THE

CANADIAN RECORD

OF SCIENCE.

VOL. IX. OCTOBER, 1904. No. 5.

ANALCITE-TRACHYTE TUFFS AND BRECCIAS FROM SOUTH WEST ALBERTA, CANADA.*

C. W KNIGHT.

(INTRODUCTION.)

In this paper are described a series of tuffs and breccias found in the south west corner of Alberta, Canada, some five miles west of the Livingstone Range. They have been carefully mapped in townships 7, 8, 9 and 10, ranges 3, 4 and 5 west of the fifth meridan. Roughly speaking, the district lies about twelve miles east of the eastern boundary of British Columbia and some fifty miles north of the international boundary. Their existence here has been known since the early eighties when G. M. Dawson of the Canadian Geological Survey referred to them in his report on the Rocky mountains.[1]

The occurrence of analcite ($Na_2O. Al_2O_3. 4SiO_2. 2H_2O$) in these pyroclastic rocks makes an interesting study. Its presence has not been previously noted by other writers. No microscopic or chemical descriptions of the rocks have been written. The mineral has lately attracted much attention as regards its origin in igneous rocks; and its formula, which may be written in various ways, especially as regards the interpretation of its one molecule of water,[2] is still uncertain. Its mode of occurence in south west Alberta is unique. So far as the writer

*Published by permission of the Director of the Can. Geo. Survey.

1. Report on the Rocky mountains between lats. 49° and 51°-30'. Report of Can. Geo. Sur. 1886.

2. Bull. 207. U.S. Geo. Sur. p. 8. Clarke and Steiger, 1902.

is aware it has never been noted occuring under the conditions here described. It is found in crystal-tuffs and breccias having the mineralogical and chemical composition of trachyte. Its form and relation to the minerals with which it is associated lead to the belief that it is a *primary* constituent of these volcanics. In other words, the analcite has been deposited from showers of volcanic debris, simultaneously with the other materials, and was therefore a primary constituent of the partially consolidated magma which gave rise to these rocks. Its primary nature is further discussed in a later part of this paper, but it may be noted here that it was only during the past fifteen years that analcite has been recognized as a primary constituent of igneous rocks. Rosenbusch still regards it as a secondary mineral.

The fact that analcite is found in a crystal-tuff of the composition of a trachyte, is believed to establish a new rock type, and the name Blairmorite[1] is here suggested for it. This point is more fully discussed later on.

The rock specimens studied in this paper are nearly all from the museum of the Canadian Geological Survey. The collection was originally placed by Dr. A. E. Barlow of the survey, in the hands of Dr. C. W. Dickson, now of Queen's University, Kingston, for investigation, but as opportunity failed Dr. Dickson he very kindly placed the specimens in the writer's hands. The work was carried on in the geological laboratories of Columbia University, New York. To Professor Kemp and Dr. Berkey of Columbia University, the writer would express his acknowledgement for advice and assistance. The writer's thanks are, however, especially due to the authorities of the Geogolical Survey for the opportunity given him to study a suite of rocks which have proved to be of exceptional interest. Dr. Adams of McGill University, Montreal, added a few specimens to the collection, and also furnished some details of an interesting rock-cut on the Crows Nest branch of the Canadian Pacific Railway, four miles east of Crows Nest Lake.

1. The town of Blairmore is located on the Crows Nest branch of the Canadian Pacific Railway: it is less than two miles from some exposures of the volcanic rocks here described.

General Geology of the District:

Mr. W. W. Leacn,[1] who in the summer of 1902 examined the Blairmore-Frank coal field, has, for descriptive purposes, placed these pyroclastics at the top of the Middle and Lower Cretaceous. Accompanying his report is a map showing the distribution of these and other rocks in the district. The volcanics have been traced in a north and south direction at least twenty-four miles. The series attains a maximum thickness of 1500 ft. and where exposed in one of the railway cuts includes some igneous flows of augite-trachyte which contain a great many inclusions similiar to the lava itself. Immediately beneath the volcanics is a thickness of 1850 ft. of various shales and sandstones, while overlying them are gray and black shales and sandstones. The extremely important coal measures of the region lie beneath the three formations just mentioned, although some coal is found above them.

The geological structure of the district is somewhat complex,[2] much faulting and folding being in evidence so that the same strata may outcrop two or three times in an east and west cross-section.

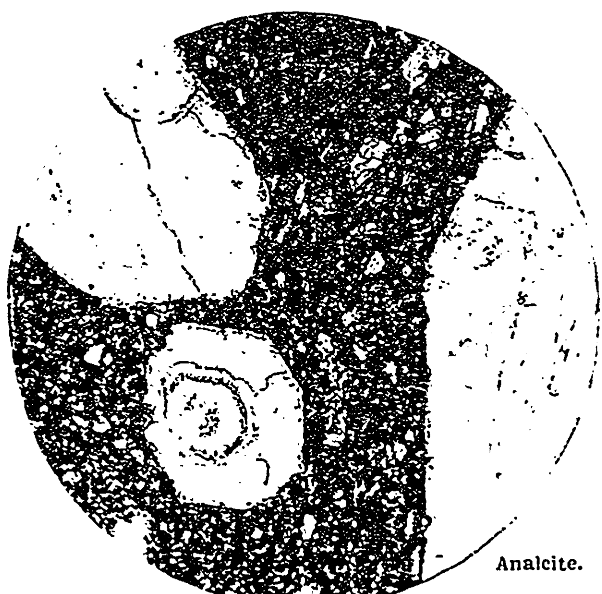
Minerals Found in the Tuffs and Breccias.

The specimens of the volcanics examined consist mostly of crystal-tuffs and breccias, generally of a grayish green or purplish color. The minerals are nearly always present in a fragmentary condition showing rough, angular outlines, although not infrequently the original crystal form has been entirely preserved, and in other cases the rounded condition is suggestive of water action. Only one of the specimens in the collection shows, however, the result of water action in its banded structure.

The following minerals have been identified in the tuffs and breccias: orthoclase, sanidine, analcite, augite, aegirite-augite, aerigite, acmite, diopside, titanite, microcline, anorthoclase, andesine, nephelite, hornblende, apatite, biotite, garnet, magnetite and various secondary minerals, such as chlorite, limonite, calcite, etc. Sodalite is probably present in small quantities and possibly leucite.

1. Summary Report Can. Geo. Survey 1902, p. 167.
2. Leach, W. W. Summary Report Can. Geo. Survey 1902, p. 169.

Orthoclase is the most abundant mineral found and is present in almost every case. It is generally fairly fresh. Twinning after the Carlsbad law is quite common while the rarer twins after the Baveno law are found in one thin section examined. The *pyroxenes*, which, with a few exceptions, are all remarkably fresh, include the interesting soda varieties mentioned above; these are recognized by their grass green color, low extinction angles—less than 6°—and the fact that the greatest axis of elasticity lies next the vertical axis. The aegirite-augite has of course higher extinction angles than acmite or aegirite. The *plagioclase felspar* present is andesine, determined by the statistical method and also by measuring extinction angles on crystals twinned according to both the Carlsbad and Albite laws. This lime-soda felspar was only found in two sections, however, and the entire series of tuffs and breccias is characteristically an alkaline one, of trachytic tendency. *Biotite* occurs, but it is rare.



Analcite.

Fig. 1. Analcite-tuff, ordinary light, actual field 2·5 mm. The large white crystals are analcite showing some of the crystal faces still preserved. Inclusions arranged parallel to the octagonol outline of the mineral are seen in the lower left hand crystal.

The amount of *analcite* present in these pyroclastic rocks varies in the different specimens of which there are forty-three in the collection. In the majority of cases it is entirely lacking while in one it makes up about two thirds of the material. (Fig. I.) When the crystal form has not been destroyed it is seen to be the icositetrahedron. In some specimens the analcite might be mistaken for certain varieties of garnet. It varies from a reddish brown to a rather dirty cream color, the former being due to iron stains. It will be noted in the analysis of this material given below that 2.85% of ferric oxide is found. Under the microscope it is seen to be clear and colorless in irregular patches, the cloudiness being due partly to the iron stains mentioned and partly to minute inclusions not always determinable -which are sometimes zonally arranged. This is seen to be the case in the crystal in the lower left hand corner of Fig. I. Optical anomalies are not common. Interesting replacements by calcite have taken place in some of the more weathered specimens. This phenomenon is well shown in Figs. II. and III. Some of the smaller analcites show complete replacement by albite. This seems to have resulted directly from the breaking up of analcite.

The properties of analcite, studied in thin section, are such that it is not always possible to distinguish with certainty this mineral from leucite. Both minerals are isometric, both show optical anomalies; and inclusions, though more characteristic of leucite, are also found in these two minerals. Since, further, the occurence of analcite as a primary mineral in tuffs and breccias has never been described in geological literature up to the present time, it was thought advisable to separate it, by means of heavy solutions, from the other materials and make a quantitative examination. Beforehand, however, it was found to give the characteristic blow-pipe reactions for this zeolite, while small fragments treated with hydrofluosilicic solutions gave the characteristic hexagonal prisms of Na_2 Si Fl_6.

The material selected for analysis is shown in Fig. I. It was taken from a railway cut on the Crows Nest branch of the Canadian Pacific Railway four miles east of Crows Nest lake.

This specimen might well be called an analcite-tuff, its clastic nature being apparent at a glance. The large white minerals are analcite (3 to 4 mm. in diameter). A few irregular prisms of a soda-pyroxene occur; they are, however, almost entirely replaced by calcite and to a lesser extent by what is undoubtedly secondary analcite. This latter mineral is perfectly clear and colorless, and is unlike the primary analcite in this respect. The fine grained matrix consists of small fragments of analcite and soda-pyroxene.

Thoulet's solution was used for the separation. On account of the very fine grained matrix a perfectly pure product was not obtained. The result of the analysis, however, as given in table I, No. A., leaves no doubt as to its identity.

It is interesting in this connection to note the experiments of Clarke and Steiger[1] on the action of ammonium chloride upon silicates. The first mineral experimented on was analcite and their work has thrown considerable light on its chemical composition. When a number of analyses of analcite, as given in text-books like Dana's Manual, are studied, it is at once apparent that they differ in a marked degree from the theoretical composition. It is not always possible to account for this difference by impure material used or errors of manipulation. The results of experiments by Clarke and Steiger seem to show that analcite is not a metasilicate as was commonly supposed, but is a mixture of ortho and trisilicates. In most cases the two salts are commingled in the normal ratio 1:1. With this hypothesis the discrepancies in the analyses become intelligible.[2] The variation from the theoretical composition in the analysis made by the writer is due to an imperfect separation by the heavy solution, as is shown by the presence of iron, calcium and magnesium oxides. For comparison the theoretical composition of analcite is given below, together with three other analyses.

1. The action of ammonium chloride upon silicates. Bull. No. 207, U.S. Geol. Sur., 1902.

2. Bull. 207, U.S. Geo. Sur., page 19.

TABLE I.

	A	B	C	D	E
SiO_2	54.39	57.06	55.8	53.92	54.55
Al_2O_3	22.08	21.48	24.1	24.60	23.18
Fe_2O_3	2.85	.13			
CaO	.29	.16			
MgO	.27				
Na_2O	11.75	12.20	12.8	12.23	14.09
K_2O	1.03			1.30	
H_2O at 110°	.55	.58			
H_2O over 110°	7.97	8.38	8.8	8.50	8.18
	101.18	99.99	101.5	100.55	100.00

A. From railway cut near the town of Blairmore on Crows Nest branch of the Canadian Pacific Railway, Alberta, Canada.

B. Wasson's Bluff, Nova Scotia, Canada. Bull 207, U S. Geo. Sur., p. 8.

C. Brevik, Dana's system of minerology, p. 597.

D. Heldburg, " " " " p. 597.

E. Theoretical composition.

The Primary and Secondary Nature of Analcite in Igneous Rock.

During the past fifteen years the primary and secondary nature of analcite in igneous rocks has been the subject of a good deal of discussion. It was originally thought to occur only as a secondary product, which view is still held by Rosenbusch. The work of Lindgren,[1] (who first recognized analcite as a primary mineral), Pirsson, Cross[2] and others[3] now leaves little doubt that analcite may occur as a primary constituent of igneous rocks. Monchiquite, which was originally described as consisting of olivene and augite in a glassy ground mass, is a good example of a basic analcite-rock. Prof. Pirsson[4] showed

1. Proc. Cal. Acad. Sci. Series 2, Vol III, July 1890.
2. Repcrt U.S.G.S., 1895, Part II, page 16. Journal of Geology, 1897, page 684.
3. *Washington, H S*, Am. Jour Sci., 1898, VI., p. 182-186. *Evans*, Quart. Jour. Geol. Soc., vol. 57. 1901, p. 38 *Ogilvie*, Jour. Geol., vol. X., 1902, p. 500. *Pirsson*, Am. Jour. Sci., 4th Ser., vol 13, 1902, p 161. *Pirsson*, Bull. 237, U.S.G. Sur. 1905.
4. Jour. Geol., 1896, p 678.

that in certain cases this so called glassy ground mass was really analcite, which was the final product of crystallization. As has been pointed out by Prof. Iddings, the difficulty of distinguishing an isotropic substance like analcite from residual glass is at once apparent.[1] Dr. Coleman has described a dike, closely related to the tinguaites, from the north shore of Lake Superior, which is exceedingly rich in analcite.[2] It contains in some cases as much as 47% of this zeolite. One of the crystal tuffs from Alberta, however, will run even higher than this. Fig. I. is a photo-micrograph of a specimen in which it will be seen that the analcite will run over 60% of the rock. It is practically an analcite-tuff.

