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THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

THE INTRODUCED AND THE SPREADING PLANTS OF ONTARIO AND QUEBEC.

By A. T. Drummond, B.A., LL.B.

Those members of our flora which have been introduced, or which have the habits of naturalized species, we may refer to one or other of five groups :—

I. Incidental escapes.
II. Adventive plants.
III. Naturalized foreign plants.
IV. Species which are both indigenous and naturalized.
V. Native species which have the habits of introduced plants.

The first, second, and third groups are well known, and only require a passing notice.

The first group embraces species which have escaped from cultivated grounds, have propagated themselves in neglected gardens, or have been casually introduced with grain or grass-seed, or in other ways, and which are not in the least permanent. Stray plants of wheat, oats, corn, and other grains growing upon our country roadsides, and upon the tracks of the railways, are familiar to us. The little heartsease, the ragged robin, and morning glory are some of our garden plants, which, unaided by continued cultivation, have occasionally, for a brief period, struggled to retain their places in the neglected flower plots.

The term adventive has been applied to foreign plants which have permanently located themselves in the country, and yet are so dependent upon some of the accompaniments of civilization that were the country to resume its preadamite condition they would probably soon disappear. Adventive plants form a numerous class, embracing most of those weeds which confine themselves to the vicinity of dwellings and barns, and to cultivated grounds. The mustards and the corncockle, familiar pests on many eastern farms, and the flax, carrot, parsnip, and artichoke, illustrate the group.

Those introduced species, which have freely spread themselves throughout the settled parts of the country, and which, though domesticated through the agency of man, are probably quite independent of him for existence, come under the category of naturalized plants. The buttercup, clover, Canada thistle and sheep sorrel, strikingly exemplify this extensive group.

The remaining groups require a more attentive consideration. All of the species referred to them are indigenous to this country; some to the settled, others to the remote districts. With many individual plants of some of the species it forms a question whether their introduced habit indicates a foreign origin or results from a tendency of the indigenous plant to abnormally spread. In certain instances the known limited distribution of the species, in its indigenous form, dispels any doubt. For example, around Lake Superior. Agassiz chronicles as native, or probably so, species whose habits, in the settled parts of the country, evince a decidedly exotic origin. Where, however, the range of both forms is extensive, indicating the limits of each is impracticable. It is indeed *possible* that not only have the rambles of the native species frequently placed them side by side with the domesticated plants, and probably quite undistinguishable from them, but that in some instances the species, though common to Europe and America, have no introduced representatives here; and that individuals of these species, which have the habits of exotics, are in reality indigenes which have wandered beyond their natural homes.

A question, replete with interest, arises in connection with these naturalized plants. Have changes of climate and of other conditions in the long lapse of years impressed new specific characters on the individuals of any species, or, if not, have they produced any permanent varieties? If even the latter were the case, it seems probable that not only might varieties be different on different continents, but the migration of these varieties might also lead to specific changes. Let the imagination trace the wanderings of one of these little plants under such circumstances.

Probably of a spreading habit in its native country, it emigrates, through one of the innumerable channels constantly open, to a foreign clime, where it becomes established, and where, in consequence of a change of conditions, some slight but permanent alteration is effected in its characters. The plant thrives, and in the lapse of years becomes a widely distributed weed. Another emigration takes place thence to a country where climatal and other conditions are different from those of either its native country or last adopted home. A more marked variety results. In the course of long time this variety appears on another continent, to be subjected to farther changes, which so destroy the identity of the plant that a botanist only acquainted with the species in its native clime, on seeing its wandering individuals here, hails the discovery of an allied plant requiring a place in specific nomenclature. It is, however, a suggestive enquiry whether if this new species or the variety were to find a footing in the country whence its progenitors came, it would retain its identity as a species or variety. The whole subject merits some investigation as to how far, in any respect, climatic or other differences produce permanent change. I cannot, however, help here recalling some analogous cases. The inland maritime plants, growing on the shores of the Great Lakes and elsewhere, have been subjected to a great change in their conditions of growth without any corresponding alteration in the distinctive characters of the species. Similar instances are recorded in the insect fauna of Lake Superior, and our attention has lately been drawn to *Pieris rapæ*, an intruding butterfly from Europe, extensively naturalized in the Province of Quebec, which here even feeds on a plant different from that which constitutes its food on the other side of the Atlantic, and yet retains its specific features unchanged.

In enumerating, in the catalogue below, species which have both indigenous and introduced representatives in the country, I briefly indicate the provincial range and habits of each plant as far as known. Our knowledge of the habits and distribution of the grasses in Ontario and Quebec is, however, so limited that I enumerate, without any accompanying notes, such species as are probably referable to this catalogue. Indeed, with respect to both this and the other catalogues, I shall be glad to have the aid of botanical friends in rendering our knowledge of the habits and range of all of the spreading and naturalized plants more complete.

Ranunculus sceleratus, L. This plant is frequent in railway and roadside ditches, and in wet places in old pastures and neglected grounds. In range it is common from the Detroit River and the southern shores of the Georgian Bay to the Lower St. Lawerence, and is native in the Hudson Bay Territory. In the two Provinces it probably chiefly occurs in the introduced state.

Barbarea vulgaris, R. Br., is often met with in gardens. Mr. Barnston (Canad. Nat. 1859) speaks of it as introduced or not according to locality. The varieties are indigenous from Lake Superior northward and westward. The plant is well known in Ontario in its introduced form, but is apparently less familiar in Quebec.

Erysimum cheiranthoides, L., is a weed in gardens at Belleville (Mr. J. Macoun), but elsewhere I know it only as a native. In the Lake Erie districts and in Eastern Ontario it is frequent, and no doubt occurs in the Eastern Townships.

Draba verna, L. This plant is little known here, and is only provisionally placed in this catalogue. Provancher cites Cap Tourmente as a station, and, according to Prof. Gray, it is not found north of the Province of Quebec. In the Southern United States and in Massachusetts it is introduced.

Turritis glabra, L. Mr. Macoun regards this as introduced around Belleville, where it occurs in newly seeded meadows. In the indigenous form its known range is from Lake Superior to Montreal and southward. In the Hudson's Bay Territory it is well diffused.

Sisymbrium Sophia, L., is occasionally met with from Prescott, in Ontario, eastwards. Whether it occurs in the indigenous state or not is open to doubt. In the Northern States it is still less known.

Cerastium viscosum, L. Torrey and Gray, in their flora, when referring to this species, as well as *C. vulgatum*, add an interrogation after "introduced." Macoun thinks it occurs in both the native and naturalized states at Belleville. It ranges from the northern shores of Lake Huron to those of the Lower St. Lawrence. Seeman notes its occurrence within the Arctic zone.

Arenaria serpyllifolia, L. Prof. Brunet says of this plant, "*Elle est certainement spontanée au Labrador.*" I have only seen it in the introduced state, but Macoun, whilst observing its occurrence in waste ground, thinks it may be indigenous at

Belleville. Although distributed from the islands of Lake Huron (Dr. Bell) to Labrador, and southward to Lakes Erie and Ontario, it does not appear to be very common.

Trifolium repens, L. Most of the individuals of this widely-diffused species met with in these Provinces are probably introduced. Agassiz seems to question whether the Lake Superior plant may not be native. My esteemed correspondent, Mr. Macoun, in a note on it, says, "*T. repens* is certainly a native, but it is also an introduced plant. I have observed it in all my wandering, and noticed that it always makes its appearance in new clearings along with *Erigeron Canadense*."

Vicia cracca, L. From Belleville eastwards this species is not uncommon. Dr. Bell considers it introduced in Gaspé; in Ontario it is certainly indigenous. It appears among the introduced plants of Agassiz and Lowell—(Agassiz's Lake Superior.)

Potentilla Norvegica, L., forms one of those species which are frequently found on roadsides and in fields, and yet may not be introduced. In its undoubtedly native state it is common from the northern coast of Lake Superior to Labrador and Newfoundland.

Potentilla Argentea, L., is found abundantly in old sandy fields at Toronto, Port Colborne, Picton and Gaspé. At Swampscott, near Boston, I obtained it on the roadside in sandy soil. It is questionably native.

Agrimonia Eupatoria, L., is frequently met with on roadsides. In Southern Africa it is a naturalized plant (D'Urban.) The indigenous form is well distributed over both Ontario and Quebec.

Galium Aparine, L. This plant, if it has not been overlooked, has a limited distribution. It occurs in the Erie district, and ranges thence to Montreal. I have only met with it in gardens, and Dr. Lawson, of Halifax, who has an extensive acquaintance with the flora of these Provinces, informs me that his experience is that the introduced form is not common except in gardens.

Taraxacum dens-leonis Desf. This is a plant of wide diffusion, extending northward to the Arctic zone. Wherever met with in the settled parts of Ontario and Quebec, its habit is that of an introduced plant.

Achillea millefolium, L., is another extensively-diffused species, which also ranges to the Arctic zone. It largely frequents roadsides and waste fields, *Xanthium strumarium*, L., occurs in the Erie district, and thence eastward. Some forms of this species are indigenous in the United States—(Gray's Manual.)

Gnaphalium uliginosum, L. Most of the species of the genus Gnaphalium have a more or less introduced-like habit. Individuals of this species are frequently met with on roadsides and in fields. The range of the plant extends over the two Provinces, except in the extreme West, where, however, it is to be looked for.

Artemisia vulgaris, L., is a common roadside plant in eastern Ontario and Quebec. Torrey and Gray (Flora N. Amer.) refer to it as indigenous in British North America. It occurs within the Arctic zone.

Cirsium arvense, Scop. *In the settled districts C. arvense* is decidedly naturalized, but some authors regard it as probably indigenous in the Hudson's Bay Territory. It is well diffused throughout Ontario and Quebec.

Plantago major, L., is very common everywhere amongst grass in fields and on roadsides. Agassiz thinks it indigenous on the north shore of Lake Superior, and Macoun has informed me of its occurrence, in the native state, on rocks along rivers in the northern part of the County of Peterborough, Ontario.

Veronica serpyllifolia, L., is a familiar field and wayside plant from the Detroit River to Gaspé and Newfoundland. Its habits are those of an introduced plant, but some observers have met with it in the native state.

Brunella vulgaris, L., is well distributed over the two Provinces. The naturalized state occurs abundantly in lawns and in pastures, and sometimes on roadsides.

Calamintha clinopodium, Benth., is well known throughout Ontario, but in Quebec does not seem to have been observed. At Kingston I think it is indigenous, and Macoun similarly regards the Belleville plant. The Lake Superior form Agassiz also considers native rather than naturalized.

Polygonum aviculare, L. This, the most common of weeds, almost everywhere meets the eye. I have only seen the introduced form, and have doubts whether it is, at any locality, indigenous. The variety *erectum* (*P. erectum*, L.) is an aboriginal, as also is var. *littorale* (*P. maritimum*, Ray.)

Humulus Lupulus, L., has escaped from cultivation, and somewhat permanently settled in some places. I have seen it around

Montreal and at Lennoxville. It is indigenous on the north shore of Lake Superior, and during the past summer I found it entwining itself among the shrubs which border Salmon Creek, in the Township of Melbourne, Province of Quebec. It can no longer be regarded as a plant of purely Western range.

Festuca ovina, Gray, var *duriuscula*, Gray.
Poa compressa, L.
P. pratensis, L.
Agrostis vulgaris, With.
Panicum glabrum, Gaudin.
P. crusgalli, L.
Triticum repens, L.
T. caninum, L.

So intimately connected in their range and habits with the exotic plants of our fields and roadsides, are our native species in their abnormally diffused states that there seems a propriety in referring to them here. Their habits are instructive as they furnish an explanation of the circumstances which have led to the introduction of foreign plants into the country in our times. Native species, when they assume these rambling habits — as most, if perhaps not all, of our domesticated exotics to a greater or less extent have in the countries from which they have come —frequently stray into grain-fields, to roadsides, wharves, and other localities, whence their seeds are readily conveyed to foreign lands, along with grain, wool, packing, personal effects of emigrants, ballast, and other means of transmission, so amply afforded. Thousands of the seeds thus yearly brought to foreign shores probably never germinate, and of those which do, perhaps but a small proportion, representing some of these hardy species, and a few others, which find a congenial climate and soil, mature and perpetuate their existence. The recurring immigration, year after year, of the same as well as occasional other species, soon, however, gives a feature to the vegetation there. The spreading habits of any of the plants. in the countries from which they have come, will have hardened their natures, and nerved them for not only enduring the vicissitudes of, perhaps, dissimilar soils, and a more trying climate, but also of encroaching upon the domains of the native vegetation. In this manner has, I conceive, arisen in a large measure the distribution of the exotic flora of our roadsides and fields. And it further seems unquestionable that those members of our indigenous flora which have this spreading habit will not only be the most likely to migrate to and become naturalized in foreign lands, but of all species which may happen to be so naturalized from here will be the most hardy, and probably have, eventually, the widest range. *Erigeron Canadense* and *E. annuum* are familiar illustrations. With an extensive range in this country, they have migrated to Europe, where, in the naturalized state, they now have a wide distribution. *Œnothera biennis* affords an example of the same feature.

Illustrative of this last group there are some well-known plants. *Ranunculus abortivus*, L., is very common on roadsides in different parts of the country. The range of the plant is from the Detroit River to the Lower St. Lawrence and Newfoundland. The variety *micranthus* occurs on the north shore of Lake Superior, and thence westward and south-westward.

Corydalis aurea, Willd. At Ottawa, I found this plant among the rocky debris on the banks of the river, along with introduced plants. Dr. Bell has observed a similar spreading tendency on the Manitoulin Islands. This habit is, as yet, but little developed, as elsewhere the species is only known in its normal state. It is well distributed over the two Provinces, except in the Erie district.

Oxalis stricta, L. At Kingston, this is common in gardens. Excepting on the north shore of Lake Superior, it is well diffused over Ontario and Quebec.

Œnothera biennis, L., is now a garden plant. It is sometimes found growing in rubbish and on road-sides. The distribution of the plant over the two Provinces is very general.

Sambucus Canadensis, L. This is exceedingly common in fence rows. It is a well-known species from the southern shores of the Georgian Bay and from the Detroit River to the Lower St. Lawrence. Its abnormal habits have been observed in the United States, and the question has been raised whether it is a native there or not.

Erigeron Canadensis, L., is a plant of wide distribution, both on this and other continents. Here it ranges over the greater portion of the two Provinces, and often occurs in neglected fields. Two other species of this genus *E. annuum*, Pers. and *E. strigosum*, Muhl. have also a tendency to become intruders.

Rudbeckia hirta, L., is a southern plant, indigenous in the Ontario peninsula, and eastwards as far as Belleville, but also frequent in grain fields around London and on St. Joseph's Island, Lake Huron, and spreading in the County of Northumberland.

Antennaria plantaginifolia, Hook. This plant is found everywhere throughout the Provinces, and beyond them extends to Hudson's Bay and the Rocky Mountains. Farm yards and the road-sides are favourite resorts of it. Among its near allies, the Gnaphaliums, there is also a tendency to spread.

Bidens frondosa, L. This, and perhaps one or two other species of the same genus, frequently stray into railway and roadside ditches. The known range of *B. frondosa* is from Lake Erie to the Lower St. Lawrence.

Lobelia inflata, L., a well distributed plant of both Provinces, occurs in grain fields in the Province of Quebec, and is thought to be the cause of some cases which have lately occurred of poisoning among cattle.

Hedeoma pulegioides, Pers. and *H. hispida*, Pursh—neither of which seems to range into the districts north of Lakes Huron and Superior and into the Province of Quebec—both have, Mr. Macoun informs me, spreading habits at Belleville.

Verbena hastata, L. is a frequent intruder on road-sides and in neglected fields. In the indigenous state it is common from the Manitoulin Islands to the neighbourhood of Quebec.

V. urticifolia, L. This species occurs in similar situations to *V. hastata*, and has a nearly analogous range.

Veronica peregrina, L. This is a well-known grass plant, occurring on lawns, in parks and elsewhere. Its recorded range is from Lake Erie to the vicinity of Quebec.

Urtica gracilis, Ait, Macoun remarks, has an introduced habit at Belleville. From Lake Superior to Anticosti this plant has been everywhere met with.

Polygonum Pennsylvanicum, L. In wet fields, road-sides, and railway ditches, this, and perhaps one or two more Polygonums are often found. *P. Pennsylvanicum* is known to range from the Manitoulin Islands to below Montreal.

Acalypha Virginica, L., is a familiar weed in some places. The species is distributed from the Erie district to about the City of Quebec.

Euphorbia maculata, L., is a known road-side plant, and is possibly an introduction from the United States. It ranges over a considerable portion of Ontario.

E. commutata, Engel., has been noticed at Shannonville, Ont., by Macoun, who remarks its introduced-like appearance.

Salix lucida, Muhl., is very common in the ditches and moist grounds (the sides of railway tracks. It is abundant throughout the two Provinces.

Panicum capillare, L.

When the Provinces were originally settled by the ancestors of the present French population, we can believe that many of the weeds of France found a home here. Immigration during succeeding years from the same country, and from Great Britain and Germany, not only repeated the introduction of many of these weeds, but largely swelled the number of introduced species. At the present day, our close commercial relations with Great Britain and the United States are producing a yearly influx of these unwelcome visitors, and scattering them broadcast over the country. Though new forms only now and then make their appearance, there is an incursion—renewed every summer to a greater or less extent—of those familiar, self-made friends of ours. At the same time, not only are these very species—along with some members of our indigenous flora—migrating from here and obtaining a footing in other foreign lands with which we are in commercial intercourse, but they must frequently reappear among their native brethren, in the countries from which they originally came. Amongst those countries between which trade relations are intimate, there must be a constant interchange in this way.

Illustrative of this immigration from different countries, there may be cited: from tropical America, *Senebiera didyma*, Pers., which occurs at Gaspé, and Montreal, and which has, probably, been directly introduced, *Chenopodium ambrosioides*, L., species of *Amaranthus*, of which there is presumption that they have come by way of the United States, and *Nicotiana rustica*, L., which Dr. Gray considers a relic of cultivation by the Indians; from the United States, *Martynia proboscidea*, Glos., probably *Acalypha Virginica*, L., and some of the Euphorbias, and from Europe, in addition to many well-known plants, *Potentilla argentea*, L., *Leontodon autumnale*, L., *Plantago lanceolata*, L., *Rumex patientia*, L., and *Cynodon Dactylon*, Pers.

The large yearly influx of population from different parts of Europe aids materially in establishing species throughout the Provinces, and the facilities afforded for the subsequent distribution of these species are especially great in consequence of the long continuous lines of railway and water communication between the seaboard and all sections of the interior. Many introduced plants are thus of wide range. *Capsella bursa pastoris*, Mœnch, *Achillea millefolium*, L., *Maruta cotula*, D. C., *Cynoglossum officinale*, L., and *Polygonum persicaria*, L., for example, extend from Lake Superior to the Lower St. Lawrence. Others, again, are quite restricted in range. *Leontodon autumnale*, L., and *Senebiera didyma*, Pers., are limited to the seaports, and *S. coronopus*, D. C., is only known from Gaspé; *Veronica chamædrys* has not been observed elsewhere than at Quebec; *Sisymbrium sophia*, L., is uncommon in the Province of Quebec and quite unknown west of Prescott, and *Plantago media*, L., has, as yet, only been observed at Toronto.

Currents may play a more important part in the introduction of exotic plants than is generally supposed. Our Canadian lake coasts supply illustrations of this agency at work. Coral islands are, it is well known, mantled with a vegetation largely resulting from the seeds carried to their shores through the medium of winds and currents. In the United Kingdom, the influence of the Gulf Stream is observable in the occurrence of *Eriocaulon septangulare*, With., *Sisyrinchium anceps*, Car., and *Naias flexilis*, Rostk, upon the western coasts. It seems, indeed, possible that the part played by this great current in the phenomena of distribution has not been brought into sufficient prominence. The evidence, though limited, suggests the enquiry whether, in addition to some local plants, others, common to the two continents, and fairly diffused, at the present day, in Europe, may not have had their starting points on its west shores, whither their seeds have been carried, by the Gulf Stream, from America, at stray times, during passing centuries, without destroying their vitality.

VOLCANOES AND EARTHQUAKES.

ABSTRACT OF A LECTURE

By T. Sterry Hunt, LL.D., F.R.S.*

It is proposed, in the present lecture, to discuss the nature and causes of volcanoes and earthquakes, with their related pheno-

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mena, and to consider the reason of their peculiar geographical distribution. Violent movements of the earth's crust are confined to certain regions of the globe, which are at the same time characterized by volcanic activity; from which it is reasonably inferred that the phenomena of earthquakes and volcanoes have a common origin. The discharge through openings in the earth's crust of ignited stony matter, generally in a fused condition, and the disengagement of various gases and vapors, accompanied by movements of elevation or subsidence of considerable areas of the earth's surface, sometimes rapid and paroxysmal, and attended with great vibratory movements, are evidences of a yielding crust of solid rock resting upon an igneous and fluid mass below. To the same conditions are also to be ascribed the slow movements of portions of the earth's surface shown in the rise and fall of continents in regions remote from centres of volcanic activity. The unequal tension of the yielding crust and the sudden giving way of the overstrained portions are probably the immediate cause of earthquake phenomena; the seat of these, according to the deductions of Mallet, is to be found at depths of from seven to thirty miles from the surface.

