TRANSACTIONS

OF

The Canadian Institute.

VOLUME VII.

TORONTO:
PRINTED FOR THE CANADIAN INSTITUTE
BY MURRAY PRINTING COMPANY.
1904.

OFFICERS

OF

THE CANADIAN INSTITUTE,

1900-1901

President,
JAMES BAIN, JR., ESQ.

1st Vice-President,	**2nd Vice-President,**
PROF. A. P. COLEMAN, PH.D.	PROF. A. B. WILLMOTT.

Secretary, - - - - - - - R. F. STUPART, ESQ.
Treasurer, - - - - - WILLIAM SCOTT, M.A.
Librarian, - - - - - - - DR. A. B. MACALLUM.
Curator, - - - - - C. H. ARMSTRONG, ESQ.
Editor, - - - - - GEORGE KENNEDY, M.A., LL.D.

Members of Council,

JOHN MAUGHAN, ESQ., CHAIRMAN BIOLOGICAL SECTION.
B. E. WALKER, F.G.S.
S. DILLON MILLS, ESQ.
ARCHIBALD BLUE, ESQ.
PROFESSOR SQUAIR.
G. G. PURSEY, ESQ.

Assistant Secretary and Librarian,
MARGARET J. LOGAN.

OFFICERS

OF

THE CANADIAN INSTITUTE,

1901 - 1902

President,
JAMES BAIN, JR., ESQ.

1st Vice-President,	**2nd Vice-President,**
PROF. A. P. COLEMAN, PH.D.	PROF. A. J. BELL, PH.D.

Secretary, - - - - - -	R. F. STUPART, ESQ.
Treasurer, - - - - - -	WILLIAM SCOTT, M.A.
Librarian, - - - - - -	PROF. A. B. MACALLUM, M.A., M.B, PH.D.
Curator, - - - - - - -	C. H. ARMSTRONG, ESQ.
Editor, - - - - - -	GEORGE KENNEDY, M.A., LL.D.

Members of Council,

JOHN MAUGHAN, ESQ., CHAIRMAN BIOLOGICAL SECTION.
PROF. W. H. ELLIS, M.A., M.B.
PROF. J. FLETCHER, LL.D.
E. C. JEFFREY, B.A., PH.D.
B. E. WALKER, F.G.S.
S. DILLON MILLS, ESQ.

Assistant Secretary and Librarian,
MARGARET J. LOGAN.

OFFICERS

OF

THE CANADIAN INSTITUTE,

1902-1903

President,

PROF. A. P. COLEMAN, Ph.D.

1st Vice-President,
R. F. STUPART, Esq.

2nd Vice-President,
PROF. A. J. BELL, Ph.D.

Secretary, - - - - - -	PROF. J. J. MACKENZIE, B.A., M.B.
Treasurer, - - - - - -	WILLIAM SCOTT, M.A.
Librarian, - - - - - -	PROF. A. B. MACALLUM, M.A., M.B., Ph.D
Curator, - - - - - -	C. H. ARMSTRONG, Esq.
Editor, - - - - - - -	GEORGE KENNEDY, M.A., LL.D.

Members of Council,

JOHN MAUGHAN, Esq., Chairman Biological Section.
B. E. WALKER, F.G.S.
PROF. W. H. ELLIS, M.A., M.B.
S. DILLON MILLS, Esq.
JAMES BAIN, D.C.L.
JOHN BERTRAM, Esq.

Assistant Secretary and Librarian,
MARGARET J. LOGAN.

CONTENTS.

TRANSACTIONS

OF THE

Canadian Institute

No. 13. AUGUST, 1901. VOL. VII. PART I.

PRICE, - $2.00

TORONTO:
MURRAY PRINTING COMPANY, 11-13 JORDAN STREET.

CONTENTS.

REV. HENRY SCADDING, D.D.

1813—1901.

PRESIDENT OF THE CANADIAN INSTITUTE, 1870-76.

TRANSACTIONS

OF

THE CANADIAN INSTITUTE.

ON THE ANATOMICAL CHARACTERS OF THE SUBSTANCE "INDIAN SOAP."

BY MISS M. DAWSON, B.SC. (LOND. AND WALES).

(Read 3rd March, 1900).

ON THE STRUCTURE OF "INDIAN SOAP."

IN December, 1898, a piece of the material used by the Indians of British Columbia as a substitute for soap, was sent to the Botanical Laboratory, Cambridge, by Prof. Anderson, of the Department of Agriculture, Victoria, B.C.

Enclosed with this was a report upon the material from Dr. Fletcher, who stated that Prof. Macoun had identified it as a Polyporus, allied to *P. betulinus*, which had become changed by its own mycelium into punk. Dr. Fletcher explained that the scroopy feeling upon rubbing the soap between the fingers is due to the presence of quantities of resin, also that it burns freely with a strong resinous odour and much black smoke, in a similar manner to birch bark, which accounts for its use by the children of the district as candles. With hot water, it scarcely produces a lather, but rubs up like clay, and leaves a chalk-like deposit on the hands after drying.

Some of this "Indian Soap" was handed to me last April by Prof. Marshall Ward for a more detailed study of its anatomy. A superficial examination suggests that the substance is either a dead fungus of the larger Polyporus type, or a mass of wood destroyed by a fungus.

It is whitish cream in colour, very friable, breaking into long, thin strands, which seem to be held together by fragments of dead matter. To the touch, it has a curious saponaceous feel, but as Dr. Fletcher remarked, does not produce any appreciable lather when rubbed up with water. If cut dry with a razor, the sections peel off like shavings, and even in very small pieces they are exceedingly impervious to cold water,—they will float on the surface for weeks. Hot water or alcohol, however, wets them readily.

If a small portion of the "soap" be teased out, it is found to consist of a meshwork of hyphæ, covered over with, and more or less bound together by irregular fragments of very varying size. With iodine, or Schultz's solution, the hyphæ stain a faint yellow, the fragments a deeper yellow. Iodine and sulphuric acid at first give a deep yellow colour, but then the sections gradually dissolve up. Phloroglucin or aniline chloride and hydrochloric acid give no trace of colour. The hyphæ stain readily with hæmatoxylin, Congo-red, carbol, fuchsin, aniline blue, etc., either in alcoholic solutions or in water solutions, if the sections have been previously treated with alcohol.

After soaking in alcohol, thin layers of the substance become semi-transparent, and show very clearly longitudinal strands, which in section show irregularly arranged circles, held together by darker portions of the material. Distributed over the "soap" occur deep brown areas, which, to the naked eye, appear like a stain. This colouration is very intense in some places, whilst in others it is scarcely noticeable. The deeper brown areas seem to mark successive layers in a direction at right angles to the longitudinal strands; there is, however, no regularity in the thickness of the layers, and here and there the dark areas cross each other. When examined microscopically, besides these longitudinal strands above referred to, the most striking character is the presence of a double set of hyphæ lying one above the other. Thus, as shown in Fig. 2, the substance is seen to consist of interwoven hyphæ, running in alternating strands longitudinally and transversely, with a more densely matted line separating these strands. The hyphæ arranged thus are colourless, very rarely branched, regular, somewhat thick walled and show but very few transverse divisions. Clamp connections occur here and there. (Fig. 12). Overlying these and very irregularly distributed are numerous dark brown hyphæ, showing frequent swellings and branchings and occasional transverse septa. (Figs. 5 and 11). To their presence undoubtedly the brown colour, mentioned above, is due, since though present throughout the material, they are very much more numerous in the more deeply "stained" areas. With this exception, it is impossible to discover any method in their distribution.

The longitudinal strands of hyphæ are especially clearly seen if a rather thick section is mounted in eau de javelle or potash, and examined under low power. The section gradually clears, owing to the almost complete solution of the coarsely granular substance, which adheres in fragments to all the hyphæ, and seems to be the cementing material which holds the whole structure together. Indeed, thin sections treated with potash are almost immediately disintegrated, breaking first along the boundary lines of the strands of hyphæ, and then the individual hyphæ are separated from one another completely.

Sections cut transversely to the direction of the longitudinal strands show circular areas of loosely interwoven hyphæ, with intermediate layers, consisting of a denser meshwork of hyphæ, running between these areas. As before, the overlying brown irregular hyphæ are visible all over the sections. (See Figs. 1 and 3).

No trace has been found of any remains of woody elements, though a very large number of sections have been carefully examined. Nor has it been possible to obtain any indication of the presence of lignin with any of the usual micro-chemical tests.

In connection with the large colourless hyphæ, one and only one group of spores has been found. They had obviously been considerably compressed and dried up, but were sufficiently clear to show a few still attached at intervals down some hyphæ. The spores are very small, apparently spherical or oval in the fresh, colourless, with slightly thickened walls. The evidence of their mode of formation is not very satisfactory, but they seem to be borne sessile upon the hyphæ in groups of two or more. (Fig. 4).

A second group of spores of another kind was found in connection with the dark brown hyphæ. Like them, they are deep brown in colour, with thick walls, mostly oval in form, and much larger than those described above. Though lying amidst the hyphæ, this group did not show any spores attached, consequently no information could be gained as to their method of formation, though there could be no doubt of their connection with this set of hyphæ. (Figs. 5 and 6). In Figs. 8 and 9 are shown very thin microtome sections, cut transversely and longitudinally as regards the strands of hyphæ.

Staining either with Congo-red or with hæmatoxylin after twenty-four hours treatment with iron alum, showed the existence of a third set of hyphæ, which had not been noticed before. These form a meshwork between the strands of larger hyphæ; they are extremely delicate and colourless, and in fewer numbers can be seen running amongst the other hyphæ, within the strands. This detailed structure was most satisfactorily seen by mounting the sections in glycerine. Dehydration with alcohol, and clearing with either clove oil or xylol, caused the hyphæ to collapse to such an extent that the appearance of the sections is greatly altered. An examination of hyphæ separated out by eau de javelle, under Zeiss Hom. Imm. $\frac{1}{15}$, confirmed the presence of these delicate colourless hyphæ amongst and upon the larger ones. (Fig. 10). This suggests that they are parasitic in nature.

As regards the function of the brown irregular hyphæ, their general characters and distribution suggested, at first, that they might represent a conducting system such as has been described by Istvanffi and Johan Olsen.* (Fig. 11).

This, however, is apparently not their function, for no treatment has been successful in decolourizing them. Even after fixing in alcohol or Rath's solution, embedding, dehydrating and clearing, they retain their brown or yellowish brown colour. They appear, too, to be present throughout the material, and though more numerous in some regions, they do not here exhibit any special characters. Beyond this, moreover, the occurrence of a group of spores, in connection with these hyphæ, makes it impossible for them to be conducting in function, but points rather to their being the hyphæ of a fungus parasitic upon the main fungus, which consists of the large, colourless hyphæ.

We come next to the consideration of the nature of the substance, which causes the saponaceous feel possessed by the material. It has already been suggested that this character is due to the presence of resin, and from all the results, which an examination of its behaviour has given, this seems to be the correct view.

It is insoluble in water but very slowly in strong alcohols, and more slowly in ether or chloroform, in each case resulting in a clear, golden brown liquid. Ether or chloroform does not precipitate it from the alcoholic solution.

* "Über die Milchsaft behälter bei den höheren Pilzen." Bot. cent., 1887.
Istvanffi, "Untersuchungen über die physiologische anatomie der Pilze, etc." Pringsh. Jahrb., xxix.

When these solvents are allowed to evaporate off, a whitish brown amorphous mass remains.

If small pieces or sections of the material be treated with eau de javelle or potash, a bright red colouration is produced, running along the boundary of the longitudinal strands and gradually diffusing over the substance. By degrees a red liquid oozes out, which turns brown in a few hours. (Fig. 7).

If these solutions be treated with acid, a heavy, brownish white flocculent precipitate is produced, pr bably the resinous acid.

Staining with dry sections of alkanna root and fifty per cent. alcohol gave an intense reddish pink colour, universally over the sections, but somewhat more intense along the edges of the strands. Alcoholic solutions of alkanna or sudan iii.* were obviously useless, owing to the extreme solubility of the substance in question in alcohol.

Some better results were obtained by using a concentrated ethereal solution of sudan. The sections, cut dry, were left in the stain for a few seconds only, then washed in water and mounted in glycerine.

These showed that the hyphæ themselves were quite unstained, whilst attached to them and scattered irregularly over them, were deeply stained fragments and drops; in addition, along the meshwork of hyphæ dividing the strands of larger hyphæ, a pale pink stain was given. The dark brown hyphæ were still visible, retaining their usual colour. (Figs. 13 and 14). This confirms the view that the resinous substance is present in the innumerable fragments, adhering to all the hyphæ, and the presence of this substance explains the clearing of sections with clove oil, xylol, or potash, when these fragments are almost completely dissolved away.

A spectroscopic examination of an alcoholic solution of the resinous substance shows a complete absorption of the blue rays.

As regards the nature of this substance "Indian Soap," the general arrangement and character of the large colourless hyphæ seem to support Prof. Macoun's conclusion that it consists of a fructification of a Polyporus,—the longitudinal strands representing an incipient stage in the formation of the Polyporus tube. The spores found, however, were not in any definite position relative to these tubes, nor was their arrangement on the hyphæ in accordance with basidial formation. The

* This dye has been described as a test for resins, fats, etc., by Buscalioni. Un nuovo reattivo per l'istologia vegetale. See Bot. Centr., Nr. 22, 1899.

whole structure has obviously been much changed by the action of parasitic hyphæ, so that we may perhaps, with justice, conclude that it consists of some large fungus, probably of the Polyporus type, which has been destroyed by two parasitic fungi, probably also to be classed with the higher forms. As a result, degeneration of some of the interwoven hyphæ seems to have taken place, giving rise to a resinous substance, to whose presence the characteristic saponaceous feeling is due.

EXPLANATION OF PLATE.

FIG 1.—Section at right angles to strands of hyphæ. Treated with potash and mounted in glycerine. Obj. $\frac{2}{3}$.

FIG. 2.—Section parallel to strands of hyphæ. Obj. $\frac{2}{3}$.

FIG. 3.—Section as in Fig. 1 under 1 inch obj. (Reduced $\frac{1}{2}$).

FIG. 4.—Group of spores in connection with the large, colourless hyphæ. Stained with carbol fuchsin. Oc. 4. Obj. Hom. Imm. $\frac{1}{12}$.

FIG. 5.—Brown hyphæ with group of spores. Oc. 4. Obj. Zeiss D.

FIG. 6.—Spores of the above group. Oc. 4. Obj. Zeiss F.

FIG. 7.—Small piece of "soap" treated with potash (5%). Shaded portions coloured deep red. (Macroscopic).

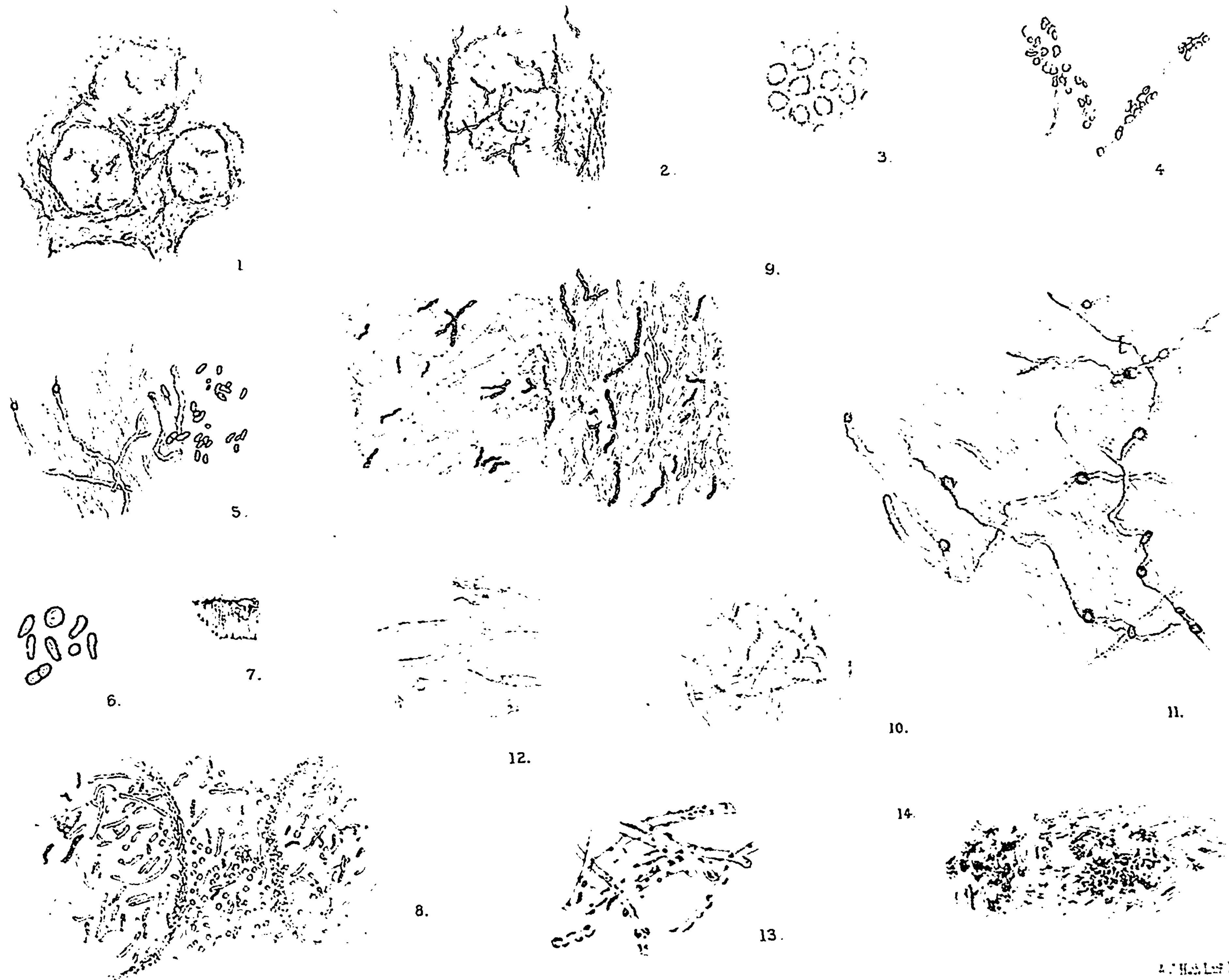
FIGS. 8 AND 9.—Microtome sections showing three systems of hyphæ. Iron alum (24 hours), and hæmatoxylin. Oc. 4. Obj. Zeiss D.

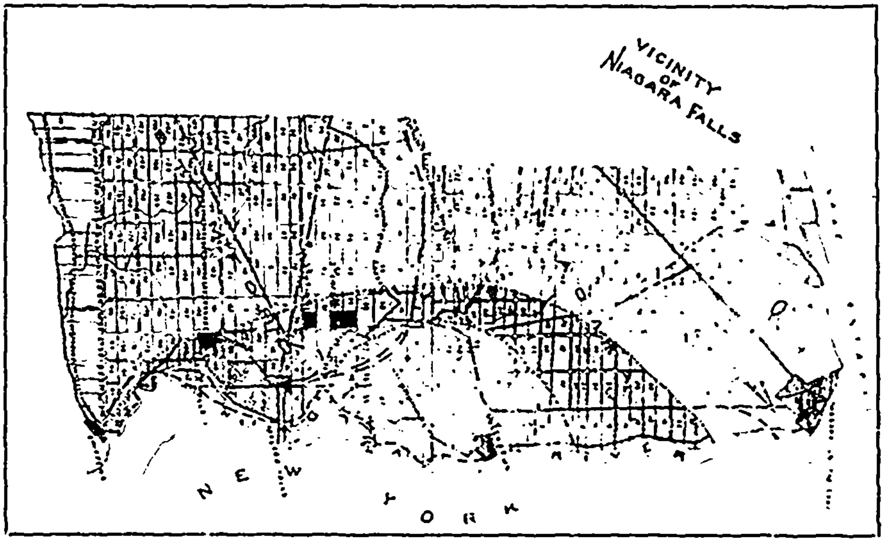
FIG. 10.—A few hyphæ, separated by the action of eau de javelle. Brown hyphæ were present, but are omitted from the figure, which shows the fine colourless hyphæ running amongst the larger colourless ones. Oc. 4. Obj. Zeiss D.

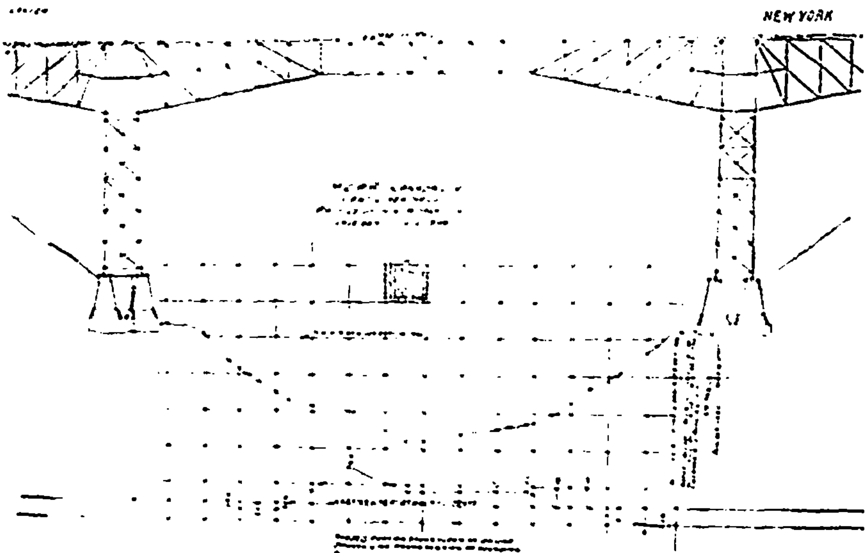
FIG. 11.—Portion of section, treated with potash, showing the arrangement of the brown overlying hyphæ, resembling that of a conducting system. Oc. 4. Obj. Zeiss D.

FIG. 12.—Portions of separated colourless hyphæ, treated with alcoholic potash. Oc. 4. Obj. Zeiss Hom. Imm. $\frac{1}{12}$.

FIGS. 13 AND 14.—Staining of resinous fragments by an ethereal solution of sudan iii. Oc. 4. Obj. Zeiss F.


1
2.
3.
4
9.
5.
6.
7.
10.
11.
12.
8.
13.
14.





ENGINEER'S REPORT OF SOUNDINGS AT M. C. R. BRIDGE.

ON THE ANCIENT DRAINAGE AT NIAGARA FALLS.

BY P. W. CURRIE.

(Read 9th March, 1901).

IN preparing this paper, the writer has gone over the ground confirming and adding proofs of the statement of others in regard to the old watercourses of the Niagara District.*

THE COURSE OF THE PRE-GLACIAL TONAWANDA RIVER IN CANADA.

The river crossed the present Niagara river nearly at right angles. The edge of the southern bank where it crossed the river is now indicated by the line of breakers above the Falls. The hollow below these breakers is directly due to the erosive action of the ancient stream. Its northern limit was the bank now called Hubbard's Hill, ending on the Canadian side at Mr. Alexander Fraser's house, and shown also on the opposite or American bank of the modern river.

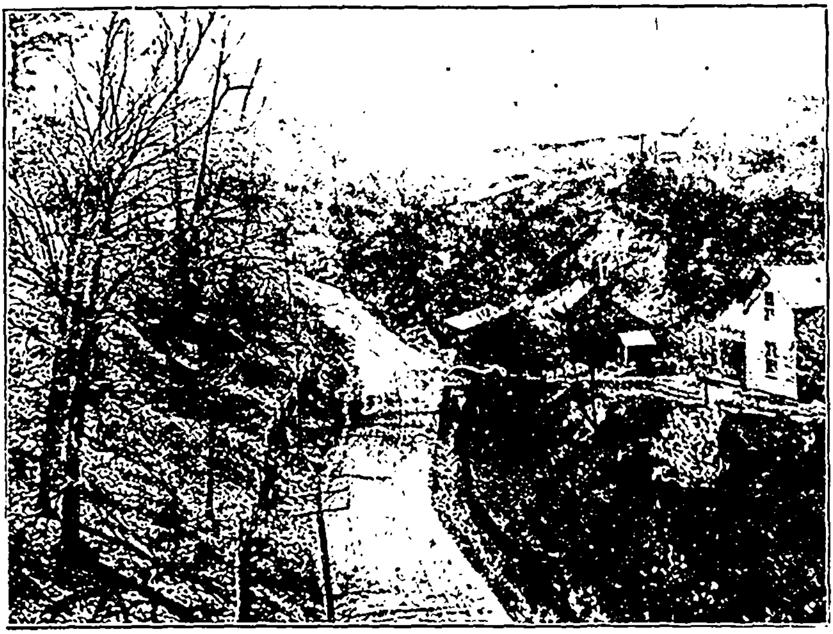
Further evidence of this former channel is found in the character of the soil and of the rock levels in Queen Victoria Niagara Falls Park. At the Dufferin Islands and at Table Rock, the rock level is at the surface. At the Power House where the bed rock is exposed, it is about eleven feet below the level of the water in the channel east of Cedar Island. Opposite the Carmelite Monastery, the rock level is about twelve feet below the water level in this same channel. At the gravel pit rock was found at a depth of about eighteen feet below the same water level. Near the high bank forming the

* He has to acknowledge the kindness of Dr. J. W. Spencer, whose theory as to the old watercourses is the one accepted in this paper; also many favours from Mr. Wilson, Superintendent of Queen Victoria Niagara Falls Park; Mr. C. H. Mitchell, Engineer at Niagara Falls, and his assistant, Mr. Howard Dixon; Mr. Rothery, Superintendent of the Park and River Railway; and Captain Carter of the "Maid of the Mist," all of whom aided very much in gathering materials for the paper.

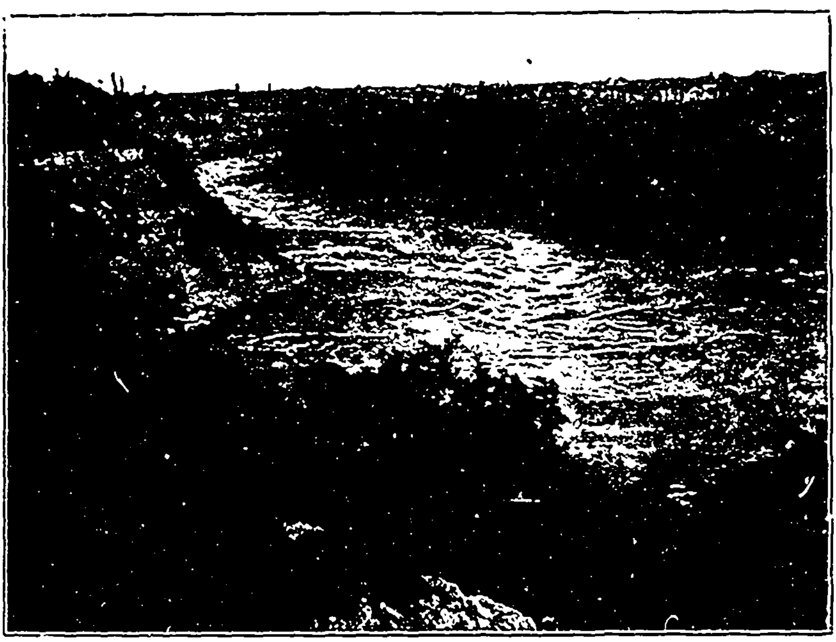
south boundary of the Park, where the Ontario Power Company sank a test pit, rock was not found till the hole was down thirty-three feet in the sand, or between thirteen and fourteen feet below the water in the channel above referred to. The dip in this part of the Park is to the south, but it is too slight to account for these differences in level.

The above facts show the existence of a V-shaped depression in the Park, the rock level sloping downwards north and south, to a point at or near the present gravel pit. The bottom of this depression is lower as it recedes from the river, so that if it were cleared of drift, the water would even now flow down it. It is also generally in a line with the course of the old Tonawanda River across the course of the present Niagara. The course of this channel through Niagara Falls South is not so easy to trace but what evidence there is, is confirmatory. At the Michigan Central Station at Niagara Falls Centre, the rock is within a foot or so of the surface. In digging the sewer in front of Victoria Hall, the excavation went down nine feet, six inches, but no rock was found. At the line between Niagara Falls and Niagara Falls South, a well was dug over thirty feet without striking rock, and where the street car turns to go to Drummondville, a well thirty-three feet deep is resting on hard pan, that is, it is not yet down to solid rock. Between Niagara Falls Centre and the Niagara Falls South boundary, the land level rises about sixteen feet, leaving sixteen feet fall in rock level in 960 feet, a difference not accounted for by the dip.

The next place where conclusive evidence of the channel is found is at St. David's ravine. The opening in the escarpment worn out here is about one and a half miles across. The banks slope gradually as do those of all ancient channels, and have not vertical walls as the gorge and other modern cañons have. The old river bed at St. David's is at present used for obtaining the fine sand which is deposited there. These sandpits are very deep, and the arrangement of the sand and gravel in them is very interesting. On the Governor Maitland estate, near them, a well over 150 feet deep was dug through sand and gravel. Mr. Warder, of Stamford, who dug many of the wells of this district, says that a deep deposit of sand and gravel is found continuously from St. David's Ravine to Niagara Falls South. On the way to the latter place, the depth of soil overlying the rock increases, but the increase in depth, he thinks, is due to the greater accumulation of drift in that direction, and not to any



Up the St. David's Ravine from G. T. R.



Whirlpool Rapids Showing Entrance to Pool.

Outlet of the Whirlpool.

Down the St. David's Ravine from G. T. R.

depression of the rock level. The latter, he thinks, remains nearly constant.

In the St. David's valley below the escarpment, are found several flowing wells. Above the escarpment, the surface drainage is either towards the Whirlpool or Thorold. It is possible these flowing wells are caused by the water of the Niagara soaking through the porous soil of the drift.

The course of the channel below the escarpment is harder to trace accurately, but by ascertaining from the farmers the facts in regard to their wells, some very interesting information was obtained, throwing a good deal of light on the subject.

Mr. Warder, whose opinion with regard to rock levels above the escarpment has been stated already, says that in St. David's village the rock is generally sixty or seventy feet below the level of the surface. On the road to St. Catharines, within a mile of the village, wells are found dug in the rock, which is, relatively, close to the surface.

On Lot 54, north of Usher's cement works, Mr. Muir has a good well. In digging it he struck red sandstone rock about twenty feet from the surface. Between Mr. Muir's farm and the lake, as far as Virgil, good springs are very scarce, and those who dig wells do not strike rock. On Lot 58, a well was dug fifty-three feet without striking rock. On Lot 33 they dug thirty-five feet, then bored fifty feet without striking rock. Mr. Harris, west of Lot 61, found rock at one hundred feet below the surface. The northern boundary of this channel seems much more indefinite than the southern one.

Where this channel crosses the Niagara river, is clearly visible on both sides of the river from the deck of the Toronto steamers. Near Queenston the river bank is formed of red shale. At a projecting point about three miles below Queenston, the shale changes to clay, and the bank is formed of clay from here to a place near the middle of Paradise Grove, where shale of the same kind as that at Queenston again forms the bank.

The space between these points, about three miles, was at one time filled with shale of the same kind as that at Queenston and Niagara. This was washed out by the ancient river, and during the glacial period, filled with clay. The map shows the probable course of this ancient stream.

Into the main stream flowed a tributary which joined it at St. David's. Its channel was relatively much narrower than that of the main stream. It appears to have been formed by the union of three small tributaries, whose waters finally came together at the Whirlpool. One followed a buried channel through the Collegiate Institute grounds, in Niagara Falls, Canada, to go by way of the present Niagara to the Whirlpool, on the way it was joined by a tributary flowing on the American side from Eagle Mount, while a third tributary seems to have flowed south from the present Devil's hole to join the combined stream at the Whirlpool.

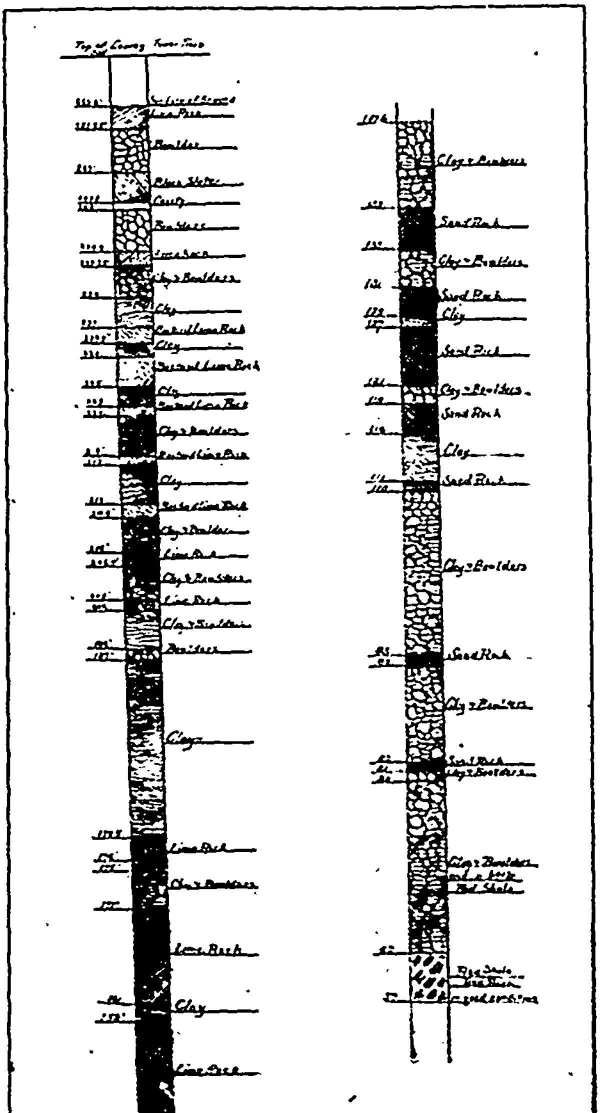
Beyond the Whirlpool, the combined stream followed nearly the course of the present Whirlpool ravine, although the latter seems to be a little to the south of the old channel. This is shown by the rocks, Niagara and Clinton, found in place in the bed of the stream at present flowing through the ravine. The bed of this stream was probably not as deep as the bottom of the present Whirlpool, the latter having its depth increased by the rotary motion of the water.

The Whirlpool ravine crosses the Grand Trunk tracks about a quarter of a mile south of the Stamford station. After this, it crosses a field and road. On the far side of the road is a pond fed by a spring creek, whose source is near the Presbyterian church in Stamford village.

From a little above the pond a wide depression, not very clearly defined, follows back towards Stamford, veering, however, northwards in the direction of the sandpits at St. David's. At the highest point of this depression in swampy ground near the side of the road, is a little grove of trees. From this starts a depression slanting downwards almost without a break to within one hundred yards of the sandpits. Any moisture falling on this depression could easily soak through the intervening gravel into the sandpits and St. David's ravine.

Outlet of Ancient Stream at Devil's Hole. Eroded Bed Points up Present Stream.

Sand Pits, St. David's.



ENGINEER'S REPORT OF TEST-BORINGS AT
M. C. R. BRIDGE.

HYPOTHESIS OF THE MODE OF GORGE FORMATION AND CHARACTER OF THE FLOOR OF THE GORGE.

The water wears a large pit in the shale underlying the Niagara limestone, leaving it projecting until, unable to support its own weight, it breaks off and falls into the water. The Clinton limestone is undermined in the same way. After falling, these great masses of rock in front of the centre of the Canadian fall, are used as pestles by the tremendous power of the water, ground against one another and against the floor of the stream, until a great hole or basin is worn out down stream from the falls.

As the water gets down stream further from the fall, it loses energy, and finally a point is reached at which it can no longer move the larger rocks. At this place they are deposited in what formerly was the floor of the basin, and over these larger pieces smaller ones are deposited successively on account of the decreasing power of the water until, at some distance from the stream, the deposit attains a maximum height, acting there as a dam, over which the accumulated water flows. This water, by erosion, wears off the top of the old deposit, so that the position of the shallow dam, of the basin in front of the falls, and of the falls itself, is gradually advancing up stream, leaving behind it, in the bed of the river, the accumulated mass of fallen blocks.

This is the way in which the gorge has been made, at least from Foster's Flats. Below this, there may be part of the stream flowing on a bed of rock in place, as there was a time in the history of the Falls in which there were three separate cascades, and this condition would destroy the power of the water to dig out a deep hole as described above.

The borings made by the Michigan Central Railway to test the foundations of the Cantilever bridge afford a remarkable confirmation of this hypothesis. For 150 feet below the waterline, or nearly 70 feet below the deepest part of the river at this point, before striking rock in place, they bored down through clay and boulders. The rock they found was the red shale of the Medina, which, according to the above hypothesis, was the bottom of the deepest part of the basin worn by the Falls when passing this point.

In his report, the engineer called some layers, lime rock, sandstone, bastard lime rock, etc. Thinking these layers might represent remains of the original hard rock, the shale having been removed by the action of the water, and its place filled by detritus, Mr. H. Dixon, assistant engineer to Mr. C. H. Mitchell, went with the writer to Queenston, where we, using transit and chain, found the thickness of the different layers of rock and shale along the cliff. We tried to correlate the hard layers with those mentioned in the borings under the bridge, but found no relation whatever existing between them. We then decided that these masses of solid rock were simply very large boulders. In his report on the soundings taken under the bridge, the engineer expresses the same opinion.

The Canadian fall at present furnishes very good evidence of the correctness of the above hypothesis. On the margin of the Horseshoe Fall, both next Goat Island and the Canadian shore, great boulders are lying at the foot of the cliff. There is no sign of any such in the centre. Then one of two things must happen,—the rocks sink where they fall at the base of the cliff, or the force of the water carries them down stream to be finally deposited somewhere else. The soundings support the latter hypothesis, for the water is deepest not right under the fall, but a considerable distance down stream. The force of the water carries the rocks forward while their gravity causes them to sink, so they wear out the basin described above.

The American fall has great masses of huge boulders at its base. These, as in the Canadian fall, have dropped from the overhanging Niagara and Clinton rocks, but the water coming over them is not strong enough to displace them. Accordingly they pile up where they fall, and instead of wearing a deeper hole, protect the underlying shale from erosion and stop the wearing action of the fall. This explains the fact that, so far, observations on the American fall can detect but little retreat, as all differences found in measurement are not appreciably greater than the allowance which may be made for errors of observation.

Evidences of a similar state of affairs are found at Niagara Glen. The main stream on the American side was strong enough to move the great rock masses, and the erosion went on continuously, leaving a clear channel, while on the Canadian side a fall of water much smaller in volume and corresponding to the present American fall, descended. During the greater part of its course it was unable to remove the large rocks, though its central part was stronger than the sides, and in the lower part, at least, left a tolerably clear channel. In the upper part however, as at present in front of the American fall, the great rock masses are now piled up close to the cliff in such a way as effectually to stop the water from wearing away the soft shale.

The deep channel being in this way partially filled, the action of the weather on the lateral walls gradually causes a talus to be deposited on the sides of the gorge, giving the older parts of the river the rough V-shape shown by the soundings taken at the Cantilever bridge.

One more thing remains to be accounted for, viz., the Whirlpool. Where the current from the Whirlpool rapids enters the Whirlpool, a ledge of rocks projects from the east bank into the Whirlpool. The appearance of the water indicates a shallow part, probably a continuation of the ledge, running clear across to the other side. The Whirlpool basin itself is very deep, probably deeper than it was worn by the Falls or by the pre-glacial stream which formerly passed here. Where the water leaves the pool the passage is very narrow, rocks in place projecting into it both from the Canadian and American sides. Even in the centre of the channel the water appears to be quite shallow.

The depth of the water in the pool is due to the course of the river. Even while it ran on the top of the bank, before the Falls reached the Whirlpool, there would be here a deep pond, in character much the same as the present one. After the Falls passed this point, the same cause would deepen the hole where the change in direction of the stream occurred.

The shallowness of the exit of the Whirlpool is comparatively easy to account for. As the Falls cut their way back from Queenston, a time would come when only a very thin wall would remain between the water of the Whirlpool and that of the gorge. As this partition would break down rapidly in its upper part, the level of the Pool would suddenly lower, leaving the last part of the quartzose sandstone to be eroded only by the mechanical force of the running water—a very slow process.

The ledge above the Whirlpool was left during the time that the thin wall below was being taken out, before the cataract at the upper part had attained power enough to excavate deeply.

The Whirlpool basin was then probably no deeper than the Medina. Since then, the peculiar character of the motion of the water and the erosive action of the stones and pebbles carried by it, have deepened the basin to its present depth.

The following is a list of the works consulted in the preparation of this paper:

"Travels in North America," Lyell.

"Geol. of the Fourth District of New York," Dr. Jas. Hall.

"The Report of the Commissioners of the State Reservation at Niagara, 1893-94," containing Mr. J. W. Spencer's papers on the "History of Niagara Falls."

"Another Episode in the History of Niagara Falls." From "Am. Jour. of Science, Vol. VI., 1898," J. W. Spencer.

"The Tenth Annual Report of the Commissioners for Queen Victoria Niagara Falls Park, 1895," containing Prof. G. K. Gilbert's Monograph on "Niagara Falls and their History."

"Origin of the Gorge of the Whirlpool Rapids," F. B. Taylor.

DÉNÉ SURGERY.

BY THE REV. FATHER A. G. MORICE, O.M.I.

(Read 3rd February, 1900).

FROM the icy wastes of the Arctic circle to the barren borders of Patagonia, under whatever clime and with any environment, or mode of life, the American Indian is more or less shamanistic in his beliefs and practices. To him disease is not that deviation from the normal state of the living organism which is understood among us to result from natural causes. In his estimation, it is mainly due to the ill-will of certain minor spirits whom he generally believes to be under a greater, rather undefined power, and even subservient to the incantations of the conjurer whose role it is to exorcise them out of the patient, free the latter's body of any noxious matter due to their machinations, or otherwise influence them to the extent of restoring him to his former state.

This particularity of the native mind is well known, inasmuch as there hardly ever was a tribe without one or more shamans, or medicine men. What would seem to be less generally understood is the fact that, even in the olden times, the aborigines were far from relying exclusively on the mysterious powers of their conjurers in cases of bodily distress. Either on the advice of the latter or independently therefrom, they frequently had recourse to natural means in order to regain lost health, alleviate temporary ailments, or obviate the result of accidents. The vegetable kingdom furnished them with antidotes against almost any ill that humanity is heir to, and, in several instances too, they resorted freely to external treatment and artificial devices, the most important of which were, among the Northern Dénés, surgical bleeding and burning.

Prof. O. T. Masson has given us, at the end of his paper on "The Ray Collection from the Hupa Reservation," a valuable list of the plants, both economical and medicinal, used by the northern California Indians. Mr. James Mooney has rendered a like service to science in his valuable essay on the "Sacred Formulas of the Cherokees."* I

* VII. Annual Report Bureau of Ethnology, pp. 324-327; Washington.

might also refer the reader to what I have myself written on the same subject in my "Notes on the Western Dénés,* pages 130-132 inclusively. This part of my study, though not intended to be exhaustive at the time of its writing, might for the present, take the place of a complete treatise on Déné medicine. But, though bleeding at least was and remains a very prevalent practice among the natives, I have been unable to discover more than one reference thereto in the whole range of the American ethnographic literature at my command. Very valuable and detailed monographs there are on almost all the chief stocks into which the northern American race is divided, which consider them from every possible standpoint, but, with the one above mentioned exception, they invariably ignore the practice of bleeding so much in vogue among the different tribes.

My attention was lately drawn to this desideratum by an article from the pen of the Rev. H. C. Meredith, published in the December number of the *American Archæologist*.† The cuts which accompany his paper represent stone implements of such unique design as to render them worthy of a moment's consideration.

Those implements have quite a history. Found, close by Indian skeletons, in the vicinity of Stockton, California, by several persons of good social standing, some of them came into the possession of the above-mentioned gentleman. To make a long story short, a few of the latter subsequently passed into the hands of a South California collector of antiquities who, after much hesitation and a consultation with a would-be expert, pronounced them to be frauds and published his opinion to that effect in the *American Archæologist*. One of his main reasons for predicating dishonesty was that he "could not imagine any practical use to which they could have been applied," an excuse which is hardly satisfactory. Thereupon Mr. Meredith came up with a spirited reply containing sworn affidavits and detailed information which leave no doubt that his relics are genuine. A number of similar objects had already, it seems, found their way into the United States Museum, Washington, D.C., and it is probably of them that a Mr. Lyman Belding wrote in *Zoe*,‡ that they "differ from anything" he had "seen elsewhere."

Those implements are chiefly noticeable for three distinct features which are more or less reproduced in all the specimens illustrated.

* Trans. Can. Institute, No. 7.

† *The American Archæologist*, vol. II, p. 319.

‡ Vol. III., p. 200.

FIG. I.

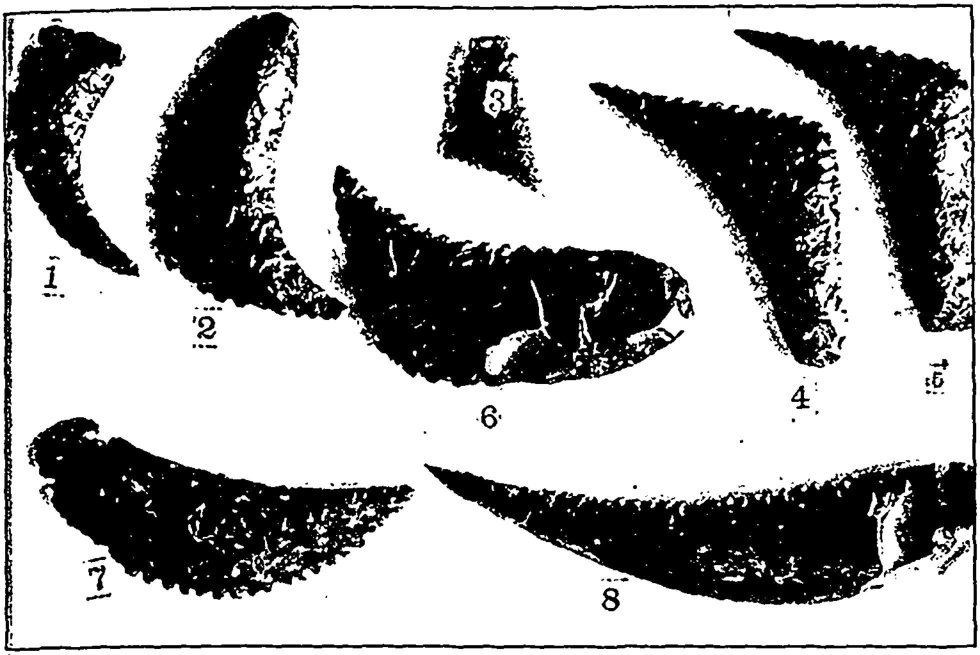
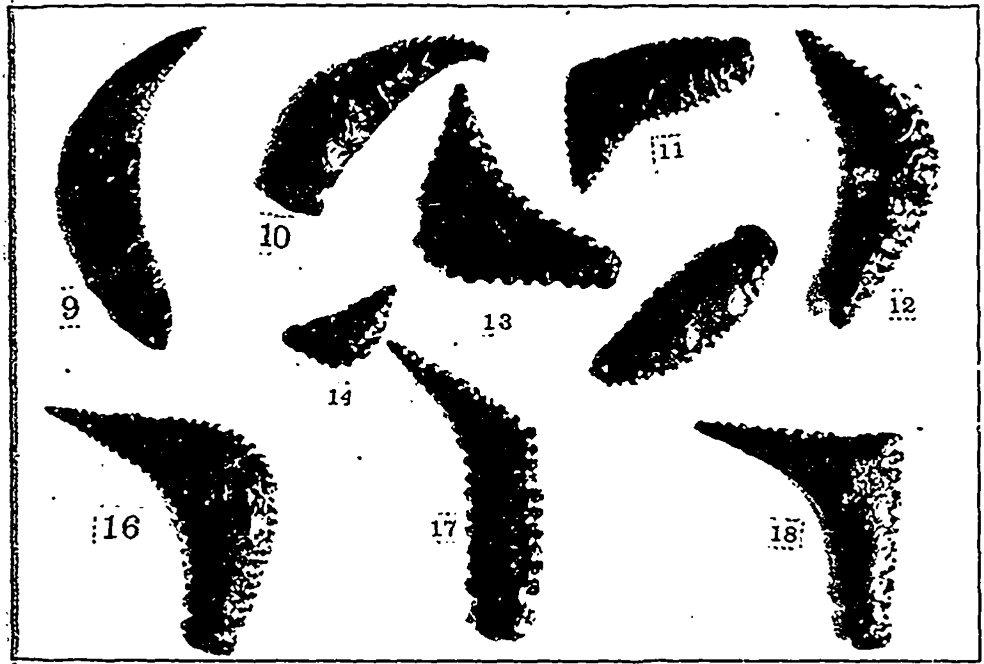


FIG. II.



FROM "THE AMERICAN ARCHÆOLOGIST."

By permission of the Proprietor, Prof. W. K. Moorehead, Saranac Lake, N.Y.

namely, their sharp points, their curved outlines and their serrated edges.

The first particularity is probably what led Mr. Meredith to incline "to the opinion that they were used on occasions of sickness and ceremony for lacerating and bleeding the temples."* My own studies of the Northern Dénés allow me, taking into consideration that analogy found in most things aboriginal, to subscribe to the reverend gentleman's conclusions. But there remain the invariable and apparently unnecessary curvedness and the indentations of the relics. That these two peculiarities were intended for a specific purpose it would be idle to deny. What was that purpose? The idea of their having been designed as saws must be abandoned owing to the nature of the material, soft and brittle obsidian. Both Prof. Wilson and Mr. Meredith are agreed on that point. On the other hand, temple-bleeders do not require to be crooked in outline or serrated on the inner curved edge as is the case with most of the implements figured in Mr. Meredith's article. A brief reference to the custom of blood-letting as it is practised among the Northern Dénés may throw some light on the question.

Among those aborigines, bleeding may be considered under five different heads. There is blood-letting proper, darting, piercing, gashing and scarifying.

The Northern Dénés have always been poor, unæsthetic workmen and, as I have noted elsewhere,† among them "where extra exertion was not absolutely necessary, it was very seldom bestowed upon any kind of work." This explains how it is that none of my informants could remember the use of, or any reference to, anything like a lancet or bleeder by their ancestors. A sharp piece of stone, a flake from one of the few tools or weapons they made, or, more generally, even a common flint or obsidian arrow-head did that duty. Yet it would seem that, in pristine times, they had something like a bleeder, for one of the tribes, the Carrier, has a word, *hokwœlh*, to designate that instrument

The first process, I said, was, or rather is—for in that respect native surgery has not changed with the advent of the whites—*net's'uket* or blood-letting proper. As among us, the operation is performed either on a vein or an artery. In the latter, and by far the commonest, case,

* Loc. cit.

† "Notes on the Western Dénés," Trans. Can. Inst., vol. IV., p. 36.

the chosen subject is the temporal artery. This is slightly cut with as sharp an instrument as can be procured, and the blood is allowed to escape until a rich red colour has succeeded the dark hue of the first flow which is supposed to be the cause of the ailment. The wound is then compressed by the application of a piece of skin or of a green leaf, according to the season. The head is afterwards bandaged so as to ensure the speedy healing of the wound.

In cases of phlebotomy, the vein at the bend of the elbow is the one operated on. Head-ache, general uneasiness, nervous complaints, catalepsy or any accidental stiffness of a limb furnish the usual pretexts for this sort of bleeding. Pains in the legs are, however, more commonly relieved by pricking or darting either side of the knee when fire was not resorted to, as shall be seen further on.

This leads me to speak of the second process, which is darting or thrusting. Though widely different from the first, it is, in the eyes of the Indians, nothing but a modification thereof, and it goes by the same name. The natives have recourse to it mostly in cases of local pains, when it is a question of congested blood either in the course of a malady or as the result of an accident, as in cases of contusions consequent on a blow, a fall, etc. It differs from the first method of blood-letting in having the flesh, not the veins, as its seat of operation. The skin is first thoroughly softened with hot water, the diseased flesh is firmly gripped or pinched out by the left hand while, with the right, the blade of a sharp knife is thrust therein. The escape of the thick, blackish blood affords immediate relief, though the operation may have to be repeated time and again. All these details I know by personal experience.

A modification of this process, the usefulness of which is practically confined to cases of head-ache, is piercing. In connection therewith, the fleshy part of the forehead is grasped as in the previous operation and then several times transfixed with an awl or a like instrument.

The fourth way of using the lancet, *net'sû'tas*, is simply the gashing or cutting open of a swelling, a sore or any unhealthy excrescence on the skin. The Dénés are rather impatient under the stress of long standing ailments. They much prefer undergoing a painful operation to waiting for the natural issue of any complaint.

We now come to the fifth way of using the surgical bleeder which will, I think, explain the curvedness and inner indentations of Mr. Meredith's crooks. It is *neznœlk'tœs* or scarifying. This is very commonly resorted to in all cases of rheumatism, local aching and *mal de raquettes*, or the spraining of the instep resulting from too severe snow-shoeing. It is also regarded by many as a panacea against several other ills of a temporary nature. It consists in scratching numerous lines on the afflicted limb, followed, in many cases, by a liberal application of the bruised root of the hemlock plant (Conium maculatum).

Now let the reader glance at Mr. Meredith's crooks. What is more natural than to suppose that the indentations thereon were designed as so many teeth of a stone currycomb intended to lessen the labour of the native surgeon, as the scratches must be very numerous, while work done with a single point would necessarily result in a useless flow of blood from the first scarifications and unduly prolong the sufferings of the patient? On the other hand, the crooked outlines of the bleeder are easily explained by the use the implement is put to. Its curvedness is simply a means of having it fit the various parts of the arm or leg whereon the simultaneous scarifications are produced.

That this is not a mere fancy of mine can readily be inferred from the fact that this peculiar method of bleeding is not confined to the Déné race. We read in the paper by Mr. J. Mooney already referred to that, among the Cherokees, "there are two methods of performing the operation (of blood-letting), bleeding proper and scratching, the latter being preparatory to rubbing on the medicine which is thus brought into more direct contact with the blood." He then explains that "scratching is a painful process. . . . In preparing the young men for the ball play, the shaman uses an instrument somewhat resembling a comb, having seven teeth, made from the sharpened splinters of the leg bone of a turkey." He further enters into minute details concerning the operation which he says is performed "on each arm below the elbow and on each leg above and below the knee."

So much for the curvedness of Mr. Meredith's implements. The indentations noticeable on some of the outer or straight edges may be explained by the fact that finally "the instrument is drawn across the breast from the two shoulders so as to form a cross, . . . so that the body is thus gashed in nearly three hundred places."*

* VII. Annual Report, Bureau of Ethnology, p. 334.

Surgical scratching on flat surfaces is also practised, though seldom enough, by the Northern Dénés.

Here are two late instances that will illustrate the circumstances under which bleeding is mostly resorted to here. About two months ago, I returned from a trip of over three weeks duration to an outpost of my central mission. On the way back, one of my companions experienced some physical difficulty with one of his feet which rendered snow-shoeing exceedingly painful, if not quite impossible. Without any loss of time, his instep was duly scarified with a pocket-knife by one of his fellow Indians. Upon my return here, I noticed one of our women who since some time had been suffering from some nervous derangement, possibly catalepsy, bandaged about the head. Enquiry brought out the fact that, during my absence, she had undergone an almost identical operation in the vicinity of the temples with the addition, this time, of a poultice of bruised hemlock roots.

Another surgical practice which was formerly much in vogue among the Carriers, but has now fallen into desultude, was that of burning. It could not properly be called cautery, as its object was not the searing of the flesh as a means of stopping blood or of preventing the extension of a local trouble. It was used mainly against rheumatism or any ill of a cognate nature, and its chosen seat of operation was very generally the joints of a limb, either the wrist, the elbow, the shoulder, or the knee. Sometimes also any part of the spine, and more seldom a spot on the bony surface of the head were likewise experimented on.

This is how the operation was performed. When an Indian had resolved to get rid of an aching pain that had become too acute for patient bearing, he took a round piece of tinder perhaps one-third of an inch in diameter, wetted with his saliva that part of its surface that was to come in contact with the flesh, and then pressed it firmly on the joint the healing of which was deemed most likely to ensure the prompt recovery of the whole limb. Next, he himself, or an obliging friend ignited the top of the tinder, which was suffered to burn down to the very flesh, wherein a corresponding sore or cavity was inevitably produced. The excruciating pain consequent on the slow combustion of the piece of fungus was ordinarly borne in the most stoically indifferent way possible. A moment of the severest anguish is nothing to the Indian, especially if accompanied by the hope of a speedy recovery; but almost any bodily discomfort, if too prolonged, is to him a torment past endurance.

To return to our surgical experiment. Should the tinder totally consume itself on the flesh, the operation was deemed a failure, and it was at once repeated on an adjoining place. Was the result of the second attempt identical with that of the first, a third spot, always close to the joint, was operated on, until, under the effect of a slight explosion due, perhaps, to the sudden contact of the fire with the serous fluid under the epiderm, the burning piece of tinder flew up as a sure token of the disappearance of the cause of pain.

The greatest faith was placed in the efficacy of this operation, and many an old Carrier bears to this day indelible marks which testify to his former trust in that "fire cure."

Another kind of operation in connection wherewith fire figured as a most important factor, was that resorted to as a cure against ear-ache. It has an even more superstitious complexion, and it is likewise on the wane. In such cases, a few hairs picked from the tail of a dog were singed and their extremities introduced, while burning, into the drum of the ear. Should the hair used have been that of a she-dog, the cure was regarded as a matter of course.

Another appliance much in vogue among the Carriers, and which, though taken from the vegetable kingdom, is hardly less effective than fire, is a sort of blister made of the bruised green leaves and stems of a plant called *waltak* in Carrier, and of the botanical identity of which I am not quite sure, though I incline to the belief that it is the *Ranunculus sceleratus*. Its caustic properties are so great that it is seldom applied directly to the flesh, sometimes a thick covering of linen stuff being unequal to the task of rendering its application bearable for more than a few moments. It is used against almost any acute pain of a local character.

Passing now to the various branches of the surgical art such as it is practised among the Northern Dénés, we may come to the setting of broken limbs. This, I am bound to say, is done in a most clumsy way. Though all our Indians, being expert huntsmen and therefore experienced butchers, know and name without the least difficulty any part of the animal anatomy, the most they formerly could do in connection with the injured human body was to try, not always successfully, to reduce dislocations. As to fractures properly speaking, no setting of the broken ends of the bone was attempted. The limb was simply enclosed, with hardly any padding, in several envelopes of birch bark with a few wooden splinters bound around as tight as possible, and then left to heal as best it could. In every instance deformity ensued as a matter of course, and even now more than one crooked leg or stiff arm is a witness to the inefficiency of Déné surgery.

In no case was amputation resorted to, except when it was self-evident that the limb, foot or finger, was too deeply cut to allow of the edges of the wound becoming reunited. In such cases, the bark of the aspen root *(Populus tremuloides)* was much esteemed as an astringent. More than once, too, persons supposed to be endowed with magic powers, and who were on that account styled *uzé hutqai* (he whose mouth effects cure), were in times past, asked to suck the blood out of the wound so as to prevent gangrene or any other undesirable result. Such persons were so much the more inclined to render this service. as they well knew that it would not be left unpaid for. And so it was that even on such occasions superstition claimed rights which, as shall be seen in the course of this essay, affected more or less nearly all surgical operations.

But if the cut did not materially affect the bone, and in other cases as, for instance, that of a serious bite from a vicious dog, the Carriers had, and indeed continue to have, recourse to suture, generally with satisfactory results. In olden times, very often shreds of moose sinews were used as thread, while sharp splinters of bone, commonly of a swan wing, did duty as a needle.

Ligature against hemorrhage was unknown. Applications of the chewed bark of aspen root took its place. When the wound or sore manifested a tendency towards decomposition, a sort of blister of the inner bark of the willow *(Salix longifolia)* and of the outer bark of the bear berry bush* was applied, generally with good results.

All cases of hernia are treated by bandaging. But sometimes the

* Not to be confounded with the Kinnikinik plant or *Arctostaphylus uva-ursi.* The plant I now refer to is a shrub four or five feet high, whose name seems to be unknown to all the English-speaking people I have met, though the plant is very abundant all through my district. French Canadians in the service of the Hudson's Bay Company call it, it would seem, *l'arbe aux sept écorces,* though it is no tree at all. The medical properties of its leaves, bark and root are highly valued by the Indians. The word I call it by is merely a translation of its Carrier name sees-mai-tceen, bear-berry-stick, or bush.

rupture has been so serious that it results in a complete protrusion of the abdominal viscera. Such cases are always fatal here. Unable to effect a cure, the Dénés try to alleviate the sufferings of the patient by means of an eagle or goose quill, slightly cut at the end, and stuck in the outward excrescence. This serves as a duct for the purulent matter which is usually formed in the vicinity of the rupture.

Incredible as it may seem, I never heard of any case of inguinal hernia, and the natives I questioned on that subject profess to be ignorant thereof.

Gunshot wounds are now treated first by sucking out the fine soot-like residue generally concomitant with the tearing of flesh by a projectile from a fire-arm, after which the shots or ball are extracted if possible, the wound carefully washed and finally covered with some emollient medicinal herbs.

I have said that amputation was unknown among the Northern Dénés. This is strictly true as regards surgical operations; but, among the Sèkanais, there was another kind of amputation which was often practised, especially by the women. This consisted in the voluntary cutting off of a finger or of part thereof as an outward sign of extreme grief, anger or resentment. It was resorted to mostly on the occasion of the death of a beloved child, sometimes upon the loss of a kind husband and, more seldom, in cases of disappointed love. More than one mother went even further, and did not hestitate to horribly lacerate the breasts her dead offspring had sucked, as a mark of her disgust that she should be left alive after the object of her affection was gone.* Not long ago there died among the Sèkanais, who trade their peltries at Fort McLeod, a woman who is said to have had but two fingers left intact. Even here, at Stuart's Lake, we have among the Carriers, a Sèkanais woman whose shortened index attests the intensity of her past troubles. On such occasions a common axe replaces the surgical knife.

The treatment of incipient deformities is hardly more serious than that of fractures. As a matter of fact, in most cases it is commenced too late and stopped too soon to be of much benefit. As with fractures, pieces of birch bark, with the addition occasionally of wooden splinters, are kept very tight over the spine or the diseased

* Such outward marks of sorrow recall facts recorded in the history of barbarous nations. Thus we read that, at the death of Attila, his followers manifested their sense of the loss they had suffered by lacerating themselves with knives.

limb by means of stout bandages. But as the patient is generally a child, and as youth has pretty much its own way among the natives, it commonly happens that said patient soon grows tired of the restraint imposed by the apparatus and easily persuades his parents to throw it away before half the time necessary for a cure has elapsed. Thus it is that hunch-backs, mostly females, are not unknown among the Dénés.

Speaking of females reminds me of a circumstance in connection wherewith Déné surgery is, as a rule, more successful. I mean that dangerous complaint known to medical men as *prolapsus uteri*. As most of the drudgery of the daily life, especially when on the wing, still falls to the lot of the woman, accidents, oftentimes quite serious, follow as a matter of course. Heavy packing, stumbling, falling, or the straining of the lower extremities frequently enough occasion the displacement, more or less pronounced, of the womb. In such cases, the treatment observed is quite rational, and therefore, it is ordinarily crowned with success. The patient is immediately laid in a recumbent position with the head rather lower than the womb, and quite commonly, by dint of external manipulation, the injured organ is pressed up to its normal place, after which strong bandages covering a plaster-like padding, added to copious draughts of the decoction of the stems of the raspberry bush, help to neutralize the effects of the accident. But I am bound to confess that, in the more severe cases, sterility ensues even in otherwise healthy women. Some persons of this Mission are quite noted for their skill in connection with all complaints of this and a cognate nature.

Considering the inconstancy of the native temperament, it speaks well for their comprehension of the gravity of such complaints that, in extreme cases, they should keep the patient as long as a full month reclining with the head in a lower plane than the rest of the body after the womb has been duly replaced. I know of one such case which was so serious that the organ had escaped from the body and was protruding almost in its entirety. It happened in a remote village long before I was here, and its treatment may therefore be considered as an instance of unassisted native surgery. It was consequent on a painful delivery, and the mother was so skilfully operated on that she lived to see several grandchildren by the daughter who was the involuntary cause of the whole trouble.

On such occasions, our Carrier women wrap their hand, preparatory to internal manipulation, with a kerchief or some soft material and, of course, perform the operation as gently and as gradually as possible.

Midwifery was formerly unknown among the Carriers as it has remained among the Tsilkoh'tin, another Déné tribe. But since the advent of civilization, it would seem that our women are not half as hardy as they used to be*, and, whenever possible, one or more of their female neighbours are now called in to assist nature in the process of parturition. So far as I know, this aid consists in external pressure only. It goes without saying that none of the various instrumental operations resorted to in grievous cases among civilized people are known among poor children of the forest, whose only cutting tools were, but yesterday, roughly flaked stone implements.

As parturifacients, three plants are chiefly valued and used to this day among the Carriers. They are the horse-tail (*Equisetum hyemale*) which is taken in strong decoctions, the bark of the Devil's bush (*Fatsia horrida*), and that of the elder (*Sambucus racemosus*), hot infusions of which are drunk previous to parturition or before the after-birth is expelled.

A particularity subsequent to delivery which is proper to the natives and is based on superstitious notions, is that relative to the placenta. This was formerly wrapped and suspended from a tree at some distance from the village. Should it have come in contact with water, the mother was believed to be doomed to perpetual sterility.

Any reader, ever so little conversant with American aboriginal sociology, knows of the sudatory or sweat-bath wherein the whole naked body is exposed, within an hermetically closed space, to the effect of steam emanating from heated stones. This is quite common among the Northern Dénés. But those Indians have besides a partial or local vapour-bath which is a favourite with lately delivered women. This is called *yœn-dīz'ai* (it—an object long or heavy—lies on the ground), while the regular sweat-bath is known as *tse'-zœl*, or the heat of stones. *Yœn-dīz'ai* consists in a round, shallow hole about one foot in diameter dug in the ground, wherein two or three red hot stones are laid. Across the apex of the cavity, small sticks are deposited gridiron-wise and then covered with moistened grass.

* That this is a common result of civilization over savage populations is shown by the following statement, one of the many which could be adduced: "When they begin to take on civilized habits, the Dakota women find they can not continue to follow the customs of their grandmothers. *Riggs Dakota Grammar*, etc., p. 208.

Finally some rag, as an old towel just soaked in water—the equivalent of the piece of tanned skin of former years—is thrown on the grass, thus completely closing the aperture of the hole, and the patient steams herself over it in the region of the womb. This contrivance is, it seems, fruitful of the most satisfactory results.

As soon as the new-born child has received the first cares necessitated by its entry into the world, due attention is paid by its mother and her attendants to its future personal appearance. Here long heads do not meet with favour; therefore the head of the infant is frequently compressed or squeezed between the hands applied to its top and to the chin. No mechanical or permanent contrivance is called into requisition. Futhermore, its eyes are time and again opened and the lids pressed asunder, not any too gently, so as to cause generous dimensions for the balls, and the tiny eye-brows* are from time to time manipulated into the most elegantly arched shape possible.

I will now close this review of the Déné surgery by mentioning an operation which the preceding pages have not prepared the reader to anticipate, I mean the extraction of cataract. Few ills are more common here than diseases of the eye. The number of blind people among the Carriers, and the Babines especially, is altogether out of proportion with the population. Snow-haze, accidental blows on the face received in the thickets, smoke from the camp fire or from underneath the fruit-drying or salmon-curing shanties, added sometime to uncleanliness on the part of the old people, are the main causes of this too prevalent complaint. Cataract is easily discerned by the natives who treat it in this wise.

A minute pellicle is torn from a piece of birch bark (*Bitula papyracea*), after which it is doubled up and its extremities firmly held between the fingers. One of the sides of the curve thus formed is then used as the edge of a scraper on the corner of the eye next to the bridge of the nose, and the thin film-like covering on the eye-ball is worked on till part of it is torn asunder, thereby affording a hold for the grasp of the fingers. These now complete the operation by gently drawing off the whole impediment to vision.