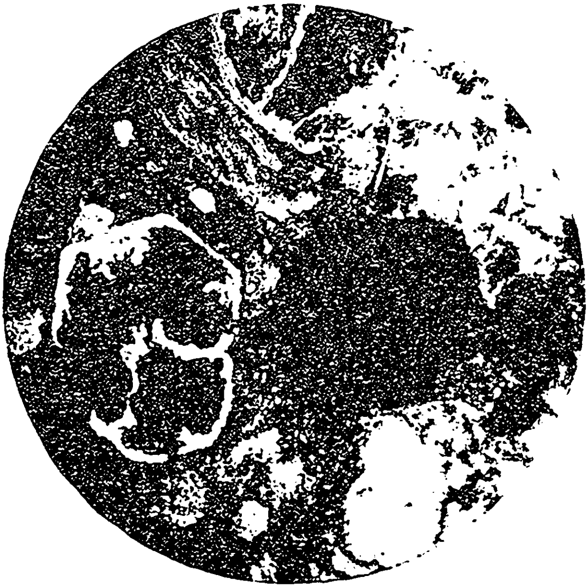


Fig. 2. Analcite replaced by calcite; crossed nicols; actual field is 2·5 mm. The large black crystal with octagonal outline, near the centre of the field, is analcite; it shows no replacement. Immediately to the left is another analcite with hexagonal outline showing replacement by calcite (white) around the edges and ramifying into the centre.

The reasons for believing that analcite is a primary mineral of these tuffs are given below. The word primary means, as already stated, that the analcite has been deposited from

1. Jour. Geo., Vol. I., p. 638.
2. Ont. Bur. of Mines 1898, p. 172. Also Rep for 1899, p. 186.

showers of volcanic debris simultaneously with the other materials of the tuff, and was therefore a primary constituent of the partially consolidated magma which gave rise to these rocks. (1) The analcite almost invariably occurs in crystal fragments or sometimes in nearly perfectly preserved crystals (icositetrahedrons). (2) Though the series of specimens studied are not on the whole fresh, still it is common to find perfectly fresh orthoclase and aegirite closely associated with analcite. This we would not expect to find if analcite were secondary after leucite (as was at one time commonly supposed) because such a radical change in chemical composition could not take place without effecting the orthoclase. (3) The fact that the various minerals sometimes reach a diameter of an inch and a half shows that crystallization took place, partly at least, at considerable depths and therefore under sufficient pressure to retain the necessary water in order that analcite should form. (4) A very insignificant amount of what is undoubtedly secondary analcite does occur, sometimes partly replacing aegirite and sometimes occuring in microscopic veinlets. This material is quite clear and colorless, and differs in this respect from the primary analcite.

It is possible that leucite in very small amount also occurs in the series of rocks, for in the ground mass of a *rock fragment* in a breccia were found roundish, clear, isotropic individuals .005 mm. in diameter. The minuteness of the material made separation of these isotropic crystals impossible; micro-chemical tests, however, were made on the very fine grained ground mass containing these crystals, giving reactions for potash but not for soda, proving the absence of analcite. The potash reaction may have resulted from the orthoclase which also occurs associated with these crystals, so that it cannot be definitely stated that leucite is present.

The Rock Types Found.

There are four rock types which may be distinguished in the specimens examined. About sixty thin sections were studied under the microscope. With one exception all the sections are seen to be characterized by high per cents of soda and potash, while quartz is persistently absent in all of them.

Augite-trachyte. A few of the hand specimens are typical trachytes, showing beautiful flow structures, and consisting essentially of orthoclase in two generations with augite as the ferro-magnesian mineral. Titanite and magnetite are common and persistent accessories, and brown garnets are usually present. Whether these specimens of augite-trachyte were taken from actual flows or whether they are merely rock fragments in the breccias, is not clear from the data accompanying them. A study of the breccias, however, shows that fragments of augite-trachyte are quite common constituents of these pyroclastic rocks. The composition of the majority of the crystal tuffs is also distinctly trachytic.

Fig. 3. Analcite replaced by calcite: crossed nicols: actual field is 2·5 mm. The mineral with octagonal outline in the centre of the field is analcite, now almost entirely replaced by calcite (white).

Tinguaite. One hand specimen only in the collection illustrates this type. It is a holocrystalline porphyritic rock with phenocrysts of orthoclase (over an inch in diameter) and augite set in a ground mass of orthoclase laths, nepheline and many aegirite prisms and needles. This rock is interesting because it was no doubt from a magna of this composition that the soda-pyroxenes of the crystal-tuffs were derived. The data accompanying the specimen do not state whether it occurs as a flow or as rock fragments in the breccia.

Andesite. One thin section of a crystal-tuff contains large quantities of the plagioclase felspar andesine. From this it may be inferred that parts of the magna from which these clastic rocks were derived, had the composition of andesite. This type is quite insignificant, the series as a whole being characteristically trachytic.

Analcite-trachyte. The presence of analcite in crystal-tuffs whose other dominant mineral is orthoclase, has resulted in a tuff having the chemical and mineralogical composition of an analcite-trachyte. In proposing a new name for this type it is to be understood, however, that no igneous flows have been found, so that the name *Blairmorite*, as suggested at the beginning of this paper, must at present be applied to the crystal tuff having the chemical and mineralogical composition of analcite-trachyte, in other words, a *blairmorite*-tuff. But a volcanic rock of such composition will no doubt be found in place in some part of the world: the analcite will occur in well developed phenocrysts (icositetrahedrons), as is shown by the crystal forms found in the tuffs described in this paper. Such a statement does not seem unreasonable since in the series of tuffs and breccias here studied, one small *rock-fragment* of this type was found. It consists of phenocrysts of orthoclase and analcite less than 1 mm. in diameter set in a ground mass of felspar laths (a few of which have the twinning lamellae of the plagioclases) and a few smaller analcites. Some titanite is also present. The fragment was certainly derived from a magma having the composition of an analcite-trachyte, and it is possible that further field work in this district may reveal the presence of such a volcanic flow.

Chemical Composition of Blairmorite.

In order to study the chemical composition of *blairmorite-tuff*, a typical specimen was selected for analysis. The writer is greatly indebted to Dr. Dickson of Queen's University, Kingston, Canada, for his kindness in preparing this analysis, which was done in duplicate. A thin section from the specimen when examined under the microscope, shows it to consist of analcite and orthoclase fragments about 3 mm. in diameter, together with three or four prisms of aegirite augite about 1 mm. long. The finer grained matrix consists of a mixture of orthoclase, analcite, aegirite-augite and small fragments of garnet. Orthoclase makes up the greater part of this matrix. The particular slide examined showed analcite to be in excess of orthoclase: but judging from the relative amounts of alkalies as given in Dr. Dickson's analysis, column II, table II, it seems that the specimen as a whole contains excess of orthoclase.

TABLE NO. II.

	I	II	IIA.	III
SiO_2	47.82	54.95	.916	52.83
Al_2O_3	13.56	18.64	.182	20.70
Fe_2O_3	4.73	4.75	.029	2.84
FeO	4.54	1.55	.021	1.19
MgO	7.49	0.60	.015	.41
CaO	8.91	2.27	.041	1.00
Na_2O	4.37	4.91	.079	9.94
K_2O	3.23	7.65	.081	4.87
H_2O +	3.37	3.35	.185	5.28
H_2O -		0.90		.37
TiO_2	0.67	0.42	.005	0.16
P_2O_5	1.10	0.18	.001	0.03
Cl	0.04			0.06
Mn O	Trace	0.34	.005	
Ba O	0.16			
SrO	0.21			
	100.20	100.51		99.62

I. Analcite basalt from dike on east side of Highwood Gap. H. W. Foote, analyst.[1]

II. Analcite-trachyte-tuff from a point some six miles south of the town of Blairmore which is situated on the Crows Nest branch of the Canadian Pacific Railway. The specimen

1. Igneous rocks, Highwood Mountains, Mont. L. V. Pirsson, Bull. No. 237 U. S. Geol. Sur. 1905.

was collected by W. W. Leach. Analyst, Dr. C. W. Dickson, Queen's University. In column IIA, the molecular proportions of this analysis are given.

III. Analcite tinguaite, San José, Tamaulipas, Mexico. H. S. Washington, analyst.[1]

For comparison two other analyses of analcite rocks are given in columns I and III. No. III is an analcite tinguaite described by G. I. Finlay.[2] It is clear, however, from his description that analcite is only an accessory mineral in the rock; and, further, he himself states that: "analcite, chiefly, results by weathering." In the phonolites, a closely related rock of the tinguaites, analcite is also known to occur as a primary mineral: [2] but it was in basic rocks like basalts and monchiquites that this zeolite was first recognized as primary.

A comparison of the analysis in column II with trachytes in general shows that it is fairly typical of this type. The silica is a little below the average, but is too high for leucite rocks like wyomingite and leucitites.[3] The alumina and alkalies also come within the range of the trachytes though the alkalies are a little above the average. The soda is not high enough for the phonolites or tinguaites. The high per cent. of water is of course due to analcite. As is usual in the trachytes the potash predominates over soda, while in the phonolites and tinguaites, on the other hand, we find soda predominating.

If we adopt the new classification of igneous rocks as proposed by Cross, Iddings, Pirsson and Washington,[4] the rock is classified as follows. The standard mineral composition, or *norm*, is first calculated and by means of the relative percents of the minerals so found it is placed in its class, order, range and subrange. Dr. Berkey, of Columbia University, very kindly assisted the writer in these calculations.

---

1. Geology of the San José District, Tamaulipas, Mexico. G. I. Finlay. Annals New York Academy of Sciences, XIV, 247-318, 1904.

2. General Geology of the Cripple Creek district. Cross. U. S. G. S., [illegible], Part II, p. 16.

3. Rosenbusch p. 364.

4. Quantitative classification of igneous rocks. 1903.

	Percent.		
Orthoclase	45.04	F	Sal.
Albite	25.68		
Anorthite	6.12		
Nephelite + $2H_2O$	9.60	L	
Diopside	3.49	P	Fem.
Magnetite	4.64	M	
Ilmenite	.76		
Hematite	1.44		
Apatite	.31	A	
H_2O	3.11		
	100.19		

Class, $\frac{\text{Sal.}}{\text{Fem}} = \frac{86.44}{10.64} > \frac{7}{1} = $ I, persalane.

Order, $\frac{L}{F}\ \frac{9.60}{76.84} < \frac{1}{7} = $ perfelic $= 5 =$ canadare.

Rang, $\frac{Na_2O + K_2O'}{CaO'} = \frac{160}{22} > \frac{7}{1} = $ peralkalic $= 1$, Nordmarkase.

Subrang, $\frac{K_2O'}{Na_2O'} = \frac{81}{79} < \frac{5}{3} > \frac{3}{5}$ Sodipotassic $= 3$ Phlegrose.

In closing it may be remarked that *blairmorite* occupies a somewhat similar position to that which theralite (nephelite gabbro) once held. Prof. Rosenbusch gave the name theralite to a rock of this composition and texture previous to its discovery in the Crazy Mountains, Montana, by Wolff.[1]

1. Notes on the Petrography of the Crazy Mts. etc., Northern Transcontinental Survey 1885

Observations upon some Noteworthy Leaf Variations, and their bearing upon Palaeontological Evidence.

D. P. Penhallow.

Our attention has been directed somewhat particularly of late to one or two noteworthy instances of leaf variation which seem worthy of record because of their important bearing upon the character of palaeontological evidence, so far as it is represented by fossil leaves. The present discussion is not advanced with a view of proving any new idea, but in the hope that it may serve to somewhat amplify our range of facts as applicable to a view expressed by Ward as long ago as 1888,[1] and since then amply proved by Holm[2] and Berry[3] with respect to *Sassafras officinale* and *Liriodendron tulipifera.* While the evidence thus brought forward amply supports the opinion of botanists generally, that leaves, when considered separately and wholly apart from the parent stem, and especially when presented in a fragmentary condition, afford no proper basis for the scientific recognition of species, any extension of our knowledge which will tend to throw light upon the extent of leaf variation among different species: the range of forms presented by the same species: the distribution of these forms on the plant, and, above all, the conditions under which such variations arise, will no doubt serve a useful purpose in correcting one of the most fruitful sources of error in the palæontological record of the past, since there is no doubt whatever, that the great multiplicity of species recorded in such important works as those of Lesquereux and Newberry and Heer, must eventually undergo revision in the light of such evidence, when it will be found that many forms now separately established are but variants of one species. It is as a small contribution to this end that the present notes are offered.

