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THE CANADIAN JOURNAL.

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A POPULAR EXPOSITION OF THE MINERALS AND GEOLOGY OF CANADA.*

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PROFESSOR OF MINERALOGY AND GEOLOGY IN UNIVERSITY COLLEGE, TORONTO.

Read, in abstract, before the Canadian Institute, December 5th, 1859.

Introductory Notice.

In attempting to convey to the general reader a practical or really useful knowledge of the Minerals and Geology of Canada, it is advisable to consider the subject under the following heads:

1. How minerals are distinguished from one another.
2. The minerals and metallic ores met with in Canada.
3. How rocks are classified and distinguished.
4. Organic Remains: their use and teachings.
5. Subdivisions and distribution of Canadian rocks.

The term "Geology" comprises, strictly, a knowledge of the physical history of the Earth, as revealed to us by the study of the rock-

* The object of the series of papers to be published under this title, is twofold: First, to enable our surveyors, farmers, and others, to determine the Canadian minerals that may come under their observation; and, secondly, to serve as an introduction to the valuable reports and other publications issued by our Geological Survey.

masses which lie around and beneath us; and by a comparison of the results of ancient phenomena, with the forces and agencies still at work in modifying the surface of the globe. As geology is thus essentially based on the study of rocks and their contents, and as rocks are made up of a certain number of simple minerals, it is necessary, or at least advisable, to obtain a knowledge of these latter (so as to be able to recognize them when met with), before proceeding to the discussion of the rocks into which they enter. With these minerals, also, it is convenient to consider a few others of economic application and common occurrence, including the more important metallic ores. In this consideration, the characters or properties by which minerals are distinguished from one another will first be explained, introductory to a Tabular Distribution of Canadian minerals. The latter will be so arranged as to enable the reader to make out the name of any one of the included species, with great facility.

I. How Minerals are distinguished from one another.

Minerals are distinguished from one another by certain characters or properties which they possess: such as form, degree of hardness, fusibility, &c. Hence, it is to these characters that our attention must be first directed.

Mineral characters are of two kinds: *physical* or *external* characters, and *chemical* characters. The former are exhibited by the mineral under ordinary conditions; the latter, only when the mineral is exposed to the action of heat or mineral acids, by which, in general, a certain degree of chemical decomposition is effected. Hence the term "chemical" as applied to these latter characters.

The physical properties of minerals are somewhat numerous; but many, although of the highest interest in indicating the existence of natural laws, and in their relations to physical science generally, are not readily available as a means of mineral discrimination. These, consequently, will be omitted from consideration in the following pages; and the other characters will be discussed only in so far as they admit of direct application to the end in view—namely, the practical discrimination of minerals one from another.*

* In the explanation of these various characters, it is occasionally necessary to refer, as examples, to a few substances of foreign occurrence. The reader will therefore understand, that the present Part of this Essay makes no special mention of the minerals of Canada, but is simply an Introduction to Part II, in which these minerals will be found arranged together.

The following are the characters in question :

1. Aspect or Lustre.
2. Colour.
3. Streak.
4. Form.
5. Structure.
6. Hardness.
7. Specific Gravity.
8. Relative Malleability.
9. Magnetism.
10. Taste, &c.

1. *Aspect or Lustre.*—We have here to consider, first: the *kind;* and, secondly, the *degree* or *intensity* of the lustre, as possessed by the mineral under examination. The kind of lustre may be either *metallic,* as that of a piece of copper, silver, &c.; or *sub-metallic,* as that of most kinds of anthracite coal; or *non-metallic,* as that of stones in general. Of the non-metallic lustre there are several varieties, as, more especially: the *vitreous* or glassy lustre—example: rock-crystal; the *resinous* lustre—ex.: native sulphur; the *pearly* lustre—ex.: talc; the *silky* lustre (usually accompanying a fibrous structure)—ex.; fibrous gypsum; the *stony* aspect; the *earthy* aspect, &c. These terms sufficiently explain themselves. Occasionally, two kinds of non-metallic lustre are simultaneously present, as in obsidian, which exhibits a "resino-vitreous" aspect; and the lustre in some zeolites is pearly within, and vitreous externally. In mica, and some few other minerals, there is frequently a *pseudo-metallic* lustre. This may be distinguished from the metallic lustre properly so-called, by being accompanied by a degree of translucency, or by the powder of the mineral being white or light-colored: minerals of a true metallic aspect being always opaque, and their powder being always black or dark-colored. So far as regards the metallic and the non-metallic lustres, there are very few minerals which exhibit (in their different varieties) more than one kind. Thus, galena, the common ore of lead, copper pyrites, &c., always present a metallic lustre; whilst, on the other hand, quartz, feldspar, calc-spar, gypsum, &c., are never found otherwise than with a non-metallic aspect. Hence, by means of this easily-recognized character, we may divide all minerals into two broad groups; and thus, if we pick up a specimen

and wish to ascertain its name, we need only look for it amongst the minerals of that group with which it agrees in lustre. The first step towards the determination of the substance will in this way be effected.

The *degree* of lustre may be either splendent, shining, glistening, glimmering, or dull; but the character is one of comparatively little importance.

2. *Colour.*—When combined with a metallic aspect, colour becomes a valuable character in the determination of minerals, because it then remains constant as regards a given substance. Thus galena, the common ore of lead, is always lead-grey; copper pyrites, always brass-yellow; native gold, always gold-yellow; and so forth. When accompanied, however, by a vitreous or other non-metallic lustre, colour is, practically, a character of no value; as in that case, the mineral may present, in its different varieties, every variety of colour. Thus, we have colourless quartz, amethystine or violet quartz, red quartz, yellow quartz, &c., just as in the vegetable kingdom, we have red, white, and yellow roses; and dahlias, &c., of almost every shade. When combined with a metallic aspect, the colour is said to be metallic; and of metallic colours we may enumerate the following:

White...	Silver-white	ex. Native silver.
	Tin-white	ex. Pure tin; cobalt ore.
Grey ...	Lead-grey	ex. Galena.
	Steel-grey	ex. Specular iron ore.
Black	Iron-black (usually with sub-metallic lustre)	ex. Magnetic iron ore.
Yellow ..	Gold-yellow	ex. Native gold.
	Brass-yellow	ex. Copper-pyrites.
	Bronze-yellow (a brownish-yellow)	ex. Magnetic pyrites.
Red	Copper-red	ex. native copper.

These metallic colours are often more or less obscured by a black, brownish, purple, or iridescent *surface-tarnish.* Hence, in noting the colour of a mineral, a newly-fractured surface should be observed. The non-metallic colours comprise, white, grey, black, blue, green, red, yellow, and brown, with their various shades and intermixtures; as orange-yellow, straw-yellow, reddish-brown, greenish-black, &c. In minerals of a non-metallic aspect, the colour is sometimes uniform; and at other times, two or more colours are present together, in spots, bands, &c., as in the varieties of quartz, called agate, bloodstone, jasper, and so forth. In Labradorite, or Labrador feldspar, a beautiful play or change of colour is observed in certain directions. The finer varieties of Opal also exhibit a beautiful and well-known iridescence.

3. *Streak.*—Under this technical term is comprised the *colour of the powder* produced by drawing or "streaking" the mineral under observation, across a file or piece of unglazed porcelain. The character is a valuable one on account of its uniformity; as, no matter how varied the colour of a mineral may be in different specimens, the streak will remain of one and the same colour throughout. Thus, blue, green, yellow, red, violet, and other specimens of fluor spar, quartz, &c., exhibit equally a white or "uncoloured" streak. The streak is sometimes "unchanged," or of the same tint as the external colour of the mineral; but far more frequently it presents a different colour. Thus, Cinnabar, the ore of mercury, has a red colour and red streak; realgar, or sulphide of arsenic, has a red colour and orange-yellow streak; copper pyrites, a brass-yellow colour, and greenish-black streak; and so forth. In certain malleable and sectile minerals, whilst the colour remains unchanged in the streak, the lustre is increased. The streak is then said to be "shining." Finally, it should be remarked, that in trying the streak of very hard minerals, we must crush a small fragment to powder, in place of using the file; because otherwise, a greyish-black streak, arising from the abrasion of the file, might very possibly be obtained, and so conduce to error. It may be observed, however, that all minerals of a non-metallic aspect, and sufficient hardness to resist the file, have a white streak.

4. *Form.*—The forms presented by minerals, may be either *regular* or *irregular*. Regular forms are called *crystals,* whether the minerals which present them be transparent or opaque. The term "crystal" was first applied to transparent vitreous specimens of quartz or rock-crystal; but, as it was subsequently found that opaque specimens of quartz presented exactly the same forms, and that opaque as well as transparent forms of other minerals existed, the term gradually lost its original signification, and came to be applied to all regular forms of minerals, whether transparent, translucent, or opaque. Minerals of a metallic lustre are always opaque; and many of these, as iron pyrites and galena, occur frequently in very regular and symmetrical

crystals. Crystals originate in almost all cases in which matter pas se from a gaseous, or liquid, into a solid state; but if the process take place too quickly, or the matter solidify without free space for expansion, crystalline masses, in place of regular crystals, will result. If a small fragment of arsenical pyrites, or native arsenic, be heated at one end of an open glass tube (five or six inches long and one-fourth of an inch in diameter), the arsenic, in volatilizing, will combine with oxygen, and form arsenious acid, which will be deposited at the other end of the tube, in the form of minute octahedrons (Fig. 3, below). In like manner, if a few particles of common salt be dissolved in a small quantity of water, and a drop of the solution be evaporated gently (or suffered to evaporate spontaneously) on a piece of glass, numerous little cubes and hopper-shaped cubical aggregations will result. Boiling water, again, saturated with common alum, will deposit octahedral crystals on cooling: the cooled water not being able to retain in solution the full amount of alum dissolved by the hot water. In like manner, sugar, sulphur, and other bodies crystallise by slow cooling from the molten state.

The study of crystal-forms constitutes the science of Crystallography. To enter into the details of this science would extend our present discussion beyond its proposed limits, and carry us altogether beyond the object in view—the simple determination of the names of commonly-occurring minerals—and hence we shall confine ourselves to the general statement, that crystals admit of being arranged in six groups, or "systems;" the forms of each individual group passing into one another by simple transitions, but having no relations to the forms of the other groups.* The names of these respective groups,

* The reader desirous to take up the study of Crystallography in a more extended manner, may attend the author's special courses of lectures which include that subject. In these, the use of crystallographic instruments is shewn, and the lectures are illustrated by numerous wood and porcelain models, drawings, and natural crystals. The following is extracted from the syllabus of the advanced course on Mineralogy:

CRYSTALLOGRAPHY, PART I.—Crystals, how defined. Formation of Crystals. Elements of Crystals: planes, edges, angles; diagonals, axes. Forms and combinations. Replacing planes. General nomenclature of Forms and simple Crystals. Law of constant Angles. Measurement of Angles. Laws of Symmetry: Holohedral, Hemihedral, and Tetartohedral Forms. Classification of Crystals. Dimorphism. Isomorphism. Compound Crystals. Distortions. Pseudomorphs.

PART II.—The six systems of Crystallization. The Monometric system. The Dimetric system. The Hexagonal system. The Trimetric system. The Monoclinic system. The Triclinic system. Method of ascertaining the system of a given Crystal.

PART III.—Optical and other physical relations of Crystallography.

with figures of a few of their more common forms and combinations, are given in the annexed tabular view.

The Monometric or Regular System.—This group includes the cube (Fig. 1), the rhombic dodecahedron (Fig. 2), the regular octahedron (Fig. 3), trapezohedrons or leucitoids (Fig. 4), pentagonal dodecahedrons (Fig. 5), &c. Fig. 6 is a combination of the cube and

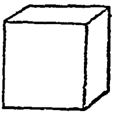


FIG. 1.

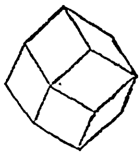
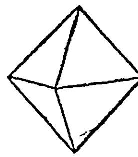


FIG. 2.



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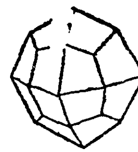

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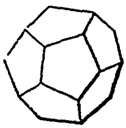

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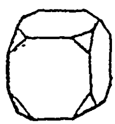

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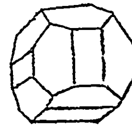
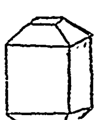


FIG. 7.

octahedron; Fig 7, a combination of the cube and pentagonal dodecahedron. Native gold, silver, copper, iron pyrites, galena, magnetic iron ore, garnet, fluor spar, rock salt, and numerous other minerals, crystallize in this system.

The Dimetric or Square-Prismatic system.—This includes, principally, square-based prisms and pyramids (or octahedrons), and their combinations. Figures 8 and nine are examples of Dimetric crystals.



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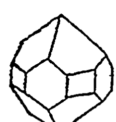


FIG. 9.

Amongst minerals, Copper Pyrites, Tin-stone, Zircon, and Idocrase, may be cited as belonging to the group.

The Hexagonal system.—Regular six-sided prisms (Fig. 10) and pyramids (Fig. 11), combinations of these (Fig 12), rhombohedrons

(Figs. 13 and 14), and scalenohedrons (Fig. 15), are included under this system. Graphite, Red Silver ores, Cinnabar, Specular Iron Ore, Corundum, Quartz, Beryl, Apatite or phosphate of lime, Cal-

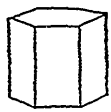
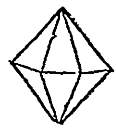


FIG. 10.



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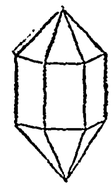

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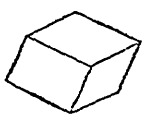

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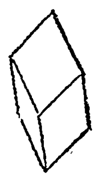

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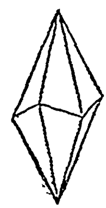

FIG. 15.

careous Spar, Dolomite, and Carbonate of Iron, are some of the principal minerals which belong to it.

The Trimetric or Rhombic system.—This system includes right-rhombic prisms, rectangular prisms, rhombic octahedrons, &c., and their combinations. Fig. 16 is a rhombic prism; figs. 17 and 18 are

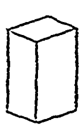

FIG. 16.

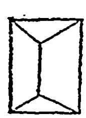

FIG. 17.

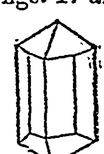

FIG. 18.

combinations belonging to this system. White iron-pyrites, mispickel or arsenical pyrites, native sulphur, topaz, staurolite, arragonite, heavy spar, celestine, and Epsom salt, are some of the principal minerals which belong to this group.

The Monoclinic or Oblique Rhombic system.—Rhombic prisms and pyramids, and rectangular prisms and pyramids, with *oblique or sloping base,* belong to this system. Figs. 19 and 20 are monoclinic combinations. The principal minerals comprise: Augite, Hornblende, Epidote, Orthoclase, or potash feldspar, Stilbite, and Gypsum.

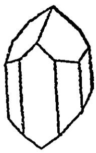

FIG. 19.

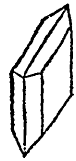

FIG. 20.

The Triclinic, or Doubly Oblique system.—The forms of this system are oblique (or they incline) in two directions. The crystals in general are more or less flat and unsymmetrical in appearance. No two planes meet at right angles; and there are never more than two similar planes present in any crystal belonging to the group. Axinite, Albite or soda feldspar, Labradorite or lime feldspar, and sulphate of copper, are the principal triclinic minerals.

Such is a brief exposition of the six crystal systems. For present purposes it will only be necessary for the student to impress upon his memory the following forms, so as to be able to recognize them when met with. The cube (Fig. 1), the regular octahedron (3), the rhombic dodecahedron (2), the pentagonal dodecahedron (5), the cubo-octahedron (6), the regular six-sided prism (10), a combination of a six-sided prism and pyramid (12) a rhombohedron (13 and 14), a scalenohedron (15), a rhombic prism (16).

