss of Scotland, nor yet to assimilate the newer or grey gneiss to the more recent or so-called metamorphic series, which, according to Sir Roderick, may be clearly distinguished in Scotland from the Laurentian gneiss.

[This newer gneissic formation of the Highands is, according to Murchison, Ramsay and others, of Lower Silurian age. Our author simply claims to have established a division in the proper Laurentian rocks of Bavaria and Bohemia. It will be seen from the recently published maps of the Laurentian region of the Ottawa, that Sir William Logan there distinguishes three great limestone formations, by which the enormous mass of Laurentian gneiss is separated into four divisions. One or two of the upper ones of these may be eventually found to correspond to the grey Hercynian gneiss of Bavaria, which is there accompanied by the Eozoon Canadense, a fossil so far as yet known characterizing the highest of the three Laurentian limestones. This grey gneiss of Bavaria appears to be lithologically distinct from the Labrador (or Upper Laurentian) series; nor do we find in the present memoir of Gumbel, any clear evidence of the occurrence either of this, or of the Huronian system, in Bavaria.—T. S. H.

After citing in this connection Sir W. E. Logan's observations on these *ancient formations*, which are shown, by the results of the Canadian Survey, to represent three great systems of sedimentary rocks, formed under conditions not unlike those of more modern formations, our author observes:—]

Accepting these views of the older Canadian rocks, it would naturally follow that organic life might be expected to reach back much farther than the so-called primordial fauna of Lower Silurian age, and to mark the period hitherto designated as Azoic.

Guided by these ideas, the geologists of Canada zealously sought for traces of organic life in the primitive rocks of that country. Dr. Sterry Hunt had already concluded that it must have existed in the Laurentian period, from the presence of beds of iron ore, and of metallic sulphurets, which, not less than the occurrence of graphite, were to him chemical evidences of an already existing vegetation, when at length direct evidence of life was obtained by the discovery of apparently organic forms in the great beds of crystalline limestone which occur in the Laurentian system. Such were collected in 1858, by Mr. J. McMullen from the Grand Calumet on the Ottawa River, and were observed by Sir Wm. Logan to resemble closely similar specimens obtained by Dr. James Wilson in Burgess, a few years previously. In 1859, Sir Wm. Logan first expressed his opinion that these masses, in which pyroxene, serpentine, and an allied mineral, alternated in thin layers, with carbonate of lime or dolomite, were of organic origin; and in 1862 he reiterated this opinion in England, without however being able to convince the English geologists, Ramsay excepted, of the correctness of his views. Soon after this, however, the discovery of other and more perfect specimens, at Grenville, furnished decisive proofs of the organic nature of these singular fossils.

The careful and admirable investigations of Dawson and of Carpenter, to whom specimens of the rock were confided, have placed beyond doubt the organic structure of these remains, and confirmed the important fact that these ancient Laurentian limestones abound in a peculiar organic fossil, unknown in more recent formations, to which has been given the name of Eozoon.*

* * * * * *

The researches of Sterry Hunt on the mineralogical relations of the Eozoon-bearing rocks, lead him to the important conclusion that certain silicates, namely serpentine, white pyroxene, and loganite, have filled up the vacant spaces left by the disappearance of the destructible animal matter of the sarcode, the calcareous skeleton remaining more or less unchanged. If, by the aid of acids, we remove from such specimens the carbonate of lime, (or, in certain cases, the dolomite which replaces it,) there remains a coherent skeleton, which is evidently a cast of the soft parts of the Eozoon. The process by which the silicates have been introduced into the empty spaces corresponds evidently to that of ordinary silicification through the action of water. It is to be noted that Hunt found serpentine and pyroxene, side by side, in adjacent chambers, and even sharing the same chamber between them; thus affording a beautiful proof of their origin through the

* Here follows, in the original, a lengthened analysis of the memoirs of Messrs. Logan, Dawson, Carpenter, and Hunt, published in the Quarterly Journal of the Geological Society of London, and already reprinted in the Canadian Naturalist.

infiltration of aqueous solutions, while the Eozoon was yet growing, or shortly after its death. * * *

Hunt, in a very ingenious manner, compares this formation and deposition of serpentine, pyroxene, and loganite, with that of glauconite, whose formation has gone on uninterruptedly from the Silurian to the Tertiary period, and is even now taking place in the depths of the sea; it being well known that Ehrenberg and others have already shown that many of the grains of glauconite are casts of the interior of foraminiferal shells. In the light of this comparison, the notion that the serpentine, and such like minerals of the primitive limestones have been formed in a similar manner, *in the chambers of Eozoic foraminifera, loses any traces* of improbability which it might at first seem to possess. * *

My discovery of similar organic remains in the serpentine-limestone from near Passau was made in 1865, when I had returned from my geological labors of the summer, and received the recently published descriptions of Messrs. Logan, Dawson, etc. Small portions of this rock, gathered in the progress of the geological survey in 1854, and ever since preserved in my collection, having been submitted to microscopic examination, confirmed in the most brilliant manner the acute judgment of the Canadian geologists; and furnished paleontological evidence that, notwithstanding the great distance which separates Canada from Bavaria, the equivalent primitive rocks of the two regions are characterized by similar organic remains; showing at the same time that the law governing the definite succession of organic life on the earth is maintained even in these most ancient formations. The fragments of serpentine-limestone or ophicalcite, in which I first detected the existence of Eozoon, were like those described in Canada in which the lamellar structure is wanting, and offer only what Dr. Carpenter has called an acervuline structure. For further confirmation of my observations, I deemed it advisable, through the kindness of Sir Charles Lyell, to submit specimens of the Bavarian rock to the examination of that eminent authority, Dr. Carpenter; who, without any hesitation, declared them to contain Eozoon.

This fact being established, I procured from the quarries near Passau as many specimens of the limestone as the advanced season of the year would permit; and, aided by my diligent and skilful assistants Messrs. Reber and Schwager, examined them by the methods indicated by Messrs. Dawson and Carpenter. In this way I soon convinced myself of the general similarity of our organic remains with those of Canada. Our examinations were made on polished sections and in portions etched with dilute nitric acid, or, better, with warm acetic acid. The most beautiful results were however obtained by etching moderately thin sections, so that the specimens may be examined at will either by reflected or by transmitted light.

The specimens in which I first detected Eozoon came from a quarry at Steinhag, near Obernzell on the Danube, not far from Passau. The crystalline limestone here forms a mass from fifty to seventy feet thick, divided into several beds, included in the gneiss, whose general strike in this region is N.W., with a dip of 40°–60° N.E. The limestone strata of Steinhag have a dip of 45° N.E. The gneiss of this vicinity is chiefly grey, and very silicious, containing dichroite, and of the variety known as dichroite-gneiss; and I conceive it to belong, like the gneiss of Bodenmais and Arber, to that younger division of the primitive gneiss system which I have designated as the Hercynian gneiss formation; which both to the north, between Tischenreuth and Mahring, and to the south, on the south-west of the mountains of Ossa, is immediately overlaid by the mica-slate formation. Lithologically, this newer division of the gneiss is characterized by the predominance of a grey variety, rich in quartz, with black magnesian-mica and orthoclase, besides which a small quantity of oligoclase is never wanting. A farther characteristic of this Hercynian gneiss is the frequent intercalation of beds of rocks rich in hornblende, such as hornblende-schist, amphibolite, diorite, syenite, and syenitic granite, and also of serpentine and granulite. Beds of granular limestone, or of calcareous schists are also never altogether wanting; while iron pyrites, and graphite, in lenticular masses, or in local beds conformable to the great mass of the gneiss strata, are very generally present.

The Hercynian gneiss strata on the shores of the Danube near Passau are separated from the typical Hercynian gneiss districts which occur to the north, on the borders of the Fichtelgebirge and near Bodenmais and Arber, by an extensive tract, partly occupied by intrusive granites, and partly by another variety of gneiss. These Danubian gneiss strata are not seen to come in contact with any newer crystalline formation, but towards the south are concealed by the tertiary strata of the Danubian plain; while towards the N.W. they are in part cut off by granite, and in part replaced by those belts of gneiss which accompany the quartz ridge of the Pfahl, and belong to the red variety or Bojian gneiss. The grey gneiss strata of the Danube might therefore be supposed to be older than this red gneiss, which from its relations in the district to the N.W., between Cham and Weiden, I had regarded as itself the more ancient formation. But the lithological characters of the grey Danubian gneiss are opposed to this view, since this rock not only presents a general resemblance to the gneiss formation of Bodenmais, which without doubt is directly overlaid by the mica-schist of the mountains of Ossa, thus shewing it to be the newer gneiss; but exhibits a repetition of the minor features which characterize the gneiss district of Bodenmais. We find in the Danubian gneiss that same abundant dissemination of dichroite, which gives rise to the typical dichroite-gneiss of Bodenmais, with nearly the same mineral associations in both cases. On the Danube, also, interstratified beds of hornblende-rock (at Hals near Passau), of serpentine (at Steinhag), and of pyrites (at Kelberg, and many points along the Danube), occur, as in the north. On the other hand, the graphite which abounds in the gneiss of Passau is not wanting at Bodenmais or Tischenreuth. The interstratified syenites and syenitic granites are, in like manner, common to all these districts; those near Passau being, however, richer in easily decomposed minerals, such as porcelain-spar (scapolite) and calcspar, are more subject to decomposition, and form the parent rock of the famous porcelain clays of the region.

These resemblances lead me to refer the Danubian gneiss, notwithstanding its apparent stratigraphical inferiority to the red gneiss, to the newer or Hercynian formation; and to explain its apparently abnormal relations by assuming a fault running along the strike from N.W. to S.E., through which the older gneiss of the Pfhal is brought up, and seems to overlie the younger.

We shall then regard the whole of the gneissic strata characterized by dichroite, which extend on the Danube from Passau to Linz, as equivalent to the Hercynian gneiss of Bodenmais, and designate it as the Danubian gneiss. We may here call attention to the abundance of graphitic beds in it, as also to the occurrence of porcelain clay, and of beds of iron pyrites and magnetic pyrites. If it is true (as maintained by Dr. Sterry Hunt) that all graphite owes its origin to organic matters, we must suppose the existence of a primordial region peculiarly rich in organic life; since graphite occurs here in almost all the strata, and in some places in such quantities that it is profitably extracted, and is largely used for the manufacture of the famous Passau crucibles. In all of the numerous graphite mines, the uniform interstratification of bands and lenticular masses rich in graphite with the gneiss is here distinctly marked. A similar arrangement is seen in the sulphurets of iron, which are more abundantly disseminated in the more hornblendic strata. The localities of porcelain-earth or kaolin are in like manner confined to the strike of the gneissic strata; and are generally contiguous to certain interstratified granitic and syenitic bands, rich in feldspar. Its frequent association with porcelain-spar, (probably nothing more than a chloriferous scapolite or anorthite,) indicates that this mineral has played an essential part in the production of the kaolin. The presence of chlorine in this mineral is highly significant, and suggests the agency of sea-water in its production.

Of particular interest, from their mineral associations, are three or more parallel bands of crystalline limestone of no great thickness, which occur conformably interstratified with the gneiss of the hills near Passau. They begin near Hofkirchen, and extend north and south, from along the Danube as far as the frontier, near Jochenstein, where the Danube leaves Bavaria. These separate limestone bands, although exposed by numerous quarries, cannot be followed uninterruptedly, being sometimes concealed, and sometimes of insignificant thickness.

* * * * * *

The large quarry of Steinhag already described, from which I first obtained the Eozoon, is one. The enclosing rock is a grey hornblendic gneiss, which sometimes passes into a hornblende-slate. The limestone is in many places overlaid by a bed of hornblende-schist, sometimes five feet in thickness, which separates it from the normal gneiss. In many localities, a bed of serpentine, three or four feet thick, is interposed between the limestone and the hornblende-schist; and in some cases a zone, consisting chiefly of scapolite, crystalline and almost compact, with an admixture however of hornblende and chlorite. Below the serpentine band, the crystalline limestone appears divided into distinct beds, and encloses various accidental minerals, among which are reddish-white mica, chlorite, hornblende, tremolite, chondrodite, rosellan, garnet, and scapolite arranged in bands. In several places the lime is mingled with serpentine, grains or portions of which, often of the size of peas, are scattered through the limestone with apparent irregularity, giving rise to a beautiful variety of ophicalcite or serpentine-marble. These portions, which are enclosed in the limestone destitute of serpentine, always present a rounded outline. In one instance there appears, in a high naked wall of limestone without serpentine, the outline of a mass of ophicalcite, *about sixteen feet long and twenty-five feet high, which, rising* from a broad base, ends in a point, and is separated from the enclosing limestone by an undulating but clearly defined margin, as already well described by Wineberger. This mass of ophicalcite recalls vividly a reef-like structure. Within this, and similar masses of ophicalcite in the crystalline limestone, there are, so far as my observations in 1854 extend, no continuous lines or concentric layers of serpentine to be observed, this mineral being always distributed in small grains and patches. The few *apparently regular layers which may be observed are soon* interrupted, and the whole aggregation is irregular. [This is well shown in plates II. and III. in the original memoir, which recall the acervuline portions, that make up a large part of the Canadian specimens of Eozoon.—Eds.]

The numerous specimens which were subsequently collected, at the commencement of the winter, show, throughout, this irregular structure, which seems to characterize the Bavarian specimens of Eozoon, as is in part the case in those from Canada. It is true *that small lenticular masses or nodules, consisting chiefly of* scapolite, measuring fifty by twenty millimeters, and even much more, are often met with, around which serpentine is arranged in a concentric manner; but even here the serpentine is in small cohering masses, and not in regular layers; nor could I, after numerous examinations of fragments of such masses, satisfy myself whether I had to deal with the commencing growth of an Eozoon, or merely with a concretionary mass; since the granular structure of the scapolite centre could never be clearly made out. Moreover *the occurrence of these nodules, arranged in a stratiform* manner, is opposed to the notion that they are nuclei of Eozoon, although in the parts around these nodules I could sometimes distinctly observe tubuli, canals, and even indications of a shell-like structure.

The portions of serpentine in the ophicalcite occur of very various sizes, from that of a millet-seed to lumps whose sections measure fifteen by six or eight millimeters. But I think I can detect within certain lines, (which are not, it is true, very well defined,) chains of serpentine grains, of nearly equal size, connected with each other. When by means of acids the lime is removed from these aggregates, a perfectly coherent serpentine skeleton is in all cases obtained, which may be compared to a piece of wood perforated by ants. * * * * * The surface of the serpentine grains is rounded, pitted, and irregular; plane surfaces and straight lines are rarely to be seen. Even when dilute nitric or acetic acid has been used to remove the lime, a white down-like coating is frequently found on the serpentine, which does not answer to the nummuline wall of the calcareous skeleton. In many cases, where the lime is very crystalline, and the more delicate organic structure obliterated, small tufts of radiated crystals, apparently hornblende or tremolite, are seen resting upon the serpentine. These crystals, when seen in thin sections, by transmitted light, may easily give rise to errors; their formation seems to have been possible only where the calcareous skeleton had been destroyed, and crystalline carbonate of lime deposited in its stead; during which time free space was given for the formation of these crystalline groups. In very many cases there are seen, by a moderate magnifying power, (in the residue from acids) deposits of small detached cylindrical stems, with some larger ones, consisting of a white matter insoluble in acids. These appear to be the casts of the tubuli which penetrated the calcareous skeleton, and of the less frequent stolons, as will be described.

The serpentine in these sections never appears quite homogeneous, but exhibits, on the contrary, irregular groups of small dark-colored globules disseminated through the mass, without however any definite indications of organic form. Still more frequently, the serpentine is penetrated by irregularly reticulated dark colored veins, giving to the mass a cellular aspect.

In certain parts of the serpentine, however, parallel lines, groups of curved tube-like forms, and oval openings, clearly indicate an organic structure like that of the Canadian Eozoon. The finely tubulated nummuline wall of the chambers, which was discovered by Carpenter, and the casts of whose tubuli appear in the decalcified specimens from Canada as a soft white velvet-like covering, could only be found in a few isolated cases in the Bavarian specimens, but was clearly made out in a few fragments. (Pl. I., 4.) The somewhat oblique section shows the openings of the minute tubuli.

It should be remarked that the serpentine at Steinhag occurs, not only replacing the sarcode in the carbonate of lime of the Eozoon, but also forming layers over the limestone strata, and moreover filling up large and small crevices and fissures, which have nothing at all to do with the organic structure. Especially worthy of notice are the plates of fibrous serpentine, *or chrysotile, often from five to ten millimeters in diameter*, which are found extending in unbroken lines through the compact serpentine.

The color of the serpentine presents all possible shades, from blackish green, to the palest yellowish green tint. Where it has been exposed to the weather, the serpentine has become of a pale brownish green, and appears changed into gymnite. The different tints are arranged in zones, and seem to mark different periods of growth. The carbonate of lime which is interposed among the grains of serpentine in the specimens from Steinhag, is either distinctly crystalline, or apparently compact. In the first case, no organic structure can be perceived; thin sections of the crystalline portions show only intersecting parallel lines; and in etched or entirely decalcified specimens, no clear evidence of the fine canal-system of the skeleton can be observed. These crystalline portions often alternate with others which are compact and but feebly translucent. In thin sections of these compact parts, the rounded forms of the delicate tubuli are very clearly discerned, provided the section is at right angles to them. In etched specimens, viewed by reflected light, these tubuli are seen to branch out in the form of tufts, exactly as described and figured by Drs. Dawson and Carpenter.

These branching and ramified tubuli rest upon the serpentine granules, and seem by anastomosis to be connected with adjacent groups. The diameter of these tubuli is from $\frac{15}{1000}$ to $\frac{20}{1000}$ millimeters. They are easily distinguishable from the delicate groups of crystals, which are also sometimes found implanted in the serpentine, by the nearly uniform thickness throughout their whole length; by their extremities, which are always somewhat crooked; and by their pipe-like form. The latter are never ramified; have a fibrous aspect; and are always straight, and terminate in a point. (Pl. I., figs. 1, 2, 3.)

Here and there are observed larger tubuli, which, so far as my observations extend, are always isolated, and nearly or quite parallel. (Pl. I., fig. 1.) Their diameter is about $\frac{7}{100}$ millimeters, and they not improbably represent those stolons or connecting channels with which Carpenter has made us acquainted.

In the decalcified specimens, delicate very slender string-like leaflets were very frequently observed, stretched between the serpentine granules; but they presented no discernible organic structure, and are perhaps only the casts of small crevices. More remarkable are the numerous canals filled with carbonate of lime, which traverse the serpentine granules, and at the surface of these are expanded into funnel shapes. They appear to represent cross connections between the calcareous skeleton.

As my object at present is merely to shew the presence, in the primitive limestones of Bavaria, of forms corresponding to the Canadian Eozoon, I will not dwell longer on these various appearances met-with in the microscopical examinations, nor on the peculiar cellular structures observed in the carbonate of lime. I will, for the same reason, only mention a specimen which exhibits, by the side of a curved main tube, a number of secondary tubuli, and farther on a parallel layer of fibres; and also another radiated form which resembles a section of a Bryozoon. It is sufficient to draw attention to the fact that, in addition to Eozoon, there are other organic remains in these crystalline limestones. There remains however to be noticed a phenomenon of some importance.

When the lime is removed by nitric or acetic acid from the interstices of the serpentine granules, there may be observed, on gently moving the liquid, extremely delicate membranes, that separate themselves from the serpentine grains, (which they covered thickly, as with a fine white down,) and now remain swimming in the liquid, so that they can readily be separated, by decantation, from a multitude of heavier particles, which, having also detached themselves from the serpentine mass, accumulate at the bottom of the vessel. These consist in great part of indistinct mineral fragments, and of small crystalline needles, together with distinct cylindrical portions, which are the broken tubuli of the Eozoon. Besides these are, here and there, distinctly knotted stems or tubules, (Pl. I., figs. 5, *a* and *b*,) which I dare not suppose to belong to Eozoon. Various other fragments of tubuli are also associated with these.

The delicate flakes, which can be obtained by evaporating the liquid in which they are suspended, shew, under a magnifying power of 400 diameters, a membranous character, and peculiar structures, which seem to be undoubtedly of organic origin.

Their forms are best understood by the figures 6, *a*, *b*, *c* and *d*. The examination of the fine slimy residues from the solution of various primary crystalline limestones, in which, from the absence of well marked foreign minerals, it may be difficult to prove the presence of distinct organic forms, will, I think, afford the quickest and readiest mode of establishing the existence of organisms.

The presence of the Eozoon in the primary limestone of Steinhag being thus established, I proceeded to examine such specimens as were at my disposal from other localities of similar limestones in the vicinity of Passau. I must here remark that these specimens, collected during my geolological examinations twelve years since, were chosen as containing intermixtures of serpentine and hornblende, and not with reference to the possibility of their holding organic remains. I succeeded however in detecting at least traces of Eozoon in specimens of the limestone from Untersalzbach, (fig. 2,) from Hausbach, Babing, (fig. 3,) and from Kading and Stetting. Moreover a specimen of ophicalcite from a quarry near Srin, in the region between Krumau and Goldenkron, among the primitive hills of Bohemia, afforded unequivocal evidences of Eozoon. Von Hochstetter moreover has received specimens of crystalline limestone from the same strata at Krumau, in which Dr. Carpenter has shown the presence of Eozoon. To the same formation belong the calcareous rocks near Schwarzbach, in the vicinity of which, as near Passau, great masses of graphite are intercalated in the gneiss hills. These limestones of Schwarzbach connect those of Krumau with the similar strata near Passau, from which they are only separated by the great granite mass of the Plockenstein hills. We thus obtain a still farther proof of the similarity of structure throughout the whole range of primitive rocks of Bavaria and Bohemia; and of the parallelism of their lowest portion with the Laurentian gneiss system of Canada. I think therefore that we may, without hesitation, *place the Hercynian gneiss formation of the mountains forming the Bavarian and Bohemian frontier, on the same geological horizon with the Laurentian system.*

Farther northward, in similar gneiss hills, occupying a limited area, a crystalline limestone occurs near Burggrub, not far from Erbendorf, from which a few specimens were at hand. They were however a reddish, very ferruginous dolomite, penetrated by fibres of hornblende and epidote, and gave me no trace of organic remains.