1. The Palæontologic History of the Genus Platanus. Proc. U S. Nat. Mus., XI, 1888.
2. Notes on the Leaves of Liriodendron. Proc. U. S. Nat., Mus., XIII. 1890. 15-35 On the Validity of some fossil species of Liriodendron. Bot. Gaz., XX, 1895, 312-316
3. Additional Notes on Liriodendron Leaves. Torreya, vol. 2, 1902, 33-37

a. b.

Fig. 1. LONICERA TARTARICA. a. Normal plagiotropic shoots with leaves of average form and size. Growth of several seasons. b. A vigorous, orthotropic shoot of one season's growth, with leave of unusual form and size.

In the grounds of McGill University, there are a number of ornamental shrubs which were planted out about 1895. Among these is a clump of tartarian honeysuckle *(Lonicera tartarica)* raised from seed at the Botanic Garden. The clump embraces about ten bushes. Until this year they have presented nothing of an unusual character in their growth. In the spring of 1903 they were top-pruned, but there was not much thinning out. As a result the bushes are now filled with numerous wiry branches which, together with larger and more normal shoots (Fig, 1*a*), bear typical or nearly typical leaves of an oblong or oval form, with a rounded and sometimes cordate base, and an acuminate apex (Fig. 2, 1-7 and Fig. 5, 2-4). According to the description in Gray's Field, Forest & Garden Botany, the leaves should be oval with a cordate base, but this does not apply typically to the shrubs in question, nor does it apply to those I have been familiar with in cultivation. The general form in the present instance, is typified by the series in figure 2. All the shrubs in question show a vigorous growth with the exception of two. As a product of the seasons growth they have extended to a height of about 3 m., this being determined by the development of shoots of unusual vigor and great length. In individual cases these shoots are upwards of 1.5 m. long with a diameter of 1.3 cm. at the base. The fact that some of these shoots originated from buds just below the excision of older branches, seems to suggest that they received an unusual amount of stimulus from the previous pruning. In all such cases, the foliage of such shoots was of unusual size, and it deviated more or less strongly from the type, so much so as to establish a feature which, at a distance of one or two hundred feet, could be easily recognized in contrast with the ordinary foliage.

The two shrubs already referred to as forming an exception to the general vigor of growth, were about 1.5 m in general height, and thus about one-half the stature of the others. One of the these, situated on the southerly side of the clump, exhibited in part, probably to the extent of 30-40 ', a remarkable reduction in size and alteration in form of the individual leaf. The second bush is on the

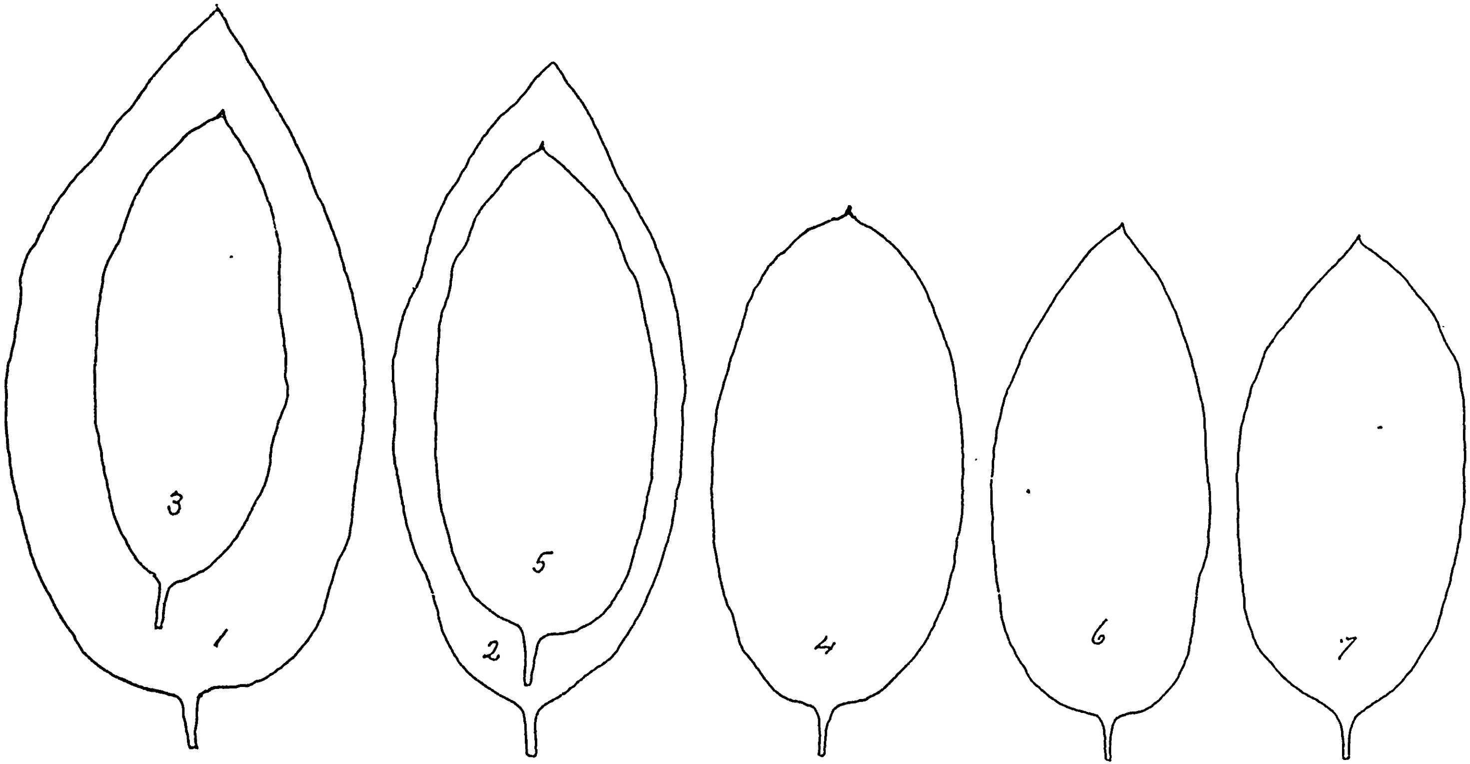


FIG. 2. LONICERA TARTARICA. Leaves of a normal, vegetative and plagiotropic shoot, in acropetal succession from 1-7.

westerly side—or more strictly north by west—of the clump, and its very remarkable leaf variation was what first of all directed my attention to the phenomenon. This bush, which had been somewhat severely pruned, was about 1.5 m. in general height. The branches were thick-set, rather short and wiry, so that the whole formed a somewhat compact head quite unlike the loose, plagiotropic branches so characteristic of the shrub. The leaves, instead of lying in one plane which is also common to the shoot, especially when the latter is dorsiventral in position, as is typical of the normal shrub, occupied the most diverse positions, and they also were curled upward from the sides. In figure 4, the series of leaves was taken from a typical branch of this shrub, the sequence of numbers from 1-12 corresponding to acropetal succession for the branch and branchlets, each group of three being taken from a separate branchlet. The more genera character of the foliage is pretty accurately represented by 7. The particular branch from which these examples were taken, was somewhat plagiotropic, and it is a fact of some interest supported by other data, that the smallest leaves were always at the base of the series, the larger being toward the end of the series and so toward the ends of the branches. An inspection of the figures will show that the leaves are all oblong; the base is rounded, never cordate, while it even becomes acute or even somewhat wedge-shaped in consequence of the decurrent blade. (1, 2, 5, 7, 8). The apex varies widely, being either acute and sometimes mucronate (1, 4, 6, 10, 11) as in ordinary foliage, or obtuse and more or less strongly rounded (2, 7, 8, 9.) Together with these alterations, the leaf blade is distinctly relatively thicker and more coriaceous In size, these leaves range from 1.14 sq. cm. to 9.50 sq. cm., the average area being about 5.09 sq. cm.

From the upper extremity of one of the pruned branches of this shrub, there developed a shoot of great vigor, in common with other similar shoots from other portions of the shrub. During the season it reached a length of 1.16 m. with a diameter of 1 cm. at the base. This shoot (Fig. 1*b*) was strictly orthotropic, while its leaves were somewhat plagiotropic, and it presented such remarkable features as to attract immediate attention. In consequence of the erect position of the branch the leaves were strictly decussate, instead of forming one plane with the branch as common to the normal, plagiotropic shoots. The most remarkable peculiarity of the leaves, however, was found in their extreme alteration of form, and their unusual size. In this case the largest leaves were at the base

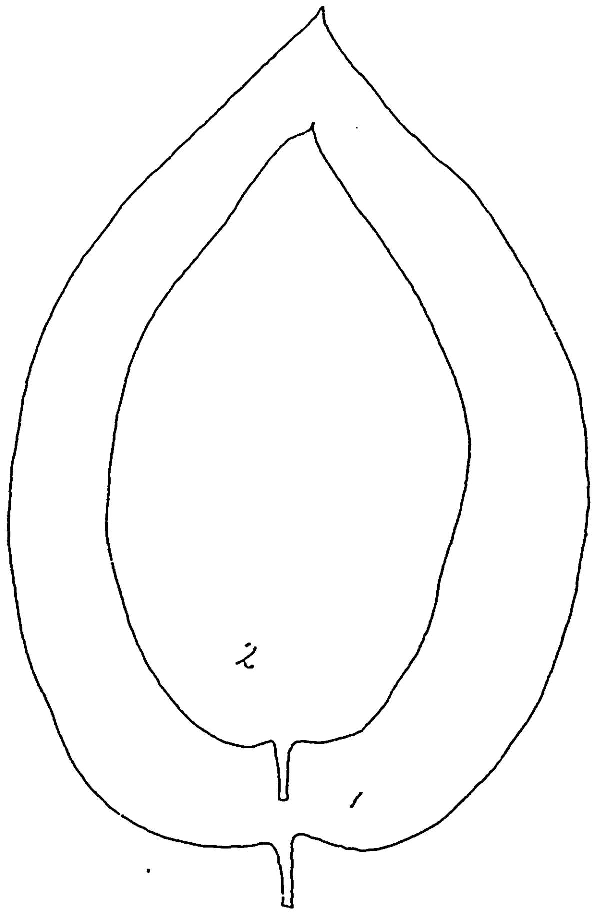


Fig. 3. LONICERA TARTARICA. Leaves of a vigorous and orthotropic shoot of one season. x $\frac{1}{1}$

of the series and the smallest at the end of the branch (Fig. 3, 1 and 2 representing the acropetal succession in the respective positions indicated), the intermediates presenting graduated sizes. As will be seen, these leaves are ovate in form and they have a distinctly cordate base. The leaves of the entire branch show an average area of about 41.61 sq. cm., ranging from 25.85 sq. cm. to 57.37 sq. cm. From this it appears that the same plant produces two sets of leaves under the same general conditions of growth, in which the extreme variation is in the ratio of 1 :50.32, the average variation being in the ratio of 1 :8.17. While we are familiar with the fact that many trees exhibit very striking differences under essentially the same general conditions of growth, the present case appears to be of a most extraordinary nature inasmuch as the different forms appear to be wholly localized and confined to particular regions of the plant; while the the differences in form and size particularly, are such as, in the case of the basswood, are usually associated with extremes of light and shade. To complete our description of this particular shrub, it should be noted that in addition to growing on that side of the clump which only received the afternoon sum as greatly modified by the proximity of a high building

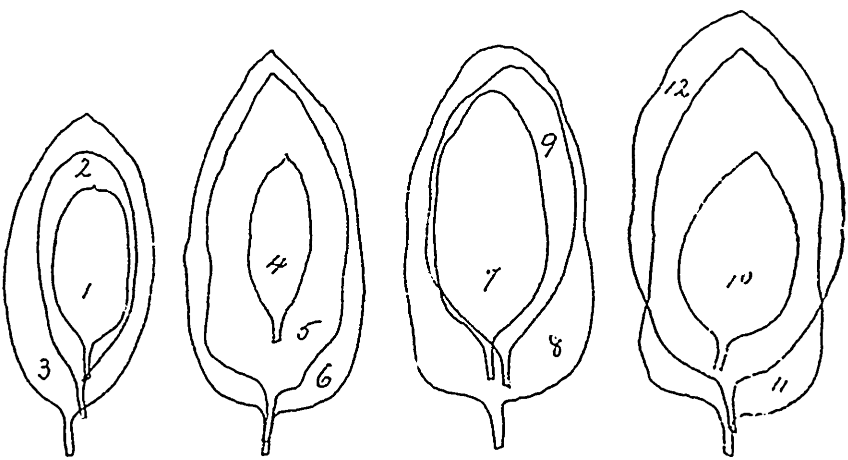


Fig. 4. LONICERA TARTARICA. Leaves from the plagiotropic branches of a much pruned shrub, reduced through correlation. x ½

within 100 feet, it was evidently crowded by the shrubs on each side, and these at any rate established conditions of relative shade by reason of their greater height of three to four feet.