The *irregular* forms presented by minerals are of very subordinate importance; so that a few of the more common need only be mentioned. Most of the terms used in reference to these, explain themselves.

Irregular mineral forms:—*Globular* or *nodular*, ex. quartz, iron pyrites; reniform or kidney-shaped, ex. quartz, &c.; botryoidal mammillated: a form made up of a series of rounded elevations and depressions, or otherwise exhibiting a surface of this character, ex. red and brown iron ore, calcedony, &c.; stalactitic, ex. calc spar, &c.; coralliform, resembling certain branching corals, ex. arragonite; dendritic or arborescent, a branching form, often made up of small aggregated crystals, ex. native silver, native copper, &c.; filiform or wire-like, ex. native silver; acicular, in needle-like crystallizations, ex. many varieties of augite, hornblende, epidote, &c. When a mineral has a perfectly indefinite shape it is said to be "massive" or "amorphous."

Structure:—In the majority of minerals, a certain kind of structure, or, in other words, the shape as well as the mode of aggregation of the smaller masses of which they are composed, is always observable. Structure in minerals may be either *lamellar*, *laminar* or *foliated*, *prismatic*, *fibrous*, *granular*, or *compact*. When the mineral, as in most varieties of calc-spar, heavy-spar, feldspar, and gypsum, for example, is made up of broad tabular masses producing a more or less stratified appearance, the structure is said to be lamellar. When the tabular masses (whether straight, wavy, or curved,) become extremely thin or leafy, as in mica more especially, the structure is said to be laminar, or foliated, or sometimes micaceous. The scaly structure is a variety of this, in which the laminæ are of small size. When the component masses are much longer than broad or deep, as in many specimens of tourmaline, beryl, calc-spar, &c., the structure is said to be prismatic or columnar. When the prismatic concretions become very narrow, the fibrous structure originates. Fibrous minerals may have either: a straight or parallel-fibrous structure, as in many specimens of gypsum, calc-spar, &c.; a confusedly-fibrous structure, as in many specimens of augite and hornblende; or a radiated-fibrous structure, as in the radiated varieties of iron pyrites, in natrolite, wavellite, &c.,—the fibres radiating from one or more central points. Minerals made up of small grains or granular masses are said to have a granular structure; ex. granular or saccharoidal limestone, granular gypsum, &c. Finally, when the component particles are not apparent, the mineral is said to have a compact structure, as in the native malleable metals, obsidian, and most varieties of quartz. Hard and vitreous minerals of a compact structure (ex. obsidian), generally show when broken, a *conchoidal fracture*, or a series of circular markings resembling the lines of growth on the external surface of a bivalve shell.

Almost all minerals, especially those of a lamellar structure, separate more readily in certain directions than in others. This peculiarity is called *cleavage*. The fragments resulting from "cleavage" have often a perfectly regular or definite form. Thus the purer specimens of calc-spar, no matter what their external form, break very readily into rhombohedrons, which measure 105°5' over their obtuse edges. Galena, the common ore of lead, yields rectangular or cubical cleavage forms; whilst the cubes of fluor-spar break off most readily at the corners or angles, and yi .d regular octahedrons, fig. 3.

Hardness.—The hardness of a mineral is *its relative power of* resisting abrasion, not that of resisting blows: many of the hardest minerals being exceedingly brittle. Practically, the character is of great importance. By its aid gypsum may be distinguished in a moment from calc-spar or limestone, calc-spar from feldspar, and copper pyrites from iron pyrites, not to mention other examples.* The degree of hardness in minerals is conventionally assumed to vary from 1 to 10 (1 being the lowest) as in the following scale drawn up by a German mineralogist, *Möhs,* and now generally adopted:

Scale of Hardness—Möhs' Scale.

1. Foliated Talc.
2. Rock Salt, a transpa nt cleavable variety.
3. Calcareous Spar, a nsparent variety.
4. Fluor Spar.
5. Apatite.
6. Feldspar.
7. Rock Crystal.
8. Topaz.
9. Corundum.
10. The Diamond.

In order to ascertain the hardness of a mineral by means of this scale, we attempt to scratch the substance under examination, by the different specimens belonging to the scale; beginning with the hardest, in order not to expose the specimens to unnecessary wear. Or, we take a fine file, and compare the hardness of the mineral with that of the individual members of the scale, by drawing the file briskly across them. The comparative hardness is estimated by the resistance offered to the file; by the noise produced by the file in passing across the specimens; and by the amount of powder so

* Gypsum may be scratched by the finger nail. Calc-spar and copper pyrites may be scratched easily by a knife; whilst feldspar and iron pyrites are hard enough to scratch window-glass. Not long ago, as mentioned by Sir William Logan, a farmer in the Ottawa district was put to much expense and annoyance by mistaking feldspar for crystalline limestone, and attempting to burn it into lime.

obtained. The degree of hardness of the mineral is then said to be equal to that of the member of the scale with which it agrees the nearest. Thus, if the mineral agrees in hardness with Fluor-spar we say, in its description, H (or hardness) =4. If, on the other hand, it be somewhat softer than fluor-spar, but harder than calcareous spar, we say, H=3.5. Finally, if, as frequently happens, the hardness of a mineral vary slightly in different specimens, the limits of the hardness are always stated. Thus, if in some specimens, a mineral agree in hardness with calc-spar, and in others with fluor-spar, we say, H = 3 to 4; or, more commonly, H = 3 — 4. If the hardness be very rigorously tested, it will frequently be found to differ slightly on different faces of a crystallized specimen, or on the broad faces and the edges of the laminæ of foliated specimens,—but this, so far as regards the simple determination of minerals, is practically of little moment.

As the minerals of which the scale of Möhs consists, may not be in all places obtainable, or always at hand when required, the author of this paper contrived some years ago another scale, agreeing closely enough for practical purposes with that of Mohs, and exacting for its application only such objects as are always to be met with. The following is the scale in question; its use explains itself:

Chapman's Convenient Scale of Hardness, to correspond with that of Möhs.

1. Yields easily to the nail.
2. Does not yield to the nail. Does not scratch a copper coin.
3. Scratches a copper coin, but is also scratched by one, being of about the same degree of hardness.
4. Not scratched by a copper coin. Does not scratch glass (ordinary window-glass).
5. Scratches glass very feebly. Yields easily to the knife.
6. Scratches glass easily. Yields with difficulty to the knife.
7. Does not yield to the knife. Yields with difficulty to the edge of a file.

8, 9, 10. Harder than flint or rock-crystal.

Convenient terms of comparison for degrees of hardness above No. 7 cannot be easily obtained; but that is of little consequence, as there are but few minerals of common occurrence which exhibit a higher degree; and these are readily distinguished by other characters. Where, in the above scale, two terms of comparison are employed, both must of course be attended to in the determination of the hardness.

Specific Gravity.—This is also a character of great value in the determination of minerals. The specific gravity of a body is its weight compared with the weight of an equal bulk of pure water. In order to ascertain the specific gravity of a mineral we weigh the specimen first in air and then in water. The loss of weight in the latter case exactly equals the weight of the displaced water, or, in other words, of a volume of water equal to the volume of the mineral. Now, the specific gravity of pure water, at a temperature of about 62°, being assumed to equal 1, or unity, it follows that the specific gravity of a mineral is obtained by dividing its weight in air by its loss of weight in water. Thus, if $a =$ the weight in air, and $w =$ the weight in water, G, or $sp. gr. = \frac{a}{a-w}$.

Example.—A piece of calcareous spar weighs 66 grs. in air, and 42 grs. when immersed in rain or distilled water. Hence its sp. gr. $= \frac{66}{66-42} = \frac{66}{24} = 2.75$.*

The weight of the mineral may be ascertained most conveniently and with sufficient exactness for general purposes, by a pair of small scales such as are commonly called "apothecaries' scales." These may be purchased for a couple of dollars, or even less. A small hole must be made in the centre of one of the pans for the passage of a horse-hair or silken fibre, about four inches in length, and furnished at its free end with a "slip-knot" or running noose, to hold the specimen whilst it is being weighed in water. The strings of the perforated pan may also be somewhat shortened, but the balance must in this case be brought into equilibrium by a few strokes of a file on the under side of the other pan, or by attaching thinner strings to it. If grain weights be used with this balance, the following will be required: 50 grs., 30, 20, 10, 5, 3, 2, 1, 0 5, 0.3, 0.2, 0.1.

The specific gravity bottle often recommended in mineralogical works, is too heavy to be carried by the scales described above. Bottles of the smallest capacity, weigh, when filled with water, at least 500 grains; and these scales will not carry more than 200, or 250 grains at the most. They are not very sensitive, indeed, when

* This is the maximum specific gravity of calcareous spar.

loaded with more than 50 or 60 grains in each pan, although often of great delicacy when carrying lesser weights. The use of the sp. gr. bottle requires a chemical balance, costing, at the very lowest, some twenty-five or thirty dollars, besides being of difficult portability; and hence its employment for general purposes is scarcely available.

Relative Malleability.—Some few minerals, as native gold, native silver, sulphide of silver, native copper, &c., are *malleable* or *ductile*, flattening out when struck, instead of breaking. A few other minerals, as talc, serpentine, &c., are *sectile*, or admit of being cut by a knife; whilst the majority of minerals are *brittle*, or incapable of being cut or beaten out without breaking. In testing the relative malleability of a mineral, a small fragment should be placed on a little anvil, or block of steel polished on one of its faces,* and struck once or twice by a light hammer. To prevent the fragment from flying off when struck, it may be covered by a strip of thin paper, held down by the forefinger and thumb of the left hand. Thus treated, malleable bodies flatten into discs or spangles, whilst brittle ones break into powder.

Magnetism.—Few minerals attract the magnet in their natural condition, although many do so after exposure to the blowpipe. (See below.) In trying if a mineral be magnetic, we chip off a small fragment, and apply to it a little horse-shoe magnet, such as may be purchased anywhere for a quarter of a dollar; or otherwise we apply the specimen to a properly suspended magnetic needle. In this manner the black granular masses which occur frequently in our gneissoid or Laurentian rocks, and in the boulders derived from them, may easily be recognised as magnetic iron ore.† Many specimens of magnetic iron ore (and also of magnetic pyrites) exhibit "polarity," or attract from a given point, one end of the needle, and repel the other.

Taste.—This is a very characteristic although limited property, being exhibited only by a few soluble minerals. In these, the taste may be saline, as in rock salt; or bitter, as in Epsom salt; or metallic, as in sulphate of iron, and so forth.

* The little anvils called "Watch-makers' anvils," are very suitable for this purpose. They may be purchased (where Watch-makers' tools are sold) for half-a-dollar, or even less.

† The other dark-coloured cleavable masses in these rocks consist of mica or more rarely of hornblende.

CHEMICAL CHARACTERS.*—These, so far as regards the determination of mineral species, comprise the results produced by the action of acids; and the relative fusibility, &c., of minerals, as ascertained by the employment of the blow-pipe.

Action of Acids.—The acid-test is resorted to, chiefly for the purpose of distinguishing the *carbonates* from other mineral substances. The majority of carbonates, as carbonate of lime, carbonate of oxide of copper, &c., when touched with a drop of diluted hydrochloric acid (the "spirit of salt" of the shops), produce a more or less vigorous effervescence. This reaction is still more marked, if a small fragment of the mineral be dropped into a test-tube containing a little of the acid. The effervescence arises from the escape of carbonic acid. Some carbonates, as carbonate of iron, dissolve very slowly, and scarcely produce any effervescence, unless employed in a pulverised state, or unless the acid be gently heated. Sulphate of lime and various other minerals dissolve in hydrochloric acid, but without causing effervescence. Quartz, feldspar, &c., on the other hand, are quite insoluble. Certain silicates, and more especially those named "zeolites" dissolve partially in hot hydrochloric acid, leaving the undissolved silica in the form of a gelatinous mass. Gold and platinum are not attacked by strong nitric acid, which dissolves copper, silver, &c., very readily. Cupreous acid-solutions have always a green or blue colour. Red copper ore dissolves with effervescence in nitric acid producing a coloured solution; by which characters it may be readily distinguished from the red silver ores.

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* The Chemical Characters of minerals are discussed in the present paper in the briefest terms. To have entered fully into these characters, would have carried us altogether beyond the object in view: the simple determination of the names of Canadian minerals. The advanced lectures given daily during the Michaelmas Term in University College, Toronto, by the author, are open to all students desirous of obtaining more ample information on the subject. The annexed extract is taken from the author's syllabus to this course of lectures:

"THE CHEMICAL RELATIONS OF MINERALOGY.

"*The Chemical Constitution of Minerals.*—1, Chemical Nomenclature as applied to Mineralogy; 2, The Laws of Combination; 3, The Atomic Theory: 4, Chemical Notation: 5, Construction of Chemical Formulæ; 6, Isomorphism, or Law of Substitution; 7, Atomic Volumes.

"*The Chemical Examination of Minerals.*—1, Action of Acids, &c. 2, Employment of the Blow-pipe, comprising: *a*, Instruments and Appliances; *b*. Reagents; *c*, Operations; *d*, Reactions; and *e*, Plan of Analysis in the examination of an unknown substance."

Students attending these lectures, are strongly advised to go through, also, a *course of* Practical Chemistry, in the Laboratory of University College, under the direction of Professor Croft.

The acids used in these experiments may be conveniently kept in small glass bottles furnished with a long glass stopper, reaching to the bottom of the bottle, and with a glass cap to prevent the escape of corrosive fumes. For geological purposes (testing calcareous rocks, &c.,) strong hydrochloric acid diluted with half its bulk of pure water, is principally used. The "specimen basket" may be provided near its upper edge with a little nest, or wicker-work pocket, for the reception of the acid bottle.

Action of the Blow-pipe.—The blow-pipe in its simplest form is merely a narrow tube of brass or other metal, bent round at one extremity, and terminating at that end in a point with a very fine orifice (*a*: fig. 21). If we place the pointed end of this instrument just within the flame (and a little above the wick) of a lamp or common candle, and then blow gently down the tube, the flame will be deflected into a horizontal position, and its heating powers will be wonderfully increased. Many minerals when held in the form of a thin splinter at the point of the blow-pipe flame, melt with the greatest ease; and some are either wholly or partially volatilized. Other minerals, on the contrary, remain unaltered; and thus, by the aid of the blow-pipe, we are often enabled to distinguish from one another, in a moment, various minerals which in external characters may be closely alike.*

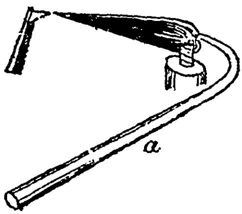

FIG. 21.

The blow-pipe has, strictly, a three-fold application. It may be employed, as just pointed out, to distinguish minerals from one another; some of these being fusible, whilst others are infusible; some attracting the magnet after exposure to the blow-pipe, whilst others do not exhibit that reaction; some imparting a colour to the flame, others volatilizing, and so forth. Secondly, the blow-pipe may be employed to ascertain the general composition of a mineral, or the presence or absence of some particular substance in it, as copper, lead, iron, cobalt, manganese, sulphur, arsenic, and the like. Thirdly, the blow-pipe may be used to determine in certain special

* More convenient forms of blow-pipe will be found described in special works on the use of that instrument, but the common form described above is quite sufficient for the simple experiments required in the determination of our ordinary minerals.

cases the actual amount of a metallic or other ingredient previously ascertained to be present in the substance under examination.*

In the employment of the blow-pipe (in conjunction with external characters) in the simple determination of our Canadian minerals, we are never compelled to resort to more than two experiments: the *fusion-trial*, and the *water-test*. The student will find it of advantage, however, to study in addition the reactions of the more common metals and metallic oxides as given in special works on the Blow-pipe. To describe these reactions in the present essay would extend the subject much beyond its allotted limits.