A brief description of the phenomena of volcanoes will be necessary as a preliminary to the inquiry which constitutes the object of our lecture. Volcanoes are openings in the earth's crust through which are discharged solid, liquid, and gaseous matter, generally in an intensely heated condition. Sometimes the ejected material is solid, and consists of broken comminuted rock, or the so-called volcanic ashes. Oftener, however, it is discharged in a more or less completely fused condition, constituting lava, which is sometimes fluid and glassy, but more frequently pasty and viscid, so that it flows slowly and with difficulty. The ejected materials, whether liquid, or solid, build up volcanic cones by successive layers—a fact which has been established by modern observers in opposition to the notion come down from antiquity, that volcanic hills are produced by an uprising or tumefaction of previously horizontal layers of rock by the action of a force from beneath. First among the gaseous products of volcanoes is watery vapor; water appears not only to be involved in all volcanic eruptions, but to be intimately combined with the lavas, to which, as Scrope has shown, it helps to give liquidity. The water at this high temperature is retained in combination under great pressure, but as this pressure is removed passes into the state of vapor, a process which explains the swelling up of lavas and their rise in the craters of the volcanoes. Besides watery vapor, carbonic, and hydrochloric acid gases, and hydrogen, both free and combined with sulphur and with carbon, are products of volcanoes. The combustion of the inflammable gases in contact with air sometimes gives rise to true burning mountains—a name which does not properly belong to such as give out only acid gases, steam, and incandescent rocky matters, which are incombustible. The escape of elastic fluids from lavas gives to them a cellular structure, but when slowly cooled under pressure, as seen in the dykes traversing the flanks of volcanoes, the stoney materials assume a more solid and crystalline condition, and resemble the older eruptive rocks found in regions not now volcanic. These include granites, trachytes, dolerites, basalts, etc., and are masses of rock which, though extravasated after the manner of lavas, became consolidated in the midst of surrounding rocks, and consequently under considerable pressure. Their presence marks either the lower portions of volcanoes whose cones have been removed by denudation, or outbursts of liquefied rock which never reached the surface. The escape of such matters, and the formation of volcanic vents, are but accidents in the history of the igneous action going on beneath the earth's surface. We shall, therefore, regard the extravasation of igneous matter, whether as lava or ashes at the surface, or as plutonic rock in the midst of strata, as, in its wider sense, a manifestation of vulcanicity, and, for the elucidation of our subject consider both those regions characterized by great outbursts of plutonic rock in former geologic periods, and those now the seats of volcanic activity, which, in these cases, can generally be traced back some distance into the tertiary epoch. To begin with the latter, the first and most important is the great continental region which may be described as including the Mediterranean and Aralo-Caspian basins, extending from the Iberian peninsula east-ward to the Thian-Chan Mountains of central Asia. In this great belt, extending over about 90° of longitude, are included all the historic volcanoes of the ancient world, to which we must add the extinct volcanoes of Murcia, Catalonia, Auvergne, the Vivarais, the Eifel, Hungary, etc., some of which have probably been active during the human period.

It is a most significant fact that this region is nearly coextensive with that occupied for ages with the great civilizing races of the world. From the plateau of central Asia, throughout their westward migration to the pillars of Hercules, the Indo-European nations were familiar with the volcano and the earthquake; and that the Semitic race were not strangers to the same phenomena, the whole poetic imagery of the Hebrew Scriptures bears ample evidence. In the language of their writers, the mountains are molten, they quake and fall down at the presence of the Deity, when the melting fire burneth. The fury of his wrath is poured forth like fire; he toucheth the hills, and they smoke, while fire and sulphur come down to destroy the doomed cities of the plain, whose foundation is a molten flood. Not less does the poetry and the mythology of Greece and of Rome bear the impress of the nether realm of fire in which the volcano and the earthquake have their seat, and their influence is conspicuous throughout the imaginative literature and the religious systems of the Indo-European nations, whose contact with these terrible manifestations of unseen forces beyond their foresight or control, could not fail to act strongly on their moral and intellectual development, which would have doubtless presented very different phases had the early home of these races been the Australian or the eastern side of the American continent, where volcanoes are unknown, and the earthquake is scarcely felt.*

Besides the great region just indicated, must be mentioned that of our own Pacific slope, from Fuegia to Aliaska, from whence along the eastern shore of Asia, a line of volcanic activity extends to the terrible burning mountains of the Indian archipelago. Volcanic islands are widely scattered over the Pacific basin, and volcanoes burn amidst the thick-ribbed ice of the Antartic continent. The Atlantic area is in like manner marked by volcanic islands from Jan Mayen and Iceland, to the Canaries, the Azores, and the Caribbean islands, and southward to Ascension, St. Helena, and Tristan d'Acunha.

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*Compare the fine lines of Pope, in the Essay on Man, where, of superstition, the poet says:

" She, 'mid the lightning's glare, the thunder's sound,
While rocked the earthquake, and while rolled the ground,
She taught the proud to bend, the weak to pray—
To Powers unseen and mightier far than they,
She, 'mid the rending earth and bursting skies,
Saw gods descend and fiends infernal rise;
Here fixed the baleful, there the blest abodes—
Fear made her devils and weak hope her gods."

The continents, with the exception of the two areas already defined, present no evidences of modern volcanic action, and the regions of ancient volcanic activity, as shown by the presence of great outbursts of eruptive rocks, are not less limited and circumscribed. In northern Europe, the chain of the Urals, an area in central Germany, and one in the British islands are apparent, and in North America there appear to have been but two volcanic regions in the paleozoic period—one in the basin of Lake Superior, and another, which may be described as occurring along either side of the Apallachian chain to the north-east, including the valleys of the lower St. Lawrence, Lake Champlain, the Hudson and Connecticut rivers, and extending still farther southward. The study of the various eruptive rocks of this region shows that volcanic activity in different parts of it was prolonged from the beginning of the paleozoic period till after its close.

Having thus before us the principal facts in the history of volcanoes, we may proceed to notice the various theories from time to time put forward to account for them. The first and most obvious notion is that of combustion, and we find early writers supposing that volcanoes might be due to the burning of coal, bitumen, or sulphur. As juster ideas were acquired of the nature of combustion, and the necessity of a supply of air for its maintenance, other chemical agencies were invoked as the probable source of internal fire. Lemery suggested the oxidation of sulphurets in the presence of water, and the brilliant discovery by Davy, in the earths and alkalies, of metallic bases which decompose water with great violence, and even with the phenomena of combustion, gave rise to the so-called chemical theory of volcanoes, which has found its defenders down to our own time. This theory supposes that the interior of the globe consists of the metallic bases of earths and alkalies, which are oxidized by the gradual access of the ocean's water, with the production of intense heat, causing the fusion of the resulting oxides, which constitute lavas and eruptive rocks. The chemical objections which may be urged against this theory are numerous, and to my mind insuperable; in addition to which it may be added that it fails to explain the facts connected with the past and present distribution of volcanoes, and is in disaccord with those views of the early condition of the globe most in harmony with the deductions of modern astronomy, physics, and chemistry.

I need not here repeat the arguments in favor of the theory which supposes our earth to be a cooling globe, which has passed through various stages, from an uncondensed nebulous mass to a liquid, and finally to its present solid condition, with a cold exterior; nor to the evidences of a regularly increasing temperature as we descend into its crust, from which it is concluded that at a depth of a few miles a heat of ignition would be attained. If we suppose the solidification of the once liquid globe to have begun at the surface, which became thus covered with a feebly conducting crust, it would not be difficult to admit, as some imagine, a still liquid centre, surrounded by a shell of congealed matter upon which are spread the sedimentary strata. Various and independent arguments from the phenomena of precession, from the theory of the tides, and from the crushing weight of mountain masses like the Himmalaya, have, however, been brought against this hypothesis of a thin crust resting upon a liquid centre, and in addition to these another important one of a different order. Judging from the known properties of the rocks with which we are acquainted, solidification should commence not at the surface, but at the centre of the liquid globe, a process which would moreover be favored by the influence of pressure. This augments the melting temperature of matters which, like the rocks and most other solids, become less dense when melted, while on the other hand it reduces the melting point of those which, like ice, become more dense by fusion. Pressure, moreover, it may be mentioned in this connection, increases the solvent power of water for most bodies, whose solution may be described as a kind of melting down with water into a compound whose density is greater than that of the mean of its constituents; the importance of this point will appear farther on. The theory deduced from the above considerations, and adopted by Hopkins and by Scrope, is briefly as follows: the earth's centre is solid, though still retaining nearly the high temperature at which it became solid. At an advanced stage in the solidifying process the remaining envelope of fused matter became viscid, so that the descent from the surface of the heavier particles, cooled by radiation, was prevented, and a crust formed, through which cooling has since gone on very slowly. There were thus left between this crust and the solid nucleus, portions of yet unsolidified matter (or even perhaps, as suggested by Scrope, a continuous sheet), and it is in the existence of this stratum, or of lakes of uncongealed matter, that we are to find an explanation of all the phenomena of volcanoes and earthquakes, of elevation and subsidence, and of the movements which result in the formation of mountain chains, as ingeniously set forth by Mr. Shaler. The slow contraction of the gradually cooling globe, a most important agency in the latter phenomena, is evidently not excluded by this hypothesis. It may be added that a similar structure of the globe, viz., a solid nucleus and a solid crust separated from each other by a liquid stratum, was long ago suggested by Halley in order to explain the phe-enomena of terrestrial magnetism. Scrope has completed this hypothesis by the suggestion that variations in tension or pressure may cause portions of matter beneath the surface to pass from solid to liquid, or from a liquid to a solid state, and in this way help us to explain the local and the temporary nature of volcanic activity.

This theory of Hopkins and Scrope, apparently so complete in itself, is an approximation to the one which I adopt, though differing from it in some most important particulars. While admitting with them the existence of a solid nucleus and a solid crust, with an interposed stratum of semi-liquid matter, I consider this last to be, not a portion of the yet unsolidified igneous matter, but a layer of material which was once solid, but is now rendered liquid by the intervention of water under the influence of heat and pressure. When, in the process of refrigeration, the globe had reached the point imagined by Hopkins, where a solid crust was formed over the shallow molten layer which covered the solid nucleus, the farther cooling and contraction of this crust would result in irregular movements, breaking it up, and causing the extravasation of the yet liquid portions confined beneath. When at length the reduction of temperature permitted the precipitation of water from the dense primeval atmosphere, the whole cooling and disintegrating mass of broken-up crust and poured-out igneous rock would become exposed to the action of air and water. In this way the solid nucleus of igneous rock became surrounded with a deep layer of disintegrated and water-impregnated material, the ruins of its former envelope, and the chaotic mass from which, under the influence of heat from below and of air and water from above, the world of geologic and of human history was to be evolved.

As we descend in the sedimentary crust of the earth, we observe a regular increase of temperature, due, as is supposed, to the slow upward passage of the central heat. In the present state of refrigeration this process is so slow that the increase of temperature in descending is only about one degree centigrade for each hundred feet; but if we admit the hypothesis of a cooling globe, it can be shown that in early geologic ages this increase must have been tenfold, or even twenty-fold greater than at present. As this augmentation of temperature in depth obeys the same law alike in the newest and the oldest formations, it follows that the accumulation of sediment at any time and place will result in a slow rise in temperature of the portion covered thereby, so that a deposit of a few miles in thickness in comparatively recent ages, and probably one of as many thousands of feet in the Laurentian or even the paleozoic period, would, after a lapse of time, so elevate the temperature of the buried portions as to produce new chemical and mechanical arrangements of the sediments. The expansive action of heat upon these porous materials, which generally include several hundredths of water, would soon be counteracted by the great contraction following chemical combination, resulting in the formation of new and denser compounds, which constitute the crystalline and metamorphic rocks. The action of silicious matters in the presence of water, aided by heat, upon the various carbonates, chlorides, sulphates, and organic matters which abound in most sedimentary formations, would generate the acid gases which are so often evolved in volcanic eruptions. It must be borne in mind that water under pressure, and at high temperatures, develops extraordinary solvent powers; while from what has already been said of the influence of pressure in favoring solution, it will be seen that the weight of the overlying mass becomes an efficient cause of the liquefaction of the lower portions of the sedimentary material. Time is wanting to discuss the great forces which from early geologic periods have been active in transferring sediments, alternately wasting and building up continents. By the depression of the yielding crust beneath regions of great accumulation there follows a softening of the lower and of the more fusible strata, while the great mass of more silicious rocks becomes cemented into comparative rigidity, and finally, as the result of the earth's contraction, rises a hardened and corrugated mass, from whose irregular erosion results a mountainous region.

Those strata, which from their composition yield under these conditions the most liquid products, are, it is conceived, the source of all plutonic and volcanic rocks. Accompanied by water, and by difficultly coercible gases, they are either extravasated among the fissures which form in the overlying strata, or find their way to the surface. The variations in the composition of lavas and their accompanying gases in different regions, and even from the same vent at different times, are strong confirmations of the truth of this view, to which may be added the fact that all the various types of lava are represented among aqueous sedimentary rocks, which are capable of yielding these lavas by the process of fusion.

The intervention of water in all lavas, of which it appears to form an integral part, was first insisted upon by Scrope, and is a fact hardly explicable upon any other hypothesis than the one just set forth. Considering the conditions of its formation, water would seem to be necessarily absent from the originally fused globe, in which the older school of geologists conceive volcanic rocks to have their source. Scheerer supplemented Scrope's view, by showing that the presence of a few hundredths of water, maintained under pressure at a temperature approaching ignition-would probably suffice to produce a quasi-solution or an igneo-aqueous fusion of most crystalline rocks, and subsequent observa tions of Sorby have demonstrated that the softening and crystallization of many granites and trachytes must have taken place in the presence of water, and at temperatures not above a low red heat. Keeping in view these facts, we can readily understand how the sheet of water-impregnated debris, which, as we have endeavored to show, must have formed the envelope to the solid nucleus, assumed in its lower portion a semi-fluid condition, and constituted a plastic bed on which the stratified sediments repose. These, which are in part modified portions of the disintegrated primitive crust, and in part of chemical origin, by their irregular distribution over different portions of the earth, determine, after a lapse of time, in the regions of their greatest accumulation, volcanic and plutonic phenomena. It now remains to show the observed relations of these phenomena, both in earlier and later times, to great accumulations of sediment.

If we look at the North American continent, we find along its north-eastern portion evidences of great subsidence, and an accumulation of not less than 40,000 feet of sediment along the line of the Appalachians from the Gulf of St. Lawrence southwards, during the paleozoic period, and chiefly, it would appear, during its earlier and later portions. This region is precisely that characterized by considerable eruptions of plutonic rocks during this period and for some time after its close. To the westward of the Appalachians, the deposits of paleozoic sediments were much thinner, and in the Mississippi valley are probably less than 4,000 feet in thickness. Conformably with this, there are no traces of plutonic or volcanic outbursts from the north-east region just mentioned throughout this vast paleozoic basin, with the exception of the region of Lake Superior, where we find the early portion of the paleozoic age marked by a great accumulation of sediments, comparable to that occurring at the same time in the region of New England, and followed or accompanied by similar plutonic phenomena. Across the plains of northern Russia and Scandinavia, as in the Mississippi valley, the paleozoic period was represented by not more than 2,000 feet of sediments, which still lie undisturbed, while in the British islands 50,000 feet of paleozoic strata, contorted and accompanied by igneous rocks, attest the connection between great accumulation and plutonic phenomena.

Coming now to modern volcanoes, we find them in their greatest activity in oceanic regions, where subsidence and accumulation are still going on. Of the two continental regions already pointed out, that along the Mediterranean basin is marked by an accumulation of mesozoic and tertiary sediments, 20,000 feet or more in thickness. It is evident that the great mountain zone, which includes the Pyrenees, the Alps, the Caucasus and the Himmalaya, was, during the later secondary and tertiary periods, a basin in which vast accumulations of sediments were taking place, as in the Appalachian belt during the paleozoic times. Turning now to the other continental region, the American Pacific slope, similar evidences of great accumulations during the same periods are found throughout its whole extent, showing that the great Pacific mountain belt of North and South America, with its attendant volcanoes, is, in the main, the geological equivalent or counterpart of the great east and west belt of the eastern world.

It is to be remarked that the volcanic vents are seldom immediately along the lines of greatest accumulation, but appear around and at certain distances therefrom. The question of the duration of volcanic activity in a given region is one of great interest, which cannot, for want of time, be considered here. It appears probable that the great manifestations of volcanic force belong to the period of depression of the area of sedimentation, if we may judge from the energy and copiousness of the eruptions of island volcanoes, although the activity is still prolonged after the period of elevation.

As regards the geological importance of volcanic and earthquake phenomena, their significance is but local and accidental. Volcanoes and earthquakes are and always have been confined to limited areas of the earth's surface, and the products of volcanic action make up but a small portion of the solid crust of the globe. Great mountains and mountain chains are not volcanic in their nature or their origin, though sometimes crowned by volcanic cones; nor are earthquakes and volcanoes to be looked upon as anything more than incidental attendants upon the great agencies which are slowly but constantly raising and depressing continents.

The theory of volcanic phenomena here set forth was first partially indicated by Keferstein in 1834, and subsequently and apparently independently by Sir John Herschel in 1837. It, however, attracted little or no attention until, in 1858 and 1859, I again brought it forward, and endeavoured to show its conformity with the facts of chemistry, physics, and geognosy. In the hasty sketch of it here given, the chemist, the geologist, and the geographer will alike discover points which require elucidation or provoke criticism, but will, I hope, find, nevertheless, a concise and intelligible statement of a theory of earthquakes and volcanoes which appears to me more in harmony with the known facts of science than any other hitherto advanced.

P. S.—In justice to myself. it should be said that at the time this lecture was delivered I had no knowledge of Prof. J. D. Whitney's excellent and suggestive paper on earthquakes, which appears in *The North American Review* for April, 1869. The relation of modern volcanic phenomena to great accumulations of newer secondary and tertiary rocks, and the connection of the foldings and contortions of sedimentary strata with great thicknesses of the same, are set forth by me in several papers, the chief of which may be found in the *Canadian Journal* for May, 1858, the *Geological Journal* for November, 1859, and the *American Journal of Science* for July, 1860 (vol. xxx., p. 133), and also for May, 1861 (vol. xxxi., pages 406–414), where the important contributions of Professor James Hall, bearing upon this question, are noticed at length.

DESCRIPTIONS OF THE CANADIAN SPECIES OF MYOSOTIS, OR "FORGET-ME-NOT," WITH NOTES ON OTHER PLANTS OF THE NATURAL ORDER BORAGINACEÆ.

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As the true relations of our palustral forms of *Myosotis* have not hitherto been explained, it may be well to call the attention of botanical students to the subject, by characterizing our plants more carefully than has been done, and endeavouring to adjust the nomenclature, I shall add a few notes on the other *Boraginaceæ*, found within the Dominion or adjoining country, with the view of promoting enquiry in regard to doubtful points of identity and distribution.

All the species in British America and the Northern States are herbaceous plants, and several of them biennials or annuals. In the Southern States, however, there are five plants of the order which assume the character of small trees or erect or twining shrubs.

In our Flora this order is chiefly remarkable for the large proportion of species of exotic origin. The nutlets are, in some species, furnished with barbed prickles, which cause them to adhere to the coats of animals, but this is of itself not sufficient to explain the large number of introduced species, and the rapidity with which they seem to have spread. The total number of Canadian *Boraginaceæ* (excluding those of the North-West) is a little over 20 species, of which one-half are introduced; in the Northern States, Gray enumerates 29 species, of which 11 are introduced; and in the Southern States, Chapman describes 22, of which 3 are introduced. There is a manifest increase of introduced species northwardly.

Myosotis, Linn. In Professor Gray's "Manual of Botany of the Northern States," 2nd edition, (1856,) *Myosotis palustris* is described, with the specific name, in the broad-faced type of indigenous species, and as a perennial, but the remark is added, "Cultivated occasionally;" then it is said that the plant "varies into smaller forms, among which high authorities rank *M.*

cæspitosa, and (with yet more reason) the intermediate var. *laxa* (*M. laxa* Lehm.) Wet places common, especially northward." In the fifth edition (1868) *M. palustris* is still kept in the broad-faced type, but its distribution is thus noted:—"Naturalized from Europe, near Boston, escaping from gardens." This is followed by var. *laxa*, (*M. laxa* Lehm.,) briefly described and ranged thus:—"Wet places, northward." In short, Prof. Gray is of opinion that the normal *M. palustris* is a European plant, but that we have a variety of it here (*M. laxa*) which is indigenous.

In Wood's "Class Book or Flora of the United States and Canada" (1867) the true *M. palustris* is not indicated, but merely the so-called *M. palustris* var. *laxa*, as perennial and indigenous, with the synonym *M. cæspitosa* Schultz.

Professor Torrey, in the "Flora of New York State," describes *M. palustris* Roth, adding the remark:—"Our plant diffe. s from the European in its smaller flowers. It seems to be the var. *micrantha* of Lehmann."

In Chapman's "Flora of the Southern United States" (1862) the name *M. palustris* does not occur at all, but *M. laxa* Lehm. is described as an annual.

In the "Flora Canadienne" of the Abbé Provancher (1868) there is but one plant described under "*Myosotis des marais*," to which the names *M. palustris* Hook, *M. cæspitosa* Schultz, and *M. lingulata* Lech., are all made to apply equally.

In Dr. Hooker's "Outlines of the Distribution of Arctic Plants" (Linn. Trans. xxiii., pp. 251—348) *M. palustris* is given in his columns for Arctic Europe, North Europe and Asia, and *North-East America*, while *M. cæspitosa* is confined to Europe and Asia.

These citations show an obvious tendency to confusion in the use of names, which arises partly from difference of opinion and partly from a mistake respecting the plants. The plant, which is naturalized from Europe in the United States, is undoubtedly the normal form of *M. palustris*; it appears to be more abundant in the British Provinces, and there is the possibility of its being indigenous with us.

The plant described by American authors as indigenous, and as a variety of *M. palustris*, does not belong to *M. palustris* at all, but is a form of *M. cæspitosa*, a species that has long been well known, and was found, in the time of Sir James E. Smith, to retain its characters under cultivation, (*vide* "English Flora.") Whether we have more than one form of *M. cæspitosa* cannot be determined without a larger series of specimens from different localities; but hitherto I have met with nothing like the *M. strigillosa* or *M. repens* of Europe, which may be looked upon as intermediate forms, and are regarded by some as belonging properly to *M. palustris.* The right of *M. cæspitosa* to rank as a distinct species has long been recognized by the best botanists of Europe, and a careful comparison of our plant with the European leaves no room for doubt as to their identity.

M. palustris Withering. Stem freely creeping and rooting at the base, then ascending; from 6 to 12 inches long; thick, angular, branched; rough, with spreading hairs; prominent ribs or wings run down the stem from the margins and mid-ribs of the leaves. Leaves all sessile, clasping decurrent, oblong-lanceolate, or linear-oblong or linear-lanceolate, usually ligulate, rarely spathulate, (the lower half of the lamina usually broader than the upper,) blunt at the apex; rough, with very short (mostly appressed) hairs or hair-points; foliage always of a uniform bright green color. Flowers large; corolla bright sky-blue, with a white circle surrounding a prominent raised yellow ring or eye; the horizontal limb of the corolla much longer than the tube; coralline divisions almost overlapping and slightly emarginate; calyx more than half as long as its pedicel; cleft nearly half way down into five segments, which are triangular-ovate; rough, with very short appressed bristles; peduncle and pedicels, with appressed hairs. Flowers in June and succeeding months, remaining long in blossom, partly from the continuous branching of the stem and successive production of new racemes in the axils, and partly from the production of fresh flowering shoots from the creeping base of the stem.

Myosotis palustris, Withering. "Arrangement of British Plants," vol. ii., p. 225; Smith, "English Flora;" Babington, "Manual of Botany;" Hooker & Arnott, "British Flora;" A. Gray, "Man. Bot.," 5th ed., p. 364 (exclude var. *laxa.*)—Regel & Herder.

Not *M. palustris* Torrey. "Flora of New York State"

This species grows in muddy spots by the margins of streams, usually on black mud, and in places liable to inundation; Sackville River and its tributaries, N.S.; Sydney, Cape Breton; also near Halifax, G.L.; Boyne Cottage, Studley Road; W. L.

