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THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

NOTES ON DAWSONITE, A NEW CARBONATE.

By B. J. Harrington, B.A., Ph.D.

Chemist and Mineralogist to the Geological Survey of Canada.

In the present paper I wish to describe a new mineral, which on account of its peculiar composition seems to be of more than ordinary interest.

In 1862 Messrs. J. H. and G. Gladstone described, under the name of Hovite, a mineral which they suggested might be regarded as a double carbonate of *alumina* and lime.* On the ground, however, of a carbonate in which alumina or sesquioxide of iron enters being unknown to chemistry, and from the fact that the so-called Hovite occurs mixed with Collyrite, a hydrous silicate of alumina, Dana regards the alumina as belonging wholly to the admixed material, and considers the lime to be present in the state of *bicarbonate*. With regard to it he says: "Although the bicarbonate referred to is known only in solution, the most likely condition for finding it in the mineral kingdom is in one of the hydrous silicates of alumina, like collyrite, in which there is present much water, loosely held; the mineral therefore is most probably a carbonate of the formula above given ($\frac{1}{2}$CaO + $\frac{1}{2}$HO) CO_2 + aq; especially since a carbonate in which Al_2O_3 or Fe_2O_3 enters is, as the authors (the Messrs. Gladstone) admit, yet unknown to chemistry."†

Now although the formation in the laboratory of a carbonate

* Phil. Mag., IV. xxiii. 462, 1862.
† Mineralogy, 5th ed. p. 709.

of alumina has been denied by some chemists, we find Fresenius stating that * "carbonates of the alkalies throw down from solutions of alumina basic carbonate of alumina." Watts in his Dictionary of Chemistry writes carbonate of alumina with a query after it, and Valentin, of the Royal College of Chemistry, says that carbonate of soda, or carbonate of ammonia, precipitates from solutions of alumina "basic carbonate of uncertain composition."† Langlois, Wallace, and Muspratt have all regarded the precipitate formed by alkaline carbonates as consisting of hydrated carbonate of alumina, but each of them has assigned to it a different formula. H. Rose, on the other hand, states that the precipitate formed by carbonate of ammonia is a compound of trihydrate of alumina with carbonate of ammonia.‡ We cannot then, I think, confidently assert that a carbonate into which alumina enters is unknown to chemistry, but simply that it is one of those points upon which "doctors differ." I refer to it here, because it has a certain bearing upon the mineral which is the subject of this paper.

This mineral is a carbonate, the principal bases in which are alumina, lime, and soda; the carbonic acid being considerably in excess of the amount required to form neutral carbonates with the bases other than alumina. It occurs in the joints of a trachytic dyke near the western end of McGill College, and having been first collected by Principal Dawson, has, in honour of him, been called Dawsonite.

The rock constituting the dyke was examined by Dr. Hunt some years ago; but no special analysis of the Dawsonite was made, as sufficient material could not then be obtained. As the composition of the dyke is of interest in connection with that of the material filling its joints, I give Dr. Hunt's description and analyses. He says §: "The *rock is divided by joints into* irregular fragments, whose surfaces are often coated with thin bladed crystals of an aluminous mineral, apparently zeolitic. Small brilliant crystals of cubic iron pyrites, often highly modified, are disseminated through the mass. The rock has the hardness of feldspar, and a specific gravity of from 2.617 to

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* Man. Qual. Chem. Anal. ed. by S. W. Johnson, M.A., p. 111. New York, 1869.

† Text Book of Practical Chemistry. London, 1871. p. 175.

‡ Watt's Dict. of Chem. vol. I, p. 779.

§ *Geology of Canada, 1863, pp. 659, 660.*

2.632. It has a feebly shining lustre, and is slightly translucent on the edges, with a compact or finely granular texture, and an uneven sub-conchoidal fracture. Before the blow-pipe it fuses, with intumescence, into a white enamel. The rock in powder is attacked even by acetic acid, which removes 0.8 per cent. of carbonate of lime, besides 1.5 per cent. of alumina and oxyd of iron; the latter apparently derived from a carbonate. Nitric acid dissolves a little more lime, oxydises the pyrites, and takes up, besides alumina and alkalies, a considerable portion of manganese. This apparently exists in the form of sulphuret, since, while it is soluble in dilute nitric acid, the white portions of the rock afford no trace of manganese before the blow-pipe; although minute dark-colored grains, associated with the pyrites, were found to give an intense manganese reaction. From the residue after the action of the nitric acid, a solution of carbonate of soda removed a portion of silica; and the remainder, dried at 300°F. was free from iron and from manganese."

No. I. is Dr. Hunt's analysis of the portion insoluble in nitric acid; No. II. that of the matters dissolved by nitric acid from 100 parts of the rock:—

	I.		II.
Silica	63.25	....	1.43
Alumina..................	22.12	....	3.43
Peroxyd of iron..........	....	....	2.40
Red oxyd of manganese...	....	....	1.31
Lime	0.56	....	0.60
Potash	5.92	....	0.40
Soda.....................	6.29	....	0.93
Volatile.................	0.93	....	....
	99.07		

The bladed, aluminous mineral alluded to by Dr. Hunt is the Dawsonite of this paper, and will now be described.

Physical Characters.—Hardness 3. Specific gravity 2.40. Lustre vitreous. Colour white. Transparent—translucent.

As mentioned above, it is bladed, but the blades show a somewhat fibrous structure, which is best seen when fragments are examined under the microscope. With polarized light it exhibits beautiful bands of brilliant colours. As regards its crystalline form I am uncertain, though it is probably monoclinic, with the inclination of the principal axis about 75°.

Chemical and Blowpipe Characters.—Before the blowpipe colours the flame intensely yellow, becomes opaque, and often exfoliates or swells up into cauliflower-like forms. After ignition in the forceps, or in the closed tube, gives a strong alkaline reaction. Fragments which have not been ignited, when placed upon a piece of moistened turmeric paper, shew no alkaline reaction; but if the finely pulverised mineral is treated with water, the water is rendered slightly alkaline. In the closed tube gives off water and carbonic acid. With nitrate of cobalt gives a fine blue colour (alumina.) With hydrochloric or nitric acid dissolves in the cold completely, with evolution of carbonic acid; and this even when the mineral is in fragments and the acid exceedingly dilute. Addition of ammonia to the solution gives a copious precipitate of alumina. Acetic acid decomposes it, but does not appear to dissolve it completely; the solution, however, gives an abundant precipitate of alumina with ammonia.

Through the kindness of Dr. Dawson I have been enabled to obtain sufficient material for two analyses. The first was made some months ago, but so strange did the results appear, that I was unwilling to publish them before making a second analysis, in order to ascertain whether the mineral was at all constant in composition.

The first analysis gave me the following results:

I.

Carbonic acid	29.88
Alumina*	32.84
Lime	5.95
Magnesia	traces.
Soda	20.20
Potash	0.38
Water	11.91
Silica	0.40
	101.56

The carbonic acid was determined with an ordinary single flask apparatus, and the water with a small chloride of calcium tube. Together they equal 41.79 per cent. Direct ignition of a separate portion of the mineral in a covered crucible gave a loss of 41.16 per cent.

For the second analysis, the material was obtained from at least twenty different specimens, and considering that the amount employed was small, the results are sufficiently close to those of

* With traces of peroxide of iron.

No. I. to warrant the conclusion that the mineral is constant in composition. They are as follows:

II.

Carbonic acid	30.72
Alumina with traces of $Fe_2 O_3$	32.68
Lime	5.65
Magnesia	0.45
Soda	20.17
Water	[10.32]
	100.00

In this analysis the total alkaline chlorides are calculated as soda, the amount of potash not having been determined.

In No. 1 the excess of carbonic acid above that required to form neutral carbonates with the bases other than alumina is 10.69; while in II. it is 11.46. This excess must either be in combination with the alumina, or else must go towards forming bicarbonates with a portion of the protoxide bases. If the alumina is not present as carbonate, we might then suppose it to exist as hydrate. There is, however, not sufficient water to form trihydrate, the compound known in nature as Gibbsite, and too much to form the monohydrate or diaspore. Native trihydrate, moreover, is only soluble in acids with difficulty, and diaspore is insoluble, unless after ignition.

The amount of water is about that which would be required to form dihydrate,—a hydrate which, as prepared in the laboratory, is soluble in acetic acid, though insoluble in the stronger acids. But hydrochloric, or nitric acid, readily dissolves all the alumina in the Dawsonite.

The crystalline character of the mineral, and the uniformity of its optical and chemical characters, forbid its being regarded as a mechanical mixture; and, for the present, we can only say that it may be a hydrous carbonate of alumina, lime and soda, or perhaps a compound consisting of a hydrate of alumina combined with carbonates of lime and soda.*

If we adopt the former view, and consider that alumina may exist in combination with carbonic acid, we need no longer consider Hovite as a bicarbonate of lime, but may adopt the suggestion of the Messrs. Gladstone, that it is a double carbonate of alumina and lime.

* There is nearly enough carbonic acid to form neutral carbonate with the lime, and bicarbonate with the soda.

THE FLUCTUATIONS OF THE AMERICAN LAKES AND THE DEVELOPMENT OF SUN-SPOTS.

By G. M. Dawson, Assoc. R. S. M.

In the course of an investigation, undertaken in my capacity as Geologist to the B. N. A. Boundary Commission, as to late changes of level in the Lake of the Woods, bearing on the accuracy of certain former surveys, I found it desirable to tabulate the better-known fluctuations of the great lakes for a series of years as a term of comparison. The observations of secular change in Lake Erie are the most complete, and these, when plotted out to scale, showed a series of well-marked undulations which suggested the possibility of a connection with the eleven-yearly period of sun-spot maxima. A comparison with Mr. Carrington's diagram of the latter confirmed this idea, and as I do not remember to have seen these phenomena connected previously, I have been induced to draw out the reduction of both curves here presented, and the table of the height of water in the lakes.

The changes of level effecting the great lakes are classed as follows by Colonel Whittlesey, who has given much attention to the subject:—

1. General rise and fall, extending through a period of many years, which may be called the "Secular Variation."

2. Annual rise and fall within certain limits, the period of which is completed in about twelve months.

3. A sudden, frequent, but irregular movement varying from a few inches to several feet. This is of two kinds, one due to obvious causes, such as winds and storms; another, described as a slow pendulum-like oscillation, has been somewhat fully discussed by Whittlesey in a paper read before the American Association at its last meeting, and is due probably to barometric changes in the superincumbent atmosphere.

The first class is the only one directly included in the present inquiry.

I.—*Table of Great Lakes.*—In Mr. Lockyer's new work on Solar Physics, chap. xxvi., entitled "The Meteorology of the Future," exhibits the parallelism of periods of solar energy, as denoted by the outburst of sun-spots, with the maximum periods of rainfall and cyclones, and for the southern hemisphere, by a discussion of his own and Mr. Meldrum's results. In the table (p. 313) I have arranged the more accurate numerical observations of the height of the lakes from registers kept for the last few years, in a method similar to that there adopted.

Prof. Kingston's observations of Lake Ontario were taken at Toronto, and measured upward from an arbitrary mark. They extend from the year 1854 to 1869, and include the minimum periods of 1856 and 1867, and the maximum of 1860. Taking the mean annual level for each minimum and maximum epochal year, and one year on each side of it, as is done by Mr. Meldrum, and deducing a mean from each of three tri-yearly periods, the agreement is close between the solar periods and those of fluctuation in the lakes.

The remaining observations are those of the U.S. Lake Survey, and include only one period each of maximum and minimum in solar spots. The measurements of the U.S. Survey are reckoned *downwards* from a mark representing the high water of 1838 in each of the lakes, but in the table here given they have been reduced so as to read upwards from an arbitrary line chosen 4 feet below that datum. They are thus rendered more intelligible and made to agree in sense with Prof. Kingston's measurements.

The result is the same in each of the lakes, only differing in amount by a few inches. A mean deduced from the U.S. Lake Survey observations in Lakes Superior, Michigan, Erie, and Ontario, gives a difference between the years surrounding the maximum of 1860 and the minimum of 1867 of 14.64 inches in favour of the former.

2. *Diagram of Curves.*—The curve representing the fluctuation of Lake Erie from 1788 to 1857 inclusive is constructed on a careful discussion of the evidence collected by Col. Whittlesey and given by him most fully in the "Smithsonian Contributions to Knowledge" for 1860.

From 1788 to 1814 there are no accurate measurements to any well-recognised datum line, and I therefore give below the measurements and approximations on which the general curve for these years has been constructed. The description of the fluctuation of the lake will be seen in many cases to apply with verbal accuracy to the sun-spot curve.

"1788—1790. By tradition derived from the early settlers, very high; according to some as high as 1838, but this is doubtful.

"1796. By the first emigrants and surveyors reported as very low—5 feet below 1838.

"1797. Rising rapidly.

"1798. Water continues to rise, but 3 feet below June 1838.

"1800. Very high; old roads flooded.

"1801. Still high.

"1802. Very low; reported by old settlers as lower than 1797.

"1806. Very low; reported by old settlers as lower than 1801—2, and declining regularly to 1809—10 when it reached a level by many considered as low as that of 1819.

"1811. Rise of 6 inches in the spring over 1810, by measurement, and a fall of 2 inches.

"1812. Rise of 14 inches in spring over 1810, by measurement, and a fall of 3 inches.

"1813. Rise of 2 feet 2 inches in spring over 1810 by measurement.

"1814. Rise of 2 feet 6 inches in spring above general level of 1813."

From 1815 to 1833, both inclusive, occasional measurement to fixed data exist; the supplementary notes are here given.

"1815. Rise of 3 feet above average level of 1814. (This statement is not confirmed by an actual measurement made in August, and is probably exaggerated).

"1816. Water still high, but falling, and continued to fall till 1819.

"1819. Lowest well-ascertained level of the waters in Lake Erie.

"1820. Stated to be in August as low as 1819.

"1821. Rising.

"1822. Rising: in the spring 4 feet below June 1838.

"1823. Rising; in the spring 3 feet 3 inches below 1838.

"1824. Rising gradually.

"1825. Rising; lowest level 3 feet below June 1838.

"1826. Rising; lowest level 2 feet 10 inches below June 1838.

"1827. About the general level of 1815.

"1829. Water still rising.

"1830. General level same as 1828.

"1831. Lower than last year; yearly change at least 3 feet.—Col. Whiting. (Probably an error as this would place the water unprecedentedly low. Col. Whiting probably ascertained that the lake was falling and erred in taking some former high-water mark for that of the preceding year).

Table showing the height of water in the American Great Lakes, measured upward from an arbitrary mark, for the years surrounding periods of maxima and minima in the occurrence of Sun-spots.

Sun-spot Periods.	Year.	Lake Ontario, from Prof. Kingston's Observations.		Lake Ontario, from U. S. Lake Survey Observations.		Lake Superior, from U. S. Lake Survey Observations.		Lake Michigan, from U. S. Lake Survey Observations.		Lake Erie, from U. S. Lake Survey Observations.	
		Yearly means.	Tri-yearly means.	Yearly means.	Tri-yearly means.	Yearly means.	Tri-yearly means.	Yearly means.	Tri-yearly means.	Yearly means.	Tri-yearly means.
Min.	1855	17·8									
	1856	20·6	21·7								
	1857	27·5									
Max.	1859	28·6		30·48		40·32		29·88		33·60	
	1860	18·3	24·7	22·68	28·80	30·24	33·12	23·76	25·92	28·32	30·60
	1861	27·4		33·12		28·26		23·88		29·76	
Min.	1866	9·3		18·36		18·12		3 72		17·76	
	1867	19·7	11.2	28·86	19.20	20·16	18·84	7·68	5·28	18·00	16·56
	1868	4·6		13·68		18·24		4·32		13·80	

Mean of maximum periods in Lakes Ontario, Superior, Michigan, and Erie, from U S. Lake Survey Observations. 29·61
Mean of minimum " " " " " " " 14·97

Difference 14·64

The measurements are in inches and decimals.

"1832. General average 2 feet 10 inches below June 1838.
"1833. General average 3 feet 2 inches below June 1838."