The Trial of Fusibility.—In order to ascertain the relative fusibility of a substance, we chip off a small particle (the smaller the better) and expose the point of this to the extremity of the blow-pipe flame —holding the test-fragment in a small pair of tongs or forceps with platinum tips;† or supporting it, if it be of a metallic aspect or of a certain weight and exhibit at the same time a coloured streak, on a piece of well-burnt pine charcoal. The particle thus exposed to the flame ought not to be larger than a small carraway seed. If it be fusible, its point, in the course of ten or fifteen seconds, will become rounded into a bead or globule. The proper method of blowing can be acquired by half-an-hour's practice. The cheeks are to be filled with air, and this is to be urged *gently* and continuously down the tube by the compression of the cheek muscles, the operator breathing at the same time (if he require to do so) through his nose. By a little practice this becomes exceedingly easy; and the blowing need never be kept up (at least in experiments of this kind) for more than a quarter of a minute at a time. A *thin splinter* will exhibit signs of fusion in ten or twelve seconds, or not at all. The use of the instrument, therefore, is easily acquired, and is in no way injurious to the health.

Thus treated:

(*a*) The test-fragment may "decrepitate" or fly to pieces. Example, most specimens of galena. In this case, a larger fragment

* See, for example, a paper by the author "on the Assaying of Coals by the Blow-pipe," first published in this Journal: Vol. III., page 208. Also Plattner's "Probirkunst mit dem Lothröhre."

† These forceps may be obtained from any dealer in chemical apparatus. For simple experiments they may be replaced by a strip of thin sheet iron bent into the form of a pair of nippers or tongs. Some twine or silk must be twisted round the middle part to prevent the fingers from being burned.

must be heated in a test-tube over a small spirit lamp, and after decrepitation has taken place, one of the resulting fragments may be exposed to the blow-pipe flame as already explained.

(*b*) The test-fragment may change colour (with or without fusing) and become attractable by a magnet. Example, carbonate of iron. This becomes first red, then black, and attracts the magnet, but does not fuse. Iron pyrites on the other hand becomes black and magnetic, but fuses also.

(*c*) The test-fragment may colour the flame. Thus, most copper compounds impart a rich green colour to the flame; compounds containing baryta, and many phosphates and borates, with the mineral molybdenite, colour the flame pale green; sulphur, selenium, lead, and chloride of copper colour the flame blue of different degrees of intensity; compounds containing strontia and lithia impart a crimson colour to the flame; some lime compounds impart to it a paler red colour; soda compounds, a deep yellow colour; and potash compounds, a violet tint.

(*d*) The test-fragment may become caustic. Example, carbonate of lime. The carbonic acid is burned off, and caustic lime remains. This restores the blue colour of reddened litmus paper. It also imparts if moistened, a burning sensation to the back of the hand or other sensitive part.

(*e*) The test-fragment may take fire and burn. Example, native sulphur; common bituminous coal, &c.

(*f*) The test-fragment may "volatilize," or dissipate in fumes, either wholly or partially, and with or without an accompanying odor. Thus, grey antimony ore volatilizes with dense white fumes; arsenical pyrites volatilizes in part, with a strong odor of garlic; common iron pyrites yields an odour of brimstone, and so forth.

(*g*) The test-fragment may fuse, either wholly, or only at the point and edges; and the fusion may take place quietly, or with bubbling, and with or without a previous "intumescence" or expansion of the fragment. Most of the so-called zeolites, for example, (minerals abundant in Trap rocks), swell or curl up on exposure to the blowpipe, and then fuse quietly. Lepidolite fuses with great bubbling, and colours the flame red. Feldspar only melts on the edges, at least, in ordinary cases.

(*h*) The test-fragment may remain unchanged. Example, Quartz, and various other infusible minerals.

The Water-test.—Many solid minerals contain a considerable amount of water, or the elements of water, in some unknown physical condition. Gypsum, for example, contains 20.93 per cent. of water. In order to ascertain if a substance yield water, we chip off a fragment (of about the size of a small pea) and heat this in a common test-tube (or better, in a small "bulb-tube" or glass tube closed and expanded at one end, as shown in the accompanying figure) over the flame of a little spirit lamp. If water be present, it will rise and condense in the form of a thin film, or in small drops, on the cold neck or upper part of the tube. When the moisture begins to appear, the tube must be held in a more or less horizontal position, otherwise a fracture may be occasioned by the water flowing down and coming in contact with the hot glass. A small spirit lamp may be made by fitting a piece of glass tubing an inch long (to serve as a wick holder) into the cork of any short, stout bottle. A proper lamp, however, with a glass cap to prevent the evaporation of the spirit when the lamp is not in use, can be purchased for a quarter of a dollar.

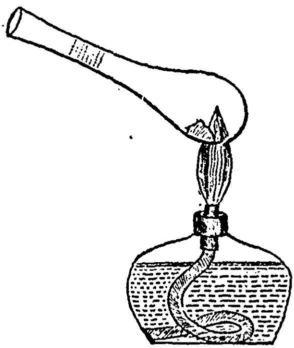

FIG. 22.

This concludes our review of the more common characters possessed or exhibited by mineral bodies. The application of these characters to the actual determination of Canadian minerals, by means of an original Tabular Distribution or Arrangement, will be shewn in the next number of the *Journal*.

ERRATA.

Figure 7 (on page 7) has been accidentally printed in a reversed position.

Page 5, line 17, *for* "realgar, or sulphide of arsenic," *read* "realgar, a sulphide of arsenic."

Page 15, line 5 from bottom, *for* "which," *read* "whilst this."

RESOLUTION OF ALGEBRAICAL EQUATIONS.

Proof of the impossibility of representing in finite algebraical functions, in the most general case, the roots of algebraical equations of degrees higher than the fourth; with methods for finding the roots of equations of the 5th, 6th, 7th, &c., degrees, in those cases where the coefficients in the given equations involve a general or variable quantity, but where, in consequence of relations subsisting between the coefficients, the roots of the equations happen to admit of being exactly represented in finite algebraical functions.

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Read before the Canadian Institute, 19th February, 1859.

DEFINITIONS.

Def. 1. In the functions which are to be considered, a variable is involved; and, when quantities are spoken of as rational or irrational, the meaning always is, rational or irrational *with respect to the variable.* Thus, c being constant, and p variable, the former of the expressions, $c + \sqrt{p}$, $\sqrt{c + p}$, is surd or irrational; and the latter, rational.

Def. 2. Surds may be distinguished as *of different orders.* The n^{th} root of a rational expression, n being a prime number, distinct from unity, is a surd of the first order. But the n^{th} root of a rational expression, when $n = n_1 n_2 n_3 \ldots n_s$, each of the numbers, n_1, n_2, &c., being a prime number distinct from unity, is a surd of the s^{th} order. Again, the n^{th} root of an expression involving surds of the s^{th} order, but of no higher order, when $n = n_1 n_2 n_3 \ldots n_t$, each of the numbers, n_1, n_2, &c., being a prime number distinct from unity, is a surd of the $(s+t)^{\text{th}}$ order, and so on. Thus, the first of the expressions,

$$(c+p)^{\frac{1}{13}},\ \left\{(c+p)^{\frac{1}{12}} + p\right\}^{\frac{2}{3}},\ c^2 + \left[\left\{\left(c+p^{\frac{1}{6}}\right)^{\frac{1}{2}} + p^{\frac{1}{16}}\right\}^{\frac{1}{3}} + \sqrt{p}\right]^{\frac{1}{33}},$$

is a surd of the third order; the second, of the fourth order; and the third, of the seventh order.

Def. 3. Every surd of a certain order is formed by the extraction of some root, (as the n^{th}), of an expression involving only surds of the order immediately inferior, n being a prime number, When we speak of *the index of the surd* so formed, the fraction $\frac{1}{n}$ is meant. For instance, if we regard $(c+p)^{\frac{1}{15}}$ as generated by the extraction of the fifth root of $(c+p)^{\frac{1}{3}}$, it is a surd of the second order, with the index $\frac{1}{5}$. From another point of view, it might be described as a surd of the second order, with the index $\frac{1}{3}$.

Def. 4. In the case of a surd of a certain order, we may distinguish *the principal surd* from its *subordinates*. Thus, under the principal surd, $(c+\sqrt{p})^{\frac{1}{3}}$, is involved the subordinate $\sqrt{p}$. Under the principal surd,

$$\left[\left\{c+(1+p^2)^{\frac{5}{7}}\right\}^{\frac{1}{8}}+(2+p)^{\frac{2}{5}}\right]^{\frac{1}{2}},$$

c being a constant quantity, are involved the subordinates,

$$(1+p^2)^{\frac{1}{7}},\ (2+p)^{\frac{1}{5}},\ \left\{c+(1+p^2)^{\frac{5}{7}}\right\}^{\frac{1}{2}},$$
$$\left\{c+(1+p^2)^{\frac{5}{7}}\right\}^{\frac{1}{4}},\ \left\{c+(1+p^2)^{\frac{5}{7}}\right\}^{\frac{1}{8}};$$

the first appearing in the principal surd only in its fifth power; and the second only in its second power. A surd which is a subordinate of the surd Y, but is not a subordinate of any surd which is itself subordinate to Y, may be termed a *chief subordinate* of Y; while those surds which are subordinates of surds subordinate to Y may be called *secondary subordinates* of Y.

Def. 5. An *integral function* of a variable is one in which no surd, principal or subordinate, occurs as the denominator, or a term in the denominator, of a fraction. For instance, c being constant, and p variable, the first of the expressions,

$$\frac{\sqrt{p}}{\sqrt{c}},\quad \left(c^2+\frac{1}{c+\sqrt{p}}\right)^{\frac{1}{3}},\quad c+\frac{1}{\sqrt{p}},$$

is an integral function of p; but the two last are not.

Cor. A given algebraical function $f(p)$ of a variable p always admits of being exhibited as an integral function. For, reduce the function to the form $\frac{N}{D}$; where each of the quantities N and D is the sum of a rational expression, which may be zero, and of a finite series of terms, each of them the product of a rational coefficient by some power of an integral surd, or by the continued product of several such powers. Take Y, one of the surds of highest order present in any of its powers in the function; and arrange the terms in N and D according to the powers of Y not exceeding the $(m-1)^{th}$, $\frac{1}{m}$ being the index of the surd Y. Then

$$f(p) = \frac{a + a_1 Y + a_2 Y^2 + \ldots + a_{m-1} Y^{m-1}}{b + b_1 Y + b_2 Y^2 + \ldots + b_{m-1} Y^{m-1}};$$

where the coefficients, b, a, b_1, a_1, &c., may involve powers of any surd in $f(p)$, except Y. No powers of Y higher than the $(m\text{-}1)^{th}$ are written; because, for instance, if there were a term AY^{m+2} in the numerator, A being an expression clear of the said Y, it might be written, $(AY^m)Y^2$. But Y^m may be written so as to involve only the subordinate surds of Y; and hence the term AY^{m+2} may be considered as contained in the term, $a_2 Y^2$. Assume

$$\frac{a + a_1 Y + \&c.}{b + b_1 Y + \&c.} = c + c_1 Y + \ldots\ldots + c_{m-1} Y^{m-1};$$

and, when the expressions, $b + b_1 Y + \&c.$, $c + c_1 Y + \&c.$, are multiplied by one another, let the product, arranged according to the powers of Y not exceeding the $(m\text{-}1)^{th}$, be, $d + d_1 Y + \&c.$; where d, d_1, &c., are clear of the surd Y. Then

$$a + a_1 Y + \&c = d + d_1 Y + \ldots\ldots + d_{m-1} Y^{m-1}.$$

Determine the m unknown quantities, c, c_1, ..., c_{m-1}, by the m simple equations,

$$d = a,\ d_1 = a_1, \ldots\ldots, d_{m-1} = a_{m-1}.$$

Then the function may be written,

$$f(p) = c + c_1 Y + c_2 Y^2 + \&c.;$$

where the coefficients, c, c_1, &c., are clear of the surd Y. Again, let a surd of the highest order present in any of its powers in the coefficients c, c_1, &c., be V; and its index $\frac{1}{n}$. By the process already exemplified, we may find, for each of the coefficients, c, c_1, &c., an equivalent expression such as

$$h + h_1 V + h_2 V^2 + \ldots\ldots + h_{n-1} V^{n-1};$$

where h, h_1, &c., are clear of the surds V and Y. Let it be remarked, that, in consequence of our having commenced with Y, a surd of the highest order in $f(p)$, it is impossible, after Y has once been disposed of, as above, that it can ever return upon our hands, as it might do, if it were a subordinate of any of the principal surds in c, c_1, &c. From the same consideration we selected V, a surd of the highest order in c, c_1, &c. We may obviously go on in the manner described, till we have exhausted all the surds that need to be disposed of, in order to make the expression for $f(p)$ altogether an integral function of p.

Def. 6. Let $f(p)$ be an algebraical function of a variable p. Instead of Y_1, a surd of the lowest order in $f(p)$, having the index $\frac{1}{m}$, write z_1Y_1 in every place where Y_1 occurs in $f(p)$ in any of its powers, z_1 being an indefinite m^{th} root of unity. Do in like manner with all the other surds of the lowest order. Again, Y_2 being a surd of the order next to the lowest in $f(p)$ thus altered, having $\frac{1}{n}$ for its index, and z_2 being an indefinite n^{th} root of unity, write z_2Y_2 for Y_2 in every place where Y_2 occurs in the function in any of its powers. Proceed in this way, till modifications of the kind described have been made upon all the surds in the function, including those of the highest order; and let the function, after having suffered all these changes, become $\phi(p)$. Denote by ϕ_1, ϕ_2, ϕ_3,……, ϕ_λ, the values of $\phi(p)$, not necessarily all unequal, that result from taking all the possible values of the indefinite numerical quantities, z_1, z_2, &c., which have been introduced into the function. These expressions, ϕ_1, ϕ_2, &c., may be termed the *cognate functions* of $f(p)$.

As it is important that a clear apprehension be formed of the manner in which we understand the terms ϕ_1, ϕ_2, &c., we subjoin illustrative examples. Let

$$f(p)=(1+\sqrt{p})^{\frac{1}{3}}+(1+\sqrt{p})^{\frac{2}{3}}.$$

$$\text{Then, } \phi(p)=z_2(1+z_1\sqrt{p})^{\frac{1}{3}}+z_2(1+z_1\sqrt{p})^{\frac{2}{3}}.$$

Here there are, including $f(p)$, six cognate functions;

$$f(p)=\phi_1=(1+\sqrt{p})^{\frac{1}{3}}+\quad(1+\sqrt{p})^{\frac{2}{3}};$$

$$\phi_2=z\ (1+\sqrt{p})^{\frac{1}{3}}+z^2(1+\sqrt{p})^{\frac{2}{3}};$$

$$\phi_3=z^2(1+\sqrt{p})^{\frac{1}{3}}+z\ (1+\sqrt{p})^{\frac{2}{3}};$$

$$\phi_4 = (1-\sqrt{p})^{\frac{1}{3}} + (1-\sqrt{p})^{\frac{2}{3}};$$
$$\phi_5 = z\,(1-\sqrt{p})^{\frac{1}{3}} + z^2(1-\sqrt{p})^{\frac{2}{3}};$$
$$\phi_6 = z^2(1-\sqrt{p})^{\frac{1}{3}} + z\,(1-\sqrt{p})^{\frac{2}{3}};$$

where z is a definite third root of unity, distinct from unity. In the three first of these equations, in order that ϕ_1, ϕ_2, and ϕ_3, may be definite, we must take a definite value of $\sqrt{p}$, and then also a definite value of $(1+\sqrt{p})^{\frac{1}{3}}$. As a new surd, $(1-\sqrt{p})^{\frac{1}{3}}$, occurs in the three last equations, we must fix upon some definite value of this surd, retaining the definite value already assigned to $\sqrt{p}$; and then ϕ_4, ϕ_5, and ϕ_6, will be definitely determined. Had we assumed

$$f(p) = (p+\sqrt{p^2-1})^{\frac{1}{3}} + (p-\sqrt{p^2-1})\,(p+\sqrt{p^2-1})^{\frac{2}{3}},$$

we should have got six cognate functions; but three of them merely a repetition of the other three; for the three which result from taking $\sqrt{p^2-1}$ with the negative sign are the same as those which result from taking it with the positive sign.

