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THE

CANADIAN NATURALIST.

SECOND SERIES.

NOTES ON POST-PLIOCENE DEPOSITS AT RIVIERE-DU-LOUP AND TADOUSSAC.

By J. W. Dawson, LL.D., F.R.S., F.G.S., Principal of McGill College.

In looking over, last winter, some of the collections made by Prof. Bell, of Kingston, when engaged in the service of the Geological Survey of Canada, I was struck with a small collection of Post-pliocene shells from Rivière-du-Loup,* as presenting a somewhat singular grouping of species; and having a few holiday weeks to spend at Cacouna, I determined to ransack thoroughly the deposits which had afforded these specimens.

The country around Cacouna and Rivière-du-Loup rests on the shales, sandstones, and conglomerates of the *Quebec group* of Sir W. E. Logan. As these rocks vary much in hardness, and are also highly inclined and much disturbed, the denudation to which they have been subjected has caused them to present a somewhat uneven surface. They form long ridges running nearly parallel to the coast, or north-east and south-west, with intervening longitudinal valleys excavated in the softer beds. One of these ridges forms the long reef off Cacouna, which is bare only at low tide; another, running close to the shore, supports the village of Cacouna; another forms the point which is terminated by the pier; a fourth rises into Mount Pilote; and a fifth stretches behind the town of Rivière-du-Loup.

* See Geology of Canada, p. 921, where, however, only a portion of the species collected are mentioned.

The depressions between these ridges are occupied with Post-pliocene deposits, not so regular and uniform in their arrangement as the corresponding beds in the great plains higher up the St. Lawrence, but still presenting a more or less definite order of succession. The oldest member of the deposit is a tough boulder-clay, its cement formed of gray or reddish mud derived from the waste of the shales of the Quebec group, and the stones and boulders with which it is filled partly derived from the harder members of that group, and partly from the Laurentian hills on the opposite or northern side of the river, here more than twenty miles distant. The thickness of this boulder-clay is, no doubt, very variable, and could not be ascertained in the neighborhood of Cacouna; but at Ile Verte it forms a terrace fifty feet in height.

Above the boulder-clay, where it has not been bared by denudation, there occurs a dark gray, soft, sandy clay, containing numerous boulders, and above this several feet of stratified sandy clay without boulders; while on the sides of the ridges, and at some places near the present shore, there are beds and terraces of sand and gravel, constituting old shingle beaches apparently much more recent than the other deposits.

All these deposits are more or less fossiliferous. The lower boulder-clay contains large and fine specimens of *Leda truncata* and other deep-water and mud-dwelling shells, with the valves attached. The upper boulder-clay is remarkably rich in shells of numerous species; and its stones are covered with Polyzoa and great Acorn-shells (*Balanus Hameri*), sometimes two inches in diameter and three inches high. The stratified gravel holds a few littoral and sub-littoral shells, which also occur in some places in the more recent gravel. On the surface of some of the terraces are considerable deposits of large shells of *Mya truncata*; but these are modern, and are the 'kitchen-middens' of the Indians, who in former times encamped here.

Numbers of Post-pliocene shells may be picked up along the shores of the two little bays between Cacouna and Rivière-du-Loup; but I found the most prolific locality to be on the banks of a little stream called the Petite Rivière-du-Loup, which runs between the ridge behind Cacouna and that of Mount Pilote, and empties into the bay between Rivière-du Loup and the pier. In these localities I collected eighty-four species, about thirty-six of them not previously published as occurring in the Post-pliocene of Canada. A list of these fossils is appended to this paper; and in connection with it I would desire to make some general remarks on the features of these interesting deposits.

We have here an indubitable instance of a marine boulder-clay. I have observed fossiliferous boulder-clays at Murray Bay, St. Nicholas, and Cape Elizabeth, but the example afforded at Cacouna and its vicinity is more clear and instructive; and there is also evidence that the surface under the boulder-clay is polished and striated, the direction of the striæ being north-east and south-west, or that of the St. Lawrence valley.*

The Cacouna boulder-clay is a deep-water deposit. Its most abundant shells are *Leda truncata*, *Nucula tenuis*, and *Tellina proxima*, and these are imbedded in the clay with the valves closed, and in as perfect condition as if the animals still inhabited them. At the time when they lived, the Cacouna ridges must have been reefs in a deep sea. Even Mount Pilote has huge Laurentian boulders high up on its sides, in evidence of this. The shales of the Quebec group rocks were being wasted by the waves and currents; and while there is evidence that much of the fine mud worn from them was drifted far to the south-west to form the clays of the Canadian plains, other portions were deposited between the ridges, along with boulders dropped from the ice which drifted from the Laurentian shore to the north. The process was slow and quiet; so much so that in its later stages many of the boulders became encrusted with the calcareous cells of marine animals before they became buried in the clay. No other explanation can, I believe, be given of this deposit; and it presents a clear and convincing illustration, applicable to wide areas in Eastern America, of the mode of deposit of the boulder-clay.

A similar process, though probably on a much smaller scale, is now going on in the Gulf. Admiral Bayfield has well illustrated the fact that the ice now raises, and drops in new places, multitudes of boulders, and I have noticed the frequent occurrence of this at present on the coast of Nova Scotia. At Cacouna itself, there is, on some parts of the shore, a band of large Laurentian boulders between half tide and low-water mark, which are moved more or less by the ice every winter, so that the tracks cleared by the people for launching their boats and building their fishing-wears, are in a few years filled up. Wherever such boulders are dropped on banks of clay in process of accumulation, a species of

* South 55° west mag., near Cacouna.

boulder-clay, similar to that now seen on the land, must result. At present such materials are deposited under the influence of tidal currents, running alternately in opposite directions; but in the older boulder-clay period, the current was probably a steady one from the north-east, and comparatively little affected by the tides.

The boulder-clay of Cacouna and Rivière-du-Loup, being at a lower level and nearer the coast than that found higher up the St. Lawrence valley, is probably newer. It may have been deposited after the beds of boulder-clay at Montreal had emerged. That it is thus more recent, is farther shown by its shells, which are, on the whole, a more modern assemblage than those of the Leda clay of Montreal. In fossils, as well as in elevation, these beds more nearly resemble those on the coast of Maine. It would thus appear that the boulder-clay is not a continuous sheet or stratum, but that its different portions were formed at different times, during the submergence and elevation of the country; and it must have been during the latter process that the greater part of the deposits now under consideration were formed.

The assemblage of shells at Rivière-du-Loup is, in almost every particular, that of the modern Gulf of St. Lawrence, more especially on its northern coast. The principal difference is the prevalence of *Leda truncata* in the lower part of the deposit. This shell, still living in Arctic America, has not yet occurred in the Gulf of St. Lawrence, but is distributed throughout the lower part of the Post-pliocene deposits in the whole of Lower Canada and New England, and appears in great numbers at Rivière du-Loup, not only in the ordinary form, but in the shortened and depauperated varieties which have been named by Reeve *L. siliqua* and *L. sulcifera*.

Of *Astarte Laurentiana*, supposed to be extinct, and which occurs so abundantly in the Post-pliocene at Montreal, only one valve was found, and its place is supplied by the allied but apparently distinct species, *A. compressa*, which is still abundant at Gaspé and Labrador, and on the coast of Nova Scotia. This exchange of *A. Laurentiana* for *A. compressa* is on these coasts an unfailing evidence of less antiquity.

A study of the varietal forms under which common species occur, also leads to the same conclusion as to the less comparative antiquity of these beds; but this is a very curious and intricate question, on which I have accumulated a great number of facts which I propose to publish at a future time.

It must be observed that though the clays at Rivière-du-Loup are more recent than those of Montreal, they are still of considerable antiquity. They must have been deposited in water perhaps fifty fathoms deep, and the bottom must have been raised from that depth to its present level; and in the meantime the high cliffs now fronting the coast must have been cut out of the rocks of the Quebec group.

The order of succession and characteristic fossils seen on the banks of the Petite Rivière-du-Loup may be stated as follows, in descending order:

1. Gravel seen on sides and tops of ridges.
2. Stratified sand and clay—*Buccinum undatum* and *Tellina Grœnlandica*.
3. Bluish sandy clay, stones, and boulders. *Balanus Hameri, Rhynchonella psittacea, Pecten Islandicus, Leda tenuisulcata, L. minuta, Tellina calcarea, Astarte compressa, Saxicava rugosa, Acmoea cœca, Scalaria Grœnlandica, Natica clausa, Buccinum scalariforme, Bryozoa* on stones, *Foraminifera*, &c., &c.
4. Stiff reddish clay with stones and boulders—*Leda truncata, L. limatula, Nucula tenuis, Tellina calcarea*, &c.

At Tadoussac, opposite to Cacouna, where the underlying formation is the Laurentian gneiss, the Post-pliocene beds attain to great thickness, but are of simple structure and slightly fossiliferous, The principal part is a stratified sandy clay with few boulders, except in places near the ridges of Laurentian rocks. This forms high banks eastward of Tadoussac. It contains a few shells of *Tellina Grœnlandica* and *Leda truncata.* It resembles No. 2 of the above sectional list, and has also much of the aspect of the Leda clay, as developed in the valley of the Ottawa. On this clay there rest in places thick beds of yellow sand and gravel.

At Tadoussac these deposits have been cut into a succession of terraces which are well seen near the hotel and old church. The lowest, near the shore, is about ten feet high; the second, on which the hotel stands, is forty feet; the third is 120 to 150 feet in height, and is uneven at top. The highest, which consists of sand and gravel, is about 250 feet in height. Above this the country inland consists of bare Laurentian rocks. These terraces have been cut out of deposits, once more extensive, in the process of elevation of the land; and the present flats off the mouth of the Saguenay, would form a similar terrace as wide as any of the others, if the country were to experience another elevatory movement. On the third terrace I observed a few large Laurentian boulders, and some pieces of red and gray shale of the Quebec group, indicating the action of coast-ice when this terrace was cut. On the higher terrace there were also a few boulders; and both terraces are capped with pebbly sand and well rounded gravel, indicating the long-continued action of the waves at the levels which they represent.

LIST OF POST-PLIOCENE FOSSILS FOUND AT RIVIERE-DU-LOUP AND CACOUNA.

*Those marked thus * have not previously been noticed as occurring in the Canadian Post-pliocene.*

FORAMINIFERA.

Polymorphina lactea, Adams.
Nonionina Scapha, F. and M., and var. Labradorica, Dawson.
Polystomella striatopunctata, F. and M.
Biloculina ringens? Lam.
Entosolenia costata, Williamson.
* Truncatulina lobulata, W. and T.
* Rotalina? turgida, Williamson.

NOTE.—Since the publication of my former list of Foraminifera from the Post-pliocene of Canada (Can. Nat., vol. iv, 1859), I have found at Montreal, *Nonionina scapha* F. and M., *Dentalina pyrula* D'Orbigny, and *Orbulina universa* D'Orbigny. Messrs. Parker and Jones have also kindly revised my former list, and concur in all the determinations, with the exception of *Polystomella umbilicatula*, which they refer to *P. striatopunctata*, and *Bulimina auriculata* Bailey, which they refer to *B. pyrula* D'Orbigny.

PORIFERA.

* Halichondria—Silicious spicules.

ECHINODERMATA.

Echinus granularis, Say.

POLYZOA.

Lepralia Belli, Dawson.
L. pertusa, Thompson.
* L. producta, Packard.
* L. trispinosa, Johnston.
L. hyalina, Fabr.
* L. ventricosa, Hassel.
* Diastopora obelia, Johnston.
Tubulipora flabellaris? Johnston.
Hippothoa expansa, Dawson.
H. catenularia? Johnston.

* Eschara elegantula, D'Orbigny.
* Celleporaria surcularis, Packard.
* Myriozoum subgracile, D'Orbigny.
* Heteroporella radiata?
* Alecto.
* Membranipora Lacroixii, Busk.

BRACHIOPODA.

Rhynchonella psittacea, Gm.
* Terebratella Labradorensis, Sow.

LAMELLIBRANCHIATA.

Pecten Islandicus, Chemn.
Leda truncata, Brown, and vars. siliqua and sulcifera.
* L. tenuisulcata, Couthouy, (pernula, Wood).
L. minuta, Mull, (caudata, Don.).
* L. limatula, Say.
Nucula tenuis, Mont., (var. expansa).
* Modiolaria discors, Linn.
M. nigra, Gray.
Mytilus edulis, Linn.
* Cardium Dawsoni, Stimpson.
* Astarte compressa, Mont. (A. Banksii, Leach).
A. Laurentiana, Lyell.
Tellina Grœnlandica, Beck.
T. proxima, Brown.
T. (Macoma) inflata, Stimpson.
Mya arenaria, Linn.
M. truncata, Linn., var. Uddevallensis.
* Panopæa Arctica, Gould. (P. Norvegica?).
Saxicava rugosa, Linn., and var. Arctica.
* Lyonsia arenosa, Moll.

NOTE.—Large suites of specimens from Rivière-du-Loup enable me to determine with certainty that *Leda tenuisulcata* Couthouy, *L. pernula* Muller, (& Wood, English Crag,) and *L. Jacksoni* Gould, are varieties of one species; that *Saxicava Arctica* is merely a variety of *S. rugosa*; and that *Leda siliqua* and *L. sulcifera* of Reeve are varieties of *L. truncata*, which is identical with *L. Portlandica* Gould.

GASTEROPODA.

* Cylichna nucleola, Reeve.
Acmœa (Lepeta) cæca, Mull.
Cemoria Noachina, Linn.
* Adeorbis costulata?
Margarita helicina, Fabr., (Arctica).
* M. cinerea, Couth.
Littorina palliata, Say.
* L. rudis, Mont.
Scalaria Grœnlandica, Perry.

Menestho albula, Moll.
* Turritella erosa, Couth.
Natica clausa, Sow.
N. Grœnlandica, Mull.
* N. catenoides? Wood.
Bela harpularia, Gould, (Woodiana, Moll.).
* B. violacea, Migh.
* B. decussata, Couth.
* B. turricula, Mont.
B. rufa, Gould, (pyramidalis).
Buccinum undatum, Linn., and var. Labradorense, Reeve.
* B. glaciale, Linn.
* B. scalariforme, Moll.
* B. cretaceum, Reeve.
Fusus tornatus, Gould, and var. despectus, Linn.
* Trophon clathratum, Linn.
T. scalariforme, Gould.
Trichotropis borealis, B. and S.

NOTE.—I regard *B. Labradorense* as merely a variety of *B. undatum*, peculiar, like the oval or almond-shaped variety of *Mytilus edulis*, to the mouths of rivers. The species which I have named *B. cretaceum* is certainly distinct, but I am by no means sure that it is really *B. cretaceum* of Reeve. *B. glaciale* is common at Montreal and at St. Nicholas; but the specimens from Rivière-du-Loup enabled me for the first time to recognize it.

ANNULATA.

* Spirorbis nautiloides, Lam.
S. vitrea, Stimp.
* S. sinistrorsa, Mont.
* S. quadrangularis, Stimpson.

CRUSTACEA.

Balanus Hameri, Asc., var. Uddevallensis.
B. porcatus, Da Costa.
B. crenatus, Brug.
Cytheridea Mulleri, Mun.
* Hyas coarctata, Leach.

Of the above species, *Panopæa Norvegica*, *Fusus tornatus*, *Leda truncata*, *L. tenuisulcata*, *Astarte compressa*, *Mytilus edulis*, *Mya arenaria* and *Littorina palliata*, had been collected at Rivière-du-Loup, by the officers of the Survey, previous to my visit. *Mesodesma Jauresii* had also been collected from littoral gravels east of Cacouna, but was not met with by me.

ON THE GENUS WOODSIA.

By Daniel C. Eaton, M.A.

Professor of Botany in Yale College, New Haven.

This genus of ferns was established by the learned Robert Brown in 1812, for the two species *Woodsia Ilvensis* and *W. hyperborea;* afterwards he added a third, *W. glabella.* These species all have a minute pateriform involucre, covered by the sporangia, and divided into numerous elongated ciliæ. The genus has since been extended so as to include species having a more manifest involucre, at first globose or irregularly hemispherical, the margin commonly ciliated or irregularly laciniated. The genus thus extended embraces twelve or fifteen species, several of them occurring in the north-temperate and sub-arctic zones, and others following the Cordilleras and the Andes, from Mexico to Chile, or inhabiting the mountains of Northern India. All the species are small ferns, growing in tufts, mostly in crevices of exposed rocks, the stipes commonly very brittle, and remaining after the fronds have fallen away.

The species of this genus I propose to arrange as follows:

§ 1. Stipes articulated, the withered fronds falling away at the joint. Involucre beneath the sorus, pateriform, deeply divided into elongated ciliæ which are inflexed over the sporangia.—*W. alpina* and *Ilvensis.*

§ 2. Stipes not articulated.

A. Involucre as in § 1, but smaller, the ciliæ scarcely visible among the sporangia.—*W. Oregana, scopulina*, and *Mexicana.*

B. Involucre cyathiform or globose, enveloping the sporangia, afterwards lacinately cleft into irregular lobes. (Physematium, Kaulf.)—*W. incisa, obtusa, mollis, Guatemalensis, Peruviana, Cumingiana*, and *elongata.**

C. Indusium irregularly sub-globose, cystiform, divided into 4-6 ciliated lobes, which are imbricated over the sporangia.—*W. polystichoides.*

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* *W. Caucasica* probably belongs here, but I have not had an opportunity of examining it. *Hypoderris Brownii* Wallich, also almost unknown to me, is referred to this genus by Mettenius:—it would constitute a third section, characterized by reticulated venation.

The species occurring in North America, excluding Mexico, are five, so far as known at present.

1. WOODSIA ALPINA. S. F. Gray, Natural Arrangement of British Plants, ii, p. 17. Moore, Nature-printed Ferns, (folio ed.), t. 47. *Acrostichum alpinum*, Bolton, Fil. Brit. p. 76, t. 42, (1790). *Woodsia hyperborea*, R. Brown, Trans. Linn. Soc., xi, p. 173, t. 11. Hook., British Ferns, t. 7 (excellent). *Acrostichum hyperboreum*, Liljeblad, Stockholm Trans. p. 201, t. 8, (1793).

Var. GLABELLA. *Woodsia glabella*. R. Brown in Rich. App. to Frankl. Journ., p. 39. Hook., Fl. Bor. Am. ii., p. 259, t. 237.

Hab.—Newfoundland to the Rocky Mountains and northward, scarcely occurring in the United States; the *var.* from Vermont and New York, to Behring's Straits (Charles Wright).

American specimens are less chaffy than common European forms, but not otherwise different. *W. glabella* has no characters to distinguish it from *W. alpina*, for the largest forms occur perfectly smooth, and the smallest ones are sometimes quite chaffy. *W. subcordata* Maximowicz, from the Amoor River, appears to be identical with *W. alpina*.

2. WOODSIA ILVENSIS. R. Brown, l. c. Hook., British Ferns, t. 8. Gray's Manual, ed. 2, p. 596. *Acrostichum Ilvense*, Linn. *Nephrodium rufidulum*, Michx., Fl. Bor. Am. ii, p. 269.

Hab.—New England to Wisconsin, southward along the Alleghanies, and northward to Greenland. Lake Winnipeg, Mr. Barnston; very fine specimens.

This fern is extremely variable in size and appearance, sometimes being scarcely an inch in height, while fine specimens from the Highlands of the Hudson River measure nine or ten inches, and grow in dense patches often two feet in breadth. It may always be distinguished from *W. alpina* by its greater chaffiness and longer pinnæ.

3. WOODSIA OREGANA, *sp. nov.*: cæspitosa glâbra; stipite inarticulato frondi sub-æquilongo basi paleaceo; frondibus elliptico-lanceolatis pinnatis, fructiferis duplo longioribus, pinnis alternis oppositisve triangulari-oblongis obtusis pinnatifidis, pinnulis ovatis dentatis obtusis; lobulis pinnularum primo reflexis sorumque celantibus mox explanatis, venulis sæpius furcatis; indusio fere nullo in cilias perbreves moniliformi-articulatas fere ad centrum diviso.

Hab.—Dalles of the Columbia River, Oregon; Major Raines,

U. S. A., 1855, (referred to *W. hyperborea* in Hooker's British Ferns). Rocky Mountains, near 40° north latitude; Hall and Harbour, No. 690a.

