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THE

CANADIAN NATURALIST.

SECOND SERIES.

NOTES ON THE GEOLOGY AND BOTANY OF NEW BRUNSWICK.

By Professor L. W. Bailey.

In a Report which I have had the honor to lay before His Excellency the Lieutenant-Governor of the Province relating to the mines and minerals of New Brunswick, some reference has been made to the results obtained during a tour from Fredericton to Bathurst, and by an examination of the rivers of Tobique and Nepisiquit. Much of the information thus obtained being unsuitable for the more especial purposes of that Report, I have, at His Excellency's desire, determined to compile the more interesting facts for presentation to the Society of Natural History. This paper, therefore, is intended as a Supplement to the Report above alluded to. It is my object to write down in as connected a form as possible, the various rambling observations of a scientific character made during a canoe exploration of the streams above-mentioned. Much of the country travelled over has not been heretofore scientifically examined; and although my trip was of too hurried a character to admit of very careful examinations, it is hoped that some of the results obtained may not be without interest and value.

Leaving the village at the mouth of the Tobique, on the 29th of June, in company with three volunteer friends, and four Indians, with their canoes, we reached the sources of that river on the 5th of July. This stream, or a portion of it, having already been the subject of a former exploration, I shall endeavor to make my observations on its character as brief as possible.

The proper outlet of the Tobique River is not apparent at its mouth, the land being low, and the stream much hidden by overgrown alluvial islands. To the geologist the true embouchure is the remarkable spot called the "Narrows," situated but a short distance above the Indian village. These narrows constitute one of the most curious and beautiful scenes to be found in the Province. The rocks which here cross the bed of the river, and which are well exposed in the perpendicular cliffs 150 feet high on both sides of the stream, are composed of slates and schists, filled with seams of quartz and limestone, and pursue a course about N. 34° E. The channel is very tortuous, and in most parts deep, having an average width of about 150 feet. The navigation of the stream is at all times difficult, requiring the utmost skill of the Indians, but during periods of freshet, becomes perfectly impassable. It is probable that a fall once existed at this place, and that the present gorge, which is about a mile in length, has been left by the gradual wearing away of the strata, until the course of the river becomes comparatively unimpeded.

Between the Narrows and the Red Rapids, which are about 11 miles distant from the mouth of the river, the land is of moderate elevation, occasionally becoming bold and picturesque. Some five miles above the Narrows, the stream passes near the base of high and precipitous cliffs of ferruginous rock, overhung with cedar, while the opposite shore is low and covered with a mixture of hard and soft woods. Occasionally terraced banks are evident, but they are much less numerous, and less remarkable than those on the river St. John. In no case did I observe more than one at the same spot, and they, as a rule, were of but little elevation. Four miles above the Narrows, a small stream, called the Pokiok, joins the main river, entering on the west bank by a fall through rock apparently dipping about sixty degrees to the northwest. Through all this district the land appears fertile, and the vegetation luxuriant. Among the trees noticed were elms and mountain ash of enormous size, cedar, spruce, fir, birch, thorn, and poplar. Of herbaceous plants I noticed the following: *Tiarella, cordifolia, Trillium erectum,* small, yellow lady's slipper; *Cypripedi-*

um parviflorum, *Iris versicolor*, *Anemone Pennsylvanica*, *Cornus Canadensis* (in flower very abundant), *C. stolonifera*, *Streptopus amplexifolius*, *Clintonia borealis*, *Viburnum opulus*, *Sanicula marilandica*, *Veronica Anagallis*, *Ranunculus acris*, *Thalictrum dioicum*, and *Primula Americana*.

The wild onion (*Allium Schoenoprasum?*) was also common upon the shore, with butter-cups, dandelions, violets, wild roses, and strawberries. Grasses and ferns were also abundant on strips of intervale, but I did not have leisure to determine them. The latter were especially luxuriant, frequently attaining a height of four and five feet. Among them I recognized *Pteris aquilina*, *Onoclea sensibilis*, *Struthiopteris*, and *Osmunda regalis*. The slates and limestones, which occupy the lower portion of the stream, are succeeded, about a mile and a half below the Red Rapids, by the outer beds of the Tobique Red Sandstone District, which, gradually widening, attains a very considerable development, and finally disappears in the neighborhood of the Blue Mountains. The soil rapidly assumes a deep, red tint, and strata of reddish sandstones are exposed in cliffs upon the shore. The red tint first becomes apparent upon the right bank of the stream; but at the Red Rapids, the sandstones, associated with coarse, red conglomerates, cross the bed of the river, with a strike about N. 70° E., and are exposed upon either bank. It is at this spot that the formation should properly begin in the coloring of our geological maps.

The Red Sandstone District of the Tobique is one of great interest and value. The rocks composing it are red and variegated sandstones, limestones, and conglomerates, with salt springs and beds of gypsum. The strata are nowhere much disturbed, and in general are of very moderate elevation. In many places the red sandstones are well exposed in the bed of the river, and being nearly horizontal, form a smooth and polished bottom. The soil of the district is excellent, and probably few portions of the Province offer so many inducements for settlement.

Near the Wapske or Wapskabegan one of the largest tributaries of the Tobique. the red sandstone strata are well exposed in nearly horizontal beds, dipping to the southeast at an angle of only five degrees. At the mouth of the Wapskabegan they are again exposed, and are interstratified with fine beds of white and pink and reddish gypsum. These are probably but a continuation of those referred to, and the line of strike between the two is N. 62° E., the dip being as above, about five degrees to the southeast. The gypsum is both compact and fibrous, and could be very readily removed for local use or transportation.

About two miles above this river, the red sandstone strata are again exposed, associated with gypsum, in what are known as the "Plaster Cliffs," attaining an elevation of 135 feet. The beds are nearly horizontal, and are apparently divided by frequent joints. The cliffs are very precipitous, in some parts overhanging the stream, and are in a very crumbling and dangerous condition. They are succeeded by other sandstones higher up the stream, with much less gypsum, and having a strike nearly north and south. They here form the bed of the river; and it seemed as we passed over them as if our canoes were gliding along a pavement of massive freestone slabs, polished by the action of the water, and here and there worn into holes by the eddies and pebbles. It is a little singular that, at the Plaster Cliffs and elsewhere, although the gypsiferous sandstones attain on the left bank of the stream an elevation of more than a hundred feet, and rise precipitously from the water, they do not appear at all upon the right, or only in beds a few feet above the level of the river.

In the geological reports of Dr. Gesner allusion is made to the existence of limestone beds about one mile above Plaster Island, and to the cavernous nature of the shore. I was unable to detect the locality referred to. We passed a spot where land travelling certainly appeared difficult and dangerous, but I saw nothing indicating the existence of former caves. Neither did I observe the stalactites, referred to by Dr. Gesner, as abundant upon the shore; but, at a spot about ten or twelve miles above the Wapske, and in the neighborhood of the Little Agulquac, I had the pleasure of finding great numbers of limestone geodes, in loose beds, overlying horizontal strata of reddish sandstones. These sandstones are divided by parallel joints, having a strike N. 62° E. (the same as that at the Wapskabegan), and form the bed of the river. The geodes are of about four inches diameter, and are lined upon their interior with fine large crystals of dog-tooth spar. This locality will afford excellent cabinet specimens.

From the Agulquac to the immediate vicinity of the Blue Mountain range, the soil continues reddish, sandstone boulders lie in the bed of the river, and immense beds are occasionally exposed. The sandstones *in situ* are distinctly seen at the Horse Island, a little more than fifty miles above the mouth of the river, and again at the Two Brooks, from which a fine view is afforded of Blue Mountain in the distance. About here I observed lying in the bed of the stream a number of boulders of milk-white quartz, highly crystallized within, but on the exterior much water-worn and rounded. The soil is apparently fertile, and the river abounds in rich intervale islands, sustaining a luxuriant vegetation. Besides many of the plants already named, I gathered by the side of the stream a single specimen of the Nodding Trillium, *Trillium cernuum*, a plant which has not, so far as I know, been found in any other portion of the Province—also *Polygonatum multiflorum*.

Higher up the stream a more distinct view of the Blue Mountain range becomes apparent. Its central peak is sharply conical, its sides making an angle of about 120°. It rises immediately from the river bank, and at its base is exposed high precipices of thinly wooded trap. A portion of the mountain is undoubtedly red sandstone, but the precipitous cliffs and *taluses* along its flanks distinctly indicate the trappean character of the summit. Near its base are seen cliffs of bright red sandstone, which I found to be calciferous like those farther down the river; but they did not, like the latter, contain distinct geodes.

Between the Blue Mountain and Nictau or Forks the land in the vicinity of the river is low, and fertile, presenting to the geologist but little of interest. At one spot only, a ridge, composed of dark, heavy, and compact rock, very much broken and distorted, crosses the bed of the river. It is apparently grauwacke, but lacks the mica of the latter.

Near the Nictau or Forks several streams combine to form the main river. The two main branches, flowing the one east and the other west, after uniting turn abruptly, and pass off to the southward. The River Marmosekel also here joins the main river.

After leaving the Nictau, and pursuing the left branch (so called, although geographically the right), the character of the country rapidly changes, becoming comparatively sterile, and supporting a much more Alpine vegetation than the district below. The trees are principally pines, firs, and cedars, covered with a long, pendant lichen (*Usnea barbata*, attaining a length of four or five feet), and the ferns are generally low, presenting little variety. One of the most common was *Onoclea sensibilis*. A few miles above the Forks, heavy beds of slates or flags cross the stream with a strike N. E. and S. W., dippi·g to the northwest at an angle of 45° and more, breaking the course of the river, and producing a fall of about one foot. The water at this point is rapid, but after passing the exposed rocks again becomes deep and tranquil. In this portion of the stream the land is low, with few trees, but is thickly covered with blade alder bushes; the soil as far as visible, being principally sand and gravel. The course of the river is very tortuous, running successively to all points of the compass. To the right of its general course, at a distance of about a mile, a high ridge is apparent for many miles, pursuing a course about N. 30° E. Gravel beds are very numerous, and occasionally large boulders are found in the stream. The pebbles composing the former are principally slaty; but rounded lumps of milky quartz are also common, with a variety of silicious rocks, among which we found a fine-tinted, transparent cornelian, jasper, and a little chalcedony.

In the vicinity of a small st-eam called the Cedar Brook, which enters the river from the northeast, we passed over strata of fine, dark slate nearly perpendicular, and having a strike about N. E. and S. W. These slates are visible for some distance, and have seams of white quartz, and sometimes of limestones, running through them. Near here I examined the plants upon the bank, and observed *Trient ilis Americana*, *Clintonia borealis*, *Oxalis acetosella*, *Smilacina bifolia*, *Linnaea borealis*, *Cornus Canadensis*, *C. stolonifera*, *Viburnum opulus*, *Sagitta sagittifolia*, *Streptopus distortus*. wild currants and raspberries, *Thalictrum* (four or five feet high), *Mitella nuda*, and *Smilacina stellata*.

The Little Tobique receives its waters from a chain of romantic lakes, completely shut in by high granitic mountains. The first of these is about two miles long and one broad, and lies at the very base of Bald or Sagamook Mountain, one of the highest peaks in New Brunswick. It is but one of a continuous chain, but rising abruptly from the lake seems to stand aloof from its less elevated companions. It is of a gently swelling outline, and, although distinc ly covered with vegetation at its summit, exposes on its sides broad and precipitous cliffs, laid bare by the action of slides, which have piobably suggested its rather inappropriate name. With three others of the party I ascended the mountain, and was well repaid by the extensive view afforded in every direction. The height, as given by Gesner, is 2,240 feet; but as he did not, I believe, visit the mountain himself, I am unaware of his authority for the assertion. I should suppose the summit to be about one-fourth of a mile above the surface of the lake, but had no means of measurement.

The ascent of the mountain is a remarkably steep one, being as much as 45° by actual clinometer measurement. It rises immediately from the side of the lake (not at a distance of several miles, as represented in all the maps of the province), and shows upon its flanks three distinct zones of vegetation. The first of these zones consists of a dense growth of pines, firs, and cedars, and extends about a third of the distance up the mountain side. The second is principally composed of white and yellow birch, with a few cedars and alders, and reaches to a very considerable elevation. The third zone is confined to the summit, and a small portion of the sides, being covered wi h a low dwarf growth of shrubs, with a few stunted birches and spruces. At many points near the summit there is no vegetation at all, the rocks being laid bare in extensive slides, and the fragments being piled upon each other in the wildest confusion. At several points, generally immediately above these slides, perpendicular masses or needles project from the general slope of the mountain, and can only be reached with difficulty. The mountain, so far as I had an opportunity of examining it, is composed of a compact red feldspar rock or felsite, and is very homogeneous in character. The entire slope of the mountain is strewed with large broken blocks of the same material, which, being overgrown with moss, and often covering deep holes, make the ascent a somewhat dangerous as well as difficult one. Boulders of similar material were also noticed far down the valley of the Tobique. I have already alluded to the three zones of vegetation on the mountain, which are equally noticeable during an ascent, or when viewed at a distance from the lake below. The herbs and shrubs noticed were about the same as those observed on the Little Tobique. The Labrador Tea (*Ledum latifolium*) was very common, increasing in quantity as we approached the summit, while *Cassandra caliculata* was also found growing abundantly. I noticed also *Trillium erectum*, *Oxalis acetosella*, *Trientalis Americana*, *Aralia nudicaulis*, *Cornus Canadensis* *Clintonia borealis*, *Streptopus amplexifolius*, *Sagittaria sagittifolia*, *Smilacina bifolia*, quantities of *Vaccinium ulig nosum*, and *Gaultheria hispidula*. Lichens were also abundant, especially *Cornicularia* and *Cenomyce rangiferina*.

There are several islands in Nictau Lake, which, pre enting as they do, great contrast to the mountain-peaks around them, should not be passed over without notice. One of these only, where we encamped for the night, I had an opportunity of examining, but the others are probably of a like description. The island referred to is about fifty feet in length and thirty in breadth, rising to a height of about ten feet above the lake, and presenting at its top a nearly smooth and level surface. The material composing it is a compact slate, and the line connecting this with the other islands above mentioned would be about N. E. and S. W. There is no continuation of such material observable on the Bald Mountain side of the lake, nor is it probable on the other, there being nothing visible but high and rugged peaks, undoubtedly igneous. I did not, however, examine the shore. The sides of the island sink nearly perpendicularly into the lake, and the depth of water surrounding them must be very considerable, as we were unable to reach bottom with our longest fishing lines.

The vegetation of the island is scanty, but quite different from anything else seen in this section of the province. There are no full-grown trees upon it, but only one or two dwarf spruces and pines, with an occasional cedar. Of herbs and shrubs I noticed the following: *Ledum latifolium*, *Sisyrinchiumanceps*, *Vaccinium Pennsylvanicum*, *V. Vitis Idaea*, *V. uliginosum?* *Solidago lanceolata?* *Potentilla Norvegica*, *Corydalis glauca*, and *Sambucus pubens*.

The occurrence of these islands, rising like needles from the bottom of the lake, and so far as visible of an entirely different character from the mountain-peaks around, is not a little singular and difficult of explanation.

The character of this portion of the province can well be studied from the summit of Sagamore Mountain. It is essentially a high table-land, sloping gradually towards the St. John, yet in its higher parts everywhere broken up into lofty hills and mountains. I was unable to ascertain any prevailing direction for the chains, peak after peak appearing wherever the eye was turned. The general direction of the lakes is about east 20° south, their form being quite irregular. The Bald Mountain range seems to pursue a course nearly parallel. This is undoubtedly the highest land in the province, and, I have heard it stated on good authority, that, with the aid of a glass, one can see to the north the mountain range of Gaspé, and again in the extreme southwest, the lofty summit of Katahdin.

The Nepisiquit, like the Tobique, has its source in a chain of romantic lakes, surrounded by lofty granite mountains. The lakes in neither case are perfectly distinct, being rather simple *expansions* of single lakes. There are three of these expanded sheets at the head of the Tobique, and four at the sources of the Nepisiquit. The portage connecting the two lines of water-shed does not exceed three miles, and now here attains an elevation of more than fifty or sixty feet.

The general direction of this transit is a little south of east, and it is merely an obscure and little-frequented footpath through the woods. The soil seemed fertile, and the vegetation varied—the plants noticed being about the same as already given The ascent from the Nictau Lake is very gradual, and near the middle of the portage the land is low and swampy. From here it again ascends until very near the Nepisiquit Lake, when it falls rapidly away to that level. I should suppose that the latter lake occupies a somewhat higher level than those on the Tobique. There are no rocks apparent anywhere on the line of crossing.

During this portion of our tour, the members of our party were greatly tormented by the incessant biting of black flies and musquitoes. The development of insect life in this portion of New Brunswick is very remarkable, and the number of insects and the ease with which they can be obtained would fully satisfy the most ardent entomologist. All the orders of insects seem to be represented, and by a great variety of genera and species. Butterflies of all shades and varieties of gaudy coloring, eight or ten different kinds of flies, gnats, mosquitoes, spiders, caterpillars, gadflies, dragon-flies, and beetles are found in the greatest profusion. I sometimes saw fifty or more butterflies swarming at rest upon a single rock, and allowing one to pick them up by the handful. Every day, and indeed almost every hour of the day, produced some new individual; and one of our party, who was a great entomologist, met with numbers which he had never seen or even read of before. A very valuable and interesting collection might be here made. The best season for such a purpose would be about the beginning of July, as they afterwards become much less numerous, and in August almost disappear.

The Nepisiquit Lakes are four in number, connected with each other by narrow straits. A line connecting them all would run nearly east and west. They are not so deep as those of the Tobique; the bottom in the Third Nepisiquit Lake being in many places, even near the centre, not more than two feet below the surface, while from the little island in Nictau Lake we were unable to reach bottom with twenty feet of line. The former are, like the latter, shut in by mountain ranges, but their elevation is not so great as those already described. Along the shores of the Nepisiquit Lakes I observed *Iris versicolor* and *Typha latifolia* growing abundantly, also *Nuphar advena*, *N. Kalmiana*, *Equisetum limosum*, *E. sylvaticum*, and *E. uliginosum*.

The Nepisiquit passes out from the lakes much more quietly than the Tobique, and descending by a rapid but unbroken current passes around the base of handsome hills, clothed with a rich green covering of birch and spruce. The land close to the river is low and covered with alder bushes, but some lofty mountains appear to the southward. The stream pursues at first a nearly uniform course a little west of south, without winding much, like the Tobique. Its bed is strewed with large and travelled granitic boulders, which though not wanting on the Tobique were much less numerous than here.

The mountains just alluded to, pursue a course, as nearly as I could make out, a little north of east, crossing the river, which works its way around their base. They are undoubtedly granitic, and in many places expose upon their flanks high and rugged cliffs of a brick-red color, giving at first the appearance of a red sandstone district. The boulders, however, which occur in the bed of the stream, distinctly indicate their character, being composed of a corse-grained feldspathic granite or *granulite*.

Near the base of one of these cliffs we were borne by the current, and so remarkable were its characters, that I at once determined to give it a more careful examination. Landing for this purpose, and approaching with one companion and an Indian guide, what we supposed to be the natural slope of the mountain, we were suddenly stopped by a tremendous chasm, which unexpectedly lay open before our feet.