Def. 7. Suppose that we form the cognate functions of $f(p)$, as described in the previous definition, with this difference, that we now proceed as though certain surds, Y_1, Y_2, &c., (in such a series all the subordinates of any surd mentioned are necessarily included), were rational. In other words, attach no indefinite numerical multipliers, (as z_1, z_2, &c.,) to any of the surds, Y_1, Y_2, &c.; but consider each of these surds as having a single definite value. The cognate functions of $f(p)$, so obtained, may be termed the cognate functions of $f(p)$, *taken without reference to the surd character of the surds* Y_1, Y_2, &c. For instance, let

$$f(p) = (2+p^{\frac{1}{5}})^{\frac{1}{7}} + (1+\sqrt{p})^{\frac{1}{3}} + (1+\sqrt{p})^{\frac{2}{3}} + \sqrt{p};$$

then the cognate functions of $f(p)$, taken without reference to the surd character of the surds, $\sqrt{p}$, $p^{\frac{1}{5}}$, $(2+p^{\frac{1}{5}})^{\frac{1}{7}}$, are,

$$\phi_1 = (2+p^{\frac{1}{5}})^{\frac{1}{7}} + (1+\sqrt{p})^{\frac{1}{3}} + (1+\sqrt{p})^{\frac{2}{3}} + \sqrt{p};$$
$$\phi_2 = (2+p^{\frac{1}{5}})^{\frac{1}{7}} + z\,(1+\sqrt{p})^{\frac{1}{3}} + z^2(1+\sqrt{p})^{\frac{2}{3}} + \sqrt{p};$$

$$\phi_3=(2+p^{\frac{1}{5}})^{\frac{1}{7}}+z^2(1+\sqrt{p})^{\frac{1}{3}}+z\,(1+\sqrt{p})^{\frac{2}{3}}+\sqrt{p}\,;$$

z being a definite third root of unity.

Def. 8. Let $f(p)$ be an integral function of a variable p; and suppose, that, if Y be *any* surd whatever, principal or subordinate, occuring in the function in its c^{th} power, and having (see Def. 3) the index $\frac{1}{s}$, c is less than s. Also, the form of the function being,

$$f(p)=A+A_1Y_1+A_2Y_2+\ldots\ldots+A_mY_m,$$

where the coefficients A, A_1, &c., are (see Def. 1) rational, and each of the terms Y_1, Y_2, &c., is either some power of an integral surd, or the continued product of several such powers, suppose that no two of the terms, Y_1, Y_2, &c., are identical. Finally, if V be any surd, principal or subordinate, occurring in the function in its n^{th} power, and if the form of V^n be,

$$V^n=(B+B_1Y_1+B_2Y_2+\ldots\ldots+B_cY_c)^{\frac{n}{r}},$$

where the coefficients, B, B_1, &c., are rational, and each of the terms, Y_1, Y_2, &c., is either some power of an integral surd, or the continued product of several such powers, the index of the surd V being $\frac{1}{r}$, suppose that no two of the quantities, Y_1, Y_2, &c., are identical. When these conditions are satisfied, the function $f(p)$ may be described as satisfying the conditions of Def. 8.

Cor. Any given algebraical function $f(p)$ of a variable p admits of being exhibited so as to satisfy the conditions of the Definition. For should a surd Y, principal or subordinate, with the index $\frac{1}{s}$, occur in the function in its c^{th} power, c not being less than s, let ws be the greatest multiple of s in c; the excess of c above ws, (which may be zero), being k. Then we may replace Y^c by $(Y^{ws})\,Y^k$; and, since the index of the surd Y is $\frac{1}{s}$, Y^{ws} may be written out so as to involve only the subordinate surds of Y. Thus the violation of the first condition of the Definition, involved in the term Y^c, is got quit of. For instance,

$$Y^c=(1+\sqrt{p})^{\frac{8}{5}}=(1+\sqrt{p})^{\frac{3}{5}}+\sqrt{p}\,(1+\sqrt{p})^{\frac{3}{5}}.$$

Next, should any such quantities as Y_1, Y_2, &c., (see above), be identical, the terms containing the identical quantities, as described, may be combined into a single term. For instance,

$$f(p)=p+\left\{1+p\sqrt{p}+p^{2}\sqrt{p}\right\}^{\frac{1}{3}}+p\left\{1+p\sqrt{p}+p^{2}\sqrt{p}\right\}^{\frac{1}{3}}$$
$$=p+(1+p)\left\{1+(p+p^{2})\sqrt{p}\right\}^{\frac{1}{3}}.$$

Def. 9. An irrational function, $f(p)$, of a variable p, is said to be *in a simple form*, when no equation such as,

$$A+BU+CV+\ldots\ldots+DY+\ldots\ldots+ET=0,\ldots\ldots\ldots\ldots(1)$$

can subsist; where the coefficients, B, C, ..., E, all of them distinct from zero, are (see Def. 1) rational; A likewise being rational; and each of the terms, U, V, ..., T, is either some power of an integral surd occurring in $f(p)$, or the continued product of several such powers; the expression on the left hand side of the equation satisfying the conditions of Def. 8. Let it be observed, that, in this paper, when we speak of a surd occurring in a function, we mean that the surd appears in the function, as a principal or subordinate surd, in some one or more of its powers, but not necessarily in the first power. Thus, the surds which occur in the function,

$$p+\sqrt{7}+(p-\sqrt{p^{2}-1})^{\frac{2}{7}}+(p-\sqrt{p^{2}-1})^{\frac{5}{7}},$$

are, $\sqrt{p^{2}-1}$, and, $(p-\sqrt{p^{2}-1})^{\frac{1}{7}}$. The first occurs in its first power; the second, in its second and fifth powers. This being kept in view, we may instance, as violating the condition above mentioned, the function,

$$f(p)=(p+\sqrt{p^{2}-1})^{\frac{1}{3}}+(p-\sqrt{p^{2}-1})^{\frac{1}{3}}\ldots\ldots\ldots\ldots(2)$$

For the equation, of the form (1), subsists:

$$(p-\sqrt{p^{2}-1})^{\frac{1}{3}}-(p+\sqrt{p^{2}-1})^{\frac{2}{3}}(p-\sqrt{p^{2}-1})=0.$$

Hence $f(p)$, as exhibited in (2), is not in a simple form.

Cor. 1. The Definition implies, that, should an irrational function of a variable p, in a simple form, and equal to zero, present itself in the form,

$$f(p)=A+BU+CV+\ldots\ldots+ET,$$

where U, V, &c., are terms of the same kind as in equation (1), and

A, B, &c., are rational, the coefficients A, B, &c., must vanish separately. Also, should $f(p)$ be of the form,

$$f(p) = A + A_1 V_1 + A_2 V_2 + \ldots\ldots + A_c V_c,$$

where each of the terms, V_1, V_2, &c., no two of them identical with one another, is either some power of an integral surd, or the continued product of several such powers, while the expressions A, A_1, &c., involve only surds distinct from those whose powers constitute the factors of the terms V_1, V_2, &c., then [it being understood, as before, that $f(p)$ is in a simple form and equal to zero] the cofficients A, A_1, &c., must vanish separately.

Cor. 2. If $f(p)$, a function of a variable p, be in a simple form, and if

$$A + A_1 Y_1 + A_2 Y_2 + \ldots + A_c Y_c = B + B_1 U_1 + B_2 U_2 + \ldots + B_m U^m ; \ldots(3)$$

where A_1, B_1, A_2, B_2, &c., none of them being zero, are rational; A and B also being rational; and each of the expressions, Y_1, U_1, Y_2, U_2, &c., is *either* some power of an integral surd occuring in $f(p)$, or the continued product of several such powers; the expressions, $A + A_1 Y_1 +$ &c., $B + B_1 U_1 +$ &c., having been arranged so as severally to satisfy the conditions of Def. 8; then the surd parts,

$$Y_1, Y_2, \ldots\ldots\ldots, Y_c \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

are identical, taken in same order, with the surd parts,

$$U_1, U_2, \ldots\ldots\ldots, U_m; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (5)$$

and, U_1 being the part identical with Y_1, the rational coefficient B_1 is equal to the rational coefficient A_1. What we mean by *identical with*, as distinguished from *equal to*, may be shown by an example. The surd $\sqrt{p^2 - 1}$ is equal to the product of the two surds, $\sqrt{p+1}$, $\sqrt{p-1}$. But the expressions, $\sqrt{p^2-1}$, $\sqrt{p+1}\ \sqrt{p-1}$, are not identical; because the only surd which appears in the former is not found in the latter; and the surds which constitute the factors of the latter do not appear in the former. The truth of the Corollary may thus be shown. Should any term in (4), as Y_1, be identical with a term in (5), as U_1, let the two terms, $A_1 Y_1$ and $B_1 U_1$, in (3), the latter removed to the left hand side of the equation, be written as one term, $Y_1 (A_1 - B_1)$. No other term in (5) can be identical with Y_1, for then it would also be identical with U_1; but since the expression, $B + B_1 U_1 +$, &c., satisfies the conditions of Def. 8, no two terms in

(5) are identical. If U_2 be identical with a term in (4), necessarily distinct from Y_1, let that term be Y_2; and let the two terms, $A_2 Y_2$ and $B_2 U_2$, in (3), the latter removed to the left hand side of the equation, be written, $Y_2 (A_2 - B_2)$. Make all other such modifications as are possible. Then equation (3) becomes,

$$(A - B) + Y_1(A_1 - B_1) + \ldots\ldots\ldots + A_a Y_a - B_n U_n + \&c. = 0\,; \ldots\ldots\ldots (6)$$

where all the terms, Y_1, Y_a, U_n, &c., are distinct; so that the expression on the left-hand side of equation (6) satisfies the conditions of Def. 8. Therefore, by Cor. 1, the coefficients, $A_1 - B_1, \ldots\ldots, A_a, B_n$, &c., vanish separately. But, since the terms A_1, B_1, &c., are all (by hypothesis) distinct from zero, this shows that there are, in fact, no such terms in (6) as those which we have written, $A_a Y_a$, $- B_n U_n$. Hence the terms in (4) are identical, taken in same order, with those in (5). Also, Y_1 being identical with U_1, we have seen that A_1 is equal to B_1.

Proposition I.

If $f(p)$ be an integral function of a variable p, not in a simple form, then an equation,

$$Y_c = P Y_1^{\lambda_1} Y_2^{\lambda_2} \ldots\ldots\ldots Y_a^{\lambda_a} \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

must subsist; where Y_c, Y_1, &c., are surds, principal or subordinate, occurring in $f(p)$, of the same order, and with a common index $\frac{1}{s}$; λ_1, λ_2, &c., being whole numbers, less than s; while P is an expression involving only such surds, occurring in $f(p)$, as are of lower orders than the surds Y_c, Y_1, &c.

For, since $f(p)$ is not in a simple form, an equation such as (1), Def. 9,

$$A + BU + CV + \ldots\ldots + DY + \ldots\ldots + ET = 0, \ldots\ldots (2)$$

subsists; all the surds involved in the equation being surds present in $f(p)$. Let

$$Y_c = P Y_1^{\lambda_1} Y_2^{\lambda_2} \ldots\ldots Y_a^{\lambda_a} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

be an equation such as (1), with this difference, that the indices of the surds Y_c, Y_1, &c., are not assumed to be equal to one another; but λ_1 is less than the denominator of the index of Y_1, λ_2 less than the denominator of the index of Y_2, and so on. Of the terms, U, V, ..., T, in (2), let those which involve among their factors surds of the highest order in equation (2), be, U, V, ..., Y; and let the sum of A and of those terms, such as ET, in (2), which do not involve surds of the highest order present in (2), be H. Then

$$H + BU + CV + \ldots\ldots\ldots + DY = 0.$$

Again, let

$$U = H_1 X_1, \; V = H_2 X_2, \ldots\ldots\ldots, \; Y = H_a X_a;$$

where X_1 is the continued product of those factors of U, which are powers of surds of the highest order in (2); X_2, the continued product of those factors of V, which are powers of surds of the highest order in (2); and so on. Then, putting

$$H + BH_1 X_1 + CH_2 X_2 + \ldots\ldots + DH_a X_a = 0, \ldots\ldots\ldots\ldots (4)$$

let us suppose, if possible, that no such equation as (3) can subsist; and, in connection with this supposition, let us make the hypothesis, that the terms, X_1, X_2, &c., are all distinct from one another. By differentiating (4) with regard to p, we get

$$H \frac{d\{\log(H)\}}{dp} + BH_1 X_1 \frac{d\{\log(BH_1 X_1)\}}{dp} + \&c. = 0 \ \ldots\ldots \ (5)$$

Multiply (4) by the coefficient of $BH_1 X_1$ in (5), and subtract the product from (5). Then

$$h H + h_2 C H_2 X_2 + \ldots\ldots\ldots + h_a D H_a X_a = 0; \ \ldots \ \ldots\ldots\ldots\ldots \ (6)$$

where the values of h, h_2, &c., are

$$h = \frac{d\left\{\log\left(\frac{H}{BH_1 X_1}\right)\right\}}{dp}$$

$$h_2 = \frac{d\left\{\log\left(\frac{CH_2 X_2}{BH_1 X_1}\right)\right\}}{dp}$$

and so on. None of the factors of the coefficient of X_2 in (6) vanish. For C (by hypothesis) is not zero. The equation, $H_2 = 0$, is virtually of the form (3), which we have supposed inadmissible. And, if h_2 were zero, we should have, by integrating the value of h_2,

$$BH_1 X_1 = k\, CH_2 X_2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

k being a constant quantity, that is, a quantity independent of p. But since X_1 and X_2 are not identical, there must be one factor of

X_1, as $M^{\frac{c}{\lambda}}$, such that X_2 either has no power of the surd $M^{\frac{1}{\lambda}}$ as one of its factors, or a power of $M^{\frac{1}{\lambda}}$ distinct from the c^{th}. Both of these alternatives are included in the assumption that $M^{\frac{r}{\lambda}}$ is a factor of X_2, r being a whole number, which is not equal to c, but may be zero. Hence, if equation (7) subsist, we have

$$BH_1 X' M^{\frac{c-r}{\lambda}} = k\, CH_2 X'', \dots\dots\dots\dots\dots\dots \quad (8)$$

where X' is what X_1 becomes when the factor $M^{\frac{c}{\lambda}}$ is rejected; and X'' is what X_2 becomes on the rejection of the factor $M^{\frac{r}{\lambda}}$. Since c and r are whole numbers, different from one another, and each less than the prime number λ, we can choose whole numbers, m and n, such that $m\,(c-r) = n\lambda + 1$. Then

$$(BH_1 X')^m M^n M^{\frac{1}{\lambda}} = (k\, CH_2 X'')^m.$$

$$\therefore M^{\frac{1}{\lambda}} = (BH_1 X')^{-m} M^{-n} (k\, CH_2 X'')^m. \dots\dots\dots\dots (9)$$