Fronds quite smooth, 2–8 inches high, 8–12 lines wide, the fertile ones much taller than the sterile, pinnate; pinnæ 9–13 pairs, the lower ones smaller, triangular and rather remote, the upper ones more crowded and larger, pinnately lobed into 3–6 divisions on each side, the divisions more or less toothed; the teeth irregular, rather acute, at first reflexed (at least in the dried specimens), but as the sporangia ripen, the frond becomes more coriaceous and at length explanate. The involucre is exceedingly minute, and consists of a few articulated ciliæ composed of a single series of nearly globular cells. In general appearance this little fern resembles small forms of *W. obtusa*, from which however the glabrous fronds and the rudimentary involucre at once distinguish it.

4. Woodsia scopulina, *sp. nov.*: cæspitosa glanduloso-pubescens; stipite inarticulato frondibus breviore basi paleaceo, frondibus erectis elongato-lanceolatis acuminatis pinnatis fere bipinnatis subtus secus venas paleolis unicæ cellularum seriei minute pubescentibus glandulisque fuscis conspersis; pinnis plerumque oppositis oblongo-lanceolatis sub-acutis fere ad costam pinnatifidis, pinnulis crebris oblongis obtusis crenatis vel crenato-lobatis; lobulis soriferis; involucro tenerrimo vix conspicuo profunde laciniato; laciniis in cilias breves articulatas angustatis.

Hab.—Rocky Mountains, near 40° north latitude; Parry No. 394, Hall and Harbour No. 690b. Columbia River; Brackenridge, (*W. Ilvensis*,) U. S. Expl. Exped. Fraser's River, near 49° north latitude; Mrs. John Miles.

A graceful species, quite distinct from all others. Stipes, as in the last straw-color above, chestnut-brown at the base, where it is chaffy with ovate acuminate brown scales. Fronds, several from the caudex, 4–10 inches high, 12–18 lines wide; finely pubescent everywhere along the rachis, costa, and veins, except on the upper surface, with slender flattened hairs, and sprinkled beneath with very minute, often compound glands; apparently bipinnate, but the costa of the primary pinnæ is narrowly winged. Pinnæ 12–20 pairs, oblong lanceolate or somewhat triangular in outline. Pinnules 6–10 pairs, ovate-oblong, crenately lobed, the teeth rather obtuse, not reflexed when young. The involucre is more evident than in the last, and consists of a central portion deeply and irregularly cleft into laciniæ, which are narrowed into rather short articulated ciliæ, the cells of the ciliæ irregularly cylindrical. *W. Mexicana* Fée, as figured, has an involucre somewhat resembling this one, and I suppose it may belong to the same group.

5. WOODSIA OBTUSA Torrey, Cat. Pl. in Geol. Report of New York, 1840. Hooker, Species Filicum, i, p. 62. *Polypodium obtusum*, Swartz, Syn. Fil., p. 39.

Hab.—New England to North Carolina, and westward to Wisconsin and Missouri. (On the Columbia River, Hook. Fl. Bor. Am., but the specimens are more likely to be *W. scopulina*.) Specimens from Texas, Ch. Wright, Nos. 830 and 2120, I refer to this species somewhat doubtfully, as the involucres are cleft into very narrow laciniately fringed lobes. Better specimens are needed to show what the plant really is.

New Haven, Connecticut. U. S. A., March 15, 1865.

ON THE OCCURRENCE OF ORGANIC REMAINS IN THE LAURENTIAN ROCKS OF CANADA.*

By Sir W. E. Logan, LL.D., F.R.S., F.G.S.; Director of the Geological Survey of Canada.

The oldest known rocks of North America are those which compose the Laurentide Mountains in Canada and the Adirondacks in the State of New York. By the investigations of the Geological Survey of Canada, they have been shown to be a great series of strata, which, though profoundly altered, consist chiefly of quartzose, aluminous, and calcareous rocks, like the sedimentary deposits of less ancient times. This great mass of crystalline rocks is divided into two groups, and it appears that the Upper rests unconformably upon the Lower Laurentian series.

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* This, and the three following papers, by Messrs. Dawson, Carpenter and Sterry Hunt are reprinted from the Quarterly Journal of the Geological Society of London, for February, 1865. Some additional notes by the authors and editors are distinguished by being included in brackets. See also a supplementary note by Dr. Dawson, on the discovery of Eozoon in Ireland on page 126.

In place of the lithographed plates published in the Quarterly Journal to illustrate the papers of Messrs. Dawson and Carpenter, selections from those, filling a single plate, are here given; besides which three woodcuts are added.—EDS.

The united thickness of these two groups in Canada cannot be less than 30,000 feet, and probably much exceeds it. The Laurentian of the west of Scotland, according to Sir Roderick Murchison, also attains a great thickness. In that region the Upper Laurentian or Labrador series, has not yet been separately recognized; but from Mr. McCulloch's description, as well as from the specimens collected by him, and now in the Museum of the Geological Society of London, it can scarcely be doubted that the Labrador series occurs in Skye.* The labradorite and hypersthene rocks from that island are identical with those of the Labrador series in Canada and New York, and unlike those of any formation at any other known horizon. This resemblance did not escape the notice of Emmons, who, in his description of the Adirondack Mountains, referred these rocks to the hypersthene rock of McCulloch, although these observers, on the opposite sides of the Atlantic, looked upon them as unstratified. In the Canadian Naturalist for 1862, Mr. Thomas Macfarlane, for some time resident in Norway, and now in Canada, drew attention to the striking resemblance between the Norwegian primitive gneiss formation, as described by Naumann and Keilhau, and observed by himself, and the Laurentian, including the Labrador group; and the equally remarkable similarity of the lower part of the primitive slate formation to the Huronian series, which is a third Canadian group. These primitive series attain a great thickness in the north of Europe, and constitute the main features of Scandinavian geology.

In Bavaria and Bohemia there is an ancient gneissic series. After the labours in Scotland, by which he was the first to establish a Laurentian equivalent in the British Isles, Sir Roderick Murchison, turning his attention to this central European mass, placed it on the same horizon. These rocks, underlying Barrande's Primordial zone, with a great development of intervening clay-slate, extend southward in breadth to the banks of the Danube, with a prevailing dip towards the Silurian strata. They had previously

[* This was first shown by Mr. T. Sterry Hunt, after his examinations of McCulloch's collections, in a paper published in the Dublin Quar. Journal of Science for 1863, p. 230. See also Silliman's Journal [2] xxxvi. 226, and Canadian Naturalist, vi. 208. Prof. Haughton of Dublin has since visited the islands of Skye and Iona, and confirmed the observations of Mr. Hunt. See Proc., of the Royal Geological Society of Dublin for Dec. 14, 1864, in the Geol. Magazine for February, 1865, page 73.—EDS.]

been studied by Gümbel and Crejci, who divided them into an older reddish gneiss and a newer grey gneiss. But, on the Danube, the mass which is furthest removed from the Silurian rocks being a grey gneiss, Gumbel and Crejci account for its presence by an inverted fold in the strata; while Sir Roderick places this at the base, and regards the whole as a single series, in the normal fundamental position of the Laurentian of Scotland and of Canada. Considering the colossal thickness given to the series (90,000 feet), it remains to be seen whether it may not include both the Lower and Upper Laurentian, and possibly, in addition, the Huronian.

This third Canadian group (the Huronian) has been shown by my colleague, Mr. Murray, to be about 18,000 feet thick, and to consist chiefly of quartzites, slate-conglomerates, diorites, and limestones. The horizontal strata which form the base of the Lower Silurian in western Canada, rest upon the upturned edges of the Huronian series; which, in its turn, unconformably overlies the Lower Laurentian. The Huronian is believed to be more recent than the Upper Laurentian series, although the two formations have never yet been seen in contact.

The united thickness of these three great series may possibly far surpass that of all the succeeding rocks from the base of the Palæozoic series to the present time. We are thus carried back to a period so far remote, that the appearance of the so-called Primordial fauna may by some be considered a comparatively modern event. We, however, find that, even during the Laurentian period, the same chemical and mechanical processes which have ever since been at work disintegrating and reconstructing the earth's crust were in operation as now. In the conglomerates of the Huronian series there are enclosed boulders derived from the Laurentian, which seem to show that the parent rock was altered to its present crystalline condition before the deposit of the newer formation; while interstratified with the Laurentian limestones there are beds of conglomerate, the pebbles of which are themselves rolled fragments of a still older laminated sand-rock, and the formation of these beds leads us still further into the past.

In both the Upper and Lower Laurentian series there are several zones of limestone, each of sufficient volume to constitute an independent formation. Of these calcareous masses it has been ascertained that three, at least, belong to the Lower Laurentian. But as we do not as yet know with certainty either the base or the summit of this series, these three may be conformably fol-

Fig. 1.—*Section from Petite Nation Seigniory to St. Jerome* (66 miles).

a. Lower Silurian.
b. Upper Laurentian.
b'. Upper Laurentian limestone.
c. Fourth gneiss.
d'. Third limestone.
d. Third gneiss.
c'. Second limestone.
x. Porphyry.
y. Granite.

lowed by many more. Although the Lower and Upper Laurentian rocks spread over more than 200,000 square miles in Canada, only about 1500 square miles have yet been fully and connectedly examined in any one district, and it is still impossible to say whether the numerous exposures of Laurentian limestone met with in other parts of the province are equivalent to any of the three zones, or whether they overlie or underlie them all.

Fig. 2.—*Section across Trembling Mountain* (21 miles).

b. Upper Laurentian.	c'. Second limestone.
c. Fourth gneiss.	e. Second gneiss.
d'. Third limestone.	f'. First limestone.
d. Third gneiss.	f. First gneiss.

In the examination of these ancient rocks, the question often naturally occurred to me whether, during these remote periods, organic life had yet appeared on the earth. The apparent absence of fossils from the highly crystalline limestones did not seem to offer a proof in negation, any more than their undiscovered presence in newer crystalline limestones, where we have little doubt they have been obliterated by metamorphic action; while the carbon which, in the form of graphite, constitutes beds, or is disseminated through the calcareous or siliceous strata of the Laurentian series, seemed to be an evidence of the existence of vegetation, since no one disputes the organic origin of this mineral in more recent rocks. My colleague, Dr. T. Sterry

Hunt, has argued for the existence of organic matters at the earth's surface during the Laurentian period from the presence of great beds of iron-ore, and from the occurrence of metallic sulphurets*; and finally, the evidence was strengthened by the discovery of supposed organic forms. These were first brought to me, in October, 1858, by Mr. J. McMullen, then attached as an explorer, to the Geological Survey of the province, from one of the limestones of the Laurentian series occurring at the Grand Calumet, on the River Ottawa.

Any organic remains which may have been entombed in these limestones would, if they retained their calcareous character, be almost certainly obliterated by crystallization; and it would only be by the replacement of the original carbonate of lime by a different mineral substance, or by an infiltration of such a substance into all the pores and spaces in and about the fossil, that its form would be preserved. The specimens from the Grand Calumet present parallel or apparently concentric layers resembling those of *Stromatopora*, except that they anastomose at various points. What were first considered the layers are composed of crystallized pyroxene, when the then supposed interstices consist of carbonate of lime. These specimens, one of which is figured, in 'Geology of Canada,' p. 49,† called to memory others which had some years previously been obtained from Dr. James Wilson, of Perth, and were then regarded merely as minerals. They came, I believe, from masses in Burgess, but whether in place is not quite certain; and they exhibit similar forms to those of the Grand Calumet, composed of layers of a dark green magnesian silicate (loganite); while what were taken for the interstices are filled with crystalline dolomite. If the specimens from both these places were to be regarded as the result of unaided mineral arrangement, it appeared to me strange that identical forms should be derived from minerals of such different composition. I was therefore disposed to look upon them as fossils, and as such they were exhibited by me at the meeting of the American Association for the Advancement of Science, at Springfield, in August 1859. See Canadian Naturalist, 1859, iv, 300. In 1862 they were shown to to some of my geological friends in Great Britain; but no microscopic structure having been observed belonging to them, few seemed disposed to believe in their organic character, with the exception of my friend Professor Ramsay.

* Quarterly Journal of the Geological Society, xv, 493.

[† Reproduced below, page 100, figures 1 and 2.]

One of the specimens had been sliced and submitted to microscopic observation, but unfortunately it was one of those composed of loganite and dolomite. In these, the minute structure is rarely seen. The true character of the specimens thus remained in suspense until last winter, when I accidentally observed indications of similar forms in blocks of Laurentian limestone which had been brought to our museum by Mr. James Lowe, one of our explorers, to be sawn up for marble. In this case the forms were composed of serpentine and calc-spar; and slices of them having been prepared for the microscope, the minute structure was observed in the first one submitted to inspection. At the request of Mr. Billings, the palæontologist of our Survey, the specimens were confided for examination and description to Dr. J. W. Dawson, of Montreal, our most practised observer with the microscope; and the conclusions at which he has arrived are appended to this communication He finds that the serpentine, which was supposed to replace the organic form, really fills the interspaces of the calcareous fossil. This exhibits in some parts a well-preserved organic structure, which Dr. Dawson describes as that of a Foraminifer, growing in large sessile patches after the manner of *Polytrema* and *Carpenteria*, but of much larger dimensions, and presenting minute points which reveal a structure resembling that of other Foraminiferal forms, as, for example, *Calcarina* and *Nummulina*.

Dr. Dawson's description is accompanied by some remarks by Dr. Sterry Hunt on the mineralogical relations of the fossil. He observes that while the calcareous septa which form the skeleton of the Foraminifer in general remain unchanged, the sarcode has been replaced by certain silicates which have not only filled up the chambers, cells, and septal orifices, but have been injected into the minute tubuli, which are thus perfectly preserved, as may be seen by removing the calcareous matter by an acid. The replacing silicates are white pyroxene, serpentine, loganite, and pyrallolite or rensselaerite. The pyroxene and serpentine are often found in contact, filling contiguous chambers in the fossil, and were evidently formed in consecutive stages of a continuous process. In the Burgess specimens, while the sarcode is replaced by loganite, the calcareous skeleton, as has already been stated, has been replaced by dolomite, and the finer parts of the structure have been almost wholly obliterated. But in the other specimens, where the skeleton still preserves its calcareous character, the resemblance between the mode of preservation of the ancient Laurentian *For-*

aminifera and that of the allied forms in Tertiary and recent deposits (which, as Ehrenberg, Bailey, and Pourtales have shown, are injected with glauconite), is obvious.

The Grenville specimens belong to the highest of the three already mentioned zones of Laurentian limestone, and it has not yet been ascertained whether the fossil extends to the two conformable lower ones, or to the calcareous zones of the overlying unconformable Upper Laurentian series. It has not yet either been determined what relation the strata from which the Burgess and Grand Calumet specimens have been obtained bear to the Grenville limestone or to one another. The zone of Grenville limestone is in some places about 1500 feet thick, and it appears to be divided for considerable distances into two or three parts by very thick bands of gneiss. One of these occupies a position towards the lower part of the limestone, and may have a volume of between 100 and 200 feet. It is at the base of the limestone that the fossil occurs. This part of the zone is largely composed of great and small irregular masses of white crystalline pyroxene, some of them twenty yards in length by four or five wide. They appear to be confusedly placed one above another, with many ragged interstices, and smoothly-worn, rounded large and small pits and sub-cylindrical cavities, some of them pretty deep. The pyroxene, though it appears compact, presents a multitude of small spaces consisting of carbonate of lime, and many of these show minute structures similar to that of the fossil. These masses of pyroxene may characterize a thickness of about 200 feet, and the interspaces among them are filled with a mixture of serpentine and carbonate of lime. In general a sheet of pure dark green serpentine invests each mass of pyroxene; the thickness of the serpentine, varying from the sixteenth of an inch to several inches, rarely exceeding half a foot. This is followed in different spots by parallel, waving, irregularly alternating plates of carbonate of lime and serpentine, which become gradually finer as they recede from the pyroxene, and occasionally occupy a total thickness of five or six inches. These portions constitute the unbroken fossil, which may sometimes spread over an area of about a square foot, or perhaps more. Other parts, immediately on the outside of the sheet of serpentine, are occupied with about the same thickness of what appear to be the ruins of the fossil, broken up into a more or less granular mixture of calc-spar and serpentine, the former still showing minute structure; and on the outside of the whole a similar mixture appears to have been swept by currents and eddies into rudely parallel and curving layers; the mixture becoming gradually more calcareous as it recedes from the pyroxene. Sometimes beds of limestone of several feet in thickness, with the green serpentine more or less aggregated into layers, and studded with isolated lumps of pyroxene, are irregularly interstratified in the mass of rock; and less frequently there are met with lenticular patches of sandstone or granular quartzite, of a foot in thickness and several yards in diameter, holding in abundance small disseminated leaves of graphite.

The general character of the rock connected with the fossil produces the impression that it is a great Foraminiferal reef, in which the pyroxenic masses represent a more ancient portion, which having died, and having become much broken up and worn into cavities and deep recesses, afforded a seat for a new growth of *Foraminifera*, represented by the calcareo-serpentinous part. This in its turn became broken up, leaving in some places uninjured portions of the general form. The main difference between this Foraminiferal reef and more recent coral-reefs seems to be that, while with the latter are usually associated many shells and other organic remains, in the more ancient one the only remains yet found are those of the animal which built the reef.

ON CERTAIN ORGANIC REMAINS IN THE LAURENTIAN LIMESTONES OF CANADA.*

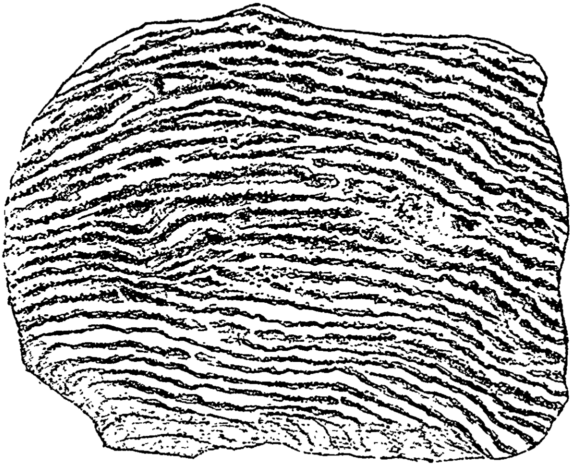
By J. W. Dawson, LL.D., F.R.S.,
Principal of McGill University, Montreal, Canada.

At the request of Sir William E. Logan, I have submitted to microscopic examination slices of certain peculiar laminated forms consisting of alternate layers of carbonate of lime and serpentine, or of carbonate of lime and white pyroxene, found in the Laurentian limestones of Canada, and regarded by Sir William as possibly fossils.† I have also examined slices of a number of limestones and serpentines from the Laurentian series, not showing the external forms of these supposed fossils.

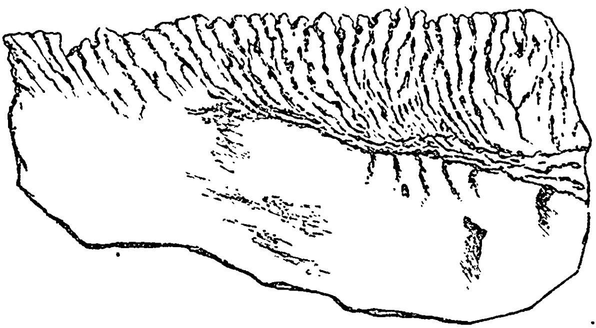
The slices were prepared by the lapidary of the Survey, and were carefully examined under ordinary and polarized light, with

[* See a preliminary notice in Silliman's Journal [2], xxxvii, 272.]
† Canadian Naturalist, 1859, p. 300.

objectives made by Ross, and by Smith and Beck; and also with good French objectives.



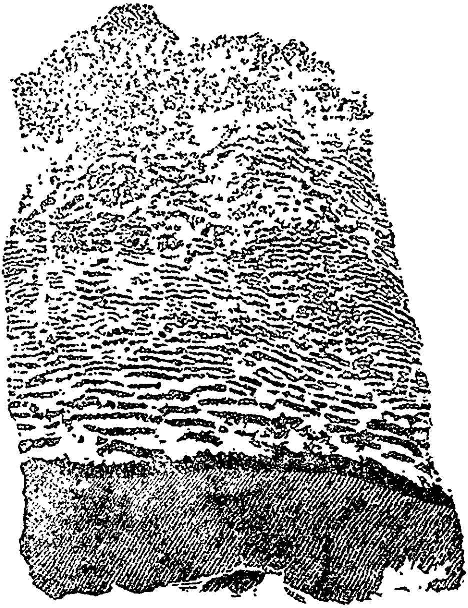
1. Weathered specimen of *Eozoön Canadense* from the Calumet, of the natural size. The replacing silicate is white pyroxene.



