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THE

CANADIAN NATURALIST.

SECOND SERIES.

THE REMOVAL AND RESTORATION OF FORESTS.

By J. W. Dawson, LL.D., F.R.S., &c.*

The woods perish by the axe and by fire, either purposely applied for their destruction, or accidental. Forest fires have not been confined to the period of European occupation. The traditions of the Indians tell of extensive ancient conflagrations; and it is believed that some of the aboriginal names of places in Nova Scotia (for example, *Chebucto*, *Chedabucto*, *Pictou*) originated in these events. In later times, however, fires have been more numerous and destructive. In clearing land, the trees when cut down are always burned, and that this may be effected as completely as possible, the driest weather is frequently selected, although the fire is then much more likely to spread into the surrounding woods. It frequently happens that the woods contain large quantities of dry branches and tops of trees, left by cutters of timber and firewood, who rarely consider any part of the tree except the trunk worthy of their attention. Even without this preparation, however, the woods may in dry weather be easily inflamed; for, although the trunks and foliage of growing trees are not very combustible, the mossy vegetable soil, much resembling peat, burns easily and rapidly. Upon this mossy soil depends, in a great measure, the propagation of fires, the only exception being when the burning of groves of the resinous coniferous trees is assisted by winds, causing the flame to stream through their tops more rapidly than it can pass along

*From 'Acadian Geology,' second edition.

the ground. In such cases some of the grandest appearances ever shown by forest fires occur. The fire, spreading for a time along the ground, suddenly rushes up the tall resinous trees with a loud crashing report, and streams far beyond their summits, in columns and streamers of lurid flame. It frequently happens, however, that in wet or swampy ground, where the fire cannot spread around their roots, even the resinous trees refuse to burn; and thus swampy tracts are comparatively secure from fire. In addition to the causes of the progress of fires above referred to, it is probable that at a certain stage of the growth of forests, when the trees have attained to great ages, and are beginning to decay, they are more readily destroyed by accidental conflagrations. In this condition the trees are often much moss-grown, and have much dead and dry wood; and it is probable that we should regard fires arising from natural or accidental causes as the ordinary and appropriate agents for the removal of such worn-out forests.

Where circumstances are favourable to their progress, forest fires may extend over great areas. The great fire which occurred in 1825, in the neighbourhood of the Miramichi river, in New Brunswick, devastated a region 100 miles in length and 50 miles in breadth. One hundred and sixty persons, and more than 800 cattle, besides innumerable wild animals, are said to have perished in this conflagration. In this case, a remarkably dry summer, a light soil easily affected by drought, and a forest composed of full-grown pine trees, concurred, with other causes, in producing a conflagration of unusual extent.

When the fire has passed through a portion of forest, if this consist principally of hardwood trees, they are usually merely scorched,—to such a degree, however, as in most cases to cause their death; some trees, such as the birches, probably from the more inflammable nature of their outer bark, being more easily killed than others. Where the woods consist of softwood or coniferous trees, the fire often leaves nothing but bare trunks and branches, or at most a little foliage, scorched to a rusty-brown colour. In either case, a vast quantity of wood remains unconsumed, and soon becomes sufficiently dry to furnish food for a new conflagration; so that the same portion of forest is liable to be repeatedly burned, until it becomes a bare and desolate 'barren,' with only a few charred and wasted trunks towering above the blackened surface. This has been the fate of large districts in Nova Scotia and the neighbouring colonies; and as these burned tracts could not be immediately occupied for agritural purposes, and are diminished in value by the loss of their timber, they have been left to the unaided efforts of nature to restore their original verdure. Before proceeding to consider more particularly the mode in which this restoration is effected, and the appearances by which it is accompanied, I may quote, from a paper by the late Mr. Titus Smith of Halifax, a few statements on this subject, which, as the results of long and careful observation, are entitled to much respect, and may form the groundwork for the remarks which are to follow.

"If an acre or two be cut down in the midst of a forest, and then neglected, it will soon be occupied by a growth similar to that which was cut down; but when all the timber on tracts of great size is killed by fires, except certain parts of swamps, a very different growth springs up; at first, a great number of herbs and shrubs, which did not grow on the land when covered by living wood. The turfy coat, filled with the decaying fibres of the roots of the trees and plants of the forest, now all killed by the fire, becomes a kind of hot-bed, and seeds which had lain dormant for centuries, spring up and flourish in the mellow soil. On the most barren portions, the blueberry appears almost everywhere; great fields of red raspberries and fire-weed or French willow spring up along the edges of the beech and hemlock land, and abundance of red-berried elder and wild red-cherry appears soon after; but in a few years the raspberries and most of the herbage disappear, and are followed by a growth of firs, white and yellow birch, and poplar. When a succession of fires has occurred, small shrubs occupy the barren, the Kalmia or sheep-poison being the most abundant; and, in the course of ten or twelve years, form so much turf, that a thicket of small alder begins to grow, under the shelter of which fir, spruce, hackmatack (*Larix Americana*) and white birch spring up. When the ground is thoroughly shaded by a thicket twenty feet high, the species which originally occupied the ground begins to prevail, and suffocate the wood which sheltered it; and within sixty years, the land will generally be covered with a young growth of the same kind that it produced of old." Assuming the above statements to be a correct summary of the principal modes in which forests are reproduced, we may proceed to consider them more in detail.

1st. Where the forest trees are merely cut down and not burned, the same description of wood is immediately reproduced. This may be easily accounted for. The soil contains abundance of the seeds of these trees, there are even numerous young plants ready to take the place of those which have been destroyed; and if the trees have been cut in winter, their stumps produce young shoots. Even in cases of this kind, however, a number of shrubs and herbaceous plants, not formerly growing in the place, spring up; the cause of this may be more properly noticed when describing cases of another kind. This simplest mode of the destruction of the forest may assume another aspect. If the original wood has been of kinds requiring a fertile soil, such as maple or beech, and if this wood be removed, for example, for firewood, it may happen that the quantity of inorganic matter thus removed from the soil may incapacitate it, at least for a long time, from producing the same description of timber. In this case, some species requiring a less fertile soil may occupy the ground. For this reason, forests of beech growing on light soils, when removed for firewood, are sometimes succeeded by spruce and fir. I have observed instances of this kind both in Nova Scotia and Prince Edward Island.

2nd. When the trees are burned, without the destruction of the whole of the vegetable soil, the woods are reproduced by a more complicated process, which may occupy a number of years. In its first stage, the burned ground bears a luxuriant crop of herbs and shrubs, which, if it be fertile and not of very great extent, may nearly cover its surface in the summer succeeding the fire. This first growth may comprise a considerable variety of species, which we may divide into three groups. The first of these consists of those herbaceous plants which have their roots so deeply buried in the soil as to escape the effects of the fire. Of this kind are the various species of Trillium, whose tubers are deeply embedded in the black mould of the woods, and whose flowers may sometimes be seen thickly spread over the black surface of woodland, very recently burned. Some species of ferns also, in this way, occasionally survive forest fires. A second group is composed of plants whose seeds are readily transported by the wind. Pre-eminent among these is the species of Epilobium, known in Nova Scotia as the fire-weed or French willow, (*E. angustifolium*), whose feathered seeds are admirably adapted for flying to great distances, and which often covers large tracts of burned ground so completely, that its purple flowers communicate their own colour to the whole surface, when viewed from a distance. This plant appears to prefer the less fertile soils, and the name of fire-weed has been given to it in consequence of its occupying these when their wood has been destroyed by fire. Various species of Senecio, Solidago and Aster, and Equiseta, Ferns and Mosses, are also among the first occupants of burned ground; and their presence may be explained in the same way with that of the Epilobium, their seeds and spores being easily scattered over the surface of the barren by wind. A third group of species, found abundantly on burned ground, consists of plants bearing edible fruits. The seeds of these are scattered over the barren by birds which feed on the fruits, and, finding a rich and congenial soil, soon bear abundantly and attract more birds, bringing with them the seeds of other species. In this way, it sometimes happens that a patch of burned ground, only a few acres in extent, may, in a few years, contain specimens of nearly all the fruit-bearing shrubs and herbs indigenous in the country. Among the most common plants which overspread the burned ground in this manner, are the raspberry, which, in good soils, is one of the first to make its appearance; the species of Vaccinieæ or whortleberries, and blueberries; the tea-berry or wintergreen (*Gaultheria procumbens*); the pigeon-berry (*Cornus canadensis*); and the wild strawberry. It is not denied that some plants may be found in recently burned districts whose presence may not be explicable in the above modes; but no person acquainted with the facts can deny that nearly all the plants which appear in any considerable quantity within a few years after the occurrence of a fire, may readily be included in the groups which have been mentioned. By the simple means which have been described, a clothing of vegetation is speedily furnished to the burned district; the unsightliness of its appearance is thus removed, abundant supplies of food are furnished to a great variety of animals, and the fertility of the soil is preserved, until a new forest has time to overspread it.

With the smaller plants which first cover a burned district, great numbers of seedling trees spring up, and these, though for a few years not very conspicuous, eventually overtop and, if numerous, suffocate the humbler vegetation. Many of these young trees are of the species which composed the original wood, but the majority are usually different from the former occupants of the soil. The original forest may have consisted of white or red pine; black, white, or hemlock spruce; maple, beech, black or yellow birch, or of other trees of large dimensions, and capable of attaining to a great age. The 'second growth' which succeeds these usually consists of poplar, white or poplar birch, wild cherry, balsam fir, scrub pine, alder, and other trees of small stature, and usually of rapid growth, which, in good soils, prepare the way for the larger forest trees, and occupy permanently only the less fertile soils. A few examples will show the contrast which thus appears between the primeval forest and that which succeeds it after a fire. Near the town of Pictou, woods chiefly consisting of beech, maple, and hemlock, have been succeeded by white birch and firs. A clearing in woods of maple and beech in New Annan, at one time under cultivation, was, after thirty years, observed to be thickly covered with poplars thirty feet in height, presenting a striking contrast to the surrounding woods. In Prince Edward Island, fine hardwood forests have been succeeded by fir and spruce. The pine woods of Miramichi, destroyed by the great fire above referred to, have been followed by a second growth, principally composed of white birch, larch, poplar, and wild cherry. When I visited this place, twenty years after the great fire, the second growth had attained to nearly half the height of the dead trunks of the ancient pines, which were still standing in great numbers; and in 1866 I found that the burnt woods were replaced by a dense and luxuriant forest principally of white birch and hackmatack, and I was informed that some of these trees were already sufficiently large to be used in shipbuilding. This is an instructive illustration of the fact, that after a great forest fire an extensive region may in less than half a century be re-clothed with different species from those by which it was originally covered.

As already stated, the second growth almost always includes many trees similar to those which preceded it, and when the smaller trees have attained their full height, these, and other trees capable of attaining a great magnitude, overtop them, and finally cause their death. The forest has then attained its last stage, that of perfect renovation. The cause of the last part of the process evidently is, that in an old forest, trees of the largest size and longest life have a tendency to prevail, to the exclusion of others. For reasons which will be afterwards stated, this last stage is rarely attained by the burned forests in countries beginning to be occupied by civilized man, and it is evident that many circumstances may occur which will prevent this restoration of the primeval forest.

In accounting for the presence of the seeds necessary for the production of the second growth, we may refer to the same causes which supply the seeds of the smaller plants appearing immediately after the fire. The seeds of many forest trees, especially the poplar, the birch, and the firs and spruces, are furnished with ample means for their conveyance through the air. The cottony pappus of the poplar seems especially to adapt it for this purpose. The seeds of the wild cherry, another species of frequent occurrence in woods of the second growth, are dispersed by birds, which are fond of the fruit; the same remark applies to some other fruit-bearing species of less frequent occurrence. When the seeds that are dispersed in these ways fall in the growing woods, they cannot vegetate; but when they are deposited on the comparatively bare surface of a barren, they readily grow; and if the soil is suited to them, the young plants increase in size with great rapidity.

It is possible, however, that the seeds of the trees of the second growth may be already in the soil. It has been already stated, that deeply-buried tubers sometimes escape the effects of fire; and, in the same manner, seeds embedded in the vegetable mould, or buried in cradle hills, may retain their vitality, and, being supplied by the ashes which cover the ground with alkaline solutions well fitted to promote their vegetation, may spring up before a supply of seed could be furnished from any extraneous source. It is even probable that many of the old forests may already have passed through a rotation similar to that above detailed, and that the seeds deposited by former preparatory growths may retain their vitality, and be called into life by the favourable conditions existing after a fire.

If, as already suggested, forest fires, in the uncultivated state of the country, be a provision for removing old and decaying forests, then such changes as those above detailed must have an important use in the economy of nature, since by their means different portions of the country would succeed each other in assuming the state of 'barrens,' producing abundance of herbs and wild fruits suitable for the sustenance of animals which could not subsist in the old woods; and these gradually becoming wooded, would keep up a succession of young and vigorous forests.

3rd. The process of restoration may be interrupted by successive fires. These are most likely to occur soon after the first burning, but may happen at any subsequent stage. The resources of nature are not, however, easily exhausted. When fires pass through young woods, some trees always escape; and so long as any vegetable soil remains, young plants continue to spring up, though not so plentifully as at first. Repeated fires, however, greatly impoverish the soil, since the most valuable part of the ashes is readily removed by rains, and the vegetable mould is entirely consumed. In this case, if the ground be not of great natural fertility, it becomes incapable of supporting a vigorous crop of young trees. It is then permanently occupied by shrubs and herbaceous plants; at least these remain in exclusive possession of the soil for a long period. In this state the burned ground is usually considered a permanent 'barren,'—a name which does not, however, well express its character; for though it may appear bleak and desolate when viewed from a distance, it is a perfect garden of flowering and fruit-bearing plants, and of beautiful mosses and lichens. There are few persons born in the American colonies who cannot recall the memory of happy youthful days spent in gathering flowers and berries in the burnt barrens. Most of the plants already referred to, as appearing soon after fires, continue to grow in these more permanent barrens. In addition to these, however, a great variety of other plants gradually appear, especially the *Kalmia angustifolia*, or sheep laurel, which often becomes the predominant plant over large tracts. Cattle straying into the barrens deposit the seeds of cultivated plants, as the grasses and clovers, as well as of many exotic weeds, which often grow as luxuriantly as any of the native plants.

4th. When the ground is permanently occupied for agricultural purposes, the reproduction of the forest is of course entirely prevented. In this case, the greater number of the smaller plants found in the barrens disappear. Some species, as the Solidagos and Asters, and the Canada thistle, as well as a few smaller plants, remain in the fields, and sometimes become troublesome weeds. The most injurious weeds found in the cultivated ground are not, however, native plants, but foreign species, which have been introduced with the cultivated grains and grasses; the ox-eye daisy or white-weed, and the crowfoot or buttercup, are two of the most abundant of these.

When a district has undergone this last change,—when the sombre woods and the shade-loving plants that grow beneath them have given place to open fields, clothed with cultivated plants,—the metamorphosis which has taken place extends in its effects to the indigenous animals; and in this department its effects are nearly as conspicuous and important as in relation to vegetation. Some wild animals are incapable of accommodating themselves to the change of circumstances; others at once adapt themselves to new modes of life, and increase greatly in numbers. It was before stated that the barrens, when clothed with shrubs, young trees, and herbaceous plants, were in a condition highly favourable to the support of wild animals; and perhaps there are few species which could not subsist more easily in a country at least partially in this state. For this reason, the transition of a country from the forest state to that of burned barrens is temporarily favourable to many species, which disappear before the progress of cultivation; and this would be more evident than it is, if European colonization did not tend to produce a more destructive warfare against such species than could be carried on by the aborigines. The ruffed grouse, a truly woodland bird, becomes, when unmolested, more numerous on the margins of barrens and clearings than in other parts of the woods. The hare multiplies exceedingly in young second growths of birch. The wild pigeon has its favourite resort in the barrens during a great part of the summer. The moose and cariboo, in summer, find better supplies of food in second growth and barrens than in the old forests. The large quantities of decaying wood, left by fires and wood cutters, afford more abundant means of subsistence to the tribe of woodpeckers. Many of the fly-catchers, warblers, thrushes, and sparrows, greatly prefer the barrens to most other places. Carnivorous birds and quadrupeds are found in such places in numbers proportioned to the supplies of food which they afford. The number of instances of this kind might be increased to a great extent if necessary; enough has, however, been stated to illustrate the fact.