Lindsay, sp. We require more information as to the occurrence of this plant before deciding definitely whether it is an introduced or indigenous species, for, being the common Forget-Me-Not, it is frequently cultivated in garden patches, and has obviously a great capacity for spreading in suitable situations.

M. palustris extends through Europe to the Altai, where it is noticed by Regel and Herder; it appears, however, to be more Southern in distribution than *M. cæspitosa.*

M. cæspitosa, Schultz. Stem nearly a foot high; usually simple, erect and straight from a short decumbent base, or only very slightly creeping; round, wiry, without wings or angles, but with a narrow furrow or "impressed line" running down from the margins of the leaves; smoothish-looking throughout and shining, especially in dried specimens, but the surface is beset with very short, appressed, conspicuous, bristly hairs. Lower leaves stalked; upper ones sessile; all more or less spathulate; broader above the middle, and rounded or blunt at the tips; the veins, especially towards the base, of a reddish color, with which the whole plant is frequently tinged. Flower small; pale sky-blue, (half the size of that of *M. palustris*, and paler in colour;) limb of corolla nearly horizontal, but slightly incurved, and equal in length to the tube. Calyx covered with appressed bristles. Flowers in June or July; one set of cymes is produced, and there is no prolonged succession of blossoms as in *M. palustris*.

M. cæspitosa, Schultz. Ledebour, Smith, Babington, Regel & Herder, Kar. & Kir., Trautv.

M. palustris, Torrey. "Fl. New York State," vol. ii., p. 87 (exclude synonyms.)

M. palustris, var. *laxa* Asa Gray. "Man. Bot., N. S." 5th ed. Wood, "Fl. of United States," p. 562.

M. laxa, Chapman. "Fl. S. States."

Not *M. strigillosa*, Bertel.

Not *M. laxa*, Lehmann?

"Var. *micrantha* of Lehmann?"—Torrey.

Ditches, drains and other moist places; usually in gravel y or stony soil. Quite common in Halifax County, N.S., as in railway drains between Bedford and Windsor Junction, roadsides at Sackville, Prince's Lodge, &c. Probably common throughout the Dominion. I have collected it at Kingston. Dr. P. W. Maclagan notes it at Chippewa and Thorold, Ont., and Mr. Macoun finds it very common about Belleville. It is common in

Northern Europe, extending to the Altai, and in America is not uncommon in low grounds throughout the States south to Florida.

M. arvensis, Hoffman. Kingston, Ont., a weed in gardens; not indigenous, but probably effectually naturalized as a plant cultivated by man against his will. Dr. Hooker observes:—"Watson finds this occasionally approximating to *cæspitosa*, and I find it difficult to separate northern forms of one from the other." This remark should set at rest all doubt as to the propriety of separating *caespitosa* from *palustris*, unless, indeed, we revert to the old Linnæn idea of one species of *Myosotis*, which no modern botanist is prepared for.

M. verna, Nuttall: Chapman, "Flora of Southern United States," p. 333 (in part). *M. stricta*, Wood: "Flora United States," p. 562 (in part probably.) *M. arvensis*, Torrey: "Fl. New York State," vol. ii., p. 88 (not of other botanists.) *M. scorpoides* (*a*) Michaux.

Whether *M. stricta* Link, Ledebour, Kar. & Kir., Trautvéteer, Regel & Herder, &c., is identical with this admits of some doubt. Millcreek, Odessa, Ont., 8th July, 1861—G. L.; Malden, Ont.—Dr. Maclagan. Mr. Macoun speaks of it doubtfully as occurring at Ox Point, below Belleville; very rare.

There are two forms, viz.:—

a. Typica. Stem simple, branching above into cymes. *M. verna*, Chapman. Indian Island, Bay of Quinté—G. L.

b. Ramosa. Much branched from the very base; whole plant more robust. Odessa, near Kingston, Ont.—G. L. Chapman's var. *macrosperma* may prove to be a distinct species.

M. versicolor, Persoon. I have no information respecting this as a Canadian plant.

M. suaveolens, (*b*) *Americana*. This plant is intermediate between the *M. suaveolens* (alpestris) of the mountains of Europe, and *M. sylvatica* of the plains. Between Fort Youcon and Lapierre's House, in the Youcon Country—Governor McTavish, sp.

Eritrichium villossum, Bunge. West of Rocky Mountains, between Ft. Youcon and Lapierre's House—Governor McTavish, sp.

Eritrichium villosum, var. *arctioides*; *E. arctioides*—D. C.; *E. villosum* Hook, fil; *E. villosum*, var. *arctioides* A. Gray, in "Parry's Plants." Fort Simpson, summer of 1853—Governor McTavish, sp.

Onosmodium Virginianum, D. C. On the common, north from Railway Station, Belleville; rather rare—Mr. Macoun. This species extends south to the dry pine barrens of Florida.

O. Carolinianum, D. C. Brantford, Ont.—Dr. P. W. Maclagan. Extends to the Southern States.

Echium vulgare, Linn. Naturalized from Europe. This plant has spread considerably in rear of Brockville, Ont. Common near the Seminary at Belleville, and on Stillman's Farm, Seymour, Ont.—Mr. Macoun. Christy's Corners, on the road from Kemptville to Spencerville, Ont.

Judge Malloch informed me that this was sown as a garden plant, about the year 1850, by a farmer of the name of Christy. It soon spread, so as to form a noxious weed on his farm, and when I visited the locality in 1862 it had spread along the road-side for four or five miles. In North Carolina and Virginia it is said to have become a troublesome weed.

The plant varies in form:

a. Plant large; weed-like; leaves green, with long, straight, erect bristles on the lower surface of the mid-ribs, as well as on the stem, and especially on the pedicels and calyx. Roadside, Tin Cap Schoolhouse, between Brockville and Farmersville. This is like the Southern plant.

b. Smaller; corolla larger, and rather wider in proportion; leaves whitish, with short, fur-like, scarcely spreading hairs, and without erect bristles on the mid-ribs; the bristles on the stem and flower stalks shorter than in *a*. Between Kemptville and Spencerville. This is like the Scotch plant.

Borago officinalis, Linn. Adventive from Europe. Sackville, N.S., G L. Roadside near Odessa, Ont.—Dr. Dupuis. Not noticed by any of the American botanists as having become wild in the States, and may be only a temporary colonist with us. It is not a plant that spreads in its native country. There is a specimen in my herbarium, from Rev. P. Somerville, labelled "Malta. Feb., 1839; very rare, if not now extinct."

Lycopsis arvensis, Linn. Adventive from Europe. Kingston, Ont. An abundant weed about Queen's College grounds and neighboring gardens. Montreal—Dr. P. W. Maclagan.

Symphytum officinale, Linn. A European plant, sparingly naturalized with us, as it is in the United States and in Europe beyond its original range. Waste ground about Queen's College, and on Prince's Street, Kingston. Roadsides near Hillton, Brighton—Mr. Macoun. Montreal, abundant; also, Niagara River—Dr. P. W. Maclagan. Probably we have more than one form, possibly more than one species. The Montreal and Niagara plants I have not seen.

Lithospermum arvense, Linn. Adventive from Europ An abundant weed in gardens at Kingston, Ont., 16th May, 1862, in fl., G. L. Montreal—Dr. P. W. Maclagan. In wheat fields, Brighton; also, Taylor's Hill, Belleville; common—Mr. Macoun. The plant varies somewhat, being either simple or divaricately branched from a straight red tap-root; the red root gives out a purple stain to paper in the herbarium. It extends south to Florida.

Var. *a. incanum*. Leaves linear, narrow, more or less canescent. Indian Island, (uninhabited,) Bay of Quinté, G. L. I have the same form from Malta. This appears to be the proper form of the plant.

b. robustum. Leaves linear, lanceolate, pale green, covered with very short setaceous hairs. This is the common weed form. English (Cambridgeshire) and Scotch specimens agree with this. It is larger than the plant from Indian Island.

L. officinale, Linn. Naturalized from Europe. Abundant about roadsides and waste places near Kingston, G. L. Montreal, abundant, and Niagara River—Dr. P. W. Maclagan.

L. latifolium, Michaux. Indigenous. Bois Blanc and other islands in Detroit River—Dr. P. W. Maclagan.

L. hirtum, Lehm. Grand Rapids, 13th July, 1851—Governor McTavish. Indigenous.

L. canescens Lehm. Indigenous. Grand Rapid, 13th July, 1851—Governor McTavish; Malden, Sandwich, Ont.—Dr. P. W. Maclagan; Assiniboine River, July, 1861; Lake Manitoba, June and July, 1861, in fl., and Fort Garry, July, 1861—Dr. Schultz, sp. Nos. 8, 66, 82 and 143.

"*L. linearifolium*, Goldie. Malden, Ont."—Dr. P. W. Macla gan. I have not seen the specimen.

Mertensia maritima, Don. More common on our coasts than on those of the United States. Abundant on the sandy shores at Great Bras d'Or, Cape Breton—G. L.; Gulf of St. Lawrence, on the New Brunswick Coast—Rev. J. Fowler; Bay of Fundy—Mr. J. F. Mathew; St. Augustine, Labrador, 1865—Rev. D. Sutherland, sp.; Anticosti, a form with glabrous leaves was occasionally met with—Mr. Verrill.

M. sibirica, var. *paniculata*. Shores of the great Lakes, &c.; Hudson's Bay—Gillespie, sp.; Fort Simpson, 1853; between York Factory and Norway House; Youcon River; Lake Superior; York Factory—Governor McTavish. The specimens vary very much in size, breadth of leaves, hairiness, roughness, &c.

Dr. Hooker observes that *Mertensia pilosa* D. C., which includes *Lith. corymbosum* Lehm., and *paniculatum* Don, is clearly referable to *denticulata* Don, the hairy calyx being a very inconstant character. These, he suggests, should all be united under *sibirica;* and in reference to *M. Drummondii* Don he finds no plicæ in the tube of the corolla, whence it must be associated with *Virginica*, of which it appears to be a northern form, but it has not been gathered anywhere between the Arctic Sea Coast and the United States. *M. Virginica* is a southern plant extending from New York and Wisconsin to South Carolina and Tennessee.

The following remain to be identified with described forms. The first is a variety of *paniculata;* the second is very different in aspect:

1. Leaves narrow, linear-lanceolate; sepals narrow, ciliate on the margins; otherwise glabrous. West of Rocky Mountains, say from Fort Youcon to Lapierre's House, W. J. H.—Governor McTavish, sp. A small plant; leaves bright green, with very few rough points.

2. Leaves orbicular to very broadly ovate, with very short hairs, but quite rough all over with hair bulbs, and perfectly glaucous; sepals externally glabrous, except at the margins. Youcon—Governor McTavish. A robust, large-leaved plant, as glaucous as *M. maritima*, but with the flowers, &c., of the *Sibirica* group.

Echinospermum Lappula, Lehm. Naturalized from Europe. Hinchinbrook, July, 1862—G. L. So common throughout some of the settled portions of Ontario that botanists have neglected to note its distribution, or to collect many specimens; but rare or absent over a large portion of the Maritime Provinces. (According to Wood it extends to Arctic America, but probably he refers to another form.) This is a rare plant in Britain, found in only one locality in the South of England. Provancher notices it as extending to Carolina, which must be a mistake, as there is no notice of it in "Chapman's Flora." Regel & Herder, in "Plantæ Semenovianæ," 1869, p. 31, describe two varieties, viz.:

a. Typicum. Prickles in two rows on the margins of the nutlets. *E. Lappula* Lehm. "Asperif," p. 121. Ledebour, "Flora Ross.," vol. iii., p. 155.

b. Consanguineum. Prickles in three rows at the base, from middle to apex two rows or one. *E. consanguineum*, Fischer & Meyer, "Index Sem. Hort. Petrop.," vol. v., p. 35. Ledebour, "Fl. Ross.," vol. iii., p. 157.

E. Redowskii, Lehm. "Asperif," p. 127; Ledeb., "Fl. Ross.," vol. 3, p. 158; A. Gray, "Man. Bot.," ed. 5, p. 365. Noticed by Prof. Gray as growing at St. Paul's, Minn., and on the plains westward, and, therefore, likely to be met with in our intercourse with the Red River country. The following species, differing in the branching and in the granulate or tuberculate, or nearly smooth back of the nutlets, and in the rugose or smooth sides, are referred by Regel as named varieties of this species, viz.: *E. strictum*, Ledeb.; *E. tenue*, Ledeb.; *E. Karelini*, Fischer; *E. oligacanthum*, Ledeb.; *E. affine*, Kar. & Kir. It is, therefore, very desirable that specimens from different localities should be examined with much care.

E. deflexum, Lehm. Differs by its recurved fruit pedicels from *E. Redowskii* and *E. Lappula*, in both of which they are erect; prickles in a single series. *E. deflexum* Lehm. "Asperif," p. 120; Ledeb., vol. iii., p. 154; Regel & Herder, "Pl. Sem., 1869," p. 30. Noticed in Hooker's "Outlines of Arctic Distribution," as occurring in N. E. America, as well as in Europe (Arctic and Southern) and Asia to N. E. I am not sure, however, whether he means this to be identical with *E. Redowskii*. Regel keeps it separate.

E. patulum, Lehm. has extremely short, erect pedicels, (flowers sub-sessile,) and is kept separate by Regel. *E. patulum* Hooker, probably different, is referred by Gray to Redowskii in "Man. Bot.," ed. 5.

Cynoglossum officinale, Linn. Naturalized from Europe. Common throughout the settled portions of Ont.—G. L.; Belœil, P.Q., 1869—Dr. J. Bell; Portland, Ont., July, 1860—Dr. Dupuis, sp. Is naturalized throughout the United States, south as far as N. Carolina.

C. Virginicum, Linn. Indigenous. Montreal—Dr. P. W. Maclagan; Belœil—Dr. Bell. Abundant in pine woods east from Castleton, Ont.—Mr. Macoun. Extends south to Florida.

C. Morisoni, D. C. Racemes numerous, slender, divaricate, bracted throughout; flowers pale-blue. Kingston, Chippewa, Malden, Ont.—Dr. P. W. Maclagan. Borders of woods and half-cleared land about Belleville—Mr. Macoun; Portland, Frontenac County, Ont.—Dr. Dupuis, August, 1860, fl. and ft.; Frankville, Kitley; also rear of Kingston; abundant along every roadside—G. L. Not noticed as occurring in Quebec Province, but probably common about Montreal.

Prof. Gray characterizes this plant as "a vile weed" in the States, and it is so, likewise, throughout a large portion of Ontario, but not in the Maritime Provinces. Notwithstanding its universal prevalence in some districts, and its complete absence in others, its distribution has not been very accurately traced. Judging from specimens in my herbarium the southern plant is more robust and more hairy than the Canadian. It extends as far south as the upper districts of South Carolina.

ON THE RANUNCULACEÆ OF THE DOMINION OF CANADA AND OF ADJACENT PARTS OF BRITISH AMERICA.

By George Lawson, Ph.D., LL.D., &c.

At a meeting of the Nova Scotian Institute held Dec. 13, 1869, Professor Lawson, of Dalhousie College, who has been for some time engaged in investigating the Botany of the Dominion, read a *Monograph of the Ranunculaceæ of the Dominion of Canada and adjacent parts of British America.* The paper, which is a lengthy one, will be published in the Transactions of the Institute; in the meantime the following brief outline of its contents may not be unacceptable to our readers:—

The Ranunculaceæ are characterised by the perfect separation of all the parts of the flower, the calyx of separate sepals, the corolla of separate petals, the stamens numerous and free, and the fruit composed of separate carpels. All these parts arise directly from the thalamus or receptacle; there is a great development in the size of the sepals, and a tendency to suppression or malformation of petals. The Ranunculaceæ are mostly herbaceous plants, with much divided leaves having broad sheathing petioles. They are characteristic of northern countries; in the Monograph, 48 indigenous and six introduced species, making 54 in all, are described, so that in proportion to territory there are fewer species in the Northern States (61), and still fewer in the Southern States (51). The most interesting point in distribution, however, is the intimate relation of many of our British American plants to those of Eastern Europe and Asia, respecting which many details were given.

The genera of our Ranunculaceæ are 16 in number:—1. *Clematis*, with fruit consisting of feathery-tailed achenes, and valvate calyx, large and petal like. 2. *Pulsatilla*, with equally large petal like sepals and feathery-tailed achenes, but herbaceous plants with a large involucre, and imbricate æstivation. 3. *Anemone*, differing from the preceding in the absence of feathery tails. 4. *Syndesmon*, with ribbed fruit, large petaloid sepals and involucrate foliage. 5. *Thalictrum*, with usually ribbed carpels, diœcious or hermaphrodite flowers, and very compound leaves, but no involucrate verticil. 6. *Ranunculus*, with medium sized green sepals, large, usually yellow, petals, and single-seeded achenes. 7. *Myosurus*, with a great development of the receptacle into a body resembling a mouse's tail. 8. *Caltha*, with a fruit composed of separate, several-seeded carpels or pods, and entire leaves. 9. *Trollius*, with similar fructification but palmately divided leaves. 10. *Coptis*, with cucullate petals and ternate leaves. 11. *Aquilegia*, with trumpet-like or spurred petals. 12. *Delphinium*, with the upper sepal produced downwards into a spur. 13. *Aconitum*, with irregular hooded calyx enclosing small abnormal stalked petals. 14. *Cimicifuga*, with deciduous sepals and follicular fruit. 15. *Actæa*, with deciduous sepals and fruit of many-seeded berries. 16. *Hydrastis*, with a fruit of many single or two-seeded berries.

The various species belonging to these genera are fully described in the paper; their synonymy is investigated and their distribution traced in detail throughout all the Provinces, and their range in other countries is likewise given. The effects of the dry and hot inland climate of Ontario are conspicuous in the absence from that Province of many plants common to the North-West and Maritime Provinces.

Several plants that have been described as Canadian are shown to have been so recorded through mistakes, and many points still unsettled are suggested for investigation. Of Clematis, we have two species, one local and the other general in its distribution, the first of these, *C. Virginiana*, grows around the rifle range at Bedford, and at Windsor N.S.; it extends to Lake Winnipeg, Isle Verte being its last point north-eastwardly. The subgenus *Pulsatilla* is confined to the North West, whence numerous specimens have been received from Gov. McTavish. The common form of the species, named *P. Nuttalliana*, is now known to be identical with *P. Wolfgangiana* of the Russian botanists, which is itself a variety of the European *P. patens*. Two forms from the North-West are described, besides *alpina*, one of which does not accord with Regel's *Wolfgangiana*. *Anemone dichotoma* is shown to be the proper name for the plant hitherto known as *A. Pennsylvanica*. Of *A. nemorosa*, the Windflower of English forests, four varieties are described as inhabiting the Dominion, one a small northern form, and another found at Belleville by Mr. Macoun. *A. Richardsonii* has been received only from the Hudson's Bay Territories. *A. Hepatica* is shown to be essentially an Ontarian and New England plant, although found to extend into Nova Scotia, having been gathered at Windsor by Professor How. *A. acutiloba* is restricted and less southern in range. *A. narcissiflora* is not known to exist within British America, although it occurs in the United States in the Rocky Mountains. *A. parviflora* is a North-Western plant, and is found also at Gaspé by Dr. Bell, of Montreal, and on Anticosti, and has usually 5, not 6 petals, as described. *A. multifida* has not yet been collected in Canada, except on the Gulf shore and in the North-West, but will probably reward some diligent searcher in Ontario. *A. Pennsylvanica* has a wide and southern range. *A. cylindrica*, a sand-hill plant, is confined to central and western Ontario.

Syndesmon is a curious little plant, a link between the Windflowers and Meadow-rues, but has only been found in two localities, although in the adjoining States it is not rare; its Canadian habitats are St. David's, Dr. P. W. Maclagan; Hamilton, Judge Logie.

Thalictrum Cornuti is a stately plant with large masses of showy white blossoms, rendering it conspicuous along the Sackville River and on the meadows at Beaver Bank, and is of general distribution throughout the Dominion. *T. purpurascens*, differing in its sessile stem-leaves, greenish flowers and drooping anthers, is to be looked for in dry situations; its record as Lower Canadian is, however, a mistake, and possibly it does not reach so far north as the St. Lawrence. *T. dioicum* has a wide range, but there are two distinct forms about Kingston which require further investigation, one growing near Kingston Mills and the other at the Penitentiary. *T. alpinum*, an arctic European plant, is confined with us to Anticosti and Newfoundland; it is general within the Arctic circle, and runs down the Rocky Mountains to low latitudes, as Arctic plants are apt to do. *T. clavatum* is a York Factory plant remarkable for its pod-like, stipitate carpels, without furrows, but with embossed veins. Of *Ranunculus* 18 species are described and 1 excluded. *R. repens* is the most common as a weed, but rare as an indigenous plant, in which character it grows near Toronto, where it has beon observed for many years by Prof. Hincks. *R. bulbosus* has been frequently reported as Canadian, but the evidence is doubtful. *R. ovalis*, *R. brevicaulis*, and *R. cardiophyllus* are referred as mere forms of *R. rhomboideus*. *R. auricomus* does not belong to our flora, and *R. affinis*, here referred as a variety of it, is confined to the Arctic Sea and the North West Hudson Bay Territories. Of *R. abortivus* two varieties (pratensis and sylvaticus) are described. *R. nivalis* was found by Dr. Rae at Repulse Bay, and the specimens agree with *sulphureus* of Solander. *R. Cymbalaria* is a seashore plant. The numerous varieties of *R. multifidus* and *R. aquatilis* still require careful comparison in the living state with European forms. *R. digitatus*, is a Rocky Mountain plant, approaching *Ficaria* of Europe. *Trollius laxus* has not been recently found in Canada. *Aquilegia Canadensis* presents two forms, and abounds in Ontario, but becomes scarce eastward and northward; it will probably be found in Annapolis, if anywhere in Nova Scotia.

A. brevistyla is quite western, and does not come so far east as to enter the Province of Ontario. *A. vulgaris*, on the other hand, is confined to Nova Scotia, except as a mere garden escape; but even with us it is only a naturalized plant, one of the Wild Flowers of England brought long years ago by the Duke of Kent, and now widely spread through the woods and along our railway banks and roadsides. *Delphinium exaltatum* is from the Youcon and Clear Water Rivers, although in the States its distribution is decidedly southern. *D. azureum* is also from the Youcon; *D. Consolida*, an introduced European plant, is found at Prescott, and *D. Ajacis*, is an excluded species, not permanently naturalized. *Aconitum delphinifolium* is kept distinct from *Napellus*, of which

Dr. Regel describes no fewer than forty varieties and forms, all named and classified. *A. semigaleatum*, not previously noticed as American, is referred as a distinct variety of *delphinifolium*; flowers very large, sepals of thin texture, spreading, galea quite depressed with a long acuminate point. These plants are indigenous, and the specimens of both are from Governor McTavish. The true *A. Napellus* is a naturalized plant. *Cimicifuga* is confined to Cayuga, in the extreme south west of Canada, where it was found by Dr. Maclagan. *Actæa rubra* is widely spread throughout the whole Dominion, but *A. alba* is south western. *Hydrastis Canadensis* is confined to Ontario, and *Adonis* is excluded, as the specimens sent to Hooker from Labrador, 30 or 40 years ago, had no doubt sprung from seeds dropped there by accident, and the plant has not been heard of or seen since.