2. Vertical transverse section of the specimen figure 1.

The specimens first mentioned are masses, often several inches in diameter, presenting to the naked eye alternate laminæ of serpentine, or of pyroxene, and carbonate of lime. Their general aspect, as remarked by Sir W. E. Logan (Geology of Canada, 1863, p. 49), reminds the observer of that of the Silurian corals of the genus *Stromatopora*, except that the laminæ diverge from and approach each other, and frequently anastomose or are connected by transverse septa.

Under the microscope the resemblance to *Stromatopora* is seen to be in general form merely, and no trace appears of the radiating cells characteristic of that genus. The laminæ of serpentine and pyroxene present no organic structure, and the latter mineral is highly crystalline. The laminæ of carbonate of lime, on the contrary, retain distinct traces of structures which cannot be of a crystalline or concretionary character. They constitute parallel or concentric partitions of variable thickness, enclosing flattened spaces or chambers, frequently crossed by transverse plates or septa, in some places so numerous as to give a vesicular appearance, in others



3. Nature-printed section of a specimen of *Eozoön Canadense* from Petite Nation Seigniory.*

[* The replacing mineral in this specimen being serpentine, the calcareous septa were dissolved from the polished surface by the action of an acid, and the fine material replacing the tubuli having been removed by the aid of a brush, a wax mould of the etched surface furnished the electrotype cast from which the above figure is printed. The lights thus represent the calcareous skeleton, and the shaded portion a thick mass of serpentine, which is distinguishable from a contiguous thin stratum of the same mineral, that seems to form the base of the Eozoön. The gradual passage from the wide chambers and thick septa to the naroccurring only at rare intervals (figure 3). The laminæ themselves are excavated on their sides into rounded pits, and are in some places traversed by canals, or contain secondary rounded cells, apparently isolated. In addition to these general appearances, the substance of the laminæ, where most perfectly preserved, is seen to present a fine granular structure, and to be penetrated by numerous minute tubuli, which are arranged in bundles of great beauty and complexity, diverging in sheaf-like forms, and in their finer extensions anastomosing so as to form a net-work (*plate, figures 2 and 4*). In *transverse sections*, and under high powers, the tubuli are seen to be circular in outline, and sharply defined (plate, figure 5). In longitudinal sections, they sometimes present a beaded or jointed appearance. Even where the tubular structure is least perfectly preserved, traces of it can still be seen in most of the slices, though there are places in which the laminæ are perfectly compact, and perhaps were so originally.

Faithful delineations of these structures have been prepared by Mr. Horace Smith, the artist of the Survey, which will render them more intelligible than any verbal description.

With respect to the nature and probable origin of the appearances above described, I would make the following remarks:

1. The serpentine and pyroxene which fill the cavities of the calcareous matter have *no appearance of concretionary structure*. On the contrary, their aspect is that of matter introduced by infiltration, or as sediment, and filling spaces previously existing. In other words, the calcareous matter has not been moulded on the forms of the serpentine and augite, but these have filled spaces or chambers in a hard calcareous mass. This conclusion is further confirmed by the fact, to be referred to in the sequel, that the serpentine includes multitudes of minute foreign bodies, while the calcareous matter is uniform and homogeneous. It is also to be observed that small veins of carbonate of lime occasionally traverse the specimens, and in their entire absence of structures other than crystalline, present a striking contrast to the supposed fossils.

2. Though the calcareous laminæ have in places a crystalline

rower and thinner ones, and finally to the irregularly aggregated mode of growth, designated by Dr. Carpenter as *acervuline*, is well seen. The white patches in the upper portion of the figure do not arise from any imperfection in the electrotype, but represent the irregular growth of this part of the calcareous skeleton.—T. S. H.]

cleavage, their forms and structures have no relation to this. Their cells and canals are rounded, and have smooth walls, which are occasionally lined with films apparently of carbonaceous matter. Above all, the minute tubuli are different from anything likely to occur in merely crystalline calc-spar. While in such rocks little importance might be attached to external forms simulating the appearances of corals, sponges, or other organisms, these delicate internal structures have a much higher claim to attention. Nor is there any improbability in the preservation of such minute parts in rocks so highly crystalline, since it is a circumstance of frequent occurrence in the microscopic examination of fossils that the finest structures are visible in specimens in which the general form and the arrangement of parts have been entirely obliterated. It is also to be observed that the structure of the calcareous laminæ is the same, whether the intervening spaces are filled with serpentine or with pyroxene.

3. The structures above described are not merely definite and uniform, but they are of a kind proper to animal organisms, and more especially to one particular type of animal life, as likely as any other to occur under such circumstances; I refer to that of the Rhizopods of the order *Foraminifera.* The most important point of difference is in the great size and compact habit of growth of the specimens in question; but there seems no good reason to maintain that *Foraminifera* must necessarily be of small size, more especially since forms of considerable magnitude referred to this type are known in the Lower Silurian. Prof. Hall has described specimens of *Receptaculites* twelve inches in diameter; and the fossils from the Potsdam formation of Labrador, referred by Mr. Billings to the genus *Archæocyathus*, are examples of *Protozoa* with calcareous skeletons scarcely inferior in their massive style of growth to the forms now under consideration.*

[* The following note is inserted in place of another, which, by an error of the printer, is in the Quarterly Journal of the Geological Society incorporated with the text:

Mr. Billings has ascertained, since this paper was written, that one of the species included in the genus *Archæocyathus*, has silicious spicula which would place it with the sponges. But two other species of the genus have, in accordance with his original description, a chambered calcareous skeleton, which is, in my opinion, similar to that of Foraminifera. (Memoirs of the Geological Survey of Canada, Nov. 1861, and reprint of the same in 1864.)—J. W. D.]

These reasons are, I think, sufficient to justify me in regarding these remarkable structures as truly organic, and in searching for their nearest allies among the *Foraminifera.*

Supposing then that the spaces between the calcareous laminæ, as well as the canals and tubuli traversing their substance, were once filled with the sarcode body of a Rhizopod, comparisons with modern forms at once suggest themselves.

From the polished specimens in the Museum of the Canadian Geological Survey, it appears certain that these bodies were sessile, with a broad base, and grew by the addition of successive layers of chambers separated by calcareous laminæ, but communicating with each other by canals or septal orifices sparsely and irregularly distributed. Small specimens have thus much the aspect of the modern genera *Carpenteria* and *Polytrema.* Like the first of these genera, there would also seem to have been a tendency to leave in the midst of the structure a large central canal, or deep funnel-shaped or cylindrical opening, for communication with the sea-water. Where the laminæ coalesce, and the structure becomes more vesicular, it assumes the 'acervuline' character seen in such modern forms as *Nubecularia.*

Still the magnitude of these fossils is enormous when compared with the species of the genera above named; and from the specimens in the larger slabs from Grenville, in the Museum of the Canadian Survey, it would seem that these organisms grew in groups, which ultimately coalesced, and formed large masses penetrated by deep irregular canals; and that they continued to grow at the surface, while the lower parts became dead and were filled up with infiltrated matter or sediment. In short, we have to imagine an organism having the habit of growth of *Carpenteria,* but attaining to an enormous size, and by the aggregation of individuals assuming the aspect of a coral reef.

The complicated systems of tubuli in the Laurentian fossil indicate, however, a more complex structure than that of any of the forms mentioned above. I have carefully compared these with the similar structures in the 'supplementary skeleton' (or the shell-substance that carries the vascular system) of *Calcarina* and other forms,* and can detect no difference except in the somewhat

* I desire to express my obligations to the invaluable memoirs of Dr. Carpenter on the *Foraminifera,* in the Transactions of the Royal Society, and in the publications of the Ray Society; without which

coarser texture of the tubuli in the Laurentian specimens. It accords well with the great dimensions of these, that they should thus thicken their walls with an extensive deposit of tubulated calcareous matter; and from the frequency of the bundles of tubuli, as well as from the thickness of the partitions, I have no doubt that all the successive walls, as they were formed, were thickened in this manner, just as in so many of the higher genera of more modern *Foraminifera*.

It is proper to add that no spicules, or other structures indicating affinity to the Sponges, have been detected in any of the specimens.

As it is convenient to have a name to designate these forms, I would propose that of *Eozoön*, which will be specially appropriate to what seems to be the characteristic fossil of a group of rocks which must now be named *Eozoic* rather than Azoic. For the species above described, the specific name of *Canadense* has been proposed. It may be distinguished by the following characters:—

EOZOÖN CANADENSE; *gen. et spec. nov.*

General form.—Massive, in large sessile patches or irregular cylinders, growing at the surface by the addition of successive laminæ.

Internal structure.—Chambers large, flattened, irregular, with numerous rounded extensions, and separated by walls of variable thickness, which are penetrated by septal orifices irregularly disposed. Thicker parts of the walls with bundles of fine branching tubuli.

These characters refer specially to the specimens from Grenville and the Calumet. There are others from Perth, C. W., which show more regular laminæ, and in which the tubuli have not yet been observed; and a specimen from Burgess, C. W., contains some fragments of laminæ which exhibit, on one side, a series of fine parallel tubuli like those of *Nummulina*. These specimens may indicate distinct species; but on the other hand, their peculiarities may depend on different states of preservation.

With respect to this last point, it may be remarked that some of

it would have been impossible satisfactorily to investigate the structure and affinities of *Eozoön*. I have also to acknowledge the kindness of Dr. Carpenter in furnishing me with specimens of some of the forms described in his works.

the specimens from Grenville and the Calumet show the structures of the laminæ with nearly equal distinctness whether the chambers have been filled with serpentine or pyroxene, and that even the minute tubuli are penetrated and filled with these minerals. On the other hand, there are large specimens in the collection of the Canadian Survey, in which the lower and older parts of the masses of *Eozoön* are mineralized with pyroxene, and have to a great extent lost the perfection of structure which characterizes the more superficial parts of the same masses, in which the chambers have been filled with a light green serpentine. Dr. Sterry Hunt has directed his attention to the conditions of deposit of these minerals, and will, I have no doubt, be able satisfactorily to explain the manner in which they may have been introduced into the chambers of the fossils without destroying the texture of the latter.

It is due to Dr. Sterry Hunt to state that, as far back as 1858, in a paper published in the Quarterly Journal of the Geological Society,* he insisted on certain chemical characters of the Laurentian beds as affording "evidence of the existence of organic life at the time of the deposition of these old crystalline rocks"; and that he has zealously aided in the present researches.

I may also state that Mr. Billings, the palæontologist of the Survey, has joined in the request that I should undertake the examination and description of the specimens, as being more specially a subject of microscopical investigation.

Before concluding this part of the subject, it is proper to observe that the structures above described can be made out only by the careful study of numerous slices, and in some instances only with polarized light. Even in the more perfect specimens of *Eozoön*, as those accustomed to such researches will readily understand, the accidents of good preservation and the cutting of the slices in the proper place and direction must conspire in order to a clear definition of the more minute structures.

It is also to be observed that the specimens present numerous remarkable microscopic appearances, depending on crystallization and concretionary action, which must not be confounded with organic structure. It would be out of place to give any detailed description of them here; but it is necessary to caution observers unaccustomed to the examination of mineral substances under the microscope, as to their occurrence. I may also mention that the

* Vol. xv, p. 493.

serpentine presents many curious varieties of structure, especially when associated with apatite, pyroxene, and other minerals, and that it affords magnificent objects under polarized light, when reduced to sufficiently thin slices.

In connexion with these remarkable remains, it appeared desirable to ascertain, if possible, what share these or other organic structures may have had in the accumulation of the limestones of the Laurentian series. Specimens were therefore selected by Sir W. E. Logan, and slices were prepared under his direction. On microscopic examination, a number of these were found to exhibit merely a granular aggregation of crystals, occasionally with particles of graphite and other foreign minerals; or a laminated mixture of calcareous and other matters, in the manner of some more modern sedimentary limestones. Others, however, were evidently made up almost entirely of fragments of *Eozoön*, or of mixtures of these with other calcareous and carbonaceous fragments which afford more or less evidence of organic origin. The contents of these organic limestones may be considered under the following heads:—

1. Remains of *Eozoön*.
2. Other calcareous bodies, probably organic.
3. Objects imbedded in the serpentine.
4. Carbonaceous matters.
5. Perforations, or worm-burrows.

1. The more perfect specimens of *Eozoön* do not constitute the mass of any of the larger specimens in the collection of the Survey; but considerable portions of some of them are made up of material of similar minute structure, destitute of lamination, and irregularly arranged. Some of this material gives the impression that there may have been organisms similar to *Eozoön*, but growing in an irregular or acervuline manner without lamination. Of this, however, I cannot be certain; and on the other hand there is distinct evidence of the aggregation of fragments of *Eozoön* in some of these specimens. In some they constitute the greater part of the mass. In others they are imbedded in calcareous matter of a different character, or in serpentine or granular pyroxene. In most of the specimens the cells of the fossils are more or less filled with these minerals; and in some instances it would appear that the calcareous matter of fragments of *Eozoön* has been in part replaced by serpentine.

2. Intermixed with the fragments of *Eozoön* above referred to, are other calcareous matters apparently fragmentary. They are of various angular and rounded forms, and present several kinds of structure. The most frequent of these is a strong lamination, varying in direction according to the position of the fragments, but corresponding, as far as can be ascertained, with the diagonal of the rhombohedral cleavage. This structure, though crystalline, is highly characteristic of crinoidal remains when preserved in altered limestones. The more dense parts of *Eozoön*, destitute of tubuli, also sometimes show this structure, though less distinctly.

Other fragments are compact and structureless, or show only a fine granular appearance; and these sometimes include grains, patches, or fibres of graphite. In Silurian limestones, fragments of corals and shells which have been partially infiltrated with bituminous matter show a structure like this. On comparison with altered organic limestones of the Silurian system, these appearances would indicate that, in addition to the debris of *Eozoön*, other calcareous structures, more like those of crinoids, corals, and shells, have contributed to the formation of the Laurentian limestones.

3. In the serpentine* filling the chambers of a large specimen of *Eozoön* from Burgess, there are numerous small pieces of foreign matter; and the silicate itself is laminated, indicating its sedimentary nature. Some of the included fragments appear to be carbonaceous, others calcareous; but no distinct organic structure can be detected in them. There are however in the serpentine many minute rounded siliceous grains of a bright green color, resembling green-sand concretions, and the manner in which these are occasionally arranged in lines and groups suggests the supposition that they may possibly be casts of the interior of minute Foraminiferal shells. They may however be concretionary in their origin.

4. In some of the Laurentian limestones submitted to me by Sir W. E. Logan, and in others which I collected some years ago at Madoc, Canada West, there are fibres and granules of carbonaceous matter, which do not conform to the crystalline structure, and present forms quite similar to those which in more modern limestones result from the decomposition of algæ. Though retaining mere traces of organic structure, no doubt would be entertained

[* This is the dark green mineral named loganite by Dr. Hunt.]

as to their vegetable origin if they were found in fossiliferous limestones.

5. A specimen of impure limestone from Madoc, in the collection of the Canadian Geological Survey, which seems from its structure to have been a finely laminated sediment, shows perforations of various sizes, somewhat scalloped at the sides, and filled with grains of rounded siliceous sand. In my own collection there are specimens of micaceous slate from the same region, with indications on their weathered surfaces of similar rounded perforations, having the aspect of *Scolithus*, or of worm-burrows.

I would observe, in conclusion, that the observations detailed in this paper must be regarded as merely an introduction to a most interesting and promising field of research. The specimens to which I had access were for the most part collected by the explorers of the Survey merely as rocks, and without any view to the possible existence of fossils in them. It may be hoped, therefore, that other and more perfect specimens may reward a careful search in the localities from which those now described have been obtained.

Further, though the abundance and wide distribution of *Eozoön*, and the important part it seems to have acted in the accumulation of limestone, indicate that it was one of the most prevalent forms of animal existence in the seas of the Laurentian period, the non-existence of other organic beings is not implied. On the contrary, independently of the indications afforded by the limestones themselves, it is evident that in order to the existence and growth of these large Rhizopods, the waters must have swarmed with more minute animal or vegetable organisms on which they could subsist. On the other hand, though this is a less certain inference, the dense calcareous skeleton of *Eozoön* may indicate that it also was liable to the attacks of animal enemies. It is also possible that the growth of *Eozoön*, or the deposition of the serpentine and pyroxene in which its remains have been preserved, or both, may have been connected with certain oceanic depths and conditions, and that we have as yet revealed to us the life of only certain stations in the Laurentian seas. Whatever conjectures we may form on these more problematic points, the observations above detailed appear to establish the following conclusions:—First, that in the Laurentian period, as in subsequent geological epochs, the Rhizopods were important agents in the accumulation of beds of limestone; and secondly, that in this early period these low forms of animal life attained to a development, in point of magnitude and complexity, unexampled, in so far as yet known, in the succeeding ages of the earth's history. This early culmination of the Rhizopods is in accordance with one of the great laws of the succession of living beings ascertained from the study of the introduction and progress of other groups; and, should it prove that these great Protozoans were really the dominant type of animals in the Laurentian period, this fact might be regarded as an indication that in these ancient rocks we may actually have the records of the first appearance of animal life on our planet.

Since the above was written, thick slices of *Eozoön* from Grenville have been prepared, and submitted to the action of hydrochloric acid until the carbonate of lime was removed. The serpentine then remains as a cast of the interior of the chambers, showing the form of their original sarcode-contents. The minute tubuli are found also to have been filled with a substance insoluble in the acid, so that casts of these also remain in great perfection, and allow their general distribution to be much better seen than in the transparent slices previously prepared. These interesting preparations establish the following additional structural points:

1. That the whole mass of sarcode throughout the organism was continuous; the apparently detached secondary chambers being, as I had previously suspected, connected with the larger chambers by canals filled with sarcode.

2. That some of the irregular portions without lamination are not fragmentary, but due to the acervuline growth of the animal; and that this irregularity has been produced in part by the formation of projecting patches of supplementary skeleton, penetrated by beautiful systems of tubuli. These groups of tubuli are in some places very regular, and have in their axes cylinders of compact calcareous matter. Some parts of the specimens present arrangements of this kind as symmetrical as in any modern Foraminiferal shell.

3. That all except the very thinnest portions of the walls of the chambers present traces, more or less distinct, of a tubular structure.

4. These facts place in more strong contrast the structure of the regularly laminated specimens from Burgess, which do not show tubuli, and that of the Grenville specimens, less regularly laminated and tubulous throughout. I hesitate however to regard these two as distinct species, in consequence of the intermediate characters

presented by specimens from the Calumet, which are regularly laminated like those of Burgess, and tubulous like those of Grenville. It is possible that in the Burgess specimens tubuli originally present have been obliterated; and in organisms of this grade, more or less altered by the processes of fossilization, large series of specimens should be compared before attempting to establish specific distinctions.

Some additional specimens, from a block consisting principally of serpentine, differ from the ordinary Grenville specimens in the more highly crystalline character of the calc-spar and serpentine, in the development of certain minute dendritic crystallizations, and in the apparent compression and distortion of the fossils. These appearances I regard as due to the mode of preservation, rather than to any original differences; certain portions less altered than the others presenting the ordinary typical characters.

Two slices of limestone from the British Islands, and supposed to be Laurentian, have been compared with the Canadian limestones above noticed. One is a serpentine-marble from Tyree. It appears to be fragmental like some of the Laurentian limestones of Canada, and may contain fragments of *Eozoön*. The other is from Ireland,* and presents what I regard as traces of organic structure, but not, in so far as can be made out, of the character of *Eozoön*. Both of these limestones deserve careful microscopic examination.

NOTES ON THE STRUCTURE AND AFFINITIES OF EOZOÖN CANADENSE.

By W. B. Carpenter, M.D., F.R.S., F.G.S.

[In a Letter to Sir William E. Logan, LL.D., F.R.S., F.G.S.]