In the case of the first short shrub which I have designated as number four, and which is represented by figure 5, this plant was situated on the easterly side of the clump, and it therefore received the sun only in the early part of the morning, being shaded during the greater part of the day. While this shrub showed about 30 to 40 % of leaves similiar to those of number three (Fig. 4), the majority were strictly dorsi-ventral on plagiotropic branches, and they approximated to the normal type not only in position, but in form and size (Fig. 4, 1-8 in acropetal succession, one of each pair of leaves from the same branch). Here it will be seen that there is marked variation from an orbicular to an oblong-lanceolate leaf, with corresponding differences in size—the largest, (2, 3, 4,) approaching most nearly to the typical leaf, especially with respect to the form of the base. The apex of these leaves is more variable than in other cases, varying from acute to obtuse and mucronate, to retuse. These leaves, which most nearly approach what Gray holds to be the typical form, range in superficial area, from 3.85 sq. cm., to 28.85 sq. cm., with an average of about 13.54 sq. cm. In specimen number 1 (Fig. 2), the leaves from 1-7 represent single members of each pair in acropetal succession, taken from the same branch, This branch was selected because it represented the average character of the prevalent form and size of leaf. It will be noted that although the apex varies somewhat, there is great constancy in the form of the base and the general outline, and not more variation in size than is commonly met with in trees and shrubs generally. These leaves range from 13.00 sq. cm. to 28.33 sq. cm., with an average of area of about 18.28 sq. cm. To recapitulate these dimensions for all our specimens, the following tabulation will be of interest:—

Comparative areas of leaves.

Number of Specimen.	Number of leaf on branch in acropetal succession.	Area in sq. cm.	Average area, sq. cm.	Ratio with No. 1 as(normal) type.	Remarks.
No. 1	1	28.33			
	5	13.51			
	7	13.00	18.28	1:1	Normal leaves.
No. 2	1	57.37			
	2	25.85	41.61	1:2.27	Strongly vegetative shoots.
No. 4	1	7.92			
	2	14.51			
	3	23.90			
	4	28.85			
	5	16.83			
	6	3.85			
	7	6.07			
	8	6.43	13.54	1:0.74	Leaves reduced but approximately normal
No. 3	1	1.56			
	2	2.71			
	3	5.74			
	4	1.14			
	5	5.41			
	6	7.94			
	7	3.33			
	8	4.87			
	10	2.58			
	11	7.58			
	12	9.50	5.09	1:0.27	Reduced leaves.

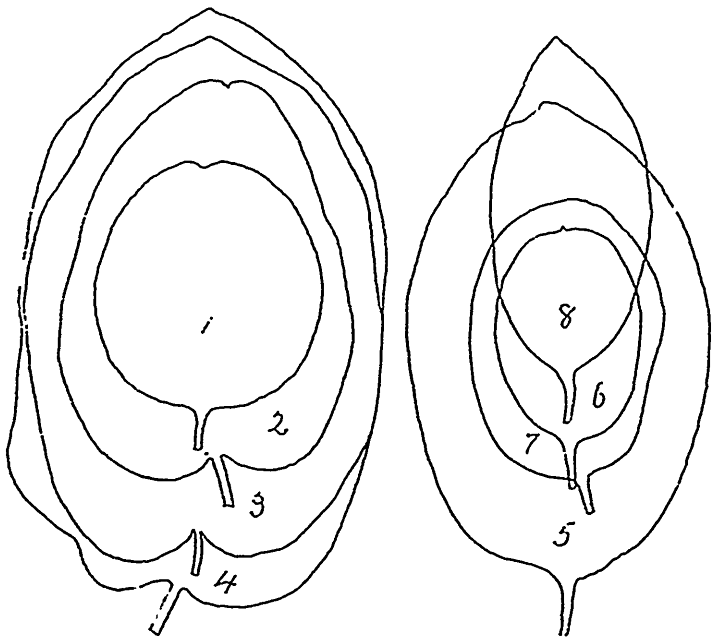


Fig 5 LONICERA TARTARICA. Leaves from the plagiotropic branches of a pruned shrub, somewhat reduced through correlation. x ½

Apart from the general fact that the growth of all shrubs during the past summer, was characterized by a more than ordinary luxuriance, there appears to be no obvious reason for the phenomenal growth of Lonicera, which requires some special explanation.

In addition to the tartarian honeysuckle, attention has been drawn to three other instances which serve to emphasize the point at issue. Clumps of *Spiraea van houttei* were planted at the same time as the Lonicera, and they have been subjected to the same course of treatment, being top pruned in the spring of 1903. The variation of leaves in this plant is a matter of familiar knowledge, but it offers collateral evidence of much value, as illustrating the conditions under which such variation arises. The strongly defined leaf variation of this plant not only constitutes a conspicuous feature of its growth,

a. *b.*

FIG. 6. SPIRÆA TRILOBATA VANHOUTTEI. *a.* Vigorous shoots of one season, developed after flowering and bearing normal leaves. *b.* Small and wiry flowering shoots bearing reduced leaves, together with more vigorous shoots produced after flowering and bearing small leaves of normal form.

but such variation is always definitely associated with a vegetative or with a reproductive condition of the branches. In the particular shrub selected for observation, there was a somewhat marked luxuriance of growth in the branches of the season (Fig. 6*a*), these being upwards of 1.27 metres long, with a diameter of 1 cm. at the base. Upon such shoots the leaves were altogether normal as to form and size, with here and there an atrophied member of the base of a branchlet (Fig. 7*a*: 3). Leaves of normal form are strongly cuneate, and show a conspicuously decurrent blade. As shown in the series (Fig. 7*a*: 1, 2, 4) the leaves increase in size upwards, but again diminish toward the apex of the shoot, to which position leaf No. 4 belongs. Excluding such abnormal forms as No. 3, such leaves show a variation between 2.78 sq. cm. and 9.65 sq. cm., with an approximate average area of 5.64 sq. cm.

The reproductive shoots produce terminal clusters of flowers which are developed with great luxuriance. This appears to influence a limited development of the branches themselves, which are always small and wiry, usually about 10 cm. in length with a diameter of 1 mm. at the base. Among these, and arising from the same main axis, are a few vegetative shoots also influenced in a marked degree by the reproductive period, but conspicuous by reason of their somewhat more vigorous development (Fig. 6*b*). They range upwards of 15 cm. in length with a diameter of 2 mm. at the base. On such vegetative shoots, which generally develop from near the extremity of the main axis and appear after the period of inflorescence is well advanced or completed, the leaves approximate very closely in form to those of the ordinary vegetative shoot. They are, however, much smaller (Fig. 7*a*: 2, 5, 6). They range in size from 1.34 sq. cm., to 3.11 sq. cm., with an average area of about 2.08 sq. cm. They therefore bear to the leaves of the ordinary vegetative shoot, the relation of 1 : 2.70. On the other hand, the leaves borne upon the short, wiry flowering branchlets, are usually much reduced in size and altered in form (Fig. 7*b*: 1 3). They vary from 0.290 sq. cm., to 1.995 sq. cm. with an average area of about 1.033 sq. cm., thus standing toward the leaves of the vegetative shoot in the ratio of 1 : 5.45. A recapitulation of these relations is as follows :—

SPIRAEA TRILOBATA VANHOUTTEI.

Comparative areas of leaves.

Number of specimen.	Number of leaf on specimen.	Area in sq. cm.	Average area. sq. cm.	Ratio of areas. Flowering branch-unity.	Remarks.
No. 1	1	4.490			Vegetative branch.
	2	9.650			
	3	0.440			Excluded from averages because unusual.
	4	2.785	5.640	1 : 5.45	
No. 2	1	0.290			Flowering branch.
	2	1.995			
	3	0.815	1.033	1 : 1	
	4	0.685			Excluded because of unusual size.
	5	1.805			
	6	3.110			
	7	1.340	2.085	1 : 2.70	

In the common basswood (*Tilia americana*) the leaves present variations in form which are confined within such a narrow range as to offer nothing of an exceptional character : while variations in size are not only of such an exceptional character as to excite comment, but they occur with great frequency and, in this region at least, constitute a well defined feature of the tree under different conditions of growth and in different situations. Individual trees will show a somewhat uniform development of leaves with a diameter of about 8.5 cm., and a superficial area of about 55 sq. cm. Other trees—and perhaps more generally—show such leaves in part, together with others about 11 cm. in diameter and with an area

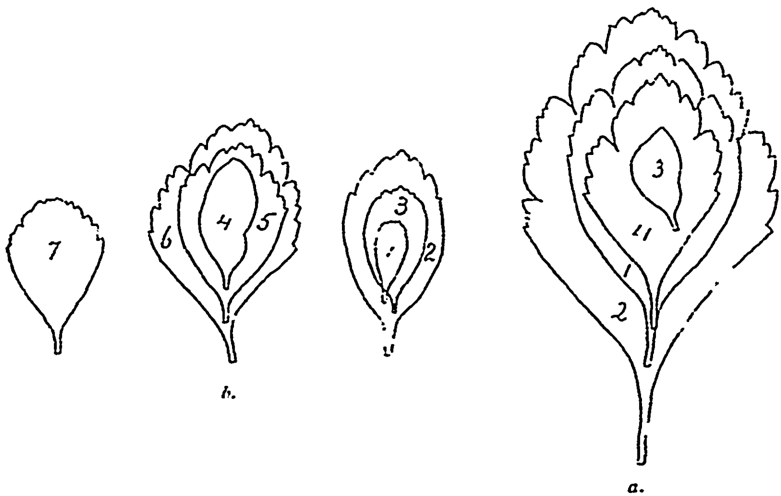


FIG. 7. SPIRÆA TRILOBATA VANHOUTTEI. *a.* Leaves from a normal vegetative shoot of the season. *b.* Leaves from a flowering branch: 1-3 developed during the period of inflorescence: 4-7 developed on lateral shoots of the flowering axis after the inflorescence had passed. x ½

of about 94 sq. cm. This latter may be taken as the typical size of the leaf for this region. But the same tree commonly produces leaves of yet larger size on the more vigorous shoots, especially the short branches arising from the main trunk where they get an excess of nutrition. Such leaves not uncommonly attain a breadth of 20 cm., and an area of 276 sq. cm. It is obvious then, that under ordinary conditions of growth in a good soil, the foliage varies somewhat widely, though the general type conforms to that of the second example.

In the woodlands of this district, the linden forms a somewhat abundant undergrowth through the development of suckers of very vigorous growth. In all such cases, the foliage is unusually large, being of the general type of the third example, and therefore conforming to the largest leaves found upon nature trees. When such young growths are much pruned, or when they arise from old stumps, the plant acquires a relatively very extensive root system which supplies it with an unusual amount of food materials. Under such circumstances the foliage is always larger than common, and reaches a maximum diameter of 24 cm. with an area 491 sq. cm. While it is obvious that the primary cause of this very wide variation is due to great vigor in growth as induced by highly favorable conditions of nutrition, it is no doubt influenced by the shade in which such plants grow in most cases. The general result, however, is to produce leaves, the extreme variation in which is in the ratio of 1 : 8.90; while the ratio of the average leaf to the extreme of development on undershrubs is as 1 : 5.24. A recapitulation of these facts would give the following:—

TILIA AMERICANA.

Comparative leaf areas.

No.	Area in sq. cm	Ratio of areas.	Remarks.
1	55.18	1:0.58	
2	93.75	1:1	Leaf of average size for most trees taken as unity.
3	276.47	:12.94	The largest foliage of mature trees.
4	491.25	1:5.24	The largest foliage of undershrubs.
Extreme variation		1:8.90	

We may now consider the foregoing facts in relation to their bearing upon palæontological evidence, and ascertain if possible, the causes for such variations.

Prof. Ward says: "It is a fact well known to botanists that, in oaks and many other trees, only the leaves on fruit bearing branches can be depended upon for determination of species," (*op. cit.* 41). While this is no doubt true in particular cases, it would be unfortunate were it to be adopted as a working rule of general application, since noteworthy instances of frequent occurrence readily suggest themselves to one as affording evidence in direct opposition to such a view, and the examples now under consideration are of that nature. In the case of Spiræa, the leaves arising upon the fertile branches are always greatly reduced in size and much altered in form Their average area is less than one-fifth that of leaves on normal, vegetative shoots. Such depauperate leaves do not find a place in the diagnosis of the species, but the latter rests upon a description of the larger forms occurring upon the non-flowering branch—forms which are in general, common to the plant as a whole, and which arise only after the period of inflorescence is well advanced or even completed, as also during a time when there is great activity in the formation of new shoots. The cause of the reduced leaves on flowering shoots is obviously to be referred to relatively defective nutrition, or, to put it in another form, to a diversion of energy and its concentration upon the reproductive process, what Goebel would describe as a survival of juvenile forms, representing arrest of development through correlation[1] with reproductive shoots. This is apparent not only through a comparison with vegetative branches, but by reason of the greatly reduced size and ephemeral character of the flowering branches which shortly disappear through a process of natural pruning; while it is further substantiated by the fact that as soon as the fruit is formed, and the energy thus employed has been liberated, the same branch gives rise to relatively vigorous branchlets with larger and more normal leaves, and the whole plant enters upon a period of most vigorous growth. In this we have a simple expression of a widely exhibited and well known law.