CANADIAN ZOOLOGY.

Messrs. Dawson have just issued a "Handbook of Zoology, with Examples from Canadian Species, Recent and Fossil," by the Principal of McGill University, one who has been engaged in teaching Natural Science and in making original observations in some of its departments. The effort is a most useful one, and must prove of the utmost service both to teachers and learners in this country. The intention of the work is to illustrate the subject by Canadian examples, and these are taken both from recent and fossil species, by which means greater completeness is secured, and the work is made useful to collectors of fossils and students of Geology. The tone and character of the work are thus explained in the preface:—

"In teaching Zoology nothing is of more importance than to have the means of directing the attention of the student to the animals of the country in which he lives. For this reason I have been in the habit of preparing a synopsis of the subject for the use of my class, with examples taken as far as possible from common native species. In preparing a new edition of this synopsis, I was advised by the publisher to give it greater extension, in the hope that it might be useful to other teachers, and to isolated students and collectors. The present manual is the result of this attempt; and the only merit which it claims is that of giving a skeleton of the subject, with illustrations taken from species which the student can collect for himself within the limits of British North America, or can readily obtain access to in public or private collections.

"Fossil animals are included as well as those which are recent, because many types not represented in our existing fauna occur as fossils in our rock formations; and because one important use of the teaching of Zoology is that it may be made subsidiary to geological research.

"I have avoided the modern doctrines of a 'physical basis of life' and of 'derivation,' because I believe them to rest on grounds very different from those of true science, and therefore to be unsuitable for the purposes of a text-book. I have also retained the Cuvierian provinces of the animal kingdom as amended by modern discoveries. I am quite aware that there are Zoologists who affirm that the Province Radiata has been 'effectually abolished' and that other provinces should be broken up; but as I cannot help perceiving that the four types of the great French naturalist exist in nature, I have not scrupled to adhere to them, *as the expression of a grand and* philosophical idea, essential to an accurate and enlarged conception of nature.

"In the present chaos of synonymy in Zoology, I have often been perplexed as to the generic and specific names to be given to our most common animals; but have endeavoured to take such a middle way between the older names and the later innovations as seemed likely to be least perplexing to the student."

To some of those who regard themselves as the more "advanced" naturalists the views above stated may be objectionable, but they are, no doubt, the safest in the present state of the subject.

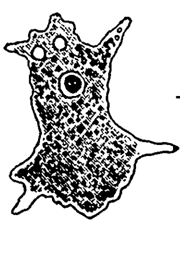
The idea of representing the various groups of animals by Canadian examples, is one which involves an immense amount of labour and research, and must necessarily, in the present state of knowledge, be more or less incomplete. Still it has been carried out to a great extent in this work, and the student and collector will find described, and often well figured, a very large proportion of our more common and important invertebrate animals. As examples, we give the following extracts, which we have selected purposely as referring to creatures not popularly much known.

They will also serve to show the profuse manner in which the work is illustrated with wood-cuts:—

RHIZOPODS.

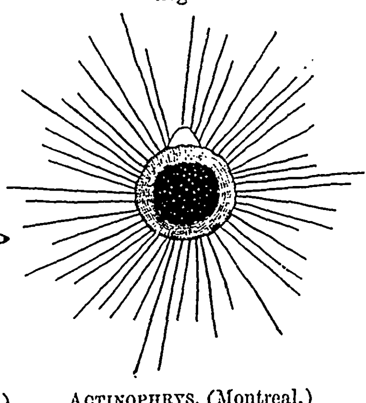
We may take, as a type of this group, the *Amoeba*, a microscopic creature frequently found in ponds containing vegetable matter. It occurs in Canada, and may readily be procured by the microscopist. Different species have been described, but they are very similar to each other. When placed under the microscope, a living specimen appears as a flattened mass of transparent jelly; the front part moving forward with a sort of flowing motion, and jutting forth into pseudopodial prolongations; the hinder part appearing to be drawn after it, and presenting fewer irregularities. In its interior are seen minute granules which flow freely within its substance, and one or more vesicles which alternately expand and become filled with a clear fluid, and contract and disappear. Often also there are certain spaces or vacuoles, in which may be seen minute one-celled plants or other particles of food which the creature has devoured, and which are in process of digestion. The outer portion of the substance of the Amoeba appears to be more transparent and dense than the central portion. So soft is the tissue that the creature seems to flow forward like a drop of some semi-fluid substance moving down an inclined surface; but as the Amoeba can move forward on a horizontal plane or up an incline, it is obvious that its movement proceeds from a force

Fig 24.



AMOEBA, (Montreal,) Magnified.

Fig. 25.



ACTINOPHRYS, (Montreal,) Magnified.

acting from within, and probably of the nature of muscular contraction. Nor are there wanting indications that these motions are voluntary and prompted by the appetites and sensations of the animal. Fig. 24 represents one of the states of a specimen from a pond on the Montreal Mountain.

Another generic form found in the same situation is *Actinophrys*, the Sun-animalcule. In this the outer coat is more distinctly marked, and the body retains a globular form, while the pseudopodia are very slender and thread-like. Fig. 25 represents a specimen found with the preceding.

Amoeba and Actinophrys belong to a family of Rhizopods; (the Amoebina,) which either have no hard covering or a thin crust or lorica covering part or the whole of the body. The remainder of the Rhizopods are protected by calcareous shells, often of several chambers and perforated by pores for the emission of pseudopodia, (*Foraminifera*,) or they are covered by a silicious shell or framework of one piece, (*Polycystina*). The whole of the Rhizopods may thus be included in the following groups, which may be regarded as sub-orders or families:

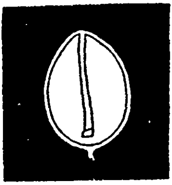
1. *Amoebina*, without hard skeletons, and mostly fresh-water.
2. *Foraminifera*, with calcareous skeletons; marine.
3. *Polycystina*, with siliceous skeletons; marine.*

The Foraminifera are the most important of these groups, since they occur in immense abundance in the waters of the ocean, and in its deeper parts their calcareous shells accumulate in extensive beds. According to Messrs. Parker and Jones, from 80 to 90 per cent. of the matter taken up by the sounding lead in deeper parts of the Atlantic, is composed of their remains. In like manner, in the sea bottoms of former geological periods, were accumulated, by the growth and death of Foraminifera, the great beds of chalk and of Nummulitic and Miliolite limestone. In the older formations, also, these creatures are found to have attained gigantic dimensions as compared with living species. A Foraminiferous organism of dimensions unequalled in the modern seas (Eozoon Canadense, Fig. 36) occurs in the Lower Laurentian, and is the oldest form of animal life known to us. The forms figured (Figs. 26 to 35), as seen under the microscope, are some of the most numerous in the Gulf of

* Some naturalists form for these a separate class or order (*Radioloria*).

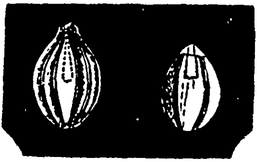
St. Lawrence; in the deeper parts of which great numbers of these creatures occur.

Fig, 26.



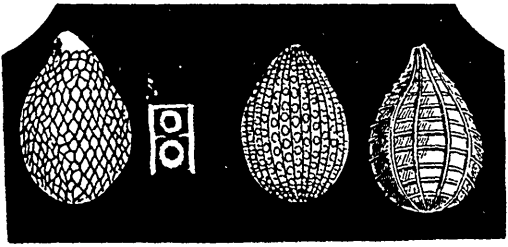
ENTOSOLENIA GLOBOSA, (Gulf St. Lawrence.)

Fig. 27.



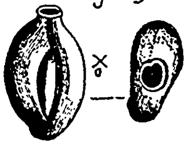
ENTOSOLENIA COSTATA, (Gulf St. Lawrence.)

Fig. 28.



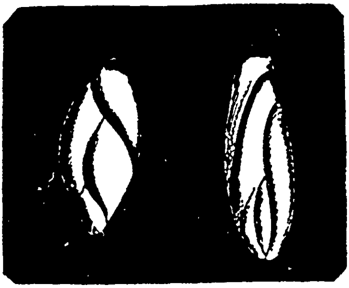
ENTOSOLENIA SQUAMOSA, three varieties, (Gulf St. Lawrence.)

Fig 29



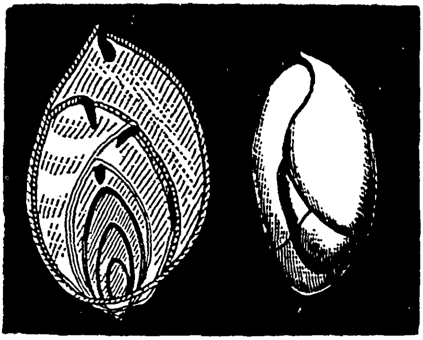
QUINQUELOCULINA SEMINULUM, (Gulf St. Lawrence.)

Fig. 30.



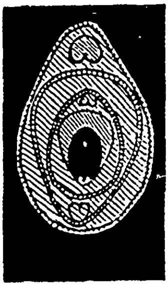
POLYMORPHINA LACTEA, (Gulf St. Lawrence.)

Fig. 31.



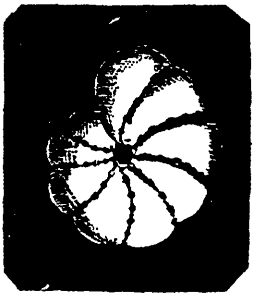
Bulimina presli, (Gulf St. Lawrence.)

Fig. 32.



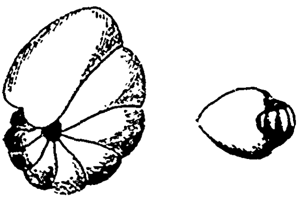
Biloculina ringens—Section, (Gulf St. Lawrence.)

Fig. 33.



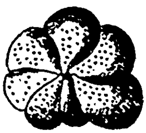
Polystomella crispa, (Gulf St. Lawrence.)

Fig. 34.



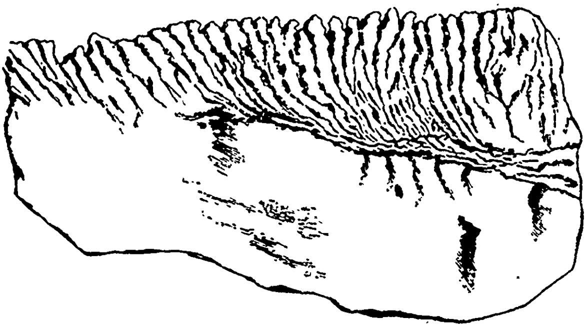
Nonionina scapha—Var. Labradorica, (Gulf St. Lawrence.)

Fig. 35.



Truncatulina lobulata, (Gulf St. Lawrence.)

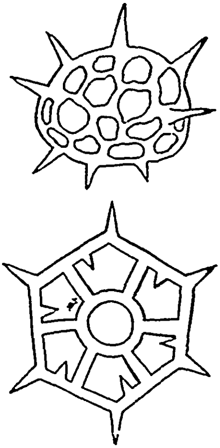
Fig. 36.



EOZOON CANADENSE—Dawson.—Laurentian system, Canada. Section of a small specimen natural size.

The Polycystina are almost equally widely diffused in the sea, though less abundant than the Foraminifera, and their silicious skeletons are often of great beauty and symmetry. Fig. 37 represents two species obtained from a depth of 313 fathoms in the Gulf of St. Lawrence, by Capt. Orlebar, R. N.

Fig. 37.



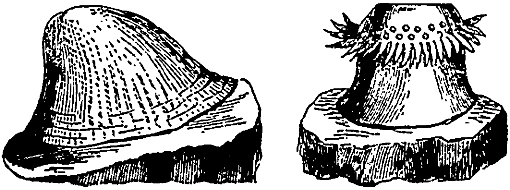
CERATOSPYRIS and DICTYOCHA ACULEATA ? Gulf St. Lawrence, 313 Fathoms.

SEA ANEMONES AND THEIR ALLIES.

The Actinias or Sea-anemones may be taken as the type of the Zoantharia; and as an example of these the species named by

Agassiz *Rhodactinia Davisii*, and which is the most common species on the north shore of the Gulf and River St. Lawrence, may be noticed here. It is probably a variety of *Actinia crassicornis* of the British coast. Externally, when expanded, it presents a cylindrical body attached at the lower extremity to a rock or stone, and at the upper having a crown of thick worm-like tentacles arranged in several rows, in the centre of which is the mouth. The external surface of the body, the tentacles and disc are often gaily coloured in shades of purple, crimson, and flesh colour, though different individuals differ very much among themselves in this respect, and also in the smoothness or tuberculated character of the body. When fully expanded, the animal has the appearance of an aster or other stellate flower. When irritated or alarmed it withdraws its tentacles. contracts the body wall over the disc, and assumes the form of a flattened cone. Its food consists of such small animals as may be attracted by its gay colours, or may accidentally come within reach of its tentacles. To enable it to seize these it has in the substance of the tentacles an apparatus of extensile and retractile thread-cells, by means of which it can hold with some tenacity any object which touches the tentacles, and can also exert a benumbing influence tending to paralyze and subdue the resistance of its prey. The specimens figured (Figs. 43 and 47,) were dredged in Gaspé, and referred to a new species, *R. nitida*, but may possibly be a variety of the above.—Another variety, found in the River St. Lawrence, is permanently tuberculated, and cannot be distinguished from *A.* (*Urticinia*) *crassicornis*, as ordinarily seen in Great Britain.

Fig. 47



ACTINIA (Urticinia) CRASSICORNIS, contracted, and smaller individual expanded.

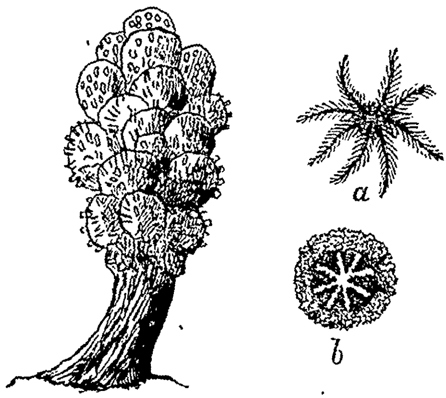
A larger and often more beautiful representative of the Actinoids is the *Metridium marginatum*, a species closely allied to the *Actinia dianthus* of Great Britain. It is found in great perfection at the mouth of Gaspé Basin, where the specimens represented in the following figures (Figs. 48, 49) were obtained. In this species the tentacles are in two series, the outer series being very numerous, and arranged on lobes of the edge of the disc.

Fig. 48.

METRIDIUM MARGINATUM, Edw. & Haime, (Gaspé.)

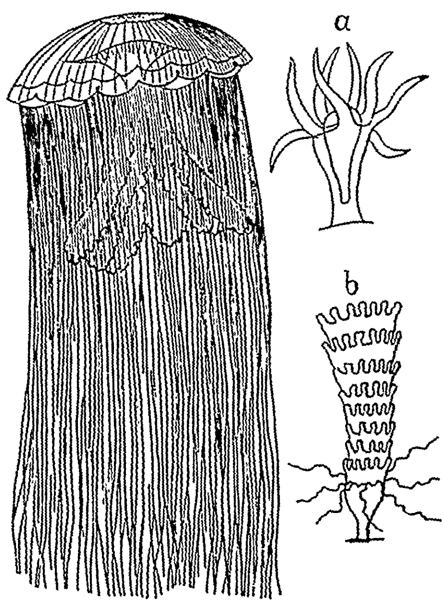
As a native example of the Alcyonoids, we may take the *Alcyonium rubiforme*, (Fig. 51,) which is sometimes cast up in storms, on the shore of the Gulf of St. Lawrence, and may be obtained alive by dredging in deep water. It presents tuberculated yellowish or pinkish masses of a club-shaped form, from an inch to three inches in length, and of a spongy or firmly gelatinous structure. The surface is studded with round or star-shaped cells of small size, from which, when the creature is alive and undisturbed, delicate semi-transparent polyps protrude themselves and extend their tentacles. These little animals can be easily distinguished from those of the last group by their pinnate tentacles, eight in

Fig. 51.



Alcyonium rubiforme, Dana, (Gaspé,) (a) Polyp expanded; (b) Polyp contracted.

Fig. 66.



Cyanea Arctica, Per. and Les. reduced.
(a) Hydroid progemy.
(b) Strobila.

number. The corallum or skeleton is of a corneous and fibrous nature, and the animals are connected by numerous canals traversing its substance.

THE SEA JELLIES.

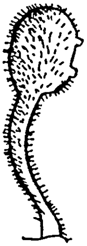
One of the best representatives of this order on our coast is the great blue Jelly-fish, *Cyanea Arctica*, (Fig. 66), which is often found in the Gulf of St. Lawrence and on the Atlantic coast of Nova Scotia, a foot or more in diameter, and is said sometimes to attain the enormous diameter of seven feet. The most conspicuous part of this creature, as it floats in the sea, is its great violet-coloured disc, the edges of which are moved slowly up and down as it swims along. In the centre of this disc below, projects the proboscis or external stomach, furnished with a profusion of filmy fringes hanging at the extremities of the four lateral processes into which its free end is divided. From the margins of the disc float backward innumerable long reddish tentacles armed with urticating thread cells, which paralyze any little animal they may touch, and enable it to be drawn into the mouth. These tentacles are often several feet in length. Between the tentacles and the base of the probocis, when the creature is mature, may be seen four great ovaries loaded with yellowish eggs. The eyes and ear-vesicles, each eight in number, are placed in notches in the margin of the disc, while circulation and respiration are provided for by a network of vessels ramifying through the disc. Though these animals are as tenuous as jelly, and contain very little solid matter, their organs are of singular complexity, and the body consists of several layers of cellular and fibrous tissues. The reproduction of the Cyanea, as described by Agassiz, forms an interesting example of the changes through which animals of this type pass in attaining to maturity. The eggs are hatched into ciliated embryos which swim freely. These attach themselves to the bottom, and are developed into little hydroids, with tentacles in fours and multiples of four (Fig. 66 a), and which have the power of increasing by gemmation. From this stage the young animal passes by a transverse fission into a sort of jointed form (the Strobila. Fig. 66 b), and this, breaking up into separate segments, produces free swimming discigerous animals, formerly known by the name of Ephyra, and which are the young of the Cyanea. Thus each animal passes through four definite stages, before attaining the perfect form, and one ovum may produce several adult Cyaneas.

Another very common species on our coasts is the white or colourless Jelly-fish, *Aurelia flavidula.* It has four white or milky spots (the ovaries) seen conspicuously through its transparent body, and has short marginal tentacles.

THE TUNICATES.

Externally these creatures are among the most uninteresting of the molluscs; their whole bodies being enclosed in a uniform sac-like coat. A species of *Boltenia*, (*B. Bolteni*, Linn.) presenting externally the appearance of a leathery sac, supported on a stalk, is not uncommon on our coasts. (Fig. 92.)

Fig. 92.



BOLTENIA BOLTENI, Linn., Gulf of St. Lawrence—reduced.

The sac has two apertures, and when the animal is alive, the sea-water is drawn into one of these, and expelled from the other by the alternate contraction and expansion of the sac. On dissecting the outer tunic, this is found to be lined with a muscular sac, which is the true mantle, and by the contraction of which water is expelled from the interior, while it is re-admitted by the elastic expansion of the outer tunic. Within the muscular sac is a delicate membraneous ciliated organ, the respiratory sac, along the surface of which the water entering by the entrant aperture is carried by the motion of the cilia, and the nutritive matter which it contains wafted toward the mouth, which lies near the bottom of the sac. The intestine doubles round and empties at the excurrent aperture, toward which also the opening of the ovarian ducts is directed. The creature, thus constituted, remains attached at the bottom of the sea, and its actions are limited to the rhythmical contraction and expansion of the tunic, by which water is continually introduced, and brings with it microscopic organisms on which the tunicate feeds. The same action subserves the function of respiration.

In addition to the Boltenia, we have several species of *Cynthia* and *Ascidia*, one of which, *Cynthia echinata*, is remarkable for its covering of stiff branching bristles. Another species, *Didemnium roseum*, exists in compound communities, encrusting sponges and sea-weeds. Dr. Packard has dredged it at Hopedale, Labrador; and at Eastport, Maine; and Mr. Whiteaves has found it at Gaspé.

There are other species of smaller size, some of them highly coloured, and others perfectly pellucid, so that the internal organs are distinctly visible through the tunic, but all may be distinguished by the sac-like tunic and the two apertures.

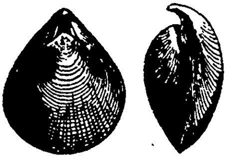
All the species found on our coast belong to the first sub-order of Tunicates, that of the *Ascidiae*, which also includes the remarkable *Pyrosomidae* of the warmer seas, freely moving forms in which the animals are grouped in radiating series in the walls of a hollow cylinder, closed at one end: these creatures are said to be impelled by the reaction of the water sent forth from the excurrent apertures.

A second sub-order, *Biphora*, includes the *Salpidæ*, also inhabitants of the warmer seas, and floating in chain-like bands of individuals, which, however, produce ova from which solitary individuals are hatched, and these in turn develope within their bodies colonies of banded Salpae. The Salpas and the Pyrosomas are gifted with that luminosity in the dark which is the property of so many marine animals.

THE BRACHIOPODS.

Of these curious and rare bivalve shell-fish, only a few species are found on our coasts. The most common is *Rhynchonella*

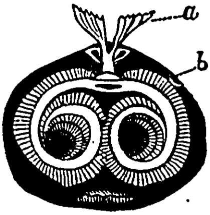
Fig. 93.



RHYNCHONELLA PSITTACEA, Linn. Gulf St. Lawrence.

psittacea, the parrot's-bill Rhynchonella. (Fig 93.) It is a little horny bivalve shell, with one valve, the dorsal, smaller than the other, the beak of which projects and has a notch (foramen) below, through which passes a stalk or pedicel for attachment. The interior of the shell is lined with the two valves of the mantle, and is occupied principally with the two-fringed and ciliated arms coiled like cork-screws. (Fig. 94.) At the base

Fig. 94.



RHYNCHONELLA PSITTACEA. Interior of dorsal valve, showing (*a*) adductor muscles, and (*b*) spiral arms; drawn from a specimen dredged at Gaspé—natural size.