From this date to 1857 many actual measurements are given by Whittlesey, and from these the curve for those years has been constructed. The whole of the observations are reduced as nearly as possible to the average level for each year by comparison with a mean annual curve for about 10 years constructed from monthly averages of bi-five-day means given by the U.S. Lake Survey. 1859 to 1869 both inclusive are from yearly means derived from continuous observations at Cleveland by the U.S. Survey. 1871 to 1873 are from information kindly furnished by Gen. Comstock, Director of the Lake Survey. I have no data for 1870.

The earlier and less systematic observers of the fluctuations of the lakes would scarcely give attention to any but the more important changes of level, and it is possible that these in many cases may have been exaggerated in amount. It would seem improbable, however, from the number of observations which have come down to us, that any variations of importance have escaped notice.

In the upper part of the diagram, the unbroken line represents Carrington's curve founded on the number of sun-spots. The broken line is a reduction of a mean curve based on the area of the spots given by De la Rue, Stewart, and Loewy in the Philosophical Transactions for 1870; and is introduced as showing the solar periods to a later date.

3. *General Remarks.*—The first four maxima of sun-spots represented in the table being separated by long intervals of years with few spots, and not being very intense, would appear to have been closely followed by L. Erie. More especially 1837, the year of greatest known intensity according to both spot curves (333 new groups of spots according to Schwabe), was marked in its effects on the lakes, giving rise in 1838 to the highest recorded level of the waters in Erie and Ontario, and probably also in Superior, though here the data are not so certain. The high-water mark of 1838 has since been employed as the datum to which all the measurements of the Lake Survey are reduced.

The three last periods of maxima of sun-spots are extreme, and the intervals characterised by their deficiency so short that the lakes seem to have been unable to follow them as closely as before. One period of high water being to a great extent merged in the next, and resulting in a general high state of the lakes for the last thirty years, which may be connected with the Wolfian Cycle of fifty-six years in the development of sun-spots, The lakes do not seem to have responded to the maximum of 1848, but by a reference to the curve of area of sun-spots, it will be seen that the intensity of this period was not so great as of those on either side of it, and the period of maximum was maintained for a very short time only. The important sun-spot maximum of 1859-60 was evident in its effect on the lakes even at their present general high level. With regard to the Lake of the Woods the data are slight, but it may be mentioned that this lake is known to have been very low in 1823, and in 1859 to have attained a point which it has never touched since, and which is about 3 feet higher than the present level. The lake is also known to have been for a good many years higher than usual, and at least one well-marked high water took place between 1823 and 1859, which may very probably have been synchronous with that of 1838 on the great lakes. This lake derives its water from the western slope of the same Laurentian range which feeds Lake Superior.

The correspondence between the periods of maxima and minima in solar-spot cycles and in the fluctuation of the great lakes, though by no means absolute, seems to be sufficiently close to open a very interesting field of inquiry, and to show the extension of the meteorological cycle already deduced by Messrs. Meldrum and Lockyer for oceanic areas in the southern hemisphere, to continental ones in the northern.

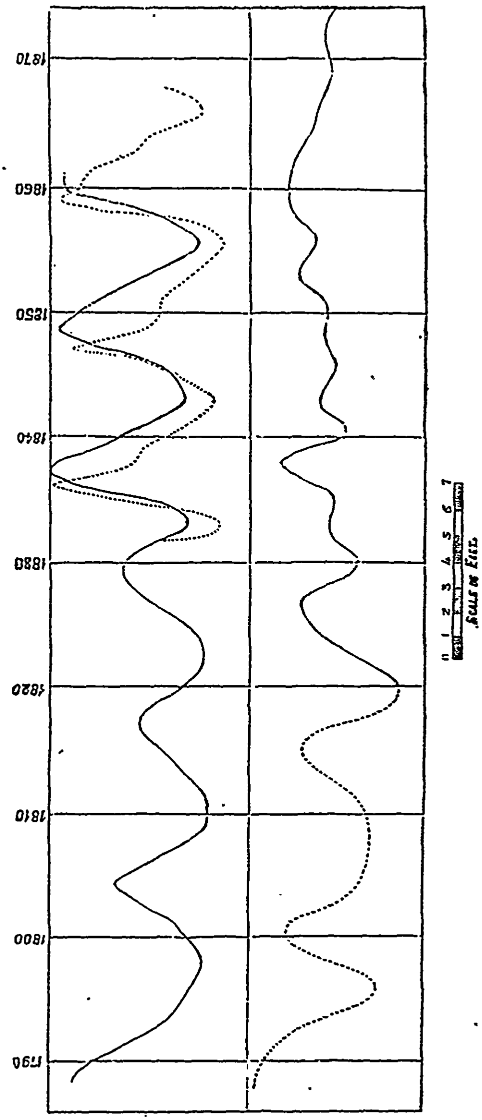
The great lakes in their changes of mean yearly level probably show a very correct average of the rainfall over a large area, and thus indicate the relative amount of evaporation taking place in different seasons. It is to be observed, however, that the actual mean annual outflow of the lakes would be a better criterion, and that from the form of the river valleys giving exit to the waters, this must necessarily increas in a much greater ratio than the measured change of level in the lake itself. It is much to be desired that such observations should be systematically made. The occurrence of seasons of great activity of evaporation and precipitation, as indicated by the lakes synchronously with those of maximum in solar-spot production, would tend to confirm the opinions previously formed as to the coincidence of the latter with periods of greater solar activity. Wolf, as quoted by Chambers, states from an examination of the Chronicles of Zurich, "that years rich in solar spots are in general drier and more fruitful than those of an opposite character, while the latter are wetter and stormier than the former." Gautier, from a more extended series of observations, including both Europe and America, has deduced an exactly opposite conclusion, which, from the evidence of the great lakes, would appear to be the correct one.

It is quite possible, however, that both may be true (see "Solar Physics," p. 430). The great lakes lying at the base of the Laurentides, where moisture-bearing winds from the southward and westward are interrupted in their course, and meet with cold currents journeying over these hills from the north, are essentially in an area of precipitation, and greater precipitation would here be the natural result of greater solar energy. In other regions excessive evaporation may result from the same cause, and this may account for the gradual desiccation which on the authority of many observers is going on at present over great areas of the inland plains of the west.

The observations here given cannot be accepted as conclusive, but derive additional importance from the large area which they represent, and may suggest more systematic investigation of the subject, and the accumulation of accurate observations, which in the course of years may lead to results of greater value.

From *Nature*, April 30th, 1874.

Comparative Diagram of the Fluctuations of Lake Erie, and Periods of greater or less Solar Activity as indicated by the occurrence of Sun-Spots.



1. Solar Spot Curves. 2. High Water, June 1838. 3. Lake Erie.

THE NATIVE COPPER MINES OF LAKE SUPERIOR.

By James Douglas, Quebec.

The Jesuit fathers who, in extending the domain of Christianity two centuries ago, explored and described parts of the American continent, which are still almost as wild as then, likened Lake Superior to a relaxed bow on whose string rests an arrow, the north or Canadian shore being the bow, the south or United States shore the bow-string, and the arrow the promontory of Keweenah, which, protruding from the south shore far across the lake, divides its waters almost into halves. This promontory, while one of the most salient geographical features of the lake, is moreover geologically and mineralogically the most remarkable, for on it, running from end to end, exist in their greatest development those cupriferous beds of trap and conglomerate in which native copper occurs under conditions most puzzling to the mineralogist, and from which it is being extracted in quantities sufficient to supply the growing wants of the United States and to threaten the stability of the copper market elsewhere.

In the present article, it is not my object to discuss the cosmical bearing of the subject, but to describe two of the most noted mines near Portage Lake and the means adopted to extract the mineral from their ores. Nevertheless, a sketch of the geology of the region and of the mining elsewhere in it is necessary as a preface. Lake Superior is framed in primitive rocks. The gneisses and granites of the Laurentian formation at places rise in bold cliffs out of the waters along the east and north shores, and where the shore line in its trend to the south-west leaves the Laurentides, the intervening space is occupied by a narrow belt of Huronian slates and conglomerates, on which seem to rest unconformably, judging from the scanty evidence afforded by the survey of this part of the north shore, but conformably, according to Brookes and Pompelly,* who have examined the lines of contact on the south shore, a series of beds of bluish shale, sandstone, indurated marls and conglomerates, interstratified with trap, which is sometimes amygdaloidal.

Sir William Logan subdivides this great mass of rock, whose

* American Journal of Science, June, 1872.

total thickness can be but vaguely guessed at, into lower and upper groups, and designates them as the upper copper-bearing rocks of Lake Superior, in distinction to the Huronian or lower copper-bearing series.

The lower group occupies the north-western shore of the lake, and sweeps rounds its extreme westerly end, but in the extension eastward of it and the upper group they are divided from the south shore by sandstones of a very different character to those which are interstratified with their own traps and conglomerates. These sandstones, which line the south shore, with but few interruptions, from Sault St. Marie to Duluth, lie in horizontal or very slightly inclined beds, and, being very friable, have been at several spots fashioned by the water into the fantastic forms known as the pictured rocks. Representatives of the same sandstone occur on some of the islands along the north shore, being all that remains above water of the soft formation out of which the bed of the lake was hollowed. But while they yielded to the destructive agency of water, the harder beds of the copper-bearing groups have withstood it, and these, therefore, as on the point of the Keweenah promontory, rise abruptly out of the lake, which has washed away entirely the sandstone from their flanks, or, as towards the base of the promontory, spring at as abrupt an angle out of the horizontal sandstone strata, or else from islands, isolated or in groups, which, however, always bear a marked relation to one another and to the lines of upheaval distinguishable on the mainland.

The lower group of these rocks which we have described as confining the western end of the lake has not produced copper in workable quantities, and differs also in lithological character from the upper group. On the south side of the lake this upper group forms distinct ranges, the more easterly of which are traceable with remarkable parallelism from the base to the point of the Keweenah promontory; and they reappear on the north shore, the more westerly in Isle Royale, in the Thunder Bay and Neepigon promontories, and in the St. Ignace group of islands, the more easterly in Michipicotin and in some of the headlands of the coast.

The age of these rocks is the subject of some difference of opinion. They seem, from the observation of Brookes and Pompelly in Northern Michigan, to conform in strike and dip with the Huronian schists, both uniformly dipping to the north at angles of $50°$—$70°$, and where the Huronian come in contact with the sandstones above mentioned, there is the same sudden alteration in dip as between these same sandstones and the copper-bearing rocks on the Keweenah promontory. Hence, one would infer that the traps and conglomerates of the upper-bearing series come next in age to the underlying Huronian schists, and that subsequently to their upheaval were deposited the sandstones whose horizontality has not been broken by any disturbing force. The sandstones are generally attributed to the lower Silurian system.

Copper explorations on the Keweenah promontory have been made at innumerable spots over a distance of 100 miles along the strike of the beds, between the Point and Lake Agogibic, but the mines which have proved productive are confined to three districts, viz., Keweenah Point or Eagle River, Portage Lake, and Onontagon.

On the Point, the copper-bearing rocks attain their greatest lateral development, and beds of conglomerate, melaphyre, and compact sandstone, with the same dip and strike, stretch from shore to shore. Thence, as they curve round in a south-westerly direction, the range diminishes in width. Some of the first mines opened were on the west coast of the promontory, where, for nearly 30 miles' members of the copper-bearing series form the shore wall.

Here the most productive group of mines is on a system of fissure veins, which cut the rocks of the northern range at right angles to their strike. The Cliff Mine, the first of the lake mines to pay a dividend, and which, from first to last, has distributed nearly $2,280,000 among its shareholders, is on a vein which, though not generally wide, was often filled with mass copper. The copper was associated with quartz, calc-spar, and other vein-stones. The contents of the fissure exhibited a banded structure, and were influenced markedly by the country rock. In this district, likewise, copper was mined from a bed of amygdaloidal trap, here known as the *ash bed*, and work was also done on conglomerate beds; but, if we except Copper Falls and the Phenix Mines, the operations on the fissure veins alone have been financially successful.

While the Cliff Mine near the point of the promontory was the first to prove that the native copper is more than a mineralogical curiosity, the Minnesota, near the south western end of the range in the Ontonagon district, became even more famous from the enormous masses of copper it produced. Here, likewise, the copper occurs in veins which, though running with the strata, are palpably subsequent formations consisting chiefly of quartz, calc spar, and laumonite. The vein stone is different from the enclosing rock, the walls are well-defined and often grooved. In the Minnesota, the masses were not only large, but frequently threw off branches into the enclosing rock, which interfered with their being detached in the usual manner by removing the country rock adjacent. The prosperity of the mine ceased after the extraction of a mass of 90 per cent copper, weighing 525 tons, in 1857. No mines here are flourishing at present, nor does there seem to be a like revival of mining industry to what is taking place in the Keweenah Point district on the *ash bed*, under the infection of the successful development of certain beds near Portage Lake.

Portage Lake and River extend so nearly across the promontory at about 60 miles from its point, that a canal less than three miles long suffices to give water communication between the east and west shores. The lake is an irregularly-shaped body, as much as two miles wide where excavated out of the low-lying sandstone, but tapering rapidly where the high, bluff cliffs of the trap beds of the copper-bearing series confine it. While still in the low-lying horizontal sandstone, it throws off towards the north-east a long arm, which expands into Torch Lake, a considerable body of water whose north-west shore almost defines the line of contact between the horizontal sandstone and the steeply-tilted copper-bearing rocks.

As the steamer enters the narrows, and there come into view the towns of Hancock and Houghton facing one another on the opposite banks, the large mills on the lake shore, and the mine buildings and tramways on the heights above, the contrast between the modes of activity and the aims of civilised man, and of the Indians, with whom the traveller, if he has been long on the lake, must have come into close contact, strikes the mind very forcibly.

Where the copper-bearing rocks are exposed by the deep fissures, whose bottom is occupied by Portage Lake, the width of the range is seven miles, and the beds dip at an angle of 54° to the north-west. They consist of traps of varying degrees of compactness and shades of colours, interstratified with conglomerates and sandstones.

According to Macfarlane, "the constituent of the traps of the Portage Lake District are principally felspar of the labradorite species, and chlorite of a species allied to delessite, with which are found occasionally mica, small quantities of magnetite, and perhaps of augite and hornblende."* He considers the characteristic trap of the region to consist of:—

Delessite	46·36
Labradorite	47·43
Pyroxene	5·26
Magnetite	0·95
	100·00

The mines in the immediate vicinity of the Lake are on the amygdaloidal trap. Many have been opened both on the north and south shores, but those only on the Pewabic lode—the Quincy, Pewabic, and Franklin mines—have returned profit to their shareholders. Of these three, the best worked, and therefore most successful, is and has been the Quincy, and we shall therefore describe it as being a typical, though the best example, of its class.

It was opened in 1849, and has been worked uninterruptedly ever since, stemming the tide of low prices when almost every other mine was carried down the current.

The lowest level is at 1330 feet along the dip of the bed, and therefore on the incline of the shaft from the surface, and the longest level is 1600 feet. The shafts and all the workings are opened in productive ground, where that can be followed; but as the walls of the copper-bearing bed are never well defined, and as tracts of rich ground abruptly alternate with stretches of barren rock, there is found considerable difficulty in keeping to the lode, as it is called. Moreover, from being pinched and poor, or even barren, it will suddenly bulge to 20 or 30 feet of rich rock. The hanging *wall* is composed of a fine-grained, compact, bluish trap, but the characteristic trap beneath is coarse-grained and amygdaloidal, and approaches in appearance to the copper-bearing rock.

The copper bed, however, while likewise generally permeated

* Geology of Canada, 1866, p. 152.

with small amygdules, is of a deeper red and breaks with a more uneven fracture. The minerals which fill the amygdules in the barren bed, viz., quartz, calcspar, laumonite, prehnite, not only fill the amygdules here, but likewise form irregular veinlets rich in copper; and the chlorite constituents of the rock prevail so largely in parts as to give it a deep green shade. Pellicles of native copper enveloped in chlorite often occupy the centre of the amygdules. We see here the tendency of the copper to aggregate with the quartz, and the *same* zeolitic minerals as compose the fissure veins of the Eagle River and the bedded veins of the Ontonagon districts; and, therefore, if we attribute the formation of the one to aqueous agencies, are led to ask whether the same agencies have not had more to do with the formation of the beds and their mineral contents than has generally been attributed to them.