But this equation will be readily seen, when the expression on its right hand side is rendered (Cor. Def. 5) integral, and made to satisfy the conditions of Def. 8, to be of the inadmissible form (3). Consequently h_2 cannot be zero; and therefore the coefficient of X_2 in (6) is not zero. In like manner it can be shown that the coefficients of all the other terms, such as X_2, in (6), are distinct from zero. Again, the coefficients of the terms, H, X_2, X_3, &c., in (6), when rendered integral functions, and made to satisfy the conditions of Def. 8, involve no surd of so high an order as those whose powers constitute the factors of X_2, X_3, &c. This will be plain if it be considered that the differential coefficient of the logarithm of any power of a surd does not involve, when arranged so as to satisfy the conditions of Def. 8, the surd in question. For instance,

$$\frac{d\left\{ \log (1+\sqrt{p})^{\frac{2}{3}} \right\}}{dp} = \frac{\sqrt{p}-p}{3p(1-p)},$$

where the differential coefficient obtained is clear of the surd

$(1+\sqrt{p})^{\frac{1}{3}}$. Since therefore the coefficients of the terms, H, X_2, ..., X_a, in (6), when arranged so as to satisfy the conditions of Def. 8, involve only surds of lower orders than those whose powers constitute the factors of X_2, X_a, &c., and since the coefficients of the terms, X_2, ..., X_a, in (6), are all distinct from zero, it follows that equation (6) is of the same character as equation (4). But equation (6) contains one term less than equation (4), X_1, having been eliminated. Therefore, in the same way in which equation (6) was derived from (4), we may deduce from (6) another equation of the same character as (6), but with a term fewer. And so on, till ultimately we get

$$b\,H + l\,X_a = 0\,;$$

where l and b, the former not zero, involve no surds of so high an order as those whose powers constitute the factors of X_a. But [compare the reasoning by which equation (9) was deduced from (8)] this is virtually an equation of the inadmissible form (3). Hence, in consistency with the hypothesis that equation (3) cannot subsist, it cannot be supposed that the terms, X_1, X_2, ..., X_a, in (4), are all distinct from one another. Should X_a then be identical with X_1, let the two terms, $BH_1\,X_1$, $DH_a\,X_a$, be combined into the single term, $X_1\,(BH_1 + DH_a)$. Make all other such modifications on equation (4) as are possible. Ultimately we get

$$H + X_1\,(BH_1 + DH_a + \&c.) + X_2\,(CH_2 + \&c.) + \&c. = 0 \ldots (10)$$

where no two of the terms, X_1, X_2, &c., are identical. But, by what has been proved, this is impossible, except upon condition that the coefficients of X_1, X_2, &c., vanish separately. Put therefore

$$BH_1 + DH_a + \&c. = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

If we compare this equation with (2), we perceive that it is of the same character as (2), with this difference, that there is no surd in equation (11) of so high an order as some of the surds in equation (2). But, in the same manner in which we derived (11) from (2), we may deduce from (11) another equation bearing the same relation to (11) as (11) bears to (2). And so on, till ultimately one of the equations, such as (10), at which we arrive, contains only one term such as X_1, with no more than a single term, such as BH_1, for its coefficient: from which it follows that B must be zero; whereas all the coefficients, B, C,........., E, in (2), were supposed (see Def. 9) to be distinct from zero. Hence some equation such as (3) must of necessity admit of being formed. Now suppose that the indices of the surds, Y_c, Y_1, &c , in (3), are, $\frac{1}{s}$, $\frac{1}{s_1}$, &c ; and that s_1 is not equal to s. By raising both sides of equation (3) to the s_1^{th} power, we may easily [compare the manner in which equation (9) was deduced from (8)] transform (3) into an equation, not involving the surd Y_1,

$$Y_c = P_1 \, Y_2^{\beta_2} \, Y_3^{\beta_3} \, \ldots\ldots\ldots Y_s^{\beta_s},$$

where P_1 is an expression such as P; β_2 being a whole number less than the denominator of the index of Y_2; β_3, a whole number less than the denominator of the index of Y_3 ; and so on. By continuing this process of reduction as far as necessary, we ultimately arrive at an equation such as (1).

Cor. Let each of the terms, Y_1, Y_2, &c., be either some power of an integral surd, or the continued product of several such powers; while A_1, A_2, &c., are algebraical expressions, distinct from zero; and A is an algebraical expression not assumed to be distinct from zero. Then, if

$$A + A_1 \, Y_1 + A_2 \, Y_2 + \ldots\ldots + A_c \, Y_c = 0, \ldots\ldots \quad (12)$$

an equation of the form;

$$Y_1 = P \, Y_n^m \, , \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

must subsist; where P is an expression involving only such surds as are present in the coefficients A, A_1, &c., or are subordinates of some of the surds whose powers constitute the factors of Y_1, Y_2, &c.; and Y_n is a term in the series, Y_2, ..., Y_c; m being either unity or zero. For, in the same way in which we eliminated X_1 from equation (4), we may proceed to eliminate successively the terms Y_2, ..., Y_c, from (12). The result of the elimination of Y_2 is,

$$\ldots\ldots + A_1 \, Y_1 \frac{d \left\{ \log \left(\dfrac{A_1 \, Y_1}{A_2 \, Y_2} \right) \right\}}{dp} + \&c. = 0 \ldots\ldots (14)$$

Here (see remarks in the Proposition) the coefficient of Y_1, when made to satisfy the conditions of Def. 8, involves no surds except such as are found in A_1 or A_2, or are subordinates of the surds whose powers constitute the factors of Y_1 and Y_2. Hence the coefficient of Y_1 in (14) is an expression such as P in (13). Should this coefficient vanish, we have $A_1 \, Y_1 = k \, A_2 \, Y_2$, k being a constant; which equation is of the form (13). Suppose that the coefficient of Y_1 in (14) does not vanish; and let equation (14), for the sake of simplicity, be written,

$$B + B_1 Y_1 + B_3 Y_3 + \ldots\ldots + B_c Y_c = 0 \ldots\ldots\ldots\ldots (15)$$

In the same manner in which we proved B_1 to be an expression such as P, it can be shown that all the other terms, B, B_3, &c., are expressions such as P. Eliminate Y_3 from equation (15), as Y_2 was eliminated from (12). The result of the elimination is

$$\ldots\ldots + B_1 Y_1 \frac{d \left\{ log \left(\frac{B_1 Y_1}{B_3 Y_3} \right) \right\}}{dp} + \&c. = 0 \ldots\ldots (16)$$

As above, the coefficient of Y_1 here is an expression such as P. Also, if that coefficient vanish, we have $B_1 Y_1 = k B_3 Y_3$, k being a constant quantity. And this equation is of the form (13). Should the coefficient of Y_1 in (16) not vanish, we may proceed to eliminate another of the terms, Y_2, Y_3, ..., Y_c; and it will be found that the coefficient of Y in the equations that result from such eliminations can never at any stage become zero, unless such an equation as (13) subsist. Suppose then that all the terms, Y_2, Y_3, ..., Y_c, can be eliminated in the manner described, without the coefficient of Y_1 at any stage becoming zero. Then ultimately we get

$$H A + K A_1 Y_1 = 0,$$

where H and K, the latter (and consequently also the former) not zero, are expressions such as P. And this is an equation of the form (13), m being taken equal to zero. Hence an equation such as (13) must necessarily subsist.

Proposition II.

In $f(p)$, an integral function of a variable p, in a simple form, satisfying the conditions of Def. 8, let Y be a surd which is not subordinate to any other in the function, its index being $\frac{1}{s}$. Arrange $f(p)$ as follows:

$$f(p) = A + A_c Y^c + A_n Y^n + A_m Y^m + \&c.,$$

where A_c, A_n, &c., are expressions distinct from zero, and clear of the surd Y; A being also clear of the surd Y; and Y^c, Y^n, &c., being distinct powers of Y, not exceeding the $(s-1)^{th}$. Let the surd T be a chief (see Def. 4) subordinate of Y, but not a subordinate of any other surd in $f(p)$; its index being $\frac{1}{r}$; and, by changing T, wherever it occurs in $f(p)$ in any of its powers, into zT, z being an r^{th} root of unity, distinct from unity, let $f(p)$, A, Y, A_c, &c., be transformed into F (p), B, U, B_c, &c.; so that

$$F(p) = B + B_c U^c + B_n U^n + \&c.$$

Then, if $F(p) = f(p)$, the terms,

$$A, A_c Y^c, A_n Y^n, \&c., \ldots\ldots\ldots\ldots (1)$$

taken in same order, are equal to the terms,

$$B, B_c U^c, B_n U^n, \&c., \ldots\ldots\ldots\ldots (2)$$

each to each; A being equal to B.

For, since $F(p) = f(p)$, we have

$$(A-B) + A_c Y^c + A_n Y^n + \&c. - B_c U^c - \&c. = 0 \ldots\ldots\ldots\ldots (3)$$

Hence (Cor. Prop. I) one or other of the following equations must subsist:

$$\left.\begin{aligned} A_c Y^c &= D(A-B), \\ A_c Y^c &= DA_m Y^m, \\ A_c Y^c &= DB_m U^m; \end{aligned}\right\} \ldots\ldots\ldots\ldots (4)$$

where D is an expression involving only such surds as occur in the expressions A, B, A_c, B_c, &c., or are subordinates of Y or of U; Y^m being a term in the series, Y^c, Y^n, &c., distinct from Y^c; and U^m representing some term in the series, U^c, U^n, &c. But, since T is not a subordinate of any surd in $f(p)$ except Y, the coefficients B, B_c, &c., involve no surds different from those which enter into the coefficients A, A_c, &c.; and therefore involve only surds which are found in $f(p)$. Also, since T is not subordinate to any of the subordinates of Y, it follows that the subordinates of U are the same with those of Y. Hence D involves only such surds as occur in $f(p)$. Therefore (Cor. 1, Def. 9,) the first and second of equations (4) are inadmissible; and the third must subsist. Adopting then the equation, $A_c Y^c = D B_m U^m$, we say that no other term in (1) than $A_c Y$ can be equal to the product of $B_m U^m$ by an expression such as

D; for, should $A_n Y^n = D_1 B_m U^m$, where D_1 involves only such surds, exclusive of Y, as occur in $f(p)$, this would give us,

$$D_1 A_c Y^c = DA_n Y^n. \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Now D cannot be zero, else $A_c Y^c$ would vanish; but A_c is (by hypothesis) not zero; and the equation, $Y = 0$, is impossible by Def. 9. Hence, since D is not zero, equation (5) is (Cor. 1, Def. 9) inadmissible. Therefore we cannot have $A_n Y^n = D_1 B_m U^m$. Consequently, as we established the third of equations (4), we can establish similar equations for all the terms in (1), after the first:

$$A_n Y^n = D_1 B_r U^r,$$

$$A_m Y^m = D_2 B_a U^a,$$

and so on; the terms, $A_c Y^c$, $A_n Y^n$, $A_m Y^m$, &c., being all different from one another, on the one hand; and the terms, $B_m U^m$, $B_r U^r$, $B_a U^a$, &c., being all different from one another, on the other hand. Hence equation (3) becomes,

$$(A-B)\,Y^c (1-D^{-1})\,A_c + Y^n (1-D_1^{-1})\,A_n + \&c. = 0;$$

where (Cor. 1, Def. 9) the coefficients, $A-B$, $A_c(1-D^{-1})$, &c., vanish separately. That is, the terms in the series (1), taken in some order, are equal to those in the series (2), each to each; A being equal to B.

Proposition III.

Let $f(p)$ be an algebraical function of a variable p, in a simple form; and let Y_c, Y_1, &c., certain surds, with the common index $\frac{1}{s}$, no one of them a subordinate of any of the others, be such that all their subordinates occur in $f(p)$. Suppose that

$$Y_c = PY_1^{\lambda_1}\, Y_2^{\lambda_2} \ldots\ldots Y_a^{\lambda_a},$$

or, as the equation may be written,

$$Y = P, \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where Y is merely a symbol used (for the sake of simplicity) to denote the continued product of the expressions Y_c, $Y_1^{-\lambda_1}$, $Y_2^{-\lambda_2}$, ...,

$Y_s^{\frac{\lambda_s}{s}}$; and P is an expression involving only such surds as occur in $f(p)$; the whole numbers λ_1, λ_2, &c., being less than s. Take ϕ, the general expression which includes (see def. vi.) all the cognate functions of $f(p)$: one of its particular forms, distinct from $f(p)$, being ϕ_1. In passing from $f(p)$ to ϕ, let P and Y become respectively Q and y; and, in passing from ϕ to ϕ_1, let Q and y become respectively P_1 and y_1. Then the equation,

$$y_1 = k\, P_1 , \text{......................} (2)$$

subsists; k being an s^{th} root of unity.

Explanatory remark.—When we speak of Y becoming y in passing from $f(p)$ to ϕ, we do not assume that the expression Y is present in $f(p)$; but we mean that all the surds which occur in $f(p)$, and are also found in Y, must, in order that Y may be transformed into y, undergo the same changes which they require to suffer in order that $f(p)$ may become ϕ.

We proceed with the proof of the Proposition. In the first place, should P be zero, $Y_c = 0$. Let Y_c be of the form,

$$Y_c = (a + a_1 S_1 + a_2 S_2 + \text{......} + a_n S_n)^{\frac{1}{s}};$$

where the coefficients, a, a_1, &c., are rational; and each of the terms S_1, S_2, &c., is either some power of an integral surd, or the continued product of several such powers; the expression, $a + a_1 S_1 +$ &c., satisfying the conditions of Def. 8. Then, since $Y_c = 0$, we have

$$a + a_1 S_1 + a_2 S_2 + \text{\&c.} = 0.$$

Now all the surds present in this equation, being subordinates of Y_c, are (by hypothesis) surds occurring in $f(p)$, a function in a simple form. Therefore (Cor. 1, Def. 9) the coefficients, a, a_1, &c., vanish separately. But, if Y'_c be what Y_c becomes in passing from $f(p)$ to ϕ, and Y''_c be what Y'_c becomes in passing from ϕ to ϕ_1, we have

$$Y''_c = (a + a_1 S'_1 + \text{......} + a_n S'_n)^{\frac{1}{s}},$$

where S'_1, &c., are what S_1, &c., become in passing from $f(p)$ to ϕ_1. Therefore $Y''_c = 0$. But, in the same way in which, from the fact that Y_c is zero, we have deduced the conclusion that Y''_c is zero, we may, from the fact that P is zero, deduce the conclusion that P_1 is zero. Also, since Y''_c is a factor of y_1, y_1 must be zero. Therefore $y_1 = k P_1$.

In the next place, should P not be zero, the expressions y^s, Y^s, y_1^s, developed by the ordinary process of involution, rendered integral, and made to satisfy the conditions of Def. 8, are of the forms,

$$\left.\begin{aligned} y^s &= A + A_1 v + A_2 t + \&c., \\ Y^s &= A + A_1 V + A_2 T + \&c., \\ y_1^s &= A + A_1 V_1 + A_2 T_1 + \&c.; \end{aligned}\right\} \dots\dots\dots (3)$$

where A, A_1, &c., are rational; and each of the expressions, v, t, &c., is either some power of an integral surd, or the continued product of several such powers; the expressions V, T, &c., being what v, t, &c., become in passing from ϕ to $f(p)$; and V_1, T_1, &c., what v, t, &c., become in passing from ϕ to ϕ_1. In like manner, the expressions, Q^s, P^s, P_1^s, satisfying the conditions of Def. 8, are of the forms,

$$\left.\begin{aligned} Q^s &= B + B_1 m + B_2 l + \&c., \\ P^s &= B + B_1 M + B_2 L + \&c., \\ P_1^s &= B + B_1 M_1 + B_2 L_1 + \&c.; \end{aligned}\right\} \dots\dots\dots (4)$$

where B, B_1, &c., are rational; and each of the expressions, m, l, &c., is either some power of an integral surd, or the continued product of several such powers; M, L, &c., being what m, l, &c., become in passing from ϕ to $f(p)$; and M_1, L_1, &c., what m, l, &c., become in passing from ϕ to ϕ_1. From (1), (3), and (4), we have,

$$A + A_1 V + A_2 T + \&c. = B + B_1 M + B_2 L + \&c. \dots\dots (5)$$

But the surds occurring in the expression on the left hand side of this equation, being necessarily subordinates of some of the surds, Y_c, Y_1, ..., Y_a, are all present in $f(p)$. Those occurring in the expression on the right hand side of the equation are likewise all present in $f(p)$. Therefore, since equation (5) subsists, the surd parts, V, T, &c., are (Cor. 2, Def. 9) severally identical, taken in some order, with the surd parts, L, M, &c.; which also (Cor. 1, Def. 9) implies, that, if V be the surd part identical with M, A_1 is equal to B_1; and so on. But since V is identical with M, and A_1 equal to B_1, and T is identical with (we may suppose) L, and A_2 equal to B_2, and so on, the equation,

$$A + A_1 V_1 + A_2 T_1 + \&c. = B + B_1 M_1 + B_2 L_1 + \&c, \dots\dots (6)$$

must subsist; because, in passing from $f(p)$ to ϕ_1, V becomes V_1, and M becomes M_1, so that V_1 and M_1 are identical, and hence $A_1 V_1$ is equal to $B_1 M_1$: and so of the other terms. Therefore from (6), (3), and (4),

$$\overset{s}{y_1} = \overset{s}{P_1} \therefore y_1 = k\, P_1 .$$

Proposition IV.