Nearly all the animals above noticed, and many others, disappear when the country becomes cultivated. There are, however, other species which increase in numbers, and at once adapt themselves to the new conditions introduced by man. The robin (*Turdus migratorius*) resorts to and derives its subsistence from fields, and greatly multiplies, though much persecuted by sportsmen. The *Junco hyemalis*, a summer bird in Nova Scotia, becomes very familiar, building in outhouses, and frequenting barns in search of food. The song sparrow and Savannah finch swarm in the cultivated ground. The yellow bird (*Sylvia æstiva*) becomes very familiar, often building in gardens. The golden-winged woodpecker resorts to the cultivated fields, picking grubs and worms from the ground. The cliff-swallow exchanges the faces of rocks for the eaves of barns and houses, and the barn and chimney swallows are everywhere ready to avail themselves of the accommodation afforded by buildings. The Acadian or little owl makes its abode in barns during winter. The boblincoln, the king-bird, the wax-wing or cherry bird, and the humming-bird, are among the species which profit by the progress of cultivation. The larger quadrupeds disappear, but the fox and ermine still prowl about the cultivated grounds, and the field-mouse (*Arvicola Pennsylvanica*), which is very abundant in some parts of the woods, is equally so in the fields. Many insects are vastly increased in numbers in consequence of the clearing of the forests. Of this kind are the grasshoppers and locusts, which, in dry seasons, are very destructive to grass and grain; the frog-spittle insects (*Cercopis*), of which several species are found in the fields and gardens, and are very injurious to vegetation; and the Lepidoptera, nearly the whole of which find greater abundance of food and more favourable conditions in the burned barrens and cultivated fields than in the growing woods.

It thus appears that, in the course of between two and three centuries, large areas of the Acadian provinces have passed through two or more of the following conditions:—i. that of primitive forest; ii. that of second-growth forest; iii. that of the burned barren; iv. that of cultivated fields. Each of these changes is accompanied with modifications of the animal population; and in primitive states of society each would imply a change in the habits of the people; and, if very extensive, might even cause migrations of tribes and important changes of population. In the old world, most countries have passed through these vicissitudes in very early times, and have subsequently reached a more stable condition, with more slow and gradual changes; and in extensive regions it has usually happened that the destruction and removal of forests have been effected piece-meal, so as to extend only over limited areas at one time. The case of Denmark would seem to have been an exception to this.* At a very early pre-historic time it seems to have been covered by forests of Scotch fir. These were destroyed, probably by a great fire like that of Miramichi. The people perished or were driven from the country, and were replaced by another race, while the forests grew up again, but were now composed of oak. Still more recently the oak forests were replaced by beech. The stages of unrecorded human history connected in Denmark with these successive forests, are thus summed up by Steenstrup and Morlot:—"1st. A *stone period*, when the inhabitants were small-sized men, brachykephalous or short-headed, like the modern Lapps, using stone implements, and subsisting by hunting; then the country, or a considerable part of it, was covered by forests of Scotch fir (*Pinus sylvestris*). 2nd. A *bronze period*, in which implements of bronze as well as of stone were used, and the skulls of the people were larger and longer than in the previous period; while the country seems to have been covered with forests of oak (*Quercus robur*). 3rd. An *iron period*, which lasted to the historic times, and in which beech forests replaced those of oak." All of these remains are geologically recent; and, except the changes in the forests, and of some indigenous animals in consequence, and probably a slight elevation of some parts of Denmark, no material changes in organic or inorganic nature have occurred.

The Danish antiquaries have attempted to calculate the age of the oldest of these deposits by considerations based on the growth of peat, and the succession of trees; but these calculations are obviously unreliable. The first forest of pines would, when it attained maturity, naturally be destroyed, as usually happens in America, by forest conflagrations. It might perish in this way in a single summer. The second growth which succeeded would, in America, be birch, poplar, and similar trees, which would form a new and tall forest in half a century; and in two or three centuries would probably be succeeded by a second permanent forest, which in the present case seems to have been of oak. This would be of longer continuance, and would, independently of human agency, only be replaced by beech, if, in the course of ages, the latter tree proved itself more suitable to the soil, climate, and other conditions. Both oak and beech are of slow

* Lyell, "Antiquity of Man"; Lubbock, in Nat. Hist. Review.

extension, their seeds not being carried by the winds, and only to a limited degree by birds. On the other hand, the changes of forests cannot have been absolute or universal. There must have been oak and beech groves even in the pine woods; and the growing and increasing beech woods would be contemporary with the older and decaying oak forest, as this last would probably perish, not by fire, but by decay, and by the competition of the beeches. The growth of peat has also been appealed to in connexion with the succession of forests as affording a mark of time; but this is very variable even in the same locality. It goes on very rapidly when moisture and other conditions are favourable, and especially when it is aided by wind-falls, drift-wood, or beaver-dams, impeding drainage and contributing to the accumulation of vegetable matter. It is retarded and finally terminated by the rise of the surface above the drainage level, by the clearing of the country, or by the establishment of natural or artificial drainage. On the one hand, all the changes observed in Denmark may have taken place within a minimum time of two thousand years. On the other hand, no one can affirm that either of the three successive forests may not have flourished for that length of time. A chronology measured by years, and based on such data, is evidently worthless; but it is interesting in connexion with our present subject to observe, that the remains preserved in the shell-heaps or 'Kjökkenmödding' of the stone age in Denmark indicate a wonderful similarity of habits and customs with those of primitive America, except that the people seem to have borne a closer resemblance to the Esquimaux than to the ordinary American Indian.

On the whole, nothing can be more striking to any one acquainted with the American Indian than the entire similarity of the traces of pre-historic man in Europe to those which remain of the primitive condition of the American aborigines, whether we consider their food, their implements and weapons, or their modes of sepulture; and it seems evident that if these pre-historic remains are ever to be correctly interpreted by European antiquaries, they must avail themselves of American light for their guidance. Much of this light has already been thrown on this subject by my friend Professor Wilson, in his "Pre-historic Man;" but one can scarcely open any European book on this subject, or glance at any of the numerous articles and papers on this fertile theme in scientific journals, without wishing that those who discuss pre-historic man in Europe knew a little more of his analogue in America. The subject is a tempting one, but I must close this notice, already too long for the space I should devote to it, by remarking, that the relations in America of the short-headed and long-headed races of men are by no means dissimilar from those of the two similar races in Europe; while it is also evident that some pre-historic skulls, supposed to be of vast antiquity, as, for instance, that of Engis, bear a very close resemblance to those of the Algonquin and Iroquois Indians.

ON THE RESPIRATORY SYSTEM OF INSECTS.

By S. H. Parkes, Birmingham, England.

The subject of the present paper is The Respiratory System of Insects, and its direct relation to their nervous, nutritive and muscular functions, and as I trust this will only be the first of a series of papers on the structure of this remarkable and interesting class in the animal kingdom, I may perhaps be permitted to make a few introductory observations.

To some minds the discussion of insect physiology may appear a well nigh threadbare and exhausted subject, so much having been said and written on the structure, habits, and economy of these creatures. But, like other branches in the great domain of scientific research, this one has still hidden wonders, which will repay the labour of diligent and persevering inquiry.

No one ever thinks of asking, "What is a Bird?" or "What is a Fish?" but the question has yet to be answered satisfactorily and scientifically, "What is an Insect?" Nor need we wonder at the difficulty which naturalists have felt, when striving to find a distinctive name for these creatures; for of all the living things which this wondrous world presents to our view, there is no one class which contains such a strange diversity as that usually designated Insects.

There are insects with wings, and without wings; with jaws, and without jaws; with two eyes, and with many thousand eyes; some as large as humming birds, and others so small that the aid of a microscope is required to enable us to see them. Some insects, with dainty appetite, sip honey from the nectaries of flowers; while others, furnished with a pair of terrible jaws, grind down the root, bark or trunks of stately forest trees. All sorts of food is devoured by them in all sorts of ways. There are honey sippers, blood suckers, cabbage eaters, insect cannibals, and even, we regret to say, men eaters!

Insects too, have all sorts of odd ways for getting on in the world. There are creepers, runners, jumpers, fliers, swimmers and divers. Some take it into their heads to walk heels upwards; while others, with as strange a fancy, swim head downwards in the water. Very queer, too, are the occupations and habits of these strange little creatures. Some, like hermits, live alone in the wilderness; while others form themselves into well ordered communities, having a queen, government, soldiery and laws.

And what fantastic shapes do they assume! what a variety of dresses do they wear! Beasts, fishes, birds, reptiles, and even plants, have all their mimic representatives in the insect world. There are black insects, and white; blue insects, and grey; insects with smooth skins, hairy skins, horny skins, and feathery skins. Some strut about in a bright coat of armour, and others are decked from "top to toe" with sparkling gems, more brilliant and dazzling than those of an eastern prince. Some few there are that encircle themselves with a beautiful halo of light, moving about like fairy sprites, in the darkness of night.

All sorts of trades and occupations are likewise pursued by these busy little mortals. There are carpenters, builders, miners, stone-masons, paper-makers, silk-weavers, sugar-refiners, upholsterers, net-makers, fishermen, scavengers, nurses, and even slave-holders! with a few tribes of lazy epicures, who seem to think (like some of their human brethren) that life was given only for eating, drinking, sleeping and enjoyment. Without insects we should neither have honey nor wax, scarlet dye nor lac. The poor silk-weaver would have to look out for another occupation, and queens, princesses, and aristocratic ladies, would be obliged to doff their shining robes and satisfy themselves with dresses of cotton, linen and wool. Fevers and other fearful diseases would make their appearances in many places for lack of the same useful tribe of busy little scavengers, and the doctor would shake his head sorrowfully for want of some potent remedy which some insects supply. In short, the world could not wag on as comfortably as it does, if even a single tribe of these much despised creatures were wanting. And no wonder, for the great Architect has made no useless thing amid the million curiosities of earth, however idle or blind man may be in seeking to understand the sublime plan!

As, however, it is not my purpose in this paper to offer a new designation for these strange and diversified animals, but rather to describe an important and essential peculiarity in the anatomy and physiology of the entire class, (which, by the way, might perhaps form a very scientific groundwork for their classification,) I will now proceed to the discussion of my subject.

A careful study of the structure and functions of organs, as developed in the lower animals, has long been considered by comparative physiologists, an important and instructive pursuit. We may thus see functions performed by the simplest possible structural arrangements, and may learn what are the essentials of such organs. Dr. Goadby (the once English but now American professor of comparative physiology,) remarks in his beautifully illustrated work on this subject, "that in this class (Insecta) the most important problem—the ultimate structure of glands—may be studied with great ease. In the higher animals, these organs are veiled by a parenchyma, which renders investigation difficult; but in insects we find them already analyzed—existing as simple tubuli, and offering every facility for the most minute examination of them. When the like organisms in man and the higher animals have been successfully treated and reduced to their elemental conditions, lo! they too, are simple tubes!" Now with regard to the special function of respiration, I think some important truths may be elicited, by a careful study of the very beautiful and elaborate arrangement by which it is effected in the insect race. It will scarcely be needful to observe—even in the most casual way—what an important part is played by this function in the economy of all organized beings. Most animals can exist for a considerable period without food; although this is an essential condition to the continuance of their life. But if the function of respiration be suspended, even for a very limited period, death is the speedy and inevitable result. Now the necessity for respiration in all animals—whether aquatic, terrestrial or ærial—results from the fact, that a continual decay takes place during every moment of such an animal's existence. Waste and renewal form one of the prominent peculiarities of organic life. And one of the peculiar phases of this physiological law is, that activity and waste bear a definite relation to each other. The more active any organ, or set of organs may be, the more rapidly does waste occur, and the greater necessity is there for rapid renewal. One of the results of waste in the animal economy is, the liberation of carbonic acid; which carbonic acid is produced by the union of the broken down carbonaceous particles of the old body with a portion of oxygen still existing in the blood. Unless this poisonous carbonic (when thus formed) be speedily removed, death is the inevitable consequence.

Thus arises the paramount necessity for the exercise of this function of respiration—which consists essentially in the removal of carbonic acid from the fluids of an animal's body, and in the interchange for this of an equivalent amount of oxygen. The mode by which this is effected, is wonderfully varied in different classes of animals; the respiratory apparatus of each great division being beautifully adapted to the peculiar mode of such animal's existence, and to the general plan of its structure. But in all cases, however complicated may be the structural arrangements this function is performed, it depends essentially on the effective action of a most exquisitely simple law, usually expressed as that of 'the diffusion of gases.' Thus:—if a bladder containing pure oxygen gas be hung up in a room or vessel containing common atmospheric air, although no distinguishable pores may exist in the membraneous bag thus containing the gas, still, after a while, an interchange will have taken place between the internal and external gases; and the bladder will ultimately be found to contain nothing but common air! This interchange will take place between other dissimilar gases under the same conditions; and thus, the beautifully simple arrangement is provided for the carrying on of this all important function of respiration. For it matters not whether an animal may exist in the water or on the land; whenever or however the blood (which may have become overcharged with carbonic acid by its passage through the body) is brought, through the intervention of an enclosing membrane, in contact with oxygen, contained either in water or in the air, this interchange—of which we are speaking—instantly takes place, and respiration, or the revivifying of the blood, is the result. It would have been interesting to trace the various structural arrangements by which this is effected in different grades of animal life; but this would lead us too far away from the special subject under consideration. It will, however, be necessary to make a passing reference to the respiratory apparatus of other animals; in order to show clearly the totally distinct, and very unique means by which it is effected in the insect race. In all other animals, whether low or high in the scale of being, wherever there is a circulation of the blood, or nutritive fluid, and as a consequence, some organ of propulsion termed a heart, this blood is sent continually to some special region of the body, where an apparatus is set apart for its constant renewal, termed lungs, in reptiles, birds and mammals, and gills, in fishes. Thus, all the blood in the body of a fish is brought successsively, through a delicate net work of vessels which spread over the gills, into direct contact with the water which bathes every portion of such gills; and thus the interchange of gases we have referred to, takes place. In the various terrestrial animals, however, lungs of different kinds are provided, and to these the blood is constantly sent, to receive the necessary aeration.

Perhaps we should also remark still further that, according to the peculiar habits of each class of animals, according to the slowness or activity of their movements and the feebleness or vigour of their vascular system, so are their lungs or respiratory organs modified. For instance, in the cold-blooded and slow moving Reptile class, the lung is little more than a simple bag, with a few air chambers lining its interior; and thus the blood, which flows through the vascular net-work lining these chambers, is somewhat slowly brought in contact with the air which is inspired.

On the other hand, in the case of birds and mammals whose muscular system is called into active and vigorous play, we find a most effective and elaborate arrangement, consisting of an almost innumerable aggregation of elastic air cells, over the walls of which is spread an immense surface of capillary net-work; so that, at every fresh inspiration, a considerable portion of the animal's blood is exposed to atmospheric influence.

Now of all the diversified grades of animals, that add variety, beauty, vivacity and utility to the wondrous planet on which we live, there is no one class which exhibits such marvellous evidence of muscular force, and untiring activity as the class Insecta. We might therefore—reasoning from analogy—have expected to find a most elaborate system of arteries and veins, conveying their blood to and from an equally elaborate and vigorous respiratory organ. Instead of this, however, we find a sudden and startling break, in what appeared to be the uniform and universal organic arrangement, ordained for the performance of this function; a complete turning upside down of the general plan. Here, in the Insect body, we have blood, it is true, and a pulsating organ (termed the dorsal vessel), which appears to give this blood a somewhat definite and uniform motion through different parts of the animal's frame. But no blood-vessels are any where to be seen, nor can we discover any one organ set apart for the special aeration of the vital fluid. But we do find something no less wonderful and interesting; nay, I would rather say, immeasurably more interesting and instructive, because illustrative of the limitless resources of that Infinite Mind which thus condenses and concentrates within the small dimensions of a point, such an exquisitely perfect and marvelously elaborate vital mechanism!