Instead of birch bark, others use for the same purpose a piece of calcined bone which, coming in contact with the waste tissue formed

* I suppose I will not teach anything to my readers by recalling the fact that Indian babies are almost always born with a full crop of hair and more than once with several teeth.

on the eye, seems to have the same drawing properties as a magnet has on a bit of iron.

In either case, the eye is left sore and bloody. It is now carefully washed, and, as a final treatment, it is bathed with a cooled infusion of the inner bark of the bear berry bush to which a little woman's milk has been added. The former especially is reputed to be quite a specific against any soreness of the eyes, though its mordant properties render its application very trying at first. With this last preparation the patient is made to retire, and, when he wakes up on the morrow, he generally feels quite well. Such operations are even now quite common and as uniformly successful. But I am inclined to believe that, considering the primitive way they are performed, at least as much credit is due to the endurance of the patient as to the skill of the oculist.

The most common form of ophthalmic trouble among the Northern Dénés is snow blindness and its resulting whitening of the affected pupil. A persistent haziness in the atmosphere and the refraction of a strong light on the water will sometimes have the same effect on persons of a delicate constitution. If allowed to develop itself unhindered, this deterioration of the pupil will completely destroy the sight. The Carriers' great remedy against this complaint, as in all cases of soreness resulting from accidental blows or tearings, is the balsam of young spruce tops *(Abies nigra)*. The upper shoots once cut off the sapling are bent and split in two and then left by the fireside. After the resinous liquid they contain has been heated out, the ball of the eye is gently coated therewith by means of a bird quill.

THE CLASSIFICATION OF THE DÉNÉS.

LETTER FROM THE REV. FATHER MORICE.

STUART'S LAKE MISSION, 2 *Jan.*, *1901*.

Editor "TRANSACTIONS C.I.," TORONTO.

DEAR SIR,—In a late communication from Prof. O. C. Mason, of the Smithsonian Institution, I find the following:—

"In the publication which you sent me, you call attention to the list of Athapaskan tribes published in the Standard Dictionary. Supposing me to be the author of that list, you make some just observations about its meagerness. I am happy to tell you that, while I wrote a great number of definitions for the Standard Dictionary, I did not make any ethnological list whatever."

Prof. Mason here refers to remarks published in the latter part of the first of my papers lately printed in the Memorial Volume (p. 82). It is indeed very unfortunate that I should have been guilty of such an injustice with regard to a scientist whom I know by personal experience to be so pains-taking and conscientious in his work. My regret is so much the greater as I more than half suspected the real author of the classification incriminated in my little paper. But the list of the editorial staff of the Standard Dictionary prefixed to that valuable publication left me no choice but to attribute the incomplete Déné classification to Prof. Mason, who is described as having been in charge of the anthropological department, while the actual compiler's name is therein associated with a branch of lexicology which has no necessary connection with ethnography.

Hoping you will kindly give this rectification as mnch publicity as was granted to the statement which has necessitated it, I remain, dear Mr. Editor,

Yours faithfully,

A. G. MORICE, O.M.I.

CRITICAL EXAMINATION OF SPANISH DOCUMENTS RELATIVE TO THE CANARY ISLANDS, SUBMITTED TO THE WRITER BY SENOR DON JUAN BETHENCOURT ALFONSO, OF TENERIFE.

BY JOHN CAMPBELL, LL.D., F.R.S.C., ETC.,

Professor in the Presbyterian College, Montreal.

(Read 26th January, 1901).

A VALUABLE treatise, published in Paris, and bearing date 1629-30, is entitled: "Histoire de la première Descouverte et Conqueste des Canaries. Faite dès l'an 1402, par Jean de Bethencourt, Chambellan du Roy Charles VI., etc." A translation of it is to be found in the publications of the Hakluyt Society, which first appeared in 1872. De Bethencourt was the first European discoverer of the Canary Islands, which passed into the hands of Spain, in whose possession they still remain. A lineal descendant of the Conquistador is Señor Don Juan Bethencourt Alfonso, a doctor of medicine and scholar of note in Tenerife. With a generous confidence in the philological attainments of the writer, he sent him last summer (1900), through M. Henri O'Shea, of Biarritz, member of the Royal Academy of History of Madrid, three important documents presenting problems for solution. These are a printed pamphlet of fifty-six pages octavo, entitled, "Vocabulario del antiquo Dialecto de los Canarios"; a folio manuscript of seventy-seven pages, designated, "Complemento al Vocabulario del antiquo Dialecto de los Canarios"; and a nineteen page manuscript quarto, with many pen and ink illustrations. bearing the heading, "Aclaraciones: Inscripciones de las islas Canarias."

The first contains vocabularies of the Guanche or Canary Island language, now extinct, taken down from the lips of the aborigines from 1503 onward. A few words go farther back, at least as far as 1482. The vocabularies embrace Religious Concepts, Titles, Arms, Clothing and Utensils, Aliments, Animals and Vegetables, Proper Names of Persons and Places, Miscellaneous Words, and a few Phrases or Sentences. They are from Lanzarote, Fuerteventura, Gran Canaria, Tenerife, Gomera, Palma and Hierro. The second implements the first very largely, especially in names of places, and in valuable notes, historical and documentary. The third is virtually a supplement to a manuscript entitled, "Inscripciones de la isla de Hierro," sent to the writer by Dr. Bethencourt in 1898, for translation. A French version of the translation, made by M. O'Shea, appeared more than a year ago in the transactions of the Biarritz Association; and the English version is now in press for the transactions of the Royal Society of Canada. The most important inscription in the present document is that on the statue called "La Virgen de Candelaria," from Tenerife, in apparently Roman letters; others in ruder script are from rock faces in Canaria, Gomera and Hierro. Such then is the material on which the writer is called upon to express a scientific opinion, as a student of language and of ancient Turanian and other inscriptions. The threefold relations of the Canary Islands to Africa, Europe and America, invest the study with special interest.

In allowing Dr. Bethencourt to speak for himself, the writer must crave his and the Institute's indulgence, inasmuch as he has dabbled but little in the Spanish tongue since college days, which lie thirty-five years in the past; and he finds some of the Doctor's rhetorical forms and quaint expressions to transcend the range of the ordinary grammar and dictionary. Unconsciously, at times, he interlards a Guanche term, perfectly significant to the dwellers on the islands, but ignored by the Castilian lexicographer. The first document has no text, being pure vocabulary. The second, or folio manuscript, contains six pages of introduction, which are as follows: "I send as much as is known of the Guanche language and of those spoken in the other islands. The printed document comprises all the words and phrases published up to this date, during four or five centuries, by authors native and foreign; and the manuscript contains what I have been able to bring together in a period of thirty years.

"Either list is replete with errors, not only of orthography and pronunciation, since each collector has gone on accommodating speeches and words to his own age, but also we have arrived at taking as Guanche what is the purest and noblest Castilian. Moreover, there is such a tendency among our people to contraction or apocope, that even speeches reduce themselves to a single common word, as, for example, the word Lerines, of the isle of Hierro, which I am sure, through thorough investigation, arose out of La era de Inez. If, to this ignorance, under the disadvantage of which labour the majority of the words which we have collected, be added the fact that almost all refer to localities and personal proper names, and that there have lived in the islands French, Portuguese, Irish, and natives of many different provinces of Spain, as well as Jews of various origins, and Indians or emigrants from the islands who have returned after many years spent in all parts of America, it will be understood how many foreign words have naturalized themselves in the country.

" owever, the difficulties of the problem do not cease here, since it is co aplicated by the thousands of negro slaves and captive Moriscos, who, in some islands more, in others fewer, have dwelt in all since the time of the first conqueror, Juan Bethencourt, until our day. It is not too rash to assert that, at certain periods, the half of the population of Lanzerote and Fuerteventura was Arab and Morisco. As the clergy and the inquisitors went about, always on the lookout for the filtration of heresy through the chinks of toleration, they employed every kind of means to put an end to it. In the parochial archives of Betancuria (island of Fuerteventura) there may be read in the book of visitation, drawn up for the delegation by the licentiate Aceituno in 1660—'that the Moriscos generally speak the Morisco language, and teach their children to speak it, and not to speak our language; for which reason it has been commanded and is commanded that, from this time forward, no Morisco shall speak the said language nor teach it to his children, under the penalty of 300 maravedis for each offence.' In the instructions of the bishop Zimenez in 1666 (according to the same archives) it is ordained that, 'from this time forward, the said Arabic language shall not be spoken, neither Traigan nor Alquiceles nor Tagolines; that the Moriscos, male and female, and other persons, shall not sing Morisco songs in the Arabic language, such being a scandalous thing and full of suspicion.' The same took place in the island of Lanzerote. In the archives of the Puebla of Teguise, referring to 1665, appears this decision, 'that, being informed that the Moriscos of this island commonly make use of the Algarabian tongue of the Moors, and teach their children to speak it, the evil be not permitted to continue.'

"Until far on in the eighteenth century, down to the reign of Charles III., the freebooters of the islands sustained intimate relations with those of the neighbouring coast (of Africa), visiting each other, inter-marrying, and maintaining amicable and family connections. It is an undoubted truth that the pirates of the nearest coast of the main land, which is removed by but half a dozen hours of navigation from the islands, had as many Canarians of the isles as Moriscos in the mutual *cabalgadas* and *razzias* which they made. Some years ago I went through these regions, accompanied by certain friends, to examine the scene where were summoned the dwellers in one of the various forts or castlets, who do much to catch little. We went round about among the *Celestinos* or Moors of the coast, inspecting those who exhibited negro, mulatto and Arab types, others indefinable, and many that were ruddy, with blue eyes. While contemplating these last, I asked myself the question: 'Were they descendants of the ancient Guanche family that existed prior to the historic epoch in the remote ages of Atlantis, or of captives taken in the Canaries, from the fifteenth century onwards, or, perhaps, specimens of the Vandal population or of other barbarians who had passed into the north of Africa?' In regard to the islands of Canaria, Tenerife, Palma and Gomera, they contained many Moriscos and many more negro slaves, not only in private service, but also as labourers on the plantations. The first of the islands referred to still has *pueblos*, such as Santa Lucia de Tirajana, in which half of the census is negro shaded or of a significant darkness, an obscurity that extends to several villages. Similar conditions obtain in Tenerife as at Adeje and other points, and the same is the case in Gomera and Palma. As for the island of Hierro, although not altogether free from these extraneous ethnic elements, it was the least contaminated, for a native peasantry lived frugally beside the many waters that irrigated their sugar and other plantations.

"Ignorance of these historical facts, and a superficial examination of the subject, have given occasion to certain writers to state, with a scientific air, that the Guanches were prognathic, not that they could find any living example of an acute facial angle, but, from the discovery of skulls fulfilling the conditions, taken from tombs opened and little studied, they generalized from rare exceptions, being misled by the spirit of novelty. This question led me, as by the hand, to occupy myself, though but lightly, with the subject of the Guanche race, in order to aid in re-establishing historic truth concerning it. Terrified by the assertions of books, the press and other deterrents, both natives and strangers repeat to all new-comers, with affected lamentation, that they possess evidence of the annihilation of the Guanche population by the *conquistadores*. It is this common and vulgar, foolish talk that professes to give knowledge. Guanches are we and all ours, all, even to the foundation of the population of the archipelago, with the foreign elements already remarked. Without doubt, inasmuch as we live, speak, dress and think in European fashion, one would have difficulty in discovering it. Let us turn to our pastoral idylls and primitive skin dress in order to recognize ourselves.

"Until the end of the eighteenth century, none of our chroniclers said, or was able to say, such impostures. Unfortunately, our writers of this age confused their minds with the ideas of the French Encyclopedists, from whose influence escaped no one of the most illustrious historians of the Canaries, not even the most notable, the erudite Viera y Clavijo. This man of positive merit, without knowing how or why, without any foundation, alienating a truth which he ought to have known, first launched his specious falsehood with all the authority with which his reputation invested it. The rest belonged to the romantic school, a couple of generations of satyr-poets, who corrupted our history. The first to protest against these falsities was M. Berthelot in his notable work, and he was followed by others in his laudable purpose. But neither the serious labours of these men, which most people do not read, even including the literati; nor the testimony of the archives, in which appear wills, and contracts of purchase and sale of the aborigines, as well as marriage contracts and judicial procedures; nor the teaching surrendered by the very opened tombs, has sufficed to retard the velocity acquired by the ball, launched forth to roll in time by the unforgotten Viera, meanwhile gliding over the area of superficial ignorance in which we live.

"On the other hand, as before the conquest, so after the fourteenth century, adventurers and pirates came from Europe to capture Guanches and sell them for slaves. From the sixteenth century onwards the natives must of necessity have taken knowledge of the Spanish nobility, not descended from Moor, Jew or Guanche; and from this and a world-wide anxiety after pride of birth, have forgotten their affiliation, of which at the time they had ability to obtain proof. Who knows whether the disappearance and frequent burning of archives and other documents was part and parcel of this foolish pride? As the erudite historian Millares tells us, the inquisitors, certainly without any fraudulent design, made very full lists of Guanche descents.

"I proceed to add the tedious illustrations. I have deemed it suitable to prefix these preparatory considerations for those who are little versed in the internal history of the Canary Island people, a people little known even to those who study uninteresting tribes leading distant and secluded lives. I trust these data will not be lost on him who undertakes the serious but glorious task of making the study of the Guanche tongue. I know of no other materials than those I send; and I do not know if there is sufficient for such an enterprise, in order to re-construct or even make known the affiliation of a language which has entirely disappeared. It is a miracle of mercy to have the subject investigated by a genuine philologist, who alone knows how to exercise a wise discrimination and a useful sifting among the farrago of errors which we hold as vocabularies of the Guanche language. Had the Canary Islanders a common tongue, or, at least, a common origin?"

So far Dr. Bethencourt, who, the writer sincerely hopes, will not be tempted to apply to him the Italian proverb, "Traditore non Traduttore." The foregoing paragraphs present at least the gist of his introduction to the vocabularies, and nothing in it has been omitted. Many books have been written on the Canary Islands, both before and after the publication of the English histories of Glasse and Thomas Nicols. The writer has had access to some of these, among them to the work of M. E. Pégot-Ogier on the "Fortunate Isles." This author and others contend for the Celtic origin of the Guanches, and for their relation with the Berber tribes of northern Africa, whence old Guanche traditions concur in bringing their ancestors. The Berber dialects are much corrupted with Arabic and in part with negro languages, but their substance in vocabulary and grammar is Celtic. While a very considerable body of Celts emigrated from the East through Europe, leaving colonies in Bavaria, the Tyrol and Umbria, and peopling Gaul and the British Islands, a large number of them, even according to British traditions, Welsh, Irish and Scottish, passed westward through Africa and left their name to the province of Numidia. Of these latter some, at least, must have crossed over into Spain accompanied by the Iberic Mauretani, to constitute together the Celt-Iberian population of that peninsula. A smaller, yet not insignificant, emigration took place, at some remote period, from Cape Nun, in Morocco, or some more western point, to Lanzarote and the adjoining islands. Was this last tide of migration purely Celtic or, like that into Spain, was it Celt-Iberian?

Not to speak here of antiquities, such as architectural remains, arms and utensils, manners and customs, of which the writer has treated elsewhere, there remain two sources of information as to the affiliation of the Canary Islanders; the evidences of their written and of their spoken language. Of inscriptions the writer has translated about sixty, thirty and more of which have been already published, leaving twenty-seven, that have not so far seen the light, to illustrate this paper. They are, with no single exception, Iberic, their characters being those of Etruria and Iberic Spain, and the language they yield being archaic Basque. The best Basque scholars of France and Spain have homologated the translations already published, and have thus placed them beyond the reach of cavil. The fact seems, therefore, to be established, that, not only in Hierro, whence came most of the inscriptions, but also throughout the archipelago, a population akin to the Basques of the Pyrenees existed in a state of literary culture, and holding the reins of power. Two of the inscriptions published by M. O'Shea, President of the Biarritz Association, in its "Bulletin Mensuel" of December, 1898, namely, Nos. XX. and XXII., make mention of one Lamia, a Roman functionary. In 23 B.C., Ælius Lamia and L. Apronius were proconsuls in Africa (Tacitus, Annales, IV., 13); and the death of Lamia is noted as occurring in 33 A.D., in Lib. VI., 27, of the same historian. But an Ælius Lamia fought against the Cantabrians, as lieutenant of Augustus (Horace, Odes, III., 17). L. Ælius Lamia again was consul in the year 3 A.D.; and L. Ælius Plautius Lamia was suffragan with Domitian in the year 80 (Fasti Consulares). The Canary Islands were discovered by the Romans before 78 B.C., for Sertorius had the idea of passing his last days in them (Plutarch, Life of Sertorius). While it is hard to decide who the Lamia was that the Hierro inscriptions celebrate, it is probable that his date lies between 23 B.C. and 80 A.D. At least three generations of Iberic kings preceded his advent to the island, thus giving a pre-Christian era for the settlement of the Canaries from Africa.

The spoken language, as represented by the vocabularies which Dr. Bethencourt has, the writer thinks, unduly disparaged, supports, to a certain extent, the written evidence for an Iberic immigration. Among the words found in Fuerteventura occurs *sorrocloco*, which Dr. Bethencourt translates—"consistia en acostarse el marido durante los dias que lo estuviera su muger durante el puerperio, con iguales atenciones." This is "la couvade" of the Basques, which M. Francisque Michel thus describes: "les femmes se lèvent immédiatement apres leurs couches, et vaquent aux soins du ménage, pendant que leur mari se met au lit, prend la tendre créature avec lui, et reçoit ainsi les complimcats des voisins" (Le Pays Basque, p. 201). This custom is mentioned by Apollonius Rhodius, the author of "The Argonauts," as peculiar to the Tibareni of north-eastern Asia Minor; Diodorus Siculus attributes it to the Corsicans; Strabo, to the Iberians of Spain; Marco Polo, to an aboriginal population of China, identified with the Miau-tze, whence Butler in his Hudibras, writes:

> "For though Chinese go to bed,
> And lie in, in their ladies' stead";

and Du Tertre and Dobrizhofer found it among the Caribs of the West Indies and the Abipones of the Gran Chaco in South America. The whole subject is discussed by the late Max Müller, in his essay on "Manners and Customs," in the second volume of Chips from a German Workshop. The writer, though allowed by competent authorities to be proficient in Basque studies, has sought in vain for the native name of the *couvade*. At length it comes to meet him from far Fuerteventura. M. Michel cites Boulanger, in seeking the origin of this strange custom. He says: "Il semble que l'on doit regarder cette conduite du mari comme une sorte de pénitence, fondée sur la honte et le repentir d'avoir donné le jour à un être de son espece.' There is no doubt that the first part of *sorrocloco* is the Basque *sor*, birth or the creature born. If Boulanger is right, the second will be *ahalge*, shame; the whole meaning "the shame of the birth." But the second may be *acheltsu*, in which case the word signifies "the care of the newly born." As the botanist rejoices over a new plant, and the numismatist over a new coin, so will etymologists be delighted with the recovery of the long lost *sorrocloco*.

The "couvade" was an Iberic, and thus a Turanian custom, and there is no evidence that Celts ever practised it. A further examination of the vocabularies, both of common and proper nouns, reveals very few more Basque terms, however. It is possible that *adarno*, a tree, may be the Basque *udarondo*, a pear-tree; *ara*, a goat, the B. *ari*, a ram; while *chede*, a boundary, is pure Basque. Also *estafia*, to beat, may come from the B. *asti*; and *gofio*, porridge of maize, is certainly the B. *sopa*, *zopa*, meaning the same thing. A mace or club, *magado*, seems to connect with the B. *makatu*, to strike with a stick; and *moca*, a javelin, with the B. *moko*, a point. Burnt ears of wheat, *rapayo*, may be derived from the B. *erre-bihi*; and the B. *dupha* is as near to the Canary *tabajo*, a milk-pail, as the Gaelic *tubog*. A flint knife, *tafique*, appears of kin to the B. *epaki*, to cut; and *tamarco*, *tamarco*, denoting a skin cloak and dress, recall the B. *zamarra*, a blouse; while *acichei*, beans, is the B. *ekosari*, *chilate*, a graminaceous herb, the B. *chilista*, lentils, and *moranguana*, strawberry, the B. *mariguri*. But these are only fifteen words out of more than 450, for which corresponding Celtic terms have been found. The Basque terms were evidently in the position of loan words. That well-known word *Jainco*, God, does not appear in the lists, but is replaced by *Acoran*, the Celtic Crom; and the same is true of all distinctively Basque terms, which could not be absent if the Guanches had been an Iberic people, and the engravers of the inscriptions.

The writer does not profess to be a Celtic scholar in the best sense of that term, but among the six hundred languages and dialects to which he has given more or less attention in a fairly busy life, he has not neglected the Celtic and their remains. He is fortunate also in possessing the friendship and collaboration of that eminent master of the Celtic languages, the Rev. Dr. MacNish, of Cornwall, who has kindly undertaken a task beyond the writer's powers, that, namely, of assigning Celtic values to the almost innumerable proper names furnished by Dr. Bethencourt, as well as to investigate the construction of larger locutions, phrases or sentences provided by him. In his attempt to explain the remaining terms, chiefly common nouns, with some verbs and adjectives, the writer must apologize for the slender Celtic outfit for the work which his library supplies. The books chiefly drawn upon are O'Reilly's Irish Dictionary, which is admirably full of botanical names, and Edward's English and Welsh Dictionary, which is correspondingly deficient.

The work of comparison had not progressed very far, before the Guanche tongue revealed itself as more Cymric (Welsh and Breton), than Gaelic. The very name Guanche seems to connect with the Welsh *gwyn*, white, and thus to have denoted a white population in the vicinity of African negroes, swarthy Arabs, and red Iberians. Among distinctively Cymric terms appear the Canary Island *guatatiboa*, the national festival, in which it is not hard to recognize the Welsh *eisteddfod; guayafan* and *guayafacan*, co-adjutor of the governor, answering to the W. *cympen* and *cympencun; punapal*, first son, the W. *pen-eppill*, the chief descendant; *malgarco*, rough music, the W. *mawlganu*, to chant; *quevechi*, dignity, the W. *gofyged; titogan*, heaven, the W. *tuddo-cwn*, the covering of the head; *amogante*, berry, the W. *magon; guanoco*, weak, infirm, the W. *gwan;* and *iguanoso*, with the same signification, the W. *egwan*. Compound words are specially valuable as tests of correct or scientific comparison. Take, for example, the Guanche word *valeron*, which denotes, "the cave of the vestals"; it is the Welsh *ffau-lle-rhian*, "the cave apartment of the virgin." The name of a Guanche god was *Atguaychafortanaman*, and this appalling word of seven syllables, means "he who holds the heavens." In Irish Gaelic, it is *adh-se-a-cabhair-t-neamh;* and the latter part "holds the heavens," is in Welsh *cymhorth-nef*. The Guanches had very many words to denote goats and other domestic animals with peculiar markings, and these, as provided by Dr. Bethencourt, so outran the writer's patience, that, after translating a few, he gave the rest up as hopeless, save in the hands of one to the Celtic manner born. Thus *manonda* is a black goat with white feet; but *ban-an-dubh*, Irish Gaelic, and *gwyn-yn-du*, Welsh, mean "white in black." A white and cinnamon goat was called *puipana*, which is Irish *buidhe-ban*, "yellow-white." A male or he-goat was *carabuco*, the Irish *culbhoc*, but the Welsh *bwch-gafr*.

Articles of food come early into the life of a nation and stay long. In the Canaries a butter-cake was called *borondango*, which is just the Welsh *barachdaen*, a slice of bread and butter; *tacerquen*, syrup of mocanes, is the Irish *deasguin*, molasses; *aculan*, fresh fat, is the W. *agalen*, a lump of butter. It has no doubt puzzled investigators of the vocabularies to understand how *asitis-tirma*, *atis-tirma* and *tis-tirma* could mean at once "invocation to God," "cry of surrender," and "a sacred cliff." The Gaelic explains it, for its *aitchim-trom*, "I beg for protection," is alike applicable as a prayer to deity and to a victorious enemy; while *diagha-drim*, in the same language, denotes a sacred ridge or mountain. Take again the Guanche battle-cry, which shows what devout warriors they were, like the crusaders at Jerusalem. Its form, as handed down, is *datana*, which looks dangerous enough for a "Cruachan"; but it is the Irish *deodhann*, "by God's help!" which in Welsh is *a ga gan Dduw*. The lists give *tara*, *tarha*, *tarja* as "sign of remembrance"; it is really the Irish *tarra*, *tarrsa*, and the Welsh *dere*, *dyre*, which mean "come thou!" Some words denoting rank, and which the writer, with smaller vocabularies, once counted to the Iberic Turdetani, who seem to have formed part at least of the Iberic population of the Canaries, are purely Celtic. Achiman, for example, was a famous royal name among the Turdetani, but the *achimenceys*, or nobles of the Guanches, were *acmhaingeach*, which O'Reilly translates "powerful, puissant, rich." So *artamy*, prince, is the Gaelic *ardmhaor*, chief magistrate; *chichiciquico*, a squire, is *gaisgidheach;* and *guaire*, noble, is just *guaire*, "excellent, noble, great," says O'Reilly.

Celtic words beginning with the letter t are often doubtful, for, as O'Reilly remarks, "the letter t is used as an adventitious prefix to all Irish words beginning with a vowel, which are of the masculine gender and are preceded by the article *an*, which in English signifies *the*." The Berbers, with whom the Guanches were most intimately related, make free use of t both before and after words. Thus *medina*, the Arabic for town, they convert into *tamdint;* *murrah*, "a woman," into *tamraut;* and *dar*, "a house," into *taddert*. It will, therefore, not be a matter of surprise that a comparison of the many Canary words, beginning with this letter, with the Celtic vocabulary, pays but little heed to what is frequently adventitious, and of no root value. In tracing the origin of certain Guanche words, it has been necessary to combine Gaelic and Cymric elements. Such, for instance, is the universal Guanche word *guanil*, denoting "wild cattle." Here the Irish *agh* gives cattle, and the Welsh *anial*, wild. So *magarefo*, a tall thin boy, combines the Gaelic *mac*, a son, and the Welsh *llipa*, lanky.

A peculiar combination, but within the limits of the Irish dictionary, translates the Guanche *omanamastuca*, bright red; it is *omh-aineamh-dathach*, which means "blood stain coloured." Some very out-of-the-way epithets are well preserved. Thus *babilon* is the nickname given by the inhabitants of other islands to a boy of Tenerife; and it is the Irish *buibiollan*, a coxcomb, which leads one to infer that the gilded youth of Tenerife prided themselves upon their personal appearance. The son of a plebeian was *achicasna*, the Welsh *gwesin;* a brave man was *altaha*, the Irish *lath* or *anthaa*, the Irish *niadh;* an idler, *debase*, was the I. *taimheach;* a vestal virgin, *harmaguade*, was the I. *er-maighdean*, noble virgin; a tall vulgar person, *tamarco*, was either the I. *tamhanach*, or the Welsh *amrosgo*, or both; and a tall slender man, *tigalate*, was the I. *teircfheolach.*

Either the Guanches lost the sound of r in many words, or their reporters omitted to notice it, while, in other cases they intruded that sound, as in *tacerquen* compared with the Gaelic *deasguin.* Among the botanical names of the Guanches that are determined, which are few, occurs that of the Cytisus, which is *tagasaste;* now *tragasaste* would not be exactly the same as *ddrewgoed*, the Welsh name of a Cytisus, the laburnum, but it is not far from it. Again *faita*, treason, leaves out the r of the Welsh *brad.* A peculiar variation is found in the word which denotes "rod fishing from the shore"; *jilmero* is the Guanche form, and *genweirio*, the Welsh. Yet they are plainly the same word. In Gomera, Dr. Bethencourt found the term *parano*, which he defines, "especie de armazon o canizo que se pone sobre el hogar para curar el queso, etc.," i.e., a stand or hurdle to place on the hearth for curing cheese, etc. This is just the Irish *brannra*, a stand, a prop, support, doubtless of the same ancient pattern in the old Guanche homes of Gomera, and in the farm houses of the Green Isle. The words signifying man are a fair indication of relationship. Of these, *antraha* answers to the Irish *anra*, common people; *coran*, to the Welsh *gwr;* *cotan*, to the I. *cathaidhe*, warrior; *guamf*, to the Welsh *ymbaffiwr*, fighter; *mago*, Guanche, to the I. *mogh*, man; *mahey*, hero, to the I. *mogan; teseique*, great man, to the I. *toiseach;* and *tingalate*, tall thin person, to the I. *tan-cleith.*

The writer has placed the botanical names in a separate vocabulary, both because they constitute a special study, and because of the indeterminateness of most of them, which are simply called, a plant, a herb, a bush, a tree. Already the Canary Island *tagasaste*, Cytisus, has been compared with the Welsh *ddrewgoed.* The two words *chibusco* and *chibusquera*, a berry and the plant that bears it, can hardly be other than the Gaelic *subha*, a raspberry, and *subcraobh*, a raspberry bush, Rubus Idaeus. In *creses*, beech-nuts, appears the Irish *grech*. The two Irish names, *Caorinlcana*, Valeriana officinalis, and *Caorogleana*, Lychnis flos cuculi, should between them explain the Canary *girolana*, a bush. *Calgbrudhan*, Ruscus aculeatus or butcher's broom, is hardly so recognizable in *givarvera*, *hivalvera*, the Canary word for it; but *guaydil*, Convolvulus floridus, answers rather to the Irish *codalian*, Mandragora or mandrake, and *codhlan*, Papaver or poppy. Bophthalmum is *joraida* in Canary, the nearest to which in Irish is *ceannruadh*, Chelidonium majus or celandine, which Piny extols as an eye-salve. The Irish *sinicin*, Sempervivum or houseleek, resembles the Canary *sanjora*, denoting the same. The Dracunculus Canariensis is *tacorantia*, and the name of the Irish Arum of the same family is *gacharonda*. A bulbous plant, *tarambuche*, invites comparison with the Welsh *crwnben*, a bulb. Mallows seem to abound in the islands, being known as *aguamante*, *amagante*, *juesco* and *vesto*, with which may be compared the Irish *ucas-fiadhain*, *mil-mheacan*, *ochus*, and *fochas*. The botanical list embraces ninety-three names of plants or their products, of which one only is certainly Basque, namely, the word for strawberry. Had Edward's Dictionary contained any botanical names worth speaking of, greater results might have been obtained, but enough are in evidence to prove the Guanches to be Celts, and Celts, moreover, in possession of some of the plant lore of the Druids.

It is unfortunate that among the Guanche words taken down at various times, the full forms of the personal pronouns do not appear. There is every reason to suppose that they were akin to those of the Berbers, which are:

I, *nekki*.	We, *nekni*.
Thou, *kemmi*.	Ye, *kunwi*, *kunwith*.
He, *netta*.	They, *nuthni*.

The nearest pronouns to these in the first and second persons are, strange as it may appear, the Peruvian of this continent. Such are:

I, *noca*.	We, *nocanchic*.
Thou, *cam*, *chema*.	Ye, *camchic*.
He, *hupa*.	They, *hupanaca*.

The divergence of the third persons is hard to explain, but the Peruvian furnishes the purer Celtic forms, since the Aymara *hupa* and *hupanaca* answer to the Welsh *efe*, *efo*, he, and *hwynt*, they. The Celtic character of much of the Peruvian vocabulary was indicated by the writer as far back as 1879, in the pages of the Canadian Naturalist of

Montreal. Now that no doubt remains as to the language of the Guanches of the Canaries being Celtic, a new interest is created in the Peruvian problem. The Celtic connection of the Peruvians is not a subject confined to the writer. In 1871, V. F. Lopez, published in Paris and Monte Video, a book entitled, "Les Races aryennes du Pérou," in which very learnedly he contended that, in spite of postpositions and other indications of Turanian syntax, the Quichua and cognate Peruvian dialects pertain to the Indo-European family of languages. M. V. Henry, a philologist of some note, made a laudatory, but, at the same time, destructive, criticism of the volume in an article read before the International Congress of Americanists, held at Luxemburg, in 1877. As, however, he therein exhibited no acquaintance with the special features of Celtic speech, his decision is not to be accepted as final. As to postpositions, he ought to have known that they are as common in Sanscrit as prepositions, an indication that the normal prepositional order of Indo-European language had. in its case, been greatly modified by the intimate presence among its speakers of a population making use of a postpositional Turanian language. If it appear that the twin elements, Celtic and Iberic, of the Canary Islands, migrated together to America, finally reaching Peru, and there insensibly fusing the divergent elements of their two distinct forms of speech, the problem of a language which puts Celtic vocables into Iberic grammatical order need no longer present difficulty. It is granted that postpositions to nouns, the postposition of the word governing the genitive, and similar peculiarities, are not Celtic, but Iberic and Turanian. Moreover, there are many Turanian vocables in Peruvian, and the ruling class in Peru, namely, the Incas, was distinctively Turanian. The unanswerable fact, however, still remains that the larger part of the Peruvian vocabularies are Celtic. Before passing to the consideration of these, it may be stated that a German author, Herr Frenzel, has recently contended for the Celtic origin of the Peruvians and of the Aztecs of Mexico.

The writer's Peruvian material has not been sufficiently abundant to enable him, as he would gladly have done, to compare the Canary Island words with it to any extent. An intimate acquaintance with the obscurer forms of Peruvian speech would be necessary for such a purpose. Ordinary vocabularies have little to tell of Eisteddfods, rock-pools, piebald goats, stone implements, and problematical plants, such as fill the Guanche lists. He has, therefore, been compelled to compare the usual vocabulary for comparative purposes with corresponding terms in the Celtic languages to the amount of some three hundred. These appear in the Appendix, after the Canary Island comparative table. Accidental coincidences in the form and sound of words may be found, to a certain extent, in all languages, however remotely disconnected. One wonders, therefore, at the statement in the Peruvian Antiquities of Messrs. Rivero and Tschudi: "The analogy so much relied on between the words of the American languages and those of the ancient continent have induced us to make an approximate estimate, as far as our means would permit, of the numerical value of the idioms of both hemispheres; and the result was, that from between eight and nine thousand American words, *one* only could be found analogous in sense and sound to a word of any idiom of the ancient continent; and that in two-fifths of these words, it was necessary to violate the sound to find the same meaning." The one word evidently that the learned authors have discovered is "the Quichua word for the sun, *Inti*, which unquestionably derives its origin from the Sanscrit root *Indh*, to shine, to burn, to flame, and which is identical with the East India word *Indra*, the sun." The real fact of the case is, that the supposed solitary *inti* is a contraction and attenuation of the Welsh *ganaid*, the sun, and appears to relate to an old Irish title of that heavenly body, which is *ion*. The reason why pretended philologists have not been able to discover relationships in languages is their ignorance of the Old World tongues that are suitable for the purpose. The gospels of St. Matthew and St. John have been translated into African Berber, and that of St. Luke into Peruvian Aymara, without the translators being conscious that they were dealing with Celtic languages, so little are these languages made use of in the sphere of comparative philology.

The three words which first drew the writer's attention to the Celtic element in Peruvian, are the following:

sheep,	ccaura, *Aymara.*	caora, *Gaelic.*
lamb,	una, "	uan, "
goat,	paca, "	boc, "

The Quichua word *llama*, which denotes the diminutive camel of South America, is the old Irish *lumhan*, a lamb, and the Aymara *pilpinto*, a butterfly, is the Welsh *balafen*. A few words in which d or t is the chief factor will exhibit the Celtico-Peruvian connection:

earth,	idatu, *Cayubaba.*	tudd, *Welsh.*
father,	tata, *Aymara*, Etc.	tad, "
father-in-law,	ttosi, *Atacama.*	tadcu, "
house,	uta, ata, *Aymara.*	ty, "
seed,	atha, "	had, "
woman,	tana, *Itenes.*	dynes, "

Here is a series of verbs:

to beat,	panay, *Quichua.*	pwnio, *Welsh.*
	huacta, "	chwatio, "
to bind,	huatay, "	caethiwo, "
to drink,	upiya, "	yfed, "
to enter,	mantana, *Aymara.*	myned, "
to go,	huma, "	imich, *Gaelic.*
to hate,	coysma, *Atacama.*	casau, *Welsh.*
to heal,	callana, *Aymara.*	gwellau, "
to kiss,	quischama, *Atacama.*	cusanu, "
to know,	yatina, *Aymara.*	adwaen, "
to learn,	yaticha, "	dysgu, "
to load,	penaclo, *Atacama.*	pynorio, "
to love,	qquipi, "	hoffi, "
to run,	huayra, *Quichua.*	gyru, "
	paway, "	ffoi, "
to sew,	chucuna, *Aymara.*	gwnio, "
to sleep,	iquina, "	huno, "
to speak,	arusi, "	areithio, "
to teach,	yatichana, "	addysgu, "
to wash,	harina, "	glanau, "
	maylla, *Quichua.*	ymolchi, "

Here are eighteen common verbs perfectly corresponding, after centuries have separated the branches of the parent stock that speak them in the New World and in the Old. Like the Guanche tongue, the Peruvian is Cymric rather than Gaelic; and, like the former, the Peruvian frequently omits the liquids r and l, as in the following:

angry,	pina, *Quichua.*	ffrom, *Welsh.*
to break,	pakiy, "	bregu, "
door,	puncu, "	porth, "
feather,	puyu, *Aymara.*	plu, "
flower,	pucher, *Atacama.*	fflur, "
hail,	chijchi, *Aymara.*	cesair, "
hot,	capi, *Atacama.*	craf, "
house,	puncu, *Aymara.*	ffronc, "
jaw,	kaki, *Quichua.*	cargen, "
night,	haipu, *Aymara.*	gosper, "
strong,	capac, *Quichua.*	cryfach, "
thigh,	changa, *Quitena.*	clun, "
throne,	tiana, *Quichua.*	tron, "

This species of phonetic decay is a common feature in the history of language all the world over, and finds its most familiar illustration in the Italian and other Romance languages as compared with the original Latin.

The English word "writing" is rendered by the Quichua *quippu.* As a matter of fact, so far as is known, the Peruvians possessed no system of writing, but preserved their records and tallies by collections of knotted cords of different colours, to which they gave this name. It is the Welsh *coffau*, to record, a term that exactly expresses the object of the cords. The word *hualpa* or *atahualpa*, which enters into the composition of the titles of the last three Incas, often written *hualppa*, denotes a fowl, and is a common Celtic designation for many kinds of birds, such as the Gaelic *gealbhan*, sparrow, *gealbhan-cuillion*, bulfinch, *gealbhan-garaidh*, hedge sparrow, *gealbhan-lion*, linnet, *gealbhan-sgioboil*, bunting, and the Welsh *golfan*, sparrow, *golff*, swallow, and *gylfinog*, curlew, whence the lowland Scottish "whaup," which is just *huallpa*. While on the subject of birds, it may not be amiss to remark that English dictionaries set down *condor* as Spanish, and some Spanish lexicons at least claim it as such. It is really the Peruvian name of the vulture of the Andes, and is a corruption of the Welsh *gwylldyr*, a vulture, to which the Gaelic *gairrfhiach* only half corresponds. The Latin *vultur* would thus appear to be of Celtic origin. The combination of the guttural and the labial in the Welsh *gwi* explains the rise, out of the same common original, of such apparently divergent forms as *condor* and *vultur*. A corruption of another kind appears in the Atacamena *quelechar*, truth, as compared with the Welsh *gwirder;* and in *ualcher*, bad, wicked, in the same dialect, in comparison with the Welsh *ysgeler*. A tendency to replace dentals by sibilants is found in the Aymara *cachomasi*, friend, and *arusi*, to speak, corresponding with the Welsh *cydymaith* and *areithio*. Many other points of comparison are worthy of note, but the vocabulary must speak for itself. This much is certain, whatever syntactical modifications have supervened in the original language, by virtue of Iberic or other Turanian admixture, the bulk of Peruvian speech is Celtic, and that almost exclusively, yet not completely, Cymric.

The problem remains, how and when did Cymric Celts find their way to the far western shore of South America? The Peruvian annals, preserved by Montesinos, Garcilasso de la Vega, and other historians, give no credible account of the advent to the vicinity of Cuzco of the ancestors of the present native population. But in both the histories named, the year 1062 is affirmed to have been the beginning of a new order of things, subsequent to a period of great corruption and decline of royal authority. Then Inca-Rocca or Sinchi-Rocca founded the dynasty which continued in power till the time of the Spaniards. This date of 1062 is very significant, for in that year, Huemac III., the last Toltec king of Tollan, in Mexico, began to reign. Two years later, according to the Mexican historians, he and his Toltecs fled before their Chichimec enemies into the south. Some records affirm that he was pursued and put to death; others that he escaped, and, in a far off land, established a new kingdom of the Sun. The only empire in the south rivalling that of Mexico, with the exception of the states of Oaxaca, Yucatan and Guatemala, which were no doubt in existence in 1062, would be that of Peru, which is then said to have had its beginning. Had the Peruvians called themselves Toltecs, the migration might be taken for granted, but there is no evidence that they did so.

Anahuac was the name of the Mexican region in which the Toltecs founded, in 717 and 752, the kingdoms of Culhuacan and Tollan. Shortly before the first date, they and the Olmecs, who have no separate history, came to Potonchan on the east coast, from a region far beyond the sea, called Chicomoztoc or the Seven Grottos. They are said to have passed through the channels of the Bahamas, to have left some of their seven crews on the shore of Florida, and to have coasted along the Gulf of Mexico till they came to their landing place and permanent settlement. The Toltecs were large, well-made men, almost as white as Europeans, and fully clothed. They were sun-worshippers and offerers of human sacrifices. In the arts of architecture, metal-work, the manufacture of cloth and many other useful articles, they excelled, and were skilled in music and in medicine. They possessed monastic institutions for men and women, had a great variety of religious festivals, and a class of learned men called *amoxoaquis*. Their history, however, as related by Aztec writers, is so corrupted by the large infiltration of very ancient traditions, such as that of Quetzalcoatl, which belongs to a period thousands of years in the past, as to be almost incapable of disentanglement, save in its chronological outline.

Apart from the matter of physical stature and complexion, for which the present Peruvian, in a state of subjection and degradation, furnishes no trustworthy data to compare, the above description of the Toltec is applicable to the subjects of the Incas. They were great masons, which as a rule Turanians are not, being carpenters instead, and built both enormous megalithic structures, and edifices of hewn stone, besides constructing admirable roads and bridges. They excelled in the textile and metallurgic arts. They worshipped the sun, and had monasteries and vestal houses devoted to that deity. Their Amautas or wise men correspond to the Toltec Amoxoaquis, and these cultivated music, astronomy and medicine, in the first and last of these far excelling the Mexicans. Their year consisted of twelve months, while that of the Aztecs and Central American peoples contained eighteen. The names given by the Amautas to some of the plants of their pharmacopœia have survived, but their botanical names are only known in a few cases, and these to South American botanists. There is a valerian among them, the *Valeriana coarctata*, and it is called *Huaritura*. The European species, *Valeriana officinalis*, bears the Irish name *Carthan-curaigh*, out of which *Huaritura* may have been evolved. A euphorbia, species not mentioned, was *Huachancana*. The Irish title of the *Euphorbia tithymalis* is *Buidhe-na-ningean*, in which the final *ningean* answers to the *ancana* of the Peruvian word. The uncouth term *Llamapuahui* denotes the *Negretia inflexa*, a plant unknown to the writer. It is not unlike the Irish *Lion-an-abhain*, the "Ranunculus aquatilis," but its fuller form, and its use in medicine, suggest the *Lion-na-mbean-sighe*, which is the name of the "Linum catharticum," or purging flax. The "Krameria triandria" is called *Maprato* and *Ratana*, and these names suggest the Irish *Bior-nam-bride*, the dandelion, and *Liathan*, the not-unsimilar marigold. The Peruvian title of the "Molina prostrata" is *Parhataquia*, and *Baladh-chnis* is the Irish yellow ladies bed-straw, or "Galium verum." The plant *Chinapaya* is not identified, but it is probably the *Chenipa* of the Canary Islands, the Irish *Cnaib*, and the well-known "Cannabis sativa," or hemp. Another unidentified plant is the *Chenchelcome*, the nearest to which is the Irish *Samharcain*, the primrose, "Primula veris." The *Panqui* may be the *Fanaigse* or dog violet, "Viola canina"; the *Fuinseach* or enchanter's night-shade, Circœa lutetiana; or *Puinecga*, sorrel, "Rumex acetosella." The names, *Checasoconche* and *Chucumpa*, invite comparison with the Irish *Sgeach-chumhra*, sweet-briar, and other *sgeachs* and *sgeachanachs*, which are thorn bushes. Another plant *Mulli* may be the *Mol* of the Canaries, an aromatic shrub, or the *Amuley* of the same, an herb, for which equivalents are offered in the vocabulary. The *Matecllu* may be the Irish *Meastorc-caoil*, St. John's wort or "Hypericum androsaemum"; or the *Bodan-na-cloigin*, yellow rattle or "Rhinanthus cristagalli." The nearest equivalent of *Tasta* is the Irish *Saisde* which denotes sage, "Salvias" of many species. The name *Masca* suggests many Irish botanical words, such as *Masog*, a small red berry; *Miosach*, another name of "Linum catharticum"; *Measog*, the acorn; *Meascan*, butterwort, "Sanicula"; and *Feusogach*, the bearded capillary or "Adiantum." The same is the case with *Chillca*, for the Irish *Caolach* denotes fairy flax, *Ceolagh*, purging flax, *Cloch*, henbane, *Sailchuach*, violet, *Salchuach*, "Viola odorata," *Seileach*, willow, etc. Finally *Huacra-huacra* resembles *Eochair*, a sprouting plant, *Iodlus*, healing herbs, *Oighreog*, wild strawberry, and *Uachdar*, "Sanicula montana."

The Peruvians called their kings Tahuantin-Suyu-Capac, or Lords of the four quarters of the earth. The title is a very old one, as certain ancient Babylonian monarchs termed themselves kings of the four regions, and others commemorated their victories over the four races or *kiprat arba*. It is to be remembered also that there was a Kirjath Arba in Palestine, it being a name of Hebron, in what afterwards became the domain of the tribe of Judah; but it is to be noted that, while *arba* is Semitic, and even Mongol for the number four, it is not so in Hittite. The Basques are familiar with the term, as appears in the Rev. Wentworth Webster's Basque Legends, one of which represents Mr. Laur Cantons as seeking a vine-dresser's daughter in marriage. Laur Cantons is the Four Quarters. There was an ancient hero called Arba, the father of Anak, whose sons, the Anakim, were Sheshai, Ahiman, and Talmai (Joshua xv., 13, 14). They were Hittites, and pertained to the Gesshurite branch of the Zerethite, Cherethite, or Dardanian family. Talmai, king of Gesshur, the father of Absalom's mother, was of this race. The name Anak became a title, and was borrowed by the Greeks in the form *anax*, to denote "a prince." In the New World it became Inca, and the Inca was suitably Lord of the Four Quarters. Arba is a common name in the Iberic inscriptions of the Canaries, and Telama or Talmai is also found in them as a princely name. Jackson, in his version of Shabeeny's Travels, says: "The opinion of the author of the History and Conquest of the Canary Islands, is, that the inhabitants came originally from Mauritania, and this he founds on the resemblance of names of places in Africa and in the islands": "for" says he, "Telde, which is the name of the oldest habitation in Canaria, Orotaba, and Tegesta, are all names which we find given to places in Mauritania and Mount Atlas. It is to be supposed that Canaria, Fuertaventura, and Lancerotta, were peopled by the Alarbes, who are the nation most esteemed in Barbary; for the natives of those islands named milk *Aho*, and barley *Temecin*, which are the names that are given to those things in the language of the Alarbes of Barbary." The Al-Arbes as founders of places called Telde seems to suggest the presence of the Toltecs in Barbary and the Canary Islands. Immediately opposite the African coast in southern Spain dwelt the Iberic Turdetani in the days of the classical geographers. Strabo calls them "the most intelligent of all the Iberians; they have an alphabet, and possess ancient writings, poems, and metrical laws, six thousand years old, as they say." Whether

Pliny's four jurisdictions of the region in which they dwelt was native, or the creation of the Roman conquerors cannot be decided.

The epomym of the Turdetani was an ancient Hittite prince named Zereth, from whose appellation, Zareth Shachar, Zaretan, and Zartanah, Palestine were called. The doubtful nature of the initial letter as liating between a sibilant and a dental, led the Egyptians, who had good knowledge of his descendants, so to write their name upon the monuments that decipherers have variously rendered it by Sardinian, Dardanian, and Cretan. In the Old Testament, they are called Cherethites; they colonized and named Crete; and some of their descendants are the Kurds of what was once Assyria. It is also more than probable that Sardinia received its first colony from this adventurous race; and the Chronicon Paschale states decidedly that the Dardanians were descendants of Heth. The Turdetani were Spanish Dardanians. The final *ni* of Dardani was the old Hittite plural; the name of the people was Zereth or Zareth, Dart or Dard, Telt or Teld. Hence arose the words Telde and Toltec, identified in various quarters with the names Arba and Anak. Another word that accompanies this race is the ancestral Hittite name Ashchur, that of the father of Zereth. The *anaktes paides* of the Greeks were the Dioscuri; the Basque language is the Euskara; and a frequently recurring Inca name is Huas-car. The Umbrian Engubine Tables speak of the *trifor Tarsinater, Tuscer, Naharcer, Iapuscer*, or the threefold Tyrrhenians, Euskara, Navarrese, and Guipuscoans. The men of Navarre or the Naharcer, became in part the Nahuatl or Navatl of Mexico. It is necessary now to consider the Celtic element in relation to the Iberic Toltecs.

From an early period, yet by no means so far back in the past as some capricious German explorers would have the world believe, the Sumerians occupied a position on the page of history. Urukh or Orchamus was king of Sumir and Accad, as was his son Dungi or Tarkhun-dara, together with Burna-Buryas, Ulam-Buryas, and many more. The Sumerian name is Zimri in Jeremiah xxv., 25, where it is united with Elam and the Medes, and it is well placed in historical time, in spite of adverse forms of biblical criticism, as that of the descendants of Zimran, the eldest son of Abraham by the Perizzite princess Keturah. The Hebrew Zimran or Zimri, "celebrated in song," stands in intimate philological relation with the Gaelic *amhra, amhran*, "a poem or song." The Zimri are mentioned along with the Elamites on the monolith of Samas-Rimmon of Assyria, a contemporary of Ahab, Jehu, and Hazael of Syria; and on the Black Obelisk of Shalmanezer

II. The Persians knew them as the Gimiri, the Greeks as the Cimmerians, and they are in part represented by the Cymri or Welsh people of the present day. Dungi or Tarkhun-dara, the son of Urukh, wrote a letter to Amenhotep IV., the Pharaoh of Tel-el-Amarna, in pure Celtic, asking for the hand of his daughter, the princess Akh, called in Egyptian Ankh-nes-paaten, whom he afterwards married, and by whom he became a Pharaoh under the title of Tutankh-Amen. The Celtic tongue in which he wrote was the Sumerian or Zimrite. A descendant of Zimran, and father of Urukh, or more properly Orchamus, was Peresh, the Buryas of the Babylonian monuments, and the brother of Orchamus was Ulam-Buryas, or Ulam, the son of Peresh. This Ulam figures in Irish legendary history as Ollamh, whom the old chronicles call Ollamh Fodhla, and represent as a great lawgiver and patron of learning. The word *ollamh* came to mean a doctor or professor of any kind of learning, as it does to the present day. A son of Ulam was Bedan, the Phaethon of the Greeks, fabled to have been drowned in the Eridanus or Padus named after him, the Eridanus being the Jordan of Palestine. This name so far has not been clearly identified on the oriental monuments, but it survives in Greek story. The second Ilus of the Dardanian line was his father Ulam, who had married into the Zerethite family of Zareth-Shachar on the Dead Sea, and had thus acquired supremacy over the Dardanians. The son of Ilus was Laomedon, which truncated and apocopated word represents Ulam-Bedan, in an inverted or Turanian order, meaning Bedan of Ulam, but which in Celtic syntax should read Bedan-Ulam. As a geographical term, it survives in Bodon-hely of Hungary, known to the classical geographers as Ulmum of Pannonia, through which country the Boii and other Celts passed on their way to the west and north; and also in the more western combination of Baden with Ulm of Wurtemburg. Potonchan, where the Toltecs and Olmecs landed in Mexico, Peten, and the Votan of legendary American history, all have reference to the ancient fame of Bedan, son of Ulam; and the Bladud of British history, who flew like Phaethon and was dashed to the earth, but who built Caer-Badus or Bath, is a corruption of Bedan, since Nennius places Badon hill at Bath. The Ulams or Ollamhs were the Olmecs of Mexican story, who were confederate with the Toltecs. Did we know more of Guanche history, their name and that of the Bedanites might appear in the Canary Islands. The Celtic Vettones in Strabo's time dwelt side by side with the Iberic Turdetani in Spain. It is not beyond the reach of possibility, that the Latin name of the Canary archipelago, "Fortunatæ Insulæ," may be a corruption of "Fotunatæ Insulæ," or the Islands of Votan or of the Votanides.

A larger name, however, marks this branch of the Celtic family. It is the Zimrite, Sumerian, Gimirian, Cimmerian, or Cymric. As the Gaelic *amhra*, *amhran* represents exactly the Hebrew *Zimri*, *Zimran*, one may expect to find the initial sibilant or guttural absent at times. The Berbers of north-western Africa, with whom it is now generally agreed that the Guanches were most intimately related, had, and probably have to-day, tribes called Zimuhr and Amor. Of the Zimuhr, it is said: "They are a fine race of men, well grown and good figures; they have a noble presence and their physiognomy resembles the Roman." And of the Amor it is recorded: "When the Sultan Muhamed began a campaign, he never entered the field without the warlike Ait Amor, who marched in the rear of the army; these people received no pay, but were satisfied with what plunder they could get after a battle; and accordingly, this principle stimulating them, they were always foremost in any contest, dispute, or battle." Gomera, the name of one of the Canary Islands, favours the connection of the Guanches with the Zimuhr of Africa and the Cymri, as the language of their vocabulary has already done. In Peru the tribe whose form of speech most closely approaches the Welsh is that of the Aymaras. It almost follows that the Peruvian Aymaras are the Mexican Olmecs under a larger designation. The Aymaras, according to Forbes, claim to have had an older and more advanced civilization than the Incas, and they were undoubtedly the masons to whom Peru owes its massive stone remains. Dr. Tschudi erroneously supposes the Aymaras to have been the tribe with whom the Incas originated. He says: "The crania of these people present differences equally remarkable, according to their respective localities, and particularly in the contour of the arch of the cranium. It is proper here to remark that there is a very striking conformity between the configuration of this race and that of the Guanches, or inhabitants of the Canaries, who used also the same mode of preserving the bodies of their dead." The latter reference is to mummification, common to the Guanches and the Peruvians. According to Forbes, the Aymaras wear their hair very long, the men plaiting theirs into one pig-tail and the women into two. This was a Guanche custom as Pégot-Ogier remarks. He also says that, "the oven of the Guanches was a hole under ground like that of the Peruvians." This writer compares a Guanche temple with similar remains at Carnac in Brittany as proof of their Celtic origin. Megalithic structures of the same character have been found throughout the Berber area, such as that at Bless in Tunis, described by Mr. Frederick Catherwood in the Transactions of the American Ethnological Society. The chief seat of the Aymaras was about Lake Titicaca, and a short distance from its shores stand the ruins of Tihuanaco, consisting of a large group of immense stones, each from six to seven yards high, placed in lines at regular intervals. It has been fitly termed "a Peruvian Stonehenge," and a tradition prevails concerning it identical with that which ancient chroniclers preserve regarding the famous English structure, namely, that it was erected in a single night by an invisible hand. Another historical parallel, that no longer seems strange, occurs in the Peruvian story of the war between the Inca Yupanqui and his warlike subject Ollanta, in which the Inca's General acted the part of Sextus Tarquinius in Livy's account of the taking of Gabii, and that of Zopyrus in Herodotus' relation of the capture of Babylon. As the original Ulam was the uncle of Dungi, who calls himself Tark'hun-dara, or Tarquin the second, he may have been the Ollanta of the legend. But there remain to this day a town and the ruins of a strong fortress called Ollanta-Tambo, the latter perched high up in a narrow tract on the banks of the river Urubamba. At any rate, in the word Ollanta survives the Olmec name. The final *ta* of Ollanta is a dialectic variation, corresponding to that which changed the Welsh *balafen*, butterfly, into the Aymara *pilpinto*.

Having thus cleared the way for explanations, it is time to indicate traces of the Olmecs in the vicinity of Mexico. Referring to the statue of Chaac-Mol at Chichen-Itza in Yucatan, Professor Short says, in his "North Americans of Antiquity": "he is adorned with a head-dress, with bracelets, garters of feathers, and sandals similar to those found upon the mummies of the ancient Guanches of the Canary Islands." And again: "Dr. Le Plongeon observed that the sandals upon the feet of the statue of Chaac-Mol, discovered at Chichen-Itza, and of the statue of a priestess found at the island of Mugeres, are exact representations of those found on the feet of the Guanches, the early inhabitants of the Canary Islands, whose mummies are occasionally met with in the caves of Tenerife and the other isles of the group." Now, the Mayas, Pokomams, and other Yucatecs, belong to a race entirely distinct from both the Iberian and the Celt, being of Malay-Polynesian origin. Brasseur de Bourbourg, quoting a Quiche document, informs us that there was in the vicinity of Yucatan a little kingdom of Peten, the name of which is neither Maya nor Quiche, but recalls Bedan and Poton-chan. The chief of this principality was Canek, a handsome and warlike young monarch, beloved by the daughter of a king and the most beautiful woman of her time, but who, against her will, had been betrothed to the king of Chichen. While the chief nobles of the latter's court were bringing home the bride in joyous procession, Canek fell upon them and carried off the princess. Then gaining the sea shore, he embarked with his prize and bore her away to his kingdom of Peten. This is the Celto-Dardanian story of Helen, taken by Paris from Menelaus, the aged bridegroom, and carried to Troy by way of Sidon. In the Celtic or British story, as told in the Mabinogion and by Geoffrey of Monmouth, the lover of Helen was Conan Meriadoc, who would have taken her from Maxen Wledig, to whom her father Eudav or Octavius, had married her. This Conan is the Conn of Ossian and of Campbell's Tales of the West Highlands; and, in Irish story, is Conn of the hundred battles, the father of an Art or Arthur. As Paris was called Alexander, so in the Indian Puranas he bears the name Harischandra, and his son that of Rohita, the Irish Art. Whatever truth may lie in the varying details of his story, this hero was a historical personage, being Baal-chanan, the last but one of the ancient line of kings, who, before the time of Moses, reigned in what subsequently became the domain of the Edomites. From the Chanan part of his name came the British Conan, the Gaelic Conn, and the American Canek. The British addition Meriadoc, like the Gaelic Murdoch and Murtough, is a Turanian or Hittite word, Merodach or Berodach, meaning the son of Beor, who was Bela or Baal, whence Baal-Peor; Merodach, therefore, is a synonym of Baal, and Conan Meriadoc is virtually Hannibal. The Greeks cut down the full name Baal-hanan to the form of Priamos, and made him the father of the handsome libertine instead of himself, and they represented him as the son of Laomedon or Ulam-Bedan, while his true father's name was Achbor, perhaps, although this is not settled, a brother of Bedan. He reigned over the Dardanian region in which lay Zareth-Shachar, and of his race were the Celtic army leaders of the Hittites; for Achbor was the Saprer of the Egyptian monuments who ruled in the time of Ramses I., and his son was called Mauro-sar. But the sons of the latter, one of whom gave his daughter in marriage to Ramses the Great, were Mauthanar and Khetasar. The first the Greeks called Antenor, and the second, Ramses' father-in-law, receives but scant mention as the Cytissorus or Cytorus of Herodotus and Strabo. Baalhanan, as the son of Achbor or Saprer, must have been the elder brother of Mauro-sar, and thus the uncle of Mauthanar. With inversion of parts, for these compound names, as on a treaty of peace with the Hittites, are in Turanian order, Mautha-nar would read Nar-mautha. This is Brugsch's form of the name; Lenormant's is Maut-nur. Now this Nur-maut is Celtic, being Near-mada, "the boar pig," and, with a change of the initial dental, is Diarmaid, the ancestor of the Campbells, and the slayer of the mighty boar, by which he was himself slain. As the son of Mauro-sar or Sar-mauro, perhaps a Gaelic Ceir-bheoil, the name of the father of the first Irish Diarmaid, he could not claim the Campbell name, which was that of his uncle Chanan-baal, or Baal-hanan, with inversion of parts. They were, therefore, pure Celts who carried the story of Canek or Conan to Central America. The exigences of the Celtic proof, and no desire to refer to the origines of the family to which he has the honour to belong, have led the writer to what may seem to some a genealogical excursus. The Bu-chanans and Bu-chans are very probably of the same Baal-chanan ancestry.

The burden of proof the writer lays on the vocabularies, which present incontrovertible evidence that the language of the Guanches was, with the exception of a few loan words of Iberic origin chiefly, purely Celtic, both in vocabulary and in grammatical construction, and that that of the Peruvians, and in particular of the Aymaras, though Iberic in grammar, was very largely Celtic in vocabulary. He has also presented evidence of various kinds for the advent of an Olmec or Celtic people to the shores of America, for their presence in the vicinity of Mexico, and finally for their existence at the present day in Peru. And in many ways he has shewn that these Celts came from the Canary Islands, where they and Iberians once dwelt side by side, and from which, as Olmecs and Toltecs, they migrated in company. As to the period of that migration, there is nothing to proceed upon but the statements of the Mexican historians as to the foundation of the Toltec monarchies. That of Culhuacan began, under the King Nauhyotl, in 717, and that of Tollan, under Mixcohuatl-Mazatzin, in 752. Are these Toltec names or Aztec disguises? Nauhyotl means in Aztec "the four quarters," and answers to the Peruvian title of the Incas. The old Basque term for *laur*, four, was *nora*, as several Etruscan records testify, perhaps the original of the Aztec *nauh* or *nahui*. To make the four quarters, the Basque offers the addition of *alde*, *unc*, *gune*, *tegi*, *toki* or *ziri*, each meaning "a place, region, or quarter." A name in the eleventh inscription of Hierro, published by Mr. O'Shea, is rendered provisionally Notara. As the Basques use *lau* as often as *laur* to denote four, the Iberians of the Canaries may have abbreviated *nora* to *no*. Then *tara* or *tari* would represent the present B. *ziri*, and the Japanese *atari*, a region; the whole as *no-tari*, giving "the four regions." Mixcohuatl or "the cloud burst" is a purely Mexican word: *buhumba* would be the Basque equivalent, and *befu*, the Japanese.

The land of Chicomoztoc or the Seven Grottos, whence came the Toltecs and Olmecs, admirably describes the Canary Islands both as to number and the peculiarities of their rock formation. These the emigrants sailed from some time in the early part of the eighth century. Now 714 was the year of the conquest of Spain by the Arabs, and before this they had taken possession of Northern Africa, whence it was but a short voyage to the Canaries. Not having access to any of the Tarikhs or Chronicles of Maghreb and Andalus, or Western Africa and Spain, the writer is unable to state when the Canary Islands were invaded, and Sir William Muir's admirable work on "The Caliphate" makes no mention of them; but Sir William Ouseley's statement, in the preface of the anonymous translator of "Sadik Isfahani," that the Mahometan geographers calculated their longitude from the Fortunate Isles eastward, would evidently indicate an ancient acquaintance with them as the world's Ultima Thule in the west. Whether the Arabs were the invaders, or the Berber tribes that refused to obey the authority of the Koran, fleeing before their arms, sought refuge in the islands, a pressure of a hostile people took place some time between the years 700 and 717. The result in any case was the westward migration of, in all probability, the whole of the Iberic population, and of a very considerable number of the Guanches. If any of the former, who, in the time of their inscriptions, were the dominant race, remained behind, the vocabularies both of proper names and common words, as well as what chronicles survive, indicate that they lost their identity, and forfeited their authority to the Celtic Guanches.

What were the circumstances of their long voyage straight in the line of the tropic of Cancer, will probably never be known. The reason why, on reaching the American islands and coasts, they did not take up their abode on them, was, perhaps, the same that made them leave their beautiful homes of many centuries, the presence, namely, of a hostile population on these, and their desire to lead a peaceful life in the New World. From at least 717 they built up their Toltec empire in Mexico, pressed upon from time to time by new immigrants from the north and west, until, after more than three centuries, they could bear the pressure no longer, and took up their weary travels again. Neither the Mexican account of their flight, nor the Peruvian story of their sudden appearance at Cuzco, favours the idea of a second voyage from the west coast, followed by a landing at a Southern Pacific port. It is more likely that they made their way overland, through Guatemala and the deadly Isthmus of Panama, helped here and there by lakes and rivers, until, traversing the mountains of Colombia, they found and named the Ucayali river, against whose tide they steered their way to Cuzco, and Lake Titicaca. There they soon forgot the stirring events of former national history in the task of founding a new empire. Four centuries and a-half of Peru followed the three hundred and fifty years of Mexico, as these had succeeded seven hundred and more of Canary Island life; and then the Spaniard came to conquer these brave wrestlers against adverse fate, who had never really been conquered before, and to abase their pride in the degradation of hopeless servitude. It is a pathetic story, made tenfold more so by the knowledge that they were, and are to-day, more than half of them, our kindred Celts, who, under better conditions might have emulated the best achievements and lives of Wales and Brittany.

THE CANARY ISLAND INSCRIPTIONS.

Of these Dr. Bethencourt writes as follows: "As far as my information goes, there are no other inscriptions than those already sent, and those which I now send. As regards those of the island of Hierro, it may be that some are here repeated, but I prefer this tiresome redundancy to the fear that there should be any incompleteness of material for elucidating the subject. If I do not remember amiss, M. Berthelot generalized the idea that the written characters of Hierro were Libyan, founded on the opinion of General Faidherbe. Later, some have begun to doubt the truth of this assertion, but nobody has interpreted them. The studies of Mr. Campbell not only confirm the conclusions of anthropologists, but also open up unsuspected horizons, and point out new departures in the history of the Guanche population, along highways almost closed for about four centuries. May it please God to deign to direct him in fixing his attention upon so interesting a problem.

Prehistoric Inscriptions of the Canary Islands.
Island of Tenerife.

"In reality none are known here, unless we count among them the Roman letters on the image of the Virgin of Candelaria, probably of scant historical interest, and the inscription of Anaga of our illustrious friend, Dr. Manuel Osuna, to my mind of doubtful existence as an inscription.

The Virgin of Candelaria.

"According to our chronicles, this image suddenly appeared on the shore of the little kingdom of Guimar, about the year 1390, over a century before the conquest of the island; and, in the course of the 15th, 16th and 17th centuries, they repeat with much frequency miracles wrought by it and similar objects throughout the archipelago, as well as in the said island of Tenerife; so that, after dispassionate critical judgment, there is nothing to do but accept the historical fact of the presence of the effigy during these centuries. There are those who observe that, in the fourteenth century, reports were current of the presence of vessels of many different nationalities in these seas, some pursuing legitimate commerce, but most entering them in order to perpetrate all sorts of piracy; and it is quite possible that some one of these barks may have lost the said image, may have bartered it as an article of trade, or have made a present of it out of a spirit of religion. Some of our people have given heed to the version of a friar, who asserted that the Virgin was the nymph or figure-head from the prow of a ship, through observing in the hinder part of the figure the marks of the rings whereby it was fastened. This image disappeared, being carried out to sea in consequence of a terrible inundation that visited the island in the twenty-sixth year of last century. As the theogony of the Guanches was abundantly complex, and they, beside being Sabaeans, were also idolaters, they supplanted one of their idols by this new sculptured figure which had fallen into their hands, giving to it special worship; what, perhaps, contributed to this being the counsel of a certain Guanche that, after a time of captivity and civilization, it would bring them their own land, as the chronicles relate. This is the foundation of the pious religious legends of the Virgin of Candelaria, which our people have preserved, and of its subsequent exaltation by the Catholic clergy.