The defile is about fifty or seventy feet deep, with almost precipitous sides, and furnishes a picture of singular wildness. The two sides of the chasm were in the most marked contrast. That by which we approached was steep and broken though covered with vegetation, while the opposite slope, which was almost perpendicular at its base, and which reached high up the mountain sides, was one dense mass of large detached blocks of reddish granite, or else the original rock from which they had been torn. On this side of the chasm scarcely a trace of vegetation could be seen, as far as the eye could reach.

The two sides of this singular defile are as strongly contrasted in their mineralogical characters as in the features just described. The first or lowest side is composed of a fine compact greyish syenite, much weathered on the surface, and covered with vegetation; the other is of the same material as the boulders I had already found farther up the river, viz.: a coarse-grained feldspathic granite, or granulite. There is no mica present in it, and but little hornblende. It is but little weathered, looking fresh and red, and, as before stated, is almost destitute of vegetation. The direction of the defile, at the point where we examined it, was nearly east and west, but soon turned off to the northward, when it could be no longer traced from where we stood. I would gladly have occupied a longer time in its exploration, but could not well afford the delay. As a point of reference for this vicinity, of which so little has heretofore been known, I have ventured to call this singular range the "Feldspar Mountains" in allusion to the mineralogical character of its principal rocks. The locality is about fifteen miles, as near as I can judge, above the Forks of the Nepisiquit River. On my journey to and from the mountain I found the following plants: *Kalmia angustifolia*, *Ribes rubrum*, *Epilobium spicatum*, *Linnaea borealis*, *Oxalis acetosella*, and others.

Below the Feldspar Mountains for a distance of many miles, the country is high and rugged, and presents an indescribably desolate appearance. As far as the eye can see, the mountain slopes have been stripped of their vegetation by extensive fires, and nothing but the charred trunks of decaying trees is now visible. Mountains are seen in every direction, the principal chain pursuing a course parallel to that of the river, about east and west. The latter descends rapidly, gliding almost in a straight line, and without a fall, down an inclined plane of three or four degrees. Boulders of feldspathic and syenitic rocks are at times very numerous; and from the fact that we passed them only at intervals, according to the windings of the current, I am inclined to think that they cross the stream in regular trains, pursuing a uniform general direction, a little south of east. These boulders are of the same material as that of the mountains I have described above, and increase in numbers and magnitude as one descends the stream. A few miles below the Forks (where the soil is alluvial, and supports extensive groves of elms) these boulders attain an enormous size, and cause numberless falls and rapids in the current. Many of them are injected with veins of milky quartz, and at times appear to be jointed. They continue to increase in quantity until one reaches a spot called the Indian Falls, where rocks *in situ*, together with huge granitic boulders, block up the stream and produce a fall of four or five feet. This is succeeded about half a mile below by another of similar elevation, the space between the two being filled with dangerous rapids. The rocks appear laminated and contorted, and are filled with veins of injected quartz, and pass the stream in a line running about 10° west of North. A portage was here necessary, during which I observed the following plants: *Wild-roses, currants,* and *huckleberries, raspberries, white* and *red clover, Epilobium spicatum, Potentilla arguta, Sagittaria sagittifolia, Kalmia angustifolia, Chrysanthemum leucanthemum, Allium Schoenoprasum, Spiraea salicifolia, Pyrola elliptica, Platanthera, orbiculata ?* and *Smilacina stellata.* A short distance below the Forks I noticed also, *Archangelica, Diervilla trifida* (not seen on the Tobique), and *Caltha palustris.*

About twenty miles above the Grand Falls of the Nepisiquit we passed the first formations of distinctly stratified rocks, consisting of slates and ferruginous slaty sandstones, much broken and contorted. They seemed to run nearly east and west, and dip northward (?) at a sharp angle. Some of the beds of slate appear to be of excellent quality.

These rocks are visible for a considerable distance, and have a strongly ferruginous color. At one point a high cliff, composed of them, projects into the stream, and was so intensely red, as to induce me to stop for the purpose of examination. I at first supposed it to be a bed of haematite, but it proved to be merely a magnesian slate, with only an external resemblance to the above named one. Much of it is soft and crumbling, and might, perhaps, be employed as a mineral paint. Some of it is probably *manganesian* also, and resembles the slates at the Tatagouche mines, in the vicinity of Bathurst. The latter are probably but continuations of the same series.

Below this point, the bed of the river is strewed with small and rounded boulders, of the size of paving-stones, and presents a very singular appearance. They are of three kinds, a bright red (feldspathic), a dark (syenitic), and green stone, and being polished brightly by the water, suggest the idea of a mosaic pavement. More ferruginous strata soon appear, dipping westward, and granitic boulders again become common. Granite ridges soon appear *in situ*, and seem to have displaced and to have been thrust through the other strata. The stream becomes rapid and violent, the vegetation of its banks poor and stunted.

The above-named rocks continue for a short distance only. About five or six miles above the Grand Falls, they are succeeded by beds of slates and slaty sandstones, with some limestone, dipping into the bed of the river at an angle of 60° to the north, the river here running about northeast. The course of the stream is nearly at right angles to the strike of the slates, which form precipitous cliffs, perhaps seventy-five or one hundred feet in height. Like the similar gorge at the mouth of the Tobique, this spot is called the Narrows, and can only be navigated by the most skilful Indians.

Between the Narrows and the Grand Falls, sandstone beds appear with a strike about north and south, and dip to the westward at a high angle.

The Grand Falls of the Nepisiquit are too well known to require description here, their beauty and the excellent salmon-fishing at their base having long since attracted travellers to the spot. Geologically, the fall has been the result of the gradual wearing away of consolidated strata; the direction of the current having been probably determined by some pre-existing fissure in the beds. The rocks composing the gorge below the falls (which is about half a mile in length) are composed of contorted ferruginous slates, having a strike nearly north and south, and a dip of 50° to the westward. Through these slates the water has worked its way, gradually widening the channel, and running for a portion of its course directly opposite to the dip of the strata, but towards the lower part making a sudden turn southward, and then nearly following their strike. On the rocks below the falls I noticed in flower, *Campanula rotundifolia*, *Potentilla arguta*, and wild roses. Many of these rocks are filled with numerous crystals of cubic pyrites.

Leaving the gorge, we soon passed over more sandstones and slates, still dipping westward. At a place called "The Great Chain" they have a dip of about 60° to the west, and cross the stream with a strike about north and south, forming a series of falls and rapids. With these sandstones are associated chloritic and talcose slates, conformable with them. At this point, besides the two plants above named, I noticed, *Allium Schœnoprasum? Sisyrinchium anceps, Diervilla trifida, Aralia nudicaulis, Streptopus distortus, Linnæa borealis. Clintonia borealis, Iris veriscolor, Cornus Canadensis, Platanthera dilatata, Archangelica, Achillaea, Lactuca elongata, Thalictrum dioicum, Apocynum androsæmifolium, Oenothéra chrysantha, Stellaria,* and *Aspidium spinulosum.*

A few miles below the Great Chain, more laminated sandstones cross the stream, with a strike N. 40° W., with a nearly perpendicular dip, highly silicious, and filled with crystals of sulphuret of iron. They soon change their course, taking a strike N. 20° E., and are much folded and contorted. With these are associated ferruginous slates, and the whole have a reddish appearance from the oxidation of their contained iron. The stream is narrow, and passes rapidly between the rocky banks.

Still descending, beds of impure iron-stone and ochre, with micaceous iron, appear on either shore, being of a soft and crumbling character. Several of the cliffs exposed upon the shore are of a bright red color. They may be seen on the left bank to overlie nearly horizontal beds of ferruginous sandstone, with small conglomerate and pebble beds, these latter in turn resting upon granite. The rocks appear to be much rounded and water-worn, even at an elevation of ten or fifteen feet above the present level of the river. The reddish beds seem to lie in a great basin formed by the underlying granite, or rather the latter forms a series of anticlinal axes, the slate and sandstone beds reposing on their flanks.

The granite beds are divided into huge blocks by parallel vertical joints, and thus present upon their river face the appearance of a wall. Their surfaces are perfectly flat; and those which form the river bed, being polished by the wear of the current, look like a massive pavement. It is in passing over these pinkish granites, that the river is wearing out the curious channels of the Pabineau Falls.

The granites at the falls are distinctly jointed, the line of the joints running due north and south. The course of the stream is parallel to these, and has probably been determined by one or more existing in its bed. The spot is one of the most singular I have seen in the Province.

Between the Pabineau and Bathurst our journey was made by land; the navigation of the river, which is one series of rapids, called the "Rough Waters," being too dangerous for canoes. From good authority, however, I have learned that the granite beds at the Falls are succeeded by slates and schists (to some extent copper-bearing); and these again underlie, near the mouth of the river, the red sandstones and conglomerates which form the north-eastern boundary of the New Brunswick coal-measures. The latter are seen near the Nepisiquit bridge, on both sides of the river; but it is not probable that they extend far below the city of Bathurst. On the left bank, near the bridge, is a curious spot, where coal (lignite?) and copper ore are intimately associated, and interstratified with sandstones, clay, and conglomerates. It was in consequence of the discovery of copper at this point, under these singular circumstances, that examinations were made for that metal farther inland, which examinations led to the discovery of the present mining-districts on the Tatagouche River. These latter are situated in bluish and dark brown slates, having a strike E. 10° S. and a southerly dip of 50°. They are probably continuous with the beds south of Pabineau, and extend for a distance of ten or twelve miles along the coast, above Bathurst, being exposed on the Nigadoo and other minor streams of that region. They seem to be highly metalliferous.

I have now given with considerable detail the results of a fortnight's ramble on these hitherto little-known rivers. Their examination was necessarily a hurried and imperfect one, the distance travelled over being not less than two hundred miles; and the results are only presented now, that a more just and accurate view may be entertained of this interesting region.

To those who are familiar with the geology of New Brunswick, it will have already become apparent that much of what has now been stated differs widely from the formerly entertained notions as to the structure of this portion of the Province. That these differences may be the more readily appreciated, I have appended to this article a carefully colored map of the district, showing as far as possible the order of succession of the rocks here exposed. The following are the most important differences between this and preceding maps:

1st. Upon Dr. Robb's map the whole course of the Tobique, with the exception of the Red Sandstone District, is colored as if passing through Upper Silurian rocks. In reality most of the country between the Blue Mountain Brook and the Forks is of a trappean character.

2nd. The calciferous slates of the Narrows are separated from the Red Sandstone district by ferruginous slates and dark sandstone. The calciferous slates and the sandstones have a northeasterly strike, and similar rocks are again seen above the Forks, with the same strike. They are probably continuous.

3rd. The exact limits of the Red Sandstone District, on the line of the river, are the Red Rapids and the Blue Mountains,

4th. The Blue Mountain and Bald Mountain rise directly from the waters of the lake or river, not at the distance of several miles, as represented on other maps.

5th. On the map of Dr. Robb no distinction is made between trappean, syenitic, and feldspathic rocks. In the accompanying map, the Blue Mountains, which are trappean, are distinguished from the Bald Mountain and Nepisiquit ranges, which are chiefly feldspathic. There is an island of slate in Nictau Lake.

6th. The upper half of the Nepisiquit, on Dr. Robb's map, is marked as running through upper Silurian strata. On the contrary the whole district, colored yellow on my map, is feldspathic, consisting partly of *granulite* and partly of *syenite*, more particularly the former. Rocks of this character, forming lofty mountain ranges, cross the stream in a northeasterly direction, and are seen nearly as far as the Indian Falls. At the latter place highly altered rocks cross the stream, with a strike 10° west of north.

7th. The granite band which has been supposed to cross the Province, from the Chepatnecticook Lakes, and which on Dr. Robb's map has the same width at the Nepisiquit which it exhibits elsewhere, really narrows in the vicinity of that stream to a very small strip, and probably soon disappears. Owing to the tortuosities of the river, these rocks appear at several successive points, and at first would lead one to believe in the existence of several granitic anticlinal axes. From the fact however that all the slates seen above the Pabineau have a westward dip, it is probable that only one band is successively exposed. Where this band finally disappears is a matter of much doubt, but it will not probably be found far beyond the position which I have assigned to it. The metalliferous slates which rest on its northern flanks re-appear on the Tatagouche River, and, as already remarked, the latter are probably continuous with those on the Nepisiquit. Possibly the granite, after passing the Pabineau, is well exposed again; but this remains to be determined.

I have only to add that my observations were, as a rule, made from a rapidly moving canoe, and must only be regarded as approximately accurate. Where the character of the country could not be ascertained, from the occurrence of belts of intervale, or the presence of alluvial matter, or boulders, the map has been left devoid of color. The granitic region assigned to the serpentine on the map is copied from that of the late Dr. James Robb.

(Read before the Natural History Society of New Brunswick, 12th February 1864.)

ON THE CHEMISTRY OF MANURES.

We extract from the Report of the Second Class of the International Jury of the Great Exhibition of 1862, the following paper. The Reporter, Prof. A. W. Hofmann, F.R.S., tells us that having invited Mr. F. O. Ward to furnish him with a succinct view of the question of manures in their relations to agricultural chemistry, the following essay was the result; which Prof. Hofmann characterises with justice as "one of the ablest and most philosophically-conceived compendiums of a complex and difficult subject which has ever come under his notice." He therefore adopted and endorsed his coadjutor's work; adding for incorporation with it, much valuable information of a special kind furnished him by Messrs. Lawes, Gilbert, Gruning, and others. With these explanatory remarks, we invite the attention of our readers to this remarkable essay, premising only that we have omitted for the sake of brevity certain portions, inserting in their places an abstract of them in brackets, and have also appended a few notes.—EDITORS.

EARLY HISTORY OF MANURES.—Manures, in the form of cattle-dung and ordinary farm-yard composts, have been known and employed from time immemorial for the fertilization of the soil; but the manures termed "artificial," which have their origin elsewhere than in the farm itself, and are for the most part of concentrated and portable character, have but of late years come largely into use. Nevertheless the manufacture of these manures, and the trade to which they have given rise, already rank amongst the most extensive of modern industries.

[The author here gives a brief history of the various processes proposed and patented in England for the preparation of artificial manures during the first third of this century. They were but three in number, of which two were for the utilization of night-soil, while a third proposed the use of a mixture of oyster-shells and gypsum. In the course of the eighteenth century three patents for manure were obtained, one of which described a mixture of sea-salt, saltpetre, lime, and Rhenish tartar, declared to "possess a magnetic quality whereby it attracts fertility, etc."]

COURSE OF EARLY SCIENTIFIC RESEARCH.—In the mean time, however, a vast store of scientific information, tending more or less directly to the elucidation of this important subject, had been in slow and silent course of accumulation, by the successive labors of many eminent experimentalists.

Not to go back further than the last century, nor even than its latter half, we shall find concentrated in this brief period, a series of brilliant discoveries, bearing more or less directly upon the manurial and agricultural questions, but far too numerous even for the most cursory narration here. Space would fail us even to enumerate the names of European celebrity that adorned this memorable epoch; but if we had to select half a dozen of the most illustrious to represent the philosophical activity, British and continental, of the period, we would venture to single out on the one hand, Black, Priestley, and Cavendish — and on the other, Lavoisier, De Saussure, and Berthollet.

During the fifty years in question the nature and composition of *air* and *water*, of *carbonic acid* and *ammonia*, (the four main forms of volatile plant-food,) were discovered, their gaseous elements isolated, and their properties determined.

The sciences of geology and meteorology at this period also began to take shape and form; enabling an insight to be gained into the origin and nature of cultivable *soils*, and into the *climatic* conditions of plant-growth.

At the same time the laws of the physical forces, particularly those of light and heat, began to be better understood, as well in their general relations, as in their special influence on plants.

The introduction of more accurate chemical methods permitted, meanwhile, a closer investigation than had before been possible, of the tissues and products of plants, and of the various transformations which those products undergo during the several stages of vegetal development.

The sound physico-chemical principles thus established had the happiest influence on physiological investigations. The organs of plants and of animals were studied in a clearer light than before; and their respiratory, assimilative, and excretory processes, together with the relations established by those processes between the three great kingdoms of nature, were gradually made out.

Among the many illustrious men who assisted in working out these great results, Lavoisier probably deserves the highest place; not, perhaps as the largest contributor of new truths to the accumulating store,—though his contributions of this kind were many and brilliant,—but because his vivid imagination, and the eminent generalizing powers with which he was endowed, enabled him to co-ordinate all the scattered researches of his time, and to display innumerable isolated facts in their true subserviency to general laws; so as (among other things) largely to extend our knowledge of the cosmic equilibrium on which sound husbandry can alone be based. Everything, indeed, that Lavoisier did bore the impress of his master-mind. He it was who first applied the Balance to the study of the phenomena of Life. He it was who first showed that while plants evolve oxygen, animals, on the contrary, consume it; carbon being oxidized or burned in their bodies as oil is burned in a lamp. His lofty tone of thought, and eloquent language, powerfully impressed his contemporaries; and chiefly to his influence and example the admirable researches of his age owe their high scope and scrupulous precision. Science never endured a severer loss than when Lavoisier met his untimely fate. But his great spirit lived after him; and researches bearing upon the noble themes he had loved to treat were carried on with, if possible, increased activity after his death. The scientific records of Europe were soon crowded with fresh masses of undigested discovery; and in a few years such another mind as his was wanted, to grapple with the growing mass of detail, and once more to create order out of the scientific chaos.

Early in the present century England, in her turn, produced a master-mind,—that of the illustrious Sir Humphrey Davy,—vast in scope and luminous in conception, as any, the greatest, of foregone times. Davy was well fitted to wear the fallen mantle of Lavoisier, and to continue his great work. It is accordingly to Davy's genius we owe that memorable treatise—truly described by Liebig as "immortal"—the "Elements of Agricultural Chemistry."

In that imperishable work all the scattered results of foregone research in this branch of science were collected and reduced to a system, which was extended and enriched by the author's own capital researches; whereof, perhaps, the most signal (in this department of science) were his analytical investigations of soils (types of all that has since been done in that way); his capital determinations of the composition and transformations of vegetal products; and his admirable experiments on the nutrition of plants, as well by leaf as by root.

To the powerful impulse and just direction impressed by Lavoisier in France, and Davy in England, in subsequent investigations of like kind, may be ascribed in a great measure their vigorous and successful prosecution by philosophers contemporary with ourselves. Of these an encyclopædic list cannot, of course, be given here; and among so many equally illustrious names, it would be difficult to single out a few, as types to represent the rest. Suffice it to say, that to the exertions of these able men we owe a large proportion of the experimental data, on which, as on a firm foundation, the edifice of modern agricultural science, physical, chemical, and physiological, has, so to speak, been, stone by stone, built up. Honor and gratitude to those who have patiently hewn out those stones from the quarry of undiscovered truth!

But as the true value of the quarried stones is only made apparent by their judicious collocation in the edifice according to the plan of the architect, so also do experimental data, separately accumulated by the toil of many, only appear in their true value and significance when comprehensively embraced, co-ordinated, and, as it were, fused into a harmonious whole, by the fiery genius of one master-mind. Such a mind was Lavoisier's in the last century; such a service was rendered by Davy to our fathers; and such, to ourselves, are the mind and the service of Justus Liebig.

Thus have France, England, and Germany, in the course of about a century, successively produced the three great Lawgivers of Modern Husbandry.