In Lonicera the case is somewhat different. There the variation of foliage is of a much more striking character; it does not arise periodically as in Spiraea but sporadically; the forms are more extreme and the variation does not depend so much upon conditions of inflorescence, since the reduced forms of the leaf and the normal forms are found about equally associated with the production of flowers. It has been shown that in the case of this plant, essentially three types of foliage have been produced, and that the reduced forms were found exclusively upon each of two individuals which, chiefly through pruning, were much inferior in stature to their neighbors. Here it is not possible to refer the alteration of form and size to the well known effects of light and

1. Organography, 55 and 143.

shade, since it has been found that in a plant growing in relative shade, the leaves were reduced to less than one-third the average, normal size. On the other hand, strongly vegetative shoots were found to bear leaves which were not only conspicuous for their alteration of form, but notable for being 2½ times larger than the normal and *eight times* larger than the reduced leaves of the same plant growing under the same general conditions of illumination. But here again we have an exception to the usual law of development, since these leaves were directly exposed, and their entire course of development was under the influence of sunlight which served in no way to inhibit their growth. It is clear then, that we cannot find an adequate explanation for such variations, either in diversion or energy incident to the reproductive period, o- in the adaptation of the leaf to conditions of illumination of which they seen to have been wholly independent. It will be recalled that these shrubs were top pruned in the spring of 1093. During the following summer they made but moderate growth which was chiefly manifested in the development of numerous, wiry side branches. The plants therefore enjoyed a period of comparative rest, during which there was no doubt a considerable accumulation or energy in the form of reserve food stored within the tissues. The somewhat more than usually favorable conditions for growth, prevalent during the past summer, formed a very happy combination of circumstances and permitted a liberation of the accumulated energy as expressed in shoots of remarkable size, and foliage of unusual form and dimensions. The abnormally large leaves, therefore, may be held to be the expression of unusually vigorous vegetation independently of conditions of light and shade; while the reduced leaves constitute an expression of diminished vigor as first manifested in the weakly branches. This explanation therefore finds justification in certain facts of much significance. (1) The reduced leaves are invariably produced upon small wiry branches indicative of poor nutrition: (2) the most vigorous shoots arise from pruned branches, often close to the point of excision where there would be likely to be an unusual deposit of food materials;

(3) essentially the same relations are manifested in Spiraea; (4) shrubs which had not been top-pruned in 1903, exhibited no special phenomena of growth in 1904, apart from the somewhat general luxuriance common to all trees and shrubs. Finally, the reduced leaves of Lonicera are to be regarded as juvenile forms which have been restored under special conditions of growth, and such reversion has been accomplished through correlation, in opposition to the influence of light, which, acting by itself, would tend to produce the opposite result as Goebel has shown in the case of *Campanula rotundifolia* in particular.[1]

In such types as Weigela, Hydrangea, *Berberis thunbergii*, and *B. vulgaris*, Euonymus, *Ampelopsis quinquefolia*, various species of Vitis, *Shepherdia canadensis*, *Syringa vulgaris* and many others which will readily occur to one, there is no essential variation in the mature foliage, as between the vegetative and the reproductive shoots, but all conform to one type, within certain narrow limits. In *Celastrus articulatus* there is a more or less well defined variation of leaves which places some of them distinctly beyond the type form, but such variation is not in any special sense distinctive of either the vegetative or the reproductive shoots, and these instances serve to enforce the idea that the foliage of the reproductive shoot cannot be taken even generally, as affording the real basis for type forms.

It has been noted that special variations of form and size of leaf often arise upon the same branch or under special conditions of growth. Thus in *Lonicera tartarica* (Fig. 4 : 1-12), it appears that in four sets of leaves, the lowest of each series (1, 4, 7, 10) is always the smallest and deviates most widely from the type, the same rule holding true of the lowest member of the series as a whole (1). This relation was found to be true of a shrub greatly modified by pruning and conditions of nutrition. But the same rule holds true to a more limited extent in a shrub which only partially expresses the effects of such conditions. (Fig. 5 : 1 and 8). In the case of normally developed branches, however, (Fig. 2 : 1-7) this rule does not

1. Organography, 242, 243.

apply, for we there find the lowest member of the series (1) to be the largest, and the others successively smaller. The same law is fully applicable to Spiraea in which the modified leaves always become simplified in form as well as reduced in size, while in Lonicera they are reduced in size without any special simplification. Now in accordance with our present views respecting the evolution of leaves, such simplification of form and such reduction in area, must be regarded as of the nature of reversions to more primitive types, as is so well exemplified in Nephrolepis, from which we may conclude that the Lonicera, which is chiefly distinguished by reduced foliage, is essentially a primitive form of the plant, and the same may also be said of the flowering branches of Spiraea. Such a view would harmonize with our knowledge of the general effects of defective nutrition, a view which otherwise gains force from the fact that the most highly developed foliage of Lonicera on shoots of unusual growth, is obviously the direct product of exceptionally favorable conditions of which ample nutrition must be regarded as one, if not the dominant factor. In these facts, then, we have a means of determining at least some of the developmental stages through which the leaves must have passed.

Instances will readily recur to one, of trees like the common basswood (*Tilia americana*), and the linden (*Tilia europea*) in which there is such constancy in the character of the foliage that, were the leaves to be found entirely apart from the tree, it would nevertheless be possible to determine the genus beyond all reasonable doubt, and even the species might be ascertained with reasonable certainty. The same would hold true of Hydrangea, Berberis, Catalpa, Syringa, Philadelphus and many others. There would be considerable doubt, however, in such a case as that of *Celastrus articulatus*, while there would be positive uncertainty as between the leaves of the young plant and those of the mature stem in *Ampelopsis veitchii*, the mature leaves of *Spiraea trilobata van houttei* and much more in that of *Lonicera tartarica*. In *Ampelopsis veitchii* and *Spiraea van houttei* it would be quite possible in accordance with palaeontological methods, to make two valid species, while in Lonicera there would be at least three possible species from the same plant. To test the impression likely to be made upon a wholly unbiassed mind, the branches of Lonicera representing four specimens, as in the figures 2-5, were placed upon the table side by side and a student who is a keen observer, was asked to give his opinion as to their specific relations. He unhesitatingly answered that certainly three, and probably all four were distinct species, while as a matter of fact they represented only three plants of the same species. It is quite obvious, therefore, that we have here cases which are to some extent the counterparts of what is presented by Liriodendron, respecting which Berry has observed that "When we look over these leaves, it is with difficulty that we can believe they belong to but one species; were they found as fossils they would undoubtedly be referred to as many different species as there are leaves." (op. cit., 37). It is obvious then, that if we are to continue the identification of species by leaves alone, we must, as already pointed out by Holm (op. cit., 312), have recourse to direct comparison with the leaves of existing species if even approximate accuracy is desired. Even under such conditions, however, there will still remain a very large and undesirable margin of error which, however valuable the specific references may be for purposes of identification and comparison, and however important such data may be for stratigraphical purposes, they after all possess but limited value—and in many cases no value at all—for the scientific botanist who sees in plant remains the one means of tracing the phylogeny of existing forms and thus, eventually, of establishing the true geological succession of the innumerable forms which have led to our present flora. If such studies possess any significance, they do serve to emphasize the great importance of giving a secondary place to those leaf remains which have heretofore claimed superior notice because of their prominence among fossil forms and their attractive appearance: while on the other hand they bring into strong relief the necessity of concentrating our attention upon the less attractive fragments of stem, the internal structure of which is certain to reward the diligent and competent student with evidence of the highest value; and it is probably safe to assert that the palæobotanist of the future will devote his attention more exclusively to the latter source of evidence, utilizing the former only so far as it may prove serviceable for purposes of confirmation.

My attention has been directed recently, to another example of leaf variation which not only serves to emphasize the conclusions already reached in several important respects, but it is remarkable and of more than usual scientific interest because it affords direct and positive proof as to the nature of certain structural alterations and the conditions under which they arise; while it also exhibits a completion of such changes within so short a period as to make the entire history one of easy record.

About five years ago a somewhat remarkable sport was developed in the conservatories of the F. R. Pierson Company, at Tarrytown-on-Hudson, from the well known, so-called Boston fern, *Nephrolepis exaltata*. This sport showed such unusual characteristics and gave promise of such possibilities, that careful cultivation followed with the production of what is now known as Pierson's fern. In 1902 this plant was exhibited at the March show of the Massachusetts Horticultural Society, and received an award of the Gold Medal as being "by far the most important and remarkable plant that has been shown before this Society for many years."[1] This verdict is fully sustained by the plant, which possesses a decorative effect of the highest value; but as we are now concerned with its scientific aspects, such considerations must be left to the horticulturist.

From information kindly supplied by the F. R. Pierson Company, it seems that this plant developed abruptly among a large number of plants of *Nephrolepis exaltata* which were being grown for commercial purposes. It did not result from unusual conditions of nourishment and care immediately succeeding a period of arrested development, nor was it the product of any other unusual conditions of environment. It

1. Trans. Mass. Hort. Soc., 1902, Part II, 145, 160.

originated as a sport under such conditions of superior care and abundant nourishment as are generally found necessary to the best growth of the plant. The chances that such a change might have arisen under natural conditions in the wild state, are possible but remote, and the present case is therefore to be taken as an exaggerated expression—an abrupt and strongly marked development—of those alterations which undoubtedly occur in the wild state, but often so gradually or at such remote intervals, as to come under observation only under the most favorable conditions of time and space. It is nevertheless exactly in harmony with recognized alterations under changed environment, such as Goessmann has long since recorded when the wild grape is brought under cultivation, or such as Bailey has frequently directed attention to as arising under cultivation, and such as are well known in botanic gardens.

The special feature of the Pierson fern is manifested in the doubling of the frond, whereby the whole organ acquires a most graceful, plume-like character. Normally the frond of the specific form is once pinnate and upwards of 1.3 m. long; but it is a characteristic of the plant that the fronds are capable of indefinite extension from their tips, a feature which is also manifested in Pierson's variety. The pinnae of the species

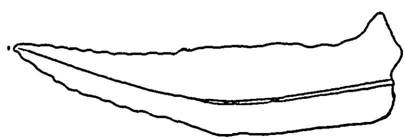


FIG. 8. NEPHROLEPIS EXALTATA PIERSONI. Normal pinna showing auricle on the upper side. x $\frac{1}{1}$

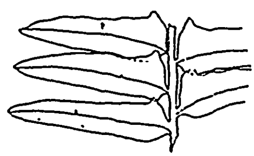


FIG 9. NEPHROLEPIS EXALTATA PIERSONI. Pinnate pinna showing the pinnules to duplicate the pinnae. x $\frac{1}{1}$

are lanceolate, upwards of 8 cm. long and auricled on the upper side. (Fig. 8.) This auricle, as will appear shortly, is a potential pinnule which it may become under favorable conditions. But here again, the indeterminate character which belongs to the unmodified frond as a whole, and not to the separate pinnae, is extended, in the variety, to each one of the pinnae. In a plant of moderate size the modified pinnae attain a breadth of 6.5 cm., and a length of 14 cm., but this latter dimension may vary very much, since it is capable of extension under the circumstances already related.

The peculiar feature of Pierson's fern is to be found in the remarkable alteration affected in the pinnae, whereby the frond becomes twice pinnate. In a fully modified pinna, there may be as many as 50 pinnules which exactly reproduce the characteristics of the pinna from which they have come, even to the auricled base. (Fig. 9.) Such pinnules have a maximum length of 3.2 cm., and a width of 7 mm. It is to be observed, however, that the transformation is not always complete, and that within the limits of individual fronds, or as between different fronds, all stages of transition may be noted. This is first expressed in the fact that from the same rhizome, normal and modified fronds will be produced, the latter being dominant and giving the prevailing character to the plant. But even in the normal fronds, there is nevertheless a well defined tendency to variation as expressed in those of most vigorous growth, whereby the normally crenate margin becomes more deeply indented on the lower side, and the leaflets become lobed or even pinnatifid. (Fig. 10.) When the transformation is completed, each pinna is again completely pinnate toward the apex (Fig. 9) remaining simple or pinnatifid only, in the region of its base, and it is this combination of features which gives to the frond as a whole, its remarkably beautiful aspect. Thus I find that even in the most fully developed modification, the base of each pinna is either unmodified or lobed or pinnatifid for a distance of upwards of 1.5 cm. (Fig. 10 and 11.) In most cases the auricle of the pinna undergoes no alteration, but occasionally it enlarges, chiefly by elongation, and assumes the aspect of a definite pinnule. (Fig. 11.) In this we undoubtedly have an expression of a tendency toward complete doubling of the organ. Wherever the energy of growth is diminished, there the pinnules become confluent and eventually pass by gradual stages, into the condition of normal, simple pinnae.