Besides these limestones of the Hercynian gneiss, there is found in Bavaria another remarkable deposit of crystalline limestone, included in the Hercynian primitive clay-slate series on the south and south-east border of the Fichtelgebirge, in the vicinity of Wunseidel. This clay-slate formation, as we have already shewn, overlies the Hercynian gneiss and mica-slate series, and is immediately beneath the primordial zone of the Lower Silurian strata met with in the Fichtelgebirge. It would thus seem to correspond with the Cambrian rocks of Wales, and with the Huronian system of Canada, as Sir Roderick Murchison has already suggested. This view is confirmed by Fritzsch's discovery of traces of annelids in the grauwacke of Przibram, and by the occurrence of crinoidal stems and foraminiferal forms, according to Reuss, in the limestone of the primitive clay-slates of Paukratz, near Reichenstein. Thus our Hercynian mica-slate, with certain hornblendic strata and chloritic schists belonging to the same horizon, would occupy a stratigraphical position similar to the Labrador series, or Upper Laurentian, of Canada.

The crystalline limestone of the Fichtelgebirge forms in the primitive clay-slate two nearly parallel bands, which I conceive to be the outcrops of one and the same stratum, on the opposite sides of a trough. It presents several parallel beds separated by intervening beds of the conformable clay-slate.

The limestone strata near Wunseidel dip from 50° to 75° S.E., and sometimes attain a thickness of 350 feet. They are in many places dolomitic. * * * * Spathic iron, in nests and disseminated, characterizes this rock, and by its decomposition gives rise to the valuable deposits of brown hematite, which are worked along the outcrop of the limestone band. Among the other minerals may be mentioned graphite, in crystalline plates, and also in small round grains and rounded compact masses in the limestone; besides which it frequently enters into the composition of the adjacent clay-slate, giving rise to a plumbaginous slate. Fluor-spar, chondrodite, tremolite, common hornblende, serpentine, cubic and magnetic pyrites, are among the minerals of the limestone. Quartz secretions are also met with, but are evidently of secondary origin. The hornblende forms rounded patches, remarkable twisted stripes, and banded parallel layers, often of considerable dimensions, as in the specimens from Wunseidel, which exhibit sheets of hornblende of from five to fifteen millimeters, separated by limestone layers of from fifteen to twenty millimeters in thickness. My examinations of the specimens of this nature, in my collection, have not enabled me to connect these hornblende layers with organic structure, nor to discover any traces of Eozoon in the highly crystalline limestone.

The result of my examinations of specimens of the limestone containing serpentine from the quarries near Wunseidel, from Thiersheim, and from between Hohenberg and the Steinberg, were however more successful. Fragments of the rock from near Hohenberg show irregular greenish stripes, which are made up of parallel undulating laminæ, or of elongated grains. This banded aggregate is a granular mixture of carbonate of lime, serpentine, and a white mineral, insoluble in acids, which appears to be a variety of hornblende. The grains of this aggregate have generally a diameter of $\frac{1}{10}$ millimeter.

When examined in thin sections, the calcareous portions appear for the most part sparry, and traversed by straight intersecting lines, (Pl. 1, fig. 7 *a*,) or divided into cellular spaces by small irregular bands, which, after the surface is etched, are seen in slight relief. The portions between these bands are granulated. (fig. 7 *b*.) More compact calcareous portions are however met with, and these are penetrated by delicate tufts of tubuli like those of Eozoon, (fig. 7 *c*,) and are adherent to the serpentine portions, which have nearly the same form as in the Eozoon of Steinhag, but are far smaller. (fig. 7 *d*.) In decalcified specimens, they are found to possess the same arched walls as the Eozoon. Their breadth in the cross section is generally about one tenth, and the diameter of the casts of the tubuli only about one hundredth of a millimeter. These broader serpentine portions are generally connected with an adjacent portion of lamellæ, (also composed of serpentine, or of a whitish mineral,) which are not more than one-half their size, curiously curved, and presenting highly arched and deeply incurved outlines, as may be seen in decalcified specimens, (fig. 7 *e*.) The study of these structures leaves no doubt that they are due to an organism belonging to the same group as the Eozoon. In order however to distinguish this distinctly smaller form of the primitive clay-slate series, with its minute contorted chambers filled with serpentine, from the typical *Eozoon Canadense* of the more ancient Laurentian system, it may be designated as *Eozoon Bavaricum*.

I have moreover subjected to microscopic examination a series of specimens from the same limestone horizon in the Fichtelgebirge, which, unlike those just described, showed no distinct foreign minerals, although presenting certain dense portions which seemed to indicate the presence of some foreign matter. These portions however showed only a cellular structure, like that in the specimen from Hohenberg, without any tubuli; nor did etching succeed in developing any structure in these wholly calcareous specimens. When therefore carbonate of lime both constitutes the skeleton, and replaces the sarcode, there is evidently little hope of recognizing these organic forms. If however the flaky pellicles which remain suspended in the acid after the solution of the lime, in these almost wholly calcareous specimens, are examined, they present a very great resemblance to the similar pellicles from the Eozoon limestone of Steinhag, already figured, which have such a striking resemblance to organic forms. The careful examination of the limestone from many other parts in the Fichtelgebirge, affords evidence of organic life similar to those of Hohenberg; thus tending more and more to fill up the interval between the Laurentian gneiss, and the primordial zone of the Lower Silurian fauna. We may therefore reasonably hope that in the study of these more ancient rock-systems, which geologists have only recently ventured to distinguish, paleontological evidence will be found no less available than in the more recent sedimentary formations. The inferences which we are permitted to draw from the discovery of organic remains in these ancient rocks, confirm the conclusion to which I had previously arrived from the study of the stratigraphical relations, and the general character of these ancient rock-systems; viz., *that there exists, in these ancient crystalline stratified rocks, a regular order of progress determined by the same laws which have already been established for the formations hitherto known as fossiliferous.*

I cannot conclude this notice of the preliminary results obtained in the investigation of the ancient Eozoon limestones of Bavaria, without adding a few observations upon some foreign crystalline limestones. It is well known that the crystalline minerals, which in numerous localities are found in these limestones, often present rounded surfaces, as if they had at one time been in a liquid state. As examples of these, Naumann mentions apatite, chondrotite, hornblende, pyroxene, and garnet. The edges and angles of these are often rounded; the planes curved or peculiarly wrinkled, and only rarely presenting crystalline faces; having in short a half-fused aspect, and offering a condition of things hitherto unexplained. One of the best known instances of this is found in the green hornblende (pargasite) from Pargas in Finland. This mineral there occurs in a crystalline limestone with fluor, apatite, chondrotite, pyroxene, pyrallolite, mica and graphite; associations very similar to those of the serpentine of Steinhag. The grains of pargasite, although completely crystalline within, and having a perfect cleavage, are rounded on the exterior, curved inward and outward, and also approximatively cylindrical in form; so that they may be best compared with certain vegetable tubercles. If the crystalline carbonate of lime which accompanies the pargasite is removed by an acid, there remains a mass of pargasite grains, generally cohering, and presenting a striking resemblance to the skeleton obtained by submitting the Eozoon serpentine-limestone to a similar treatment. The tubercles of pargasite are then seen to be joined together by short cylindrical projections, which are however readily broken by pressure, causing the mass to separate into detached grains. *The highly crystalline and ferruginous* carbonate of lime which is mingled with the pargasite, shews no organic structure either when etched or examined in thin sections; although the pargasite presents forms similar to those observed in the serpentine of Steinhag. The surfaces of the curved cylindrical and tuberculated grains of pargasite are in part naked, and in part protected by a thin white covering. In some parts fine cylindrical growths are observed, and in others cylindrical perforations passing through the grains of pargasite. By a careful microscopical examination of the surface of these grains (Pl. I., fig. 8), numerous small tubuli, sometimes two millimeters in length, are clearly seen, and by their exactly cylindrical form may be readily distinguished from other pulverulent, fibrous *and acicular crystal*line mineral matters. These cylinders consist of a white substance, which contrasts with the dark green pargasite, and have the diameter of the tubuli of Eozoon, or from $\frac{1}{1000}$ to $\frac{1}{3000}$ millimeters. A single large cylinder was also observed lying obliquely across between two of the pargasite tubercles. (Pl. I., fig. 8 *a.*) In the decalcified specimens, a white mineral, probably scapolite, was observed side by side with the green pargasite; sometimes forming groups of tubercles like the latter; while in other cases a single tubercle was found to be made in part of the green and partly of the white mineral. From these observations there can scarcely remain a doubt that these curiously rounded grains of pargasite imbedded in *the crystalline limestone of Pargas represent the* casts of sarcode-chambers, as in the Eozoon; and that they are consequently of organic origin. From the great similarity between the forms of the pargasite grains and the Eozoon-serpentine, we may fairly be permitted to assume the presence of Eozoon in the crystalline limestones of Finland.*

Similar relations are doubtless to be met with throughout the crystalline limestones of Scandinavia, wherever such mineral species occur in rounded grains or in tuberculated forms. The notion that these forms are of organic origin, and have been moulded in the spaces left in a calcareous skeleton by the decay of animal matter, receives a strong support from the observations of Nordenskiold and Bischof. The former found in a tuberculated pyrallolite, 6·38 per cent. of bituminous matter, besides 3·58 per cent. of water; while Bischof states that the same mineral becomes black when ignited, and when calcined in a glass tube, gives off a clear water with a very offensive empyreumatic odor.

There may also be mentioned in this connection a phenomenon which is probably related to those just described. Upon the pyritous layers which occur in the Hercynian gneiss near Boden, are found great quantities of grains of quartz, almost transparent, and with a fatty lustre, which have in all cases rounded undulating forms, precisely resembling the pargasite tubercles from Finland. Dichroite also sometimes occurs in this region in similar shapes, although it also, in many cases, forms perfect crystals. The evidence of organic forms may perhaps be found in these masses of quartz and dichroite, though their treatment will necessarily present difficulties.

A specimen of crystalline limestone, with rounded pyroxene (coccolite) grains from New York, showed, after etching by means of acids, no traces of tubuli; but the grains of coccolite, remaining after the entire removal of the carbonate of lime, were found to be connected with each other by numerous fine cylindrical tubuli and skin-like laminæ. The surface of the rounded coccolite grains was much wrinkled, and studded with small cylindrical processes of a white mineral, sometimes ramifying, and apparently representing the remnants of a system of tubuli which had been destroyed by the crystallization of the carbonate of lime. The flaky residue from the solvent action of the acid exhibits, under the microscope, laminæ, needles, and strings of

* These belong to the primitive gneiss formation of Scandinavia, which the geologists of Canada, so long ago as 1855, referred to the Laurentian system.—T. S. H.

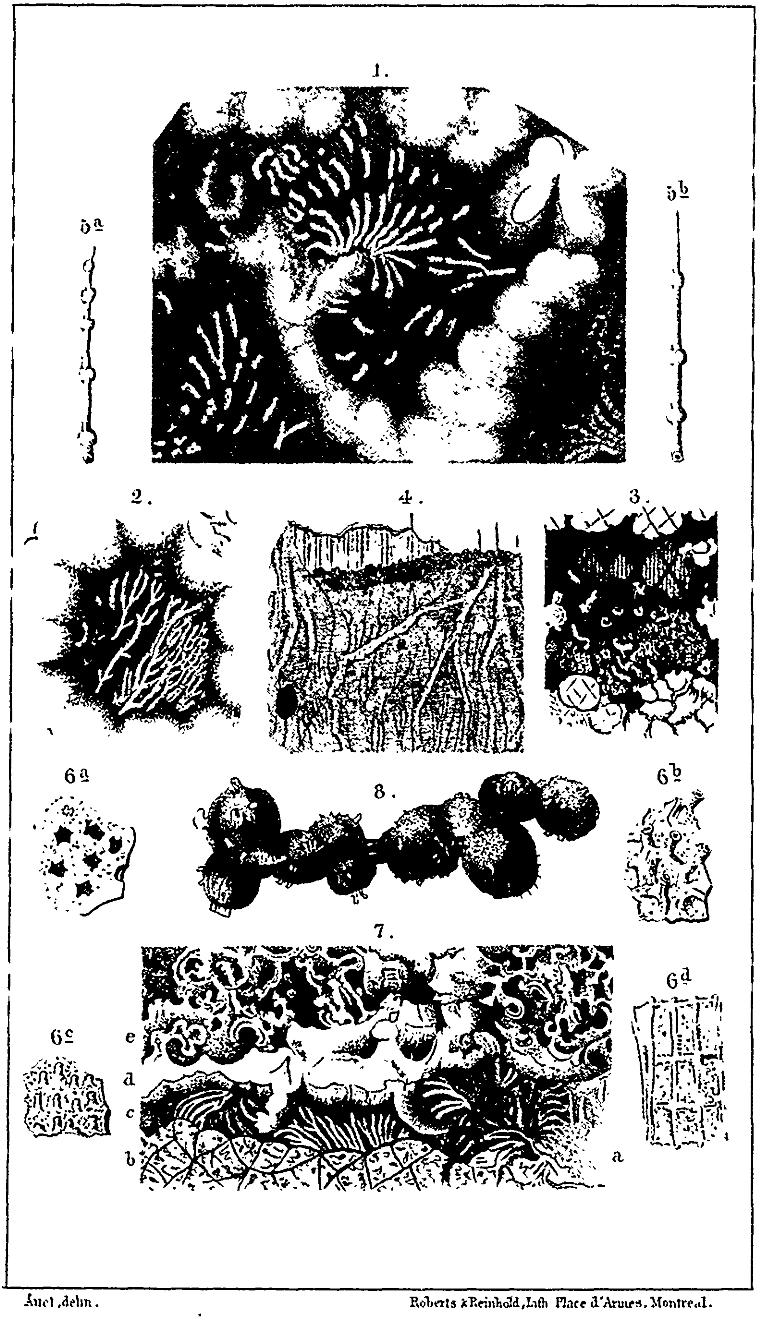
globules similar to those described in the residue from the Eozoon ophicalcite of Steinhag, with which, and with the hornblendic limestone of Pargas, this coccolite-bearing limestone of New York seems to be closely related.

A fragment of ophicalcite from Tunaberg in Sweden bears a striking resemblance to the coarser marked varieties of this rock from near Passau. The carbonate of lime between the tubuli is very sparry; and after its removal, a perfectly coherent serpentine skeleton is obtained, as in the Passau specimens. The surface of the serpentine tubercles is abundantly covered with acicular crystalline needles of various lengths, whose inorganic nature is unmistakeable. The sediment from the acid solution also contains a prodigious quantity of these same small crystalline needles. On etching a specimen of this rock with dilute acid, the same needles were found in most places; but here and there, in isolated, less crystalline and more solid portions of the carbonate of lime, there were seen curved and ramified tubuli, undoubtedly *corresponding* with the tubuli of Eozoon, and having the same size and manner of grouping as in the Eozoon of Passau. The ophicalcite of Tunaberg is therefore to be classed with the Eozoon-bearing limestones.

A specimen of crystalline limestone from Boden in Saxony, holding rounded grains of chondrodite, hornblende and garnet, and furnished me by Prof. Sandberger, showed, after etching, tubuli of surprising beauty, both singly and in groups, but only in small isolated compact portions of the carbonate of lime. The sparry crystallization of this mineral seems to have frequently destroyed the cohesion of the very delicate tubuli, the fragments of which may be observed in very large quantity in the flaky residue from the solution.

A blackish serpentine limestone from Hodrisch in Hungary, showed by etching no traces of tubuli. The granular residue from its solution in acids showed under the microscope large quantities of cell-like granules, with a central nucleus, and generally joined in pairs, like the spores of certain lichens. More rarely however three or four of such grains were joined together. By far the greater part of them were of one and the same size, although occasionally others of double size were met with. Their regularity of form is much in favor of their origin from organic structure.

A fragment of ophicalcite from Reichenbach in Silesia, which Prof. Beyrich kindly furnished me, showed distinct parallel bands



Auct. delin. Roberts & Reinhold, Lith. Place d'Armes, Montreal.

Gümbel on Eozoön from the primitive rocks of Bavaria.

of serpentine with curved and undulating outlines, resembling the Eozoon ophicalcite of Canada. The etched portions show, in the carbonate of lime between the serpentine, or in the interspaces of the serpentine, the same relations as the limestone of Hohenberg from the primitive clay-slate formation. The tubuli, which have a certain resemblance with those of Hohenberg, are stuck together, as if covered by an incrustation. Further examinations of this limestone are required to determine more definitely the organic nature of its enclosures.

A fragment of similar limestone without serpentine, from Raspenau, shows not the remotest trace of any organic structure whatever. The same negative results were obtained with a specimen of granular limestone from T. npobepa in Brazil; and with a very coarsely crystalline carbonate of lime, holding chondrodite, from Amity, New Jersey. These negative results show that organic remains are sometimes wanting in the primitive crystalline limestones, as well as in those of more recent formations. The occasional absence from the primary limestones of these regular structures is therefore an indirect argument for their organic origin.

Explanation of the Plate.

Figure 1. Section of *Eozoon Canadense*, with its serpentine replacement, showing the fine tubuli and the canal-system, from the limestone of the Hercynian gneiss formation at Steinhag; seen by reflected light, and magnified 25 diameters.

2. Section of Eozoon from the limestone of Untersalzbach; 25 diameters.

3. Section of Eozoon from the limestone of Babing.

4. Section of Eozoon from the limestone of Steinhag; 120 diameters.

5, *a* and *b*. Knotted tubuli from the insoluble residue of the Steinhag limestone; 300 diameters.

6, *a*, *b*, *c*, and *d*. Flocculi from the same residue; 400 diameters.

7. Section of *Eozoon Bavaricum*, with serpentine, from the crystalline limestone of the Hercynian primitive clay-state formation at Hohenberg; 25 diameters.

a. Sparry carbonate of lime.
b. Cellular carbonate of lime.
c. System of tubuli.
d. Serpentine replacing the coarser ordinary variety.
e. Serpentine, and hornblende, replacing the finer variety, in the very much contorted portions

8. Aggregated grains of pargasite, remaining after the solution of the carbonate of lime, from the granular limestone rock of Pargas.

ON THE CANADIAN SPECIES OF THE GENUS PICEA.

By the ABBÉ O. BRUNET, of Laval University

Botanists have always recognized the existence in North America of two trees which may be referred to the genus *Picea*, established by Link. They are the *Abies alba* of Michaux, and the *Abies nigra* of Poiret, (*A. denticulata*, Michaux). These two species have been imperfectly described, and are almost always confounded; some authors, moreover, have regarded them as nothing more than varieties of one and the same species. These considerations have led me to study these interesting trees in detail, and to complete, as far as possible, their history.

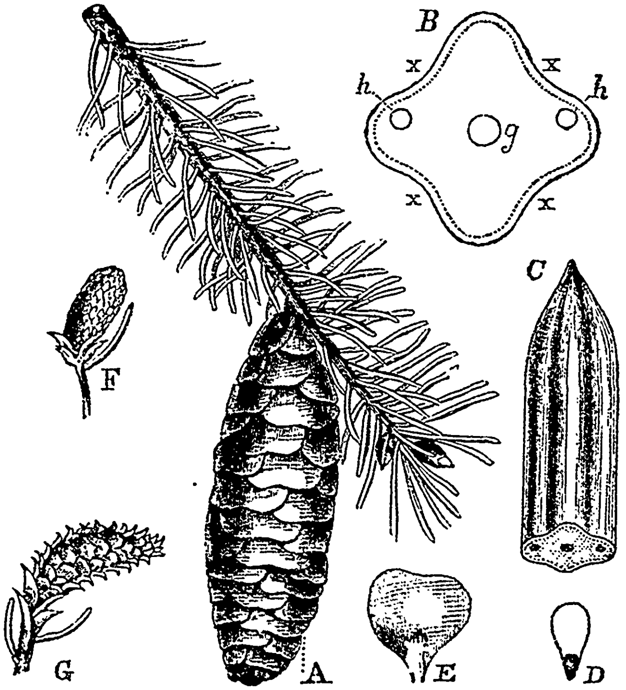
Genus PICEA, LINK.

Leaves persistent, solitary, scattered, and surrounding the branches, tetragonal, stiff, marked on both sides with white lines of numerous stomata; male flowers clustered towards the ends of the branches; cones pendulous, persistent, terminal or axillary; seeds without resiniferous ducts, separating after a time from the base of the wing. Wood, almost white, with resiniferous ducts, having no distinction of alburnum or duramen; cells of the medullary rays without large pits; groups of cubic lignified cells in the older bark.

PICEA ALBA.

The *Picea alba* is one of the most abundant trees in Canada, extending throughout the province. To the northward, following the line of the Saguenay, it is found, diminished in size, along the Mistassini, but disappears altogether about the cascades of that river (Michaux MS.) to reappear in the Hudson Bay territory; where, according to Dr. Richardson, it grows to a large size, and is the most important forest tree of those northern regions.

The *Picea alba* in favourable situations generally attains a height of from seventy to eighty feet, with a diameter of ten feet at the base; in the Saguenay district however, trees of this species are said to have been found, from 130 to 140 feet in height. These large trunks taper gradually and regularly towards the top; they are very straight, and the branches extend horizontally, and are arranged so as to form a regular pyramid, the summit of which is long and slender, giving to the tree a very characteristic aspect. In places exposed to the force of the tempests it becomes stunted in growth, creeping as it were, along the soil. This is well shown in Anticosti, where, on the cliffs and at the point of the island, these trees are seen extending from ten to twenty feet in length, though scarcely five feet in height, and forming a sort of hedge, which is almost insurmountable. In the interior of the island, however, the tree assumes its ordinary aspect.