Sheets of native copper occur between the joints of the trap in the copper bed, and formed evidently through infiltration, are found also between the trap blocks beyond the walls of the bed. An indication of subsequent aqueous action is seen in the streaks of clay which smear to a great depth the faces of the trap blocks. A single cross course, carrying quartz, but no copper, is said to have been met with. The width of the bed of copper-bearing ground is supposed to be about 70 feet; not that in any place 70 feet of productive rock has been found, but when copper has been lost on one wall, as much as 70 feet have been driven through what is supposed to be the same bed, and copper found in what has been taken for the other wall. More than once, cross cuttings for many fathoms have thus resuscitated parts of the mine where it was feared the copper had given out altogether. The suddenness with which the rock will change and lose its metalliferous character is very remarkable, and affects, naturally, the productiveness of the mine from year to year.

Copper-bearing beds alternate, however, with barren trap for a distance of 500 feet, as determined by a cross cut eastward from the 70 fathoms level of the neighbouring Pewabic Mine. In the report of the agent of that mine, in 1863, he anticipates that the following copper beds would be reached at the distances indicated. The results justified his predictions. From the Pewabic lode, the distances of the adjacent strata were:—

As Anticipated.		As Determined.	
Old Pewabic	148 feet.	Old Pewabic	171 feet.
Green Amygdaloid	285 "	Green Amygdaloid	275 "
Albany and Boston	382 "	Albany and Boston	380 "
Epidote or Mesnard	465 "	Epidote or Mesnard	448 "
Conglomerate	520 "	Conglomerate	500 "

To the West of the Quincy and Pewabic lode, little mining has been done on the lake shore, the Hancock being the only copper-bearing bed extensively worked.

The heaviest copper lies generally near the foot wall. Throughout the region the metal is classed according to its size as mass, barrel, and stamp work. Mass copper is confined to the other districts; but the Quincy Mine yields a certain quantity of barrel work, or copper pieces of such size that they can be separated from adhering rock without the aid of water dressing. The quantity is, however, small, compared with that which is scattered in particles so small that machinery and mechanical concentration alone can separate them from their matrix. The means used to effect the separation are the same in all the mills of the district.

The equipment of the Quincy Mine above and below ground is excellent. The hoisting cars are of heavy boiler plate. Here and at other mines the cars discharge themselves by means of a very simple device. They are shaped like large coal-scuttles, and run on four wheels; but on the same axle, and projecting beyond the back wheels, are wheels of smaller diameter, which, when the car reaches the spot where it is to be emptied, run up inclines secured on each side beyond the track. Thus the back wheels are lifted off the track, while the four wheels remain on the rails and the body of the waggon, tilted forward, shoots out its contents.

Heretofore it has been the custom in the Portage Lake shore mines to calcine the rock, and thus render it more friable; but following the example of the Calumet Mine, a hammer like a pile driver has been introduced into the Quincy ore-house, which reduces the larger blocks to a size suitable to the Blake crusher, and for hand-picking. The ore undergoes the following treatment. Discharged from the hoisting car, it is carried down an incline to the ore-house, which is on the brink of the steep hill overlooking the lake. The ore-house is provided with a hammer, under which, as stated, the largest blocks, weighing often over a ton, are broken. Such blocks require enormous force to shiver them, inasmuch as they are generally permeated with metallic copper in arborescent masses, which so binds the rock together, that even when broken, fresh force has to be used to drag the detached stones asunder. In the ore houses a preliminary hand sorting of the rock takes place before it is further reduced in size by Blake's crushers. Beneath the Blake crushers, other hand pickers are stationed, who separate still more of the barren or almost barren rock; and the ore, reduced in quantity to about two-fifths of what was hoisted out of the mine, is run down the steep inclined tramway to the copper house.

Stamps are used invariably throughout the peninsula for crushing the ore. Cornish rolls have been tried, but without benefit. They become so often clogged with the larger lumps of copper, and, thus kept apart, so much stuff passes through uncrushed, that the quantity of raff was enormous, and the yield of the rolls small. In the Quincy Mill, when running to its full capacity, 70 square shafted stamps, weighing 900 lbs. each, and with a drop of 16 inches, crush 232 short tons of rock, or 3·3 tons per stamp head per diem through screens perforated with $\frac{1}{4}$-inch holes. Two of the batteries are engaged upon the barrel work, which is, by their pounding action, more perfectly freed from rock than it can be in the ore-house, but has, of course, to be removed from the battery-box; and all the battery-boxes have to be cleaned out twice a day. From the batteries the ore passes on to shaking sieves perforated with $\frac{1}{8}$-inch holes, and fine and coarse are further classified before being concentrated by entering with a full stream of water a succession of long triangular troughs which diminish in diameter and depth as size after size is drawn off to its proper hutch. The hutches everywhere used are piston hutches with fixed bottoms; and though in different mills they go under different names, the differences are in reality trifling. Collom's jigs are those most commonly used, and consist of a central piston-box divided into two compartments, each of which is in communication with an adjacent compartment in which the sieve is fixed and into which the copper that passes through the sieve falls. The pistons of the two hutches are pressed down by a single rock shaft, and each piston is lifted back into position by a spring—a desirable motion—as the down stroke is thus sharp and rapid, and the up-stroke slower. But the hutch is open to the objection that, as each piston covers only half the corresponding sieve, a wave is propagated from one end of the sieve to the other, which interferes with the regular subsidence of the ore. As the ore is imperfectly sized, some collects in the sieve and is removed from time to time, but most falls into the bottom, whence it is carried away by the flow of water.

The hutches are arranged, with a view to saving labour, in tiers one below the other, so that the scimpings from one flow into a hutch on a tier below, and the concentrate is re-concentrated in like manner. Water being the carrier, no handling, or very little, is required from the time the ore is thrown into the stamps till it is shovelled from the receiving tank as 80 to 90 per cent copper.

One of the most perfect mills on the lake shore is that of the old South Pewabic mine—now the Atlantic. In it, the stuff crushed by Ball's stamps is concentrated by 112 hutches arranged in seven tiers. There, also, the rotating German buddle is found to save the copper from the slimes effectually and cheaply. In the Quincy Mill, the old-fashioned percussion-table takes out the coarse slimes, and tributers re-treat the refuse from the whole mill in a separate building with English buddles. The coarse concentrate generally runs to nearly 90 per cent of copper, the fine, which cannot be separated, without repeated washing, from the iron—which we have seen is a constituent of the trap matrix—sometimes stands as low as 50 per cent; but all the mills aim at delivering an average of 80 per cent to the smelting works.

Side by side with the Quincy Mill is the Pewabic Mill, in which Ball's stamps are used. A comparison of the tailings from the two mills, made by Mr. Macfarlane, is interesting. He found

QUINCY MILL.

Scimpings from coarse ragging	0·06	per cent
Scimpings from fine ragging	0·73	"
Buddle tailings	0·46	"

PEWABIC MILL.

From head of run	4·93	per cent.
" middle of run	3·00	"
" end of run	3·13	"
" heap outside of run-house	0·66	"
" sand bank	1·00	"

The Ball stamps may influence the result, through the volume of water required for their efficient working, and which, not being separated from the suspended ore, may in some cases flood the hutches.

The annual reports of the Quincy Mining Company are models, presenting the work done and the cost of doing it in clearest detail. From the report for 1872 we summarise the following particulars. During the year, there were stoped 5165 fathoms, and sunk in shafts and winzes 898 feet—say 150 fathoms, and driven 1974 feet—say 329 fathoms. Assuming the specific gravity of the rock to be 2·7, and that therefore there are 18 tons to the cubic fathom, there were broken 101,592 tons of rock. As there were 60,828 tons stamped, about 4-10ths of the rock was separated by hand-picking. The mining, raising, and picking cost for the year amounted to 283,487·30 dols., or 2·79 dols. per ton of rock raised, while the milling cost was 64,783·79 dols., or 1.06 dols. per ton of rock stamped. This large amount of rock yielded 2,804,954 lbs. of concentrated mineral, which produced 2,276,308 lbs. of ingot. There was recovered, therefore, only 1·12 per cent of copper from the rock mined, and yet there were divided, as the year's profits on working, 210,090 dols.

In 1872, copper brought an exceptionally good price, selling at 32½ cents per lb., but as a set-off, wages were high, the average wage of miners on contract being 60·62 dols., and the yield of the ground per fathom lower than its wont.

Distributing the cost over the mineral produced, we find that, as 2,804,954 lbs. of mineral—which, without making an allowance for the slight loss in smelting, must have contained 81·1 per cent of copper—were obtained at a cost for mining and concentrating of 461,147·83 dols., each pound cost 16·44 cents; but when the cost of smelting, transport, insurance, and commission was added, each pound of ingot cost 22·93 cents U. S. currency, or, say, 20 cents in gold. Copper has fallen to 25 cents U.S. currency, but as wages have declined proportionately, and the cost of production therefore has been lessened, there is not likely to be a very serious decrease in the profits. Besides distributing this large sum among the shareholders, there were added to construction account,—for permanent improvements likely to lessen the cost of future production,—67,227·65 dols., so that the real profits of the year were 277,318·35 dols., which certainly could have been realised only by good management and by the employment of every possible labour-saving appliance for the working of an ore yielding but 1·1 per cent of copper.

Another mine even more interesting to the mineralogist, and more startling in its yield, is the Calumet and Hecla. It is situated 13 miles from Portage Lake, in a north-east direction, on a bed of conglomerate, which, however, it is not easy to identify with any of the beds that abut on the lake, as the range widens as it approaches the Point and the beds flatten. While the mineral range at the lake is 7 miles across, at the Calumet and Hecla it is 13 miles wide, and the dip declines from an average angle of 54° to 38°. Copper had been extracted from conglomerate beds before the opening of this mine, but never with good financial results. From the Albany and Boston Mine, where both a conglomerate and an amygdaloidal bed are worked, specimens very similar to the rock since yielded by Calumet were obtained; but the failure of this and other mines led to a distrust in, and a too hasty condemnation of, conglomerate mines. It is to be feared the opposite error may now be run into.

The Calumet Mine was discovered about 13 years ago. An inn, the half-way house between Hancock and Eagle River, stood in the forest near where the mine is now, and was kept by a Cornish man. His pig—so tradition tells—fell into a pit, which proved to be an old Indian working. It was dragged out so besmeared with green that the owner at once suspected the existence of copper. Since then, two little towns,—Calumet and Red Jacket,—have sprung up, and as great a change has taken place beneath the surface of the soil. Two mines on adjacent locations, though in the same bed, viz., the Calumet and Hecla, are owned and worked by one company. This mine has now reached a depth of 1060 feet on the incline of the bed, or 600 feet vertical, and one of the upper levels is 3000 feet long. Most of the copper comes from a bed of conglomerate, in which a hard red porphyritic pebble is embedded in a cement of the same rock, and of native copper. The pebbles in the rich rock are smaller and more rounded than beyond the rich chimnies. The pebbles composing the conglomerate are seldom themselves cupriferous, though some of them are. I have a large pebble from the conglomerate bed which is identical in appearance with the compact chocolate-coloured rock of the Quincy Mine, and is throughout permeated with a little copper in the same manner as the rock, but for a depth of about two lines from the surface it is ensheathed in fine-grained copper, which, as well as the copper permeating it, may have penetrated the pebble or been deposited around it,—it is difficult to say which. In the conglomerate also occur boulders of solid copper. Some are said to exhibit a concentric arrangement of the copper, but one I had cut through the centre was homogeneous in structure, but contained, embedded in the copper, a few crystals of quartz and felspar.

Interstratified with the conglomerate are thin bands of copper sandstone, the copper being in fine grains, sometimes deposited pure, at others mixed with epidote and quartz or finely-ground porphyry, the laminæ easily separable from one another. In their midst are sometimes embedded pebbles of copper. Bands of hard compact sandstone, from the disintegration of the same rock as compose the conglomerate, are met with beneath the foot wall, on the hanging wall, or in the bed itself. A specimen in my possession exhibits successive layers firmly compacted, some of conglomerate, others of coarse-grained and others of fine-grained sandstone, with a surface distinctly ripple marked. The aqueous origin of the bed cannot be doubted, but whether the copper was mechanically or chemically deposited, it is more difficult to decide. The easier explanation of its occurrence is on the hypothesis of a mechanical deposition, but, as militating strongly against it, is the undoubted fact that the conglomerate pebbles very rarely carry copper. The effects of subsequent chemical action are beautifully exhibited in a clay *flucan* which, from the surface to nearly the lowest level driven, lines in places the foot-wall. In it, embedded in soft clay, derived from the disintegration of the rock, and which harden into a mass that might almost be mistaken for a piece of trap, occurs with calcspar, laumonite[1] and quartz, copper in dendritic masses, distinctly crystallised. Some of the specimens taken from the flucan undoubtedly exhibit instances of false crystallisation, plainly showing the impress of the crystals amidst which they were formed, but others are as undoubtedly themselves crystallised. *Vugs* also occur lined with crystals of epidote, and calc spar, and spongy copper; and through the bed there passes diagonally what is called a dropper. It is only a few inches wide, but consists of what is locally called brick copper, which is accompanied by crystallised silicated minerals, entangled in which are conglomerate pebbles. It has unmistakable *slickensides*, on which the copper is actually polished.

A bed of amygdaloidal trap overlies the conglomerate, and is in places rich in copper. Some of the amygdules are completely filled with copper, in others a small nucleus of copper is enveloped in calc spar or epidote, while a coating of red ferruginous-looking earth lines the cell. A trap, similar in appearance, is worked by the South Pewabic Mine on Portage Lake, but there its richness is deceptive, for the copper forms in this shell only around an earthy nucleus.

The long levels of the Calumet and Hecla run through three rich chimnies of conglomerate, the longest about 1300 feet. They dip to the north, and are widening out rather than otherwise in its lower levels. Between these rich streaks, large tracts of which will yield a 20 per cent ore, are others of poorer ground, and others still almost barren, which are left standing. The average width of the productive portions is 13 feet.

There are broken, raised, and concentrated 740 tons of rock a day. To handle such a large quantity, work has necessarily to be thoroughly systematised both below and above ground, and machinery utilised to the utmost.

Each mine possesses six shafts,—or twelve in all,—eight only of which are connected by levels, and four only used as hauling shafts. The shafts are sunk at 400 feet apart, and levels are driven every 90 feet. Between each two shafts two winzes are sunk, and three stopes 30 feet high are opened on each side of each winze, so that eighteen stopes are worked between each two shafts. Six feet of ground are left standing on each side the shafts, and a heavy arch below each level supports the roof, and gives firm foundation to the road-way. A wall of heavy stulls provided with gates at every 10 feet protect the road-ways, and allow large accumulations to be made in the stopes. Timbering is a heavy item of expense, as the trap which composes the roof is very liable to fall out in pyramidal blocks. The mine-work is done by contract,—stoping by the fathom, drifting and sinking by the foot. The contractor must deliver his rock at the nearest hauling-shaft. The traps are 4 feet apart in the levels, and 4 feet 4 inches in the shafts, as the cars have to be large to receive the heavy blocks which break away in the stopes. The miners are allowed to send to the surface blocks not over 1 ton weight, but the cars are constructed to hold 2 tons.

Drifting is done with great economy, by machine-drilling. Seven Burleigh drills of large size, with 2-inch bits, are steadily at work in each mine, and it is found that with them a drift 10 feet wide can be driven at 8·00 dols. less per foot than a 6-foot drift by hand-labour. This calculation leaves out, however, the cost of the motor power. In the Quincy Mine, the same drills are being thrown aside as uneconomical,—a discrepancy in result which may be accounted for by the fact that in the Calumet there is a well-defined selvage, whereas in the Quincy the drifts are run through solid rock, and grooves must be scooped out beneath the face of this advancing drift,—an operation not easily performed with a cumbrous drill.