A question naturally arises in this connection. Does this alteration of external form involve definite structural variations, or is it simply a case of distribution in space? An examination of the normal pinna shows that its length bears the relation to the length of the modified pinna, of 1:1.75. In the normal pinnae the veinlets number 8 per centimetre, and they therefore have an average interval of 1.25 mm. In the modified pinnae, on the other hand, the midribs of the pinnules which are, of course, the anatomical equivalents of the veinlets in the normal pinnae, number 1.66 per centimetre, and they are therefore seperated by an average interval of 6.03 mm. We discover from this that in undergoing alteration, the veinlets of the normal pinnae have become separated in the pinnules in the ratio of 1:4.80. Such a relation at first suggests a simple extension of parts, but while the veinlets become separated by an interval nearly five times greater than normal, the corresponding alteration in longitudinal dimensions of the pinna, in its transformation into the compound form, shows an increase of only three-fourths of the original dimensions. It is therefore obvious that the change has involved an actual obliteration of parts to the extent of one-fourth of the vascular structure as represented in the original veinlets.

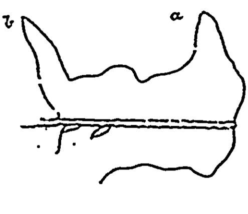


Fig. 10. NEPHROLEPIS EXALTATA PIERSONI. Base of compound pinna showing at *a* the somewhat enlarged auricle, at *b* the first pinnule, and between on both sides, the potential pinnules as exhibited in the lobes. x ½

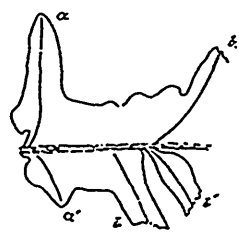


Fig. 11. NEPHROLEPIS EXALTATA PIERSONI. Base of a compound pinna showing at *a* the first pinnule with a corresponding development at *a'* *bb* the first pinnules and *b'* the first free pinnule. x ½

We now come to the relation which these changes in external form bear to the reproductive process. This plant is said to become modified only with respect to its sterile fronds, which is substantially the same as saying that the variety cannot be reproduced through spores since we must recognize that except for varia tion of degree, the same differences exist between members of an individual, as between different individuals, and we may correctly assume that spores which are produced only on unmodified fronds will be incapable of reproducing the characteristics of the modified frond. This is borne out by the observed fact that propagation depends entirely upon runners which are developed very freely, and through which the plant multiplies with great readiness. I find, however, that the above statement requires some modification, since it is not true in the strict sense.

An examination of a plant which was selected at random, shows that while fruit is produced on the unmodified fronds in the usual way, this capacity also extends to transitional forms where the tendency to modification is as yet but feebly expressed. But more than this, I have found that completely modified fronds also bear fruit. The specimens under observation are too immature to determine what perfection such fruit might attain in all cases, but that which is produced at the base of the pinnae is spore bearing, and from this the inference might be justified, that even the pinnules are productive of spores. We are therefore compelled to recognize the fact that while the modification of the frond is attended by sterilization, this is not complete, and it is probably of the nature of a temporary loss of functional power which may be restored as the variety becomes more firmly established. Fortunately we are able to avail ourselves of information which has an important bearing upon the correct solution of this question. A similar variety of the Boston fern has recently been produced by Mr. L. H. Foster whose name it bears. This fern, however, is characterized by the fact that the modified fronds *do bear* spores, though the plant does not exhibit that luxuriance of growth which is so marked a feature in Pierson's fern.

It is quite clear that transformations of the nature represented by Nephrolepis must have the same bearing upon palaeontological evidence as in the previous cases; but this plant is of scientific interest in another and far more important sense, and we are led to ask, what significance have these facts from the standpoint of evolution?

The various transformations which we have studied in Nephrolepis afford direct and positive proof of the origin of compound leaves by modification of the simple, primary form as stated by Goebel,[1] who illustrates the general course of development by the very striking variations exhibited in *Anadendrum medium*; and by Ward, who has shown that such a course of development is also exhibited in fossil forms. But Goebel directs attention to the general effect of light and shade which operate in such wise that conditions of shade always tend to the development of rounded and simplified, juvenile forms, so that the effect of light would be to reduce the area with a tendency to splitting up or compounding.[2] This is exactly in accord with the changes in Nephrolepis piersoni and the conditions under which such changes arise, since it is found that it demands for its best development, an abundance of light.

The compounding of the leaf in Pierson's fern, being in itself an expression of highly developed vegetative powers, is intimately associated with other changes of a no less striking and significant character. The almost complete obliteration of the sporogenous tissue, and hence obliteration of the usual reproductive function which survives mainly in unmodified parts, is in precise accord with Bower's theory respecting the origin of the sporophyte, and it is to be attributed to "correlation" with the assimilative tissue. But as already seen, Pierson's fern does show a tendency to the formation of sporogenous tissue even on completely transformed parts, thus indicating that with greater stability in the variety, it becomes possible for this reproductive tissue to be reestablished. This is made clear in the case of Foster's fern, in the fact that the sporogenous tissue not only persists from the first, but that the plant shows a corresponding diminution in size; so that as between the two forms, it comes to be a simple case of relative arrest through correlation. We may therefore expect to find that these two plants exhibit different degrees of stability with respect to their special forms, and such differences do exist to

1. Organography, 158.
2. Ibid. 242.

some extent. Thus in Foster's fern, where there is a relatively low vegetative power with the free formation of spores, there is no special tendency to reversion and the form is apparently well fixed. Unfortunately we have no evidence as to the perpetuation of the sport through the medium of spores, since no attempt has yet been made to propagate the variety in that way, and it is therefore impossible to say if the character is so far fixed as to define a new species. In Pierson's fern, where the vegetative powers are relatively in excess, there is a great want of stability with a constant tendency to reversion. This is expressed in the production of normal fronds, as also in the development of fronds showing all degrees of transitional alteration, and in the very limited extent to which spores are produced on the modified fronds. Finally, it is altogether probable that in these examples we have instances illustrative of the theory of Mutation as formulated by De Vries, giving us a fairly clear conception of the general conditions under which such mutation may arise ; but the evidence falls short of a complete demonstration with respect to the transmission of characters through the reproductive process, and we are therefore unable as yet, to define either of these ferns as a species, although they may eventually prove to be such when proper experiments are made in the germination of the spores.

Along the British Pacific Cable.

Otto Klotz.

On the 31st day of December, 1900, articles of contract were made by Her Majesty's Government, Canada, New South Wales, Victoria, New Zealand and Queensland on the one part, and the Telegraph Construction and Maintenance Company on the other, for the construction and laying of the Pacific Cable. The contract called for the completion of the whole cable on or before 31st December, 1902. The cable was finished two months earlier and after undergoing the required test of a month, entered upon its commercial career on December 8th, 1902. Thus was the project, that had been advocated with persistence from some quarters for a quarter of a century, made an accomplished fact. The missing link of about 8000 miles across the Pacific between Canada and Australia, in the world's metallic girdle, was now supplied. Before the cable was laid a survey was made of the route and the character of the ocean bed was examined.

From the survey the number of miles (nautical) of cable required for the different sections was found to be as follows:

From Vancouver Island to Fanning Island	3654
" Fanning Island to Suva, Fiji........	2181
" Suva to Norfolk Island............	1019
" Norfolk to Queensland (Moreton Bay)	906
" From Norfolk to New Zealand.....	513

The first section of the cable is about a thousand miles longer than any that had been laid before. This necessitated a considerable increase in copper for the conductor and in gutta percha for the dielectric. The working speed of a submarine telegraph cable depends on, and is inversely proportional to, the product of the total resistance of the conductor multiplied by the total electro-static capacity of the core, so that, other things being equal, the speed varies inversely as the square of the length of the cable. In the long section there were used 600 lbs. of copper and 340 lbs. of gutta percha per nautical mile. On the Fanning-Suva section 220 lbs. of copper and 180 lbs. of gutta percha; and on the remaining three sections the copper and dielectric were in equal proportions of 130 lbs. each.

In the neighborhood of Fiji at a depth of 2500 fathoms, a temperature of 34.1° Fahrenheit was noted, being the lowest temperature taken during the survey. There is very little difference in the temperature of the ocean at great depths, say below 3000 fathoms, over a great extent of the earth's surface, the temperature being only a few degrees above the freezing point, or 32° Fahrenheit. The greatest depth, 3070 fathoms, about three and a half miles, was found on the Fiji-Fanning section, where the bottom specimens consisted principally of radiolarian ooze. This ooze is found at the greatest depths, and was obtained by the Challenger's deepest sounding in 4475 fathoms. The United States steamer Nero sounded in 5269 fathoms, 6 miles (this last being the deepest sounding recorded in the ocean), and the material brought from the bottom was radiolarian ooze. Of the 597 samples of sea bottom obtained on the Pacific Cable survey, 497 were such that they could be divided into distinct types of deposits It was found that

294	samples	referred to	globigerina ooze[1]
65	"	"	red clay
43	"	"	radiolarian ooze
45	"	"	coral mud or sand
27	"	"	pteropod ooze
12	"	"	blue or green muds
11	"	"	organic mud or clay.

The pressure at a depth of 3000 fathoms, in which a considerable portion of the Pacific Cable is laid, is about four tons to the square inch. When the cable is being laid at such depths, it will be approximately twenty miles astern of the ship before it touches the bottom.

Deep sea cables last longer in the tropics than in the northern oceans. The reason is to be found in the fact that in the tropics marine life, from which globigerina ooze is derived,

1. Report by Sir John Murray.

is more abundant than in the more northerly or southerly waters. It is the sun and the warmed surface water that call into life these countless globigerina, which live for a short space, then die and fall to the bottom like dust, making such a good bed for the cable to rest in. In the arctic currents, where the surface is cold, the water does not teem with life in the same way as it does in the tropics, and consequently there is less deposit on the bottom of the ocean.

A submarine cable consists, first, of a core, which comprises the conductor, made of a strand of copper wires, or of a central heavy wire surrounded by copper strips as in the Pacific cable, and the insulating covering, generally made of gutta percha, occasionally of india rubber, to prevent the escape of electricity. As far as cabling is concerned, this is really all that is necessary, an insulated conductor. This, however, would not, in the first place, be sufficiently heavy to lay in the ocean, and, secondly, would be too easily injured and destroyed by the many vicissitudes to which it would be subjected. For this reason, a protection in the form of a sheathing of iron or steel wires surrounds the core; the nature, size, and weight of the sheathing being dependent upon the depth of the water and kind of ground over which it has to be laid. The deep sea section, being the best protected from all disturbing influences outside of displacement of the earth's crust by earthquakes or volcanic action, is naturally the one of smallest dimensions; and for the shore end, which is exposed to the action of the waves, to driftwood, to the grinding of ice in the more northerly latitudes, and to the danger of anchorage, especially of fishing boats, the sheathing must be very heavy. So that while the deep sea cable is somewhat less than an inch in diameter, that for the shore ends is nearly 2½ inches in diameter The action of the waves is limited to a depth of only about 13 fathoms, so that their influence on the cable, manifested by wear and chafing, is confined to the shore end.

The Pacific Cable is equipped with the most modern apparatus at the various stations, and the cable is worked duplex, that is, messages are sent and received on the same cable at the same time.

Immediately upon completion—Oct. 31, 1902—of the British Pacific Cable, Canada made preparations to extend her longitude determinations, which had been carried from Greenwich to Vancouver across the Pacific, thereby making with the longitude carried eastward via. Madras, a continuous longitude circuit round the world. The writer was placed in charge of the work and with him was associated Mr. F. W. O. Werry, B. A. Each observer was provided with similar astronomic outfits, and at each station occupied, a brick or cement pier was built and a small observatory erected. Mr. Werry occupied Fanning and Norfolk inlands, and the writer Vancouver; Suva, Fiji; Southport, Brisbane and Sydney, Australia; Doubtless Bay ard Wellington, New Zealand.

Every night during the campaign the observers compared their clocks over the cable. The comparison was made with an accuracy of two thousandths of a second. By this comparison is measured too the time it takes for a signal to travel over the cable. This of course varies with the distance. On the longest section, over four thousand statute miles, it took thirty-four hundredths of a second, or say a third of a second from the minute a clock ticked at one end, until it recorded in ink that tick at the other end. The following table is self-explanatory.

Section.	Length of cable laid. Naut. miles.	Pounds of copper and gutta percha per naut. mile	Electro-motive force. Volts.	Resistance per naut. mile. Ohmes	Transmissions Sec. Time.	Rate per second. Statute miles.
Bamfield—Fanning	3457.8	600 340	50	2.03	s .3422	11.600
Fanning—Suva	2043.1	220 180	55	5.54	.2807	8.400
Suva—Norfolk	981.5	130 130	30	9.35	.1401	8.000
Norfolk—Southport	836.7	130 130	30	9.35	.1016	9.800
Norfolk—Doubtless Bay	518.7	130 130	10	9.35	.0528	11.300

The comparison of the clocks combined with the clock correction determined by each observer from tourist observations on stars, gives the difference of longitude between the two stations. The result is, however, invested with a correction due to the difference in nervous temperament or constitution, technically known as the personal equation of the two observers. To ascertain this quantity, although only a fractional part of a second, special observations are taken for determining the same. The observer with sluggish temperament puts a place too far west; to him the stars do not transmit over the threads in the telescope until they are actually past. On the other hand, the nervous susceptibilities of another man may be so constituted that the observer anticipates an event, imagines the star to be on the thread when in fact it has not reached there, and thereby observes as if he were in reality to the east of his true position by a quantity equal to his personal equation. The work was begun in March 1903 and completed at Sydney Australia in January 1904. The first mutually satisfactory exchange of clock signals between the cable station at Southport, near Brisbane, and Norfolk island cable station and Sydney, was had on September 28th, 1903, so that that day may be considered as the one on which for the first time the earth was girdled astronomically.