PICEA ALBA, Link.

A. Branch with cone, gathered in winter.
B. Transverse section of leaf; *g.* vascular bundles; *h.* resiniferous canals; *x.* parts of leaf where the stomata occur; × 50 diameters.
C. Point of leaf, enlarged ten diameters.
D. Ripe seed with its wing.
E. Seminal scale, dorsal view.
F. End of a branch with a male flower. (May 27, 1863.)
G. End of a branch with a female flower. (Ditto.)

The bark of this tree is whitish upon the branches, but on the old trunks it appears as a corky tissue, ferruginous-brown in color, with a scaly rhytidoma, cracked in all directions, and separating in whitish-gray plates. Some have supposed that both the specific and vulgar names of this tree are derived from the whitish color of its bark.

The leaves are from six to ten lines in length, and about three fourths of a line in breadth, ordinarily curved, presenting few stomata on both surfaces, summit acute, but much less so than is the leaf of *Abies (Picea) Menziesii*; section of the leaf quadrangular, presenting two resiniferous ducts larger than those of *P. nigra*. The leaves of *P. alba* are much more robust than those of *P. nigra*, but their size varies very much, even upon the same individual; the same is true of the form, which is also very variable.

The male catkins are ovate, not pedicellated, about six lines long; length of the anthers one line. Female flowers in cylindrical catkins, violet-red in color, and ten lines in length. Cones cylindrical, reddish-brown, from one to two and a half inches in length, numerously disseminated at the extremity of the branches, and in the axils of the leaves; scales thin, six lines long, rhomboidal, entire, slightly indented at the summit. Seeds small, brown, a line long, with an oval wing of a very pale yellow color, three times that length; embryo with from six to eight cotyledons.

This tree in the vicinity of Quebec blossoms about the end of May, and its fruit ripens in the autumn of the same year. The warmth of the following spring-time opens the scales of the cones, and liberates the seeds. These require for their germination about twenty days; twelve days later the young plant escapes from its envelopes, and appears with its numerous cotyledons, which resemble precisely the other leaves. The plumula of the young plant is not apparent before two or three months.

The wood of the white spruce is very white, compact, and harder than that of the white pine (*Pinus strobus*). The annual rings are sometimes three lines in breadth, and are for the most part strongly marked, the autumnal wood being dark colored. The medullary rays are composed of a layer of uniform cells (figures A. and B, p. 109). The resiniferous canals (figure C.) which are distinguishable by the aid of a magnifyin gglass, furnish an excellent characteristic, and a ready means o distinguishing the wood of the species of *Picea* from that of any other conifers.

This wood is more subject to cracking than that of the white pine, and is liable to shrink when not perfectly dried. It is, however, much employed for flooring, on account of its greater hardness, and is largely exported from Quebec in the form of planks. It is also esteemed for its lightness and elasticity, for which quality it is employed for the ship-yards. All the houses which, in the country parts of Canada are made of hewn logs, and are known as log-houses, are constructed of white spruce, which is also employed for the frame-work of steeples, of bridges, etc. The bark of the tree furnishes curved timbers, or knees, as they are called, which are used for ship-building, although inferior to those furnished by the tamarack (*Larix Americana*). The aborigines make use of the tough rootlets, previously macerated in water, to sew the seams of their bark canoes.

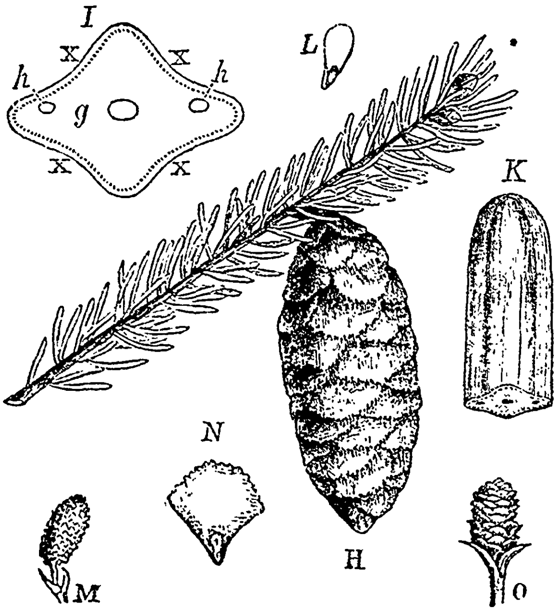
The pyramidal form of this tree, the regularity and number of its branches, and its abundant foliage, make the white spruce one of the best of ornamental evergreen trees. It moreover adapts itself to almost any soil, not too solid and compact, so that it is one of the Canadian trees best fitted for plantations. The readiness with which the white spruce throws out auxilliary buds renders it fit for pruning, and enables us to make of it excellent hedges, which may advantageously replace these of hawthorn.

This sketch of the white spruce would be incomplete if we did not mention a parasitic insect, which frequents it, and causes the small galls which are often seen upon this tree. They may be observed in the spring-time at the ends of the young branches, where they are dark red in color, and resemble in miniature the fruit cones. We met them for the first time at the end of May, 1863, on the island of Orleans, and again some time later near the Château Bigot, in the rear of Quebec. Baron Osten-Sacken, after having examined the specimens which we sent him, informs us that these galls are produced by a species of *Aphis*, hitherto unknown to science.

PICEA NIGRA.

The *Picea nigra* is even more widely spread in the north of America, than the preceding species, for it is found farther to the northward, and beyond the Saguenay, in elevated localities, where, as already remarked, the *P. alba* disappears. Michaux the elder, in his manuscript journal, informs us that the black spruce is met with, in a stunted form, upon the hills bordering on Swan Lake, and that it is only on the height of land, or water-shed between the St. Lawrence and Hudson Bay that it entirely disappears, giving place to the *Pinus rupestris* which reigns alone in those boreal regions.

The *Picea nigra* in certain localities may reach a height of seventy feet, and a diameter of from fifteen to eighteen inches, but is generally smaller, and seems to diminish in size as we go



PICEA NIGRA, Link.

H. Branch with a cone, gathered in January, 1865.
I. Transverse section of the leaf; *g.* vascular bundles; *h.* resiniferous canals; *x.* parts of the leaf having stomata: × 50 diameters.
K. Point of a leaf, enlarged ten diameters.
L. Ripe seed with its wing.
N. Seminal scale, dorsal view.
M. End of a branch with a male flower. (June 5, 1865.)
O. End of a branch with a female flower. (Ditto.)

northward. In the vicinity of Quebec its height is not above seventy feet, and in the valley of the Saguenay, it does not exceed forty or fifty feet, with a diameter of eight or ten inches. It prefers a deep, black, and moist soil, thickly covered with moss, but in places which are constantly wet or covered with water, as in peat bogs, it grows but indifferently, and rises to no great height.

The bark of the *P. nigra* is yellowish on the young branches; the older trunks are covered with a reddish corky rhytidoma, the cracks in which are chiefly vertical, and which exfoliates at last in little plates, more or less rectangular in shape.

The leaves are from five to seven lines in length, and about three fourths of a line in breadth, flattened, and with the apex obtuse. They are of a sombre green color, and are supported on sterigmata twice as prominent as those of the preceding species. The leaves of the *P. nigra* are shorter, more closely appressed to the branches, and more flattened than those of the *P. alba*. They also present more numerous rows of stomata, amounting sometimes to not less than five or six rows on each side of the median vein, and the diameter of their resiniferous ducts is smaller.

The male catkins are ovoid, slightly pedunculate, and three or four lines in length. The female flowers are also in ovoid catkins, violet-red in color, six or eight lines in length, which are at first upright, but after impregnation are bent sharply downwards. The cones are ovoid, reddish-brown, from one inch to one and a half inches in length, slightly pedunculate; scales thin, about six lines in length, with undulated and denticulated edges. The seeds are black, with an oval wing, smaller than that of *P. alba*. The embryo has ordinarily four cotyledons, rarely more. This tree flowers in the month of June, about a week later than the preceding species, and ripens its seeds the same year. The seeds germinate in three or four weeks, and demand a great deal of moisture. After the fall of the perisperm, the young plant generally presents four seed-leaves, which have the form of the ordinary leaves, and already present the sombre green color which characterizes the foliage of the *P. nigra*.

In the localities most favourable to the development of this species, and in places where the white pine has become rare, the black spruce is cut by the lumberers. It is manufactured into planks and boards, and the wood is employed for the same uses as that of the white spruce. The woods of these two species of *Picea* offer no perceptible differences in structure, color, lightness, or other qualities. They are equal in value, and command the same price in the Quebec market.

Picea nigra, var. *grisea;* gray spruce.

This spruce does not appear to differ essentially from the black spruce in its organs of fructification. Its leaves are however of a more or less dingy and grayish green, and its bark has a lighter red color than the typical black spruce: The gray spruce is found principally in poor soils. This variety often attains a very large size. We measured one of these trees in the eastern section of Rimouski, and found it to be 160 feet high, with a diameter of four feet.

In certain parts of Canada an infusion of the leaves of the *Picea nigra* is used as a common drink. The Abbé Ferland in his *Voyage au Labrador* speaks of "the little black spruce which creeps over the rocks, and whose leaves infused in hot water furnish a beverage which by the peasants is preferred to tea." It is with this plant also that is made the fermented liquor known as spruce beer. As it may not be without interest, we copy a description of the mode of preparing this beverage a century since, copied from Duhamel, (*Traité des arbres et arbustes*, Paris, 1755.)

"The white spruce * (*épinette blanche*) which is a species of *Epicea*, having smaller leaves and cones than that cultivated in France, serves in Canada to make a wholesome beverage, which is not agreeable when tasted for the first time, but becomes so by use. As a similar drink might be made very cheaply from our own *Epicia*, I give the receipe. . . . .

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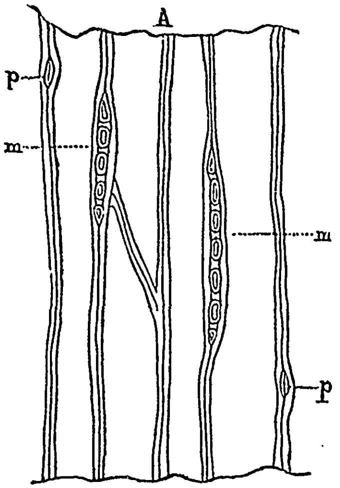
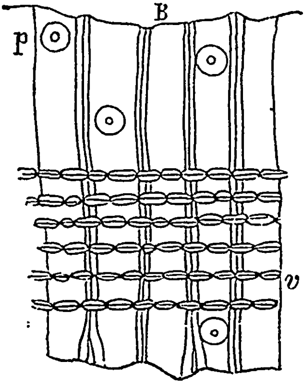
* This is evidently an error of the author, since the black spruce has always been employed for making this kind of small beer.

The French of Lower Canada apply the name of *Epinette* to several trees; the *Larix Americana* is by them called *épinette rouge*, and the white and black spruce are respectively *épinette blanche*, and *épinette noire*, while the name of *épinette grise* is given to what we regard as a variety of the latter, *P. nigra* var. *grisea*. The origin of this word, which is not applied to any tree in France, is by no means clear. It has, however been used from an early date in the history of the colony, as will appear from the following citation from the *Histoire Naturelle du Canada*, of Pierre Boucher, 1663. "Il y a une autre espéce d'arbre qu'on nomme épinette; c'est quasi comme du Sapin, si non qu'il est plus propre a faire des masts de petits vaisseaux, comme des chaloupes et des barques, estants plus fort que le Sapin."

"For a barrel, a boiler holding at least a quarter more is required. This being filled with water, and heated, a bundle of spruce branches, broken small, and about twenty-one inches in girth, is added, and the water is kept boiling until the bark readily peels off from the whole length of the branches. Then a bushel of oats is roasted by portions, in a great iron pan, about fifteen sea-biscuit,





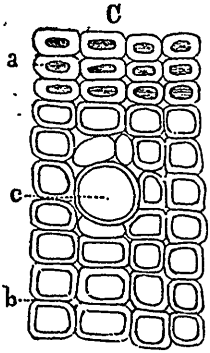


Figure A. Longitudinal tangential section of the wood of *P. alba*. *c.* ligneous cellules; *m.* medullary rays; *p.* discs; (500 diameters.)

Figure B. Longitudinal section, parallel to one of the medullary rays; *v.* medullary rays; *p.* discs; (500 diameters.)

Figure C. Transverse section of the same wood; *a.* fibres of the autumnal wood; *b.* fibres of the spring wood; *c.* resiniferous ducts; (300 diameters.)

These figures were drawn by the author and engraved by Mr. G. J. Bowles.

or in place of them, twelve or fifteen pounds of bread, cut in slices, are also roasted, and with the oats, added to the boiling kettle, where they remain till the spruce branches are well cooked. These branches are now taken out, and the fire extinguished. The bread and oats then settle to the bottom, and the spruce leaves are removed by a skimmer; after which are added six quarts of molasses or syrup, or in place thereof twelve or fifteen pounds of coarse sugar. The liquid is then put at once into a fresh red-wine cask; and if it is wished to give more color to the liquor, the lees, and five or six quarts of the wine are left therein. When the liquid is only lukewarm, a pint of beer-yeast is added, the whole well stirred. to mix it, and the cask then filled to the bung-hole, which is left open. Fermentation soon begins, and much scum is thrown off; during this time the cask must be filled from time to time with a portion of the liquid which has been kept apart in some wooden vessel. If the cask is bunged at the end of twenty-four hours, the liquor is sharp and lively as cider, but if it is wished to have it milder, the cask should be filled twice a day, and not bunged till fermentation is over. This liquor is very refreshing and wholesome, and those accustomed to it drink it with pleasure, especially in summer."

ON THE OBJECTS AND METHOD OF MINERALOGY.

By Dr. T. Sterry Hunt, F.R.S.

(Read before the American Academy of Sciences, Jan. 8, 1867.)

Mineralogy, as popularly understood, holds an anomalous position among the natural sciences, and is by many regarded as having no claims to be regarded as a distinct science, but as constituting a branch of chemistry. This secondary place is disputed by some mineralogists, who have endeavored to base a natural-history classification upon such characters as the crystalline form, hardness, and specific gravity of minerals. In systems of this kind, however, like those of Möhs and his followers, only such species as occur ready formed in nature, are comprehended, and the great number of artificial species, often closely related to native minerals, are excluded. It may moreover be said in objection to these naturalists, that, in its wider sense, the chemical history of bodies takes into consideration all those characters upon which the so-called natural systems of classification are based. In order to understand clearly the question before us, we must first consider what are the real objects, and what the provinces, respectively, of mineralogy, and of chemistry.

Of the three great divisions, or kingdoms of nature, the classification of the vegetable gives rise to systematic botany, that of the animal to zoology, and that of the mineral to mineralogy, which has for its subject the natural history of all the forms of unorganized matter. The relations of these to gravity, cohesion, light, electricity, and magnetism, belong to the domain of physics; while chemistry treats of their relations to each other, and of their transformations under the influences of heat, light, and electricity. Chemistry is thus to mineralogy what biology is to organography; and the abstract sciences, physics and chemistry, must precede, and form the basis of the concrete science, mineralogy. Many species are chiefly distinguished by their chemical activities, and hence chemical characters must be greatly depended upon in mineralogical classification.

Chemical change implies disorganization, and all so-called chemical species are inorganic, that is to say unorganized, and hence really belong to the mineral kingdom. In this extended sense, mineralogy takes in not only the few metals, oxyds, sulphids, silicates, and other salts, which are found in nature, but also all those which are the products of the chemist's skill. It embraces not only the few native resins and hydrocarbons, but all the bodies of the carbon series made known by the researches of modern chemistry.

The primary object of a natural classification, it must be remembered, is not like that of an artificial system, to serve the purpose of determining species, or the convenience of the student, but so to arrange bodies in orders, genera, and species as to satisfy most thoroughly natural affinities. Such a classification in mineralogy will be based upon a consideration of all the physical and chemical relations of bodies, and will enable us to see that the various properties of a species are not so many arbitrary signs, but the necessary results of its constitution. It will give for the mineral kingdom what the labors of great naturalists have already nearly attained for the vegetable and animal kingdoms.

Oken saw the necessity of thus enlarging the bounds of mineralogy, and in his Physiophilosophy, attempted a mineralogical classification; but it is based on fanciful and false analogies, with but little reference either to physical or chemical characters, and in the present state of our knowledge is valueless, except as an effort in the right direction, and an attempt to give to mineralogy a natural system. With similar views as to the scope of the science, and with far higher and juster conceptions of its method, Stallo, in his Philosophy of Nature, has touched the questions before us, and has attempted to show the significance of the relations of the metals to cohesion, gravity, light, and electricity, but has gone no farther.

In approaching this great problem of classification, we have to examine—first, the physical condition and relations of each species, considered with relation to gravity, cohesion, light, electricity, and magnetism; secondly, the chemical history of the species; in which are to be considered its nature, as elemental or compound, its chemical relations to other species, and these relations as modified by physical conditions and forces. The quantitative relation of one mineral (chemical) species to another, is its equivalent weight, and the chemical species, until it attains to individuality in the crystal, is essentially quantitative.

It is from all the above data, which would include the whole physical and chemical history of inorganic bodies, that a natural system of mineralogical classification is to be built up. Their application may be illustrated by a few points drawn from the history of certain natural families.

The variable relations to space of the empirical equivalents of non-gaseous species, or, in other words, the varying equivalent volume (obtained by dividing their empirical equivalent weights by the specific gravity), shows that there exist, in different species, very unlike degrees of condensation. At the same time, we are led to the conclusion that the molecular constitution of gems, spars and ores, is such that those bodies must be represented by formulas not less complex, and with equivalent weights far more elevated than those usually assigned to the polycyanids, the alkaloids, and the proximate principles of plants. To similar conclusions, conduce also the researches on the specific heat of compounds.

There probably exists between the true equivalent weights of non-gaseous species and their densities, a relation as simple as that between the equivalent weights of gaseous species and their specific gravities. The gas, or vapor of a volatile body, constitutes a species distinct from the same body in its liquid or solid state, the chemical formula of the latter being some multiple of the first, and the liquid and solid species themselves often constituting two distinct species of different equivalent weights. In the case of analogous volatile compounds, as the hydrocarbons and their derivatives, the equivalent weights of the liquid or solid species approximate to a constant quantity, so that the densities of these species, in the case of homologous or related alcohols, acids, ethers and glycerids, are subject to no great variation. These non-gaseous species are generated by the chemical union, or identification, of a number of volumes or equivalents of the gaseous species, which varies inversely with the density of these species. It follows from this, that the equivalent weights of the liquid and solid alcohols and fats must be so high as to be a common measure of the vapor-equivalents of all the bodies belonging to these series. The empirical formula, $C_{114}H_{110}O_{12}$, which is the lowest one representing the tristearic glycerid, ordinary stearine, is probably far from representing the true equivalent weight of this fat in the liquid or solid state; and if it should hereafter be found that its density corresponds to six times the above formula, it would follow that liquid acetic acid, whose density differs but slightly from that of fused stearine, must have a formula, and an equivalent weight about one hundred times that which we deduce from the density of acetic acid vapor, $C_4H_4O_4$.

Starting from these high equivalent weights of liquid and solid hydrocarbonaceous species, and their correspondingly complex formulas, we become prepared to admit that other orders of mineral species, such as oxyds, silicates, carbonates, and sulphids, have formulas and equivalent weights corresponding to their still higher densities; and we proceed to apply to these bodies the laws of substitution, homology, and polymerism, which have so long been recognized in the chemical study of the members of the hydrocarbon series. The formulas thus deduced for the native silicates and carbon-spars, show that these polybasic salts may contain many atoms of different bases, and their frequently complex and varying constitution is thus rendered intelligible. In the application of the principle of chemical homology, we find ready and natural explanations of those variations, within certain limits, occasionally met with in the composition of certain crystalline silicates, sulphids, etc., from which some have conjectured the existence of a deviation from the law of definite proportions, in what is only an expression of that law in a higher form.

The principle of polymerism is exemplified in related mineral species, such as meionite and zoisite, dipyre and jadeite, hornblende and pyroxene, calcite and aragonite, opal and quartz, in the zircons of different densities, and in the various forms of titanic acid and of carbon, whose relations become at once intelligible if we adopt for these species high equivalent weights and complex molecules. The hardness of these isomeric or allotropic species, and their indifference to chemical reagents, increases with their condensation, or, in other words, varies inversely as their empirical equivalent volumes; so that we here find a direct relation between chemical and physical properties.

It is in these high chemical equivalents of the species, and in certain ingenious, but arbitrary assumptions of numbers, that is to be found an explanation of the results obtained by Playfair and Joule in comparing the volumes of various solid species with that of ice; whose constitution they assume to be represented by HO, instead of a high multiple of this formula. The recent ingenious but fallacious speculations of Dr. Macvicar, who has arbitrarily assumed comparatively high equivalent weights for mineral species, and has then endeavoured, by conjectures as to the architecture of crystalline molecules, to establish relations between his complex formulas and the regular solids of geometry, are curious but unsuccessful attempts to solve some of the problems whose significance I have endeavoured to set forth. I am convinced that no geometrical groupings of atoms, such as are imagined by Macvicar, and by Gaudin, can ever give us an insight into the way in which nature builds up her units, by interpenetration and identification, and not juxtaposition of the chemical elements.

None of the above points are presented as new, though they are all, I believe, original with myself, and have been, from time to time brought forward, and maintained, with numerous illustrations, chiefly in the American Journal of Science, since March, 1853, when my paper on the Theory of Chemical Changes and Equivalent Volumes, was there published. I have however thought it well to present these views in a connected form, as exemplifying my notion of some of the principles which must form the basis of a true mineralogical classification.