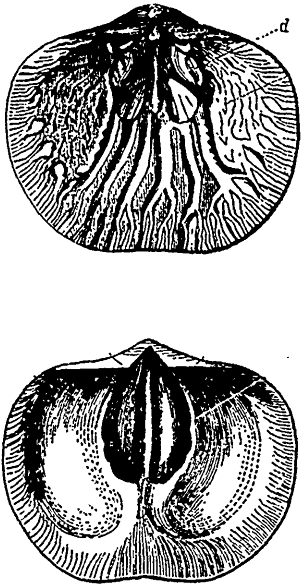
of these is the mouth, leading to a small stomach and short intestine. It has a more complicated nervous and circulating system than those of the Tunicates, and has several pairs of muscles placed near the hinge for opening and closing the shell and regulating the movements of the creature on its pedicel. The Rhynchonella is found attached to stones and dead shells in moderately deep water.

In addition to this species, we have on our coasts *Terebratulina septentrionalis*, of more elongated form than the above-named species, ribbed longitudinally, with a round perforation at the beak, instead of a notch, and with an internal shelly loop. Other species found on our coasts are *Waldheimia cranium*, and *Terebratella Spitzbergensis*, a northern form found in Labrador, and also fossil in the post-pliocene clay of Rivière du Loup. *Waldheimia cranium* has as yet been found only on the coast of Nova Scotia, by Willis. It has been ascertained that the young of some Brachiopods much resemble Polyzoa in form and structure. (Morse).

Though recent Brachiopods are few in species, vast numbers are found fossil. Mr. Billings's catalogues include nearly 100 species, from the lower Silurian alone, in Canada; and Dr. Bigsby, in his Thesaurus Siluricus, enumerates 429 species from the Silurian of America, whereas less than 100 living species are known in the whole world at present.

Many of the fossil Brachiopods differ considerably from those that are recent, and are placed in different families. We can recognise their general resemblance to the modern forms by the impressions of the mantle and muscles on the valves. Fig. 95 represents the interior of the dorsal and ventral valves of an Orthis, showing the muscular and mantle impressions, teeth and foramen.

(Fig. 95.)



ORTHIS STRIATULA, after Woodward.

(A) Dorsal valve, showing the muscular impressions at (d); also the vascular impressions of the mantle, and the notch, tooth and brachial processes in the hinge.

(B) Ventral valve, showing the impressions of the hinge and pedicel muscles.

NOTES ON THE STRUCTURE OF THE CRINOIDEA, CYSTIDEA, AND BLASTOIDEA.

By E. BILLINGS, F. G S., Palæontologist of the Geological Survey of Canada.

(Reprinted from the American Journal of Science, II., vol. xlix, p. 51, and continued from this vol., ante p. 293.)

5. *On the Homologies of the Respiratory Organs of the Palæozoic and recent Echinoderms, and on the "Convoluted Plate" of the Crinoidea.*

In a former note I have advanced the opinion that:—"The grooves on the ventral disc of *Cyathocrinus*, and also the internal "*convoluted plate*" of the Palæozoic Crinoids, with the tubes radiating therefrom, belong to the respiratory, and perhaps in part to the circulatory systems — not to the digestive system. The convoluted plate with its thickened border seems to foreshadow the "œsophageal circular canal," with a pendant madreporic apparatus, as in the Holothuridea." (This vol. ante, p. 282.) I should have referred it to the madreporic system of the existing Echinodermata in general, instead of to that of the Holothuridea in particular. At the time the note was written I had in view the madreporic sack of *Holothuria* which, as will be shown further on, most resembles in form that of *Actinocrinus*. The figures and descriptions, which follow, are intended to show the gradual passage or conversion of the respiratory organs of the *Cystidea, Blastoidea and Palæocrinoidea* into the ambulacral canal system of the recent echinoderms, and that as the convoluted plates of the former have the same structure and connections as the madreporic sacks and tubes or sand canals of the latter, they are, most probably, all the homologues of each other.

Among the Cystideans we find several genera, such as *Cryptocrinites*, *Malocystites*, *Trochocystites*, and apparently some others, whose test is totally destitute of respiratory pores, being composed of simple, solid plates like those of the ordinary Crinoidea. In a second group of genera, among which may be enumerated *Caryocystites, Echinosphærites, Palæocystites,* and *Protocystites,*

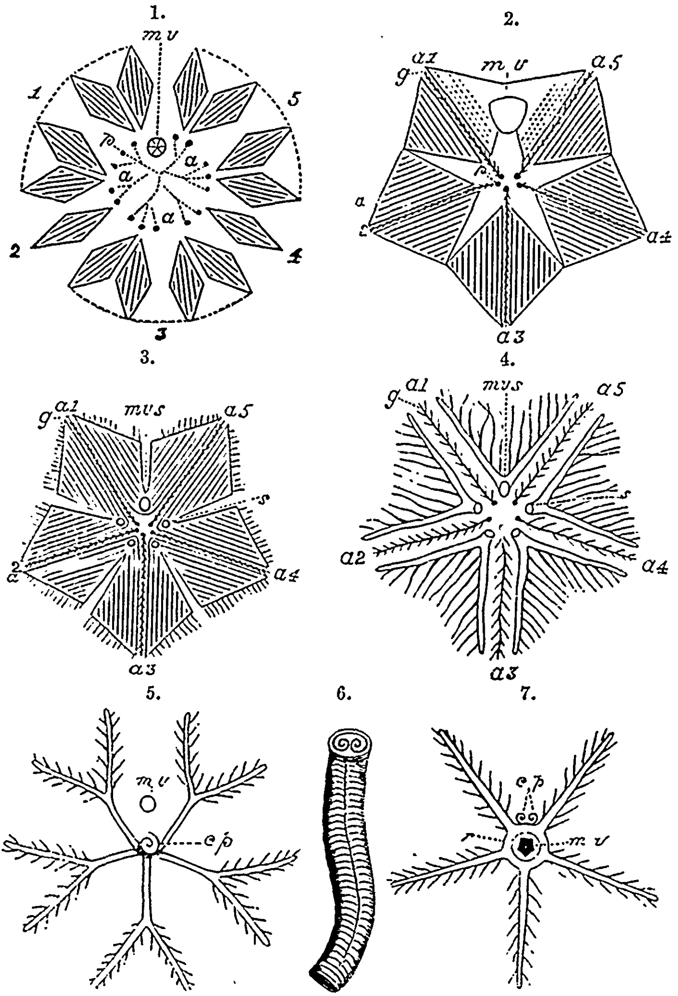


Fig. 1. The upper part of *Caryocrinus ornatus*, the test being removed in order to show the internal structure of the fourteen hydrospires that surround the summit. The parallel lines represent the flat tubes. The other figures exhibit the modifications which the hydrospires undergo in passing through:—2. *Codaster*. 3. *Pentremites* with broad ambulacra. 4. *Pentremites* with single tubes. 5. *Palæozoic Crinoids* with a convoluted plate attached to the centre of radiation. 6. Sand canal or madreporic tube of a starfish inclosing a doubly convoluted plate 7. Ambulacral canals of a starfish with the doubly convoluted plate of the sand canal attached to the œsophageal ring. The following letters have the same reference in all the figures in which they occur: *a*, an arm or ambulacrum; *m v*, mouth and vent combined in a single aperture; *m v s*, mouth, vent and spiracle; *g*, ambulacral groove; *p*, ovarian pore; *s*, spiracle; *cp*, convoluted plate; *r*, œsophageal ring.

the whole of the external integument seems to have been respiratory, as all, or nearly all, of the plates of which it is composed, are more or less occupied by variously arranged, poriferous or tubular structures. The Cystideans of these two groups hold the lowest rank of all those known. In their general structure they are mere sacks of a globular, ovate, or (as in the case of *Trochocystites*) flattened form. Their test consists of an indefinite number of plates without any radiated arrangement. They were also, according to our present knowledge, the first to make their appearance, two of the genera, *Trochocystites* and *Eocystites*, having been discovered in the primordial zone. No other echinoderms have been found in rocks of so ancient a date.

Next in order may be placed those genera whose test is composed of a definite number of plates, which have, to some extent, a quinary arrangement. Thus, *Glyptocystites*, *Echinoencrinites*, *Apiocystites*, and several others, have each four series of calycine plates, of which there are four plates in the basal and five in each of the other three series. The respiratory areas or hydrospires are reduced in number—ten to thirteen in *Glyptocystites*, and three in most of the other genera of the group. Neither in the plates nor in the hydrospires is there exhibited any tendency to a radiated arrangement. The most ancient genus of this family is *Glyptocystites*, which first appears in the Chazy limestone and seems to have become extinct in the Trenton. The other genera occur in various horizons between the Chazy and the Devonian.

In the genera *Hemicosmites* and *Caryocrinus* the hydrospires in the upper part of the test converge toward, but do not reach, the central point of the apex, thus forming the commencement of that concentration and complete radiation which is exhibited in the ambulacral canal system of the higher echinoderms. In a former note (this vol. p. 286,) it is pointed out that *Caryocrinus* has thirty hydrospires,—ten at the base with their longer diagonals vertical — a zone of six round the middle, with their diagonals horizontal, and a third band of fourteen around the upper part of the fossil. These latter are represented in fig. 1, as if spread out on a plane surface. On consulting this figure it will be seen that the flat tubes of the hydrospires, represented by the parallel lines, all converge toward the central point from which the dotted lines radiate. This point is the position of the mouth in the recent echinoderms, but in *Caryocrinus* it is occupied by a large solid imperforate plate. The hydrospires are arranged in five groups. Commencing at *m v* and going round by 1, 2, &c., there are four in the first group; one in the second; four in the third; one in the fourth and four in the fifth. These five groups represent the five ambulacral canals of the recent echinoderms. In the specimen from which this diagram was constructed there are the bases of fifteen free arms to be seen situated at the outer extremities of the dotted lines. At the base of each arm there is a small pore, *p*, which I believe to have been exclusively ovarian in its function. The hydrospires have no connection whatever with the arms and are, moreover, all of them entirely separated from each other. If, then, they represent the ambulacral system of the recent echinoderms, it is quite certain that that system was at first, (or in the undeveloped stage in which it existed in the Cystidea,) destitute of the œsophageal ring.

In *Codaster* a further concentration of the respiratory organs is exhibited. There are here only five hydrospires and they are all confined to the circle around the apex. Two of them are incomplete in order to make room for the large mouth and vent (*m v*, fig 2.) They are each divided into two halves by an arm, *a*1, *a*2, &c. They are only connected with the arms to this extent, that these latter lie back upon them. The arms are provided with pinnulæ, but it is not at all certain that they (the pinnulæ) were in any direct communication with the hydrospires. It is evident that *in all the Cystidea,* (and in none is it more obvious than in *Caryocrinus*,) there was no connection between the hydrospires and the pinnulæ. The main difference (so far as regards the evidence of the presence or absence of such a connection) between *Caryocrinus* and *Codaster*, consists in this, that in the former the arms are erect and do not touch the hydrospires, whereas in the latter they are recumbent and lie back upon them. Each of the arms of *Codaster* has a fine ambulacral groove and all of the grooves terminate in a single central aperture. But as this aperture was covered over by a thin plated integument, as in the Blastoidea, I have not shown it in the diagram, but only the five pores, *p*.

No one who compares a *Codaster* with a *Pentremites* (the internal structure of the latter being visible) can doubt that the hydrospires of the two genera are perfectly homologous organs. If we grind off the test of a species of the latter genus, selecting one for the purpose which has broad petaloid ambulacra such as those of *P. Schultzii*, the structure exposed will be that represented in the diagram, fig. 3. In *Pentremites* as in *Codaster*, the five hydrospires are divided into ten equal parts by the five rays, *a*1, *a*2, &c. In *Codaster* these ten parts remain entirely separate from each other, but in *Pentremites* they are re-united in pairs, the two in each interradial space, being so connected, at their inner angles, that their internal cavities open out to the exterior through a single orifice or spiracle (*s*, figs. 3 and 4). This is best shown in fig. 4, intended to represent the structure of *P. ellepticus* (Sowerby) as described by Mr. Rofe, Geol. Mag., vol. ii, p. 249. In this species the hydrospires instead of being formed of broad sacks, with a number of folds on one side, consist of ten simple cylindrical tubes connected together in five pairs. The only difference between the structure of fig. 3 and fig. 4 is in the width of the tubes and in the absence of folds in the latter. These two forms are moreover connected by intermediate grades. Species with 11, 10, 8, 6, 5, 4 and 2 folds being known, there is thus established a gradual transition from the broad petaloid form to the single cylindrical tube.

Between the *Cystidea* and the *Blastoidea* the most important changes are, that in the latter the hydrospires become connected in pairs, and also, are brought into direct communication with the pinnulæ. In the Palæozoic Crinoidea (or at least in many of them,) concentration is carried one step further forward—the five pairs of hydrospires being here all connected together at the centre, as in fig. 5. There is as yet no œsophageal ring, (as I understand it) but in its place the convoluted plate, described in the excellent papers of Messrs. Meek and Worthen. This organ, according to the authors, consists of a convoluted plate, resembling in form the shell of a *Bulla* or *Scaphander*. It is situated within the body of the Crinoid, with its longer axis vertical, and the upper end just under the centre of the ventral disc. Its lower extremity approaches but does not quite touch the bottom of the visceral cavity. Its walls are composed of minute polygonal plates, or of an extremely delicate net work of anastomosing fibres. The five ambulacral canals are attached to the upper extremity, radiate outward to the walls of the cup, and are seen to pass through the ambulacral orifices outward into the grooves of the arms.

The ambulacral canals of the Crinoidea are, for the greater part, respiratory in their function. They are, however, as most naturalists who have studied their structure will admit, truly the homologues of those of the Echinodermata in general. In the higher orders of this class the canals are usually more specialized than they are in the lower—being provided with prehensive or locomotive organs. In all of the existing orders, including the recent Crinoidea, we find an œsophageal ring.

To this organ, which is only a continuation of the canals, are attached the madreporic appendages. These consist of small sacks, or slender tubes, varying greatly in form and number in the different genera. That of the Starfish *Asteracanthion rubens* is thus described by Prof. E. Forbes:—"On the dorsal surface is seen a wart-like striated body, placed laterally between two of the rays; this is the *madreporiform tubercle or nucleus*. When the animal is cut open, there is seen a curved calcareous column running obliquely from the tubercle to the plates surrounding the mouth; Dr. Sharpey says it opens by a narrow orifice into the circular vessel. It is connected by a membrane with one side of the animal, and is itself invested with a pretty strong skin, which is covered with vibratile cilia. Its form is that of a plate rolled in at the margins till they meet. It feels gritty, as if full of sand. When we examine it with the microscope we find it to consist of minute calcareous plates, which are united into plates or joints, so that when the investing membrane is removed it has the appearance of a jointed column. Prof. Ehrenberg remarked the former structure, and Dr. Sharpey the latter: they are both right. Both structures may be seen in the column of the common cross-fish."—(Forbes, British Starfishes, p. 73.)

In Prof. Joh. Muller's work, "Uber den bau der Echinodermen," several forms of the madreporic appendages of the different groups of the recent Echinodermata are described. In general they are composed of a soft or moderately hard skin, consisting of a minute tissue of calcareous fibres, or of small polygonal plates. The walls are also, sometimes, minutely poriferous. In all the Holothurians the madreporic organ is a sack attached by one of its ends to the œsophageal canal, the other extremity hanging freely down into the perivisceral cavity, not connected with the opposite body wall as is the sand canal of the starfishes. (Op. cit., p. 84.) In its consisting of a convoluted plate the madreporic organ of *Actinocrinus*, therefore, agrees with that of the starfishes, while in its being only attached at one extremity it resembles that of the Holothurians.

The convoluted plate of the Palæozoic Crinoids and the madreporic sacks and tubes (or sand canals) of the recent Echinoderms, therefore, all agree in the following respects:—

1. They have the same general structure.

2. They are all appendages of the ambulacral system.

3. They are all attached to the same part of the system, that is to say, to the central point from which the canals radiate.

The above seems to me sufficient to make out at least a good *prima facie* case for the position I have assumed. When among the petrified remains of an extinct animal, we find an organ which has the same general form and structure, as has one that occurs in an existing species of the same zoological group, we may, with much probability of being correct in our opinion, conclude that the two are homologous, even although we may not be able positively to see how that of the fossil is connected with any other part. But when, as in this instance, we can actually see that it is an appendage of another organ, or system of organs rather, which is known to be the homologue of the part with which that of the existing species is always correlated, we have evidence of a very high order on which to ground a conclusion. By no other mode of reasoning can we prove that the column of an *Actinocrinus* is the homologue of that of *Pentacrinus caput Medusæ.*

In an important paper, entitled "Remarks on the Blastoidea, with descriptions of New Species," which Meek and Worthen have kindly sent me, the authors, in their comments upon my views, state that:—

"In regard to the internal convoluted organ seen in so many of the *Actinocridæ* belonging to the respiratory instead of the digestive system, we would remark that its large size seems to us a strong objection to such a conclusion. In many instances it so nearly fills the whole internal cavity that there would appear to be entirely inadequate space left for an organ like a digestive sack, outside of it, while the volutions within would preclude the presence of an independent digestive sack there. In additon to this, the entire absence, so far as we can ascertain, of any analogous, internal respiratory organ in the whole range of the recent *Echinodermata*, including the existing Crinoids, would appear to be against the conclusion that this is such, unless we adopt the conclusion of Dujardin and Hupé, that the Palæozoic Crinoids had no internal digestive organs, and were nourished by absorption over the whole surface. We should certainly think it far more probable that this spiral organ is the digestive sack, than a part of a respiratory apparatus."

The objection here advanced does not appear to me to be a strong one. In many of the lower animals the digestive organs are of inconsiderable size in proportion to the whole bulk. In the Brachiopoda, for instance, the spiral ciliated arms fill nearly the whole of the internal cavity, the digestive sack being very small and occupying only limited space near the hinge. These arms, although not the homologues of the convoluted plates of the Palæozoic Crinoids, have a strong resemblance to them, and are, moreover, at least to some extent, subservient to respiration. They are certainly not digestive sacks. In the recent echinoderms the intestine is usually a slender tube, with one or more curves between the mouth and the anus. It fills only a small part of the cavity of the body, the remainder being occupied mostly by the chylaqueous fluid, which is constantly in motion, and undergoing æration, through the agency of various organs, such as the respiratory tree and branchial cirrhi of the Holothuridea, the dorsal tubuli of the Asteridæ and the ambulacral systems of canals of the class generally. In no division of the animal kingdom do the respiratory organs occupy a larger proportion of the whole bulk than they do in the Echinodermata. The great size which the convoluted plate attains in some of the Crinoids is, therefore, rather more in favour of its being a respiratory then a digestive organ.

Prof. Wyville Thomson says, that inside of the cavity of the stomach of the recent Crinoid, *Antedon rosaceus*, there is a spiral series of glandular folds, which he supposes to be a rudimentary liver. (Phil. Trans. R. S., 1865. p. 525.) It is barely possible that the convoluted plate may represent this organ. At present I think it does not.

I believe that the reason why the convoluted plate attained a greater proportional size in the Palæozoic Crinoids, than do the sand canals of the recent Echinoderms, is that the function of the system of canals, (of which they are all appendages,) was at first mostly respiratory, whereas in the greater number of the existing groups, it is more or less prehensive or locomotive, or both.

(To be continued.)

NOTES ON SOME POINTS IN THE STRUCTURE AND HABITS OF THE PALÆOZOIC CRINOIDEA.

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Reprinted from the Proceedings of the Academy of Natural Science, Philadelphia, 1869, p. 323.*

Through the kindness of Mr. Charles Wachsmuth, of Burlington, Iowa, we have recently had an opportunity to examine some unique and exceedingly interesting specimens of Carboniferous Crinoids, showing parts of the structure of these animals, in some instances, never before observed, so far as we are at this time informed. In a few instances, these specimens show internal organs entirely free from the matrix, and although like all the other solid parts of these curious creatures, composed of numerous calcareous pieces, really surpassing in delicacy of structure the finest lace-work, and so frail that a touch, or even a breath, might almost destroy them. Some of these specimens we propose to notice here, but, before proceeding to do so, we avail ourselves of this opportunity to express our thanks to Mr. Wachsmuth for the zeal, industry, skill and intelligence he has brought to bear, in collecting and preparing for study, such an unrivalled series of the beautiful fossil Crinoidea of this wonderfully rich locality. Some idea of the extent of his collection of these precious relics may be formed, when we state that of the single family *Actinocrinidæ* alone, after making due allowance for probable synonyms, he must have specimens of near 150 species, or perhaps more, and many of them showing the body, arms and column.

It is also due to Mr. Wachsmuth, that we should state here that he is not a mere collector only, but that he understands what he collects, and knows just what to collect, as well as how to collect.

Below we give substantially some notes of observations made in his collection, followed by some remarks on other specimens at Springfield:

1. *Synbathocrinus*, Phillips. Some of Mr. Wachsmuth's speci-

* For further observations on the subject of this important paper, see the notes of Dr. Lutken and E. Billings, in this vol. pp. 267 and 427.

mens of a species of this genus show that it is provided with a long, slender, pipe-stem like ventral tube, or proboscis, apparently equalling the arms in length. Also, that a double row of minute alternating marginal pieces extends up within the ambulacral furrows of the arms, apparently all their length. We are not aware that these characters have been hitherto noticed in any of the publications on this genus. It will be seen, however, farther on, that minute marginal pieces probably occupied the furrows along the inner side of the arms of other types of Crinoidea, as well as this.

2. *Goniasteroidocrinus*, Lyon and Casseday. Some unusually fine specimens of the typical species of this genus (*G. tuberosus*) in Mr. Wachsmuth's collection, from Crawfordsville, Ind., show the slender pendent arms much more distinctly than any we had before seen, and from these it seems evident that those arms are stouter than we had supposed, and that there are not more than five or six of them to each of the ten openings. In the specimen figured by us on page 220 of the second volume of the Illinois Reports, these arms were only imperfectly seen by working away, with great difficulty, the hard matrix between two of the produced rays of the vault, which we have termed pseudobrachial appendages, or false arms. In clearing away the matrix of this specimen, we had cut just far enough to expose the edges of the arms on each side of the deep ambulacral furrow, so that each of these edges presents the appearance of being a separate and distinct, very slender arm, composed of a single series of pieces, and without any ambulacral furrow on the outer or ventral side; whereas there is a well-defined ambulacral furrow, bearing the tentacula along its margins, on the outer side of the arms, and when the matrix is removed from these ambulacral furrows, the arms can be seen to be composed each of a double series of small alternately-arranged pieces. It is barely possible that in specimens of this species with the arms *perfectly preserved*, that the ambulacral furrows may be covered on the outer or ventral side by a double series of alternating pieces, and that the tentacula* may connect

* We use the term tentacula here in the sense it is generally used by palæontologists, with reference to the delicate pinnulæ along the arms of Crinoids, and of course not as applying to the minute fleshy organs along the ambulacral furrows, usually termed tentacles by those who have investigated the recent Crinoids

with little openings along each side, though there certainly *appear* to be only open furrows in the specimens examined.