The ore is broken in two ore-houses, each of which is provided with a pile driver to shatter the large masses—a Blake's crusher with 18 by 24 inch opening, and six smaller Blakes, with 8 by 15 inch openings, but no attempt is made at selecting by hand, but all the ore raised passes to the mill.

From the crushers the ore falls into huge hoppers, whence it is discharged as called for into the railway cars. All the appliances, in fact, are on a scale such as we are in the habit of associating with iron mining. A five-mile railroad unites the concentrating works on Torch Lake with the mine, and over it two hundred car-loads of 4-ton capacity each are carried daily.

The mills present no feature of special interest. In one are three of Ball's stamps, and in the other four. Six of these powerful machines are running regularly, and crush up the whole yield of the mines. To each stamp there are assigned 20 jigs.

The stamps are steam-hammers. The slide valve is worked by eccentric gearing, and the piston rod is inserted into the head of the shaft, which is 9 inches in diameter.. The stamp-head is 22 by 14 inches, and weighs 6 cwts. Its upper surface is provided with a bevelled ridge, which slides into a slot in the bottom of the shaft, and is then keyed home. When working on the amygdaloidal trap, Ball's stamp heads, made with white iron and a small percentage of Franklinite and tough pig, last a month. At the Calumet Mills they are worn out in six days, but the renewal involves a stopping of a stamp of only 50 minutes. Each stamp works in a separate stamp-box, which is five-sided, and discharges from three sides through steel plates, perforated with 3-16th inch holes. Each stamp can crush daily 120 tons of this exceedingly hard rock, and is said to consume 25 horse-power; 3000 gallons of water a minute are pumped to the two mills. The great advantages of using the stamp are that so much work can be done with so little machinery and in so contracted a space, and that so little time is occupied in repairs. The Calumet Mills never stop. The Quincy mill is idle for about one month out of twelve.

The scimpings are not clean. They carry from 1·40 per cent. to 1·80 per cent of copper, 0·40 to 0·80 of which is as oxide. Twelve tons of copper, therefore, are thrown away daily.

The Calumet Company publishes no report, but the following figures are, if not quite, very nearly correct. There are 1600 hands employed, 260 contracts are set in the Calumet, and a somewhat greater number in the Hecla. The cost of breaking a fathom of ground varies from 20·00 to 22·00 dols., and it yields 21 tons of rock; the cost of dressing exceeds that at the Quincy mine, standing at 1·17 dols. per ton. In 1872 the mine produced 9717 tons of ingot. The quantity of ore raised daily was about 740 tons, or 266,400 tons per year of 360 days; and, therefore, as it produced 9717 tons of ingot, the ore actually yielded 3·6 per cent of copper. This large amount of work was rewarded by profit in proportion; for there was distributed among the shareholders, in 1872, 2,750,000 dols.; and during that same year large sums were expended in permanent improvements. The result in every respect is unparalleled in the history of copper mining; and all owners of copper mines with no such brilliant promise can only hope that it may not be repeated; for the effect of a very few such mines would be most depressing.

Adjoining the Hecla another mine is being opened by the Osceola Mining Company, which, from surface indications, will be very rich. The Allonez near by is expected to turn out well, and on the Isle Royale attention is again being given to long-neglected conglomerate beds, and the prospects of success is there good also. The Royale, though belonging to Michigan, lies close to the Canadian shore. As already pointed out, the copper formation is largely developed from Michipicoten to Thunder Bay on the main land and on Canadian Islands.

With the experience gained on the south shore, explorations could now be conducted on the north, with better chance of success than heretofore. What little has been done has revealed the existence of deposits that would not have remained unworked had they been situated on the opposite shore.

The following statistics, officially correct, are taken from the annual circulars published by the "Portage Lake Mining Gazette."

The production of all the mines on the promontory for the year ending Nov. 30, 1873, was as follows:—

	Tons.	Pounds.
Calumet and Hecla for year ending Nov. 30, 1873	11,551	1,938
Quincy, for year ending Nov. 30, 1873..........	1,680	180
Franklin Pewabic..............................	671	1,673
Houghton	285	—
Schoolcraft	270	1,520
Concord.......................................	72	—
Isle Royale...................................	143	1,417
Atlantic, for broken season...................	464	701
Albany and Boston, broken season..............	50	—
Sumner, for year ending with close of navigation	77	—
Other sources.................................	8	—
Total.........................	15,194	1,429
Production in 1872...............	12,612	319
Increase in 1873................	2,582	1,110

Keweenaw Point District.

	Tons.	Pounds.
Central, for year ending Nov. 30, 1873...........	1,081	1,983
Copper Falls, for year ending with close of navigation	834	927
Phenix..	350	—
Cuff	279	1,264
Delaware, for year ending Nov. 18, 1873	55	742
Amygdaloid, broken season	19	303
Other sources.................................	2	184
Total..........................	2,781	1,903
Product in 1872.................	1,836	894
Increase in 1873................	945	1,009

Ontonagon District.

	Tons.	Pounds.		Tons.	Pounds.
Ridge........	150	113	Knowlton....	39	1,864
National	131	318	Rockland	16	460
Minnesota....	103	1,700	Mass	6	868
Flint Steel...	45	1,356	Adventure ...	3	1,238
Bohemian....	40	500	Tremont.....	—	700
			Total.........................	537	1,117
			Product in 1872	725	1,000
			Decrease in 1873................	187	1,883

Recapitulation.

	Tons.	Pounds.
Portage Lake District........................	15,194	1.429
Keeweenah Point District....................	2,781	1,963
Ontonagon District...........................	537	1,117
Grand Total for 1873............	18,514	4,449

Or about 14,811 tons of ingot.

The Copper Mineral (of about 80 *per cent.) produced from* 1845 *to* 1874.

1845 to 1854	7,642
1854 to 1858........................	11,312
1858............................	4,100
1859............................	4.200
1860............................	6,000
1861............................	7,500
1862............................	9,962
1863............................	8,548
1864............................	8,472
1865............................	10,791
1866............................	10,[illegible]76
1867............................	11,735
1868............................	13,049
1869............................	15,288
1870............................	16,183
1871............................	16,071
1872............................	15,166
1873............................	18.514
Total............	194.909

About 150,575 tons ingots; value about $82,000,000.

In 1872 there were distributed in dividends—

Calumet and Hecla................	$2,750,000
Quincy..........................	350.000
Pittsburgh and Boston (Cliff)	100,000
Central	80,000
Minnesota.......................	50.000
Franklin	20,000
Pewabic.........................	20,000
National	20,000
Total dividends...........	$3,390,000
Total assessments.........	190,000
Excess of dividends over assessments..	3,200,000

The same mines have been remunerative from their openings and have yielded 11,810,000 dols.

The paid-up capital on the same mines amounts to the trifling sum—

	Dollars.
Calumet and Hecla	800,000
Quincy	200,000
Pittsburgh and Boston	110,000
Central	100,000
Minnesota	436,000
Franklin	370,000
Pewabic	235,000
National	110,000
	2,361,000
Increase of dividend over assessments,	9,449,000

There is, of course, another side to the picture. Of 111 mining companies formed, only the eight above enumerated and the Copper Falls Company have paid dividends. Many of the companies were organised to work locations where there was no copper at all, and others failed through ignorance and bad management. The total amount levied, as far as can be ascertained, has been 19,296,500 dols.

All the copper produced in the Peninsula is smelted at Hancock on Portage Lake, or at Detroit, branches of the same establishment. Detroit takes the mass copper from the Keweenah and Ontonagon Districts, as the furnaces there are constructed to receive it. The roof of the reverberatories are lifted, and masses of 10 tons lowered on to the bed, when the roof is replaced, luted down, and the fires lighted. In the Hancock establishment only the barrel and stamp work of the Portage District is treated.

The mineral from each mine is smelted apart, and the copper returned in ingots; 18·00 dols. per ton being charged for the first smelting, and 12·00 dols. for every ton of slag and coarse copper re-smelted..

In the Hancock establishment there are seven reverberatories and two cupola furnaces.

The copper is smelted without any flux in the reverberatories, in charges of 16 tons. Eight to ten hours are occupied in running down, two to three hours in poling, and three hours in ladling out. When pressed for time nine charges are smelted a week.

The product is about 78 per cent of the copper as ingot, a rich slag which is returned to the reverberatory, and a poorer slag which is re-smelted in Mackenzie's blast-furnace with lime as a flux. The valuable product from the cupola is a coarse copper of 85 per cent, which is treated in the same manner as the crude mineral, and a poor slag carrying not over 3-10ths per cent of copper.

One thousand pounds of coal are said to be consumed in the reverberatories to every 2000 lbs. of mineral smelted. Poling is done with birch rods. At Detroit, when poplar could no longer be obtained, oak was substituted without affecting the toughness of the metal.—*Quarterly Journal of Science.*

NOTES ON THE MARINE FISHERIES, AND PARTICULARLY ON THE OYSTER BEDS, OF THE GULF OF ST. LAWRENCE.*

By J. F. Whiteaves.

The following notes are, to a large extent, a compilation of scattered items of information, gathered from various persons residing along the coast. Captain J. N. Purdy, who commanded the *Nickerson* during the first three cruises, and who has had great experience as a fisherman, both in Canada and in the United States, has helped me very considerably in the preparation of this part of my report; and to him I am indebted for most of the facts subjoined. The late M. H. Perley's Report on the Sea and River Fisheries of New Brunswick, published at Fredericton in 1852, contains a valuable amount of local information not to be met with elsewhere. These notes may be looked upon as supplementary to that useful volume. The classification adopted is essentially that of Dr. Gunther's Catalogue of Fishes, in the British Museum. Professor Theodore Gill has published a critical "Synopsis of the Fishes of the Gulf of St. Lawrence and Bay of Fundy," in vol. ii., new series of the "Canadian Naturalist." As this latter paper is probably more accessible than Dr. Gunther's elaborate work, the names given by both authorities are quoted here. References are made only to those fishes or invertebrates which are of some economic importance.

Mackerel.—*Scomber, scomber*, Linn., and *S. pneumatophorus?* De La Roche. Gunther. *Scomber grex*, Mitchill, Gill.

For the last four years mackerel have re-appeared in White and

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* From the Sixth Annual Report, published by the Department of Marine and Fisheries, Ottawa, 1874.

Green Bays, on the north-east coast of Newfoundland. They have been caught in Bras d'Or Lake, Cape Breton, with herring nets, in winter; also at Port Hood, Cape Breton, in December. During the first year mackerel grow to five or six inches in length. The "tinker mackerel," spoken of by Perley, are the fry of the common species, which, in the second year, attain a length of 10 inches. In the Bay des Chaleurs mackerel spawn in May and June, and occasionally a few as late as July. This fish prefers a rocky bottom, particularly banks; it does not apparently dislike sandy ground, but seems to avoid muddy bottoms. Ground *Menhaden* are largely used by American fishermen to bring mackerel to the surface. The Lower-Canadian fishermen use first coarse salt, and then ground fresh herring, for the same purpose. French Canadians do not seem to understand the proper mode of curing mackerel. They split them the wrong way, do not soak them enough, or kill them at once. This is unfortunate, as mackerel often abound in the northern part of the Gulf, especially in Gaspé Bay, and these badly-cured fish are quite unfit for the market. It is said that the use of purse *seines* for taking mackerel is a very wasteful mode of fishing, as more are often caught than can be cured, and quantities are killed unnecessarily this way. It might possibly be desirable to prohibit the capture of spawn mackerel.

TUNNY, or HORSE MACKEREL.—*Thynnus thynnus*, Linn. Gunther. *Orcynus secundo-dorsalis*, Storer. Gill.

Occasionally eaten on the North Shore and on the Labrador coast. A fish largely cured in the Mediterranean, but never, so far as I can learn, prepared for the market by Canadians.

TAUTOGA, or BLACK FISH.—*Tautoga onitis*, Linn. Gunther and Gill.

A delicious table fish, but too rarely found to be of much practical value. Very rarely taken at St. John, New Brunswick, and in the Bay of Fundy.

COD.—*Gadus morrhua*, Linn. Gunther and Gill.

Codfish appear to leave shallow soundings and the inshore banks in winter, and go farther out to sea. A large school visits the east coast of Cape Breton, from Chetigan, round by Scatari, in April. Cod appear to spawn all the year round, even in winter. Schools have been taken spawning on Brown and George's Banks, in February and March, also in November and December in the Bay of Fundy and elsewhere. A few codfish are taken now and then in Gaspé Bay in winter. It is not an uncommon circumstance for a school of cod to follow herring as far as Mahogany Islands, at the entrance of St. John Harbor, New Brunswick, in February and March, where they are taken plentifully with trawls by the inshore fishermen. This school does not apparently strike in shore during the summer, at least not in New Brunswick. A peculiar variety of this fish, "with a dark back and a black ring round the jaws" (Purdy) is taken on the Orphan and Bradelle Banks, as well as on the east coast of Prince Edward Island. They are of a large size and will, it is said, only take the hook *at night*, hence they are known to the fishermen as "night fish." With the exception of haddock, cod is the only fish that is well cured in the northern part of the Gulf. Cod prefer a bottom of stones, gravel, or sand, especially where shells and crabs abound. The season for cod. north of the Bay des Chaleurs, is from about May 15th to November 15th. In Bras d'Or Lake, Cape Breton, also on the north coast of Newfoundland and in the Bay of Islands, cod and herring are caught in winter through holes cut in the ice. The "bull-dog" cod, spoken of by Perley, are supposed to be individuals which have been bitten when young by other fish. A prejudice seems to exist along parts of the coast against the use of "trawls" or bultow lines, but I have not heard of any that appear to me sound arguments against them. It is believed by many experienced fishermen that quantities of young cod are annually destroyed by drag seines, used for bait near shore, but it is not easy to suggest a remedy for this state of things. The clam, of which Perley says the cod are particularly fond, is *Cyrtodaria siliqua*.

HADDOCK.—*Gadus æglefinus*, Linn. Gunther. *Melanogrammus æglefinus*, Linn., sp. Gill.

Most plentiful on the south and west coast of Nova Scotia, and on the west coast of New Brunswick, but common throughout the Gulf. This species is taken all the year round, generally in schools alone, but sometimes associated with cod. They frequent clam banks, in from twelve to eight fathoms. A very valuable market fish, and one which will be much more so when the Intercolonial Railway is opened. At Digby, St. Andrew's and Western Isles, "finnan Haddies" are prepared for various markets in Canada and the United States. Haddocks are taken on the west coast of Newfoundland in winter.

POLLACK.—*Gadus virens?* Linn. Gunther. *Pollachius carbonarius*, Bon. Gill.

Although this fish is commonly called "pollack" by the fishermen of the lower provinces and by those of the United States, it is not the same as the pollack of Europe. Its proper name is the coal fish, and it is common to both shores of the Atlantic. The species is locally known as the "sea-salmon," and is of somewhat southern distribution. It does not appear to range farther north than the Bay des Chaleurs, if so far, and has never been taken in the waters of the Province of Quebec. The species is most frequent in tideways in Nova Scotia and New Brunswick. As a table fish it is preferred by many to cod. To the north of the North Cape of Prince Edward Island no great business is done in the curing of pollack. They are, exceptionally, caught in winter among cod. They are not often taken on banks, but mostly along the shore. They school like mackerel, and are caught at the surface, to which they are brought by ground bait. Their food is said to consist largely of herring. The livers of this species yield the best oil; it is used for machinery and in making leather. Salted and dried pollack is worth from \$2 to \$3 per quintal.

"OLD ENGLISH HAKE."—*Merluccius vulgaris*, Flem. Gunther. *Merlucius bilinearis*, Mitch. Gill.

The fishermen of the lower provinces endorse Dr. Gunther's view that this species is identical with the true hake of Europe. Locally it is called whiting, though the whiting of English authors (*Gadus merlangus*) is a very different fish. Hake are caught in purse seines, also in herring and pogy nets. They are not much used for food, and are rarely if ever cured.

AMERICAN FORKED HAKE.—*Phycis Americanus*, Storer. Gunther. *Phycis tenuis*, Gill.

This fish is the "ling" of the Jersey merchants. The species of forked hake in the Gulf require careful examination, as there are as many as three species in that region. On the east and west coast of New Brunswick, and on the north of Nova Scotia, the "ling" is taken from July to November. It is common on muddy bottoms throughout the Gulf; is salted and dried, with very little sun, exported to the United States, and from there to South America.