On the way to the Fiji Islands a visit was paid to the Hawaiian islands, but it is unnecessary to dilate on their charm, yet it is not all charm and constant blue sky. With Nature it is as Schiller says of man: "Des Lebens ungemischte Freude ward keinem Irdischen zu Theil." A plant originally introduced for ornamental purposes in Honolulu has now spread over the islands and has proved such a curse that the government is doing its utmost for its extermination. It is the lantana.

In Hawaii we received the first Polynesian greeting—the melodious ALOHA, the word being equivalent to our "welcome" or "good-day," but literally meaning "Love to you." The preponderance of vowels in this word as well as in all Polynesian words, gives the language a softness foreign to those of Teutonic root.

I arrived in Fiji in May, which is one of the autumn months in the southern hemisphere. My first impression was that I had landed in a hot-house—the oppressive, warm, moisture-laden atmosphere, where one smells the soil and the rank vegetation, almost overcame me. I began to perspire, and in six weeks lost 20 pounds—that is, in weight. As my coming had been cabled, quarters had been secured for me. Immediately the first night I saw big things, like birds, flying about my domicile. I asked what they were,—cockroaches were the answer. However, I had no fear, as I was too heavy to be carried away. When I was about retiring in a bed canopied with mosquito netting, I saw a spider fully six inches across on the netting. I promptly took aim and killed the arachnid. In the morning I informed the landlady of the incident. She thereupon told me I had done wrong, saying it was not only a harmless creature but useful for eating mosquitoes. The next discovery I made was that my leather boots which were black the night before, were now green—covered with mould, a small herbarium of the lower vegetable organisms. There is some compensation, however, for the common scarlet hisbiscus flower and the leaves of the same shrub are very efficacious for blacking boots. Of course I had to discard my tweed suit, and donned the white flannel coat and trousers I had brought with me, but these also were too warm for one born and brought up where the Great Bear rides high in the heavens. So I provided myself with white cotton garments. There was too much of the *al fresco* in the native costume for me—I wasn't a Fijian.

I was surprised to find that among the white people there (and there are not many), those who indulge in liquor, almost invariably drank Scotch and soda. Upon expressing my astonishment that under a tropical sun, ardent spirits were used in preference to beer or wine, I was told the latter affected the liver; this same explanation was given later too in Australia and in India. Not knowing whether I have a liver or not I can not personally corroborate the theory.

My next experience was when I set up my instrument and gazed in the southern sky. The good old Pole-Star that had kept me straight, or as the astronomer would say, had given me my azimuth these many years, had long sunk in the sea, and in my march to these shores other stars had risen from the southern horizon. The Southern Cross was now with us, but it was not conspicuous. Ninety nine out of a hundred persons must be shown the Cross before they recognize it. Its a poor constellation beside our Dipper or Great Bear. The fact that the ancients did not recognize the Cross as a separate constellation, but included it in Centaur, shows that it is not very conspicuous. The people of the southern hemisphere can boast, however, of having the star nearest the earth, the bright star in Centaur. To give an idea how near it is, let us imagine it to be peopled and that the people can see things going on on the earth, then they would now be seeing the last stages of the Boer war, soldiers moving about South Africa, for the light takes over four years to travel from the earth to Alpha Centauri. Two other phenomena of the southern sky may be referred to, viz: the Coal Sacks and Magellanic Clouds. The first are dark spots in the heavens resembling small black clouds, and are due to the absence (to the naked eye) of stars. Especially one of them is well marked, but the casual observer on a clear night, would not have his attention arrested to infer its true meaning, just as the Magellanic Clouds are in reality a galaxy of stars, appearing as two fleecy, white, drifting terrestrial clouds.

The two large islands, Viti Levu and Vanna Levu, of the Fiji group are quite mountainous, and have extinct volcanoes. These mountains effect the climatic conditions materially. The prevailing winds being the South East Trades, it follows that the southeastern sides of the islands are wet, and the opposite side comparatively dry. The former is clothed with woods and rank vegetation while the latter is more of an open and grass country. The most fertile island of the group is Tavinni, the richness or fertility being due to the vulcanic soil, reminding one of Hawaii.

It is almost impossible to make a botanical collection in Fiji. In the first place so many of the specimens are of gigantic size, and in the second place, even if preserved, they would be sure to turn mouldy. My experience was that of others.

Along the roadside (Suva) many red flowers are seen, reminding one of our clover, for the resemblance is very strong. The plant that bears them is a thorny vine—the sensitive plant, which when touched closes or folds its small leaves.

Commercially the principal products of Fiji are sugar, copra (dried cocoa-nut) and green fruit (bananas, pine-apples, etc). One might be tempted to say that everything grows or will grow in Fiji on account of the richness of the soil, ample moisture and warmth. But this is not the case. Its very exuberance and fertility, and want of seasons of rest for nature's work, are incompatible with the successful growth of grapes, apples, raspberries, strawberries, tomatoes, potatoes and other of our common and valued products. Prodigal as nature is in the tropics, it is the temperate zone that products the staff of life.

I was interested in a visit paid to a plantation where were grown the vanilla bean, turmeric, allspice, coffee, tea, cacao (from which chocolate is made), the cocaine plant, cotton, pepper, pine-apples and ginger. It may be remarked that the vanilla plant belongs to the orchids, and is trained or grown on cotton trees planted for the purpose. Another peculiar thing about the plant is that the flowers are not self-fertilizing, and the fertilization is done by hand. Whether the introduction of bees would obviate this manual labor, I am not prepared to say. The vanilla bean when pulled from the plant, would readily pass for our long green vegetable bean. At this stage it is wholly devoid of aroma. This is only developed in the kilns and by a sweating process, when the alkaloid vanillin is produced.

The South Sea Islanders are essentially vegetarians, although fish form an important part of their diet too. The hunt furnishes them nothing but the wild pigeon and the duck. There is no other game or wild animal. The principal food of the Fijian is the yam, a big root something like our mangle, as a rule though far larger. The next vegetable mostly eaten is the taro, which belongs to the Arum family, and is grown on very wet ground. Probably the finest tree in the South Seas is the bread-fruit tree with its large, glossy, indented, bright-green leaves. It will be remembered that the mission of the ill-fated ship "Bounty," Captain Bligh, whose crew mutinied (1789), was to gather bread-fruit trees for transplanting to the West Indies. The bread-fruit is green, its surface prettily marked, and in shape it resembles a Rugby football, but is not so large. These three vegetables—the yam, the taro, and the bread-fruit may best be described as taking the place of our potato.

We all delight in a piece of coral, its delicate form, its infinite variety of design, but when one has been among the living coral, in the riotous marine flower garden, where the most resplendent colors vie with each other and revel in their warm bath, then the corals of our drawing-rooms appear in their true light, as skeletons, dead things, bereft of their pristine beauty. A visit to a coral reef, resting midst those exquisite blue blue waters at low tide, is one of the greatest charms that the South Sea has to offer. The varied life seen, the intensely rich colors displayed, enchant one. The coral reef is to the naturalist an El Dorado, to the navigator a bête noir.

Another article of commerce is the *bêche de mer* or *trepang*, which may be seen at Suva by the ton in its dried or commercial stage. It is a sea-slug about as thick as the wrist and nearly a foot long. It is one of the greatest delicacies of the Chinese epicure, and no dinner amongst the *bon ton* in China is considered complete without soup of the *bêche de mer*. It is said to take a week to cook. Dinner orders must be given rather early.

The South Sea Islanders, especially the Samoans and Tongans, are cleanly in their persons. The Polynesians, after their daily bath, generally rub themselves with scented cocoanut oil. Formerly sandalwood, which was abundant, served the purpose of perfume by grating it on coral. Now, sweet-smelling flowers are used. Many a time in the early evening was I made aware of my approach to the Samoan quarters by the fragrance borne on the balmy air. Undoubtedly these people of the coral strand are far cleaner than the average white man.

Many months were spent on the coral-ribbed islands, resting in these fascinating waters of the South Seas, where the natives dream life away, oblivious of the "strenuous life" we have invented. There astronomy and time reckoning are based on no solstices or equinoxes, but simply on the yam, their staple food.

From Fiji I sailed for Queensland, Australia, passing *en route* New Caledonia, known as a French penal colony and for its large deposits of nickel.

In Australia, the land of sunshine and drought, of gold and sheep, of eucalypti and rabbits, of kangaroos and emu, of possibilities and development, of inverted nature, the astronomer finds a transparent sky. In the land of the Maori—New Zealand—across the ever-restless Tasman Sea, the element from the antarctic and tropics struggle with each other for supremacy to the detriment of the star-gazer.

Hitherto the basal longitude for both Australia and New Zealand had been brought eastward from Greenwich the international zero meridian, via Madras and Signapore, so that joining that circuit at Sydney to the one across the Pacific completed the first astronomic girdle of the world, and furthermore showed how well the astronomer could proceed step by step, ever determing his distance from Greenwich, until he met his fellow astronomer (at Sydney) coming from the opposite direction, and question his position on the earth. The supreme moment had arrived. Is the east longitude of the one the complement of the west longitude of the other? Does the girdle they have made fit, or is it too small or too large? Thousands and thousands of miles of cable and land lines had been used to transmit the pulsations of the clocks, many links had been forged to complete the chain, many hundreds of stars had been called from heaven to record their constancy, and skilfully the astronomer had welded the whole into one structure.

But no work of man is perfect, eternal vigilance is the price of precision. When the longitude brought from the west closed at Sydney with that from the east, the discrepancy was about a tenth of a second of time; the two astronomers had started in opposite directions around the earth to meet each other, travelling across seas and continents, and finally found their respective trysting places within the same area not larger than an ordinary town lot. May we say, this was a measure of the quality of their work? The world was girdled astronomically.

NOTES.

Ophiothrix fragilis is one of the most common British Ophiurids. Some years ago when at Plymouth, England, I succeeded in obtaining a large number of the larvæ in all stages of development, and I have been engaged for the last two years in working out their structure. The adult, like all Echinodermata, is radially symmetrical, but the larva is bilaterally symmetrical, more markedly so than any other Echinoderm larva which I have examined. Further, it shows during its development, traces of a *metameric* repetition of parts such as is found in bilaterally symmetrical animals like Annelida. This metamerism is exhibited in the cœlom or body-cavity vesicle. This is budded off from the apex of the gut when the larva is 2 days old, and it immediately divides into right and left halves. At the age of eight days, each half divides into a posterior vesicle lying at the side of the œsophegus. At the age of fifteen days each of the anterior vesicles buds off a thick walled posterior portion. The left one becomes the *hydrocœle* or rudiment of the water-vascular system of the adult, whilst the right loses its cavity and becomes a solid mass of cells whose further fate I am engaged in tracing.

E. W. MacBride.

Zoological Laboratory,
McGill University, April, 1905.

The Marine Biological Station of Canada will open for the summer during the month of May, under the Directorship of Prof. E. E. Prince, assisted by Dr. Stafford who will be in immediate charge. The Laboratory will be located at Gaspé where investigations will be continued with respect to the problems relating to fish culture, which have been dealt with at other stations during the last five years.

The Royal Society of Canada will hold its next Annual General Meeting at Ottawa, during the week commencing May 22nd., under the Presidency of Mr. Benjamin Sulte.

The Marine Biological Laboratory at Woods Holl, Mass., will open its eighteenth session on the first of June and continue until the first of October. Twenty private research rooms have been placed at the disposal of the Carnegie Institution, to whose Secretary applications for their occupation should be made. In the Department of Zoology 35 private research rooms for investigators, and 20 research *tables for beginners who wish to take up problems under the* direction of the staff, are at the disposal of the Director to whom applications should be made. In the Department of Botany a certain number of private rooms and research tables are at the disposal of the Director to whom applications should be addressed. The prospectus offers attractive courses in the several departments under the guidance of recognized specialists.

The Annual Field Day of the Natural History Society will be held this year at Mt. Johnson, Iberville, P. Q., on the 10th of June, leaving the Windsor Street Station at 9 o'clock a.m. The rich and diversified flora which clothes the slopes of Mt. Johnson, covers its bold rock faces and fills the ravine cutting across its eastern section; its peculiar geological structure, now well exposed by quarrying operations; and the interesting place which it occupies in the group of Monteregian Hills, make it one of the most attractive as well as the most accessible of all the locailties the Society has visited in its annual excursions.