"The appearance of the image, according to the ancient historians who had seen it, was as follows. It was of painted wood, compact but not very heavy, and about five hands high, along with the pedestal which was two fingers in thickness. Its colour was brown, the face of a fair size, and the eyes large and full. The head was bare, with the hair spread out on the shoulders and braided in six plaits. The female figure carried a naked infant on the right arm, which in its time grasped with both hands a little golden bird, and in the left hand was a taper painted green, with a hole in the lower part for the purpose of increasing it at will. It was fully clothed from the throat to the feet, without any opening whatever. Its cloak was of blue and gold, with much golden flower work behind, and, falling in front over the shoulders, was attached at the breasts by a coloured cord of a span wide. The left foot, a little uncovered by the skirt, was shod with coloured serge. The dress and cloak were adorned with Roman letters of green colour upon a gold ground, which nobody so far has been able to interpret. On the collar are the following:—*See Inscription I. a.*

"On the border or margin of the dress below are these:—*See Inscription I. b.*

"All are not here, for in order to give away as a relic, some one had broken off a piece of the skirt and of the pedestal. In the part of the sleeve near the left wrist are:—*See Inscription I. c.*

"The robe was girt about below the breasts, which on both sides had a very graceful effect, with a girdle of blue, on which were the following:—*See Inscription I. d.*

"The border of the cloak was of burnished gold, and the right side contained these letters:—*See Inscription I. e.*

"The letters on the border of the left side were:—*See Inscription I. f.*

"On the lower part of the cloak at the back were these letters:—*See Inscription I. g.*

"The scientific importance of deciphering these letters may limit itself to an acquaintance with one of the nations that navigated these seas in antiquity.

(The description of the supposed inscription of Anaga is omitted, since it presents no definite trace of phonetic writing).

Island of Canaria.

"Some inscriptions have been publicly talked of, as found in the ravine of Los Balòs in the pueblo of Santa Lucia, and, as far as I can remember, the subject was treated either by Dr. Chil or the Señores Millares, all illustrious historians of our archipelago, but the first to make them known through the press was Dr. Verneau, about 1882, in the 'Revue d'Ethnographie' of Paris. Up to this time in which we find ourselves no one has deciphered them.—*See Inscriptions II. and III.*

"Inscriptions of the ravine of Los Balos in the pueblo of Santa Lucia in Gran Canaria. (Dr. Bethencourt's notes on the supposed written remains of Gomera are omitted, because his illustrations are mere fragments, conveying no information. His statement regarding Fuerteventura is, that no real inscriptions have come to light there.

And his carving from the island of Palma is an obscure pictograph, of which the writer has no solution to offer).

Island of Hierro.

"Besides the inscriptions which I had the pleasure of sending you, and which you have so brilliantly interpreted, in turning over some papers which I had forgotten, relating to different excursions made to this island, I came across some that I do not remember to have mentioned. In this state of doubt I take the liberty to send them.

Inscriptions of La Dehesa.

"These are engraved on strata of lava, some of a dark brown colour, others of a reddish yellow, those of the latter tint presenting themselves first when the superficial layer broke or peeled away. These same characters are either in a dark brown or in a light gray ground, which makes one suspect they were engraved at different periods, given the uniformity of the state of the rock, and the depth of the layer. But this is no place for premising, without serious foundation to support it. The characters have a very marked savour of antiquity, and we are disposed to believe that in order to trace them, stone chisels were made use of, perhaps of phonolite (clinkstone) which abounds in those regions, having been brought from other parts, and also hammers, likewise of stone. Our people are under the impression that the etchings were engraved with such instruments, and the sight of them justifies the conjecture. Moreover, we have observed no bold strokes nor sharp cuts, such as would be made by a metal chisel. These sites present all the characteristics of having been inhabited in remote ages, by the remains of curious edifices of a primitive type, which we do not describe, so as not to overload the notes, like *kitchen-middens* in increasing strata, by little altars or 'pireos,' on which the natives sacrificed live ewes and kids. In the different mounds of lava, more or less cleft by the wear of time, which has torn away from the foot of the outside slope that forms, from east to west, as it were, a semicircle, and which are found laid out on a ground more or less inclining to yellow and grayish brown, consisting of granulated lava, mixed with hillocks of sand, we copied the following inscriptions :—*See Inscriptions IV., V., VI.*

(There are over twenty altogether, but the rest are either mere useless fragments of phonetic writing, or pictographs, which the writer does not profess to decipher).

Inscriptions of Tejeleita.

"They are sculptured on prisms of basalt which form a steep rock five or six metres high. Some of them have given way. The rock faces the west, being thus protected from rain and the prevailing winds. The characters have been also traced with a stone chisel, like those of La Dehesa, though basalt is much harder than lava:—*See Inscriptions VII., VIII., IX., X.*

Inscriptions of the Port of La Caleta.

"These are also engraved on prisms of basalt which form a wall about three metres high, as well as on others fallen away from this to the sea-shore. In these sites are vestiges of the habitations of the Bimbapes or aborigines of Hierro, shell-heaps and *kitchen-middens*, small altars, stew-holes or 'pireos' for sacrifice. Many of the prisms have fallen away:—*See Inscriptions XI. to XXVI.*

Inscriptions of La Candia.

"They are engraved in a cave which was formed at a *salto* or jutting rock at the base of the ravine (*barranco*)."—*See Inscription XXVII.*

There are two more in this group, but they are too imperfect to admit of satisfactory decipherment. Such then is the material which Dr. Bethencourt has furnished to shed light upon the ancient history of the Canary Islands. Having studied the Northern Turanian characters as found in many lands and ages, from the Sinaitic of hoar antiquity to the Etruscan and Celt-Iberian of a pre-Christian century or two, and from the Buddhist Indian of the fourth century B.C. and the Siberian of the fifth A.D., to those of the American Mound-Builders as late as the thirteenth century, the writer had no difficulty in identifying the lines of the Virgin of Candelaria, and the ruder outlines of the rock-faces, with what is best known as Etruscan script, although it is morally certain that its writers in the Canaries never saw Etruria. Copies of the interpretations now submitted have been sent not only to Dr. Bethencourt, to whose courtesy the writer is indebted for his knowledge of the inscriptions, but also to Mr. O'Shea, the well-known author of "La Maison Basque," "La Tombe Basque," and many other valuable works in English, French and Spanish, who will submit them to the critical judgment of the best Basque scholars.

This it is necessary to state, because, while there are many in Canada who can pass a pertinent opinion upon the Celtic side of the argument presented in this paper, it is doubtful if there be one possessed of sufficient knowledge of Basque to appreciate the simplest and most evident coincidences between that language and the subject matter of the inscriptions. The writer may, perhaps, be permitted to insert here one of the many flattering testimonials that have come to him, alike through printed publications and literary correspondence, as to his proficiency in Basque studies. Mr. O'Shea, after other kind things, remarks: "Our native Basque scholars cannot account for your thorough acquaintance, not only with the modern forms of their language, but with that also of the primitive roots." And yet the writer was once publicly taken to task in this Institute for presuming to know Basque!

The old Turanian characters are not alphabetic, but constitute a more or less imperfect syllabary, imperfect because in many cases one character represents all the powers of a consonant, for instance, Λ, which may be ra, re, ri, ro or ru. In transliterating, the equivalents of the characters are grouped, as nearly as convenient, first in the order in which the characters appear in the inscriptions, and afterwards in their order of modern reading. A table of phonetic values of the characters, and a grammatical analysis of the texts, is appended to the paper, so that those who are curious to examine the method of interpretation may have every facility for so doing. Of the former there are necessarily two parts, inasmuch as Dr. Bethencourt's Roman letters on the Virgin of Candelaria present that Graeco-Roman aspect of the Etruscan characters, which has misled almost, if not all, interpreters to assign to them the phonetic equivalents of the European alphabet, which naturally has led to no results.

INSCRIPTION I.

The Virgin of Candelaria.

Line a.—ko i en tu po no en tu me ne ra au.
koi entu pono entu Menera au.
desire hear grief hear Menera this.

"Let this (goddess) Menera hear the prayer, hear the sorrow!"

(The ornamental cross at the end of this line and in the following lines is a mere punctuation mark).

Line b.—ni ar ba mi, au ra ne ka i ka i, ba me ne ra er en ai.
ni Arba imi, aur ne Kai Kai, ba Menera errunai.
I Arba place, child to Caius Caius, if Menera will pity.

"I, Arba place (this) for the child Caius, if Menera will compassionate Caius."

Line c.—so to be ri u ga ne ka ai ta en tu ka i ba ra ka ko.
Sotoberri uga neke aita entu Kai barka ka.
Sotoberri mother weary father hear Caius forgiving by.

"Hear the mother Sotoberri, the weary father, by forgiving Caius."

Line d.—mi ra er mi to ri se me ma gu re er en.
mira erimi etorri seme ema gure erren.
spectacle cause place come son give our compassion.

"Coming to cause to set up a spectacle, to give the son our compassion."

Lines e.—ma sa mi, u ga ra er ka an re, au ra ne la ka tu ne mi, ar ba be ne ka.
emaitsa imi, uga ra erruki anre, aur ne lekatu ne imi Arba be neke.
gift place mother to pitiful lady child to please to place Arba under weary.

ga be au ka ri di o me te ba hi ga be ai ta au ka i di o er ka.
gabe au ekarri dio ematu bahi-gabe aita au Kai dio erruki.
deprivation this to bear he calm pledge deprived father this Caius he pities.

"Placing a gift to the mother (and) to the child of the compassionate lady, to be pleased to put (strength) under Arba this weary loss to bear. Let him calm this pledge-deprived father; let him compassionate Caius."

Lines f.—pa be tu mi au ra ka ri, ni ga be tu mi koi, en tu ka mi ra au ra, be re be ha be ha ka er ka.
pabetu imi aur ekarri, ni gabetu imi koi, entuka mira aur bere beha behaka erruki.
to help place child carry I bereaved place desire in hearing regard child own behold in beholding pity.

ar tu be ha me ne ra au do i be kai er ka ga go ra te ka.
artu beha Menera au doi be Kai erruki gogoratu ka.
take glance Menera this justice under Caius compassionate remembering by.

"I, the bereaved, place the desire to have help to carry the child (in remembrance). In hearing, look at the child; behold (thine) own (and) in beholding, pity. Take a look, thou Menera; with justice compassionate Caius by remembering.

Line g.—ka ol au mi ni o, er ka ka ni o du en ar ba mi o bi ne au pa be ba.

achol au imi nio, erruki egi nio duen Arba imi obi ne au pabe ba.

care this place I to him, pity make I to him it is who Arba places tomb to this help place.

"I place this attention to him; I make pity for him; it is I, Arba, who set at the tomb a place of help."

This inscription, or series of inscriptions, is as Etruscan as if it had come from a Tuscan cemetery, in which the bones of many a Caius lie. The image is that of the goddess Menera and her son, the first of whom can hardly be Minerva, a virgin deity, but some mother goddess, whose name is compounded of the Basque *men*, "power, authority." The name of the father of Kai or Caius, namely Arba, is, as has already appeared, one of the chief personal designations of the royal line of the Canary Island Iberians, who named the Teldes, and in migration became the Toltecs. There is, therefore, no reason to suppose the image foreign to the islands, but rather is there reason to regard it as a survival of the mortuary votive offerings made by their Iberic inhabitants in ancient times. The image of Menera and her son, with the inscribed prayer, was originally attached to the sepulchre of young Kai or Caius by his father, Arba, and his mother, Sotoberri, as a phylactery. Wherever the Celtic Guanches first obtained it, there seems to be little doubt that they were ignorant of its real nature, and regarded it as one of their mother-goddesses, that the Abbé Banier, in his "Mythology Explained by History," and other writers, show to have been common throughout the Celtic area of Europe. Judging it alike by the form of its characters and the simplicity of its language, the image and its inscription must have been of much antiquity, perhaps a century before the Christian era. The grammatical forms *dio*, *nio* and *duen* denote attention to literary style such as does not characterize many of the inscriptions of the same region.

The next inscription is from Canaria, and reads in Japanese order from top to bottom, but, unlike Japanese, the columns begin at the left.

INSCRIPTION II.

ge	u	go	ko	go
ma	tsi	ma	i	ma
ma	ta	ta	ta	ma
si o	ta	ya	ya	ma
	ya ba	so	go	ma
			be	

Age Mama zio utsite Taya ba Goma Taya so,
indicates Mama to him to leave Taya if Goma Taya regard.

koi Taya jabe Goma ema Mama
wishes Taya lord Goma gives Mama.

"Mama indicates to him (that he will) evacuate Taya, if Goma desires the regard of Taya. Mama gives Goma (to be) lord of Taya."

As the Iberic name Felde remained in the islands after the departure of the Toltecs, it is probable that they left other names, which the Guanches did not supersede, just as many Pictish and other Iberic names survive in the British Islands. Such in Scotland are the Goldenberry hills, whose true name was the Basque *golde-nabara*, "the ploughshare." Places called Taya and Taha are not uncommon in the Canaries. The inscription records the cession of an inhabited tract, so called, by a chief named Mama to another bearing the designation Goma, or perhaps *gomu*, the remembrance. That it was inhabited is indicated by the *so* or regard of its people as a factor in the cession. Taya may be the modern *itai*, a scythe, reaping hook, so called on account of its appearance, like the Greek Zancle or Messana. The prefix of vowels, such as the *i* of *itai* seems to be a modern feature of language; in Etruscan days, the verbs "to give" and "to place" seem to have been *ma* and *mi*, not *ema-n* and *imi-ni*, as now.

INSCRIPTION III.

This is to be read in the same order as No. II.

pi		
mo	ra	
ta	au	
ya	do	de
au	i	be
bisi	ta	sisa
ta	ka	be
te	ma	hi
	tu	

Pimo Taya au bizitate arau doi Taka ematu debe esatz behi.
Pimo Taya this inhabitant right just Taka gives forbidding word cows.

"Pimo, this inhabitant of Taya, according to law, gives Taka notice, forbidding cows (to trespass)."

This also is an inscription of Taya belonging to a different period from that of the first Pimo, which is the Etruscan or old Basque numeral "one," and may here mean *princeps*, replacing the former Mama and Goma. The inscription is imperfect, the word "to trespass," "to pasture," "to seek shelter," being doubtless defaced as is often the case with prohibitory notices. This is not the only inscription relating to cattle, which appear, in ancient times to have constituted the chief wealth of the islands.

The remaining documents that are legible are from the island of Hierro, the smallest and most westerly of the group, where the Iberic element seems to have been in greatest force, and whence, in all probability, it migrated to America.

INSCRIPTION IV.

This is to be read in the same way as the foregoing:

ma	bi	
sis-a	ma	al
la	ku	

Machisala Bimaku al.
Machisala Bimaku power.

"Machisala, the potentate of Bimbachos."

Dr. Bethencourt says that the aborigines of Hierro were called Bimbapes. In the inscription, one Machisala, perhaps *motz-zale*, "the Shearer," is made Lord of a place called Bimaku. Such a name as Bima or Bimaku would have no chance of surviving as such on the lips of Latin peoples, but would undoubtedly be strengthened into Firma or Palma.

INSCRIPTION V.

This brief document is to be read horizontally, from left to right:

ga no be ta.
Ganibeta.
"Knife."

In the writer's article on "The Oldest Written Records of the League of the Iroquois," in Vol. VI. of the Transactions of the Institute, p. 260, he has translated a Sinaitic inscription of the nineteenth century B.C., which reads: "Hadad, lord of the whole earth, son of the metallurgist, the noble Bedad," in which "metallurgist" translates *ganibeta*. Never dreaming of finding the name or title in the Canaries, he wrote: "This is undoubtedly the Hadad, son of Bedad, of Genesis xxxvi., 35, 36, who succeeded Husham in the range of Hor, and smote Midian in what afterwards became Moab. The name of his city was Avith, that is to say, Abydos in Egypt. His father, Bedad or Beda, he calls the metallurgist, as one who was among the first to work the mines of Arabia Petraea. The modern Japanese name for a metallurgist is *kane-fuki*, but the ancient Hittite term for smelting was *beta*. The remarkable thing, however, about the word *kanebeta* is that it is the original of the English *knife* and French *canif*, which were derived from the Basque *ganibet*, a knife, the meaning of which in old Hittite days was simply 'smelted or manufactured metal.'" M. Van Eys suggests a derivation from the Provençal *canivet*, but the debt is plainly the other way. As the writer has indicated elsewhere, (The Nations of Canaan; *Presbyterian College Journal*, November, 1900, pp. 10-13), the Hebrew Hadad is an attempt to render the Basque *Otadi*, which means a field of gorse, broom, or whin. In Egyptian, an equivalent leguminous plant was called *usert*, the *osiritis* of Pliny, and, with the addition of *sen*, a tree or shrub, gave name to the Usertsens of Abydos, famous Pharaohs of the so-called twelfth dynasty (Brugsch, Egypt under the Pharaohs). These Usertsens were Hadads or Otadis. A body of their tribal descendants arrived in Britain at some pre-Christian period, and were known to the classical writers, drawn upon by Richard of Cirencester, as the Ottadini, who dwelt along the borders of England and Scotland. Their ancient traditions formed the subject of the "Gododin" of Aneurin, a famous Welsh bard. A lordly offshoot of this family remained behind in Anjou in France, till, in the twelfth century, their chief, Geoffrey, married Matilda, Queen of England, and brought into that country the royal line of the Otadis, Usertsens, or, in Latin speech Plantagenistas (which are words that perfectly translate the former) to become the Plantagenets, from whom, in the female line of John of Gaunt, His Gracious Majesty King Edward in part descends. In translating two of the already published Hierro inscriptions, Nos. XVI. and XXI. of M. O'Shea, the writer mistook the value of two characters and rendered by *Osata* what should have been *Otadi*. The person so called in No. XVI., is termed "the Son of Tane, King of Amahetzio."

In the persons of Ganibeta and Otadi, this family must have been fully domiciled in Hierro, and this will account for the number of inscriptions in that island. Ganibeta and Otadi belonged to the Hamathite, Beerothite, or Kenite stock, who were, *par excellence*, scribes (I. Chronicles II., 55), and who wrote the inscriptions of Arabia Petraea called Sinaitic. As Hamathites, they are represented by the greatly cherished name of the Japanese, *Yama-to*, or "The Mountain Door," as well as by the Amoxoaquis of the Mexican Toltecs, and the Amautas of the Peruvians, who were their wise men, for the synonymous word Kenite is derived from the Japanese *Ken*, "intelligent, clever, wise." These scribes must in part have accompanied the Zerethites or Toltecs of the Canaries, both in their migration thither, and afterwards to America; for, not only were the sages of Peru called Amautas or Hamathites, but also the word Amauta enters into the composition of no fewer than eleven names of the Incas given by Montesinos. While the original word Hamath undoubtedly meant the same as the Japanese Yama-to, the Mountain Door, from the application of the term to scribes, it came to denote a book or library, as in the Akkadian forms *sumuk*, *samak*, the Japanese and *Loo-Chooan shomotsu* and *shimutzi*, and the Mexican *amox*, whence the wise men or Amoxoaquis.

It is worthy of note in this connection that Berothai, the Syrian capital of a Hadad-ezer or Ben-Hadad of this race, leads back to an ancient Hittite Beeroth, named evidently after Beeri, a father-in-law of Esau, whose wife was Bashemath, and his daughter Judith or Yehudith. Homer and the Greek dramatists have preserved the eponym of Beeroth as Proteus, the old man of the sea; his wife Bashemath as Psamathe, and his daughter as Eidothea. Beeri, the father of Bedad and grandfather of the first Hadad, or Usertsen of Abydos, gave name to the Bharatan race of India, celebrated in that famous epic, the Maha-Bharata, of which Yudhish-thira or Hadad-ezer is the principal hero. The Parthians of the Persian Empire were the same race, and their kings, Tiri-dates, bore the name with inversion of parts. In Welsh history the well-known word Brython has nothing to do with the Cymri or any other Celtic people, and as certainly has no connection with the Sassenach. The Brython were Iberic Picts, in other words, the Ottadini. There are two curious passages, in the poems of Taliesin, the Welsh bard, and in one by an anonymous author, which seem to point, not only to an Iberian connection of the Welsh, but to the fact that the Iberians were their instructors in mythology and many things beside. In his Angar Cyvyndawd, Taliesin says:

"Tracthator fyngofeg,
Yn Efrai, yn Efroeg."

Davies translates this in his "Mythology of the British Druids": "My lore has been declared in Hebrew, in Hebraic." The other poem, entitled The Praise of Lhudd the Great, contains the following passage in a foreign tongue, which Davies thought might be Phoenician:

"O Brithi Brith oi,
Nu oes nu edi,
Brithi, Brith anhai
Sych edi edi eu roi."

This the writer turns into more modern Basque form as follows:

"O Brithi, Brith oi,
Nu o-etsi, nu adi:
Brithi, Brith anai
Zac adi, adi au arau."

This is more Etruscan than modern Basque, and means:

"O Brithi, associate of Brith,
Pay attention to me, hear me:
Brithi, brother of Brith,
Do thou hear, hear this measure."

Either Brith or Brithi, besides being Proteus, the sea-deity, and the Indian Bharata, is the Brutus of Geoffrey of Monmouth, and of the Brut d'Angleterre. His original sanctuary or oracle was called Beeroth. The Viscomte Chasteigner applied to the writer last winter (1899), for the derivation of the name Biarritz, which he had traced back in various forms of orthography as far as 1186. After much study, its original was found in Beeroth, derived from *Be-ur-i*, or "he of the great water or the sea," as *Be-ur-ots*, "the sound of the great water," or as *Be-ur-itz*, "the speech of the great water." It was at first, doubtless, an oracle of the Ottadini, whose name Pliny disguises as Oscidates, and places in the vicinity of Biarritz. Such is the long excursus to which the simple mention of Ganibeta has, it is to be hoped, not unprofitably led. It remains to observe that Amahetzio, the city of Otadi, son of Tane, has a Hamathite, or, Peruvianly speaking, Amauta look. In the Etruscan inscriptions is found the equivalent of the Japanese *shomotsu* and Mexican *amox*, "a book," which is wanting in modern Basque, namely *ezaumcka*, in the compound word *egin-ezaumcka*, which translates the Latin Volumnius, "a book maker." This is virtually the Akkadian *sumuk*, *samak*, "a library."

INSCRIPTION VI.

This also reads horizontally from left to right; it is of no historical importance.

be ha tu de be
Behatu debe
to look forbid

"It is forbidden to look."

INSCRIPTION VII.

It follows the order of Nos. II. and III.

au	ai
arbe	ta
ma	arbe
	ma

Au Arbema aita Arbema.
This Arbema father Arbema.

"Arbema, the father of this Arbema."

The name of father and son may be *Arpimo*, "the first in front." Hittite names generally descend from grandfather to grandson.

INSCRIPTION VIII.

It reads like No. VII.

arbe	ta	ma
sis-a	bera	
sama		

Arbe esatz asma Tabera ema.
Arbe spoken indication Tabera gives.

"Tabera gives a sign of speech to Arbe."

M. O'Shea's No. XVII. mentions Tabera, whose name, accompanied by the figure of a turtle, suggests the modern Basque *chaberama*, the turtle or tortoise, and the Iroquois *anowara*. He is made the father of three chiefs, Ola, Mamaye, and Machi. Ola's son was Temane; his, Maneta; and Maneta's Olaochita or Ahaluste, in whose time the Roman envoy Lamia visited Hierro. This lapces Tabera four generations before that event, and if Arbe be his progenitor, as is probable, this must be a very ancient monument indeed.

INSCRIPTION IX.

This reads from left to right in both lines, save in the case of the solitary subscribed character at the end of the first:

ma mu ta ma i ta ta mo
be
si ta si ta tu
Mamuta mai Tatamobe Chitachi edatu.
funereal tablet Tatamobe Chitachi erects.

"Chitachi erects a sepulchral tablet to Tatamobe."

A name like Chitachi is Chisetachi of M. O'Shea's No. XXIII. It may connect with *chichtatu*, *sistatu*, *sistatze*, "to pierce, strike with a pointed weapon." Chisetachi erected a monument to Chioko. Tatamobe may be *edat-ambe*, "great extent," or it may connect with *tumpa*, "the sound made by a slight blow."

INSCRIPTION X.

This is to be read perpendicularly:

be ma
la ka
Bela-maka.

"Bela-Maka."

Bela-Maka or Maka-Bela is a common Hittite name, found on the Mound-Builder tablets of Davenport, Iowa, as Wala-Maka and Maka-Wala. Its first appearance in history is in Genesis xxiii, 9, 17, 19, where it has the form Machpelah. It thus appears to have been a Zocharite or Teucrian name, rather than Zerethite or Dardanian. In the form Belamaka it may possibly relate to that strange Basque word *palanka*, *palenka*, "bar of iron." The Japanese *maki-wari*, an axe, suggests some form of the Basque *maka*, *makatu*, to strike, in connection with *makilla*, a stick, as if it had been originally *mak-pilla*, a striking instrument.

INSCRIPTION XI.

To be read perpendicularly and from the left :

sipisai		
si	ma	3
bara	ma	u
at	ma	ma
ta	te	ri
	mara	

Ichpichoi Sibara atita Mama ema Temara 3 umerri.
In tribute Sibara holder Mama gives Temara 3 young cattle.

"Temara gives Mama, the lord of Sibara, three young cattle in tribute."

Mama has appeared in No. II. as ceding Taya to Goma. Here he occupies the position of a chief of feudal rank, to whom Temara is subject. The estate or kingdom of Mama was Sibara, perhaps derived from *sapar*, a bush, *zembera*, thickets, with reference to the nature of the land.

INSCRIPTION XII.

This is read in the same way :

te	go
ra	sasa
au	ma
ra	i
ma	pi
	mo
	i

Tera aur ema kosatze mai Pimoi.
Tera child gives inscribed tablet Pimo to.

"The child of Tera gives an inscribed tablet to Pimo."

Tera may be *Ateri*, the sheltered or serene. Pimo is the Etruscan numeral one. It may be that Tera or Ateri's son's name was also Pimo, and that the Pimo of the inscription was his grandfather.

INSCRIPTION XIII.

Reads as the preceding:

	o
	pisa
pi	ma
mo	bi
	sisa

Pimo Opisama bizitza.
Pimo Opisama inhabiting.

"Pimo, the inhabitant of Opisama,"

It is more than probable that this is the Pimo of No. XII., and that Opisama should be read *obi samatz*, the vault, or literally, "the court of the grave."

INSCRIPTION XIV.

Follow the same order, but see final u-ma-ri.

		ma	bi		
	be	masi	si	3	ri
o	al	au	sa	u	ma
si	ar	ka	te		
ko i	te	ra			
ai ta					

Otsekoi aita be Alarte ema emaitz Aukara bizitzate 3 umerri.
Otsekoi father under Alarte give present Aukara inhabitants 3 young cattle.

"The inhabitants of Aukara give a present of three young cattle to Alarte, under the father of Otsekoi."

It is possible that *aitabe* is one word and the same as the modern *aitaba*, grandfather, in which case the Inscription would read "to Alarte the grandfather of Otsekoi," The names are all significant. Aukara is evidently *Aukera*, the choice, rather than *okher*, oblique, or *ukhur*, leaning forward. An instance of the use of the word "choice" in geographical nomenclature is Rogelim in Gilead (I. Samuel, xvii, 27, etc.), which is the Gaelic *rogh-eallamh*, "the choice of the flock." Alarte is the holder of power or authority, and Otsekoi is the ambitious, literally, "desirous of fame."

I

a.- T.IEPFSEPMERI ✠

b. EAFM ✠ IRENINI ✠ FMEAREI ✠

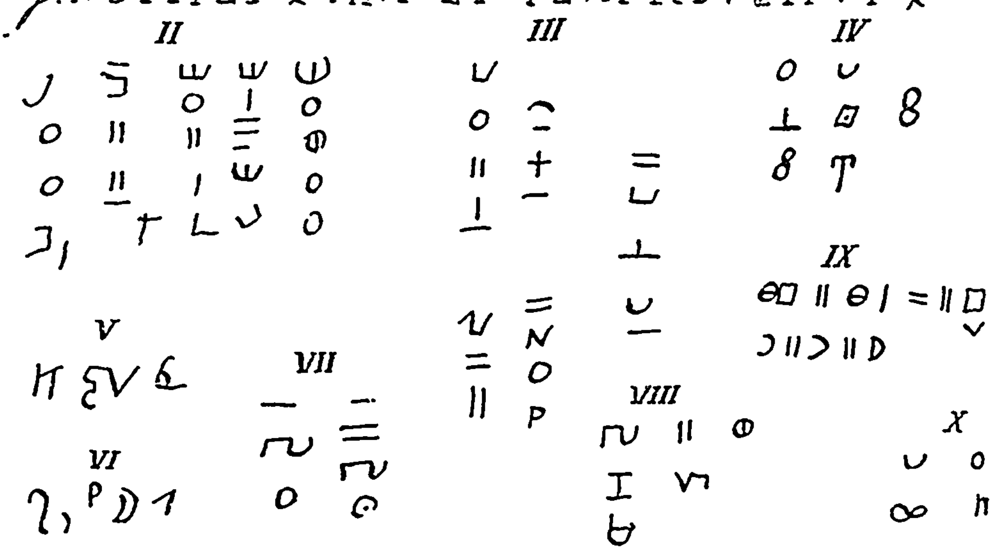
c. LPVRINENIPEPNIFANT ✠

d. MARMPRLMOTARE.

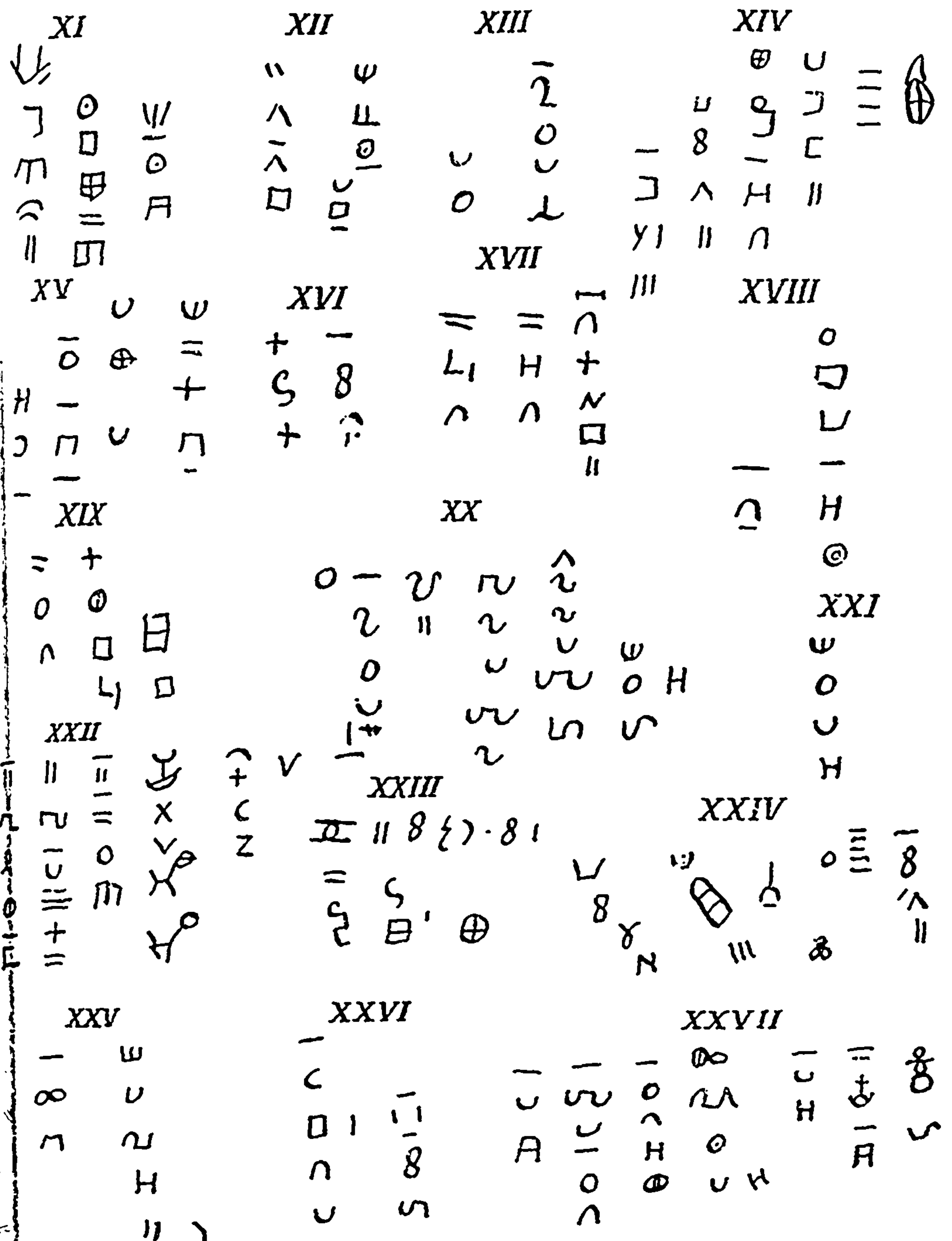
e. OLM ✠ INRANER ✠ IAEBNPEM ✠ RFVEN ✠ NV-
-INA PIMIIFINVIIPI ✠ NIPIAN ✠

f. FVPMIRNA ✠ ENVPMTI ✠ ERNMRIR ✠ VRVIVIN-
-RN ✠ APVIMERI ✠ PIVNIAN ✠ NTRIIN ✠

g. NBIMEI ✠ ANNEI PERFMIV[illegible]IFVF ✠



INSCRIPTIONS.



INSCRIPTIONS.

INSCRIPTION XV.

Follows the same perpendicular order:

				go
		·	pi	ti
		au	mo	tu
	ka	ma		
pi	si	i	be	
mo	i	ar		ar
ma		au		au

Pimo ema Kasii au mai arau: Pimo be goititu arau.
Pimo gives to Kasi this tablet suitable: Pimo under erects suitably

"Pimo gives this fitting tablet to Ikasi: the underling of Pimo correctly sets it up."

This is evidently an earlier inscription than No. XIII., which commemorates the death of Pimo or the first. Ikasi, the learner, has no other memorial. The postposition *be*, under, below, is probably the shortest name in the world for a servant.

INSCRIPTION XVI.

In the same order:

da	au
no	la
da	ra
	te

Danda au Alarte.
Tribute this Alarte.

"The tribute this Alarte (gives, receives, etc.)."

In No. XIV. Alarte, the grandfather of Otsekoi, receives the tribute of Aukera. This may be another record of such feudal dues, paid on a different occasion. The document is imperfect.

INSCRIPTION XVII.

The order of reading is the same:

		au
it	te	ra
saha	ka	de
ra	ra	ka
		ma
		te

Itzahar Tekara aur Deka mate.
Itzahar, Tekara child Deka King.

" Itzahar, son of Tekara, King of Deka."

The word for king is the equivalent of the Japanese *mi-to*, *mi-kado*, the honourable door, or sublime porte. In Basque it would be *mi-ate*, an abbreviation of *mira-ate*, the admirable door. The Basque *ate* and the Japanese *kado*, are probably the original of the English "gate," and cognate words in other languages, including the Gaelic *geata*. Lexicographers are almost absolutely ignorant of the extensive Iberic element in all Indo-European and even Semitic languages. There are also debts the other way, as in the Basque *pan-toka*, a pile of stones, and the Japanese *ban-jaku*, a boulder, in which *pan* and *ban* are not native words, but ancient survivals of the Semitic *eben*, a stone, denoting former intercourse with Hebrews, Assyrians and similar orientals. Itzahar means "the old ox," which, in Turanian nomenclature, is not remarkable. Sitting-bull belonged to the same race. Even in Celtic, the Babylonian Sin-Gasit, who is the original of the British legendary Hen-gist, is *sean-gaiscidh*, the old warrior, a name which he no doubt received as a child. Tekara may be the Basque *zigora*, the rod, scourge, etc. Deka again may stand for *ideki*, open.

INSCRIPTION XVIII.

In perpendicular or Japanese order:

	ma
	ma
	be
au	ha
ra	ka
u	ma

Au arau Mama beha Kama.
This right Mama regards Kama.

"Kama thus suitably shews regard to Mama."

The name Mama has already appeared in No. II., an inscription not of Hierro, but of Canaria, where it is combined with that of Goma, a word not unlike Kama or Gama. Canaria is a considerable distance from Hierro, but the multitude of its inscriptions, as compared with other islands, suggests that Hierro may have been chosen by the Iberic aborigines as their place of sepulture, and thus that the Mama and Gama of this inscription are the Mama and Goma of No. II.

INSCRIPTION XIX.

Read in the same way:

te	de	
ma	ma	
ra	ma	al
	sai	ma

Temara Dema Masai ai ema.
Temara tribute Masa-to power gives.

"The tribute of Temara gives sovereignty to Masa."

The name of Masa does not occur elsewhere, unless it be in M. O'Shea's XXII., in which the Roman Lamia is called a Masa, Basque *mesu, mezu*, envoy. Instead of Masa as a proper name, one might read *mezui* "to the envoy" or Lamia, which would relegate the inscription to the early days of the Roman empire. Temara has already found mention in N . XI., as the tributary of Mama, lord of Sibara. Temara may be *zamari*, the horse, or *zamar*, the crab. In Japanese *temari* is a hand-ball.

INSCRIPTION XX.

Reads like the preceding, but has lacunae or partial defacements:

				ra		
ma	i	bi	rabe	no		
	no	te	no	no		
	ma		be	be	go	
	be		berabe	berabe	ma	ka
	ha		no	sari	be	
	au					

*Mai anoma beha au bite * * * * rabe no Beberabe no ranono Beberabe zari Goma beka.*

Tablet contributed regards this envoy * * * * *rabe* of Beberabe of towards Beberabe commander Goma chief.

"The contributed tablet regards this envoy (bitezar) * * * * (a tribute) towards Beberabe: the commander Beberabe, chief of Goma."

This imperfect inscription seems to relate to a military man and an envoy, so that, instead of, "the chief of Goma" standing in apposition to him, the words may denote the giver of the tablet. The writer knows of no Basque or Etruscan name or word like Beberabe, but as Bibi-rube, it is just what an Etruscan document would turn the Latin Vibius Rufus or Rufinus into. There was a C. Vibius Rufinus in the Roman consulate 22 A.D., to whose family the supposed *bitezar* or envoy may have belonged, although his date would suit the time of one at least of the Lamias.

INSCRIPTION XXI.

go
ma
be
ka

Goma beka.
Goma chief.

"The chief of Goma."

Unfortunately, the name of the chief is lost.

INSCRIPTION XXII.

u	at	u	be	ar	be
da	erbe	da	hei	di	
beri	o	ha	tu	za	
al	bi	te	de	no	
ma	a	am	be		
u	te	bera	mopira		
sa	da		mopira		
	te				

Udaberri al ema osa atherbe obi ate edate: udahate ambera beheitu debe mopira mopira ardizain be.

Spring power gives overseer shelter cave door extend: summer more than lower forbids eight eight shepherd under.

"In spring, the overseer gives authority to open the door of the cave shelter: in summer he forbids to lower (into it) more than eight (times) eight, under a shepherd."

The inscription, which does not contain a single proper name, is the best test of the correctness of the method of interpretation.

INSCRIPTION XXIII.

This reads horizontally, from left to right, with a slight variation :

simasa	te	la	no	si	le	ya
te						
	no					
no	ma i		ma			

Chimasa Tela nausi, Leyate non mai ema.
Chimasa Tela lord. Leyate, who tablet gives.

"Chimasa, lord of Tela, Leyate who gives the tablet."

Talaya, by some derived from the Arabic, denotes "a look out on the coast;" Chimasa may be a form of *zematu*, to threaten, meaning "the menacer," and Leyate signifies "the zealous."

INSCRIPTION XXIV.

This irregular inscription is to be read in the main perpendicularly :

be	go		am 5	a
la	ramama	o		hal
ma		ro		ure
ka	ai ta	i	3	te

Belamaka Goramama aita oroi 5 amar 3 ahal urte.
Belamaka Goramama father remembers 5 tens 3 power year.

"Belamaka, the father of Goramama, remembers fifty-three years of authority."

The name of this aged sovereign appears alone in No. X. His son's may be *gora-mama*, "the exalted spirit."

INSCRIPTION XXV.

o	go
le	be
ro	arpe
	ka
	te i

Olero jabe Arpekatei.
Olero lord Arpekate to.

"To Arpekate, lord of Olero."

Olero or Oloro invites comparison with Oleron or Oloron in the Lower Pyrenees. Arpekate is, perhaps, a verbal form of *erpeka*, a stroke of the claws, meaning "to claw."

INSCRIPTION XXVI.

Also, with one variation, perpendicular:

o	
sa	ai
ma i	ta
ar	i
be	al
	beri

Os[illegible]mai Arbe aitai Alberri.
Pays-attention tablet Arbe father to Alberri.

"The tablet honours Alberri, the father of Arbe."

Arbe appears in No. VIII., as one of the oldest of the kinglets of Hierro. Alberri, his father, furnishes a still higher antiquity. The name may mean as it stands "new authority." It is not at all likely to be *alfer*, lazy, *alabere*, similarly, etc., but it might easily be *elbarri*, the crippled, lame, *ilberri*, the new moon, or *ilbera*, the waning moon.

INSCRIPTION XXVII.

Perpendicular, like the last:

a	a	u	le	o	te	
be	berabe	me	rosari	be	da	al
re	be	ri	mo	ka	tu	me
	u	ka	pi ka		a	na
	me	ma			ri	
	ri					

Abere aberabe be umerri: umerri kama lerrozarri mopika: obeka athedatu ari almena.

Cattle tread under lambs: lambs shepherd place-in-order by twos: better take away ram virility.

"Cattle tread under the lambs. The shepherd will place the lambs two in a rank. It is preferable to deprive the rams of their virility."

This last inscription is worthy of comparison with No. XXII., both denoting, not only the existence in Hierro of a pastoral Iberic population, but also that of a population whose humble class of shepherds was able to read such engraved notices. This seems to indicate that education was general in the islands, or at least among the Iberians in them, before the Christian era, and in the early Christian centuries. Can it be that all their writing was confined to rock faces; or had they, as Strabo asserts regarding their congeners, the Turdetani of Spain, books and parchment documents, containing, among other things, an account of their eventful history? Everything tends towards the suspicion that they once had such memorials, which may not all have perished. Librarians and similar custodians pay little attention to documents which they cannot read, and can, therefore, neither class nor catalogue. The question is worth asking, not only of archivists in the Canary Islands, but also of the same in Spain, southern France, Italy, and north-western Africa, whether a little research may not bring to light important historic facts concerning a race that has played no small role on the stage of the past.

GENERAL VOCABULARY.

COMPARING THE CANARY ISLAND DIALECTS WITH IRISH-GAELIC, WELSH AND BASQUE: I., W., B.

aala, alamen,	water,	lo lua, uaran, I. ur B.
abara, abora,	god,	adbar, adbal I. *cause*; peryf W. *creator*.
abimbar,	to throw stones,	beim-bair I.
acaman, achaman,	highest god,	acmhaing I. *puissance*.
acano,	lunar year,	eigh I. *moon*, cann I. *full moon*, eang I. *year*.
acaman,	sun,	huan W., samh I., shems Arabic.
achacae, chacais,	rock pools,	cuas I. *cavity*.
achahuaran,	great god,	aigh-urraim I. *upholding power*.
achemen,	milk,	segh I. *milk*, seghamhuil I. *milky*.
achic,	son, descendant,	ac I., esil W.
achicaxna,	peasant, clown,	gwasan W.
achicuca, aguahuio,	illegitimate son,	ac-cuig I. *secret son*.
achijerres,	trifles,	ceirriach W.
achimaya,	mother,	iog, iogain I.
achimencey,	noble,	acmhaingeach I.
achjucanac,	supreme god,	uchaf, uchbenaeth W.
achjuragan,	god and lord,	uachdarach I., udd-dragonoll W.
achormaza,	green figs,	boccore Arabic.
acoran, achoran,	god,	crom I.
acucanac,	highest god,	aige-ceannach I., *the upholder of authority*.
aculan,	fresh fat,	agalen W. *lump of butter*.
adago,	goat's milk,	at I. *milk*.
adarg,	shoulder (of rock),	otir I.
adargomo,	arm of rock,	otir-gob I.
adarno,	tree,	udarondo B. *pear-tree*.
aemo,	water,	aw W., amh, amhan, en I.
afaro,	corn, grain,	bar I.
aguayan,	dog,	cian W.
ahicasna,	son of plebeian,	gwesyn W., oganach I.
ahico,	dress, skin shirt,	gwisg W., haik Arabic.
ajerjo,	torrent,	easar, easard I.
aho, ahof,	milk,	as, ceo I.
alcorac, alcoran,	god,	uileghlic I. *all-wise*, uilecoireach I., ollgwyr W. *all-just*.
algarabana,	wheat and barley,	iolach-arban I. *mixed grain*.
alio,	sun,	haul W.
aljereque,	narrow wall,	cul-gwyrch W.
almogaren,	temple,	armighthear I. *sanctified*, airmhidh I. *vow*, airmhidin I. reverence.

almogaroc,	adoration,	ermygiad W., urnaighe I, *prayer*, iarrata I. *asked.*
altacayte,	brave man,	lath-cathacl I. *war-champion.*
altaha,	brave man,	lath I., lluyudwr W.
althos,	god,	alla, alladh, alt, art I.
amago, umiago,	sacred mount,	myg W. *sacred.*
amodagas,	sticks sharpened with fire,	maide I. *stick*, miodog I. bidog W. *dagger.*
amolan,	butter-cake,	eim-aran I.
ana,	sheep,	oen W., uan I. *lamb.*
anepa,	lance,	omna I.
anthaa,	brave man,	niadh I. *hero.*
antieux,	house,	anedd, W.
antraha,	man,	anra I. *mean men.*
ara,	goat,	ari B. *ram.*
aramatonaque,	barley cakes,	eorna-taoisnighthe I.
archormaze,	green figs,	bokkore Arabic.
arguna,	saddle bag,	bolgan W.
aridaman,	flock of sheep, etc.,	airmheadh I, *herd of cattle*, altain I, *flock*, porthmon W. *drover.*
artamy, arteme,	chief, prince,	ardmhaor I. *chief magistrate.*
asidir-magro,	invocation to God,	magh-adraidh I. *field of adoration.*
asitis-tirma,	invocation to God,	aitchim-trom I., *I beg for protection.*
atguaychafortanaman,	he who holds the heavens,	adh-se-a-cabhairt-neamh I. cymhorth-nef W.
atinavina, atinaviva,	hog,	aitheach-ban I. *sow*, hob W.
atis-tirma,	cry of surrender, invocation to God,	aitchim-trom I., *I beg for protection.*
auchones,	connections of caves,	uaigh, uaighneach I, *cave.*
auchor,	cave dwelling,	ogof W., coire I.
azamotan,	barley bread,	haidd-miod W. *barley cake.*
axa,	goat,	seaghach I. *he-goat.*
axe, xayo,	mummy,	ecc, echt I. *dead.*
azarquen, tacerquen,	syrup of mocanes,	deasguin I. *molasses, etc.*
babilon,	*nickname of Tenerife* child,	buibiollan I. *coxcomb.*
baifo,	kid,	beag-boc I., bitika B.
balma,	cloud, veil,	beala I.
belete, beleten,	first milk,	flaith I.
benesmen,	harvest,	pen-cywain W. *first harvest.*
benesmer,	August,	beinn fomhar I. *first harvest.*
bimba,	round stone,	beim I. *to strike.*
bochafisco,	roasted grain,	poeth-plisgo W., bocht-blaosg I.
borondango,	butter-cake,	barachdaen W. *bread and butter* barantionsan I.
bosigaiga,	el pene (Spanish),	biach I., potzuak B.
burgado,	shell-fish,	bylchiad W., murac I.
cancos,	priests of medium rank,	carnach I. *heathen priest.*
cariana,	rush basket,	crannog I.
cariano,	large bag,	crannog I.
carabuco,	*earthen jar with handle*,	*cailphig I.*
carabuco,	male goat,	culbhoc I., bwch-gafr W.
casjua,	the cud,	athchagnadh I.

cel,	moon,	gealach I.
cela,	month,	gealach I.
chabogo, chaboigo,	cavern,	ogofawg W.
chabor,	royal palace,	sabhal I. *granary, storehouse.*
chacanisos,	feet,	cos I.
chafija,	debility,	afiechyd W.
chacares,	castanets,	cliciwr W.
chafariles,	rock pools,	tiobhar I.
chajaco, chajasco,	litter, bier,	caiteach I. *winnow sheet.*
chajaija,	dark colour,	gwywgoch W.
chajajo,	corpse, dead,	aisc, eag, oighidh I.
chajinasco,	cumular clouds,	eachanach I. *stormy.*
chalafusco,	crevice in mountains,	scalp I.
chamato,	woman,	cyffoden, cymones W., gamh, caomhog, coint I.
chayofa,	nose,	comar, comhor I.
chede,	limit, boundary,	chede B.
cherga,	belly,	croth W., cilfin I.
chescaro,	mean, penurious,	cagaltach I., cyrrithus W.
chibichibi,	a game,	gogampau W., subha I.
chibusco,	rope,	suag, sioman I.
chichiciquico,	squire,	gaisgidheach I.
chihisquico,	cavalier,	gwych W.
chilhisquizo,	squire,	giollasguain I.
chinea,	lower hell,	anwn W.
chinichibito,	change of pasture,	cyfnewydiad W. *change.*
chiribito,	ear mark on cattle,	cearbhach I. *ragged, torn,* clustnod W.
chirrimile,	small helix,	cregyn W., creachan I.
chirripota,	pubescent girl,	gwryf W.
chiscano,	bone,	seic, asna I., asgwrn W.
chiscanado,	bony,	asnach I., esgirnig W.
chivato,	kid,	gabhar I. *goat,* giden W.
ciguena,	female goat or ewe,	ceathnaid I, *sheep.*
chocos,	chips of wood,	casnaig I., coed W. *wood.*
coran,	man,	gwr W.
coruja,	red owl,	sgreachog I.
cotan,	man,	cathaidhe I. *warrior.*
creses,	beech-nuts,	grech, creachach I.
cuna,	dog,	cu I., cian W.
cuncha, cancha,	little dog,	cynos W.
cuteto,	piebald animal,	caideacha I. *spotted.*
datana,	war cry,	deodhann I. *by God's help,* a gagan Dduw W. *god grant.*
debase,	idler,	taimheach I.
eccero,	limit, boundary,	cwr W.
echeyde,	hell,	avagddu W.
efequen,	place of worship,	impuighim I. *pray.*
embrosear,	poison water,	amh-briosog, rossachd I.
enac,	night,	nos W.
ere, eres, erales	fresh water holes,	feirsde, earc I.
esmira,	bee-hive,	smeraighe I. *swarming of hive.*
esquen,	house,	iosdan I.
estafia,	to beat,	asti B.

fagayo,	teat, udder,	boig I., piw W.
faira,	round stone,	bair I., bwrw W.
faisca,	spark of fire,	bacht I.
faita,	treason,	brad W., fionaih I.
fayacan,	governor,	peneun W.
fayeao,	priest,	*faigh I.*
faysage,	councillor,	feasach I., *knowing, skillful.*
		fasuigheadh I., *knowledge of law.*
fe,	crescent moon,	fas I., *cresent, growing.*
firaneas,	gray,	bracach I.
firanque,	beetle,	primpiollan I., chwilen W.
fol, fole,	big bag,	bolg I.
furna, furnia,	abyss.	uffern W., ith frionn I.
gabio,	evil spirit,	siabhra I.
gabeit, gabiota,	devil,	siobradh I.
gagames,	appetite,	geogamhail I.
gahuata,	devil,	sighidh, siogidh I.
gaire, gayre,	war-councillors,	gearait I., *prudent.*
galiot,	devil,	*goilline I.*
gama,	enough,	cmyhwys W.
gambuesa,	shed for wild cattle,	gabhann I., *a pound.*
ganigo, guanigo,	earthen pot,	cunnog W., *cuinneog* I.
ganofa,	generous,	hynaws W.
gara,	island, rock in sea,	sgeir I.
garajao,	water fowl,	cureag I., gwyach W
garepa,	chip, shaving,	sgealp, sgolb I.
garepa,	spark,	gwraich W., caor I.
garfa,	lance,	gearrgath I., gwaywffon W.
gocho,	little yard,	cata I.
gofio,	porridge,	sopa, zopa B.
gongo,	hole,	ionga I.
goran,	yard,	cro, cru I.
goro,	circus, arena,	chwareufa W.
gouro.	little yard for kids,	cal, corlan W.
groja,	laughter,	*gaire I., chwardd* W.
gua,	son of,	ua I.
guacaeque,	jug of measure,	cuachog I.
guacaros,	bettle,	chwil W.
guachafisco,	reduce to powder,	creafog I.
guaclo, juaclo,	natural cave,	ceule W., iseal I.
guague,	measure,	cuachog I.
guaire,	noble,	guaire I., gwerlin W.
guamf,	man,	ymbaffiwr W., *fighter.*
guan,	son of,	gein I., cenaw W.
guanac,	estate,	ceannas I.
guanac,	republic,	ceannach I.
guanaja,	devil,	einioes W.
guanarteme,	king,	ardmhaor, airdimnhe I.
guanhot,	favour, gift,	cymhorthi W.
guanoco,	weak, infirm,	gwan W.
guanoth,	steward of estate,	ceannart I.
guanil,	wild cattle,	agh I., *cattle,* anial W., *wild.*
guapil,	skin cap,	cwflen W., caba, caibin I.

guardaseme,	king,	airdcheim I., *eminence.*
guarirari,	who anchors the world,	accaire I., heor W., *anchor.*
guatatiboa,	national festival,	eisteddfod W.
guaya, iguaya,	spirit,	sia I.
guayca, guaycos,	buskins,	asacheos I., gwentas W.
guaycas,	sleeves,	cuachog I.
guayafacan,	co-adjutor of governor,	cympencun W.
guayfan,	co-adjutor of governor,	cympen W.
guayere,	populace,	gwerin W.
guayoto, huayota,	devil,	sigidh, gosda I.
guijon,	ship,	cwch W.
guirre,	vulture,	buri W., gairrfhiach I.
guisne,	pudenda,	caise I.
gurancho,	cave for animals,	gurna I., cor-ychain W.
gurgusiar,	to cry,	gairgala, golghair I.
gurgusiar,	to examine, pry,	chwilgar W., cuartughadh I.
hana,	help,	anaice, congain I.
hara,	ewe,	caora I., *sheep.*
harba,	loan,	airle I.
harhuy,	sheep skin,	caorach I.
harmaguade,	vestal virgin,	er-maighdean I., *noble virgin.*
hecheres hamanates,	councillors,	agarach comchaint I., uchreithwr cymanfa W.
herguele,	shoeing,	archeniad W.
hero, herez,	cistern,	fuaran I.
hirahi, hiragi,	heaven,	earc I.
huirmas,	large sleeves,	llawes W.
ife,	white,	aoibhe I., *fair*, abead Arabic.
iguanoso,	weak, infirm,	egwan W.
iguaya hiraji,	god of heaven,	sia erc I.
ilfe,	hog,	lia I., llwdn W.
irichen,	wheat,	rhygen W., *rye.*
iruene,	devil,	iarog I.
irvene,	apparition,	airidh, arrach I.
jameo,	water hole in lava,	uam, uain I., *a hollow.*
jao, josio,	term of endearment,	cu, W.
jarco,	dead,	erca I.
jeren,	shaft of mill,	garan W., seaghlan I.
jilmero,	rod fishing from the shore,	genweirio W.
jucancha,	god universal,	sia-ceannach I.
jurnia,	abyss,	fuirne I., uffern W.
juvague,	fat ewe,	mamog W.
leren,	irrigation ditch,	llyr W., flirim I.
lia,	summer sun,	les, leus, lo I., *light.*
lion,	sun,	laom I., *blaze of fire.*
machafisco,	object of little value,	meas-beag I.
magado,	mace, club,	piocaid, picidh, fascut I., makatu, makilla B.
magarefo, magarejo.	tall thin boy,	mac I., *boy*, llipa W., *lanky.*
magido,	fire wood,	fagoid I., ffagod W.
mago,	Guanche,	mogh I., *man.*
maguas, magada,	vestal,	maighdean I.

mahey,	hero,	mogan I.
maho, maxo,	shoe,	mogan I., amgoesan W.
majee,	sun,	mais I., mychedin W. *sunshine.*
malgareo,	rough music,	mawlgann W.
maniota,	little bag.	mang I., amner W.
manonda,	black goat with white feet,	ban an dubh I., gwyn yn du W. *white in black.*
marona,	fried meat,	mollwyn W. *mutton*, bruin I. *stew.*
masiega,	thatch,	imseing I. *covering.*
maxio,	enchanted spirit,	mwei W.
mayan,	piece, part,	men Arabic.
meneeit,	heir apparent,	fineachas I. *inheritance.*
mesdache,	relaxation,	feisteas I.
minaja, minaj,	goat,	meann, mionnan I. *kid.*
misgan, misgano,	cat-hole,	musgan I.
moca,	javelin,	meas I., moko B. *point.*
moneiba, moreiba,	female idol,	menerbh I. *goddess of dyeing.*
malan,	buttermilk fat,	mehin W. *fat*, molchan I. *buttermilk cheese.*
naguayan,	animal, insect,	ednogyn W., snagan I.
oche, hoche,	grease, fat,	usg, iach I.
omanamastuca,	bright red,	omh aineamh dathach I. *blood stain* coloured.
oranjan,	god,	arnaigh I.
orduhy,	court, hall,	ard-tig, alladh I.
parano,	a stand,	branara I.
puipana,	white and cinnamon goat,	buidhe-ban I, *yellow-white.*
punapal,	first son,	pen-eppill W.
quebehi, quehibi,	dignity,	ceap I.
quevechi,	dignity,	gofyged W.
queviliiera,	greatness,	gwehder, cynghori W.
rapayo,	burnt ears of wheat,	erre-bihi B.
reste,	support, defence,	airchiseacht I.
sabor,	counsel, advice,	cyfarwyddiad W.
sabuco,	sharpened stick,	yspig W., cipin I.
safiro,	insect,	gwiban W., giuban I.
samarin,	priest,	seanmoirighe I.
sera,	cheese-hoop,	cor, cylch W.
serfacaera,	priestess,	seirbhiseach I. *attendant.*
sigone,	noble, leader,	seighion, soichinealach I.
sisa,	yard to attract wild cattle,	gaiste I. *trap.*
sorrocloco,	the *couvade*,	sor-acholtsu, sor-ahalge B. *care of newly-born, shame of newly-born.*
	(This is not a Celtic custom).	
sunta,	war fleet,	uiginge I.
suzmago,	dart,	saeth W., sais-macha I.
tabajo, tabajoste,	milk-pail,	tubog I. duphe B.
tabese,	cooked whey,	chwig W. *whey.*
tabite, tebite,	handled pot,	poite, poitin I.
tabona,	stone knife,	deimhne I. *edge tool.*
tabor,	royal palace,	sabair I., ysgubor W. *granary.*
tafiaque,	lancet shaped flint,	twca W., diobadh I.
tafique,	flint knife,	samhagh I, *edge*, epaki B. *cut.*

tafrique,	stone knife, lancet,	speal̇g I. *splinter.*
tafugada,	much, abundant,	hafog W.
tagoro, tagoror,	town council,	tagra I., dadllewr W. *discuss.*
taguacen,	hog,	arcain I.
taguado, taguao, taguas,	squeezing ladle,	guasg W. *a squeeze.*
tahatan,	ewe,	dafad W.
tahuyan,	skin petticoat,	hugan W., *gown.*
tajalaque,	palm leaf,	duilleog I. *leaf.*
tajorase,	goat under one year,	aos arraise I., oes cyrhaedd W. *age attaining.*
tajos,	night-bird,	eos W. *nightingale.*
tajuco,	milk-pail,	dabhach I.
talabordon,	slope against the sea,	tuilemara don I. *on account of the tide.*
tamaide,	fountain,	tiobraid I.
tamaite,	big, swollen,	ymchydd W.
tamaismia, tamasma,	sparrow,	camhuin, scamoghuin I. *wry-neck.*
tamaro,	short fur cloak,	zamarra B., ionar I.
tamarco,	skin dress,	zamarra P., sgabul I.
tamarcano,	violent blow,	tuargain I. *beating.*
tamarco,	tall vulgar person,	amrosgo W., tamhanach I.
tamarco,	large fat adder,	diamhar I.
tamasaque,	lance,	amusadh I. *attack.*
tamazen,	hog,	mochyn W.
{tamogantacoran, tamogante en acoran,	house of God,	tamhait an crom I.
tamonante,	inspired priesthood,	dewin W., deamhnoir I. *prophet*, conjurer.
tamogitin, tamogan in,	house,	tamhaighim I. *I dwell.*
tamozanona,	fried meat,	mochyn W., *pig*, muc anong I. *fried pork.*
tamozen,	barley,	tumdhias I. *bushy ear of corn.*
tano, taño,	straw basket,	toin, tonna, tonnog, tunog I.
tara, tarha, tarja,	sign of remembrance,	dere, dyre W., tarra, tarrsa I. *come thou (here).*
tarhais,	tree,	dair I., derw W. *oak.*
taro,	stone granary,	daras I. *house.*
tarqui,	call to speak,	*see* tara.
tarquis,	certainly,	deigh I.
tarute,	ambassador,	treithu W.
tasaigo, teseque,	corpse,	taise I.
tazasa,	shaft of mill,	deatachan I. *chimney.*
tasorma,	flat stone,	sarn W.
teberite,	cattle mark, ear clip,	diobhaladh I. *mutilation*, gofyriad W. *clipping.*
tebija,	little handled earthen pot,	pig, pigin I.
tefene,	roasting grain,	teibidh I. *harvest making.*
tegala,	shepherd's enclosure,	teagair I.
tazufre,	goat skin bag,	tais-cofra I.
tegue,	yellowish chalk,	dathach I. *coloured, chromatic.*
teguevelt,	ewe,	othaisg-allaidh I. *wild sheep.*
teguevita,	goat,	othaisg-fiadha I. *wild sheep.*
tehuete,	small skin bag,	tiach, tiochog, I., cod W.

teigue,	hard land,	tingh I., tew W. *dense.*
teique, teseique,	argillaceous earth,	toes W., doigh, taos I. *dough.*
tejuete,	shepherd's bag,	tiach I.
teniques,	three stones of hearth,	teinngha I. *relating to the fire,* teinntein I. *the hearth.*
teofuivite,	goat or ewe skin,	fetha-boc I.
testadal,	coloured chalky earth,	des-dathach I.
teste,	trace of animal,	deisidh I. *it sat, rested.*
teseique,	great man,	toiseach I.
tezerez,	cudgels,	tagar I. *fight,* zigor B.
tezezez,	sticks of wild olive,	zotz B. *small sticks.*
tibiabin,	priestess,	dewin-ben W.
tibibeja,	small handled earthen pot,	pibeyn W.
tifia,	correction,	cosp W.
tifiar,	to steal,	cipio W.
tigalate,	tall slender man,	teirefheolach I.
tihagan, tihaxas,	ewe,	othisc, othaisg I.
timargo,	invocation,	diomrac, I. *temple,* diamaireachd I. mystery.
timixiraqui,	measure, weight,	tomhas, toimhseacan I.
tingalate,	tall thin person,	tan-cleith I.
tirma,	sacred cliff,	drim I. trum W. *cliff.*
tisamago,	sacred cliff,	diagha-magh I. *sacred field.*
tistirma,	sacred cliff,	diagha-drim I.
titogan,	heaven,	ditin ceann I., tuddo cwn W. *covering of the head.*
tofio,	handled pot,	cib W., tupin B.
tofio, tabajoste,	cattle trough,	dabhach I.
tolmo,	land slide,	deillion I. *slide away.*
tozio,	crockery,	toes W., taos I. *dough.*
trichen,	wheat,	triosg I. *grain.*
trifa,	corn, grain,	arba I.
tufa,	ewe,	dafad W.
tujite,	little purse,	tiach, tiachog I.
urraja,	cry to scare hawks,	oergri W.
valeron,	cave of vestals,	ffau-lle-rhian W. *cave-room-virgin.*
varode,	lance,	bruidh, bioradh, morgha I.
verdone,	big stick,	buailtin, baircin, farachdach I.
xerco,	shoe,	cuarog I., archen W.
yubaque,	reed mat,	beach I.
zeloy,	son,	gille I.
zonfa,	hole, centre, navel,	ion, ionga I.
zucaha,	daughter,	oghachd I.
zucasa,	legitimate son,	ac-aicsi I. *heir.*

NAMES OF PLANTS.

aceben,	plant,	easping-ban I. *ox-eye daisy*, Chrysanthemum leucanthemum.
aciche i, haquichey,	beans, vetches,	ekosari B.
aderno,	hardwood tree,	derwen W. *oak*.
afaro, ofaro,	grain,	bar I., brachtan I., *wheat*.
agonan,	plant,	cenamh I., *samphire*, Crithmum maritimum.
aguamante,	mallow roots,	ucas-fiadhain I., *mallow*, Malva sylvestris.
aijara,	bush or bramble,	easair I. *thorn*.
aijota,	mushroom,	caochog I. *puff-ball*.
aites,	plant,	uath I. *white thorn*, Crataegus oxyacantha, iodha I. *yew*, Taxus baccata, otc B. *broom*, Genista tinctoria, aiteann I. *furze*, Ulex europæus.
ajinajo, jinajo,	bush,	conasg I. *furze whins*, Ulex europæus.
alcaritofe, algaritofe,	Cedronella canar,	lus-grafandubh I. *horehound*, Ballota niger.
alchofe,	yellow flowered thorn,	oirchiabhach I. *golden haired*.
algafita,	Agrimonia,	leatach-buidhe I. *lady's mantle*, Alchemilla vulgaris.
algarfe,	Cedronella trip,	lusgrafanban I. *horehound*, Ballota alba.
amagante,	mallow,	mil-mheacan I. *mallow*, Malva sylvestris.
amogante,	berry,	magon, bacon W.
amuley,	herb,	amharag I. *mustard*, Sinapis arvensis; amaraich I. *scurvy grass*, Cochlearea officinalis.
anarfeque,	wormwood,	mormont I. *wormwood*, Absinthium latifolium; norp I. *houseleek*, Sempervivum tectorum.
aromatan,	barley,	eorna I.
balo,	Plocamia pendula,	bhalla I. *wall pellitory*, Parietaria officinalis.
bejique, bequeque,	Sempervivum,	beidiog W. *evergreen*.
bequeque,	*ib*,	feusogach I. *bearded capillary*, Adiantum capillus veneris.
berode,	*ib*,	bythwyrdd W. *evergreen*.
beya,	plant,	bihi B. *corn*, fead I. *bulrush*, Typha latifolia; fiag I. *rushes*, Juncus; feith I. *honeysuckle*, Lonicera periclymenum.
bicacaro,	Canaria,	bascart I. *cinnamon*, Laurus cinnamonum.

bubango,	gourd,	pepog I., pompiwn W.
cadil, cail,	food plants,	cadhal, cal I. *coleworts.*
carisco,	grapes,	caora I.
chabora,	plant,	seamar, seamrog I. *clover*, Trifolium repens.
chajil,	plant,	cagal I. *cockle*, Agrostemma githago: cuisle I. *hepatica*, cucuillean I. *bed-straw*, Galium verum; casair I. *thorn.*
chajinate,	plant,	cas. hoidhach I. *haresfoot.*
chaguira,	plant,	chosgair I. *laurel*, Laurus nobilis: cocoil I. *burdock*, Arctium lappa.
chenipa,	herb,	cnaib I. *hemp*, Cannabis sativa.
cheremina,	plant,	chermen B. *pear*, goirmin I. *woad*, Isatis tinctoria; coireaman I. *coriander*, Coriandrum sativum; guirmin I. *indigo*, gorman I. *bluebottle*, Centaurea cyanus; surramont I. *southernwood*, Artemisia abrotanum; searbhan I. *dandelion*, Leontodon taraxacum.
chibusquera,	plant,	subcraobh I. *raspberry*, Rubus idaeus.
chibusco,	berry of same,	subha I. *rasp-berry.*
chilate,	graminaceous herb,	chilista B. *lentils*, seirg I. *clover*, Trifolium pratense.
cofecofe,	Chenopodium,	pigogo W. *spinach*, Spinacea oleracea; gabaisde I. *cole-worts.*
cosco,	herb,	cusag I. *wild-mustard*, Sinapis arvensis.
creses,	beech-nuts,	grech I.
garao, garse,	sacred tree,	caorran I. *mountain-ash*, Pyrus aucuparia.
garasera,	plant,	glasair I. *betony*, Betonia officinalis.
girolana,	bush,	caoirinleana I. *valerian*, Valeriana officinalis; caorogleana I. *meadow-pink*, Lychnis flos cuculi.
givarvera, hivalvera,	butcher's broom,	calgbrudhan I., Ruscus aculeatus.
golgora,	plant,	zurchuri B. *poplar*, culuran I. *birth-wort*, Aristolochia; galluran I. *angelica*, Angelica sylvestris; glasair I, *betony*, *see* garasera.
guasimo,	plant,	gaoicin I. *arum*, Arum maculatum; hasuin B. *nettle.*
guaydil,	convolvulus floridus,	codhlan I. *poppy*, Papaver; codalian I. mandrake. Mandragora.
gurman,	plant,	corrman I. *wall pennywort*, ? Sedum: gorman I. *bluebottle*, Centaurea cyanus, *see* cheremina.
haran,	fern,	ira B., chorrain I. *Asplenium.*
iguaje,	plant,	cuigeag I. *cinquefoil*, Potentilla reptans; cusag I. *wild mustard*, Sinapis.

irama,	shrub,	arne I. *sloe*, Prunus spinosa; oruin I. *beech*, Fagus sylvatica; uillean I. *honeysuckle*, Capritolium periclymenum.
irichen,	wheat,	ceirchen W. *oats*.
jarjado,	shrub,	groisaid I *gooseberry*, Ribes grossularia: curcais I. *flag, bulrush*.
jirdana,	shrub,	caorthainn I. *quickbeam*, ?. Pyrus aucuparia; crithean I. *aspen*, Populus tremula; cailtin I. *hazel*, Corylus avellana; scrutan I. *hawkweed*, Hieracium; sraidin I. *shepherd's purse*, Capsella bursa pastoris.
jopebe,	herb,	sobha I., bebog W. *sorrel*, Rumex acetosa; copog I. *dock*, Rumex obtusifolius; fib I. *bilberry*, Vaccinium myrtilus.
joriada,	Bophthalmum,	ceannruadh I., *celandine*, Chelidonium majus.
jorjal,	plant,	crostal, crutal I. *moss*.
juesco,	mallows,	ochus I., Malva vulgaris.
loro,	tree,	llawryf W. *laurel*, Laurus nobilis.
marmojarse, marmojoce,	herb,	barbog, barbrog I. *barberry*, Berberis vulgaris; borramotur I. *wormwood*, Artemisia absynthium; feoran-curraigh I. *water horehound*, Lycopus europæus.
marmolan,	mountain tree,	malabhar I. *dwarf elder*, Sambucus humilis.
mocan,	Visnia mocanera,	meacan I. *taprooted plants*, meangan, maothan I. *osier*.
mol,	aromatic shrub,	marros I. *rosemary*, Rosmarinus officinalis.
morangana,	strawberry,	mariguri B.
name, niame,	plant,	noinin I. *daisy*. Bellis perennis.
orijama,	plant,	oragan I. *wild marjoram*, Origanum vulgare.
orixama,	Cneerum pul.	raga'm I. *sneezewort*. Achillea ptarmica.
pirguan,	plant,	fraochan I. *bilberry*, Vaccinium myrtilus; bairgin I. *buttercup*, Ranunculus repens, mearacan I. *foxglove*, Digitalis.
romame,	fruit of thorn,	remhan I. *French wheat*, ? Polygonum fagopyrum.
sajira,	plant,	seichearlan, seicheirghin I. *primrose*, Primula veris.
sanjora,	Sempervivum,	sinicin I. *houseleek*, Sempervivum.
saquitero,	tree,	sgeachmhadra I. *wild rose*, Rosa canina.
sorame,	little bush,	surrabhan I. *southern wood*, Artemisia abrotanum.

tababoire, tabajoiri,	aromatic herb,	bofulan I. *mugwort*, Artemisia vulgaris; biorfheir I. *water-cress*, Nasturtium officinale.
tabaibo,	Euphorbia,	dathabha I. *hellebore*, Helleborus niger.
tacorantia, taragontia,	Dracunculus canar,	gacharonda I. *arum*, Arum maculatum.
tadaigo,	bush,	sceitheog I. *hawthorn*, Crataegus oxyacantha.
tagasaste,	Cytisus,	ddrewgoed I. *laburnum*, Cytisus alpinus.
taginaste,	bush,	giogun-ard, oigheannach I. *thistle* Cirsium lanceolatum.
tajose, tajarnollo,	plant,	cuigeag, cuigmhearmhuire I. *common cinquefoil*, Potentilla reptans.
tamozen,	barley,	tumdhias I. *bushy ear of wheat.*
tanjose,	plant,	caineog I. *barley and oats.*
tarabaste,	herbaceous plant,	treabhach I. *winter rocket*, Eryssimum barbara; tromblhod I. *vervain mallow*, Malva? gropis I. *mallow.*
tarambuche	bulbous plant,	crwnben W. *bulb.*
tarhais,	tree,	darach I. *oak.*
tasaigo,	plant,	sgathog I. *cotton grass*, Eriophorum polystachion: sgathog I. *trefoil*, Trifolium.
tebete,	mountain tree,	eabhadh I. *aspen*, Populus tremula.
tinanbuche,	bryony,	cnaibuisge I. *water neck weed.*
titimalo,	purgative plant,	taithfhuillean I. *wood-bine*, Lonicera periclymenum.
togia,	sand plant,	taga I. *teazle*, Dipsacus.
trichen,	wheat,	rhych W. *rye.*
trifa,	wheat,	arba I.
vesto,	mallow roots,	fochas I. *mallow*, Malva.