The careful examination which I have made—in accordance with the request you were good enough to convey to me from Dr. Dawson, and to second on your own part—into the structure of

[* Given by mistake as "Iona" in the Journal of the Geological Society. It is a specimen of Connemara marble from the collection of Dr. Hunt, who supposed it to be Laurentian. See note on page 93, and for further observations on this marble see below, p. 128.]

the very extraordinary fossil which you have brought from the Laurentian rocks of Canada,* enables me most unhesitatingly to confirm the sagacious determination of Dr. Dawson as to its Rhizopod characters and Foraminiferal affinities, and at the same time furnishes new evidence of no small value in support of that determination. In this examination I have had the advantage of a series of sections of the fossil much superior to those submitted to Dr. Dawson; and also of a large series of decalcified specimens, of which Dr. Dawson had only the opportunity of seeing a few examples after his memoir had been written. These last are peculiarly instructive; since in consequence of the complete infiltration of the chambers and canals, originally occupied by the sarcode-body of the animal, by mineral matter insoluble in dilute nitric acid, the removal of the calcareous shell brings into view not only the internal casts of the chambers, but also casts of the interior of the 'canal-system' of the 'intermediate' or 'supplemental skeleton,' and even casts of the interior of the very fine parallel tubuli which traverse the proper walls of the chambers. And, as I have remarked elsewhere,† "such casts place before us far more exact representations of the configuration of the animal body, and of the connexions of its different parts, than we could obtain even from living specimens by dissolving away their shells with acid; its several portions being disposed to heap themselves together in a mass when they lose the support of the calcareous skeleton."

The additional opportunities I have thus enjoyed will be found, I believe, to account satisfactorily for the differences to be observed between Dr. Dawson's account of the *Eozoön* and my own. Had I been obliged to form my conclusions respecting its structure only from the specimens submitted to Dr. Dawson, I should very probably have seen no reason for any but the most complete accordance with his description: while if Dr. Dawson had enjoyed the advantage of examining the entire series of preparations which have come under my own observation, I feel confident that he would have anticipated the corrections and additions which I now offer.

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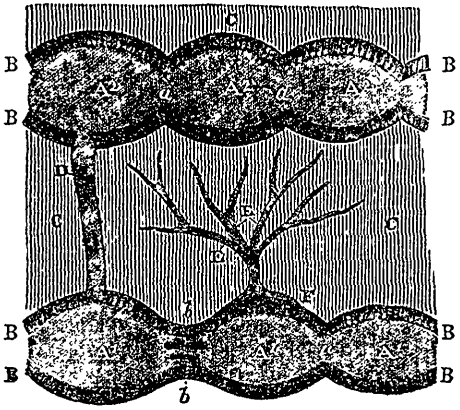
* The specimens submitted to Dr. Carpenter were taken from a block of Eozoön rock, obtained in the Petite Nation Seigniory, too late to afford Dr. Dawson an opportunity of examination. They are from the same horizon as the Grenville specimens.—W. E. L.

† Introduction to the Study of the Foraminifera, p. 10.

Although the general plan of growth described by Dr. Dawson, and exhibited in his photographs of vertical sections of the fossil, is undoubtedly that which is typical of *Eozoön*, yet I find that the acervuline mode of growth, also mentioned by Dr. Dawson, very frequently takes its place in the more superficial parts, where the chambers, which are arranged in regular tiers in the laminated portions, are heaped one upon another without any regularity, as is particularly well shown in some decalcified specimens which I have myself prepared from the slices last put into my hands. I see no indication that this departure from the normal type of structure has resulted from an injury; the transition from the regular to the irregular mode of increase not being abrupt, but gradual. Nor should I be disposed to regard it as a monstrosity; since there are



4. Diagram illustrating the structure of Eozoön.

A', A', A'. Three chambers of one layer, communicating with each other directly at *a*, and by three passages through a shelly partition at *b*.

A^2, A^2, A^2. Three chambers of a more superficial layer.

B, B, B. Proper wall of the chambers, composed of finely tubular shell-substance.

C, C, C. Intermediate or supplemental skeleton, traversed by D, a stolon of communication between two chambers of different layers, and by E, E, a canal-system originating in the lacunar space F.

many other *Foraminifera* in which an originally definite plan of growth gives place, in a later stage, to a like acervuline piling-up of chambers.

In regard to the form and relations of the chambers, I have little to add to Dr. Dawson's description. The evidence afforded by their internal casts concurs with that of sections, in showing that the segments of the sarcode-body, by whose aggregation each layer was constituted, were but very incompletely divided by shelly partitions; this incomplete separation (as Dr. Dawson has pointed out) having its parallel in that of the secondary chambers in *Carpenteria.* But I have occasionally met with instances in which the separation of the chambers has been as complete as it is in Foraminifera generally; and the communication between them is then established by several narrow passages exactly corresponding with those which I have described and figured in *Cycloclypeus.**

The mode in which each successive layer originates from the one which had preceded it, is a question to which my attention has been a good deal directed; but I do not as yet feel confident that I have been able to elucidate it completely. There is certainly no regular system of apertures for the passage of stolons giving origin to new segments, such as are found in all ordinary Polythalamous Foraminifera, whether their type of growth be rectilinear, spiral, or cyclical; and I am disposed to believe that where one layer is separated from another by nothing else than the proper walls of the chambers,—which, as I shall presently show, are traversed by multitudes of minute tubuli giving passage to pseudopodia,—the coalescence of these pseudopodia on the external surface would suffice to lay the foundation of a new layer of sarcodic segments. But where an intermediate or supplemental skeleton, consisting of a thick layer of solid calcareous shell, has been deposited between two successive layers, it is obvious that the animal body contained in the lower layer of chambers must be completely cut off from that which occupies the upper, unless some special provision exist for their mutual communication. Such a provision I believe to have been made by the extension of bands of sarcode, through canals left in the intermediate skeleton, from the lower to the upper tier of chambers. For in such sections as happen to have traversed thick deposits of the intermediate skeleton, there are generally found passages distinguished from those of the ordidary canal-system by their broad flat form, their great transverse diameter, and their non-ramification. One of these passages I have distinctly traced to a chamber, with the cavity of which it communicated through two or three apertures in its proper wall

* *Op. cit.*, p. 294.

(plate, figure 3. *c*); and I think it likely that I should have been able to trace it at its other extremity into a chamber of the superjacent tier, had not the plane of the section passed out of its course. Riband-like casts of these passages are often to be seen in decalcified specimens, traversing the void spaces left by the removal of the thickest layers of the intermediate skeleton.

But the organization of a new layer seems to have not unfrequently taken place in a much more considerable extension of the sarcode-body of the pre-formed layer; which either folded back its margin over the surface already consolidated, in a manner somewhat like that in which the mantle of a *Cypræa* doubles back to deposit the final surface-layer of its shell, or sent upwards wall-like lamellæ, sometimes of very limited extent, but not unfrequently of considerable length, which, after traversing the substance of the shell, like trap-dykes in a bed of sandstone, spread themselves out over its surface. Such, at least, are the only interpretations I can put upon the appearances presented by decalcified specimens. For on the one hand, it is frequently to be observed that two bands of serpentine (or other infiltrated mineral), which represent two layers of the original sarcode-body of the animal, approximate to each other in some part of their course, and come into complete continuity; so that the upper layer would seem at that part to have had its origin in the lower. Again, even where these bands are most widely separated, we find that they are commonly held together by vertical lamellæ of the same material, sometimes forming mere tongues, but often running to a considerable length. That these lamellæ have not been formed by mineral infiltration into accidental fissures in the shell, but represent corresponding extensions of the sarcode-body, seems to me to be indicated not merely by the characters of their surface, but also by the fact that portions of the canal-system may be occasionally traced into connection with them.

Although Dr. Dawson has noticed that some parts of the sections which he examined present the fine tubulation characteristic of the shells of the Nummuline Foraminifera, he does not seem to have recognized the fact, which the sections placed in my hands have enabled me most satisfactorily to determine,—that the proper walls of the chambers everywhere present the fine tubulation of the Nummuline shell (plate, figs. 3, 6); a point of the highest importance in the determination of the affinities of *Eozoön*. This tubulation, although not seen with the clearness with which it is to be discerned in recent examples of the Nummuline type, is here far better displayed than it is in the majority of fossil Nummulites, in which the tubuli have been filled up by the infiltration of calcareous matter, rendering the shell-substance nearly homogeneous. In *Eozoön* these tubuli have been filled up by the infiltration of a mineral different from that of which the shell is composed, and therefore not coalescing with it; and the tubular structure is consequently much more satisfactorily distinguishable. In decalcified specimens, the free margins of the casts of the chambers are often seen to be bordered with a delicate white glistening fringe; and when this fringe is examined with a sufficient magnifying power, it is seen to be made up of a multitude of extremely delicate *aciculi*, standing side by side like the fibres of asbestos. These, it is obvious, are the internal casts of the fine tubuli which perforated the proper wall of the chambers, passing directly from its inner to its outer surface; and their presence in this situation affords the most satisfactory confirmation of the evidence of that tubulation afforded by thin sections of the shell-wall.

The successive layers, each having its own proper wall, are often superposed one upon another without the intervention of any supplemental or intermediate skeleton such as presents itself in all the more massive forms of the Nummuline series; but a deposit of this form of shell-substance, readily distinguishable by its homogeneousness from the finely tubular shell immediately investing the segments of the sarcode-body, is the source of the great thickening which the calcareous zones often present in vertical sections of *Eozoön*. The presence of this intermediate skeleton has been correctly indicated by Dr. Dawson; but he does not seem to have clearly differentiated it from the proper wall of the chambers. All the tubuli which he has described belong to that canal-system which, as I have shown,* is limited in its distribution to the intermediate skeleton, and is expressly destined to supply a channel for its nutrition and augmentation. Of this canal-system, which presents most remarkable varieties in dimensions and distribution, we learn more from the casts presented by decalcified specimens, than from sections, which only exhibit such parts of it as their plane may happen to traverse. Illustrations from both sources, giving a more complete representation of it than Dr. Dawson's figures afford, have been prepared from the additional specimens placed in my hands (plate, figure 7).

* *Op. cit.*, pp. 50, 51.

It does not appear to me that the canal-system takes its origin directly from the cavity of the chambers. On the contrary, I believe that, as in *Calcarina* (which Dr. Dawson has correctly referred to as presenting the nearest parallel to it among recent *Foraminifera*), they originate in lacunar spaces on the outside of the proper walls of the chambers, into which the tubuli of those walls open externally; and that the extensions of the sarcode-body which occupied them were formed by the coalescence of the pseudopodia issuing from those tubuli.*

It seems to me worthy of special notice, that the canal-system, wherever displayed in transparent sections, is distinguished by a yellowish-brown coloration, so exactly resembling that which I have observed in the canal-system of recent *Foraminifera* (as *Polystomella* and *Calcarina*) in which there were remains of the sarcode-body, that I cannot but believe the infiltrating mineral to have been dyed by the remains of sarcode still existing in the canals of *Eozoön* at the time of its consolidation. If this be the case, the preservation of this color seems to indicate that no considerable metamorphic action has been exerted upon the rock in which this fossil occurs. And I should draw the same inference from the fact that the organic structure of the shell is in many instances even more completely preserved than it usually is in the Nummulites and other *Foraminifera* of the Nummulitic limestone of the early Tertiaries.

To sum up,—That the *Eozoön* finds its proper place in the Foraminiferal series, I conceive to be conclusively proved by its accordance with the great types of that series, in all the essential characters of organization;—namely, the structure of the shell forming the proper wall of the chambers, in which it agrees precisely with *Nummulina* and its allies; the presence of an intermediate skeleton and an elaborate canal-system the disposition of which reminds us most of *Calcarina;* a mode of communication of the chambers when they are most completely separated, which has its exact parallel in *Cycloclypeus;* and an ordinary want of completeness of separation between the chambers, corresponding with that which is characteristic of *Carpenteria.*

There is no other group of the Animal Kingdom to which *Eozoön* presents the slightest structural resemblance; and to the suggestion that it may have been of kin to Nullipore, I can offer the most distinct negative reply, having many years ago carefully studied

* *Op. cit.*, p. 221.

the structure of that stony Alga, with which that of *Eozoön* has nothing whatever in common.

The objections which not unnaturally occur to those familiar with only the ordinary forms of *Foraminifera*, as to the admission of *Eozoön* into the series, do not appear to me of any force. These have reference in the first place to the great *size* of the organism; and in the second, to its exceptional mode of growth.

1. It must be borne in mind that all the *Foraminifera* normally increase by the continuous gemmation of new segments from those previously formed; and that we have, in the existing types, the greatest diversities in the extent to which this gemmation may proceed. Thus in the *Globigerinæ*, whose shells cover to an unknown thickness the sea-bottom of all that portion of the Atlantic Ocean which is traversed by the Gulf-stream, only eight or ten segments are ordinarily produced by continuous gemmation; and if new segments are developed from the last of these, they detach themselves so as to lay the foundation of independent *Globigerinæ*. On the other hand in *Cycloclypeus*, which is a discoidal structure attaining two and a quarter inches in diameter, the number of segments formed by continuous gemmation must be many thousand. Again, the *Receptaculites* of the Canadian Silurian rocks, shown by Mr. Salter's drawings* to be a gigantic Orbitolite, attains a diameter of twelve inches; and if this were to increase by vertical as well as by horizontal gemmation (after the manner of *Tinoporus* or *Orbitoides*) so that one discoidal layer would be piled on another, it would form a mass equalling *Eozoön* in its ordinary dimensions. To say, therefore, that *Eozoön* cannot belong to the *Foraminifera* on account of its gigantic size, is much as if a botanist who had only studied plants and shrubs were to refuse to admit a tree into the same category. The very same continuous gemmation which has produced an *Eozoön* would produce an equal mass of independent *Globigerinæ*, if after eight or ten repetitions of the process, the new segments were to detach themselves.

It is to be remembered, moreover, that the largest masses of sponges are formed by continuous gemmation from an original Rhizopod segment, and that there is no *à priori* reason why a Foraminiferal organism should not attain the same dimensions as a Poriferal one,—the intimate relationship of the two groups, notwithstanding the difference between their skeletons, being unquestionable.

* First Decade of Canadian Fossils, pl. x.

2. The difficulty arising from the zoophytic plan of growth of *Eozoön* is at once disposed of by the fact that we have in the recent *Polytrema* (as I have shown, *op. cit.* p. 235) an organism nearly allied in all essential points of structure to *Rotalia*, yet no less aberrant in its plan of growth, having been ranked by Lamarck among the Millepores. And it appears to me that *Eozoön* takes its place quite as naturally in the Nummuline series as *Polytrema* in the Rotaline. As we are led from the typical *Rotalia*, through the less regular *Planorbulina*, to *Tinoporus*, in which the chambers are piled up vertically, as well as multiplied horizontally, and thence pass by an easy gradation to *Polytrema*, in which all regularity of external form is lost; so may we pass from the typical *Operculina* or *Nummulina*, through *Heterostegina* and *Cycloclypeus* to *Orbitoides*, in which, as in *Tinoporus*, the chambers multiply both by horizontal and by vertical gemmation; and from *Orbitoides* to *Eozoön* the transition is scarcely more abrupt than from *Tinoporus* to *Polytrema*.

The general acceptance, by the most competent judges, of my views respecting the primary value of the characters furnished by the intimate structure of the shell, and the very subordinate value of plan of growth, in the determination of the affinities of Foraminifera, renders it unnecessary that I should dwell further on my reasons for unhesitatingly affirming the Nummuline affinities of *Eozoön* from the microscopic appearances presented by the proper wall of its chambers, notwithstanding its very aberrant peculiarities; and I cannot but feel it to be a feature of peculiar interest in geological inquiry, that the true relations of by far the earliest fossil yet known should be determinable by the comparison of a portion which the smallest pin's head would cover, with organisms at present existing.

I need not assure you of the pleasure which it has afforded me to be able to co-operate with Dr. Dawson and yourself in this development of my previous researches; but I may venture to add the anticipation that the discovery of *Eozoön* is the first of many discoveries in the Laurentian series, which will vastly add to our knowledge of the primæval life of our globe. And I am strongly inclined also to concur in the belief expressed by Dr. Dawson in a private letter to myself, that a more thorough examination of some of the Silurian fossils (such as *Stromatopora*) hitherto ranked among corals and sponges, will prove that they are really, like *Eozoön* and *Receptaculites*, gigantic *Foraminifera*.

EXPLANATION OF THE PLATE,

Illustrating the Structure and Affinities of Eozoön Canadense.

Of the figures here given, 1, 3, 6 *a*, 6 *b*, and 7, are selected from two plates given by Dr. Carpenter to illustrate his paper; while 2, 4, and 5, are from the plates accompaning Dr. Dawson's description, and are from drawings by Mr. Horace H. Smith, the artist of the Survey.

The figures, with the exception of 7, are from transparent sections of specimens in which the original shell was well preserved, and its minutest cavities infiltrated with serpentine. Figure 7 is from a specimen from which the calcareous skeleton was removed by an acid, and represents the internal casts of the tubes, as seen by reflected light.

Fig. 1. Vertical section of regularly stratified portion of *Eozoön* showing the ordinarily continuous connection of the chambers of each stratum; magnified 10 diameters.

2. Horizontal section of *Eozoön* from Grenville, magnified 25 diameters; *a*, systems of tubuli; *b*, secondary chamber.

3. Portions of two chambers of different layers, showing at *a*, *a*, the proper walls of their chambers; at *b*, *b*, the intermediate skeleton; and at *c*, *c*, a stoloniferous passage: magnified 25 diameters.

4. One of the systems of tubuli cut transversely; magnified 100 diameters.

5. Part of a system of tubuli cut transversely; magnified 200 diameters.

6. Portions of the proper wall of the chambers, showing its Nummuline tubulation, as seen at *a* in longitudinal, and at *b* in transverse section; magnified 100 diameters.

7. Cast of the interior of canal-system; an entire group magnified 10 diameters.

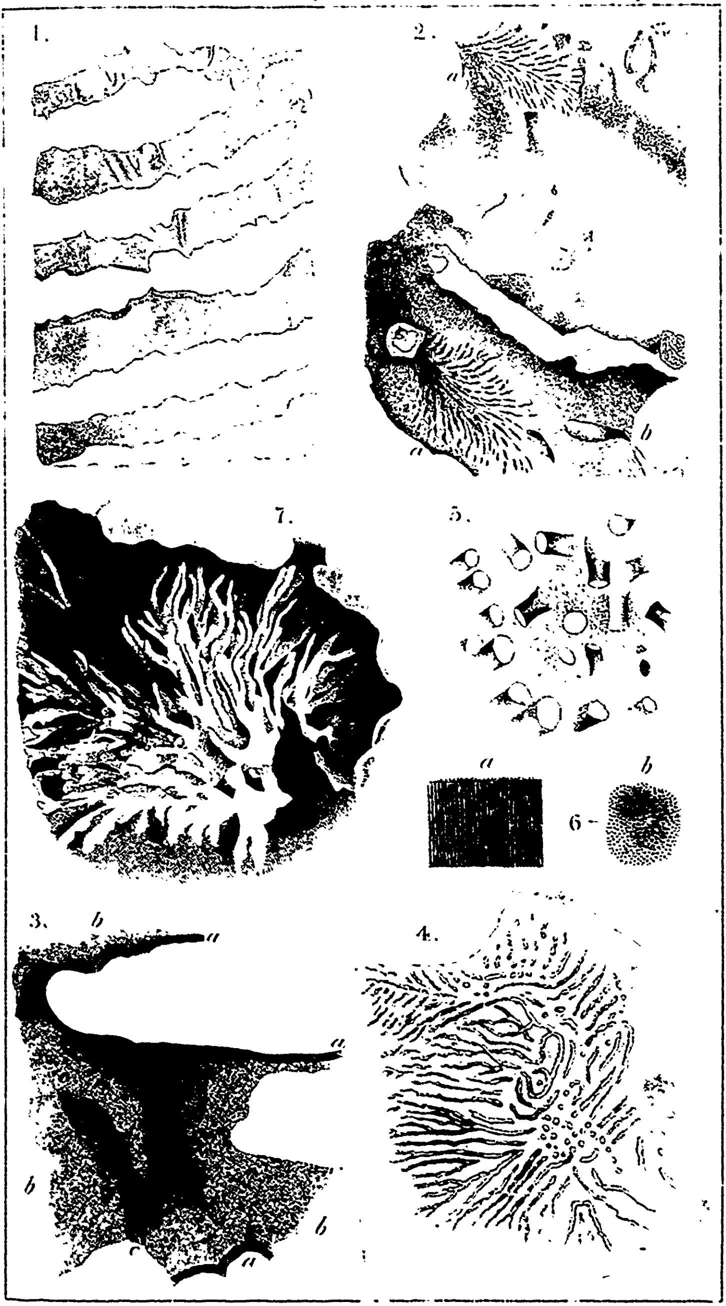
ON THE MINERALOGY OF EOZOÖN CANADENSE.*

By T. Sterry Hunt, M.A., F.R.S.