THE TORSK, TUSK, OR CUSK.—*Brosmius brosme?* Linn. Gunther. *Brosmius Americanus?* Gill.

The common cusk of the St. Lawrence is taken all the year round, especially in the Bay of Fundy, where the fish occurs in many localities. Cusks are dried and cured with codfish, and fetch a better price than the latter in the West Indian market. There are two species of cusk in the St. Lawrence, but their geographical range has not yet been accurately defined, and I am not sure which of the two kinds is the one most frequently used.

HALIBUT.—*Hippoglossus Groenlandicus?* Gunther. *Hippoglossus Americanus*, Gill.

The Canadian halibut are said to frequent the outer banks in winter and the inshore fishing grounds in spring and summer. They feed on shells, crabs, lobsters, sculpin, &c., and can hardly be caught in quantity except by trawling. They are highly prized by inland consumers, and fetch a comparatively high price. About August halibut are caught in large numbers to the north of Anticosti. They are generally sold by draught (of 224 pounds) and sent to Quebec.

FLOUNDER.—*Pleuronectes Americanus*, Walb. Gunther. *Pseudopleuronectes Americanus*, Walb., sp. Gill.

A common fish everywhere in the Gulf, and occasionally exposed for sale in the markets at Halifax, Nova Scotia.

SMELT.—*Osmerus viridescens*, Lesuer. Gunther. *Osmerus mordax*. Mitchell.

This delicious little fish is, or may be, taken abundantly throughout the Gulf all the year round. In Gaspé Bay smelts are caught in winter like tommy cods, through holes in the ice. In New Brunswick and Nova Scotia smelts are exported to New York and Boston. The species appears to spawn in April and May, and extends up the River St. Lawrence, at least as high as Quebec, in the spring and autumn.

CAPELIN.—*Mallotus villosus*, Mull., &c.

The habitual use of this fish as manure, along the coast, is considered objectionable, as it tends to drive the cod further out to sea.

HERRING.—*Clupea harengus*, Linn. Gunther. *Clupea elongata*, Lesuer. Gill.

In Gaspé last year the first herring of the season appeared about the 25th of April. The fishing began about the 10th of May and lasted until about the 25th of June, after which capelin struck in for a week or perhaps eight or nine days. The "drifting" season in and just outside of Gaspé Bay usually commences about the middle of June, and lasts to the end of July. At

Grand Manan Rips, Captain Purdy informs me, the use of brush weirs has destroyed one of the most valuable herring fisheries in the Gulf. The herrings once caught there were the largest and fattest, and fetched the best price of any in the Dominion. In the opinion of Captain Purdy, the use of drag seines and of brush weirs should be prohibited. At Grand Manan, Campo Bello, and Deer Island, the destruction of young herrings by brush weirs has driven the cod from those localities. The New Brunswick winter fisheries are, or were, an important source of wealth to that province. As many as eighty vessels loaded with fish at West Isles, New Brunswick, for United States Ports, from October, 1872, to April, 1873. In April, 1873, forty sail of United States fishermen came to St. Andrew's Bay, New Brunswick, to buy herring for bait on the inshore bank fisheries. It is feared that the use of purse seines will either destroy or materially injure the herring fishery. In winter the New Brunswick herring frequent river estuaries and harbors with muddy bottoms. The rigorous protection to spawn herring at Grand Manan and St. Andrew's Bay is undoubtedly a great public benefit. For many of these details I am indebted to Captain J. N. Purdy.

MENHADEN, OR "POGY."—*Clupea menhaden*, Mitch. Gunther. *Brevoortia menhaden*, (Mitchell) Gill. A fish of very rare occurrence in Canadian waters. Of late years none have been found in New Brunswick or to the north of Grand Manan. Menhaden are largely used as bait for mackerel, cod, and halibut. The head, tail, backbone, and offals of this fish are converted into manure by grinding, pressing, and adding a little salt to them so as to make a kind of guano. In the United States this preparation is worth from $16 to $20 per ton. Iced menhaden is used as bait for cod and halibut, and the meat of the same fish salted and subsequently finely ground is employed to bring mackerel to the surface. The United States method of fishing for mackerel is greatly disliked by fishermen resident along the coast. The effect of it seems to be to draw mackerel further out to sea, and it seems tolerably certain that in many bays, as in some of those of the East coast of Cape Breton, for example, no mackerel are found now where they formerly used to be plentiful. At the same time the use of menhaden is not illegal, and United States fishermen always were allowed to take mackerel (except inshore) before the fishery clauses of the Treaty of Washington came into force. It would be desirable perhaps to try and acclimatize menhaden in British waters. All that would be necessary would be to send a vessel or two, each provided with a well room, to the United States, and liberate the menhaden thence procured, at the mouth of any of the New Brunswick or Nova Scotia Rivers, such as St. Andrew's Bay, L'Etang, Lepreaux, or Musquash, in New Brunswick; or St. Mary's Bay and its tributaries, or Tuskeet River, in Nova Scotia.

The Lobster. *Homarus Americanus*, Edwards. The lobster fisheries of the River and Gulf of St. Lawrence, are of very great economic importance, more especially now that the supply of this popular article of food is not equal to the demand for it in the United States and in Europe. At present large quantities of lobsters are shipped to these countries from New Brunswick and Nova Scotia. In spite of their increased commercial value, it is nevertheless a fact that in some of the northern parts of the Gulf good marketable lobsters are still used to manure the fields! Few can doubt the propriety of at least attempting to discourage a proceeding at once so reprehensible and wasteful. The latest regulation, forbidding the taking of lobsters less than a pound and a half in weight, is much complained of by persons engaged in this fishery. They urge that it would be better to allow lobsters weighing a full pound to be taken, but not any under that weight. Mr. W. S. Brown, who has a lobster canning establishment at Shippegan, has kindly given me an account of some of his experiences during the past summer. He says that a few small red eggs begin to form under the tails of the lobsters early in July, and at the end of September the tails were filled up, and 80 or 90 per cent. of the lobsters taken had eggs attached to them. Late in September these eggs had become nearly the size of B.B. shot, and were very dark in colour. At this time the few that were taken near the shore were mostly males. Mr. Brown thinks that the lobsters leave the shore in October, and go to deposit their eggs in deep water, and that this latter operation is performed sometimes as late as November or December. In July and August, Mr. Brown writes me, "I found that 80 to 90 per cent. of the lobsters had an abundance of eggs, and that 60 to 70 per cent. of them would weigh less than a pound and a half. Five lobsters weighing $1\frac{1}{2}$ lbs each will shell out about one pound of fish, and my average this season has been about four and a half lobsters to the pound or can." "The heavy gale of last August drove more lobsters ashore within five miles of my packing houses than I could make use of during the whole summer." "They formed a row of from one to five feet deep, and I should estimate them at an average of one thousand to every two rods of shore." "The next that came in shore after these were very small, averaging from two to four inches in length, and upwards, and the coast seemed alive with these small lobsters." It might be desirable to establish protected breeding grounds for lobsters in the Gulf, on somewhat the same general principle as oyster beds are formed. The season for lobsters varies with the locality. In Gaspe Bay they are taken in July and the beginning of August, but further south they appear earlier and stay later. In the southern part of the Bay des Chaleurs and on the northern New Brunswick coast, they approach the shore late in May, and leave it for deep water more or less late in September. There seems to be a great difference of opinion among the coast fishermen as to the time when lobsters spawn. Very small specimens, always less than an inch in length were frequently taken by the towing net in July and August at some distance from land, swimming about among floating weed. The Hon. W. H. Pope writes me that lobsters often burrow in the sides of oyster beds during the winter months.

Canadian Oysters. *Ostræa Virginiana*, Lister: and *Ostræa borealis*, Lamarck. It is not necessary or desirable to enter minutely here into the somewhat complicated history of the synonymy of the two Canadian species of oyster. It is sufficient for my present purpose to say that the long and narrow oyster, which is abundant in Virginia, New York Bay, &c., was the first of the oysters known in Europe from the temperate parts of North America. The species was known to Linnæus, and was originally described by Lister as *Ostræa Virginiana*. For the shorter and more rounded form, Lamarck at a later date, proposed the name of *Ostræa borealis*, and gave a short diagnosis of the species. Some varieties of this latter mollusc came so near to specimens of the common British and north European oyster, that it is difficult to distinguish between them. *Ostræa Virginiana* is much the rarest of the two Canadian oysters, but between it and the *O. borealis*, there are so many intermediate varieties and connecting links, that many naturalists doubt the value of the specific relation proposed.

As the geographical range of the two forms is very similar, and as my principal object is to call attention to their economic importance, the two species, or varieties, will be considered together. In the Gulf of St. Lawrence, oysters are usually found in very shallow water, nearly always in depths of less than three fathoms, in sheltered bays or mouths of rivers. In New Brunswick, as has been shewn before by Perley, they range from Caraquette to Baie Verte. Capt. Purdy informs me that oysters have been taken up on the flukes of anchors, in 7 fathoms water, between Little and Big Caraquette Banks, in the Bay of Chaleurs. On the coasts of Prince Edward Island, oysters are found in suitable localities, from Pinette River to the west point on the Northumberland Straits side; and in Malpeque or Richmond Bay, from Cascumpeque to New London on the northern. In Cape Breton they appear to be confined to Bras d'Or Lake and its tributaries, where the oyster region extends from St. Ann's to Mira River and St. Peter's Bay; The few oysters to be met with off Nova Scotia, occur at Jeddore Head, 20 or 25 miles east of Halifax Harbor, also Country Harbor, St. Mary's River and Lipscombe Harbor, Guysboro' Co., on the outside; and Pictou Harbour, River John, Wallace, Charles River, and Pugwash, in Northumberland Straits. (Purdy.) We did not find traces even of oysters in any part of the area between Cape Breton and Prince Edward Island, nor in any part of Northumberland Straits where the bottom is deeper than five or six fathoms, that is to say not in any of the open parts.

In answer to a letter asking for information on several points connected with the oyster beds of the Gulf, the Hon. W. H. Pope has kindly given me a most interesting and valuable account of the oyster beds of Prince Edward Island, together with many items of practical information on the subject, which no one else is so well qualified to give. The following paragraphs, to which quotation marks are affixed, are extracts from letters received from Mr. Pope, and are printed by his permission.

"Oysters *have* flourished is every tidal river and bay in Prince Edward Island. At the present time, productive oyster beds are found in Richmond, Cascumpec, and Hillsborough Bays, and in the rivers flowing into these inland waters. I might almost say in these localities alone. The produce of the beds in Hillsborough Bay is very inconsiderable. The official returns of imports and exports to and from Prince Edward Island, for 1872, shew that 9,490 barrels of oysters were shipped from this Island in the previous year."

"From Summerside,	7,572 barrels	} Produce of Richmond Bay.
" Malpec,	840 "	
" Cascumpec,	718 "	" Cascumpec Bay.
" Charlottetown,	230 "	} Chiefly produce of Richmond Bay.
" Orwell,	130 "	

"The dredge has never, to my knowledge, been employed in the waters of Prince Edward Island. Oysters are fished with "tongs," from depths varying from three or four feet to twelve, and even fifteen feet. It is scarcely practicable to fish oysters, with tongs, at a depth greater than fifteen feet."

"I am not aware of the existence of oyster beds in any part of the Straits of Northumberland, or of the sea surrounding the Island. Some years ago I observed a quantity of oyster shells on the sand at the north end of the Tryon Shoals (which are situated on the south side of the Island); they were about a quarter of a mile from the shore. Some of the shells were filled with sand, more compact than much of our sandstone rocks. When I first observed these shells, my opinion was that they had been washed ashore from beds situated in the deep water of the Straits of Northumberland. It has since occurred to me that they are *in situ*, and are the remains of an ancient oyster bed which had been destroyed by the sand. The existence of a soft muddy bottom in the vicinity of these shells supports the supposition that at some period this muddy bottom was more extensive than at present; that the oyster bed was then formed, and was destroyed by the encroachment of the sand forming the Tryon Shoal."

"During the past ten or twelve years, *millions* of tons of oyster shells and mud have been taken up by our farmers, from oyster beds, by means of dredging machines, worked by horses on the ice. In many instances the beds have been cut through, and in some places the deposits of shells have been found to be upwards of twenty feet in thickness. It is probable that many of the oyster beds ceased to be productive of oysters, ages before the settlement of the country by Europeans. Extensive deposits of oyster shells are now found covered by several feet of silt. How were the oysters upon these beds destroyed? The natural process of reproduction and decay would cause the oyster beds formed on the bottom to rise so near to the surface of the water, that the ice would rest on them. The weight of heavy masses of ice upon the beds would injure the oysters, and the moving of the ice, when forced by tide or wind across the bed, would soon destroy them. I have observed the more elevated portions of an oyster bed, over which ice had been thus forced. Several inches of the surface of the bed, including all the living oysters, had been driven before the ice, and the shells and oysters so removed, had been deposited in a miniature *moraine* on the slope of the bed, where the water was sufficiently deep to allow the ice to pass over it. This crushing and grinding process would destroy many of the oysters; some would be crushed and broken, others smothered in the *moraine*. The gradual silting up of the river would prevent the running of the ice, and the oyster beds would, in time, be covered, as we now find them. Deposits of oyster shells (covered with mud), twenty feet in depth, are found in rivers, in the deepest parts of which there are not now fourteen feet of water."

"Oysters thrive on muddy bottoms, but they will not live if imbedded in mud: many oyster beds have been destroyed by mud alone. The annual fishing of oyster beds, if not carried to excess, improves them. In the process of fishing the surface of the bed is broken up, the shells and oysters lifted out of the mud, and a supply of material (cultch) afforded such as the oyster *spat* requires, and without which it must perish."

"Oysters upon natural beds are seldom, if ever, killed by frost. I have known oysters to thrive upon a hard stony bottom, notwithstanding that the ice rested upon them once in every twenty-four hours throughout the winter. Some of these oysters grew adherent to a small flat rock about eight inches in thickness. The oysters on the top of the rock were killed when they attained their second years' growth, I think, by pressure, as those on its edges were never injured by ice or cold."

"Oyster beds in rivers in which sawdust is thrown in large quantities would probably be injured by it. The sawdust would, I think, be carried by the current over the beds, and the roughness of their surface would detain some of it. The interstices between the shells and oysters would probably become filled with sawdust and mud. Mud and decomposing sawdust constitute a most offensive compound."

"The area of productive oyster beds in the Dominion is comparatively limited, and altogether inadequate to supply the demand for oysters which is now enormous, and which is increasing every year. Unless the existing beds be protected and improved, and new beds formed, the day will soon come when the oyster beds of the Dominion will cease to produce. Our neighbours of the United States tell us that Virginia alone possesses more than one-and-a-half millions of acres of oyster beds, and, notwithstanding the fact that oysters increase much more rapidly in the warmer waters of Virginia than they do in this latitude the authorities of that State have expressed their fears that the oyster beds of Virginia, if left open to the world, and dredged at all seasons of the year, will become extinct."

"The rivers and estuaries of this Island are admirably adapted for the cultivation of oysters. The oysters found in its bays are not to be excelled in flavour, and if fished late in autumn they will keep good for months. I see no reason why hundreds of thousands of acres of oysters beds should not be formed in these bays, which would produce vast quantities of oysters in quality much superior to the oysters of Virginia. The material for the formation of such beds is at hand in the ancient ones; and oysters with which to sow them could be had at little cost during the warm calm days of summer."

"We have a 'close season,' from June until September, but the law prohibiting fishing during this season is openly violated. Oysters are caught and exposed for sale in every month in the year, and salmon are destroyed upon their spawning beds with the utmost impunity. I shall be happy to hear that the Dominion Government have resolved to enforce the laws for the protection of oysters, salmon and trout. We now form part of the Dominion, as you know, and have a right to look for wiser legislation and a better administration of law."

"You inquire—'do you think oysters, would thrive in somewhat deeper water than that in which they are now found, if sown there?' I think they would thrive in the deepest part of any inland water, if placed upon suitable ground."