What is there then, in the anatomy of an insect, which claims the special and careful attention of a modern physiologist? Not only (I humbly think) the mere structural difference, which I will now briefly describe, but the physiological inference which may possibly be deduced therefrom, as to the true nature and immense importance of the respiratory function in the animal economy. As this paper will be accompanied by a series of microscopic preparations, illustrative of some of the structural peculiarities here alluded to, it will not be necessary to give any lengthened verbal description. I will merely remark, therefore, that instead of the blood (which flows in grooved channels or canals through the body of an insect) being forced to one spot to receive oxygenation, the air is conveyed to it, by means of a most elaborately arranged system of external breathing mouths, termed spiracles, and internal air tubes, termed trachea. Although the plan of respiration is the same essentially in all insects, the modifications of these breathing organs is as wonderfully varied as the external appearance and peculiar habits of the creatures themselves. When it is remembered that insects pass through a series of metamorphosis, some living in water at one period of their existence, and then assuming an aerial life; others burying in the earth, during their early days, and then coming forth to roam abroad amid the forest trees; and when we recollect that almost all exist under very different external conditions, at different periods of their changeful history, and that in each of these states respiration is an indispensible function, we need not be surprised to find striking and important modifications in the physical structure of their breathing organs, suited in each case to the peculiar exigencies of the individual. It will be impossible, therefore, in this paper to do more than indicate the prevailing structure. And first, with regard to the spiracles, or external breathing organs of these creatures. If you will examine the body of almost any insect, you will perceive, arranged along each side of the abdomen and thorax, a series of openings, each bounded by a dark colored ring. The office of these, is to admit air to the interior of the animal's body, and to regulate its admission and expulsion according to existing circumstances. The essentials of these spiracles appear to be, 1st, a marginal ring of horny or cartilaginous substance, capable of being opened and closed by an arrangement of muscles, (thus forming the framework of the spiracle, and serving as a support to the delicate tubes within); and 2nd, a variously arranged membrane, or fringe, or system of horny plates, placed within this horny ring, for the purpose of preventing the entrance of dust or other matter, which might stop up the air passage within, and thus cause the death of the animal. The number of these spiracles, possessed by different insects, varies of from two to eighteen; the number frequently differing in the same insect, according as it is in its larval or perfect state. In every order (as before observed) there is some peculiar modification in the structure of this important organ; and even striking variations in different members of the same order, as will be seen in the specimens sent to illustrate this paper. It is supposed by some entomologists, that some of these spiracles, (namely, the abdominal ones,) are specially concerned in the inspiration of air; and that those situated in the thorax are designed for its expulsion. The point most worthy of notice and admiration, however, in the structure of these organs is, the perfect and exquisitely beautiful manner in which provision is made for the protection of the elaborate system of vessels to which they lead. In some beetles, peculiarly liable to be infested by parasites, (which parasites attach themselves to the softer parts of the body where the spiracles are placed,) there is a membranous covering with a narrow opening, thickly studded with sharp spines. In others, whose habits are of a burrowing character, we find the entrance guarded by an admirable arrangement of horny or cartilaginous plates, while in many of the dipterous and neuropterous insects, there is an elegant arrangement of fringed processes, which, for beauty as microscopic objects, can scarcely be surpassed. Some writers have supposed that the humming or buzzing noises made by many insects, when on the wing, is produced by these spiracle appendages, during the rapid ingress and egress of the air; an effect similar to that which is produced by the sweeping of the air over the strings of an eolian harp. The most important vital purpose, however, is doubtless that to which I have already alluded—the protection afforded to the air vessels within. There is also another important end which they may serve, and one which, I think, has not been observed by any writer on the subject. It is this: the modification of the temperature of the air, as it enters the trachea, and the preservation of that within the body, at the normal standard of heat, usually existing in the different members of this class. For this purpose these fringes and plates and membranous folds, would be admirably adapted, and would act in precisely the same way as the metallic framework of a respirator does when worn by consumptive persons. A question might here naturally arise, as to the production and maintenance of animal heat in the insect economy. But the full discussion of this subject would demand more time than we have at disposal. Many interesting observations have been made, which show that the temperature of different insects varies greatly, especially those living in societies (as the hive bee) whose normal standard of heat is very much higher than that of other classes. There has been a prevailing notion that the temperature of insects is altogether regulated by that of the external atmosphere in which they live, but this opinion is, I think, at variance with the common principles of animal physiology; and it is, moreover, contradicted by a variety of experiments, bearing on this questien. There can be little doubt, I think, that the standard of heat, in different species of insects, is regulated very much by the degree of muscular activity manifested by them; for this would involve a more rapid and vigorous respiration, and a greater consequent evolution of heat. Without pursuing this question farther, however, I would remark finally respecting the spiracles of insects, that however beautiful and elaborate they may be in their structure, and however perfectly adapted to the habits and peculiarities of the creatures possessing them, they are but the portals to an inner sanctuary of wonders, unspeakably transcending all human contrivances in execution, and surpassing human thought, even in conception. The fact that insects breathe, and that their respiration is carried on by means of an elaborate system of air tubes, which ramify extensively through the interior of their body, has long been known, and has been described by writers on this subject. But very few, I believe, until lately, have been able to show, by actual demonstration, to what an almost infinite extent these wonderful air channels divide and sub-divide, and how they spread over and penetrate, almost every membrane and fibre of an insect's body. The principle published accounts of the Respiratory System of insects, have been descriptive chiefly of the larger species of lepidopterous caterpillars; also of coleoptera, neuroptera and diptera. Preparations of these are of course more easily made and displayed, than the demonstration of the same system in the smaller tribes. As the microscope, however, has gradually been improved, and as microscopic manipulation has also kept honorable pace in the same onward march, so have the more minute marvels of this wondrous material world been gradually unfolded; and a restless and insatiate craving has been awakened in the minds of physical philosophers, which has prompted them to *see* and to *touch*, not only the most minute organs, of the most minute organism, but even the very molecules of which those natural substances are composed. The great cry of the physiological microscopist now is, More magnifying power—more light. Well, suppose he could obtain both, what would he then want? Why, most assuredly—I verily believe—something which he does not now possess: more mental power; and a far more steady and delicate touch, to enable him to handle and separate such infinitesimal forms of matters. And even then, he would still "see through a glass darkly," for he would certainly never touch that invisible essence, which gives vitality to the visible form! But this is a digression—for my purpose, in this paper, has been, not to speak of what is impossible and unattainable, but to show what marvellous results have been attained by patient microscopic research, and by persevering practical manipulation. As an illustration of this, I have had prepared for examination, not only the larger tracheal system, dissected from the body of a large caterpillar, but the same system of respiratory tubes taken from the body of a human flea. In another slide containing a specimen of Pediculus, the body of the creature has been rendered transparent, and so mounted, as to show the entire respiratory system *in situ*. Preparations will also accompany this paper, showing the minute ramifications of air vessels over the stomach of the house fly, and of the honey bee, also over the nerve ganglia of a caterpillar. In another slide containing the contents of the head of the honey bee, may be seen the singular and somewhat puzzling connection between these air vessels distended by their peculiar spiral fibres, and the salivary glands of this insect. In this preparation it will be seen that, instead of a large spiral vessel, dividing and sub-dividing into extremely fine tubes, and these tubes ramifying over the part requiring aeration (as in other cases), these tubes appear to be modified and converted into the very gland structures themselves? And in another slide, may be traced the connection of these wonderful air tubes, with the muscles, the ovaries, and the gizzard of a flea. Perhaps I should remark by the way, that the existence of this last mentioned organ, a flea's gizzard, was, some time since, warmly discussed by a number of microscopists. It is well known that insects, possessing a suctorial apparatus, are not usually furnished with a gizzard, of which is essentially a grinding or triturating organ. But the late Professor Quckett (whom it was the writer's great privilege to know) asserted in spite of all opposition, and contrary to analogy, that the flea possessed this organ; and so it turns out! For the clever little Frenchman who made this flea preparation for me, has managed to demonstrate the fact; and to mount the minute dissection (thus made with an amazing amount of patient persevering skill) in a most exquisitely beautiful manner.

But what of these air tubes, about which so much has already been said? On examining the preparations which accompany this paper, you will observe that they consist of two membranous tubes—one inside the other—and that between these delicate membranes, there is coiled a spiral fibre which tapers down smaller and smaller, as the tubes subdivide; and which continues its course down to the most minute vessel that the microscope can reveal. The purpose which this spiral fibre serves, affords a striking and beautiful illustration of that marvellous design and adaption, which is exemplified in the whole of the great Creator's works. As these tubes contain only air, they would be liable to collapse by the constant pressure of surrounding organs, and still more by the violent contortions of the animal when moving about were it not for these spiral fibres, which combine lightness, firmness, elasticity, and every other needful requisite. So admirably do they fulfil their intended purpose, that the human inventor has copied them, to strengthen his elastic india rubber gas pipes and other tubes of similar character.

But what of the termination,—the ultimate distribution of these elaborately constructed tubes? And what of the purpose they are intended to subserve? With regard to their distribution; no one, perhaps, has gone so far in demonstrating their universality and extreme fineness, as Dr. Beale, with his 25th-inch object glass, and with this, which gives a magnifying power of nearly 3000 diameters, he has traced both air tubes and nerve fibres interlacing and spreading over the sarcolemma of muscular fibre, taken from the larva of the blow fly, a single fibre of this insect's muscle being completely encased in a net work of these inconceiveable minute and wondrous air tubes, whose very existence requires a power of 3000 diameters to reveal?

And not only do they thus intertwine about the fibres of an insect's muscles, but they penetrate the very substance of the nerve ganglia of the body; entering the head, and spreading over that optic nerve which receives impressions through ten thousand compound eye lenses; penetrating the wings, and giving lightness and energy to those untiring organs of flight; spreading over the stomach and other abdominal viscera; and aerating every particle of that blood which bathes and surrounds all the internal organs! I know not, gentlemen, what your feelings may be when you examine with your microscopes such unspeakably wonderful and complicated organisms, condensed and crowded within an almost invisible point of space; and this mechanism vitalized, directed and controlled during the period of its existence by an individual will, and by an unerring instinct. I know not, I say, what you may think and feel about the origin and design of such manifestations of constructive wisdom and skill; but for myself, I can say, it produces in my mind the most profound emotions of humility and awe; nay, rather, I would say, of adoring gratitude to that Infinite Being, who, while he displays to my astonished sight a spectacle so grand and glorious, as I look through my telescope at a starry universe, has also stooped so low, as to lay at my very feet the same incontestible proofs of His own "Infinite power and Godhead."

But what of the Physiological necessity for such a complicated mechanism? Can we suppose that the mere general aeration of the blood, such as is supposed to take place in the pulmonary respiration of higher animals, calls for this excessive elaboration and minute sub-division of air tubes in the insect economy. These tubes penetrate and twine about the interior of organs, which cannot possibly be bathed as other parts are, by the nutritive fluid. What is this atmospheric air ?—this component fluid which all animals must breathe, but which to insects appears to be pre-eminently " the breath of life." Does it contain something more than oxygen, carbonic acid and nitrogen ? Is there not ammonia, and that wonderful substance ozone ? And is it not the carrier of that still more wonderful something, which we call electricity ? It may yet appear, as science advances, that in our respiration, there is something more effected than the mere interchange of oxygen and carbonic acid, with one or two subordinate results ; and that the character of the air we breathe, and the air we live in, is a question of no mean importance to individuals and to communities. Not only do we, like all other terrestrial beings, draw this atmospheric air within our bodies, during the process of respiration, but, like a great ocean, it encompasses us about on every side. And like that deep and dark blue ocean of waters, whose restless vicissitude of storm and calm, is changing our land marks, and modifying our climates ; so this great ocean of air, carries in its bosom the same wonderous law of mutation. For, the electrical changes which are constantly taking place in its upper strata, producing sometimes very sudden hygrometric and thermometric changes in the lower regions, must and do affect the conditions of animal health, to a very great extent. The effect produced by physical alterations in the atmosphere upon the nervous system of animals, and the peculiar influence of atmospheric air upon the bodies of animals (especially upon man) externally, when freely exposed to its action, have not, we think, had that attention from the scientific men that the subject deserves.

I must not, however, go further with this subject, but will conclude by quoting the eloquent language of Dr. Williams; which langugage he also puts into the form of interrogation. " What can be the meaning of these incomparable pneumatic plexuses, which embrace immediately the very ultimate elements of the solid organs of the body ?—those minute microscopic air-tubes, which carry oxygen in its gaseous form, unfluidified by any intervening liquid, to the very seats of the fixed solids which constitute the fabric of the organism ? The intense electrical and chemical effects, developed by the immediate presence of oxygen at the actual scene of all the nutritive operations of the body, fluid and solid, give to the insect its vivid and brilliant life, its matchless nervous activity, its extreme muscularity, its voluntary power to augment animal heat. Such contrivances, subtle and unexampled, reconciles the paradox of a being, microscopic in corporeal dimensions and remarkable for the minuteness of the bulk of its blood, sustaining a frame, graceful in its littleness, yet capable of prodigious mechanical results."

SOME STATISTICAL FEATURES OF THE FLORA OF ONTARIO AND QUEBEC,

AND A COMPARISON WITH THOSE OF THE UNITED STATES FLORA.

By A. T. Drummond.

The recent issues by Prof. Gray of a fifth edition of his Manual of Botany of the Northern United States and by Mr. Horace Mann of a Catalogue of the Phænogamous Plants of the United States east of the Mississippi, have suggested the thought that with the materials for a flora of Ontario and Quebec, which have been for some years accumulating, the prominent statistical characteristics of our local vegetation might now be indicated with reasonable certainty, and a fair comparison instituted between them and those of the flora of the United States. That any statistics given will, in coming years, be altered in consequence of additions made to our flora, is certain. There is reason to believe that a considerable number of phænogamous and filicoid plants not at present known to occur within our geographical limits, will yet be detected there. Whilst, however, these statistics are not invested with absolute certainty, they can, I think, be regarded as fair general conclusions.

The works of Michaux, Pursh, Hooker, Torrey and Gray, etc., afford much information regarding the flora of this part of the continent, but since their publication our knowledge of it has been greatly extended. Foreign as well as provincial scientific journals have within the past few years contained valuable papers on the subject of Canadian botany. The institution of a society, whose special aim was the promotion of botanical research in our midst, infused for a time much interest in the study, and resulted in the accumulation of considerable material for a provincial flora. Some of the papers and catalogues were published in the society's 'Annals,' but many are still in manuscript. To these latter, as well as to other catalogues in the hands of the editor of this journal, I have been permitted to have access, and from them have derived much aid in arriving at the results given hereafter.*

Endeavours have already been made to bring the flora of Ontario and Quebec into one connected view. The work of the Abbè Provancher, in the French language, which was published some years since, is upon an ample scale, and contains descriptions of the plants referred to in it, whilst the more recent brochure of the late Prof. Hubbert is simply an arranged catalogue, which was intended as the precursor of his contemplated Hand-book of the Canadian Flora. Prof. Hubbert's list, in addition to the results of his own collections, as well as of those of his correspondents, probably contains all previously published information bearing on the subject.

The views of authors, of course, vary considerably with regard to orders, genera and species; however, for the purposes of comparison with the flora of the United States, those of Prof. Gray, as expressed in the recent edition of his Manual of Botany, are here adopted. Further, it should be premised that only flowering and filicoid plants are referred to in this paper, our knowledge of the lower cryptogams being as yet too limited; and it should be added that when speaking of the Northern States and the United States or Union, no more extended geographical limits are intended than are kept in view in the Manual on the one hand and Mr. Mann's catalogue on the other.

The prominent features in the distribution of the plants of Quebec and Ontario have been indicated in another place. With regard to the nature of the flora of the United States, it may be, in a general way, said that in the eastern and central portions of the Northern States the vegetation embraces a mountain and a woodland flora, which, excluding the more southern

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* In addition to the catalogues cited in the foot note to p. 406, vol. i. (new series) of this journal, I have had access to those of Dr. Thomas, of the Rivière-du-Loup flora, and Dr. J. Bell, of the Maintoulin Island flora; to the notes of Prof. Hincks on Toronto plants (through Prof. Hubbert), and to the elaborate lists of Dr. McLaggan and Mr. John Macoun, the former of whom collected in different sections of the provinces, but chiefly in the western peninsula, and the latter in the vicinity of Belleville.

forms, is similar to that of Ontario and Quebec; that as the Mississippi is approached there is a transition to a prairie flora in some districts, and in others to the flora of the western plains and wooded country; that along the Atlantic coast there is a maritime flora, some former members of which now occur in special inland localities; that the line of distribution of many of the United States plants has a north-westward trend; and that the Southern States have their semi-tropical species, many of which do not range as far as, whilst others extend within, the geographical limits of the Northern States. All these circumstances largely affect the number and character of the species in each region.

In our two Provinces there are representatives of one hundred and fourteen natural orders. Of these Magnoliaceæ, Melastomaceæ, Dipsaceæ, Bignoniaceæ, Phytolaccaceæ, Lauraceæ, Ceratophyllaceæ, Platanaceæ, Amaryllidaceæ, Commelynaceæ, and Xyridaceæ, are, as far as known, confined to Ontario. No order is, however, peculiarly provincial; all have their representatives in the Northern States among the one hundred and thirty-two orders which embrace the flora of that section of the Union. It is nevertheless a not uninteresting circumstance that, although there are eighteen of these Northern States orders which have no place in our Provincial flora, they comprise only thirty-five species, most of which are Southern States forms.

The genera which have representatives in Ontario and Quebec number 575, of which 428 are dicotyledenous, 124 are monocotyledenous, and 23 comprise the filicoid plants.

Of indigenous genera five are unknown south of the Great Lakes. These are Cochlearia, Crepis, Armeria, Pleurogyne, and Elæagnus, each of which comprises a single species. Crepis and Elæagnus are, with us, only found along the upper lakes, and are probably entirely western in their distribution, whilst the remaining three are of semi-arctic range. In addition to the above there are some introduced genera, as Scabiosa, Tragopogon, Ajuga, and Borago, which apparently have not been noticed in the United States. Within the geographical limits of Prof. Gray's work are 834 genera, 631 of which are dicotyledonous, 175 monocotyledonous, and 28 are filicoid. There are thus 263 genera in the Northern States which are without either indigenous or introduced representatives in either Ontario or Quebec.