The remains of *Eozoön Canadense*, a Foraminiferal organism recently discovered in the Laurentian limestones of Canada, present an interesting subject of study, both to the mineralogist and geologist. For a zoological description of this organic form the reader is referred to the preceding descriptions by Dr. Dawson and Dr. Carpenter.

The details of structure have been preserved by the introduction of certain mineral silicates, which have not only filled up the

[* See preliminary notice, Silliman's Journal [2] xxxvii, 431.]



EOZOÖN CANADENSE, DAWSON.

chambers, cells, and canals left vacant by the disappearance of the animal matter, but have in very many cases been injected into the tubuli, filling even their smallest ramifications. These silicates have thus taken the place of the original sarcode, while the calcareous septa remain. It will then be understood that when the replacement of the *Eozoön* by silicates is spoken of, this is to be understood of the soft parts only; since the calcareous skeleton is preserved, in most cases, without any alteration. The vacant spaces left by the decay of the sarcode may be supposed to have been filled by a process of infiltration, in which the silicates were deposited from solution in water, like the silica which fills up the pores of wood in the process of silicification. The replacing silicates, so far as yet observed, are a white pyroxene, a pale-green serpentine, and a dark-green alumino-magnesian mineral, which is allied in composition to chlorite and to pyrosclerite, and which I have referred to loganite. The calcareous septa in the last case are found to be dolomitic, but in the other instances are nearly pure carbonate of lime. The relations of the carbonate and the silicates are well seen in thin sections under the microscope, especially by polarized light. The calcite, dolomite, and pyroxene exhibit their crystalline structure to the unaided eye; and the serpentine and loganite are also seen to be crystalline when examined with the microscope. When portions of the fossil are submitted to the action of an acid, the carbonate of lime is dissolved, and a coherent mass of serpentine is obtained, which is a perfect cast of the soft parts of the *Eozoön*. The form of the sarcode which filled the chambers and cells is beautifully shown, as well as the connecting canals and the groups of tubuli; these latter are seen in great perfection upon surfaces from which the carbonate of lime has been partially dissolved. Their preservation is generally most complete when the replacing mineral is serpentine, although very perfect specimens are sometimes found in pyroxene. The crystallization of the latter mineral appears, however, in most cases to have disturbed the calcareous septa.

Serpentine and pyroxene are generally associated in these specimens, as if their disposition had marked different stages of a continuous process. At the Calumet, one specimen of the fossil exhibits the whole of the sarcode replaced by serpentine; while, in another one from the same locality, a layer of pale green translucent serpentine occurs in immediate contact with the white pyroxene. The calcareous septa in this specimen are very thin, and are transverse to the plane of contact of the two minerals; yet they are seen to traverse both the pyroxene and the serpentine without any interruption or change. Some sections exhibit these two minerals filling adjacent cells, or even portions of the same cell, a clear line of division being visible between them. In the specimens from Grenville, on the other hand, it would seem as if the development of the *Eozoön* (considerable masses of which were replaced by pyroxene) had been interrupted, and that a second growth of the animal, which was replaced by serpentine, had taken place upon the older masses, filling up their interstices.

The results of the chemical examination of these fossils from different localities may now be given:—

I. A specimen of *Eozoön* from the Calumet, remarkable for the regularity of its laminated arrangement, gave to warm acetic acid 27·0 per cent of soluble matter, consisting of carbonate of lime 97·1, carbonate of magnesia 2·9; = 100.

II. Another specimen of the fossil, from Grenville, replaced by pyroxene, yielded in the same way 12·0 per cent of soluble matter, which was composed of carbonate of lime 98·7, carbonate of magnesia 1·3; = 100.

III. In this specimen of the fossil, which adjoined the last, serpentine was the replacing mineral. The soluble portion from this equalled 47·0 per cent, and consisted of carbonate of lime 96·0, carbonate of magnesia 4·0; = 100. It thus appears that the septa in these specimens of *Eozoön* are nearly pure carbonate of lime. The somewhat larger proportion of magnesia from the last is due to the use, as a solvent, of dilute nitric acid, which slightly attacked the serpentine.

The pyroxene of the above specimens is a very pure silicate of lime and magnesia; that from I gave, by analysis, silica 54·90, lime 27·67, magnesia 16 76, volatile matter 0·80; = 100·13. A partial analysis of the pyroxene from II yielded lime 28·3, magnesia 13·8. This specimen was interpenetrated with serpentine, amounting to about 10·0 per cent, which was first removed by the successive action of heated sulphuric acid and dilute soda-ley. The serpentine from III yielded silica 42·85, magnesia 41·68, protoxide of iron 0.67, water 13·89; = 99·09. As already mentioned, this serpentine had lost a little magnesia from the action of nitric acid. A similar serpentine from the Calumet, associated with the *Eozoön*, gave silica 41·20, magnesia 43·52, protoxide of iron 0.80, water

15·40; = 100·92. These serpentines from the Laurentian limestones are remarkable for their freedom from iron-oxide, for their their large amount of water, and their low specific gravity.*

Specimens of *Eozoön* from Burgess differ from the foregoing in the composition both of the replacing material and septa. The latter consist of a somewhat ferriferous dolomite, the analysis of which was made upon portions mechanically separated from the enclosed silicate: it yielded carbonate of magnesia 40·7, carbonate of lime, with a little peroxide of iron, 59·0; = 99·7. The septa of the specimen from this locality are in some parts more than 3·0 millimetres in thickness, and exhibit the chambers, cells, and septal orifices; but no tubuli are seen. The replacing material has the hardness of serpentine, for which it was at first mistaken. Its color is blackish-green; but olive-green in thin sections, when it is seen by transmitted light to be crystalline in texture. Its fracture is granular, and its lustre feebly shining. It is decomposed by heated sulphuric acid, and was thus analyzed, yielding the result I. The centesimal composition of the soluble portion is given under II.

	I.	II.	III.
Silica	33·75	35·14	36·50
Alumina	9·75	10·15	10·80
Magnesia	30·24	31·47	28·20
Protoxide of iron	8·19	8·60	9·54
Water	14·08	14·64	14·62
Insoluble sand	2·50	..	..
	98·51	100·00	99·66

The silicate which here takes the place of the pyroxene and serpentine observed in the other specimens of *Eozoön* is one of frequent occurrence in the Laurentian limestones, and appears to constitute a distinct species, which I long since described under the name of loganite, and which occurs at the Calumet in dark brown prismatic crystals.† I have since observed a similar mineral in two other localities besides the one here noticed. The result III, which is placed by the side of the analysis of the Burgess fossil, was obtained with a greenish-grey sparry prismatic variety from North Elmsley, having a hardness of 3·0, and a specific gravity of

* See my descriptions, Silliman's Journal [2] xxvi, 236.

† Phil. Mag., 4th ser., vol. ii, p. 65.

2·539. These hydrous alumino-magnesian silicates, which I have included under the name of loganite,* are related to chlorite and to pyrosclerite in composition ; but these last are distinguished from it by their eminently foliated micaceous structure.

When examined under the microscope, the loganite which replaces the *Eozoön* of Burgess, shows traces of cleavage-lines, which indicate a crystalline structure. The grains of insoluble matter found in the analysis, chiefly of quartz-sand, are distinctly seen as foreign bodies imbedded in the mass, which is moreover marked by lines apparently due to cracks formed by a shrinking of the silicate, and subsequently filled by a further infiltration of the same material. This arrangement resembles on a minute scale that of septaria. Similar appearances are also observed in the serpentine which replaces the *Eozoön* of Grenville, and also in a massive serpentine from Burgess, resembling this, and enclosing fragments of the fossil. In both of these specimens also grains of mechanical impurities are detected by the microscope; they are however rarer than in the loganite of Burgess.

From the above facts it may be concluded that the various silicates which now constitute pyroxene, serpentine, and loganite were directly deposited in waters in the midst of which the *Eozoön* was still growing, or had only recently perished; and that these silicates penetrated, enclosed, and preserved the calcareous structure precisely as carbonate of lime might have done. The association of the silicates with the *Eozoön* is only accidental; and large quantities of them, deposited at the same time, include no organic remains. Thus, for example, there are found associated with the Eozoön-limestones of Grenville, massive layers and concretions of pure serpentine; and a serpentine from Burgess has already been mentioned as containing only small broken fragments of the fossil. In like manner large masses of white pyroxene, often surrounded by serpentine, both of which are destitute of traces of organic structure, are found in the limestone at the Calumet. In some cases, however, the crystallization of the pyroxene has given rise to considerable cleavage-planes, and has thus obliterated the organic structures from masses which, judging from portions visible here and there, appear to have been at one time penetrated by the calcareous plates of *Eozoön*. Small irregular veins of crystalline calcite, and

* For a description of this and similar silicates, see Geology of Canada, p. 491.

of serpentine, are found to traverse* such pyroxene-masses in the Eozoön-limestone of Grenville.

As already mentioned in Sir W. E. Logan's description, it appears that great beds of the Laurentian limestones are composed of the ruins of the *Eozoön*. These rocks, which are white, crystalline, and mingled with pale-green serpentine, are similar in aspect to many of the so-called primary limestones of other regions. In most cases the limestones are non-magnesian, but one of them from Grenville was found to be dolomitic. The accompanying strata often present finely crystallized pyroxene, hornblende, phlogopite, apatite, and other minerals. These observations bring the formation of siliceous minerals face to face with life, and show that their generation was not incompatible with the contemporaneous existence and the preservation of organic forms. They confirm, moreover, the view which I some years since put forward, that these silicated minerals have been formed, not by subsequent metamorphism in deeply buried sediments, but by reactions going on at the earth's surface.† In support of this view, I have elsewhere referred to the deposition of silicates of lime, magnesia, and iron from natural waters, to the great beds of sepiolite in the unaltered Tertiary strata of Europe; to the contemporaneous formation of neolite (an alumino-magnesian silicate related to loganite and chlorite in composition); and to glauconite, which occurs not only in Secondary, Tertiary, and Recent deposits, but also, as I have shown, in Lower Silurian strata.‡ This hydrous silicate of protoxide of iron and potash, which sometimes includes a considerable proportion of alumina in its composition, has been observed by Ehrenberg, Mantell, and Bailey associated with organic forms in a manner which seems identical with that in which pyroxene, serpentine, and loganite occur with the *Eozoön* in the Laurentian limestones. According to the first of these observers, the grains of green-sand, or glauconite, from the Tertiary limestone of Alabama are casts of

* Recent examinations have shown that some of these masses encrusted with *Eozoön* replaced by serpentine, consist of crystalline pyrallolite (rensselaerite), which seems, like the other silicates, to have replaced the organic matter of the Rhizopod. Further examinations aided by the microscope, are however needed to determine with certainty the relations of the *Eozoön* to these masses of pyrallolite.

† Silliman's Journal [2] xxix, 284; xxxii, 286. Geology of Canada p. 577.

‡ Silliman's Journal [2] xxxiii, 277. Geology of Canada, p. 487.

the interior of Polythalamia, the glauconite having filled them by "a species of natural injection, which is often so perfect that not only the large and coarse cells, but also the very finest canals of the cell-walls and all their connecting tubes, are thus petrified and separately exhibited." Bailey confirmed these observations, and extended them. He found in various Cretaceous and Tertiary limestones of the United States, casts in glauconite, not only of *Foraminifera*, but of spines of *Echinus*, and of the cavities of corals. Besides, there were numerous red, green, and white casts of minute anastomosing tubuli, which, according to Bailey, resemble the casts of the holes made by burrowing sponges (*Cliona*) and worms. These forms are seen after the dissolving of the carbonate of lime by a dilute acid. He found, moreover, similar casts of *Foraminifera*, of minute mollusks, and of branching tubuli, in mud obtained from soundings in the Gulf-stream, and concluded that the deposition of glauconite is still going on in the depths of the sea.* Pourtales has followed up these investigations on the recent formation of glauconite in the Gulf-stream waters. He has observed its deposition also in the cavities of *Millepores*, and in the canals in the shells of *Balanus*. According to him, the glauconite grains formed in *Foraminifera* lose after a time their calcareous envelopes, and finally become "conglomerated into small black pebbles," sections of which still show under a microscope the characteristic spiral arrangement of the cells.†

It appears probable from these observations that glauconite is formed by chemical reactions in the ooze at the bottom of the sea, where dissolved silica comes in contact with iron-oxide rendered soluble by organic matter; the resulting silicate deposits itself in the cavities of shells and other vacant spaces. A process analogous to this in its results, has filled the chambers and canals of the Laurentian *Foraminifera* with other silicates; from the comparative rarity of mechanical impurities in these silicates, however, it would appear that they were deposited in clear water. Alumina and oxide of iron enter into the composition of loganite as well as of glauconite; but in the other replacing minerals, pyroxene and serpentine, we have only silicates of lime and magnesia, which were probably formed by the direct action of alkaline silicates, either

* Silliman's Journal [2] xxii, 280.

† Report of United States Coast-Survey, 1858, p. 248.

dissolved in surface-waters, or in those of submarine springs, upon the calcareous and magnesian salts of the sea-water. Experiments undertaken with the view of determining the precise conditions under which these and similar silicates may thus be formed, are now in progress.

Appendix to Dr. Dawson's Paper (pages 99—111).

Since the above papers were published, I have had opportunities of examining slices and decalcified specimens of *Eozoön* from Petite Nation, the locality which afforded the specimens referred to by Dr. Carpenter (pages 112, 116), and I have much pleasure in adding my testimony to his observation of the distinctness of the proper wall of the chambers from the supplemental or intermediate skeleton, as exhibited in these specimens. In the specimens previously examined I could not distinctly ascertain that the structure of the proper wall had been preserved, except in a small fragment from Burgess, not certainly known to be of the same species with the specimens from Grenville. Although I believed that such a distinction must have existed, I could not affirm that it had been preserved. I therefore regard these additional structures, ascertained by Dr. Carpenter, as affording strong confirmation of the foraminiferal nature of *Eozoön*, and as indicating its high rank in the order of Foraminifera; while at the same time no more satisfactory guarantee for the correctness of the observations made here could be given, than the concurrence of one whose authority in such subjects is deservedly so high.

It is also gratifying to find in recent British publications,* notices to the effect that Mr. Sanford has found the structure of *Eozoön* in the Laurentian limestone of Ireland), the Connemara marble of the Binabola Mountains) already referred to on page 111. Mr. Sanford's specimens have been further examined by Prof. Rupert Jones, who says: "except that the serpentine replacing the sarcode is lighter than in specimens furnished by Sir William Logan, there is no real difference between the two." *Eozoön Canadense* will thus, in all probability, be found to be characteristic of the Laurentian, and possibly of a particular portion of that series on both sides of the Atlantic, and will become important to palæontologists as a means of recognizing rocks of this early life-zone. It would appear also that in Ireland as in Canada the remains of the creature have

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* Geol. Mag., Nov. 1864; Reader, Feb. 25, 1865.

contributed largely to the formation of limestone, since Prof. Jones remarks that he has detected its structure abundantly in chips of 'Irish-green' marble from marble-works in London; and Mr. Sanford represents a somewhat extensive bed of limestone in the Binabola Mountains, as abounding in it throughout, though not always in a good state of preservation. J. W. D.

NOTES ON CERTAIN SPECIES OF NOVA-SCOTIAN FISHES.

By J. Matthew Jones, F.L.S.

The Yellow Perch.—*Perca flavescens.*

Perca flavescens	Cuv. et Val., ii, p. 46.
" "	Rich., Faun. Bor. Amer., p. 1, pl. 74.
" "	Storer, Fishes of Mass., p. 5.
" "	DeKay, N. Y. Faun., p. 3, pl. 1, fig. 1.
" "	Holb., Ich. S. C., p. 2, pl. 1, fig. 1.
" "	Gunth., Cat. Fishes, i, p. 59.
Bodianus flavescens	Mitch., Ph. Trans. N. Y., i, p. 421.

This fish is very common in the fresh waters of this province, and is similar in habit to the common perch of Europe. It is sold in the Halifax market during winter in small bunches of a dozen each at the rate of sixpence sterling per bunch, but it is not much esteemed as food.

Gunther, in his catalogue of the acanthopterygian fishes in the British Museum collection, states his belief, after an examination of the skeletons of this and the European *P. fluviatilis*, that they are merely varieties of one and the same species.

Its geographical distribution is extensive,—being found in nearly every part of North America.

Sculpin.—*Cottus Grœnlandicus.*

Cottus Grœnlandicus	Cuv. et Val., iv, p. 156.
" "	Rich. iii, pp. 46, 297, pl. 95, fig. 2.
" "	Storer, Fishes of Mass., p. 16.
" "	De Kay, p. 54, pl. 4, fig. 10.
" "	Gunth., Cat. Fishes, ii, p. 161.
" Scorpius	Fabr., Faun. Grœnl., p. 156.

This daring and voracious fish is very abundant on our shores. It cares but little for the presence of man, and will not leave its position in the shallow water even when roughly touched with a boat-hook. It acts as a perfect scavenger at the fish-curing stations, gorging itself with the refuse thrown into the sea. Although somewhat repulsive in appearance and mode of life, it is remarkable for the beauty of its colors, which, in some specimens, are highly brilliant. The Rev. J. Ambrose informs me that a deep red-colored variety is found at St. Margaret's Bay, and is known to the fishermen under the name of 'deep-water sculpin.' The sculpin is very tenacious of life, existing for some time after removal from its native element.

NORWAY HADDOCK.—*Sebastes Norvegicus.*

Sebastes Norvegicus..................Cuv. et Val., iv., p. 327, pl. 87.
" " ....Yarrell, Brit. Fishes, i, p. 87.
" " ....Rich., Faun. Bor. Amer., p. 52.
" " ....Storer, Fishes of Mass., p. 26.
" " ....De Kay, p. 60, pl. 4, fig. 2.
" " ....Gunth., Cat. Fishes, ii, p. 95.
Perca marina..........................Pennant, Brit. Zool., iii, p. 226.
Holocentrus Norvegicus..............Lacep., iv, p. 390.

This beautiful fish, which vies in brilliancy of color with the gaudy-coated denizens of the tropical seas, is by no means uncommon on our coast during winter and summer. It occurs more frequently, perhaps, during the winter season. As the minute young has been procured from the stomach of a cod caught in the vicinity of Halifax, it is more than probable that it breeds with us. When fishing for cod, it is taken on the banks several miles from shore, and is known in the Halifax market as the 'John-a-Dory,' where it sells at the rate of two pence sterling each, but is never exhibited for sale in any quantity. The Greenland and Arctic seas appear to be the proper habitat of this species. I have procured the opercular spines from the Kjockkenmoedding on our Atlantic coast.

SPOTTED WRYMOUTH.—*Cryptacanthodes maculatus.*

Cryptacanthodes maculatus.............Storer, Fishes of Mass., p. 28.
" " ....Gunth., Cat. Fishes, iii, p. 291.

A fine example of this rare fish was taken while swimming with its head out of water near the Commercial Wharf, Halifax, on the 14th of June 1860, and was presented to me by Andrew Downs, Esq. It was perfectly white in color, and had the exact appearance of a cast in plaster of Paris. This white color changed—after it had been some time in spirits—to a light brown about the body, but the head still retains its original plaster hue. Dr. Storer appears to have been the original discoverer of this curious fish on the Atlantic coast of America.]