THE AMERICAN ASSOCIATION AT BUFFALO, AUGUST, 1866.

ON A NEW NOMENCLATURE.

BY PROF. S. D. TILLMAN OF NEW YORK.

The author, in this paper, gave a brief account of the amendments and alterations made in our present nomenclature, which originated with DeMorveau, Lavoisier, Bertholet and Fourcroy in France, in the year 1787. He showed furthermore, that it cannot be adapted to the new views of chemical combinations, according to the atomic system, without producing serious confusion, and rendering all our present works on chemistry comparatively worthless. He therefore proposed to let the old nomenclature remain as the exponent of the system of combining proportions, or so called "equivalents," and to give new names to atomic combinations, which would express both the views of Berzelius and Gerhardt. The method was devised by him many years ago, but until there was a general agreement among advanced chemists with regard to the numbers expressing atomic weights, it would have been useless. Under the lead of Gibbs, in this country, and Canizzaro in Europe, those of the unitary school who double the numbers represented by the symbols O, C, and S, now also double the numbers of at least fifty other symbols, and thus all objections have been removed in regard to using a system of names based upon atomic weights. The nomenclature now proposed is also adapted to the typical classification, first proposed by a distinguished member of this Association, Dr. T. Sterry Hunt, which, with a few modifications, has been very generally adopted by European chemists. Prof. Tillman's method of construction may be briefly explained in the following heads :

1. The system is based on abbreviations of the universally received names of the metals, and on the chemical symbols of the metalloids, or non-metallic elements, with such modifications as were imperatively required.

2. The name of each chemical element relates not to its mass, but only to a minimum combining proportion, termed an atom, or to some multiple of it. The atom is therefore the unit of measurement, and the starting point of the scale in each series of compounds.

3. The atomic name of each of the 50 metals now well-known, consists of two syllables, and ends with the consonant *m*.

4. The name of each of the 13 metalloids terminates with a different consonant; arsenic and tellurium, classed by some chemists among the metalloids, are by this arrangement included among the metals.

5. The number of atoms of any element is designated by the vowel immediately preceding the terminal consonant. The numerical power of the vowels advances with the order in which they are placed in the alphabet, thus 1, 2, 3, 4 and 5 are represented by a, e, i, o and u, each having a short or stopped sound, and the same vowels, each preceded by e, and having the long or full sound, represent 6, 7, 8, 9 and 10. Other letters represent higher numbers, so that any number to 1000 is readily denoted.

6. The following metalloids are represented by their symbolic letters: One atom of Fluorine is *af*, one atom of Bromine *ab*, one of Nitrogen *an*, one of Carbon *ac*, one of Sulphur *as*, one of Phosphorus, *ap*. For reasons which need not here be stated, an atom of Hydrogen is *al*, of Oxygen *at*, of Chlorine *ad*, of Iodine *av*, etc.

7. The manner of uniting these syllables may be thus illustrated: The protoxide of iron is *Ferramat;* the sesqui-oxide of iron, *Ferremit;* the black or magnetic oxide, *Ferrimot;* sulphate of protoxide of iron, *Ferrmasot;* sulphate of sesqui-oxide of iron, *Ferremisoit.*

The combinations containing carbon and hydrogen are so numerous that it was found essential to use another letter, *r*, to designate carbon—*ar* and *ac* each denote an atom of carbon. Two atoms of hydrogen are designated by *h*, thus *ach* is equal to $C_2 H_2$ in the old notation. This is the important increment in several series of organic radicals. The first of the alcohol-forming radicals is *achal*, methyl; the second, *echal*, ethyl; the third, *ichal*, propyl; the fourth, *ochal*, butyl; the fifth, *uchal*, amyl, etc. These radicals play the part of monatomic metals.

The author gave specimens of the new names for several thousand compounds; and showed their application in cases of isomerism, where, for instance, ten bodies, having the same ultimate components, are distinguished by ten different names. The doctrine of substitutions was also very clearly set forth; and derivatives were so classified and simplified as to be readily comprehended.

The author then proceeded to show the manner in which names were provided for salts containing water of crystallization, and for solutions containing either an indefinite or definite quantity of water.

In future chemical investigation, the speaker thought increasing significance must be given to the state of dilatation in which the body under consideration exists; he therefore proposed to designate every gas, and every volatile body after it is formed into vapor, by prefixing to the new name the letter *g*. For instance, carbonic oxide is *gart*, CO; carbonic anhydride (commonly called carbonic acid gas), *garet*, CO_2; sulphuretted hydrogen, *gelus*; olefiant gas, *gerlel*; carburetted hydrogen gas, *garol*; oxychloride of carbon gas, *garted*; etc. So of volatiles heated to the boiling point; for instance, bisulphide of carbon, *ares*, when heated to 49° Centigrade, is a vapor, denoted by *gares*; water, *elat*, heated to 100° Cent. or steam, is *gelat*.

In conclusion the speaker proposed that the new names, if approved, should be used at first side by side with the old names, and in lieu of the notation. Chemical writers, who study brevity of expression will fully appreciate the saving of pen and type work, as seen in the following statement of a recent discovery in the old and new manners. Lossen has succeeded in replacing an atom of hydrogen in ammonia by an atom of hydrogen and oxygen, or hydroxyl, thus forming hydroxalamine, which may be thus stated: 'Lossen has succeeded in replacing *al* in *ilan* by *alt*, thus forming *altelan*.'

The speaker thus, in one paper, attempted to present to his hearers the whole chemical field; yet, as he passed from one division to another, he only cited such examples as seemed essential to prove the copiousness and capacity of the new nomenclature. A more complete elucidation and application of it was reserved for succeeding papers.

ON THE PRIMEVAL ATMOSPHERE.

Dr. Hunt adverted, in commencing, to a theory first put forward by him to explain the chemical conditions of our globe. Starting from the notion of an igneous origin, he had contended that the mass probably commenced cooling at the centre, and thus gave rise to an anhydrous solid nucleus, having a crust of silicates, with an irregular surface, while the chlorine, carbon and sulphur, together with all the hydrogen, and an excess of oxygen, formed the atmosphere. As cooling from radiation went on, the first precipitate from this dense atmosphere must have been an intensely acid liquid, which, attacking the crust of the silicates, separated vast amounts of silica, and became saturated with earths and alkalies, forming the primeval sea. This condition of things, he claimed, was in strict accordance with the known chemical laws, and flowed logically from the hypothesis of the origin of our planet. The early ocean should thus have abounded in salts of lime and magnesia; and this is confirmed by the saline waters from the Paleozoic rocks, which represent fossil sea-water of that ancient period. Dr. Hunt here referred to his extended chemical and physical investigations of the older rocks, and their mineral springs, in support of this view.

The stronger acids of chlorine and sulphur having been separated from the atmosphere, a decomposition of the silicates of the exposed portion of the earth's crust, under the influence of carbonic acid, moisture, and heat, went on, resulting like the modern process of kaolinization, in the production of a silicate of alumina or clay, and carbonates of the protoxyd bases. In this way great quantities of carbonate of soda were formed, which, decomposing the lime and magnesia salts of the sea, gave rise to the first limestones, and to chlorid of sodium. Hence the clays, the limestones, and the sea-salt were the joint results of a process which was slowly removing from the earth its carbonic acid, and fitting it for the support of higher forms of life. These views of Dr. Hunt, first put forward in 1858 and 1859, are gradually being received and appropriated by writers, who do not always acknowledge the source of them. They are here insisted upon as preliminary to some considerations on the atmosphere of early times, when it must have contained, in the form of carbonic acid, the whole, or the greater part of the carbon now present in the strata of the earth, and in bodies of fossil coal.

Simple calculations show that the carbonic acid contained in a layer of pure carbonate of lime extending over the earth, with a thickness of 8·61 meters, would, if set free, double the weight of our atmosphere; and that from 13·65 meters, (about forty-four feet), would double its volume. It moreover appears that a similar layer of ordinary coal, one meter in thickness, would suffice to convert into carbonic acid the whole of the oxygen of the atmosphere: so that if, as is probable, the whole amount of coal and carbonaceous matters on the earth exceeds this quantity, there must have been an absorption of the oxygen, set free during the conversion of carbonic acid into coal, this oxygen being probably retained by peroxyd of iron. Disregarding this, however, and admitting that the carbonic acid, corresponding to a layer 8·61 meters of limestone [about twenty-eight feet] were present in our atmosphere, the effect would be most remarkable. The height of the barometric column would be doubled; the boiling point of water, raised to 121° Centigrade [250° Fahr.]; and, as the absorptive power of an atmosphere of carbonic acid is, according to Tyndal, ninety times that of dry air, the temperature of the lower regions of the atmosphere would be greatly elevated, and the whole climatic conditions of the earth modified. Yet, as the amount of carbonic acid required to produce these results is probably but a small proportion of that now fixed in the limestones of the earth's crust, we should find this condition of things at a period, geologically, not very remote, and in still earlier times the earth must have had a far denser and more highly carbonated atmosphere than that just supposed. The relations of such a condition of things to the animal and vegetable world furnish fruitful themes for conjecture and experiment; and its influence on chemical processes is not less worthy of consideration, as a single instance will show. Some years since, I pointed out that the explanation of the almost constant association of gypsum and magnesian limestone in nature, was to be fouud in the fact that solutions of bicarbonate of lime and sulphate of magnesia decompose each other, with production of solutions of sulphate of lime and bicarbonate of magnesia. By spontaneous evaporation, the former may be in part separated as gypsum; but as in this process the bicarbonate is changed into mono-carbonate of magnesia, this partially decomposes the gygsum, regenerating carbonate of lime, and the results of the experiment in an ordinary atmosphere are imperfect. I find, however, that by infusing into the drying atmosphere a large proportion of carbonic acid, the separation by evaporation goes on regularly, and the gypsum is deposited in a pure state, enabling us thus to realize the conditions of earlier geologic periods, when vast beds of gypsum, with their accompanying magnesian limestone, were deposited in evaporating basins at the earth's surface, beneath an atmosphere charged with carbonic acid.

Ebelman has speculated on the probable existence of a much larger proportion of carbonic acid in the atmosphere of earlier geologic times; and Dana, Tyndal, and anterior to them, the late Major E. B. Hunt, have considered its meteorological relations;

but the chemical history of this carbonic acid, considered with reference to its origin, its fixation in the form of limestones, and and its influence on chemical processes at the earth's surface, are points for the most part peculiar to the author, and, in part, now brought forward for the first time.

ON THE GEOLOGICAL STRUCTURE OF THE SOUTHERN PART OF MINNESOTA.

BY PROF. JAMES HALL, OF ALBANY.

The object of this paper is mainly to show a clear and depicted geological structure of formations of different age, over a large part of Minnesota, heretofore regarded as deeply covered by drift deposits.

In going west from the Mississippi River at St. Paul, we pass over the older SILURIAN formations of Trenton limestone, Magnesian limestone, and Potsdam sandstone, which extend as far as the lower bend of the Minnesota, at Mankato. Beyond this, in ascending the Minnesota River, for more than one hundred miles, no palæozoic formations are at present known. Approaching the Minnesota, at New Ulm, over the high prairie from the East, we find frequent exposures of a metamorphic rock, having on its weathered surface a syenitic aspect, which is in reality a quartzite, of gray, variegated or reddish color. On the Minnesota River, at Redstone ferry, these quartzites are found to have a decided dip to the eastward or south-eastward, and we have an exposure of one hundred and fifty or two hundred feet of thickness.

TRIASSIC.—Abutting against the upturned edges of these quartzites of Huronian age, there is a series of horizontal strata, consisting of red marls, reddish and variegated, and red and gray limestones, which are referred to the Triassic system.

CRETACEOUS.—Lying upon the latter formation, and likewise horizontally stratified, is a series of marls, clays, sandstones, and beds of earthy coal, having altogether a thickness of perhaps two or three hundred feet. The sandstones contain fragments of plants or trees, and leaves of the willow, poplar, liriodendron, and magnolia, all of which are referred to the age of the Cretaceous formations.

PRAIRIE FORMATION.—Covering all these, except in the river banks, and at intervals in the prairie, is the deposit of drift and lighter soil, constituting the Prairie formation.

From the Minnesota at Redstone ferry west-ward, the Cretaceous formation extends for forty miles unbroken, when we come again to the red quartzites, which dip in the opposite direction, or to the westward; and continues for seventy miles, coming out again at the Pipestone locality, on the Sioux valley. At some point higher up the Minnesota valley, the Cretaceous formation occupies large areas resting on Laurentian rocks.

The result of these investigations shows a portion of the outcrop of a synclinal axis on the east of the Minnesota, with a valley of forty miles in width, which has been eroded in the line of a great anticlinal axis; while beyond this is a synclinal axis of quartzites, of similar character, which forms the foundation of the great Coteau-des-Prairies, which extends for more than four hundred miles to the northwest, rising seven or eight hundred feet above the lower prairie.

We have the evidence that the synclinal axis referred to is the highest portion of the country, while the anticlinal axis had been eroded prior to the age of the Triassic formation.

The chains of lakes of this part of the country, lie in the plateau of the synclinal axis, while the line of the anticlinal is free from this feature; and the same conditions, essentially, prevail in a portion of a more eastern synclinal, which lies to the east of the Minnesota River.

ON PETROLEUM.

At the opening of the session, Dr. T. Sterry Hunt read an interesting paper on Petroleum, of which the following is a brief synopsis.

He had shown in 1861, that the mineral oil of Western Canada was indigenous in the Corniferous limestone; wells sunk in the outcrop of which have yielded, and still yield, oil in that region, and also in Kentucky, according to Lesley. At that time (1861) he called attention to the existence of petroleum in the limestones of the Trenton group, and had, since then, in the Geology of Canada, in 1863, insisted upon these Lower Silurian oils as likely to prove, in some regions, of economic importance—a prediction verified by the recent developments in the Lower Silurian strata of the Cumberland, in Kentucky, and the oil wells of the Manitoulin Islands, which latter are sunk through the Utica into the Trenton formation. Another important point, on which he had been the first to insist, was that the accumulation giving rise to productive wells, occurs along the lines of anticlinal folds, where the oil would naturally accumulate in fissures, or in porous strata, in obedience to well-known hydrostatic laws. This view, first insisted upon in a lecture published in the *Montreal Gazette* for March, 1861, was further developed in a paper on Petroleum in the *Canadian Naturalist* for July, 1861, and simultaneously by Professor E. B. Andrews in *Silliman's Journal*. Since then, this view, though frequently opposed, is gaining ground; and, according to Prof. Andrews and Dr. Newberry, is sustained by all experience in the oil fields of the United States, as it also is in Canada. This remark applies to large accumulations, and to flowing wells, but oil may doubtless flow slowly from horizontal strata containing it.

As to the origin of the petroleum, Dr. Hunt supposes that it is indigenous in the two limestone formations already mentioned, and that it may have thence risen and accumulated in overlying pervious strata, or in fissures capped or sealed by impervious beds, such as the Pennsylvania sand-rock, or quarternary gravel beds.

He is inclined to think, however, that petroleum may also be indigenous in certain sandstones of Devonian or Carboniferous age, and referred to Lesley's observations to this effect, closely agreeing with those of Wall and Cruger in Trinidad, where fossil plants are sometimes found partly converted into petroleum, and partly into lignite.

Dr. Hunt regards the process by which animal and vegetable hydrocarbonaceous tissues have been converted into solid or liquid bitumen, as a decay or fermentation, under conditions in which atmospheric oxygenation is excluded, so that the maximum amount of hydrogen is retained by the carbon; and as representing one extreme of a process, the other of which is found in anthracite and mineral charcoal, the two conditions being antagonistic, and excluding each other, and the production of petroleum implying, when complete, the disappearance of the organic tissue. Hence pyroschists, the so-called bituminous shales, and coal, are not found together with petroleum, but in separate formations, and it is to be borne in mind that the epithet bituminous applied to the former bodies is a mistaken one, since they seldom or never contain any bitumen, although, like all fixed organic bodies, they yield hydrocarbons by destructive distillation. The fallacy of the notion which ascribes petroleum to the action of subterranean heat on strata holding coal and pyroschists was exposed; and it was remarked, among arguments founded upon the impermeability of many of the petroleum-bearing strata, that the oil of the Trenton limestone occurs below the horizon of any pyroschists, or other hydrocarboneous rocks.

A discussion on the subject of Petroleum followed, in which Dr. Andrews, Prof. Hall and Prof. Newberry took part.

ON THE LAURENTIAN LIMESTONES AND THEIR MINERALOGY.

BY DR. T. STERRY HUNT, F.R.S.

The author alluded to the existence in the Lower Laurentian system of three limestone bands or formations, of great but variable thickness, which might fairly be compared with the great limestone groups of the North American paleozoic system. In addition to these, there is probably a fourth and newer limestone formation belonging to the lower or true Laurentian, besides one or more in the unconformable overlying Labrador series or Upper Laurentian. The three limestone formations first named are separated by great masses of gneissic and quartzose strata, and are intimately associated with beds in which silicates of lime and magnesia prevail, together with graphite, and various metallic ores. The minerals associated with these limestones, and their accompanying strata, were next considered, and it was shown that they occur, both disseminated in the beds, and filling fissures or veins which traverse the strata. The importance in a geological point of view of these veinstones, which from their mode of formation might be named *endogenous rocks*, was insisted upon. They may attain very great dimensions, and may include any or all of the mineral species belonging to the adjacent stratification, variously grouped, and sometimes having a banded arrangement parallel to the walls of the vein. Among the characteristic minerals of these veins are calcite, apatite, pyroxene, hornblende, serpentine, chondrodite, orthoclase, scapolite, phlogopite, quartz, garnet, idocrase, epidote, spinel, corundum, sphene, zircon, magnetite, and graphite. Some of these occasionally occur in a nearly pure state, filling the veins, as graphite, pyroxene and apatite. Veins of crystalline carbonate of lime, generally including some one or more of the preceding minerals, are often met with, and it is these which have given rise to the notion maintained in this country by Emmons, and in Europe by Leonhard and others, that crystalline limestone is either partially or entirely of eruptive origin, these calcareous veinstones having been confounded with intrusive dykes. From such veinstones a transition may be traced to those in which orthoclase and quartz prevail, often to the exclusion of lime and magnesia compounds. We have then true granite veinstones, in which tourmaline, beryl, muscovite, cassiterite, and columbite are sometimes met with. These *endogenous rocks*, in which are often concentrated the rarer chemical elements of the rocks, are to be carefully distinguished from intrusive dykes which are *exotic rocks*. Such veins are not peculiar to the Laurentian system, but are found in crystalline strata at various ages. The crystalline limestones of Scandinavia, which offer so many remarkable resemblances to those of New York, New Jersey and Canada, are however of Laurentian age, and the nature of their veins has been well understood by Scheerer.

The rounded angles of crystals of certain minerals from the calcareous veins of the Laurentian system, especially of the crystals of apatite and quartz, which Emmons had supposed to be due to a commencement of fusion, is to be regarded as the result of a partial resolution of the previously deposited crystals, and as marking a stage in the progressive filling of the veins. Crystals of orthoclase, pyroxene, sphene and zircon, though accompanying these rounded crystals, retain the sharpness of their angles, because of their permanence in the heated alkaline solutions which circulated through these yet partially filled veins. The various minerals of these veinstones have been deposited from aqueous and saline solutions, at elevated temperatures, and the experiments of Daubree and of De Senarmont, and the microscopic observations of Sorby, support this view. Plutonists begin to understand that water cannot be excluded from rocky strata, but is all-pervading, and that at greater depths, kept by pressure in a liquid state, at an elevated temperature, and having its solvent powers augmented by alkaline salts, it plays a most important part in metamorphosis, and in the formation of veinstones. The author supposed, with Mr. Hopkins, that in earlier geological periods the increase of temperature in buried strata was far more rapid than at present, so that great heats prevailed at comparatively small depths from the surface, and produced important chemical and molecular changes. The temperature at which the various silicated and other minerals, including graphite, were dissolved from the strata and crystallized in the veins, he supposed to have been, judging from various analogies, between the melting point of tin and low redness.

The distinction between the apatite, graphite and magnetite disseminated in the beds, and the same minerals in the veins, was particularly insisted upon. As to the origin of the principal silicious minerals of the limestones, such as serpentine, chondrodite, pyroxene, rensellaerite and loganite, Dr. Hunt regards these as having been directly depos ted as chemical precipitates from the seas of the time; and cites the example of the *Eozoon Canadense*, an abundant fossil of the age, found imbedded in these silicates, which enclose it, and fill the minute pores of its calcareous skeleton. To a similar chemical precipitation he attributes the serpentines, talcs, chlorites and epidotes which occur in more recent rocks, and may be found in their incipient state before the metamorphosis of these rocks, which has for the most part only crystallized and re-arranged the already-formed amorphous silicates. The chemical agencies which gave rise to these silicates of lime, magnesia, iron and alumina were briefly discussed, and declared to be still active, although probably to a less degree than formerly.

(*Corrected from the Newspaper Reports.*)

ADDRESS TO THE MEMBERS OF THE MONTREAL NATURAL HISTORY SOCIETY,

DELIVERED MAY 18TH, 1866.

BY CHARLES SMALLWOOD, M.D., LL.D., D.C.L., &c., President of the Society.

MY LORD AND GENTLEMEN,—The rolling wheels of time have again brought us to this our annual re-union. Thirty-nine years have passed away since this Society was founded; and it now devolves upon me, as your President, (a position which I owe to your individual kindness,) to resign into your hands the charge you have placed in my keeping. I felt at the outset my utter inability to fulfil those duties which my predecessors have so well and so efficiently discharged; but I relied upon your help and assistance, and was assured that what was wanting in my own personal exertions, would be supplied by your advice and help. In this, gentlemen, I have not been disappointed; and permit me now to tender to each of you individually my best and warmest thanks for the forbearance and kindness you have at all times shewn to me in those shortcomings which have occurred during my tenure of office. And while it is with feelings of gratitude that I tender to you my resignation, they are mingled, nevertheless, with feelings of pride for the honor you have conferred upon me.