The relative numerical proportion of monocotyledonous and dicotyledonous genera decreases from our section of the continent southward. Thus, in Ontario and Quebec monocotyledons are to dicotyledons as 1:3.46; in the Northern States as 1:3.61, and in the whole of the States east of the Mississippi as 1:4.13. The numerical relations of filicoid to phænogamous genera present much more marked differences. In the Provinces the proportion is as 1:24, whilst in the Northern States it is as 1:28.9.

The relative positions of the orders with respect to the number of genera in them vary to some, though not to any considerable, extent in the two countries. In the Northern States and the whole Union these relative positions are not much different. Compositæ and Graminæ, however, assume the precedence there in each case as well as here. Arranging the large orders represented in each country according to priority in point of number of included genera, the following results are presented:

In Ontario and Quebec.

Compositæ	56	Filices, Liliaceæ and Umbelliferæ, each	19
Graminæ	47	Cruciferæ and Rosaceæ, "	17
Labiatæ	24	Ranunculaceæ and Scrophulariaceæ, "	15
Ericaceæ	22	Orchidaceæ	14
Leguminosæ	21	Caryophyllaceæ	12

In Northern States.

Compositæ	86	Umbelliferaeæ	27
Graminæ	67	Scrophulariaceæ	25
Leguminosæ	39	Filices	22
Labiatecleæ	33	Ranunculaceæ and Cruciferæ, each	20
Liliaceæ and Ericaceæ, each	28	Rosaceæ	18

Of the 576 genera in the two Provinces, 291 or rather more than one-half, are referable to the twelve orders which take precedence in the first of these lists. The aggregate of the genera in the second list barely attains the half of the whole number of genera which have representatives in these States.

The largest interest is of course invested in the species which occur within our geographical limits, and in the numerical relations of the orders and genera with regard to the species which they embrace. The details given with respect to them will be less wearisome.

Recent discoveries have confirmed the occurrence in Canada of several species whose previous claims to a place in our flora rested solely on the authority of Michaux or Pursh. I have therefore experienced a reluctance to exclude any of their species—unless the occurrence of the plant is very improbable—on the mere ground that it has not been noticed by subsequent observers. This reluctance is increased by the circumstance that the Lake Superior and lower St. Lawrence districts, where many, if not most, of these species are supposed to occur, have received but a limited exploration. Though *Sabbatia gracilis*, *Utricularia subulata*, and *Ilex glabra* are probably errors, I have had no hesitation in admitting *Rhododendron maximum*, *Phlox maculata*, *Trichostema dichotomum*, *Andromeda tetragona*, and even *Gnaphalium sylvaticum*, which occurs in Labrador and may very well be found within our extreme north-eastern limits. The same course in admitting or rejecting species has been adopted with regard to other authors.

Special reference will hereafter be made to introduced plants. Here, in order to exhibit the mass of the vegetation of each country and the relative proportions which classes, orders and genera bear to one another with regard to the entire number of species which they include, both indigenous and introduced plants are, without distinction, embraced in the statistics of species now given.

As far as considerable care can extend the catalogue, there are 1,676 flowering and filicoid plants in Ontario and Quebec. Of these, 1,161 are referable to dicotyledonous, 450 to monocotyledonous, and 65 to filicoid species. Monocotyledons are thus to dicotyledons as 1:2.5, and to phænogams as 1:3.5. In the Northern States the relative numerical proportions are almost identical, and the extension of the comparison to the whole Union does not much alter them. The large number of monocotyledonous species is very remarkable, and evinces a climate and physical conditions very favourable to these plants. Again, filicoid plants are to phænogams in the Provinces as 1 to 25, whilst in the Northern States they are as 1 to 28.7.

Some facts of considerable interest are presented by the relations which the different orders bear to one another, and to flowering plants, with respect to the number of included species. In ten natural orders are grouped nearly one-half of our indigenous and introduced species, and eighteen orders represent about two-thirds of them. Another interesting feature which appears quite as conspicuous in the United States flora, is that Cyperaceæ, Gramineæ, Orchidaceæ, and Liliaceæ embrace the greater portion of our endogenous plants. Again, in the United States, east of the Mississippi, the Compositæ number 1-7th, and the Cyperaceæ 1-11th of the entire phænogamous flora; whilst in the Provinces the same orders comprise nearly 1-9th and 1-11th, and in the Northern States 1-8th and 1-10th respectively. The grasses bear very nearly the same relations to flowering plants—1-12th to 1-13th—in the three divisions of country mentioned. Among other orders there are some marked differences in the proportions as they are exhibited in the different geographical regions;—in some the species proportionably increase from Canada southward; in others, the reverse of this is the feature. The five examples cited below will illustrate these particulars:—

	Ontario and Quebec.	*Northern States.*	*United States.*
Leguminoseæ	1-29th	1-21st	1-18th
Euphorbiaceæ	1-95th	1-72nd	1-58th
Rosaceæ	1-25th	1-32nd	1-40th
Cruciferæ	1-31st	1-39th	1-49th
Ericaceæ	1-34th	1-38th	1-43rd

Among the smaller orders there are instances quite as marked. Convolvulaceæ increases from eight species within our limits to twenty-four in the Northern States, and forty-one in the whole Union; and the Malvaceæ are similarly augmented from eight to twenty-two and forty-four; whilst in Cupuliferæ the species, in which are sixteen, twenty-three, and thirty-one, respectively, the numbers proportionally diminish. These circumstances tend, of course, to indicate the well-known facts, that, whilst some of the orders mentioned are semi-tropical and southern temperate, others are more abundant in the northern temperate regions of America.

The number of species occurring within our limits in each of the large orders is indicated below. To admit of a comparison being more easily made, the numbers in the same orders in the United States are placed in parallel columns.

	Ontario and Quebec.	*Northern States.*	*United States.*
Compositæ	194	324	481
Cyperaceæ	155	248	336
Graminæ	124	212	287
Rosaceæ	65	81	92
Leguminosæ	55	120	199
Cruciferæ	51	65	74
Ericaceæ	47	68	84
Labiatæ	47	76	108
Orchidaceæ	46	57	71
Scrophulariaceæ	44	66	94
Filices	44	57	76
Liliaceæ	42	62	78
Caryophllaceæ	34	33	70
Polygonaceæ	34	38	54
Umbelliferæ	28	45	58

To somewhat complete the parallel drawn, it will be useful to bring to view the number of species in the more important genera of Ontario and Quebec and of the Northern States. To extend the comparison to the flora of the Southern States may diminish its interest, as many of the conspicuous genera there are but scantily or not at all represented north of the Great Lakes or in the valley of the St. Lawrence. The carices, it will be observed, constitute nearly 1-14th of our flowering plants. The asters comprise thirty-one and the solidagos twenty-six species—the larger number in each case being in Ontario—and together form 1-28th of phænogams. The maximum development of these two genera is probably in the Northern States, but they do not there form so conspicuous a relation to the entire vegetation as, though they comprise seventy-eight species, they constitute but 1-33rd of the flowering plants. Along the northern banks of the lower St. Lawrence and among the Laurentide hills to the northward, the same genera are, in both number of species and individuals of each species, poorly represented; and in the effect which they elsewhere have upon the aspect of the shubby and herbaceous vegetation, they are replaced by *Cornus Canadensis* and Vacciniums

Ontario and Quebec.		*Northern States.*	
Carex	118	Carex	153
Aster	31	Aster	41
Solidago	26	Solidago	37
Polygonum	19	Juncus	25
Ranunculus and Juncus, each	18	Potamogeton and Euphorbia, each	23
Salix	17	Polygonum	22
Viola	16	Cyperus and Scirpus, each	21
Euphorbia and Habenaria, each	15	Panicum and Helianthus, each	20
Panicum	14	Desmodium and Ranunculus, each	19
Potamogeton and Rumex, each	13	Habenaria	18
Poa	12	Quercus, Viola and Eleocharis, each	17
Vaccinium	11		

Common to Ontario and Quebec on the one hand, and to the Northern United States on the other, there are no less than 1,591 flowering and filicoid plants. Of these, 1,089 are dicotyledonous, 440 monocotyledonous, and 62 filicoid species. There are thus eighty-five species which are without representatives across the border. Of these, however, it should be specially observed nineteen are manifestly introduced, and there are therefore only sixty-six indigenous plants which, as between the two Provinces and the Northern States, are peculiar to the former. There is thus a very marked similarity between the floras of these two sections of country. The indigenous species referred to include the following:—

Anemone narcissiflora, L.
Thalictrum alpinum, L.
Ranunculus affinis, R. Br.
R. cardiophyllus, Hook.
Caltha natans, Pallas.
Aquilegia vulgaris, L.
Arabis patula, Graham sp.
A. brachycarpa, Torr. & Gray sp.
A. retrofracta, Graham.
Erysimum lanceolatum, R. Br.
Vesicaria arctica, Richn.
Draba hirta, L.
D. muralis, L.
Thlaspi montanum, L.
Cochlearia tridactylites, DC.
Arenaria arctica, Steven.
Linum perenne, L.
Astragalus Labradoricus, DC.
Dryas octopetala, L.
D. Drummondii, Hook.

Geum geniculatum, Michx.
Rubus arcticus L.
Rosa stricta, Lindl.
Epilobium tetragonum, L.
Ribes oxyacanthoides, L.
Saxifraga Grœnlandica, Hook.
S. nivalis, L.
Angelica lucida, L.
Sium latifolium, L.
Cornus suecica, L.
Nardosmia frigida, Hook.
Aster Lamarckianus, Nees.
A. cornuti, Nees.
Matricaria inodora, L.
Gnaphalium sylvaticum, L.
Antennaria Carpathica, R. Br.
Senecio canus, Hook.
Hieracium vulgatum, Fries.
Crepis runcinata, T. & G.
Andromeda tetragona, L.
Ledum palustre, L.
Armeria vulgaris, L.
Penstemon gracilis, Nutt.
Pedicularis palustris, L.
Melampyrum pratense, L.
Mertensia Sibirica, Don.
M. pilosa, Don.
Gentiana acuta Mx. v. stricta, Hook.
Pleurogyne rotata, L.
Rumex acetosa, L.
R. domesticus, Hartm.
Elæagnus argentea, Ph.
Salix reticulata, L. var. vestita.
Alisma natans, Ph.
Echinodorus subulatus, Engel.
Iris tridentata, Ph.
Eriophorum capitatum, Host.
E. russeolum, Fries.
Carex Macounii, Dew.
Carex bicolor, Allioni.
C. ovata, Rudge.
Elymus Europæus, L.
Triticum Macounii, Dew.
Asplenium viride, Hudson.
Woodsia hyperborea, R. Br. *
Equisetum littorale, Kuhl.

A critical examination of the above catalogue suggests some remarks. *Ranunculus affinis* and *R. cardiophyllus* will by some authors be referred to *R. auricomus* Linn., which, however, is a known British-American plant, and is absent from the United States flora; *Geum geniculatum*, *Angelica lucida*, and *Aster cornuti* are species of which not much is known; *Carex Macounii* and *Triticum Macounii* were only discovered about two years since, and, when their range is more fully known, may be found to occur south of the lakes; *Sium latifolium* Prof. Gray rejects from his manual as erroneously applied to the broad-leaved form of *S. lineare* Michx., and here a similar mistake may probably have been made; and *Equisetum littorale* perhaps requires confirmation. Prof. Gray, again, in the manual, takes no notice of *Arabis brachycarpa*, which Torrey and Gray locate at Fort Gratiot, Michigan; of *Nardosmia frigida* (to which *N. sagittata* Hook. is referred) which, on Pursh's authority, occurs on the highest mountains of Vermont and New Hampshire; of *Ledum palustre*, whose occurence in Vermont and Pennsylvania is mentioned by Beck; or of *Penstemon gracilis*, to which Wood gives a place in his flora, with Chicago as a locality. It should be further observed that *Matricaria inodora* is adventive though not native in Maine. *Aster borealis*, Prov., if a good species, and not a variety of *A. aestivus*, must be added to the list. If the twelve

*Editor's Note.—My esteemed correspondent, the late Mr. Horace Mann, sent me specimens of this fern, collected by himself on Willoughby Mountain, Vermont. *Lycopodium alpinum*, long known as a Newfoundland plant, may be added to this list; it occurs on the north shore east of Point de Monts, and probably elsewhere. D. A. W.

species referred to be rejected from the catalogue, there still remains fifty-four species unrepresented in the Northern States.

In connection with the non-occurrence of these plants in the Northern States, their range becomes a subject of considerable interest. Speaking generally, some are of semi-arctic and boreal types, and only occur in the more northern or otherwise suitable stations; others are entirely western in their distribution; whilst there are a few which are sparingly distributed in the Provinces, or with whose range we have but a limited acquaintance. *Ranunculus affinis*, *Thalictrum alpinum*, *Vesicaria arctica*, *Cochlearia tridactylites*, *Saxifraga Grœnlandica* and *S. nivalis* are peculiar to the arctic climate, and, with the exception of the Ranunculus and Cochlearia, are also denizens of the coasts of Greenland. *Arenaria arctica*, an interesting discovery of which was not long since made at Muskoka Lake, Ontario, by one of Prof. Hincks's students; *Dryas Drummondii*, a pretty species in the Gaspé collections of Dr. Bell; *Astragalus Labradoricus*, *Rubus arcticus* and *Pleurogyne rotata* are examples of a less arctic type, though the little Arenaria penetrates the polar regions beyond Whale Sound on the West Greenland coast. *Ribes oxyacanthoides* is said by Torrey and Gray to occur throughout Canada; and *Caltha natans*, *Aquilegia vulgaris*, *Linum perenne*, *Rosa stricta*, *Matricaria inodora* and *Elæagnus argentea* are probably limited to the north western parts of Ontario, and may be looked for in the neighbouring districts of the Northern States.

ON LESKIA MIRABILIS (GRAY).

By Prof. S. Lovén.

*Communicated by Dr. Christian Lütken, Assistant Zoologist in the Museum of the University, Copenhagen.

This little paper, inserted in the Proceedings of the Royal Swedish Academy for 1867, well deserves the attention of palæontologists, though its principal aim is to redescribe a little-known *recent* Sea-Urchin from the Eastern Seas, because this animal throws a peculiar light on certain important points in the morphology of Cystidea. It is, moreover, distinguished by all the ingenuity, accuracy, and profound knowledge which is peculiar to the works of the celebrated Scandinavian zoologist.

* From the Geological Magazine, vol. v., p. 179.

The genus *Leskia* is described, in 1851, by Dr. J. E. Gray, in the "Annals," and subsequently, in 1855, in the Catalogue of Recent Echinida, from specimens from Lugard, in Mr. Cummings's collection. It is most intimately allied to the Spatangidæ, of which it has the general stamp, but is distinguished from them, and therefore the type of a peculiar family (*Leskiadæ* Gray) or tribe (*Palæostomata* Lovén) by the peristome and periproct being closed up with a few "triangular converging valves," those of the vent with some small "spicula" in the centre. Dr. Gray has already remarked that "in the form of the mouth and vent it has considerable affinity with the fossil Cystidea, especially the genus Echinosphærites." The detailed description given by Prof. Lovén quite confirms this remarkable combination of features; the characters assigned to the Palæostomata are as follows: "*testa oviformis, peristomium non labiatum, pentagonum, æquilaterale, ore quinqueralis, anus intra periproctium centralis, valvis clausur quinque octo ; aperturæ genitales binæ ; semita unica peripetala.*" Leskia is a true Spatangoid, *save the mouth and the vent ;* the latter, instead of being surrounded by a threefold circle of minute plates, the greater and outermost, has only five, seven, or eight great triangular outer plates, and an equal number of minute inner papillæ. The peristome is not bilabiate with a prominent under-lip, nor is it formed principally by the ambulacral plates; it is pentagonal, and bordered almost exclusively by the interambulacralia ; there is no buccal membrane covered with three to five series of irregular plates, decreasing inwards, but the mouth is closed up by five equal triangular plates, inserted on the five sides of the peristome. "No living Echinid has such a mouth;" but the author thinks that the genus Toxaster of the 'Neocomien Inférieur,' whose peristome was pentangular, not labiate, might possibly—though the configuration of its mouth somewhat more approaches to that of the true Spatangidæ—have had a similar organization.

In the Silurian Cystidea again, we find precisely the same structure as in the recent East Indian Sea-urchin, viz., in the commonly so-termed 'ovarian pyramid,' which, after the opinions of Gyllenhal, Wahlenberg, Pander, Hisinger, de Koninck, and Billings, is really the mouth, whilst Von Buch, with some inconsistence, makes it the mouth of Caryocrinus, but the genital outlet in the other Cystidea, and Joh. Muller and Volborth sought the mouth in the centre of the converging ambulacral furrows. The remarkable observations on *Sphæronites pomum* and *Echinosphærites aurantium*, by means of which Prof. Lovén draws the conclusion that Leskia is a Spatangoid *with the mouth of a Cystidean*, we will give with his own words. (See figures on page 443.)