The following is a brief description of the dimensions, &c. of the specimen in my collection:

Extent, 33 inches. Depth at the deepest part across vent 2½ inches; at caudal extreme, 9 lines. Diameter of body at base of pectorals, 3 inches. Extent of head, 4¼ inches; breadth at broadest part, the juncture with the neck, 4½ inches; depth, from summit to extended bony point beneath, 3½ inches; circumference over expanded gill-covers, 11½ inches. Horizontal gape of mouth, 2¾ inches. Lower jaw 4 lines in advance of upper. Teeth conical, two rows in lower jaw curved inwards and extending outwards at chin; four rows in upper jaw, the third and fourth of which are incomplete. Palatines, armed with small teeth posteriorly. Lips, wide, protruding from either side of divisional ridge to posterior corner. Snout abrupt, indented at extreme. Two triangular fleshy processes occur on either side of the nasal bone. Eyes, 9½ lines distant from each other, diameter 4½ lines. An elevated bony ridge commences immediately above the eyes, and runs back for 4 lines, then rising gradually to the summit of the caput 3 inches from chin-point, and descending again to post extreme of head. A deepened pit-like depression of the form of the eye occurs behind each eye and a smaller pit between them in advance, situate in the groove formed by the bony ridge above the eyes. The bony ridges are distant from each other at widest part, 8 lines. A bony elevated ridge also occurs in front of the eyes. Anus about 3 lines in advance of anal fin. The branchiostegous rays are much inflated, causing the gill-covers to appear as if severed from the head. The dorsal and anal fins are higher at posterior extreme close to the caudal, the former having rays an inch long near its termination, and its commencement partially hid in a groove. The pectorals are 5 lines in extent, having a basal width of 8½ lines; they are rounded, and the eight primal rays (with the exception of the first) jointed about 2 or 3 lines from their tips. The caudal is 2 inches 8 lines in extent, having a spread of 2 inches.

MACKAREL.—*Scomber vernalis.*

Scomber vernalis...............DeKay, p. 101, pl. 12, fig. 34.
" " ....Cuv. et. Val., viii, p. 48.
" " ....Storer, Fishes of Mass., p. 41.

Scomber scomber...............Yarrell, Brit. Fishes, ed. 2, i, p. 137.
" " ....Owen, Osteol. Cat., i, p. 61.
" " ....Gunth., Cat. Fishes, vol. ii, p. 357.

As with the common herring of this coast, I have every reason to believe that this fish is identical with the European species, and must adhere to such opinion until satisfactory evidence is shown to prove the contrary. Gunther in his catalogue even includes *S. grex* under the same head; but as I have not had an opportunity of examining one of this latter species, I am unable to speak as to the similarity which exists between them. The shores, harbors, and inlets of this province, particularly on the eastern and northern coasts, are annually visited by vast multitudes of the common mackarel, some of which are smaller and others larger than the medium-sized individuals. They are classed by merchants and fishermen as of three kinds:—No. 1, the largest and fattest; No. 2, the medium sized; and No. 3, the smallest. The habits of the mackarel are very capricious: some seasons it visits us in such vast abundance that the waters literally swarm with them; while in others, loud complaints are heard of their scarcity. Many are the reasons given to account for this singular habit; but no satisfactory conclusion can be reached until accurate observers on different parts of the coast take cognizance of the abundance or scarcity of their usual food during the time of their visit, and also of the temperature of the water, whether influenced by the warm current of the Gulf stream, or the colder waters of the Arctic current. Much remains for the investigation of the naturalist ere a true solution can be given to the mystery which hangs around the periodical appearance of marine fishes on our shores; and it must ever be a source of regret that some of our better-educated fishermen do not put their knowledge of the habits of fish to advantage by communicating any facts which would tend to throw light upon so interesting a subject.

From the middle of September to the end of October, appears to be the season of the best mackarel-fishing on our eastern coast, the larger kind being generally more abundant towards the close of the latter month. About the middle of June the spawn is generally ripe for depositing. Along the coast it is said that mackarel prove poisonous to pigs, but I have no facts to verify such an assertion. This fish is also supposed to be free from disease of any kind. Some years ago a fisherman at Prospect near Halifax was spearing for eels in mid-winter through the ice near shore, in the sandy mud, and to his surprise caught a mackarel which appeared half torpid, and had its eyes covered with a filmy substance. Was this fish hibernating in the mud, or what could have brought it into such position at a time of year when its fellows were supposed to be away at some distance in the deep?

To show the extent to which the mackarel-fishery is carried on in our Province, I may state that in the year 1860, 49,748 barrels of mackarel were cured by our fishermen. But this is nothing in comparison to the total amount taken off the coast by United States fishermen and others who resort to these grounds in the season in their large and well-appointed craft, with more tackle than our fishermen possess. Specimens of No. 1 mackarel often attain large dimensions: one taken in the harbor of Port Mulgrave in September 1861, weighed two lbs., and measured 17 inches in length.

TUNNY.—*Thynnus vulgaris.*

Thynnus vulgaris..................Cuv. et Val., viii, p. 58, pl. 210.
" " ....Yarrell, Brit. Fishes, i, p. 150.
" " ....Storer, Fishes of Mass., p. 47.
" thynnus..................Gunth., Cat., ii, p. 362.
Scomber thynnus..................Don., Brit. Fishes, i, pl. 5.
" " ....Risso., Ich. Nice, p. 163.

The tunny is very common on our eastern coast during the summer months, and is known to the fishermen as the 'albicore.' The Rev. John Ambrose informs me that it visits St. Margaret's Bay regularly every summer, several specimens being taken and rendered down for oil. They have been especially abundant this autumn (1864) in that locality.

SWORD-FISH.—*Xiphias gladius.*

Xiphias gladius..............Risso., Ich. Nice, p. 99.
" " ....Cuv. et. Val., viii, p. 255, pl. 225, 226.
" " ....Storer, Fishes of Mass., p. 51.
" " ....DeKay, p. 111, pl. xxvi, fig. 79.
" " ....Yarrell, Brit. Fishes, i, p. 164.

The sword-fish is by no means common on our coast, and only makes its appearance at intervals in our harbors and bays. One was taken last year in Bedford Basin, at the head of Halifax Harbor.

BUTTERFISH.—*Gunnellus vulgaris.*

Gunnellus vulgaris..................Nilss., Skand. Faun., iv, p. 200.
" mucronatus..............DeKay, p. 153, pl. 12, fig. 36.
" " ....Cuv. et Val., xi, p. 427.
Blennius gunnellus..................Rich., Faun. Bor. Amer., p. 91.
" " ....Lacep., ii, p. 503.
Centronotus gunnellus..............Gunth., Cat. Fishes, iii, p. 285.
" " ....Bloch., Schn., p. 167.
Muroenoides guttata................Storer, Fishes of Mass., p. 65.

In the transactions of the Nova Scotian Institute of Natural Science (Part i, p. 50) I described this species from specimens forwarded to me by the Rev. J. Ambrose, who procured them with the dredge, in twelve to fourteen fathoms water, at the entrance of St. Margaret's Bay, in August 1860. I find that they are common on the coast, and afford food for the more voracious ground-feeders. DeKay's *G. mucronatus* does not coincide in color with the present species; but as it particularly corresponds in all other respects, I scarcely consider this variation a sufficient reason for disputing its identity, as all ichthyologists are aware how many familiar forms vary in the color of their markings, although beyond all doubt belonging to the same species.

WOLF-FISH.—*Anarrhicas lupus.*

Anarrhicas lupus..............Linn., Syst., i, p. 430.
" " ....Fabr., Faun. Grœnl., p. 138, n. 97.
" " ....Lacep., ii, pp. 299, 300, pl. 9, fig. 2.
" " ....Rich., Faun. Bor. Amer., p. 95.
" " ....Yarrell, Brit. Fishes, ed. 3, ii., p. 384.
" " ....Gunth., Brit. Mus. Cat., iii, p. 208.
" " ....DeKay, p. 158, pl. 16, fig. 43.
" " ....Nilss., Skand. Faun., iv, p. 208.
" maculatus ....Bloch., Schn., p. 496.

A very common fish in our waters, and perhaps the most voracious of all. When taken from the water it is covered with a thick coating of slime, which renders it difficult to be taken hold of. In February 1863, when examining the Greenland shark (*Scymnus borealis*) which had been taken by some of our fishermen, I observed two of these wolf-fish, of good size, protruding from its mouth, the shark having disgorged them after its capture.

ANGLER.—*Lophius piscatorius.*

Lophius piscatorius..............Linn., Syst., i, p. 402.
" " .... Cuv. et Val., xii, p. 344, pl. 362.

Lophius piscatorius ....Nilss., Skand. Faun., p. 245.
" " ....Gunth., Cat. Fishes, iii. p. 179.
" " ....Rich., Faun. Bor. Amer., p. 103.
" " ....Storer, Fishes of Mass., pp. 71, 404.
" Americanus..............DeKay, p. 162, pl. 28, fig. 87.

This is not an uncommon fish, although I have only had an opportunity of examining one specimen, which was forwarded by the Rev. J. Ambrose from St. Margaret's Bay.

BERGALL.—*Ctenolabrus burgall.*

Ctenolabrus burgall..............Gunth., Cat. Fishes, iv. p. 90.
" cœruleus..............DeKay, p. 172, pl. 29, fig. 93.
Crenilabrus burgall..............Storer, Fishes of Mass., p. 78.
Labrus burgall..............Bloch., Schn., p. 251.

This species is known to the fishermen as the 'conner.' It is abundant in Halifax Harbor during the summer months, and is readily taken with hook and line by boys at the wharves. In the summer of 1862, when the French fleet anchored here, the sailors used to catch them in great numbers for cooking, but the inhabitants rarely touch them. At St. Margaret's Bay, according to Mr. Ambrose, they are given as food to pigs; but as the pork of these fish-fed pigs always tastes oily in consequence, they are generally fed upon other food, and well dosed with sulphur, for a short time prior to being killed.

Gunther gives as a variety of this species *C. uninotatus*, which is taken in our harbor in company with the former. It differs in having a black spot on the base of the two anterior soft dorsal rays. DeKay makes it a distinct species.

PIPE-FISH.—*Fistularia* —— ?

A very fine specimen of this genus was taken on the 16th of September 1863, at Portuguese Cove, near Halifax. As I had only an opportunity of examining it for a few minutes after its purchase by a tradesman, the following very deficient description was all I could draw up at the time. It did not resemble very closely the *F. serrata* of Storer and DeKay, nor could I identify it with the *F. tabacaria* of the latter author, although the orbital processes corresponded. It was of greater size than either of the specimens mentioned by DeKay and Storer, and may possibly prove new to the Nova-Scotian fauna.

DESCRIPTION.—Extent from frontal extreme to caudal termination, 31 inches; from frontal extreme to base of snout immediately anterior to eye cup, 7 inches; from frontal extreme to commencement of dorsal, 24 inches 2 lines; from frontal extreme to posterior edge of opercle, 10 inches; from pectorals to ventrals, 4 inches 7 lines; from ventrals to anal, 8 inches 8 lines; from anal to caudal, 4 inches 1 line; breadth at fifteen inches from frontal extreme, 1 inch 7½ lines; over pectorals, 1 inch; over dorsal, 1 inch 2 lines; over caudal base, 4 lines; vertical base of caudal extreme, 3½ lines; width of mouth over base of snout, 5 lines.

Head:—Width over eyes, 8 lines; vertical depth over eyes, 9 lines. Two bony processes at anterior occipital angle of eye cup.

Mouth:—Vertical gape, 1 inch; horizontal gape, 7½ lines; armed with small teeth on vomer and jaws; lower jaw 2 lines in advance of upper.

Eyes:—Lateral diameter, 10 lines; vertical diameter, 5 lines.

Fins:—Pectoral; diameter at base, 7½ lines. Dorsal; diameter at base, 1 inch 2½ lines. Ventrals; extent, 9 lines; diameter at base, 3 lines. Anal; diameter at base, 1 inch 2½ lines. Caudal; extent, 1 inch 7½ lines; caudal filament broken off 1 inch 7½ lines from base.

Color:—Above, reddish brown; beneath, cupreous, longitudinally lined with white.—*Communicated by the Natural History Society of* [*St. John*] *New Brunswick.*

OBITUARY NOTICES.

CAPT. JAMES M. GILLISS, U. S. N.—Captain Gilliss, the Superintendent of the Washington Observatory, died suddenly, at Washington, of apoplexy, on Thursday, the 9th of February. The Naval Observatory, under his charge at the time of his death, was constructed from his plans, and equipped with its original instruments by him, during the years 1843–44, Congress having authorized its establishment by an Act passed in 1842; but only since 1861, when Maury, faithless to his country, left his post of duty, has it been under his abler direction. It would have been better for the scientific reputation of the country had it continued in his hands. An earlier observatory at Washington fitted up mainly by him, had been the scene of his labors from 1838 to 1842, and in the volume containing the results—the *first* volume of American Astronomical Observations—Mr. Gilliss expresses in his Preface, his pleasure that "the prosecution of these observations should have resulted in the foundation of a permanent Naval Observatory."

During the three years 1849 to 1851, Capt. Gilliss was in Chile in charge of the U. S. Expedition for determining the Solar Parallax; and if his observations failed of all that was expected of them, it was from the want of that coöperation in the northern hemisphere which was reasonably looked for by him. The National Intelligencer (Washington, U. S.) of the day before his death (Feb. 8), contains his last astronomical communication,—one relating to the planet Mars,—dated Feb. 7.

Capt. Gilliss was an observer of great skill and accuracy, a man of noble personal character, and a patriot in the highest sense of the word. Three of his sons have been in the recent armies of his country, and the eldest—a captain—reached home from the Libby prison, after four months' imprisonment, only the day before his father died.—*Silliman's Journal.*

George P. Bond.—It is seldom that astronomical science has received a more severe blow than that occasioned by the death of George Philips Bond, of Harvard College, Philips Professor of Astronomy, and Director of the Observatory connected with that institution. After a lingering illness of more than a year, during which his ardor in the study of the heavens led him oftentimes to exposures entirely incompatible with the state of his health, he closed a useful and an unblemished life on the 17th of February,—eight days after his compeer, Captain Gilliss.

As an accurate and truthful observer of astronomical phenomena, he was, without question, unequalled by any one in this country, and among the first in the world. In his short career he contributed many valuable papers of original discoveries and calculations to various periodicals and institutions in this and other countries. His greatest work, and that which gave him honor the world over, is his account of the Donati comet, which constitutes the third volume of the Annals of the Observatory. To this, the palm of unrivalled excellence has been freely awarded by the best astronomical observers of Europe.* Well trained by his lamented and dis-

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* We are informed that, a month since, Mr. Bond received word from President De La Rue, of the Royal Astronomical Society, that the Society, at its last annual meeting in January, had voted him a gold medal for his work on this comet.

tinguished father, and taking advantage of the best telescope mounted in so high a southern latitude, he explored with searching scrutiny the great nebula of Orion, a work which he pursued with untiring zeal and anxiety in his latter days; and while we fear his waning strength may have left it incomplete in form, we are assured, and rejoice in the assurance, that abundant ability remains in the observatory to prepare it for publication.

We might dwell much longer on his astronomical history, but the necessary brevity of this notice requires that we should turn to his private life. It is rare indeed, that so many virtues are blended in any man. His innocent unpretending manners, the perfect absence of every air of vanity or pretension, crowned with an unwavering Christian faith and deep sense of religious obligation, secured for him, not the mere respect, but the kindest regard of all who had the happiness of his acquaintance.—*Silliman's Journal.*

BIOGRAPHICAL NOTICE OF THE LATE HUGH FALCONER, M.D., &c. &c.—Hugh Falconer was one of those rare men,—an original discoverer; and his life is deserving of a larger record than that of a man who gains the popular fame of a discoverer by writing of other men's labors.

On the 29th of February 1808, Hugh Falconer was born at Forres, in the north of Scotland, a town best known from its traditional connection with the 'blasted heath' of Macbeth. He received his early education at the grammar school of Forres, and afterwards studied arts for four years at the University of King's College, Aberdeen, and medicine for four years at the University of Edinburgh. From the former University he received the degree of A.M., and from the latter, in 1829, the degree of M.D. As a boy, he had exhibited a decided taste for the study of natural objects, which he eagerly followed up in Edinburgh under the systematic tuition of Profs. Graham and Jameson. Qualified for the practice of medicine by the diplomas of the Royal College of Surgeons and of the University of Edinburgh, he was nominated to an appointment as assistant-surgeon on the Bengal Establishment. But not having attained the required age of twenty-two years, and the real bent of his mind being upon natural history, he devoted the compulsory interval to assisting the late Dr. Nathaniel Wallich, in the distribution of his great Indian herbarium, and to the study of geology and palæontology. The Museum of the Geological Society, under the charge of Mr. Lonsdale, gave him access to the collection of Indian fossil mammalia from the banks of the Irawaddy formed by Mr. John Crawford, during his mission to Ava. The description of these remains by Mr. Clift had excited much interest in the scientific world, as the first instance in which the ground was broken in the Palæontology of tropical regions. In both cases the occupation proved of material service to the subject of our memoir in his subsequent career, and in the latter instance it determined the labors to which he afterwards so zealously devoted himself. For, immediately after his arrival in Calcutta, in September 1830, he undertook the examination of a collection of fossil bones from Ava, in the possession of the Asiatic Society of Bengal, and communicated a short paper upon them, which appeared early in 1831, in the third volume of the 'Gleanings in Science,' an Indian journal then conducted by the late Mr. James Prinsep.

Early in 1831, Dr. Falconer was ordered to the army station of Meerut, in the north-western provinces. His first and last military duty during twenty-six years of service was to take charge of a detachment of invalids proceeding to the Sanatorium of Landour in the Himalayas. This led him to pass through Suharunpore, where the late Dr. Royle was then superintendent of the Botanic Gardens. Kindred tastes and common pursuits soon knit Falconer and Royle together; and at the instance of his friend, Falconer was speedily appointed to officiate for him during leave of absence, and, on his departure for Europe in 1832, to succeed him in charge of the Botanic Garden.

In 1832 Dr. Falconer commenced his field explorations by an excursion to the sub-Himalayan range; and from the indication of a specimen in the collection of his friend and colleague Captain, now Sir Proby T. Cautley, he was led to discover vertebrate fossil remains *in situ* in the tertiary strata of the Sewalik Hills. Early in 1834 Dr. Falconer gave a brief account of the Sewalik Hills, describing their physical features and geological structure, with the first published section showing their relation to the Himalayas.

The researches thus begun were followed, about the end of 1834, by the discovery, by Lieuts. Baker and Durand, of the great ossiferous deposits of the Sewaliks, near the valley of Markunda, westward of the Jumna and below Nahun. Capt. Cautley and Dr. Falconer were immediately in the field; and, by the joint labors of these four officers, a sub-tropical mammalian fossil Fauna was brought to light, unexampled for richness and extent in any other region then known. The Sewalik explorations soon attracted notice in Europe, and in 1837 the Wollaston medal in duplicate was awarded for their discoveries to Dr. Falconer and Capt. Cautley, by the Geological Society, the fountain of geological honors in England.

Concurrently with these researches, Dr. Falconer's official duties as superintendent of the Suharunpore Botanic Garden led him to explorations in the snowy range of the neighboring Himalayas. In 1834, a commission was appointed by the Bengal government to inquire into and report on the fitness of India for the growth of the tea plant of China. Acting on the information and advice supplied by Dr. Falconer, the commission recommended a trial. The government adopted the recommendation; the plants were imported from China, and the experimental nurseries were placed under Falconer's superintendence in sites selected by him. Tea-culture has since been greatly extended in the north-west.

In 1837 Dr. Falconer was ordered to accompany Burnes's second mission to Caubul, which preceded the Affghan war. United at Peshawur, the party consisted of Burnes, Mackeson, Leech, Lord, Wood, and Falconer. Of these six officers, the sole survivor now is Wood, the explorer of the Oxus. Dr. Falconer first proceeded westward to Kohat, and the lower part of the valley of Bunguish, in order to examine the Trans-Indus portion of the Salt range; and then, in company with Lieut. Mackeson, made for Cashmeer, where he passed the winter and spring, examining the natural history of the valley. The following summer (1838) he crossed the mountains to Iskardo, in Bulkistan, and, by the aid of Rajah Ahmed Shah, traced the Shiggar branch of the Indus to its source in the glacier on the southern flank of the Mooztagh range, now ascertained to be 28,200 feet above the level of the sea. Having examined the great glaciers of Arindoh and of the Brahldoh valley, he then returned to India, *via* Cashmeer and the Punjab, towards the close of 1838, to resume charge of his duties at Suharunpore. During the whole of this expedition to Cashmeer, Falconer kept copious diaries, which, it is to be hoped, are in a state fit for publication.