The origin of Amber. The recent discovery of amber in the Cretaceous deposits of Staten Island, New York, has directed renewed attention to the origin of this valuable material which is now known from the investigations of Dr. Hollick and Dr. Knowlton, to have been derived in some instances, at least, from various species of coniferous trees of the type of Sequoia and the Agathis which at present constitutes the source of the well-known "Kauri gum" of Australia.

D. P. P.

The Mycelium of Dry Rot. Recent observations of the dry rot as developed in one of the buildings of McGill University, have brought to light certain unusual features in growth which are worthy of notice with a view to having attention directed to similar possibilities elsewhere. The fungus which was the typical *Merulius lachrymans*, passed through an opening in a brick wall of a diameter not exceeding one inch, and thus entered a coal bin constructed of brick walls and cement floor. The fungus was not discovered until the coal was nearly exhausted at the end of the winter, and it was therefore completely dried out. It was nevertheless seen to have travelled along the surface of the brick wall for more than two yards from the point of entrance, and from the wall it spread into the coal for a distance of six inches, often completely enfolding lumps of hard anthracite in its growth. It should be noted that the coal was put into the bin wet. The important question for solution is, "did the fungus convey its nutrient materials from the wood work of the adjacent room for a distance of three yards, as seems probable?

D. P. P.

ABSTRACT FOR THE MONTH OF APRIL, 1905.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min	Range	* BAROMETER. † Mean.	Max.	Min.	Range.	‡ Mean relative humidity.	WIND. General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY
1	34.1	39.0	29.0	10.0	30.25	30.32	30.21	.11	76	N.W.	21.3	86	....	....	....	1
SUNDAY........ 2	29.9	30.3	21.0	13.3	30.33	30.39	30.28	.11	84	N.W.	14.3	91	....	...	....	2 ....SUNDAY
3	39.0	46.0	30.1	15.9	30.14	30.28	29.92	.36	49	N.W.	13.5	89	....	...	....	3
4	42.4	48.0	37.0	11.0	29.75	29.92	29.69	.23	72	S.	18.3	..	.06	....	.06	4
5	45.6	52.0	41.2	10.8	29.75	29.80	29.70	.10	60	S W.	15.8	69	.12	....	.12	5
6	37.2	45.7	33.5	12.2	29.42	29.71	29.27	.44	90	N.W.	20.4	..	.37	....	.37	6
7	35.0	40.1	31.2	8.9	29.59	29.64	29.50	.14	62	W.	16.8	62	.06	....	.06	7
8	34.3	42.0	27.4	14.6	29.68	29.72	29.64	.08	59	W.	18.4	60	....	....	....	8
SUNDAY....... 9	40.8	50.9	31.2	19.7	29.72	29.74	29.65	.09	58	W.	21.3	30	.01	....	.01	9 ....SUNDAY
10	45.8	48.9	42.5	6.4	29.62	29.67	29.53	.14	75	S.W.	16.8	07	.00	....	.00	10
11	42.5	53.2	31.0	22.2	29.67	29.74	29.59	.15	80	S.W.	6.8		.08	....	.08	11
12	41.7	47.5	36.4	11.1	29.78	29.85	29.63	.22	61	N.W.	9.6	92	.12	....	.12	12
13	47.5	60.9	33.0	27.9	29.70	29.84	29.59	.25	55	S.W.	16.8	73	....	....	....	13
14	39.2	47.8	32.0	15.8	29.75	29.80	29.63	.17	50	N.	10.2	32	....	....	....	14
15	38.3	43.7	31.2	12.5	29.75	29.82	29.66	.16	34	N.W.	11.3	72	....	....	....	15
SUNDAY........16	33.9	39.4	30.0	9.4	29.52	29.66	29.43	.23	82	W	15.4	40	....	0 1	.01	16 ....SUNDAY
17	32.2	36.5	27.3	9.2	29.52	29.70	29.44	.26	81	N.W.	24.8	..	....	0.1	.01	17
18	32.6	38.0	25.8	12.2	29.84	29.93	29.70	.23	75	N.W.	23.6	80	....	....	....	18
19	41.8	50.3	30.3	20.0	29.87	29.97	29.73	.24	53	W	27.0	27	....	...	....	19
20	48.4	55.9	42.5	13.4	29.73	29.80	29.68	.12	62	W	21.4	..	.01	....	.01	20
21	34.2	50.6	30.0	20.6	29.85	29.94	29.79	.15	77	N.	20.8	..	...	2.3	.23	21
22	39.6	47.1	31.0	16.1	30.10	30.17	29.94	.23	58	N.W.	13.5	75	....	....	....	22
SUNDAY........23	42.3	49.7	34.1	15.6	30.28	30.33	30.17	.16	48	N.W.	13.0	56	....	....	....	23 ....SUNDAY
24	41.5	54.6	34.5	20.1	30.10	30.32	29.89	.43	70	N.W.	25.2	07	.19	....	.19	24
25	44.0	55.8	34.0	21.8	29.93	30.07	29.74	.33	49	N.W.	25.0	56	....	....	....	25
26	54.6	66.5	44.2	22.3	29.60	29.74	29.47	.27	39	W	27.7	87	....	....	....	26
27	50.2	59.5	40.6	18.9	29.68	29.77	29.60	.17	50	N.E.	14.4	84	....	....	....	27
28	55.0	68.2	36.4	31.8	29.78	29.87	29.70	.17	48	S.	8.8	94	....	....	....	28
29	53.9	62.3	50.0	12.3	29.59	29.70	29.49	.21	63	S.W.	25.6	..	.04	....	.04	29
SUNDAY........30	44.7	54.0	39 6	14.4	29.74	29.81	29.64	.17	76	N.W.	11.6	24	.03	....	.03	30..........SUNDAY
Means......	41.39	49.8	33.9	15.9	29.801	29.90	29.70	.20	63.2	N 79° W	17.61	46.3	1.09	2.5	1.34	.......Sums.........
31 Years means for and including this month......	40.81	49.2	33.0	16.2	29.955	......	......	.20	66.8	......	[‡] 16.36	[§] 49.3	1.76	5.0	2.23	31 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	1518	65	79	....	1455	1021	5454	3091	
Duration in hrs..	100	6	10	....	97	57	265	185	
Mean velocity....	15 2	10.8	7.9	....	15.0	17.9	20 6	16.7	

Greatest mileage in one hour was 44 on the 25th.
Greatest velocity in gusts was 60 on the 25th
Resultant mileage 8,386

Resultant direction, N.79°W.
Total mileage, 12,683.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

§ 24 years only. ‡ 19 years only.

The greatest heat was 68.2° above zero on the 28th. The greatest cold was 21.0° above zero on the 2nd, giving a range of temperature of 47.2 degrees.

Warmest day was the 28th. Coldest day was the 2nd.

Highest barometer reading was 30.39 on the 2nd; lowest barometer was 29.27 on the 6th, giving a range of 1.12 inches.

Minimum relative humidity observed, was 24 on the 28th.

Rain fell on 12 days.

Snow fell on 3 days.

Thunder on the 20th.

Auroras on 3 nights.

Halos on 3 nights.

ABSTRACT FOR THE MONTH OF MAY, 1905.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min.	Range	* BAROMETER. † Mean.	Max.	Min.	Range.	‡ Mean relative humidity.	WIND. General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
SUNDAY........ 1	38.0	47.5	33.1	14.4	29.92	30.03	29.83	.20	54	N.W.	20.5	50	....	.00	.00	1 ....SUNDAY
2	45.3	54.0	33.3	20.7	30.02	30.09	29.96	.13	47	N.W.	18.0	56	....	...	....	2
3	42.9	47.2	40.1	7.1	29.91	29.96	29.86	.10	94	N.E.	9.8	..	.68	....	.68	3
4	52.9	63.3	42.4	20.9	30.14	30.23	29.92	.31	51	N.E.	11.4	96	.01	....	.01	4
5	52.1	56.8	46.0	10.8	30.11	30.22	29.98	.24	62	S.W.	21.0	..	.15	....	.15	5
6	61.2	66.8	52.0	14.8	29.96	30.06	29.72	.34	64	S.W.	14.0	42	.09	....	.09	6
7	56.6	61.4	45.5	15.9	29.73	29.91	29.60	.31	66	S.W.	25.9	48	.02	....	.02	7
SUNDAY....... 8	51.0	60.8	39.9	20.9	29.88	30.00	29.72	.28	62	S W.	12.2	55	.00	....	.00	8 ....SUNDAY
9	48.9	53.8	45.5	8.3	29.76	29.98	29.61	.37	71	N.W.	24.4	24	.22	....	.22	9
10	54.1	66.0	42.1	23.9	30.09	30.13	29.98	.15	39	N.W.	12.0	99	....	....	....	10
11	60.7	69.4	46.2	23.2	30.04	30.12	29.91	.21	39	S.W.	6.6	77	....	....	....	11
12	59.5	68.0	47.5	20.5	29.94	29.97	29.91	.06	41	N.E,	13.4	87	.00	....	.00	12
13	58.1	69.5	45.8	23.7	29.96	30.00	29.94	.06	63	S.W.	13.9	65	....	....	....	13
14	63.1	69.4	58.0	11.4	29.86	29.97	29.78	.19	68	S.W.	12.8	12	....	...	....	14
SUNDAY........15	58.7	65.7	51.8	13.9	29.77	29.80	29.74	.06	92	S.E.	6.1	..	.26	....	.26	15 ....SUNDAY
16	54.6	63.0	48.3	14.7	29.83	29.86	29.79	.07	87	N.E.	10.2	3	.00	....	.00	16
17	56.6	69.5	48.3	21.2	29.75	29.83	29.69	.14	82	S.E.	6.5	65	.16	...	.16	17
18	52.9	60.2	47.5	12.7	29.55	29.69	29.48	.21	91	N.W.	20.6	17	.51	....	.51	18
19	46.1	53.7	42.2	11.5	29.59	29.70	29.47	.23	64	N.W.	21.3	39	03	....	.03	19
20	46.3	53.3	38.3	15.0	29.80	29.94	29.69	.25	67	N.W.	16.9		.05	....	.05	20
21	49.8	57.4	42.3	15.1	29.97	29.99	29.94	.05	60	W.	15.4	21	....	....	....	21
SUNDAY........22	53.6	63.1	44.9	18.2	29.93	30.01	29.88	.13	45	N.W.	17.6	81	....	....	....	22 ....SUNDAY
23	46.1	53.9	35.8	18.1	30.05	30.09	30.01	.08	50	N.E.	7.5	63	....	....	....	23
24	56.4	68.4	41.8	26.6	29.99	30.05	29.93	.12	46	S.W.	12.7	84	....	...	....	24
25	64.5	77.1	50.0	27.1	29.90	29.95	29.82	.13	61	S.W.	7.0	79	....	....	....	25
26	60.1	63.2	55.3	7.9	29.87	30.02	29.79	.23	90	S.W.	11.7	1	.27	....	.27	26
27	55.6	65.0	44.2	20.8	30.08	30.16	30.00	.16	58	N.W.	6.0	71		....	....	27
28	61.2	71.0	50.8	20.2	29.95	30.00	29.91	.09	63	S.W.	14.4	64	...	....	....	28
SUNDAY........29	59.2	68.5	50.0	18.5	29.89	29.96	29.84	.12	55	S.W.	20.4	48	.00	....	.00	29.......... SUNDAY
30	55.5	62.2	49.4	12.8	29.95	30.02	29.85	.17	51	N.E.	13.0	93	....		....	30
31	52.7	61.7	41.8	19.9	30.07	30.14	30.02	.12	57	N.E.	8.5	94	....	....	....	31
Mean......	54.01	62.3	45.2	17.1	29.913	30.00	29.83	.17	62.6	N 86° W	13.62	50.7	2.45	. .	2.45	.......Sums.........
31 Years means for and including this month......	54.90	64.2	45.9	18.3	29.934	......	......	.17	66.1	......	§ 14.31	¶ 51.4	2.90	....	2.90	31 Years means for and including this month.

‖ ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	450	1299	136	75	869	2741	1973	2587	
Duration in hrs..	44	118	20	9	84	193	121	154	1
Mean velocity....	10.2	11.0	6.8	8.2	10.4	14.2	15.0	16.8	

Greatest mileage in one hour was 35 on the 7th.
Greatest velocity in gusts was 48 on the 7th
Resultant mileage, N.80°W.

Resultant direction, 4,645.
Total mileage, 10,130.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

¶ 24 years only. § 18 years only.

‖ Velocity for part of month from City Hall records.

The greatest heat was 67.1° above zero on the 25th. The greatest cold was 33.1° above zero on the 1st, giving a range of temperature of 44.0 degrees.

Warmest day was the 25th. Coldest day was the 1st.

Highest barometer reading was 30.23 on the 4th; lowest barometer was 29.47 on the 19th, giving a range of .73 inches.

Minimum relative humidity observed, was 28 on the 22nd.

Rain fell on 16 days.

Snow fell on 1 day.
Thunder on 2 days.
Rainbow on the 20th.
Auroras on 2 nights.
Lunar Halos on 2 nights.