"Good specimens of *Sphæronites pomum* Gyll., collected by Prof. Angelin, show its organization more distinctly than usual. He had observed that this animal had no stalk, but adhered immediately to rocks or other objects through a part of its lower surface, which is without pores, and surrounded by a ridge formed of the somewhat thickened, free, smooth border of the undermost plates. This surface of attachment is of a very variable form and extension in different specimens,—round and but little excavated in some, oblong and deep in others,—depending upon the nature of the object to which it adhered. On the point opposite to this basal surface lies the apex with the ambulacral apparatus. In the middle of a somewhat deepened area *d*, through which five delicate but distinct ambulacral furrows pass towards five arms, whose bases form a circle, which however is broken at *f*, one-fifth of its circumference. Where the furrows reach the arms, they will be seen to pass into an oblong hole *e*, which is the lumen of the broken furrow of the lost arm: in every remaining arm-base you will see an indication of the branching of the arms and of the central channels of the branches. Close up to the ambulacral circle lies the 'pyramid' or mouth *a*, closed by its five valves of unequal dimensions; two of them are emarginate on one side in order to give space to the two adjoining outermost arms, which are less than the others, and, as it were, crippled, the right by its vicinity to an oral valve, the left by an apparatus *b*, that cannot be interpreted otherwise than as an external genital organ. When it is tolerably well preserved, it is conical, with a rounded apex, without any terminal aperture; for vestiges of valves I have sought in vain, but in two specimens I found the two pores indicated in the figure. From this organ a ridge *c* runs towards the next arm, suggesting the idea of the possible existence of a 'madreporite.' The centre of the brachial apparatus forms with the genital organ and the oral orifice a compressed but only slightly inequilateral triangle. In *Echinosphærites aurantium* the relative position of these parts is the same, but the triangle which they form with each other is much larger, longer, and more inequilateral, because the distances are greater, especially that of the mouth from the ambulacral apparatus, which is correctly described and delineated by Volborth and Joh. Muller. Close to this is seen the other 'orifice,' viz., the external genital organ. All specimens that I have examined have this so-termed 'orifice' in such a condition that it most likely is the remnant of a prominent broken part, and it must be assumed that in this species also it had a conical form, but remained mainly in the surrounding stone-matrix. Volborth's figure (Ueber die Russischen Sphæroniten, x. ix. f. 9) appears to be correct, but gives no complete evidence as to the presence of the three valves. That the 'pyramid,' which in Leskia is the armature and covering of the mouth, is the same thing in Cystidea, is now quite certain; in the last-named group it was, doubtless, also the vent. The mouth does not lie where J. Muller and Volborth sought for it, viz., in the centre of the ambulacral furrows; and the organ, interpreted as the vent by Volborth and Von Buch, is more correctly regarded as an external sexual organ."

It is not my intention to criticise the various interpretations of the morphology of Cystidea given by different authors, or to trespass on the space here allowed me by a detailed examination of all the questions entangled with them. But should I venture to express any humble opinion of my own on this important point in the morphology of Echinodermata, I must first confess that hitherto I have been very sceptical as to the theory advocated so very ingeniously by Mr. Billings and now upheld by Mr. Lovén. The concordance between these two authorities is nevertheless not so great as would be supposed—that the 'pyramid' was the mouth of the Cystidea, and that this orifice accordingly would lie elsewhere than in the centre of the ambulacral system, where it lies in all living Echinoderms and (I may add, where it did lie, I have no doubt, also in the Palæozoic Crinoids, where no superficial ambulacral channels are to be seen, but where they pursued their way on the inferior surface of the 'vault' through the 'ambulacral orifices' at the base of the arms,—as shown by Mr. Billings, with those researches (see Decades Geol. Survey of Canada) I was, I regret, unacquainted when I wrote my paper on Pentacrinus, etc.) I know no other exception to this rule; and would it not be a dangerous thing—not to be done without very strong arguments—to give up the leading principle of Palæontology, viz., that only from the organization of the *living* form can we learn to understand that of the *extinct*? Might we not thus too often run the risk of giving up ourselves to the delusions of fancy! When we remember how minute and concealed the mouth often is in *recent* Crinoids, we should not be puzzled at its being almost or quite invisible in *fossils;* and if we should search for the interpretation of an orifice, closed by a definite low number of triangular valves, will not several recent Echinidæ (*Echinocidaris, Echinometra arbacia, Leskia* itself,) give us the answer, that such an aperture could (at least) be a vent? Nor can I well conceive that an aperture should altogether fail to exist in the centre of the ambulacral system of Cystidea. How otherwise could the ambulacral vessels communicate with the interior? And if such an orifice *must* be assumed (though it be often obliterated and hidden in the fossils), why should not this apical or ambulacral orifice be also the mouth as in Asteridæ and recent Crinoids, and the valvular orifice be the vent, analogous to the proboscis of the Palæolithic Crinoids, or the oral tube of the living?* The superiority of size of the presumed mouth is not, as Mr. Billings thinks, a very good argument. Has not the anal tube in many of our recent Crinoids (*Antedon, Actinometra, Pentacrinus*) the same preponderance over the minute buccal orifice? Nor has the repeated revision of the published descriptions of other Cystidea, accessible to me, convinced me of the correctness of a theory, according to which the mouth would, in many instances, lie very far from the arms, sometimes nearer to the base (the stalk or point of attachment) than to the apex of the calyx. The argument deduced in later times from the presumed existence of five similar peristomatic valves in the recent Pentacrini, I have elsewhere had the opportunity of refuting;† no such hard "clapets" are to be seen in *P. Mulleri,* and until their existence is *proved* in other recent Pentacrini, I must doubt, or rather deny, their existence at all!‡ On the other hand, I must confess that matters are considerably altered by these highly valuable investigations of Prof. Lovén, who, for the first time, supports this theory with strong (perhaps convincing)

* The analogy between the valvular aperture of Caryocrinus and the 'proboscis' of Crinoids is also argued by Mr. Billings (Dec. No. 3, p. 22).

† Om Vestindiens Pentacrinen, p. 205 (Vidompel. Meddel. f. d. Naturhist Forneing, 1864).

‡ Prof. Lovén told me himself that during his last stay in Paris he succeeded in getting access to the original specimen of Mr. Duchassaing, in the collection of the late Mr. Michelin. It did not show the five valves, because it had no peristome at all!

arguments. It is now no longer a mere hypothetical supposition —hitherto it was in reality no more—but a real scientific explanation, borne out by well established facts and undeniable analogies from living forms.* To Dr. Gray we certainly owe the first intimation of this analogy between Leskia and Cystidea, but while the knowledge of that genus rested on a single examination, there might still linger some doubt whether its importance in this respect had not possibly been overrated. Science, therefore, must be highly indebted to Prof. Lovén for his small but valuable memoir, and for the excellent observations laid down in it. The absolute denying of the existence of an apical orifice in that place where, in other Cystidea at least, such an orifice was also believed to exist, is particularly recommended to the attention of future investigators of Cystidea, as bearing upon the very heart of the question. *Adhuc sub judice lissit!*

NOTE BY E. BILLINGS, F.G.S.

Professor Lütken is certainly mistaken when he makes use of the expression, "It is *now* no longer a mere hypothetical supposition, hitherto it was in reality no more," etc. The earlier Palæontologists, Gyllenhal, Wahlenberg, Pander and Hisinger, described the valvular orifice of the Cystidea as the mouth, but they never proved it to be so. Indeed they could not do so, for the data, *i. e.*, the structure and functions of the arms of the Crinoids living in the sea at the present time, were not known. In 1845 Leopold von Buch pronounced the aperture in question to be an ovarian orifice, and the small one in the apex the mouth. His views were adopted by Prof. E. Forbes, in his beautiful memoir on the British Cystidea and by Prof. J. Hall in the Palæontology of New York. In my first attempt at describing fossils, in 1854, I followed these three last named distinguished Naturalists, in a paper on the Cystidea of the Trenton Limestone at Ottawa, published in the Canadian Journal. But in 1858, while re-investigating the subject for my Decade, (No. 3,) I saw that they were wrong, and proved it according to the ordinary rules of comparative anatomy. If any organ of an extinct animal is the exact homologue of an organ possessed by an existing species (of the the same zoological group), its function must have been the same.

* To these analogies might be added, that between the valves of Cystideæ and those of the young (larval) Antedon.

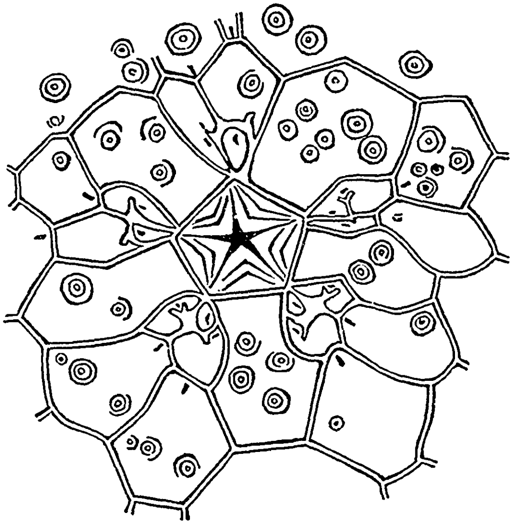

Fig. 1.

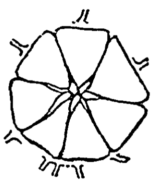

Fig. 2.

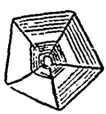

Fig. 3.

Fig. 4.

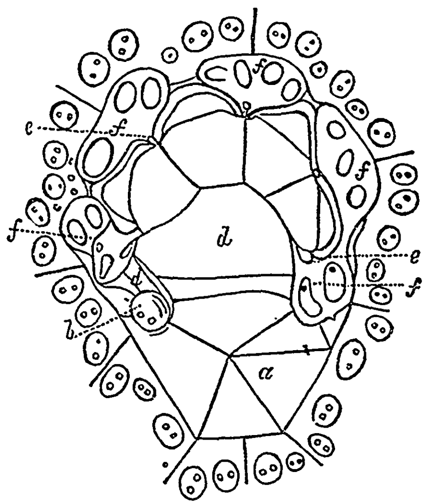

Fig. 5.

Fig. 1. Mouth and adjoining parts of *Leskia mirabilis* Gray. Fig. 2. Vent of the same. Figs. 3 and 4. The mouth of *Echinosphærites aurantium* Gyll. Fig. 5. The apex of *Sphæronites pomum* Gyll. (*a.*) The mouth. (*b.*) The genital process. (*c.*) Its ridge. (*d.*) The ambulacral area with its furrows. (*e.*) The lumen of the furrows. (*f.*) The base of the five arms.

The principal office of the arms of the existing Crinoids is the maturing of the ova. On comparing the arms of the extinct Crinoids with those of the species living at the present day, we find that both have the same anatomical structure and, consequently, they are all the homologues of each other. The small apertures, at the bases of the arms of the ancient species, are the passages through which the ovarian tubes and the vessels of the ambulacral system gained access to the grooves and pinnulæ. Their functions were first pointed out in my Decade. The arms of the Cystidea are the homologues of those of the Crinoids. This at once proves that, in the Cystidea, the orifice at the apex, which in all cases opens out into the grooves of the arms, is the ovarian aperture. The large lateral orifice is undoubtedly the exact homologue of the valvular opening in the summit of Caryocrinus which is admitted by all to be the mouth. I proved all this in my Decade, and consequently in 1858, the date of the publication of that work, the theory that the lateral aperture of the Cystidea is the mouth, ceased to be a mere hypothetical supposition as Dr. Lütken calls it.

The Cystideans are rare fossils; few Palæontologists have occasion to examine them, and consequently only a few have given their opinion on this vexed question since 1858. J. W. Salter, the celebrated English Palæontologist says: "I strongly suspect Mr. E. Billings is right; this is the anal, not the ovarian Pyramid,"* thus partly adopting my views. Prof. Wyville Thompson also agrees with me that it is not the ovarian orifice, but then he strongly opposes me in the view that it is the mouth on the same ground, that is alluded to by Dr. Lütken, *i.e.*, that it is not situated in the centre of the radial system.† Prof. J. D. Dana has recognised it as the homologue of the oral and anal aperture of the Criniods, which is exactly the opinion advocated in my Decade‡; and now it gives me much satisfaction to add the illustrious name of Prof. S. Lovén to this short list.

With regard to the grounds taken by Prof. Wyville Thompson and Dr. Lütken, I freely admit that if it is impossible for an Echinoderm to have the mouth situated anywhere except in the

* Memoirs of the Geological Survey of England, vol. iii, p. 286.

† Edinburgh New. Phil. Jour. vol. xiii p. 112.

‡ Manual of Geology p. 162.

ambulacral centre, then my theory falls to the ground. But all experience in Palæontology has proved over and over again, that although we can show that the extinct animals, whose remains we find buried in the earlier formations, possessed organs identical in their functions with those of the existing races, yet they were not always combined together in the same manner. As an example we have only to refer to the Crinoidea. In the few species known to live in the seas of the present day, the mouth and the vent are separate orifices; but in the palæozoic species they were combined into one. Why, then, is it impossible that the mouth and radial centre, which are now united, could not be separate in the earlier ages? This question, however, can be decided without argument. I have specimens lying before me, in which we can see the mouth and also the radial centre, and at the same time see that they are not in the same place. A long train of reasoning is not necessary,—only simple inspection.

A FEW POINTS OF INTEREST IN THE STUDY OF NATURAL HISTORY.

THE PRESIDENT'S ADDRESS BY THE REV. A. DE SOLA, LL.D.

LADIES AND GENTLEMEN,—The study of Natural History, if merely considered in its aspect of a branch of human knowledge, has a claim on every one's attention. It is a knowledge which is not merely power, but pleasure; and has claims great and peculiar on both the theoretical and practical man. The theoretical will find in it almost boundless scope for absorbing and interesting cogitation in such inquiries as the origin of species, spontaneous generation, the animal or vegetable character of certain obscure forms of life, the correlation of physical forces, mutual relations of the physical and vital forces, and similar modern engagements of human thought. The other great class, the practical, who have been taught by the books of their earliest youth to appreciate the difference between 'eyes and no eyes,' will also be prepared fully to admit with the student of Natural History that, merely to see an object, or to remember its name, is not to know it; and that if thoroughness of knowledge be essential or desirable in all the practical engagements of life, it must be equally so in our study of the countless objects of nature's universal domain—objects that are inseparably connected with the supply of all human necessities and comforts. But this knowledge is not merely useful, it is also elevating and interesting in the highest possible degree; and this I will proceed to show as far as I can in the brief limits to which I must confine myself, by seeking in the three great kingdoms of nature some practical illustrations of the truth of these assertions.

The animal world, from which we may take our first illustration, presents, from its lowest to its highest forms, a series of organic structures progressing with almost imperceptible gradation in perfection of development and complexity of organization. Amongst the simplest of its representatives are the Protozoa, the great majority of which are too small to be distinguished without the aid of the microscope. They are graphically described by Dr. Wm. B. Carpenter as consisting of "seemingly structureless jelly." They perform those vital operations which we are accustomed to see carried on by an elaborate apparatus without any special instruments whatever; a little particle of apparently homogeneous jelly changing itself into a greater variety of forms than the fabled Proteus,—laying hold of its food without members, swallowing without a mouth, digesting without a stomach, appropriating its nutritious material without absorbent vessels or a circulatory system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves, multiplying itself without eggs, and not only this, but, in many instances, forming shelly coverings of a symmetry and complexity not surpassed by those of any molluscous animal. And yet these creatures have performed, and are still performing, one of the chief parts in the history of this globe. With them, we arrive at that mysterious border-land which divides, and yet seemingly blends, the organic and inorganic world; where we find arising the simplest vegetable and animal structures scarcely distinguishable from each other, and beyond which we cannot proceed in our search for the beginning of life. Yet the earnest student when examining them feels with more than ordinary intensity the profound mystery of life, and will continue to investigate the phenomena they present in eager hope of new revelations. But the Protozoa have not ungenerously left without reward the researches made in their behalf. They have presented to man's astonished sight objects of marvellous beauty in the form and structure of the microscopic shells of many of them. They have also enabled him to obtain enlarged conceptions respecting the nature of species and the laws of organic life, and have taught him to recognize in these minute organisms some of the chief builders of the earth's crust,—many of its component rocks being the stupendous monuments of their labors, and in which they lie entombed.