In another letter received later, Mr. Pope expresses the hope that the Minister of Marine and Fisheries will think proper to appoint a commission to report upon the oysters and oyster fisheries of the Island, and intimates that in such an event he would have no objection to give his services gratuitously.

The only oyster beds which we were able to examine at all in detail were those in Shediac bay. On these grounds, in very shallow water, the dredge came with the bag more or less full of oysters, or rather of oyster shells (for upwards of ninety per cent.

of the specimens were dead), together with some other common kinds of shells, &c., and a little blackish mud, which smelt very offensively. As there is a lumber mill in the bay, this ground is probably an example of the "offensive compound of mud and decomposing sawdust," of which Mr. Pope speaks. In a whole afternoon's dredging we only got two or three living oysters. Being detained a few days at Point du Chêne, I endeavoured to get some idea of the fauna of the bay, at depths of from low-water mark to three fathoms, particularly with the view of ascertaining what kinds of marine animals were associated with the oysters, and how many of them were injurious to that mollusc. The following is a list of the species collected in Shediac Bay; those which are supposed to be more or less inimical to the oyster being italicised:—

CRUSTACEA.

Cancer irroratus. *Say.*
Crangon vulgaris. *Fab:*
†Gammarus ornatus. *Edw.*
Idotea irrorata. *Say.*

MOLLUSCA.

Ostrea borealis. *Lam.*
O. Virginiana. *Lister.*
Mytilus edulis. Linn.
Modiola modiolus. Linn.
Mercenaria violacea. *Schum.*
Gemma Tottenii, *St.*
Callista convexa. *Say.*
Petricola pholadiformis. *Lam.*
and var. dactylus.
Mactra solidissima *Chemn.*
Mya arenaria.
" truncata.
Angulus tener. *Say.*
Thracia Conradi (fine & frequent.)
Pandora trilineata, *Say.*
Solen ensis, v. Americana.
‡ Teredo, sp. (in a spruce log).
Haminea solitaria. *Say.*
Cylichna pertenuis. *Migh.*
Acmæa alveus. *Conrad.*
Crepidula fornicata. *Linn.*
" unguiformis. *Lam.*
Paludinella minuta.
Odostomia trifida. *Totten.*
Turbonilla interrupta. *Totten.*
Lunatia heros. Say.
Bittium nigrum. *Totten.*
Nassa obsoleta. *Say.*
" trivittata. *Say.*
Astyris lunata. *Say.*

ECHINODERMATA.

Asteria vulgaris St.
Cribella sanguinolenta.
Echinarachnius parma.
Echinus Dröbachiensis.
Caudina arenata (*Gould*)

In addition to these, algæ were tolerably plentiful, and a small number of annelids and zoophytes was collected. Of course the short catalogue given is by no means offered as a complete list of the fauna of the oyster beds. The chief living enemies of the oyster in its native waters are starfishes, sea eggs (Echinus), carnivorous sea snails or whelks (the "drills" of the European oystermen), and mussels. So far as I could see, these do not exist in sufficient abundance in Northumberland Straits to be of any serious disadvantage.

Many once productive beds, in various parts of the Gulf, now yield almost nothing; and there is too much reason to fear that unless precautionary measures are adopted, the oyster fisheries of the eastern part of the Dominion will soon become a thing of the past. The raking of the beds has been palpably excessive and wasteful; no such thing as cleansing the ground and scattering the spat during the close season has ever been practised; the pollution of the grounds by refuse of mills, by silting up, and a variety of other causes, has led to the present state of ruin and decay which we now see. Neglect, waste, and excessive cupidity have almost destroyed these oyster beds, and will ultimately entirely do so unless remedial measures are adopted.

THE CARNIVOROUS HABITS OF PLANTS.*

I have chosen for the subject of my address to you from the chair in which the Council of the British Association has done me the honour of placing me, the carnivorous habits of some of our brother-organisms—Plants.

Various observers have described with more or less accuracy the habits of such vegetable sportsmen as the Sundew, the Venus's Fly-trap, and the Pitcher-plants, but few have inquired into their motives; and the views of those who have most accurately appreciated these have not met with that general acceptance which they deserved.

Quite recently the subject has acquired a new interest, from the researches of Mr. Darwin into the phenomena which accompany the placing albuminous substances on the leaves of Drosera and Pinguicula, and which, in the opinion of a very eminent physiologist, prove, in the case of Dionæa, that this plant digests exactly the same substances and in exactly the same way that the human stomach does. With these researches Mr. Darwin is still actively engaged, and it has been with the view of rendering him such aid as my position and opportunities at Kew afforded me, that I have, under his instructions, examined some other carnivorous plants.

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* Address in the Department of Zoology and Botany, British Association, Belfast, August 21, by Dr. Hooker, C. B., D.C. L., Pres. R.S.

In the course of my inquiries I have been led to look into the early history of the whole subject, which I find to be so little known and so interesting that I have thought that a sketch of it, up to the date of Mr. Darwin's investigations, might prove acceptable to the members of this Association. In drawing it up, I have been obliged to limit myself to the most important plants; and with regard to such of these as Mr. Darwin has studied, I leave it to him to announce the discoveries which, with his usual frankness, he has communicated to me and to other friends; whilst with regard to those which I have myself studied, Sarracenia and Nepenthes, I shall briefly detail such of my observations and experiments as seem to be the most suggestive.

Dionæa.—About 1768 Ellis, a well-known English naturalist, sent to Linnæus a drawing of a plant, to which he gave the poetical name of Dionæa. "In the year 1765," he writes, "our late worthy friend, Mr. Peter Collinson, sent me a dried specimen of this curious plant, which he had received from Mr. John Bartram, of Philadelphia, botanist to the late King." Ellis flowered the plant in his chambers, having obtained living specimens from America. I will read the account which he gave of it to Linnæus, and which moved the great naturalist to declare that, though he had seen and examined no small number of plants, he had never met with so wonderful a phenomenon:—

"The plant, Ellis says, shows that Nature may have some views towards its nourishment, in forming the upper joint of its leaf like a machine to catch food; upon the middle of this lies the bait for the unhappy insect that becomes its prey. Many minute red glands that cover its surface, and which perhaps discharge sweet liquor, tempt the animal to taste them; and the instant these tender parts are irritated by its feet, the two lobes rise up, grasp it fast, lock the rows of spines together, and squeeze it to death. And further, lest the strong efforts for life in the creature just taken should serve to disengage it, three small erect spines are fixed near the middle of each lobe, among the glands, that effectually put an end to all its struggles. Nor do the lobes ever open again, while the dead animal continues there. But it is nevertheless certain that the plant cannot distinguish an animal from a vegetable or mineral substance; for if we introduce a straw or pin between the lobes, it will grasp it fully as fast as if it was an insect."

This account, which in its way is scarcely less horrible than the descriptions of those mediæval statues which opened to embrace and stab their victims, is substantially correct, but erroneous in some particulars. I prefer to trace out our knowledge of the facts in historical order, because it is extremely important to realise in so doing how much our appreciation of tolerably simple matters may be influenced by the prepossessions that occupy our mind.

We have a striking illustration of this in the statement published by Linnæus a few years afterwards. All the facts which I have detailed to you were in his possession; yet he was evidently unable to bring himself to believe that Nature intended the plant—to use Ellis's words—"to receive some nourishment from the animals it seizes;" and he accordingly declared, that as soon as the insects ceased to struggle, the leaf opened and let them go. He only saw in these wonderful actions an extreme case of sensitiveness in the leaves, which caused them to fold up when irritated, just as the sensitive plant does; and he consequently regarded the capture of the disturbing insect as something merely accidental and of no importance to the plant. He was, however, too sagacious to accept Ellis's sensational account of the *coup de grace* which the insects received from the three stiff hairs in the centre of each lobe of the leaf.

Linnæus's authority overbore criticism, if any were offered; and his statements about the behaviour of the leaves were faithfully copied from book to book.

Broussonet (in 1784) attempted to explain the contraction of the leaves by supposing that the captured insect pricked them, and so let out the fluid which previously kept them turgid and expanded.

Dr. Darwin (1761) was contented to suppose that the Dionæa surrounded itself with insect traps to prevent depredations upon its flowers.

Sixty years after Linnæus wrote, however, an able botanist, the Rev. Dr. Curtis (dead but a few years since) resided at Wilmington, in North Carolina, the head-quarters of this very local plant. In 1834 he published an account of it in the *Boston Journal of Natural History*, which is a model of accurate scientific observation. This is what he said:—"Each half of the leaf is a little concave on the inner side, where are placed three delicate hair-like organs, in such an order that an insect can hardly traverse it without interfering with one of them, when the two sides suddenly collapse and enclose the prey, with a force surpassing an insect's efforts to escape. The fringe of hairs on the opposite sides of a leaf interlace, like the fingers of two hands clasped together. The sensitiveness resides only in these hair-like processes on the inside, as the leaf may be touched or pressed in any other part without sensible effects. The little prisoner is not crushed and suddenly destroyed, as is sometimes supposed, for I have often liberated captive flies and spiders, which sped away as fast as fear or joy could carry them. At other times I have found them enveloped in a fluid of a mucilaginous consistence, which seems *to act* as a *solvent, the insects* being more or less consumed in it."

To Ellis belongs the credit of divining the purpose of the capture of insects by the Dionæa. But Curtis made out the details of the mechanism, by ascertaining the seat of the sensitiveness in the leaves; and he also pointed out that the secretion was not a lure exuded before the capture, but a true digestive fluid poured out, like our own gastric juice after the ingestion of food.

For another generation the history of this wonderful plant stood still, but in 1868 an American botanist, Mr. Canby, who is happily still engaged in botanical research—while staying in the Dionæa district, studied the habits of the plant pretty carefully, especially the points which Dr. Curtis had made out. His first idea was that "the leaf had the power of dissolving animal matter, which was then allowed to flow along the somewhat trough-like petiole to the root, thus furnishing the plant with highly nitrogenous food." By feeding the leaves with small pieces of beef, he found, however, that these were completely dissolved and absorbed; the leaf opening again with a dry surface, and ready for another meal, though with an appetite somewhat jaded. He found that cheese disagreed horribly with the leaves, turning them black, and finally killing them. Finally, he details the useless struggles of a Curculio to escape, as thoroughly establishing the fact that the fluid already mentioned is actually secreted, and is not the result of the decomposition of the substance which the leaf has seized. The Curculio being of a resolute nature, attempted to eat his way out,—"when discovered he was still alive, and had made a small hole through the side of the leaf, but was evidently becoming very weak. On opening the leaf, the fluid was found in considerable quantity around him, and was without doubt gradually overcoming him. The leaf being again allowed to close upon him, he soon died."

At the meeting of this Association last year, Dr. Burdon-Sanderson made a communication, which, from its remarkable character, was well worthy of the singular history of this plant; one by no means closed yet, but in which his observations will head a most interesting chapter.

It is a generalisation—now almost a household word—that all living things have a common bond of union in a substance—always present where life manifests itself—which underlies all their details of structure. This is called *protoplasm*. One of its most distinctive properties is its aptitude to contract; and when in any given organism the particles of protoplasm are so arranged that they act as it were in concert, they produce a cumulative effect which is very manifest in its results. Such a manifestation is found in the contraction of muscle; and such a manifestation we possibly have also in the contraction of the leaf of Dionæa.

The contraction of muscle is well known to be accompanied by certain electrical phenomena. When we place a fragment of muscle in connection with a delicate galvanometer, we find that between the outside surface and a cut surface there is a definite current, due to what is called the electromotive force of the muscle. Now, when the muscle is made to contract, this electromotive force momentarily disappears. The needle of the galvanometer, deflected before, swings back towards the point of rest; there is what is called a *negative variation*. All students of the vegetable side of organised nature were astonished to hear from Dr. Sanderson that certain experiments which, at the instigation of Mr. Darwin, he had made, proved to demonstration that when a leaf of Dionæa contracts, the effects produced are precisely similar to those which occur when muscle contracts.

Not merely, then, are the phenomena of digestion in this wonderful plant like those of animals, but the phenomena of contractility agree with those of animals also,

Drosera.—Not confined to a single district in the New World, but distributed over the temperate parts of both hemispheres, in sandy and marshy places, are the curious plants called Sundews—the species of the genus Drosera. They are now known to be near congeners of Dionæa, a fact which was little more than guessed at when the curious habits which I am about to describe were first discovered

Within a year of each other, two persons—one an Englishman, the other a German—observed that the curious hairs which every-one notices on the leaf of Drosera were sensitive.

This is the account which Mr. Gardom, a Derbyshire botanist, gives of what his friend Mr. Whateley, "an eminent London surgeon," made out in 1780:—"On inspecting some of the contracted leaves we observed a small insect or fly very closely imprisoned therein, which occasioned some astonishment as to how it happened to get into so confined a situation. Afterwards, on Mr. Whateley's centrically pressing with a pin other leaves yet in their natural and expanded form, we observed a remarkably sudden and elastic spring of the leaves, so as to become inverted upwards, and, as it were, encircling the pin, which evidently showed the method by which the fly came into its embarrassing situation."

This must have been an account given from memory, and represents the movement of the hairs as much more rapid than it really is.

In July of the preceding year (though the account was not published till two years afterwards), Roth, in Germany, had remarked in *Drosera rotundifolia* and *longifolia*, "that many leaves were folded together from the point towards the base, and that all the hairs were bent like a bow, but that there was no apparent change on the leaf-stalk." Upon opening these leaves, he says, "I found in each a dead insect; hence I imagined that this plant, which has some resemblance to the *Dionæa muscipula*, might also have a similar moving power."

"With a pair of pliers I placed an ant upon the middle of the leaf of *D. rotundifolia*, but not so as to disturb the plant. The ant endeavoured to escape, but was held fast by the clammy juice at the points of the hairs, which was drawn out by its feet into fine threads. In some minutes the short hairs on the disc of the leaf began to bend, then the long hairs, and laid themselves upon the insect. After a while the leaf began to bend, and in some hours the end of the leaf was so bent inwards as to touch the base. The ant died in fifteen minutes, which was before all the hairs had bent themselves."

These facts, established nearly a century ago by the testimony of independent observers, have up to the present time been almost ignored; and Trecul, writing in 1855, boldly asserted that the facts were not true.

More recently, however, they have been repeatedly verified: in Germany by Nilschke, in 1860; in America by a lady, Mrs. Treat, of New Jersey, in 1871; in this country by Mr. Darwin, and also by Mr. A. W. Bennett.

To Mr. Darwin, who for some years past has had the subject under investigation, we are indebted, not merely for the complete confirmation of the facts attested by the earliest observers, but also for some additions to those facts which are extremely important. The whole investigation still awaits publication at his hands, but some of the points which were established have been announced by Professor Asa Gray in America, to whom Mr. Darwin had communicated them.

Mr. Darwin found that the hairs on the leaf of Drosera responded to a piece of muscle or other animal substance, while to any particle of inorganic matter they were nearly indifferent. To minute fragments of carbonate of ammonia they were more responsive.

I will now give the results of Mrs. Treat's experiments, in her own words:—

"Fifteen minutes past ten I placed bits of raw beef on some of the most vigorous leaves of *Drosera longifolia*. Ten minutes past twelve two of the leaves had folded around the beef, hiding it from sight. Half-past eleven on the same day, I placed living flies on the leaves of *D. longifolia*. At twelve o'clock and forty-eight minutes, one of the leaves had folded entirely round its victim, and the other leaves had partially folded, and the flies had ceased to struggle. By half-past two, four leaves had each folded around a fly. The leaf folds from the apex to the petiole, after the manner of its vernation. I tried mineral substances, bits of dried chalk, magnesia, and pebbles. In twenty-four hours neither the leaves nor the bristles had made any move in clasping these articles. I wetted a piece of chalk in water, and in less than an hour the bristles were curving about it, but soon unfolded again, leaving the chalk free on the blade of the leaf."

Time will not allow me to enter into further details with respect to Dionæa and Drosera. The repeated testimony of various observers spreads over a century, and though at no time warmly received, must, I think, satisfy you that in this smal family of the Droseraceæ we have plants which in the first plac capture animals for purposes of food, and in the second, dige and dissolve them by means a fluid which is poured out the purpose; and thirdly, absorb the solution of animal matter which is so produced.