If $f(p)$, an integral function of a variable p, be in a simple form, each of its cognate functions is in a simple form.

It is self-evident that the Proposition is true for all functions which involve only surds of the first order. Suppose the law to have been found to hold for all functions which do not involve surds above the $(n-1)^{\text{th}}$ order: it may then be proved true for a function, $f(p)$, involving surds of the n^{th}, but of no higher, order.

For take ϕ, the general expression which includes all the cognate functions of $f(p)$; one of its particular forms, distinct from $f(p)$, being ϕ_1; and suppose, if possible, that ϕ_1 is not in a simple form. Then an equation such as (1). Prop. I,

$$Y_c = P\, Y_1^{\lambda_1}\, Y_2^{\lambda_2} \ldots\ldots Y_a^{\lambda_a} ,$$

must (Prop. I.) subsist; all the surds involved in the equation being surds which occur in ϕ_1. We may write this equation in the form,

$$y_1 = P, \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where y_1 denotes the continued product of the expressions Y, $Y_1^{-\lambda_1}$, &c. Let y_1 in ϕ_1 correspond to y in ϕ, and to Y in $f(p)$: that is to say, y is what Y becomes in passing from $f(p)$ to ϕ, and y_1 is what y becomes in passing from ϕ to ϕ_1. In like manner, let P in ϕ_1 correspond to Q in ϕ, and to R in $f(p)$. Let the the surds Y_c, Y_1, &c., in ϕ_1, correspond to Y'_c, Y'_1, &c., in $f(p)$; and since the surds Y'_c, Y'_1, &c., have the common index $\frac{1}{s}$, let their forms be,

$$Y'_c = V_1^{\frac{1}{s}},\ Y'_1 = V_1^{\frac{1}{s}}, \ldots\ldots, Y'_a = V_a^{\frac{1}{s}} .$$

Take $F(p)$, a function involving all the surds which occur in the expressions R, V_c, V_1, ..., V_a; and let the particular cognate function of $F(p)$, obtained by making the same changes in the surds involved in $F(p)$ as require to be made in order to pass from $f(p)$ to

ϕ_1, be $F_1(p)$. Then the surds occurring in $F(p)$ are all of lower orders than Y'_c, Y'_1, &c.; hence they are all of lower orders than the n^{th}. But we are at present reasoning on the hypothesis that the law sought to be established in the Proposition holds for all functions which do not involve surds above the $(n-1)^{th}$ order. Therefore, since $F(p)$, containing only surds which occur in $f(p)$, is in a simple form, it follows that the function $F_1(p)$ also is in a simple form. Now, if we refer to equation (1), we find that the surds involved in P, and all the subordinates of those surds whose powers constitute the factors of y_1, occur in the function $F_1(p)$. Therefore, by Prop. III, we can deduce from (1) the equation,

$$Y = k\,R,$$

k being a constant quantity. But this is an equation such as (1), Prop. I.; all the surds appearing in the equation being surds which occur in $f(p)$. Such an equation, however, is directly at variance with the hypothesis that $f(p)$ is in a simple form. And hence ϕ_1 cannot but be in a simple form. Consequently the law sought to be established in the Proposition holds good for all functions which do not involve surds above the n^{th} order.

Since, therefore, the law holds good for functions involving only surds of the first order, and since, on the hypothesis of its holding good for functions involving only surds of orders not higher than the $(n-1)^{th}$, we have shown that it must hold good for functions involving only surds of orders not higher than the n^{th}, it holds good universally.

Proposition V.

If $f(p)$, an integral function of a variable p, in a simple form, be a root of the algebraical equation, $F(x) = 0$, in which the coefficients of the powers of x are rational functions of p, then ϕ_1, any one of the cognate functions of $f(p)$, is a root of the same equation.

For take ϕ, the indefinite expression which includes all the cognate functions of $f(p)$; and let $F(\phi)$, $F\{f(p)\}$, $F(\phi_1)$, developed by the ordinary process of involution, and arranged so as to satisfy the conditions of Def. 8, be,

$$F(\phi) = A + A_1 Y_1 + A_2 Y_2 + \ldots\ldots + A_c Y_c,$$
$$F\{f(p)\} = A + A_1 V_1 + A_2 V_2 + \ldots\ldots + A_c V_c,$$
$$F(\phi_1) = A + A_1 U_1 + A_2 U_2 + \ldots\ldots + A_c U^c;$$

where A, A_1, &c., are rational; and each of the terms, Y_1, Y_2, &c., is either some power of an integral surd, or the continued product of several such powers; V_1, V_2, &c., being what Y_1, Y_2, &c., become in passing from ϕ to $f(p)$; and U_1, U_2, &c., what Y_1, Y_2, &c., become in passing from ϕ to ϕ_1. The expression for $F\{f(p)\}$ can only involve such surds as are present in some of their powers in $f(p)$. And $f(p)$, by hypothesis, is in a simple form. Therefore $F\{f(p)\}$, as exhibited above, is in a simple form. It also satisfies the conditions of Def. 8. But, since $f(p)$ is a root of the equation, $F(x) = 0$, $F\{f(p)\}$ is equal to zero. Therefore, in the expression for $F\{f(p)\}$, the coefficients A, A_1, &c., must (Cor. 1, Def. 9) vanish separately. Hence, $F(\phi_1) = 0$; and consequently ϕ_1 is a root of the equation, $F(x) = 0$.

Cor.—Let $f(p)$ be an integral function of p, in a simple form; and let certain surds in $f(p)$, viz.: y_1, y_2, &c., (in which series of terms, as was noticed in Def. 7, all the subordinates of any surd mentioned are necessarily included), have definite values attached to them; and let the cognate functions of $f(p)$, taken according to the manner described in Def. 7, without reference to the surd character of y_1, y_2, &c., be

$$\phi_1,\ \phi_2,\ \phi_3,\ \ldots\ldots,\ \phi_n.$$

Also let $F(x) = 0$, be an equation in which the coefficients of the powers of x are rational as far as all surds except y_1, y_2, &c., are concerned; that is, the coefficients contain no surds besides y_1, y_2, &c. Then, if $f(p)$ be a root of the equation, $F(x) = 0$, any one of the terms, $\phi_1, \phi_2, \ldots\ldots, \phi_n$, (the definite values of y_1, y_2, &c., being adhered to), is a root of the same equation. For, in this case, in the same manner in which the expressions for $F\{f(p)\}$ and $F(\phi_1)$ in the Proposition were formed, we get

$$F\{f(p)\} = A + A_1 V_1 + A_2 V_2 + \&c.$$
$$F(\phi_1) = A + A_1 U_1 + A_2 U_2 + \&c.;$$

where A, A_1, &c., are rational as far as all surds except y_1, y_2, &c., are concerned; and each of the expressions, V_1, V_2, &c., is either some power of a surd in $f(p)$, not contained in the series, y_1, y_2, &c., or the continued product of several such powers; U_1, U_2, &c., being what V_1, V_2, &c., become in passing from $f(p)$ to ϕ: the expressions for $F\{f(p)\}$ and $F(\phi_1)$ satisfying the conditions of

Def. 8. In passing from $f(p)$ to ϕ, no change is made on A, A_1, &c., because the surds entering into these expressions are the same in $f(p)$ as in ϕ_1. But since $F\{f(p)\}$ is equal to zero, the coefficients A, A_1, &c., must (Cor. 1, Def. 9) vanish separately. Therefore $F(\phi_1) = 0$; and ϕ_1 is a root of the equation, $F(x) = 0$.

(To be continued.)

ON THE GEOLOGY OF BELLEVILLE AND THE SURROUNDING DISTRICT.

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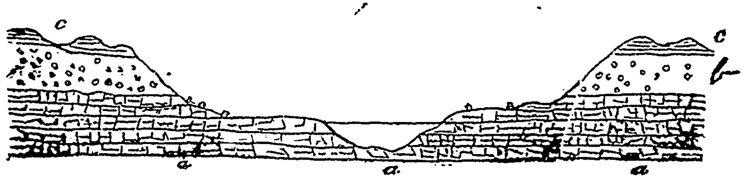
Read before the Canadian Institute, December 17th, 1859.

For the information of distant readers, it may be observed that the town of Belleville, in Canada West, is situated at the mouth of the River Moira near the western or closed extremity of the Bay of Quinté. The Trent, a broad and important river, enters this bay at the upper end, about ten miles west of the Moira, or rather constitutes by its ex-extension, the bay itself. The Salmon River or Shannon on the other hand flows into the same waters some eight or nine miles to the east of Belleville. The observations contained in the present paper apply almost exclusively to the tract of country thus bounded respectively on the east and west by the Salmon River and the Trent; and extending from a short distance along the shore of Prince Edward's County (south of the Bay of Quinté,) to some ten or twelve miles inland or to the north of the Bay. A few remarks, however, furnished by a hasty visit to the back township of Elzevir, are also incorporated in this paper—leaving the geological details of the iron district of Belmont, Madoc, &c., for a future communication.

Throughout this tract of country (as indeed almost everywhere within the Province,) the eye is at once struck by evidences of ancient denuding forces of an action both prior and subsequent to the deposition of the Drift; and, as a corollary to this action, of the much lower level of the land, relative to the water, at a comparatively recent period of geological history. The shores of the Bay of Quinté in very many places, and the high banks or terraces which run, with more or less of interruption, a short distance inland along the course of the above-named rivers, and which were evidently washed at one time by waters either salt or fresh, afford abundant proofs of this earlier physical condition of the district. The foundation rock, so to say, of this locality, is the well-known Trenton Limestone. This, although exposed in numerous places, is generally capped by a considerable thickness of Drift clay, sand, and gravel, with boulders of limestone and various gneissoid rocks, such as lie more or less immediately along the northern confines of the tract in question. Around Belleville itself, more particularly, the upper portion of the Drift consists of very finely stratified sand and light-coloured plastic clay, overlying gravel and other coarser materials with boulders of various kinds. The accompanying sketch-section across the River Moira will serve to convey an idea of the extensive denudation to which the Drift has been here subjected. In



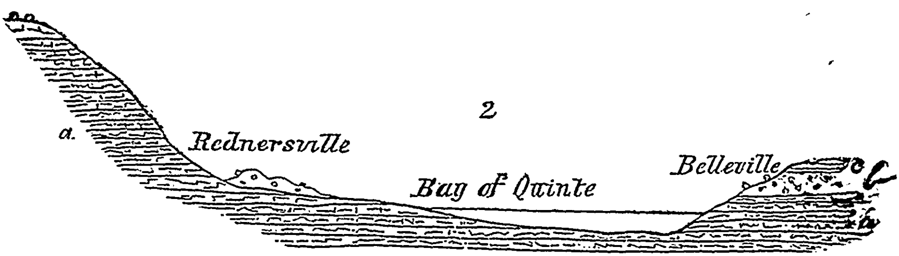
this section, *a* is the upper thin-bedded portion of the Trenton limestone, and *b* and *c* are the Drift beds. In consequence of this denudation the beds *c* are only of partial occurence, but I remarked them in several places at considerable distances apart. They are especially well shewn on the side of a hill or steep bank through which a street is cut, in the vicinity of the Court-house, Belleville.

A deposit of calcareous tufa derived in great part from minute fresh-water shells belonging to *cyclas, planorbis,* and other genera, constitutes a comparatively recent formation extending over a considerable area on the top of the drift bank or high ground on the west side of the river. It marks the site of an old swamp, now drained off. The same modern calcareous formation occurs still more extensively along the foot of the so-called "mountain" at Trenton, (where it was kindly pointed out to me by the Rev. Mr. Bleasdell of that village,) and undoubtedly in many other places; although the above were the only spots in which it came under my personal observation. It may be stated, as a general rule, that a deposit of calcareous tufa or shell-marl will be found under the vegetable mould around the margins of almost all our smaller lakes, these having occupied at one period a larger extent of surface than that included within their present areas. As a mineral manure, this calcareous deposit ought to possess considerable value, but I did not find any particular importance attached to it either at Belleville or Trenton, and it seemed to be very little used.

The limestone surface immediately under the Drift appears throughout the entire district to have been polished and grooved by glacial action; but it is only here and there, and more especially where a recent removal of the Drift deposit has taken place, that the results of this action are now visible. At the period of my visit to Belleville (June 1859) a beautiful example of polished and striated rock had just been laid bare in some drain excavations on the south side of Bridge Street, west of the Moira; and I observed the same effects on the exposed faces of limestone at "The Plains," between the Moira and the Shannon; and, still more distinctly, opposite the Shannonville Station, on the north side of the Grand Trunk Railway. At the latter locality, large slabs of rock exhibited a polished surface equal to that of plate-glass, with fine striæ running across it in a general N.W. and S.E. direction. By the effect of weathering, however, these results of ancient glacial action become more or less rapidly obliterated.

The Trenton limestone of the district in question is lithologically divisable into two distinct sets of beds. Of these, the upper are thin-bedded (passing indeed into shales,) and are exceedingly fossiliferous; whilst the lower are thick-bedded and almost destitute of fossils. These lower beds are well displayed at the quarries on Ox Point, and at other places eastward along the Bay of Quinté. They form a most excellent building stone. The upper or thin-bedded limestones crop out extensively along the banks of the Trent, Moira, and Salmon rivers, and are exposed in most of the road cuttings of the district, and along the line of the Grand Trunk Railway. They literally teem with the more common fossils of the Trenton group. A list of those actually collected, is given below. These beds lie apparently in horizontal layers, but at Ox Point and other places some low anticlinals or undulations are visible, and a careful examination of the district shows a slight but general dip towards the south-west. A road cutting near the west bank of the Moira exposes a bed of calcareous clay about a foot in thickness interstratified with the shaly limestones of the upper part of the Trenton series. This bed, pointed out to me, by Campbell Wallbridge, Esq., of Belleville, contains numerous impressions of *strophomena alternata* and other Trenton forms, and is thus (as shown moreover by its position amongst the shaly limestones) a true member of the group. It is the first example of this kind of association that I have met with in the Trenton series, but a similar interstratification of clay and limestone beds has been seen, I believe, in other places.

About Belleville, the most prolific fossil localities are the river banks, and an old cutting for a mill-race on the east bank of the river, a little north of the Railway Station. The banks of the river (the Salmon) at Shannonville, and a cutting on the Railway at that place, about half a mile west of the Station, are also good localities; whilst around Trenton village many excavations and small quarries will be found exceedingly rich in fossils. On the steep side also of the high land at Rednersville in Prince Edward's County, some good specimens may be procured. This is the highest position occupied by the Trenton Limestone immediately around Belleville. I was led to understand by persons residing in Belleville, that the rock was not limestone; but it consists simply of the same shaly limestone as that seen on the banks of the Moira, as shewn in the following section (lettered as in figure 1), from which moreover, an idea may be gleaned of the vast amount of denudation which must have taken place in that neighbourhood, both before and after the deposition of the Drift.