It is not, gentlemen, due to any personal exertions or energy on my own part that we have arrived at this, the termination of another year of great prosperity and increased usefulness; but it is to those friends whose scientific efforts have been so well directed; and it is to you who have trodden so zealously the path of those few devoted men whom we may be proud to call our predecessors and the founders of this Institution. It is, I repeat, to your efforts that our increased prosperity must be attributed. It is a noble object that has invited us to these Halls of Science. We meet together to contemplate the teachings of God in Nature; and our mutual aim should be, and we hope has been, to decipher some new word in the pages of that great book, in order that we may the better learn the will and the workings of Him who ordereth all things well. We have sought to study the method of God's workings in nature; for in the vision of science there is nothing too minute for our notice, or unworthy of it. The means for the investigation of almost every branch of Natural Science are gradually extending; and the Montreal Natural History Society is not the least important of those institutions which are spreading over our country, and the world generally, scientific knowledge, for science is nothing more than knowledge reduced to order. But to say that science is worthy of your pursuit, is at best a waste of words. You know too well its importance; for by science we have converted the products of our forests and our fields into articles of commerce; we have by science abridged human labour to an immense extent; we have by science invented machines, some of immense power, all but surpassing human efforts at calculation, and others which almost rival the winds in swiftness, propelled on road-ways that have compassed our globe by their iron bands; and science, again, has nearly achieved a victory over the velocity of thought, light and sound, in the invention and application of our electrical telegraph.

Where shall I specially turn to contemplate the wondrous works of God, or to follow up the yearly march of science? Shall I dip with a Logan, a Dawson, a Hunt, and a Billings, beneath the rocky covering of our globe, for a subject of discourse? I dare not. Their mantle would not fall with graceful folds upon one so incompetent as myself. Our reports and journals bear ample evidence of their united labours and individual researches. Or shall I stroll through the deep forests or over the flowery sod, where once trod the footsteps of a Holmes or a Barnston, one of whom was removed from among us full of years and of honour; while the other had scarcely entered upon the busy stage of science ere he was called away? But why should I hesitate to find a suitable theme in the vast domains of science? Why should I say more? Ascend with me above the dust, ascend with me far above those sure foundations that were laid in the ages of this our world, far, far gone by; ascend with me above the clouds,—those cirrous clouds, where the heavens are never obscured, where the atmosphere is pure and free from mist,—in the balmy but intensely cold regions of space, where our earth, with its lofty mountains and fertile valleys, with its noble mansions and its lovely cottages, is only seen as a small planet; where our sun itself is dwindled to a twinkling star; where the starry host is nearly lost from vision,—merged, as it were, into a milky way;—and where the great girdle of the heavens itself is but a faint nebulous mass. Yet deep even into this immensity of space science has cast its divining rod.

A Herschel discovered a world eighty times larger than our own, which revolves in its circuit in a long period of time, corresponding to more than 80 of our years, ere its curved course is run. Round this planet, thus removed some eighteen hundred millions of miles, six moons revolving like our own accompany it on its onward and extended course.

But from this distant world the shout of science was still *Onward!* A Le Verrier and an Adams, with a colossal stride, placed one foot, as it were, on our earth, and another on the surface of this distant globe, and pointed out the spot where Neptune was to be found, a planet still further removed from us, and whose period of revolution was more than double that of Uranus. But even that planet appears near us when we measure the nearest star that bedecks the vaulted canopy of heaven; for that is twenty billions of miles distant from our sun.

If geology marks the progressive development of the rocks on our globe, and counts its periods by millions of years, (for the rocks are but incidents in the earth's history,) surely the astronomer may well be lost in admiration by the contemplation of these wondrous works that are manifest in

> " the wide expanse,
> Where stars, and suns, and systems shine."

The progress of astronomical science has shown us that our sun can no longer be regarded as the centre of our solar system, but that all the starry host is moving yearly in a grand procession towards another, a far distant central sun, the great centre of our universe; and we may well say, in the words of the poet,

> " He sets the bright procession on its way,
> And marshals on the order of the year."

Scarce a year has passed without adding to our list of the Asteroids, until the number now reaches 85; while a very few years ago it was but four. Are these asteroids the particles of a larger planet? or are they new worlds opened up to human vision, aided by science in the construction of the telescope? or have they been for ever wanderers in the pathless regions of space? Here science will one day, with a spectroscope, tell us if they are the remains of a larger body. A short time will no doubt set this question at rest, for if they are the particles of a larger planet, which from any cause has burst asunder, the spéctra will furnish the same results for them all.

Modern investigations have shown that our sun possesses an atmosphere, and that this atmosphere is disturbed by some action that renders visible certain spots at different times, spots which led Galileo to demonstrate the rotation of the sun upon its axis. It is the opinion of modern observers that the photosphere, (our sun's atmosphere) consists of solid or liquid bodies of a greater or less magnitude, either slowly sinking, or suspended in equilibrio in a gaseous medium; and that either the body of the sun itself is older than the surrounding medium, or else that some chemical or molecular changes have taken place where a spot is formed; or that it is produced by matter coming from a colder region; or, may be, by the solidification of its particles. But more recent investigation would tend to show that the body of the sun itself is hotter than the surrounding photosphere.

From the surface of the sun that imponderable fluid, light, is diffused, shedding on this earth all the brilliancy of colour, and tinting the landscape with an ever-varying degree of beauty. What a glorious expanse of view, and what a vast field of knowledge has been revealed within even the few past months, bearing on this subject of spectral analysis.

The immortal Newton, by means of the prism, resolved light into its ultimate rays in the solar spectrum, a fitting rival to the rainbow. Fraunhofer discovered that this spectrum was traversed by numerous dark lines or bands which gave no light or colour, indicating that at the source from whence they emanated, the rays of light were absorbed in their passage from the sun to our earth, and probably some by the earth's atmosphere. More probably some are absorbed in the atmosphere of the sun itself, for the most recent investigations in this department of physical research have shown that a glowing and gaseous atmosphere surrounds the solid nucleus of the sun, which, possessing a still higher temperature, approaching the intense heat of the brightest whiteness.

The polarized rays of this light exhibit spectra still more beautiful and intense than the solar spectrum itself. Forms of the most symmetrical order are constantly presented when a polarized ray of light is passed through various substances; and these appearances are constantly varied when we change, by means of pressure, the molecular arrangement of these bodies.

And are we not, by the photographic art, able to preserve, in unfading lines, the lineaments of those we love, of those that are great, and wise, and good; as well as to transfer to paper, by this process of *sun-painting*, those cherished spots on earth most dear to us, every modulation of the landscape, the familiar dell, and the rippling river by our homes of childhood?

But the progressive march of science has not stopped here. The investigations by means of the spectral analysis have penetrated into those regions of space to which I have already alluded, and the fixed stars have been the objects of intense interest. The astronomers had well said that they were distant suns, like our own, shining by their own light; and this opinion has been confirmed by the spectroscope. They are composed of the same matter as our sun; and in the spectra of these stars, the dark lines are wonderfully well brought out and defined.

Many of the stars of the first magnitude have been subjected to direct experiment; and it has been shown that they possess in their atmospheres many of our terrestrial elements. *Aldebaran*, a star of the first magnitude, possesses sodium, magnesium, hydrogen, calcium, iron, bismult, tellurium, antimony and mercury, besides others which give negative evidence only. *Alpha Orionis* has been carefully examined, and contains most of the above-named elements with the exception of hydrogen. The presence of hydrogen has been noticed in the sun, and in almost forty fixed stars, and is eminently characteristic, showing that its presence belongs to the atmospheres of the luminous bodies themselves, and not merely to our own atmosphere.

These investigations have confirmed and demonstrated, beyond the shadow of a doubt, that all the planets shine by light reflected from the sun, and that any variety differing from the solar spectrum may be attributed to the peculiar properties of the atmospheres that surround the planets themselves.

One of the most important and interesting deductions to be drawn from these researches, is in connection with the origin of the colour of the stars. That a difference of colour in the stars does exist, is too well known to require any comment: for "one star differeth from another star in glory." And it is now no longer a matter of conjecture that the brightest stars at least are, like our sun, giving energy and life to systems of worlds like our own, adapted for the abode of intelligent life. While yellow and red stars are the most frequent, in double stars the contrasted colours are green and blue. The source of the light of the stars must be a solid or liquid body in a state of incandescence, as only such bodies, when raised to a high temperature, give out a continuous spectrum. In the case of the fixed stars and the sun, this continuous spectrum becomes crossed by dark bands, which are produced by the absorbing power of the constituents, held in a vaporous form in the investing atmospheres. These atmospheres vary in chemical constitution, according to the elements composing the star; and the dark lines are produced by the absorptive power of the vapours forming the stellar atmospheres. They correspond to the bright lines they would form in an incandescent state, and would be the strongest and most numerous in the more refrangible portions of the spectrum, consequently a star would have a red or orange tint should that part of the spectrum suffer least absorption: while, on the contrary, should the red and yellow portion have most lines, the blue and green rays would then predominate in the colour of the star.

In *Sirius*, the 'dog star,' which is of a brilliant white, there are no lines sufficiently intense, in any particular part of the spectrum, to interfere with our receiving the light in about the same proportion as to the quantity of the different coloured rays, to that which starts from the incandescent light-giving surface. Sodium, magnesium, hydrogen, and probably iron, have been found in this star; and even a photograph on wet collodion has been obtained. In reference to double stars, observations on *Beta Cygni* and *Alpha Hercules* confirm these observations.

Various opinions have been ventured on the composition of the nebulæ. It has been affirmed that they are masses of minute stars, and only require higher optical powers to reduce them to distinct vision. The construction of Lord Rosse's telescope was looked forward to as tending to set the matter at rest; but, instead of this, it seemed to involve the question in still greater difficulty. Its solution was not lost sight of during the past year, and the spectrum observation has been shown to have an important bearing on the nebular hypothesis of the cosmical origin of the universe. It shows that the elementary substances must have existed in different proportions at different points of the nebulous mass; otherwise, by condensation, equal portions of the elements from the surrounding vapour would have been collected.

There is also an analogy to the manner in which the components of the earth's crust are distributed, for some of these elements are widely diffused through vegetable, animal, and mineral matter.

It has been further shown that it is only liquid and solid bodies that give out a continuous spectrum; while gases alone, when rendered luminous by heat, give out light which, after dispersion by the prism, is found to consist of certain degrees of refrangibility only, and which appear as bright lines on a dark ground, contrary to the solar spectrum, which shows dark lines on a bright ground. This fact has shown that, in the nebulæ, large masses of gas exist, and they possess no resemblance whatever to stars or clusters of stars. The nebulæ, therefore, are not masses of stars removed to such a distance as to render them irresolvable, but consist, for the most part, of luminous gases.

This presents to us, at once, another instance of unity in nature, by recognizing each of the simple bodies held in suspension in the flame, whose rays are decomposed by the prism. The dispersion of the sun's rays by the prism forms the standard of observation; any deviation will shew either bright lines in the place of dark ones, or dark lines in the place of bright ones. Nickel, chromium, magnesium, iron, potassium, sodium, barium, copper, cobalt and zinc, are found always present in the sun's atmosphere in a state of vapour.

The possession of an atmosphere by the moon has been the subject of frequent investigation and conjecture; but, by the spectrum analysis, it is now rendered certain that the moon has no atmosphere, at least on that side presented to our view. This has been lately further confirmed by observing the different spectra shown by the occultation of a star by the moon at the moment of contact, by obtaining the two separate spectra at once in the field of view.

It may be thought that the few remarks on the branches of science to which I have more immediately alluded, do not fairly come within the scope of the Natural History Society. But as, in looking over the annual addresses for the past few years, I found no account of any of the progressive steps in the sciences generally, except in those of Geology and Botany, I deemed it not unworthy to allude to some of these more recent researches in other departments of physical science.

I ought not to close this short address without expressing my great regret that Montreal does not possess any adequate means, owing to the want of proper instruments, for prosecuting the science of Astronomy. A climate like that of Lower Canada, which furnishes, upon an average, 120 nights in a year suitable for celestial observation, offers a vast field for astronomical labours, and also for the investigations now being carried on in celestial chemistry, and the spectum analysis. Since our last annual meeting, many original papers on subjects more intimately connected with Natural History have been read before the Society, or printed in the *Canadian Naturalist*, the perusal of which will shew that many new and curious facts have been observed and recorded, bearing upon the geology, zoology and botany of British North America. These papers will furnish evidence that the members of this Society have not been idle during the past session, and that some of them have devoted a considerable time to the study of those objects which come more directly within its scope. Those who are more particularly engaged in the study of natural history in Canada, know further that investigations have been carried on during the past Summer, the results of which have not yet been recorded. Among the papers to which I may more particularly refer are: four on Geology and Palæontology, by Dawson, Billings, Packard and Whiteaves; four on Zoology, by

Stimpson, Parkes, Couper and Ritchie; two on Botany, one by Mr. Watt, and another from Dr. Gibb; and one on Geography, from Dr. Hunt. I would refer to the pages of the *Canadian Naturalist* for more ample information on these points.

The pursuit of science, in its legitimate sense, is to endeavour to advance man's happiness, and to elevate and refine every human sentiment. Associations of a like character to our own are intended to diffuse intelligence and the light of truth to man, to fit him for a higher state of existence.

The study of nature has formed the object of the most elevated and aspiring thoughts,—thoughts that have dwelt on the works and wonders of creation. What is more beautiful or more elevating than those aspirations that direct us to contemplate the wisdom and goodness of God? and what can be more pleasing than that kindred minds should associate in mutual harmony, and contribute each his small portion (though small) to the grand treasury of knowledge and of truth? Nor is it possible to suppose that the onward progress of true science will ever operate to the disparagement of that devout homage we owe to Him in whose hands are held our daily wants and future destiny; but on the contrary science, if directed in the proper paths, will aid in fitting us, after a life devoted to its pleasures and its beauties, for the enjoyment of that intellectual intercourse which has ever been among the holiest and noblest aspirations of man.

I have not entered much (nor did I intend) into the business part of the Society's operations, properly so called, leaving it to your Council, Scientific Curator and Treasurer to present their reports, which, I have no doubt, will be very satisfactory. But I must not forget to mention the eminent and efficient services of Mr. Whiteaves. A look into our museum will, I am sure, convince any one of the amount of labour he has bestowed; and I feel sure that your Council will render also a good account of his recent visit to England.

For my own part, I am sorry to say that a lack of time has prevented me from filling the office of President so well as I could have wished. In resigning the charge into your hands, I must be allowed to express a fervent wish that increasing prosperity may mark our way; and to say that we may congratulate ourselves on our increasing usefulness in spite of a Winter of more than ordinary excitement, owing to a most wicked and unheard-of threat of invasion of our country by strangers, many of our young men having taken up arms in defence of our homes. But I trust that now peace is again restored to us, and hope that war, with all its appalling features, may merge into the calmer pursuits of science; and that the Montreal Natural History Society may long continue to diffuse and spread knowledge; for

> " There's beauty all around our paths, if but our watchful eyes
> Can trace it 'midst familiar things, and through their lowly guise."

ON THE VITAL STATISTICS OF MONTREAL.

By Philip P. Carpenter, B.A., Ph. D., Hon. Sec. of the Montreal Sanitary Association.

In the *Canadian Naturalist* for 1859, pp. 173-186, was published the first attempt to eliminate and explain the sanitary statistics of Canada. The facts and figures therein set forth were carefully scrutinized in this and other cities. As was to be expected, the conclusions arrived-at were frequently called in question; but the writer was charged with inaccuracies which belonged to the data, and not to the working-out of the materials. The figures were not set forth as accurate; but only as the *nearest approach to accuracy which was then attainable.*

The census of 1861 has now furnished elements for comparison with similar results in the previous decade; and the yearly tabulation of burials and baptisms in the city of Montreal and in the adjacent counties has added to the cumulative evidence of the peculiar unhealthiness of the city. It is proposed, in the present paper, to present the results of these two sources of information; and to compare them with a third source, viz. the weekly returns of interments at the city cemeteries, which were not accessible to the writer in 1859.

A. Census of 1861.

It must be premised that the deaths are twice tabulated in the census returns, viz. under ages, and under diseases. On analyzing these in order to ascertain the proportions of deaths from xymotic diseases, of deaths under 5 years, and of deaths above 70 years, to the total deaths, it was found that in Quebec City, then the capital of Canada, there was no less a discrepancy than 296, in the total number of deaths recorded, between these two tabulations. Such a glaring inaccuracy in a work executed at considerable expense, and demanding the greatest care to make it of practical value, is not calculated to raise the character of the Canadian Executive; and throws considerable doubt on the value of the returns in general. Evidence is given in the 'Second Report of the Financial and Departmental Commission,' Feb. 1864, pp. 32 et seq., that "the irregularities in the returns themselves resulted from the ignorance of many of the enumerators as to the object of the different columns; and carelessness in leaving some of them blank, or filling them in a manner that was *manifestly absurd.* Where the addition of several columns should have agreed with the total given in some other column, it *often happened that irreconcilable differences occurred.* . . . Some mode of bringing these totals into harmony was necessary; and an arbitrary system of what I must call *cooking the figures* was resorted to for the purpose."

The returns for Montreal City are said to have been made with the greatest attainable accuracy; yet the deaths for the year are only stated as 2,038, while we know that 3,181 interments actually took place during the year at the two cemeteries, being a difference of 1,143, or *more than* 50 *per cent.* If it be supposed that this marvelous discrepancy arose from a different division of the year, the fact remains that the interments for 1860 were 3,171, and for 1862, 3,461; in neither case presenting a perceptibly lower rate.

If such be the manifest and gigantic untruth in the returns of the two largest cities of British America, it is hard to place any reliance on returns of places of less importance, least of all of country districts. Even if the figures had been accurately given, they would only have established facts for a single year, which might have exceptional: as it is, they must only be accepted for comparative, not for absolute results. Such as they are, they are presented in the following table, where the first two columns A and B give the actual population and mortality. Column C presents the average deaths among each thousand of the population. Column D shews the number of deaths, out of every hundred from all causes, which were due to xymotic diseases. When this proportion is permanently high, it is a sure sign of bad air outside or within the dwelling, or of polluted water: where it is exceptionally high (as, apparently, in Ottawa, Laval, Vaudreuil, Soulanges and Laprairie) it betokens an epidemic, which is probably due to cumulative corruptions: where it is remarkably low, it may be taken as a very favourable sign of the sanitary conditions. Column E gives the percentage of the total deaths which took place under five years of age. If accurate, unless there were some special infantile epidemic, the high or low percentage in this column ought to be a sure test of sanitary condition; but the high rate in healthy Upper Canada, never falling below 35 p. c., and in even the country districts of Lower Canada (with the exception of Soulanges), needs some explanation not yet given. Column F gives the number, out of every hundred deaths, which were of people above the allotted term of 70 years of age. Contrary to the previous columns, it ought to be highest in the most healthy districts; but the numbers are so low that they could only be trusted on an average of years, or for a large population. Thus the low rate for Three Rivers, and the very high rate for Soulanges (*nearly five times that of Montreal*) are probably accidental. Column G exhibits the proportion between the births and deaths in the year; the figures representing the deaths in each district to every hundred births. If accurate, these ought to be lowest in the most healthy districts, as we see in the case of Verchères which presents only half the death-rate of Montreal.

The last column, H, representing the number of Catholics out of every hundred in the population, has been added to test the value of a suggestion made in certain quarters that the religious customs of the French Canadians, who bring their infants to be baptized in the church, even in the coldest weather, was a main cause of the excessive infantile mortality of Montreal. It will be seen that the proportion of Catholics is *less in Montreal* than in any other quoted district of Lower Canada, except Sherbrooke.

The returns may be regarded (subject to exceptions) as sufficiently correct to show the *comparative* mortalities of cities and adjacent counties, and to compare these with the ratios worked-out from the preceding census. It is presumed that the causes of inaccuracy will affect the different returns in somewhat of the same ratio. They must also be taken (whether accurate or not) as our only data for the actual population; and, by comparison with the census of 1851, for the yearly average rate of increase. There was no temptation to "cook the figures" in this, the easiest part of the work; least of all, to reduce the population below its actual extent.

In all the columns which include Quebec city, two sets of figures are bracketed together for the reason stated above. Analogy proves that the higher rate, assigning 1,111 deaths, is more likely to be correct.

1. *Sanitary Statistics of the Census of* 1861.