It is worthy of note, in this connection, that there certainly are species, agreeing exactly in all other known characters with this genus, that have no open furrow along the outer or ventral side of the arms, which are distinctly seen to be round on the outer side, and show there a double series of interlocking pieces along their entire length, while the tentacula connect along the inner, or under side, as the arms are seen hanging down. This is clearly seen to be the case in a beautiful specimen of *G. typus* (=*Trematocrinus typus*, Hall) in Mr. Wachsmuth's collection, and we can scarcely doubt that in this species there is an open furrow on the inner (under) or dorsal side of the arms. If not, the arms must be tubular, in consequence of having the ambulacral canal enclosed all around, excepting at the points where the the tentacula connect along each side.

3. *Cyathocrinus*, Miller. Specimens of this genus showing the vault (more properly the ventral disc) have very rarely been seen. In England a few examples have been found, and these have been supposed to show two openings, one central and another lateral; the latter, according to Prof. Phillips' and Mr. Austin's figures, being provided with a slender marginal tube, or so-called proboscis. Some of Mr. Wachsmuth's specimens, however, of *C. malvaceus* and *C. Iowensis*, Hall, showing the vault, have led us to doubt the existence of a central opening in the vault of this genus, when the specimens have this part entire. The specimen of *C. malvaceus* shows the remains of the usual narrow lateral proboscis, and also has an opening in the middle of the vault, but from the appearance of this opening, as well as from the structure of the vault of a specimen of *C. Iowensis*, in which this opening is closed, we can scarcely doubt that it was also closed in the specimen of *C. malvaceus*, when entire. The remaining parts of the vault of the *C. malvaceus* mentioned consist of only five comparatively large pieces, alternating with the upper inner edges of the first radial pieces,—the one on the anal side being larger than the others, and forming the base of the inner side of the proboscis. These five pieces connect with each other laterally and extend inward some distance, but not so far as to meet at the centre, where there is a sub-semicircular opening, nearly as large as that in the remaining base of the proboscis. Along each of the sutures between the five vault pieces mentioned,

a comparatively large furrow extends inward from each arm-base to the central opening. These we regard as continuations of the ambulacral furrows from the arms, though there is also a minute opening at each arm-base, passing directly downward into the cavity of the body, which was probably for the passage of the arm-muscles.

Looking at this specimen alone, one would naturally suppose there must have been, during the life of the animal, two distinct openings in the vault, as appears to be the case in the specimen of *C. planus*, Miller, figured by Prof. Phillips and Mr. Austin. But on examining the specimen of *C. Iowensis* mentioned above, we find that it shows the base of the small lateral proboscis, with the five principal vault-pieces alternating with the first radials the one on the anal side being larger than the others, and the same ambulacral furrows extending inwards from the arm-bases, all exactly as in the *C. malvaceus*. But here we find the central opening undoubtedly closed by several vault-pieces, while the ambulacral furrows, extending inward from the arm-bases, pass in under these central pieces, and are themselves occupied, or covered, by a double series of alternating, very minute pieces, which probably also extend on, all the way up the ambulacral furrows of the arms as marginal pieces.

From our examinations of these two specimens, which are the only examples of the genus we have seen, showing the vault-pieces, and seem to be typical forms of the genus in all other respects, we are strongly inclined to think the specimen of *C. planus*, figured by Prof. Phillips and Mr. Austin, has had these central vault-pieces removed by some accident. The fact that these pieces in the specimen examined by us, in Mr. Wachsmuth's collection, seem not to be deeply implanted between the five larger surrounding pieces mentioned. but rather rest, as it were, partly upon the narrow bevelled points of the inner ends of the latter, between the ambulacral furrows, so as to allow room for these furrows to pass under, would render them less firm, and more liable to be removed by any accident, and may possibly account for their absence in the English specimen mentioned.

In regard to the pieces covering the central part of the vault, and which, from the way they are arranged for the ambulacral furrows to pass under them, were apparently more liable to be removed than the others, we would remark that they do not present the prominent appearance, and uniformity of size and form, of the movable pieces composing what is often called the ovarian pyramid in the Cystids, but certainly have all the appearances of true fixed vault-pieces, and scarcely project above the others surrounding them. Consequently we cannot believe it at all probable that this genus had a central mouth, opening directly through the vault; though its ambulacral canals evidently converged from the arm-bases to the middle of the vault, partly above the outer vault-pieces, and under those composing the middle of the vault. That these furrows terminated at the entrance of the alimentary canal, under the middle of the vault, as those of *C mutula* converge to the mouth, in the same central position, is highly probable; and, as will be seen further on, we are much inclined to believe that the minute organisms upon which we are led, from analogy, to think these animals subsisted, were conveyed to the entrance of the alimentary canal along the ambulacral furrows, without the agency of any proper mouth, opening directly through the vault. Hence we think it probable that the small tube, usually called the proboscis, situated near the posterior side of the ventral disc, rather corresponds to the tubular anal opening similarly situated in *Comatula Mediterranea*.

From our description of the vault of these species, it will be seen to present considerable similarity to that of *Crotalocrinus rugosus*, excepting that in that genus, owing to its great number of arms, the ambulacral furrows, or canals, bifurcate several times between the middle of the vault and the arm-bases, while in *Crotalocrinus* there is no lateral proboscis, nor, apparently, even any visible opening, judging by the figures we have seen, though we suspect it may have a small opening at the periphery of the ventral disc, on the posterior or anal side. In the group of depressed *Platycrini* for which Troost proposed the name *Cupellæcrinus* we observe a somewhat similar vault, at least in some of the species; also in *Coccocrinus*. In such forms there would seem to be, as it were, an intermediate gradation between the modern Crinoids and the prevailing Palæozoic types, as has been pointed out by Mr. Billings.

4. *Convoluted support of the digestive sack, in the Actinocrinidæ.* The presence of a large convoluted body, resembling in form the shell of a *Bulla* or *Scaphander*, within the body of several types of the *Actinocrinidæ*, was noticed by Prof. Hall in vol. xii, p. 261 of the Am. Journ. Sci., in 1866, though he made no suggestions there in regard to the functions it probably

performed in the internal economy of these animals. In the second volume of the Illinois Geological Reports, published soon after, we figured, on page 191, a specimen of *Strotocrinus*, with this body seen in place, and stated that we regarded it as having been connected with the digestive apparatus of the animal.

Both in Prof. Hall's and our own remarks, this organ was spoken of as a convoluted *plate*. This, however, we now know is not strictly correct, for although composed of hard calcareous matter, and in some species somewhat dense in structure, it seems to be always constructed of a great number of minute pieces, and generally has a more or less open or porous texture; while in some cases it presents the appearance of an exceedingly delicate net-work. It seems never to be attached to the bottom of the visceral cavity, though it extends down nearly to the bottom. It is open at both ends (the opening at the lower end being generally smaller than the other), and is placed with its longer axis nearly so as to coincide with that of the body of the Crinoid. In some species it is more or less dilated at the upper end, while in others it is contracted at both ends, so as to present, as above stated, the form of the shell of a *Bulla*. It has apparently no columella, but is more or less loosely convoluted, with a spiral ridge descending the interior, and sometimes another ascending the exterior. Its walls are generally of moderate thickness, but they often appear to be thicker than natural, in consequence of the presence of inorganic incrustations, of calcareous or silicious matter, which also disguise its real structure.

In *Actinocrinus Verneuilianus*, Shumard, this body is narrow below, and sub-cylindrical above to the top, which is slightly dilated. The small opening at the lower end has a thickened rim, which passes around spirally, so as to ascend the outside, as a rather stout ridge, all the way to the top, making nearly two turns and apparently also forming a rim partly around the top. The surface of the whole organ, as well as of its external spiral ridge, has the usual rough appearance, and when fragments of it are held up, so as to be examined by transmitted light, through a good pocket-glass, it is seen to be composed of a great number of very minute polygonal pieces, varying somewhat in form and size. When these pieces are examined under a magnifier, by reflected light, they show shining facets, like crystals, though they are evidently not surface incrustations, but actually compose the walls, or substance of the organ itself. No pores or meshes were observed passing through the walls of this organ in this species, in which it appears to be more than usually dense.

In another specimen in Mr Wachsmuth's collection, apparently of *Actinocrinus proboscidialis*, this organ, as seen with one or more of the outer turns removed, has an oval or sub-elliptic form, being contracted and twisted at both ends, so as to present very nearly the appearance of the shell of some species of *Ovulum*. Its walls are quite thin, and seem to form more convolutions than in any other species in which we have had an opportunity to examine it. As seen by the aid of a magnifier by transmitted light, it presents a very beautiful appearance, being composed of a great number of minute pieces, with numerous openings passing through between them. The little pieces and the openings between them, are of nearly uniform size, and arranged so that there are usually one or two of the former intervening between any two of the openings.

Another of Mr. Wachsmuth's specimens of *Actinocrinus securus*, Hall, has one side of the body removed so as to show about two-thirds of the convoluted organ, the upper part of which is broken away. The part remaining has a short wide sub-cylindrical form, with a rather broad, obliquely truncated lower end, which is not tapering, as in the other species. Under a magnifier it is seen to be composed of an extremely fine net-work, far surpassing, indeed, in delicacy of structure, the finest laces that it is perhaps within the power of human skill to fabricate; and as it is entirely free from any surrounding matrix, excepting at one side below, the specimen has to be handled with great care, as a mere touch of this delicate part would probably cause it to fall into hundreds of little minute fragments. On examining it under a magnifier, the bars of which it is composed are seen not to intersect each other at any uniform angle, but anastomose, so as to impart a kind of irregular regularity, if we may so speak, to the form and size of the meshes. Of these little bars there are two sizes, the larger forming the larger meshes, while within the latter a smaller set of processes extend partly or entirely across, so as to form more minute meshes; the whole presenting a beautiful appearance, of whice it would be difficult to convey a correct idea by a mere description alone, without the aid of figures.

From analogy, judging from what is known of the internal structure of the recent genus *Comatula*, in which several authors have noticed a reticulated calcareous structure secreted within the tissue of the softer parts of its alimentary canal, we may infer that this convoluted organ was, as it were, a kind of frame work, secreted for the support of the digestive sack, which was probably more or less convoluted in the same way in many, if not all of the Palæozoic Crinoids, though not apparently, in all cases, endowed with the power of secreting a sufficient dense structure of this kind to leave traces of its existence in a fossil state.

So far as we are at this time informed, this organ has yet been very rarely observed in any other family than the *Actinocrinidæ*, though it was probably more or less developed in various other groups. In one instance Mr. Wachsmuth found it in a *Platycrinus*, but here it seems to be, in the specimen found, merely a spongy mass, not showing very clearly the convoluted structure. Some traces of what was supposed to be something of this kind were also observed by him in one of the Blastoids.

5. *Ambulacral canal passing under the vault in the Actinocrinidæ.* In the third and fourth Decades of descriptions and illustrations of the Canadian Organic Remains, Mr. Billings, the able palæontologist of the Geological Survey of the Canadian provinces gives some highly interesting and instructive remarks on the ambulacral and other openings of the Palæozoic Crinoids. In these remarks he noticed, at length, some striking differences between the vault, or ventral disc, of these older types, and that of the few living examples of this extensive order of animals. That is, he noticed the facts, that while in the living *Comatula* and *Pentacrinus*, the ambulacral canals are seen extending from the arm-bases across the surface of the soft skin-like ventral disc, to the central mouth, and these genera are provided with a separate anal opening, situated excentrically between the mouth and the posterior side, that in the Palæozoic Crinoids the ventral disc is very generally, if not always, covered by close-fitting, solid plates, showing no external traces whatever of ambulacral furrows extending inward from the arm-bases; and that in nearly all cases they are merely provided with a single excentric or sub-central opening, often produced into a long tube, which, like the vault, is made up of solid plates. He showed that there is no evidence whatever that the ambulacral canals, in these older types, were continued along the surface of the vault from the arm-bases to the only opening, whether sub-centrally or laterally situated, and that in cases where this opening is produced in the form of a greatly elongated proboscis, or tube, such an arrangement of the ambula-

cra would be almost a physical impossibility. Hence he concluded that the ambulacral canals must have passed directly through the walls of the body at the arm-bases; and he gave several figures of various types, showing openings at the base of the arms, through which he maintained that the ambulacra must have passed to the interior of the body from the arms.

Although these arm-openings had long been well known to all familiar with our numerous types of western Carboniferous Crinoids, in which they are very conspicuous, and we had never entertained any other opinion in regard to them, than that they are the only passages of communication that could have existed between the softer parts occupying the ambulacral furrows of the arms, and the interior of the body, Mr. Billings was the first author, so far as we are at this time aware, who called especial attention to them in this regard. We regret that we have not space to quote a portion, at least, of his remarks on this subject, and would advise the student to read attentively the whole of both of his articles alluded to.

The specimens at Mr. Billings' command enabled him to trace the courses of the ambulacral canals from the arms, through the walls of the body at the arm-bases, and to ascertain the additional fact that, after passing through the walls, they seemed to have turned upward; but beyond this he had not the means of tracing them farther.

A single specimen of *Actinocrinus proboscidialis*, however, in Mr. Wachsmuth's collection, is in a condition (thanks to the great skill of that gentleman, and the exceedingly fortunate state of preservation, by which its delicate internal parts remain almost entire, and without any surrounding matrix) to throw much additional light on this subject. By very dextrous manipulation, Mr. Wachsmuth succeeded in removing about half of its vault, so as to expose the internal parts, in place, and in an excellent state of preservation. The convoluted organ already described in other species is in this comparatively large, sub-cylindrical in the middle, apparently tapering at the lower end, and a little dilated at the upper extremity. It seems to be rather dense, and shows the usual rough appearance, but as we had no opportunity to examine any detached fragments of it by transmitted light, we did not determine whether or not it has pores passing through it, though it probably has, at least when entirely free from any inorganic incrustation. Its slightly dilated upper end seems to stand with its middle almost, but apparently not exactly, under the middle of the nearly central proboscis of the vault; while at the anterior side of its upper margin, and a little out from under the proboscis, it shows remains of a kind of thickened collar, which we found to be composed of minute calcareous pieces. From this there radiate five ambulacra, composed of the same kind of minute pieces as the collar itself, each ambulacrum consisting of two rows of these minute pieces alternately arranged. They are each also provided with a distinct furrow along their entire length above. As they radiate and descend from their connection with the top of the convoluted frame-work of the digestive sack, they all bifurcate, so as to send a branch to each arm-opening, those passing to the posterior rays curving a little at first above, so as not to pass directly under the proboscis. These ambulacra, although passing along obscure furrows in the under side of the vault, which are deepest near the arm-openings, are not *in contact* with the vault, or visibly connected with any other parts than the top of the convoluted digestive sack, and the outer walls at the arm-openings. Each of their sub-divisions can be traced into an arm-opening, and it is very probable that they continued out on the ambulacral furrows of the arms and tentacula. At one point in one of these ambulacral canals, beneath the vault, some evidences of the remains of two rows of minute pieces were observed alternating with the upper edges of those composing the under side of these canals, and thus apparently covering them over. The condition of the parts is such, however, as scarcely to warrant the assertion that this was really the case, though we are much inclined to think it was. If so, these canals must have been, at least under the vault, hollow tubes, formed of two rows of pieces below, and two above, all alternately arranged.

We are not aware that any evidences of the existence of these delicate ambulacral canals, composed of minute calcareous pieces, and passing beneath the vault from the arm-openings to the summit of the convoluted digestive sack, have ever before been observed in any Crinoid, recent or extinct; and we can but think it probable, that the extremely rare combination of circumstances that brought them to light in this instance may not again occur for centuries to come, with regard to another specimen. That they correspond to the ambulacral canal seen extending from the arm-base to the mouth, on the *outside* of the ventral disc in *Comatula*, is clearly evident.

The presence of furrows radiating from the central region of the under side of the vault to the arm-openings, in various types of Palæozoic Crinoids, must have been frequently observed by all who have had an opportunity to examine the inner surface of this part. Messrs. DeKoninck and Lehon figure a portion of the vault of *Actinocrinus stellaris* in their valuable *Recherches sur les Crinoides du Terr. Carb. de la Belgique*, pl. iii, fig. 4 f, showing these furrows, which they seem to have regarded as the impressions left by the muscles of the viscera. The inner surface of the vault of most of our western Carboniferous Crinoids is known to have these furrows more or less defined, either from specimens showing this inner surface, or from natural casts of the same. In some instances they are very strongly defined from the central region outward to the arm-bases, to each of which they send a branch. In *Actinocrinus ornatus*, Hall, for instance, they are generally so strongly defined as to raise the thin vault into strong radiating ridges, separated by deep furrows on the outer side. In *Strotocrinus*, the vault of which is greatly expanded laterally, and often flat on top, these internal furrows, in radiating outward, soon become separated by partitions, and as they go on bifurcating, to send a branch to each arm, they actually assume the character of rounded tubular canals, some distance before they reach the arm-bases.

That these furrows or passages of the inner side of the vault were actually occupied during the life of the animal by the ambulacral canals as they radiate from the top of the convoluted digestive sack to the arm-openings, we think no one will for a moment question, after examining Mr. Wachsmuth's specimen of *Actinocrinus proboscidialis*, which we have described, showing all these parts in place. It is also worthy of note, that in all the specimens of various types in which these furrows of the under side of the vault are well known, whether from detached vaults, or from casts of the interior of the same, they *never converge directly to the opening of the vault, but to a point on the anterior side of it*, whether there is a simple opening or a produced proboscis. The point to which they converge, even in types with a decidedly lateral opening of the vault, is always central or very nearly so, and even when the opening is nearly or quite central, the furrows seem to go, as it were, out of their way to avoid it, those coming from the posterior rays passing around on each side of it to the point of convergence of the others, a little in advance of the opening. That the ambulacral canals here, under this point of convergence of the furrows in the under side of the vault, always came together and connected with the upper end of the convoluted frame-work of the digestive sack, we can scarcely entertain a doubt.

Now in looking at one of these specimens, especially an internal cast of the vault, showing the furrows (or casts of them) starting from a central, or nearly central point, and radiating and bifurcating so as to send a branch to each arm-base, while the opening or proboscis of the vault (or the protuberance representing it in the cast) is seen to occupy a position somewhere on a line between this central point from which the furrows radiate, and the posterior side, one can scarcely avoid being struck with the fact, that this point of convergence of the ambulacra, under the vault, bears the same relations in position to the opening of the vault, that the *mouth* of a *Comatula* does to its *anal* opening. And when we remember that eminent authorities, who have dissected specimens of the existing genus *Comatula*, maintain that these animals subsisted on microscopic organisms floating in the sea-water, such as the *Diatomaceæ*, minute *Entomostraca*, etc.,* which were conveyed to the mouth along the ambulacral canals, perhaps by means of cilia, we are led from analogy to think that the Palæozoic Crinoids subsisted upon similar food, conveyed in the same way to the entrance of the digestive sack. If so, where would there have been any absolute *necessity* for a mouth or other opening directly *through* the vault, when, as we

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* Bronn mentions the fact (Klassen des Thierreichs. Actinozoa, II, p. 211), that the remains of *Diatomaceæ*, of the genera *Navicula*, *Actinocyclus*, *Coscinodiscus*, and of Entomostraca, were found in the stomach of *Comatula*, and suggests that, when such objects, in floating in the sea-water, came in contact with the ambulacral furrows of the pinulæ, they were conveyed along these furrows to those of the arms, and thence in the same way into the mouth. He ridicules the idea, sometimes suggested, that the food may have been handed by the pinnulæ or arms directly to the mouth.

Dujardin and Hupé also state (Hist. Nat. des Zoophytes Echind., p. 18), that the living *Comatula* was "nourished by microscopic *Algæ* and floating corpuscles, which the vibratile cilia of the ambulacra brought to the mouth." That they may have sometimes swallowed a larger object, that accidentally floated into the mouth, however, is not impro bable, and would not, if such was the case, by any means disprove the generally accepted opinion that these animals received their food almost entirely through the agency of their ambulacral canals.

know, the ambulacral canals were so highly developed *under* it from the arm-openings to the entrance into the top of the alimentary canal? Indeed it seems at least probable, that if the soft ventral disc of *Comatula* had possessed the power of secreting solid vault-pieces, as in most types of Palæozoic Crinoids, that these vault-pieces would not only have covered over the ambulacral furrows, as in the Palæozoic types, but that they would also have hermetically covered over the mouth, and converted the little flexible anal tube into a solid calcareous pipe, such as that we often call the proboscis in the extinct Crinoids.

From all the facts, therefore; now known on this point, we are led to make the inquiry whether or not, in all the Palæozoic Crinoids in which there is but a single opening in the vault—whether it is a simple aperture or prolonged into a proboscis, and placed posterially, sub-centrally, or at some point on a line between the middle and the posterior side—this opening was not, instead of being the mouth, or both mouth and anus as supposed by some, really the anal aperture alone; and whether in these types the mouth was not generally, if not always, hermetically closed by immovable vault-pieces, so far as regards any direct opening through the vault?

We are aware of the fact, that at least one apparently strong objection may be urged against this suggestion, and in favour of the conclusion that the single opening seen in these older Crinoids was the mouth, or at least performed the double office of both anal and oral aperture. That is, the frequent occurrence of specimens of these Palæozoic species, with the shell of a *Platyceras* in close contact by its aperture, either with the side or the vault of the Crinoid, and not unfrequently actually covering the only opening in the vault of the latter, so as to have led to the opinion that the Crinoid was in the very act of devouring the Mollusk at the moment when it perished.

Amongst the numerous beautiful specimens of Crinoids found in the Keokuk division of the Lower Carboniferous series at Crawfordsville, Indiana, there is one species of *Platycrinus* (*P. hemisphæricus*), that is so abundant that probably not less than two hundred, and possibly more, individual specimens of it have been found there by the different collectors who have visited that noted locality; and, judging from those we have seen, apparently about one-half of these were found with a moderate sized, nearly straight, or very slightly arched and conical *Platyceras* (*P.

infundibulum), attached to one side by its aperture, between the arms of the Crinoid, and often so as to cover the single lateral opening in the vault of the same.* From the direction of the slight curve of the apex of the *Platyceras*, it is also evident that it is always placed in such a manner, with relation to the Crinoid, that the anterior side of the Mollusc was directed upward, when the vault of the Crinoid was turned in that direction.† A species of *Goniasteroidocrinus* (*G tuberosus*, Lyon and Casseday), found at the same locality, also has frequently a *Platyceras* attached to the top of its nearly flat vault, so as to cover the only opening in the same. It is worthy of note, however, that it is always another, sub-spiral, *Platyceras* (very similar to *P. æquilaterum*), that we find attached to this Crinoid, so that here at least, it would seem that each of these two Crinoids has its own particular species of *Platyceras*.