At some of the above mentioned localities, and especially in the old mill-race near the Railway Station at Bellevile, I found *Columnaria alveolata*, until recently considered typical of the Black River Limestone, associated with ordinary Trenton fossils; and near the Episcopalian Church at Shannonville, I found the same coral with *Stromatocerium rugosum*, also accompanying Trenton species. These types therefore, (as already shewn by Sir William Logan and others, from the examination of other localities) although highly characteristic of the Black River Limestone, are not absolutely peculiar to that formation (or sub-formation) as was formerly thought to be the case. The subjoined Table gives an enumeration of the fossils collected, during my visit, at Belleville and in the surrounding district.

PLANTS:

Indistinct fucoids, and at Rednersville an undescribed form presenting a thick primary stem-mass, with numerous dichotomous branchings.

CORALS and CRINOIDS:

Stromatocerium rugosum (Shannonville). *Stenopora fibrosa* (the *Chætetes lycoperdon* of Hall, &c.): Variety 1, *ramosa*, the branched form, most abundant on the surfaces of the flat layers along the banks of the Moira; Variety 2, *concava*, the flattened or salver-shaped form concave above, abundant everywhere, more especially at the Railway cutting near Shannonville; Variety 3, *globosa*, the true "puff-ball" form, rather uncommon. *Columnaria alveolata* (Belleville, Shannonville). *Petraia (Streptelasma) cornicula*. *Glyptocrinus ramulosus?* (stem fragments only.

BRYOZOONS:

Ptilodictya (Stictopora) acuta, common at most of the fossiliferous localities, with a few other (indeterminable) forms.

BRACHIOPODS:

Lingula quadrata. *Rhynconella increbescens* (not common). *Strophomena alternata* and *S. filitexta* (both exceedingly abundant). *Leptæna sericea*. *Orthis testudinaria* (also very abundant); *O. tricenaria* (beautifully preserved); *O. pectinella*; *O. lynx* (only observed by me at Trenton).

CONCHIFERS:

Of this Class I did not meet with any determinable forms.

GASTEROPODS:

Pleurotomaria lenticularis, *Murchisonia gracilis*; *M. bellicincta*; *M. sub-fusiformis* (?) *Subulites elongata*.

PTEROPODS (?):

Conularia Trentonensis (not very common).

CEPHALOPODS:

Orthoceras (*Endoceras*) *proteiforme*; *O. bilineatum*; *O.* ——— (undetermined species); *O. tenuifilum*, or a related species with beaded siphuncle.

TRILOBITES:

Asaphus platycephalus (= *Isotelus gigas*, exceedingly common in a fragmentary state); *A. megistos* (rare). *Ceraurus pleurexanthemus* (very abundant). *Calymene Blumenbachii* (tolerably common, and well preserved). *Trinucleus concentricus* (two fragments only, found at Shannonville).

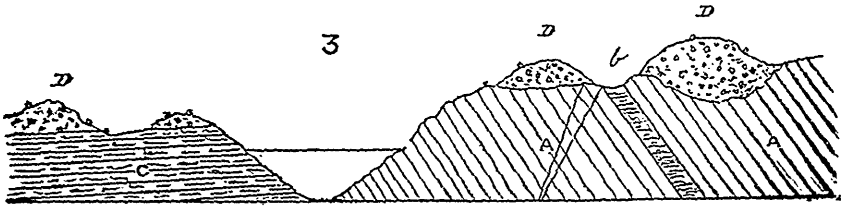
In the above list it will be seen that I have placed the coral commonly known as *Chætetes lycoperdon*, under the genus *Stenopora*, of Lonsdale. D'Orbigny's *Monticulipora*, to which genus the branched form has been referred, appears to agree in all essential respects with *Stenopora*, and to be thus an unnecessary addition to the list of Favositian genera. *Calamopora* of Goldfuss (including amongst others, *Favosites*, *Stenopora* and *Chætetes*) can scarcely be employed without risk of misconception, and is therefore now almost universally abandoned. *Favosites* differs essentially from *Stenopora* and *Chætetec* in possessing perforated cell-walls. The imperforate favositoidean corals fall into two series: the one exhibiting fissiparous and the other gemmiparous reproduction. The former show in the fracture the *interior* of the tubes, and constitute the genus *Chætetes*. The latter show the *outside* of the cell-walls (reproduction taking place by the lateral interpolation of new tubes) and they form the genus *Stenopora*. To this genus, if the above definition as given by McCoy and others, hold good, our so called *Chætetes* undoubtedly belong. This admitted, our common forms, the *Calamopora fibrosa* of Goldfuss, may be legitimately placed under McCoy's *Stenopora fibrosa*, and conveniently sub-divided into three varieties: the branching form (variety *ramosa*); the flat, cup-shaped or salver-shaped hemispherical form (variety *concava*); and the globular or true "puff-ball" form (variety *globosa* or *lycoperdon*). It often happens that whilst one variety is exceedingly abundant at a special locality, the other two are altogether absent. McCoy ("British Palæozoic Fossils," p. 24,) makes but two varieties: *lycopodites* and *regularis*, the latter including the branched and polymorphous forms; but those given above, so far as regards Canadian examples, will be found I think of more convenient adoption.

The "petites saillies coniques," the distinguishing character of d'Orbigny's *Monticulipora*, appear to be a necessary consequence of the mode of reproduction exhibited by *Stenopora*.*

On proceeding north of Belleville, the thin-bedded limestone gives place to the lower or thick beds, and these in turn merge into a silicious limestone, the probable equivalent of the Black River subdivision; although the country is so thickly covered by Drift, that sections are only observable here and there. At the village of Hungerford, in the township of that name, the grey silicious limestone is seen to overlie a series of thin flat layers of a reddish calcareous sandstone with pale green spots distributed irregularly through its mass. This rock is apparently an abnormal form of the Potsdam sandstone, or, perhaps a bed of passage between the Potsdam sandstone and the Calcareous sand rock, as it contains from 40 to 50 per cent. of dolomitic carbonate of lime. I found no traces of organic remains in it. I should be inclined to look upon it as the calcareous sand rock, were it not for its agreement, in certain of its physical characters, with the Potsdam sandstone as recognised elsewhere. From this part of the country however, westward to Georgian Bay, the beds between the base of the Trenton and the outcrop of the Laurentian series, are more or less obscure—thinning out altogether, or merging, as it were, one into the other. About three miles north of Hungerford village (or perhaps less, the intermediate space being greatly obscured by Drift) the Laurentian or Gneissoid rocks begin to crop out, dipping at a high angle to the north-east, or in a contrary direction to the slight dip of the Silurian strata. Close to the southern limit of the Laurentian outcrop a fine band of crystalline limestone occurs, interstratified with dark grey and reddish beds of gneiss. This may be conveniently examined at the village of Bridgewater in Elzevir Township on the property of Billa Flint, Esq., to whose enterprising spirit, that part of the country owes so much. The specimens of crystalline limestone obtained at this spot, form a marble of excellent quality. I have to regret that from want of time I was unable to examine the run of the band, and its quality at other points. A few fragments of galena and some impure steatite were shown to me, as having been met with near at hand.

* These remarks were written several months ago. In the last number of the *Canadian Naturalist*, we were gratified to find the identity of the so-called *Chætetes lycoperdon* with *Stenopora fibrosa* also adopted by Mr. Billings.

The accompanying sketch-section across the little River Scoot, was taken near Mr. Flint's village. It may serve to convey an idea of the relative positions of the various beds which occur there. In this section, *A* represents the Gneissoid strata, with the band of crystalline limestone *b*; *C* denotes the Lower Silurian beds (limestone above, and, by inference, the reddish sand-rock below, as seen farther south); and *D*, denotes the Drift deposit.



In concluding this brief notice of the more salient geological features of Belleville and its vicinity, I am anxious to express my obligations to the family of Lewis Wallbridge, Esq., M. P. P., for much information respecting points of interest to be visited, and for the presentation of many fossils obtained in the neighbourhood.

REVIEWS.

Galbraith and Haughton's Scientific Manuals. Experimental and Natural Science Series: Manual of the Animal Kingdom; Protozoa. By Professor J. Reay Greene.

This small volume has a double title; we have chosen that which presents it as the commencement of an extended series of manuals, because we thus give most information to our readers. Those who obtain it alone from curiosity respecting its particular subject, would make use of the other.

It is a beautifully printed, carefully illustrated, and neatly got up volume, containing only 88 pages, with a Bibliography of the subject, questions for examination, and an index; to this are prefixed 30 pages of general introduction. Of course there is, within such limits, no attempt to characterise or enumerate genera and species. The object aimed at, is a general view of structure, arrangement and distribution. In the case of the Protozoa, this may be all that most people need or could profit by, but as we rise in the animal kingdom, such a manual would appear very meagre. We see announced as forthcoming, another Zoological volume from the pen of the author of that which lies before us, and a Botanical one from that of Professor Harvey of Dublin. We are curious to see whether the present manual is to be a model as to size, and if so, how the learned authors will acquit themselves in such trammels; but our present business is with Professor Greene's manual of the sub-kingdom, Protozoa. It must in the first place be conceded that in this department of zoology, accessible and trust-worthy information is greatly needed, and would be gladly received by a large class of readers. Professor Greene appears to be well acquainted with what has been written on the subject, and has laudably exerted himself, to give a clear, though much compressed account of what is known, in relation to these elementary forms of animal life. We are not satisfied with his mode of treating their classification. He regards them as being as yet too little understood for the limits of classes and orders to be well determined, and therefore only gives under the titles of the several groups which have been proposed, the subdivisions recommended by the authors who have chiefly studied them, accompanied by such structural and physiological particulars respecting at least some typical species as seem to be established by sufficient authority. For practical usefulness we should have preferred some attempt, even if confessedly only provisional, to harmonise what we seem to have learned from various investigators into a consistent system whose parts are brought into proper relation to each other and to the whole; and we confess we have no such ideas as to the necessary foundations and limits of what are entitled to be called *classes* and *orders*, as would deter us from applying these terms to the greater and secondary divisions, which, though liable to modification by increasing knowledge, seem now to express the relations of the creatures, which we agree with the author in regarding as a distinct, well established sub-kingdom of the animal kingdom. He indeed complains of the characters of PROTOZOA being almost wholly negative, but this may perhaps appear to be almost unavoidable in a *lowest* division of any large collection of objects. In the vegetable kingdom, the method we prefer, separates as a sub-kingdom, those plants which are without Vascular tissue—the mode of diposing that tissue when present, giving characters to the remaining sub-kingdoms,—and so in the animal kingdom, the development and disposition of the nervous system characterise the four higher divisions, whilst Protozoa are animals consisting of an animated jelly, (Sarcodium) with little differentiation of parts and no perceptible nervous system. We are aware indeed that there may possibly not be one of the sub-kingdoms, certainly none excepting the highest, in which there are not instances, where no nervous system can be demonstrated; but in all such instances there is a manifest conformity to a type of structure, which directs our judgment as to the position of the object, whilst in Protozoa, wherever we have a tolerable acquaintance with the life history of the creature we recognise not only the absence of the characteristics of another sub-kingdom, but the presence of certain features properly belonging to that we are considering. If we have materials in our hands which really justify us in establishing a sub-kingdom of Protozoa, they can hardly fail to suggest some opinion as to the mode of sub-dividing it. If groups of creatures have been examined and intelligibly described, the question of their relation to other known groups, and the comparative importance of their distinctive marks will arise, and should be solved to the best of our ability.

It seems to us, that the possession of a mouth, and consequently of an alimentary sac, with a somewhat definite figure, and an outer covering, differing in some degree from the mass of the body, characterise *Infusoria* (in the now received limited sense,) as the highest class of Protozoa. From them, *Rhizopoda* are distinguished, by having no difference, so far as is known, or only a slight difference in certain parts, in their external covering from the mass of their bodies, and by their power of protruding portions of their substance, in the form denominated Pseudopodia. Possibly the naked Rhizopoda, the Arcellina, the Foraminifera, and the Polycystina may be so many good orders in this class. Thalassicollida may be nearer akin to Sponges: of Gregarinida, nothing can as yet be satisfactorily decided, until a full history of at least some species, removes the doubts which at present are unavoidable respecting their nature.

Sponges for which we may adopt the name of *Amorphozoa*, form a third distinct class. Since no protrusion of pseudopodia is attributed to Thalassicollida and in some of them at least, cellæform bodies, seeming to contain germs are surrounded by spicules, not unlike the peculiar ovarian spicules of some sponges; we may perhaps regard these organisms as one order of Amorphozoa. Without waiting for the expression of Dr. Bowerbank's views, we would not decide on the subdivision of the class, but would temporarily employ one of the existing arrangements to afford us that aid of system without which we can hardly proceed a step usefully in the study of nature. Whatever may be its defects, that founded on the nature of the skeleton, may serve the purpose, and at least exhibits remarkable analogies with the arrangement of Rhizopoda; Thalassicollida representing naked Rhizopoda, the horny sponges having a certain correspondence with Arcellina—those with Silicious spicula being the analogues of Polycystina, and those with Calcareous spicula of Foraminifera. Did our space permit, we should endeavour to ascertain the proper arrangement of Infusoria also, being well convinced, that all other information is in a great degree thrown away, if not connected with an intelligible system, and that methods which are necessarily only provisional and in which we may be sensible of great defects, are yet far preferable to any attempts at communicating anatomical, physiological, or descriptive matter independently of systems, which never carry the student beyond insulated facts, and barren, because unconnected observations.

Although Professor Greene may not exactly see these things in the same light that we do, we are by no means insensible to the merits of his book. The Introduction is excellent and useful, and its extent can hardly deter the idlest reader. His accounts of the low, and generally minute organisms of which he treats are highly interesting, and cannot fail to diffuse information, and lead to the increase of knowledge, by enlisting a host of new inquirers. The proprietors of the series have done their part well, and their first number holds out a favourable promise for those which are to follow; if what is more important is not sacrificed to over-anxiety after compression.

W. H.

The Old Glaciers of Switzerland and North Wales. By A. C. Ramsay, F.R.S. and G.S. London: Printed by Spottiswood and Co. 1859.

Amongst the various records of a by-gone condition of things presented by Nature's archives to the interpretation of the geologist, few can compete in interest, and perhaps in difficulty of solution, with those belonging to the great Drift or Glacial epoch: that period in the history of the earth's mutations, which immediately preceded, and gradually passaged into, the present or historic age. Broadly spread across the entire northern hemisphere, southward to a mean latitude (on this continent) of about 40° N., and again extending many degrees northwards from the southern pole, lie vast beds of clay, and sand, and gravel, mixed up with and overlaid by heaps of travelled stones or boulders; stones that have been brought by natural agencies, often across intervening seas and valleys, and over mountain ridges, miles and miles away from their original localities. Where hard and compact rocks lie underneath this boulder formation, or rise up amongst it, their surfaces are almost always found to be rounded, or smoothed and polished, and marked likewise in long and straight lines with narrow grooves and scratches. If these peculiarities be not always observable on exposed rock surfaces, their absence is chiefly due to the disintegrating action of the atmosphere, as they necessarily become obliterated, sooner or later, by the effects of weathering.

In Canada the drift formation is largely developed; and in many places the underlying limestone and other rocks exhibit the polished surfaces and the long lines of grooving t alluded to. But it is in mountainous countries that the phenomena of the drift epoch are portrayed to us in their grandest outlines. There, in many localities within the limits of latitude already pointed out, the hill-sides present their rounded contours, smoothed, polished, and striated; the hill-tops bear their loads of boulder stones, balanced one upon another, or perched, perhaps, on isolated points of rock; and the valleys show their excavated hollows and lake-basins, their barriers of heaped up boulders, their high and furrowed walls, with other memorials of abrading agencies belonging, it may be there, to an older time, but which are still in action amongst the frozen solitudes of the remote north, and in the higher valleys of the Alps and other mountain chains. In these valleys the broad ice-rivers still slowly push their way amidst the surrounding rocks, wearing and abrading them, and piling up at lower levels their stony burdens in the form of huge moraines.* This however leaves the tale half told. To complete our view of the phenomena under which the drift accumulations took place, we must

* In many glaciers the formation of a terminal moraine is prevented it should be observed by the action of the stream which results from the melting of the ice.

picture in addition the likeness of a northern sea, girt with protruding glaciers from which drift off the floating icebergs with their freight of rock and stone. This rocky freight, as the icebergs melt in lower latitudes, is necessarily scattered over the hill-tops, the plains, and valleys of the deep sea-bottom. We must picture also, over broad areas, vast sinkings and upheavals of the land, going grandly on through the slow lapse of centuries; the stranding and piling up of icebergs on shoals and coasts; the southern migration and subsequent retrogression of northern organisms; and the gradual dawn of softening climatic influences, coupled with the shrinking back of glacial forces to within their present limits.