COMPARATIVE VOCABULARY OF PERUVIAN.

(Q. QUICHUA, QT. QUITENA, A. AYMARA, AT. ATACAMA, I. ITENES, C. CAYUBABA, S. SAPIBOCONO, AND Y. YURACARES), WITH CELTIC (A. ARMORICAN, G. GAELIC, E. ERSE, AND W. WELSH.)

	Peruvian.	*Celtic.*
above,	araja A.,	goruch W.
after,	ucata A.,	gwedi W.
air,	huayra Q.,	awyr W.
all,	taque A.,	gac E.
angry,	pina Q.,	ffrom W.
arm,	hicani A.,	caine W.
armpit,	huallhuancu Q.,	cesail W.

	Peruvian.	*Celtic.*
arrow,	n .cchi A.,	picell W.
ashes,	ι uella A.,	ulw W.
ask,	isquina, mayina A.,	gofyn, ymofyn W.
bad,	valchar, ualcher At.,	ysgeler W. *wicked.*
basket,	sappa A.,	cawell W.
beard,	tironcayu A.,	rhawn W. *hair.*
beat,	panay Q.,	pwnio W.
	huacta Q.,	chwatio W.
belly,	puraca A.,	bru, bolg G.
below,	urac Qt.,	goris W.
	ichen At.,	is, isod W.
bind,	huata, huatay Q.,	caethiwo W.
bitter,	haru A.,	chwerw W.
black,	chamaka A.,	much W.
	coca A., hachi At.,	cuchiog W.
blood,	huila A.,	fuil G.
	yahuar Q.,	crau W., cru G.
blue,	selqui At.,	glas G. W.
body,	hanchi A.,	neach G.
bone,	cchalta A.,	seis E.
bow,	picta Q.,	bwa W.
branch,	ali A.,	osgl W.
bread,	tanta Q., ttanta A.,	teisen W. *cake.*
break,	pakiy Q.,	bregu W.
breast,	haiti At.,	uchd E.
	pivur At.,	afell W.
bring forth,	sarma At.,	esgor W.
butterfly,	pilpinto A.,	balafen W.
buy,	rantiy Q.,	prynydd W. *buyer.*
cheek,	buca I.,	boch W.
choice,	ahllay Q.,	ethol W.
clear,	illan, illari Q.,	glain, eglur W.
cloak,	iscallo A.,	casul W.
clothes,	sau A., acsu At.,	gwisg W.
cold,	chiri Q., serar At.,	oer, goroer W.
corpse,	aya Q.,	ec E.
cut,	cuta A.,	cat W., *a cut.*
dance,	taymi Q.,	llemain W.
dark,	kata Q.,	caddug W. *darkness.*
dead,	hinata A.,	ymado W.
death, die,	huanhu, huanuy Q.,	angau, angeu W.
	amaya A.,	mas W.
	mulsi At.,	marw W.
deep,	ccorahua A.,	craff W.
demon,	supayu A., zupai Q.,	siabhra E.
	huantahualla A.,	enaidmall W.
deer,	lluchos, taruco Q., taruja A.,	cellaig W. *stag.*
dew,	sulla A.,	gwlith W.
dice,	huayru Q.,	ffrist W.
do,	rurani Q.,	llunio W. *make.*
dog,	anu A.,	cain W.
	alljo Q., locma At.,	llechgi W. *cur.*

	Peruvian.	*Celtic.*
door,	puncu A., Q.,	porth W.
dress (woman's),	anoco A.,	gynog W. *gowned.*
drink,	upiya Q.,	yfed W.
dry,	chaki Q.,	sych W.
dust,	turo Q.,	stur G.
ear,	iradike C.,	clust W.
earth,	idatu C.,	tudd W.
	hoire At.,	daiar W.
	lacca A.,	llwch W. *dust.*
eat,	oloma At.,	llewa W.
end,	ccorpa A.,	gorphyn W.
enter,	mantana A.,	myned W.
equal,	cusca A.,	cystal W.
eye,	nairi A.,	meilyn W.
	iyocori C.,	suil G., crai W.
face,	akanu A.,	gwyneb W., cainsi E.
faggot,	picho A.,	ffasg W.
fall,	tincuna A.,	disgyniad W.
falsehood,	selima At.,	celwydd W.
	karina A.,	creinio W. *to lie.*
fat,	lanccu A.,	bloneg W.
	huira Q.,	gwer W.
father,	tata A., S., Q.,	tad W.
father-in-law,	ttosi At.,	tadcu W.
fear,	ajsarana A.,	dychryn W.
feather,	puru Q., puyu A.,	pluen, plu W.
field,	cancha Q.,	caint W.
	vaca At.,	maes W.
	yapu A.,	ceufaes W.
	tunar At.,	cymle W.
figure, form,	culam At.,	eilun W.
fire,	humur At.,	ufel W.
	nina A., Q.,	tan W.
	cuati S.,	goddaith W.
flesh,	aicha A., aycha Q.,	hig A., eig W.
	sabur At.,	ymborth W. *meat.*
flower,	pucher At.,	fflur W.
fly,	cuspi Q.,	gwiban W.
foot,	kayu A., cuchi At.,	cas G.
	ebbachi S.,	ped W.
fountain,	puquio Q.,	ffynon W.
fowl,	hualpa A.,	golfan W. *sparrow*, gylfinog W. *curlew*, etc.
fox,	atoc Q.,	gwyddgi W.
friend,	cachomasi A.,	cydymaith W.
frog,	hampatua A.,	llyffant W.
	ccaira A., kayra Q.,	creiniog W.
ghost,	llantu Q.,	gwyllon W. *plural.*
girl,	ppucha A.,	bachgenes W.
	tahuaco A.,	hogen W.
	imilla A.,	plah A., merch W., *daughter.*
give,	huiti I.,	dodi W.

	Peruvian.	*Celtic.*
go,	humi A. Q.,	imich G.
goat,	paca A.,	boc G.
	sila, telir At.,	llill W.
gold,	ccori Q., coori A.,	aor W.
good,	asque A.,	gwiw W.
	alli Q.,	lleso' W.
granary,	coptra Q.,	ysgubor W.
great,	capur At.,	syberw W.
green,	ccari, khal At.,	cri, glas W.
	komer Q.,	gorm G.
hail,	chijchi A.,	cesair W.
hand,	tachlli A., arue C., uru I.,	llaw W.
harness,	recau At.,	trec W.
hate,	coysma At.,	casau W.
have,	tausi At.,	dygyd W.
he,	hupa A.,	efe W.
head,	dala Y.,	talcen W.
	ppekei A.,	pen W.
	lacsi, hlacse At.,	llyw W.
heal,	callana A.,	gwellau W.
	hampi Q.,	cymodi W.
health,	ccaya At.,	iechyd W.
heart,	haiti At.,	uchd E. *breast.*
heaven,	urajpacha A.,	goruch W. *above.*
horn,	huakra Q., quajra A.,	adharc G.
hot, heat,	cambs At.,	twym W.
	capi At.,	craf W.
	huntu A.,	chwantus W.
	conic Q.,	cynhesu W. *to heat.*
house,	uta, ata A.,	ty W.
	puncu A.,	ffronc W. *hut.*
	turi, t'huri At.,	twlo W. *hut.*
	huasi Q.,	ios-da G.
in,	na A.,	an G.
increase,	aliyani A.,	helaethu W.
iron,	quella A.,	caled W.
jaw,	kaki Q.,	cargen W.
king,	capac Q.,	ceap E.
	curaca Q.,	goruch W. *supreme.*
kiss,	quischama At.,	cusanu W.
know,	yatina A.,	adwaen W.
lamb,	una A.,	uan G., oen W.
	chita Q.,	gid W. *kid.*
lance,	chuqui Q.,	gwayw, ysgeth W.
laugh,	teshma At.,	dychwardd W.
leaf,	llakka A.,	duilleag E.
learn,	yaticha A.,	dysgu W.
leg,	chara A.,	esgar W., cara E.
life,	haka A.,	bwch W.
light,	ccana A.,	cain, cynneu W.
lip,	uirpa, sirpi Q.,	gwefus W.

	Peruvian.	*Celtic.*
load,	penaclo At.,	pynorio W.
love,	qquipi At.,	hoffi, cudeb W.
louse,	lappa A.,	lleuen W.
male,	orko Q.,	gwryw W.
man,	chacha A.,	cia G.
	kkari A., Q.,	gwr W.
	huataki I.,	cathaidhe E., *warrior.*
medicine,	ccolla A.,	iachaol W.
meet,	tinquy Q.,	cynghyd W.
middle,	chaupi Q., taipi A.,	cefnaint W.
moon,	irare C.,	lloer W.
	quilla Q.,	gealach G.
	ccamur At.,	eighmor E.
morning,	ccara A.,	gwawr W. *dawn.*
mother,	mama A., Q., At.,	mam W.
	cua S.,	iog E.
mountain,	monono Y.,	mynydd W.
	kkollo A., iruretui C.,	gallt, garth W.
	pata Q., pico I.,	ponc, bre W.
mouth,	quaipi, khaipe At.,	safn W.
	simi Q.,	genau W.
much,	alloja A.,	lliaws W.
nail,	khin, qquini At.,	ewin W.
	sillu A.,	hoel W.
neck,	cunka Q., conka A.,	cegen, W. *throat.*
night,	haipu A.,	be E., gosper W. *evening.*
no,	hani A.,	chan G.
nose,	ibarioho C.,	ffri W.
	cenca Q.,	comhor E.
old,	ucuti I.,	gwth W.
open,	istorana A.,	egori W.
paint,	llampi Q.,	lliw W.
palace,	inca-pillca Q.,	plas W.
peace,	tecum At.,	tangnef W.
pigeon,	culcataya A.,	colom-cuddan W.
pike,	tupina Q.,	gwaywffon W.
plant,	liga A.,	llys W.
pot,	payla A.,	paeol W.
	potor At., ppucu A.,	pot W.
priest,	pachacuc A.,	faigh E.
rabbit,	cuys Q.,	cwning W.
race,	ayllo A.,	hil W.
rain,	hallu A.,	gwlaw W.
reed,	curcura A.,	corsen W.
rest,	sama A.,	seib W.
red,	pako A., Q.,	basc E.
rich,	capac At.,	cyfoethog W.
	quaraj Q.,	goludog W.
ripen,	poccoy Q.,	ffaethu W.
river,	hahuiri A.,	suir G.
	mayu G.,	afon W., amhain G.
road,	peter At.,	fford W.

	Peruvian.	*Celtic.*
round,	moyoc Q.,	amgant W.
run,	huayra Q.,	gyru W.
	paway Q.,	ffoi W.
see,	ulla A.,	seall G., gweled W.
	ricu Q.,	edrych W.
	unjana A.,	cenio W.
seed,	atha, sata A.,	had W.
servant,	yana A.,	gweinydd W.
sew,	chucuna A.,	gwnio W.
shadow,	chitua A.,	cysgod W.
sheep,	ccaura A.,	caora G.
shoe,	usuta, ojota A.,	esgid W.
sick,	onchok Q.,	gwanychu W. *sicken.*
sin,	chata A.,	gwyd W.
sister,	collacha A., turay Q.,	chwaer W.
sit,	tiyay Q.,	eistedd W.
skin,	ccara Q.,	croen W.
sleep,	punu Q., iquina A.,	hun A , huno W.
	iqui A.,	cysu W.
small,	huchuy Q.,	ychydig W.
	hisca A.,	bach W.
smoke,	heuque A.,	mygu W.
snake,	katari A.,	nathair G., neidr W.
sour,	callcu A.,	sarug W.
speak,	sana A.,	cynanu W.
	ni Q.,	yngan W.
	arusi, arusina A.,	areithio W.
spread,	takay Q.,	teddu W.
star,	sillo, huarahuara A.,	seren W.
	coyllur Q., halar At.,	reult G.
stone,	ccala A.,	careg W., gall G.
string,	lica Q.,	llin W.
	chanca A.,	tant W.
strong,	capac Q., At.,	cryfach W. *stronger.*
sun,	inti A., Q.,	ganaid W.
	villca A.,	haul W.
	puine Y.,	huan W.
	camosi S.,	samh E.
swallow,	reganama At.,	llyncu W.
sword,	calhua Q.,	claiseach E., cledd W.
tail,	chupa Q.,	cynffon W.
take,	hapi Q.,	tybio W.
teach,	yatichana A.,	addysgu W.
thigh,	changa Qt.,	clun W.
throat,	etippi S.,	gwddf W. *neck.*
thorne,	tiana Q.,	tron W.
throw,	toccnaclo At.,	tawlu W.
tie,	chinuna A.,	cynhas W. *mutual tie.*
trumpet,	equeppa Q.,	cadbib W. *fife.*
trunk, stock,	capintin Q.,	cyff W.
truth,	quelechar At.,	gwirder W.
village,	lican At.,	llan W.

	Peruvian.	*Celtic.*
vulture,	condor At.,	gwylldyr W.
wall,	perecca Q.,	bwrch W.
wash,	maylla Q.,	ymolchi W.
	harina A.,	glanau W.
water,	cubi S.,	aw W.
	puri At.,	mer W.
	yaku A., Q.,	uisge G., gwy W.
	sama Y., como I.,	
	huma A.,	amh E. *ocean.*
weave,	tilana A.,	eilio W.
well,	pucyo A.,	pydew W.
white,	hanco, hancona A.,	guen A., gwyn, can W.
	yurac Q.,	pur W.
wife,	liqui At.,	gwraig W.
wild,	kita Q.,	chwidr W.
will,	muna A.,	myn W.
	chicatha A.,	gogwydd W.
	orichuhuenhua C.,	gorchymyn W. *to will.*
winter,	casac-puchu A.,	gauaf W.
wizard,	pachacuc Q.,	faigh E.
woman,	rakka Q.,	gwraig W.
	marmi A.,	merch W.
	tana I.,	dynes W.
word,	aru A.,	gair W.
worm,	lacco A.,	llyngyr W. *worms.*
writing,	quippu Q.,	coffau W. *to record.*
young, youth,	huaina A.,	ieuaint, ieuanc W.
	iroco I.,	ir W.

GRAMMATICAL ANALYSIS OF THE INSCRIPTIONS.

No. I. *a.* koi *Basque*, desire.
entu *Basque*, to hear.
pono *Basque*, root of pontsu, *humeur sombre.*
Menera, a goddess, composed of B. *men*, power.
au B., this.

b. ni B., I.
Arba, proper name masculine, probably the root of the B. *arrapatu*, to seize.
imi B. imi-ni, ipi-ni, to place.
aur B., child.
ne B., n, an, en, to.
Kai, proper name latinized as Caius.
ba B., if.
erru-nai, compound of *erru*, root of B. *erruki*, compassion, and *nai*, will.

c. Sotoberri, proper name feminine, compounded of B. *soto*, vault, cellar, and *berri*, new.
uga, old B. word for mother, survives in *ugazama*, second mother *ugazaita*, second husband of the mother, and *ugatz*, mother's milk.
neke B., difficult, fatiguing, trouble, poverty.
aita B., father.
barka, root of B. *barkatu*, to pardon.
ka B., postposition, by, with.

d. mira B., astonishment, admiration from *miratu*, to behold, but here employed as a substantive, a spectacle or object to be seen.
erimi, from B. *er*, cause and *imi-ni* (see above, *b*).
etorri B., to come.
seme B., son.
ema, root of B. *ema-n*, to give.
gure B., our.
erren, peculiar form of erruki (see *erru-nai*, *b*).

e. emaitsa B., present, gift.
imi, see *b*.
uga, see *c*.
ra B., to.
erruki B., compassion, here an adjective.
anre B., lady.
aur, see *b*.
ne, see *b*.
lekatu B., to please.
be B., under.
neke, see *c*.
gabe B., without, deprivation.
ekarri B , to carry : original of the English word.
dio B., he does it to him.
ematu B., to calm.
bahi B., pledge.
gabe, see above.
erruki, see above.

f. pabetu B., to help.
imi, aur, ekarri, see above *b* and *e*.
gabetu B., to deprive.
entuka B. *entu*, to hear, and *ka*, by.
mira B. *miratu*, behold, see.
bere B., own.
beha B. *behatu*, behold.
beha-ka B., by beholding.
artu B., take, hold.
doi B., just, right.
gogoratu B., to remember.

g. achol B., care.
nio, Etruscan for *diot*, I do it to him, but B. imperfect of the same is *nion*.
egi B. *egin*, to do.
duen B., who has, for B. *den*, who is.
obi B., tomb, grave.
pabe B., help.
ba, Etruscan and Japanese, place.

No. II. age B. appearance, *age-ri*, declaration.
zio, Etruscan for *dio*, he does it to him; but the B. imperfect of the same is *cion* or *zion*.
utsite B. *utzi*, *utziten*, to leave.
ba B., if, see No I. *b*.
so B., regard.
jabe B., lord.

No. III. bizitate B. *biztandu*, *biztanle*, inhabit, inhabitant.
arau B., rule, night.
doi B., see No. 1 *f*.
ematu B., to give, fuller form of *ema-n*.
debe B., prohibition, B. *debekatu*, forbid.
esatz B. *esan*, *esaten*, to say.
behi B., cow.

No. IV. al, ahal B., power.

No. VI. behatu, see No. I. *f*
debe, see No. III.

No. VII. au, aita, see No. I. *a*, *c*.

No. VIII. esatz, see No. III.
asma B., a sign, indication.
ema, see No. I. *d*.

No. IX. mamuta B. *mamu*, phantom, *mamutu*, act a ghost.
mai B., table, tablet.
edatu B., to stretch, to extend.

No. XI. ichpichoi B. *ichpicho*, "pari, gageure," in dative.
atita, obscure form of *atchiki*, *itcheki*, to hold.
umerri B., lamb, small cattle.

No. XII. kosatze, now B. *koskatzen*, to carve.
mai, see No. IX.

No. XIII. bizitza, see No. III., *bizitza* now means "la vie."

No. XIV. aitabe B. *aitaba*, grandfather.
emaitz B., see No. I *e*.
bizitzate, see No. XIII.
umerri, see No. XI.

No. XV. goititu B., to raise.

No. XVI. danda B. "pact, obligation."

No XVII. mate, explained in text *ad loc*.

No. XVIII. No new words.

No. XIX. dema B., "gageure."

No. XX. anoma B. *ano*, portion and *ema*, given.
bite-zar B., envoy.
no B., sign of genitive.
ranono B. *rano*, towards.
zari in B., *agint-zari*, *buru-zari*, a captain; Japanese *kashira*, Semitic *sar*, Sclavonic *czar*, Teutonic *kaiser*, etc., etc., a universal word.
beka, form of B. *bekoki*, front, forehead, a chief.

No. XXI. beka, see above.

No. XXII. osa, old form on Iberic inscriptions of the Isle of Man. Its root is o as in B. *o-artu*, to give attention. In Japanese it is *uya-mai*, and also means "to give reverence." Here it denotes, *sa*, the person giving *o*, attention, to the flocks.
atherbe B., shelter.
obi B., grave, pit, cave.
ate B., door.
edate B. *edatu*, extend.
udabate is not B. *udahaste*, a synonym of *udaberri*, spring, but, as *uda-berri* is literally "new summer," so *uda-bate* will be "end of summer."
ambera, now B. *ainbertze*, as many as.
beheitu, B. *beheiti*, to lower.
mopira, Etruscan S. See the writer's Etruria Capta.
ardizain B., shepherd.

No. XXIII. nausi B., master, more commonly *nabusi*.
non, Etruscan "who."

No. XXIV. oroi B., to remember, fuller *oroitu*.
am for *amar* B. ten.
ahal, al B., power, authority.
urte B., year.

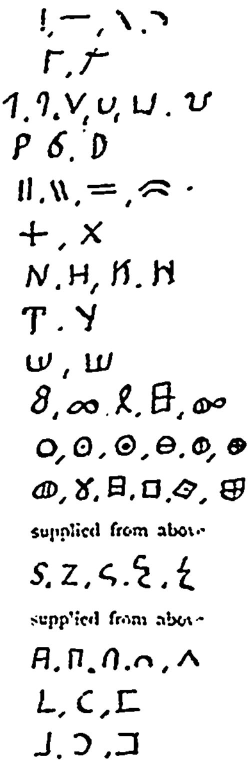
No. XXV. jabe, see No. II.

No. XXVI. osa, see No. XXII., here employed as verb; perhaps it should be written *o-tsu*.

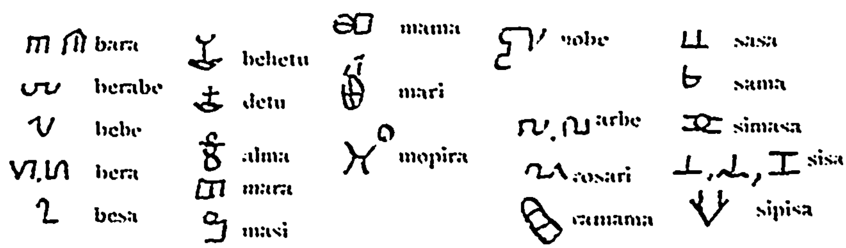
No. XXVII. abere B., cattle.
aberabe, survives in *apurtu*, *apurtzen* "baisser."
kama, evidently denotes one who has the care of sheep and other cattle. The writer does not know it as Basque. To keep domestic animals in Japanese is kai-oki.
lerrozarri B. *lerro*, a rank, and *ezarri*, to place.
mopi-ka, Etruscan *mopi*, 2, and B. *ka*, by.
obeka B. *obeki*, better.
athedatu for B. *itoitea*, or *ateratzen*.
ari B., ram.
almena B., power, vigour.

PHONETIC VALUES OF THE CANARY ISLAND CHARACTERS.

	Virgin.	Rocks.
vowel, diphthong, aspirate syllable, . .	I	
b, p syllables with a, o, u, ...	F	
" " e, i, ...	V	
to, tu, syllables, ...	P	
ta, te, ti, "	II	
da, de, di, syllables, ...		
ka, ga, "	N	
ko, ku, go, gu, syllables.	T	
go, syllables, ...		
l, "	B	
ma, mo, mu, syllables, ...	O	
me, mi, "	M	supplied from above
na, no, nu, "	S	
ne, ni, "	E	supplied from above
r, syllables, ...	A, R	
sa, so, su, syllables, ...	L	
se, si, chi, zi, syllables, ...		



COMPOUND CHARACTERS ON ROCKS.



THE RIPENING OF CHEESE AND THE RÔLE OF MICRO-ORGANISMS IN THE PROCESS.

F. C. HARRISON, AGRICULTURAL COLLEGE, GUELPH.

(Read 23rd March, 1901).

DURING the last twenty-five years the ripening of cheese has been the subject of numerous investigations, and although the problem has been attacked in many varied ways, it cannot be said, even now, that the changes which cheese undergoes from the time it is made until it is ready to be eaten have been fully explained.

The task of the investigator is, no doubt, a difficult one, owing to the many different kinds of cheese manufactured, the various ways in which they are made, and the diverse methods used to ripen them. The difficulties do not by any means end here. No two cheeses are exactly alike; the bacterial flora of the milk changes constantly; the methods of manufacture differ slightly from day to day, and more so from season to season; the temperature and humidity of the curing room usually alter with the outside temperature; and lastly the difficulty of sampling and the methods of analysis leave much room for improvement. The constant publication of some new culture method for lactic acid bacteria suggests that as yet no completely satisfactory method of cultivating them has been discovered.

Ferdinand Cohn, in 1875, declared that the ripening of cheese was a fermentation due to the influence of fermenting organisms. He microscopically investigated rennet, and finding bacteria present in this substance concluded that the ripening of cheese was due to bacteria introduced into the cheese from this source. He considered that the milk sugar underwent butyric fermentation. He also found *B. termo, micrococci*, and the *Hay bacillus* present in the cheese, and came to the conclusion that these were introduced with the rennet, because Remak had found *B. subtilis* in the stomachs of calves.

A few years later Duclaux published his researches upon Cantal cheese, a soft cheese manufactured in France. He isolated a number of micro-organisms, six of which he supposed were of special importance, —an alcoholic, a lactic, a butyric, and a ferment acting upon casein and forming alkaline nitrogenous compounds of simple composition. Of the remaining two ferments, one was a vibrio, which preferred an optimum temperature of 75 to 80 F., formed spores, and caused the development of carbonic acid and hydrogen gas when grown in milk. The casein was transformed into an albuminous substance, soluble in water; small amounts of butyric acid and sodium butyrate were formed.

Duclaux attributed the matting together of the cheese after it was cut, to the action of this vibrio, which he thought caused the parts of the coagulum to stick together and form a solid mass of cheese; consequently the presence of this germ was desirable, but unfortunately should the germ enter the coagulum itself gas was produced; and, as a consequence, the cheese became puffy or swollen.

The other ferment was more objectionable because it formed acetic acid, and a substance of an intensely bitter taste.

In conclusion, he considered the ripening to be caused by the butyric ferment, because under its influence the casein was precipitated, but afterwards gradually dissolved or digested. This ferment was probably helped by others which acted upon the albuminoids so as to split them up into compounds of a less complex nature; ammonia being the simplest.

Benecke made a microscopical analysis of Emmenthaler cheese of different ages. He found Cohn's rod-like bacteria, which were probably identical with *B. subtilis*, and also yeasts. In consideration of the circumstance that the formation of peptone like bodies took place chiefly at the beginning of the ripening process, and that at this time an increase of schizomycetes, probably identical with *B. subtilis*, was noticed, Benecke arrived at the conclusion that the ferment which brought about the peptonization of the fresh curd was *B. subtilis*. The objection that *B. subtilis* was an aerobe and could not live in the interior of hard cheese, he set aside and followed the observation of Liborius, according to which *B. subtilis* retained its peptonizing qualities even though the air was shut off, provided that some kind of sugar was available. The gradual disappearance of the milk sugar was accountable for the diminishing of the rod-like forms in cheese which had reached a more advanced stage of ripeness. In conclusion, Benecke believed that the formation of amides (Leucin, etc.) was not due to the action of the Schizomycetes.

In 1887, Duclaux published the results of further studies upon

Cantal cheese, and was able to study them in pure culture. The dilution method of culture was then in vogue, and some writers have criticised the accuracy of his work on this account. Not only did Duclaux isolate a large number of species, but he was able to contribute other interesting details as to form, spore formation, aerobic and anaerobic characters, physiology, and the nature of the fermentation products of the different micro-organisms, that he studied. To all species isolated, he gave the generic name Tyrothrix (cheese-threads), and of these seven were aerobic and three anaerobic. All but one of these germs possessed the ability of coagulating the casein; and, subsequently digesting the coagulum. From one of the most energetic of these bacteria *(Tyrothrix tenuis)* Duclaux isolated a ferment which was able to convert the casein into a soluble peptone. This he called casease and the product of its action on casein he named "caseone"; this latter substance might be even further split up into other substances, as leucin and tyrosin. Several of the other species isolated also produced the last named substances.

Adametz, working at Sornthal, in Switzerland, in 1889, upon Emmenthaler and Cottage cheese (a soft variety) isolated nineteen different, well characterized schizomycetes and three yeasts. Of the first, seventeen were new species and were supposed to influence the ripening process. Contrary to previous investigations, neither *B. subtilis* nor *B. butyricus* was found. He divided these bacteria into three groups.

(a). Such as dissolved the paracasein, or changed it to a peculiar spongy condition. Soluble albuminoids and peptones were produced in greater or less quantities at the same time, and these were accompanied by traces of smelling (*e.g.*, Butyric acid) and tasting (*e.g.*, bitter extractive matters) substances.

(b). Such as developed slowly in sterilized milk, and for which unchanged paracasein was not a favorable soil, but they easily assimilated the substances produced by the first group.

(c). Such as had no appreciable effect upon any of the nutritive substances herein concerned, and whose presence or absence made no difference to the ripening of the cheese.

The Cottage cheese was distinguished bacteriologically from Emmenthaler by the following points:

1. The larger bacterial content (in one gram of Emmenthaler 850,000 germs, and in one gram of Cottage cheese 5,600,000 bacteria).

2. The greater number of species.

3. The relation of the peptone gelatine liquefying to non-liquefying colonies (1:300 to 1:600 in Emmenthaler against 1:90 to 1:200 in Cottage cheese).

The bacterial content of Emmenthaler was shewn to grow during the ripening process from 90,000 to 850,000 and finally he ascribed to the liquefying germs the rôle of ripening the cheese.

Adametz also demonstrated that when disinfectants like Thymol and Kreolin were mixed with the curd, the ripening process was totally checked. The same result ensued from attempts to ripen Hauskäse (Cottage cheese) in an atmosphere of Carbon disulphide.

De Freudenreich by the use of better methods, such as the employment of whey peptone gelatine, and more accurate triturations obtained much higher figures than Adametz. He followed, step by step, the ripening of a single cheese, in order to see if the changes the cheese passed through were the work of special microbes, and to see if the species present at the commencement of ripening continued active until the end of the process. The cheese was analysed at intervals of eight to fifteen days, and like Adametz he found in fresh cheese many different micro-organisms which quickly disappeared as the cheese aged, so that at the end of eighteen days, a microbe called *Bacillus x*, by the author, predominated in the culture plates; and at the end of sixty-four days, only this bacillus was found. The analyses were continued until the 155th day when the ripening was perfect. The cheese at this time contained 1,662,500 bacteria per gramme, all being *Bacillus x*. The highest number counted was 8,975,000 when the cheese was fifty-two days old, but there were considerable fluctuations in the numbers found.

The *Bacillus x* was a true type of lactic acid germ, somewhat similar to Adametz' No. xix, and forming, like it, lactic acid.

De Freudenreich described minutely the morphology, physiological properties, and the resistence of this germ to desiccation and chemical agents, and in the end came to the following conclusions:

1. The ripening of cheese was the work of bacteria; without bacteria there was no ripening.

2. Two periods could be distinguished in the ripening: the first characterized by the presence of many species, and the second distinguished by the predominance of one bacterial species. In most cases

this single microbe was *Bacillus x;* when it was absent, it was replaced by other bacteria belonging to the same class of lactic acid ferments

Adametz had also found in predominating numbers a germ very like *Bacillus x*, and which also behaved as a true lactic ferment.

It did not appear probable that these germs alone produced all the phases of ripening without the co-operation of other bacteria.

Lloyd, who was appointed by the Council of the Bath and West of England Society to make investigations upon Cheddar cheese making, did much work on this subject; and, although no numerical data are given, he stated after making over 100 separate cultivations that, "In the manufacture of Cheddar cheese, one and only one organism plays an important part up to the time the curd is put into the vat, and that organism is *Bacillus acidi lactici.* Further, when the cheese was ripe, this bacillus was most abundant, and that the ripening during the first few months depended mainly on *B. acidi lactici*, supplemented as the cheese grew older by the growth and action of *B. amylobacter.*"

De Freudenreich in 1895 followed up his first work by a very extensive contribution to the subject. He analysed bacteriologically five Emmenthaler cheese made at the Rütti Dairy School. By means of special methods, such as the use of milk serum gelatine, milk agar, anaerobic culture methods, and partially sterilized cheese emulsions, he endeavoured to give the best opportunities for the liquefying species to grow, especially Duclaux's Tyrothrix forms. The latter were, however, found only a few times. The principal liquefiers present were bacilli belonging to the *subtilis* and *mesentericus* groups. These researches corroborated his former work.

The lactic acid species, abundant from the start, increased greatly during the ripening process, whilst the liquefying germs were few in number and decreased rapidly.

The most complete numerical data given of a single cheese were as follows:

Age in Days.	*Number of Bacteria per Gramme.*
Fresh Cheese 1	750,000
9	15,000,000
33	20—30,000,000
42	40,000,000
65	20,000,000

Forms resembling Tyrothrix were found only four times out of sixteen analyses.

Hay bacillus types were found only six times out of eleven analyses. Agar surface plates were used for isolating these germs as they favoured the growth of this group of micro-organisms.

The remaining analyses agreed very closely with the above; on one occasion, however, the large number of 100,000,000 lactic acid bacteria per gramme were found in cheese ten days old.

In addition to these analyses, a number of cheese were made with starters made from the microbes isolated during the investigation, as well as many of Duclaux's Tyrothrix forms. The experimental cheese were compared with control ones; and in most cases the ripening was not normal. In conclusion, de Freudenreich drew the following conclusions from his observations and experiments:

1. Those often looked upon as prime factors in the ripening of cheese—the gelatine liquefying bacilli (Tyrothrix, Potato, or Hay bacillus) are not numerous in cheese, and generally not in milk.

2. Far from multiplying in the cheese, they seem, even if added to it in great quantities, to die off rapidly, unless when added in the spore form, in which case they remain alive for a longer time, but without multiplying.

3. Added to milk set for cheese, they seem neither to produce fermentation nor favour it.

4. Probably various lactic ferments play the principal, if not the only part, in the ripening of Emmenthaler cheese. In the soft cheese, on the contrary, *Oidium lactis*, and also yeasts, take part in the ripening.

Under the heading of "Character and Variability of species of Tyrothrix," W. Winkler found after an examination of species of Tyrothrix that, "whilst some, as *T. tenuis*, were more allied to the hay and potato bacilli, others as *T. urocephalum* and *T. filiformis* were more nearly connected with the granulo-bacteria. They adapted themselves with great ease to different nutrient media, and their characters thereby became altered. In milk, they were more or less peptonizing. Butyric acid was only produced by a few of them. Milk sugar favoured their growth, but seemed to interfere with their peptonizing power." Three varieties of Tyrothrix tenuis were cultivated: (1) a form which peptonized milk and liquefied gelatin; (2) a form which produced lactic acid, but did not liquefy gelatin; (3) a fluorescing type which formed a red pigment on potato.

Winkler stated that, "*Bacillus xvi*, *Adametz*, which was undoubtedly a species of Tyrothrix, was an example of the conversion of a lactic acid bacterium into a peptonizing organism. *T. urocephalum* and *T. tenuis* were found to aid the ripening of cheese, and there were grounds for believing that in this ripening, peptonizing bacteria played the principal part. A bacteriological examination of hard cheese always shewed a greater preponderance of lactic acid bacteria, and this might possibly be explained in this way, that certain peptonizing bacteria changed in the cheese to lactic acid bacteria, especially strongly developing the property of producing lactic acid. Aside from the behaviour of *T. tenuis* and *T. urocephalum* that of *Bacillus xvi, Adametz* in Emmenthaler cheese confirmed this view."

These results of Winkler were subsequently made the subject of a special research by Wittlin working under von Freudenreich. The experiments were made with a culture obtained originally from Duclaux, and after many cultivations on gelatin, no evidence was forthcoming to support the conversion contended for. Wittlin failed to be convinced that *Tyrothrix tenuis* could be converted into a lactic acid bacterium ; and the author supposed that Winkler's results were due to contamination.

By making emulsions of various cheeses and inoculating milk therewith, De Freudenreich was able to obtain absolutely anaerobic bacilli. These bacilli probably formed butyric acid. One of the two isolated, formed spores and from its shape, it was evidently a clostridium form. He named it *Clostridium foetidum lactis.* This germ, as its name implied, imparted a disagreeable odour to the milk, did not grow on gelatin, but on agar developed slowly giving rise to a cheesy odour. It apparently entirely dissolved the casein of milk, this medium turning yellow, only a slight sediment remaining. Later de Freudenreich became convinced that this clostridium was identical with the bacillus of malignant oedema. I have also found this bacillus in two small experimental cheese, made from Swiss milk, its pathogenicity and cultural characteristics leaving no room to doubt its identity.

In a Holland cheese, Weigmann found two aromatic bacilli. These gave the milk cultures a cheese aroma. When pasteurised milk was inoculated with these forms, and cheese made. it ripened and resembled Swiss cheese. These germs were gelatine liquefiers and digested the casein of the milk.

A very systematic study of the rise and fall of the bacteria in Cheddar cheese was made by Russell and Weinzirl. Six cheeses were analysed at various periods, and the qualitative distribution of the bacteria found at the different stages is thus graphically delineated by the author's diagram.

The general results are thus summarized :

1. There is at first a marked falling off in the number of bacteria in green curds for a day or two. (Period of initial decline).

2. This is followed by a very rapid increase in numbers, in which the bacteria reach scores of millions of organisms per gram. (Period of increase).

3. This period is followed by a diminution in numbers at first rapid but later more gradual, until the germ content sinks to insignificant proportions. (Period of final decline).

4. The time necessary to reach the maximum development (second period) is hastened or retarded by such external conditions as temperature, etc.

5. The second period also marks the beginning of the physical change that occurs in the cheese in the earlier part of the breaking down of the casein.

6. *The bacterial flora of cheese differs markedly from that of milk.* In milk, the lactic acid bacteria predominate, but accompanying them are always liquefying or peptonizing organisms, and as a rule bacteria capable of developing gaseous bye-products.

In the ripening cheese the peptonizing or casein digesting bacteria are quickly eliminated ; the gas producing bacteria disappear more slowly, sometimes persisting in very small numbers for a long time.

The lactic acid bacteria on the other hand develop enormously for a time until the cheese is partially ripened, when they too begin to diminish in numbers.

7. *The generally accepted theory that the peptonizing or digesting* bacteria are able to break down the casein in the cheese as they do in milk is improbable because this type of bacteria fails to increase in the cheese and usually disappears before there is any evidence of physical change in the condition of the casein. The same is true where cheese is made from pasteurised milk to which copious starters of these peptonizing organisms have been added.

8. The coincidence existing in point of time between the gradual ripening of the cheese and the marked development of the lactic acid

bacteria seems to indicate that these phenomena are causally related. This view is further strengthened by the fact that cheese made from pasteurised milk in which the lactic acid bacteria have been destroyed fail to ripen in the normal manner, while the addition of a pure lactic acid ferment to the pasteurised milk permits the usual changes to occur in a probably normal way.

Schirokich took up the study of this problem by preparing in milk pure cultures of some peptonizing bacteria as well as of lactic bacteria and then investigating by means of chemical analysis the changes which took place in the milk in the course of the development of the micro-organisms in it. The change in the composition of the milk was studied as to (1) the quantity of the casein of the milk converted into soluble form ; (2) the amount of ammonia found in the cultures, and (3) the amount and kind of fatty acids produced by the micro-organisms.

With reference to the first point, it was found that while the peptonizing bacteria converted during the first fifteen days of their culture almost all of the casein of the milk into proteids soluble in water, and the remainder into products of decomposition, the lactic bacteria did not alter in the slightest, the amount of nitrogen in the soluble protein matter after thirty days of culture. In other words, while the bacteria of the former group acted very energetically on the casein, those of the latter group did not affect it at all. The fungus *Oidium lactis* was also found very active in changing the casein, although in a lesser degree than the peptonizing bacteria.

Further, the author found in the cultures of the *Oidium lactis* less ammonia than in those of the peptonizing bacteria, and none whatever in the cultures of the lactic bacillus.

Finally, on comparing the nature of the fatty acids formed in cheese (the author experimented with hard Gruyére and soft Brie cheese) and those produced by the bacteria in pure cultures, he found that the mixture of the volatile acids caused by the bacteria not liquefying gelatine did not correspond to those which are formed either in the hard or in the soft cheese. On the contrary, the volatile acids produced by the peptonizing bacilli were found to be very similar to the mixture of these acids produced in the ripening of Gruyére cheese. And, lastly, great similarity was observed between the volatile acids of the soft Brie cheese and those produced by the fungus *Oidium lactis*.

Thus, all three lines of investigation pursued by the author lead to the conclusion that the bacteria of lactic fermentation, though present in milk and cheese in very great numbers, do not induce the changes in the casein in the process of ripening, and if they exert any influence at all, it is only indirect, since these bacteria do not dissolve casein, do not give off ammonia, and do not form the volatile acids characteristic of ripened cheese. The peptonizing bacteria and the fungus *Oidium lactis*, on the other hand, produced all the changes of casein which take place in the ripening of cheese; they yield soluble proteids and decompose albuminous compounds with the formation of ammonia and volatile acids corresponding to those occurring in the cheese.

It is pointed out that the peptonizing bacteria would appear from the foregoing to play an exclusive part in the ripening of cheese, but such a conclusion would overlook the important fact established by the analysis of Bondzinsky, viz.: that there is in cheese only a small quantity of peptone which is not precipitated by ammonia sulphate. In opposition to this fact, the author found while investigating the nature of the soluble albuminous bodies in pure cultures of peptonizing bacteria that, under the influence of these micro-organisms, the casein is converted almost entirely into peptone. In view of these opposing facts, the author concludes that the joint action of the peptonizing bacteria and the lactic acid bacteria must be considered as essential to the ripening of cheese, and that this should serve as a starting point for future investigations of the process.

The lactic acid bacteria are not capable of producing this process, while the peptonizing bacteria, when they multiply without any check, carry on the decomposition too energetically and to an undesired extent, but in the presence of lactic bacteria, which in a measure restrict and regulate the development and activity of the peptonizing bacteria, the joint effort of all these micro-organisms gives the desired results.

From this point of view, the chief care in the production of cheese should be that both the peptonizing and the lactic bacteria are in the curd, and that the proper conditions for their life activity are provided. But the peptonizing bacteria, especially the *Bacillus subtilis*, are very widely distributed and multiply with extreme ease; therefore from a practical standpoint, no provision need be made for their presence, and attention should be confined to the lactic acid bacteria.

Having defined the part which the peptonizing bacteria play in the ripening of cheese, the question still remains unsettled whether these bacteria, which are according to de Freudenreich present in hard cheese in small numbers, act as such in the process of ripening, or by means of diastase secreted by them at the beginning of the process. The author states that in experiments made by him, it was shown that the diastase in question, named by Duclaux, casease, acts just as energetically in the absence of the bacteria by which it is secreted as in their presence. From this, it would follow that if casease is a factor in the ripening of cheese, it would have to be present only in a small amount.

Von Freudenreich's results in two series of experiments made in 1897, considerably strengthened the theory that the lactic acid germs were the chief factors in the ripening process. He grew a number of lactic acid bacteria, isolated from cheese, in sterile milk to which chalk had been added to neutralize the acid formed by the bacteria. These bacteria were thus able to continue their growth, and at the end of two or three months a portion of the casein was found to be converted into soluble products. Thus cultures of three different species of lactic acid germs gave 5.1, 6.4, and 2.4 times as much soluble nitrogen as there was present in the original milk. The reaction of these cultures was not acid, but neutral or slightly alkaline.

Von Freudenreich concludes his second paper by stating that "It appears from my experiments that the lactic acid ferments, especially those isolated from cheese, are endowed with the power of rendering the casein soluble and decomposing it. Emmenthaler cheese, as compared with the results of Bondzynski, gives even more conclusive results. Thus, the latter author found in the filtrate of two emulsions made from ripe Emmenthaler cheese 1.44 and 1.51 per cent. of soluble nitrogen. The nitrogen of the amides gave 0.93 and 0.82 per cent. These figures are nine to ten times higher than mine, but Bondzynski analysed cheese and I milk. But it takes eleven kilograms of milk to make a kilogram of cheese and the agreement is as perfect as can be when we consider that the experimental conditions (temperature, etc.), were not identical. These results, proved by my numerous experiments, show that the lactic acid ferments are in enormous numbers in ripening cheese, whilst other species, as the Tyrothrix class, are relatively rare, and this fact permits us to affirm that the microbic agents in the ripening of cheese ought to be looked for among the lactic acid ferments."

A new factor in the ripening of cheese was the discovery of an unorganized ferment, or enzyme, in milk by Babcock and Russell. These authors kept milk in contact with an excess of chemical substances that destroyed the metabolic activity of bacteria, but which did not suspend entirely the action of the organized ferments. Under these conditions the milk coagulated, and there was a progressive formation of soluble proteids (albumoses and peptones) comparable to the breaking down of the casein in the normal ripening of cheese. Bacterial life was not absolutely excluded from the milk with which the experiments were performed, but by elaborate precautions, their numbers were minimized as much as possible.

Cheese was also cured under anaesthetic conditions. A cheese kept under chloroform and heavily saturated with this anaesthetic, even when more than a year old was physically thoroughly broken down and resembled a well cured cheese. Chemically, more than fifty per cent. of the casein was converted into soluble products, which amount is about the same as that found in normal cheese of the same age. Bacteriologically it was sterile.

These experiments seemed to the authors to indicate that the inherent enzymes in the milk played a very important rôle in the breakdown of the casein.

The year following this discovery, 1897, the authors published additional studies, and named the ferment *galactase*, on account of its presence in milk. It was found that this enzyme was allied to trypsin, the digestive ferment of the pancreas, and in this connection, it is interesting to note that Jensen independently discovered that cheese made from pasteurised milk with the addition of ether to prevent bacterial action, and a certain amount of pancreas to furnish the trypsin, cured more quickly, and contained nearly fifty per cent. more soluble nitrogen than cheese made without the addition of pancreas.

This ferment, however, differs from trypsin, in that it gives rise to a certain amount of free ammonia. It also differs with regard to the temperature at which its action is most energetic.

Storch's test for determining whether milk has been heated to a temperature exceeding 80° C. depends on the presence of galactase, the activity of which is destroyed by this temperature.

Babcock and Russell also made extensive researches on the distribution of galactase in different species of mammalia, in individual milks at the same or different periods of lactation, etc.

As to the structures in the body in which the enzyme is found, the authors have not yet examined the mammary glands for its presence, but suggested the close relationship between the blood and milk, as s[illegible] in the production of immunizing substances in the milk of anim[illegible]s rendered artificially immune to bacterial poisons.

Barthel has recently pointed out that normal cows' milk contains large numbers of leucocytes, and attributes Storch's test to their presence in the milk.

He even considered the leucocytes, or an enzyme secreted by them, as the cause of the phenomena observed by Babcock and Russell and by them attributed to galactase. The leucocytes also behave in the same manner towards anæsthetics as galactase, and another indication that the colour reaction obtained in Storch's test is due to the presence of leucocytes, is that whey gives a reddish-brown and not a blue colour as in the case of milk. The latter colour has been shown by Storch to be due to the casein of the milk.

Schirokich, in 1898, experimented on the diastases produced by *Tyrothrix tenuis.* He grew the bacillus for four days at 35° C., and then filtered the culture through a porcelain filter, and added the germ free filtrate to sterilized milk. The milk was digested and the casein became soluble in water, but the liquid had not the odour of cheese. He then tried another method. A pure culture of a lactic acid ferment was made in sterilized milk, and, as soon as complete coagulation had occurred, five per cent. of the sterile diastase from Tyrothrix was added, and the mixture kept at 35 C. The diastase acted slowly on the casein, and at the end of fifteen days the mixture had a typical cheesy smell. This experiment was repeated several times with like results. Further experiments showed that the intensity of the cheesy smell depended on the amount of acid present in the milk when the diastase was added.

In conclusion, Schirokich suggested the use of pure cultures of lactic acid together with digesting bacteria and casein, as the ripening seemed to be a special kind of symbiosis.

In a series of articles in the Milch Zeitung (1899) Weigmann discussed the rôle of he lactic acid bacteria in the ripening of cheese, especially referring to the work of de Freudenreich. He drew the following conclusions, from his own experiments and also those of other investigators:

1. The special lactic acid bacteria are not cheese ripening bacteria, the form used by de Freudenreich in his experiments being only facultative, or more probably degenerate lactic acid bacteria.

2. Lactic acid bacteria have an important rôle in cheese ripening, not in actually taking part in the ripening, but by directing the process in the right direction.

3. This function consists in eliminating certain forms of bacteria and fungi by the lactic acid formed, and providing an acid nutrient medium upon which only such bacteria and fungi can thrive as can withstand the acid or consume it. The micro-organisms which consume the acid prevent its accumulation in too strong a degree, take part in the peptonizing and flavour producing processes, and enable other bacteria or fungi, whose activity was weakened by the acid, to continue their work.

4. The specific character of a particular kind of cheese depends upon the predominating form of micro-organism, which the manner of preparation and the handling of the cheese have brought about.

Boekhout and Vries made Edam cheese from pasteurised milk inoculated with a lactic acid ferment isolated from Edam cheese, but this cheese failed to ripen.

Cheese made from pasteurised milk and inoculated with a plug of fourteen day old cheese did not ripen, and the same result took place with cheese made from pasteurised milk and mixed with five per cent. market milk.

Better cheese was made from milk heated to 55° C. for half an hour and treated exactly as in the above experiments, but even this cheese could not be called normal.

Then these investigators attempted to get milk as germ free as possible, by washing the hind quarters of the cow with soap and water, followed by three per cent. boracic acid. The milker's hands were similarly treated. The milk obtained was not quite sterile, but so poor in bacterial content that a portion remained a long time in the incubator at 22° C. without change.

This milk was divided into two equal portions without the addition of any cultures, and this part acted as a check on the other portion with which the following three experiments were made:

1. Milk inoculated with fourteen day old cheese.

2. Milk inoculated with a lactic acid bacterium isolated from Edam cheese.

3. Milk inoculated with market milk.

In numbers one and three experiments, there was a normal ripening, but the cheese made from milk inoculated with the lactic acid bacillus failed to ripen.

The cheese made from the control milk did not ripen at all.

From these experiments, the authors concluded, that:

1. The heating of milk changes the casein and prevents ripening.

2. If we look for the ripening organisms among the lactic acid bacteria, we must remember that not all the lactic acid bacteria are able to cause the ripening.

3. The theory of Babcock and Russell is incorrect, otherwise the control cheese would have ripened.

4. If the theory of Weigmann should be confirmed, it must be qualified in so far that the organisms are still alive on the fourteenth day, for the cheese used was inoculated with fourteen day old cheese.

De Freudenreich and Jensen's experiments on the relation between lactic acid ferments and the ripening of Emmenthaler cheese were very extensive and thorough. They conclude that the Tyrothrix bacilli take no part in the ripening. They did not multiply in normal cheese, and even when added in large numbers they exerted no influence on the decomposition products, in fact their influence was harmful.

The natural enzymes (galactase) perhaps participate in the ripening, by rendering the casein soluble, and thus facilitate the operations of the lactic acid ferments. Pasteurising deteriorates the quality of Emmenthaler cheese. Another fact brought out was the loss of the soluble constituents of cheese during ripening.

The results of de Freudenreich's experiments in 1900 confirmed the work of Babcock and Russell upon galactase. Several new facts were also demonstrated. The presence of 0.3 and 0.5 per cent. of lactic acid considerably decreased the action of the diastase.

Twenty per cent. of ether was added to milk sterilized at 120 C. and this was then inoculated with a few drops of an emulsion of spores of *Tyrothrix tenuis*, and kept at 35 C. Another lot was similarly treated, except that the emulsion of spores was previously heated to 100 C. to destroy the enzymes present. At the end of three months, the latter sample had undergone no change and contained 0.053 per cent. of soluble nitrogen; and in the first sample, a change commenced at the end of four weeks, and progressed rapidly during the next two months. At the end of that time, there was some digestion of the casein, and the chemical analysis showed 0.098 per cent. of soluble nitrogen. This experiment showed that not only were the diastases produced by bacteria capable of action on casein, but even bacteria themselves or even their spores might contain digesting enzymes. De Freudenreich does not believe with Babcock and Russell that galactase plays the principal rôle in the ripening of cheese, but that in rendering the casein soluble, it probably prepares for and facilitates the work of the bacteria which cause the ripening, and the special taste of cheese.

Jensen studied the origin and properties of the enzymes found in cheese, both hard (Emmenthaler) and soft (Limbourg) varieties. To determine if galactase played any part in the ripening, he examined the following four points:

1. Is the galactase of milk in sufficient quantity in the curd to be able to produce an appreciable transformation of the casein?

2. How long does galactase remain in the cheese?

3. Are the natural conditions met with in cheese such, that the galactase can exercise its action?

4. Does the pepsin of the rennet take part in the ripening of cheese?

By a series of analyses, too long to quote in this paper, Jensen partially answered the above questions. Thus he concluded:

1. As cheese is made with rennet, galactase and the pepsin in rennet are present in sufficient quantities to produce changes in the casein.

2. Soft cheese is richer in enzymes than hard cheese.

3. The quantity of free lactic acid in soft cheese is sufficient to hinder the action of galactase, and consequently favour the action of the pepsin. In hard cheese, on the contrary, the quantity of free lactic acid present is smaller and only helps in a slight degree the action of pepsin at the expense of the galactase.

To determine which of the two factors, the lactic ferments or galactase, plays the principal rôle in the ripening of Emmenthaler cheese, Jensen compared the changes which naturally occurred in the casein of cheese with those caused by *each* of the two factors above mentioned. The action of galactase was rendered insignificant by using one per cent. of Formalin to prohibit bacterial action. Whilst to show the action of this enzyme, fifteen to twenty per cent. of ether was used to destroy the bacterial life. Again, the chief function of galactase is in its rendering albuminoid substances soluble, and the principal rôle of the lactic ferments is to form decomposition products. Thus, at the commencement of the ripening of Emmenthaler cheese, soluble albuminoid substances are first formed and only traces of decomposition products; and as soon as the free lactic acid is neutralized, the lactic acid bacilli commence their work, and immediately there is a considerable increase in the decomposition products. The quantity of these latter products constantly increases during the rest of the ripening process, whilst the augmentation of soluble albuminoid substances diminishes. In other words, the lactic acid bacteria or their enzymes become more and more the only factor in the ripening, probably because the galactase becomes gradually enfeebled.

In a few words, the changes that occur in the casein during the ripening of Emmenthaler cheese seem to consist of a metabiosis between galactase and the lactic acid bacteria.

From the results of his researches, Jensen thus describes the process of ripening in Emmenthaler cheese:

The curing is due to different fermentations accompanied by two simultaneous processes—salting and drying. The term fermentation is used to signify the chemical decomposition, due to organized ferments or to unorganized ones.

Salting helps to keep the cheese, moistens the crust, and facilitates the drying. These two actions (salting and drying) delay fermentation, especially at the outside of the cheese.

Before transferring the cheese to a warmer room, salting and drying continue for some time, during which interval the galactase begins its action and dissolves or renders the casein soluble. At the same time, the amount of free lactic acid gradually diminishes.

As soon as the cheese is placed in a warmer room, the lactic acid bacteria commence to increase, the temperature of the interior of the cheese probably rises, and the greater part of the soluble albuminoid substances form and the production of the holes finishes. The drying out of the cheese also occurs more quickly at this temperature. Finally, the cheese is transferred to a cooler room, in which the cheese age, until they are considered ripe. During this time, the bacteria slowly die out, but their enzymes continue to act, and increase the quantity of the products of the decomposition of casein. During the last fermentation, the final salting is given, and drops of liquid (tears) form in the holes in the cheese.

Babcock and Russell, in 1900, experimented upon the action of rennet on cheese, and concluded from a number of experiments:

1. That an increase in the amount of rennet extract used in making cheese does increase the amount of soluble nitrogenous products, which measure the progress of cheese ripening.

2. Increase in amount of rennet used does not increase the water content of cheese; and, therefore, the ripening of cheese cannot be indirectly affected in this way.

3. The products of peptic digestion in milk and cheese are confined to the higher decomposition products, viz., albumoses and peptones precipitated by tannin.

4. The increase in soluble nitrogenous products and also in milk due to an increase in amount of rennet extract used are confined to those bye-products that are peculiar to pepsin, thus indicating that the digestive action of rennet extract is attributable to the action of the pepsin incorporated with rennet extract.

5. The crucial test of this conclusion was made by adding purified pepsin to milk and making the same into cheese, where rennet extract was or was not added to curdle the milk. In such cheese digestion has been increased in those cases to which pepsin has been added, and this increase has been confined to those bye-products that are characteristic of pepsin, and which also appear in cheese made with high quantities of rennet.

6. The digestion in cheese incident to pepsin is determined mainly by the degree of acidity developed in the milk and curd. In Cheddar cheese, peptic digestion probably does not begin until the acidity of the milk is approximately 0.3 per cent. lactic acid.

7. Acid salts as phosphates, etc., favour peptic digestion in milk in a manner comparable to free acids.

8. *Free acid does not normally exist in Cheddar cheese, the* apparent acidity being due to acid salts.

The results of the first researches of Chodat and Hofman-Bang were published in 1898, and their conclusions were as follows:

1. A single species of bacterium can produce the digestion of the casein and the characteristic odour of cheese.

2. That contrary to the opinion of de Freudenreich but in agreement

with that of Duclaux, bacteria which are not lactic acid producers can ripen cheese.

3. The acidity at the commencement of ripening was not necessary to bring about the solubility of the casein.

In their second paper (1900), they criticised de Freudenreich's work and report fresh results. De Freudenreich had shown that lactic acid bacteria could attack and render soluble portions of the *casein of milk*, but Chodat and Hofman-Bang point out that it has not been shown that the lactic acid bacteria can attack *coagulated casein;* and these two substances are so different that the results which have been obtained with the casein of milk cannot be applied *à priori* to coagulated casein.

These authors then experimented to see if the lactic acid bacteria were capable of dissolving coagulated casein. They isolated five different germs from Emmenthaler cheese, all of which produced lactic acid, and others volatile acids, as formic, acetic, and valerianic. These germs were grown on coagulated sugar-free casein, which had been previously sterilized at 120° C., for three successive days. At the end of three months, the acidity of the lactic ferments and the percentage of soluble nitrogen were determined, and it was found that the bacteria were well developed and were not contaminated, and that the quantity of soluble nitrogen had not increased. All the cultures had a feeble butyric odour. From this experiment, the authors concluded that de Freudenreich was wrong when he said "That the lactic acid bacteria play the principal rôle in the ripening of Emmenthaler cheese." Further, they thought the lactic acid bacteria in their cultures grew at the expense of the casein dissolved in the water used for moistening the curd in the culture flasks.

The lactic acid bacteria were also sown in flasks containing casein modified by casease obtained from a species of Tyrothrix. The casein was not dissolved by the Tyrothrix, and after the lactic germs had grown on this substance for two-and-a-half months, there was no increase in the percentage of soluble nitrogen.

Again, they seeded sterilized casein with living Tyrothrix, allowed it to grow until the curd was softened, without becoming liquid, and then sterilized germs and casein together at 120° C. Upon the casein thus prepared they placed a lactic acid bacillus, but with negative results, no increase of soluble nitrogen was demonstrated, which showed that the lactic acid germ had not been able to attack the casein.

Klein and Kirsten rendered heated milk suitable for cheese-making by adding calcium chloride. In their experiments they were able to produce normal cheese of several varieties (Bachstein, Spitz, Remoudou, Kloster, etc.) by heating the milk to temperatures varying from 85° C. to 100° C. for different periods of time, treating it with calcium chloride (twenty-five grams of calcium oxide per litre) and adding either cultures or starters. Cheese made by this method not only ripened normally but also gave a larger yield than cheese made from non-heated milks.

My own studies on the bacterial content of cheese were commenced in 1896 at the Bacteriological Laboratory of Dr. Russell, at the University of Wisconsin. During that summer and the following one of 1897, many analyses of Canadian Cheddar cheese were made, the methods of analyses being similar to those already published in the various reports of the Wisconsin Experiment Station. Briefly described, they are as follows:

A sterilized test-tube was sent to a factory with the request that a plug of cheese be placed therein, and asking that the cheese trier be sterilized with steam before use. A typewritten form accompanied each tube, upon which the cheesemaker filled out particulars as to the age of the cheese, condition of manufacture, amount of rennet used, etc. From one to five days elapsed between the taking of the sample and the making of the analyses; and, on many occasions, the cheese received was very greasy or had otherwise deteriorated owing to the very hot weather, and the length of time taken in transit. Doubtless these facts have contributed to bring about the diversity of the results shewn in my first table.

On arrival at the laboratory, one gram of cheese was weighed out and triturated with ten grams of sterilized sugar, sand or powdered glass. Sterilized water was then added and various dilutions made, differing with the age of the cheese. The medium used at Wisconsin was the ordinary beef peptone gelatin, with or without the addition of milk sugar. From two to five plates were made.

Subsequently this method was improved on, by using sterilized warm water (37° C.) for the dilutions, and yeast water lactose gelatin for medium. To this a small quantity of precipitated chalk was usually added. This medium gave excellent results compared with the ordinary nutrient gelatin or whey peptone gelatin, the colonies of the lactic acid bacteria were larger, and the dissolving action of these germs on the chalk materially aided the labour of counting.

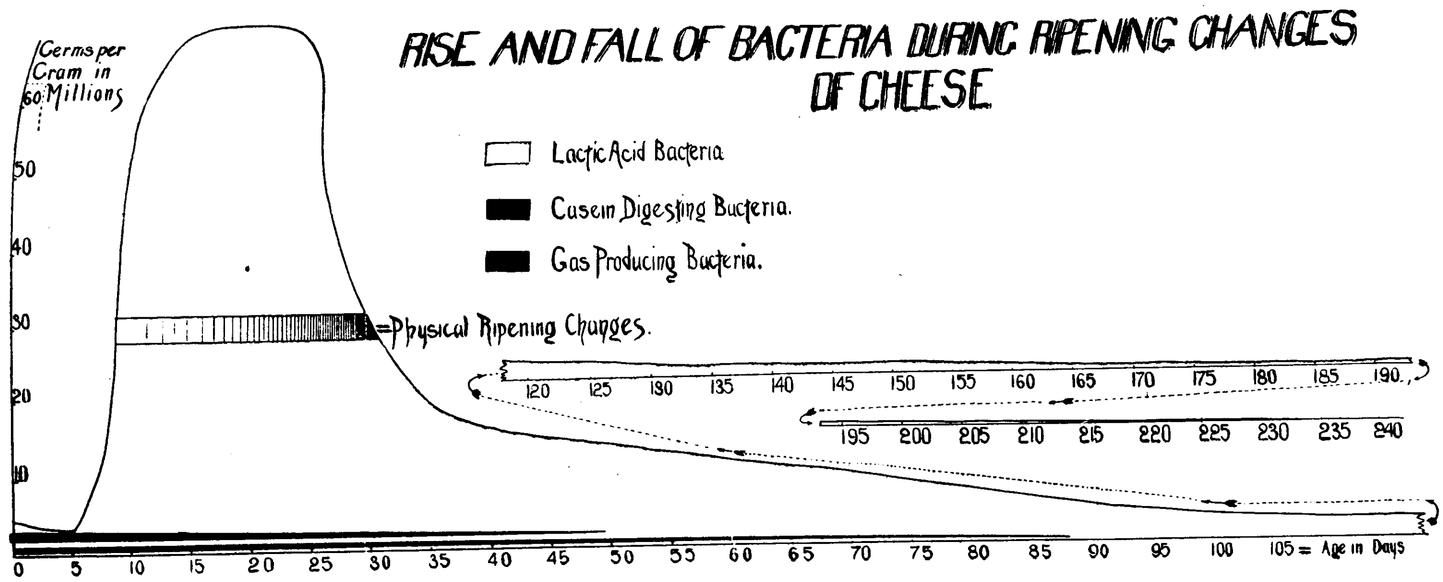
Following de Freudenreich's plan of obtaining the liquefying germs, surface cultures were occasionally made. This method also helped in the isolation of yeasts, the surface colonies of which were far easier to spot than those deep in the gelatin.