Not without interest, also, will be found the study of the shell-fish, long considered the most inert and stupid of all animals. "Les mollusques," wrote Virey, even within our own time, "sont les pauvres et les affligés, parmi les êtres de la création; ils semblent solliciter la pitié des autres animaux." On the other hand, Lorenz Oken exclaims, "Surely a snail is an exalted symbol of mind slumbering deeply within itself!" Shakespeare's fool hit the happy medium between extremists, when he told King Lear that the reason why the snail has a house, was "to put his head in, not to give it away to his daughters, and have his horns without a case." Lucian ridiculed the philosophers who spent their lives inquiring into the soul of an oyster; but a modern writer is yet more severe on the conchologists when he says "Lucian's wiseacres were respectable when compared with their brethren, who care for neither an oyster's soul nor body, but concentrate their faculties in the contemplation of its shell." But this writer may have forgotten that the conchologist—reversing the procedure of the lawyer of the fable, who gave to his clients the shells and kept the oyster to himself—may be as much warranted in examining the waves, scales, and ribs of the shell, as is another to anatomize the contained creature, which, says Lentitius, "animal est aspectu et horridum et nauseosam, sive ad spectes in sua concha clausum," etc. Without claiming too much for the shell-fish, we may assert that the student will find them possessing quite a sufficiency of acuteness and sensibility, and their instinctive proceedings are often very surprising. Some of these proceedings of mollusks, it is true, we are not always inclined to admire; for instance, those of the Teredo, or ship-worm, that terrible destroyer of ships, landing-piers, and dockyards; though, perhaps, he may consider he is only offering just retaliation for man's unceasing warfare against his cousins—the oysters. I may not stay to take a more particular view of the mollusks, but will proceed to notice a few points of interest in the study of the vegetable kingdom.

About a century and a quarter ago, Linnæus declared the number of the different kinds of plants to be 5,938. Half a century afterwards the estimate had increased five-fold. In 1847 it was announced as 92,920; and now, Meyers and others calculate the entire vegetation of our planet to consist of some 200,000 species. The aborigines of New Zealand have learned to distinguish by name some 700 species of the trees and plants produced on their own island, a number considerably greater than that described by Theophrastus in the first history of plants ever given to the world. But besides those plants which the pious and philosophic Ray says "are by the wise disposition of Providence proper and convenient for the meat and medicine of men and animals"—besides those which enable the botanist, like his prototype in Milton's Comus, to

> "Ope' his leathern scrip
> And show simples of a thousand names,
> Telling their strange and vigorous faculties,"

we find vegetable life in its most simple form and development represented by the mere primary cell; and of the one-celled plants the most interesting order is the Diatomaceæ. The yellow-dust, which falls like rain on the Atlantic, near the Cape-de-Verde Islands, and occasionally drifts even to Italy and Central Europe, was found by Ehrenberg to consist of myriads of silicious-shelled microscopic plants. Darwin discovered that a cloud of dust, drifting through the air from America to Africa, and coming in contact with the rigging of the ship in which he was sailing, consisted of the shelly coverings of diatoms. The naturalists of the Antarctic Expedition constantly found them adhering to the lead, after sounding depths in the ocean which would have engulphed the loftiest peaks of the Andes. Humboldt, on the other hand, has shown that they float in the upper currents of the atmosphere perhaps for years, until brought down to the earth by vertical currents. But, turning from these —and the almost equally interesting family of the Fungi, which are so destructive to our bread, fruits, and other objects of domestic economy,—I would now, on the Solomonian principle of ascending from the hyssop to the cedar, say a few words respecting some of the giants of vegetation. I take, as an illustration, the celebrated big-trees of California. This group of huge conifers (placed botanically between the pine and the juniper) was discovered in 1850, by some hunters when pushing their way through a hitherto unexplored forest in the Calaveras country, about 240 miles from San Francisco. It is deeply to be regretted that cupidity and vandalism have led men to hew down the largest of the group, for the purpose of making a show of it. One measured ninety-six feet in circumference, and afforded ample space for thirty-two persons to dance on; theatrical performances were given on it in 1835; it measured three hundred and two feet as it lay on the ground. The so-called 'Mother of the Forest' is ninety feet in circumference, and three hundred and twenty-seven high. The largest, called the 'Father of the Forest,' is forty-two feet in circumference and four hundred and fifty high—only a few feet lower than the Pyramids of Egypt. As a set-off to this barbarity—which, be it said, no where called forth greater indignation than in the United States, —the Wellingtonia,* as these trees were called by the English (Washingtonia by the Americans), have become acclimated in England and Scotland, where their growth, first recorded in inches, is now annually reported in feet. The propagation of these trees lead us to examine, as points of interest in the vegetable kingdom, the more general subjects of the propagation of plants by nature's wondrous provisions, their fertility and preservation.

Recurring for an instant to the Diatomaceæ, I may here remark that the existence of these minute uni-cellular organisms may lead the uninitiated to doubt whether they could well answer that apparently easy question, What is a plant? Further investigation would show that it is difficult for the greatest adept to do so, and that when it is attempted to draw a line of demarcation between the primary conditions and forms of animal and vegetable life, no problem in the science of nature is more obscure; and the difficulty increases too with our knowledge. Perhaps this may be sufficiently shown by those familiar objects, the sensitive plant and the sponge. It was always held by naturalists that the property or character distinguishing animals from plants is feeling, which is evinced in the lower forms of animal life by their shrinking from the touch. But when we try vegetables as well as animals by this rule, we find many plants (one example is the *Mimosa pudica*, or sensitive plant) endowed with a far higher degree of susceptibility to external impressions than is evinced by some of the lower races of animals under the

* Dr. Torry has shewn conclusively that these trees belong to the genus Sequoia.—Ed.

operation of tests which, if applied to the higher races, would amount to torture. Thus, the art of ingeniously tormenting has been exhausted in vain upon the imperturbable sponge, which is so endowed with vital powers as to render its animal nature unquestionable;—lacerated with forceps, bored with hot irons and saturated with the fiercest acids of the chemist, it has never once given any symptom of suffering or sensibility. These facts may be sufficient to show that no difference of a physical or chemical nature can be established between plants and animals in that low part of the organic world where these two great divergent branches have their source, and that any attempt to separate them must be arbitrary and artificial. Here, then, the student of Natural History learns the great lesson of a fundamental unity prevailing throughout organic nature; he sees exhibited to him a sequence without interruption in the working out of the divine idea of creation from man spiritual and immortal, in whose wonderful organization meet and culminate the structural perfections of all the animals, down to the primary cell in which both vegetable and animal life exhibits its simplest form of development.

Turning now to the third of nature's great kingdoms, I would remark that no one has ever questioned the utility of that study which directs and guides us in our search within the bowels of the earth for the ores and other substances that are at once the sources of national wealth and the supply of human wants and comforts. But while the utility of the study of mineralogy is everywhere conceded, geological research, which is inseparably connected with it, has been regarded not without much suspicion and disfavor. Irrespective of the fact that all quarrying and mining undertakings must be properly based on and directed by, geological knowledge, how different the aspect which a section of country exhibits to the eye of a geologist and of the uninformed spectator. Whether it present sand, gravel or alluvial soil, and in its form, hill or valley, solid rock or detached boulders—all add to the interest and pleasure of the scientific observer. The stone turned up by the ploughman, and which would not interrupt his whistle, or call forth the slightest interest in the stolid wielder of pick and mattock, has, for the geologist, sermons and histories, exhibiting to him mighty changes and wondrous revolutions, that have completely changed the surface of the globe he lives on. The careless laborer breaks the stones that have no other interest in his eye than that they are intended to mend roads; and the quarryman cuts out his slabs, the highest utility of which he deems their appropriation to building or ornamental purposes. Both crush or cut to pieces, in all the blindness of ignorance, the fossil forms of unknown organisms contained in them, but from which the geologist learns the botany and zoology of former ages of the world, and which enable him to predict the great changes to take place in the future. The achievements of geology are, however, too numerous and important even to be glanced at within my limits, but I would venture to say something respecting one of its sub-divisions—Ichnology, or the study of fossil footsteps—revealing to us wonders of the past such as the imagination of even a Milton or a Danté could never conceive.

Possibly Robinson Crusoe himself was not so much astonished at the footprints on the sands of his desolate island, as the naturalist who first saw the footmarks of birds on a slab of sandstone which was turned up by the plough of an American boy in 1802, at South Hadley, in the valley of the Connecticut River. From this valley, the tide of conjecture flowed over other continents, until it seemed finally to settle down into the theory that the Noachic flood had rolled over those sandstone slopes, the surface of which, when the waters subsided, was so soft as to readily receive the imprints of a bird's foot. The traces, then, were those by which the raven of Noah had written the historical fact of his standing on the earth itself; and so the foot-prints were finally set down as those of Noah's raven. For another quarter of a century or more, this dictum of popular ignorance remained uncontroverted, men of science paying but little attention to it, until a Scotch clergyman, Dr. Henry Duncan of Ruthwell, in 1828, called attention to fossil tracks in connection with the sandstones of Corncocklemuir. Dean Buckland, by means of his Bridgewater Treatise, gave wide circulation to Duncan's discoveries, showing that these impressions were found through a depth of forty-five feet of rock, not on a single stratum only, but on many successive strata, thus demonstrating that they had been made at successive intervals. The sandstones of Dumfrieshire are supposed to have been wide-spread expanses of sand of a littoral character, visited and covered by the ancient tides, some of their surfaces, recording atmospheric conditions, being sometimes pitted with hollows, the results of a pelting shower, and these pittings have occasionally such a well-defined and distinct course, that one can ascertain the direction of the wind, which bore the rain clouds along with it. The sandstones of Cheshire, again, exhibit sufficient evidences of solar influence. We find here the sun-dried surfaces of the clayey strata associated with the sandstone, over which animals formerly crawled, cracked and shrunk by the solar beams. Sometimes they present beautiful sand ripples, the result of a gentle breeze breaking the stiff surface of a shallow pool of sea water on these sandy shores. There may also be found instances of the evaporation of salt-water, and the crystallization of sea-salt, from the natural salt pans of the ancient beaches. Another noticeable fact is the almost constant and uniform direction of the impressions. They nearly all indicate that the animals, which Sir William Jardine shows must have belonged to some forms of tortoise, walked from the west towards the east. Further discoveries of fossil footsteps were made in the United States in 1835; the impressions resembled the feet of birds, and were found in the sandstone rocks near Greenfield. Dr. Hitchcock, President of Amherst College, showed that they were actually produced by the feet of living birds, and that one of the tracks had been made by a pair of feet, each leaving a print twenty inches in length. Says the eminent Owen: "Under the term *Ornithichnites giganteus*, Dr. Hitchcock did not shrink from announcing to the geological world the fact of the existence, during the period of the deposition of the red sandstone of the valley of the Connecticut, of a bird which must have been at least four times larger than the ostrich." Says Hugh Miller, "I have already referred to flying dragons, real existences of the Oolitic period, that were quite as extraordinary of type, if not altogether so huge of bulk, as those with which the Seven Champions of Christendom used to do battle; and here we are introduced to birds that were scarcely less gigantic than the roc of Sinbad the sailor." I might add to Miller's remarks, that the Bar Yuchné, that enormous bird of the Talmudic legend, seems to find identification here.

But I must hasten to conclude these remarks, already too long. They must necessarily convey but a very faint idea of the boundless field of interesting and pleasurable inquiry awaiting the student of Natural History; still, I trust, they will not be without effect in leading into this field, some of those who have not hitherto entered at all. To such my concluding words would be in the accents of caution and advice. I would say, You must needs fearlessly concede to modern science all that is claimed for it, to this extent, that in its dealings with the great physical powers or elementary forces which pervade and govern the material world, it has been led or even forced into a bolder form and method of inquiry,—that inductions of a higher class have been reached, and generalizations attained, going far beyond those subordinate laws in which science was formerly satisfied to rest,—that the precision and refinements of modern experimental research strikingly distinguish it from that of any anterior time,—that physical researches generally in our own day have a larger scope and more connected aim, experiment being no longer tentative merely, but suggested by views which stretch beyond the immediate result, and hold in constant prospect those general laws which work in the universe at large. But, let it be ever remembered that there is also exhibited in our own day, a marked fondness for what is new and difficult and unintelligible in philosophy,—a spirit that takes pleasure in stigmatizing as hindrances to truth in physical science, all such opinions as are fostered by ancient and popular belief, including those which assume Scriptural authority for their foundation. In their too hot zeal against dogmatical authority, we find some falling into the opposite rashness of lending their authority and favour to hasty and partial experimental deductions, or to doctrines still in their infancy, and checked or controverted by opposite opinions of equal weight. Let, then, the dangerous effects of gratifying too prevalent a taste for transcendental inquiries in science be duly marked and carefully avoided, regarding it as cause for gratitude and felicitation that they are corrected by the cotemporaneous activity of those philosophers who make experiment and strict deduction the sole measure and guides of their progress.

ON SEEDS AND SAPLINGS OF FOREST TREES.

By Dr. J. D. Hooker, F. R. S., etc.*

Forestry, a subject so utterly neglected in this country, that we are forced to send all candidates for forest appointments in India, to France or Germany for instruction both in theory and

* One of the Reports on the Paris Exhibition.

practice, holds on the continent an honourable, and even a distinguished place amongst the branches of a liberal education. In the estimation of an average Briton, forests are of infinitely less importance than the game they shelter, and it is not long since the wanton destruction of a fine young tree was considered a venial offence compared with the snaring of a pheasant or rabbit. Wherever the English rule extends, with the single exception of India, the same apathy, or at least inaction, prevails. In South Africa, according to the colonial botanist's reports, millions of acres have been made desert, and more are being made desert annually, through the destruction of the indigenous forests ; in Demarara the useful timber trees have all been removed from accessible regions, and no care or thought given to planting others ; from Trinidad we have the same story ; in New Zealand there is not a good Kandi Pine to be found near the coast, and I believe that the annals of almost every British colony would repeat the tale, of wilful, wanton waste and improvidence.

On the other hand, in France, Prussia, Switzerland, Austria, and Russia, the forests and waste lands are the subjects of devoted attention on the part of the Government, and colleges, provided with a complete staff of accomplished professors, train youths of good birth and education to the duties of state foresters. Nor, in the case of France, is this law confined to the mother country ; the Algerian forests are worked with scrupulous solicitude, and the collections of vegetable produce from the French colonies of New Caledonia, etc., contain specimens which, though not falling technically under Class 87, abound in evidence of their forest products being all diligently explored.

The collection exhibited by the Administration of Forests of France is by far the finest of its kind ever brought together; the enumeration of its contents alone fills an instructive pamphlet of 160 octavo pages, classified as follows, and which further contains a great deal of useful information on the geology of the forest regions, the growth, strength, and durability of timber, and many other matters concerning which no certain information is obtainable in this country. It consists of:—

1. Forest map of France, showing the relations between the distribution of the forests and the geology of the country.

2. A collection, in the shape of books, of the indigenous and naturalized woods. Each species is represented by several specimens, differing in their origin and qualities. The specimens, of which there are 1,300, are divided into two classes; namely, woods of ordinary leaf-bearing trees, and of conifers; these in each class are arranged alphabetically.

3. Collection of truncheons of the most important indigenous species; 223 specimens.

4. Experiments and observations on the density of woods, particularly with regard to age. Specimens exemplifying the opinions given.

5. Collection of seeds and fruit of indigenous and naturalized species.

6. Complete collection of corks of all ages and qualities, and of French production, furnished by the cork oak (*Quercus suber*) and the western oak (*Q. occidentalis*).

7. Barks and astringent substance suitable for tanning or dyeing.

8. Resins from the *Pinus maritima* and *P. Laricio;* methods of procuring them, and their various products.

9. Charcoals.

10. Different products resulting from the carbonization of wood.

11. Forest sawmills; three models.

12. Instruments for felling, prunning, etc., trees, and for collecting resin. A pusher for directing the fall of trees felled by uprooting. The 'Flamm' saw Rollers for the removal of logs from young plantations without injury to the latter.

13. Relievo of the valleys of Barr and Andlau (Lower Rhine), to show the arrangement of the forest roads established there. Sledge tracks with sledges, tramway with waggons, metalled roads.

14. Relievo of the perimeter of the plantations of Labouret, above Digne (Basses Alpes). Photographs of mountains to be laid down with grass or replanted.

15. Photographic forest herbarium, consisting of photographs of the branches with leaves, fruit, and flowers of the various forest trees, all of the natural size.

It only remains to add that the specimens are well selected and excellent, the method of ticketing leaves very little to be desired, and the arrangement is admirable.

With regard to the other collections, chiefly appertaining to Class 87, the reporter has little to say; there was no English exhibitor, and up to the end of April, when the jurors were called together for the purpose of deciding upon the merits of the exhibitors, there were no collections of any importance ready for adjudication.

Further, various circumstances occurred that rendered it impossible to consider certain collections of plants, some of whose contents might be considered as referable to Class 87, from other cognate classes, and it hence became necessary to amalgamate the duties of Class 87 with those of other classes, including that class under which hardy conifers more naturally came, as objects of landscape gardening or ornamental planting, and not of forestry proper. Under this head comes the beautiful collection of hardy conifers of Messrs. Veitch & Sons, to which the first prize was awarded, with the full complement of marks; and the same firm carried off the first prize for a collection of the rarest Coniferæ not yet in commerce.