	A	B	C	D	E	F	G	H
	Population.	Total Deaths.	Deaths per 1000 living.	Percentage of total deaths from Xymotic Diseases.	Percentage of total deaths under 5 years.	Percentage of total deaths above 70 years.	Number of Deaths to each 100 Births.	Percentage of Catholics.
ALL CANADA........	2,507,657	23,088 23,384	9.2 9.3	22.3 21.9	49.7 48.9	7.0 6.8	24 25	48
Upper Canada........	1,396,091	10.160	7.2	18.6	42.1	6.6	19	18
Do. less 5 cities.........	1,292,207	8,813	6.8	18.9	41.4	7.0	17	18
Toronto	44,821	727	16.2	14.2	48.7	3.5	45	27
Hamilton...............	19,096	217	11.3	18.9	49.9	3.7	31	25
Ottawa.................	14,669	172	11.7	32.5	48.2	3.5	29	56
Kingston	13,743	129	9.4	16.3	34.9	5.4	26	34
London.................	11,555	102	8.8	7.8	39.2	3.0	24	18
Lower Canada..........	1,111,566	12,928 13,224	11.6 11.9	25. 24.5	55.4 54.2	7.3 7.1	31 32	85
Do. less 2 cities.........	970,134	10,075	10.3	25.1	53.3	8.2	29	86
Do. less 4 cities.........	958,177	9,877						
Montreal	90,323	2,038	22.5	23.5	66.0	3.4	55	73
Quebec.................	51,109	815 1,111	15.9 21.7	27.6 20.2	55.2 40.5	4.1 3.6	46 63	81
Quebec *County*.........	27,893	411	14.7	14.8	48.2	10.2	38	87
Three Rivers	6,058	106	17.5	21.7	56.6	1.9	44	92
Sherbrooke	5,899	92	15.6	27.1	42.1	6.5	39	46
Hochelaga *County*......	16,474	226	13.7	23.0	74.3	2.6	40	88
Jacques Cartier "	11,218	140	12.4	18.6	52.1	5.7	39	92
Laval "	10,507	152	14.4	32.9	56.5	8.5	58	99
Vaudreuil "	12,282	163	13.3	34.3	60.7	8.0	34	91
Soulanges "	12,221	149	12.2	29.5	28.2	14.7	29	94
Laprairie "	14,475	183	12.7	35.5	58.4	5.4	49	96
Chambly "	13,132	121	9.9	17.3	43.0	6.6	28	96
Verchères "	15,485	167	10.8	18.5	49.7	8.9	27	99
Total of 8 Counties round Montreal.....	105,794	1,301	12.3	26.2	52.8	7.5	36	94
Montreal City..........	90,323	2,038	22.5	23.5	66.0	3.4	55	73
Excess for Montreal.....	—15,471	+737	+10.2	—2.7	+13.2	—4.1	+19	—21
Total of 7 of the above Counties, leaving out Verchères...........	90,309	1,134	12.5	27.3	53.3	7.3	38	94
Montreal City...........	90,323	2,038	22.5	23.5	66.0	3.4	55	73
Excess for Montreal.....	+14	+904	+10.0	—3.8	+12.7	—3.9	+17	—21
Comparison of London..............	11,555	102	8.8	7.8	39.2	3.0	24	18
Montreal.............	90,323	2,038	22.5	23.5	66.0	3.4	55	73
Excess for Montreal	+78,768	+1,936	+13.7	+15.7	+26.8	+.4	+31	+55

In the above schedule is first given the general average for the whole of Canada, from Gaspé to Essex, including the cities.

Next come the figures; 1. for the whole of Upper Canada; 2. for the same, excluding the five principal cities, but including all the others; and 3. for the five cities, in the order of their population. As compared with England, one cannot but be struck with the extremely low rate of mortality throughout. English insurance companies doing business in the province according to their home tables, may expect to gain considerably on life policies.

The third group presents the principal statistics for Lower Canada; first for the whole province; next for the same, leaving out the two unhealthy cities, Montreal and Quebec; next for the province, leaving out also Three Rivers and Sherbrooke; (these however, although as unhealthy as Toronto, do not affect the general average;) next for Montreal, and for Quebec with its double entry of "uncooked" figures; next for the county of Quebec, leaving out the city; and lastly for the two smaller towns, which, though healthy in comparison with their populous neighbours, are much more unhealthy than the larger cities of Upper Canada.

The next group contains the figures for the eight counties round Montreal, which were included in the registration district, and whose returns are preserved at the Protonotary's Office. Some of these display a high rate both of xymotic and of infantile mortality; yet when their total is added up, and the average taken and compared with that of the city repeated below, the *excess of deaths amounts to one citizen taken yearly out of every hundred,* who would have lived had he dwelt in the country, with the same climatal conditions, and a preponderating Catholic element.

The contrast is perhaps rendered more apparent by leaving out Verchères from the above total, and thus bringing the country population to an almost exact equality with that of the city. Although the abstraction of this healthy district somewhat raises the death-rate for the rural population; we find that in that year 904 *persons were killed by city life;* 12 per cent more of city than of rural deaths were of children under five years; less than half the number reached the age of 70; and there were 17 additional deaths to set against each hundred births. This was in spite of special epidemics which appear to have visited at least half of the rural districts, and which caused nearly 4 out of every hundred deaths more than in the city.

The last group of figures shews the contrast between Montreal, the most unhealthy, and London, the most healthy of Canadian cities, which presents a death-rate below that of the rural districts of Lower Canada. It appears that the *extra* mortality of Montreal amounts to 137 in every 10,000 persons; that for every 10 persons who die in London, 25 die in the older city; and that, out of every hundred deaths, more than 26 additional cases of children cut off under 5 years of age are found in Montreal.

The following is a comparison of the statistics of population and mortality between the census of 1851 and that of 1861. Some particulars from the report of the (English) Registrar General for 1857* are added.

2. *Comparative Sanitary Statistics of the Census of* 1851 *and of* 1861.

	Population.		Total Deaths.		Deaths per 1000 living.		Excess of Deaths in 1861 over rural districts of	
	1851.	1861.	1851.	1861.	1851	1861	Upper Canada	Lower Canada
ALL CANADA	1,842,265	2,507,657	19,449	23,384	10.5	9.3	6,269	...
Upper Canada..	952,004	1,396,091	7,775	10,160	8.2	7.2	558	...
Do. less 5 cities	880,737	1,292,207	6,754	8,813	7.5	6.8	...	...
Toronto........	30,775	44,821	474	727	15.4	16.2	411	263
Hamilton.......	14,112	19,096	172	217	12.2	11.3	86	19
Ottawa.........	7,760	14,669	90	172	11.5	11.7	71	20
Kingston.......	11,585	13,743	185	129	15.9	9.4	35	..
London........	7,035	11,555	100	102	14.2	8.8	23	..
Lower Canada..	890,261	1,111,566	11,674	13,224	13.1	11.9	5,668	1778
Do. less 2 cities.	790,494	970,134	8,632	10,075	10.9	10.3	3,395	....
Montreal.......	57,715	90,323	1,978	2,038	34.4	22.5	1,417	1101
Quebec...... ..	42,052	51,109	1,064	1,111	25.3	21.7	761	582
All England......						22.0		
London......						25.0		
Eastbourne, Sussex......						15.0		
Liverpool......						36.0		
Average Deaths in all England from xymotic diseases, out of every hundred deaths......						22.0		
Do. under five years......						39.1		

If these returns could be relied upon, they would present an extremely flattering picture of Canada in general, and even of the cities in particular, as compared with the rural districts and cities of England, and as compared with its own condition ten years previously; Toronto and Ottawa being the only cities in which

* This is the latest return accessible at the free library in the Mechanics' Institution. It represents an average of many years. Not a single district in England is found to have a mortality less than 15 per 1000, or more than 36.

the mortality has increased. But as we know that the deaths for Montreal are glaringly understated, we are obliged to doubt the accuracy of the returns in other districts also. As the registers of interments at cemeteries and churchyards must be always accessible to the enumerators, it is hoped that the authorities will take the necessary steps to insure accuracy at the next decennial census.

The following table has been calculated in order to estimate the proportion borne between the interments at different ages, and the number living at the same age. The "total deaths" are probably much below the real numbers, but the *ratio between the ages* may be sufficiently near the truth.

3. *Population and Deaths in Montreal at different ages: from the Census of* 1861.

1861.	Number living.	Total Deaths.	Deaths per 1,000 living at the *same age*.	Quebec. Do.	Lower Canada, less 4 cities.
Under 1 year	3,700	1,006	271·3	161·9	82.6
From 1 to 2 years	3,183	179	56·2	48·8	43·8
" 2 to 3 "	2,883	70	24·3	33·2	16.0
" 3 to 4 "	2,821	46	16·3	17·9	10.2
" 4 to 5 "	2,609	44	16·5	11·6	7·2
" 0 to 5 "	15,196	1,345	88·5	58·4	32·3
" 5 to 10 "	10,363	86	8·3		
" 10 to 15 "	9,200	37	4·0		
" 15 to 20 "	10,890	55	5·5		
" 0 to 10 "	25,559	1,431	55·9	(It was not judged necessary to complete the table for adult deaths in Quebec and the rural districts.)	
" 10 to 20 "	20,090	92	4·5		
" 20 to 30 "	18,174	119	6·5		
" 30 to 40 "	11,044	89	8·6		
" 40 to 50 "	7,248	50	6·9		
" 50 to 60 "	4,476	72	16·0		
" 60 to 70 "	2,460	56	22·8		
Above 70 and unknown	1,272	129	101·4		
All Ages	90,323	2,038	22·5		

It appears, therefore, that for every hundred children who die under one year in Montreal, aly *sixty* die in Quebec, and *thirty* in the country districts. For every hundred who die under five years in Montreal, *sixty* die in Quebec, and only *thirty-six* in the country districts.

B. PROTONOTARY'S RETURNS.

It appears, by the rate of increase ascertained from the census of 1861, that the population of Montreal City must have been greater than that assumed in the table printed in the *Canadian Naturalist*, 1859, p. 176, so far as the later years are concerned. Subtracting that rate, viz., 3,260 annually, to find the population before 1861, and adding it for the subsequent years,* we are able to present a table approximately correct, as follows :

4. *Montreal City: Returns of Baptisms and Funeral Services.*

Year.	Supposed Population	Births.	Deaths.	Excess of Births over Deaths.	Deaths per 1.000 living.	Deaths per 100 Births.
1859	83,803	4,238	2,581	+1,657	30·8	60
1860	87,063	4,438	3,016	+1,422	34·7	68
1861	90,323	4,579	3,005	+1,574	33·2	65
1862	93,583	4,811	3,222	+1,589	34·4	67
1863	96,843	5,388	3,510	+1,878	36·2	65
1864	100,103	4,024	4,306	— 282	43·0	107
1865	103,363	4,339	3,732	+ 607	36·1	86
Average of 7 years	93,583	4,545	3,390	+1,155	36·2	74
Average of 6 years(—1864)	92,496	4,632	3,177	+1,455	34·3	68

The returns from which this table is constructed were the most accurate known at the time the former article was written. They are now known to be consideraby below the truth. They only profess to register religious services at birth and death; so that many children are born, and some corpses perhaps interred, without the names appearing in the clerical registers. The returns are not always sent in with becoming punctuality; and none are yet accessible for the year 1866. Their chief use is in furnishing data for the comparison of births and deaths; and of the city with the country districts. These last consisted, from 1859–1861, of the following counties, viz.: Hochelaga, Jacques Cartier, Laval, Vaudreuil, Soulanges, Laprairie, Chambly and Verchères. In 1862 Vaudreuil, and in 1863 Soulanges, were removed to another registration district; but their averages have been added in, to make the returns for the different years correspond. The population in 1861 is taken from the census; a comparison of this with the census of 1861 gives 3817 as the average yearly rate of increase. It is probable that these country returns are more accurate than those of the city; the population being less affected by immigration; and the proportion who are careless as to religious observances being much smaller. It will be specially noticed that there is no remarkable fluctuation in births in 1863–4, nor extra mortality in 1864.

* This simple mode is not exact, being less than the real rate. But as the recorded deaths are also below the real numbers, the lower totals of population make the averages more near the truth.

5. *Eight Adjacent Counties: Returns of Baptisms and Funeral Services.*

Year.	Supposed Population	Births.	Deaths.	Excess of Births over Deaths.	Deaths per 1,000 living.	Deaths per 100 Births.
1859	98,160	4,087	1,881	+2,206	19.1	46
1860	101,977	4,013	1,787	+2,226	17.5	44
1861	105,794	3,935	1,799	+2,136	17.0	45
1862	109,611	3,882	2,020	+1,862	18.4	52
1863	113,428	3,895	1,823	+2,072	16.0	47
1864	117,245	3,712	2,019	+1,693	17.1	54
1865	121,062	3,943	2,045	+1,898	16.9	52
Average of 7 years	109,611	3,923	1,911	+2,012	17.4	48
Do. Montreal	93,583	4.545	3,390	+1,155	36.2	74
Balance for the city, + and—	—16,028	+ 622	+1,479	— 857	+18.8	+ 26

It appears, therefore, that although the average population of Montreal is more than *sixteen thousand less* than that of the eight counties, (making a difference greater than the whole population of Verchères,) it furnishes yearly 1479 *more deaths*, being at the rate of 188 additional yearly deaths among each myriad of the living population, which is *more than double the country rate of dying*.

It is found to be a standard fact in sanitary statistics, that, by a compensating power in nature, extra deaths are accompanied by extra births, so that if a city has above the normal number of *births* in proportion to the population, it will be found to have also an abnormal number of *deaths*. We find therefore that, for the *smaller population* of Montreal, there is yet a yearly *excess of 622 births*; yet in spite of this, there is a yearly loss to the city, on comparing the balance of births and deaths with that of the country, amounting to 857 souls, or 26 extra deaths out of every hundred births. Such is the contrast presented, not by a single year, as in the census returns, but by the average of seven years, between the city and the country, both having the same climatal conditions, and the balance of comforts and the means of living being decidedly in favour of Montreal.

C. Interments at the Cemeteries.

We have been obliged to express doubts as to the accuracy of the previous returns. Those of the census, even if correct, apply to one year only. Those of the clergy apply only to religious services; and among them may be some which are not accurately registered. But of the graves dug, and the coffins actually interred, there can be no mistake. That the name, age, and other circumstances attending the death of a citizen should be actually entered in the register, without that person actually having died, cannot be believed. Citizens may have died, and been interred elsewhere; they may have been interred at the cemeteries, and by bare possibility an entry not have been made; the returns may not therefore be complete, but they cannot be gainsaid so far as they go. That such and such numbers of persons were interred at Cote des Neiges and at Mount Royal Cemeteries on such and such dates, is recorded in black and white, and forms a record of human life prematurely cut off, truly fearful to contemplate.

It is no doubt true that several interments are made of country residents: but the suburban districts are not populous enough materially to affect the averages; and the number of countrymen buried from them is probably balanced by citizens who die or are interred elsewhere. The census returns of population may indeed be incorrect; and therefore the assumed yearly increase, and the actual rate of mortality per thousand. But there are three classes of facts which are not affected by these chances of error, and which are of the highest importance; viz.: 1. the comparative mortality from one year to another; 2. the comparative mortality at different seasons of the year; and 3. the comparative mortality of children and adults.

In accordance with a Municipal Bye-Law, weekly returns are tabulated, at the office of the City Clerk, of all interments in the burial grounds of the City of Montreal. They are compiled from sheets sent from the "Catholic Cemetery;" and from the "Protestant Vaults or Burial-ground." The latter is said to include all interments made elsewhere than in the Cote des Neiges Cemetery. These sheets are ruled to contain the

			MALES.		
No.	*Name.*	*Date of Decease.*	*Children.*	*Married Men.*	*Widowers.*

	FEMALES.			
Bachelors.	*Children.*	*Married Women.*	*Widows.*	*Unmarried Women.*

AGE.			PLACE OF RESIDENCE.			
Years.	*Months.*	*Days.*	*Street.*	*Ward.*	*Country.*	*Disease.*

The last two columns, in the Catholic sheet examined as a specimen, and even the previous ones of place of residence, are imperfectly filled up. With more care in the registration, and with accurate tabulation extending over a series of years, these sheets might afford materials for *fixing the special localities of* *extra mortality*, which might produce most important results. Many of the streets being extremely long, and containing houses, even in the same ward, differing very greatly in sanitary condition, the *number* of the house ought *in every case* to be recorded. As in England, no interment ought to be allowed, without the production of a duly authorized medical certificate, assigning both the *proximate* and the *remote* cause of death, *both of which* should be recorded.

The only items tabulated in the City Clerk's register are the *numbers* in the columns for males and females, and the *totals for each week*. There are two columns for disease, simply divided between 'epidemic' and 'others;' but the epidemic of cholera, which caused this return to be instituted, (on July 16, 1854,) having terminated in November, no returns have been entered under the disease columns since that date. The columns for 'children' include all deaths under twelve years of age.

The returns for 1854 are of course incomplete. There is an entry of 274 deaths from cholera, from June 28 to July 11; and of the total deaths registered from cholera being 1067, principally in July. The greatest mortality was in the week ending July 23rd, viz.: 281; the least, Nov. 25, viz.: 33. The totals are as follows:

6. *Partial Returns of Deaths in Montreal, for the Cholera year*, 1854.

1854.	Children.	Adults.	Total.	Weekly Average.
July, 3 weeks.............	414	396	810	270.0
Aug., 4 "	262	278	540	135.0
Sept., 5 "	211	93	304	60.8
Oct., 4 "	103	60	163	40.7
Nov., 4 "	99	74	173	43.2
Total.....................	1,089	901	1,990	99.5

The cemetery tables enable us to present the complete returns for twelve years, from Jan. 1, 1855, to Dec. 31, 1866, inclusive; and to divide them between 'children' and adults.

The population for each year has been calculated, as exactly as possible, not by adding and subtracting a fixed quantity, as in tables 4 and 5, but according to the *average rate of increase*, which is found to be very nearly 4·7 per cent.; (that of all England being somewhat under 2 p. c.) Of course a considerable part of this large increase is due to immigration, and is a fluctuating element. This was probably greatest during the American war, and least in 1866, when the nominally high wages in the United States tempted many to emigrate. Due allowance is made for the excess of deaths over births in 1854 and 1864.

The following table presents the total population; the total deaths; the deaths of all above 12 years of age, called *adults;* and of those under 12, classed as children. Corresponding columns exhibit the proportion of each entry of death to 1000 living persons *of all ages.* A separate column exhibits the proportion between every 100 deaths of *persons of all ages above* 12, and the corresponding deaths in the same year below 12. *In every year except* 1866, *the latter are more than double.*—In order to render more conspicuous the high death-rate of the city, a tenth column shews the average group of individuals among whom a *single death* occurs, viz.: among every 30 in the healthier years, every 28 in the balance of years, every 22 in 1864, and every 17 in the cholera year. The eleventh column shews the actual number of deaths which occurred in the city above the rural average; that is, of lives which might have been saved, had the people been scattered over the neighbouring counties. The last column presents the same *excess* of city death, as compared with each 1000 living.

It will be observed that although so large a proportion of the moribund population were killed off in the cholera year, the succeeding year, 1855, was still unhealthy. From 1856-1859, the mortality, though frightfully great, was below the average. The six years from 1860-1865 march on with steady course, presenting a death-rate only equalled, in the worst English cities, during periods of special pestilence. In 1866, there is a marvellous and sudden rebound to the death-rate of the least unhealthy year, 1858. During 1864, there was a terribly fatal epidemic of scarlatina, its virulence being no doubt caused by the accumulations of xymotic poison, which then attained their maximum. These fluctuations are brought out most strongly in the column for children's deaths: they are much slower in affecting adults. With them the rise does not begin till 1863; it is even somewhat lower in 1864; and there is no change for the better in 1866.

7. *Rate of Mortality for the City of Montreal,* 1855–1866 : *from the Cemetery Returns.**

Year.	Population.	Deaths of *Adults.*	Or per 1000 of all ages living.	Deaths of *Children.*	Or per 1000 of all ages living.	Deaths of Children to every 100 deaths of adults.	Total Deaths.	Or per 1000 of all ages living.	Or one Death in every	Yearly excess of deaths of all ages as compared with adjacent counties.	Or per 1000 living.
1855........	68,347	712	10.4	1,704	24.6	236	2,416	35.2	28 living.	1,250	18.3
1856........	71,581	743	11.1	1,617	22.6	204	2,360	32.9	30 "	1,279	17.9
1857........	74,951	796	10.6	1,694	22.6	213	2,490	33.3	30 "	1,442	18.3
1858........	78,483	771	9.8	1,739	22.1	226	2,510	32.0	31 "	1,334	17.0
1859........	82,180	847	10.3	1,919	23.2	225	2,766	33.7	29 "	1,197	14.6
1860........	86,040	922	10.7	2,249	26.1	244	3,171	36.8	27 "	1,659	19.3
1861........	90,323	945	10.4	2,236	24.7	237	3,181	35.2	28 "	1,643	18.2
1862........	94,568	996	10.6	2,465	26.0	245	3,461	36.6	27 "	1,811	19.2
1863........	99,011	1,071	11.8	2,535	25.6	217	3,606	36.4	27 "	2,019	20.4
1864........	103,664	1,165	11.2	3,536	34.1	305	4,701	45.3	22 "	2,921	28.2
1865........	106,375	1,171	11.0	2,854	26.8	243	4,025	37.8	26 "	2,216	20.9
1866........	111,374	1,226	11.0	2,384	21.4	194	3,610	32.2	30 "	1,669	15.0
Total......	....	11,365	....	26,932	....	....	38,297	....	....	20,440	....
Average of 12 years..	89,860	947 out of 61,224 adults living.)	10.5 or 15.4 per 1000 adults, or 1 in every 65 adults, yearly.	2,224 (out of 29,099 living.)	25.0 or 77.2 per 1000 children, or 1 in every 13 children every year.	238	3,191	35.5	28 "	1,696	18.9
Estimated population of the cholera year 1854.	66,097	....	....	....	....	....	3,878	58.7	17 "	2,624	39.7
Do of 1867..	116,608										

* The table may be thus read :—" In 1864 the population of the city being 103,664, 4701 corpses were interred ; that is, 453 out of every myriad living (98 above the average), or *one* out of *every* 22 persons in the city. If the same people had lived in the country round, 2,921 need not have died, or 282 lives would have been saved in every myriad. But of the corpses interred, only 1165 were above twelve years old ; that is, 112 out of every myriad living, which is only seven above the average. All the other corpses were of *children under twelve,* viz., 3,536, or 341 out of every myriad people in the city, which is 91 above the average. In that year, *to every hundred who died from twelve years old upwards, there were no less than* 305 *infants and young children under twelve.*" In the same way, all the tables may be read without decimals, by quoting 1,000 for 100, and 10,000 for 1,000: or, for common purposes, the 1,000 may be retained, and the decimal figure omitted.

We are now in a position to judge of the statistics recorded under sections A & B. The following table exhibits these in comparison with the totals from the cemeteries. It appears that during the eleven years *no fewer than 2,134 deaths have escaped registration by the clergy;* being never less than 76 in a year; on the average 194; and, in the deadly year, actually 395. The average equals 6 per cent of the total deaths; or 22 unrecorded deaths to every 10,000 living.