Anaerobic methods of culture failed to show any obligate anaerobes.

Pake's apparatus was used for counting the colonies, but when these were too numerous, a low power of the microscope was employed and from five to ten per cent. of the total number of microscope fields in a Petri dish of eighty m.m. diameter were counted, and computations made therefrom.

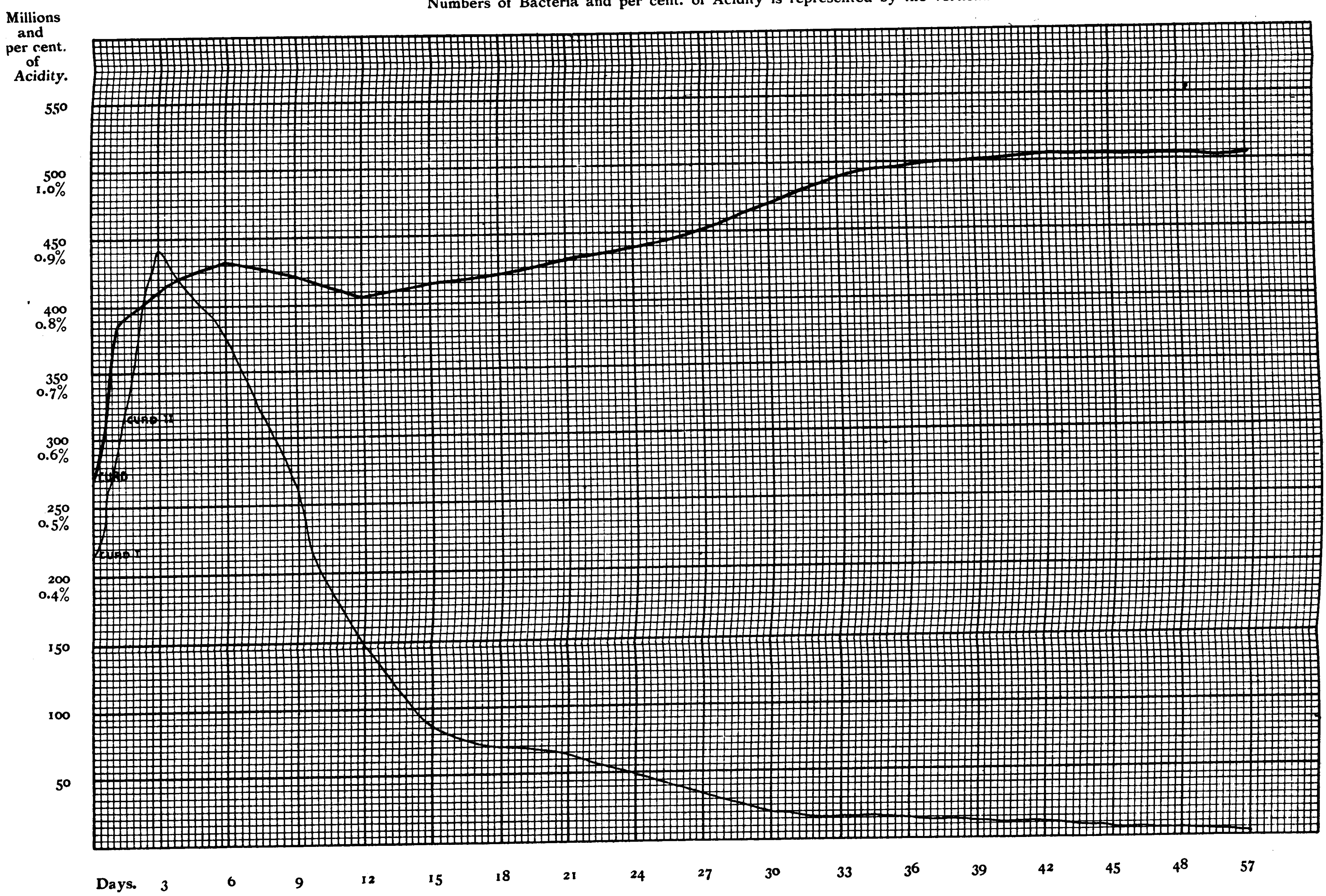
TABLE I.

Age of Cheese.	Month Cheese was made in.	Average temperature of curing room.	Rennet.	No. of germs per gram.	Lactic Acid Bacteria.	Digestors.	Gas Producing.	Yeasts.	REMARKS.
6 Days.	August.	70° F.	3 oz.	152,000,000	150,000,000	....	500,000	1,500,000	
7 "	July.	65° F.	3⅓ oz.	66,600,000	64,225,000	175,000	2,200,000	....	
11 "	August.	75° F.	3 oz.	28,800,000	28,200,000	1,500	120,000	400,000	
14 "	August.	75° F.	3⅓ oz.	74,800,000	71,300,000	......	3,500,000	3,500,000	
17 "	August.	75° F.	3 oz.	20,000,000	17,000,000	......	2,125,000	875,000	
22 "	August.	60-75° F.	3½ oz.	26,000,000	25,410,000	882,500	500,000	7,500	Cowy flavour.
23 "	July.	70° F.	3 oz.	64,000,000	57,600,000	500	200,000	6,000,000	Milk very gassy.
24 "	July.	70-78° F.	2½ oz.	33,600,000	33,100,000	100	50,000	400,000	
24 "	June.	65-70° F.	3 oz.	44,800,000	44,700,000	......	....	50,000	
25 "	July.	70° F.	3⅓ oz.	44,800,000	44,700,000	......	80,000	....	
29 "	June.	50-75° F.	3 oz.	4,500,000	4,500,000	....	.....	15,000	Plug received in a very greasy condition.
30 "	July.	74° F.	3½ oz.	5,500,000	5,400,000	....	100,000	......	Plug received in a very greasy condition.
30 "	July.	70° F.	3 oz.	17,750,000	17,700,000	......	.....	30,000	
31 "	July.	72° F.	4 oz.	5,000,000	4,900,000	......	....	100,000	
33 "	June.	74° F.	2½ oz.	8,500,000	8,500,000	.....	......	....	
34 "	July.	70° F.	3 oz.	7,500,000	7,000,000	500,000	....	....	Willow flavour (maker's remark).
36 "	July.	65° F.	3¼ oz.	8,600,000	8,600,000	....	....	25,000	
37 "	July.	75° F.	3 oz.	18,000,000	18,000,000	15,000	......	5,000	
37 "	June.	77° F.	3½ oz.	3,500,000	2,800,000	....	....	700,000	
40 "	July.	65-70° F.	3 oz.	5,800,000	5,800,000	......	....	....	
42 "	June.	65° F.	3⅓ oz.	4,900,000	4,850,000	......	....	49,000	
45 "	July.	70° F.	3 oz.	12,600,000	12,600,000	150	....	....	
50 "	June.	70° F.	3⅓ oz.	10,500,000	9,750,000	....	....	750,000	
51 "	June.	75° F.	3⅓ oz.	3,150,000	3,090,000	....	....	63,000	
51 "	June.	75° F.	3⅓ oz.	1,050,000	939,000	.....	....	111,000	Acid did not develop in milk.
58 "	June.	70° F.	3⅓ oz.	630,000	598,000	....	....	31,500	
68 "	May.	60° F.	2⅔ oz.	16,800,000	16,800,000	......	....	7,500	
403 "	July.	60-70° F.	......	1,400	1,350	.....	....	50	Taken out of curing room when matured.



Rise and Fall of Lactic Acid Bacteria during the Ripening of Canadian Cheddar Cheese.
Rise and Fall in the amount Acidity during the Ripening of Canadian Cheddar Cheese.

Time period is represented by the horizontal in periods of three days.
Numbers of Bacteria and per cent. of Acidity is represented by the vertical.



NUMBER AND KIND OF BACTERIA IN CHEESE AT DIFFERENT STAGES OF RIPENING.

CHEESE I.

Age in Days.	No. of Bacteria per gram.	Lactic Acid Bacteria.	Gas Producing Bacteria.	Casein Digesting Bacteria.	Yeasts.
Curd.	290,000,000	289,700,000	....	50,000	250,000
2 Days.	430,000,000	429,599,000	....	1,200	400,000
5 "	387,000,000	386,849,000	....	1,200	750,000
10 "	217,000,000	219,599,000	....	700	40,000
15 "	85,000,000	84,818,000	....	50	182,000
20 "	64,000,000	63,800,000	....	......	200,000
25 "	38,000,000	37,810,000	....	.....	190,000
30 "	22,000,000	21,760,000	....	.....	240,000
40 "	7,000,000	6,867,000	....	25	133,000
50 "	3,500,000	3,430,000	....	.....	70,000

REMARKS.—The temperature of the curing room was from 65° F. to 75° F. The ripened cheese was of good flavour and texture.

CHEESE II.

Age in Days.	No. of Bacteria per gram.	Lactic Acid Bacteria.	Gas Producing Bacteria.	Casein Digesting Bacteria.	Yeasts.
1 Day.	520,000,000	514,900,000	5,000,000	100,000	....
3 "	480,000,000	477,000,000	3,000,000	25,000	2,000
7 "	275,000,000	274,250,000	700,000	2,000	45,000
12 "	270,000,000	269,900,000	5,000	......	27,000
17 "	130,000,000	129,000,000	....	500	70,000
24 "	83,000,000	82,900,000	....	100	32,000
31 "	31,000,000	31,000,000	....	.....	14,000
51 "	6,700,000	6,700,000	....	.....	0,500

CHEESE III.

Age in Days.	No. of Bacteria per gram.	Lactic Acid Bacteria.	Gas Producing Bacteria.	Casein Digesting Bacteria.	Yeasts.
2 Days.	340,000,000	340,000,000	....	5,000	10,000
9 "	214,000,000	214,000,000	....	......	70,000
16 "	134,000,000	133,750,000	....	......	250,000
23 "	88,000,000	86,500,000	....	.....	1,500,000
30 "	37,000,000	35,780,000	....	......	1,220,000
37 "	27,500,000	26,700,000	....	.....	800,000
45 "	12,250,000	11,950,000	....	......	300,000

Both of the above cheeses were of good flavour.

ACID IN CHEESE.*

Method.—Five grams of cheese and an equal amount of glass were ground together in a mortar; 100 c.c. of water was then added and well mixed with the cheese. After standing fifteen minutes, the mixture was filtered through a dry filter paper, and 25 c.c. of the clear filtrate taken for the determination of the acidity. Phenolphtalein was used as indicator.

Where the acidity was determined in an unfiltered portion, as much as two per cent. of acid was found in the older cheese, probably due to the casein neutralizing the alkali.

Curd at Milling showed .54 per cent. acid figured as lactic acid.
" Salting " .76 " "

Cheese	6	days old	from Salting	showed	.86	per cent. acid.
"	6	"	"	"	.86	"
"	13	"	"	"	.81	"
"	13	"	"	"	.79	"
"	20	"	"	"	.86	"
"	20	"	"	"	.90	"
"	27	"	"	"	.90	"
"	27	"	"	"	.86	"
"	34	"	"	"	.93	"
"	34	"	"	"	1.02	"
"	41	"	"	"	1.08	"
"	41		"	"	1.08	"
"	48	"	"	"	1.08	"
"	48	"	"	"	1.08	"
"	55	"	"	"	1.08	"
"	165	"	"	"	1.08	"
"	225	"	"	"	1.08	"

The work of Russell and Wenizirl on the normal cheese flora of Wisconsin cheese, during the entire history of the cheese from the time it was made until it was consumed, has been duplicated in my laboratory, but with these differences:

1. Canadian Cheddar cheese was the subject of study.

2. The culture medium used was somewhat different; yeast-water, lactose gelatine, whey peptone gelatine, and ordinary beef broth lactose gelatine were employed. From six to ten Petri dishes were poured for each analysis.

*These determinations were made by R. Harcourt, Associate Professor of Chemistry, Ontario Agricultural College.

3. The oldest cheese analyzed was fifty-one days old. Russell gave the result up to 108 days for two cheeses, and up to 237 days for one.

The general results of these studies on Canadian cheese are shown by the diagram and tables, and demonstrate the enormous increase of the lactic acid bacteria in the initial stages of cheese-making. From the moment the milk is placed in the vat, every condition favourable for the growth of this class of micro-organism is carefully fostered. The greatest number found was in cheese two or three days old; at this age, one cheese contained 520 millions bacteria per gram, nearly five times as many as Russell observed in Wisconsin cheese.

From this point the numbers decline at first rather rapidly, but subsequently the decrease is more gradual.

Comparing my results with Russell's and summarizing them, I might state that in Canadian Cheddar cheese there is:

1. *Period of increase* in which the bacteria develop most rapidly in the curd, and in the cheese up to the age of two or three days, followed by

2. *Period of rapid decline*, in which the numbers fall away somewhat rapidly until about the thirteenth day, when the cheese may be said to enter the final

3. *Period of slow or general decline*, in which their numbers slowly decrease, at the 430th day but 1,400 per gram were found.

The results, whilst agreeing with Russell's, as to the enormous development of the lactic acid bacteria in cheese, differ in that there is no period of "Initial Decline," and that the "Period of Increase" virtually takes place in the curd. The maximum number are present in the cheese at the moment it is taken out of the press. The "Period of Final Decline," I have subdivided, although my two divisions may be quite well taken together.

If in connection with this remarkable increase of lactic acid bacteria, we examine the amount of acid present in the curd and cheese, we find that the greatest increase in acidity occurs between milling and salting. From this point until the cheese is forty days old there is a gradual and progressive increase. Thus, the increase in acidity from the time of milling until the cheese was six days old was 0.32 per cent. calculated as lactic acid, and the increase from the latter age to forty-one days old was exactly the same, 0.32 per cent.; but in the former case, the increase was accomplished in six days, and in the latter thirty-five days.

Whilst the increase in numbers of the lactic acid bacteria can fully account for the initial increase in acid, no ready explanation can be given for the gradual and progressive development of acidity from the sixth to the fortieth day. The acidity is due more to acid salts than to free acid, and it may be that some change occurs in the acid bases, and perhaps some of the fatty acids are liberated.

The "Period of Rapid Decline" is practically synchronous with the gradual increase of acidity, and the "period of gradual decline" is coincident with the maximum amount of acidity. This increase, followed by an almost permanent amount of acidity, may possibly explain why the bacteria die out at first rather rapidly and subsequently somewhat more slowly, the least resistant germs being killed off quickly by the slow accumulation of acid followed by the gradual death of the stronger individuals.

Lactic acid bacteria.—The prevalent lactic acid species present in all samples was undoubtedly the *B. acidi lactici* of Esten. This author stated that this bacterium is identical in every particular with Günther and Thierfelder's organism. In most of the samples of cheese it was the predominating lactic acid bacterium present. Next in numbers was *B. lactis aerogenes*, or a form closely allied to it. This microbe curdled milk into a soft curd, and after some time gas bubbles appeared. When cultures of the above two organisms were seeded together in sterilized milk, a firm curd was produced with little or no gas. Occasionally a micrococcus producing a buff-coloured colony, and also torulae were found. Both of these turned litmus red and coagulated it into a solid curd with no separation of whey.

Gas producing bacteria.—The gas producing bacteria belonged usually to either the *B. coli* group or else to the *B. lactis aerogenes* group. In the former group many varieties have been cultivated, showing considerable differences as to motility, indol and gas production. Nearly all writers on dairy bacteriology blame varieties of this bacillus for producing gassy milk and bad flavours. In several instances the cheese was mottled when this germ was present and this result might be possibly brought about by the bleaching action of the hydrogen liberated in the cheese by this ubiquitous microbe.

According to Weinzirl the "huffing" of cheese results from the activity of a large number of Hueppe's *B. acidi lactici*. Cohn considers this germ to belong to the aerogenes group, but the forms of this bacterium that I have met with in Canadian cheese show considerable variations from the type, especially with regard to the appearance of the gelatine colonies which simulate rather that of B. acidi lactici (Esten).

This group does not increase in cheese and I have not found them in cheese older than thirty days.

The liquefying bacteria found in Canadian cheese were not numerous, and their numbers decreased as the cheese ripened, so that in three weeks old cheese they were seldom found. A constant endeavour was made in order to isolate micro-organisms belonging to this class, but usually without success. On one occasion the presence of a larger number of digesting bacteria than usual was associated with a bad flavour in the cheese.

Some seven different species of liquefying germs have been isolated. Probably the commonest species were forms almost identical with Hueppe's *Bacillus butyricus*. This germ was several times found in fair numbers, from cheese taken from very warm curing rooms. The next most common species was a clostridium form, which grew in long threads. On gelatine, it formed a brown granular colony, and milk was completely digested. It might belong to Duclaux's Tyrothrix group.

What was evidently a variety of Conn's *B. varians lactis* was also isolated.

Two or three forms met with seemed allied to the Proteus group, and seemed to be closely related to *B. fulvus* (Zimmermann). These were found only in young cheese.

Practically the whole of this group gave rise to bad flavour or odours in milk. Butter has been made from cream ripened with some of these bacteria, and invariably a bad product was produced

YEASTS.

I have found yeasts quite commonly present in Canadian cheese, and frequently in large numbers. This fact was first noted whilst studying at Wisconsin University in Professor Russell's laboratory, but no special endeavour was then made to give them the best conditions for growth. Since, I have used yeast water gelatine, and alc wort gelatine, for their isolation. The latter medium is excellent, as other bacteria that may be present in the sample do not find it a suitable pabulum.

So far as my experiments are concerned, they are the only micro-organisms that actually increase in cheese. Cheese No. 3 illustrates the increase of yeasts that may take place in cheese, and some of the analyses in Table I support this conclusion.

Whilst I have applied the name yeasts to this class, most of them are species of *Torula*, as they form no spores, even under the conditions prescribed by Hansen. They may be classified roughly here as beneficial and injurious. The former either act like the lactic acid bacteria in milk, produce acid, and give a firm curd, or they may make but little acid and after considerable length of time digest the casein. The injurious species have more diverse habits. Thus some are able to ferment lactose, form gas, and give rise to bad flavours in the cheese. A species of torula isolated in 1900, besides causing gas formation, produced a bitter flavour, which gave much trouble in as many as four factories in the same district.

Another species of torula caused no perceptible change in milk, but when grown with a lactic acid bacterium it produced a mottled appearance in the cheese. I was able to produce such mottles in milk containing a little cheese colour, and seeded with a lactic acid bacillus, or a drop of lactic acid and the torula.

The great difficulty which a cheese maker experiences when working with yeasts is the remarkable tolerance they shew to acidity, so that a maker is unable to repress an undesirable yeast fermentation by the addition of a vigorous lactic acid starter. Some of the torulae I have isolated grew luxuriantly in peptone solutions containing 2.25 per cent. of lactic acid. This fact undoubtedly explains their increase in cheese.

Nothing can be said as to the place of origin of these yeasts.

Other bacteria in Cheese.—During these investigations a number of other forms, not falling into any of the classes I have mentioned, have been isolated. Some of these produced undesirable flavours and others were inert. Nothing need be said of these in this paper, on account of their occasional occurrence, or unimportance to my subject.

My experiments and results are perhaps rather few, and too little chemical work has been done to justify much theorizing on what causes the ripening of cheese, but from a review of the works of others and my own results, I may perhaps be justified in making a few remarks.

Three most important facts seem well supported by good evidence and trustworthy experiments :

1. The enormous number of lactic acid bacteria in hard cheese, and the very small numbers of liquefying or digesting bacteria.

2. The existence of galactase, a natural enzyme inherent in fresh milk.

3. The ability of rennet to cause the change of non-soluble nitrogenous products to soluble ones.

If we grant that these three facts are proved, and we may safely do so, our inquiry into the cause of the ripening of cheese will be somewhat simplified.

The lactic acid bacteria seem to be able to cause an increase in the amount of soluble nitrogenous products in the casein of milk (de Freudenreich). Klein and Kirsten also state that normal cheese may be made from pasteurised milk (hence free from enzymes) with the aid of starters. Russell, before the discovery of galactase, stated "that the addition of a pure lactic acid ferment to the pasteurised milk permits the usual changes to occur in a perfectly normal way."

On the other hand, Boekhout and Vries were unable to produce normal cheese (Edam) made from aseptic milk with the addition of a culture of lactic acid bacteria, but at the same time they admit that perhaps some other variety of lactic acid bacteria might bring about the ripening changes.

Chodat and Bang grew lactic acid bacteria on coagulated casein, but the quantity of soluble nitrogen in this mass did not increase; so that taking into account these facts, we are bound to admit that there exists more or less doubt as to the ability of the lactic acid bacteria to alone bring about an increase in the amount of soluble nitrogen.

Babcock and Russell's discovery of galactase led them to consider that the "breaking down of the casein was due in larger part to the action of this enzyme"; in fact, they attribute to galactase the principal rôle in the ripening of cheese. Both de Freudenreich and Jensen confirmed the presence of this enzyme in milk, but they do not consider that it is the all-important factor in the curing process. Boekhout and Vries completely deny its ability to ripen cheese, and Klein and Kirsten's experiments show that soft cheeses ripen normally, even when made from milk in which the enzyme has been destroyed by heat.

My experiments show that the amount of acid present in Canadian Cheddar cheese is sufficient to inhibit and perhaps altogether stop its action in cheese; for, if as shown by de Freudenreich, 0.5 per cent. of lactic acid can considerably enfeeble its action, then the amount of acidity in normal Canadian Cheddar cheese might still more diminish the action of galactase, as the percentage of acidity in the manufactured cheese varies at different ages from 0.76 per cent. to 1.08 per cent.

Thus, we are bound to conclude that, as far as Canadian Cheddar cheese is concerned, the presence of galactase is of little importance.

There now remains the question of the ability of rennet to cause the ripening changes.

Jensen was the first to show that curing might be accelerated by incorporating pancreas with the curd, and subsequently Babcock and Russell and Jensen simultaneously proved that the pepsin in rennet increased the higher decomposition products, as albumoses and peptones in cheese.

There is also the well-known fact that cheese-makers increase the amount of rennet when they want a fast curing cheese.

Now rennet acts more quickly and better in acid solutions, and it seems that the rôle of the lactic acid bacteria, whose growth in the milk is so carefully fostered by the cheese-maker, is to bring about or create the requisite acidity so that the pepsin of the rennet can exercise its digestive action on the cheese.

There is practically no increase in the number of lactic acid bacteria after the cheese have been taken from the press, but the amount of acidity increases and Schirokich's experiments proved that the diastase of Tyrothrix (which is similar to rennet in its action) was able to act on the casein when the requisite amount of acid was present.

This connection, for we can hardly call it symbiosis, between the action of rennet and lactic acid bacteria will serve to harmonize the results of the experiments of other investigators. Thus, if we substitute the enzymes of rennet for Schirokich's bacterial enzymes, the curing process may thus be explained, and Weigmann's theory that the lactic acid bacteria direct the process of curing in the right direction by eliminating undesirable forms of bacteria by the lactic acid formed, is quite in accord with my proposal.

Summarized, the ripening of cheese may be said to be caused by the digestive action of the rennet on the insoluble nitrogenous matter of the cheese, in the presence of acid formed by the lactic acid bacteria. The large amount of acidity also prevents or inhibits the growth of other (and perhaps undesirable) species of bacteria.

LITERATURE.

ADAMETZ. "Bakteriologische Untersuchung über den Reifungsprozess der Käse." Landw. Jahrbücher, XVIII, 1899, p. 227-269.

BABCOCK & RUSSELL. XIV, XV, XVI and XVII, Reports of the Wisconsin Experiment Station (1897-1900).

BARTHEL. Nord. Mejeri. Tdn. 14, 1899, p. 215, E.S.R. XI, p. 785.

BENECKE & SCHULZE. "Untersuchungen über den Emmenthaler Käse und über Einige andere Schweizerische Käsersorten." Landw. Jahrbücher, XVI, p. 317-400, and Centralblatt f. Bakt., I, 1887.

BOEKHOUT & OTT DE VRIES. "Untersuchungen über der Reifungsprozess des Edamer Käses." Centralb. für Bakt. II Abt., 1899, p. 304.

CHODAT & HOFMAN BANG. Bulletin de l'herbier Bossier, 1898, p. 713. Annales de L'Institut Pasteur, 1901, p. 37.

COHN, F. "Beitrage zur Biologie der Pflanzen." 1875, Bd. 1, 3 Heft. s. 191.

DUCLAUX. "Fabrication, maturation et maladies du fromage de Cantal." Annales agronomique, 1878.

"Le lait, etudes chemiques et microbiologique." Paris, 1887. (Deuxième tirage augmenté, 1894.)

VON FREUDENREICH. "Recherches preliminaires sur le rôle des bacteries dans la maturation du fromage d'Emmethal." Annales de Micrographie, II, 1890, and Landwirt. Jahrb. d. Schweiz, V, 1891. "Weitere bakteriologische Untersuchungen und Reifungsprozess des Emmenthaler Käses." Landwirt. Jahrb. d. Schweiz, VIII, 1894, und Centralb. f. Bakt. II Abt., Bd. 1, 1895.

"Ueber den jetzigen stand der bakteriologischen Forschung auf dem Gebiete des Käsereifungsprozess." Centralb. f. Bakt., II Abt., 1 Bd., 1895. "Ueber die Erreger der Reifung bei dem Emmenthaler Käse." Annales de Micrographie, 1897, and Landw. Jahrb. d. Schweiz, XI, 1897, "Sur la maturation des Fromages." Annales de Microg., X, 1898, p. 279. "Ueber die Beteiligung der Milchsäure bakterien an der Käsereifung." Centralb. f. Bakt. II, Bd. 5, 1899, p. 24.

VON FREUDENREICH. "Note sur la galactase." L'Annuaire Agricole de la Suisse, 1900.

VON FREUDENREICH & JENSEN. Centralb. f. Bakt., II Abt., 1900, 12 et seq.

HARRISON. "Die Lebensdauer des Tuberkel-Bacillus im Käse." Landwirt. Jahrbüch der Schweiz, 1900.

JENSEN. "Studien über die Enzyme im Käse." Centralb. f. Bakt. II, Bd. VI, 1900. Landwirtschaf. Jahr. d. Schweiz., 1900.

"Tidskr. for Fysik og Kemi." 2, 1897, pp. 92-114; abs. in Centbl. Agr. Chem., 26, p. 707.

KLEIN & KIRSTEN. "Versuche betreffend die Herstellung von Käsen aus erhitzer Milch." Milch Zeitung, 1900, 1901.

LLOYD. "Observations on Cheddar Cheese Making." Bath and W. Eng. Soc. Reports 1891, 1892 and 1893.

PAMMEL. "An aromatic bacillus of cheese." Iowa Agricul. Expt. Sta. 1894, Bull. 21.

RUSSELL & WEINZIRL. "The rise and fall of Bacteria in Cheddar Cheese." Centralb. f. Bakt., II Abt., III Bd., 1897. Wisconsin Experiment Sta. Report, XIII, 1896, p. 95.

SCHIROKICH. "Sur le Maturation des Fromages." Annales de l'Institut Pasteur, Vol. 12, 1898, p. 400.

"The ripening of cheese and the role of micro-organisms in the process." Selsk Khoz. Lyesov., 98, 1896, pp. 263-288. Abstract in E.S.R., Vol. 9, 1897-8, p. 286.

STORCH. "40 Beretring fra den Kgl. Vetrinar-und Landbohöjskoles Laboratorium for landökonomiske Forsög, 1898."

WEIGMANN. "Ueber den jetzigen stand der bakteriologischen Forschung auf den Gebiete des Käsereifungsprozess." Centralb. f. Bakt. II, Bd. II, 1896, No. 5.

Centralb. f. Bakt., II Abt., 1898, p. 593.

Milch Zeitung, 1899.

WEINZIRL. "The Bacterial Flora of American Cheddar Cheese." Centralb. f. Bakt. II, Bd. VI, 1900.

WINCKLER. "Zur Charakteri rung der Duclauxschen Tyrothrix arten, etc." Centralb. f. Bakt. II. Abt., Bd. 11, 1896.

WITTLIN. "Ueber die angebliche Umänderung von Tyrothrix tenuis in ein Milch säurebakterium." Centralb. f. Bakt. II Abt., Bd. II, 1896.

GŒTHE'S FAUST.

BY PROF. L. E. HORNING.

(Read 13th April, 1901).

The following tabular comparison of the three stages in which Gœthe's Faust, Part I. is known, has been drawn up by Prof. Horning, of Victoria University, Toronto. It was submitted in the first of a series of studies in Gœthe's masterpiece.

The numbering of the lines is according to Schmidt's Edition of the *Urfaust*, Seuffert's reprint of the *Fragment* and the Weimar Edition of Part I.; where advisable totals of lines in the corresponding scenes are indicated.

URFAUST, 1773-1775?	FRAGMENT, 1790.	PART I., 1808.
		1. Zueignung, 1-32.
		2. Vorspiel auf dem Theater, 33-242.
		3. Prolog im Himmel, 243-353.
1. Nacht, 1-248.	1. Nacht, 1-248. Urf. 122, 123=122. " 194, 195 replaced by 195. 155, 194 are added.	4. Nacht. *a* 354-605 (252 lines). Urf. 122, 123=475. " 194, 195 replaced by 548. 507, 547, 598-601 are added. *b* 606-807.
		5. Vor dem Thor, 808-1177.
		6. Studierzimmer I., 1178-1529.
2. Schülerscene, 249-444 (196 lines). 249-262=1868-81 Pt. I. 263-266=1882-95 " 267-332 .... 333-340=1896-1903 Pt I. 1904-1909 " 341-394=1910-1963 " 1964-2000 " 395-444=2001-2050 "	2. *a* 249-346 (98 lines). *b* 347-529 (183 lines) Schülerscene. ......347-360. 361-374. ....375-382. .. ...383-388. .. ..389-442. ..... 443-479. ......480-529. *c* Faust tritt auf, 530-551.	7. Studierzimmer II. *a* 1530-1769. *b* 1770-1867. (98 lines). *c* 1868-2050-Schülerscene. (183 lines). Result=70 lines omitted. 57 " added. 22 " " as *d*. Changes? *d* Faust tritt auf, 2051-2072.

URFAUST, 1773-1775?	FRAGMENT, 1790.	PART I., 1808.
3. Auerbach's Keller. *a* 445-452. *b* 25 lines of prose. *c* Rattenlied. *d* 48 lines of prose. *e* Flohlied. *f* 83 lines of prose. (In all 210 lines).	3. Auerbach's Keller. 552-815 (264 lines). Changes?	8. Auerbach's Keller. 2073-2336 (264 lines). Changes?
4. Landstrasse, 453-456		
	4. Hexenküche, 816-1067. (252 lines).	9. Hexenküche, 2337-2604. (268 lines). 2366-77 } = additions. 2390-93 }
5. Strasse, 457-529.	5. Strasse, 1068-1140.	10. Strasse, 2605-2677.
6. Abend, 530-656.	6. Abend, 1141-1267.	11. Abend, 2678-2804.
7. Allee, 657-718 (62 lines).	7. Spaziergang, 1267-1327. (60 lines). *Note.*—Between 1277 and 1278 two lines omitted = 667-668 of Urfaust.	12. Spaziergang, 2805-2864. (60 lines). *Note.*—Between 2814 and 2815 two lines omitted = 667-668 of Urfaust.
8. Nachbarinn Haus, 719-878. *Note.*—726 and 727 blank.	8. Der Nachbarinn Haus, 1328-1487. *Note.*—Two lines inserted = 1356-7 = between 748 and 749 of Urfaust.	13. Der Nachbarinn Haus. 2866-3024. *Note.*—Two lines inserted = 2893-94 = between 748 and 749 of Urfaust.
9. Faust and Mephistopheles, 879-924(46). Wie ist's?	9. Faust and Meph., 1488-1535 (48). *Note.*—Lines 1509-10 added, = between 899 and 900 of Urfaust. Changes?	14. Faust and Meph., 3025-3072. (48). *Note.*—Lines 3046 and 3047 added = between 899 and 900 of the Urfaust. Changes?
10. Garten, 925-1053. • (129).	10. Garten, 1536-1664. (129).	15. Garten, 3073-3204. (132). *Note* 1.—"Er liebt mich" of line 3184 is counted as one line in Fragment = 1643. Is this a printer's error? *Note* 2.—Lines 3149-52 added = between 1611 and 1612 of Fragment.
11. Ein Gartenhäuschen, 1054-1065.	11. Ein Gartenhäuschen, 1665-1676.	16. Ein Gartenhäuschen. 3205-3216.

URFAUST, 1773-1775?	FRAGMENT, 1790.	PART I., 1808.
See 18 *b*.	See 15.	17. Wald und Höhle. *a* 3217-3341 (125 lines). *b* 3342-3369 (28 lines). *c* 3370-3373 (4 lines). *Note* 1.—*b* = Urfaust 18 *b*. " 2.—This scene = Fragment 15. Changes? Espec. ll 3346-48. 3363. 3366.
12. Gretchens Stube, 1066-1105.	12. Gretchens Stube, 1677-1716.	18. Gretchens Stube, 3374-3413.
13. Marthens Garten, 1106-1235.	13. Marthens Garten, 1717-1846.	19. Marthens Garten, 3414-3543.
14. Am Brunnen, 1236-1277 (42 lines)	14. Am Brunnen, 1847-1889. (43 lines). *Note.*—Ach, 1853, counted as one line.	20. Am Brunnen, 3544-3586. *Note.*—Ach, 3550, counted as one line.
See 18 *b*.	15. Wald und Höhle, *a* 1890-2014 (125 lines). *b* 2015-2042 (28 lines). *c* 2043-2046 (4 lines). *Note.*—*b* = Urfaust 18 *b*. *Note position of scene in Part I.*	See 17.
15. Zwinger, 1278-1310.	16. Zwinger, 2047-79.	21. Zwinger, 3587-3619.
See 17 for Part I. *a*. See 18 *a* for Part I. *c*.	*Dropped.*	22. Nacht—Strasse vor Gretchens Thür. *a* 3620-45. (26 lines) *cf.* Urfaust 17. *b* 3646-49. (4 lines). *c* 3650-59. (10 lines) *cf.* Urfaust 18 *a*. *d* 3660-3775 (116 lines).
16. Dom, 1311-71 (61 lines).	17. Dom, 2080-2137 (58 lines). *Note* 1.—After 2094 line omitted = Urfaust 1326. *Note* 2.—2124-27 = 5 lines in Urfaust = 1356-60. *Note* 3.—2131-35 = 6 lines in Urfaust = 1364-69.	23. Dom, 3776-3834 (59 lines). *Note* 1.—Line 3789 added after 1323 of Urfaust. *Note* 2.—After 3791 a line omitted = Urfaust 1326. *Note* 3.—Lines 3821-24 = 5 lines in Urfaust, 1356-60. *Note* 4.—Lines 3828-32 = 6 lines in Urfaust, 1364-69.

URFAUST, 1773-1775?	FRAGMENT, 1790.	PART I., 1808.
17. Nacht — Vor Gretchens Haus. 1372-97 (26 lines) *cf.* Part I. 22 *a.*	*Dropped.*	See 22 *a.*
Faust and Mephistopheles (vor Gretchens Haus).		
a 1398-1407 (10 lines) *cf.* Part I. 22 *c.*	*Dropped.*	See 22 *c.*
b 1408-1435 (28 lines) *cf.* Part I. 17 *b*	See 15 *b.*	See 17 *b*
		24. Walpurgisnacht, 3835-4222.
		25. Walpurgisnachtstraum, 4223-4398.
19. Faust and Mephistopheles. *Prose.*	*Dropped.*	26. Trüber Tag. *Prose.*
20. Nacht, 1436-1441.	*Dropped.*	27. Nacht, 4399-4404
21. Kerker. *Prose.*	*Dropped.*	28. Kerker, 4405-4612. *Verse.* Other Changes ?

PHYSICAL GEOLOGY OF CENTRAL ONTARIO.*

BY ALFRED W. G. WILSON.

(Read 20th April, 1901.)

CONTENTS.

* This paper was written as a thesis for the Doctorate of Philosophy at Harvard University, and was presented in May, 1901.

INTRODUCTION.

LOCATION.—That portion of the Province of Ontario designated CENTRAL ONTARIO is a triangular area with its base on Lake Ontario to the south; the western arm is formed by the Niagara escarpment in its extension from Hamilton to Collingwood; the northern boundary follows the edge of the crystalline rocks from Georgian Bay to a point on the St. Lawrence river a short distance east of Kingston.

Historical References and Sources of Information.—Previous to the institution of the Geological Survey of Canada, in 1843, there had been no systematic studies of the geology of Upper Canada, now the Province of Ontario. Before that date much even of the then unsettled parts of the Province had been surveyed into townships, and more or less accurate maps prepared. Admiral Bayfield's surveys of the Great Lakes were the most important work upon the shore-lines of the Province. The present available maps, though in part corrected by more recent work, are based largely upon these early surveys. Dr. J. J. Bigsby had published (1829) a few papers in which reference is made to certain features of the area under discussion. After the institution of the Survey, the most important work is that of Alexander Murray. Between 1843 and 1856 Murray had explored and mapped a large portion of the present Province. His work in 1843 in the western portion of this area, and in 1852 in the eastern portion, forms the basis of our present knowledge of its geology. The first systematic account, in which all of Murray's work is summarized, was published by Sir William Logan in 1863. This volume, entitled "The Geology of

Canada," is still the standard work of reference for the geology of "Old" Ontario. Since 1863 there has been little work in the area under the auspices of the Survey, except some work in 1886, the results of which have not yet been made public. Both previous and subsequent to Logan's summary there have been many shorter papers published upon various topics. Some of these will be noted in the text.

In the preparation of the present paper the writer has made use of many sources of information, and due acknowledgment will be made in the appropriate places. During the last few summers, as opportunity offered, the greater number of localities referred to in the context have been visited, and use has been made of the writer's own observations in the field.

The writer wishes to acknowledge his indebtedness to Mr. J. M. Clarke, of Albany, for the identification of a number of fossils; and to Professor W. M. Davis, of Harvard University, for advice and criticism while this paper was in preparation.

Résumé.—The area comprises, in all, about 6,500 square miles of territory. Within its limits are found rocks ranging in age from the Archean to the Niagara. These are overlaid by a great complex of deposits dating from the Pleistocene epoch. Everywhere along the northern boundary the various members of the crystalline series are found passing beneath the Cambro-Silurian sediments; in some localities outliers of the sediments are found upon the crystallines; again, inliers of the latter are found wholly or partially surrounded by the former. At one time the sediments extended much farther towards the north; their removal has revealed ridges, valleys, and residual monadnocks, the sub-mature topography of a well-dissected plain of denudation, a plain long antedating the Cambrian.

The basal members of the sedimentary series are destitute of fossils, and consist of more or less coarse detritus; above them thick deposits of fossiliferous limestone were formed, and in many localities this limestone rests directly upon the crystallines. These limestones are in turn overlain by bituminous shales.

A second cycle of slow depression, much greater than the former, resulted in the formation of a similar series of deposits, the upper members of which lie beyond the area under consideration.

In the long interval from the close of the last period of deposition within the area until the beginning of the Pleistocene epoch, during

which the northern portion of this continent is supposed to have, at different times, stood at different but undetermined elevations above the then sea-level, the rocks of this area were exposed to the atmospheric agencies of disintegration and degradation. The result was the development of a topographic system whose remnants, though partly obscured by the deposits of the Pleistocene epoch, are still recognizable.

Extensive climatic changes, by some supposed to be the product of, or accompanied by, elevation of this and adjacent portions of North America, interrupted these processes of dissection ; ice, in the form of *sheet-glaciers*, modified the topography produced in previous epochs, and introduced large amounts of material from the adjacent crystalline area. During the close of the epoch, the time of melting of the glacier, the clay, sand, gravel and boulders which it carried were deposited. The waters collected in great lakes in front of the retreating ice. Around their shores deltas were built, beaches formed, and benches cut ; and a new system of drainage lines was instituted.

Again, however, changes in relative elevations of different parts, and the withdrawal of the ice, led to the partial dismemberment of the drainage systems, to the definition of the present lake basins, and to the development of new lines of drainage, which are essentially the same to-day, though these and the lake levels are being slowly modified by secular changes of elevation.

TOPOGRAPHY OF THE PRE-SEDIMENTARY FLOOR.

Diverse Character of the Crystallines.—The crystalline series along the northern boundary of the area comprise rocks in greatest variety, crystalline limestones, micaceous and hornblendic schists, and gneiss, the latter very abundant. Associated with these are plutonic and volcanic rocks, acid, basic, and of intermediate varieties. The whole region has been one of complicated folding and intense metamorphism. The schistose structure of the rocks, throughout the area, is nearly vertical, and has a northeast southwest trend, with local variations from this general direction.

This great variety of rocks would necessarily offer different resisting powers to erosive agencies, and give rise to very diverse topography. In travelling through the region on foot one is continually ascending or descending. Even then he cannot fail to note the many small tarns, muskegs, and beaver-meadows found so frequently upon the upland areas.

Even-topped Character of the Uplands.—Almost anywhere in the region the ascent of a height, from which a good view can be obtained, will disclose a remarkably even sky-line, indicative of the even character of the upland surface, with occasional greater elevations standing out in relief. One of the best localities to see this is from the crest of the divide between Deer bay and Stony lake, almost the middle point of the northern boundary of the area. The waters of Deer bay lie 120 feet below; to the north-east is the small Lovesick lake; to the east, three miles away, is the basin of Stony lake, the water-level being thirty feet below that of Deer bay. The sky-line of the upland upon the opposite side of these basins is remarkably even. Almost directly east, twelve miles in an air line, are the Blue Mountains at the other end of Stony lake, rising above the general level. These ridges, locally called mountains, are syenitic masses which stand out nearly 200 feet above the rolling surface of the surrounding district.

A most striking view over the upland is that obtained from the summit of the cliff near the narrows of Haliburton lake, in the township of Harburn, forty-five miles north of Stony lake. Here the observer will be standing about 175 feet above the lake, and over 1,000 feet above Lake Ontario, this being one of the highest points in Central Ontario. The waters of Haliburton lake flow southerly. Within a radius of ten miles are a number of small lakes and streams whose waters flow to the west, north or east, eventually reaching the Georgian Bay or the Ottawa river.

Looking towards the east, south or west, the even upland plain appears to have a slight inclination to the south. Towards the north the direction of inclination is not so evident. Over the upland there are sometimes large, nearly flat areas of muskeg, a feature in which it is comparable to the uplands of Norway.

Dissection.—Though still in an early stage of the cycle, the region as a whole is much dissected. Minor ridges and valleys trending prevailingly northeast and southwest are the dominant topographic features of the upland areas; deep, steep-sided valleys, due apparently to later dissection, interrupt the continuity of the upland surface: slopes, frequently of almost bare rock, are common, and steep cliffs not infrequent. At the borders of the sedimentary series the difference in level between the general upland surface and the bottoms of the larger valleys would average about 150 feet; further north, in areas which have perhaps been much longer denuded, this difference is much greater. All the deeper valleys are now lake basins; many of the larger basins in the vicinity of Haliburton are 'eep, so that the depth of the valley bottoms below the level of the upland plain is frequently as much as 400 feet. The less-deep lateral valleys seem frequently to be graded with respect to the lake surfaces. In some localities, in small areas upon the upland, the topography is rolling, with only occasional low ridges and shallow valleys, except close to the present lake depressions.

Gradients.—The general even character of the skyline throughout the crystalline area justifies a comparison of the arithmetic gradients of the surface upon which the sediments rest, as ascertained by the differences between the elevations of a number of localities within the area. Data to institute a comparison along a series of parallel lines, outside of the sedimentary area, are not available. Radially from the upland surface in the vicinity of Haliburton lake to a number of points along the base of the Cambro-Silurian escarpment, between Georgian Bay and Kingston, the average gradient is nearly nine feet per mile.

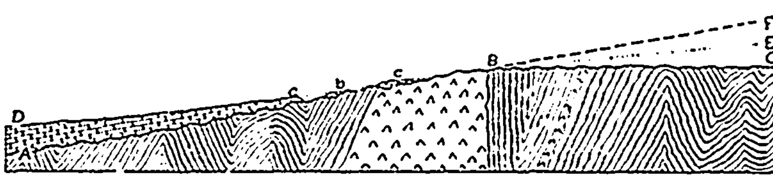


FIGURE 1.—AB represents the plain beneath the sedimentary cover ; BC, the plain north of the edge of the cover ; DB, the plain over the surface of the sediments ; *a*, the escarpment, *b* and *c*, outliers. Vertical exaggeration about forty times.

At Toronto the crystallines are known to be about 1,100 feet beneath the present surface. Two other borings, one at Cobourg, and the other in the township of South Fredericksburg, indicate that the floor is over 500 and over 600 feet, respectively, below the surface at these localities. The average gradient beneath the sedimentary cover along a series of lines from the foot of the Cambro-Silurian escarpment to the bottoms of these borings indicates that the gradient beneath the cover varies from twenty-two feet per mile in the western portion of the district to over forty-one feet per mile at the eastern end. The relative attitudes of these two surfaces are represented in figure 1, where AB represents the edge of a cross section of the plain beneath, and BC the edge of a cross section of that outside the sedimentary area.

Upon the surface of the sediments toward the eastern part of the area, the gradient appears to lie between that beneath and that without the cover (figure 1, DB). In the vicinity of Toronto it, in part, approximately coincides with that upon the surface of the crystallines to the north. The surface is too irregular to justify any general comparison. In the area studied, that portion lying east of a line running a little to the east of north from the west side of Balsam lake is inclined towards the southeast. West of this line the inclination is towards the west.

The meagre data available thus indicate that beneath the sedimentary cover towards the western end of the area the average gradient is more than double that of the uncovered portions, while at the eastern end it is about four times as great. Near the western end, the gradient from the summit over the crystallines to the Black River escarpment, and over the surface of the Palaeozoic strata, is nearly the same. This gradient is less than half the average gradient of the northern side of the basin of Lake Ontario (23.7 feet).

The relative positions of the three plains suggest certain problems which may be summarized thus:—

1. Do these three plains represent three distinct periods of planation?

2. Are AB and BC of the same age, but now discordant by warping?

3. Did the plain AB formerly extend upward in the direction BF; is BC of the same age as DB, or is it younger?

4. Is the discordance between AB or DB and BC produced by warping?

The accordance of the plains DB and BC towards the western end of the area is suggestive of warping elsewhere. Data of a detailed character as to the gradient upon the uncovered crystalline areas and upon the sedimentary outliers of the plain AB between the point represented by B and the front of the escarpment *a* have not been obtained. Without them the evidence available is inadequate to solve the problems.

It should be added that the relative arrangement of the three plains, represented as meeting in a broad angle at B, is purely fortuitous. The data in hand are not enough to determine whether AB and BC represent two intersecting plains, or portions of a continuous arc, and whether all three have a common point of intersection.

Similar relations between two plains of denudation upon crystalline rocks, meeting at low angles, have been found by Van Hise in Wisconsin ('96), and by Smyth in the region south of Lake Superior ('99).

Darton has described a somewhat similar case in Virginia ('94, 582). In the Grand Cañon of the Colorado we have an actual transverse section of two such intersecting plains, both older than the Cambrian, but meeting at a much higher angle.

THREE PROBLEMS STATED.—Among the many problems which present themselves for consideration, three, which have reference to the character of the sedimentary floor, seem worthy of special attention :—

1. Have we here an ancient sub-maturely dissected plain of denudation, a kind of geographical fossil, or is this topography the result of post-sedimentary causes?

2. In either event is there any possibility of approximately dating its origin?

3. Is the plain wholly the product of sub-aerial processes, or have we here a plain of submarine abrasion, and subsequent dissection?

FIRST PROBLEM, PRE-SEDIMENTARY TOPOGRAPHY.—Turning now to a consideration of the first of these problems, it will be necessary to describe, with some detail, a number of special localities which seem to afford evidence for its solution.

Inliers.—In the township of Verulam, about midway between Sturgeon Point and Bobcaygeon at the foot of Sturgeon lake, conspicuous among the hills just north of the lake, is a ridge of aplitic granite known locally as Red Mountain. The exposed base is about sixty feet and the crest one hundred and ninety feet above the level of Sturgeon lake. The ridge itself is about 2,000 feet in length and 600 in breadth; the longer axis strikes N 23°E. The crest is rounded, but falls off at the northwest corner very abruptly, at an angle of about 80°; on the east the inclination, though less, is still too steep for a person to descend in safety. At the south end the descent on both sides, though steep, is less precipitous. The crest and sides, especially towards the north, are free from boulders; but the southern end, where the crest is lower, is strewn with large and small sharply angular fragments derived from the ridge itself, together with some large blocks of limestone. Forming a belt one hundred yards in width is marshy ground, beyond which are lower ridges of morainic material. Half a mile to the west of this ridge, occurs a second much smaller granitic ridge trending in the same direction. The deposits of drift seem to obscure any limestone deposits which occur in the immediate vicinity. Four and a half miles to the west, at Sturgeon Point, thin-bedded fossiliferous Trenton limestones are found dipping north at less than one degree. On the south shore of the lake other outcrops of limestone occur, with very light southerly dip. To the north, the edge of the Cambro-Silurian escarpment, looking out over the main body of the Archean, is found at a distance of about 11.5 miles (as measured on the maps).

Is this the summit of a monadnock, buried when the sediments were deposited, and since uncovered in the progress of denudation; or have there been granitic intrusions since the formation of the stratified deposits? In this locality positive evidence either way seems to be lacking.

Further east, just north of Varty lake, and four miles from the edge of the escarpment, is a small oval dome of pink gneiss. Towards the north end of the dome four shafts, on a line transverse to the longer axis, penetrate the overlying limestone and show that the dip is nine degrees east on one side, and very much less on the other. A short distance away from the dome the strata have a dip of less than one degree. Near the southern end, where the gneiss is exposed, the limestone strata, quite close to the contact (the last few feet are covered with sod) are in an attitude which indicates that they abut against the gneiss. The higher strata, which once must have overarched the dome, have been eroded away. Here then we have beds of limestone strictly conformable with each other, and parallel to the surface upon which they rest, where seen in the shafts, arching over a dome of gneiss. So far as could be ascertained there is no evidence of post-sedimentary elevation.

In the valley of Mill creek, a small stream, the outlet of Sydenham lake, about five miles from the main area of the archean, is a small ridge of gray micaceous gneiss. The valley of the creek is about one mile in width, and flat floored; the nearest of the two bounding escarpments is 400 yards away, and the crest is 105 feet above the valley floor. The small crystalline ridge has evidently been exposed by the agency which carved the deep broad valley. Similar exposures of gneiss are found in the depressions occupied by many of the lakes of the Trent river system, on the Moira river, and elsewhere in like situations.

Still further east, at Kingston Mills, just west of the bridge across the gorge of the Great Cataraqui creek, there is a railway cut transverse to a granite ridge. The west end of this cutting passes through a small mass of calcareous quartz conglomerate, lying in a hollow upon the flank of the granite. The contact between granite and conglomerate shows in cross section on both sides of the cutting. There are, in all, about twelve feet of strata, dipping lightly to the west. The contact plane between these strata and the granite has, for the upper two-thirds of its length, a dip of about thirty-five degrees to the west. Towards the base this dip flattens out, and just where the line of contact passes beneath the material of the railway bed, the bedding of the sediments and the surface of the granite seem to be parallel (figure 2).

In this calcareous conglomerate are found fragments of crinoid stems and the casts of a Cameroceras. Several specimens of the latter, composed of white crystalline calcite, were taken from one of the lower beds at a point six inches from the granite. Other specimens more than five feet distant from the granite are identical in appearance with

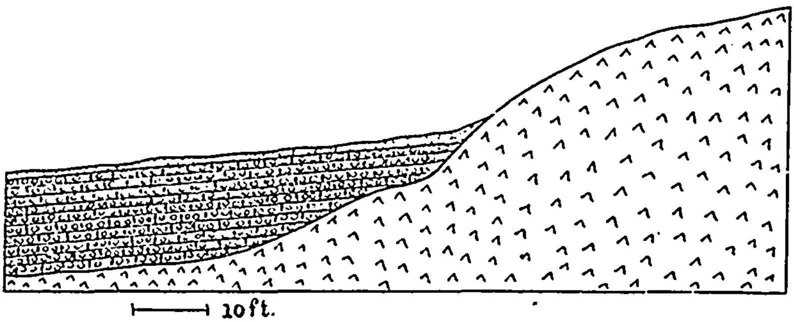


FIGURE 2.—Diagram to show the relative positions of the calcareous quartz conglomerate and the granite at Kingston Mills railway cut. Horizontal and vertical scales equal.

those obtained close to it. Neither rock has undergone any changes such as might be expected were the granite a post-sedimentary intrusion.

On the southwest flank of the same hill, at a slightly higher elevation, is a small exposure of a compact, fine-grained, gray limestone, with a conchoidal fracture, and in close proximity to the granite, which can be followed around it. A quarter of a mile west the limestone beds in the valley are fifteen feet in thickness.

Three and two-thirds miles almost directly south of this, at Fort Hill, on Barriefield common, midway between the Gananoque road and the river shore, occurs an ovoid quaquaversal dome with a gneissic core. The direction of the main axis of the dome is about northeast. The strike of the gneissic structure is about east and west, while the dip is almost vertical. The limestone forms a low infacing ridge, in places broken down. The maximum dip, sixteen degrees, occurs on the southwest side of the dome, but rapidly becomes less as one recedes from the central core. On the northeast side the dip is five and a-half degrees to the south of east, but away from the core, this also diminishes. The limestone is compact, fine-grained, and fossiliferous. In texture it much resembles that found upon the higher exposures on the southwest flank of the granite ridge at Kingston Mills. (figure 3.)

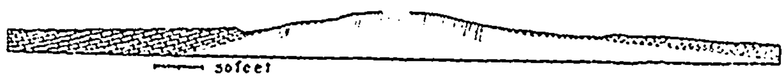


FIGURE 3.—Transverse section of the quaquaversal dome at Fort Hill, Kingston. Horizontal and vertical scales equal.

One-third of a mile east of the dome, the nearly horizontal limestones form an easterly-facing escarpment, talus covered, facing a large area of crystallines, partly gneiss, but mainly a dark red granite. The valley between is about one hundred yards in width, but towards the northeast the depth and width diminish. and the limestones, still almost horizontal, outcrop near the granite (figure 4). This granite is itself a

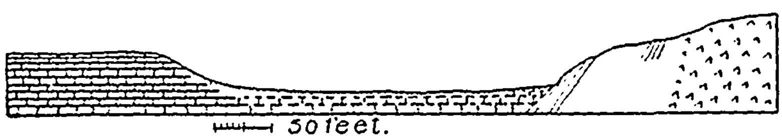


FIGURE 4.—Diagram to show the apparent relative positions of the limestone and crystallines east of Fort Hill. Horizontal and vertical scales equal.

large inlier from the western side of the arm of the crystalline series which connects the Canadian archean with that in New York. East and north, through the township of Pittsburg, there are many ridges of gneiss with a general northeast trend, thes trikes being sympathetic with the direction of the ridges, and the dips nearly vertical, or when inclined, the inclination is generally the same on both sides of the ridge in question. Between some of the ridges long tongues of horizontal strata extend northeastward, frequently, though not always, with an escarpment facing the gneiss. In no place does the limestone show a dip sympathetic to the inclination of the ridge adjacent, though there are cases where the relative positions of the two are such that the dip ought to be nearly thirty degrees, if the gneissic ridge were elevated after the deposition of the sediments.

With reference to these ridges of gneiss, and to the unroofed dome at Fort Hill, Dr. Drummond writes: "The Laurentian strata have been here elevated into these great ridges at a period subsequent to the

Black River times" ('92, 110). So far as indicated in the context, the only evidence upon which this deduction is founded, is the occurence of the limestone strata "at a high angle," dipping outward from the central dome of gneiss. The evidence, as stated, seems inadequate to admit of the broad conclusion reached.

If the ridges were elevated subsequently to the deposition of the strata, *i.e.*, were ridges of deformation, certain necessary results would follow. Over large areas the gneissic structure is frequently parallel. If, in such an area, a ridge is formed by elevation without faulting, in a region where the dips are not exactly vertical, the inclination on the side of the new ridge toward which the structure hades would be steepened, and that on the side opposite lessened. A traverse across the ridge in the direction of hade would show a decrease to a minimum where the grade was greatest, followed by an increase through the normal at the crest, to a maximum where the grade was at a maximum upon the opposite side, and then decrease to the normal (figure 5). In a series of such ridges this *diversity of dip* would occur *uniformly* across the ridges.

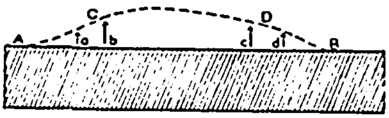


FIGURE 5.—If AB represent the position of the surface of the gneiss before upheaval, and ACDB the position of the surface of the dome after upheaval, then that portion that moves upward at *a* will have a less distance to rise than that at *b*. Therefore the dips between *a* and *b* will be steepened. Similarly, on the opposite side the dips will be lessened. Beneath the crest the uplift will be uniform, and hence there will be no alteration of dip. Where the grade of the new ridge is steepest the change from the original dip will be greatest.

Secondly, strata adjacent to *all* the ridges would be inclined in sympathy with the elevation, the greatest inclination being nearest the steepest and highest ridges; where the inclination of the ridge is very steep the strata would be affected for a longer distance away from the centre of elevation, or if the uplift did not affect the strata at any great distance, faulting and slipping would occur.

If the uplift took place gradually, or rapidly, during the period of deposition of the strata, the *uniform diversity of dip* in the structure of the ridges would be as in the first case. The strata would tend to thin out over the crest, if the material were somewhat coarse. If the uplift were very great some of the beds might even end in wedges against the sides of the ridge. The other necessary results would be as in the former case, though faulting and slipping are less likely to occur, owing to the softness of the beds. In the sections as usually exposed it would be very difficult to distinguish between intersedimentary and postsedimentary uplift.

Had the ridges existed prior to the deposition of the sediments, having been the product of erosion, the structure of ridge and valley would frequently have the same dip; in cases where the dips varied the diversity would not be systematic. The position assumed by the sediments would depend upon three factors, two of which are, in practice, determinable by observation, the third by inference only. The steepness of the grade of the ridge would necessarily be an important factor. Where the grade was light the sediments would be deposited evenly over the inclined floor. As the inclination of the floor increased the tendency would be for the beds to wedge out and finally to abut against, rather than to rest upon the incline. The fineness or coarseness of material and the degree of agitation of the water would be important varying factors. Where the waters were quiet, and the sediments coarse, the deposition could take place upon slopes down which the materials would readily move if the waters were agitated. If the sediments were fine, the slopes upon which they could rest would be much steeper. The angle of repose for the sediments will then vary as each factor varies, and hence numerous variations are possible and many of these are also probable.

The deduction leads to inquiry as to what is the maximum angle of repose at which, under what may be called normal conditions of deposition, strata of different compositions may be deposited, for obviously this must be known before we can determine, from the dip alone, whether strata were deposited in an inclined position. The number of variants is too great to permit of a complete reply to the question; it seems advisable rather to apply the criteria already deduced to the facts under consideration, and indirectly to obtain a partial answer to the last problem.

In the areas where the gneiss is not obscured by a cover in the bottoms of the valleys, we frequently find the dips the same over large areas of ridge and valley; sometimes there is diversity, in the valley it may be vertical while in the ridge it is inclined, or vice versa, but *uniform diversity* is not found. This *uniform continuity* and lack of *uniform diversity*, particularly in areas where the structures are inclined away from the vertical, would alone indicate that these are not ridges of deformation, but on the contrary, would lead us to infer that they are the result of erosion.

Attention has already been called to the lack of sympathetic dip in limestones adjacent to steep gneissic ridges. At Kingston Mills cut the upper part of the granite face was too steep for the coarse sedimentary deposits to rest upon it under the then existing conditions. Consequently they moved down, as deposited, to a position of stable equilibrium, producing in the slipping, the slight upward drag seen in the beds just at the contact. At the ridge near Varty lake, and at that one now fronting the escarpment east of Fort Hill, similar conditions probably prevailed. The steep face of the ridge in the latter case has a slope of about thirty-five degrees, in some places it is even steeper, yet the limestones show no sympathetic dip, (figure 4). At Fort Hill, where the grade indicated by the strata is *now* sixteen degrees, the water would probably be somewhat deeper, and the calcareous sediments were very fine grained. The inclined position of the much coarser sediments at Kingston Mills, and the state of preservation of the fossils in these coarse sediments, indicate that the water was moderately quiet so there seems no adequate reason why the finer material should not have been deposited in its present inclined position at Barriefield common, (figure 6). With reference to the other criteria, thinning out of

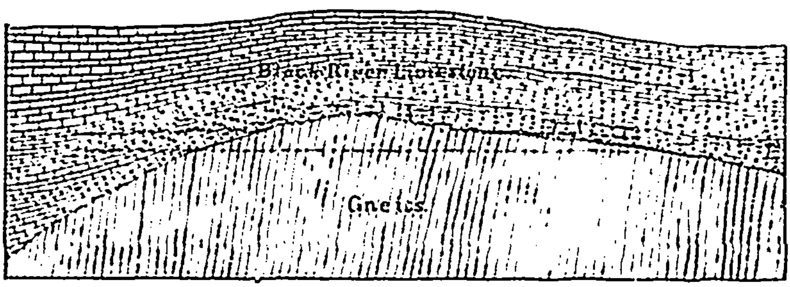


FIGURE 6.—An ideal section to show the probable conditions at Fort Hill before degradation and denudation. The dotted lines show the bottom and top of figure 3.

beds, faulting and slipping, so far as known the two latter are absent, and the first can only be applied rarely.

The balance of evidence thus seems to indicate that the ridges are of pre-sedimentary origin, and that the sedimentary strata were deposited essentially in the positions in which we find them to-day. It is interesting to note that at the base of the cliff on Deer bay, in the distance of a little over a mile, there is a continuous transverse section of no less than five light anticlinal domes in strata which are only removed a few feet from the gneiss, here below the water level. The arch dies out in about the first twenty feet of strata. Above that, so far as the eye can judge, they are nearly horizontal.

Logan ('63, 98), refers to strata near Millburn (then, Daly's Mills) having comparatively high angles of dip near the junction with the

Laurentian, where they seem "almost always to be slightly accommodated to the worn surface." Laflamme ('84, 15; '86, 43) has noted similar features in the Lake St. John region; and Adams ('93, 338) has drawn attention to the fact that the *roche moutonnée* character of the Laurentian rocks was impressed upon them in pre-Cambrian times.*

Outliers.—Similar evidence as to the character of the pre-sedimentary surface is offered in the vicinity of the numerous outliers upon the crystallines.

Conclusions.—In Central Ontario, from the evidence afforded by the inliers of Archean within the area of Palæozoics, and of the outliers of Palæozoic strata upon the Archean, it seems that the sediments were laid down upon an uneven floor essentially the same as that presented at the present day by the Laurentian areas along the borders of the Cambro-Silurian escarpment.

Examples elsewhere.—These buried oldland surfaces are found in many other localities. Sometimes the eroded surface is almost a plane, as seen in the Grand Cañon section of the plain upon which the lower Palæozoic deposits rest. Again the surface may have had irregularities many hundred feet in height, as shown by the Baraboo ridge in Wisconsin, or as seen in an area in the Scottish Highlands, described by Geikie. (See Newberry, '58, 57; Irving, '72, 99, and '77, 427; Dutton, '82, 209; Geikie, '88, 400; Bell, '94, 362; Keyes, '95, 58; Van Hise, '96, 59).

SECOND PROBLEM, DATE OF EROSION.—The second and third problems for consideration have reference to the time and conditions of erosion by which this pre-sedimentary topography was produced.

From the writings of the earlier geologists the prevailing view seems to have been, that the Palæozoic sediments were laid down upon a rising sea bottom, and that the Archean areas in Canada represent the first emerged land. The more recent view is that the sediments were accumulated on a sinking land surface.

In this area, the granites, gneisses, and schists date from Archean time. The evidences of a vast amount of denudation afforded by the truncating surfaces, and the absence of lower and middle Cambrian sediments from every portion of the area, make it improbable that during the deposition of these sediments elsewhere the land here was below sea level. The consensus of opinion, based upon the study of

* See also Lawson, 1890.

the conditions of the pre-Cambrian floor, and upon the distribution of the Cambrian sediments over North America, is that during the interval of the deposition of early Cambrian sediments there was a great interior continent, of which Central Ontario would form a part.

Walcott ('91, 567) thus sums up the conclusions from his studies on "North America during Cambrian time":—1. "The pre-Cambrian Algonkian continent was formed of the crystalline rocks of the Archean nuclei, and broad areas of superjacent Algonkian rocks that were more or less disturbed and extensively eroded in pre-Cambian time. Its area was larger than at any succeeding epoch until Mesozoic time."

* * * * * * * * * * * * *

4. "The interior continental area was, at the beginning of Cambrian time, an elevated, broad, relatively level plateau between the Paleo-Appalachian sea on the east, and the Paleo-Rocky Mountain barrier on the west."

* * * * * * * * * * * * *

7. "The Cambrian Sea began to invade the great Interior Continental area in late Middle Cambrian time, and extended far to the north toward the close of the period."

8. "The depression of the continent in relation to sea level began in pre-Cambrian time and continued with a few interruptions until the close of Paleozoic time."

Many conclusions with reference to events which occurred so long ago must necessarily be somewhat uncertain. With our present knowledge of the evidences, it seems that during Archean and early Cambrian times this area formed part of a continental area. The processes by which the even-topped upland was produced operated so long ago that it is impossible to determine their precise nature. The character of the subsequent dissection appears to indicate that the present topographic features of the uplands were, in the main, the product of subaerial erosion during a pre-Potsdam period of elevation.

The balance of evidence thus leads to the conclusion that the present surface features of the crystalline area, at least along the borders of the Palæozoic sediments, are essentially the same as they were in pre-sedimentary times. The problem now arises as to the process by which the degradation and the denudation produced the even-topped upland and the varying features of the present topography.

It would be well to note with reference to the term *even-topped*, that a personal equation must be considered. The expression is used here to describe the sky-line of the upland plain, where for long distances, so far as the eye can judge, it appears with no marked irregularity. In many parts of the area the surfaces of large lakes offer horizontal lines for comparison. Occasional irregularities occur, and these frequently make abrupt changes in the otherwise even line. *Upland plain* has been used to indicate that imaginary surface whose elevations accord with the elevations of the even sky-lines, as seen in many parts of the area. *Upland* indicates portions of the present land surface whose elevation accords closely with the upland plain, and whose surface presents only minor irregularities, as compared with the greater irregularities of the surface of the region as a whole (figure 7). The present

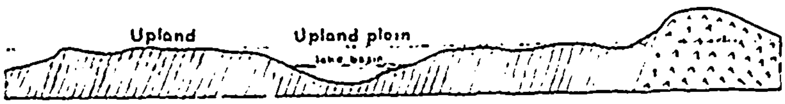


FIGURE 7.—Diagram to illustrate the definitions of terms.

topography is such that although the slopes are frequently graded, there are few areas to which the corresponding term lowland should be applied. The change in gradient from the valley side to the upland is frequently so marked as to justify the use of the term *shoulder* to describe the place where the change occurs.