It was in the year 1837 that the British Association for the Advancement of Science, perceiving the immense accumulation of facts, for the most part unsystematized, which had already taken place in organic chemistry, and was annually increasing therein, invited Justus Liebig, who had already attained to eminence by his extensive researches in this branch of science, to write a report upon its then condition; which honorable duty the illustrious philosopher undertook. In the year 1840, Liebig, in fulfilment of this engagement, produced his memorable work on "Organic Chemistry in its Applications to Agriculture and Physiology." In ordinary hands such a report would, in all probability, have been but a compilation, more or less compendious, of facts already known, and conceptions already proposed for their co-ordination. But the original genius of Liebig, essentially philosophical and constructive, impressed upon his work a very different character.

He began by sweeping away the fallacious theoretical views which were at that time in vogue,—particularly the so-called "Humus theory,"—and replacing them by a theory of his own, wider in scope, and more conformable with truth. With this, the so-called "Mineral theory," as a general clue for his guidance, Liebig was enabled to thread the labyrinth of intermingled facts and fallacies, which had necessarily resulted from so many investigations, inductive and deductive, carried on for so many years, by so many independent thinkers and experimentalists, and recorded in so many scattered memoirs. All of these he was enabled to weigh and appreciate, by the criterion of a new law, or rather system of laws, themselves evolved during his large induction, and established (in a great measure) by help of the very facts they served to elucidate and connect.

Profiting by the controversial criticism which his book, on its appearance, did not fail to provoke, Liebig made it more perfect in successive editions; and extended it by additional volumes, some modestly entitled "Familiar Letters," some promulgated as codes of Natural Law, but all forming parts of a connected series, in which, as in a mirror, is displayed the progressive development of Liebig's views, in the light of his own and of contemporary researches. By these labors, pursued with unwearied industry during upwards of twenty years, Justus Liebig has unquestionably shed upon his all-important theme a flood of light, as copious and brilliant to the full as that which it successively received, in former days, from the luminous minds of Lavoisier and Davy. Indeed, of the affiliation of his labors to those of his immediate predecessor, Liebig himself, in the dedication of his work to the British Association, speaks with becoming humility and justifiable pride:—

"I have endeavored," he says, "to follow the path marked out by Sir Humphrey Davy, who based his conclusions only on that which was capable of examination and proof. This is the path of true philosophical inquiry which promises to lead us to truth, the proper object of our research."

Of Liebig's views, and of the rapid and profound revolution of opinion they brought about, occasion will arise to speak in a subsequent page. Meanwhile, it may suffice to remark that, amongst other things, they completely overthrew the conceptions previously entertained as to the nature and operation of manures.

[Here referring again to the history of patent manures in England, the author remarks, that, as a result of the newly-awakened interest in the subject of scientific agriculture, no less than ninety-six patents for manures were registered between 1850 and 1855; and he estimates that the whole number of such patents registered from 1842 to 1862 was at least 200.]

This long series of inventions comprises plans and processes for turning to account, as manure, almost all the known forms of animal waste and ejecta: such as, for example, the night-soil and sewage of towns; the rags of woollen, silken, and leathern clothing; the débris of manufactures in which horn, bone, hides, bristles, gut, and other organic and nitrogenous materials are used; the spent animal or bone charcoal of the sugar refineries, and other phosphatic residua; the ammoniacal liquors of gas-works; the alkaline wash-waters of soap, dye, bleach, and many other factories; —in a word, several hundred forms of residua,—nitrogenous, phosphatic, and alkaline,—formerly cast away as worthless rubbish.

These, the respective patentees propose to subject to various processes, mechanical, physical, and chemical: such as, for example, in the case of liquors, to concentration by boiling down, or precipitation by chemical agency; in the case of solid residua, of crushing, grinding, or other process of comminution; or to chemical disintegration by powerful solvents, acid or alkaline according to the circumstances in each case; or to maceration in water; or to torrefaction by fire; or to digestion, at low or high pressure, sometimes in moist, sometimes in dry or super-heated steam.

Several of the patents include recipes for mixing the products thus obtained with each other, or with products of a different origin, to adapt them (as the inventors allege) for special crops or for peculiar soils. Many of these proposals possess merit; though a still larger number exhibit ignorance on the projectors' part; while a certain percentage almost seem to have been concocted with a view to profit by the ignorance of others.

SUPERPHOSPHATE OF LIME MANUFACTURE.—First in importance, and *nearly* first also in chronological order, among the manure-patents enrolled since the publication of Liebig's book in 1840, stands the celebrated patent granted in 1842 to Mr. J. B. Lawes,* for converting tricalcic into monocalcic phosphate by means of sulphuric acid. The invention of this process, so far as it applies to the treatment of recent bones, is not claimed by Mr. Lawes, but belongs to Justus Liebig, who suggested it in his great work already quoted. As this suggestion has become the foundation of the modern industry of manures, and its authorship has been the subject of controversy, the Reporter feels bound to record, in the foot-note below, Liebig's own words on the subject.†

The great merit of Mr. Lawes consists, first, in his having extended the application of sulphuric acid to phosphates of *mineral*

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* Lawes (J. B.), Patent No. 9353, May 23, 1842.

† "The form in which they [bones] are restored to a soil does not appear to be a matter of indifference. For the more finely the bones are reduced to powder, and the more intimately they are mixed with the soil, the more easily are they assimilated. The most easy and practical mode of effecting their division is to pour over the bones, in a state of fine powder, half of their weight of sulphuric acid diluted with three or four parts of water, and after they have been digested for some time to add 100 parts of water, and sprinkle this mixture over the field before the plough. In a few seconds, the free acids unite with the bases contained in the earth, and a neutral salt is formed in a very fine state of division. Experiments instituted on a soil formed from *grauwacke*, for the purpose of ascertaining the action of manure thus prepared, have distinctly shown that neither corn nor kitchen-garden plants suffer injurious effects in consequence, but that, on the contrary, they thrive with much more vigor."—"Organic Chemistry in its Application to Agriculture and Physiology," pp. 184, 185.

origin, such as apatite, and to the *fossil* bone-phosphate known as coprolite; and, secondly, in his having devised means and appliances for carrying out the manufacture on an industrial scale. Those upon whom it has devolved to organize a new industry, and to overcome the difficulties that spring up, unforeseen, at every stage of such a work, will know how to appreciate at their just value Mr. Lawes's services in this respect. Indeed, in his double capacity, as a manufacturer of manures, and as an indefatigable experimentalist on their effects, Mr. Lawes merits recognition as one of the most active promoters of agriculture now living. Nor would it be just, in such a mention to overlook the large share of service rendered by Dr. Gilbert, the able coadjutor of Mr. Lawes, in the experimental and analytic department of his labors.

Mr. Lawes appears to have made his first essays in the manufacture of superphosphate in 1841–2; and, on the success of these experiments, to have begun his great manufactory at Deptford, in 1843. Many similar works have since sprung up, and the manufacture has grown to enormous magnitude. Mr. Lawes himself produces 18,000 to 20,000 tons of superphosphate annually; and the total yearly production of superphosphate in Great Britain is estimated by him as ranging from 150,000 to 200,000 tons.

Mr. Lawes has favored the Reporter with the following interesting particulars as to the most recent and improved mode of manufacturing superphosphate, its average composition, and its present market price:—

" The phosphatic materials are first ground to a very fine powder by millstones; the powder is then carried up by means of elevators, and discharged continuously into a long iron cylinder, having agitators revolving within it with great velocity. A constant stream of sulphuric acid, of sp. gr. 1·66, enters the cylinder at the same end as the dry powder, and the mixture flows out at the other end in the form of a thick mud, having taken from three to five minutes in passing through the machine. The quantity turned out by such a mixing-machine is about 100 tons daily. The semi-fluid mass runs into covered pits ten to twelve feet deep, each of sufficient size to hold the produce of the day's work. It becomes tolerably solid in a few hours, but retains a high temperature for weeks, and even months, if left undisturbed.

" The composition of a superphosphate, of good quality, made partly from mineral phosphate and partly from ordinary bones, may be stated as follows:

Soluble phosphate	22 to 25 per cent.
Insoluble phosphate	8 " 10 " "
Water	10 " 12 " "
Sulphate of lime	35 " 45 " "
Organic matter	12 " 15 " "

Nitrogen 0·75 to 1·5 per cent.

" If sufficient sulphuric acid were used to decompose the whole of the phosphate of lime, the product would be too wet to be packed in bags, and would require either to be mixed with extraneous substances of a dry and porous nature, or to be artificially dried.

" The price of the best descriptions of superphosphate ranges from 5*l.* 15s. to 6*l.* 10s. per ton, and of that made from purely mineral phosphate from 4*l.* to 5*l* 5s. per ton."

Of the raw materials annually worked up into superphosphate in Great Britain, Mr. Lawes estimates that about half is derived from the deposits of fossil bone-earth, or coprolite, discovered of late years in several parts of England. Bone-ash, chiefly imported from South America, animal charcoal from Germany, and bones from all parts of the world, together supply about forty per cent more of the raw material; while the remaining ten per cent of the total supply is made up by guano (chiefly of the less nitrogenous and more phosphatic kinds), with a little apatite (say 200 to 500 tons per annum), obtained from Spain, Norway, and America.

IMPORTATION OF MANURES INTO GREAT BRITAIN.—These data alone might serve to indicate that the industry of manures, since the impulse it received in 1840, has afforded occupation not only to the inventive and manufacturing, but also to the commercial activity of the English nation. But of this the origin and development of the guano-trade affords direct evidence.

[Here follows an historical sketch of the growth of the trade in guano, from which we learn that the first experiments with this manure in England appear to have been made from 1838 to 1840. Messrs Gibbs & Sons, its principal importers, commenced in 1842 by importing 182 tons of guano. In 1843 they imported 4667 tons, and in 1862 their total supplies (as well for foreign as for British consumption) equalled no less than 435,000 tons. Of this between one-third and one-fourth was retained for use in the United Kingdom. Its price, which has varied from 9*l.* to 15*l.*, is now about 12*l.* the ton.]

The extraordinary success of the Peruvian guano-trade led to voyages of discovery in search of fresh deposits; several of which have been found and extensively worked on the islands of the West African coast and elsewhere. Nor has commercial enterprise confined itself to guano. Nitrate of sodium, formerly valued chiefly as a substitute for saltpetre in the sulphuric-acid manufacture, has of late years come more and more largely into use as a powerful fertilizer; and the vast deposits of this substance successively opened up in several parts of the South American continent are now extensively worked for the supply of the English manure-market. As for bones and bone-ash, they have been imported by thousands of shiploads, not merely from the boundless South American pampas,—feeding-grounds and cemeteries of unnumbered herds, from immemorial time,—but also from populous European countries, whose soil could by no means spare them so well, and whose fertility must have been seriously impaired by their withdrawal.

Good and Evil of the Trade in Manures.—The manure-trade presents itself, therefore, in two aspects; the one advantageous, the other detrimental to mankind. Nothing can be more advantageous than the collection and utilization of fertilizing residua formerly cast away as worthless. The fossil phosphates quarried out of the bosom of the earth, and the guano extracted (by the successive intervention of seaweeds, fishes, and penguins) from the depths of the ocean, are evidently so much treasure fairly won from nature for the legitimate enrichment of mankind.* Even the withdrawal of recent bones and bone-ash, from plains untenanted as yet save by wild cattle, to fertilize the corn-fields of the populous old world, must be accounted a legitimate commerce. But the boundary line is over-passed, and the manure-trade becomes abnormal, when bones are withdrawn from one populous country to enrich the exhausted fields of another.

Nor is the detriment thus occasioned confined to the country whose soil is impoverished. In the closely knit relations of modern commerce, the impoverishment of any one commercial country reacts on the prosperity of all the others, by diminishing the stock of exchangeable wealth in the world. If Germany, for instance, grows less corn, her purchasing power for foreign goods, say

* See, in this connection, a paper by Mr. Sterry Hunt on Fish-Manures (Canadian Naturalist, vol. iv, pp. 13-23), where will be found much information on the theory of manures and on their commercial value.—Editors.

French or British, is proportionally diminished, and commerce suffers *pro tanto*. The gain to France and England is, therefore, but illusory, if either robs a neighbor's soil to fertilize her own.

In a work just published,* Baron Liebig sternly rebukes England for her over-eagerness to buy up, in the form of bones, the phosphatic wealth of countries less advanced than herself in financial and industrial power; and for the apparent recklessness with which she squanders forth these treasures (ill-gotten and ill-spent), down her innumerable sewers to the sea. The great agricultural teacher manifests alarm at the superabundant zeal with which the most diligent of his pupils obeys his lessons; and to other nations he earnestly points out the ruinous consequences that must ensue to them from the exportation of phosphates, drawn from their soil, to stay the exhaustion of the English fields. His cry of warning is couched in terms of almost passionate invective:—

England (he exclaims) is robbing all other countries of the conditions of their fertility. Already, in her eagerness for bones, she has turned up the battle-fields of Leipsic, of Waterloo, and of the Crimea; already from the catacombs of Sicily she has carried away the skeletons of many successive generations. Annually she removes from the shores of other countries to her own, the manurial equivalent of three millions and a half of men; whom she takes from us the means of supporting, and squanders down her sewers to the sea. Like a vampire she hangs upon the neck of Europe, nay of the entire world, and sucks the heart-blood from nations, without a thought of justice towards them, without a shadow of lasting advantage for herself.

It is impossible (he proceeds to say) that such iniquitous interference with the Divine order of the world should escape its rightful punishment; and this may perhaps overtake England even sooner than the countries she robs. Most assuredly a time awaits her, when all her riches of gold, iron, and coal will be inadequate to buy back a thousandth part of the conditions of life, which for centuries she has wantonly squandered away.

It must be admitted that these strictures, though somewhat harsh in tone, are not without a certain degree of truth. It may, however, be urged, on the other hand, that they apply only to one branch, among many, of British manurial industry,—and even to

* "Einleitung in die Naturgesetze des Feldbaues." Von Justus von Liebig. Braunschweig, Vieweg und Sohn, 1863.

that branch only partially. For, since the British coprolite-beds have been extensively worked, they have supplied fossil phosphates at a price so low as to supersede, in a great measure, the supply of recent bones, for agricultural purposes, from Continental countries. Nor do the laws of political economy permit us to doubt that undue scarcity, artificially created, gradually raises market price to an extent which becomes at last prohibitory; so that the evil provides its own corrective. Of this, indeed, a very apposite illustration reaches the Reporter while he writes. M. Clemm-Lenniga, manufacturer of Manheim, informs him that English fossil phosphates are being extensively exported to Germany; he himself (M. Clemm-Lennig) receiving considerable supplies of this material from British ports. The balance of trade seems, therefore, to be arriving at a just equilibrum in this matter, as, indeed, it always does, if only it be left to swing freely.

MODERN HISTORICAL EVENTS CONNECTED WITH THE DEVELOPMENT OF THE MANURIAL INDUSTRY.—But were England a more signal offender than she is, or ever has been, against what may be termed the manurial equilibrium of the world, she might plead her justification in the train of modern historical events which have brought her manurial industry into its present remarkable phasis; a phasis purely transitional, and which marks the crisis of a momentous revolution, even now in course of accomplishment.

The events here alluded to, like the revolution in which they are culminating, have their common origin in the memorable invention of the steam-engine by Watt.

The new motive power placed by Watt's genius at the disposal of mankind, after having transformed in succession every other main branch of human industry—the spinning and weaving of raiment, for example; the arts of locomotion, by land and sea; all the various forms of brute drudgery, such as lifting, hewing, pumping, grinding, &c.; all the technical plastic arts, from the shaping of the most stubborn metals to the moulding of the most delicate clay—in a word, after having lightened for mankind all the other forms of toil, is now making its way into the farm, and impressing upon the operations of husbandry an equally signal revolution.

It is important to observe that the transformations which have preceded this final, and most momentous change of all, have not only prepared the way for it, but have, at the same time, rendered its advent an indispensable necessity; as a very brief consideration will show.

It is, in the first place, by the operation of steam-power that the *handicrafts*, formerly pursued by families dispersed in villages over the whole surface of the land, have been replaced by *manufactures*, conducted in colossal factories, determining the agglomeration of enormous populations, in rapidly developed towns and cities, located usually (for the convenience of trade) upon streams and rivers leading to the sea.

Food has naturally followed population; and corn and cattle, vegetables and fruit, are daily poured from the country into the towns, in streams of constantly increasing magnitude. The quantity of fertilizing residua resulting from the consumption of these provisions, and requiring, in fair husbandry, restoration to the distant fields from which they come, undergoes, of course, proportionate augmentation; and the problem of their re-conveyance to the land has been, and still is, one of annually increasing difficulty.

During the earlier development of the factory-system, the old mode of urban defecation, by means of cesspools emptied periodically, was in vogue; and much of the night-soil produced in the great manufacturing towns found its way back from these stagnant receptacles to the land.

But as the populations assembled in these industrial encampments grew vaster and more dense, diseases of the so-called *zymotic* class became more and more rife among them; and though the respective causes of the several forms which zymotic or febrile disease assumes remained unknown, it was gradually established by professional investigations that they had all one common favoring condition in the putrescent effluvia of stagnant filth.

To the few scientific inquirers who traced out this relation, it became apparent that the stagnant cesspool system was radically vicious, and must be rooted out at any cost. They perceived that urban populations could only be preserved from febrile disease by the daily removal of their ejecta before its entry into the state of putrefaction; and for this end a system of house and street drains, kept constantly washed with abundant supplies of water, seemed to afford the readiest means.

Here again the power of steam was on the side of progress.

The public water-supply of towns, no longer led, as of old, in wooden pipes, to public fountains, thence to be fetched in pail and pitcher to the dwellings, was urged by steam-pumps at high pressure, through iron pipes having lateral branches, into the houses themselves, and even up to their highest floors. This permitted the adoption of Bramah's water-closet (a capital invention) with its swift water-rush and trapped exit-drain, instead of the noisome privy, untrapped and waterless, with its stagnant pit of putrescence beneath. And though Bramah's closet itself was a costly piece of mechanism, cheaper contrivances of like kind soon followed, bringing within reach of the poor as well as the rich the inestimable blessing of cleanly defecation.

These ameliorations had, however, gained but little attention, and were but slowly making their way, when, in 1836, the views of their advocates received at once a terrible confirmation and a powerful impulse, by the sudden outburst of the Asiatic cholera. * * * * * * * * * * * * * * * * The consternation it produced was universal; and it gave rise to that remarkable series of researches, conclusions, and practical reforms, known collectively as the modern Sanitary Movement.

Under this new influence the substitution of flowing drains for stagnant cess-pools was carried on with much increased activity; though obstructed by a vehement controversy as to the proper size and form of the drains. Small circular stone-ware tubes were recommended by one party; large brick flat-bottomed sewers by the other. The tubular system happily proved to be the cheapest as well as the best; and its advocates, after a ten years' struggle, finally carried the day. Whole towns are now drained through 12-inch pipes, which would formerly have been deemed of scant dimension for the drainage of a single mansion.

The application of the manurial streams from urban drains to irrigate farm-lands was also warmly advocated by the sanitary reformers, but as warmly declared impracticable by several leading engineers; whose views upon that part of the question prevailed.