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* We at one time thought these shells attached to the side of this *Platycrinus*, to be out of reach of the opening, or supposed mouth, because we had not seen specimens showing the position of the opening in this species, and had supposed, from its similarity to *Platycrinus granulatus*, Miller, and other species without a lateral opening, that such was also the case with this. We have since seen specimens, however, showing that is has a lateral opening, and therefore belongs to the group *Pleurocrinus*, to that it is probable these shells often cover this opening.

† Prof. Richard Owen has noticed, in his Report on the Geological Survey of Indiana, p. 364 (1862), the frequent occurence of a *Platyceras* attached to this same *Platycrinus*, at this locality, and proposed to name the *Platyceras*, *P. pabulocrinus*, from the supposition that it formed the chief food of these Crinoids. It is probable that the *Platyceras* for which he proposed this name, is the same we named *P. infundibulum*, but as he gave no description of the species, and but an imperfect figure, we cannot speak *positively* as to its identity. Prof. Hall has also proposed the name of *P. subrectum* for this Crawfordsville *Platyceras*, but he had previously used the same name for a very different, New York, Devonian species of this genus.

Prof. Yandell and Dr. Shumard have also figured in their paper entitled "Contributions to the Geology of Kentucky," a specimen of *Acrocrinus*, with a very similar *Platyceras* apparently attached to its vault.

Amongst all the numerous Crinoids found at Burlington, Iowa, we are aware of but a single instance of one being found with a *Platyceras* attached, and that is a specimen of *Actinocrinus ventricosus* in Mr. Wachsmuth's collection, which has a crushed shell of a *Platyceras* connected with its vault.

In all of these, and numerous other examples that might be mentioned, it is worthy of note that it is to species of Crinoids with a simple opening in the vault, and not to any of those with a produced proboscis, that we find these shells attached in this way;* and it is so rarely that we find shells of any other genus than *Platyceras*, apparently attached to, or in contact, with the body of a Crinoid, that it seems probable where other shells are occasionally so found, that their connection with the Crinoid may be merely accidental. If it could be established as a fact, that these Crinoids were actually devouring these Molluscs, by sucking out, or otherwise extracting and swallowing their softer parts, in any instance where they have been found with a shell attached over the opening of the vault, this would, of course, establish the fact that this opening is the mouth, or, at least, that it must have performed the office of both oral and anal aperture. But to say nothing in regard to all that is known of the habits and food of the recent Crinoids being so directly opposed to such a conclusion, the fact that so large a proportion as nearly one-half of all the individuals of some species should have died at the precise moment of time when they were devouring a *Platyceras*, and should have been imbedded in the sediment and subsequently fossilized without separating from the shell, seems, to say the least of it, very improbable.

And it is even more difficult to understand upon what principle an animal with its viscera incased in a hard unyielding shell, composed of thick, close-fitting calcareous pieces, and with even its digestive sack, as we have reason to believe, at least to some extent, similarly constructed, could have exerted such powers of suction as to be able to draw out and swallow, through an aperture in its own shell, often less than one-tenth of an inch in diameter, the softer parts of a mollusk nearly or quite equal in volume to the whole of his own visceral cavity. hat they ever did so, however, becomes still more improbable when we bear in mind the fact, that the animal supposed to have performed this feat, lived, at least during the whole of its adult life, attached to one spot by a flexible stem, that only allowed it a radius of a foot or so of area to seek its prey in; while the mollusc it is supposed to have so frequently devoured, from its close affinities

*Possibly due to the fact, that in species with a proboscis there is much less room for attachment to the vault.

to the genus *Capulus*, may be supposed to have almost certainly lived most of its life attached to one spot.* In such a case, why should the Crinoid have so frequently left the *Platyceras* to grow within its reach to nearly its adult size before devouring it? But if from some unknown cause it should have done so, by what means could the Crinoid have pulled loose the Mollusk (which, from analogy, we may reasonably suppose held with some degree of tenacity to its place of attachment), and placed it with the aperture of its shell over the opening supposed to be its own mouth? That it could have used its arms and tentacula as prehensile organs, in this sense, is extremely improbable from their very structure, so much so indeed that few if any of the best authorities who have investigated the recent Crinoids, believe that they ever used these appendages to hand directly to the mouth, even minute organisms.†

But we believe the strongest argument against the conclusion that the Crinoids, so frequently found with the shell of a *Platyceras* attached to them, died while in the act of sucking out, or otherwise extracting the softer parts of these Mollusc, remains to be stated. In the first place, if such really was the nature of the relations between the Crinoid and the Mollusc, it is of course

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*Most of the best European authorities on Palæontology refer these shells even to the existing genus *Capulus*.

†In many instances it is clearly evident that it would have been an *absolute impossibility* for certain types of our Carboniferous Crinoids to have handed any object, great or small, directly to the only opening through the vault. That is, where this opening is at the extremity of a straight rigid tube, often nearly twice the length of the arms, even to the extreme ends of their ultimate divisions. We are aware that some have supposed this tube, or proboscis, to have been flexible, and the Messrs. Austin even thought it was especially designed and used for the purpose of sucking out the softer parts of Polyps. If flexible, we might suppose that in those cases where it was so much longer than the arms, that it could have been curved so as to bring its extremity within reach of the ends of the arms; but although we have in a few instances seen this tube more or less bent, a careful examination always showed that, where this was not due to an accidental fracture after the death of the animal, it was caused by the plates composing it being on one side larger, or differently formed from those on the other, and evidently not to flexibility. We find the arms, which were evidently flexible, folded and bent in every conceivable manner, but the tube of the vault is, in nine cases out of ten, if not more frequently, when not accidentally distorted, found to be perfectly straight, or a little inclined to one side or the other.

self-evident that the continuation of the life of the latter must have necessarily been of very short duration after it came in contact with the Crinoid. Yet we have the most conclusive evidence that such was not the case; but that on the contrary, in most of, if not all of these instances, the *Platyceras must have lived long enough in contact with the Crinoid to have adapted the sinuosities of the margins of its shell exactly to the irregularities of the surface of the Crinoid.*

We have taken some trouble to examine carefully a number of specimens of *Platycrinus hemisphæricus*, and *Goniasteroidocrinus tuberosus*, from Crawfordsville, Indiana, with each a *Platyceras* attached, and in all cases where the specimens are not too much crushed or distorted, or the hard argillaceous shaly matter too firmly adherent to prevent the line of contact between the shell and Crinoid to be clearly seen, the sinuosities of the lip of the former closely conform to the irregular nodose surface of the latter. Owing to the fact that in some cases the shell has evidently been forced by accidental pressure against the surface of the Crinoid, so as to become somewhat crushed, this adaptation is not always so clearly evident; but in most cases it is more or less visible, while in some it is strikingly manifest. In one instance of a *Platycrinus* now before us, with a *Platyceras* attached, as usual, to its side, between the arm-bases of two of its adjacent rays, and of rather larger size than those usually found attached to this species, the adaptation of the irregularities of its lip, so as to receive the little nodes and other prominence of the Crinoid, is so clearly manifest that a moment's examination must satisfy any one that the shell must have grown there. Being, as we stated, a larger individual than we usually see so situated, it not only occupies the whole of the interradial or anal space to which it is attached, but its lateral margins on each side coming in contact with the arm-bases of the Crinoid, as the shell increased in size, had formed on either side *a profound sinus in its lip for the reception of these arms.* These sinuses are not only in precisely the *proper places*, but of exactly the *proper size and form* to receive the adjacent arm on each side; the entire adjustment being so exact, that it seems scarcely possible that the shell could have been removed during the life of both animals, and after the Mollusc had attained its present size, without either breaking its lip or breaking off the arms of the Crinoid. Unfortunately, in clearing away the rather hard argillaceous matrix, before the arrangement of the parts was clearly comprehended, these arms were broken away, but their stumps are still seen protruding from the sinuses, which are so deep as almost to present the appearance of isolated perforations, though it is evident, on a careful examination, that they are only deep emarginations extending up from the edge of the lip.

In looking at the sides of this *Platyceras*, which has the form of a very slightly arched cone,* and stands out nearly at right angles to the side of the Crinoid, it is easy to see, from abrupt curves in the lines of growth, along up its sides, on a line above the sinuses mentioned, that these sinuses commenced forming abruptly at points about half way up; and on measuring across between these points with a pair of dividers, the space between is found to coincide very closely with that between the inner sides of the arm-bases protruding from the sinuses. Hence it is evident that the shell had commenced forming these sinuses in its lip exactly at the period of its growth, when it had attained a breadth that brought the edges of its lip in contact with the arm-bases. After this, it had increased very little *in breadth* between the arms of the Crinoid, though it had grown somewhat wider above and below, and *nearly doubled its length*. Whether or not it covers the opening in the side of the vault of the Crinoid we are unable to say, since the folded arms (which are, as usual in these cases, well preserved) and adhering matrix, cover the vault. We have scarcely any doubt now, however, that the *Platyceras* does, in this, as in most of the other cases, actually cover the opening in the side of the vault of the Crinoid.

From the facts stated it is, we think, evident that these Molluscs actually lived long enough after their connection with the Crinoids, to which we find them attached, not only to have adapted the edges of their lip to fit the surface of the Crinoid, but to have generally increased more or less in size, and in some instances, at least, to have actually nearly or quite doubled their size. Admitting this to be the case—and we think there can be no reasonable doubt on this point—we can no longer believe that these Crinoids were preying upon the Molluscs; and we therefore think no well-grounded arguments can be based upon the fact of their being so frequently found attached in the manner described,

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*It being the common species of *Platyceras* that is usually found attached to this *Platycrinus*.

in favour of the conclusion that the opening in the vault of these Crinoids is the mouth.

But, if they were not in the habit of eating these Mollusks, it may be asked what could have been the nature of the relations between the two, that so frequently brought them together as we now find them? The first explanation that suggests itself is, that possibly the Mollusk may have been preying upon the Crinoid. But the fact, already stated, that these Mollusks evidently lived long enough attached to these Crinoids, as we have every reason to believe, during the life of the latter, to have at least increased the size of their shells considerably, if not indeed during their entire growth, is alone an almost insurmountable objection to such a conclusion. Doubtless, like other marine sedentary animals, these Molluscs, when very young, floated freely about in the sea, until they found a suitable station to attach themselves, where they remained during life. May they not, therefore, have been attracted to the bodies of Crinoids by the numerous little organisms brought in by the action of cilia, along the ambulacral furrows of the arms of the Crinoids, or in currents produced by the motions of the arms of the latter? The excrementious matter of the Crinoid could doubtless have passed out under the foot of the *Platyceras*, supposing the opening in the Crinoid sometimes covered by these shells to have been the anus, but it is difficult to conceive how food could have passed in, if we suppose this opening to be the mouth.

ON THE EXISTENCE OF ROCKS CONTAINING ORGANIC SUBSTANCES IN THE FUNDAMENTAL GNEISS OF SWEDEN.

By Messrs. IGELSTRÖM, NORDENSKIÖLD, and EKMAN.*

1. ON THE OCCURRENCE OF THICK BEDS OF BITUMINOUS GNEISS AND MICA-SCHIST IN THE NULLABERG, PARISH OF OSTMARK, PROVINCE OF WERMLAND, IN SWEDEN.

By L. I. IGELSTRÖM.

The parish of Ostmark, as well as other parts of western and northern Wermland, is filled with high and steep hills of

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* Reprinted from communications read to the Royal Swedish Academy of Sciences at Stockholm.

hyperite, between which the common crystalline rocks, gneiss, hornblende, mica-schist and others, intervene. The bituminous gneiss and mica-schist occur interstratified in common reddish granite-gneiss at the western part of the high and precipitous Nullaberg, occupying a thickness of more than twenty fathoms, and extending along almost the whole side of the mountain. The dip of the strata is about 70° eastward, and they are covered first by a bed of hyperite and then with parallel strata of other granitoid rocks.

Generally, the bituminous substance is rather uniformly distributed through the range, in the gneiss as well as in the mica schist, and the entire mass has a black colour. The naked eye is hardly able to discern any particles of coal. When coarsely ground the rock resembles gunpowder, but when ground finer, it grows darker, either of the colour of soot, or resembling pyrolusite. When beaten with the hammer, it emits a bituminous smell, like anthraconite, and also when heated by the blowpipe; it then gives a flame. When calcining 5.32 grammes in an open crucible of platinum, I was not able completely to burn the whole of the bituminous substance, even after adding several times nitric acid; a little coal always remaining unconsumed. The loss of weight, however, was 12.03 per cent; the ashes were gray. When heated in a retort of thin iron plates, twelve pounds emitted much combustible gas, while a yellow combustible oil, as well as a colourless incombustible fluid was collected in the recipient. When the gas was allowed to escape through a hole of one inch in diameter, a fine and bright flame was obtained during four hours; during the fifth and sixth hour the flame grew bluer and fainter. The powder in the retort remained as black as before the distillation, though with rather a high lustre. It had lost 15,6 per cent of its volume.—The specific gravity of the rock is 2,19.* It is so loose, that a man may in about half an hour sink in it a hole of two feet.

On a closer examination of the bituminous strata it is very difficult, from the general homogeneousness of the bed, to decide whether and where it is gneiss or mica-schist, that is impregnated with bitumen, but nevertheless one finds that both the above-named rocks, and thin layers of chlorite schist constitute

* When weighed in the hand, it feels very light, compared with silicates in general.

parts of the range. Thus, above the main bed and somewhat separate from it, I met with thin layers of common mica-schist, alternating with layers of mica-schist more or less impregnated with bitumen. Silvery laminæ of mica also form thin seams in the main bed. With regard to the gneiss, on the other hand, occasionally in the black bituminous rock one meets with somewhat paler stripes and seams, showing that feldspar here forms the principal constituent of the mass. The stratification is, however, distinct enough to show that it is not a dike, but stratified gneiss and mica-schist, conformable to the surrounding parts we here see before us. In some places the bituminous rock contains round, whitish, thinly interspersed particles of the size of a pea, as well as nodules of anthracite of about the same size. As I at first supposed the latter to be asphalt, I concluded, that the whole bed was impregnated with that substance; when, however, these nodules afterwards were proved, by experiments, to be anthracite, that supposition lost its foundation and yet I cannot decide what kind of bituminous substance it is, that to so large an extent impregnates the rock. It seems nevertheless to be fully decided, that the impregnation is analogous to that in alum-slate, for instance, and that consequently our gneiss and mica schist must be removed from the place they occupy as "primitive rocks," to the series of sedimentary and fossilferous strata, as limestone, alum-slate, &c.

2. Note on the Mineral Character of the Rock.

By A. E. Nordenskiöld.

There are at Nullaberg two kinds of bituminous rocks, viz:

a) a rock of a schistose structure, abounding in mica.

b) a rock almost devoid of mica, and showing but slight appearance of layers in the arrangement of its ingredients.

As Mr. Igelström shows, these rocks alternate in parallel beds, with common mica-schist, gneiss, and hyperite. The principal ingredients are, in *b*—greyish white orthoclase, in *a*—greyish-white orthoclase and silver-white mica; in both mingled with variable portions of a black carbonaceous or coal-like substance. No quartz is to be discovered. When the mica prevails and the rock contains less of the carbonaceous substance, it has such a striking resemblance to ordinary mica-schist, that even the ablest geologist would mistake it for this common rock, and I should not wonder if such bituminous mixures of mica and feldspar, or bituminous mica-schist, were found to be abundant in almost all our districts of crystalline rocks. When the carbonaceous substance becomes more predominant, the silver-white colour passes into dark brown, and this colour totally prevails in the variety *b*, which at a superficial glance seems to be a quite homogeneous, black or dark brown substance. A closer examination, however, shows, that this colour comes from innumerable small black, well defined grains immixed in the greyish orthoclase. Some scales of mica, of the same aspect as the mica in the schistose variety, and small grains of calcite, may also be discovered. Occasionally the felspar and calcite are concentrated into somewhat larger white nodules, free from the black mineral.—If the variety *b*—(*b* contains less of bitumen)—is heated in the air or in oxygen, the carbonaceous substance is destroyed, and the blackish colour changes into greyish-white. Before the piece is red-hot, a combustible gas is given off, enveloping the heated mineral in a flame, resembling the flame of burning hydrogen. Even when heated in a retort the rock gives much gas, in this respect quite resembling bituminous coal. With boiling alkali a dark brown solution is obtained, which gives with muriatic acid a brown flocculent precipitate.

The carbonaceous substance is very brittle, and the rock is therefore more friable than common gneiss, not more, however, than might be presumed of a gneiss penetrated with cavities of the form and volume of the immixed coaly particles. But near the surface the rock is already much decomposed, and so brittle that large pieces may be crumbled with a few blows. The grains of orthoclase, both in the altered and unaltered rock, break *along the cleavages of the felspar*, and the fracture of the rock is thus crystaline. Accordingly we have here not to do with a sandstone, but with a rock, probably originated by the solidification and crystallization of a claylike sediment, consisting of organic substances and inorganic matter, of the same constituents as the common felspar. That a change in the relative position of the atoms, *i.e.*, a crystallisation *in a solid mass* tending to a disposition of its molecules according to the best conditions of equilibrinm, did take place, *without the aid of water or heat*, during the immense time that has elapsed since the gneiss period, seems not at all improbable, when we consider, that such a change often takes place, for instance in the axis of a locomotive in the course of a few years, in the monoclinic sulphur or the yellow iodide of mercury in a few seconds.

3. Chemical Analysis of the Rock.

By F. L. Ekman.

The following are the results of an analysis of various specimens of Nullaberg-rock from the mineralogical collection of the Royal Academy of Science in Stockholm.

The principal ingredient in this species of rock was felspar, a portion of which formed colourless stripes, *coarser or finer*, in the fracture of the dark stone. Even the dark material itself was chiefly composed of felspar, which however was so thickly overspread with small grains of organic carbonaceous matter, as entirely to conceal the appearance of the felspar. These grains were in part visible to the naked eye, and when a little of the dark stone was crushed between glass plates under the microscope, the carbonaceous substance appeared as opaque, angular broken particles. and the felspar uncoloured; one or two flakes were slightly tinged with yellow.

Mica appeared thickly scattered in separate or conglomerate scales. Quartz I could not observe.

Carbonate of lime occurred together with felspar in the small round balls of white colour, copiously sprinkling some of the specimens, though in some instances it had been fretted out by the action of the air and water. It sometimes appeared, less visibly, mixed with tl remaining mass, but was sometimes entirely absent.

In five specimens of different character I found the following proportions of organic matter (traces of water included) and carbonate of lime :

	1.	2.	3.	4.	5.
Organic matter......	7.10,	10.67,	10.36,	5.44,	9.08.
Carbonate of lime....	2.57	(0,07)	14.30	2.75	0.00.

The following is the analysis of the rock, when free from organic matter and carbonate of lime :

	1.	5.
Silica....................	65.03	65.25.
Alumina....................	19.61	
Red Oxyd of Iron.......	0.45	
Lime....................	0.19	
Magnesia..................	0.20	
Potash.....................	14.46	
Soda.......................	1.06	
	101.00.	

When larger quantities (40—80 grammes) were macerated at the ordinary temperature with diluted nitric acid, well determinable quantities were obtained of phosphoric acid and chlorine, as also of lime, the last even in the specimen 5 (in which, though 11 grammes were analyzed, no carbonic acid was found). Hence one may conclude that the rock contains a little apatite. Traces of manganese and copper were also observed. The silicious ingredients of the rock were also a little dissolved, and it may perhaps be inferred, that the traces of silica were separated before testing for phosphoric acid.

The organic ingredient may be easily obtained in a very pure state by washing, when a sufficient quantity of the rock is employed. The purest specimen that I obtained afforded after combustion only 3.17 p.c. of a reddish ash, but still contained some mineral fragments. The ash, of which those fragments constituted perhaps the principal part, showed no reaction on curcuma paper. In a few centigrammes, collected after analysis, I found gypsum, oxyd of iron, silica (and phosphoric acid ?) apparently derived from the combustion of the organic matter.

The carbonaceous substance thus purified forms a light powder of a beautiful bluish black colour. It is but slightly hygroscopic and is not easily wetted with water. When heated, it concretes a little, but without melting or sensibly changing its state of aggregation, and produces a transient but brilliant flame; the remaining coal smoulders very slowly out. The specific gravity I found to be 1.299; after the removal of all remaining stony matter, it would probably be about 1.27. Analysis by combustion gave the following results (ash and water being supposed to be removed):

The carbonaceous substance obtained from

	No. 3.	No. 2.		Medium.
Carbon..........	88.68	88.79	—	88.74
Hydrogen.......	5.35	5.56	—	5.46
Azote.............	—	—	0.67	0.67
Oxygen..........	—	—	—	5.13
				100.00

The carbonaceous substance is generally but little affected by solvents. Spirit of 90 per cent. pure alcohol became yellow and dissolved scarcely one per cent of a substance, probably colourless when pure, and easily soluble in alcohol; when heated it *yielded a thick white vapour and slowly blackened.* Ether dissolved ½ per cent. of a substance of the same nature but less coloured. Chloroform, like alcohol, was coloured deep yellow, and left a similar residuum, the quantity of which was however not determined. Oil of turpentine had no more dissolving effect than alcohol or ether. N.B: The experiments with alcohol, ether and oil of turpentine were performed by boiling the substance in the solvents for several hours.

A warm solution of one part caustic potash in twenty parts water, dissolved 5 per cent. and became black-brown. From this solution, by the action of acids, was obtained a very voluminous brown precipitate soluble in pure water. After the extraction of this 5 per cent, the remainder was unalterable in a heated solution of caustic potash, though exposed for several hours to its action.

The following are the results of some experiments made with reference to the products of dry distillation, performed on a small scale, the presence of air being as much as possible avoided, and in an apparatus that permitted a bright red-heat. When rapidly heated the substance* gave carbon 74 p.c. and volatile products 26 p. c. When slowly heated it gave 11 p. c. fluid products, of which about three-fourths consisted of a yellow neutral oil, lighter than water; the gases developed were first acid, afterwards alkaline, and the water after distillation was strongly alkaline.

One gramme of the substance gave, rapidly heated, 258 cubic centimentres of gas of 23° Centig. temp., collected and measured over water. In the gas when fully purified with carbonic acid I found 2.7 vol. p. c. of hydrocarbons absorbable by bromine. In another experiment, where the oils were for the most part decomposed during the distillation, 313 cubic centimeters of gas were obtained from one gramme of the substance.