THIRD PROBLEM, CONDITIONS OF EROSION.—Two hypotheses have been offered to account for the origin of topography of this nature. The one would consider it as the product of a single cycle, the other as the product of two or more (n+1) cycles. The first, the "bevelling" hypothesis, would consider the present features as those of an ancient mountain system reduced to maturity and possibly re-elevated and made more rugged. The second would consider that the even uplands (produced during a long interval of time, at a period when the land stood relatively near base level) are remnants of the upland plain, and that the present valleys and lowlands were due to an increased activity of the agencies of degradation and denudation because of subsequent elevation.

If the area is part of an old mountain system reduced to its present form by bevelling, the present elevations must have once been higher and more rugged than they now are (figure 8, ABCDEF). In the process of degradation the ruggedness would be reduced and the slopes become graded by the removal of waste from the mountain sides and its transportation to the valleys, where it would either remain or be removed according to circumstances. Eventually, there would be a uniformly graded slope from stream bed to mountain top (AGCDHF). After the production of this slope the process will continue, but more slowly, with the gradual reduction of the crest, and corresponding

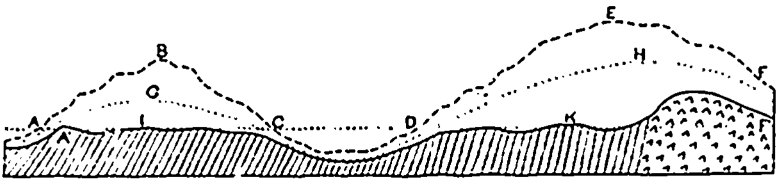


FIGURE 8.

decrease in grade, approaching but never reaching complete horizontality. Of necessity there will always be one point, or a series of points in line, higher than all the rest. From here the gradient would be downwards in all directions. In the late mature stages, when there is some approach to a nearly smooth surface over the whole mountain, there will be no abrupt change in slope.

Such an explanation of the process of degradation makes no provision for the occurrence of areas of greater or less extent with almost identical elevation, (A′ IC, DK); nor for the abrupt changes in gradient such as occur at the shoulders before mentioned (A′, C, D.) Hence, in the writer's conception of the process, it seems inadequate to explain significant facts of the present case.

The two-cycle (n + 1 cycle) hypothesis would explain these peculiarities by postulating a previous cycle (or cycles) of erosion in which the land was cut down to a surface of very faint relief and subsequently elevated and dissected, the new valleys not having yet extended their graded slopes far enough to completely obliterate the plain of the former cycle. The shoulders were produced where the change in gradient from the present valley side to the older plain occurs.

In almost every locality where the Cambro-Silurian sediments are seen in contact with the crystallines, the surface is seemingly quite fresh. Except in one known locality, where a distinct arkose of angular material is found, the old soil cover seems to be completely gone. The process by which this cover was removed and the surface of the Archean freshened, is at present undetermined.

SUMMARY.—The present topography of the pre-sedimentary floor may be regarded as the product of a degradation which produced a planation surface, and the residual monadnocks, as indicated by the even-topped upland. This surface was uplifted to permit of the renewed activities that carved and denuded the ungraded, or partly-graded slopes of sub-maturity, now presented wherever it has been freed from the Palæozoic cover. This latter dissection and denudation antedates the sediments, within this area, commonly called Potsdam, and may well have taken place in early and middle Cambrian times.

The ancient pre-sedimentary surface may be conveniently described as a sub-maturely dissected and denuded peneplain dating from before early Cambrian times.

THE PALÆOZOIC SERIES.

A Question of Correlation.—In tracing the geological history of this area, by means of the nature and relations of the different deposits found adjacent to and within its boundaries, there is a question that must not be disregarded, as to the correlation of partly eroded stratified deposits, at a low angle of dip, around the margin of an oldland area. In the formation of a series of deposits upon a slowly sinking land surface, the normal distribution of material is the formation of sand and pebble beds at the shore line, grading gradually into clays and muds, and thence into calcareous deposits (figure 9). Any given stratum must have three synchronous members, each merging gradually into the

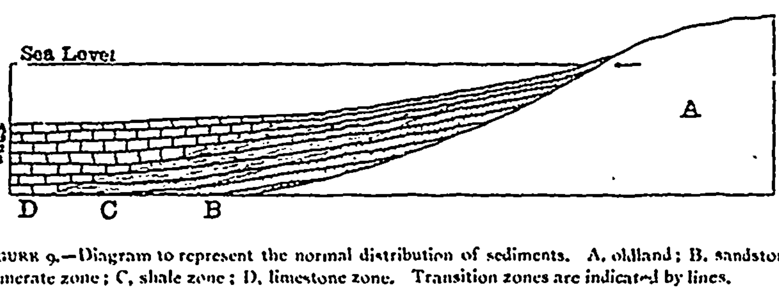


FIGURE 9.—Diagram to represent the normal distribution of sediments. A, oldland; B, sandstone and conglomerate zone; C, shale zone; D, limestone zone. Transition zones are indicated by lines.

adjacent member. The beds composed of strata which have been deposited successively must also each consist of these three members. During the time of the formation of any given bed the forms of life existing at that time will be distributed over the surface of that bed, each in its appropriate locality. The sand-loving forms will be near the shore, the mud-loving forms in the areas which afterwards become converted into shale, and the forms which thrive best in deep clear water will be found further seaward. At the transition zones where there is a merging of conditions there will be a merging of forms. Accidents may happen by which the normal distribution is slightly disturbed; and some few forms may exist in all three zones.

Since the production of the deposits, their thickness, and their other relations depend upon the two factors, *rate of depression* and *rate of supply of detritus*, with varying conditions as to depth of water, there are many possible variations from the normal arrangement. The result of one such variation is represented diagramitically in figure 10, where the rate of supply of detritus has been sufficiently in excess of the rate

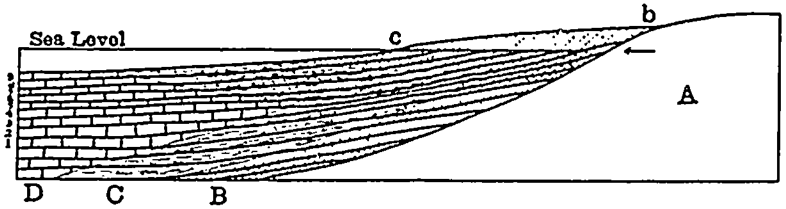


FIGURE 10.—Diagram to represent a special variation in the distribution of sediments. A, oldland; B, sandstone and conglomerate zone; C, shale zone; D, limestone zone. Transition zones are indicated by lines. *bc*, sub-aerial deposits.

of depression of the land, to permit of the transgression of the sands over the seaward zones. If a rapid variation had taken place in the opposite direction, the muds and sands might become mingled along the shore, and eventually the limestones might rest directly upon the oldland surface. Irregularities in the variations of each factor will lead to many irregularities and overlaps along the zones of transition.

By subsequent processes, after a greater or less interval of time, these deposits will become indurated and form sandstones and conglomerates, shales, and limestones. If, after uplift, the greater part of the sediments are eroded away, and small remnants, perhaps as outliers, remain in protected areas, we may find limestone in one place which is contemporaneous with sandstone in another, though the fossils in each are wholly unlike. Moreover, deposits, of entirely different epochs, may be almost identical because derived from the same source.

SANDSTONES.—In Central Ontario, particularly towards the eastern end, where the sediments occur in ellipsoidal basins, and with a very slight and irregular dip, the sandstones and some of the other beds entirely without fossils, there is a strong a priori argument for considering that the *sandstones* and *some of the limestones* are contemporaneous. The oldest sediments, within the area, which can be identified by fossils, are the Black River limestones. Conformably below these are beds, which in some cases carry fossils that are supposed to mark a transition vertically from the Chazy at least, but which equally well may mark a transition horizontally. Chiefly as outliers, but occasionally passing beneath the non-fossiliferous beds below the identified beds of the Black River formation, are a series of sandstones usually termed Potsdam. (The maximum thickness is, locally, sixty feet). As no fossils, except some very obscure Scolithus borings, have, so far as the writer knows, ever been found in these beds; and as *Potsdam* is a term introduced to describe rocks where certain definite stratigraphic and faunal relations hold, it is inadvisable to apply the term until these well defined relations are proven to exist here. Even were fossils found in the sandstone, the possibility of their being, *in this locality*, contemporaneous with the lower limestone beds, would not be diminished.

Much of the sandstone of these deposits, in this area, occurs in depressions between pre sedimentary ridges. There are many angular fragments of gneiss and quartz, both large and small, included in the sandstone. In many places there are no known beach-worn pebbles, and no fossils, even in very thick beds; the material has been well sorted and consists almost wholly of quartz grains; the beds are frequently very massive and obscurely cross-bedded; ripple marks are absent or very obscure in many localities. There thus seems to be good reason for thinking that much of this sandstone may be waste which was laid down here, possibly by streams, after the crystalline surface had been smoothened and freed from its residual soil, if such ever existed, but before the advent of the sea, and that the shoreline of that time is now concealed by the overlying deposits. Subsequently, in the rapid depression of the land immediately preceding the time when the limestones overlapped upon the crystalline area, the surface of these sands may have been evened off, and perhaps a small amount of new material was added.

ARKOSE.—There is one known locality in which the non-fossiliferous sediments beneath the identified Black River limestone are especially interesting. At the foot of the escarpment on Deer bay, just at water level, a few well marked beds of arkose are exposed. The beds average about ten inches each, the whole deposit being an unknown amount over six feet in thickness. This arkose consists of translucent partly worn crystals and fragments of quartz and angular fragments of pink orthoclase feldspar, cemented with a dark reddish-purple feldspathic and calcareous cement, with occasional patches which resemble the argillaceous portions of some of the succeeding beds. The rock is readily friable and forms a beach of small gravel just at the foot of the cliff. The constituents of this arkose are distinctly different from those of the adjacent gneiss. The nearest outcrop of gneiss is one hundred yards away, and the water between reaches a maximum depth of nine feet, but, from the conformation of the bottom, the exposed portion of the deposits must evidently be within a very few feet of the gneiss immediately below it. The deposits may be regarded as a remnant of the old soil cover of pre-sedimentary times, slightly rearranged.

BLACK RIVER AND LATER FORMATIONS.—Succeeding these unidentified beds are the Black River limestones, which form a cuesta, whose northern boundary forms an escarpment extending from Georgian Bay to Kingston. The Black River beds are succeeded by the Trenton limestones with a thickness, as calculated from the dips near the eastern end across Prince Edward county, of over 1,400 feet. These are overlain by about 100 feet of Utica shales. Above this are nearly 800 feet of Lorraine shales and sandstones, overlaid in turn by 545 feet of Medina marls and sandstones. The upper bed of the Medina is, in Central Ontario, a heavy gray sandstone, about twelve feet in thickness, but occasionally thicker. The beds above this, found in the Niagara escarpment, consist of Clinton dolomitic limestones and shales, overlaid by the Niagara limestone. Throughout the region, so far as known, there is no observed unconformity between the beds of the various formations.

SUMMARY OF THE PALÆOZOIC HISTORY.—The geologic history of the area, subsequent to the period of denudation and dissection of the crystallines, was begun by a depression of the land, during which some small amounts of sand were deposited along and near the shores, with deposits which formed shales and limestones in the deeper waters. This depression continued somewhat faster than the rate of supply of detritus, and finally limestones, which, however, contain siliceous material, were deposited over the whole area. The waters were "richly tenanted by a great variety of forms of invertebrate life, and representing the culmination of invertebrate animals in the Lower Palæozoic" (Dawson, '89, 73). The great thickness of the deposits indicates that the Trenton epoch was of considerable duration. Towards the close of the limestone-forming epoch a variation took place, the new material supplied to this area was in the form of clays and muds. The change in the character of the deposits was accompanied by a change in the types of animal life here present. This change, marked by the Utica shales, was probably caused in part by a decrease in the rate of depression of the land. That it did not cease is shown by the thickness of the deposits.

Throughout the Lorraine epoch the area has been one of large sandy mud flats, alternately bare, exposed to the sun and rains, and submerged. The shallow sea appears to have endured for some time, since these deposits gradually give place to the sandstones of the Medina epoch. During the Medina there has been an alternation of the depth of the ocean here, as evidenced by the mingled sandstones and marls, the former with mud cracks, ripple and current marks. The final stage of the Medina led to the accumulation of a broad thick band of fine-grained siliceous sandstone, free from ferric oxide, in marked contrast to the majority of the lower beds.

The succeeding epoch must have begun with a relatively rapid depression of the land, since the overlap of the Clinton dolomitic limestone upon the upper sandstone of the Medina is abrupt. The depression seems to have continued rapidly enough to permit of the overlap of the succeeding Niagara rocks upon the crystalline areas far to the north. From the purity of the limestone, and from the types of organic remains, and their abundance, it is inferred that the waters of this epoch were clear and warm. The materials from which the limestone is made were probably drawn from the sea water by the invertebrate animals in the making of their hard parts.

This second great limestone-making epoch was followed by a gradual shallowing of the water, during which the Guelph dolomites were formed. Eventually the water became very shallow; enclosed lagoons, occasionally flooded, were numerous; in these lagoons the salt and gypsum beds of the Onondaga were formed by the evaporation of the water and the concentration and precipitation of the saline compounds in solution.

The sandstones of the succeeding Devonian period are now many miles distant from the front of the Niagara cuesta. They may at one time have reached out and overlapped it, but if so, what their north-eastern extension may have been is unknown. During the period of their formation the central portion of the Archean area may have been above water, and the denudation which has subsequently removed all the Niagara limestone, with a very few small protected areas excepted, could then have already begun. It is interesting to note that the peneplain represented by BC (figure 1, page 144) may date its beginning from this Devonian degradation.

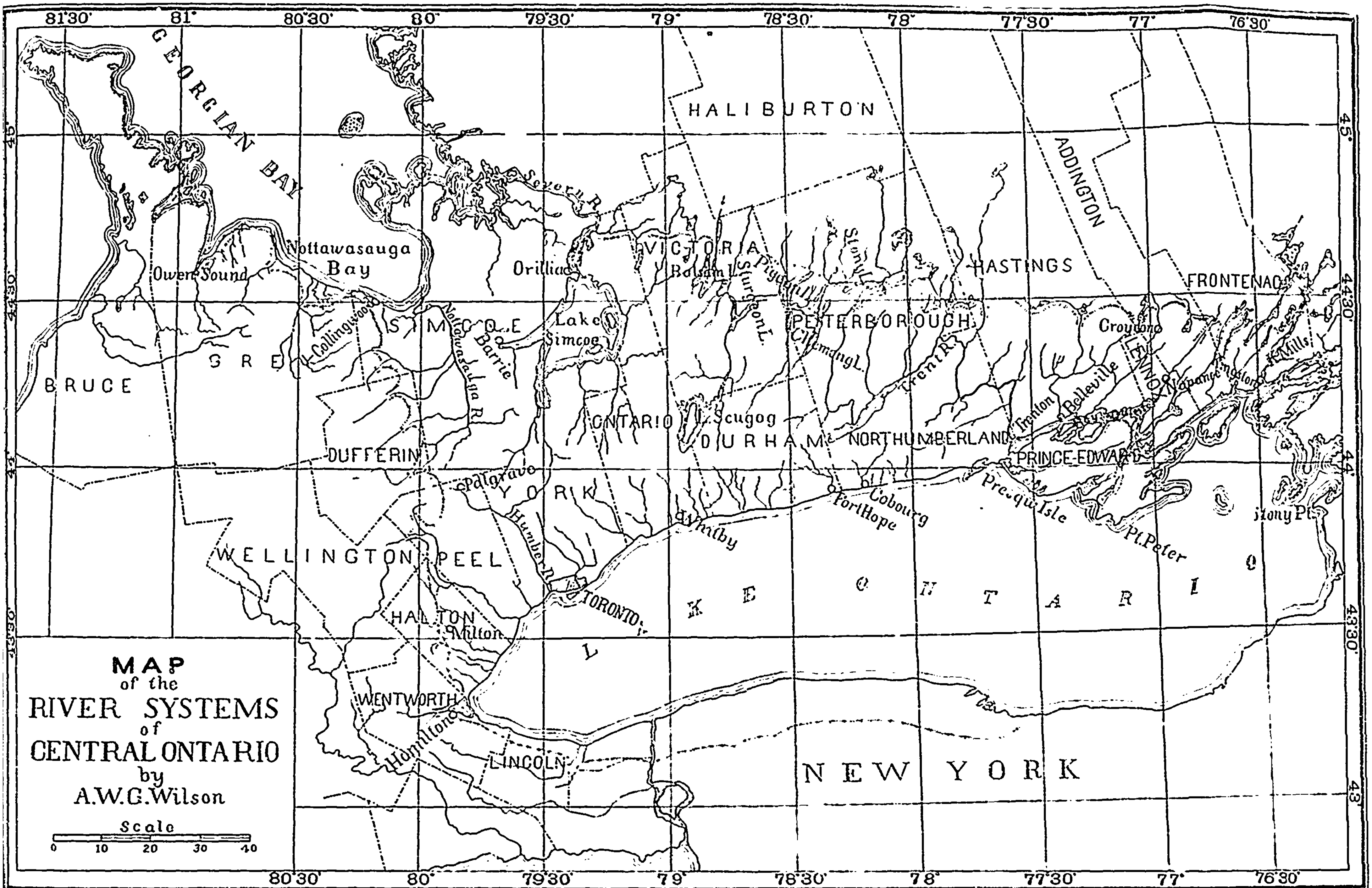
The area had thus taken part in three great cycles of deposition concomitant with three great continental oscillations, or a long continued single oscillation of varying rate. During two of the cycles great limestone deposits were made within its boundaries. The nearest known areas of Lower Carboniferous are in Michigan, 140 miles away, and their composition is such that it is usually inferred that ever since the close of the Devonian period this area has been above sea level and exposed to denudation and dissection.

POST-CARBONIFEROUS HISTORY.

MESOZOIC, CAINOZOIC AND EARLY PLEISTOCENE EPOCHS.—There is little or no direct evidence of the history of the area during Carboniferous and Mesozoic time. The late Mesozoic was a period of extensive peneplanation throughout most of North America. In Wisconsin and Michigan to the west, and in New York and Pennsylvania to the south, the remnants of the planation surface have been recognized. It seems probable that the same planation processes, working northward from these areas, and southward from the Arctic region, may have, in part, produced the younger of the two plains upon the Archean areas in Canada. It is true, this plain may be of pre-Palæozoic age. Whether it is such, and yet younger than that beneath the sediments cannot be shown until it is proven that the sediments once actually rested upon it, and not upon a surface now eroded away. This latter would be the former northward extension upon which they now rest (figure 1, BF p. 144). The study of the isolated outliers, such as those of the small areas of limestone in the Lake Nipissing region and elsewhere, may show that they are preserved because thrown into their present protected positions by the downthrow of a fault block. If so, the probability of this plain being of Cretaceous age will be strengthened. By way of comparison it may be noted that a series of faults dislocated the early sedimentary rocks of Sweden and Norway. Later planation left only a few small patches at baselevel, upon the downthrown blocks. Subsequent elevation of the whole area, and erosion of these softer remnants produced a series of depressions, in some of which are still found isolated patches of the soft rocks. The lower portions of these depressions frequently form lake basins, the most noted of which are Boren, Roxen, Glan, and Braviken.

The period of Cretaceous planation was followed by an undetermined amount of elevation of portions of the continent, probably including this area. The immediate effect of such an uplift would be the active

MAP I.


MAP
of the
RIVER SYSTEMS
of
CENTRAL ONTARIO
by
A.W.G. Wilson
Scale
0 10 20 30 40
GEORGIAN BAY
HALIBURTON
ADDINGTON
VICTORIA
HASTINGS
FRONTENAC
PETERBOROUGH
SIMCOE
GREY
BRUCE
DUFFERIN
ONTARIO
DURHAM
NORTHUMBERLAND
PRINCE EDWARD
LENNOX
YORK
WELLINGTON
PEEL
HALTON
WENTWORTH
LINCOLN
NEW YORK
Nottawasauga Bay
Owen Sound
Orillia
Lake Simcoe
Barrie
Collingwood
Severn R.
Balsam L.
Sturgeon L.
Pigeon L.
Chemung L.
Trent R.
L. Scugog
Croydon
Belleville
Trenton
Napanee
Kingston
Whitby
Port Hope
Cobourg
Presqu'Isle
Pt. Peter
Stony Pt.
Palgrave
Humber R.
TORONTO
Milton
Hamilton
LAKE ONTARIO
81°30' 81° 80°30' 80° 79°30' 79° 78°30' 78° 77°30' 77° 76°30'
45° 44°30' 44° 43°30' 43°

renewal of the process of subaerial degradation, and the development of topographic forms and an adjusted drainage system appropriate to a region underlain by alternate series of strong and weak rocks at low angles of dip. During the extensive Pleistocene glaciation the topographic features, the product of the preceding cycle, may have been largely modified, destroyed, or otherwise obliterated, and new forms produced.

Measure of erosive work.—Our measure of the work performed during these two periods must necessarily be derived from a knowledge of the present features, and of the conditions existing before the operation of the erosive agents. The proportion to be assigned to either period depends upon a knowledge of the relative competence of the processes of degradation, and of the time during which they were operating. The amount of work performed by either process, and by both, will vary with the locality, and with the conditions under which the process is in operation, *e.g.* geographical position, elevation, position with reference to baselevel, character of the rocks, relation to the ice front and to the névé of a glacial lobe. At present the knowledge of the total effects of both processes, and of the method of operation of sheet-glacier ice, seem too limited to warrant the assignment of a definite portion of the work to either, except in local cases.

PRESENT FEATURES.—*General Description.*—The Niagara cuesta is a prominent topographic feature extending along the south shore of Lake Ontario from east of Rochester to Hamilton, thence northward across Ontario to the Manitoulin Islands, thence curving southwestward to the east of Green Bay and across parts of the States of Wisconsin, Illinois and Iowa. Lakes Erie, Huron, and Michigan are situated upon the outer lowland; Lake Ontario, Georgian Bay, and Green Bay lie upon the lowland in front of the cuesta; Lake Superior lies in a position outside of both lowland and cuesta.

The cuesta-front forms one boundary of a great inner lowland. The southwestern loop of this lowland is best developed in the State of Wisconsin, and may thus be appropriately designated the WISCONSIN LOWLAND. The eastern part, the ONTARIO LOWLAND, includes the basins of Lake Ontario and Georgian Bay, as well as the adjacent land areas. The two parts of the inner lowland are connected by a narrow, more or less submerged belt, passing across the Manitoulin Islands. It has been found convenient to refer to the present unsubmerged part of the Ontario lowland, within the Province of Ontario, as the CENTRAL ONTARIO LOWLAND. (Map I.)

The northeastward extension of the Ontario lowland merges gradually with the cuesta formed by the Black River strata. The escarpment-front of the Black River cuesta extends from the vicinity of Kingston northwestward to Georgian Bay, and thence across the bay, beneath whose waters it seems to be still traceable, to the Manitoulin Islands. The unsubmerged portion of the escarpment averages about ninety feet in height, and locally is occasionally much higher. In the region west of Lake Simcoe, and in northern parts of Hastings and Addington counties, it is partly obscured by drift deposits.

The fronts of both cuestas present many irregularities appropriate to development under subaerial processes. The principal physical features of "Old" Ontario are those characteristic of an ancient coastal plain which has passed through a period of planation followed by one of uplift, dissection, and the development of an adjusted drainage system. Similar topographic forms have been developed, also with varying strength and expression, in Middle England, in the Paris Basin and elsewhere near oldland areas.

The drift deposits in Central Ontario form a prominent ridge, or series of ridges, the Oak Ridges, of varying breadth, lying at an average distance of about ten miles north of Lake Ontario, and extending eastward to the vicinity of Trenton. At the western end, near Palgrave, the thickness of the deposits is sufficient to almost obliterate the escarpment of the Niagara cuesta. A number of spurs extend southward and northward from the main ridge.

This morainic ridge divides Central Ontario into two drainage slopes, a northern and a southern. The Trent river, the largest stream within the area, conveys a large percentage of the drainage from the northern slope, and from the southern slopes of the crystalline area to the north, across the ridge to the Bay of Quinte in the vicinity of Trenton. The remaining portion of the drainage of this northern slope reaches Georgian Bay, chiefly by the Severn river from Lake Simcoe basin, and by the Nottawasaga river. The waters from the southern drainage slope reach Lake Ontario by a number of small streams. East of Trenton the drainage, which is across the area from within the Black River cuesta, is controlled almost wholly by the rock topography.

The present features of Central Ontario, as a product of the operation of the two processes, Pliocene and early Pleistocene subaerial erosion, and Pleistocene erosion by sheet-glacier ice, are of special interest, not only in themselves, but because of their relation to the

PLATE I.

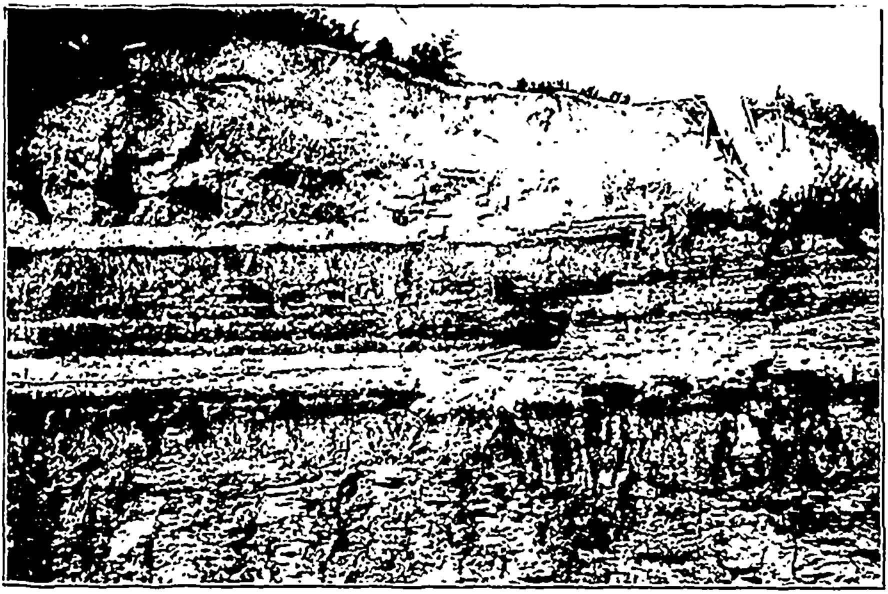


FIGURE 1.—Pleistocene deposits at Taylor's Brick Mills, Toronto. The lowest beds are Lorraine shales; these are overlain by a thin sheet of till, and this in turn by the beds of the first Interglacial epoch. (Photo. taken 1895).

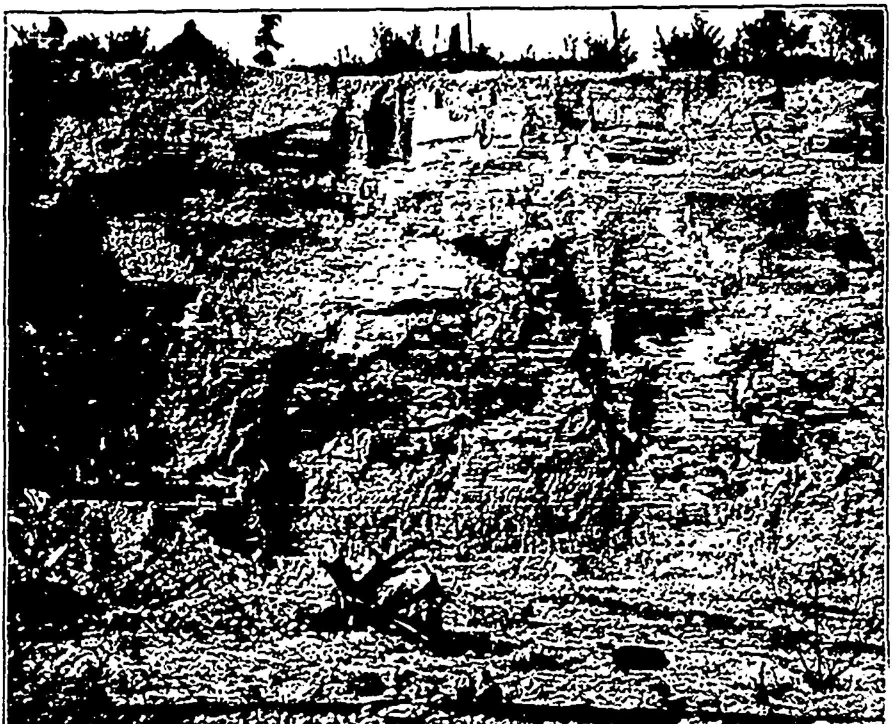


FIGURE 2.—Pleistocene Deposits at Taylor's Brick Mills, Toronto. Beds of the second Interglacial epoch. (Photo. taken 1895).

question of the origin of the basin of Lake Ontario. Although over large areas the topography of the rock floor beneath the Pleistocene deposits cannot be ascertained, there are also large areas in which there is no difficulty in determining its essential features, often even to minute details. Since the interpretation of the features of this rock topography depends upon its relation to the overlying Pleistocene debris, it has been thought best to first describe in outline, these latest deposits.

Pleistocene Deposits.—Hinde ('77), Coleman ('94, '95, '97, '98, '99, 1900), and others, have described Pleistocene deposits occurring in the vicinity of Toronto, notably at Scarboro' Heights, describing three sheets of glacial till. The two upper sheets overlie thick deposits of stratified and finely laminated clays and stratified fossiliferous sands and gravels. (Plate I.) One hundred miles east of Toronto, just north of Trenton, occur series of deposits in which is cut a sea-cliff attributed to Lake Iroquois. The crest of the Iroquois sea-cliff is 718 feet (bar.), and the rock surface just east of this, along the Trent River is about seventy-eight feet above Lake Ontario.* The total thickness is thus 640 feet. These deposits show three till sheets alternating with two series of stratified beds, chiefly sands and gravels. The precise thickness of each of the five series of beds has not been ascertained as yet, but the till beds certainly, and the stratified beds probably, are much thicker than the similar beds at Toronto.

Between this locality and Toronto, in each of four other transverse sections northward from Lake Ontario, the three till sheets have been encountered by the writer. In a trip, on foot, along the lake shore from Presqu' Isle to Burlington beach, the two lower of these three till sheets have been traced for a long distance. East of Port Hope, between Bowmanville and Whitby, and west of Toronto, a till sheet rests in many places directly upon the rock surface. Sometimes only the upper portion of this sheet is visible, and occasionally it passes wholly below the lake level. Provisionally this lowest sheet may be considered as the equivalent of the lowest till sheet at Toronto and at Trenton.

From Port Hope westward a second till sheet, with varying thickness, resting upon stratified deposits, both sands and laminated clays, and once (near Oshawa) upon the lower till sheet, can be followed along the lake shore almost continuously to Scarboro'. At Scarboro' there is a nearly continuous section about nine miles in length. Between Port Hope and Trenton the edge of this sheet lies from one to four miles

*There is a continuous exposure of rock surface along the Trent, transverse to the ridge, and in a number of localities to the eastward the general topography of the rock surface can be well established.

back from the lake shore. Provisionally this bed, from its position, not from any identification of underlying beds, may be correlated with the middle till sheet, the lower of the two sheets exposed at Scarboro'.

Except in the Scarboro' section, the edge of the third till sheet is found at a varying distance back from the lake shore. At Trenton it is about three miles from the Bay of Quinte; in Northumberland county it is about six miles north of the lake. Its extent northwest of Toronto has not been traced. The upper till in these localities is thus provisionally correlated with the upper till in the Scarboro' section and in the vicinity of Toronto. In no place, so far as the writer is aware, is it known to rest upon the middle till sheet, but always upon stratified sands, gravels, or clays. In Northumberland and Durham, and elsewhere, the upper till sheet is overlain by a series of stratified sands and gravels.

In the districts around Lake Scugog and around Lake Simcoe, and for some distance on either side of these areas, till sheets, overlying sands and gravels also occur. From their relative position and other relations, there is reason to think that the upper one of these is the equivalent of the third till sheet on the Lake Ontario side of the ridge.

The middle till sheet rests unconformably upon the beds of the first interglacial epoch; the amount of erosion which preceded its deposition cannot at present be determined because the necessary data are not all collected. Obviously the amount of erosion to be attributed to the ice sheet is also, at present, indeterminate. A maximum limit of less than five miles may be assigned in one case for part of the underlying deposits, because of the fragments of Utica shale in the middle till. It may be possible to define the upward limit later when the precise relations of the stratified beds are worked out.

In the Scarboro' section this till sheet fills an old erosion valley in the underlying stratified deposits. Hinde ('77, 402), who first described the depression, regarded it as a result of glacial erosion, but recent investigators, because of its form, location transverse to the direction of the ice movement, and the absence of any evidence of violent erosion, consider it an old river valley. Similar but smaller depressions, some of which even Hinde regarded as stream channels, are found elsewhere in the Scarboro' section, and more rarely in sections to the east. At the eastern end of the Scarboro' section, where the ice *ascended across the beds*, the stratified beds, which underlie the till sheet, are very much contorted and plicated. Westward from this there is little or no

PLATE II.

FIGURE 1.—Plications in stratified sands of the first Interglacial epoch, Scarboro' Heights.

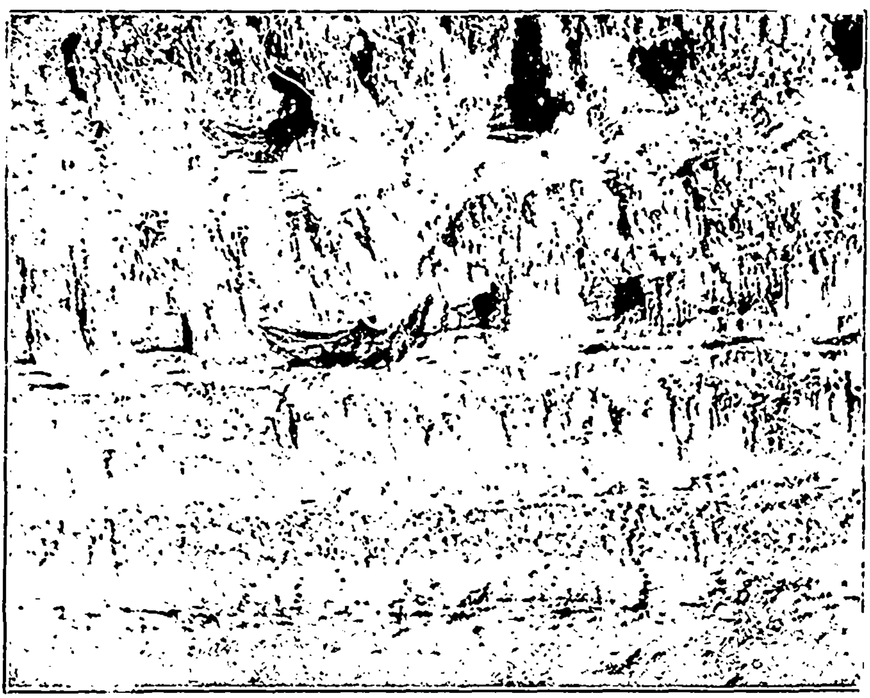


FIGURE 2.—Laminated clays and sands slightly folded by the overriding ice sheet, near Newtonville.

plication, not even at the crossing of the old depressions, and the till sheet descends at the opposite side of the section. Some twelve miles further west it again ascends over plicated beds. In some sections east of Scarboro' the till sheet is seen in clear cut cross section ascending across the beds with almost no plication of the underlying deposits (Plate II).

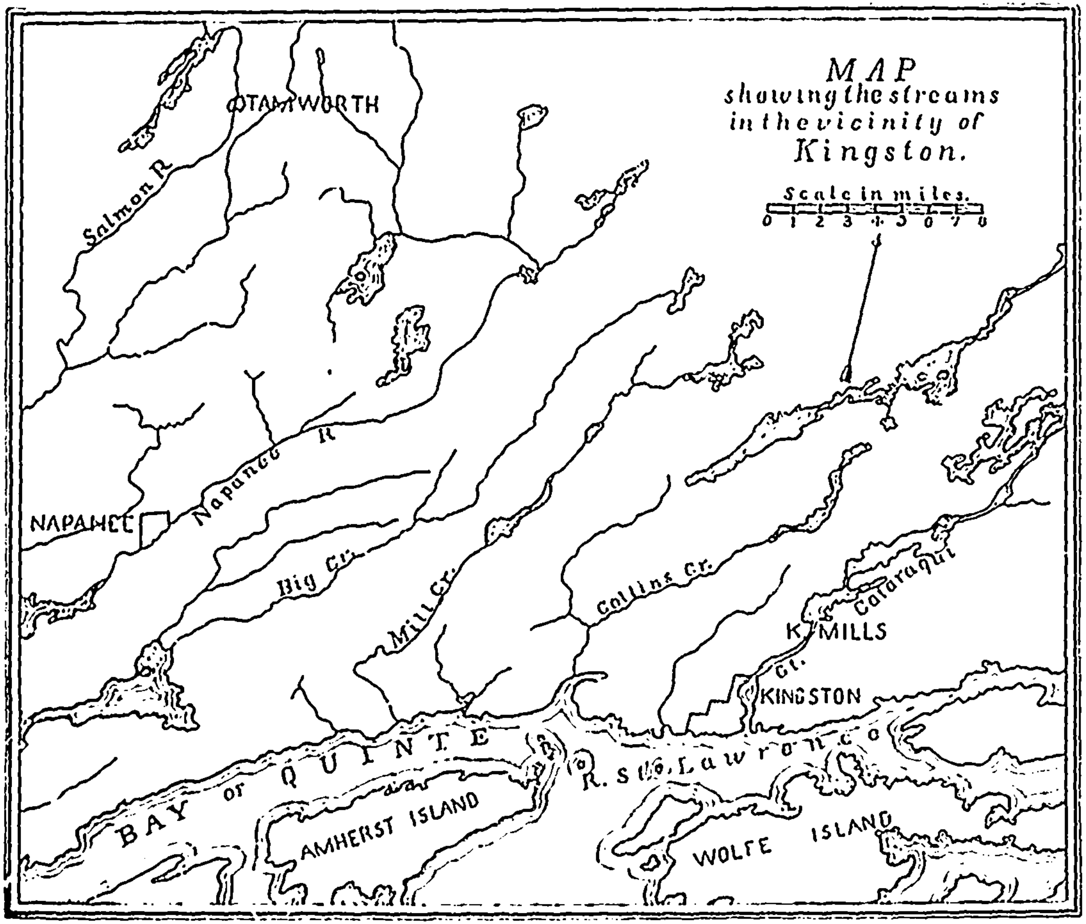
Whether the three periods of glacial transgression and retreat, marked by the three till sheets and the intermediate deposits in Central Ontario, are to be correlated with similar periods as determined to the south of the lake, or represent local variations in the later positions of one ice sheet, it is at present impossible to say. The correlation of the deposits in the two localities, for lack of sufficient knowledge of intervening areas, is not yet definitely determined. Professor Chamberlin has provisionally classified the fossiliferous beds beneath the middle till sheet as contemporaneous with the interval preceding the Wisconsin formation, regarding the middle till sheet of the Toronto sections as equivalent to the Wisconsin till ('95b, 273). He suggests that the Toronto beds might lie in a position at least one hundred miles back from the front of the ice sheet whose till deposits overlie them ('95a, 768; see also, Coleman, 1900).

A feature of particular interest is the fact that here are two sheets of glacial till, overlying still soft sands and gravels, over which the ice that deposited the till sheets must have transgressed. In its transgression the ice sheet has passed over large areas without leaving any mark of disturbance in the underlying beds. In some cases, not in all, where it ascended, the beds on the side from which the ice came are very much disturbed, but the disturbance is confined to the place of ascent. Many instances of modern glaciers over-riding soft deposits have been cited as evidence of the inability of the ice to do significant erosive work. To this the principal objection has been that this inability is shown only at the edge of the sheet. In Central Ontario, whatever the distance between these beds and the edge of the ice sheet which overlay them may have been, it is extremely improbable that at its maximum extension they were just at the margin. There were two periods when the ice overran obviously very incoherent deposits, and there is no known evidence of great erosion by these ice sheets *alone*, over a distance of more than one hundred miles in length, and of a width undetermined, but more than six miles for the middle till sheet, and over an area very much larger for the upper, and perhaps for both. Whatever may have been the amount of material eroded by the ice during these two advances, there is an enormous amount still in place, lying between the rock floor and the youngest till sheet. The inability of the sheet-glaciers, under certain unknown conditions, to remove this material during the two last periods of transgression, raises the question as to whether these conditions may not have existed also during the period of operation of the first ice sheet, when it was overriding bed rock instead of soft sands and clays. This question can in part be answered by a study of the bed rock features.

Eastern Rock-Valleys.—The eastern boundary of the moraines is approximately a line running northeast from Trenton to a point just south of Croyden in the northern part of the township of Camden, Addington county. East of this line in the southern part of the county of Hastings, in Prince Edward, in Lennox and Addington, and in Frontenac, the topography of the underlying rock surface is but little concealed, large areas of almost bare limestone are quite common. This is also essentially true of the rock topography along the margin of the Black River cuesta between Mud Turtle lake and Kingston, with the exception of a narrow belt in part of Huntingdon and Hungerford townships.

In the eastern counties the drift cover is very thin, and rock valleys, now occupied by streams, can be followed readily from their outlet on Lake Ontario or the Bay of Quinte, more or less completely across the limestones towards the Archean. In these counties there are six at least which can be followed all the way across, each to a long narrow lake whose limestone scarped basin is floored with crystalline rocks. There are many more which reach nearly across (Map II). From a map study of Jefferson county, New York state, it seems probable that at least some of the streams in that state belong to this category. The whole series of valleys, some twenty-five and more, is remarkable for its parallelism, the general direction being southwest, and for the regular spacing of the streams. The valley depressions of some are readily traceable under the lake waters, with some complications, to a line running between Stony Point and Point Peter, and in some cases beyond. Where these valleys are unsubmerged, their sides, at the lower ends, are generally steeper on the southeast, towards which the rocks dip, and less steep, sometimes broadly open, on the northwest. Towards the upper end, especially in the case of those which reach the Archean highlands, the valleys are sometimes still broad, but both sides are of about equal altitude and steepness. The average depth is about one hundred feet, locally often much more, and rarely less, except in the smaller valleys. Towards the lower end the width varies to about five miles, while at the upper ends they are usually much narrower.

MAP II.


MAP
showing the streams
in the vicinity of
Kingston.
Scale in miles.
0 1 2 3 4 5 6 7 8
TAMWORTH
Salmon R.
NAPANEE
Napanee R.
Big Cr.
Mill Cr.
Collins Cr.
Cataraqui
K. MILLS
Cr.
KINGSTON
BAY of QUINTE
AMHERST ISLAND
R. St. Lawrence
WOLFE ISLAND

Near the edge of the cuesta, the breadth is sometimes over a mile, and some of the valleys are remarkably flat-bottomed, occasionally with gneiss outcropping in the floor, the sides being limestone. Very frequently the bounding walls in the upper reaches are so steep that they are in places unscalable.

The intervalley spaces are flat topped, inclined gently southward at a less angle than the dip, and have a thin, more or less discontinuous covering of drift, rarely enough to significantly change the flat upland topography. Some few of the intervalley areas, though flat topped, are very narrow in parts, even to one hundred yards in width.

The drift blocked equivalents of these valleys are found all the way to the vicinity of Lake Simcoe and perhaps beyond. The upper reaches along the Black River cuesta, are generally occupied by streams or lakes. The Trent river, through part of its course, occupies portions of several of these. The Bay of Quinte, itself a complex, may be a member of the series.

The lower courses of all lie below the level of the first interglacial deposits, and in some cases the lowest till sheet, overlaid by some of the interglacial beds, is found within the valleys. They are thus either of glacial or of preglacial origin.

The axial direction of the drumlins in Hastings county, corroborated by the direction of striæ upon the inter-valley upland surfaces, indicates that the direction of ice flow sometimes made an angle of about fifteen degrees with the direction of these valleys. Sometimes, just at the edge of the escarpment, striations are found on a curved rock surface bending down obliquely into the valley. The best example is on Mill creek, about two miles west of Sydenham. Occasionally in the valley bottom striæ are found which are not accordant in direction with those upon the adjacent upland, but which nearly accord with the direction of the valley sides, suggesting in some cases, local oblique motion beneath the general ice stream. In other cases the direction of ice motion and that of the valley coincide. As a rule the escarpments and valley-sides, where the rock is exposed, are little, and generally not at all, scoured. On the other hand, where there is a change in the direction, and the valley is bounded by a steep rock wall, that cliff face is sometimes polished smooth on the thrust side, but not elsewhere, in one case, near Napanee, for over one hundred feet below the crest. The postglacial retreat of the escarpments has been very small in some cases, and in others nothing at all, there being no talus in some places, in others striæ rounding over the edge, or, again, the cliff presents a polished face. In one

PLATE III.

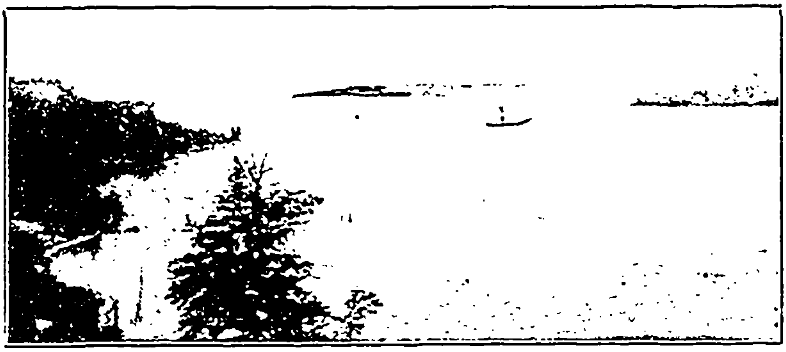


FIGURE 1.—Long Reach, on the Bay of Quinte—a drowned rock-valley.

FIGURE 2.—Benches on the lower Trent, north of Trenton.

case a broad open valley (Great Cataraqui) suddenly turns slightly and narrows to a gorge cut in granite, through which the ice has passed. In another case (Consecon creek, Prince Edward county) the present creek heads on the upland and runs southwesterly, the valley gradually broadening and deepening. About a mile to the east of its head the Bay of Quinte valley, (Plate III., fig. 1) whose depth below the upland at this place is 185 feet, cuts across at an angle of about fifty-five degrees.

These valleys are all, with the single exception of the gorge at Kingston Mills, carved out of homogeneous limestones, lying in a nearly horizontal position. Before the carving of the valleys the country must have been one of almost no relief. The adjacent region, from which the ice came, is also one of low relief. There are thus no topographic features which would cause the action of the sheet-glacier to be concentrated along certain lines which are oblique to its own general direction of motion, and there is no reason why these lines should sometimes unite into one trunk valley. The expectation is that a sheet of ice would under such circumstances tend rather to reduce than to accentuate topographic features. This was true in this area in the case of the second ice sheet, and has been shown to be true elsewhere, and therefore is not an assumption as to a method of *sheet-glacier* action. It is known that an *ice stream*, which invades a valley of subaerial erosion tends to destroy the systematic arrangement of spurs and re-entrants. That a sheet-glacier in a less confined area would tend to erode systematic valley-systems more or less athwart its course seems highly improbable.*

On the contrary, their form and adjustments are appropriate to stream erosion. Loose debris in the bottoms of the valleys near their heads, pinnacles, and isolated outliers along the valley sides, are, however, almost completely wanting. Occasionally the present stream is held back, forming a small pond, by the accumulation of a little drift debris across a portion of the valley, or by a rock obstruction. Where the tributary valleys join a main valley there is no discordance, or as Playfair puts it, there is "such a nice adjustment of their declivities, that none of them join the principal valley, either on too high or too low a level; a circumstance which would be infinitely improbable, if each of these valleys were not the work of the (predecessor of the) stream that flows in it." ('02, 102).

The fact that these valleys are broadly open towards the southwest,

*Compare with the valley of the Rhine, Davis, 1900, p. 275.

and are narrow and steep-walled towards the northeast, indicates that the streams which carved them flowed towards the southwest. These streams may have been initially consequent on a plain inclined towards the southwest, but whose inclination has since been altered by secular uplift or depression, so that the present St. Lawrence flows over the lowest portion of the sag. The direction of the streams has undoubtedly also been controlled by the direction of the master joints of the limestone, and the valleys may have been developed by headward growth of streams guided by these joints. To the writer this latter alternative seems the more probable, though additional field work is necessary before a definite opinion can be expressed. The outlet to the present St. Lawrence seems to be a complex of several of these valleys in which the water is now flowing in a reversed direction owing to secular changes in elevation.

Jointed and Fissured Uplands.—Another feature of the rock surface of the limestone uplands, found upon the intervalley ridges, along the Black River escarpment, and upon the many outliers in front of the escarpment, is the joint structure, which has split the surface layers into rhomboidal blocks of various sizes. Subsequent weathering of the upper blocks especially, has widened the fractures and rounded the edges of the blocks more or less. In some cases we find till and pieces of gneiss in these widened fractures, and in others the glacial striæ bend obliquely downwards in crossing the curved surfaces near the open fissures. Again, over wide areas of almost bare rock, the joints occur, but the blocks are close together and there is no weathering or rounding of the edges, and the striæ cross the joints without deflection. These features occur sometimes within short distances of each other on limestones that are identical in texture, and so far as known, identical in composition. They are found both at the edges of the upland and some distance back from them; unfissured areas are sometimes found close to the edge of the escarpments.

The jointing which produced the rhomboidal blocks preceded the earliest ice advance. The relation of the ice-scoured surface to the open fissures shows the existence of these fissures before the advent of the ice which planed that surface. The low temperature of the subglacial water, and the absence of organic matter in solution, except the small amount derived from the preglacial soils, render it improbable (but not impossible) that the subglacial waters could have materially widened them. During interglacial times, at least portions of the area were below the level of standing water, and were possibly covered with ice, so that it seems very probable that much of the weathering pro-

PLATE IV.

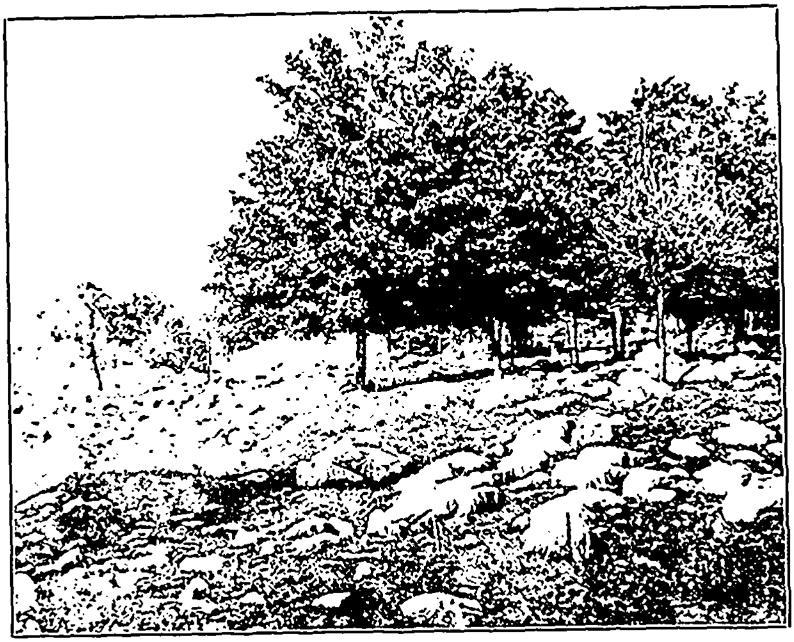


FIGURE 1.—Blocks on the Black River cuesta, about one-third of a mile from its edge, near Stoco Lake.

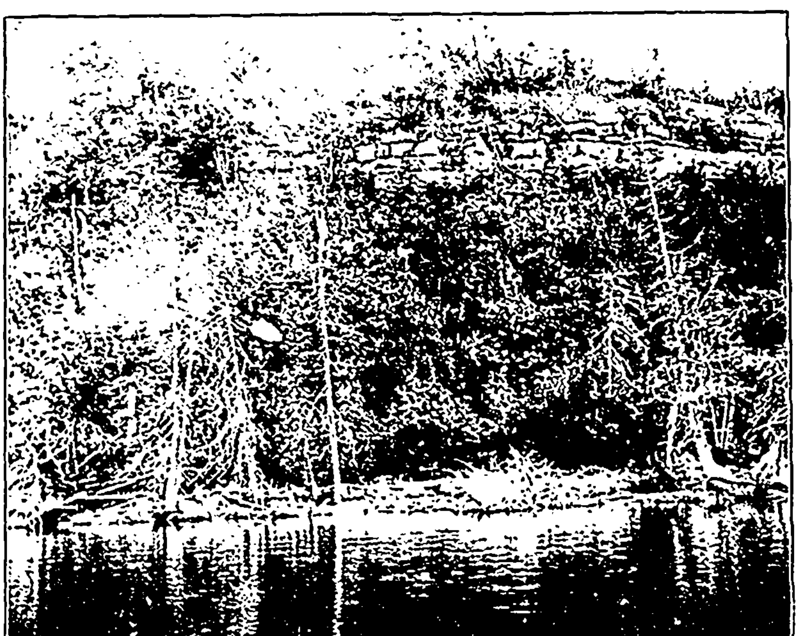


FIGURE 2.—The front of the Black River cuesta, Deer Bay. Talus nearly to the crest.

cesses which opened the fissures must have operated during preglacial time. In any event ice which was capable of scouring passed over the area after the fissures were opened, removed some of the blocks from small areas, but left still larger areas with the blocks still in position, even on narrow ridges.

The topography of these uplands is in many places similar to that peculiar to a limestone region undergoing the process of subaerial degradation. A comparison with ridges in like situations in the unglaciated area of Wisconsin shows that the similarity is very striking. In central Ontario, however, there are no pinnacles nor small prominences in front of the escarpments. Many of the larger outliers still remain as such, generally each with a steep cliff and talus slope in the direction from which the thrust of the ice-sheet came. On the lee side there is a long trail of rhomboidal blocks from the rear slopes of the outlier. (Plate IV, fig. 1.)

Along the escarpments where the old cliff faced the ice thrust there is always a well defined talus slope, sometimes right up to the crest. (Plate IV., fig. 2.) When the direction of the cliff approaches parallelism with the direction of ice motion, the talus is frequently much smaller and occasionally nearly wanting. Where the valley sides are graded to the edge of the upland, loose blocks usually seem to be altogether wanting in the valleys. Whether any of the original soil cover is still in situ it is at present impossible to say. Certainly much of the present soil is imported.

Gorges and Valleys of the Niagara Cuesta.—Along the Niagara cuesta from east of the Dundas valley, described by Spencer ('81), to Cabot's Head on Georgian Bay, are a number of incisions transverse to the escarpment, varying from deep and narrow gorges to deep but broadly open valleys, sometimes as much as ten miles across the mouth, whose bottoms are occupied by obsequent streams flowing to the inner lowland. There seem to be three types of these valleys; first, narrow short and deep gorges, which in some cases might almost be described as hanging gorges, since they are not yet cut down to grade with respect to the rock floor in front of the escarpment. Second, narrow steep-walled gorges, which so far as known appear to be graded with reference to the frontal rock floor. Third, deep broadly open valleys, whose upper reaches may become gorges. They are graded with respect to the rock floor of the inner lowland some distance, sometimes a number of miles, away from the immediate vicinity of the escarpment.

The gorges of the first type seem to be free from drift debris, and their immature form would indicate that they are largely of postglacial origin. The second and third types are usually more or less drift filled, especially in the upper reaches of the third type. The valleys of the second type are relatively narrow and steep walled. The level to which their mouths are graded is not known. The valleys of the third type are broadly open at the point of exit from the cuesta, and some of them penetrate ten to eighteen miles back from its front. Occasionally they are indicated by topographic depressions beyond the point where the bounding rock scarps can actually be followed, though the amount of drift material upon the cuesta has usually obliterated all rock-surface features beyond the limits already mentioned. The rock-walls of each valley (except the Dundas valley as far as can be traced at present) tend to converge, but convergence to a point of union has only been demonstrated for the walls of some of them. Some have also tributary lateral gorges. Spencer has described several entering the Dundas valley. In these tributaries the walls usually unite and the present stream falls over a cliff. The tributary gorges may belong to any one of the three types.

Owen Sound, sometimes wrongly designated a fiord, Colpoy's bay, and other bays upon the Georgian Bay coast, may serve as illustrations of the type (Map III). *There are, however, between Owen Sound and* Burlington, a number of valleys, not submerged, and equally typical. The north shore of Manitoulin Island seems also to possess many comparable with these, but developed on Trenton and older strata.

As in the case of the rock-sided valleys at the eastern end of the area, we lack an accurate knowledge of the precise form of valley which a sheet-glacier, acting on homogeneous rocks in a region of very low relief, might possibly be capable of eroding, and of the form of escarpment-front, which it might, acting alone, produce. It is necessary then to make the partial assumption, that if the sheet-glacier were capable of producing such topographic features, the products would bear a definite relation to the direction of ice advance, and would, in homogeneous rock, assume forms less tortuous than those carved by the more mobile erosive agent, running water charged with sediment.

The direction of the valleys as a whole is entirely independent of the general direction of the ice movement, whether it be determined from the evidences out upon the lowland or from those upon the crest of the cuesta at the edges of the valleys. They lie in all positions through an angle of about 180°; all but one (that at Dundas) in such a position

PLATE V.—VALLEYS IN THE NIAGARA CUESTA.

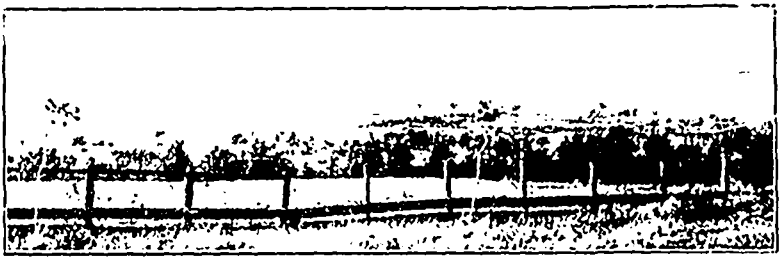


FIGURE 1.—View across the unsubmerged valley of the Bighead river. Cape Rich in the right background. Looking west.

FIGURE 2.—View across a portion of the unsubmerged valley of the Beaver river. Blue Mountains in the distance. Looking east.

FIGURE 3.—Fisher's Gully, a tributary of the Dundas valley, showing systematic arrangement of spurs and reentrants.

that any water which formerly flowed through them must have reached the lowland in front of the cuesta. In many of them the rock scarps which form their sides show no evidences of glacial action. Had the ice advanced up or down them we would expect to find ascending or descending glacial striæ. In places there is a systematic arrangement of alternate spurs and re-entrants, producing a tortuous channel, eminently characteristic of stream erosion, but, if we may judge from existing examples elsewhere, such as no ice stream could have passed through. (Compare with the valley of the Rhue, Davis, **1900**, 275.)

The Owen Sound valley, and several others along the Georgian Bay shore, both northwest and southeast of this, in their lower reaches, flare broadly open towards the direction of the ice advance. Striæ show that in part they controlled the direction of the ice motion, diverting it, in the Owen Sound case, about fifteen degrees to the east of its general direction. This broadly open portion of the valley was certainly modified by the ice. Along the eastern side of Owen Sound, and similarly in some of the other embayments in the escarpment, there are spurs which have not been removed, while upon the western sides, which received the thrust of the ice, the escarpment presents a much more even face.

North of Owen Sound in Colpoy's bay, and between Lion's Head and Cape Croker, there are a complicated series of channels, irregular bays, and islands in front of the escarpment. The different channels bear no definite relation to the direction of the ice movement in adjacent regions, some being even transverse to it. There is no evidence of discordance where the smaller side channels join the principal channel.

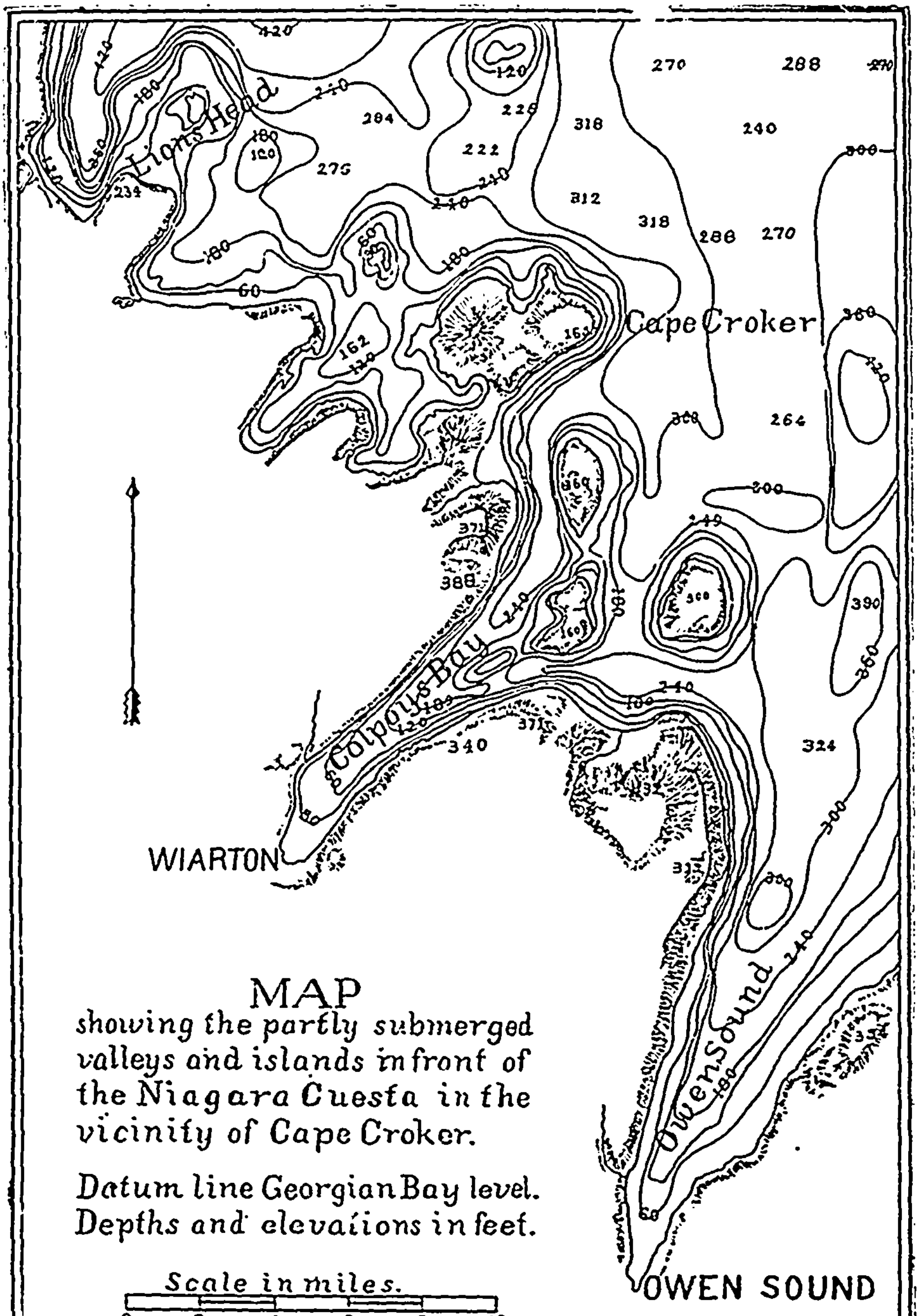
Between Owen Sound and Collingwood there are two unsubmerged sinuses extending far inland. Through one of these the Bighead river enters Georgian Bay at Meaford. The other, which reaches back for more than fifteen miles, over eight miles in breadth at the mouth, and about 1,000 feet in depth, is now the valley of the Beaver river, which enters the bay at Thornbury (Plate V, figs. 1 and 2). Between Collingwood and Hamilton there are a number of similar valleys. The most important of these are those now occupied by the Noisy, Mad, Nottawa, Nottawasaga and Credit rivers, Sixteen-Mile creek and Twelve-Mile creek. A branch of this latter heads on the outlier west of Milton, and through its upper course passes between it and the main escarpment. The largest of all the valleys is that at Dundas, described by Spencer (**'81**). (Plate V, fig. 3.)

In most of these the mouth of the valley is more or less drift-encumbered, but it can be shown in several cases at least that they are graded with respect to some level lower than that of the Medina sediments immediately in front of the escarpment. This is definitely proven for those which lie northwest of Collingwood, for the Dundas valley, and for some others north of Burlington.

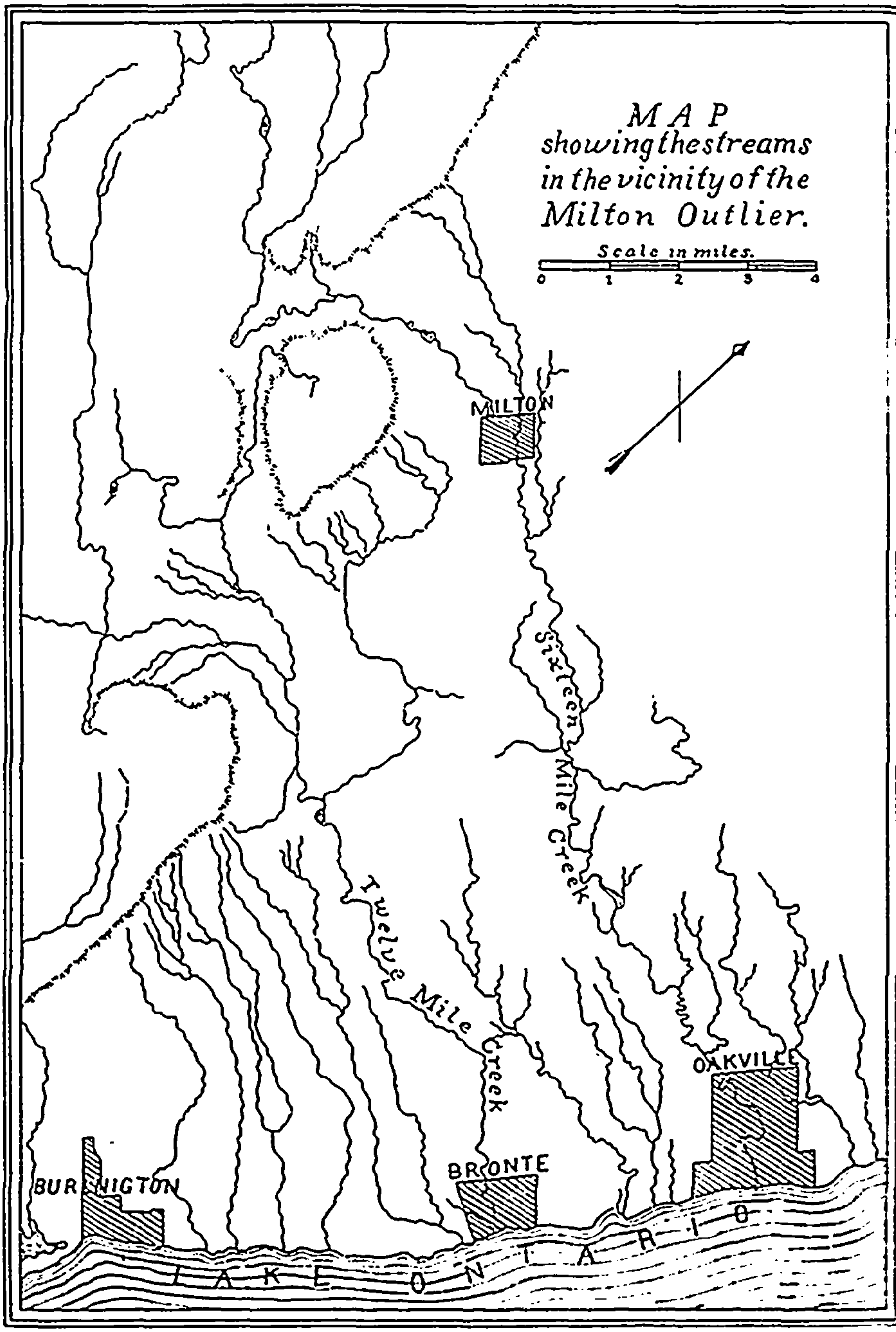
Hence, the systematic form of each, their direction independent of the ice movement, and other features cited, render it very improbable that they are due to glacial erosion. On the contrary, they may all except the Dundas valley, be regarded as due to the development of obsequent drainage, tributary to some master stream or streams running along the inner lowland. Some of them are, in their lower courses, occupied by till, which in some cases is, and in others probably is, that of the lowest till sheet; many of them are graded to a level on the rock floor, which must have been deeply submerged at the time of the deposition of the lowest interglacial beds. In the Dundas valley some stratified deposits are found overlying the till. The similiarity of form and development of the valleys whose relations to the lowest till sheet and to the interglacial beds has been proven, to those in which the relations are unknown, because not worked out, renders it probable that none of them are of interglacial origin. It is possible, though very doubtful, that the upper reaches of some of them may have developed during interglacial time.