The second invasion of Asiatic cholera, in 1849, gave a new impulse to the abolition of cesspools; and the value of tubular drains, of small size and rapid scour, for their replacement, had by that time obtained very general recognition. But the leading engineers of England, while admitting, theoretically, the value of sewage to fertilize land, still denied the soundness and economy of the mechanical arrangements proposed by the Sanitary Reformers for its distribution. On an engineering question, public opinion (not unnaturally) sided at the outset with the engineers. The new system has had, therefore, to encounter a professional opposition, all the more formidable for being thoroughly conscientious. Probably that opposition, with the controversy it has engendered, and, above all, the experiments to which it has given rise, constitutes a wholesome ordeal to test the soundness of the new plan, and to bring about the correction of such weak points as it may present. But in the mean time, the application of town sewage to farm-lands, on an extensive, national scale, has stood, and still stands, adjourned.

Hence the present condition, obviously transitional, of the great manufacturing and commercial towns of England; hence the insufferable pollution of her streams and rivers; hence that prodigious squandering of the elements of human blood, for which she is so bitterly reproached by Liebig.

But the same mighty power of steam which brought about the centralization of the manufacturing population in great towns, with the evils thence ensuing, and the sanitary ameliorations by which those evils were (in part) subdued, came fraught with other principles also, and other events, not less influential in the development of the manurial industry. Among these the most conspicuously important, in their bearing upon this great industry, were the doctrine and practice of Free Trade. The historical affiliation of Free Trade to steam-power is direct and obvious. The millions congregated by steam-power had to be fed. To the working of the new factory-system cheap corn was as necessary as cheap coal. The restriction of bread-supplies, and, the consequent enhancement of their price, by artificial means, to benefit a class, became utterly inadmissable. Protection, always a fallacy, was now also an anachronism; and after a severe struggle, and a long series of transitional expedients, the ports of England were thrown open freely to foreign supplies of food. The cultivators of this cold northern soil were thus exposed to the competition of rival food-growers, tilling, beneath warmer suns, the more prolific corn-fields of the south. Upon this unequal competition the English territorial proprietors entered, as upon a struggle for life or death. Abundant manuring seemed at the outset their main, if not their sole resource; hence the rapid and prodigious development of the guano-trade; hence the multiplication of manurial products from every form of waste, as manifested in the patent records; hence the celebrated "nitrogen theory" and the "high-farming" system, to which allusion will presently be made; hence, lastly, that ransacking of the whole world for bones, so criminal in Liebig's view.

Application of Steam-Power to Agriculture.—But steam-power, which has imposed upon the British cultivator this struggle for existence, brings him also the means of issuing victorious from the encounter. Why may not the steam-urged ploughshare pass to and fro through the field, as the steam-driven shuttle passes through the fabric in the loom? If pure water can be pumped by steam-power at an infinitesimal cost into a town for its supply, why may not the very same water, enriched with the *ejecta* of the population, and so converted into a powerful manure, be also pumped out of the town by steam-power, and applied to maintain the fertility of the land? In a word, why may not husbandry rise, in its turn, from the rank of a *handicraft* to that of a *manufacture;* the farm be organized and worked like a factory; and food, like every other commodity, be at length produced by *steam-power?* These questions are now in every mouth; and the agricultural revolution they imply appears to be, at this moment, in course of accomplishment by the English people. Already, on many an English farm, the characteristic tall factory-chimney is seen rising among the trees; the steam-engine is heard panting below; and the rapid thrashing-wheel, with its noisy revolutions, supersedes the laborer's tardy flail.

Already, at somewhat fewer points, the farm-locomotive stands smoking in the field, winding to and fro, round the anchored windlass, the slender rope of steel which draws the rapid plough-share through the soil; thus furrowed twice as deep, and thrice as fast, as formerly by man and horse; and thus economically enriched with proportionately-increased supplies of atmospheric plant-food. And lastly, already, at still rarer intervals, the subterranean pipes for sewage-irrigation ramify beneath the fields, precisely as the pipes for water-distribution ramify beneath the streets of the adjacent town; the propelling power being in both cases that of steam.

These innovations are doubtless still experimental; and like all innovations, they are vaunted by some with premature zeal as perfect; while others, with pardonable scepticism, decry them as utterly impracticable. , Truth for the present seems to lie between these extremes. The steam-plough, though answering well in large and level fields with favorable soils, still requires adaptation to less easy conditions of tillage. The Tubular Irrigating system is still liable to the sudden influx of storm-waters, over-burdening, and often over-mastering, the steam-pumps, so as seriously to interfere with the economy of the distributive operation. But inventive research and practical experiment are rapidly proceeding side by side, and every year, not to say every month, sees some fresh truth elicited, some previous "impossibility" achieved.

UTILIZATION OF URBAN EJECTA AS MANURE.—The separation of surface-water from sewage is, by a certain number, confidently relied on to solve the problem of sewage utilization, in conformity with Mr. F. O. Ward's formula,—"*the rainfall to the river, the sewage to the soil.*" Others are of opinion that sewage, even when diluted by admixture with rain-swollen brooks, may be economically pumped on the land. A third party believe gravitation to be the only economical distributive power for sewage; and open gutters, contoured along the undulating ground, the only channels suited for its conveyance.

On these mechanical questions the Reporter, as a chemist, has of course no opinion to offer. But that the reckless squandering of town-sewage to the sea, if continued on its present prodigious scale, must, in a few generations, justify the worst forebodings of Liebig, and that the same steam-power which has induced the evil can alone supply the remedy, the Reporter confidently believes.

[Here follows a notice of the systems of urban defecation pursued in Baden and in Japan, with the remarks of Liebig thereon.]

The organization of the so-called "Continuous tubular circulating system," by which, with the aid of steam-power, the healthy and ceaseless interchange of pure water and manurial liquor between town and country is now sought to be achieved, seems destined to constitute the mechanical compliment of the great chemico-physiological truths promulgated by Justus Liebig; from whose powerful genius the promoters of this plan anxiously anticipate not merely its adoption, but its incorporation in his great agricultural edifice, as its crown and pinnacle.

It is not however pretended by the warmest advocates of this system, that it can be accomplished by a single generation. It is admitted, on the contrary, that the complete tubularization of the farms of Europe must be a task as gradual as the complete drain and water pipeage of her towns, or as the universal extension of her railway and electric communications. But as the magnitude of such a project may be, for many minds, the very pivot on which their judgment of it, favorable or adverse, may turn, the Reporter quotes here, from a speech of Mr. F. O. Ward (in 1855), some remarks bearing on this point.

" It is argued," said the speaker, after adverting to the cost of the requisite pipeage,—" it is argued from this vast expenditure, and widely-extended range of distribution, that the plan is impracticable. But I think this resembles the arguments used against gas-lighting at the outset. 'What!' it was said in the old days of oil-lamps, to the daring innovators who proposed gas-lighting, 'do you seriously ask us to tear up all the streets of our towns, and lay down thousands of miles of subterranean arteries, to circulate a subtile vapor through every street and into every house, to do, at the costs of millions upon millions, what our lamps and candles already do sufficiently well?' Such was the language used ; and the proposal of gas-lighting was regarded at the outset, by the majority of mankind, as the wildest and most visionary halluncination. But when Murdoch's factory had been illuminated with gas, the whole problem was virtually solved; and when the first line of gas-lights burned along Pall Mall, the illumination of all the towns of Europe became a mere question of time. Just so, when the first farm was successively laid down with irrigating tubes for the distribution of liquid manure, there ceased to be any force in the argument about the quality and cost of pipeage for this purpose. * * * Nor should we be deterred from grappling with the sewage problem by contemplating the vast magnitude of the results to which it will lead in the course of time—of generations, perhaps, when the whole subsoil of Europe will probably be piped for the distribution of liquid manure, just as all Flanders is already honey-combed with tanks for its storage."

SUMMARY OF THE MANURE-QUESTION IN ITS HISTORICAL RELATIONS.—If the foregoing views be correct, the present peculiar and provisional condition of the manurial industry in England is due to a series of concatenated influences, springing from the invention of the steam-engine as their common source, and comprising the development, under its influence, of the modern manufacturing system, with its centralized swarms of population,—leading, on the one hand, to increased demand for food, and to the consequent proclamation of Free trade,—leading also, on the other hand, to reiterated invasion of Asiatic pestilence, and to the consequent abandonment of the cesspool-system, in favor of certain tubular arrangements, designed for the continuous removal and utilization of the manurial waters, and now in midway course of organization. Wholesome controversy, the mother of experiment, enlightens, while it retards this revolution; and if, meanwhile, as Liebig alleges, England "sucks, vampire-like, the blood of Europe," it is because she herself (in this sense) bleeds from a thousand wounds. As the closure of these, now her most ardent desire, shall be progressively accomplished, so, in like proportion, will she be absolved from further need of the sanguinary supplies, for which she now pays so dear. To drop metaphor,—as the new circulating mechanism for the utilization of sewage-manure shall be progressively worked out and realized in England, so, in like degree will her importations of manure fall off; till at last, when her manurial circulation shall be complete, the course of the manure-trade may be reversed, and England may be in a condition to send back to the continents which supply her with food, the fertilizing elements therein contained, or their equivalent.

In some degree, no doubt, the development of the human race, accelerated as it assuredly will be by more abundant food-supplies, may tend to prevent these manurial economies, by the absorption, in increasing quantities, of what may be termed man's floating capital of phosphates—to wit, those held in human skeletons and blood. But large reserves of these, and of all other fertilizing materials, are fortunately open to our exploitation, in the as yet unappropriated domains of nature,—the ocean, the atmosphere, and the underlying strata of the earth. To these mineral sources the manufacturer of manures, guided in this respect by the general course of modern industrial history, will doubtless have recourse in an increasing degree. By aid of the steam-engine, as already explained, we are enabled to draw from the air, and to fix in the rapidly and economically comminuted soil, increased supplies of volatile plant-food. The same system will assist to open up, for use (not waste), the phosphatic and alkaline reserves of the soil. To the increasing substitution of fossil for recent bones, as raw material, in the superphosphate manufacture, reference has already been made; and in the section on potash, the new means at our disposal for extracting this fertilizer from the ocean and the primitive rocks, have been set forth at length.*

It is not necessary however to pursue these reasonings further; nor to trace, to a more distant future, the probable influence of foregone and contemporary events on the course of the manurial industry. The Reporter will have accomplished his wish should the attention of governments and individuals throughout the world be directed by these cursory remarks to the double revolution, Sanitary and Agricultural, now taking place in England; and to the signal benefits likely to accrue therefrom to the British nation, and ultimately to the whole human race.

MODERN THEORY OF PLANT-NUTRITION. NATURE AND OPERATION OF MANURES.—Quitting the historical aspect of the question, the Reporter proposes now to offer a few remarks on the nature and *modus operandi* of manures, and on the grand and simple laws which govern their relations to the soil and the crop. For the clear apprehension of these it will be necessary, in the first instance, briefly to direct attention to the nature and functions of plants, and to the modern theory of their alimentation. Growing as they do, with their leaves spread forth in the air, and their roots radiating in the soil, plants necessarily draw from these media the materials of which they consist. As fertile soils are rich in the debris of previous vegetation, such as dead roots, leaves, and the like, crumbl d to *mould* or *humus;* and as this humus is slightly soluble in water, which is constantly supplied to the soil in the form of rain and dew; it was formerly and not unnaturally believed, that the aqueous solution of organic matter thus formed

* Reference is here made by the Reporter to a previous section of this report, pp. 48–52. From this it appears that the process for the economic extraction of potash-salts from sea-water, as described by Mr. Sterry Hunt (Canadian Naturalist, vol. iii, pp. 105–109), has been still further perfected by Mr. Merle, who employs artificial cold to aid the process; and has now established, in the south of France, very extensive works for the purpose of carrying out Mr. Balard's processes with this improvement. As regards the extraction of potash from feldspathic rocks, the late experiments of Ward and Wynants, as noticed in the report, show that by carefully calcining feldspar with proper proportions of lime or chalk and fluor-spar, a frit is obtained from which nearly all the potash may be removed in a caustic state by the action of water.—EDITORS.

was imbibed by the roots plunged therein, and so conveyed as food to the living tissues. According to this view, plants were supposed to live, like animals, on organic food, more or less resembling in chemical composition the tissues which it nourished. This was the old *organic* or *humus* theory of plant-nutrition, referred to above as having been attacked and demolished by the great author of the *mineral* theory, now universally accepted. Liebig indeed proved, in the clearest manner, partly by *data* ready to his hand, partly by his own incomparable researches, that it is not possible for plants to obtain their nutriment in the form of *organic* matter. He showed that the Vegetal kingdom of nature is interposed between the Mineral and the Animal Kingdoms, with the special function of elaborating from the former the food of the latter.

Thus, for example, with reference to carbon, the weightest solid constituent of plants, Liebig proved it to be absolutely impossible that a sufficient supply of this element should reach them in the form of dissolved organic matter, or humus. In this demonstration Liebig took as his data, first, the ascertained solubility of humus in rain water; secondly, the known average quantity of rain-water falling annually on an acre of land; and lastly, the quantity of carbon annually yielded by the average crop of that area, whether in the form of hay, timber, or corn and straw. With these elements of calculation, Liebig demonstrated irrefragably that humus, as such, is not soluble enough to serve as plant-food; seeing that the whole annual rainfall, even if completely saturated with humus, and entirely absorbed by the growing wheat-plants, grass, or trees, would not supply a fourth part of the carbon removed from the farm in those crops. Liebig showed further, that the growth of perennial plants (forest trees for example), so far from exhausting the soil of humus, tends on the contrary, to occasion its accumulation therein; vegetation, in point of fact, being a condition precedent of humus, not humus of vegetation.

Supply of Carbon to Plants.—Pursuing a chain of argument in which the researches of De Saussure, Boussingault, and many others, were, by a masterly and luminous induction, brought to bear in support of his own conceptions, Liebig established the fact, now universally received, that carbon is conveyed to plants, not in any *organic* combination whatever, but as a *mineral* gas, formed by the aid of atmospheric oxygen, and termed carbonic acid.

The steps of research by which our present knowledge of this matter was built up by Liebig, from data partly collected, partly original, cannot be here enumerated, but the received view may be thus briefly summed up: Every 32 lbs. of atmospheric oxygen can take up, without change of volume, 12 lbs. of carbon in the form of carbonic-acid gas. This gas, on the other hand, plants have power to absorb by leaf and root; and by their vital force, coupled with the action of the solar light upon their leaves, to decompose. The carbon they reduce to the solid form, and fix in their growing tissues; the oxygen they restore to the air. The oxygen thus liberated by living organisms takes up fresh carbon from effete organic matter; whether from the debris of vegetables themselves, *e. g.* mouldering humus, slowly oxydized within the soil; or from vegetal fuel (recent or fossil) rapidly oxydized by combustion; or from the residuary materials of animal life, circulating in the blood, and eliminated by oxydation during the respiratory process; or lastly, from the final residuum of animal life, —the *corpse*, which also, during its decay and dissolution, yields carbon in abundance to the oxygen of the air. Thus, by the intervention of atmospheric oxygen as its carrier, carbon, in the form of carbonic-acid gas, is transferred from dead to living organisms, the air constantly receiving from the former as much carbon as it supplies to the latter.

Cosmic Equilibrium of the Atmosphere, how far doubtful.—Whether or not the ever-active processes which collectively supply carbon to the air *exactly* balance those which perpetually co-operate to withdraw it, so as to form a perfect and unalterable cosmic equilibrium, we do not know. The assertion is often made, and popular writers are in the habit of extolling the assumed arrangement as an admirable provision of nature. But we are in truth quite ignorant on this subject; no reliable data having come down to us as points of comparison by which to determine any variation that may have taken place, and be still in progress, in the composition of the atmosphere. And here the Reporter cannot but remark in passing, that it is time systematic observations were begun in Europe, to serve as a starting-point, or first term of comparison, by which our successors, if not ourselves, may be enabled to elucidate this question; than which none can be conceived of deeper importance to mankind.

True Functions of Humus.—Reverting to the humus in the soil, its true office, as contradistinguished from the imaginary functions assigned it of old, may now be clearly perceived. As living organisms feed on the carbon restored to the air by their defunct predecessors, and as humus is but the debris of previous vegetation in a soil, the carbonic acid developed by its decay must play a proportionate part in nourishing the crop then in course of growth. Hence the necessity of an atmosphere within the soil to oxydize the humus, and thereby to reduce its carbon from the organic to the mineral condition, so as to make it assimilable by plants. The necessity of such an *underground atmosphere* is an established fact; air being as essential as warmth and moisture to the germination of seeds, and to the development of plants. One of the main services rendered by ploughing consists in the loosening of the soil, and the multiplication within it of interstitial air-spaces. Of like kind is (in one of its aspects) the benefit rendered by subsoil-drainage to water-logged soils; whose interstices of course receive air from above, as fast as the redundant water is drained off from below. Lastly, one principal advantage of the porosity of soils, and of their consequent *surface attraction*, consists in their property, thence derived, of condensing and retaining within their pores so much of the underground air. The oxygen thus brought into close contact with humus, attacks it and becomes charged with its carbon; remaining thus charged, within its pores, as carbonic-acid gas,—the appropriate mineral carboniferous plant-food, as already explained. This gas, meeting with the moisture also retained in humus by the surface-action of its pores (termed, with reference to fluids, *capillary attraction*), is therein dissolved, and so presented to the ramifying rootlets in the most favorable manner for imbibition by the so-called *osmotic* action of their membranous spongioles, and the suction-power developed by the evaporation of their sap from the leaves.

In this way do decaying organic bodies replenish the atmosphere, whether above ground or below, with gaseous carbon; which the atmosphere, in its turn, conveys to the plants; whose leaves appear to inhale it as gas, but to whose roots it is supplied in watery solution. The carbon of the plant and the carbon of the soil have but one primal origin, the atmosphere. From this source the carbon constantly flows; to this reservoir it as constantly returns. The humus of the soil, and the tissues of plants, are but successive resting-points for carbon in its circulating course.

It is now easy to understand that forest-trees and other perennial plants, growing slowly but continuously, year after year, and possessing a comparatively vast expanse of foliage and of roots, can thrive in soils less rich in mouldering humus, and therefore in carbonic-acid gas, than is needful for certain annuals,—such as, for instance, the wheat-plant,—whose term of existence is brief, whose foliage scanty, whose roots small (especially during the earlier stages of its development), and whose growing power is of a proportionately delicate quality. In this latter case, art may usefully intervene to concentrate, within narrower limits of time and space, the supply of carbon diffused by nature over a more extended area and a longer term. This explanation justifies, in the case of wheat and similar crops, additional supplies, not only of carbon, but also of other forms of plant-food; and it leads to the consideration of "high farming," its objects, its dangers, and its normal limits,—which may, however, be conveniently reserved for brief elucidation further on.

SUPPLY OF WATER TO PLANTS.—Meanwhile a few remarks are due to the plant-food next in order of weight to carbon; viz., to hydrogen and oxygen; which are supplied to plants in combination with each other, as water.