Before the investigations of Mr. Darwin had led other persons to work at the subject, the meaning of these phenomena was very little appreciated. Only a few years ago, Duchartre, a French physiological botanist, after mentioning the views of Ellis and Curtis with respect to Dionæa, expressed his opinion that the idea that its leaves absorbed dissolved animal substances was too evidently in disagreement with our knowledge of the function of leaves and the whole course of vegetable nutrition to deserve being seriously discussed.

Perhaps if the Droseraceæ were an isolated case of a group of plants exhibiting propensities of this kind, there might be some reason for such a criticism. But I think I shall be able to show you that this is by no means the case. We have now reason to believe that there are many instances of these carniovrous habits in different parts of the vegetable kingdom, and among plants which have nothing else in common but this.

As another illustration I shall take the very curious group of Pitcher-plants which is peculiar to the New World. And here also I think we shall find it most convenient to follow the historical order in the facts.

Sarracenia.—The Genus Sarracenia consists of eight species, all similar in habit, and all natives of the Eastern States of North America, where they are found more especially in bogs, and even in places covered with shallow water. Their leaves, which give them a character entirely their own, are pitcher-shaped or trumpet-like, and are collected in tufts springing immediately from the ground; and they send up at the flowering season one or more slender stems bearing each a solitary flower. This has a singular aspect, due to a great extent to the umbrella-like expansion in which the style terminates; the shape of this, or perhaps, of the whole flower, caused the first English settlers to give to the plant the name of Side-saddle Flower.

Sarracenia purpurea is the best known species. About ten years ago it enjoyed an evanescent notoriety from the fact that its rootstock was proposed as a remedy for small-pox. It is found from Newfoundland southward to Florida, and is fairly hardy under open-air cultivation in the British Isles. At the commencement of the seventeenth century, Clusius published a figure of it, from a sketch which found its way to Lisbon and thence to Paris. Thirty years later Johnson copied this in his edition of Gerard's Herbal, hoping "that some or other that travel into foreign parts may find this elegant plant, and know it by this small expression, and bring it home with them, so that we may come to a perfecter knowledge thereof." A few years afterwards this wish was gratified. John Tradescant the younger found the plant in Virginia, and succeeded in bringing it home alive to England. It was also sent to Paris from Quebec by Dr. Sarrazin, whose memory has been commemorated in the name of the genus, by Tournefort.

The first fact which was observed about the pitchers was, that when they grew they contained water. But the next fact which was recorded about them was curiously mythical. Perhaps Morrison, who is responsible for it, had no favourable opportunites of studying them, for he declares them to be what is by no means really the case, intolerant of cultivation (*respuere culturam videntur*).

He speaks of the lid, which in all the species is tolerably rigidly fixed, as being furnished, by a special act of providence, with a hinge. This idea was adopted by Linnæus, and somewhat amplified by succeeding writers, who declared that in dry weather the lid closed over the mouth, and checked the loss of water by evaporation. Catesby, in his fine work on the Natural History of Carolina, supposed that these water-receptacles might "serve as an asylum or secure retreat for numerous insects, from frogs and other animals which feed on them;"—and others followed Linnæus in regarding the pitchers as reservoirs for birds and other animals, more especially in times of drought; "*præbet aquam sitientibus aviculis*."

The superficial teleology of the last century was easily satisfied without looking far for explanations, but it is just worth while pausing for a moment to observe that, although Linnæus had no materials for making any real investigation as to the purpose of the pitchers of Sarracenias, he very sagaciously anticipated the modern views as to their affinities. They are now regarded as very near allies of water-lilies—precisely the position which Linnæus assigned to them in his fragmentary attempt at a true natural classification. And besides this, he also suggested the analogy, which, improbable as it may seem at first sight, has been worked out in detail by Baillon (in apparent ignorance of Linnæus' writings) between the leaves of Sarracenia and water-lilies.

Linnæus seems to have supposed that Sarracenia was originally aquatic in its habits, that it had Nymphæa-like leaves, and that when it took to a terrestrial life its leaves became hollowed out, to contain the water in which they could no longer float —in fact, he showed himself to be an evolutionist of the true Darwinian type.

Catesby's suggestion was a very infelicitous one. The insects which visit these plants may find in them a retreat, but it is one from which they never return. Linnæus' correspondent Collinson, remarked in one of his letters, that "many poor insects lose their lives by being drowned in these cisterns of water;" but William Bartram, the son of the botanist, seems to have been the first to put on record, at the end of the last century, the fact that Sarracenias catch insects and put them to death in the wholesale way that they do.

Before stopping to consider how this is actually achieved, I will carry the history a little further.

In the two species in which the mouth is unprotected by the lid it could not be doubted that a part, at any rate, of the contained fluid was supplied by rain. But in *Sarracenia variolaris*, in which the lid closes over the mouth, so that rain cannot readily enter it, there is no doubt that a fluid is secreted at the bottom of the pitchers, which probably has a digestive function. William Bartram, in the preface to his travels in 1791, described this fluid, but he was mistaken in supposing that it acted as a lure. There is a sugary secretion which attracts insects, but this is only found at the upper part of the tube. Bartram must be credited with the suggestion, which he, however, only put forward doubtfully, that the insects were dissolved in the fluid, and then became available for the alimentation of the plants.

Sir J. E. Smith, who published a figure and description of *Sarracenia variolaris*, noticed that it secreted fluid, but was content to suppose that it was merely the gaseous products of the decomposition of insects that subserved the processes of vegetation. In 1829, however, thirty years after Bartram's book, Burnett wrote a paper containing a good many original ideas expressed in a somewhat quaint fashion, in which he very strongly insisted on the existence of a true digestive process in the case of Sarracenia, analogous to that which takes place in the stomach of an animal.

Our knowledge of the habits of *Sarracenia variolaris* is now pretty complete, owing to the observations of two South Carolina physicians. One, Dr. M'Bride, made his observations half a century ago, but they had, till quite recently, completely fallen into oblivion. He devoted himself to the task of ascertaining why it was that *Sarracenia variolaris* was visited by flies, and how it was that it captured them. This is what he ascertained: "The cause which attracts flies is evidently a viscid substance resembling honey, secreted by or exuding from the internal surface of the tube. From the margin, where it commences, it does not extend lower than one-fourth of an inch. The falling of the insect as soon as it enters the tube is wholly attributable to the downward or inverted position of the hairs of the internal surface of the leaf. At the bottom of a tube split open, the hairs are plainly discernible, pointing downwards; as the eye ranges upward they gradually become shorter and attenuated, till at or just below the surface covered by the bait they are no longer perceptible to the naked eye, nor to the most delicate touch. It is here that the fly cannot take a hold sufficiently strong to support itself, but falls."

Dr. Mellichamp, who is now resident in the district in which Dr. M'Bride made his observations, has added a good many particulars to our knowledge. He first investigated the fluid which is secreted at the bottom of the tubes. He satisfied himself that it was really secreted, and describes it as mucilaginous, but leaving in the mouth a peculiar astringency. He compared the action of this fluid with that of distilled water on pieces of fresh venison, and found that after fifteen hours the fluid had produced most change, and also most smell; he therefore concluded that as the leaves when stuffed with insects become most disgusting in odour, we have to do, not with a true digestion, but with an accelerated decomposition. Although he did not attribute any true digestive power to the fluid secreted by the pitchers, he found that it had a remarkable anæsthetic effect on flies immersed in it. He remarked that "a fly when thrown into water is very apt to escape, as the fluid seems to *run* from its wings," but it never escaped from the Sarracenia secretion. About half a minute after being thrown in, the fly became to all appearance dead, though, if removed, it gradually recovered in from half an hour to an hour.

According to Dr. Mellichamp, the sugary lure discovered by Dr. M'Bride, at the mouth of the pitchers, is not found on either the young ones of one season or the older ones of the previous year. He found, however, that about May it could be detected without difficulty, and more wonderful still, that there is a honeybaited pathway leading directly from the ground to the mouth, along the broad wing of the pitcher, up which insects are led to their destruction. From these narratives it is evident that there are two very different types of pitcher in Sarracenia, and an examination of the species shows that there may probably be three. These may be primarily classified into those with the mouth open and lid erect, and which consequently receive the rain-water in more or less abundance; and those with the mouth closed by the lid, into which rain can hardly, if at all, find ingress.

To the first of these belongs the well-known *S. purpurea*, with inclined pitchers, and a lid so disposed as to direct all the rain that falls upon it also into the pitcher; also *S. flava*, *rubra*, and *Drummondii*, all with erect pitchers and vertical lids; of these three, the lid in a young state arches over the mouth, and in an old state stands nearly erect, and has the sides so reflected that the rain which falls on its upper surface is guided down the outside of the back of the pitcher, as if to prevent the flooding of the latter.

To the second group belong *S. psittacina* and *S. variolaris*.

The tissues of the internal surfaces of the pitchers are singularly beautiful. They have been described in one species only, the *S. purpurea*, by August Vogl; but from this all the other species which I have examined differ materially. Beginning from the upper part of the pitcher, there are four surfaces, characterised by different tissues, which I shall name and define as follows:—

1. An *attractive* surface, occupying the inner surface of the lid, which is covered with an epidermis, stomata, and (in common with the mouth of the pitcher) with minute honey-secreting glands; it is further often more highly coloured than any other part of the pitcher, in order to attract insects to the honey.

2. A *conducting* surface, which is opaque, formed of glassy cells, which are produced into deflexed, short, conical, spinous processes. These processes, overlapping like the tiles of a house, form a surface down which an insect slips, and affords no foothold to an insect attempting to crawl up again.

3. A *glandular* surface (seen in *S. purpurea*), which occupies a considerable portion of the cavity of the pitcher below the conducting surface. It is formed of a layer of epidermis with sinuous cells, and is studded with glands; and being smooth and polished, this too affords no foothold for escaping insects.

4. A *detentive* surface, which occupies the lower part of the pitcher, in some cases for nearly its whole length. It possesses no cuticle, and is studded with deflexed, rigid, glass-like, needle-formed, striated hairs, which further converge towards the axis of the diminishing cavity; so that an insect, if once amongst them, is effectually detained, and its struggles have no other result than to wedge it lower and more firmly in the pitcher.

Now, it is a very curious thing that in *S. purpurea*, which has an open pitcher, so formed as to receive and retain a maximum of rain, no honey-secretion has hitherto been found, nor has any water been seen to be secreted in the pitcher; it is, further, the only species in which (as stated above) I have found a special glandular surface, and in which no glands occur on the detentive surface. This concurrence of circumstances suggests the possibility of this plant either having no proper secretion of its own, or only giving it off after the pitcher has been filled with rain-water.

In *S. flava*, which has open-mouthed pitchers and no special glandular surface, I find glands in the upper portion of the detentive surface, among the hairs, but not in the middle or lower part of the same surface. It is proved that *S. flava* secretes fluid, but under what precise conditions I am not aware. I have found none but what may have been accidentally introduced in the few cultivated specimens which I have examined, either in the full-grown state, or in the half-grown when the lid arches over the pitcher. I find the honey in these as described by the American observers, and honey-secreting glands on the edge of the wing of the pitcher, together with similar glands on the outer surface of the pitcher, as seen by Vogl in *S. purpurea*.

Of the pitchers with closed mouths, I have examined those of *S. variolaris* only, whose tissues closely resemble those of *S. flava*. That it secrets a fluid noxious to insects there is no doubt, though in the specimens I examined I found none.

There is thus obviously much still to be learned with regard to Sarracenia, and I hope that American botanists will apply themselves to this task. It is not probable that three pitchers, so differently constructed as those of *S. flava, purpurea,* and *variolaris*, and presenting such differences in their tissues, should act similarly. The fact that insects normally decompose in the fluid of all, would suggest the probability that they all feed on the products of decomposition; but as yet we are absolutely ignorant whether the glands within the pitchers are secretive, or absorptive, or both; if secretive, whether they secrete water or a solvent; and if absorptive, whether they absorb animal matter or the products of decomposition

It is quite likely, that just as the saccharine exudation only makes its appearance during one particular period in the life of the pitcher, so the digestive functions may also be only of short duration. We should be prepared for this from the case of the Dionæa, the leaves of which cease after a time to be fit for absorption, and become less sensitive. It is quite certain that the insects which go on accumulating in the pitchers of Sarracenias must be far in excess of its needs for any legitimate process of digestion. They decompose; and various insects, too wary to be entrapped themselves, seem habitually to drop their eggs into the open mouth of the pitchers, to take advantage of the accumulation of food. The old pitchers are consequently found to contain living larvæ and maggots, a sufficient proof that the original properties of the fluid which they secreted must have become exhausted; and Barton tells us that various insectivorous birds slit open the pitchers with their beaks to get at the contents. This was probably the origin of Linnæus' statement that the pitchers supplied birds with water.

The pitchers finally decay, and part, at any rate, of their contents must supply some nutriment to the plant by fertilising the ground in which it grows.

Darlingtonia.—I cannot take leave of Sarracenia without a short notice of its near ally, Darlingtonia, a still more wonderful plant, an outlier of Sarracenia in geographical distribution, being found at an elevation of 5,000 ft. on the Sierra Nevada of California, far west of any locality inhabited by Sarracenia. It has pitchers of two forms; one, peculiar to the infant state of the plant, consists of narrow, somewhat twisted, trumpet-shaped tubes, with very oblique open mouths, the dorsal lip of which is drawn out into a long, slender, arching, scarlet hood, that hardly closes the mouth. The slight twist in the tube causes these mouths to point in various directions, and they entrap very small insects only. Before arriving at a state of maturity the plant bears much larger, suberect pitchers, also twisted, with the lip produced into a large inflated hood, that completely arches over a very small entrance to the cavity of the pitchers. A singular orange-red, flabby, two-lobed organ hangs from the end of the hood, right in front of the entrance, which, as I was informed last week by letter from Prof. Asa Gray, is smeared with honey on its inner surface. These pitchers are crammed with large insects, especially moths, which decompose in them, and result in a putrid mass. I have no information of water being found in its pitchers in its native country, but have myself found a slight acid secretion in the young states of both forms of pitcher.

The tissues of the inner surfaces of the pitchers of both the young and the old plant I find to be very similar to those of *Sarracenia variolaris* and *flava*.

Looking at a flowering specimen of Darlingtonia, I was struck with a remarkable analogy between the arrangement and colouring of the parts of the leaf and of the flower. The petals are of the same colour as the flap of the pitcher, and between each pair of petals is a hole (formed by a notch in the opposed margins of each) leading to the stamens and stigma. Turning to the pitcher, the relation of its flap to its entrance is somewhat similar. Now, we know that coloured petals are specially attractive organs, and that the object of their colour is to bring insects to feed on the pollen or nectar, and in this case by means of the hole to fertilise the flower; and that the object of the flap and its sugar is also to attract insects, but with a very different result, cannot be doubted. It is hence conceivable that this marvellous plant lures insects to its flowers for one object, and feeds them while it uses them to fertilise itself, and that, this accomplished, some of its benefactors are thereafter lured to its pitchers for the sake of feeding itself!

But to return from mere conjecture to scientific earnest, I cannot dismiss Darlingtonia without pointing out to you what appears to me a most curious point in its history; which is, that the change from the slender, tubular, open-mouthed to the inflated closed-mouthed pitchers, is, in all the specimens which I have examined, absolutely sudden in the individual plant. I find no pitchers in an intermediate stage of development. This, a matter of no little significance in itself, derives additional interest from the fact that the young pitchers to a certain degree represent those of the Sarracenias with open mouths and erect lids; and the old pitchers those of the Sarracenias with closed mouths and globose lids. The combination of representative characters in an outlying species of a small order cannot but be regarded as a marvellously significant fact in the view of those morphologists who hold the doctrine of evolution.