Islands and Outliers.—In Lake Ontario towards the eastern end, and extending as far west as Presqu' Isle, are a great many large and small limestone islands and shoals, all lying north of the line between Stony Point and Point Peter. Gull Island, four miles west of Cobourg, is also a limestone island. In the northern part of Lake Huron, between Cape Hurd and Grand Manitoulin Island, are a number of small rock islands. Some of these are of rock fragments at water level, the bed rock not being visible, but the large majority are composed of bed rock in situ. The Manitoulin Islands are rock islands. In Georgian Bay many of the islands are of limestone rock—attention will be specially called to those along the Bruce peninsula (Map III). In Lake Simcoe, along the east side, there are a few islands with limestone bases. Many of these islands are unsubmerged portions of the higher irregularities of the series of escarpments. Some of them lie in front of the main escarpments, as indicated by soundings around them.

On the Central Ontario lowland in Halton county, just west of Milton, is an outlier, capped by Niagara limestone, severed completely


Lions Head
Cape Croker
Colpoys Bay
WIARTON
Owen Sound
OWEN SOUND
MAP
showing the partly submerged valleys and islands in front of the Niagara Cuesta in the vicinity of Cape Croker.
Datum line Georgian Bay level.
Depths and elevations in feet.
Scale in miles.
0 2 4 6 8 10

MAP IV.


MAP
showing the streams
in the vicinity of the
Milton Outlier.
Scale in miles.
0 1 2 3 4
MILTON
Sixteen Mile Creek
Twelve Mile Creek
OAKVILLE
BRONTE
BURLINGTON
LAKE ONTARIO

from the main escarpment, having a surface area of about four square miles (Map IV). Were the land under water this would form a large island, comparable to some of the islands already noted along the Bruce peninsula. Similar outliers may occur elsewhere along the line of the escarpment. In some other localities in front of the cuesta, outliers, capped with Medina sediments and surrounded by drift-filled valleys, were noted, suggesting a similarity to the Milton outlier, but being further out on the iowland, they had perhaps undergone greater degradation.

In front of the Black River escarpment, notably in Hastings county, are a number of outliers of limestone, with much jointed and fissured upper beds. Some few of the outliers are of sandstone. If the region were partly submerged these also would form islands in front of the escarpment. As already noted, many of these outliers present a steep face, with a talus slope at the base, towards the direction of the ice advance, and a long trail of loose blocks on the lee side.

Some of the islands and outliers were certainly in areas protected from ice erosion. The case of the Manitoulin Islands cannot be considered, as the writer has not sufficient personal knowledge of the facts. In the great majority of cases, however, they do not occupy such protected places, and there is direct evidence that the ice transgressed them. Their relation to the escarpments, and the effects which have been produced by the ice, seem clearly to indicate that they had an existence prior to the advance of the ice sheet. The more salient features were smoothed off, but the essential features are still preserved.

Depth of Excavation.—Another interesting fact is the remarkable uniformity in the depth of excavation of the lowland below the crest of the Niagara cuesta. At Cabot's Head the depth is about 800 feet, at Collingwood 1,100, near Dundas 1,000.* The unsubmerged portion of the Ontario lowland is located on rocks ranging from the Trenton to the Medina; the submerged portion is on Trenton in both cases. The lowland has thus been excavated on rocks of four different horizons, and of very diverse texture.

Lowland Rock-Surface.—An almost continuous transverse section of the rock surface of the lowland is shown along the north shore of Lake Ontario, parallel to the Dundas valley, from Hamilton to Lorne Park (twenty-five miles). Between here and the river Rouge (thirty miles)

*743 measured, 1,000 calculated. Spencer, '81, 323.

there are many exposures in the valleys of creeks and rivers. and in a few places along the shore. It is thus known that there is no extensive discordant deepening for forty miles east of Burlington Heights. The lowest part of this section, with reference to the present lake level, is situated on Lorraine shales and sandstones. The surface is lightly rolling, but the average elevation toward the escarpment is about one foot per mile. At right angles to the lake shore it varies to about fifteen feet per mile.

Between the Rouge and Whitby (thirteen miles), there is no known rock exposure. At Whitby and near Bowmanville the Utica shales come to the surface; between these two points there is possibly a valley twelve miles in breadth, but probably of no great depth. For twenty miles east of Bowmanville, to Gull Island (three miles east of Port Hope) the rock, Trenton limestone, is again concealed. From Gull Island to Presqu' Isle (twenty miles), there are a number of exposures of Trenton limestone. East of Presqu' Isle the rock is continuous to below Kingston.

Between the Rouge and Presqu' Isle the upper edge of the lowest till sheet seldom sinks below the water line. Were there any very deep or cañon-like depression of the rock surface the till might reasonably be expected to give some indication of the existence of such depression, for in every case within the area, where such depressions are known to occur, the till sheets above would give ample evidence by their accordant depressions.

Along the Georgian Bay unsubmerged portions of the old valleys are in some cases over 1,000 feet below the escarpment, and are graded with reference to a level still lower. So far as is at present known there is no evidence of discordant deepening due to the movement of the ice along the front of the escarpment in a direction different from that of the general movement; if such deepening has taken place it is not located on the soft Medina strata, but on the Lorraine, which are known to form escarpments, or upon the Trenton. In no case, so far as the writer is aware, has drift from a higher geological horizon been found overlying a lower horizon, well out on the lowland, a result which must obtain if there has been significant lateral motion of the ice from the Georgian Bay region.

Summary.—The work of the ice sheet in Central Ontario seems to have been that of smoothing off pinnacles, small spurs, and other outlying features of the limestone areas. Only the larger of these topographic forms were able to resist the ice, and these, more or less modified, have remained to form islands or outliers in front of the different escarpments, or the spurs of the intervalley ridges along the valley sides. The essential features of the topography are not destroyed, though they are more or less completely obscured and obstructed by drift.

The relation of the area to the fronts of the ice sheets which crossed it is not yet determined. The results of the writer's studies at present suggest that the great moraine of Central Ontario is largely an interlobate moraine between an ice lobe coming from the east of north, and a lobe coming from the east; and that the lateral spurs, on the north and on the south sides of the great moraine, represent the positions successively occupied by the retreating ice front.* The area seems to have been almost always one receiving deposits rather than one from which the soil and rock was being removed.

The streams which produced the pre-glacial valleys throughout the Central Ontario lowland, and the obsequent streams of the Niagara cuesta must have been tributary to some trunk stream, or perhaps to two such master subsequents. The location of these trunk streams would normally be along the lines of deepest cutting. Their direction of flow cannot be determined at present, though that of the tributaries is known from the forms of the valleys. Those on the Black River cuesta flowed southwest, those from the Niagara cuesta northeast, east, and southeast. Obviously the trunk stream, though flowing parallel to the escarpment, must have had some outlet from the region. Determining the location of this valley has been one of the chief difficulties to be met by the river-erosion hypothesis for the origin of the basin of Lake Ontario. The attitude with respect to the present St. Lawrence valley, and certain other features of the rock valleys in the vicinity of Kingston, and the immature character of the present St. Lawrence channel render it extremely improbable that the waste from the lowland was ever carried out through this channel. If the drainage of the Ontario lowland was that of a normally developed river lowland there is but one known outlet which is at all suitable, that by the Dundas valley.† The course of the valley from the vicinity of Copetown westward is highly problematic. Spencer considers that it was towards the south, while Grabau (1901) has recently advocated an extension towards the west, in continuation of an initial consequent direction. The direction of flow of the streams that occupied this valley has not

*See Chamberlin, '95a, p. 768.

†This suggestion had occurred to the writer before he was aware of Dr. Grabau's opinions, referred to below.

been definitely determined. A river flowing westerly through this outlet would be a normal consequent stream, and tributary streams from both sides would occupy the position of normally developed subsequents. The attitude of the broadly open valleys along the Georgian Bay suggest that there may have been a second master stream with an outlet southwestward from the bay. At present our knowledge is so imperfect that the direction of flow of these master streams, and their relations to these different valleys, which may be members of a normally developed system, have not been determined.

The probability that there were streams on the Central Ontario lowland, to which the streams in the preglacial valleys, already described, were tributary, makes it equally probable that similar features were developed to the southeast along the basin of the present lake. At present we know neither the depth to the rock floor of the basin, nor the amount of drift filling. The relation of the basin to the ice lobes is also unknown. Hence differential deepening, which has not operated on the unsubmerged lowland, may perhaps have been in effective operation in the portion of the basin east of the Niagara river, and west of Stony Point.

PLEISTOCENE HISTORY—*A Summary*.—The Pleistocene deposits of Central Ontario present a complex which has not yet been studied in sufficient detail to warrant more than a brief reference to certain salient features. The best known locality is that in the vicinity of Toronto, where the order of succession of the deposits has been established. The probable relations of these deposits to similar beds elsewhere in the area have already been noted. Mention has also been made of certain sands and gravels which overlie the third till sheet in some parts of the area. The fossils of the lowest group of interglacial beds at Toronto indicate that the climate of that part of the region was, for a time, warm and temperate, perhaps like that of Ohio. During this period the lake was connected with the Mississippi drainage, a connection which may have been an inheritance from the cycle preceding the first ice advance. Whether the ice sheet at this time had withdrawn wholly from the region, or only part way, must at present be a matter of conjecture. The fossils of the upper beds of the first interglacial deposits indicate climatic conditions approaching those of the lower Gulf of St. Lawrence and the Labrador coast at the present day. The close of the interglacial period was followed by an interval during which there was a considerable amount of erosion, just how extensive is not determined. The interglacial beds of the latter epochs have, as yet, been little investigated.

PLATE VI.—PLEISTOCENE LAKE BENCHES.

FIGURE 1.—Transverse section of the Iroquois bench and sea-cliff, Scarboro' Bluffs.

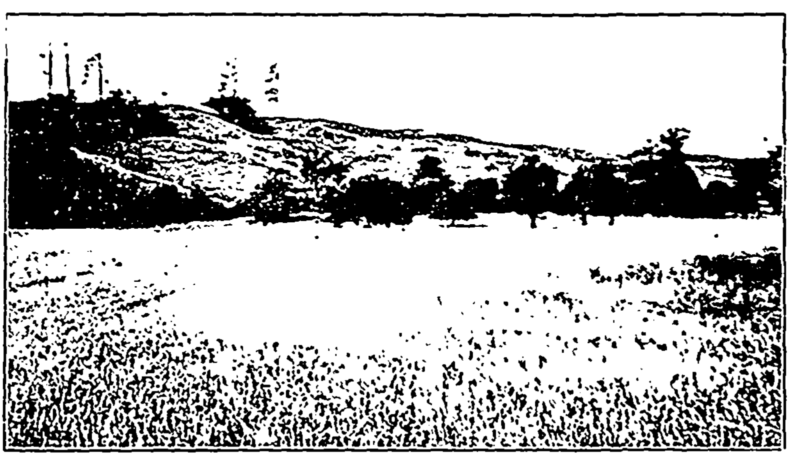


FIGURE 2.—Iroquois bench and sea-cliff, and light morainic topography of the third till sheet, Scarboro' Bluffs.

PLATE VII.—PLEISTOCENE LAKE BENCHES.

FIGURE 1. Iroquois bench and sea-cliff, Scarboro' Bluffs.

FIGURE 2.—Boulder pavement in front of a sea-cliff, near Lake Simcoe and south of Orillia.

While the ice sheet was retreating across Ontario, a series of lakes were formed between its front and the highlands to the south and west. In the latter stages of the ice retreat, portions of the present land area of Central Ontario were beneath the waters of these lakes. The land was being gradually elevated at the northeastern end, so that at present the old shores are not parallel with the surfaces of the existing lakes. The deposits of the different periods of ice transgression and retreat have been so little studied, and so little differentiation seems to have been made between the deposits of sands and gravels of these periods, and those formed by their re-arrangement during the periods of the great Pleistocene lakes, that at present there is much confusion with regard to the history of the area during the Great Lakes epoch. (Plates VI and VII.)

RECENT HISTORY—*A Summary.*—Since the withdrawal of the Pleistocene lakes the amount of erosion has been small. The courses of the present streams are in part determined by the valleys of the preglacial rivers, in part by the position assumed by the drift deposits with respect to the retreating ice sheets, and in part to the controls exercised by the Pleistocene-lake beach-deposits. There is at least one lake (Scugog) whose drainage seems to have been affected by the differential uplift indicated by the present attitude of the old lake beaches.*

Some of the streams have cut through the glacial deposits into the bed rock. Streams entering Lake Ontario west of Toronto, or flowing into the Georgian Bay, have cut deep steep-sided ravines and valleys through drift and shale. Some few, in the vicinity of Oakville, have cut deep straight-sided, flat-bottomed valleys through about forty feet of drift and eighty-five feet of shale.† The present streams meander in courses largely independent of their valley sides, here truncating an old spur, there widening the former meander belt. Sometimes there are two or three back meanders between adjacent spurs of the old valley. In the upper courses, where the stream is still working upon glacial debris, these misfit meanders are especially common. In the great majority of cases there seems to be but one terrace below the general level of the area adjacent to the valley.

North and east of Toronto, the Trent, the Moira, and a few smaller streams, have in part cut new channels in Trenton limestones. The channels, which average perhaps twenty-five feet in depth, are straight-

*This may be true of Pigeon and Chemong lakes also.

†In one case 400 yards in width.

sided and flat-bottomed. In almost all of these the river breaks into rapids, and occasionally plunges over a low fall (Plate VIII). In parts of the lower course of the Trent there are two rock terraces, one a small rock-cut bench, the other due to the removal of the drift debris from the old rock surface. There is reason to think that in parts of the course there are remnants of yet higher terraces upon the drift, but they are not conspicuous topographic features (Plate III, fig. 2, p. 171).

The relations of all of these terraces to the Pleistocene lake levels and to the former water supply are interesting problems which have not been considered. The present valleys are inappropriâte in size and form to the present streams in flood.

Parts of the present valleys of these streams and their tributaries, and the valleys of all streams east of the Moira, are rock-valleys, not of recent origin, and have already been described under the caption "Eastern Rock-Valleys."

Along Lake Ontario the waves have cut benches and sea cliffs in the drift deposits. The longshore action is distributing the material, thus derived, east and west from the vicinity of Whitby, forming bars. spits and hooks. Towards the west the most important of these are Toronto Island and Burlington Beach. Towards the east, from Presqu' Isle neck to Point Peter, there are a great many bars blocking the ends of partly submerged rock valleys, and forming large and small lakes. Back from some of these bars, small sand-dune belts have formed.

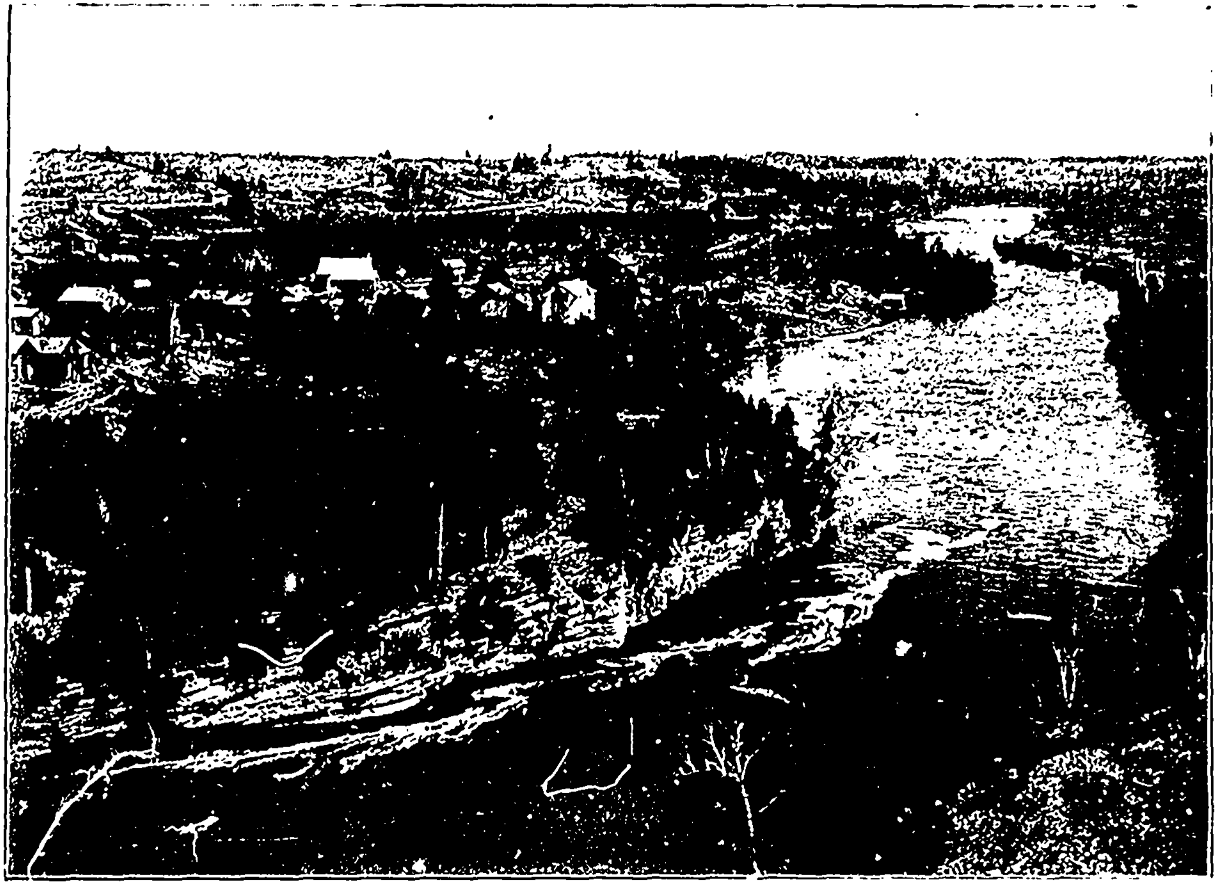


PLATE VIII. —The young channel of the Trent river below Fenelon Falls.

—Photo. by J. H. Stanton, Fenelon Falls.

LITERATURE.

ADAMS, F. D., 1893. "On the Typical Laurentian Area of Canada." Jour. Geol., Vol. I, pp. 325-340.

BELL, ROBERT, 1894. "Pre-Paleozoic Decay of Crystalline Rocks North of Lake Huron." Bull. Geol. Soc. Amer., Vol. V, pp. 357-366.

BIGSBY, J. J., 1829. "A Sketch of the Topography and Geology of Lake Ontario." Phil. Magazine, 2nd Ser., Vol. V, pp. 1-15, 81-87, 263-274, 339-347, 424-431.

CHAMBERLIN, T. C., and SALISBURY, R. D., 1885. "The Driftless Area of the Upper Mississippi Valley." 6th Ann. U.S.G.S., pp. 199-322.

CHAMBERLIN, T. C., 1895 (a). "Glacial Phenomena of North America." In Geikie's "The Great Ice Age," pp. 724-775.

1895 (b). "The Classification of American Glacial Deposits." Jour. Geol., Vol. III, pp. 270-277.

COLEMAN, A. P., 1894. "Interglacial Fossils from the Don Valley, Toronto." Amer. Geol., Vol. 13, pp. 85-93.

1895. "Glacial and Interglacial Deposits near Toronto." Jour. Geol. Vol. III, pp. 622-645.

1897. "Glacial and Interglacial Deposits at Toronto." Brit. Ass. Adv. Sci., pp. 650-651.

1898. "Canadian Pleistocene Flora and Fauna." Report of the Committee. Brit. Ass. Adv. Sci., pp. 522-529.

1899 (a). "Canadian Pleistocene Flora and Fauna." Report of the Committee. Brit. Ass. Adv. Sci., pp. 411-414.

1899 (b). "Lake Iroquois and its Predecessors at Toronto." Bull. Geol. Soc. Amer., Vol. X, pp. 165-176.

1900. "Canadian Pleistocene Flora and Fauna." Report of the Committee Brit. Ass. Adv. Sci., pp. 328-339.

DARTON, N. H., 1894. "Outline of the Cenozoic History of a Portion of the Middle Atlantic Slope." Jour. Geol., Vol. II, pp. 568-587.

DAVIS, W. M., 1900. "Glacial Erosion in France, Switzerland and Norway." Proc. Bost. Soc. Nat. Hist., Vol. XXIX, pp. 273-322.

DAWSON, J. W., 1889. "Handbook of Canadian Geology." Montreal.

DRUMMOND, A. T., 1892. "The Physical Features of the Environs of Kingston." Can. Rec. Sci., Vol. V, pp. 108-117.

DUTTON, C. E., 1882. "Tertiary History of the Grand Cañon District." Monograph II, U.S.G.S.

GEIKIE, A., 1888. "Recent Work of the Geological Survey in the North-west Highlands of Scotland." Quart. Jour. Geol. Soc., Vol. XLIV, pp. 378-441.

GRABAU, A. W., 1901. "Guide to the Geology and Palæontology of Niagara Falls and Vicinity." N.Y. State Museum, Bull. XLV.

HINDE, G. J., 1877. "The Glacial and Interglacial Strata of Scarboro' Heights and other Localities near Toronto." Can. Jour., New Series, Vol. XV, pp. 388-413.

IRVING, R. D., 1872. "On the Age of the Quartzites, Schists, and Conglomerates of Sauk County, Wisconsin." Amer. Jour. Sci., Ser. 3, Vol. III, pp. 93-99.

1877. "Geology of Central Wisconsin." Geol. of Wis., Vol. II, Part 3, pp. 406-636.

KEYES, C. R., 1895. "A Report on Mine la Motte Sheet." Sheet Report No. 4, Missouri Geol. Surv.

LAFLAMME, J. C. K., 1884. "Report of Geological Observations in the Saguenay Region." Can. Geol. Survey, 1882-83-84, Part D.

1886. "Note sur le contact des formations paléozoïques et archéennes de la province de Québec." Proc. Roy. Soc. Can., Vol. IV, Sect. 4, pp. 43-47.

LAWSON, A. C., 1890. "Note on the Pre-Paleozoic Surface of the Archean Terranes of Canada." Bull. Geol. Soc. Amer., Vol. I, pp. 163-174.

LOGAN, W. E., 1863. "Geology of Canada." Can. Geol. Survey.

MURRAY, ALEX., 1843. "Report on the Geology of parts of the champaign region of Western Canada." Can. Geol. Surv., pp. 51-91.

1848. "Report on the Western and Huron Districts." Can. Geol. Survey.

1850. "Report on parts of the Western Peninsula." Can. Geol. Survey.

1851. "Report on the Geology of the Region between the St. Lawrence and Ottawa Rivers." Can. Geol. Survey.

1852. "Report on the district between Kingston and Lake Simcoe." Can. Geol. Survey.

NEWBERRY, J. S., 1858. "Colorado Exploring Expedition." Lieut. J. C. Ives, Part III. Published by order of the Secretary of War, Washington, 1861.

PLAYFAIR, J., 1802. "Illustrations of the Huttonian Theory of the Earth." Edinburgh.

SMYTH, H. L., 1899. "The Crystal Falls Iron-Bearing District of Michigan." Monograph XXXVI, U.S.G.S., part II, pp. 329-487.

SPENCER, J. W., 1881. "Discovery of the Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario; With Notes on the Origin of our Lower Great Lakes." Proc. Amer. Phil. Soc., Vol. XIX, pp. 300-337. Abstract in Can. Nat. and Geol., New Series, Vol. X, pp. 65-79.

VAN HISE, C. R., 1896. "A Central Wisconsin Baselevel." Science, New Series, Vol. IV, pp. 57-59.

WALCOTT, C. D., 1891. "The North American Continent during Cambrian Time." 12th Ann. U.S.G.S., pp. 523-568.

OBSERVATIONS ON BLOOD PRESSURE.

WITH SPECIAL REFERENCE TO CHLOROFORM.

BY R. D. RUDOLF, M.D., EDIN., M.R.C.P. LOND., TORONTO.

(Read 27th April, 1901).

INTRODUCTION.

THIS paper contains the results of work which I have conducted during the past three years in the Physiological Department of Toronto University. A grant of money was made by the Scientific Grants Committee of the British Medical Association towards defraying the expenses, and is here gratefully acknowledged.

The work has been of a somewhat intermittent character, owing chiefly to the difficulty in obtaining a steady supply of animals. The kymograph used was a Ludwig one, with a glass pen writing in ink upon white paper. The tracings thus obtained were very long, as often experiments extended over several hours, and only short pieces of them are able to be used here to bring out the points mentioned in the text.

I have as far as possible avoided theorizing, being rather content to state the results which were actually obtained under given conditions; a certain amount of speculation is occasionally inevitable however.

I am greatly indebted to Professor A. B. Macallum for much valuable advice, and to Mr. Scott, D.Sc., for constant assistance in the carrying out of the experiments.

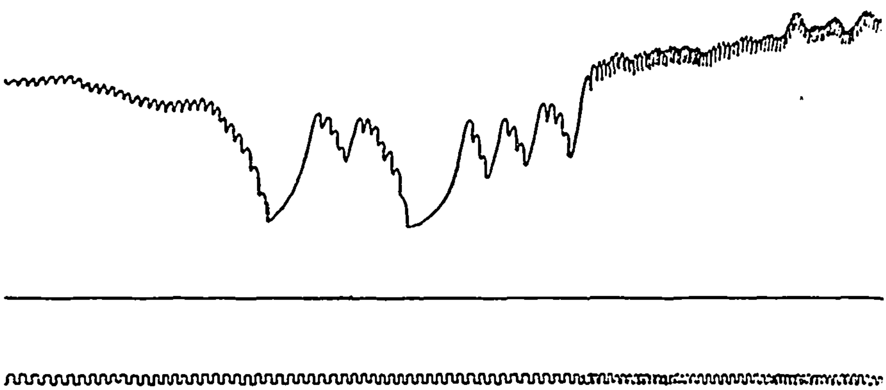
Before actually passing on to discuss alterations in blood pressure produced by definite causes, one should mention that occasionally strange falls in the blood pressure of dogs occur without any apparent cause. If these were not noted they might be wrongly interpreted.

1

TRACING I.—9/3S.—Dog under Morphia. No Chloroform for several minutes. This fall in blood pressure occurred without apparent cause and gradually disappeared.

Tracing I shows one of these vagaries. The animal, a mongrel spaniel, weighing about 40 lbs., had been given three-quarters of a grain of morphia an hour before the experiment began. It then was chloroformed. After it was completely insensible and for several minutes had not been taking any more of the anæsthetic, this fall in pressure occurred. It looked somewhat like that produced by irritation of the vagus nerve, and it was suggested that the canula in the left carotid might be producing this, but nothing was altered and yet the pressure recovered of itself and the fall did not recur during the two-hour experiment.

5



TRACING II.—3/7.—Dog under Morphia. No Chloroform for several minutes. Shows marked fall in pressure with slowing of pulse. Animal horizontal. Cause of fall not apparent and it was spontaneously recovered from.

Tracing 2 shows another fall occurring under similar circumstances to the last. The animal had not had any chloroform for several minutes. In this case the fall is even more marked, and looks extremely like that produced by irritation of the vagus, but it completely disappeared without any of the factors having been altered, and did not recur.

Such falls as these, when they happen to occur during the actual administration of chloroform, may be the unexpected ones described by the Glasgow Commission on Chloroform, and which Lieut.-Col. Lawrie ascribed to asphyxia; we will refer to this point later on.

It was frequently noted how much different dogs varied as regards the amount of their blood pressure and pulse rate. Often poorly-nourished and small varieties of dogs had high pressures, whilst large, well-nourished animals had the opposite.

THE NORMAL EFFECTS OF GRAVITY.

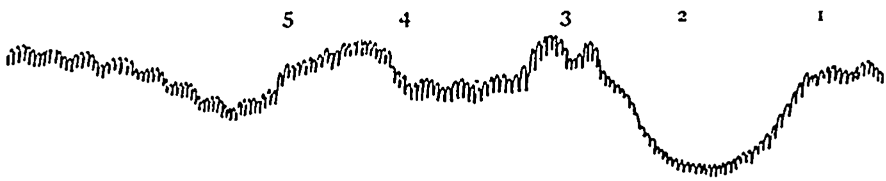
It has long been known clinically that the circulation of the blood is affected by the posture of the body, and that in weakened states of the circulation the blood and other fluids, obeying ordinary hydrostatic laws, tend to accumulate in the most dependent parts of the body. Further, it had been noted that if the posture of the body be *suddenly* altered, *e.g.*, if a person be raised from the horizontal to the erect posture, the inertia of the blood tends to make it lag, and as a result the upper pole of the body, including the brain, temporarily becomes more or less bloodless, and in consequence the individual may actually faint. This method of inducing insensibility was actually employed by a Parisian surgeon, who then operated upon his patient, rendered thus insensible to pain. George Hayem[1] writes as follows: "Phlebotomists had known for a long time the influence of position on the production of syncope when Piorry instituted his experiments on the subject. He bled some dogs upright, and they fell at the end of a certain time into a sort of state of dissolution with suspension of respiration. He stopped the hæmorrhage then and placed the animal head downwards, and immediately it breathed again. Often the same experiment could be repeated many times on the same dog. I repeated the experiments in 1880 and found them to be perfectly correct." It has constantly been observed, moreover, that some individuals are much more susceptible to such changes of posture than others, and that almost any person if temporarily weakened in any manner, will tend to suffer from dizziness or even faintness on suddenly assuming the erect posture.

The effects of different postures and of sudden and gradual alterations of these, have of late years been studied more accurately in animals by means of tracings of the blood pressure. The very beautiful tracings put on record by the 2nd Hyderabad Commission on Chloroform are examples of these observations, and more recently Mr. Leonard Hill has added some of the same nature. My experiments were done on dogs, with the exception of a few upon cats, and they confirm largely what has already been observed and recorded. In each case the animal was secured in a trough which was so constructed that it could be swung into any angle with the horizon, with the canula in the artery always remaining in the axis of rotation. The canula was further carefully kept at the same level as the manometer. Unless for some special reason the canula was always placed in the proximal end of the left

1 "Death from Hæmorrhage," Archive de Physiologie, 1888, p. 102.

carotid artery. The animals were all under the influence of some anæsthetic, the nature of which is mentioned when necessary; but as the effects of posture were more or less the same in all cases, it may be inferred that they were not due to the anæsthetic, except as regards degree. As a rule some morphia was first given hypodermically, and then very little chloroform sufficed to keep them quiet.

Tracing 3 is from a dog under chloroform. Where the tracing begins he is horizontal, and the canula is in the carotid. At 1 the hind feet were suddenly lowered. and the pressure is seen to markedly fall. When placed horizontal again at 2 the pressure rapidly rose and went above the normal for a short time, 3, and then resumed the normal line. This is a very constant feature in such tracings, and is probably due partly to inertia, and partly to the compensation which has been taking place



TRACING III.—1/3.—Normal effects of gravity on carotid blood pressure. Dog under Chloroform. 1 Animal placed vertical (feet downwards). 2 Horizontal again. 3 Compensation continuing. 4 Head downwards. 5 Horizontal again.

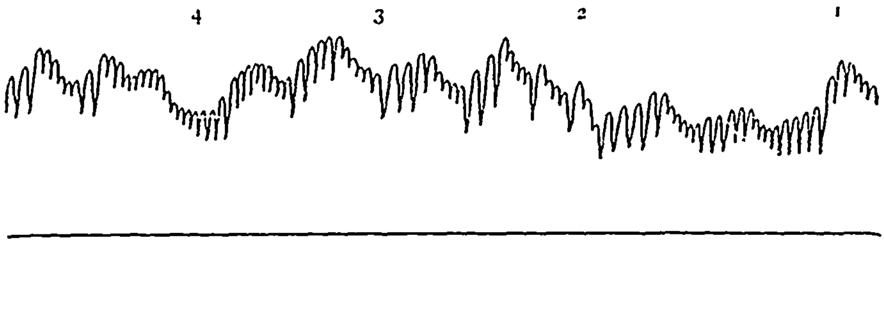
against the effect of the vertical position still continuing after the animal is again horizontal. This compensation, as we shall see, is partly affected by increase in the rate of the heart-beat and partly by constriction of the arteries, while contraction of the abdominal wall is also of service here.[1] At 4 the animal was suddenly placed in the vertical feet-up posture, and at once the carotid pressure rose. This rise was not so great as the fall which occurred in the feet-down posture, and a rule may be deduced that *the lowering of a pole of the body does not raise the arterial blood pressure in it so much as raising that pole lowers it.*

When placed horizontal at 5 the pressure fell below the normal line for the same reasons that it rose above that line at 3.

Some dogs are not nearly so susceptible to the effects of gravity as

1 "Influence of Gravity on the Circulation." Hill and Barnard. Journal of Physiology. Vol. XXI., 1897.

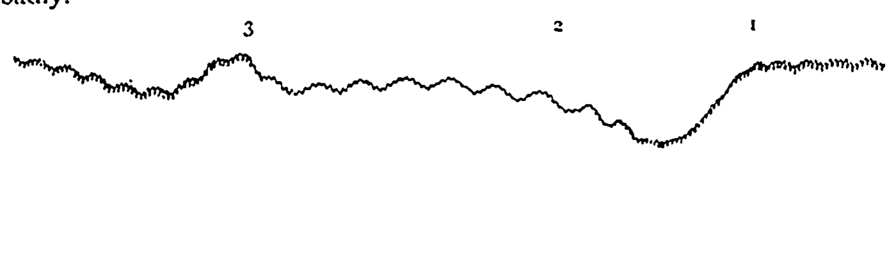
others. Thus, Tracing 4 is from a dog under morphia and chloroform just as in the previous experiment, and yet the change in pressure in the different postures is very slight. I found that cats are especially



TRACING IV.—9/22.—Dog under Morphia and Chloroform. 1 Vertically feet downwards. 2 Horizontal. 3 Head downwards. 4 Horizontal.

immune to the effects of change of posture; and Mr. Leonard Hill records[1] that some animals, *e.g.*, certain species of monkeys, actually *over*-compensate, and thus have a higher carotid blood pressure in the feet-down than in the normal posture.

Most animals compensate somewhat after a short time for the vertical feet-down position. As one might expect, animals that habitually or frequently assume the vertical posture are better able to compensate against any fall in blood pressure in this posture than are animals which do not naturally become vertical. Thus apes and domestic fowls compensate well, while snakes and hutch rabbits compensate badly.[2]

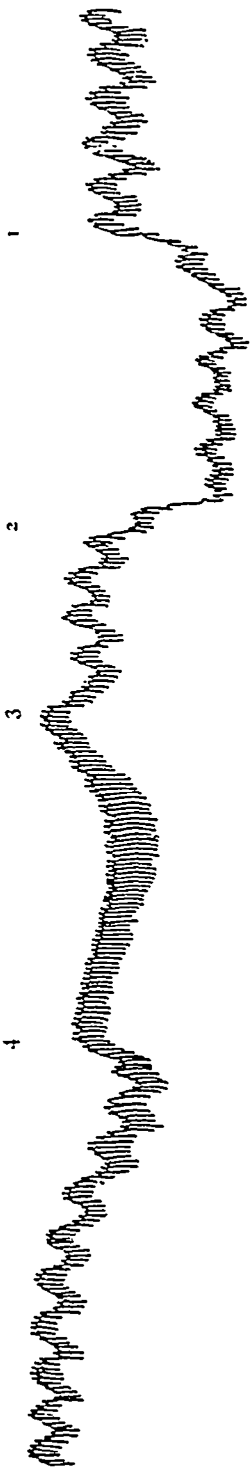


TRACING V.—9/19.—1 Vertically feet downwards. 2 Compensation occurring for vertical posture. 3 Horizontal again.

Tracing 5 shows such compensation. At 1 the animal was placed vertical, and at 2, though still in the vertical posture, the blood pressure

1 "The Cerebral Circulation," page 88.

2 Leonard Hill. "Further Observations on the Influence of Gravity on the Circulation." Supplement to the Journal of Physiology, Vol. 23, Feb. 27th, 1897.



TRACING VI.—9/28.—Canula in carotid. 1 Feet down. 2 Horizontal. 3 Head down. Compensation for this posture shown. 4 Horizontal.

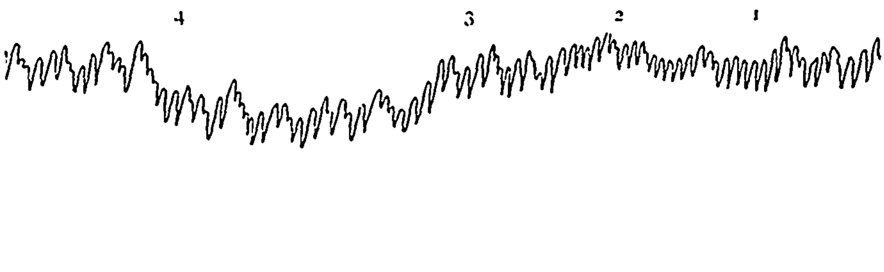
is seen gradually to right itself. At 3, on the animal being placed horizontal, the pressure went for a moment above the normal line, the *compensation still continuing.*

But if the vertical posture be maintained for a long time this *compensation will fail, as shown by* Mr. Hill on certain animals[1], and as often shown clinically when people faint from long standing. The *swelling of horses' legs from long* standing is another familiar illustration of the same thing.

Tracing 6 shows compensation for the feet-up posture. At 3 the feet were raised and the pressure in the carotid temporarily rose, but although the animal was kept in this position it soon fell to the normal line, and when the animal was placed horizontal at 4, the compensation continuing for a while, the pressure actually went below the normal.

When the canula is placed in the *proximal end of another artery, e.g.,* the femoral, as in Tracing 7, the same phenomena are observed. Then, of course, the vertical feet-up posture causes a *fall* in pressure, and the vertical feet-down a rise. This tracing illustrates well again the rule that the rise produced in the pressure in the vessels of a pole of the body by lowering that pole is not so great as the fall produced by raising it.

1 Ibid.



TRACING VII.—9/26.—Canula in horizontal end of femoral artery. 1 Feet down. 2 Horizontal. 3 Feet up. 4 Horizontal.

The effects of posture are less marked in the distal end of a divided artery than in the proximal. Tracing 8 is taken from the distal end of the femoral artery. In it the respiratory waves appear, and the whole pressure is considerably lower than in the proximal end of the same

TRACING VIII.—9/22.—Canula in distal end of femoral artery. 1 Horizontal. 2 Head downwards. 3 Horizontal.

artery. When the hind feet are lowered the pressure is scarcely altered (before tracing begins), but when they are raised the pressure slowly falls somewhat. This is another illustration of the rule above mentioned.

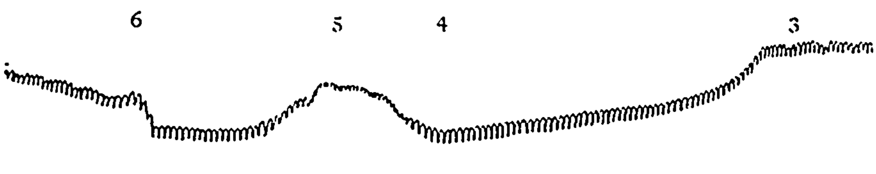
TRACING IX.—1/5.—Canula in proximal end of splenic artery. 12 Vertically feet down. 13 Horizontal. 14 Feet up. 15 Horizontal.

Tracings taken from the proximal end of the splenic artery show a marked fall in the feet-down position, and a slight fall in the feet-up. Thus the pressure falls in both vertical postures, but especially in the feet-down one. Tracing 9 is taken from the proximal end of the splenic artery. At 12 the feet were lowered, and after a short hesitation the pressure fell markedly. At 13 the animal was replaced in the horizontal position. At 14 it was swung into the vertical feet-up position, and a slight fall occurred.

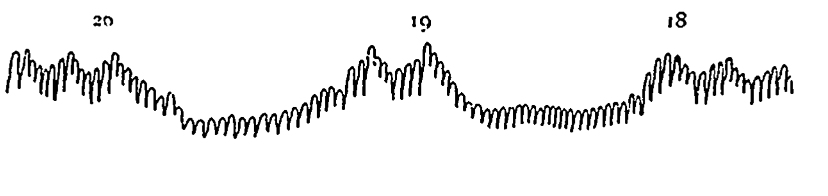
So much for the changes in pressure uninfluenced as far as possible by anything except posture. I next proceed to the effects of certain factors in increasing and decreasing the blood pressure, and its susceptibility to gravity and inertia.

ABDOMINAL PRESSURE.

Tracings 10 and 11 show the effect of firm abdominal pressure in raising the blood pressure while this is low from the animal being in the vertical posture. In 11 the vertical position assumed at 18 produced a slight fall, and abdominal pressure applied at 19 raised the tracing to



TRACING X.—3/10.—3 Vertical. Pressure continued to fall. 4 Abdominal pressure. 5 A pressure removed. 6 Horizontal.



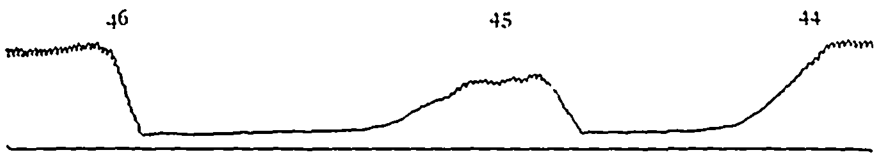
TRACING XI.—1/2.—18 Vertical. 19 Abdominal pressure. 20 Horizontal.

even above the normal line. In the former tracing the pulse was hastened by the abdominal pressure, in the latter it remained unaltered.

Abdominal pressure, however, in order to be effectual, must be of an exceedingly firm nature, and probably pressure upon the aorta itself has something to do with the result. It has been shown indeed that when the aorta is compressed by itself a marked rise in the general blood pressure occurs[1]. Far more abdominal pressure is necessary than would be required merely to empty the abdominal veins—this being the usual explanation of how the resulting rise in blood pressure is brought about.

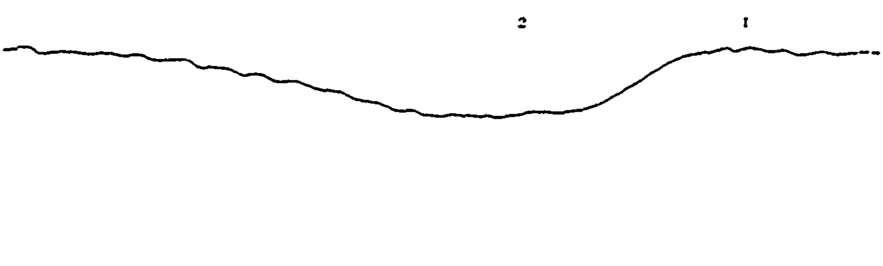
1 J. A. McWilliams, British Medical Journal, Vol. II., 1890, p. 835.

Hill and Barnard give a tracing[1] showing the effect of abdominal pressure. In it the pressure actually goes above the normal line, as it also did in tracing 11 just given, and in order to get such a rise a large amount of abdominal pressure must have been applied, and probably the aorta was more or less completely obstructed by this. I tried the tightening of an abdominal bandage as described by Mr. Leonard Hill,[2] but got almost negative results. Consequently I believe that slight supporting of the abdominal walls by bandages can have little or no effect upon the general blood pressure, and the comfort given by such to a certain class of patients cannot be attributed to any appreciable rise of blood pressure. One point, however, must be here borne in mind, and that is that while in healthy animals the abdominal wall is normal, in certain individuals it is abnormally flaccid.



TRACING XII.—1/3.—Spinal cord previously divided at level of last dorsal vertebra. 44 Vertical. 45 Abdominal pressure. 46 Horizontal.

Tracing 12 shows the effect of abdominal pressure on a vertical animal in which the blood pressure was standing almost at zero on account of previous division of the spinal cord.



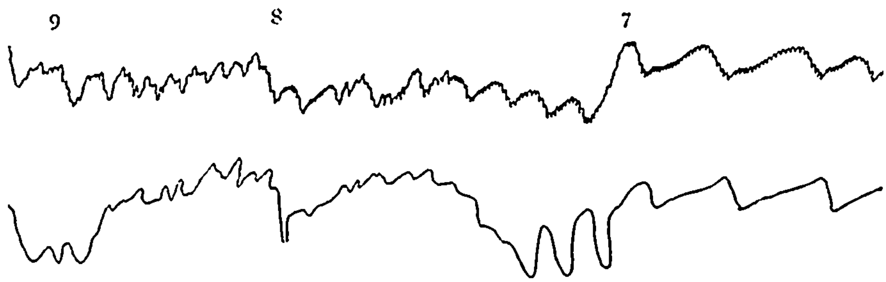
TRACING XIII.—9/20.—Canula in distal end of femoral artery. 1 Abdominal pressure. 2 Pressure removed.

Tracing 13 shows the effect of abdominal pressure on the blood pressure in the distal end of the femoral artery. The animal being horizontal, as seen the pressure slowly fell, which goes to prove that, as

1 Tracing 86, Journal of Physiology, Vol. XXI., 1897.

2 "The Cerebral Circulation," p. 100.

previously stated, the aorta must be compressed during firm abdominal pressure.

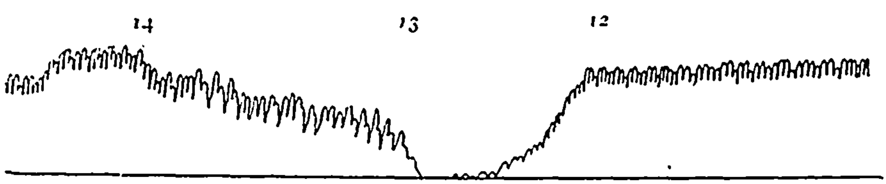


TRACING XIV.—1/3.—Dog under Atropin. 7 Vertical. 8 Struggling. 9 Horizontal. Lower line is respiratory tracing.

Tracing 14 shows the effect of posture on an animal in which the vagi had been paralysed by atropine. At 7 it was placed vertical, with very little fall in pressure. The effects are practically the same as when the vagi are intact.

Division of the Spinal Cord at various levels.

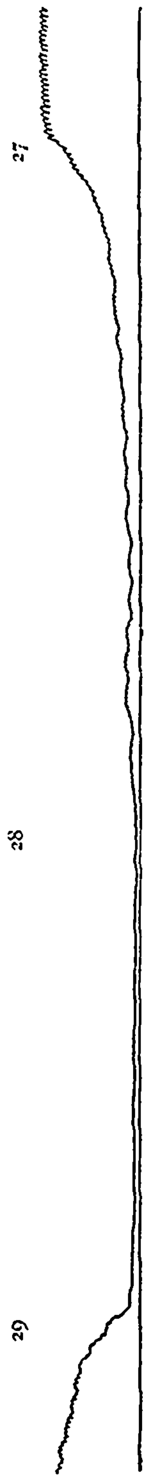
This always produces a great lessening in the compensation for the feet-down position.



TRACING XV.—3/10.—Spinal cord previously divided opposite 8th dorsal vertebra. 12 Vertical. 13 Horizontal. 14 Head down.

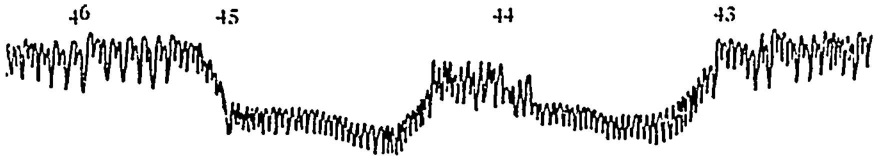
Tracing 15 illustrates this point. The cord had been divided opposite the eighth dorsal vertebra, and the pressure in the horizontal position fell somewhat. When the animal was placed in the vertical feet-down posture at 12, the pressure fell rapidly and threatened to actually become negative. The pulse did not hasten, in fact, slowed somewhat. The pressure rose about the ordinary amount in the feet-up posture, as shown at 14.

Tracing 16 shows the carotid blood pressure occurring in a dog in which the spinal cord had been divided near the eleventh dorsal vertebra. In this case the pulse increased greatly in rapidity as the pressure fell on the animal being placed vertical at 27. The animal was kept in the feet-down position for some minutes without any appearance of compensation occurring, and was placed horizontal again at 29. Now the vaso-motor fibres for the splanchnic nerves leave the cord above the level of the eighth dorsal nerve; the section in this experiment took place well below this, and thus the vessels of the splanchnic area were not paralysed by the operation, yet a very marked fall occurred. This woud point to the fact that the vessels of the lower part of the body are very largely concerned in the keeping up of the normal blood pressure in the feet-down position, because when they are paralysed the pressure markedly falls.



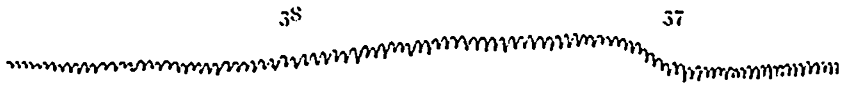
TRACING XVI.—7/25.—Spinal cord previously divided opposite 11th dorsal vertebra. 27 Vertical. 29 Horizontal again. No compensation occurred.

If the distal end of the divided spinal cord be stimulated by the Faradic current, the pressure in the carotid artery is decidedly raised, as shown in Tracing 17. Here the animal, in which the spinal cord had been previously divided in the lower dorsal region was placed feet-down at 43, with the result that the pressure fell. At 44 the distal end of the



TRACING XVII.—1/2.—Spinal cord previously divided in lower dorsal region. 43 Vertical. 44 Faradic stimulation of distal end of cord. 45 Horizontal. 46 Distal end again stimulated—no effect.

divided cord was stimulated as mentioned, and a considerable rise in pressure took place. At 45 the animal was replaced in the horizontal position. This experiment again shows how dependent the general blood pressure of the body is upon the vaso-motor tone of the vessels in its lower part. When the animal was placed horizontal again,



TRACING XVIII.—8/22.—Spinal cord previously divided opposite last dorsal vertebra. Animal horizontal. 37 Distal end of cord stimulated by Faradic current. 38 Stimulus removed.

similar stimulation of the distal end produced no effect. Tracing 18 shows only a slight rise on stimulation of the distal end of the cord while the animal was horizontal. This is a result which one would naturally expect.

The vaso-motor influence of the lower part of the body is supposed to be very limited and chiefly confined to the skin.[1] The experiments just related, however, would suggest that the vascular tone of the lower part of the body is of considerable importance in the regulation of the general arterial blood pressure. Without doubt the splanchnic area is the one chiefly concerned in the regulation of the blood pressure, but it is here suggested that the tone of the lower limbs is of more importance in this regard than is generally recognized.

1 Foster's Physiology, Part I.

THE EFFECT OF CERTAIN DRUGS ON THE BLOOD PRESSURE.

Morphia.—Morphia was used hypodermically upon about forty-five dogs. It was followed in every case by salivation, in the majority of instances by vomiting and in a few by purging. The action of this drug on dogs appears to be very much like that of Apomorphine on man in these respects. Morphia produced distinct slowing of the pulse, and made the animal go under chloroform more easily and stay unconscious longer, and this entirely coincides with what many clinicians have observed.

Chloroform.—This anæsthetic was always administered on a towel, and no attempt was made to measure the dose. In none of the dogs did vomiting occur after the administration of chloroform had been commenced even when they had had morphia previously, and I find no mention of this complication occurring during the anæsthesia of these animals in any literature.

In all of fifty-two dogs killed by chloroform *the respiration distinctly stopped before the heart.* The period between the stoppage of the respiration and the cessation of the heart's action varied from a few seconds to several minutes. As a rule, the more concentrated the chloroform vapour was, the shorter this period became. In nearly all cases the respiration stopped before the pulse tracing had disappeared, but on several occasions, when it seemed as if the heart had ceased, auscultation showed that it was still beating. After the respiration had stopped the first sound of the heart would get weaker and weaker and at last cease, while the second sound would remain loud and clear for some time and then gradually also cease. The question as to whether the respiration or the heart stops first in chloroform poisoning is one about which a great deal of controversy has raged, and the point is not yet unanimously settled. The Hyderabad Commission held that the respiration always stopped first, and that there was no such thing as chloroform syncope.[1] Dr. A. R. Cushny performed many careful experiments with different dilutions of chloroform to see the effect on the heart. If the vapour was very concentrated the heart was affected, but he says, "Although I cannot agree with the Hyderabad Commission that the heart always continues to beat after the respiration ceases, yet the difficulty of maintaining the concentration necessary to paralyze the heart simultaneously with the respiration is extremely great, and I

1 Lieut.-Col. Lawrie, Lancet, March 14th, 1891.

should think in ordinary chloroform administration such a simultaneous paralysis can never occur.[1] Lieut.-Col. Lawrie stated in Appendix No. 3, of the Report of the Hyderabad Commission[2] that chloroform has no direct action upon the heart, and this is quoted again in a letter upon the Report of the Anæsthetic Commission in the British Medical Journal of January 19th, 1901. I have no doubt, however, but that chloroform does poison the heart muscle in the same way as it must more or less poison every organ in the body. As stated, in all of my fifty-two experiments in this regard the respiration stopped before the heart. If the amount of chloroform given be very great, however, artificial respiration, even if immediately commenced, will not save the animal—showing that the heart as well as the respiration is poisoned. Dr. H. C. Wood in an address delivered before the International Medical Congress in Berlin in 1890,[3] says, "We definitely proved that in the dog chloroform has a distinct direct paralysing influence on both respiration and circulation; that the respiration may cease before the heart, or the two functions may be simultaneously abolished; but that in some cases the heart is arrested before the respiration. We have several times seen the respiration continue as long as one or even two minutes after the blood pressure had fallen to zero, and the blood had completely disappeared from the carotid artery." This might well be and yet the heart might have been found to be still beating if auscultation had been practised. In trying to explain the results of the Hyderabad Commission he says further on, "It may be that the heat or other climatic conditions surrounding the pariah dog make his heart less sensitive to the action of chloroform than the hearts of dogs in northern climates." J. Harris[4] in testing an apparatus for producing painless death of lower animals by chloroform, which had been taken out from England to India, found that it would not work, the reason being that the high temperature prevented the concentration of the chloroform vapour. By placing ice in the chambers animals were readily killed. I can quite understand this, and have frequently noticed during the Indian hot weather that it was more difficult than usual to get patients "under," especially if a punkah were swinging near by. On the other hand it is hard to explain the following statement, "It is stated that iced chloroform has been used in 14,000 cases in Würzburg, Bavaria, without any ill results. Rapidity of administration, comparative freedom from danger and absence of nausea

1 Lancet, March 14th, 1891.

2 Lancet, January, 1893.

3 British Medical Journal, August 16th, 1890.

4 Indian Medical Record, May 19th, 1890.

are the advantages claimed for this preparation[1]." My experiments were done through the several Canadian seasons upon many varieties of dogs, and yet I never found the heart stop before the respiration, although, as stated, on several occasions the pulse tracing did so. Dr. B. W. Richardson in my opinion stated the case aright when he wrote that "death in man during chloroform anesthesia is not generally due to respiratory failure, but that in animals the physiological death from chloroform is a respiratory failure."[2] He says that Snow also thought so.

In my experiments the animals were killed with chloroform in the horizontal and vertical postures, after poisoning with various drugs, cutting of one or both vagi nerves, division of the spinal cord at various levels, opening of the abdomen, bleeding, etc., and yet, as stated, the respiration always stopped before the heart.

Post mortem examinations were made on most of the animals so killed, but the condition of the heart and great vessels then does not seem to be any indication of what it was just after death, as artificial respiration, abdominal pressure and other restoratives were all tried, and these must have altered the conditions of things. Such remarks may also apply to the results of post mortems on persons who have so died. With this proviso, one may say that the right side of the heart was always engorged with blood, and that the left was generally more or less empty, but occasionally also was full. In one case after death from chloroform, followed by artificial respiration, the animal's body was frozen, and transverse sections of the chest made. Here the right side of the heart was found to be engorged and the left was partially filled with blood.[3]

The most dangerous time for a dog is while he is going under first. Then, if he be struggling, the danger is great. In most cases, as already stated, when the breathing had stopped under these circumstances, artificial respiration would restore it and save life, but occasionally it failed to do so.

When chloroform is given slowly and sufficiently diluted then the animal goes under completely without necessarily much, if any, fall in blood pressure. This is in agreement with Shore and Gaskell's results.[4] The least struggle, however, even if only of the nature of increased respiration, temporarily sends up the blood pressure more or

---

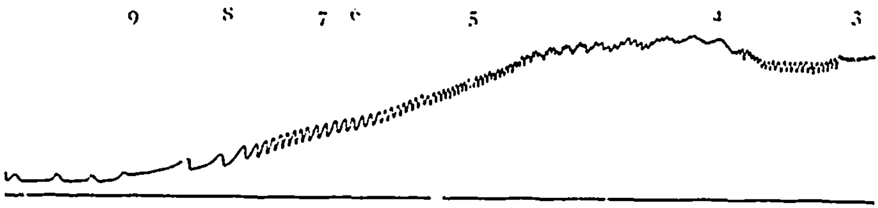
1 Philadelphia Medical Journal, 1900, Vol. II., p. 1,113.

2 Asclepiad, 1890.

3 "Death from Chloroform," by the author, Canadian Practitioner and Review, Feb., 1898.

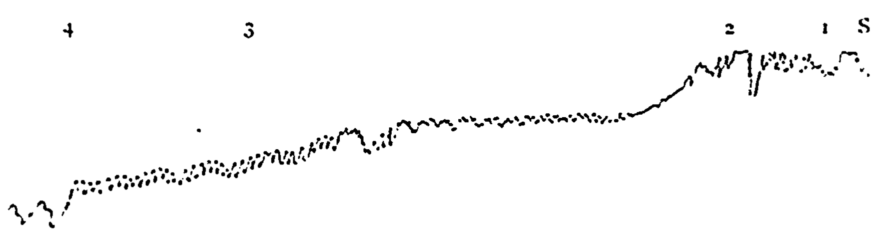
4 British Medical Journal, 1891, Vol. II., p. 1089.

less, and as surely lowers it immediately afterwards. This after lowering may be partly of the nature of compensation, but it is most probably due, in part at least, to the struggling causing a greater inhalation of the drug, and hence poisoning by it.



TRACING XIX.—6/31.—Chloroform poisoning. Animal Horizontal. 3 Chloroform pushed. 4 Struggling. 5 Pressure falling and pulse slowing. 6 Chloroform removed. 7 Respiration ceased. 8 Pulse very slow. 9 Artificial respirations.

Tracing 19 shows a very typical tracing of chloroform *poisoning*. The animal was horizontal when the chloroform was pushed at 3. He had not had any morphia. A slight temporary fall, with slowing of the pulse occurred, which is very frequently the case, followed by struggling at 4, with a consequent rise and hastening of the pulse. Then about forty seconds after the commencement of the chloroform, a rapid fall with slowing of the pulse, set in. The chloroform was removed at 6, but several seconds later, the respiration ceased, and the pressure fell more, with great slowing of the pulse. Artificial respiration was commenced twenty seconds after the respiration failed, and the animal recovered. Even though the chloroform towel be removed as soon as ever the struggling sets in, the temporary rise followed by a fall occurs, sufficient chloroform vapour being present in the air passages to produce this train of events. Conclusion 19 of the Anæsthetic Committee of the British Medical Association is that "struggling must be regarded as a source of very grave danger under chloroform," and Lieut.-Col. Lawrie's rule, as given in his recent book on chloroform (p. 111) is "never to give *chloroform while there is struggling or irregular breathing.*" With this clinical rule my experiments on dogs entirely agree.



TRACING XX.—3/11.—Chloroform poisoning. S Struggling. 1 Chloroform pushed. 2 Pressure began to fall quickly. 3 Chloroform removed as pulse slowing. 4 Respiration stopped.

In Tracing 20 another illustration of the same thing occurs. At S, the animal, which was not at all under the influence of an anæsthetic, began to struggle violently, and the result was a rise in pressure, with quickening of the pulse. At 1 chloroform was started and pushed. The pressure began to fall quickly at 2 with great hastening of the pulse. At 3 chloroform was stopped, as the slowing of the pulse heralded threatened respiratory failure, but at 4 the respiration did cease, with the usual great slowing of pulse and fall of blood pressure. The animal eventually recovered under artificial respiration. This extreme and sudden fall of the blood pressure occurring synchronously with the stoppage of the respiration was noted by the first Hyderabad Commission, who stated the case as follows. "Although a gradual loss of tension in the arteries took place after the first stage, the decrease of tension was more abrupt when the respiration became affected. The stoppage of the respiration was always succeeded by a sudden increase in the relaxation of the coats of the femoral artery and a fall in tension." It is difficult, however, to understand how they could have concluded that, "It was further observed that struggling demanded that the chloroform be pushed and not withheld." No advice could well have been more dangerous than this, and fortunately the second Hyderabad Commission put it right. The chart just given shows that struggling raises the pressure, and that if chloroform be commenced *during* the struggling, then the pressure falls almost at once, in fact, it seems from what we have observed that the preliminary rise in blood pressure in chloroform anæsthesia is not due to any vaso-motor stimulation, but rather to the almost constant slight struggling—it may be only increased breathing—which occurs then. Dr. J. A. McWilliam[1] found that "with moderate respiration the results of a certain dose of chloroform were very slight, whereas the same dose during exaggerated respiration caused great depression and extensive fall of blood pressure."

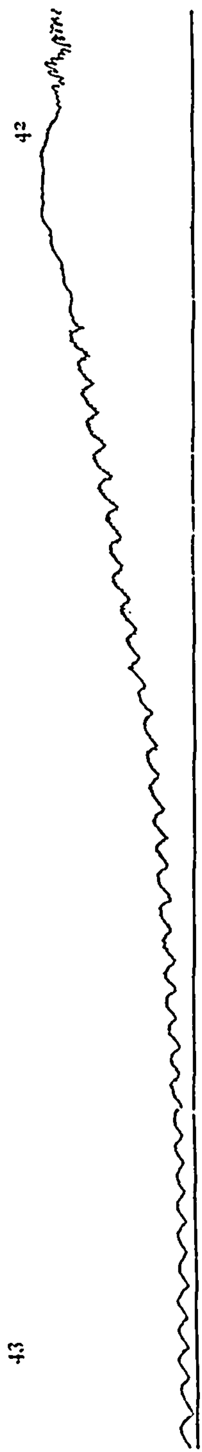
While all admit that a considerable dose of chloroform produces a great fall in blood pressure, it is not settled how it does so. Many believe that it is due to the paralysing action of the drug on the vaso-motor centre,[2] while on the other hand, Shore and Gaskell's cross circulation experiments seem to prove that it is due to the direct action of chloroform on the heart. These cross circulation experiments, however, involve a very difficult technique, and when repeated by others have not always given the same results.[3]

---

1 British Medical Journal, Oct. 1890.

2 Journal of Physiology, Vol. XXI., Nos. 4 and 5, 1897.

3 "Cross Circulation Experiments," Lieut.-Col. Lawrie, Lancet, 1898, Vol. II, p. 24.



TRACING XXI.—14/39.—Dog horizontal. 42 Right carotid divided and with it the vagus. 43 Respiration still very ample although pressure almost zero.

There can be no doubt but that chloroform can weaken and even paralyse the heart, and that chloroform can weaken and even paralyze the vaso-motor centre, but the question at issue is, which of these two actions is it that occurs first. In my opinion it would be exceedingly unlikely if either one should occur alone, and the probabilities are that the fall in pressure is due to both factors occurring in different degrees in different animals. In one case the vaso-motor centre might prove the more susceptible to the poison, while in another the heart might first show its effects. In both cases a fall in pressure would occur.

The importance of the fall is very differently guaged by different observers. As already stated, all have noticed it. The Hyderabad Commission actually considered it a safeguard, arguing that where the pressure was low less chloroform would be carried to the centres, and therefore these were not so likely to be poisoned; and J. A. McWilliam argued in the same manner.[1] On the other hand Mr Leonard Hill thinks that this fall in pressure, due in his opinion to paralysis of the vaso-motor centre by chloroform, is actually the cause of death in such cases, and he believes that the respiratory failure which occurs so constantly in dogs poisoned by chloroform is due to the anæmia of the respiratory centre resulting from a fall in pressure. Without venturing to express an opinion on so important a point one may say that a mere fall of blood pressure with assumed anæmia of the respiratory centre does not soon cause stoppage of the respiration but rather stimulates it, as shown in Tracing 21, where the animal was bled to death and the respiration continued even after the blood had ceased to flow from the severed vessel. H. C. Woods and W. S. Carter[2] have shown that even great

1 British Medical Journal, 1890, Vol. II. p.834.
2 Journal of Experimental Medicine, Vol. II, p. 130.

anæmia of the brain produced by tying both carotids and both vertebral arteries produces little if any change as a rule in the respiration. From this fact they were led to the conclusion that, "The respiratory centres are remarkably insensitive to a lowering of their blood supply." Further, I have frequently observed that the respiration stopped while the pressure was still comparatively high, and only after the cessation of the breathing did the pressure somewhat suddenly fall to zero. Tracing 20 illustrates this point. One might say in fact that the pressure only falls very low after the respiration fails and that probably the stoppage of the respiration due to poisoning of the respiratory centre is the cause of this sudden extra fall in the already slowly falling pressure. It seems that as the factors which maintain the blood pressure become weakened by chloroform the respiratory pump becomes more necessary to the upkeep of this pressure than it usually is, and hence when it stops the pressure drops at once. Possibly, however, an anæmic respiratory centre is more susceptible to the toxic effects of chloroform than one not so anæmic, and this special susceptibility Mr. Hill believes he has noticed along with others.[1]

When the blood pressure falls greatly from chloroform and remains low, life must be endangered, but in my experience animals do not die more easily from chloroform administered in the vertical than in the horizontal position, and it is decidedly harder to kill a dog with chloroform when the pressure is very low from hemorrhage than when this is not the case. The second Hyderabad Commission noted this point thus, "In Experiment III, the splanchnics were divided, a proceeding which, as is often said, bleeds the animal into its own vessels. The pressure was after this exceedingly low, but chloroform was given and various other actions taken, and then chloroform had to be pushed on a saturated sponge enclosed in a cap for eleven minutes before the respiration ceased."[2] Again J. A. McWilliams writes as follows,[3] "The fall of blood pressure is in a certain sense protective. It retards the continued access of the anæsthetic into the vital organs. I have frequently been struck with the good resisting power shown to the influence of both chloroform and ether in animals in which a very low pressure was present due to other causes than anæsthetics, *e.g.*, vaso-motor paralysis." He rightly adds that, "On the other hand the fall of blood pressure may become excessive and prove a source of great danger." If then it is harder to kill a dog by chloroform

1 "Causation of Chloroform Syncope," by L. Hill, British Medical Journal, April 17th, 1897.
2 Second Hyderabad Commission Report.
3 British Medical Journal, October, 1890.

when the pressure is low than when it is not so, why should it be that all anæsthetists are agreed upon the danger of giving anæsthetics when the patient is sitting up? The answer I believe lies in the fact that most deaths which occur in practice in the administration of chloroform are *not* cases of poisoning from the drug but *are due to syncope resulting either from the pain of an operation commenced too soon or from fear.* A close perusal of the Clinical Report of the Lancet leads one to the same conclusion. Very many of the deaths which have occurred during the administration of chloroform were not cases of poisoning at all, as the dose was too small. The following cases summarised from this report are probably examples of these.