The source of this aliment is too familiar to need even indication here. Yet the natural mechanism by which water is distributed to plants, in the form of rain and dew, is too wonderful and beautiful to be passed in silence. Shakespeare, who always arrived at truth through beauty, was struck with the all-pervasive diffusion of rain, and with the admirable tempering of its descent by the atmospheric resistance. Its soft fall upon the unruffled foliage symbolized for him Mercy's sweet grace and "unstrained quality," whereof he says,

"It droppeth as the gentle rain from heaven
Upon the plants beneath."*

Shelley too, personifying the Cloud, sings beautifully:

"I bring fresh showers for the thirsting flowers
From the seas and the streams."

A volume of prose could scarcely express with more precision and completeness than these four lines the philosophy of the aqueous

* This is commonly printed "upon the *place* beneath." But as *place* cannot be effected by the gentleness of rainfall, and *plants* can, the latter seems the more likely to have been Shakespeare's word.

food-supply of plants,—so finely divided, so delicately dropped, and so grandly replenished by the colossal water-service of the world. As indeed of carbon, so of water, the atmosphere is, for plants, the mighty reservoir and ever-flowing fount. In point of fact, every cubic foot of air upholds between two and three grains of water invisibly dissolved; and as fast as this condenses above to floating clouds and falling rain, so, in annual quantity precisely equal, is it fed below by the evaporation of "the seas and the streams." This process however, like all the other great operations of Nature, is subject to perturbation, in the redress of which human Art finds its appropriate sphere. In temperate climates, the formation, distribution, and condensation of rain-clouds take place, on the whole, with sufficient regularity to insure, in ordinary seasons, enough of this aliment to the crops. It is otherwise in tropical regions. There, superfluous deluges of rain, and long-protracted droughts, succeed each other; so that artificial irrigation becomes the prime condition of tropical husbandry. Irrigation might, indeed, be fairly described as the *high farming* of the tropics; and water as their most precious *manure*.

Water, indeed, is not merely the vehicle of all other aliments for plants, it is also an aliment itself—in the sense that it assumes the solid form in their tissues, entering into their chemical consitution, and contributing largely to their weight. Wood, for example, after having been thoroughly dried, still consists, for nearly half its weight, of the elements of water. Water, moreover, is the chief constituent of the sap of plants; and its rapid evaporation from their surfaces creates the internal vacuum to which they owe the astonishing suction-power of their roots; as Hales first proved by his capital experiments on this subject published in 1717.

SUPPLY OF NITROGEN TO PLANTS.—Last in order, because least in quantity, yet by no means on that account lowest in importance. stands the nitrogen among the volatile constituents to plants. It is of peculiar interest, as one of the costliest and most eagerly-sought manurial elements, and as that concerning which the principal agricultural controversy of the day is now raging. Nitrogen like carbon, and the elements of water, has in the atmosphere its source and reservoir; flowing thence to living organisms, and thither restored by their decay and dissolution after death. It is thus diffused, chiefly in combination with hydrogen, as ammonia; a gas in the highest degree diffusible in air, soluble in water, and absorbable by porous bodies such as vegetal mould. It is, therefore, readily washed down from the air by the rain and dew, and as readily imbibed by the soil, and retained within its bosom by the peculiar physico-chemical force, already referred to as "surface-action." All fertile soils contain abundance of ammonia thus availably presented for absorption by the roots of plants. The leaves of plants also absorb ammonia from the air in quantities varying with the different genera and species.

It is not only however in the form of ammonia that atmospheric nitrogen is supplied to plants. Nitrogen combines with atmospheric oxygen to an extent always appreciable, and much augmented under certain circumstances (as, for instance, during lightning-storms), to form nitric acid; which is washed down to the soil by the rain, and assists, certainly by its solvent powers, probably also as aliment itself, in the nutrition of plants. Nitric acid also originates to some extent, as a secondary product of the decay of nitrogenous organic matters; these yielding ammonia, which oxydation converts into nitric acid and water. Furthermore, a nitrogen-compound, containing both hydrogen and oxygen, viz. nitrite of ammonium, has been lately ascertained (by Schönbein) to originate during the slow oxydation of phosphorous; two equivalents of atmospheric nitrogen taking up two equivalents of water to produce it. Nitrite of ammonium is similarly generated (according to Kolbe and Böttger) during the oxydation of hydrogen, and of hydrocarbons generally. Indeed there is fair reason to surmise that the generation of this salt accompanies all processes of slow oxydation; such as, for example, that of humus in the soil. These facts are of the deepest interest; and should the supposed universality of this natural reaction, as a concomitant of slow oxidation, be confirmed, a powerful light will be thrown on the nature and source of the nitrogenous alimentation of plants. It will indeed be a remarkable discovery, as Liebig (who cites these facts in his admirable work above mentioned*) justly observes, should it be found that the very process by which carbon is rendered available as plant-food, operates also to bring atmospheric nitrogen into a form in which it is assimilable by plants.†

* This view of the origin of nitrous acid and ammonia from atmospheric nitrogen does not belong to Schönbien, but was previously enunciated by Mr. Sterry Hunt (Canadian Journal, April, 1861). See also Nickles, Silliman's Journal [2], xxxv, 263-271.

† "The Natural Laws," &c., pp. 326-328, Eng. ed.

Whether *free* atmospheric nitrogen is assimilable by plants is a moot-point. M. G. Ville and others maintain that it is: M. Boussingault, from the results of experiments extending over twenty years, draws the opposite conclusion. Messrs. Lawes, Gilbert, and Pugh, in an elaborate paper lately published,* record the result of a series of valuable experiments on this point; and their conclusions are confirmatory of M. Boussingault's view. This therefore appears to be the opinion supported by the preponderating weight of experimental evidence; a circumstance which renders Schönbein's observation, and the conclusion to which it points, doubly interesting and important.

ATMOSPHERIC DERIVATION OF PLANTS AND HUMUS.—Thus far the atmosphere, and the moisture and gases it contains, supply the food on which plants live; the soil serving merely as a sponge to bring into contact with the roots their share of this air-derived food. Even the carbon-yielding humus, though it immediately surrounds the roots, supplies them not directly, but only through the intervention of what has been above termed the *underground* atmosphere, by which it is slowly burned. Each successive generation of plants leaves its roots and other debris behind it; thus replenishing the soil with a fresh stock of air-derived humus, *eremacausis*, or decay, in its turn. Every shower washes down nitrogen, in its acid or alkaline form, from the air; and the same cloud-supplied water furnishes the crops with their oxygen and hydrogen. It is evident that from centuries of such plant-growth as this no exhaustion of the soil would ensue.

There is certainly no result of modern investigation more calculated to strike the mind with wonder and admiration than this fact,—that the mighty forests which clothe the earth, and all the vast expanse of herbage and waving crops, and all the living animals which feed on these and each other, including man himself, the lord of all, are built up, so far as concerns nineteen-twentieths of their weight, entirely of invisible gases and vapor supplied by the atmosphere.

Thus upheld, and moving with the wind, the carbon and nitrogen compounds chiefly diffused below, the watery clouds suspended above to wash them down, these, the materials of the whole organic kingdom, hover invisible around us; and by a distributive mechanism the most grand and simple that can be conceived, all

* Lawes, Gilbert, and Pugh, "Phil. Trans." vol. cli, p. 431, 1861.

animated nature is wafted, as on wings, to every corner of the habitable earth. No mountain-fastness so remote, no wild so desolate, no ocean rock so lonely and so bare, but thither also float, and there descend, the viewless elements of life dissolved in air. The tiny lichen, that scarce stains the wave-worn cliff, in its wild solitude is not alone. Its food is floated to it day by day; and the same elements, sailing on the same winds, build up the delicate tissues by means of which it lives, and furnish the oxalic acid wherewith it excavates the grave that holds its dust when dead. That dust, be it remembered, is the primitive *humus*, and the earliest form of *soil*. It is derived, like the lichen itself, from the air, and it confirms the saying of Liebeg, that it is not humus which generates plants, but plants which engender humus.

(*To be continued.*)

ON PISCICULTURE.

The importance of the artificial breeding of fish, which the French have dignified with the name of pisciculture, is such that we have thought well to bring before our readers some of the results obtained in England and in Norway. For this we are indebted in the first place to a lecture recently delivered in London by Frank Buckland, Esq., and published in *The Journal of the Society of Arts*, for March 11, 1864. This lecture we have somewhat abridged. In the second place, we extract a very interesting chapter from Rev. M. R. Barnard's *Sport in Norway*, giving a description of the method of fish-breeding pursued in that country. Lastly, we copy from *The Angler-Naturalist*, an excellent book by H. C. Pennell, lately published by Van Voorst, what the author designates as Proved Facts in the History of the Salmon. —Editors.

On Fish-Hatching: By Frank Buckland.

This is one of the most practical applications of the study of natural history that has been brought to notice of late years. The mode of hatching valuable fish, such as the trout and salmon, by artificial means, is no longer an experiment. It has, I have been pleased to see, been lately gazetted by public consent to the rank of a science, which is every year attracting more attention. I shall not weary you by entering into the history of the art: suffice it to say, that the first discoverers were two poor French fishermen, Gehin and Remi. All honor to their names for the great good they have done to their fellow-creatures.

You will find in books a statement repeated over and over again, —a fault very common in treatises on natural history,—that the Chinese were the first to practice pisciculture. But let me tell you what their pisciculture consists of. They have no idea (I have it from the best authority, viz. of officers in the army who have travelled there) of hatching fish in troughs, such as we see in European establishments, nor have they yet arrived at the practice of impregnating the eggs artificially. What they do is this: They observe the spawn of fish hanging about the bushes, having been placed there by the fish themselves. They collect this spawn, hang it up in tubs and ponds, and let it hatch out of itself. But though they have not the science that we have, yet they are pisciculturists in a most practical manner; for I have it on the authority of an eye-witness, that when the Chinese flood their paddy or rice fields with water, they turn out into those flooded fields large numbers of fish, which feed upon the worms, insects, &c., which they find in the mud, and this without injury but rather benefit to the plants themselves. When the fields have had enough water, the Chinese water-farmer opens the hatchways, catches what fish are fat enough and sends them to market; the others he lets out into another fresh-flooded paddy-field for a pasture. In fact, the Chinese herd their fish, and drive them from one pasture to another, just as a shepherd drives his sheep from one field to another These fish are, it is said, great coarse things, and appear to be something between a chub and a tench. There are, I believe, no representatives of the Salmonidæ in China.

Leaving the history of the subject at this point, I would now proceed to the practice of the art. There may be some who say, Why not let the fish breed for themselves? Doubtless, if left alone in a perfect natural state. they would multiply themselves to an enormous extent, as is the case, I am told, at Petropaulowski, where the salmon are occasionally left high and dry by the subsiding of the floods, and such numbers of them perish in this way as to cause a plague by the putrefaction of their bodies.

When we consider the vast number of eggs which nature has given to fish, it is a wonder, indeed, that all the world is not fish. The *eggs* of fish are simply the hard roe of fish; and if you examine the next red-herring for breakfast you will find that the hard roe is composed of a large number of little balls, each of which might possibly come to a fish. You will find in books on natural history the number of eggs in fish. Not trusting altogether to these statements, I have been at some considerable pains to count the eggs* of the following fish. To begin with the salmon, these fish carry about 1,000 eggs to a pound of their weight; so if we can get a fish weighing twenty-five pounds, we have no less than 25,000 eggs.

If therefore a female salmon weighing 20 lbs. deposited her eggs in some safe place, and they all eventually became marketable fish, which would be in three or four years' time, we should find that the eggs of this one salmon would yield no less than 178 tons 11 cwt. of salmon fit for food; and supposing we put this down at 2s. per lb., it would be worth £40,000. Even supposing only a quarter of the young fish ever became marketable, still this one fish would yield a value of £10,000, and all without costing any human being a half-penny for food. A trout of one pound weight contains over 1000 eggs, a perch of half a pound 20,592, a smelt of two ounces 36,652, a sole of one pound 134,466, a herring of half a pound 19,840, a mackerel of one pound 86,120, and a cod of twenty pounds not less than 4,872,000 eggs, while an oyster yields about 1,500,000.

It may be asked, therefore, what becomes of all the eggs of the

* The way to count the eggs is this: Make a few cuts with a knife in the membrane which contains the roe, and then plunge it into water which is, at the moment of immersion, positively at the boiling-point. Being composed of albumen, the eggs obey the natural law and coagulate in an instant. Then add a little common salt, and continue to boil the eggs till they all become quite detached from the membrane, and swim about in the water, loose like marbles. If they adhere to the membrane, they should be gently removed by a short brush, or by shaking in the boiling water. I then, when all the eggs are quite loose, draw off the water and pour the eggs into a dish, drying them slowly in the sun, or in an oven, the door of which is left open to prevent their becoming baked into lumps. I then weigh the whole mass of eggs, and put down the total weight on paper. After which I weigh out five grains of the mass, and get them counted over carefully under a magnifying hand-glass, on white paper. This is ladies' work.

salmon, trout, &c.? The same thing that happens to the common fowl happens to the fish. In the case of the fowl, we ourselves eat many thousands of eggs, and we know how good they are for various culinary purposes. And as in the case of the fowl, so also with the fish-eggs: there are enemies innumerable that seek to destroy them; even the water itself is occasionally antagonistic to their well-being.

First of all, then, many of the fish's eggs do not get at all impregnated, or, not becoming properly buried in the gravel, are washed away by the stream. In proof of this I would mention the following: There are no good spawning-places in the Thames; the fish—and the Thames trout are really fine fish—are therefore obliged to deposit their eggs in the rapids in the centre of the stream. Some of the nests where trout had been actually seen to deposit their eggs have lately been carefully examined, and not a single egg could be found: they had all been carried away by the stream, or devoured by insects, of which thousands were found in the nest. A friend, writing from Hampshire, says that he has examined the nests where the salmon have been seen to spawn, but no eggs could be found. Even supposing the eggs have been properly deposited in the nests, down come the floods and overwhelm the place. Thus, my friend Mr. T. Ashworth informs me, that at the beginning of the season over 275,000 eggs were taken from salmon and placed in his hatching-boxes. Immediately after this was done, the waters arose, and of the eggs which had been exposed to their violence hardly one could have survived. Then again, we have the reverse of floods, *i. e.* the droughts, which leave the eggs exposed; or, as it happens in Hampshire, the fish lay their eggs in what is called "the drawings"; the water is let off them, and the eggs of course perish. Fish again are great enemies to their own eggs. I have myself frequently seen two or three small trout hiding behind the nest, and as the female deposited her eggs, swim after and eat them. Trout have also been often observed, with their tails in the air, robbing the nests. Even females will eat their own eggs. What wonder then that trout should be so scarce when both father and mother devour their offspring. I myself have frequently, from the maws of trout, taken eggs which they had stolen from the spawning-beds; and my friend Mr. Ashworth tells me that he has actually hatched out 500 eggs taken from the mouth of one fish-robber.

Supposing the eggs to have been properly laid in their nests, they become the prey of pests innumerable. The larva of the may-fly and the dragon-fly (justly called the river-tiger) act the same part to the fish-eggs in the water as do the hedgehogs and other vermin to the pheasant-eggs on land.

Among birds the fish-eggs have many enemies as well as friends. The chief of the former are common ducks, which, with their spade-like bills, soon get all the eggs out of the nests and devour them. The swans, though very graceful ornaments in a pond, do a deal of mischief to the fish, especially in the Thames. Two birds, the water-ouzel and dab-chick, have been accused as poachers after fish-eggs. I have examined the crops of several of these birds, and have invariably found them to contain the remains of insects, but no fish-eggs. This matter was fully discussed at the Zoological Society, and the verdict first arrived at was "not proven," and on second consideration the water-ousel was fully acquitted from the charge of eating spawn. True it is he is ever feeding upon the spawning-beds; he goes there to eat the insects that are devouring the eggs, but he himself does not touch them at all.

The moor-hens, however, I am pretty sure, will eat the eggs of the fish. A good observer tells me that one morning the moor-hens got to his hatching-boxes and cleared all the eggs out of them. There is another bird which does a good deal of harm to the fish-hatcher. A friend writes to me to say that he has killed several king-fishers under the wires where his fish were confined. Herons also are terribly destructive to the fish in the spawning-beds.

We have seen what becomes of the fish's eggs if they are left to themselves. It is necessary, therefore, for man to interfere, and take the eggs from the fish and keep them under his charge. In all matters of interference with nature, we cannot do better than take nature herself as a guide. We observe that the fish makes her nest of her own accord in a rapid, shallow, and gravelly stream. We therefore must put the eggs in an artificial nest where the following requisites are present: a stream more or less rapid; gravel; darkness; and perfect quiet. This stream must be allowed to run over the eggs perpetually, day and night, until the young fish are hatched out, just as it would do in the brook.

At the piscicultural establishment at Huningue, in France, the eggs are placed upon glass rods, such as I now show you, during the time of incubation. I would however most humbly beg to differ from the great authorities who use the glass bars: for in the first place, the fish do not find glass bars at the bottom of the water on which to deposit their eggs, but they always find gravel; in the second, it is absolutely necessary that the egg should be perfectly motionless for some thirty-five or forty days. If you place a round egg against two glass bars which are also round, the whole being under water, you at once get the best possible conditions for motion of the egg on the glass bar at the slightest touch, and you certainly do not get what you chiefly want,—perfect immobility; for if the water be turned on from a tap a little too fast, or you happen to touch one egg with a camel-hair brush, all the eggs in the box immediately run against each other, and begin to dance and roll about. Again, when the young fish begin to hatch out, their umbilical bags very often get caught between the bars, and then they perish; or if they fall through, they get into water that is much too deep for them, and whence it is very difficult to extract them without disturbing every egg in the box. This is done in the French plan, by taking out a cork and letting the water run off from under the bars.

By placing the eggs *on gravel*, on the contrary, all this difficulty is obviated. The eggs can be placed so that they do not touch one another; so that the dead ones do not contaminate their live neighbors, and may be easily picked out by a pair of forceps; so that the inequalities of the gravel will keep them perfectly steady; so that the young fish when coming out of the egg —like the young snake casting his skin in a furze-bush—may have facilities afforded him to get rid of his shell, and be not like his neighbor on glass bars, who slips about thereon like a clumsy skater upon well-swept ice.

You will observe, of course, when you examine the fish-hatching boxes now in the room, that we do not in one respect adhere to nature; that is, we do not cover the eggs with gravel, as does the parent fish. The only reason why the parent fish buries her eggs is because of the light, which is unfavorable. All roots and seeds of plants, we may observe, are buried in the ground; it would appear, therefore, that at first darkness is absolutely necessary for the development of the first germs of life. Again, if the eggs are exposed to the light, a white fungus immediately appears upon them. All this is obviated in a moment by placing wooden covers on the boxes, for these keep out all the light, and obviate all the inconveniences of bringing the eggs where you cannot see them, and cannot watch their progress.

There are two kinds of hatching-apparatus, which may be used; —one out of doors, for carrying out operations on a large scale; and the other for use on a smaller scale in-doors.