In the case of the census returns, the deficiency is still more startling; *no fewer than 36 per cent of the total deaths* having escaped recording.

8. *Comparison of 3 returns of Deaths in Montreal,* 1855-1865.

Year.	Cemetery Returns.	Clergy Returns	Not entered in Clergy returns.	Census Return	Not entered in Census Return
1855	2,416	2,231	185		
1856	2,360	2,284	76		
1857	2,490	2,367	123		
1858	2,510	2,299	211		
1859	2,766	2,581	185		
1860	3,171	3,016	155		
1861	3,181	3,005	176	2,038	1,143
1862	3,461	3,222	239		
1863	3,606	3,510	96		
1864	4,701	4,306	395		
1865	4,025	3,732	293		
Total....	34,687	32,553	2,134		

MORTALITY OF 1861.—Cemetery....................35.2 per 1000 living.
Protonotary....................33.2 "
Census....................22.5 "
Not registered by the clergy... 2.0 "
Not recorded in census........12.7 "

These facts are surely sufficient to convince the most sceptical of the importance of a compulsory civil registration of births and deaths. In addition to the usual details, it is very necessary to provide that no death be registered without the production of a medical certificate, declaring the remote as well as the proximate cause of death. There should be heavy penalties for any interment without previous registration.

The next step in our analysis leads to very important results: it is, to distribute the total deaths for each year under the *months* in which they occur. This is done in table 9 for all ages; in table 10, for children under 12; and in table 11, for children above 12 and adults. The numbers which include five weeks instead of four are distinguished by large-faced figures. The totals for each year are added at the bottom; *for the same month in the twelve years*, in the last column.

9. *Total Deaths in Montreal, of all ages, for each month from January, 1855, to December, 1866.*

Year.	1855	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Total of each month, for 12 years.
January ..	138	135	217	194	206	209	215	262	287	411	291	227	2,792
February.	203	150	184	188	188	204	204	215	186	308	275	234	2,539
March . . .	260	227	196	148	182	263	233	277	218	360	259	297	2,920
April	235	176	193	187	243	223	182	199	231	521	385	293	3,063
May.	18[illegible]	215	259	215	177	239	212	336	294	366	303	258	3,051
June	252	183	191	180	238	399	272	339	304	413	326	284	3,381
July.	245	240	256	311	451	383	407	457	462	637	556	415	4,858
August . . .	271	318	312	217	286	309	378	440	504	449	420	387	4,321
September	218	194	159	243	188	300	270	243	280	300	426	394	3,245
October . .	135	155	202	221	217	210	256	216	273	317	266	265	2,741
November	91	1[illegible]2	156	167	168	181	317	271	283	252	249	260	2,567
December.	182	165	144	193	222	251	235	206	284	367	269	296	2,814
Total of each year.	2,416	2,360	2,490	2,510	2,765	3,171	3,181	3,461	3,606	4,701	4,025	3,610	38,297

10. *Deaths of Children under 12 in Montreal, for each month, from 1855–1866.*

Year.	1555.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Total of each month, for 12 years.
January. . .	119	85	159	134	133	125	129	174	176	312	201	150	1,897
February .	117	87	133	127	126	135	124	154	108	235	187	146	1,679
March . . .	189	151	127	97	113	185	163	186	138	273	184	183	1,980
April	164	116	123	119	165	144	114	131	140	387	254	183	2,040
May.	121	140	176	149	133	171	144	228	197	266	206	152	2.074
June	189	124	128	114	176	325	180	263	218	317	234	181	2,440
July.	203	179	188	287	351	302	337	391	376	519	453	341	3,927
August . . .	213	281	237	158	224	242	294	338	397	365	320	289	3,358
September	161	134	125	166	94	216	197	176	195	241	335	280	2,320
October . .	79	105	115	148	143	130	180	139	197	210	174	157	1,777
November	48	106	89	114	108	117	216	156	193	173	154	156	1,630
December.	119	109	94	135	153	157	158	129	200	238	152	166	1,810
Total of each year.	1,704	1,617	1,694	1,739	1,919	2,249	2,236	2,465	2,535	3,536	2,854	2,384	26,932

11. *Deaths of Adults and Children above 12 in Montreal, for each month, from 1855–1866.*

Year.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	Total of each month, for 12 years.
January. . .	19	50	58	60	73	84	86	88	111	99	90	77	895
February .	86	63	51	61	62	69	80	61	78	73	88	88	860
March. . . .	80	76	69	51	69	78	70	91	80	87	75	114	940
April	71	60	70	68	78	79	68	68	91	134	131	110	1,028
May.	65	75	74	75	44	68	68	108	97	100	97	106	977
June	72	59	63	66	62	74	92	76	86	96	92	103	941
July.	42	61	68	62	109	81	70	66	86	118	103	74	931
August . .	58	67	75	59	62	67	84	102	107	84	100	98	963
September	57	60	64	77	94	84	73	67	85	59	91	114	925
October. . .	56	50	87	81	74	80	76	77	76	107	92	108	964
November	43	66	67	53	60	64	101	115	90	79	95	104	937
December.	63	56	50	58	69	91	77	77	84	129	117	130	1,004
Total of each year.	712	743	796	771	847	922	945	996	1,071	1,165	1,171	1,226	11,365

In order to bring out more vividly the startling differences exhibited by the foregoing tables, not in one year only, nor in many, but in *each one of a long series*, a fresh series of tables has been constructed, nos. 12-14, exhibiting the average *weekly* mortality of each class during each month. This is done by dividing the previous items by 4 or by 5; fractions below one-tenth being omitted. The averages for each year, and for the sum of years, are in each case *constructed from the totals*, and not by the mere addition of the previous items, which would involve error from the disregarded hundredths.

12. *Average Weekly Mortality, of all ages, for each month from January, 1855, to December, 1866.*

Year.	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	Average per week in each month, for 12 years.
January....	34.5	33.7	43.4	38.8	41.2	52.2	53.7	65.5	57.4	82.2	72.7	56.7	52.7
February...	50.7	37.5	46.0	47.0	47.0	51.0	51.0	53.7	46.5	77.0	68.7	58.5	52.9
March......	52.0	45.4	49.0	37.0	45.5	52.6	46.6	55.4	54.5	90.0	64.7	59.4	54.1
April.......	58.7	44.0	48.2	46.7	48.6	55.7	45.5	49.7	57.7	104.2	76.6	73.2	60.1
May.......	46.5	43.0	50.0	43.0	44.2	59.7	53.0	67.2	58.8	91.5	75.7	64.5	57.6
June... ...	50.4	45.7	47.7	45.0	59.5	79.8	54.4	84.7	76.0	103.2	81.5	56.8	65.0
July...	61.2	60.0	64.0	69.8	90.2	95.7	101.7	114.2	115.5	127.4	111.2	103.7	93.4
August.....	67.7	69.6	62.4	54.2	71.5	77.2	75.6	88.0	101.0	112.2	105.0	96.7	82.1
September..	43.6	48.5	47.2	60.7	47.0	60.0	67.5	60.7	70.0	75.0	85.2	78.8	62.4
October...	33.7	38.7	40.4	45.8	43.4	52.5	64.0	54.0	54.6	63.4	66.5	66.2	51.7
November..	22.7	34.4	39.0	41.7	42.0	45.2	63.4	54.2	70.7	63.0	62.2	65.0	50.3
December. .	36.4	41.2	36.0	48.2	44.4	50.2	58.7	51.5	71.0	73.4	53.8	59.2	52.1
Average week for 12 months.	46.4	45.4	47.9	48.2	52.2	60.9	61.1	66.5	69.3	88.7	77.4	69.4	61.2

13. *Average Weekly Mortality of Children under* 12, *for each month, from Jan.* 1855, *to Dec.* 1866.

Year.	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	Average per week in each month, for 12 years.
January........	29.7	21.2	31.8	26.8	26.6	31.2	32.2	43.5	35.2	62.4	50.2	37.5	35.8
February........	29.2	21.7	33.2	31.7	31.5	33.7	31.0	38.5	27.0	58.7	46.7	36.5	34.9
March..........	36.0	30.2	31.7	24.2	28.2	37.0	32.6	37.2	34.5	68.2	46.0	36.6	36.6
April............	41.0	29.0	30.7	29.7	33.0	36.0	28.5	32.7	35.0	77.4	50.8	45.7	40.0
May............	30.2	28.0	35.2	28.0	33.2	42.7	36.0	45.6	39.4	66.5	51.5	38.0	38.9
June...	36.0	31.0	32.0	28.5	44.0	65.0	36.0	65.7	54.5	79.2	58.5	36.2	46.9
July...........	50.7	44.7	47.0	57.4	70.2	75.5	84.2	97.7	94.0	103.8	90.6	85.2	75.5
August..........	53.2	56.2	47.4	39.5	56.0	60.5	58.9	67.6	79.4	91.2	80.0	72.2	63.3
September......	32.2	33.5	31.2	41.5	23.5	43.2	49.2	44.0	48.7	60.2	67.0	56.0	44.6
October.........	19.7	26.2	23.0	29.6	28.6	32.5	45.0	34.7	39.4	42.0	43.5	39.2	33.5
November......	12.0	21.2	22.2	28.5	27.0	29.2	43.2	31.4	48.2	43.2	38.5	39.0	31.9
December......	23.8	27.2	23.5	33.7	30.6	31.4	39.5	32.2	50.0	47.6	30.4	33.2	33.5
Average week for 12 months...	32.8	31.1	32.6	33.4	36.2	43.2	43.0	47.4	48.7	66.6	54.9	45.9	43.0

14. *Average Weekly Mortality of Adults and Children above* 12, *for each month from Jan.,* 1855, *to Dec.,* 1866

Year.	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	Average per week, in each month, for 12 years.
January	4.7	12.5	11.6	12.0	14.6	21.0	21.5	22.0	22.2	19.8	22.5	19 2	16.9
February	21 5	15.7	12.7	15.2	15.5	17.2	20.0	15.2	19.5	18.2	22.0	22.0	17.9
March	16.0	15.2	17.2	12.7	17.2	15.6	14.0	18.2	20.0	21.7	18.7	22.8	17.4
April	17.7	15.0	17.5	17.0	15.6	19.7	17.0	17.0	22.7	26.8	26.2	27.5	20.1
May	16.2	15.0	14.8	15.0	11.0	17.0	17.0	21.6	19.4	25.0	24.2	26.5	18.5
June	14.4	14.7	15.7	16.5	15.5	14.8	18.4	19.0	21.5	24.0	23.0	20.6	18.1
July	10.5	15.2	17.0	12.4	20.0	20.2	17.5	16.5	21.5	23.6	20.6	18.5	17.9
August	14.5	13 4	15.0	14.7	15.5	16.7	16.8	20.4	21.4	21.0	25.0	24 5	18.1
September	11.4	15.0	16.0	19.2	23.5	16.8	18.2	16.7	21.2	14.7	18.2	22.8	17.8
October	14.0	12.5	17.4	16.2	14.8	20.0	19.0	19.2	15.2	21.4	23.0	27.0	18.2
November	10 7	13 2	16.7	13.2	15.0	16.0	20.2	23.0	22.5	19.7	23.7	26.0	18.3
December	12.6	14.0	12.5	14.5	13.8	18.8	19.2	19.3	21.0	25.8	23.4	26.0	18.6
Average week for 12 months	13.7	14.3	15.3	14.8	15.9	17.7	18.1	19.1	20.6	21.9	22.5	23.6	18.1

It was natural to expect that there should be some difference between the mortality at different seasons of the year. It is found in England, on the average of 10 years, that this difference does not affect in the same degree the town and the country population.

15. *English Seasonal Variations between Town and Country Mortality.*

	Large Towns.	Country.	Town Excess.
Deaths in an average quarter, for every 1000 living	25.9	20.0	5.9
Do Winter quarter	27.5	22 8	4.7
Do Spring "	24.6	20.8	3.8
Do Summer "	26.2	17.8	8.4
Do Autumn "	25.4	18.7	6.7

The town excess is thus shown to be intensified most in summer, and next in autumn; no doubt because the zymotic poisons are rendered most active in the hottest weather, and their influence continues till the frosts of winter. The effect of the heat in the five *plague years* of London which have been recorded in history is very noteworthy. The bills of mortality shew the following average for every 1000 persons living.

16. *Plague Years in London.*

Winter Quarter :	January, February, March	17	per 1000 living.
Spring "	April, May, June	20	"
Summer "	July, August, September	163	"
Autumn "	October, November, December	50	"
Total		250	" or 1 in 4

But if there are no special stenches to be drawn-out into virulence by the summer sun, the cold of winter renders it the most unhealthy of the seasons; as shown by the following table for a year in which the minimum temperature was 11°.

17. *Mortality of London Seasons in* 1830.

Winter Quarter	Average Temperature	36°	Total Deaths	8.5	per 1000 living.
Spring "	" "	53°	"	7.0	"
Summer "	" "	61°	"	6.0	"
Autumn "	" "	45°	"	6.6	"
Total of the year........	Mean "	48.9°	"	28.1	"

The same is shown in the average of all England for 1857; when, the average quarter being assumed as 1000 deaths, winter furnished 1050, autumn 1045, spring 955 and summer 950. A long series of observations has led to such uniform results in England that the Registrar General is able to predict a definite excess of mortality for every considerable fall in the thermometer. The severe frost of Jan. 1867, caused an excess of 732 deaths in a fortnight in London alone; of which only 50 were of young persons under 20, and 411 were of old people about 60. The same frost raised the death-rate in the 13 large towns to 31 per 100.

It would therefore be naturally expected that in the extreme cold of a Lower Canadian winter, the death-rate would rise proportionally. But it is not so. For adults there is a marvelous uniformity between the different months of the year. Old people, and indeed all above 12, do not appear to be rendered moribund either by the intense frosts of winter or the unhealthy heats of summer. On the average of 12 years, it does not appear that their mortality varies more than 9 out of every 10,000 living at all ages; or as 10 to 12 between January, the most healthy, and April, the least healthy of the months. The *lowest* recorded mortality was in January, 1855, (many of the moribund adults having been cut off by cholera in the previous summer); and the contrast of the year is consequently the greatest, being 16.8 between that month and February. The *highest* recorded mortality of adults was in April, 1866, when the thawed stenches of an unusually severe winter were precipitated on the putrifying corruptions of previous years; the contrast of the year between April and July being 9·0. The year of death, 1864, affords a somewhat greater contrast, viz., 12·1 between April and September; but those above twelve years old do not appear to have been more unhealthy than usual.

If winter cold does not specially kill the aged, we are not surprised to find that it appears by no means unhealthy to children.

The five coldest months are uniformly the most healthy; the two hottest, not only uniformly unhealthy, but so frightfully destructive that *July kills off 247 children out of every 10,000 of all ages living, in addition to the 184 who die in November;* which is as 23 to 10, or *more than double.* This is *nearly double* the excess of the terrible year of death 1864 over the most healthy of the years 1858. These facts are brought out in fearful contrast in the following table.

17. *Comparative Weekly Mortality of each Month, on the average of 12 years;* 1855–1866.

Deaths of Children. — Yearly average to 1000 of all ages living		Deaths of Adults. — Yearly average to 1000 of all ages living		Deaths of all ages. — Yearly average to 1000 of all ages living		Total yearly mortality to 1000 of all ages living.	
November	18.4	January	9.7	November	29.0	1858	32.0
October	19.3	March	10.0	October	29.8	1866	32.4
December	19.3	September	10.3	December	30.1	1856	32.9
February	20.2	February	10.4	January	30.5	1857	33.3
January	20.6	July	10.4	February	30.6	1859	33.7
March	21.2	June	10.5	March	31.3	1861	35.2
May	22.5	August	10.5	May	33.3	1855	35.3
April	23.2	October	10.5	April	34.8	1863	36.4
September	25.3	November	10.6	September	36.1	1862	36.6
June	27.1	May	10.7	June	37.6	1860	36.8
August	30.8	December	10.8	August	47.5	1865	37.8
July	43.1	April	11.6	July	54.0	1864	45.3
Average	24.8	Average	10.5	Average	35.5	Average	35.6
Excess of July over Nov	24.7	Excess of April over Jan.	.9	Excess of July over Nov.	25.0	Excess of 1864 over 1858	13.3
Or as one to	2.3	Or as one to	1.2	Or as one to	1.9	Or as one to	1.4

But this is not all the contrast. It is rendered even more marked by comparing not the months but the *weeks* of greatest and least mortality. This is done for each year in table 18. It will be noticed that the maximum is UNIFORMLY *in July or the first week in August.* The minimum is always in one of the cold months; or at least, as shown in the notes, a cold week appears with nearly as low a rate. There is one distinct exception for the minimum of 1866, which appears in June: for this there is a clear reason, which will presently be shown to add a striking confirmation to the general rule. In the year of mother's woe, 1864, there is an excess in July of 101 deaths over the 44 of October; which is the same as adding 51 per 1000 to the death rate of the city. In the cholera year, the deaths rose from 33 to 281; which last, if continued, would have added 195 per 1000 to the death rate of the city.—a mortality which only admits of parallel with the plague years of London before the fire. In this table, the extremes are of total mortality; as we have seen but little change in that of adults, there is no doubt that if the maxima and minima of children's deaths had been eliminated, the result would have appeared even more appalling.

18. *Weeks of Maximum and Minimum Mortality in Montreal,* 1855–1866.

Year.	Highest Mortality in week ending	Lowest Mortality in week ending	Which is at the yearly rate, per 1,000 of the living inhabitants, of Maximum	Minimum	Range of variation at yearly rate per 1,000 living.	Actual Range of variation between max. and min. weeks.	General Average of year per 1,000 living.
1854	July 23..281	Nov. 25..33	221	26	195	248	61.4
1855	Aug. 4.. 78	" 17..18	59	13	46	60	35.3
1856	" 2.. 93	" 22..19	67	14	53	74	32.9
1857	July 18.. 79	Dec. 19..25	55	17	38	54	33.3
1858	" 17.. 81	Nov. 13..29	53	19	34	52	32.0
1859	" 9.. 97	*May 7..30	61	19	42	67	33.7
1860	" 7..106	Nov. 17..36	64	27	37	70	36.8
1861	" 20..118	†Mar. 9..31	67	18	49	87	35.2
1862	" 19..123	Dec. 6..43	68	23	45	80	36.6
1863	" 25..124	‡Feb. 7..44	65	23	42	80	36.4
1864	" 2..145	Oct. 22..44	73	22	51	101	45.3
1865	" 1..127	" 28..45	59	21	38	82	37.8
1866	" 21..121	§June 9..44	54	19	35‖	77¶	32.4

* Nov. 5 and 19 are each quoted at 33; Oct. 8 at 32; and Jan. 8 at 33. All other weeks in the year are 40 or above.
† December 21 is quoted at 55.
‡ October 17 is quoted at 45.
§ Jan. 20 and Dec. 1 are each quoted at 45.
‖ Average range per 1,000, without cholera year, 42.
¶ Actual range of variation, on the average of 12 years, (leaving out 1854,) 72.

The number of living children in Montreal under 12 is to the total population as 29,249 is to 90,323: those of children under 5 years to the total children as 15,196 is to 29,249; those under 1 year to those under 5 as 3,700 to 15,196. From these elements, furnished by the census of 1861, and from the corresponding totals of deaths, the deaths of Montreal children under 12 years may be calculated *in proportion to those living, of the same ages.*

19. *Death-rate of Montreal Children under* 12, *as compared with* 1000 *children living at the same age.*

Average of years, months, and ages.	Estimated number of living children.	Total Deaths of Children.	Deaths per 1000 living children.	Or, one death out of every		
Average of 12 years, 1855-1866, for all children under 12.....	29,099	2,244	77 2	13 children living.		
The child-killing year, 1864, for all children under 12.....	33,591	3,536	105.2	9½	"	"
The least unhealthy year, 1866, for all children under 12......	36,066	2,384	66.1	15	"	"
The most unhealthy month, JULY, 1855 to 1866, for all children under 12..........	29,099	3,927	134.9	7½	"	"
The least unhealthy month, November, 1855-1866, for all children under 12..........	29,099	1,630	56.3	18	"	"
Lower Canada, less 4 cities, 1861, for all children under 12	293,579	10,796	36.8	27	"	"
Average of Montreal children under 5 years, 1855-1866......	15,119	2,139	141.5	7	"	"
Average of Montreal children under 1 year, 1855-1866........	3,681	1,599	434.1	2¼	"	"

That is, three out of every seven children born in Montreal, die before they are one year old!! Or, out of every 7 children under five years of age, living at the beginning of the year, one (on the average) will die before its close. Or, out of every 13 children of all ages under 12, living in the city, on the average one will die during the year. It appears from the census returns, that even of the children living on the Island outside the city limits, or in any country district from Soulanges to Gaspé, out of every group of 27 one must expect to lose his life within the year; but if those children had been taken to live in Montreal in 1864, *two* out of 19 would have been seized by the destroyer; even if they had lived amongst us last year, when children had a better chance of life than ever before, death would have seized one in every fifteen. Should these children spend July with their friends in the city, for twelve consecutive years, they must expect to follow to the cemetery twice that number of their companions.

Lastly let us compare the slaughter of the innocents in Montreal with their condition in different parts of England. Table 20 compares the deaths of children of different ages with the *total deaths at all ages* during the same year.