Series A, Case 3.—Fistula in ano, dose ½ dram on towel, anæsthesia incomplete, felt pain; in one minute pulse failed.

Case 28.—Extraction of tooth, sitting posture, 25 drops on sponge, only 4 or 5 respirations, operation not begun, on being asked a question answered in thick and trembling voice and stretched out her arms, face became bluish, eyes haggard, head and arms fell, she was dead.

Case 73.—For delirium tremens following a fracture, ½ dram on lint, after 2 or 3 inspirations the man writhed and fell back dead, not under influence.

Series B, Case 56.—For removal of finger, 30 drops on lint, syncope.

Case 105.—Castration, 15 to 20 drops on lint, pulse ceased.

Case 285.—Reduction of dislocation, ½ dram, pupils dilated and heart's action failed.

Case 426.—Dressing sprain of ankle, a few drops, syncope.

Sir J. Y. Simpson well remarked in this connection[1] that, " All the patients that die under the hand of the operator when chloroform is used do not necessarily die from the effects of the chloroform upon the constitution. In several of the recorded cases the dose given was too small to have had any such fatal effect. Before the time that anæsthetics came to be used deaths on the operating table often occurred. Such cases have been recorded by Brodie, Cooper, Home, Travers, etc., etc., but they excited no marked share of professional

1 Works of Sir J. Y. Simpson, p. 148.

attention, as they were generally supposed to be accidents against which no action could be of any use. Of late years and since chloroform has been employed they have usually been directly and at once ascribed to the deleterious action of chloroform." He then gives details of a number of cases of fatal syncope immediately before or during operations in which chloroform had not been used. Here is one example, "A few days after the discovery of chloroform, a case of hernia which had been strangulated for a few hours was brought into the Infirmary, and Professor Miller thought it a case demanding operative interference and one in which chloroform should be tried; but I could not be found in time to give it, and the patient was operated on without an anæsthetic. Professor Miller had only proceeded the length of dividing the skin when the patient fainted and died with the operation unfinished. If the chloroform had happened to be used and this fatal syncope had occurred while the patient was under its action the whole career of the new anæsthetic would have been at once arrested. Such cases teach us at least that caution is required in our reasoning and inferences, seeing death may occur and has occurred in operations without chloroform, and with phenomena quite similar to those ascribed to the action of chloroform." The distinction between deaths from chloroform and deaths simply occurring during the administration of chloroform is even more important to-day than it was in Simpson's time. Nowadays so many patients have a dread of chloroform that one would expect cases of syncope to occur occasionally when patients are going under the anæsthetic and are still conscious and afraid. R. Ballard[1] discusses this point well and argues that children and dogs are less apt to be afraid, and hence are less likely to suffer from syncope; and the British Medical Journal in an annotation suggests[2] that the reason why parturient women are less apt to suffer from chloroform is that they do not dread it. Snow[3] mentioned several cases in which, although chloroform was administered, death was attributed by him to fright. In all only a small quantity of chloroform had been given and that freely diluted, and in every case great fear and apprehension were noted before the administration. The fact that many deaths which occur during the use of chloroform are not due to the use of the anæsthetic, is further brought out by the recent Report of the Anæsthetic Committee of the British Medical Association. Out of eighteen cases of death "under chloroform" they found that only three were due entirely to the drug, four were chiefly due to it, and the remaining

1 Lancet, 1898, Vol. I. p. 1,253.

2 British Medical Journal, 1900, Vol., p. 35.

3 Treatise on Anæsthetics, 1858.

eleven—more than 50 per cent—were doubtful. Their 17th Conclusion is that, "Imperfect anæsthesia is the cause of a large number of cases of danger under chloroform."

We have seen that workers differ greatly as to the danger of great falls in blood pressure due to chloroform administration. It seems clear, however, that such falls are at any rate indications that the patient is very deeply under, and if only one could clinically recognize such a fall with ease it would be a valuable danger signal. Duplay and Hallion[1] hope before long to describe a method of ascertaining the blood pressure during surgical operations under anæsthetics; and if they or any one else should succeed, a valuable result will have been attained.

Occasionally during the administration of chloroform, *sudden* falls of blood pressure may occur, along with marked slowing of the pulse, evidently of the nature of vagus inhibition of the heart. Such falls were noted by the Glasgow Commission, and were considered to be a cause of sudden death under chloroform.[2] The members of this Commission, in discussing the points of agreement between them and the Hyderabad Commission, say that "Both observed peculiarly sudden and unexpected falls of pressure and slowing of the heart. The Commissions differed as to the origin of these. The Hyderabad Commission attribute it to asphyxia; the Glasgow Commission say not asphyxia, whatever may be the cause."[3] These falls closely resemble those which we gave early in this work as occurring occasionally in dogs apparently without cause; no chloroform being administered at the time. When they occur during the administration of chloroform the Hyderabad Commission, as stated, consider them to be asphyxial and of no danger, in fact, the opposite, as tending to prevent the further absorption of the poison. Lieut.-Col. Lawrie[4] dogmatically states that, "The special effects which the Glasgow Commission attributed to chloroform were produced by accidental asphyxia . . . the slowing of the pulse and circulation through stimulation of the vagus is a safeguard in chloroform poisoning."

Tracing 22 shows such a fall. Chloroform was started at 7, the dog being already slightly under. He struggled a little. The sudden fall occurred ten seconds later. The chloroform was not removed, and yet

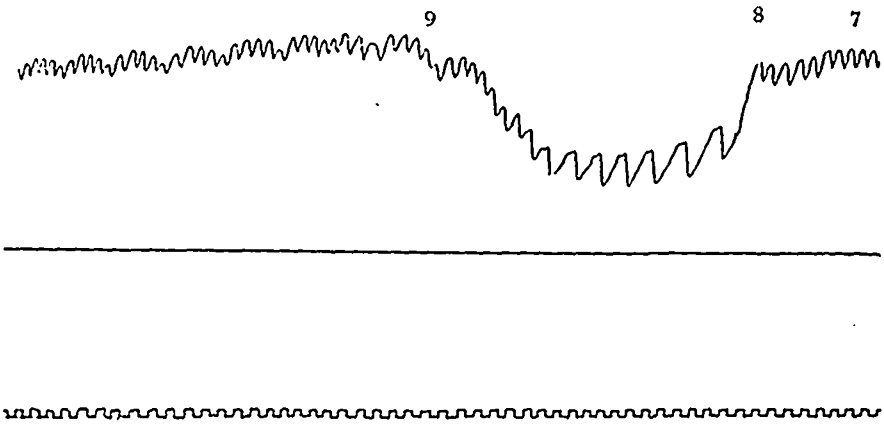
1 Archives Generales de Medicine, Aug. 1900.

2 Journal of Anatomy and Physiology, Vol. XIII., p. 395.

3 "Remarks on the 2nd Hyderabad Commission," by Drs. McKendrick, Coats and Newman, British Medical Journal, June 14th, 1900.

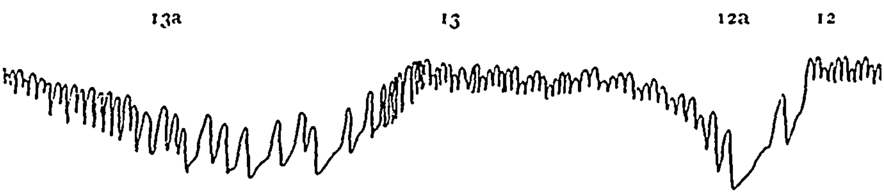
4 Lancet, June 21st, 1900.

twenty seconds later the fall had been partly recovered from and the pulse had resumed its former rate. A strong resemblance will be seen between this tracing and one produced by either stimulation of the



TRACING XXII.—9/23.—No Morphia. 7 Chloroform pushed, dog being horizontal. 8 Sudden fall in pressure with slowing of pulse. Chloroform continued and yet pressure normal again at 9.

distal or the proximal end of the vagus, as shown in Tracing 23, and it seems that all are agreed that such falls are of the nature of vagus inhibition. Whether the vagus centres are directly stimulated by the chloroform, or are more or less reflexly affected through afferent nerves, or whether the stimulation is of the nature of asphyxia, it is hard to say. From the fact that the fall disappears even if the chloroform be continued, I would be inclined to agree with the Hyderabad Commission



TRACING XXIII.—3/11 Dog horizontal. Left vagus previously divided. 12 Distal end of cut vagus stimulated by Faradic current. 13 Proximal end stimulated.

that such is not a source of danger; and as regards the nature of the vagus inhibition, from the same fact, I would consider that it is caused by strong vapour irritating the sensory branches of the vagus, and as the sensory nerves become numbed the reflex disappears. It is not a constant phenomenon, however, even when very concentrated vapour is used. Another case from similar stimulation might show reflex laryngeal spasm. The fact that these occasional, probably safe, falls in pressure do occur in dogs is not sufficient ground in my opinion for changing the view that usually a markedly slow pulse is an urgent indication for the immediate removal of the anæsthetic.

As a rule, unless an animal has just been struggling violently, the pulse becomes considerably slowed when he is going under chloroform and becomes fast when he is coming out. The exception mentioned is struggling, and this, as has been already shown, may so hasten the pulse that it only slows when, or just before, the respiration stops. The cause of this slowing is doubtful, some attributing it to stimulation of the vagus by the chloroform vapour, some to the direct poisoning of the heart muscle, and others again to asphyxia. Whatever the cause of this gradual slowing may be, it is a valuable sign clinically. The fall of pressure is evidently not due alone to it, as shown by the fact that such falls occur when the vagi are divided, when atropine is given (vide tracing 47), or while the pulse is still fast after struggling (vide tracing 20). Nevertheless the fall in pressure and the slowing of the pulse as a rule go hand in hand in deep chloroform narcosis.

As regards the effect of posture during chloroform narcosis, generally speaking the animal is rendered less resistant to the effects of gravity than is one not so poisoned, and hence the vertical feet-down position produces a greater fall than it would otherwise do. If the animal be first placed feet-down and then chloroform be pushed, as might be inferred, the pressure falls more freely than when the drug is given in the horizontal position. This is in accordance with Mr. Leonard Hill's observations, when he considers chloroform to be the most powerful agent known for abolishing the mechanisms which compensate for the influence of gravity.[1]

The effects of various operations on the blood pressure while the animal was under chloroform were tried, and as a rule they were chiefly negative.

TRACING XXIV.—3/8.—Dog under Chloroform and horizontal. 10 Abdomen opened freely. 11 Splenic artery tied.

Tracing 24 is taken from a dog completely anæsthetized with chloroform and lying horizontal. At 10 the abdomen was freely opened

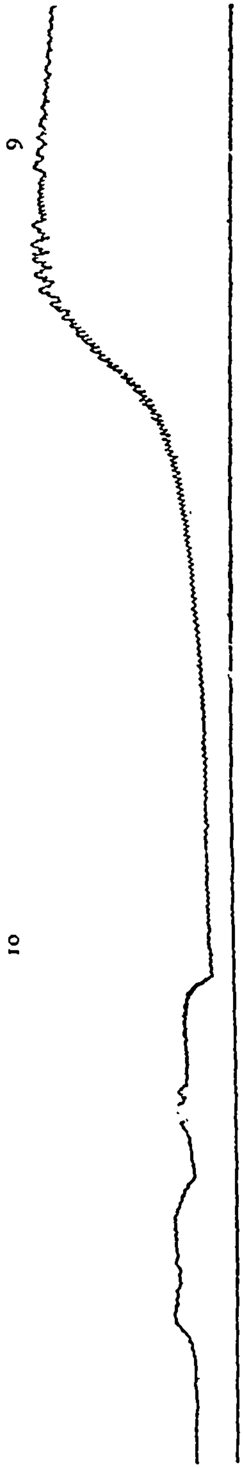
1 Journal of Physiology, Vol. XXI, Nos. 4 and 5, 1897.

and the splenic artery was tied at 11, and yet no fall in pressure occurred. A slight rise in fact occurred at 11, which might have been due to the tying of the artery. Thus no sign of shock appeared, and this is in accordance with the results obtained by the Hyderabad Commission, who were unable to produce shock in dogs under chloroform by any operation they tried.

COMPLICATIONS ARISING DURING THE ADMINISTRATION OF CHLOROFORM.

Various complications may occur at any time during the administration of chloroform, which produce more or less effect on the blood pressure and are as well often dangerous. Vomiting never seems to take place in dogs under chloroform, as already noted. The effects of struggling have been already discussed.

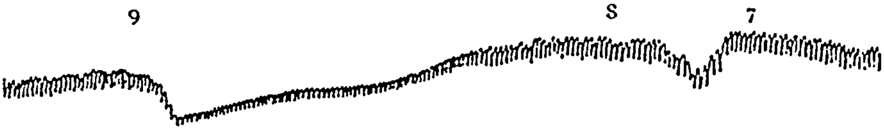
The inhalation of fluid when occurring during anæsthesia is sometimes a source of great danger. Tracing 25 is taken from a dog under chloroform. When this tracing begins he is already in the feet-down position. At 9 two hundred ccs. of an aqueous solution (of chloretone) were poured down his throat. He swallowed distinctly several times, but did not seem to breathe again. The pressure after a slight transitory rise fell rapidly, but the pulse remained fast. At 10 he was placed horizontal, and some rise of pressure occurred. Artificial respiration was tried, but did not seem to work well—no sign of life appeared and he was evidently dead. On opening the thorax the right side of the heart was found to be enormously distended with blood, as were also the veins entering it. The left side was nearly empty. The lungs contained



TRACING XXV.—7/18.—Dog under Chloroform and vertical. 9 200 c.c. of fluid poured into fauces. 10 Horizontal.

frothy blood, and evidently the animal had died of drowning. This chart shows that in acute asphyxia, as stated by the Hyderabad Commission, the pressure may fall rapidly. The pulse, however, did not slow as the Commission found it to do, and the chart bears no resemblance to one in which death occurs from chloroform poisoning (unless indeed the animal be already under atropine.)

1.. Tracing 26 a dog under chloroform had already had some solution (of chloretone) poured into the stomach by means of a tube. While still vertical the remains of the solution, about 1 oz., were poured into the fauces, the tube having been removed. At once at 7 the



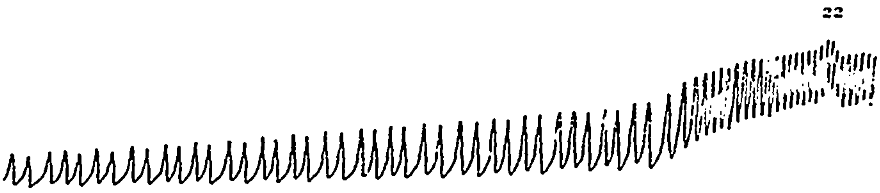
TRACING XXVI.—38.—*Dog under Chloroform and vertical. 7 An ounce of fluid poured into fauces—*gasped. 8 Some of solution inhaled. 9 Horizontal. Animal recovered.

pressure fell, then rose for a few seconds, and then began to fall steadily with slight hastening of the pulse. The animal was placed horizontal and began to breathe again, and finally recovered. This chart shows the danger of even small quantities of fluid accumulating in the fauces while the laryngeal reflex is done away with by an anæsthetic. Even tracheotomy might not save the patient, as the fluid is quickly drawn into the lungs themselves, as shown *by the post mortem examination of* the dog from which Tracing 25 was taken.

These charts agree then with Lieut.-Col. Lawrie's *contention* that in asphyxia the pressure falls. The fall is only marked in *obstructive* asphyxia, however. When asphyxia is brought about by free opening of the pleural cavities producing pneumo-thorax, so that although the animal is breathing hard no new air enters the collapsed lungs, then after many violent acts of inspiration the respiration ceases and then only the pressure falls and the pulse becomes markedly slowed. Kenow and Shenbeck[1] showed that in animals whose respiration was paralyzed by Curara asphyxia produced a rise in pressure, then a gradual fall, then a strong increase and finally a fall to death.

1 "On Blood Pressure in Asphyxia," Skandin Arch. f. Physiologie, I, 603-641, Tap. 5, 6.

Tracing 27. In this animal double pneumo-thorax had been produced in the manner described with very free openings through the parietes. The whole tracing is too long to reproduce here, but the



TRACING XXVII.—3/11.—Double pneumothorax previously produced with very free openings through parietes. Pressure well maintained until respiration stopped at 22. Pressure then fell with slow pulse—asphyxia.

pressure was well maintained until respiration stopped at 22. Then it fell and the pulse became very slow and ceased a couple of minutes later.

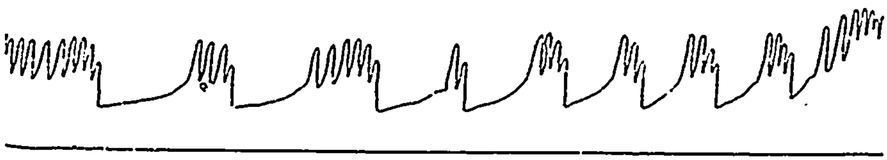
A momentary rise will be noticed at 22 just after the respiration ceased.

In Tracing 28, on the other hand in which both pleuræ had been freely opened, a marked respiratory wave appeared with some rise in pressure when the trachea was clamped at 22. At 23 the attempts at

TRACING XXVIII.—3/11.—Double pneumothorax previously produced. 22 Trachea clamped. 23 Efforts at breathing ceased and then arterial pressure fell.

respiration stopped, and then the pressure fell slowly with marked slowing of the pulse. About three minutes later the pulse became fast and the pressure rose a few mms., giving a good example of delirium cordis.

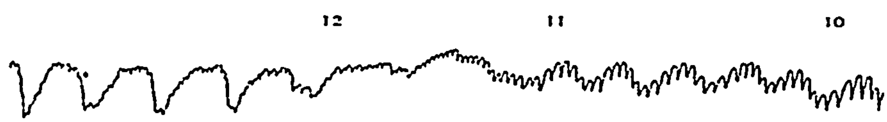
Thus it may be seen that very different tracings are got in different conditions of asphyxia, and that no one description will suffice for every form. This probably is the reason why Lieut.-Col. Lawrie and his critics got so far apart in their statements, some asserting that the pressure fell in asphyxia, and others that it rose, *e.g.*, Dr. J. H. Potter wrote:[1] "We have in asphyxia increased blood pressure with lividity; in fatal chloroform narcosis we have just the opposite, viz., diminished blood pressure with pallor." They were both right probably, for, as shown, the question of whether the pressure rises or falls in asphyxia entirely depends on how the asphyxia is produced. It seems that as long as efforts at respiration are made as in 28 the pressure is maintained but as soon as such efforts cease then the pressure falls. In chloroform poisoning the respiratory centre is paralyzed and there are no efforts at respiration and therefore the pressure may at once fall.



TRACING XXIX.—9/31.—Animal inhaling strong Chloroform vapour. Inspiratory stridor.

Inspiratory Stridor.—Tracing 29 shows the effect upon the blood pressure of inspiratory stridor produced by the inhalation of strong chloroform vapour. A fall occurred during each inspiration.

In Tracing 30 the left vagus had been already cut. At 10 the right vagus was being handled, which produced some fall of pressure At 11 this nerve was divided and immediately the pulse increased in rate, the pressure rose and the respiratory curve became more marked. Each dip in the tracing was accompanied by an inspiratory stridor,



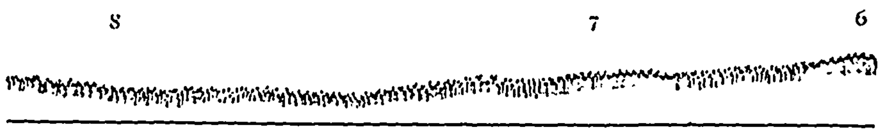
TRACING XXX.—9/31.—Left vagus already divided. 11 Right vagus cut. 12 Inspiratory stridor set in evidently of a paralytic nature.

evidently caused by the flapping together of the vocal cords, the muscles of which had been paralyzed by division of the vagi. This result, however, is not a constant one on division of the vagi. Thus, either spasm of the laryngeal muscles as shown in Tracing 29, or paralysis, as shown in Tracing 41, may produce inspiratory stridor, and this stridor is shown to have a marked effect on the pressure. The stridor due to spasm disappears as the animal becomes more deeply anæsthetized; that due to paralysis does not so go away.

---

1 The Lancet, Vol. I, 1890.

A Rigid Condition of the Body may occur while the animal is deeply under chloroform and may disappear as he comes out. Tracing 31 is taken from a case of this kind. The animal was completely anæsthetized and still taking chloroform at 6, but the jaws were rigidly closed. At 7 he was still very rigid and the jaws could not be forced apart. Chloroform was stopped at 8, and soon the spasm lessened and the jaws relaxed, and without giving any more chloroform a stomach



TRACING XXXI.—1/4.—Animal completely under Chloroform. 7 Rigid condition of body. 8 Chloroform stopped and rigidity soon ceased.

tube was passed with ease. I have seen this rigidity occur clinically occasionally under ether to a marked degree, and to a less extent under chloroform. G. O. C. Mackness[1] mentions a case where "suddenly clonic spasms of the face and limbs came on" under chloroform where the patient recovered; while E. W. Dickson[2] gives an instance where such ended fatally. Fourteen cases are mentioned by the Anæsthetic Committee of the British Medical Association in which fits or epileptic convulsions were noticed.[3]

METHODS OF RESUSCITATION IN CHLOROFORM POISONING.

Of all methods tried artificial respiration was found to be by far the most certain method of restoring animals in which the respiration had stopped as a result of chloroform poisoning. In the majority of cases it was successful, though occasionally, even when started as soon as the natural respiration had ceased, it failed to save life. In these latter cases probably the heart and vaso-motor centre were paralyzed almost synchronously with the respiration. The method followed was rhythmical compression of the chest, and the effect on the blood pressure consists in a rise during each expiration. In using the method the air passages must be kept free by keeping the tongue firmly pulled out and if necessary introducing the tip of the index finger into the rima glottidis, by which means the vocal cords are kept apart. The Lancet Clinical Report mentions a case "where mechanical stimulation of the larynx by pressing the finger down to the rima glottidis was said to

1 British Medical Journal, Dec. 7th, 1895.

2 British Medical Journal, Oct. 19th, 1895.

3 Report of the Anæsthetic Committee, British Medical Journal, Feb. 23rd, 1891.

have been successful in restoring life," and apart from this probable reflex action, the pressure of the finger assures the operator that the cords are swung apart.

One soon learns to tell whether artificial respiration will be successful or not in a given case by the "feeling" of the chest. If this feel elastic, and it be easy to make the air pass in and out, all is well; but if this be not the case, even although the air passages be free, it is bad. Why this should be I am not quite certain, but certainly artificial respiration on a dead dog will not produce the amount of respiratory tide in such that it will do in a living animal. It must be remembered that when one compresses the chest the air is not thus *directly* pressed out, but the compression lessens the cubic capacity of the thorax and then the elasticity of the lungs drives the air out. If this elasticity be lessened then compression of the chest will not so readily cause the air to pass out. This is observed in cases of Emphysema. where the elasticity of the lungs is more or less lost[1] and expiration in consequence becomes difficult.

As the animal recovers under the influence of artificial respiration it becomes progressively easier to make a good flow of air in and out of the chest, until at last this occurs spontaneously, and when once this stage has been reached I have not seen the respiration fail again. The Hyderabad Commission report such cases, however.

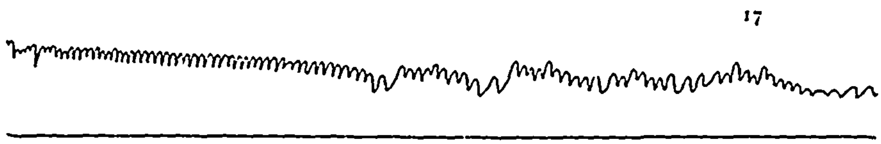
TRACING XXXII.—9/40—Dog poisoned with Chloroform. 4 Respiration ceased but heart could be heard on auscultation. 5 Artificial respiration. 6 Pulse appeared and pressure rose. 7 artificial respiration stopped at 6 and pulse here failed and pressure fell again. 8 Artificial respiration again. 9 Pulse started again and soon after natural respiration commenced and animal recovered.

Tracing 32 illustrates the beneficial effect of artificial respiration on the pulse and blood pressure. At 4 the animal was very deeply poisoned with chloroform, the pressure was almost zero, and the respiration had stopped, and the pulse was absent from the chart though the heart could be heard to be beating. The chloroform had been removed. At 5 artificial respiration was started, and the waves produced by it are visible on the tracing. At 6 the pressure suddenly rose, and with it the pulse appeared. At 7 artificial respiration was stopped, and at once the pressure fell again and the pulse disappeared. At 8 artificial respiration was resumed, and at 9 the pressure rose again and the pulse reappeared.

1 Diseases of the Lungs. Sir Douglas Powell.

Artificial respiration was stopped and the pressure fell slightly, but natural respiration soon set in, and after that the animal gradually recovered, the pulse as usual becoming very fast during recovery. This tracing shows then the good effect of artificial respiration on the heart. The method might almost as properly be called "artificial circulation" as "artificial respiration;" which name would constantly remind one that he was directly acting on the heart while performing the movements of the method.

The effect of Tracheotomy on the blood pressure is interesting. Besides being useful in cases where some obstruction in the air passages exists above the level of the wound thus made, the operation appears to



TRACING XXXIII.—9/31.—Dog poisoned by Chloroform. Respiration stops. Artificial respiration tried without avail. 17 Trachea opened and respiration commenced at once and remained.

stimulate the respiration reflexly. In Tracing 33 the respiration had ceased as a result of chloroform poisoning, while the pulse continued. Artificial respiration had been performed, but no attempt at natural respiration appeared. The tongue had been drawn out forcibly and repeatedly (Laborde's method), and the air passages were clear. Tracheotomy was performed at 17, and at once the animal commenced to breathe and soon recovered.

Tracing 34 shows the same phenomena even better. Natural respiration had stopped here for several minutes. The puncturing of the trachea at 27 at once was succeeded by a gasp and rise in blood

TRACING XXXIV.—9/28.—Dog poisoned with Chloroform. Natural respiration stops for ten minutes; Artificial respiration being continued. 27 Trachea opened and artificial respiration continued as before. 28 Natural respiration occurred and animal recovered.

pressure as shown in the tracing, and the animal recovered. The air passages were clear. The effect on the respiration here is evidently of the nature of reflex stimulation. The same thing is seen often when the surgeon is performing tracheotomy for any condition. As the trachea is punctured a violent gasp occurs. In desperate cases of chloroform poisoning it might be justifiable to thus operate in the hope of producing this reflex effect.

Forcible Pulling Forward of the Tongue seems, as has long been noted clinically, to stimulate respiration, and in several of the dogs it seemed to be the last straw starting respiration. Professor Syme in a clinical lecture delivered in 1884[1] said, "Attention to the tongue is another point we found of great consequence. When respiration becomes difficult or ceases we open the mouth, seize the tip of the tongue and pull it well forward, and there can be little doubt that death would have occurred in some cases if it had not been for the use of this expedient." It has been recently demonstrated that pulling on the tongue does not open the glottis, and it would seem more probable that it reflexly stimulates the respiration. The chloroformist who has been trained in Edinburgh always has a pair of fenestrated artery-forceps handy for this purpose.

The preceding notes and tracings emphasize the following points as regards the effects of chloroform.

First, that any struggling during its administration greatly hastens the toxic effects, and that hence the drug should be removed while such lasts, and then should be given more gradually when the patient is quiet again. One frequently sees clinically the chloroform pushed at such a juncture, especially if the struggling has been started by the surgeon commencing the operation; but struggling without any such cause generally indicates that the vapour is too concentrated, and struggling due to this is doubly dangerous.

Second, a fall in blood pressure is hard to detect accurately clinically, but it is usually accompanied by slowing of the pulse, and such is a danger signal, and the chloroform should be at once removed. This slowing may occasionally be of a transient nature and due to stimulation of the vagi by concentrated vapour: or it may be the more serious slowing in the wake of which lies respiratory failure.

Third, if respiratory failure should occur—and it is much more likely to do so during the preliminary administration than later on—then artificial respiration is by far the most valuable method of restoring it. Artificial respiration not only keeps up the respiratory tide but also, as shown in Tracing 45, directly stimulates the circulation and raises the blood pressure, in fact the circulation may be feebly carried on for a

1 Lancet, June 21st, 1885.

short time by respiration alone. Thus, whether one believe that chloroform kills by respiratory paralysis or by heart failure, or by vaso-motor paralysis, artificial respiration should be resorted to at once, and should rank; in my opinion, above all other remedies which may afterwards or along with it be attempted.

Fourth, forcible pulling out of the tongue, the placing of the finger in the rima glottidis, and the performance of tracheotomy all seem to stimulate respiration.

Fifth, the horizontal position is advisable when chloroform is being administered, not because respiratory failure is less likely to occur in that position, but because the risk of syncope is thus greatly lessened. Syncope is in my opinion the cause of death in most cases reported, and in many at least is not due to chloroform poisoning at all, but to the shock of pain or emotion before the patient is fully under or when he is coming out.

The actions of three drugs were investigated in regard to choroform poisoning. These were, Nitrite of Amyl, Hydrocyanic Acid, and Atropine.

Nitrite of Amyl.—This drug was given in several cases where the respiration had ceased as a result of chloroform poisoning, but no beneficial results were obtained. In each case one or more capsules containing the drug were crushed in the fauces while artificial respiration was being maintained.

Hydrocyanic Acid.—On the first of January, 1898, an article appeared in the *Lancet* by Professor Hobday, of the Royal Veterinary College of London. In it he suggested the use of hydrocyanic acid as an antidote in cases of chloroform poisoning. The dose recommended was 1 minim of Scheele's acid by the mouth for every seven or eight pounds of body weight. He stated that he had found it invariably useful in animals in which, as a sequence to chloroform poisoning, the respiration had stopped. He had already published[1] a list of forty-three observations on various animals, including dogs, cats, horses, sheep and calves, showing the results obtained by this method of resuscitation. In the last paper he refers to a series of fifteen additional consecutive cases in which H.C.N. had been successfully used in dogs after the respiration had actually ceased. Dr. A. Wilson, of Manchester, in the next number of the *Lancet*[2] opposed this view very strongly, arguing on theoretical grounds that as H.C.N. is the most powerful of all respira-

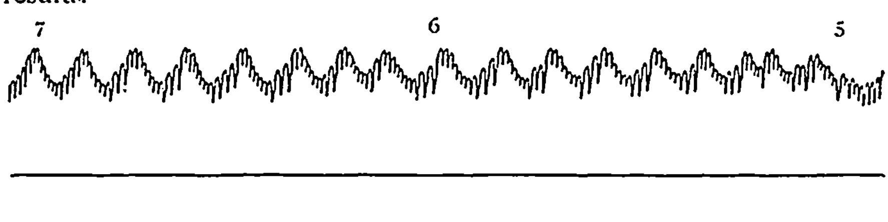
1 Journal of Comparative Pathology and Therapeutics, June 1896.
2 Lancet, Jan 8th, 1898.

tory, poisons, hence it could not be useful when the respiration was already paralyzed by chloroform. He concluded by saying that "It would be useful if Professor Hobday could give an account of the effects of the dose he recommends on a healthy animal." The argument that because H.C.N. is the most powerful of all respiratory poisons in fatal doses, therefore it could not do good in any dose, was so obviously open to criticism that I determined to take advantage of Dr. Wilson's suggestion to Professor Hobday and to try the effect of the drug in non-lethal doses on a healthy animal.

Ex. I.—A healthy mongrel collie dog, weighing thirty-three pounds, was given hypodermically in the back 9 3-7 minims of Acid Hydrocyan. Dil. (equal to 4 5-7 minims of Scheele's Acid, *i.e.*, 1 minim of Scheele's Acid to every seven pounds of body weight) at 2.48 p.m. The room was at 58° F. Notes were made every thirty seconds of his condition. They may be summarized by saying that in two minutes the animal was breathing hard and rapidly, with mouth open as if after exertion. This continued for five minutes and then he vomited. The breathing gradually became normal again. He vomited once more at 3.1 p.m. and then all symptoms disappeared and he remained well.

The effect then of a dose of 1 minim of Scheele's acid to every seven pounds of body weight is, very briefly, first, great stimulation of the respiration; second, vomiting; third, recovery.

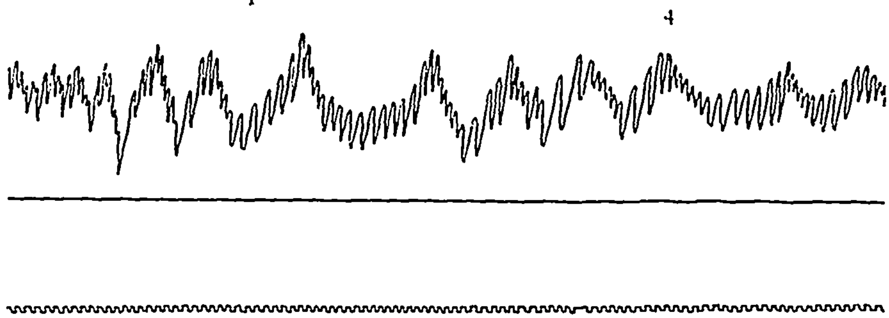
In order to note the effect of the drug on the blood pressure, pulse and respiration, several dogs were used. They were previously given some morphia hypodermically and afterwards just enough chloroform to keep them quiet so that there should be no struggling to mar the, results.



TRACING XXXV.—1/4.—Effect of small dose of H.C.N. Dog slightly under Morphia and Chloroform and horizontal. 5 Five minims dilute H.C.N. into fauces. 6 Respiration more ample. 7 Pulse raised from 87-106. Recovery.

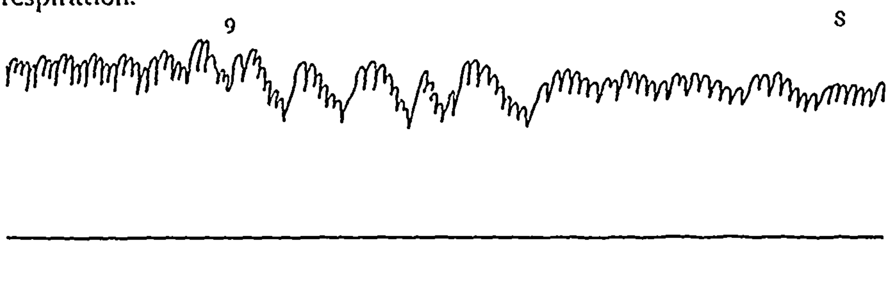
Tracing 35 illustrates the effect of a small dose of the drug. The animal had been given ½ grain of morphia hypodermically half an hour before the experiment began. He weighed about seventeen pounds. At 5 he was lying horizontal and breathing quietly, twelve to the minute, with a pulse of eighty-seven, and was slightly under chloroform.

5 minims of dilute H.C.N. (equal to 2½ minims of Scheele's acid) were injected into the fauces. The respiration almost at once became more ample—although this is not fully brought out in the tracing—but it was not hastened; and the pulse was raised from 87 to 106. No bad effects followed, and 7½ minutes later the animal was reported as quite normal again. Here then a dose of about 1 minim of Scheele's acid to seven pounds of body weight increased the amplitude of the respiration, slightly hastened the pulse, but did not otherwise alter the tracing, and no bad effects were produced.



TRACING XXXVI.—9/29.—Effects of small dose of H.C.N. Dose administered just before tracing begins. 4 Respiration very ample, pulse slightly irregular, pressure unaltered.

Tracing 36 is from a dog of about nine pounds weight which had been given ¼ grain of morphia half an hour before the experiment commenced. One minute before the tracing commences 3 minims of dilute H.C.N. were injected hypodermically. A few seconds later (at 4), the respiration was deep and sighing and somewhat irregular, the pulse was slightly faster, and the pressure remained unaltered. After that the respiration became hastened, but beyond the tracing the animal completely recovered. Thus a slightly larger dose than Professor Hobday recommended, about 1 minim of Scheele's acid to six pounds of body weight, produced no bad effects when given hypodermically. The chief alteration noticed was marked increase in the amplitude of the respiration.



TRACING XXXVII.—3/10.—Effects of H.C.N. Dose administered at S. 9 Breathing very ample, pressure rather higher.

TRACING XXXVIII.—13/35.—Repeated doses of H.C.N. 17 First dose, respiration excited and somewhat irregular, pulse hastened and pressure slightly raised.

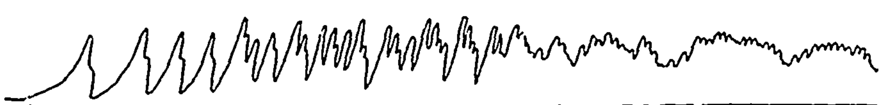
Tracing 37 is from a dog twenty-two pounds in weight which had previously been given ½ grain of morphia hypodermically. Some minutes before this tracing begins he had been given 6 minims of nitrite of amyl, but the effects of this had completely worn off. He was now given three minims of Scheele's acid by the mouth, *i.e.*, about the maximum dose recommended by Professor Hobday. In a few seconds, as shown by the tracing, the respiration became very ample and then hastened, the pulse somewhat increased in speed and the pressure was a little raised. No bad effects ensued.

Next we come to a series of experiments undertaken to find the effects of repeated doses of H.C.N.

Tracings 38, 39 and 40 are from the same dog and show well the effects of repeated doses of the drug. The dog was a fox terrier weighing about twelve pounds. At 17, 3 minims of Scheele's acid were placed on the back of the tongue. Almost immediately the pulse hastened, the respiration became greatly excited, irregular and more ample, and the blood pressure rose somewhat. A couple of minutes later, fifteen seconds before tracing 39 begins, the dose was repeated. The same effects occurred, but soon wore off, and at 18a the tracing looks as it did before the first dose of H.C.N. was administered. Two minutes later the dose was again repeated at 19 (in tracing 40). The respiration once more became excited, but soon grew infrequent, the pulse became much slower and the pressure fell, making the chart look like that from one form of asphyxia, and soon the animal died of respiratory failure. The thorax was quickly opened and the heart was seen to be still beating—and it continued to beat even after it was completely removed from the body; and, when the contractions had ceased, they could for several minutes be started again by simply putting the heart under a stream of cold water. But although the heart was beating when the chest was opened it was practically empty, and a wound made in the left ventricle did not bleed to any extent. In this case death resulted from 9 minims of Scheele's acid given to a twelve pound dog in three doses within four minutes. The result was death from respiratory failure, but before this occurred

TRACING XXXIX.—9/26.—Repeated doses of H.C.N. 18 Second dose given. Respiration excited. 18a Pulse slowing.

there was great and repeated stimulation of the respiratory centre. As with many other drugs, a small dose produces one effect and a larger dose the opposite—stimulation in the one case, paralysis in the other. It is the first stage, that of stimulation only, which is produced by the dose recommended by Professor Hobday. N. Grehaut[1] showed that repeated small doses of H.C.N. produced powerful stimulation of the respiration. After the injection of 5 c.c. of a 1/10,000

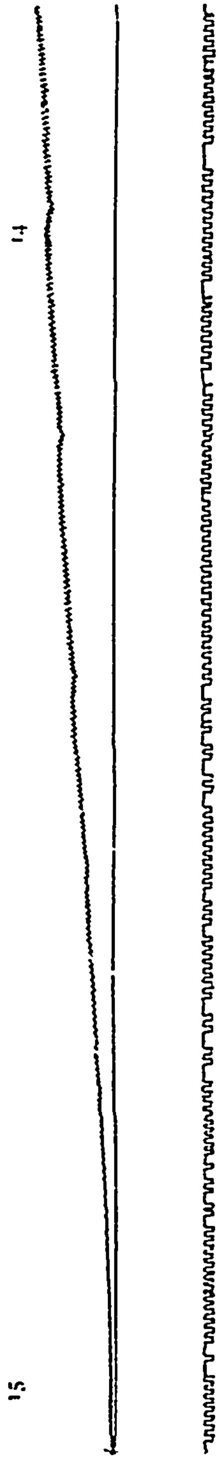


TRACING XL.—9/17.—Repeated dose of H.C.N. 19 Third dose. Respiration excited and then slowed and stopped about 20. Pulse slowed, pressure fell to zero.

solution of pure H.C.N. into the jugular vein of a dog weighing 10 kilo., the respiratory movements immediately became more ample and soon again returned to their ordinary rhythm. He found that 7/1,000 c.c. of pure H.C.N. killed a 9 kilo. dog in seventeen minutes.

Next, single doses just sufficient to produce death were given to several dogs in order to note the sequence of events. An animal weighing about sixteen pounds was given 10 minims of dilute H.C.N. (equal to 5 minims of Scheele's acid) hypodermically. He had already had 3 minims half an hour before. The pulse rate, blood

1 Physiolog. Researches on H.C.N. Archiv. de Physiol. 1890, p. 133.



TRACING XLI.—7/16.—Final stage of fatal H.C.N. poisoning. Last respiration occurred about 14. 15 Heart stops.

pressure and respiration were noted at frequent intervals as given below:

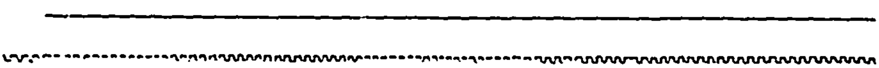
	Pulse.	*Respiration.*	*Blood Pressure.*
Just before administration..	105	24	125 mms.
Two minutes after administration..............	156	39	125 mms.
Two minutes later........	228	29	140 mms.
Two minutes later........	168	24	140 mms.
Two minutes later........	174	27	140 mms.
Four minutes later........	160	18	
Four minutes later........	111	12	
Four minutes later.. ..... (Tracing assuming an asphyxial type with great amplitude of pulse waves.)	44	10	
Four minutes later........	34	5	
Two minutes later........	88	7	Pressure now commencing to fall steadily.
Two minutes later...... .	118	2	

Tracing 41 shows the last stage of this case. The last respiration occurred at 14, the pressure fell steadily, and the pulse became fast at the last.

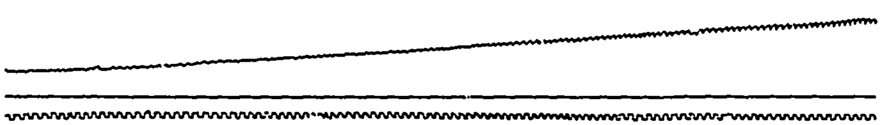
Another dog was treated in the same manner, and the next tracings show the effects at intervals. The animal weighed about ten pounds and was given 10 minims of dilute H.C.N. hypodermically, following on 4 minims a few minutes before. He had had no morphia. Just before the last dose was given the pulse was 82, the respiration 16, and the pressure good. (He had quite recovered from the first small dose.)

	Pulse.	*Respiration.*	*Blood Pressure.*
Two minutes after last administration	160	26	In statu quo.
Two minutes later..	50	7	In statu quo.
Three minutes later (tracing 42)	42	7	In statu quo.
Three minutes later.	100	Just stopped	Falling steadily.
Six minutes later...	Tracing 43 shows the termination of this experiment. The heart stopped after beating rapidly to the end.		

22a



TRACING XLII.—9'28.—Poisoning by H.C.N. seven minutes after fatal dose was given. P. 42 R. 7 pressure still maintained.



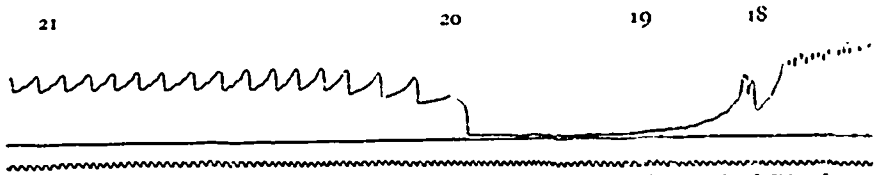
TRACING XLIII.—9'31.—Poisoned by H.C.N. Last stage. Respiration already stopped.

The sequence of events then from a small fatal dose is as follows: First, preliminary stimulation of the respiration and pulse, the former increasing in amplitude as well as in speed; second, slowing of the respiration and pulse, the pressure being maintained; third, stoppage of the respiration, pulse increasing in speed and pressure falling; fourth, pressure falling to zero, pulse remaining fast until death.

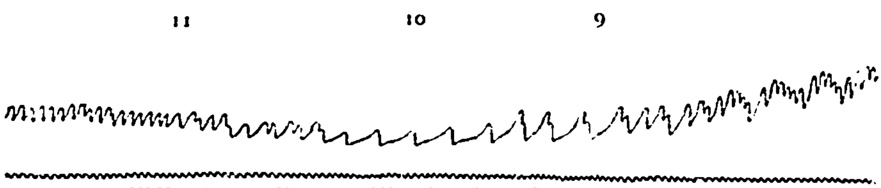
I poisoned four dogs thus which had previously had a hypodermic dose of morphia. In none of them did vomiting occur, nor convulsions. One dog which had had no morphia or chloroform showed a strong tendency to convulsions before death from a dose just sufficient to obtain a fatal result. He vomited frequently. When the dose of the drug is largely in excess of what is necessary to produce death, then the animal almost at once passes into a state of convulsion.

From these experiments it would seem that the dose of Scheele's acid recommended by Professor Hobday, viz., 1 minim of Scheele's acid to seven pounds of body weight, is a safe one in a dog. Such a dose, or a lesser one, produces the stage of stimulation of the pulse and respiration with no alteration in the blood pressure. The effect of the drug soon wears off, and the animal seems to be none the worse.

The next tracings show the effect of using H.C.N. when danger *has occurred* from chloroform poisoning. A thirty-pound dog while vertical was given chloroform until the respiration stopped. In Tracing 44 the respiration stopped at 18. At 19, 4 minims of dilute H.C.N. were administered hypodermically. At 20 he was placed horizontal and respiration of a very fast nature at once commenced. In the tracing the big waves represent the pulse, slow because asphyxial, and the little ones are the respiration. The pulse is sixteen per minute, and the respirations are sixty. Beyond this the pulse hastened, the pressure improved and the animal completely recovered. No artificial respiration was here employed, and it seems probable that this animal was saved by H.C.N. The placing of him horizontal greatly aided the result.



TRACING XLIV.—3/10.—Antidotal use of H.C.N. Animal vertical. 18 As a result of Chloroform pressure fell and respiration stopped here. 19 Animal apparently dead. H.C.N. hypodermically. 20 Horizontal. 21 Respiration 60 per minute, pulse 20 (large waves are pulse and smaller ones respiration). Animal recovered.



TRACING XLV.—3/11.—Antidotal use of H.C.N. Animal being vertical, Chloroform pushed, pressure fell and respiration ceased at 9. 10 H.C.N. given. 11 Pressure rising, respiration rapid (not shown on tracing).

In another case an animal was apparently saved from fatal chloroform poisoning only to die from H.C.N. poisoning. A dose equal to 1 minim of Scheele's acid to three pounds of body weight was used, and hence it was not to be wondered at that he eventually died. Tracing 45 was taken from this case. While the animal was in the vertical posture chloroform was pushed, and at 9 respiration stopped, and the pulse as usual became exceedingly slow—ten per minute—and the pressure fell to almost zero. At 10, twenty-five seconds after the cessation of respiration, 7½ minims of dilute H.C.N. were injected into the fauces. Respiration of a very rapid nature commenced almost at once, although it produced no sign on the tracing, and at 11 the following note was made: "Blood pressure rising; respiration good although not shown on chart." Thus, so far nothing but good had resulted from the H.C.N., and the animal seemed certain to recover. But now symptoms of H.C.N. poisoning set in as follows: 2½ minutes from the time of administration of the H.C.N. natural respiration stopped, and the pulse was thirty-eight. One minute later artificial respiration was commenced. Five minutes later the animal was placed horizontal, with the result that the pressure rose slightly. The finger was introduced into the glottis. With each artifical respiration a spasm of the depressor muscles of the lower jaw was felt. This spasm gradually spread to the muscles of respiration, and eight minutes after the administration of the H.C.N. the spasm evolved itself into natural respiration. This stopped two minutes later, and artificial respiration this time failed to restore it. The animal died 19½ minutes after the administration of the H.C.N. This animal "died cured" so far as the chloroform was concerned.

Bearing in mind the extreme uncertainty of the strength of preparations of H.C.N., I took special care to procure from a reliable source a fresh supply for each of the experiments. Scheele's acid is roughly double the strength of the dilute Hydrocyanic Acid of the British Pharmacopœia. I used the drug both by the mouth and hypodermically, and seemed to get about the same results by either method. My experiments taken in conjunction with the more numerous ones of Professor Hobday would suggest that in *true* cases of chloroform poisoning, when the respiration has stopped or seems likely to do so, it would be well to try the use of a medicinal dose of this powerful drug. It could be given, hypodermically or by the mouth, as an adjunct to artificial respiration and other restoratives. Cyanide of potassium would be the most suitable preparation to keep on hand for such emergencies, being a more staple body than the solution of acid. The B.P. dose of the dilute acid is 2 to 6 minims, and that of the U.S.P. 1 to 15 minims. Professor Hobday recommended a dose of 1 minim of Scheele's acid to seven pounds of body weight. For a man weighing, say 140 pounds, according to this the dose would be 20 minims of Scheele's acid; that is 40 minims of the dilute acid. Although such a dose appears to be safe in animals, I should very much hesitate to recommend it in practice even in an emergency; but the full B.P. dose of 6 minims could be employed with absolute safety, and that of the U.S.P., viz., 15 minims of the dilute acid, might be used if necessary. Forty-nine minims is the smallest fatal dose of which I can find any record.[1]

Atropine.—The action of this drug has been very thoroughly and repeatedly studied of late, and my experiments do little but confirm the results which others have obtained. Atropine has been termed by Binz[2] "the most powerful of all stimulants"; Wood and Cerna[3] have

1 Taylor's Medical Jurisprudence.
2 Lectures on Pharmacology Binz, Vol. I., p. 93.
3 Journal of Physiology, 1892, p. 882.

proved its potent action in stimulating the respiration, increasing "the air movement," as it does in suitable doses, from 100 to 300 per cent. Nevertheless the drug does not seem to have come into general use in practice as a stimulant, although Lauder Brunton and others have urged its value in conditions requiring stimulation. I have discussed this question more fully elsewhere.[1]

I used ten dogs in studying the action of atropine in conjunction with chloroform, and the results may be discussed under two headings:

First, The effects of atropine when administered previously to the giving of the anæsthetic, and

Second, the antidotal action of atropine when given after poisoning from chloroform has occurred.

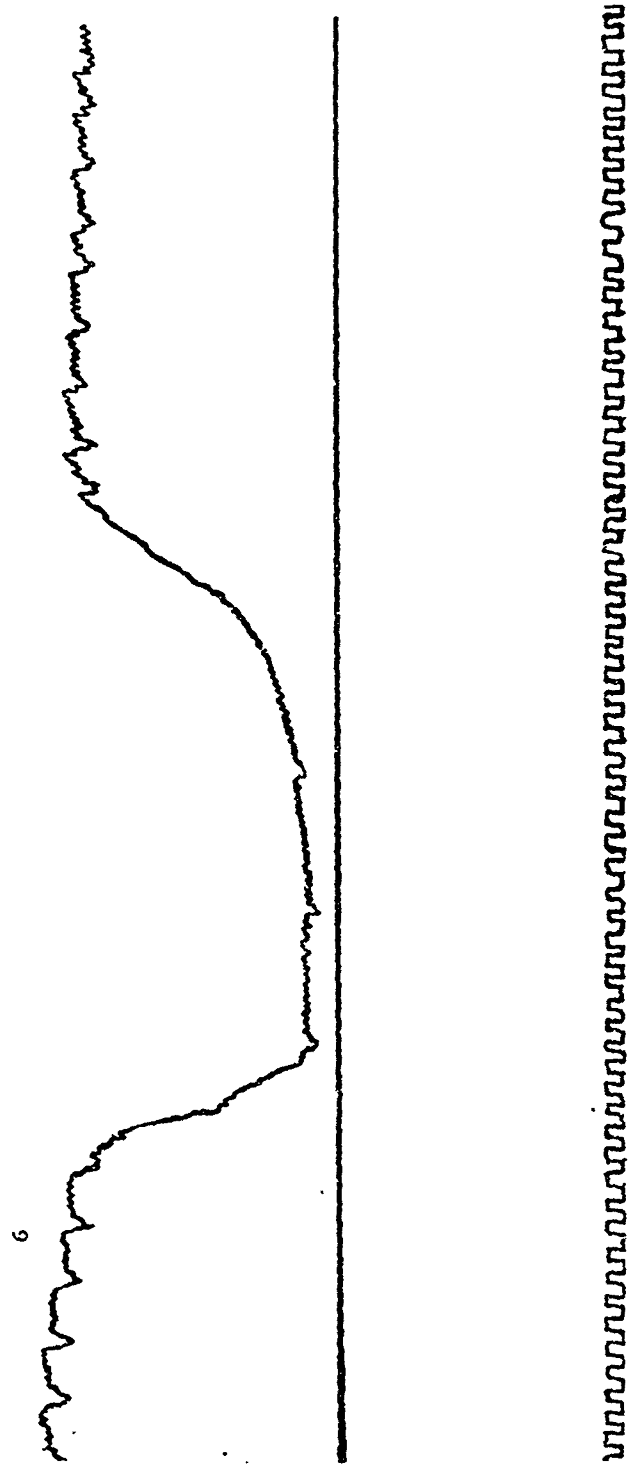
Seven of the dogs were previously given morphia, while three were not so treated.

In the first place it may be noted that the effect of gravity on an animal under the influence of atropine may be quite as marked as without it. In Tracing 46 the dog, while thoroughly under atropine, was placed vertical at 5 and the pressure is seen to fall in a very decided manner. This is scarcely what one would have expected on general principles, and it may be that the heart is already beating up to its maximum and hence can do no more when called upon to compensate for the fall in pressure. In tracing 14, however, gravity produced very little effect under similar conditions.

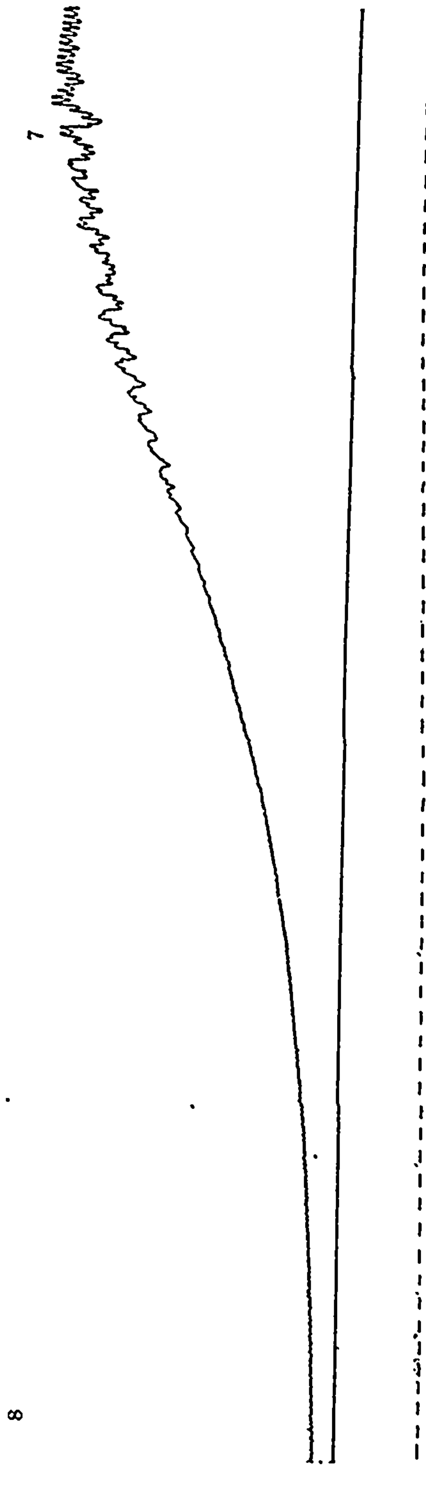
The use of atropine with a view to preventing danger during the administration of chloroform has long been strongly recommended by certain writers, and has been as vigorously opposed by others. Many anæsthetists, especially in Scotland, regularly give a hypodermic injection of it either alone or combined with morphia before commencing chloroform, and in Lyons this method is much used.[2] The Glasgow Commission found as a result of their experiments that atropine lessened the danger of death from chloroform, believing as they did that strong inhibition of the vagus from chloroform was a real danger, which would be impossible when this nerve was paralyzed by atropine. Lieut.-Col. Lawrie, on the other hand, representing the second Hyderabad Commission, opposed the use of the drug, arguing that: "If the Committee regard the effect of atropine as beneficial they

1 "Notes on Atropine," by the author. Montreal Medical Journal, October, 1900.

2 "Les Accidents du Chloroforme et leur Remède." Ann. et Bull. de la Soc. de Méd. Gand. 1889. p. 253.



TRACING XLVI.—9/13.—Dog under atropin. 5 Vertical. 6 Horizontal again.



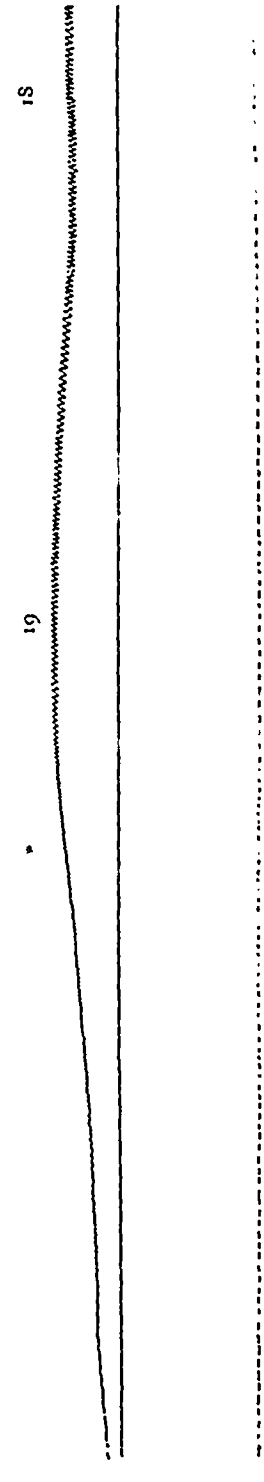
TRACING XLVII.—7/18.—Dog under Atropin. Horizontal. Chloroform pushed at 7 while animal struggling. Pressure fell rapidly, but pulse remained fast. Respiration did not stop and animal recovered. 8 Chloroform removed.

must intend to imply that the inhibitory action of the vagus is a danger in chloroform administration when atropine is not used, or that the normal action of a healthy nerve is a danger to life." This is in my opinion a most fallacious argument. An animal inhaling concentrated chloroform vapour is not in a normal condition; and because in normal life the gentle inhibitory action of the vagus does no harm, it does not at all follow that a great amount of the same inhibition set up by the action of chloroform may not be dangerous. Although I consider that this argument is fallacious I do not go so far as the Glasgow Commission did in believing that vagus inhibition is really a danger in chloroform administration. When such inhibition occurs, if the chloroform merely be continued, the reflex is soon deadened and then the heart is released. In my limited experience a dog under the influence of atropine is decidedly harder to kill with chloroform than one not so conditioned, whatever be the theory as to how the atropine acts. If, however, chloroform be pushed persistently in an atropinized dog the pressure falls steadily, the pulse remains fast, and after some minutes — 5½ minutes in one experiment and 7½ in another—the respiration stops, and two or three minutes later, the pressure being nearly at zero, the pulse ceases.

In Tracing 47, the animal having been previously placed under atropine, chloroform was pushed at 6. No morphia had been given. A good deal of struggling occurred, followed by a rapid fall in blood pressure. Chloroform was removed, and the animal quickly recovered. It is interesting to note that although the pressure fell so low the respiration did not stop as would almost certainly have been the case if atropine had not been given. This tracing shows incidentally that the fall in blood pressure in chloroform poisoning is not dependent upon slowing of the heart's action.

The action of atropine as an antidote to chloroform poisoning does not seem to have attracted much attention. Dr. H. C. Wood[1] found that in a dog in which the respiration had stopped from chloroform poisoning "a hypodermic injection of 10 c.cs. of a two per cent. solution of atropine altered the rate of the pulse but had no apparent effect on the pressure and respiration, and in no wise prevented the final cardiac arrest." 10 c.cs., however, was such an enormous dose, representing as it does about three grains of atropine, that he might well have got such a result when a more moderate quantity might have saved the animal. This quickening of the pulse which Dr. Wood refers to is shown in Tracing 48. In this case the animal had been atropinized and then chloroform had been pushed until the respiration stopped at 18. After that the pressure rose gradually and then as gradually sank again with hastening of the pulse. After the pulse

1 British Medical Journal, Aug. 16th, 1890.



TRACING XLVIII.—7/23.—Dog previously atropinized. Then Chloroformed. Respiration stopped at 18. 19 Shows slight rise in pressure.

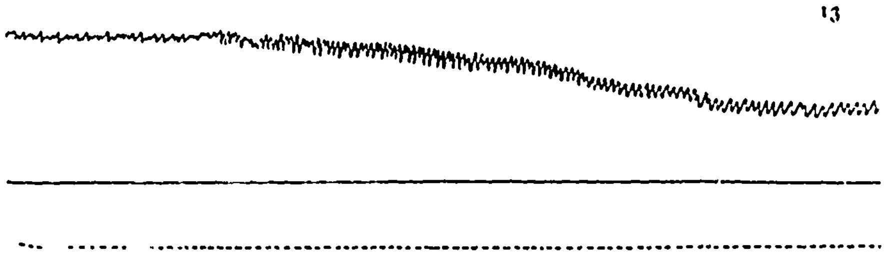
had disappeared the second sound of the heart could be heard on auscultation for about half a minute and then it too disappeared and the animal was dead.

This slight rise after the respiration had stopped occurred in all the dogs poisoned with chloroform following on atropine, and probably points to a circulation made more vigorous by atropine. Dr. Reichert, of Philadelphia, in a recent article,[1] shows that after the respiration has been paralyzed by atropine, if the breathing be maintained artificially, then even as much as six times the lethal dose of the drug may be administered and yet recovery may ensue. He shows, as is of course well known, that atropine kills by paralysis of the respiratory centre; that next the vaso-motor centre is poisoned; and last of all the heart. These results if confirmed emphasize the importance of artificial respiration being continued if necessary for hours in cases of atropine poisoning in man.

In several dogs in which the respiration had stopped as the result of an overdose of chloroform, I found that atropine seemed to have a powerful antidotal action, acting in this respect very much as Hydrocyanic acid does. In a fox terrier dog which was being anæsthetized by chloroform the respiration, subsequent to some struggling, rather suddenly ceased. The canula had not yet been introduced into the carotid. Artificial respiration was used without success. The tongue was forcibly dragged upon and was seen to be deeply cyanosed. The heart could not be heard on auscultation. 1/50 of a grain of atropine was injected under the skin over the precordia, and the swelling thus produced was rubbed until it disappeared. About one minute later the heart was felt to be beating rapidly, artificial respiration was stopped, and in a few minutes natural respiration commenced in a shallow manner and the animal recovered. Exactly the same sequence of events occurred in another dog. Unfortunately in neither of these animals had the canula been adjusted in the carotid, and therefore we are unable to produce any tracings. The former dog had had ¼ grain of morphia hypodermically thirty minutes before the emergency occurred; the latter had not had any.

I reproduce one tracing from a case in which recovery from chloroform poisoning seemed at least to be hastened by the use of atropine. In Tracing 49 the animal was so deeply poisoned by chloroform that the respiration had already stopped. Atropine was injected at 13.

1 Philadelphia Medical Journal, Jan. 19th, 1901.



TRACING XLIX.—9/26.—Dog poisoned with Chloroform. Respiration had already stopped. Atropine injected at 13. No artificial respiration used.

The pulse soon became fast and respiration commenced. No other means of resuscitation were employed.

My experience would lead me to the following conclusions:

First, the previous use of atropine lessens the tendency to death from chloroform poisoning in dogs. Theoretically also one might assume that from its powerful stimulating effect on the circulation it would, especially if combined with morphia, tend to lessen the chance of syncope occurring during, but not necessarily due to, chloroform administration.

Second, that when, during the administration of chloroform, danger has occurred, either in the form of syncope or of respiratory failure, atropine in moderate doses (say $\frac{1}{100}$ grain) would tend to stimulate both the circulation and the respiration, and hence would be a valuable adjunct to other means of saving life in such emergencies.

REV. HENRY SCADDING, D.D.

Since the last issue of THE TRANSACTIONS OF THE CANADIAN INSTITUTE, one of its most honoured members has passed away in the person of the Rev. Dr. Scadding, who died on 6th May last, in Toronto, at the great age of eighty-eight. Born at Dunkeswell, Devonshire, England, on 29th June, 1813, where his father was factor to Major-General Simcoe, he came to Canada when only seven years of age, and his whole subsequent life has been identified with Toronto, except the four years—1833-1837—that he spent at St. John's College, Cambridge. Before proceeding to Cambridge for his university education, he had received his preliminary training at Upper Canada College, of which institution he was the first "head-boy." Receiving his B.A. degree in 1837, he returned to Canada, and became one of the masters in Upper Canada College. He was also the first rector of Holy Trinity Church, Toronto, and laboured for many years in both capacities, till compelled by failing health to relinquish active work. But though in a manner retired from public life, he by no means became an idler. His eighteen years of editorship of *The Canadian Journal*, and his numerous contributions to its pages, are the record of a busy, though tranquil life. In addition to the numerous papers read by him before The Canadian Institute, he published several volumes, chiefly elucidating historical and archæological points relating to Canada, and especially Toronto. For the six years, 1870-1876, he filled the office of president of The Canadian Institute. He was also the first president of The York Pioneers, and was one of the founders of The Ontario Historical Society. He was an M.A. of Cambridge, 1840;

D.D. of Cambridge, 1852; and D.D. of Oxford, 1867. Dr. Scadding was pre-eminently a lover of books, and in his long life accumulated a large and valuable library, in which were many rare and curious books. He was also an enthusiastic numismatist, and until his latest years he preserved a deep interest in his native county, and was on terms of intimacy with various members of the Simcoe family; and one of the objects for which he most earnestly laboured was the erection in Toronto of a statue of the first lieutenant-governor of Upper Canada. It must have been a peculiarly heavy affliction to him that in his later years his sight so failed him that his whole intercourse with his beloved books was maintained through a reader. And yet he did not repine. His was a peculiarly gentle and placid nature. Courteous, kind, modest, unassuming, he shewed himself in his relations with his fellows the genuine, humble, Christian gentleman. Of him it may truly be said that he wore the white flower of a blameless life;

> Cui Pudor, et Justitiæ soror,
> Incorrupta Fides, nudaque Veritas
> Quando ullum inveniet parem?

It will be long before his venerable figure will pass out of the recollection of his friends. It was fitting that the end of such a life should come gently and quietly. There was no disease, no pain; it was only the exhaustion of Nature's powers; and he slept into eternal life as peacefully as he had lived.

OFFICERS

OF

THE CANADIAN INSTITUTE,

1901-1902.

President:

JAMES BAIN, Jr., Esq.

1st Vice-President:

PROF. A. P. COLEMAN, Ph.D.

2nd Vice-President:

PROF. A. I. BELL, Ph.D.

Secretary	R. F. STUPART, Esq.
Treasurer	WILLIAM SCOTT, M.A.
Librarian	PROF. A. B. MACALLUM, M.A., M.B., Ph.D.
Editor	GEORGE KENNEDY, M.A., LL.D.
Curator	C. H. ARMSTRONG, Esq.

Members of Council:

JOHN MAUGHAN, Esq., Chairman Biological Section.
PROF. W. H. ELLIS, M.A., M.B.
PROF. J. FLETCHER, LL.D.
E. C. JEFFREY, B.A., Ph.D.
B. E. WALKER, F.G.S.
S. DILLON MILLS, Esq.

Assistant Secretary and Librarian:

MARGARET J. LOGAN.