I far prefer the in-door apparatus, which is very simple in construction, more certain of success, cleaner, neater, and at the same time affords the great pleasure to the owner of being able to observe the progress of the eggs. The slate-boxes on the tables are those used by my friend, Mr. Ponder, at Hampton, in which he has hatched so many thousands of fish, paying for the boxes out of his own pocket, and giving his time gratuitously for the Thames Angling Preservation Society. They are three feet long, and three and a half inches deep. They should be placed one above the other, after the manner of the steps of a staircase, and so arranged that the water runs through them all in zigzag manner. Some gravel, about the size of peas, must be obtained from a gravel pit, not from the river-side. It must be well boiled to destroy all the seeds of vegetation, be washed perfectly clean, and then placed in the troughs, so that there should be an inch of gravel, an inch of water, and an inch above the water. Place in the eggs, put on the wooden covers, see that the stream runs properly, and leave them entirely alone in the boxes. Such as these have this year, at Hampton, hatched out, and are still hatching out no less than 124,700 fish and eggs.

All that is requisite is a gentle and incessant flow of water, and what is water enough for one trough is, as a matter of necessity, enough for half-a-dozen or so. In London houses the supply of water is often limited; it is a comfort therefore to know that the same water can be used again twice or three times.

If you wish to hatch your fish in boxes out of doors, you must adopt the same principle as that applied to in-door boxes, recollecting the requisites,—a clear running stream, clean gravel, and darkness. Full details of both in-door and out-door apparatus, and also the proper mode of working them, can be found in my little book.*

The eggs having been placed in the boxes and left totally undisturbed, in course of time the eyes of the young fish will be seen like two black spots in the egg. The time required for this appearance to exhibit itself depends entirely on the temperature.

* Fish-hatching. Tinsley Brothers, Catherine Street, Strand. Price 5s.

The proper temperature of the water, both in and out of doors, ought to range from 40° to 50°. Mr. Ponder's observations tell him that at this temperature it requires thirty-five days for the eyes to appear, and that they hatch out fourteen days afterwards. The same result has been obtained by him for two successive seasons with very little variation. Again, he has observed that when the temperature was 50° (in the spring of the year) the eyes of the fish were visible in twenty-six days, and that he hatched them out in ten days afterwards. Lay it down however for an axiom, that the higher the temperature for the egg the weaker the fish produced from the egg. Anything above 50° is weakening.

The first fish hatched out from a batch are the weakest, the last are the healthiest; when however they once begin to hatch, they will come out all in a mass, two, three, or four thousand of a morning. The proper temperature for trout and salmon eggs is 40° to 50°.

Grayling however appear to be an exception to this rule. Mr. Ponder has obtained a fair supply of the ova of these fish, which the Thames Angling Preservation Society are introducing in the Thames. The quantity obtained amounted to between fifteen and twenty thousand; and though several of these died, for they are most delicate things to carry, the remainder did very well. They are much more delicate than trout-ova, both in appearance and hatching, and seem to die at the least provocation. They are beautifully transparent, and, when viewed in the sun, of a lovely opalescent hue. He has discovered about these a most interesting, and I believe, a novel fact. The body of the fish is perfectly visible in nine days, and the fish will actually hatch out of the egg in fourteen days.

All difficulties and trouble with the eggs having been overcome, we are at length rewarded by seeing the young fish begin to come out of the egg. At this time the tail of the fish may be observed moving from side to side with a rapid vibratory movement inside the egg. The young fish, when hatched, increase in size daily; and the darkening of the transparent substance which would eventually be the body, and the development of the fins, have already proved one fact, and this (as the question has frequently been put to me) I shall venture now to mention. The eggs do not grow—*i. e.*, they do not increase in circumference or in diameter,—but the fish inside the egg most certainly increases in bulk, till at last it becomes so large that the egg-shell suddenly bursts, and out comes the young fish.

In the gradual development of the young salmon and trout we begin with a globule of albumen. We see within it a faint line, and two black spots. Day by day these become larger, till the young fish is born. After this, the umbilical vesicle is absorbed, the color appears on the scales, the long single crests, which one observes at birth running down the upper and lower parts of the body, resolve themselves, as it were by magic, into the various fins distinctive of the adult creature, and we have a perfect fish before us.

It is most interesting to watch an egg at the moment of hatching. You may happen to be gazing on a particular egg, when of a sudden you will see it split in twain, at the part corresponding with the back of the fish; you will then see a tiny head with black eyes and a long tail appear, and you will see the new-born creature give several convulsive shudders in his attempts to free himself from the now useless shell. Poor little fellow! he can't manage to get out: the shell is too tight for him. Take, therefore, a soft hair-pencil, press lightly on the egg-shell,—he seems to know you are his friend,—he gives another vigorous kick or two, and presto! he is free, and has commenced life. If we judge from his motions, he must enjoy it, for away he swims as fast as his tiny and wriggling tail will carry him, round and round in a circle, and then plump down he goes to the bottom of the tank, and reclines on his side, breathing freely with his gills for the first time in his life.

It would appear that it is not possible for the fish to remain long enough in the egg to come out ready to eat food at once, as is the case with the ovo-viviparous creatures. They have therefore attached to their belly a bag, which contains the nourishment that the young fish must absorb before they are able to shift for themselves. The moment the contents of the bag are gone, they begin to feed with the mouth.

In various creatures the progress of development is different. Thus, for instance, in the human baby, the first portion of the body developed is the lower jaw, and this for an obvious reason, because the most material want of the baby is to obtain the mother's milk by suction.

Now, in the case of the fish, nature has kindly packed up all the nourishment that it will want for some six or eight weeks in a neat little bag or parcel, which she has affixed to the body of the fish in such a manner that it can be absorbed into the system; while as the fish does not suck milk like a warm-blooded animal, its lower jaw is not developed.

What is, then, the most important organ to the young fish? He has numerous enemies, and it is his first object to get out of their way. The eyes, therefore, are the organs which first arrive at perfection. The eye is in perfect working order at the moment of birth, though the rest of the body is far from complete.

One of my many visitors to the tanks at the *Field* newspaper office, where I exhibited the process last year, was narrating to me how he once caught an enormous salmon in the Tay, weighing some thirty odd pounds; this put the idea into my head to weigh one of my salmon. He has, poor little fellow, a deal to make up before he arrives at thirty pounds, for at present (four days old) he hardly turns the scale at two grains.

By the kindness of Mr. Ashworth, of Cheadle, near Manchester, I am enabled to show you a drawing of the young fish which weighs about two grains. He has also given me the following observations as regards the increase of weight in the young salmon: The fry at three days old is about two grains in weight. At sixteen months old it has increased to two ounces, or 410 times its first weight. At twenty months old, after the smelt has been in the sea, it has become a grilse of eight and a half pounds: it has increased sixteen times in three or four months. At two years and eight months old it becomes a salmon of twelve to fifteen pounds in weight; after which its increased weight of growth has not been ascertained, but by the time it becomes thirty pounds in weight it has increased to 115,200 times the weight it was at first.

Among the numerous progeny of fishes, it could hardly be expected that all of them would be straight-limbed and healthy; we find, therefore, occasionally, but not very commonly, crippled and deformed fish. Thus I show you, this evening, diagrams and living specimens of a fish of a cork-screw shape, also of a fish with four eyes and one head, also of a salmon and of a charr with two heads and one body. I take the greatest care of these fish, and trust they will live, and should they be caught hereafter by any angler they would astonish him.

As regards the practical treatment of the young fish, and the question as to when they should be turned out into the stream, as well as many other points, I must beg to refer again to my little book on fish-hatching.

Having had now two years' practical experience in hatching fish, I bethought me whether this year I could not somewhat add to the science of the matter, and have therefore instituted several experiments as regarded the duration of the vitality of the milt and ova, whether kept separate in bottles, or taken from dead fish. This, I am convinced, is a most important point, and it may possibly lead to many practical results. The first experiment which I tried was with a fish found dead in the river, having been killed by a heron, and which had probably been dead twenty-four hours. The eggs, which I impregnated with fresh milt, are now in my boxes, and very few of them have died.

I have also tried a series of experiments as regards keeping the milt and ova separate in bottles for times varying from ten minutes up to sixty-eight hours. The results hitherto have been favorable, but I cannot be certain that fish will hatch out of these eggs. Should however the experiment succeed, the important practical bearing of this will at once be perceptible. Thus for instance I impregnated at Worcester some salmon-ova fresh from the fish, with trout-milt which had been sixty-eight hours in a bottle, but very few of these eggs are as yet dead. Again, I brought some salmon-eggs from Worcester and impregnated them with fresh trout-milt at Mr. Samuel Gurney's, Carshalton. The eggs in this case were twenty-nine hours old.

It is generally a difficult matter to get the eggs, whether of trout or salmon, properly operated upon, and then sent from a distance to the hatching-boxes; it therefore occurred to me that if I could possibly get the eggs from dead fish to hatch equally as well as those from live fish, it would save a great deal of time and expense, as well as trouble. Fish therefore have been sent up to me dead, packed in moss, and I have taken the eggs from them after twelve hours, twenty-four hours, and eighty hours. It is almost impossible to tell from any test that I know of, whether these eggs have been properly impregnated. Time alone will prove this. If the experiment succeed, we shall be able to write to our friends in the extreme north of Scotland, or in the furthermost part of Ireland, and ask them to catch the fish and send them to London, where they can be operated upon just as well as though an express messenger had been sent many hundred miles to do it.

Those who have experienced the sad disappointments that I have had with eggs sent even from short distances, and supposed to have been properly operated on, which arrive quite hard, white, and opaque, and, of course dead (the cause of this being generally the shaking of the railway, or bad packing), can appreciate the immense advantage of operating on dead fish. Now if we never unpack the eggs at all, and leave them as nature has herself arranged, then we shall have more chances of success than by the clumsy attempts of human hands to send them in a tin or glass vessel. The only objection to the plan is that the parent fish are of a necessity destroyed, which is not the case when they are treated in the usual manner.

I have often been asked if operating on fish and taking their eggs from them killed them? My answer is that we have this year taken over one hundred thousand trout-eggs, and have not killed, to my knowledge, one single fish, male or female. Those gentlemen, therefore, who have been good enough to allow us to operate on their fish,* whether salmon or trout, need not be in the least fear that any injury has been done to the fish, who, for aught I know to the contrary, may really feel much obliged to us for the trouble we have saved them of making their nests and depositing their eggs.

It has been objected by some that these experiments with dead fish, and with milt and ova taken from fish, and kept separate many hours, have been tried before. In the *Field* of Feb. 27, 1864, "the Chronicler" quotes from M. Coste, the eminent and learned professor of embryology in the Collège de France, a statement that milt will remain alive for twenty-four hours. I have however carried my experiments further on this point, and have ascertained, through the kindness of my friend Mr. H. B. Hancock, that the spermatozoa in the fish would live for so long a period as 141 hours, that is to say, nearly six days. It must however be remarked that both M. Coste and myself have separately come to the same conclusion, viz., that water must not be added to the dead fish till the moment that it is required for use, for it appears

* There is a special clause in the Act of Parliament which does away with the illegality of taking spawning-fish with the net for the *bona fide* purpose of obtaining their eggs for the purposes of pisciculture.

that the spermatozoa assume their peculiar vibratory quick action when water is added to them, otherwise they are quite quiescent. This is a most important point as regards the actual bringing the theory into practice.

I here desire to state, once for all, as I wish every one to remember, that I do not say that my experiment in keeping the milt and ova separate for so long a time will succeed, and that healthy young fish come from the egg, nor again am I at all sure that fish will hatch from eggs taken from the dead fish; but there is however no reason why the experiment should not be tried, for nature has many choice secrets in her laboratory which she has yet withheld from us, and which she will only disclose to us by asking her in the form of experiments varied and repeated in every possible manner.

Thus far I have attempted to show what becomes of the eggs of the fish in their natural state; how they may be taken care of, and what great results may be, with good luck and careful management, obtained. I would venture now to report progress and the result. The first originators and supporters of the important science of fish-hatching for the public good were the French Government, who have, as most of you are aware, erected a magnificent series of buildings, which may be fairly denominated a fish-manufactory, at Huningue, near Basle.

I must now mention what has been done in her Majesty's dominions. The first place established (that I know of) was at Perth, where thousands of salmon are hatched by artificial means annually. In Mr. W. Brown's admirable little book* will be found details as to the number of eggs laid down, &c. One of the consequences of this artificial hatching, Mr. Brown informs us, is as follows: We find that in the year 1828, the year of the passing of Home Drummond's Act, the rental of the salmon-fisheries of the Tay was £14,574. It gradually fell off every year afterwards till 1852, when it reached the minimum, amounting to £7,973. In 1853 the artificial rearing commenced; and in 1858, when the statement was printed, the rental was £11,487; it has now reached what it was in 1828." Mr. Brown has been kind enough to send me the latest news as follows:—

" The number of ova deposited in the boxes at Stormontfield

* The Stormontfield Experiment on the Salmon. Glasgow: Murray and Son. London: Arthur Hall, Virtue and Co. Price 3s.

in November and December 1862 was about 250,000; in 1863 (last spawning) about 80,000. The reason that so few eggs were got during the last spawning-season was the unfavorable state of the river for netting operations."

One of the greatest results in practical fish-hatching has been obtained by my friend Mr. Thomas Ashworth, and his brother, for they have actually peopled with salmon Lochs Mask and Corrib, an area of lakes containing thirty-five acres of water. In 1861, Mr. Ashworth laid down 659,000 salmon-eggs; he being, in his own words, "confident that he could breed salmon much easier than lambs." In December 1862 he deposited no less than 770,000 salmon-eggs, making in the two years 1,429,000. Mr. Ashworth tells me that the total cost of doing this has been exceedingly small.

Fish-Culture in Norway: By Rev. M. R. Barnard.

During the last ten years, the attention of the Norwegian Government has been directed towards the propagation of salmon by artificial means. In a country like the Scandinavian peninsula, which has such an extent of seaboard, and which abounds in rivers large and small, running into fiords which intersect the coast, there are so many natural facilities afforded for the protection of the young fish, that it only requires some additional attention on the part of the inhabitants themselves to make Norway stand at the head of the salmon-producing countries of Europe.

Fully alive to the disadvantages which many parts of the country labor under in an agricultural respect, owing to the rigor of winter and the unfertile nature* of the soil, the government, with a laudable generosity, has endeavored to promote the propagation of fish by rendering pecuniary assistance, and by the appointment of officers to superintend in the management of the operation.

It is somewhat remarkable that the artificial propagation of fish was first discovered in Norway by a simple laboring man in 1848. One harvest-time he had been obliged to keep at home on account of a bad leg. To amuse himself he used to get down to the river-side and watch the trout on their spawn-ground. Being of

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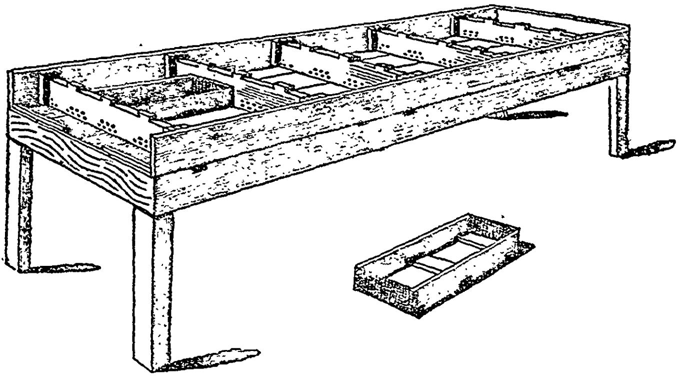
* The whole area of Norway is about 121,800 square miles, of which not more than 1,060 are under cultivation.

an observant nature, he was struck with the manner in which the operation was carried on. He remarked that the male fish placed itself alongside of the female in such a position that its head reached to about the middle of the body of the latter. He further noticed, that whilst the process of discharging the ova was going on, the female turned somewhat on her side with a quivering sort of motion, and that the male emitted his milt simultaneously. It therefore occurred to him that by pressing the spawn out of the female, and the milt from the male at the same time, in water, he would obtain a quantity of fructified eggs, which, by being placed in convenient places in brooks, would in due time bring forth fish. No sooner conceived than executed. He threw out his nets and caught a male and a female fish ready to spawn. His wife took the one, and he the other, and they squeezed their contents out into a bowl of clean water. He then took the eggs and placed them in a sheltered place in a stream where there were previously no trout. The following summer he was rejoiced to see that it swarmed with fish. Convinced, therefore, of the success of his plan, he constructed for himself a breeding-box close to his house; and notwithstanding the jeers and scoffs of his neighbors, who thought it impious, to say the least, in interfering and meddling with things which belonged to Nature alone, continued to breed fish every autumn. Such was the first attempt at hatching ova in Norway!

I will now proceed to give a brief account of the hatching-apparatus generally in vogue in that country, as communicated to me by Professor Rasch.

The case in which the hatching-boxes are placed (and which is under shelter, so that the water does not freeze) is twelve feet long, thirty-four inches wide inside, and five inches deep. The bottom must be perfectly water-tight, and very evenly planed. The sides are formed of single smooth-planed boards, which fit tightly against the bottom, to prevent any leakage ensuing. The uppermost end of the case, into which the water runs from the pipe, is of the same height as the sides. The whole is divided into five compartments, the first of which receives the water from the pipe. This compartment is eighteen inches wide, while the other four are each thirty inches wide. The partition-boards are one inch lower than the sides of the case, and have holes bored in them at a distance of two inches from the bottom, by means of a hot wire. They are bored in two rows (*vide* fig. 1.), four below, and three above. The water can thus run evenly throughout the length of the case.

The hatching-boxes (fig. 2), four of which are placed in each compartment, are constructed as follows: The sides consist of smooth-planed board, two feet long, three inches high, and an inch and a half thick. The bottom is a glass plate, two feet long, and seven inches wide. The ends are of perforated zinc, or brass wire-work, the same height as the sides, which are strengthened by two transverse pieces of wood. All the wood-work should be of well-seasoned material; and those parts which come in contact with the water should be glazed, as any resinous or pitchy substance in the wood would prove injurious to the ova. I should mention that the first compartment into which the water falls should be furnished with a network lid of zinc wire, which forms the bottom of a framework three or four inches high, so as to prevent the water running into the next compartment except through the holes in the zinc lid. Thus the larvæ of destructive insects, worms, &c., will be kept out. The upper end of the case should stand two



inches higher than the lower end. The water which runs out from the last compartment is prevented running out the whole width of the case by means of two pieces of wood, which are fastened to the sides, and reach nearly to the middle, and is carried off by a pipe.

The slimy deposit which comes even from the purest water, and settles on the eggs (it is not detrimental unless there be too much of it), can easily be got rid of by gently moving the boxes, and allowing it to pass through the ends.

After the lapse of about four weeks, it will be well to take the hatching-boxes out of the case to ascertain which eggs are good. The action of the air will render them all transparent; but on replacing them in the water, the unfruitful ones will assume a milky opaque color. These can readily be removed with a pair of fine pincers or long tweezers. The exposure to the air does not hurt the eggs, but care must be taken that they do not become dry on the surface. After repeating this process three or four times, all the bad eggs can be removed. "I am convinced," is the remark of Professor Rasch, "that in a case of the above size I could hatch 10,000 salmon-ova in each box, which would thus give a total of 160,000," there being four hatching-boxes in each of the four compartments. If the fry are to be kept any time in the boxes, care must be taken that they be not overstocked; but 3,000 may well be kept in them from two to three months."

Where water from a spring cannot be directly obtained, the following plan is often adopted. The scale of operations is however necessarily more limited. A large tub, or other wooden vessel, is fitted with a tap. Care must be taken that it shall have previously lain a sufficiently long time in water, so that all the deleterious substances from the wood shall have been extracted. It is then placed on a stand at a sufficient height from the ground to allow the case containing the hatching-boxes to be placed beneath the tap; and they should have a gentle inclination, so that the upper end be about half an inch higher than the lower.