The collection at Billancourt, which did not exist in April, was visited by Dr. Moore, F.L.S., associate juror, in August, and he found many very interesting plants suited for forest purposes amongst them, but they were not exhibited under Class 87, and I shall therefore allude to them here in reference to their being probably, at some future period, introduced into plantations in such considerable quantities as to be profitable as timber trees.

M. Accidin, nurseryman, Lisseux, was awarded the first prize for a collection of forest conifers, which consisted of the kinds usually selected for the same purpose in England, along with many rare species which are not yet sufficiently abundant for forest planting, though they may yet become suitable for that purpose when the prices at which they now sell are lowered at least ninety per cent. *Pinus grandis*, *P. nobilis*, *P. Nordmanniana*, *P. Benthamiana*, *P. Coulteri*, etc., all of which were in this collection, are not likely to be either moderate in price or plentiful for many years to come. There were equally rare Thujas and Cupressus in this collection, as well as other scarce coniferæ, which obviously cannot be considered under Class 87.

M. Accidin had also a large collection of trees generally used in forest planting, such as oaks, Juglans, willows, etc.

Among the oaks, *Quercus castaneæfolia*, *Q. ambigua*, *Q. aquatica* and *Q. haliphlæos* were fine foliaged kinds.

M. Rissot, Inspector of the Forests of the Bois de Boulogne, exhibited a good collection of conifers, more suitable in general for forest planting; among which were some Mexican species of Pinus, which seemed hardy looking kinds. The same exhibitor had also a good general collection of forest trees.

A series of plants were also exhibited for the purpose of showing the effects of prunning by different methods, preparatory to planting in forests and in towns, as well as for ordinary ornamental purposes. This was not a successful exhibition, as many, in fact nearly all, the trees which had been brought for the purpose were dead, owing to their having been removed at a late period of the year.

ON THE EXTRACTION OF COPPER FROM ITS ORES IN THE HUMID WAY.

By Thomas Macfarlane.

In a former paper on this subject published some time ago in this Journal,* I described a series of experiments, which had, for their object, the economical extraction of the copper contained in the poor pyritous ores of the Eastern Townships. The results of these experiments may be briefly stated here. It was shewn—1st, That it is impossible to remove from a very pyritous ore, by simple calcination with common salt, and lixiviation with water, more than a small proportion of its copper contents; 2nd, That by calcining such an ore with twice its weight of impure iron oxide, and the necessary quantity of common salt, it is possible to remove 95 per cent. of the copper; 3rd, That, if, in such an operation, a temperature much above redness be employed, copper is, to a considerable extent, volatilized; 4th, That in order to complete extraction it is necessary that the materials should remain undisturbed during calcination; 5th, That even with the use of a large quantity of iron oxide and salt, it is impossible to extract the whole of the

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* Vol. ii [2nd series], p. 219.

copper from ores containing purple copper or copper pyrites, without any admixture of iron pyrites. Although in some respects very successful, these experiments still left much to be wished for. Ores deficient in sulphur could not at all be efficiently treated. Even the pyritous ores required to be mixed with a large quantity of iron oxide in order to the complete removal of the copper. This, although favorable to the extraction, largely increased the bulk of material to be treated, and consequently the cost of calcining.

While visiting the Bruce and Wellington mines, on Lake Huron, last summer, I was forcibly reminded of the vital importance to them of an easy and economical process for extracting the copper of their ores, which consist, almost exclusively, of copper pyrites in a matrix of quartz. It may be safely assumed that one-fourth to one-third of the copper in these ores is lost in the present system of ore dressing. Of equal importance would such an economical humid process be to the Harvey Hill mines, in Megantic county, Quebec, where the ores are also too poor in sulphur to be advantageously treated by any known extraction process. It occurred to me that the difficulty, caused by the scarcity or absence of sulphur, might be overcome by furnishing the ore with sulphuric acid in the shape of calcined sulphate of iron, giving it at the same time the proper proportion of common salt, from the decomposition of which by the sulphate of iron chlorine might be developed for the formation of proto-chloride of copper. It next occurred to me that on precipitating the copper from the solution of the latter salt by metallic iron, a solution of proto-chloride of iron would result, which, on evaporation to dryness, would furnish an effective re-agent for treating fresh portions of ore. And, lastly, it appeared to me, that an easy method of procuring this proto-chloride of iron in the first instance would be to dissolve together equivalent quantities of green vitriol and common salt, crystallise out the sulphate of soda, and evaporate the mother liquor to dryness. The proto-chloride during evaporation might become partially oxidized, but this would not lessen its effectiveness in the proposed application.

At the first opportunity I proceeded to ascertain by experiment, in the laboratory, whether these ideas were capable of being applied successfully, and the following is an account of some of the trials made. Through the kindness of James Bennetts, Esq., Manager of the West Canada Company's works on Lake Huron, I had been furnished with various samples of ores from their mines. Slimes from the Wellington and Copper Bay mines were first operated on by calcining them with proto-chloride of iron in a muffle furnace at a dull red heat. Fumes of volatilized chlorides were abundantly developed, especially on stirring the mixture. The results obtained were very variable. With Wellington Mine slimes of 2.9 per cent., one experiment gave 0.5 per cent. copper soluble in water, 0.7 per cent. insoluble and 1.7 per cent. volatilized. In a second trial with the same slimes and a larger quantity of chloride, 1.5 per cent. were dissolved, 0.8 per cent. left insoluble, and 0.6 per cent. volatilized. In a third experiment with Copper Bay slimes of 2.1 per cent., the whole of the copper was rendered soluble. But such a result as the last mentioned was only attainable occasionally, and it became very evident that high temperature and unlimited access of air often combined to make the result unfavorable and at least uncertain. The temperature at which the sulphurets contained in the slimes oxidized, seemed to be so high as to cause a sublimation both of the chlorides of iron and copper. I therefore, in the subsequent experiments, calcined the one previous to treating it with chloride of iron.

The ore next operated on was an average sample of the crush-work at the Wellington Mine, as it comes from the crusher to the jiggers in the ore dressing works. On shaking it on a sieve having fifteen holes to the lineal inch, it was separated into a coarser and finer part, the former assaying 2.6 per cent. and the latter 5.2 per cent copper. On calcining and further pulverising the finer part, and sifting it on a finer sieve, it separated into one part, coarser in grain, and containing 4.41 per cent. and three parts finer containing 5.58 per cent. copper. The latter sort was heated over a spirit lamp, with one-fourth of its weight of proto-chloride of iron, in a retort through which a current of air had passage. In one experiment 3.9 per cent., and in another 4.3 per cent. of the copper contents were rendered soluble in water. In the first experiment water dissolved out proto-oxide of iron along with the copper, but in the second, which had been heated longer, all iron in the solution was present as peroxide.

Having observed in one of these experiments, that the air contained in the retort seemed sufficient for converting the proto-chloride of iron into perchloride and peroxide, ($6\ Fe\ Cl + O_3 = Fe_2\ O_3 + 2\ Fe_2\ Cl_3$), it occurred to me that the current of air passing through the retort might be dispensed with. Twelve grammes, calcined ore from the Wellington Mine, assaying 5.22 per cent., were intimately mixed with three grammes of the dry chloride, and heated over a spirit lamp in a common digesting flask for twenty or twenty-five minutes. These experiments resulted as follows:

	I.	II.	III.
Dissolved by water per cent.	4.76	4.76	4.96
Remaining in residue "	.59	.32	.28

In II and III there were respectively extracted 91.18 and 95.02 per cent. of the copper contents. The residues contained respectively one-third and one-fourth of one per cent. copper. None of the solutions obtained in these experiments contained any protoxide of iron, but there was abundance of peroxide present. This proves that, although an excess of proto-chloride was used, all of it was decomposed as above explained. Little or none of the perchloride of iron was observed to sublime during the heating. It would therefore seem that, in these experiments, the protoxide of copper was converted into proto-chloride by simply exchanging its oxygen for the chlorine of the perchloride of iron ($3\ Cu\ O + Fe_2\ Cl_3 = 3\ Cu\ Cl + Fe_2\ O_3$).

Although the calcareous nature of the ores of Acton Mine gave little hope that experiments on them with this process would be successful, I nevertheless tried a few, but never obtained more than one per cent. of copper from an eight per cent. ore.

Ore of five per cent. from the Albert Mine, near Lennoxville, was next calcined and heated with one-fifth of its weight of chloride, as above described; 90.2 per cent. of its copper was rendered soluble in water.

I next returned to experimenting with the slimes from Wellington Mine, which had been unsuccessfully treated by calcining them with the chloride in the muffle. They were first calcined, and then leached out with hot water, whereby some sulphate of copper formed in the calcination was removed. After drying they assayed 1.77 per cent. Ten grammes mixed with one gramme of the chloride and heated over the spirit lamp for fifteen minutes gave up 1.33 per cent. of its copper to water, while 0.44 per cent. remained in the residue. The same quantities heated for twenty minutes gave 1.55 per cent. soluble and 0.22 per cent. in the residue. Neither of the solutions contained protoxide of iron, and of peroxide, the solution from the first experiment gave more than that from the second.

The plan of using the chlorides of iron for the extraction of copper is not proposed here for the first time, but the manner of using it advantageously, as indicated by the above experiments, differs essentially from those heretofore proposed. The above experiments shew that direct calcination of a raw ore with the re-agent, under unlimited access of air, seldom leads to a successful or a reliable result. On the other hand, when the ore is previously calcined, the temperature kept low, and the current of air excluded, the application of the chloride becomes advantageous and practicable.

In the above trials, and others which have not been mentioned, the copper was sometimes determined volumetrically, and sometimes precipitated by iron and weighed. The residual solutions from the latter operation were evaporated to dryness, and the proto-chloride of iron recovered. The precipitated copper was easily compressed, in a diamond mortar, into little solid cakes readily fusible to buttons before the blow-pipe.

This process of extracting copper would seem to be capable of affording more reliable and more economical results than any hitherto proposed. Any ores, whether rich or deficient in sulphur, may be treated by it, except those containing carbonates of lime or magnesia. The exclusion of air, and the low temperature employed, render a decomposition or volatilization of the proto-chloride of copper, when once it is formed, impossible. There being no free acids in the solutions obtained, an equivalent quantity only of metallic iron is consumed. By evaporating the residual solutions, the re-agent is always recovered, and thus a further saving is effected. The amount of copper contained in the insoluble residues, is, in most cases, below, and never exceeds that of copper furnace slags, while the cost of the process will not exceed one-third of the expense of the ordinary method of producing copper from its ores by smelting.

With regard to applying it on the large scale, there would appear to be no grounds for anticipating any difficulty. The pulverisation of the ore would be most economically effected by wet stamps. If allowed to drain thoroughly, after being thrown out of the slime pits, it could then be completely dried and calcined, at the same time, in reverberatory or other furnaces. The roof of these furnaces might consist of cast iron plates which might form the hearths of chambers wherein the operation of heating the roasted ore with the chloride might be performed. The lixiviation is a matter of no difficulty, and with regard to precipitating the copper, it would be well to do this quickly, in vats heated by steam, in order to obtain a perfectly pure product. The evaporation of the waste solutions might be effected by waste heat from the calcining furnaces without any special expense for fuel. In short, there is nothing to prevent its economical application, and in all probability, an establishment for treating copper ores in this manner will shortly be established in connection with one of our Canadian Mines.

Actonvale, January 11th, 1869.

ON THE ORGANISATION OF MOSSES.

By R. BRAITHWAITE, M.D., F.L.S. *

In former times many of the smaller cryptogamic plants were termed mosses, and although no order of plants is better defined or more readily recognized, the name is still vulgarly applied to lichens, as Iceland Moss, Cup Moss, and the shaggy forms growing on old trees; to algæ as Irish Moss; and even to some fungi. But the plants we have to consider are the mosses *par excellence*, Musci veri, or frondosi, as they have been termed, to distinguish them from the Musci hepatici, or liverworts.

By the ancients this group was but little regarded, for then plants were sought after on account of their real or supposed medicinal virtues; yet they had a Muscus cranii humani, or moss of a dead man's skull, which no doubt in the days of signature medicine was found of great service in head complaints. The first special work on the subject is the Historia Muscorum of Dillenius, published in 1741, remarkable for the excellence of its engravings, and containing also lichens and algæ.

Linnæus enumerates many mosses in his Species Plantarum, but he seems to have paid little attention to cryptogamic plants,

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* Read before the Quekett Microscopical Club, June 28th, 1867, and cited from Science-Gossip.

and hence often confounded them. His erroneous notion, that the capsule was an anther, and the spores pollen, led his followers astray, though we may chiefly attribute it to the want of sufficient optical assistance.

John Hedwig, however, now gave to the world those great works which have rendered his name immortal, and fully entitle him to rank as the founder of Bryology. He was undoubtedly the first to discover the sexual organs in these plants, and his clear diagnosis of species is indicated by the great number which still bear the names he imposed.

These were followed by the valuable Bryologia Universa, and other works of the learned Bridel, whose critical eye greatly augmented the number of species; and in our day Wilson, and Mitten, and, lastly, Professor Schimper, have immensely extended our knowledge of them, the Bryologia Europæa, of the last named author, being the grandest contribution ever made to a single department of botanical study.

Bridel heads the first chapter of his Muscologia Recentiorum with the querry, "Quid sit muscus?" (What may a moss be?), and this I hope you will be able to answer, after becoming acquainted with the details of their structure.

The mosses, to a cursory observer, may appear uninviting from their minuteness and apparent similarity, yet when we call the microscope to our aid, the exquisite beauty of their structure is at once apparent. They are entirely cellular, and it is not surely a subject for admiration, that by mere diversity in form, arrangement, and construction of cells, we are able to characterize near 9,000 species in this one class of plants?

THE SEED OR SPORE—This is very minute, yet varying in diameter between $\frac{1}{6}$ and $\frac{1}{100}$ of a millimetre; in some minute mosses it is of large size, the capsule containing only ten or twenty spores; in others it is very minute and innumerable. The spore is globose, of a yellow, rufous, or brown colour; its surface smooth or covered with rough points, and it consists of a mother cell, or primordial utricle, enveloped in an outer coat, or exospore, the contents being chlorophyl, starch, and oil globules, with mucus.

The first result of germination is the rupture of the outer coat, and protrusion of the primordial utricle or cell, which immediately commences division, the new cells repeating the process, until a dense felt of branched confervoid threads results, which we term the prothallium, and forming the green film we may often notice in spring coating damp walls. and banks, and long mistaken for species of algæ (figs. 1, 2, 3). From various cells of this, young

Fig. 1. Spore of Funaria hygrometrica.

Fig. 2. Spore of Funaria hygrometrica germinating.

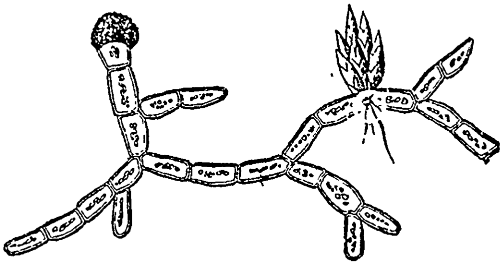

Fig. 3. Prothallium and young plant.

plants are developed, whose fine radicles penetrate the soil; their leaves shoot up, and they become like the parent from which the spore emanated; and being now capable of maintaining an independent existence, the prothallium, no longer needed, dies away, except in a few minute annual mosses of delicate texture, where it is persistent during their whole life. But some mosses rarely produce fruit; yet it is necessary that their reproduction should be ensured, and we find prothallium also developed from tubercles on the roots, from gemmæ or buds occurring on the leaves, or even from the cell-tissue of leaves themselves; while in some mosses a portion of the leaves become altered into gemmæ, and clustered in a head on the top of a naked stalk called a pseudopodium, as in *Tetraphis pellucida* and in Aulacomnium (fig. 4).

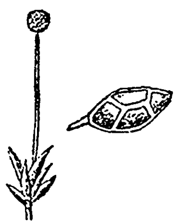

Fig. 4. Pseudopodium of Aulacomnium androgynum, with one of the gemmæ.

The roots.—These are slender fibrils, by which the plants are attached to their place of growth—the soil, crevices in the bark of trees, or rocks—and consist of a single series of cells, the septa between which are always oblique to the axis of the filament. Adventitious radicles or rhizinæ of a brown or purple colour also frequently occur on the stem, uniting the plants into a dense matted tuft, and like a sponge conveying water to every portion.

THE STEM.—Often simple, and sometimes so short as to appear wanting, it is in the terminal fruited mosses repeatedly forked, for on the cessation of each annual growth, a lateral bud is thrown off at the apex, producing an innovation or secondary stem; in the lateral fruited mosses, however, the stem is truly and repeatedly branched. It is of the same thickness throughout, for it grows only at the apex, or is acrogenic, and is composed of dense elongated cells, which thus render it firm and tough, those of the outer layer being often richly coloured.