20. *Death-rate of Children living in Montreal and in England, compared with every* 1000 *deaths at all ages.*

	Deaths under 1 year.	Deaths under 5 years.	Deaths under 12 years.
North Lancashire	174.3	318.7	377.3
All England	214.5	391.0	447.4
London	190.3	404.2	453.4
Liverpool	256.9	482.6	528.6
Montreal	501.1	670.3	703.2
Excess of Montreal over Liverpool	244.2	187.7	174.6
Do do North Lancashire	326.8	351.6	325.9

The London death-rate of children is below the average, because of the large immigration of adults. There is perhaps a proportionate immigration into Montreal, for similar reasons. Liverpool is a commercial city, like our own with great natural advantages, but cursed with a neglect of the sanitary laws. It is cursed also by drink and by debauchery, to a greater extent than any other town in England. Being the most criminal as well as the most unhealthy city in the island, it is called the *Plague-spot on the Mersey.* Yet the plague-spot on the St. Lawrence is *nearly twice as fatal,* in the first year of being, as the polluted queen of the Mersey, with its cul-de-sac courts and tide-backed sewers; while round the sands of Morecambe Bay (within a fraction) only *one* of the coffins contains an infant of days to *three* which are laid within the bosom of our mountain forests, because the city rulers, and the owners and occupiers of their dwellings, denied them the right to breathe, even for one short year, the pure air that nature is for ever wafting to our otherwise favoured city.

It was well said, in the Sanitary Report presented to the imperial parliament in 1858, pp. xxvii. that "1. The lives of young children, as compared with the more hardened and acclimatized lives of the adult population, furnish a *very sensitive test of sanitary circumstances*, so that differences in the infantine death-rates, are, under certain qualifications, the *best proof of differences of household condition* in any number of compared districts. 2. Those places where infants are most apt to die, are necessarily the places where survivors are most apt to be sickly; and where, if they struggle through a scrofulous childhood to realize an abortive puberty, *they beget a sicklier brood than themselves.* A high local mortality of children must almost necessarily denote a *high local prevalence of those causes which determine a degeneration of race.*" These words are prompted by long experience, built on facts which cannot be gainsaid. If they are true of all high rates of infantile mortality, how awful must be their truth in this city where the rate is *the highest yet presented!* And if the number of graves in our cemeteries prove these things to be true on the average of the whole city, what must be the harvest of death if we subtract the population living on the healthy mountain-side, and mark the coffins from the houses in Griffintown! Surely a fearful responsibility rests on the members of the City Council, and especially on the members of the Health and Road Committees, as well as on all owners of property and householders in the city. Has any man a right to draw money from the rents of houses, by living in which children cannot but be killed? Has the Council a right to compel owners and tenants to cleanse their premises, while it leaves the streets, over which it assumes the entire control, unsewered and even *reeking with the surface filth of years?* *

* Instances were recorded by the Sanitary Association, of women who were compelled last summer to open their windows over the reeking fumes of the back courts, *because they could not bear the still greater stenches of the street.*

During the year 1864, without any known special predisposing cause, but apparently through the cumulative virulence of the deadly agencies *always at work*, the fearful scourge of mortal disease carried off 3,516 of our children, or 341 out of every myriad of our population, *which exceeded even the abnormal number of our births by* 280. It does not appear that the legal guardians of the public health took any steps to mitigate this frightful calamity; and again in 1865, the mortality of children (as well as of adults) was above even the high average of twelve years.

But in the spring of 1866, owing to a wholesome dread of cholera, a strong public opinion, an Order in Council, and the labours of the Sanitary Association (then first formed), the Corporation appointed two Health Officers *for three months*, and detailed police to act as inspectors. *Only a very partial surface cleansing of the yards was the result;* the streets remaining as before, the subsoil retaining all its pollutions, and the production of fresh poisons unchecked; and yet what was the result of this, aided probably by the unusually cold, wet, and windy season? *Four hundred and seventy lives of children were saved* as compared with the previous year; and June, which on the average is the most unhealthy month except July or August, *actually furnished the week of lowest deaths.* Yet, no sooner was the cleansing finished, and the July sun drew forth to the surface the substratum of xymotic poison, than the death-rate of the children rose at once from 362 per myriad to 852; and the *deaths of adults in the whole year exceeded those of* 1865 *by fifty-five.*

But if this minute instalment of what ought to be done, produced at once such a marvellous benefit as the saving of 470 children's lives, what might not be expected, were councillors, owners of property and householders to perform their manifest duties? And if they are not willing, for the love of God and the good of their brethren, to obey the plain laws of health and remove the causes of disease and death, ought not the power of the law to protect the helpless, and prevent the selfish from robbing their neighbours of their happiness, and the very lives of themselves and their children?

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REVIEW.

FERNS: British and Foreign; By John Smith, A. L. S.

The well-known ex-curator of the Royal gardens, Kew, has lately published this most useful fine manual; intended primarily to assist fern cultivators, it is nevertheless valuable also to botanists. He gives a very interesting history of the introduction of exotic ferns into European gardens; an essay on the genera of ferns and their classification; an enumeration of the ferns at present cultivated, and very full instructions on their cultivation. Mr. Smith's mode of classification aims to be natural and his tendency is to multiply genera unduly. His enumeration extends to 1084 species (nearly half of those known to science); he gives many synonyms, a reference to the best descriptions and engravings in standard works, and wood-cut illustrations of the genera. Sir William Hooker recently said of our author :—

"The formation of this fine collection [of cultivated ferns in "Kew gardens] is mainly due to the exertions and ability of Mr. "John Smith. His knowledge of ferns and his writings upon "them, justly entitle him to rank among the most distinguished "Pteridologists of the present day."

Mr. Smith gives us, northern North Americans, no credit for having the following ferns in our native flora:

Phegopteris rhætica (the Polypodium alpestre of British botanists), which is found on the eastern side of the Rocky Mountains; Dryopteris Thelypteris, one of our commonest ferns; Polystichum Lonchitis, which has a wide range and is locally plentiful; Scolopendrium vulgare, which is local but also abundant; Asplenium Ruta-muraria, which is found in all the neighboring States, as far west as Michigan and further south than Virginia; A. viride, which ranges from Newfoundland to the Rocky Mountains, and perhaps thence to the Pacific Ocean; and A. septentrionale, not uncommon on the Rocky Mountains. We learn nothing of our author's views on Woodsia; he gives only two species, Ilvensis and hyperborea, and gives North America credit for neither of them; moreover his wood-cut, which is said to be a frond of Ilvensis, is unmistakeably hyperborea, as we understand that species.

We believe the following to be bad species: — Asplenium Michauxii is A. Filix-fœmina, one of the most variable of ferns; Cystea tenuis is merely a form of the protean C. fragilis; Aspidium atomarium should have been referred to C. bulbifera; Osmunda spectabilis is not separable from O. regalis, nor does our Onoclea Struthiopteris differ from the European form. Onoclea gracilis, and Ophioglossum pedunculosum are unknown to us. Mr. Smith's arrangement of the following species of the genus Dryopteris (or Lastrea) is not understood by us. He places American plants thus: Filix-mas, remota, rigida, marginalis, Goldiana, dilatata, cristata, intermedia, spinulosa. We look on their affinities in a different light, and would arrange them as shewn below. Four of these forms we consider to be unquestionably one species; dilatata is our more common form northward, and is well-marked as a variety, intermedia is identical with spinulosa and remota (as we understand it) hardly separable from it, while cristata is more closely allied to Goldiana than to any of the forms of spinulosa.

The publisher has done his part well, the book is neatly got up, well printed and remarkably cheap.

The question,—under what circumstances is the author or emendator of a genus justified in writing his own name after such old species as he chosen to place in it? has lately been discussed; we incline to answer, "under no circumstances," being of opinion that a specific name should never be changed, and that the original author's name should always be affixed to it. We append a catalogue of northern North American ferns, giving our views of the nomenclature and classification of this order; it includes all the species mentioned by Michaux and by Dr. Gray, and most of those mentioned by Pursh and by Hooker. The classification is based principally on that of Dr. Mettenius. A few species known to us only by name are omitted.

W.

Suborder POLYPODINEÆ.

Tribe ACROSTICHEÆ.

Chrysodium, Fée.

1. C. aureum (Linn. 1525).

Metten. Fil. Lips. 21; Acrostichum a. Linn. Sp. Pl.; Michx. Fl. Bor.-Am. ii. (1820) 272.

Tribe POLYPODIEÆ.

Vittaria, Smith.

1. V. lineata (Linn. 1530).

Swartz, Syn. Fil. 109; V. angustifrons, Michx. 261.

Polypodium, Linn. in part.

1. P. vulgare, Linn. 1544.

Willd. Sp. Pl. v., 172.

2. P. polypodioides (Linn. 1525).

P. ceteraccinum, Michx. 271; P. incanum, Swartz 35, Pursh 659, Gray's Manual, ed. 2nd, 590.

Gymnogramme, Desvaux.

1. G. triangularis, Kaulfuss,

Enum. Fil. 75. Found on Vancouver Island by Mrs. [illegible]les.

Cheilanthes, Swartz.

There are three well-defined species of this genus within Gray's limits; but as they have been sadly confused by some authorities, I am unable to give synonyms, nor do I know to which of the three Michaux's *Nephrodium lanosum* should be referred.

1. C. vestita, Swartz 128.

Willd. 458; Gray's Manual, 592.

2. C. tomentosa, Gray's Man.

Link, Fil. Hort. Berol, ii., 42? Hook. Sp. Fil. 65?

3. C. lanuginosa, Nuttall.

C. gracilis, Metten. Cheil. 36.

Cryptogramme, R. Brown.

1. C. crispa (Linn. 1522).

R. Brown, App. Frank. Journ. 754. Osmunda, Linn. Allosorus, Bernhardi. "Isle Royal in Lake Superior;"—Moore: probably the following.

2. C. acrostichoides R. Br. 767.

Hooker considers these two plants to be specifically identical, which is probably correct. Mr. Moore considers them generically distinct.

Pellæa, Link.

1. P. gracilis (Michx. 262).

Hook. Sp. Fil. ii., 138. Pteris g. Michx. 262, Pursh 668. Ledebour and Moore refer *Pteris Stelleri* (Gmelin) here, while Swartz and Hooker refer it to *C. crispus*; should the former prove to be correct, this plant must be named *Pellæa Stelleri*.

2 P. atropurpurea (Linn. 1534).

Link, Fil. Hort. Berol, 59. Pteris a. Linn. Michx. 261, Pursh 668.

Pteris, Linn. in part.

1. P. aquilina, Linn. 1533.

P. caudata, Linn. 1533. Pursh 668 is a variety found in the Southern U. S. and elsewhere.

Adiantum, Linn.

1. A. pedatum, Linn. 1557.

Tribe ASPLENIEÆ.

Blechnum, Linn., Presl.

1. B. Spicant (Linn. 1522).

Smith, Turin Trans. v. 411 Osmunda, Linn.; Lomaria, Desv.; B. boreale, Swartz 115, Pursh 669.

2. B. serrulatum, Rich.

Michx. 261; Pursh 669.

Woodwardia, Smith.

1. W. areolata (Linn. 1526).

Lowe's Ferns, iv. t. 46. W. angustifolia, Smith; Onoclea nodulosa, Michx. 272; W. onocleoides, Willd.; Pursh. 669.

2. W. Virginica (Linn. Mant. 307).

Smith, l. c. 412; W. Banisteriana, Michx. 263.

Scolopendrium (Smith) Hook.

§ *vera*.

1. S. vulgare, Smith 421.

Asplenium Scolopendrium, Linn. 1537; S. officinarum, Swartz 89.

§ *Camptosorus*, Link.

1. C. rhizophyllus (Linn. 1536).

Link, Fil. Hort. Berol, ii. 69.

Asplenium, Linn.

1. A. pinnatifidum, Nuttall,

Gen. N. A. Plants, ii. 251.

2. A. montanum, Willd. 342.

A. Adiantum-nigrum, Michx. 265.

3. A. Ruta-muraria, Linn. 1541.

4. A. septentrionale (Linn. 1524).

Hoffman, Deuts. Fl. ii. 12.

5. A. viride, Hudson,

Fl. Ang. 385; A. Tri.-ramosum Linn. 1541.

6. A. Trichomanes, Linn. 1540.

A. melanocaulon, Willd.; Pursh 666.

7. A. ebeneum, Aiton,

Hort. Kew. iii. 462; A. trichomanoides, Michx. 265.

8. A. marinum, Linn. 1540.

Attributed to the Lower Provinces by Sir Wm. Hooker,—probably in error.

9. A. angustifolium, Michx. 265.

10. A. thelypteroides, Michx. 265.

Athyrium, Roth.

1. A. Filix-fœmina (Linn. 1551).

Roth, Fl. Germ. iii. 65; N. filix-f. and N. asplenioides, Michx. 268; also Aspd. angustum, Willd., Pursh 664. Perhaps an Asplenium.

Tribe Aspidieæ.

Phegopteris, Fée.

1. P. Dryopteris (Linn. 1555).

Fée, Gen. Fil. 243. Nephrodium D., Michx. 270. (Mr. Moore refers Michaux's plant to the next species.)

2. P. Robertiana (Hoffm.).

P. calcarea, Fée, l. c. 243; Polypodium calcareum, Smith; doubtfully distinct from *P. Dryopteris*. Universally but erroneously attributed to North America.

3. P. connectile (Michx. 271).

Polypodium Phegopteris, Linn. 1550; P. connectile, Willd. 200, Pursh 659. Michaux's name ought to be restored to this plant; it has priority over those of Fée or Mettenius.

4. P. hexagonoptera (Michx. 271).

Fée, Genera Filicum, 243.

5. P. rhætica (Linn. 1552).

P. alpestris, Mettenius; Polypodium alpestre, Hoppe; Aspidium rhæticum, Swartz 59. Cascades; Rocky Mts. 49° N. Lat., Dr. Lyall.

[P. montana (Volger).

More properly *Aspidium montanum*; though it has been placed here by Fée.]

Aspidium, Swartz.

Polystichum, Roth.; Dryopteris, Adanson.

§ *Dryopteris* (Schott) A. Gray.

Lastrea, Presl; Nephrodium, Richards, R. Brown, Hooker; Polystichum, D.C., Koch, Ledebour.

1. D. Thelypteris (Linn. 1528).

Gray's Manual, Ed. 1st. 630.

2. D. Nov-Eboracensis (Linn. 1552).

Gray, l. c. 630, N. thelypteroides, Michx. 267.

3. D. montana (Volger).

Aspd. Oreopteris (Ehrhart) Swartz 50. Mr. Moore says that *Aspidium montanum* has been found in Vermont—certainly an error.

4. D. spinulosa-dilatata.

Polypodium dilatatum, Hoffman; Aspd. dilatatum, Swartz 420; and A. dumetorium, Willd. 263. D. dilatata, Gray, l. c. 631. Dr. Gray justly considers this fern (which is common in eastern C. E.) to be merely a variety of *Aspidium spinulosum* Swartz.

5. D. spinulosa-vera.

Polypodium spinulosum Retzius; Aspd. s. Swartz 54, 520; A. intermedium, Willd. 262. Common west of Quebec.

6. D. spinulosa-remota.

Aspd. remotum, A. Br.; Nephrodium r. Hook. Br. Ferns, t. 22; Aspd. Boottii, Tuckerman. Dr. Gray refers *Dryopteris remota* here (as *A. spinulosum* var. *Boottii*)—it may prove to be a distinct species; it is not well known to me.

7. D. cristata (Linn. 1551).

Gray, l. c. 631; A. Lancastriense, Sprengel, Swartz 52.

8. var. majus (Eaton).

A. filix-mas, Pursh 667?

9. D. Goldiana, Hook.

Gray, l. c. 631; A. filix-mas, Pursh 662?

10. D. Filix-mas (Linn. 1551).

Schott, Gen. Fil. t. 9. Rocky Mts.

11. D. marginale (Linn. 1552).

Gray, l. c. 632.

12. D. arguta (Kaulf. 242).

N. rigidum var. Americanum, Hook. Sp. Fil. 60.

13. D. rigida (Hoffm.).

Not of Gray, l. c. 631. A. rigidum, Swartz 53. Attributed to North America by Mr. Bentham—doubtless in error.

§ *Polystichum*, Schott,

Presl, A. Gray; Aspidium, Richards, R. Brown, Ledebour.

1. P. fragrans (Linn. 1550).

A. fragrans, Swartz, 51. In technical characters this plant is more properly *Dryopteris fragrans*, and is so considered by Hooker, Ledebour, etc. I agree with Dr. Gray in considering that its natural affinity places it here.

P. aculeatum (Linn. 1552).

A. aculeatum and A. lobatum (Aiton) Swartz 53, and A. angulare, Willd. 257. The typical form (A. aculeatum, Willd. etc.) has not been found in North America. Mr. Moore's remark—"extends "from the eastern U. S. to Columbia on the north-"west coast"—is certainly an error. We have, however, two well-marked and constant varieties.

2. var. Braunii (Koch).

A. Braunii, Spenner; P. Braunii, Fée; which is allied to the European *Aspidium aculeatum* var. *angulare*.

3. var. lobatum; Deakin.

A. lobatum (Aiton) Swartz, Willd. 260. *Aspidium aculeatum* var. *lobatum* was found by Mrs. Girdwood during the past summer on Ile Perrot, near Ste. Anne.

4. P. Lonchitis (Linn. 1548).

Schott, Gen. Fil. t. 9.

5. P. acrostichoides (Michx. 267).

Schott, Gen. Fil. t. 9.

6. P. munitum (Kaulf. 230).

Referred by Mr. Moore to *A. falcinellum*, Swartz 46. Vancouver Island, and 49° N. Lat., Dr. Lyall.

Cystea, Smith.

I adopt Sir J. E. Smith's characteristic name for this genus, as I do not consider Bernhardi's genera to be of much value.—Eng. Fl. iv. 260, 281.

1. C. bulbifera (Linn. 1553).

Aspidium b., Swartz 59. "A. atomarium Muhl.", Gray!

2. C. fragilis (Linn. 1553).

Smith, l. c. 285; N. tenue, Michx. 269; A. atomarium and A. tenue, Pursh 665.

3. C. montana (Lamarck).

Aspidium, Swartz 61. Said to be found in north-western America.

Woodsia, R. Br.

1. W. Ilvensis (Linn. 1528).

R. Br. Linn. Trans. xi. 173; Neph. rufidulum, Michx. 269; W. Ilvensis and W. hyperborea, Pursh 660.

2. W. alpina (Bolton).

W. hyperborea, R. Br. l. c. t. 11, Hook. Br. Ferns, t. 9; W. alpina, Moore, Nat. pr. Br. Ferns, t. 106. More properly *W. Ilvensis* var. *alpina*. Scarcely distinct from No. 1—from which, however, it may usually be distinguished by its smoothness, shorter pinnas, more rounded lobes, and darker (often almost ebeneous) stipes which have fewer scales.

3. W. hyperborea (Liljeb.)

Newfoundland, per Geological Survey. I regard the *Acrostichum hyperboreum* of Liljeblad as quite distinct from the *A. alpinum* of Bolton, (Fil. Brit. t. 42), and as very closely allied to No. 4.

4. W. glabella, R. Brown.

Rich. App. 39; Hook. Fl. Bor.-Am. t. 237. Probably identical with No. 3 and thus *W. hyperborea* var. *glabella*, but very distinct from Nos. 1 and 2.

5. W Oregona, Eaton.

In Can. Nat. (1865) 90.

6 W. scopulina, Eaton.

l. c. 91.

7. W. obtusa (Sprengel).

Torrey, Cat. Pl. 1840; Aspidium, Swartz 420, Pursh 662.

Onoclea, Linn.

1. O. sensibilis, Linn. 1517.

O. obtusilobata is merely an abnormal form having semi-fertile fronds.

2. O. Struthiopteris (Linn. 1522).

Swartz 111.; Struthiopteris Pennsylvanica, Willd. 289, Pursh 666. Hardly generically distinct from Onoclea.

Tribe DAVALLIEÆ.

Dicksonia, L'Heritier.

1. D? punctilobula (Michx. 268).

Kunze in Silliman's Journal, Nov. (1848) 88. D. pilosiuscula (Muhl.) Willd. 484; Pursh 671.

Sub. HYMENOPHYLLEÆ.

Hymenophyllum, Smith.

1. H. ciliatum, Swartz 147.

Pursh 671. Doubtless an error of Pursh; he may have collected *Trichomanes radicans*, which is found in the Southern States.

Suborder SCHIZÆINEÆ.

Schizæa, Smith.

1. S. pusilla, Pursh 657.

Lygodium, Swartz.

1. L. palmatum (Linn. 1518).

Swartz 154; Ctenium paniculatum, Michx. 275. Hydroglossum, Willd. 84, Pursh 656.

Suborder OSMUNDINEÆ.

Osmunda, Linn.

1. O. regalis, β. Linn. 1521.

O. spectabilis, Willd. 98, Pursh 658.

2. O. Claytoniana, Linn. 1521.

Pursh 657; O. interrupta, Michx. 273, Pursh 657.

3. O. cinnamomea, Linn. 1522.

Suborder OPHIOGLOSSEÆ.

Botrychium, Swartz.

1. B. Lunaria (Linn. 1519).

Swartz 171. Osmunda, Linn.

2. var. simplex.

B. simplex Hitchcock.

3. B. matricariæfolium, A. Braun.

Osmunda matricariæ, Breyn. B. rutaceum, Swartz 171. Possibly identical with No. 1. Doubtfully North American.

4. var. lanceolatum.

Osmunda lanceolata Gmel. B. lanceolatum, Angstrom. Possibly a distinct species.

5. B. virginianum (Linn. 1519).

Swartz 171; Pursh 656; B. gracile Pursh 656; Botrypus, Michx. 274.

6. B. lunaroides (Michx. 274).

Swartz 172; B. fumarioides, Pursh 655.

7. var. obliquum, Gray.

B. obliquum (Poir.) Muhl., Pursh 655.

8. var. dissectum, Gray.

B. dissectum (Poir.) Muhl., Pursh 656.

Ophioglossum, Linn.

1. O. vulgatum, Linn. 1518.

O. vulgatum and O. bullosum, Michx. 275-6, Pursh 655.