The water, having passed through the boxes, empties itself into another vessel, at least as large as the tub, and should be regulated that it shall run out in twenty-four hours. The tub, therefore, only requires replenishing once in that time. If the water be at all muddy, it is well to place a layer of fine sand mixed with charcoal at the bottom of the tub.

Even in a common tea-saucer a great many ova may be hatched out. The saucer is placed in a deep soup-plate, and a couple of moss-stalks laid over the edge in such a manner that they shall act as syphons. A constant flow of water thus takes place from the saucer into the plate. In about twelve hours half the water from the saucer will have run out, so that it will require filling again morning and evening. When necessary, fresh moss-stalks can be substituted.

It is of course best to procure the male and female fish to be operated upon direct from their breeding-ground, and as short a time as possible before the spawning commences. Where this is impossible, they should be kept in fish-boxes or reservoirs; care however be taken that they be not kept too long in confinement before being used, as this would have an injurious effect both on the ova and the milt. One male fish is sufficient to fructify the ova of a great many females, and can be used from six to eight days in succession.

It is not difficult to ascertain when the female is ready to spawn. Her distended abdomen yields easily to a gentle pressure, and an undulating movement which is perceptible on touching it, shows that the spawn is already disconnected from the ovary. She should then be held by the head in a vertical position, so that the ova will of their own weight fall down towards the vent. When the fish are large, it is best to have three persons to assist. One takes the fish by the head, and the other by the tail, holding it horizontally over a dish, the vent downwards, whilst the third very gently presses along her stomach and sides. When the bottom of the dish has been covered with ova, in layers of two or three deep, the fish can be released into the tub of water from which she was taken. The dish, by the way, must previously have been nearly filled with water. Before operating on the male fish, the water from the fish had better be drained off, and fresh poured in. The male fish is then taken and handled in the same way. A small quantity of milt, just sufficient to discolor the water after being gently stirred with the fingers, is sufficient. It is then put back again into the tub, and while the female is again being brought out, the contents of the dish are to be emptied into another tub half filled with pure water. When all the roe has been pressed out and fructified as before with the milt, and again emptied into this tub, the water is allowed to run out through a hole previously bored in the side about an inch above the bottom. By the motion of the water running out, all the eggs will be brought into contact with the milt. In about five or ten minutes the ova can then be removed into the hatching-boxes.

If the eggs are in a fit state, the very smallest pressure is sufficient to squeeze them out; and it has been found that with due care the female suffers no injury from the manipulation, and will be as fruitful the following year as ever.

The unfruitful eggs, after they have been some time in the hatching-boxes, will be covered with a peculiar parasitical plant, *Leptomitus clavatus*, which gives them the appearance of being wrapped in cotton. These should be removed, as though the other eggs will not be immediately infected, yet the fibres of this vegetable growth will in time get around them, and prevent the water having free access to them, when they too will die. The unfruitful salmon-eggs should be at once removed; but when the ova are very small, as is the case in trout, &c., it is better to wait till the parasitical plant has appeared before removing "the tares from the wheat," as the operation can then be performed more easily. It is therefore much better not to have a layer of small stones at the bottom of the case, as many of the ova will sink between them, and from remaining unperceived may in time cause great damage. It is true that the salmon instinctively makes a hole, and covers her ova with small stones. But she, in all probability, only adopts this precaution in order *to protect them against their numerous foes*, and not that the development of the embryo may be thereby in any way accelerated.

It might not unnaturally be supposed that it is best to transport the ova in the same element as that in which they are deposited in the ordinary course of things, viz., *in water*. But it must at the same time be remembered, that every fertile egg contains a living being, which requires a constant supply of air for its preservation, and that the quantity of air contained in a confined vessel is more rapidly consumed by the ova than fresh air can be absorbed from the surface. The consequence will be that unless fresh water be constantly supplied, or the water in the vessel be by some means aërated, the embryo contained in the egg must die. But not only will the constant replenishing the vessel with fresh water be troublesome, and often impossible, but it will also be attended with great risk to the safety of the ova.

If it is borne in mind that it is not the water, but the air which is therein contained, that is essential to the preservation of the ova, it will be apparent that if they be kept moist, and have a constant supply of fresh air, the necessary conditions will be obtained. The readiest and easiest way is to pack them in damp moss (the marsh moss, *Sphagnum*, which absorbs moisture like a sponge, is the best), through which the air will readily circulate.*

* Professor Rasch told me that he has hatched ova in damp moss, without even immersing them in water at all.

In a common wooden box the moss will retain its dampness so as not to require wetting for several days. And indeed caution is requisite when it is so sprinkled, that the temperature of the fresh water be not lower than that of the moss. Moreover, it is only necessary to sprinkle the topmost layer of the moss, as the moisture will gradually percolate through the contents of the box. Neither should too much water be sprinkled on at one time, lest the ova at the bottom of the box should be immersed. To obviate this contingency, it is best to turn the box over once at least in the course of the day.

In packing the box, the bottom should first be evenly covered with a thick layer of the moss, which should be previously washed quite clean. On this a layer of eggs should be evenly spread, then should come a thinner layer of moss than before, and so on, alternate layers of eggs and moss till the box is nearly full. On the top of all, a layer of moss of the same thickness as the first should be laid; so that when the lid is fastened down, the whole will form a compact mass, and all shifting of the contents be rendered impossible. The elasticity of the moss will prevent the slightest danger from pressure accruing to the ova. If the weather is extremely severe, the box should be protected. It may be remarked, that ova should not be transported till the eyes of the embryo are visible.

A few precautions are necessary on unpacking such a box containing ova. The temperature of the box, and of the water in the hatching-case, must be compared with a thermometer. Supposing that of the former to be the greater, the moss should be gradually sprinkled with water from the latter till they are both equal. Great care must be taken not to hurry this operation.

The contents of the box should then be emptied into a good-sized tub half filled with water of *the same temperature as that in the hatching-case.* By gently moving the hand about among the moss, the ova will sink to the bottom, and the moss remain floating on the surface. The water should now be drained off, and the ova at once deposited in the hatching-boxes.

Should the water in the hatching-boxes, however, be of a higher temperature than the moss in which the ova were conveyed, these can be at once removed into the hatching-cases after they have been detached from the moss as above described.

The greatest care must be taken to prevent the entrance of insects and larvæ into the hatching-apparatus. The most dangerous enemy to the ova and the young fish, is, perhaps, the water-newt (*Sorex fodiens*). If the apparatus cannot be raised to a sufficient height above the ground, it should be protected with a perforated tin or zinc lid.

A curious instance occurred at the hatching-establishment at Greffsen, a water-cure establishment near Christiania, a few years ago. The apparatus was raised two feet above the ground, and was not, therefore, protected with such a lid. A large quantity of eggs had been hatched out, when, one fine morning, the young fry had nearly all disappeared! A number of traps were accordingly set on the floor of the house, and the following morning the intruder was captured. It turned out to be a water-rail, which had found ingress through the mouth of the drain.

The *Dytisci*, *Hydrophili*, and their larvæ, and the larvæ of the *Libellula* and *Agrion*, are also very dangerous enemies. The *Libellula depressa* is especially a deadly foe, and will even devour the fish of two to three months old. It is extremely tenacious of life; and has been known, after having been kept a whole day in spirits, to recover when placed in water where there were young fish, and in a very short time to commence attacking them as if nothing had happened.

Proved Facts in thf History of the Salmon: By H. C. Pennell.

1. Salmon and Grilse invariably spawn in fresh water if possible; both the eggs, and the young fry whilst in the Parr state, being destroyed by contact with salt water.

2. The eggs are usually deposited on gravelly shallows, where they hatch in from 80 to 140 days, according to the temperature of the water. Eggs remaining unhatched beyond the latter period will seldom hatch at all, possibly from having been destroyed by the low temperature.

3 The eggs deposited by the female will not hatch under any circumstances unless vivified, after exclusion, by the milt of the male; and—at least up to the period of migration—there is no difference whatever in fry bred between Salmon only, between Grilse only, between Salmon and Grilse, between Salmon and Parr, or between Grilse and Parr.

[The female Parr cannot spawn; but the male Parr possesses, and constantly exercises, the power of vivifying Salmon and Grilse eggs.]

4. The fry remain one, two, and, in some cases, three years in the rivers as Parr before going down to the sea; about half taking their departure at one year, nearly all the others at two years, and the remainder (which are exceptional) at three years old.

5. All young Salmon-fry are marked with bluish bars on their sides until shortly before their migration, up to which period they are Parrs; they then invariably assume a more or less complete coating of silvery scales and become Smolts,—the bars, or Parr-marks, however, being still clearly discernible on rubbing off the new scales.

6. The young of all the species here included in the genus *Salmo* have at some period of their existence these bluish bars; and consequently such marks are not by themselves proofs that fry bearing them are the young of the true Salmon (*Salmo salar*).

7. Unless the young fish put on their Smolt-dress in May or early in June, and thereupon go down to the sea, they remain as Parrs another year; and without Smolt-scales they will not migrate, and cannot exist in salt water.

8. The length of the Parr at six weeks old is about an inch and a half or two inches; and the weight of the Smolt before reaching the salt water from one to two ounces.

9. In at least many cases, Smolts thus migrating to the sea in May and June return as Grilse, sometimes within five, generally within ten weeks, the increase in weight during that period varying from two to ten lbs., the average being from four to six lbs.; and these Grilse spawn about November or December, go back to the sea, and in many cases re-ascend the rivers the next spring as Salmon, with a further increase of from four to twelve lbs. Thus, a fish hatched in April 1854, and marked as migrating in May 1855, was caught as a Salmon of twenty-two lbs. weight in March 1856.

10. It appears certain however that Smolts do not always return during the same year as Grilse, but frequently remain nine or ten months in the sea, returning in the following spring as small-sized Salmon.

[It will thus be seen that the fry of the Salmon are called *Parrs* until they put on their migratory dress, when they become *Smolts* and go down to the salt water; *Grilse* if they return from the sea during the first year of their migration; and at all other periods *Salmon*.]

11. It has also been clearly proved that, in general, Salmon and Grilse find their way back to spawn to the rivers in which they were bred, sometimes to the identical spots,—spawn about November or December,—and go down again to the sea as "spent fish," or "Kelts," in February or March,—returning, in at least many cases, during the following four or five months, as "clean fish," and with an increase in weight of from seven to ten lbs.

[Shortly before spawning, and whilst returning to the sea as Kelts, or spent fish, Salmon are unfit for food, and their capture is then illegal. "Foul fish," *before* spawning, are, if males, termed Red fish, from the orange-colored stripes with which their cheeks are marked, and the golden-orange tint of the body; the females are darker in color, and are called Black fish. *After* spawning, the males are called Kippers, and the females Shedders or Baggits.]

This, in a condensed form, is the present state of our positive knowledge as regards the leading facts in the history of the Salmon as it occurs in British waters.

REVIEW.

Comparisons of American Languages with those of the Old World.*

Under the title noted below, "N.O.," a writer in the Lower Canada Journal of Education, attacks some rather bold statements respecting the American languages, made by M. Renan in his work on the Primitive Languages. In an ethnological point of view the subject is of interest, and we are glad that any one acquainted with our native languages is disposed to take it up. The American languages have usually been regarded as altogether distinct from those of other parts of the world, and as very dissimilar among themselves. Yet the most superficial examination shows that similarities of grammatical forms and of root-words exist over wide areas of the American continent, and among tribes per-

* "Jugement erroné de M. Ernest Renan sur les Langues Sauvages," (par N. O. Pamphlet reprinted from the Journal d'Instruction Publique.)

fectly separated from each other. There have also not been wanting students of the subject, who supposed they could discover links of connection with the languages of the old world. Still the subject has been pursued only in a desultory manner, and it presents a rich and comparatively unexplored field. It is more especially important in connection with the bold theory of Retzius, based on cranial conformation, that the "long-headed" Indian races of Eastern America may have been of North African or South European origin. This would make America the meeting ground of the opposite extremes of human migration to the East and the West, as it seems certain that the Indians of Western America are related to the races of Northern Asia. To us this theory receives strong confirmation, not only from the similar physical conformation of the Guanches of the Canaries, and some of the North African races, but also from the facts which have been ascertained as to the form, habits, and rites of the earliest aborigines of Europe. In the further solution of such questions, the study of the languages is most important, and we need a careful and thorough comparison of all the Eastern American tongues, more especially with a view to the question of their possibly having originated from colonists landing on the West-India Islands from some part of the shores of the Mediterranean, and this at a remote period when the languages of Europe were in their most primitive state. The task is a difficult one, requiring the combination of the learning of many men and laborious investigation; but if any reliable positive results could be obtained, the labor would not be in vain. In the meantime we give a few extracts from the pamphlet of "N. O.," in illustration of his protest against the dictum of M. Renan, that the idea of the primitive unity of language is a chimera:—

"Mr. Renan will be perhaps surprised to learn that that Iroquois tongue which he had considered so barbarous has, nevertheless certain very curious analogies with the learned languages. Thus those Hebrew and Indo-Germanic quadriliteral and quinquiliteral roots, of which M. Renan makes such a show in his book of comparative philology, are also found in the Iroquois tongue; and certainly the words raonraon, kitkit, 8iion8iion, taraktarak, sarasara, teriteri, k8isk8is, herhar, tsiskoko, k8itok8ito, iekonienk, 8irok8iro, and others may very well be compared with *gargar*, *tsiftsêf*, *tsiltsêl*, GARGARISER, GARGARIZEIN, pipivit, PIPI-

ZEIN, tintinnavit, klingeln, and other like words given in the list of Mr. Renan. Let us then conclude that for onomatopœia the American languages are second to none, and that among them the Iroquois is distinguished by its tendency to take the quadriliteral form. But there are other analogies.

" Such will be the analogy which exists between the Algonquin prefixes and the Hebrew affixes.

SabaktaNI,	thou hast forgotten me,	NI, me,	Heb. aff.
JadeKA,	thy hand,	KA, of thee,	
RagheLO,	his foot,	O, of him,	
NInaganik,	he forgets me,	NI, me,	Alg. pref.
KInindj,	thy hand,	KA, of thee,	
O,	his foot,	O, of him or of her,	

" This is an example which might be considered as an argument in favor of the homogeneity of languages, and which demonstrates, moreover, that the savage tongues have not a character exclusively sensuous, in the sense that Mr. Renan gives to that word, but that they are, at least as psychological as the Indo-Germanic languages.

" The Algonquin root ENIM serves to express all the intellectual operations, all the dispositions of the soul, all the emotions of the heart, all the acts either of the mind or the will. Thus it will be said: ni *minsenimdam*, I am contented; ni *gackenindam*, I am sad; ni *minsenima*, I am satisfied with somebody; ni *cinge nima*, I am not satisfied with it; ni *sakenima*, I am heartily attached to him; *nindapitenima*, I esteem him: ni *nickenima*, I trouble his mind, I make him angry; ni *pagosenima*, I make my supplications to him in my heart, I pray to him inwardly; ni *kitsit8a8enima*, I venerate him, I think him worthy of honor; ni *kikenima*, I know him; ni *k8aiak8enima*, I know him perfectly; ni *piziskenima*, I can remember him; ni *mika8enima*, I remember him; ni *mitonenima*, I think of him; ni *nib8aka8enima*, I believe him wise; ni *tat8enima*, I understand it, I conceive it, I seize it with the mind; *ninol obtitcienima*, I reach him with my thought, my mind reaches up to him; ni *tanenima*, I believe him present; ni *panenima*, he escapes my thought, my mind cannot reach him; ni *8anenima*, I forget it, I lose the remembrance of it; ni *tangenima*, I touch it (him) with my mind, it seems to me that I touch it (him).

" Is not the importance of this root ENIM a thing truly worthy to be remarked, as it is without contradiction a hundred times more productive than its congeners *anime* and *animus ?*

"The Latin *animus* has been compared to the Greek *anemos.* We can with as much, nay with more reason, compare our root *enim* to this last one. In fact it is found in the form *anim,* with the Greek meaning, in the impersonal verbs *animat,* the wind blows; *pitanimat,* the wind blows this way; *ondanimat,* the wind comes from that direction, etc., etc.

"But here is another peculiarity which comes to our mind which cannot fail to draw the attention of an Oriental scholar:

"In Hebrew, the third person masculine singular of the first tense of the indicative serves to form all the other persons and all the other tenses of the verb.

"In Algonquin, the third person singular common gender of the present of the indicative serves to form all the other tenses and persons of the verb.

"Thus it is said in Hebrew: qâthal, he has killed; qâhaltâ, thou hast killed; qâthalti, I have killed. In the same way it will be said in Algonquin: nicise, he kills, ki nici8e, thou killest, ni nici8e, I kill.

"In both languages, the third person does not take any characteristic for itself, whilst the two others are accompanied or preceded by the signs which distinguish them, ta, ti, ki, ni.

"The third person is then the root of the verb. Therefore that is the reason why the Algonquin dictionary gives first that person, in imitation of the Hebrew.

"We have said that the syntax of our two savage languages is *pretty complicated.* It is too much so to allow us to enter, in a review like the present one, into the details which would be necessary to give a correct idea of it. For the same reason we will not give the list of the conjugations either Iroquois or Algonquin; we shall only say that they are divided into copulative, disjunctive, suppositive, concessive, causal, temporal, adversative, optative, and expletive.

"We have affirmed that these two languages are very clear, very precise, expressing with facility not only the exterior of ideas, but still more their metaphysical relations. In fact, the Algonquin has not less than eight moods, whose names are: indicative, conditional, imperative, subjunctive, simultaneous, participle, contingent, and gerund. With the exception of this last one, all these moods have several tenses. The total number of them is twenty-nine. The verbs in Iroquois have twenty-one tenses, divided into three moods, indicative, imperative, and subjunctive.

" Nouns are scarcely less marvellous; they are conjugated rather than declined. It will be said in Iroquois: kasitake, at my feet; sasitake, at thy feet; rasitake, at his feet: and in Algonquin: nisit, my foot; kisit, thy foot; osit, his foot: as it is said: ktahahtos, ni 8*ab*, I see; satkahtos, *ki*8*ab*, thou seest; rathkatos, 8*abi*, he sees. The prefixes of nouns are almost the same as those of the verbs. There are in Iroquois, as well in the conjugation of nouns as in theconjugation of verbs, fifteen persons, of which four are in the sing, five in the dual, five in the plural, and an indeterminate one. The Algonquins have only seven persons; but their nouns possess, nevertheless, a prodigious number of inflexions on account of the accidents to which they are liable, the list of which is: the diminutive, the deteriorative, the ultra-deteriorative, the investigative, the dubitative, the near preterite, the remote preterite, the locative, the obviative, the superobviative, the possessive, the sociative, and the modificative."