In 1840, his health, shattered by previous attacks of jungle fever, rheumatic fever, dysentery, and disease of the liver, the results of incessant exposure, gave way; alarming indications of constitutional break up set in; and in 1842 he was compelled to seek for a chance of recovery by sick leave to Europe, bringing the natural history collections amassed by him during years of exploration of the Himalayas and plains of India.

Soon after his arrival in England in the autumn of 1843, fresh duties devolved on him in connection with the Sewalik fossils. Capt. Cautley had presented his vast collection to the British Museum. Its extent and value may be estimated from the fact that it filled 214 large chests, and that the charges on its transmission alone to England amounted to £602 stg. Dr. Falconer's selected collection was divided between the India House and the British Museum. the great mass was presented to the former, but a large number of unique or choice specimens, required to fill blanks or improve series, was presented to the latter. Most of the specimens were still imbedded in matrix. The authorities at the India House fitted up a museum room specially for the reception of their acquisitions; and Sir Robert Peel's government gave a liberal grant to prepare the materials in the national museum for exhibition in the *Palæontological gallery. Dr. Falconer* was intrusted with the superintendence of the work, and rooms were temporarily assigned to him by the Trustees in the British Museum.

His botanical collections were less fortunate. Having partially suffered from damp on the voyage to England, they were left deposited in the India House during his second absence in India, and the specimens underwent a ruinous process of decay. In 1857 Dr. J. D. Hooker applied to the Court of Directors for the herbarium collections in the India House, and saved a few of the Cashmeer and Himalayan dried plants.

In 1848, on the retirement of the late Dr. Wallich, Dr. Falconer was appointed his successor as Superintendent of the Calcutta Botanic Garden, and Professor of Botany in the Medical College. In 1850 he was deputed to the Tenasserim Provinces to examine the teak forests, which were threatened with exhaustion from reckless felling and neglected conservation. His Report, suggesting remedial measures, was published in 1850, in the "Selections from the Records of the Bengal Government." In 1852 he communicated a paper "On the Quinine-yielding Cinchonas and their Introduction into India." In 1854, assisted by his friend, the late Mr. Henry Walker, he undertook a "Descriptive Catalogue of the Fossil Collections in the Museum of the Asiatic Society of Bengal," which was published as a distinct work in 1859. In the spring of 1855 he retired from the Indian Service;

and on his return home he visited the Holy Land, whence he proceeded along the Syrian coast to Smyrna, Constantinople, and the Crimea, during the siege of Sebastopol.

Soon after his arrival in England he resumed his palæontological researches, and in 1857 he communicated to the Geological Society two memoirs "On the Species of Mastodon and Elephant occurring in the Fossil State in England." Having occupied himself during several years with the special investigation of the mammalian Fauna of the pliocene, as distinguished from that of the quaternary period of Europe, he was conducted to the examination of the Cave Fauna of England. In 1860 he communicated a memoir on the numerous ossiferous caves of Gower, explored or discovered by his friend, Lieut.-Col. Wood. The existence of *Elephas antiquus* and *Rhinoceros hæmitæchus* as members of the Cave Fauna was then for the first time established, and the age of that Fauna precisely defined as posterior to the Boulder Clay, or period of the glacial submergence of England. In 1862, Dr. Falconer communicated to the British Association at Cambridge an account of *Elephas Melitensis*, the pigmy fossil elephant of Malta, discovered with other extinct mammals, by his friend, Capt. Spratt, C.B, in the ossiferous cave of Zebbug. This unexpected form presented the Proboscidia in a new light to naturalists.

For nearly thirty years Dr. Falconer had been engaged more or less with the investigation of a subject which has lately occupied much of the attention both of men of science and the educated classes generally, viz. the proof of the remote antiquity of the human race. In 1833, fossil bones, procured from a great depth in the ancient alluvium of the valley of the Ganges, in Hindostan, were figured and erroneously published as human. The subject attracted considerable attention at the time in India. In 1835, while this interest was still fresh, Dr. Falconer and Capt. Cautley discovered the remains of the gigantic miocene fossil tortoise of India, which, by its colossal size, realized the mythological conception of the tortoise which sustained the world on his back. About the same time, several species of fossil Quadrumana were discovered in the Sewalik Hills, one of which was thought to have exceeded in size the ourang-outang, while another was hardly distinguishable by millemetrical differences from the living 'Hoonuman' monkey of the Hindoos. Coupling these facts with the occurrence of certain existing species, and of the camel, giraffe, horse, &c., in the Sewalik Fauna, and with the further important fact that the plains of the valley of the Ganges had undergone no late submergence, and passed through no stage of glacial refrigeration to interrupt the previous tranquil order of physical conditions, Dr. Falconer and Capt. Cautley were so impressed with the conviction that the human race might have been early inhabitants of India, that they were constantly on the look out for the upturning of the relics of man or of his works from the miocene strata of the Sewalik Hills. In their account of the gigantic tortoise, after discussing the palæontological and mythological bearings of the case, they sum up by stating,—"The result at which we have arrived is, that there are fair grounds for entertaining the belief that the Colossochelys Atlas may have lived down to an early epoch of the human period, and become extinct since."

Ten years later, Dr. Falconer resumed the subject in India, while investigating the fossil remains of the Jumna. In May, 1858, having the same inquiry in view, while occupied with his cave researches, he communicated a letter to the Council of the Geological Society, which suggested and led to the exploration of the Brixham cave, and the discovery in it of flint-implements of great antiquity, associated with the bones of extinct animals. In conjunction with Prof. Ramsay and Mr. Pengelly, he drew up a report on the subject, which, communicated in the autumn of the same year to the Councils of the Royal and Geological Societies, excited the interest of men of science in the case. Following up the same object, he immediately afterwards proceeded to Sicily, to examine the ossiferous caves there, and discovered the 'Grotto di Maccagnone,' in which flint implements of great antiquity were found adhering to the roof-matrix, mingled with remains of hyænas now extinct in Europe. Having examined the collection of M. Boucher de Perthes, on his route to Sicily, he was impressed with the authenticity of some of the flint implements discovered in the valley of the Somme, and urged his friend, Mr. Prestwich, who is of the highest authority in this branch of geology, to proceed there, and investigate the conditions of the case. Thus, in 1859, the subject of the antiquity of the human race, which had previously been generally discredited among men of science, was again launched upon fresh evidence in both the stratigraphical and cave aspects. Since then it has been actively followed up by numerous inquirers; and Dr. Falconer himself was contemplating, and had indeed actually commenced, a work on 'Primeval Man.'

In 1863, Dr. Falconer took an active share in the singularly-perplexed discussion of the *cause célèbre* of the human jaw of Moulin-Quignon; and, in the conference of English and French men of science held in France, he expressed doubts as to its authenticity, but in that guarded and cautious manner which was characteristic of him. In the spring of last year he called attention in the 'Times' to an account of the remarkable works of art by 'Primeval Man' discovered by his friends, Messrs. Lartet and Henry Christy, in the ossiferous caves of the Dordogne; and in September he accompanied his friend, Prof. Busk, to Gibraltar, to examine caves in which marvellously well-preserved remains of man and mammals of great antiquity had been discovered. Before starting, he drew up, in conjunction with Mr. Busk, a preliminary report on the specimens brought from Gibraltar to this country, which was presented to the British Association at Bath. He suffered considerably from exposure and fatigue on his return journey through Spain from Gibraltar, so that the inclement winter told with additional force upon a constitution naturally susceptible of cold and weakened by long exposure and disease in India. On January 19th, on his return from a meeting of the Council of the Royal Society, he felt depressed and feverish. The attack speedily became developed into acute rheumatism, complicated with bronchitis and congestion of the lungs, which proved fatal on the morning of January 31st. On the 4th of February his remains were committed to their last resting-place, at Kensal Green, in the presence of a large number of his sorrowing friends and fellow-laborers.

From what has been said, it is obvious that Falconer did enough during his lifetime to render his name immortal in science as one of the greatest palæontologists that ever lived. But the work which he published was but a small fraction of that which he actually accomplished. The amount of scientific knowledge which has perished with him is prodigious, for he was cautious to a fault; he never liked to commit himself to an opinion until he was sure that he was right; and he has died, in the fulness of his power, before his race was run.—*Abridged from The Athenæum.*

REVIEWS.

"MONOGRAM OF THE BATS OF NORTH AMERICA." By H. Allen, M.D. Washington: Published by the Smithsonian Institute.

This is a valuable contribution to our knowledge of a group of animals little studied, though of great interest. As an incitement to their study, we take the following extracts from the introduction:—

Among the numerous agents which Nature employs for restricting the excessive increase of the insect world, the bats hold a conspicuous position. Eminently adapted to an animal regimen, the vast majority of these animals are exclusively insectivorous in their habits. Mosquitos, gnats, moths, and even the heavily-mailed nocturnal *Coleoptera*, fall victims in large numbers to their voracious appetites. Certain members of the order, such as flying Foxes (PTEROPODIDÆ), are strictly frugivorous, it is true; and others, as the Dog-bat of Surinam (*Noctula leporina*), classified as an insect-eating bat, partakes occasionally of fruit in addition to its more animal diet. None of the species found in this country, however, are known to subsist on any other than insect food. In this respect they hold a decided relationship to certain birds; and it is interesting to observe how, under different circumstances, these widely-separated animals serve us to the same end. The functions which the latter perform during the day, the former assume in the evening. The latter prey upon the diurnal insects, while the former feed exclusively upon the crepuscular and nocturnal kinds. The disappearance of the birds of day is a signal for the advent of the dusky host, which, as it were, temporarily relieve from duty their most brilliant rivals in guarding the interests of Nature.

But, while thus connected with birds in their position in the world's economy, bats have none of that grace of form or beauty of coloring so characteristic of the others. Their bodies are clumsy and repulsive; their hues are dull and unattractive; nor can the eye dwell with pleasure upon their grotesque and awkward motions. This aversion—so universally evinced toward these little animals —is heightened by the associations of the time and place of their daily appearance. Attendant, as they are, upon the quiet hours of twilight, when the thickening gloom is conducive to the development of superstitious feeling, bats have always been associated with ideas of the horrible and the unknown. In olden times, when the imagination of the people exceeded the accuracy of their observations, it was one of the numerous monsters inhabiting their caverns and forests. It has done service in many a legend; its bite was fatal; it was the emblem of haunted houses; its wings bore up the dragon slain by St. George.

It is easy to trace from this early impression the permanent position that the bat, as an emblem of the repulsive, held in letters and the arts. It is mentioned in the book of Leviticus as one of the unclean things. Its image is rudely carved upon the tombs of the ancient Egyptians. The Greeks consecrated it to Proserpine. It is part of the infernal potion of the witches in Macbeth, while Ariel employs it in his erratic flights. In art, its wings have entered largely into the creation of those composite horrors, evil spirits; nor have modern artists escaped from the absurdity of encumbering the Satan of Holy Writ with like appendages.*

Of this association with the monstrous the intelligent observer ceases to take note when the finer beauties of structure develop themselves under his gaze. Upon acquaintance, he learns, perhaps with surprise, that, in anatomical and physiological peculiarities, and zoological position, the bat is a subject for study worthy of the attention of the most contemplative. Indeed no order of animals is more interesting, and none has received greater attention from the hands of savans.

The early pioneers of natural history were far astray in their endeavors to correctly define the nature and position of the bat.

"Some authors place bats among the birds, because they are able to fly through the air; while others assign them a position among the quadrupeds, because they can walk on the earth. Some again, who admitted the mammalian nature of the creatures, scattered them at intervals through the scale of animated beings, heedless of any distinction excepting the single characteristic in which they took their stand, and by which they judged every animal.

* To this fancy of the ancients of placing the wings of a bat upon demons, is happily opposed the sweet conceits of poets in adorning the figures of angels and cherubim with the wings of birds. The wing of a bat is sombre and angular; that of a bird is of delicate hues, and replete with curves. It is therefore poetic justice to have the one become an emblem of the infernal, as the other is an expression of the heavenly form.

These are but a few of the diverse opinions which prevailed among the naturalists of former times, among which the most ingeniously quaint is that which places the bat and the ostrich in the same order, because the bat has wings, and the ostrich has not."*

Without reviewing the recorded errors of these observers, we will be content to call the attention of the reader to the following brief account of the structure of flying animals, so that the true position of the bat among them may be definitely fixed.

There are two distinct types of modifications which the vertebrate skeleton has undergone in adapting the animal for flight, both of which depend upon some peculiarity in the structure of the anterior extremities; and in order to obtain a correct opinion of them, we propose to cast a glance at each in turn.

The first act of the bat, after emerging in the evening from its retreat, is to fly to the water. The following account, illustrating the peculiarity, as well as showing the enormous numbers in which these animals will live together, is of great interest. It is from the pen of M. Figaniere, Minister to this country from Portugal, in a letter addressed to Prof. Henry, Secretary of the Smithsonian Institution:—

"In the winter of 1859, having purchased the property known as Seneca Point, on the margin of the Northeast River, near Charlestown, in Cecil County, Maryland, we took possession of it in May of the next year. The dwelling is a brick structure covered with slate in the form of an L two-storeyed, with garret, cellars, and a stone laundry and milk-house attached. Having been uninhabited for several years, it exhibited the appearance, with the exception of one or two rooms, of desolation and neglect, with damp, black walls, all quite unexpected, as it had been but very slightly examined, and was represented in good habitable condition, merely requiring some few repairs and a little painting.

"The boxes, bundles, and other packages of furniture which had preceded us, lay scattered around and within the dwelling: these, with the exception of some mattresses and bedding for immediate use, were hastily arranged for unpacking and placing in order at leisure. The weather, which was beautiful, balmy, and warm, invited us toward evening to out-door enjoyment and rest after a fatiguing day of travel and active labor; but chairs, settees, and benches were scarcely occupied by us on the piazza and lawn,

*Wood, Nat. His., 1 (Mam.), 114.

when, to our amazement, and to the horror of the female portion of our party, small black bats made their appearance in immense numbers, flickering around the premises, rushing in and out of doors and through open windows—almost obscuring the early twilight, and causing a general stampede of the ladies, who fled, covering their heads with their hands, fearing that the dreaded little vampires might make a lodgment in their hair.

"This remarkable exhibition much increased our disappointment in regard to the habitable condition of our aquisition, and was entirely unexpected, inasmuch as the unwelcome neighbors were in their dormant state and ensconced out of sight when the property was examined previous to purchase. With their appearance, and in such immense numbers, the prospect of immediate in-doors arrangement and comfort vanished; the paramount, the urgent necessity was to get rid of such a nuisance as quickly as possible; and the question was, by what means could this be accomplished. Our scientific friends and acquaintances, both in New York and Philadelphia, were consulted; various volumes of natural history where examined in order to ascertain the peculiar habits of the vermin, but we derived no effectual consolation from these sources. One of our friends, indeed, sent us from New York an infallible exterminator in a form of a receipt obtained at no inconsiderable cost. Strips of fat pork saturated with a subtle poison were to be hung up in places where the annoying creatures did most congregate; of this they would surely eat, and thus 'shuffle off their mortal coil.' How many revolving bat-seasons it might have re-required by this process to kill off the multitude, the urgency of the case would not allow us to calculate, and the experiment was therefore abandoned.

"Evening after evening did we patiently, though not complacently, watch this periodical exodus of dusky wings into light from their lurking-places one after another, and in some instances in couples and even triples, according as the size of the holes or apertures from which they emerged in the slate-roofing would permit. Their excursions invariably commenced with the cry of the 'whip-poorwill,' both at coming evening and early dawn; and it was observed that they always first directed their flight towards the river, undoubtedly to damp their mouse-like snouts, but not their spirits, for it was likewise observed that they returned to play hide and seek, and indulge in all other imaginable gambols; when, after gratifying their love of sport and satisfying their voracious appetites (as the absence of mosquitos and gnats testified), they would re-enter their habitation, again to emerge at the first signal of their feathered trumpeter. I thus ascertained one very important fact, namely, that the bat, or the species which annoyed us, ate and drank twice in twenty-four hours. Such appeared their habit, such therefore was their indispensable need. Upon ascertaining this fact, after having tried suffocation by the fumes of brimstone with only partial success, I concluded to adopt a more efficient plan of warfare ; and for this purpose commenced by causing all the holes, fissures in the wood-work, and apertures in the slating to be hermetically sealed with cement. This put a stop to their egress. But to avoid their dying by starvation and deprivation of water, which would manifold increase the annoyance by adding their dead to their living stench, I ordered apertures of about two feet square to be opened in the lathe and plastered partition on each side of the garret windows, and also in the ceiling of every garret room ; lastly, when the bats' reveille was sounded by the bugle of the whippoorwill, all the hands of our establishment, men and boys, each armed with a wooden implement (shaped like a cricket-bat), marched to the third floor, 'on murderous deeds with thoughts intent;' a lighted lantern was placed in the middle of one room, divested of all furniture, to allure the hidden foe from their strongholds. After closing the window, to prevent all escape into the open air, the assailants, distributed at regular distances to avoid clubbing each other, awaited the appearance of the bats, enticed into the room by the artificial light, and impelled by their own natural craving. The slaughter commenced, and progressed with sanguinary vigor for several hours, or until brought to a close by the weariness of dealing the blows that made the enemy bite the dust, and overpowered by the heat and closeness of the apartment. This plan succeeded perfectly. After a few evenings of similar exercise, in vhich the *batteurs* became quite expert in the use of their weapon,every wielding of the wooden bat bringing down an expiring namesake, the war terminated by the extermination of every individual of the enemy in the main building. However, there still was the cock-loft of the laundry, which gave evidence of a large population. In this case I had recourse to a plan which had been recommended, but was not carried out in regard to the dwelling-house. I employed a slater to remove a portion of the slating which required repairing. This process discovered some fifteen hundred or two thousand bats, of which the larger number were killed, and the remainder sought the barn, trees, and other places of concealment in the neighborhood.

"In the main building nine thousand six hundred and forty bats, from actual counting, were destroyed. This was ascertained in the following manner: After the battling of each evening the dead were swept in one corner of the room, and in the morning, before removing them to the manure-heap, they were carefully counted and recorded. Many had been killed before and some few after the reckoning was made, and were not included in it, nor were those killed under the adjoining laundry roof. The massacre commenced by killing fewer the first evenings, the number increasing, and then diminishing towards the end; but it was generally from fifty or a hundred, up to six hundred and fifty,—the highest mortality of any evening's work,—dwindling down to eight, five, three, and two.

"This species of bat is generally small, black, and very lively. Some smaller than the ordinary size were found, probably young ones, and one or two larger, supposed to be grandfathers, or of a reddish hue, which was thought to be from age. These vermin were generally more or less covered with a small-sized bug, not very dissimilar to the common chinch, but of a different species. As previously stated, the bat has a very disagreeable odor, which pertains to its ejection.

"The manure, as well as the bodies of the slain, was used to fertilize the flower and vegetable garden; and thus, in some degree, they served to compensate us for the annoyance to which we had been subjected. The manure, however, required to be applied with caution; since, if used in too large a quantity, it appeared to burn the organism of the plants.

"To remove the very disagreeable odor which remained in the upper part of the house, various kinds of disinfectants were employed with some advantage; but the most effectual method resorted to was that of opening holes of about four inches square, two at each gable-end, to permit a current of air to pass through.

"These holes were covered with iron gauze to prevent the reentrance of any of the remainder of the army of the enemy which might hover around the premises.

"At the end of five years the odor has now nearly disappeared, being hardly perceptible during a continuance of very damp weather."

The fact mentioned above of the numerous parasites infesting bats is perhaps the most revolting features in these creatures. The enormous population of *Acari* found upon their bodies is due to the great generation of animal heat in their close haunts, a condition conducive to a rapid increase of all kinds of vermin. In this country the common bed-bug (*Cimex lectularis*) is frequently found upon their fur. The entrance of a bat with its precious burden, into the open window of a farm-house, is the solution of that frequently-propounded question of the despairing house-wife, "Where *can* the bugs come from?"