In the analysis of the organic substance no attention has been paid to the amount of sulphur contained. Even in the original rock, when melted with carbonate of soda, this element plainly shows itself, and in the carbonaceous substance, containing 3.17 p.c. ash, I found no less than 0.81 p.c. Whether the iron remarked in the ash be there in sufficient quantity to unite with the sulphur and compose pyrites, or whether, as is possible, there be an overplus contained in the organic substance is as yet undecided.

* The substance always considered as free from ash.

Finally I may remark, that I have found Mr. Bahr's interesting statement that the rock contains iodine confirmed. When 7.5 grammes of substance, containing 21.7 p.c. of ash, were burned with 14 grammes of almost pure lime, the burned mass treated with water and nitric acid, and the iodine transferred to silver and thence to cadmium, the little amount of solution of cadmium showed strong signs of the presence of iodine. The iodine was recognized by receiving it first on chloroform, thence on silver again, and lastly on starch.

When twelve grammes of the same kind of lime were dissolved with proper care in water and the same kind of nitric acid as that used in the experiment, the solution, when analogously treated, yielded a little chlorine but no trace of iodine. For the sake of brevity I do not here detail any operations caused by the substance's containing sulphur, especially as fuller details of the experiments will shortly be published in the proceedings of the Royal Swedish Aca y.

ON THE GEOLOGY AND SILVER ORE OF WOODS' LOCATION, THUNDER CAPE, LAKE SUPERIOR.

By Thomas MacFarlane.

Part II.

(*Continued from page* 47.)

On the north-western part of the location a large area is occupied by the rock which forms the summit of the cliffs of Thunder Cape. At the western end of these cliffs, on the location, this rock is found to overlie the grey argillaceous sandstones and shales, described in the first part of this paper. In following the line of junction between these and the overlying crystalline rock, the observer frequently fancies that he can detect unconformability; but so slight is the dip of the underlying strata, and so inaccessible in places is the point of contact, that it is impossible for him to obtain certainty until he reaches the eastern end of the cliffs. Here, not only does the unconformability become plainer, but the conglomerate bed and the white sandstones, which have been described as succeeding, in ascending order, the same grey argillaceous sandstones on the eastern part of the location, are found to crop out beneath the crystalline covering, and to be unconformably overlaid by the latter. An attempt has been made to represent the relations of these various rocks in the section which accompanies the map. From this it will be apparent that the summit rock of Thunder Cape is not a bed interstratified between the grey argillaceous and the white and red dolomite sandstones, but an overflow which has spread over both these groups after their deposition and partial disturbance. The cliffs at the east end of Thunder Cape would form the eastern extremity of this overflow, unless it should be found that the rock of the Paps between Black Bay and Lake Superior, and those of other overflows in the Nipigon district, resemble that of Thunder Cape. Southwest from Thunder Cape large areas are occupied by the same rock, which contributes in a marked degree to form the picturesque coast lying between Fort William and Pigeon River.

The rock whose geological relations have just been described, and which, with its roughly columnar structure, adds so much to the imposing appearance of Thunder Cape, is very hard and crystalline, and exhibits no appearance of stratification or parallelism among its constituent minerals. It is very little acted on by the atmosphere, but separates into large rectangular blocks, which, becoming detached from the rock above, form an enormous talus at the bottom of the cliffs, sometimes completely obscuring the debris from the underlying strata. The rock is readily recognizable as a compound one, its constituents being of distinctly different colours. These vary in size from one-twentieth of an inch in diameter to very minute grains, and in general the fine-grained varieties are found immediately over the underlying strata, while the coarse-grained varieties are more frequent on the summit of the cliffs. The principal constituents are greyish white feldspar and black hypersthene, the former mineral being generally the most abundant The hypersthene is but slightly influenced by the atmosphere, and on exposed surfaces retains most of its lustre and hardness, while the accompanying feldspar is bleached and decomposed. A softer dark greenish coloured mineral, probably hornblende, is also present, as well as magnetite in small quantity. It would therefore appear that the rock in question is hypersthenite, or, as the name has been more recently modified, hyperyte. Four different specimens, tested as to specific gravity, gave respectively 3.061, 3.034, 3.009 and 2.922.

The explorations made upon the location during the summer and fall of 1869 did not result in the discovery of any new veins of much economic value. A few very narrow and unimportant veins, noted on the map, were found on the face of Thunder Cape cliffs, and at a few other points in the interior of the location. Much more important, because of great width, are the veins noted as occurring on Shangoinah Island, and running parallel with its length. In places this network of veins has a width of forty feet, enclosing, however, much rock, the greatest width of pure veinstone being about three feet. The veinstone consists of large-grained calcspar, accompanied by saponite and iron pyrites. Several days were spent in blasting on the vein and searching for silver in it, but without result; nor did the iron pyrites contain any, except the merest traces. It is to be remarked that the general course of this suite of veins is N. 50°E., consequently almost at right angles to that of the Silver Islet vein. On this account, and because of the coarse grain of of the veinstone, and because also of its similarity to that of the dyke veins, in which nothing of value has been hitherto discovered, it is not anticipated that the veins of Shangoinah Island will ever turn out to be of much value.

Pyritic Island, which lies inside of Shangoinah Island, was also carefully explored. No veins were detected anywhere upon it, but a band of reddish weathering rock runs through its length from north-east to south-west. It contains finely disseminated plumbago, copper, iron and magnetic pyrites, and also 0.02 per cent. of silver, a quantity, however, too small to be economically available.

The continuation of Silver Islet vein, across Burnt Island, and upon the main land, was carefully explored for a distance of about one mile from the lake. On Burnt Island a large quantity of earth was removed, and excavation done on the vein, which was found to be irregular at the point where it intersects the most southerly dyke. Here calcspar, quartz and fluorspar form the veinstone, with small grains of galena, blende, iron and copper pyrites, but no silver. The vein was uncovered at numerous points inland without obtaining any better result

The situation of the rich vein at Silver Islet is such that work was only possible upon it on the calmest days, when neither wind nor swell disturbed the water. Even at the best, its extreme coldness prevented the men from working in it longer than half an hour at a time, and then not very effectually. The same cause made it impossible to blast under water with success. The holes were bored, although with difficulty, but the insertion of the cartridge and the tamping was almost invariably a failure. Nevertheless, by working in a depth of from two to four feet of water, mostly with moils and bars, forty-six half-barrels of good ore were extracted from the vein. These formed three different parcels, which were despatched at different times, after the pieces had been broken down to a size not exceeding one inch and a half in diameter, and after a sample of each parcel had been taken in the regular manner. These samples I assayed on the spot before the blow-pipe, and afterwards in the muffle furnace. The results by the latter process, which did not differ materially from those done before the blow-pipe, are given in the following statement, together with the weights and values of each parcel.

No. of Parcel.	No. of Barrels.	Nett weight.	Percentage of Silver.	Ounces per ton of 2240 lbs.	Values per ton.	Total Values.
1	16	3429	2.760	889	$1111.25	$1701.10
2	21	4080	4.344	1417	1771.25	3226.20
3	9	1946	5.147	1680	2100.00	1824.37
	46	9455				$6751.67

Nothing could be more conclusive than these figures for establishing the value of the vein, and justifying considerable outlay in the attempt to establish a mine on Silver Islet. On the 12th of August last a shaft was begun in the centre of the islet, and afterwards a shaft-house erected over it, containing, besides the shaft-house proper, a sleeping apartment, as well as a kitchen or eating apartment for the men. This building was protected on the west side by a screen of two-inch planks, extending from the ridge of the roof, at the same inclination, down to the rock of the islet. This served to ward off, from the house and shaft, the heavy spray driven over the islet and building during southwest gales. At such times we felt perfectly secure upon the islet, although from the heavy sea it was unapproachable by a boat. The sinking of the shaft was continued until a depth of 18 feet, or 12 feet below the level of the lake had been attained. At this depth several small veins were struck, which brought with them more water than could be advantageously raised by the windlass. The men were therefore removed to the main land, to cut the timber required for the cribbing and other extensive works already planned, and which it is intended to carry out energetically in the spring.

Besides the minerals mentioned in the first part of this paper as occurring in the vein of Silver Islet, large patches of the veinstone impregnated with graphite are frequently met with, and also, in the neighbourhood of the rich ore, cobalt bloom and nickel green. Besides the small nuggets and grains of pure metallic silver, there are also found in the rich ore thin plates and grains of a sectile mineral having a reddish-brown colour like that of niccolite, and containing arsenic, cobalt, nickel and silver, the latter in greatest quantity. This would appear to be a new mineral, and worthy of more minute examination.

Actonvale, 1st February, 1870.

NATURAL HISTORY SOCIETY.

MONTHLY MEETINGS.

(*From October to December*, 1869.)

First monthly meeting, October 25th, 1869; Principal Dawson in the chair.

The following donations were announced:—

TO THE MUSEUM.

Brittle star from Panama, *Ophiura teres* Lyman; from R. J. Fowler.

Sixty species of British crag fossils; from A. Bell.

Three species of Montreal post-pliocene fossils; from R. McLachlan.

Bead and fragments of pottery dug up in Mansfield Street; from W. McLennan.

A Canadian Lynx, *Lynx Canadensis*; from Mrs. Demaray.

TO THE LIBRARY.

Reliquiæ Aquitanicæ; Parts 8 and 9; from the executors of the late Henry Christy.

Discoveries in Science by the Medical Philosopher, by Sir G. Duncan Gibb, Bart., M.A.; from the Author.

Queries on the Red Sandstone of Vermont and its Relations to other Rocks, by Rev. John B. Perry; from the Author.

Annual Report of the Trustees of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass., with the Report of the Director; from the Trustees.

Annuaire de l'Université Laval pour l'Année Académique 1869-70, Quebec; from the University.

Report of the Minister of Public Instruction of the Province of Quebec for the year 1867 and in part of the year 1868; from the Education Office.

General Report of the Minister of Public Works for the year ending June 30, 1868, Ottawa; from the Dominion Government.

The Spiders of Prussia, by A. Menge; from the Author.

PROCEEDINGS.

Principal Dawson read a paper "On some New Fossil Plants, &c., from Gaspé," of which the following summary is presented:

"The Peninsula of Gaspé, between the St. Lawrence and the Bay des Chaleurs, is of no small note in the history and geology of Canada. It was the first point in Canada at which Cartier touched in his first voyage; and, after availing himself of anchorage in Gaspé Bay and holding intercourse with the Micmacs, he prepared to prosecute his voyage up the mighty river of which he had learned from the Indians; but, opposed by the strong west winds of autumn, he abandoned the attempt, and bore away for France, leaving the exploration of the St. Lawrence for his second voyage. Gaspé had the honour to be the first part of Canada explored by the Geological Survey under Sir William Logan, when the geology of the peninsula was found to be most interesting and varied. At Cape Rosier the geologist sees the contorted shales of the Quebec group, which run all the way along the south side of the St. Lawrence from Quebec to this point. Passing toward Cape Bon Ami, the limestones of the Upper Silurian rest unconformably on these Lower Silurian beds, and rise into stupendous cliffs, 600 feet in perpendicular height, on the north side of Cape Gaspé. Dipping to the southward, these are overlaid at Little Gaspé by the Devonian sandstones, which extend along the north side of Gaspé Bay, and, rising on the south side, form a symmetrical valley occupied by the waters of the most beautiful bay in Canada. Towards the mouth of the bay the Devonian sandstones, the representatives of the Old Red Sandstone of Scotland, are overlaid by Lower Carboniferous rocks, and a little further to the southward are again pierced by the edges of the Upper Silurian limestones, forming, with the overlying carboniferous conglomerates, the magnificent scenery of Percé and its arched rocks. We have in Gaspé representatives of the Lower Silurian, the Upper Silurian, the Devonian, and the Lower Carboniferous periods, all admirably exposed in coast cliffs; and in the case of the Upper Silurian and Devonian, abounding in characteristic fossils. The visit of Principal Dawson had reference to farther study of the fossil plants of the Devonian sandstone, many species of which have been described in his papers in the "Canadian Naturalist" and in the "Journal of the Geological Society." With Messrs. G. T. Kennedy and G. M. Dawson, he explored the north and south sides of Gaspé Bay, and obtained large and interesting collections of fossil plants. Among these are two large trunks of *Protaxites Logani*, a beautiful species of *Psilophyton*, and a species of *Cyclostigma*, a genus hitherto found only in the Devonian rocks of Ireland. Several interesting remains were also found, including species of large fishes (*Machairacanthus*); and Mr. Kennedy was so fortunate as to find a *Cephalaspis*, the first representative of the genus as yet found in America. The animal fossils have been placed in the hands of Mr. Billings and Dr. Newberry for comparison, and the plants will probably be described in detail in the course of the coming winter."

Specimens of some of the more interesting fossils above referred to were exhibited to the Society.

Mr. A. S. Ritchie then read a paper on the Small Cabbage Butterfly (*Pieris rapæ*), which appeared in the September number of this Journal, page 293.

Mr. J. F. Whiteaves made a communication, entitled, "On some Results obtained by Dredging in Gaspé and off Murray Bay." This paper also will be found in the September number, at page 270.

Second monthly meeting, November 29th, 1869; Principal Dawson presiding.

DONATIONS TO THE MUSEUM.

A Chinese bank-note; from A. S. Hutchison.

TO THE LIBRARY.

Statutes of Canada, 1869; from the Dominion Government.

Manuscripts relating to the early history of Canada, Quebec; from the Literary and Historical Society.

Physical Culture in Harvard College, by Nathan Allen, M.D., Lowell, Mass.; from the Author.

PROCEEDINGS.

Col. Wolseley, Q.M.G., Dr. Griffith Evans, and A. Selwyn, F.G.S., Director of the Geological Survey of Canada, were elected members of the Society.

Mr. E. Billings read a paper "*On the Genus Scolithus and* some Allied Fossils," which will shortly appear in our pages.

Dr. P. P. Carpenter made a communication "On Different Modes of Computing Sanitary Statistics, with special reference to the opinions lately published by Mr. Andrew A. Watt."

Considerable discussion ensued on this subject, and Dr. Trenholme moved a vote of thanks to Dr. C. for the labour he had devoted to the subject, which was seconded by Mr. Drummond, and carried unanimously.

Mr. Joseph acknowledged that the Sanitary Association had done great good, but took exception to some of the figures.

Mr. D. P. Watt said we could not get over the facts of the excessive proportion of deaths under one year; nor of the fatal miasma of July and August.

Principal Dawson said that two things were established conclusions: 1st. We ought to have more accurate data; if the Council will not conduct registration as in other cities, they should let us know why they cannot; if only ten infants die prematurely, we ought to find out and remedy the evil. 2nd. Even in the healthy parts of the city, the summer months are usually unhealthy, in consequence of the prevalence of diseases difficult to cure. All should unite in seeking to remove those evils.

The third monthly meeting, which should have been held on the 27th of December, 1869, was postponed to January 31st, 1870. J. F. W.

GEOLOGY AND MINERALOGY.

THE MAGNETIC IRON SANDS OF CANADA, by Dr. T. Sterry Hunt, F.R.S.—Extract of a letter published in the American *Engineering and Mining Journal* of February 8, 1870.—The sands from the mines of the crystalline rocks in Canada, as in most other regions, hold considerable quantities of iron ore, which along the shores of lakes and of the sea is seen partially separated by a natural process of concentration through the action of the water. The ancient marine sands which are found in the lower St. Lawrence, from the present sea-level to altitudes of several hundred feet, are often banded and barred with layers discolored by black iron ore grains, and in some places beds of several inches in thickness are almost free from the admixture of silicious sand. More generally, however, to obtain it of such a degree of purity requires a process of artificial concentration by washing or otherwise. The black sand thus obtained is not homogeneous, but may be separated into a magnetic and a non-magnetic portion, the latter predominating in the washed sand. While the magnetic part is nearly pure magnetic iron ore, the other portion contains from thirty to thirty-five per cent. of titanic acid, and consists in great part of titanic iron (menaccanite) with some admixture of garnet.

Successful attempts have been made to work these iron sands at Moisie, where they are treated in bloomery fires, and are reduced without difficulty, the daily yield of iron to each furnace being as great as in the similar furnaces of Northern New York, where non-titaniferous ores are used. The bar iron thus produced is of excellent quality and retains no titanium in its composition, while the fluid and readily crystallizable slags hold a great deal of titanic acid as a silico-titanate. The layers of iron sand at the Moisie are very rich, and the same is true of many other deposits in that vicinity and at Mingan, Natashquan, and elsewhere; but in many localities there are great quantities to be obtained which yield by washing from eight or ten per cent. to thirty or fifty per cent. of heavy black sand. Attempts have been recently made to purify these by means of a magnetic separator, which leaves behind both the silicious and titanic portions. For the bloomery fire it is true such a degree of purification is not necessary, but for some of the newly proposed processes of direct conversion, or for the manufacture of malleable iron from pig metal by the Ellershausen process, and generally for ore intended for exportation, it is deemed desirable to get as high a per-centage of iron as possible, or in other words, to obtain pure magnetic iron ore. This, in the case of these titaniferous iron sands, can only be attained by the use of magnets. Dr. Larue, professor of chemistry at the Laval University, Quebec, has contrived for this purpose a simple and ingenious machine, which appears to be entirely novel in its arrangements, and is very efficient and rapid in its action. One of these I have seen in operation at Quebec, and of another put in operation at Clifton, New York, I have been furnished with an account by Dr. Larue. This machine, which is fitted with batteries of permanent magnets, occupies a space about six feet by five, and is four feet high. From three tons of sand, holding one-third of magnetic ore, it will separate in an hour one ton containing over ninety-nine per cent. of magnetic iron—or twenty-four tons in twenty-four hours. The wear and tear, and the motive power required are very small, and two men can, it is said, tend ten machines.

It was estimated at Clifton that the cost of purifying such iron sand would not exceed three cents per ton. Of course, if applied to massive ores, the cost of crushing and sifting would be added. By proper adjustment, this machine may be adapted to the preparation of lean massive ores for the bloomery fire, or for other direct methods of conversion into iron or steel. Meanwhile the deposits of iron sand which may be utilized by means of this machine, on the north shore of the St. Lawrence, from the Saguenay to Newfoundland, are practically inexhaustible. Dr. Larue informs us that inasmuch as a rich sand may be passed through the machine as rapidly as a poor one, the yield of the machine varies directly with the proportion of magnetite present; so that a sand containing say nine per cent. would yield six tons in twenty-four hours. Even the poorer sands may thus be used with advantage.

It is not, however, to the lower St. Lawrence that these sands are confined; they are met with in considerable quantities at Batiscan, between Quebec and Montreal, and a large accumulation of black iron sand at the mouth of Lake Huron attracted attention some years since. Similar deposits have been observed on both shores of Lake Erie, and I was informed more than twenty years ago that attempts had been made to collect the iron sand along the lake, and use it, together with bog ore, in a blast furnace on the Canadian shore. The iron sands of Taranaki, in New Zealand, are well known; and similar sands, according to Bruno Kerl, are worked in open hearths near Naples.

Black magnetic iron sands are found distributed in greater or less abundance, in numerous localities along the seaboard of Connecticut and Rhode Island, and it is said upon some of the adjacent islands. The utilization of these abundant and wide-spread deposits of an ore which is free from phosphorus and sulphur, and may be obtained in a great degree of purity by the magnet, is a problem well worthy the attention of metallurgists, and is already attracting considerable attention.

OBITUARY NOTICE.

By late advices from Christiania we learn, with regret, of the loss which science has sustained by the decease of Prof. Michael Sars, the eminent zoologist. He was born on the 30th of August, 1805, at Bergen, where his father was a shipowner. After finishing his academical studies at Christiania, and evincing at an early age his predilection for natural science, he entered into priest's orders, and in 1830 became pastor at Kinn, in the diocese of Bergen. Ten years afterwards he had charge of the parish of Manger in the same diocese. As both these parishes were on the sea-coast, Sars had constant opportunities of pursuing his zoological researches. In 1829 he published his first essay, entitled "Bidrag til Söedyrenes Natur-historie," and in 1846 the first part of his celebrated work Fauna littoralis Norvegiæ. In 1854 he was appointed Professor Extraordinarius of Zoology at the University of Christiania, a position which he filled up to the time of his lamented death with great honour to his country, and to the satisfaction of the whole world of science. His celebrity as a zoologist, as well as a palæontologist, was fully recognised by all naturalists and geologists, and he was elected a member of several foreing scientific societies. Our own distinguished countryman, the late Edward Forbes, individually showed his appreciation of Sars's labours in the eloquent pages of his own posthumous work, "The Natural History of the European Seas," when he said, "More complete or more valuable zoological researches than those of Sars have rarely been contributed to the science of Natural History, and the success with which he has prosecuted investigations, claiming not only a high systematic value, but also a deep physiological import, is a wonderful evidence of the abundance of intellectual resources which genius can develope, however its lot be cast." * * * By the observations of Sars on the development of the Medusæ he greatly advanced our knowledge of that remarkable physiological phenomenon known as the alternation of generations, which Chamisso had first indicated in the Salpæ. His last publication, "Mémoire pour servir à la connaissance des Crinoïdes vivants," caused especial interest, by showing that a race of animals, supposed to be extinct for a period so long as only to be measured by the duration of several past geological epochs, occurred in a living state in the abysses of the Norwegian seas; and this discovery mainly induced the recent exploration of our own seas at great depths, which has produced such wonderful results The published works of Sars are seventy-four, and they are not less sound and valuable than numerous.

It is exceedingly to be regretted that, in spite of the most rigid economy, the large family of Professor Sars is left in very impoverished circumstances, six of the children being wholly unprovided for."—*Extracted from a notice by Mr. J. G. Jeffreys, F.R.S., in "Nature."*

EDITOR'S NOTE.—The Authors request that the following alterations be made in their articles:—

For Dec., 1866, vol. iii, p. 156, (reprint p. 20) line 4, for 3,516 read 3,536.
" " " " " 6, " 280 " 282.
" " " " " 5, for "which" read "so that the total deaths." [This error is repeated in the First Annual Report of the Sanitary Association, page 3, column 2, line 28, where for "children" read "persons."]
For June, 1869, present vol. p. 189, (reprint p. 4) table 4, the *supposed population* should be 106,375; and the deaths per 1000, 35.3; altering the average of the latter to 35.2. P. P. C.

For Sept., 1869, present volume.
Page 140, line 11, for "this region" read "continental Acadia."
" 143, " 6, insert here pp. 147 (omitting the table), 148, 149 and 150 as far as line 34.
" 152, " 21, for "second" read "fifth," and three lines below, for "fourth" read "seventh."
" 154, " 21 and elsewhere, omit the references to *Primula Mistassinica*.
" 155, " 27, insert "III. CONTINENTAL TYPE."

INDEX.

D. A. W.