A multitude of questions and objections might be raised even on the few points stated above. The following, for example, have been suggested to us by an eminent hebraist:

The first of the three words cited as examples of the Hebrew (sabaktani) is not Hebrew, but belongs to another, though cognate language. In this first example, therefore, we think M. Renan will be disposed to deny the analogy. The reviewer through inadvertence has here given his opponent an advantage. Then again without objecting that in the one language the *ni* is prefixed, and in the other post-fixed, we must recollect that in Hebrew, *ni*, which is only the objective case of the pronoun when immediately joined to a verb, is used but very seldom, especially when compared with the fuller prevalence of the form *i*, and that in verbs the *n* for the first person is *never* used in the past tenses, and in the future tenses the *n* and the *i* are *both* omitted, and the letter *a*, the other fragment of the absolute form of the pronouns, is employed. It is only right to keep these points in view, in establishing the analogy sought to be set up. In the second example cited, Iadeka (more properly yadecha), the *a* is changed into *i* in the Iroquois, and the *o* of the third person is not used in the verb, e. g., (p. 20,) niciSe, he kills. The reviewer however informs us of very interesting facts respecting the composition of the tenses of the verbs, as compared with the Hebrew forms, and it is more of these interesting facts that we would desire.

Again, while N. O. is quite right on scientific grounds to condemn M. Renan's unphilosophical reference of certain analogies to chance, it may not be quite right to object as he does, to what M. Renan has to say on the subject of onomatopœia, and in which he but coincides with such eminent modern critics as Gesenius, Fürst, etc. N. O. is doubtless acquainted with the original Hebrew text of the Scriptures. Can he, then, ignore the remarkable prevalence of Onomatopœia, more especially in the early books of the Sacred Volume? And need we remind him that this prevalence of onomatopœia in the early history of the language is of no small value in discussing the question of the primitive language —"unité primordiale du langage" which, says N. O., is treated by M. Renan as "ridicule chimère, et mythe le plus bizarre." We are not quite clear as to whether the reviewer holds the Hebrew to be the primitive language of man; but for his Algonquin "kokoc, kokoko, kackacipinesi, kakaki, makaki, etc.," how many examples could we cite, not only in the Hebrew, but in the later Latin family of languages. Here are a few: Hebrew לקק, lackack, English, he licked; Italian leccare; French lécher: so in Greek λεχεῖν, German lecken. Next Hebrew קרא, kara; English, he cried; Italian, gridare; Fr. crier; Ger. schreien. Our limited space, however, compels us to leave this topic here. Scarcely more satisfied are we with the meagre list of quadriliteral and quinquiliteral Iroquois roots which N. O. opposes to a yet shorter list of Hebrew and other similar roots, as an offset to those "dont M. Renan fait un si pompeux étalage." We shall wait for the more elaborate effort which we desire to see from the reviewer before we fully give in our adhesion to the following important claims: "Concluons donc qu'en matière d'onomatopées, les langues américaines ne le cèdent à aucune, et que parmi elles, l'iroquois se distingue par des tendances à revêtir la forme quadrilitère."

Similar objections may be raised to comparisons of Algonquin with Greek and Latin, as 'enim,' above referred to, or the root "tang" in the verb to touch, or another which has been suggested as a parallel,—the prevalence of the root "ouk," or "oik," in the sense of house or dwelling. More especially would such objections be strengthened by the fact stated by N. O., that perhaps the root "sit," foot, is the only one common to the neighboring Iroquois and Algonquin languages; unless, indeed, it should appear that these two languages have been derived the one from the east, the other from the west, and have met in Canada. To give force to these comparisons of roots, it would be necessary to show that they occur also in the Carib, or other languages of that region, and in the extinct Guanche of the Canaries, or in some of the ancient languages of Northern Africa or Southwestern Europe. At one time there was a strong tendency to get up fanciful resemblances between languages. The tide has turned, and the prejudices of scholars are all the other way. For this very reason we thank N. O. for his effort, and would encourage, in the interests of ethnology, all the honest cultivators of the comparative philology of even those primitive tongues, unjustly neglected as barbarous and uncultivated; though for that very reason, like the habits and rites of the people who speak them, they may, as Dr. Wilson has well shown, be of inestimable value in interpreting the primitive relations of men, and their condition in "pre-historic times."

MEETING OF BRITISH ASSOCIATION.

Geography and Ethnology.

In this section, after some opening observations on the progress made between 1838 and 1863 in the vast centre of industry on the Tyne, the President remarked: "I will first call your attention to some of the leading geographical results in British Geography which have been brought about since we last met here. At that time four years had elapsed since (at our first meeting in Scotland) I directed the attention of this Association to the untoward condition of the Topographical Survey of the British Isles, by showing that no map of any country north of the Trent was in existence; in short, that all the North of England and the whole of Scotland were in that lamentable state; whilst the survey of France, and of nearly all the little states of Germany, had been completed. Having roused public sentiment to this neglected state of the national map,—so neglected, indeed, that one of the great headlands (Cape Wrath) was known to have been laid down some miles out of its proper place in all maps and charts,—deputations to the government followed, in the first of which I pleaded the cause of geography; but with little or no effect as regarded the North of England, and my native country, Scotland. In the twenty-nine years which have elapsed between the period when the question was first agitated at Edinburgh, considerable progress has, doubtless, been made; but it is surely a reproach to a powerful country like Britain that in thirty years we have only just seen the region between the Trent and the Tyne delineated and laid down on a real map,—*i. e.*, on the one-inch scale,—whilst even yet the maps of the northernmost English counties are unfinished. With the extension of the survey to the North of England and Scotland, not only has the six-inch scale been adopted, but much larger cadastral plans, on the 25½-inch scale, have been and are in execution. While these plans are, I grant, most valuable to individual proprietors, they are beside the purposes of the geographer—inasmuch as they exhibit no attempt whatever at the delineation of physical features. Hence I regret that their execution should have been preferred to the completion, in the first instance, of an intelligible and useful map of the British Isles, which, if made to depend on the *previous* completion of the large-scale plans, will still involve, I fear, the lapse of another very long period before the whole country will possess what geographers consider a map. The most powerful cause which has retarded the progress of good cartography has been the frequently-recurring cold fits of indifference and consequent cutting off of the supplies by which our legislature has been periodically affected, and which have necessarily occasioned a collapse and stagnation in the works of this important survey. As respects my own special department, or the "Geological Survey," I deprecate still more strongly the delay of the construction of the one-inch map, seeing that no geologist can labor in the Highlands of Scotland, and accurately delineate their interesting rock-formations, by coloring any of the defective country-maps of that region. Let us now cast a rapid glance over the progress of discovery in distant lands, and particularly where our countrymen have signalized themselves. At former meetings of this Association, we have dwelt on the early discoveries of new lands in the interior of Australia, in which the names of Mitchell, Eyre, Sturt, Leichhardt, and others have been always mentioned with honor and respect. The latter journeys of the brothers Augustus and Frank Gregory have earned for these good surveyors the highest honors of the Royal Geographicel

Society, for their extensive researches and determinations of longitude and latitude in Northern, Eastern, and Western Australia. Whilst more recently, the bold expedition of Burk and Wills cost these noble fellows their lives, the latest researches of their successors stand out as indeed most singularly successful. M'Douall Stuart, after various previous triumphs, in one of which he reached the watershed of North Australia, has actually passed from Adelaide, in South Australia, to Van Dieman Bay on the north coast, in latitude 15 deg. S. Contemporaneously with this last expedition, M'Kinlay, proceeding also from Adelaide, reached the Gulf of Carpentaria, and thence travelled to the eastern shore; and Landsborough, realizing all the value of the discoveries of Burk and Wills, and penetrating from the Gulf of Carpentaria, traversed the continent southward until he regained the noble colony of Victoria, in which the expedition was organized. The rapid rise of the different colonies in Australia is truly marvellous; and whilst we have successfully occupied all the available ports and lands along the eastern, southern, and western sides of this great continent, we are, I rejoice to say, now beginning to extend our settlements to the north coast, the occupation of which I have advocated for many a year, on political as well as on commercial and colonial grounds A few years only of practical researches have dispelled our ignorance respecting the interior of this vast mass of land; in which, though there are wild desert tracks, there are also many rich and well-watered oases of fine pasture-grounds, through which the colonists may open out communications across the continent from the south and east to the northern shores. A short time only, I venture to predict, will elapse before towns arise at the head of the Gulf of Carpentaria, as well as at the mouth of the Victoria River of the north; from whence, as well as from the new settlement of Cape York, Australia will have a direct communication with our great Indian Empire."

Referring to the discovery of the sources of the Nile, the President remarked upon the fact that "traveller after traveller, from the days of the Egyptian priests and of the Roman emperors down to modern periods, had endeavored to ascend the Nile to its source, and all had failed"; and that it was by reversing the process, and by proceeding from the east coast of Africa, near Zanzibar, to the central plateau land between North and South Africa, that Captains Speke and Grant had solved the problem.

The President, after stating the subjects of greatest interest to be discussed in this section, remarked: "In the commencement of this address, I spoke of the comparatively few means we possessed in 1838 of reaching rapidly this flourishing town; and now I need not remind you that we are surrounded by a network of railroads, which wind along valleys, or are driven under your hills. Still less at our former meeting here had the genius and sagaciousness of Wheatstone overspread the country with the electric telegraph, enabling men rapidly to transact important affairs in our largest cities, whether separated by a few miles or by hundreds of miles from their correspondents. At the last Manchester meeting, indeed, we interchanged questions and answers with the philosophers of St Petersburgh during an evening assembly; and since then great advances have been made in transmitting telegrams round the world. In this way a vast stride will be made in the ensuing winter by the extension of the telegraph from Constantinople through Asia Minor; and thence, *via* the Persian Gulf, to the country of Mekran, at the head of the Indian Ocean, and so to the British possessions in India. At the same time, other efforts are in progress to carry a system of telegraphs from Russia through Siberia, and thence across the Desert of Gobi to Pekin. The great desideratum, however, of connecting Europe with America by a submarine telegraph remains to be accomplished. With a view to that desirable end, the Council of the Royal Geographical Society warmly supported a proposal by Dr. Wallich to effect a complete survey of the sea bottom, as a precursor to the actual laying down of a cable upon the vast unknown irregularities of the submarine surface. We naturally supported an effort like this, which was certain to throw much light on Natural History and Physical Geography; and we rejoiced in the preliminary researches which had been made towards the establishment of an electric line overland to British India; because they, for the first time, laid open to European knowledge countries which, though unknown to the moderns, were seats of power when Alexander the Great and his lieutenants invaded India. The soundings which ascertain the nature of the bottom of the ocean, not only give us the outlines and characters of various sunken rocks, sands, and mud-banks, and of vast and deep cavities, but inform us where the under-currents prevail, and where at vast depths the surface is tranquil and unruffled in some places, whilst in others submarine volcanoes disturb the sea-bottom. Nay, more, these submarine operations have taught us that animals cannot only live, but flourish, preserving even their colors, at the enormous depth of one mile and a half. We thus see how the efforts of the nautical surveyors and the engineers to spread the electric telegraph are not merely destined to be useful to mankind, but also to elicit great and important truths in Natural History, the development of which is specially connected with the pursuits of the geographer and the ethnologist."

The address concluded by a reference to the appointment of so skilful and philosophical a naturalist as Mr. John Lubbock to the chair of President of the Ethnological Society, and to the appointment of Mr. F. Galton as Secretary, under whose auspices an increased activity was being already shewn.

MISCELLANEOUS.

The Earthquake of April, 1864.

In the *Canadian Naturalist*, Vol. v., p. 379, will be found a list of all the earthquakes observed in Canada up to that of October, 1860. Since that time, with the exception of a few slight and local shocks, chiefly in the vicinity of Murray Bay and the Saguenay, which appear to be points of special intensity for the seismic agency of this country, there have been no earthquakes felt until Wednesday, April 20th, 1864, when a shock of no great intensity was felt throughout a great part of Lower Canada. Like other Canadian earthquakes it was felt almost simultaneously over a wide extent of country, indicating perhaps that its source was deep-seated, and the vibrations propagated almost vertically to the surface. At Quebec the shock was felt between 1.10 and 1.15 p.m.;* and at L'Islet, Danville, Montreal, and other places, in so far as can be ascertained, the hour was nearly the same, except in the case of Father Point, where a shock is said to have been felt at 11 o'clock. Unless there is some mistake in the statement this must have been a shock not felt elsewhere. In so far as reported, the shock seems to have been most violent at Quebec, where, as well as at several other places, two distinct vibrations

* Or according to other statements at 1.20 P. M.

were noted by some observers. The reports do not give much information as to the direction of the vibration, but it was probably, as in the earthquake of 1860, from east to west, or from southeast to northwest.

The only remarkable point in relation to this earthquake is its occurrence at a season when seismic energy in this region seems, from past experience, to manifest itself less frequently than at most other times. Only four out of eighty-three recorded earthquakes in Canada and its vicinity have occurred in April; the autumn and winter being the seasons of greatest seismic activity.

The following extracts from Quebec newspapers give some details of interest:—

The *Mercury* says:—"The earth trembled violently; every house was shaken as if an explosion of gas or gunpowder, or an *eboulement* of the rock had taken place—only no noise was heard. Some fancied that a heavy weight had fallen upon the floors above them, and, indeed, that was our own sensation. The walls of the house rocked; the windows rattled; and we rocked ourselves. To make sure that the power-press had not fallen to pieces, we examined the press-room, but found all right there. The inmates of the rooms above us, horror-stricken, came down stairs to enquire what the matter was; people from the street came tumbling in to ask us if we had felt any unusual sensation: the people over the way felt it; the cruet stands were overset, plates broken, and the whole dinner-table service at Russell's set in motion; the soldiers rushed out of their bomb-proofs on the citadel, where the shock was, we are informed, the most severe; in St. John street without, people ran from their houses, and hosts of people besieged the gates of the gas-works. In the streets, however, the shock was not sensibly felt, and by some persons not felt at all. It is fully believed that the concussory effect upon the houses was greater than when the laboratory blew up. A gentleman informs us that at Mount Pleasant the shock appeared to come from the southwest with a gradually increasing rumbling noise, and ended with a report as of a distant explosion. At the house of Mr. Mainguy, in Scott street, near the Lewis Road, the earth has opened in two places in a passage leading to the yard, and a quantity of earth was thrown down from the siding of the cellar.

The *Chronicle* states:—"About ten minutes or a quarter past one, yesterday afternoon, the city was "frightened from its propriety" by a shock of an earthquake—of brief duration and unattended by any serious results, but sufficiently violent to give an idea of the destruction which would have been caused had the convulsion of the earth lasted as many minutes as it did seconds. The shock was of a peculiar nature. It was not of the swaying or vibratory species—it was a shaking of the ground precisely similar in effect with that caused on a bridge by the passing of a heavy train at a considerable speed. In the houses it was felt to a much greater extent than by persons in the streets—this fact being of course easily explained by the motion communicated to floors, the rattling of windows, doors, furniture, glass-ware, and loose fixtures. Several persons appear not to have felt the quivering motion of the ground out of doors, and were therefore surprised to see persons rushing into the streets, anxiously enquiring what had occurred. In the houses the rumbling or jarring sound was however, positively alarming. In some instances ornaments and ill-secured panes of glass fell from windows. The shock lasted, as nearly as can be determined, five or six seconds. Of course, on such an occasion, few persons could be found with sufficient presence of mind to count at the moment the duration of the convulsion, and it can therefore only be estimated by the recollection of the event.

"In the upper portions of the city—on the Cape, in the Citadel, and in St. Lewis suburbs—the shock seems to have been most severe. In the Lower Town and St. Roch's, however, it was felt with sufficient force to send thousands of persons into the streets to enquire if another explosion had taken place, if the gas works at Orleans wharf, Palais, had blown up, or if a portion of Cape Diamond had given way and crushed the houses in Champlain street. All these surmises were indulged in at the moment. That with regard to the gas works, however, grew into a rumor that spread like wildfire, and hundreds ran or drove towards the Palais to find that it was unfounded. This rumor was doubtless strengthened by the fact that many persons fancied that they perceived a gaseous smell immediately after the shock. But the absence of anything like the loud report which characterizes an explosion seems to have led most people to attribute it at once to its true cause.

"There were none of the signs of the elements which usually herald the coming of earthquakes in southern latitudes. The sky was cloudless at the time, the weather clear and agreeable, with what mariners would call a " stiff breeze." The wind prevented the effect of the earthquake from being noticeable on the river, although some observant persons say that the surface of the water appeared darker than its ordinary color while the concussion lasted."

The *News* adds the following :—" The shock was so sudden that to those who were within doors it appeared as if the chimney-wall or roof of their own or their neighbor's house had given way and was tumbling down. At the Artillery Barracks, the men ran from their rooms into the square and up towards the magazine, fully convinced that another explosion had taken place. On the citadel, too, where we are told the shock was most violent, the men ran in terror from their bomb-proof rooms into the square, and crowded the ramparts to see where the explosion had occurred.

" We learn that in the ship-yards at St. Roch's, the ships on the stocks waved to and fro. Some persons say they distinctly saw the river rise in some parts to a height of nearly ten feet, and that it receded almost immediately."

Mr. Herbert Williams writes to the Quebec *Chronicle* as follows, from Harvey Hill Mines, under the date of Thursday April 21 : " At 1.15 p.m., yesterday, a smart shock of an earthquake was felt in this district, lasting from ten to fifteen seconds. It was also perceived by some of our miners, who were at the time working at a depth of 180 feet below the surface. The undulation at this place, as nearly as I could judge, seemed to travel from southwest to northeast, the wind blowing at the time from the northeast. At 6.40 p.m., we had a brilliant flash of lightning without its usual accompaniment of thunder; the sky at the time was perfectly clear, the wind blowing strong from the northeast. As yuo will, I doubt not, receive many communications from different parts of the Province, it may be interesting to learn the time of its appearance at different places. Hence I send you the above facts of its occurrence here."

On Organic Remains in the Laurentian Rocks of Canada.

(Letter from Sir W. E. Logan to the Editors of " Silliman's Journal.")

" In August, 1859, I exhibited to the American Association at Springfield, Mass., specimens of what was regarded by me as an organic form externally resembling *Stromatocerium*, and found in the Laurentian limestone of the Ottawa. These were described by me in the *Canadian Naturalist* for that year (vol. iv, p. 300), and afterwards figured in the *Geology of Canada*, p. 49. In 1863, similar forms were detected by the Geological Survey, in the serpentine-limestone of Grenville, sections of which we have prepared and submitted for microscopic examination to Dr. J. W. Dawson. 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 *Carpenteria*, but of much greater dimensions, and presenting minute points which reveal a structure resembling that of other foraminiferous forms, as for example *Calcarina* and *Nummulites*.' Figures and descriptions will soon be published by the Geological Survey.

"Large portions of the Laurentian limestones appear to be made up of fragments of these organisms, mixed with other fragments which suggest comparisons with crinoids and other calcareous fossils, but cannot be distinctly determined. Some of the limestones are more or less colored by carbonaceous matter, which Dr. Dawson has found to exhibit under the microscope evidences of organic structure, probably vegetable.

"In this connection, it may be noticed that Mr. Sterry Hunt, in a paper presented to the Geological Society of London in 1858, (see also Silliman's Journal, [2], xxxvi, 296,) insisted upon the presence of beds of iron-ore, metallic sulphurets, and graphite in the Laurentian series as "affording evidence of the existence of organic life at the time of the deposition of these old crystalline rocks."

Dr. Dawson has proposed for this fossil the name of *Eozoön Canadense*, under which it will shortly be fully described.

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