Of individual anecdotes of bats we have but few examples. The following, illustrating the material instinct, is taken from Godman's Nat. Hist., i, 1831, 56. It is narrated by Mr. Titian Peale:—

"In June, 1823, the son of Mr. Gillespie, the keeper of the city square, caught a young red bat (*L. Nov-Eboracensis*), which he took home with him. Three hours afterwards, in the evening, as he was conveying it to the Museum in his hand, while passing near the place where it was caught, the mother made her appearance and followed the boy for two squares, flying around him, and finally alighted on his breast, such was her anxiety to save her offspring. Both were brought to the Museum—the young one firmly adhering to its mother's teat. This faithful creature lived two days in the Museum, and then died of injuries received from her captor. The young one, being but half grown, was still too young to take care of itself, and died shortly after."

Like most specialists in these days, the author has a tendency to form genera and families on very trivial characters, and thus arrives at a classification which, though convenient for reference, is not natural. As a consequence of this, he elevates the bats to the rank of an *Order*, an arrangement which certainly will not accord with any natural division of the class Mammalia.

Of the species described in the work, the following have been recognised at Montreal:

Lasiurus cinereus, Palisot de Beauvois, (the Hoary Bat).
Lasiurus Nov-Eboracensis, Tomes, (the Red Bat).
Scotophilus noctivagans, Leconte, (the Silvery-haired Bat).
Vespertilis subulatus, Say, (the Little Brown Bat).

"Flora of the British West-Indian Islands." By A. H. R. Grisebach, M.D., Professor of Botany, in the University of Gottingen, London, 1864.

This is one of the Colonial Floras, to which reference has often been made in our pages. It includes all the Phenogamic plants and vascular Cryptogamia, with full indices and a table of the local names. Dr. Gray says of it: "The preface gives an account of the circumstances under which the work was undertaken, and of the materials which the author so sedulously and promptly elaborated. West-Indian botany was very difficult and confused: 'Almost all the principal authors who have written on West-Indian plants belong to the last century, and consequently to the Linnæan school, and a general synopsis of West-Indian plants has never before been attempted, not even by Swartz, whose flora contains descriptions of his new species only, with a few remarks on allied forms.' Moreover, the British West Indies offer only the separate fragments of a larger flora. Trinidad, as its geographical situation indicates, naturally belongs to the flora of Venezuela and Guiana. The northern Bahamas might be supposed to have a vegetation very like that of East Florida, from which they are separated by the Gulf Stream; but this seems not to be the case. 'Jamaica, again, from its mountainous character and more distant position; most of the Leeward islands, from being wooded volcanos; and the majority of the windward ones, with a dry climate and a low calcareous soil,—form three divisions of this tropical archipelago, which show as many peculiarities. Thus the whole of the British West Indies, as comprised in this flora, may be divided into five natural sections, each with a distinct botanical character.' Altogether they amount to about 15,000 English square miles, or nearly twice the area of Wales. But yet Hayti alone is nearly twice, and Cuba nearly thrice, as large as all the British Islands together, and not only far richer in vegetation, but far less explored; the publications of Jacquin, Swartz, &c., having been almost confined to the British possessions; so that it was with old species mainly, that Dr. Grisebach had to deal, those which were 'the foundation, indeed, of our scientific knowledge of the flora of tropical America. And these have so often been misunderstood that their synonyms are far more numerous than their numbers.' A general West-Indian flora being out of the present question, we learn with interest that Dr. Grisebach is preparing a special paper on the geographical range of the West-Indian plants, including the capital island of Cuba, which Mr. Charles Wright has so industriously and successfully explored through its length and breadth, and is expecting still further to explore."

COUNT RUMFORD AND HIS RESEARCHES ON HEAT.—The highest law in physical science which our faculties permit us to perceive, is, to quote the words of Faraday, "the Conservation of Force." The generalizations which serve to illustrate this great principle of the conservation of force in all its varied applications, are generally referred to as the law of the Correlation of Forces, and have been set forth by various writers within the last twenty years. Prof. Youmans, who is already favorably known for his new Class-book of Chemistry,—a work which deserves, by its lucid method, scientific accuracy, and felicity of illustration, to supersede all others as an elementary manual,—has just rendered an important service to the scientific student by bringing together in a single volume a series of expositions of this doctrine of the correlation and conservation of force,* by Grove, Helmholtz, Mayer, Faraday, Liebig, and Carpenter. With the exception of the first named, a treatise of considerable extent, and of great merit, which has gone through at least two editions, and the wonderful essay of Mayer on Celestial Dynamics, the productions here collected are scattered through scientific journals not always accessible to the general reader. Besides bringing them together with notes, explanatory remarks, and a good index, Dr. Youmans has, in a modest introduction of forty pages, given a review of the subject, and has called attention to the labor of that most remarkable thinker of our day, Herbert Spencer, who, to use our author's words, "has the honor of crowning this sublime inquiry by showing that the law of conservation, or, as he prefers to call it, of the Persistence of Force, as it is the underlying principle of all being, is also the fundamental truth of all philosophy."

It would have added to the value of this excellent compilation if our author had included in it the essay of Dr. Joseph Henry, on the Conservation of Force, published in the Agricultural Report of the United States Patent Office for 1857, and in Silliman's Journal [2], xxx, 32; and Dr. Joseph Leconte's exposition of the Correlation of Physical, Chemical, and Vital Forces, and of the Conservation of Forces in Vital Phenomena, which appeared in the same Journal [2], xxviii, 305. A valuable, and in many respects,

* The Correlation and Conservation of Forces: a series of expositions by Prof. Grove, Prof. Helmholtz, Dr. Mayer, Dr. Faraday, Prof. Liebig, and Dr. Carpenter. With an introduction and brief biographical notices of the chief promoters of the new views: by Edward L. Youmans, M.D. New York: D. Appleton & Co. Montreal: Dawson Brothers.

original contribution to this subject will be found in a thesis by Dr. Maurice Bucke on the Correlation of Physical and Vital Forces, Montreal, 1862.

Our object at present, however, in noticing Dr. Youmans's book is to bring before our readers his sketch of the life and scientific labors of Count Rumford, to whom, as he has proved, belongs the merit of having, long before any other one, shown that heat was a mode of motion, demonstrating its immateriality and the conversion of its mechanical force into heat. It is, says Dr. Youmans, with a just feeling of national pride, that we recall that "the two men who first demonstrated the two capital propositions of pure science, that lightning is but a manifestation of electricity, and heat but a mode of motion, were not only Americans by birth and education, but men eminently representative of the peculiarities of American character—Benjamin Franklin and Benjamin Thompson, afterwards known as Count Rumford."

"Benjamin Thompson was born at Woburn, Mass., in 1753. He received the rudiments of a common school education; became a merchant's apprentice at twelve, and subsequently taught school. Having a strong taste for mechanical and chemical studies, he cultivated them assiduously during his leisure time. At seventeen he took charge of an academy in the village of Rumford (now Concord), N. H., and in 1772 married a wealthy widow, by whom he had one daughter. At the outbreak of revolutionary hostilities he applied for a commission in the American service, was charged with toryism, left the country in disgust, and went to England. His talents were there appreciated, and he took a responsible position under the government, which he held for some years.

"After receiving the honor of knighthood, he left England and entered the service of the elector of Bavaria. He settled in Munich in 1784, and was appointed aide-de-camp and chamberlain to the Prince. The labors which he now undertook were of the most extensive and laborious character, and could never have been accomplished but for the rigorous habits of order which he carried into all his pursuits. He reorganized the entire military establishment of Bavaria, introduced not only a simple code of tactics, and a new system of order, discipline, and economy among the troops, and industrial schools for the soldiers' children, but greatly improved the construction and modes of manufacture of arms and ordnance. He suppressed the system of beggary, which had grown into a recognized profession in Bavaria, and become an enormous public evil;—one of the most remarkable social reforms on record. He also devoted himself to various ameliorations, such as improving the construction and arrangement of the dwellings of the working classes, providing for them a better education, organizing houses of industry, introducing superior breeds of horses and cattle, and promoting landscape-gardening, which he did by converting an old abandoned hunting-ground near Munich into a park, where, after his departure, the inhabitants erected a monument to his honor. For these services Sir Benjamin Thompson received many distinctions, and among others was made Count of the Holy Roman Empire. On receiving this dignity he chose a title in remembrance of the country of his nativity, and was thenceforth known as Count of Rumford.

"His health failing from excessive labor and what he considered the unfavorable climate, he came back to England in 1798, and had serious thoughts of returning to the United States. Having received from the American government the compliment of a formal invitation to revisit his native land, he wrote to an old friend requesting him to look out for a 'little quiet retreat' for himself and daughter in the vicinity of Boston. This intention, however, failed, as he shortly after became involved in the enterprise of founding the Royal Institution of England.

"There was in Rumford's character a happy combination of philanthropic impulses, executive power in carrying out great projects, and versatility of talent in physical research. His scientific investigations were largely guided and determined by his philanthropic plans and public duties. His interest in the more needy classes led him to the assiduous study of the physical wants of mankind, and the best methods of relieving them; the laws and domestic management of heat accordingly engaged a large share of his attention. He determined the amount of heat arising from the combustion of different kinds of fuel, by means of a calorimeter of his own invention. He reconstructed the fire-place, and so improved the methods of heating apartments and cooking food as to produce a saving in the precious element, varying from one-half to seven-eighths of the fuel previously consumed. He improved the construction of stoves, cooking-ranges, coal-grates, and chimneys; showed that the non-conducting power of cloth is due to the air enclosed among its fibres, and first pointed out that mode of action of heat called *convection;* indeed he was the first clearly to discriminate between the three modes of propagation of heat,—radiation, conduction, and convection. He determined the almost perfect non-conducting properties of liquids, investigated the production of light, and invented a mode of measuring it. He was the first to apply steam generally to the warming of fluids and to the culinary art; he experimented upon the use of gunpowder, the strength of materials, and the maximum density of water, and made many valuable and original observations upon an extensive range of subjects.

"Prof. James D. Forbes, in his able Dissertation on the recent Progress of the Mathematical and Physical Sciences, in the last edition of the Encyclopedia Britannica, gives a full account of Rumford's contributions to science, and remarks:

'All of Rumford's experiments were made with admirable precision, and recorded with elaborate fidelity, and in the plainest language. Every thing with him was reduced to weight and measure, and no pains were spared to attain the best results.

'Rumford's name will be ever connected with the progress of science in England by two circumstances; first, by the foundation of a perpetual medal and prize in the gift of the council of the Royal Society of London, for the reward of discoveries connected with heat and light; and secondly, by the establishment in 1800 of the Royal Institution in London, destined primarily for the promotion of original discovery, and secondarily for the diffusion of a taste for science among the educated classes. The plan was conceived with the sagacity which characterized Rumford, and its success has been greater than could have been anticipated. Davy was there brought into notice by Rumford himself, and furnished with the means of prosecuting his admirable experiments. He and Mr. Faraday have given to that institution its just celebrity, with little intermission, for half a century.'

"Leaving England, Rumford took up his residence in France, and the estimation in which he was held may be judged of by the fact that he was elected one of the eight foreign associates of the Academy of Sciences.

"Count Rumford bequeathed to Harvard University the funds for endowing its professorship of the Application of Science to the Art of Living, and instituted a prize to be awarded by the American Academy of Sciences for the most important discoveries and improvements relating to heat and light. In 1804 he married the widow of the celebrated chemist Lavoisier, and with her retired to the villa of Auteuil, the residence of her former husband, where he died in 1814.

"Having thus glanced briefly at his career, I now pass to the discovery upon which Count Rumford's fame in the future will chiefly rest. It is described in a paper published in the transactions of the Royal Society for 1798.

"He was led to it while superintending the operations of the Munich arsenal, by observing the large amount of heat generated in boring brass cannon. Reflecting upon this, he proposed to himself the following questions: Whence comes the heat produced in the mechanical operations above mentioned? Is it furnished by the metallic chips which are separated from the metal?

"The common hypothesis affirmed that the heat produced had been latent in the metal, and had been forced out by *condensation* of the chips. But if this were the case, the capacity for heat of the parts of metal so reduced to chips ought not only to be changed, but the change undergone by them should be sufficiently great to account for *all* the heat produced. With a fine saw Rumford then cut away slices of the unheated metal, and found that they had *exactly the same capacity for heat as the metallic chips.* No change in this respect had occurred, and it was thus conclusively proved that the heat generated could not have been held latent in the chips. Having settled this preliminary point, Rumford proceeds to his principal experiments.

"With the intuition of the true investigator, he remarks that 'very interesting philosophical experiments may often be made, almost without trouble or expense, by means of machinery contrived for mere mechanical purposes of the arts and manufactures.' Accordingly, he mounted a metallic cylinder weighing 113.13 pounds avoirdupois, in a horizontal position. At one end there was a cavity three and a half inches in diameter, and into this was introduced a borer, a flat piece of hardened steel, four inches long, 0.63 inches thick, and nearly as wide as the cavity, the area of contact of the borer with the cylinder being two and a half inches. To measure the heat developed, a small round hole was bored in the cylinder near the bottom of the cavity, for the insertion of a small mercurial thermometer. The borer was pressed against the base of the cavity with a force of 10,000 pounds, and the cylinder made to revolve by horse-power at the rate of thirty-two times per minute. At the beginning of the experiment the temperature of the air, in the shade, and also in the cylinder was 60°F.; at the end of thirty minutes, and after the cylinder had made 960 revolutions, the temperature was found to be 130°F.

"Having taken away the borer, he found that 839 grains of metallic dust had been cut away. 'Is it possible,' he exclaims, 'that the very considerable quantity of heat produced in this experiment—a quantity which actually raised the temperature of upward of 113 pounds of gun-metal at least 70°—could have been furnished by so inconsiderable a quantity of metallic dust, and this merely in consequence of a change in the capacity for heat?'

"To measure more precisely the heat produced, he next surrounded his cylinder by an oblong wooden box in such a manner that it could turn water-tight in the centre of the box, while the borer was pressed against the bottom. The box was filled with water until the entire cylinder was covered, and the apparatus was set in action. The temperature of the water on commencing was 60°. He remarks, 'The result of this beautiful experiment was very striking, and the pleasure it afforded amply repaid me for all the trouble I had taken in contriving and arranging the complicated machinery used in making it. The cylinder had been in motion but a short time when I perceived, by putting my hand into the water and touching the outside of the cylinder, that heat was generated.'

"As the work continued, the temperature gradually rose; at two hours and twenty minutes from the beginning of the operation, the water was at 200°, and in ten minutes more it actually boiled! Upon this result Rumford observes, 'It would be difficult to describe the surprise and astonishment expressed in the countenances of the bystanders, on seeing so large a quantity of water heated and actually made to boil without any fire. Though there was nothing that could be considered very surprising in this matter, yet I acknowledge fairly that it afforded me a degree of childish pleasure which, were I ambitious of the reputation of a grave philosopher, I ought most certainly rather to hide than to discover.'

"Rumford estimated the total heat generated as sufficient to raise 26.58 pounds of ice-cold water 180°, or to its boiling-point; and he adds, 'from the results of these computations, it appears that the quantity of heat produced equally, or in a continuous stream, if I may use the expression, by the friction of the blunt steel borer against the bottom of the hollow metallic cylinder, was *greater* than that produced in the combustion of nine wax candles each three-quarters of an inch in diameter, all burning together with clear bright flames.

'One horse would have been equal to the work performed, though two were actually employed. Heat may thus be produced merely by the strength of a horse, and in a case of necessity this might be used in cooking victuals. But no circumstances could be imagined in which this method of producing heat could be advantageous, for more heat might be obtained by using the fodder necessary for the support of the horse, as fuel.

'By meditating on the results of all these experiments, we are naturally brought to that great question which has so often been the subject of speculation among philosophers, namely, What is heat? Is there such a thing as an igneous fluid? Is there anything that with propriety can be called caloric?

'We have seen that a very considerable quantity of heat may be excited by the friction of two metallic surfaces, and given off in a constant stream or flux *in all directions*, without interruption or intermission, and without any signs of *diminution* or *exhaustion*. In reasoning on this subject we must not forget *that most remarkable circumstance*, that the source of the heat generated by friction in these experiments appeared evidently to be *inexhaustible*. [The italics are Rumford's.] It is hardly necessary to add, that anything which any *insulated* body or system of bodies can continue to furnish *without limitation*, cannot possibly be a *material substance;* and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in those experiments, except it be MOTION.'

"No one can read the remarkably able and lucid paper from which these extracts are taken, without being struck with the perfect distinctness with which the problem to be solved was presented, and the systematic and conclusive method of its treatment. Rumford kept strictly within the limits of legitimate inquiry, which no man can define better than he did. 'I am very far from pretending to know how, or by what means or mechanical contrivances, that particular kind of motion in bodies, which has been supposed to constitute heat, is exerted, continued, and propagated, and I shall not presume to trouble the Society with new conjectures. But although the mechanism of heat should in part be one of those mysteries of nature which are beyond the reach of human intelligence, this ought by no means to discourage us, or even lessen our ardor in our attempts to investigate the laws of its operations. How far can we advance in any of the paths which science has opened to us, before we find ourselves enveloped in those thick mists, which on every side bound the horizon of the human intellect!'

"Rumford's experiments completely annihilated the material hypothesis of heat, while the modern doctrine was stated in explicit terms. He moreover advanced the question to its quantitative and highest stage, proposing to find the numerical relation between mechanical power and heat, and obtained a result remarkably near to that finally established. The English unit of force is the foot-pound, that is, one pound falling through one foot of space; the unit of heat is one pound of water heated 1°F. Just fifty years subsequently to the experiment of Rumford, Dr. J. P. Joule, of Manchester, England, after a most delicate and elaborate series of experiments, determined that 772 units of force produce one unit of heat; that is, 772 pounds falling through one foot produces sufficient heat to raise one pound of water 1°F. This law is known as the mechanical equivalent of heat. Now, when we throw Rumford's results into these terms, we find that about 940 units of force produced a unit of heat, and that, therefore, on a large scale, and at the very first trial, he came within twenty per cent. of the true statement. No account was taken of the heat lost by radiation, which, considering the high temperature produced, and the duration of the experiment, must have been considerable; so that, as Rumford himself noticed, this value must be too high. The earliest numerical results in science are rarely more than rough approximations, yet they may guide to the establishment of great principles. Certainly no one could question Dalton's claim to the discovery of the law of definite proportions, because of the inaccuracy of the numbers upon which he first rested it.

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"Those doctrines [of the correlation and conservation of forces] have received their subsequent development in the various directions, by many minds, but we may be allowed to question if the contributions of any of their promoters will surpass, if indeed they will equal, the value and importance which we must assign to the first great experimental step in the new direction.

"The claims of Rumford may be summarized as follows:

I. He was the man who first took the question of the nature of heat out of the domain of metaphysics, where it had been speculated upon since the time of Aristotle, and placed it upon the true basis of physical experiment.

II. He first proved the insufficiency of the current explanations of the sources of heat, and demonstrated the falsity of the prevailing view of its materiality.

III. He first estimated the quantitative relation between the heat produced by friction and that by combustion.

IV. He first showed the quantity of heat produced by a definite amount of mechanical work, and arrived at a result remarkably near the finally-established law.

V. He pointed out other methods to be employed in determining the amount of heat produced by the expenditure of mechanical power, instancing particularly the agitation of water, or other liquids, as in churning.

VI. He regarded the power of animals as due to their food, therefore as having a definite source and not created; and thus applied his views of force to the organic world.

VII. Rumford was the first to demonstrate the quantitative convertibility of force in an important case; and the first to reach, experimentally, the fundamental conclusion that heat is but a mode of motion.

"In his late work upon heat, Prof. Tyndall, after quoting copiously from Rumford's paper, remarks: 'When the history of the dynamical theory of heat is written, the man who, in opposition to the scientific belief of his time, could experiment, and reason upon experiment, as did Rumford in the investigation here referred to, cannot be lightly passed over.' Had other English writers been equally just, there would have been less necessity for the foregoing exposition of Rumford's labors and claims; but there has been a manifest disposition in various quarters to obscure and depreciate them. Dr. Whewell, in his history of the Inductive Sciences, treats the subject of thermotics without mentioning him. An eminent Edinburgh professor, writing recently in the Philosophical Magazine, under the confessed influence of 'patriotism,' undertakes to make the dynamical theory of heat an English monopoly, due to Sir Isaac Newton, Sir Humphrey Davy, and Dr. J. P. Joule; while an able writer in a late number of the North British Review, in sketching the historic progress of the new views, puts Davy forward as their founder, and assigns to Rumford a minor and subsequent place."

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