THE LEAVES.—These are always sessile and simple, their form usually ovate or lanceolate, but varying in every degree between orbicular and awl-shaped. They are inserted spirally on the stem, though sometimes appearing to be distichous, or in two opposite rows; they may be erect, or spreading, or reflexed, or curled, and again they may be secund, or all turned to one side. The margin may be simple, or have a thickened border, entire or toothed, plane or wavy, involute or revolute.

The leaves may also be nerveless, but usually there is a central nerve, which may be short, or reach the apex, or be excurrent in a point, or long hair, and some mosses have two nerves. In the Polytricha, the nerve consists of a number of erect lamellæ, on its upper surface. The leaves consist of a single, sometimes of a double, or triple stratum of cells, the form and arrangement of which constitute the areolation, and afford characters of the greatest importance in the diagnosis of species, indeed used by some recent Bryologists, as Carl Müller and Hampe, for the chief divisions in classification.

In form, the cells are hexagonal, but varying to quadrate, rohmboidal, or linear, according to the density of their arrangement, and their surface may be smooth, or covered with minute papillæ. They contain granules of chlorophyl, which is often beautifully distinct, and the cause of the fine green colour, well seen in *Bryum capillare*, while in others it is expended on the growth of the cell, or the thickening of its walls, and thus in many mosses, while the cells in the upper part of the leaf retain their chlorophyl, those at the base are empty, hyaline, and elongated; in a few mosses the chlorophyl is wanting, and hence they have a white aspect, as in the family Leucobryaceæ.

Occasionally the basal wing of the leaf is occupied by cells, which differ from the rest, being enlarged or deeply coloured, and the presence or absence of these alar cells has been conveniently used by Prof. Schimper to divide the great genus Dicranum into two sections. When the cell-ends join by horizontal walls, they are termed Parenchymatous, and in one form of these, the cell walls are thickened, and the cell proper reduced to a mere point, producing the dotted areolations of Grimmiaceæ and others (figs. 5, 6). When the cell ends are pointed, we have rhombic areolæ,

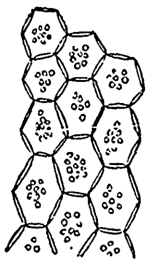

Fig. 5. Areolation of Pottia truncata.

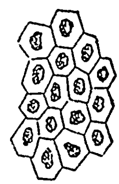

Fig. 6. Areolation of Grimmia apocarpa.

and these are termed Prosenchymatous, as in Bryum (figs. 7, 8). I must add that occasionally stipuliform organs occur intermixed with the stem leaves, as in *Hypnum molluscum;* these are named Paraphyllia.

An anomalous form of leaf occurs in the genus Fissidens, in which it appears to be vertical, and split into two laminæ for a part of its length. This split portion is, however, the true leaf, but the nerve and one wing have taken upon themselves extraordinary development, and there is also a lamina formed along the back of the nerve, these additional parts being named the apical and dorsal laminæ (fig. 9).

The reproductive organs.—It is now satisfactorily determined that these are of two kinds, male and female, and unless they occur near each other, the fruit is not produced; as an instance, I may refer to *Fissidens grandifrons,* of which male plants only have been found in Europe, female only in America, hence the fruit is unknown.

Hedwig was the first who pointed out the nature of these minute organs, but his views were long opposed, for Roth and Meese asserted that when sown, they produced young plants, and hence were gemmæ or buds.

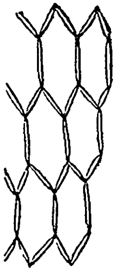

Fig. 7. Areolation of Bryum cæspiticium.

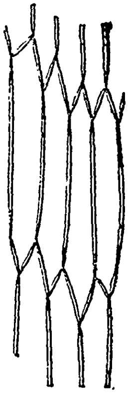

Fig. 8. Areolation of Hypnum rutabulum.

As in flowering plants, we find the sexual organs present three modes of arrangement, and the species may be:—

Synoicous—when male and female organs are combined.

Monoicous—when they are separate, but on the same plant.

Dioicous—when separate, and on different plants.

The male or barren flowers are either terminal or lateral, and consist of an involucre of minute leaves termed the perigonium;

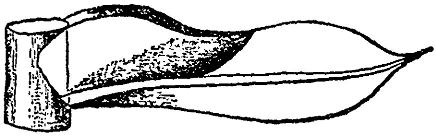

Fig. 9. Leaf of Fissidens taxifolius.

these perigonial leaves vary in number, and in form and texture differ considerably from those of the stem, becoming gradually thinner and more delicate toward the centre. Some mosses have no perigone, but the male organs nestle in the axils of the stem leaves; in others the flower terminates the stem as a beautiful disc or rosette, well seen in the coloured heads of Polytrichum; and again it may be gemmiform, or like a minute bud composed of a few imbricated leaves, as in Hypnum.

Enclosed by the perigone are the antheridia, organs analogous to the stamens of flowering plants; these vary in number, are somewhat sausage-shaped, and usually intermixed with them are numerous jointed threads termed paraphyses, whose use no doubt, by the mucus they contain, is to keep moist and preserve the vitality of the antheridia, for in the open discoid flower they are most numerous, but in the closed gemmiform flower few or none (fig. 10). The antheridial sac contains the Spermatozoids, minute clavato-filiform bodies with two cilia, and coiled spirally, which on the rupture of the antheridium move about with great activity; they are most readily seen in the Polytricha (fig. 11).

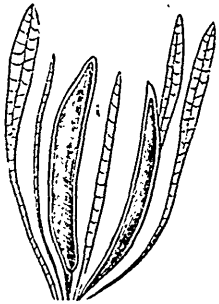

Fig. 10. Two Antheridia and Paraphyses of Polytrichum.

The female or fertile flower, in a similar way, consists of leaves forming a perigynium, which enclose the archegonia, corresponding to the pistils of flowering plants; and so the oval base of an archegonium is named the germen, enclosing in its centre the germinal cell, and the tapering upper part the stylidium (fig. 12).

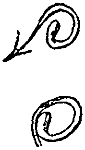

Fig. 11. Spermatozoids.

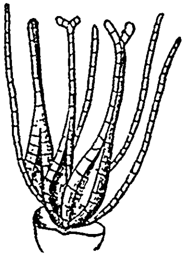

Fig. 12. Three Archegonia and Paraphyses of Bryum.

The inner leaves of the perigynium, as the fruit forms, become enlarged into a sheath round the base of the fruit stalk, forming what is called the perichætium, which is very distinct in Hypnaceæ.

Of the archegonia in each flower, seldom more than one is fertilized; sometimes, however, four or five may be, and we have as many fruits enclosed in one perichætium as in Mnium and *Dicranum majus*.

Having made you acquainted with the reproductive organs, we shall be prepared to follow out their functions. As stated, the antheridium at maturity bursts at the apex, and out pass the spermatozoids as a cloud of active particles; the archegonium equally prepares for their reception, the apex of the stylidium ruptures, the edges of the aperture roll back forming a trumpet-shaped orfice, from which we can trace a fine duct passing down to the germinal cell, and more evident now because it has acquired a reddish tinge. Both Hofmeister and Schimper have seen the spermatozoids within this canal.

The germinal cell, now fertilized, immediately commences its own proper development, first downward; perforating the base of the archegonium, it fixes itself in the receptacle or apex of the stem, just as a stake is driven into the earth; then upward to form the seta or fruit stalk, and the contents of the archegonium being thus consumed, its delicate walls are ruptured, the lower part remaining attached to a process of the receptacle, as a little sheath—the vaginula (fig. 13); the upper carried aloft, becomes

Fig. 13. Young fruit of Orthotrichum crispum, showing Vaginula and hairy Calyptra.

Fig. 14. Mitriform calyptra of Encalypta.

the calyptra, or veil, and the seta, having attained its full length, begins to enlarge at the apex to form the capsule.

THE CALYPTRA OR VEIL envelops the young fruit, and is thin and membranous; it is sometimes torn irregularly, or it remains even at the base, when it is termed mitriform, or it is slit up on one side, when we call it cucullate or dimidiate; it is usually smooth, but sometimes densely hairy (figs 14, 15, 16).

THE THECA OR CAPSULE.—This presents an infinite variety of forms, but all of the greatest elegance; it may be globose, ovate, pear-shaped, or cylindric, straight or arched, erect or pendulous, smooth or furrowed. In some it is swollen all around at the base,

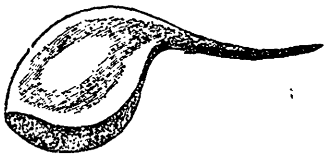

Fig. 15. Cucullate inflated Calyptra of Funaria.

Fig. 16. Cucullate conic Calyptra of Fissidens.

and this part is usually of a different colour, and is named the apophysis (fig. 17); in others it bulges out on one side of the base, and is then said to be strumose (fig. 18).

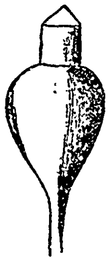

Fig. 17. Fruit of Splachnum ampullaceum with small conic lid, cylindric capsule, and obovate apophysis.

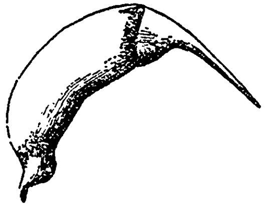

Fig. 18. Strumose capsule of Dicranum Starkii, with rostrate lid and annulus.

Closing the mouth of the capsule, we see a little cap—the operculum or lid, in shape flat, conical, or beaked; this, at maturity, is thrown off, either by the swelling of the contents or by the shrinking of a contractile ring of cells interposed between the lid and mouth of the capsule, which is named the annulus; well seen in the common Funaria. In the genus Andreæa there is no lid, and the capsule opens by splitting into four valves (fig. 19); and in another section there is also no lid, the capsule giving exit to the spores by breaking up from decay (fig. 20). These

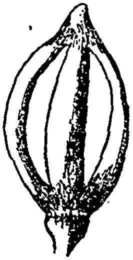

Fig 19. Schistocarpous fruit of Andreæa.

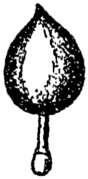

Fig. 20. Cleistocarpous fruit of Pleuridium subulatum.

characters enable us conveniently to arrange mosses in three divisions:—

Schistocarpi—the Split-fruited Mosses.

Cleistocarpi—the Closed-fruited Mosses.

Stegocarpi—the Lid-fruited Mosses.

The wall of the capsule consists of several layers of cells, the outer of which becomes indurated at maturity, and often richly coloured.

Enclosed with in thecapsule is the Sporangium, or Spore-sac, consisting o^c two strata of cells, the outer of which is contiguous to the lining membrane of the capsule, or is suspended from it by delicate threads; the inner is united to a pillar, occupying the

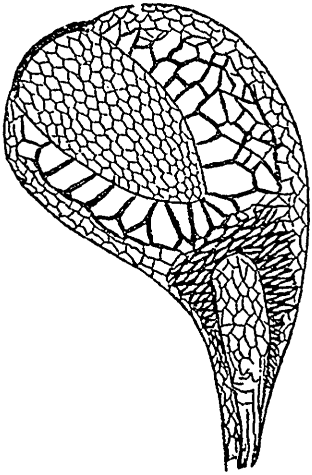

Fig. 20. Section of Fruit of Funaria, showing Sporangium suspended by threads.

central axis of the capsule, and named the Columella, the apex of which joins the lid, and sometimes falls away with it, though occasionally we see the columella projecting from the mouth of the capsule like a style (figs. 21, 22). The lid having fallen

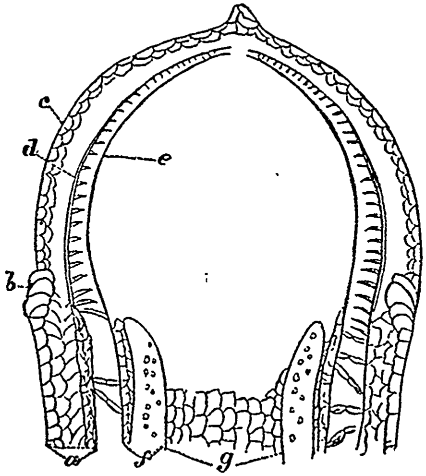

Fig. 21. Section of upper part of fruit of Mnium hornum, *a.* wall of capsule, *b.* annulus, *c.* lid, *d.* tooth of outer peristome, *e.* tooth of inner peristome, *f.* cavity of sporangium and spores, *g.* Columella.

away, the mouth of the capsule is seen, sometimes naked, when it is termed gymnostomous, but usually adorned by the beautiful appendage named the Peristome, consisting of curious hygroscopic tooth-like processes in a single or double series.

The simple peristome, or the outer one when double, originates from the lining membrane of the capsule; its teeth are always constant in number, 4, 8, 16, 32, 64, and present an infinite variety

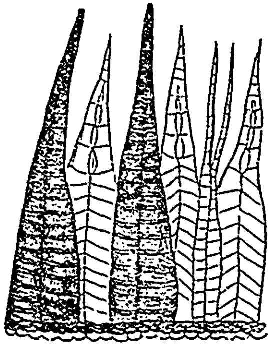

Fig. 22. Part of inner and outer peristomes of same.

of forms (figs. 24, 25, 26). They consist of two strata of cells, the outer in two rows, transversely jointed (trabeculate), richly coloured, and often separated for a part of their length, in the central or divisural line; the inner in one row, thin and hygroscopic, and projecting inward as transverse lamellæ (figs. 22, 23, 27). In the Polytrichaceæ, however, they are quite different, and consist of a mass of agglutinated filaments, and Mr. Mitten uses this distinction to separate all mosses into two sections,

Fig. 23. Transverse section of tooth of outer peristome.

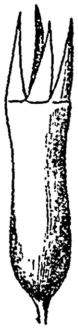

Fig. 24. Fruit of Tetraphis pellucida, peristome of four teeth.

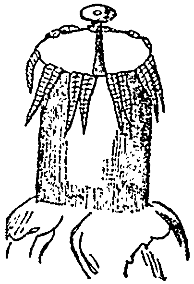

Fig. 25. Splachnum sphæricum, with eight bigeminate teeth, and exserted columella.

Arthrodonti, those with jointed teeth, and Nematodonti, those with filamentous teeth. In the Polytricha, also, the top of the columella is dilated into a membrane, closing the mouth of the capsule, and joined to the points of the teeth; this expansion has been named the epiphragm or tympanum (fig. 27).

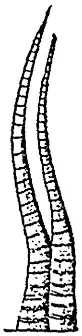

Fig. 26. Bifid tooth from peristome of Fissidens.

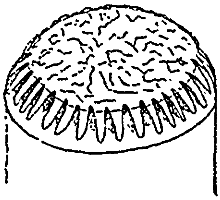

Fig. 27. Peristome and tympanum of Pogonatum aloïdes.

The inner peristome takes its origin from the outer wall of the spore sac, and is a thin plicate, or keeled membrane, divided into processes of cilia, which usually stand opposite the interspaces of the outer teeth, and occasionally one to three still finer ciliola, occur between the cilia (fig. 22).

The spores are formed from the cells, filling the spore sac, and are always free from the spiral threads found in the Hepaticæ.

In the above account I have not included the Sphagnina or Bog-mosses, as the views of recent writers tend to separate them as a distinct class, parallel with Mosses and Hepaticæ.

THE GENUS BOTRYCHIUM.—Dr. Milde has recently published an elaborate monograph of this genus, in which he recognizes the following species:—1. *B. Lunaria* Swartz. 2. *B. crassinervium* Ruprecht; a Siberian species. 3. *B. boreale* Milde; North Europe and said to be North American. 4. *B. matricariæfolium* A Braun. 5. *B. lanceolatum* Angstrom. 6. *B. simplex* Hitchcock. 7. *B. ternatum* (Thunberg). 8. *B. lanuginosum* Wallich. 9. *B. daucifolium* Wallich. 10. *B. Virginianum* Swartz. The first six species appear to be unduly numerous; Mr. Baker (very properly) condenses 2, 3, 4 and 5 into one, under the name *B. rutaceum* Swartz giving 5 the rank of a variety, but he recognizes 6 (which is hardly more than a variety of 1) to be a good species. The normal form of 7 is a plant of East Asia; the European *B. rutæfolium* A. Braun, and the American *B. lunarioides*, with its forms *obliquum* and *dissectum*, being reduced to varieties: the latter form is more of an accidental 'sport' than a botanical variety. Mr. Baker considers 8 to be a variety of 10; 8 and 9 are found only in East Asia. The normal form of 10, well known to Canadian botanists, is found throughout America from Canada to Brazil, and is widely dispersed in Europe and in Asia. D. A. W.

ERRATA.

On page 38, line 7, for 'ten miles daily,' read 'ten *inches* daily.'
On page 431, line 28, for '263,' read '268.'
On page 432, line 28, for '576,' read '575.'
On page 434, line 44, for '33,' read '53,' as the number of species in the Northern States referable to Caryophyllaceæ.

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