Nepenthes.—The genus Nepenthes consists of upwards of thirty species of climbing, half shrubby plants, natives of the hotter parts of the Asiatic Archipelago from Borneo to Ceylon, with a few outlying species in New Caledonia, in Tropical Australia, and in the Seychelle Islands on the African coast. Its pitchers are abundantly produced, especially during the younger state of the plants. They present very considerable modifications of form and external structure, and vary greatly in size, from little more than an inch to almost a foot in length; one species, indeed, which I have here from the mountains of Borneo, has pitchers which, including the lid, measure a foot and a half, and its capacious bowl is large enough to drown a small animal or bird.

The structure of the pitcher of Nepenthes is less complicated on the whole than that of Sarracenia, though some of its tissues are much more highly specialised. The pitcher itself is here not a transformed leaf, as in Sarracenia, nor is it a transformed leaf-blade, like that of Dionæa, but an appendage of the leaf developed at its tip, and answers to a water-secreting gland that may be seen terminating the mid-rib of the leaf of certain plants. It is furnished with a stalk, often a very long one, which in the case of pitchers formed on leaves high up the stem has (before the full development of the pitcher) the power of twisting like a tendril round neighbouring objects, and thus aiding the plant in climbing, often to a great height in the forest.

In most species the pitchers are of two forms, one appertaining to the young, the other to the old state of the plant, the transition from one form to the other being gradual. Those of the young state are shorter and more inflated; they have broad fringed longitudinal wings on the outside, which are probably guides to lead insects to the mouth; the lid is smaller and more open, and the whole interior surface is covered with secreting glands. Being formed near the root of the plant, these pitchers often rest on the ground, and in species which do not form leaves near the root they are sometimes suspended from stalks which may be fully a yard long, and which bring them to the ground. In the older state of the plant the pitchers are usually much longer, narrower, and less inflated, and are trumpet-shaped, or even conical; the wings also are narrower, less fringed, or almost absent. The lid is larger and slants over the mouth, and only the lower part of the pitcher is covered with secreting glands, the upper part presenting a tissue analogous to the conducting tissue of Sarracenia, but very different anatomically. The difference in structure of these two forms of pitcher, if considered in reference to their different positions on the plant, forces the conclusion on the mind that the one form is intended for ground game, the other for winged game. In all cases the mouth of the pitcher is furnished with a thickened corrugated rim, which serves three purposes: strengthens the mouth and keeps it distended; it secretes honey (at least in all the species I have examined under cultivation, for I do not find that any other observer has noticed the secretion of honey by Nepenthes), and it is in various species developed into a funnel-shaped tube that descends into the pitcher and prevents the escape of insects, or into a row of incurved hooks that are in some cases strong enough to retain a small bird, should it, when in search of water or insects, thrust its body beyond a certain length into the pitcher.

In the interior of the pitcher of Nepenthes there are three principal surfaces: an *attractive*, *conductive*, and a *secretive* surface; the *detentive* surface of Sarracenia being represented by the fluid secretion, which is here invariably present at all stages of growth of the pitcher.

The attractive surfaces of Nepenthes are two: those, namely, of the rim of the pitcher, and of the under surface of the lid, which is provided in almost every species with honey-secreting glands, often in great abundance. These glands consist of spherical masses of cells, each embedded in a cavity of the tissue of the lid, and encircled by a guard-ring of glass-like cellular tissue. As in Sarracenia, the lid and mouth of the pitcher are more highly coloured than any other part, with the view of attracting insects to their honey. It is a singular fact that the only species known to me that wants these honey-glands on the lid is the *N. ampullaria*, whose lid, unlike that of the other species, is thrown back horizontally. The secretion of honey on a lid so placed would tend to lure insects away from the pitcher instead of into it.

From the mouth to a variable distance down the pitcher is an opaque glaucous surface, precisely resembling in colour and appearance the conductive surface of the Sarracenia, and, like it, affording no foothold to insects, but otherwise wholly different; it is formed of a fine network of cells, covered with a glass-like cuticle, and studded with minute reniform transverse excrescences.

The rest of the pitcher is entirely occupied with the secretive surface, which consists of a cellular floor crowded with spherical glands in inconceivable numbers. Each gland precisely resembles a honey-gland of the lid, and is contained in a pocket of the same nature, but semicircular, with the mouth downwards, so that the secretive fluid all falls to the bottom of the pitcher. In the *Nepenthes Rafflesiana* 3,000 of the glands occur on a square inch of the inner surface of the pitcher, and upwards of 1,000,000 in an ordinary sized pitcher. I have ascertained that, as was indeed to be expected, they secrete the fluid which is contained in the bottom of the pitcher before this opens, and that the fluid is always acid.

The fluid, though invariably present, occupies a comparatively small portion of the glandular surface of the pitcher, and is collected before the lid opens. When the fluid is emptied out of a fully formed pitcher that has not received animal matter, it forms again, but in comparatively very small quantities; and the formation goes on for many days, and to some extent even after the pitcher has been removed from the plant. I do not find that placing inorganic substances in the fluid causes an increased secretion, but I have twice observed a considerable increase of fluid in pitchers after putting animal matter in the fluid.

To test the digestive powers of Nepenthes I have closely followed Mr. Darwin's treatment of Dionæa and Drosera, employing white of egg, raw meat, fibrine, and cartilage. In all cases the action is most evident, in some surprising. After twenty-four hours' immersion the edges of the cubes of white of egg are eaten away and the surfaces gelatinised. Fragments of meat are rapidly reduced; and pieces of fibrine weighing several grains dissolve and totally disappear in two or three days. With cartilage the action is most remarkable of all; lumps of this weighing 8 or 10 grains are half gelatinized in twenty-four hours, and in three days the whole mass is greatly diminished, and reduced to a clear transparent jelly. After drying some cartilage in the open air for a week, and placing it in an unopened but fully formed pitcher of *N. Rafflesiana*, it was acted upon similarly and very little slower.

That this process, which is comparable to digestion, is not wholly due to the fluid first secreted by the glands, appears to me most probable; for I find that very little action takes place in any of the substances placed in the fluid drawn from pitchers, and put in glass tubes; nor has any followed after six days' immersion of cartilage or fibrine in pitchers of *N. ampullaria* placed in a cold room; whilst on transferring the cartilage from the pitcher of *N. ampullaria* in the cold room to one of *Rafflesiana* in the stove, it was immediately acted upon. Comparing the action of fibrine, meat, and cartilage placed in tubes of Nepenthes fluid, with others in tubes of distilled water, I observed that their disintegration is three times more rapid in the fluid; but this disintegration is wholly different from that effected by immersion in the fluid of the pitcher of a living plant.

In the case of small portions of meat, ½ to 2 grains, all seem to be absorbed; but with 8 to 10 grains of cartiage it is not so —a certain portion disappears, the rest remains as a transparent jelly, and finally becomes putrid, but not till after many days. Insects appear to be acted upon somewhat differently, for after several days' immersion of a large piece of cartilage I found that a good-sized cockroach, which had followed the cartilage and was drowned for his temerity, in two days became putrid. In removing the cockroach the cartilage remained inodorous for many days. In this case no doubt the antiseptic fluid had permeated the tissue of the cartilage, whilst enough did not remain to penetrate the chitinous hard covering of the insect, which consequently decomposed.

In the case of cartilage placed in fluid taken from the pitcher —it becomes putrid, but not so soon as if placed in distilled water.

From the above observations it would appear probable that a substance acting as pepsine is given off from the inner wall of the pitcher, but chiefly after placing animal matter in the acid fluid; but whether this active agent flows from the glands or from the cellular tissue in which they are imbedded, I have no evidence to show.

I have here not alluded to the action of these animal matters in the cells of the glands, which is, as has been observed by Mr.

Darwin in Drosera, to bring about remarkable changes in their protoplasm, ending in their discoloration. Not only is there aggregation of the protoplasm in the gland cells, but the walls of the cells themselves become discoloured, and the glandular surface of the pitcher that at first was of a uniform green, becomes covered with innumerable brown specks (which are the discoloured glands). After the function of the glands is exhausted, the fluid evaporates, and the pitcher slowly withers.

At this stage I am obliged to leave this interesting investigation. That Nepenthes possesses a true digestive process such as has been proved in the case of Drosera, Dionæa, and Pinguicula, cannot be doubted. This process, however, takes place in a fluid which deprives us of the power of following it further by direct observation. We cannot here witness the pouring out of the digestive fluid; we must assume its presence and nature from the behaviour of the animal matter placed in the fluid in the pitcher. From certain characters of the cellular tissues of the interior walls of the pitcher, I am disposed to think that it takes little part in the processes of either digestion or assimilation, and that these, as well as the pouring out of the acid fluid, are all functions of the glands.

In what I have said I have described the most striking instances of plants which seem to invert the order of nature, and to draw their nutriment—in part, at least—from the animal kingdom, which it is often held to be the function of the vegetable kingdom to sustain.

I might have added some additional cases to those I have already dwelt upon. Probably, too, there are others still unknown to science, or whose habits have not yet been detected. Delpino, for example, has suggested that a plant, first described by myself in the Botany of the Antartic Voyage, *Caltha dionæafolia*, is so analagous in the structure of its leaves to Dionæa, that it is difficult to resist the conviction that its stucture also is adapted for the capture of small insects.

But the problem that forces itself upon our attention is, How does it come to pass that these singular aberrations from the otherwise uniform order of vegetable nutrition make their appearance in remote parts of the vegetable kingdom? why are they not more frequent, and how were such extraordinary habits brought about or contracted? At first sight the perplexity is not diminished by considering—as we may do for a moment—

the nature of ordinary vegetable nutrition. Vegetation, as we see it everywhere, is distinguished by its green colour, which we know depends on a peculiar substance called chlorophyll, a substance which has the singular property of attracting to itself the carbonic acid gas which is present in minute quantities in the atmosphere, of partly decomposing it, so far as to set free a portion of its oxygen, and of recombining it with the elements of water, to form those substances, such as starch, cellulose, and sugar, out of which the framework of the plant is constructed.

But, besides these processes, the roots take up certain matters from the soil. Nitrogen forms nearly four-fifths of the air we breathe, yet plants can possess themselves of none of it in the free uncombined state. They withdraw nitrates and salts of ammonia in minute quantities from the ground, and from these they build up with starch, or some analogous material, albuminoids or protein compounds, necessary for the sustentation and growth of protoplasm.

At first sight nothing can be more unlike this than a Dionæa or a Nepenthes capturing insects, pouring out a digestive fluid upon them, and absorbing the albuminoids of the animal, in a form probably directly capable of appropriation for their own nutrition. Yet there is something not altogether wanting in analogy in the case of the most regularly constituted plants. The seed of the castor-oil plant contains, besides the embryo seedling, a mass of cellular tissue or endosperm filled with highly nutritive substances. The seedling lies between masses of this, and is in contact with it; and as the warmth and moisture of germination set up changes which bring about the liquefaction of the contents of the endosperm and the embryo absorbs them, it grows in so doing, and at last, having taken up all it can from the exhausted endosperm, develops chlorophyll in its cotyledons under the influence of light, and relies on its own resources.

A large number of plants, then, in their young condition, borrow their nutritive compounds ready prepared; and this is in effect what carnivorous plants do later in life.

That this is not a merely fanciful way of regarding the relation of the embryo to the endosperm, is proved by the ingenious experiments of Van Tieghem, who has succeeded in substituting for the real, an artificial endosperm, consisting of appropriate nutritive matters. Except that the embryo has its food given to it in a manner which needs no digestion—a proper concession to its infantine state—the analogy here with the mature plants which feed on organic food seems to be complete.

But we are beginning also to recognise the fact that there are a large number of flowering plants that pass through their lives without ever doing a stroke of the work that green plants do. These have been called Saprophytes. Monotropa, the curious bird's nest orchis (*Neottia nidus-avis*), Epipogium, and Corallorhiza are instances of British plants which nourish themselves by absorbing the partially decomposed materials of other plants, in the shady or marshy places which they inhabit. They reconstitute these products of organic decomposition, and build them up once more into an organism. It is curious to notice, however, that the tissues of Neottia still contain chlorophyll in a nascent though useless state, and that if a plant of it be immersed in boiling water, the characteristic green colour reveals itself.

Epipogium and Corallorhiza have lost their proper absorbent organs; they are destitute of roots, and take in their food by the surfaces of their underground stem structures.

The absolute difference between plants which absorb and nourish themselves by the products of the decomposition of plant-structures, and those which make a similar use of animal structures, is not very great. We may imagine that plants accidentally permitted the accumulation of insects in some parts of their structure, and the practice became developed because it was found to be useful. It was long ago suggested that the receptacle formed by the connate leaves of Dipsacus might be an incipient organ of this kind; and though no insectivorous habit has ever been brought home to that plant, the theory is not improbable.

Linnæus, and more lately Baillon, have shown how a pitcher of Sarracenia may be regarded as a modification of a leaf of the Nymphæa type. We may imagine such a leaf first becoming hollow, and allowing *débris* of different kinds to accumulate; these would decompose, and a solution would be produced, some of the constituents of which would diffuse themselves into the subjacent plant tissues. This is in point of fact absorption, and we may suppose that in the first instance—as perhaps still in *Sarracenia purpurea*—the matter absorbed was merely the saline nutritive products of decomposition, such as ammoniacal salts. The act of digestion—that process by which soluble food is reduced without decomposition to a soluble form fitted for absorption—was doubtless subsequently acquired.

The secretion, however, of fluids by plants is not an unusual phenomenon. In many Aroids a small gland at the apex of the leaves secretes fluid, often in considerable quantities, and the pitcher of Nepenthes is, as I have shown elsewhere, only a gland of this kind, enormously developed. May not, therefore, the wonderful pitchers and carnivorous habit of Nepenthes have both originated by natural selection out of one such honey-secreting gland as we still find developed near that part of the pitcher which represents the tip of the leaf? We may suppose insects to have been entangled in the viscid secretion of such a gland, and to have perished there, being acted upon by those acid secretions that abound in these and most other plants. The subsequent differentiation of the secreting organs of the pitcher into aqueous, saccharine, and acid, would follow *pari passu* with the evolution of the pitcher itself, according to those mysterious laws which result in the correlation of organs and functions throughout the kingdom of Nature; and which, in my apprehension, transcend in wonder and interest those of evolution and the origin of species.

Delpino has recorded the fact that the spathe of Alocasia secretes an acid fluid which destroys the slugs that visit it, and which he believes subserves its fertilisation. Here any process of nutrition can only be purely secondary. But the fluids of plants are in the great majority of cases acid, and, when exuded, would be almost certain to bring about some solution in substances with which they came in contact. Thus the acid secretions of roots were found by Sachs to corrode polished marble surfaces with which they came in contact, and thus to favour the absorption of mineral matter.

The solution of albuminoid substances requires, however, besides a suitable acid, the presence of some other albuminoid substance analogous to pepsine. Such substances, however, are frequent in plants. Besides the well-known diastase, which converts the starch of malt into sugar, there are other instances in the synaptase which determines the formation of hydrocyanic acid from emulsine, and the myrosin which similarly induces the formation of oil of mustard. We need not wonder, then, if the fluid secreted by a plant should prove to possess the ingredients necessary for the digestion of insoluble animal matters.

These remarks will, I hope, lead you to see, that though the processes of plant nutrition are in general extremely different from those of animal nutrition, and involve very simple compounds, yet that the protoplasm of plants is not absolutely prohibited from availing itself of food, such as that by which the protoplasm of animals is nourished, under which point of view these phenomena of carnivorous plants will find their place, as one more link in the continuity of nature.

NOTE ON CARNIVOROUS PLANTS.—Mr. Andrew Murray writes to the *Gardener's Chronicle* that he has, within the last few weeks, made some observations at the Ochil Hills, Kinross-shire, on *Pinguicula* and *Drosera*, with reference to the fly-digesting powers they are asserted to possess. He states that he found the leaves of *Pinguicula* close, quite independently of a fly being in them or not. "The leaves are found with their margins in all stages of curling over, some with no insect on them much more curled over than others with several." The secretion which Dr. Hooker states kills a captured insect, he finds is glutinous, and he believes it does not fall on to the insect, but that death results from the secretion adhering to and closing up the spiracles by which the insect breathes. With regard to *Dionæa* he suggests that it should be carefully noted (1) whether the secretion is never present until after an insect has been captured; (2) whether it is always present after one has.—*Nature*.

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