It was thus by observations conducted in northern lands and seas, and in Alpine valleys, that the true nature of our drift phenomena became gradually elucidated. Professor Ramsay, in the attractive essay now before us, has placed in striking parallel—not from the descriptions of others, but from personal observation and research—some of the glacier valleys of Switzerland, with the romantic Pass of Llanberis and other valleys of North Wales. Commencing with the Swiss valleys, he lays before us a rapid but graphic sketch of the glaciers of the Aar: shewing how incontestible is the fact, that, vast as are these glaciers now, they shrink into insignificance when compared with their extension in former times. The same fact is observable, indeed, with regard to almost all the glaciers of these Alpine valleys. On this subject, after mentioning some modern instances of the advance and retreat of glaciers, Professor Ramsay remarks:—"But all such historical variations in the magnitude of glaciers are trifling compared with their wonderful extension in pre-historic periods. There is perhaps scarcely a valley in the High Alps in which the traveller, whose eye is educated in glacial phenomena, will not discern symptoms of the former presence of glaciers where none now exist; and in numerons instances, far from requiring to be searched for, these indications force themselves on the attention by signs as strong as if the glacier had disappeared but a short time before the growth of the living vegetation. So startling, indeed, are these revelations that for a time the observer scarcely dares to admit to himself the justness of his conclusions, when he finds in striations, moraines, *roches moutonnées*, and *blocs perchés*, unequivocal marks of the former extension of an existing glacier, a long day's march beyond its present termination; and further, that its actual surface of to-day is a thousand feet and more beneath its ancient level."

With regard to the Aar valley, the glaciers of which are taken as type-forms in relation to this inquiry, our author observes in addition: "Below the lower glacier of the Aar, the stream winds through one of those gravelly flats, so frequent in old glacier valleys, and at its lower end, where this plain narrows towards the Grimsel, a boss of granitic gneiss, well *moutonnée*, nearly bars the valleys across which the path leads. It is partly covered by striations, well marked on the slope that looks up the valley, telling the observer not only of the previous extension of the glacier thus far, but also that the ice which filled the plain pressed strongly on the higher side of the boss, and was forced upwards till it fairly slid over the rock, the lower part of the ice being quite unchecked by the opposing bar. I mention this especially, because similar phenomena were often pointed out by Buckland in describing the old glaciers of North Wales. On either hand, all the way from the glacier to this point, the mountain sides show the same mammillated contours that mark the rock above the ice, and a little further down the valley, the signs of glacial action become even unusually obtrusive. A large hill rises from the valley on the right, up which the road winds to the Hospice of the Grimsel. On the left is the narrow gorge of the Aar, and on the other side of the hill the sullen lake of the Grimsel half encircles it far above the level of the river. At its outflow the lake is partly dammed up by a little moraine-like dêbris; but it requires no soundings to tell that the rounded rocks close by, passing under the rubbish, form the chief retaining barrier of the water. On both banks, except when weather-worn, the rocks are ice-worn, and the lake is nearly looped into two by *roches moutonnées* that project from either bank toward the centre, like Llyn Idwal above Nant Francon, and the lakes of Llanberis, if these were undivided by the alluvial strip below Dolbadarn Tower. At its farther end a long, narrow, high, rounded barrier of solid rock (over which the glacier formerly poured) crosses the valley, damming up the lake in that direction; and here so great has been the pressure, that I found proof of the ice having been forced into a narrow transverse fissure, which it polished and striated quite out of the direction of its general flow. The lake is a complete rock basin similar to some of the tarns of North

Wales, and such as I only know in regions where glaciers once have been.

"On the hill that rises behind the Hospice, the glacial striations on the rocks gradually circle round to the further end of the lake, following the sweep of the valley; and it soon becomes apparent that this hill itself, is but a gigantic *roche moutonnée,* mammilated and striated all over, on which erratic blocks were left by the decrease of the glacier of the Aar after a period in which it rose so high, that it not only filled the hollow of the lake, and pressed upward over the ridgy barrier at its further end, but actually overflowed the entire hill. If from its polished side you survey the opposite ridge of the Aar valley, the vast size of the old glacier becomes still more strongly impressed upon the mind. A great wall of rock rises sharply above the river course, and on its side the striations which cover it, have been deflected upwards, at a low angle, the effect of the intense jamming to which the thick ice was subjected in its downward course, when obstructed by the great *roche moutonnée* that rises in the middle of the valley between the lake and the mountains on the opposite side of the Aar. Above this wall, the mountain is moutonnée almost to the very summit, where at length the serrated peaks of the highest ridge rise sharply above the ice-worn surfaces. The valley has been filled with ice almost to the very brim."

After thus discussing in their past and present bearings, the glacial phenomena of these Swiss valleys, our author turns to the valleys of Cænarvonshire that lie around the majestic Snowden, and traces out, in these, step by step, the former existence of immense glaciers, whose dimensions rivalled in grandeur the great ice-rivers of the ancient Alps. He then considers the question of identity of time with respect to the extinct glacial phenomena of Wales and the ancient extension of the Alpine glaciers. "But these things being true, [the former existence, &c., of glaciers in the valleys around Snowden], what relation in time is there between the old glaciers of Switzerland and those of Wales? The elements from which to attempt a solution of this question are few. First, it may be said that the signs of glaciation in the former extension of still existing Swiss glaciers, are not only identical in all respects with those of the extinct glaciers of Wales, but also that in many an Alpine valley all the ice marks remain, even when no diminished glacier still holds its place amid its uppermost recesses. These in all respects may be compared to the ancient glaciers of the neighbouring Jura, the Vosges, or of Wales. Again, when we consider that the great old glaciers of the Oberland apparently opened out on the broad drift-covered territory that extends northward to the Jura, there is another point of resemblance. So similar in general structure and in all its adjuncts is this Drift with that of the north of Europe, that I see no reason whatever to doubt their identity. To add weight to this opinion, I may quote the high authority of Mr. Smith of Jordan Hill, who informed me, that he recollects seeing in the museum at Berne, a neglected collection of *Swiss shells*, arctic in their grouping, and subfossil, like those of our Newer Pliocene beds; and in the museum at Geneva a similar collection, among which was *Mya Udivalensis*. Further, it is well known that in the superficial deposits associated with these, the bones of the great hairy elephant (E. primigenius), and other mammalian remains, occur by the Lake of Geneva, at Winterthur, and in other places; and though no one that I know of, has yet attempted to prove the ploughing of drift out of the mouths of Swiss valleys by the older and larger glaciers, yet in every other respect the conditions are so identical, that I am prepared to expect that this also will be proved, and I cannot resist the conclusion that, when glaciers filled the valleys of Wales, it was at that very time (the Newer Pliocene epoch) that the glaciers of Switzerland attained their great original extension.

Further, in spite of the modern fact that far south of the equator, the cold is greater than in equivalent northern latitudes, it is difficult not to speculate on the probable existence of a climate perhaps colder for the whole world, during what is often called the glacial period; a period when not only the Alps, but all Scandinavia, were full of great rivers of ice descending to the sea; when the White Mountains of North America also had their glaciers, (as I was informed in 1857, in conversation with Agassiz,) and when the great glaciers of the Himalayah, as described by Dr. Joseph Hooker, descended 5000 feet below their present levels, the older moraines being in one instance only 9000 feet above the sea, whereas the present end of the glacier lies at a height of 14,000 feet.

Another point often occurs to my mind,—what relation have these extinct glaciers to the human period? This is a subject on which we still are in the dark, but considering that in Newer Pliocene bone-caves, flint knives have been found,—there is reason to believe, coeval with elephants, rhinoceroses, and other Mammalia, partly extinct;—and that in France, at Abbeville and Amiens, well formed flint hatchets of an old type occur in fresh-water and marine strata of so-called *Upper Tertiary* date; and also, that a human skull was dug out of the so-called Pliocene volcanic ashes of Auvergne, it is possible, and perhaps even probable, that, long after the Drift was raised above the sea, the eyes of men may have looked upon the glaciers of Wales, when in their latter days, the ice had shrunk far up into the highest recesses of the mountains."

In calling the attention of our readers to this ably-written essay, we must not forget to mention, that its author has added much to the interest of his descriptions by a number of charming little vignette illustrations, and by a valuable map of the country around Snowden. In the latter, the directions of the rock-striæ, with the moraines and other vestiges of the ancient glaciers of North Wales, are indicated from Professor Ramsay's personal explorations.

E. J. C.

The Family Herald. John Lovell, Montreal.

A periodical of a somewhat novel and attractive character has been added to our Canadian Literature under this name. Issued in the form of a Newspaper sheet, and embracing scientific, literary and general news; it partakes in some respects of the united characteristics of *Chamber's Journal*, and the *London Athenæum*. A tale or novel runs through a series of chapters, in successive numbers; well selected stories, poems, and literary gleanings occupy other of its columns; and a good space is devoted in each number to Reviews. Its news columns are severally set apart to "Canada and the Lower Provinces," "England," "Scotland," "Ireland," and The "United States." The only thing omitted is party politics;—and, without any disparagement to the uses and value of our free press, as one of the elements of our social life and freedom, we believe that to many fair and young readers, *The Family Herald* will be none the less welcome for the omission.

The Editor of this new Canadian periodical is Mr. G. P. Ure, a gentleman long connected with the press; and the character of the earlier numbers of his new serial, show that he is making the best use of his opportunities and experience. When the great influence of the daily press is considered, not on politics only, but in forming the tastes, and training the minds of so large a portion of the community, to whom, such constitutes their most frequent reading, it cannot but be acknowledged that a periodical thus combining somewhat of the attractiveness and accessible brevity of the newspaper, with the careful literary characteristics of the scientific periodical, or monthly magazine, supplies one of the great wants of our industrious and advancing community. If the *Family Herald*, is conducted with the same good taste and judiciousness in the selection of its materials, which have been manifested in its earlier numbers, it cannot fail to meet with the success it merits. D. W.

On the Classification and Geographical Distribution of the Mammalia —being the lecture on Sir Robert Reade's foundation, delivered before the University of Cambridge,, in the Senate-house, May 10, 1859,—*to which is added an appendix, on the Gorilla, and on the extinction and transmutation of species.* By Richard Owen, F.R.S. &c. &c. London: John W. Parker and Son, West Strand. 1859.

Everything which proceeds from the pen of Professor Owen will be received with lively interest and with respectful attention. The present lecture is a pretty full exposition of his views respecting the Classification of Mammalia according to the cerebral system, which he has derived from a long series of dissections, and a diligent use of such opportunities as have perhaps never before been possessed by a comparative anatomist. That his system is an important improvement on that of Cuvier, can hardly be denied.

Every unprejudiced observer of nature will feel favourably disposed towards a method which brings *Edentata*, [Bruta] *Cheiroptera, Insectivora* and *Rodentia* into close relationship. We cannot help looking a little suspiciously at the multiplication of orders, and are disposed to anticipate still further improvements. In the meantime, all honour is due to Professor Owen's labours; and his present explanation of the characters of the various tribes is to be highly valued. In connection with this lecture, the author has published two papers which form an appropriate and valuable supplement to it. Appendix A is a note on the extinction of species, "being the conclusion of the Fullerian course of lectures on Physiology for 1859." Appendix B is on the Orang, Chimpansee, and Gorilla, in reference to the transmutation of species, and runs to a considerable extent. Our present limits forbid extracts, or analysis, but in naming the subjects we excite the curiosity of our readers to know the opinions of the chief of comparative anatomists, and they can readily satisfy it, by having recourse to the work itself, which *deserves the careful study of all who are interested in these* pursuits.

W. H.

Archaia; Or Studies of the Cosmogony and Natural History of the Hebrew Scriptures. By J. W. Dawson, LL.D., F.G.S., Principal of McGill College, &c. Montreal: B. Dawson and Son. 1860.

Dr. Dawson's recent contribution to the literature of the Bible—for in such light must his *Archaia* be chiefly regarded,—has reached us just as we are going to press; and, hence, we are unable to devote to it the space to which it is so justly entitled, both by the distinguished name of its author and by its own intrinsic merits. As the issue, moreover, of a Canadian publisher, it has further claims upon us: ill met, we are afraid, by this too scanty and too hurried notice. Archaia is essentially composed of a series of critical essays or discourses founded on the opening chapter of Genesis; but the author enlarges his field of inquiry by various references to other passages of the sacred writings; more especially in the bearings of these on the Mosaic record of creation, and in their connexion with the study of nature generally. For the successful composition of a work of this kind, the author possesses many peculiar qualifications: a ready command of language, a clear and logical method of discussion, an intimate acquaintance with the discoveries and researches of *modern science, and, above all, an evidently sincere and strong faith* in the divine truths of Revelation. With these qualifications, although preceded on the same path by many active investigators, he has produced, as might be expeccted, an interesting and popularly written book; and one, moreover, containing various subordinate points of a novel character. The very nature of the subject renders, however, a work of this description more or less unsatisfactory to many readers. Perhaps to the scientific investigator, and to those whose thoughts have long dwelt on these questions, more especially; but if the work before us, leave the mind in some respects unsatisfied, we cannot but admit that in its expansive treatment of the subject it has gone far beyond its predecessors. The author, in his preface, hopes that his work may aid in some degree in redeeming the subject from the narrow views which are unhappily too prevalent: and of this, if those who entertain such views can be led to read the book, we have but little doubt. In this respect alone, therefore, apart from its general value, we may fairly welcome it, and urge its perusal upon those who still blindly look upon geology, and upon natural science generally, as antagonistic in some undefined manner to the spirit of Revelation.

It is difficult to extract a passage, sufficiently independent of the context for quotation, without occupying a larger space than our limits permit; but the following from one of the introductory chapters, in which the author claims for the Holy Scriptures a deeper insight into natural phenomena than many have hitherto foreseen, may serve as an ample of the style and general expression of the work:

"The law of type or pattern in nature is distinctly indicated in the Bible. This is a principle only recently understood by naturalists, but it has more or less dimly dawned on the minds of many great thinkers in all ages. Nor is this wonderful, for the idea of type is scarcely ever absent from our own conceptions of any work that we may undertake. In any such work we anticipate recurring daily toil, like the returning cycles of nature. We look for progress, like that of the growth of the universe. We study adaptation both of the several parts to subordinate uses and of the whole to some general design. But we also keep in view some pattern, style, or order, according to which the whole is arranged, and the mutual relations of the parts are adjusted. The architect must adhere to some order of architecture, and to some style within that order. The potter, the calico-printer, and the silversmith, must equally study uniformity of pattern in their several manufactures. The Almighty Worker has exhibited the same idea in his works. In the animal kingdom, for instance, we have four leading types of structure. Taking any one of these—the vertebrate, for example—we have a uniform general plan, embracing the vertebral column constructed of the same elements; the members, whether the arm of man, the limb of the quadruped, or the wing of the bat or the bird, or the swimming paddle of the whale, built of the same bones. In like manner all the parts of the vertebral column itself in the same animal, whether in the skull, the neck or the trunk, are composed of the same elementary structures. These types are farther found to be sketched out,—first in their more general, and then in their special features—in proceeding from the lower species of the same type to the higher, in proceeding from the earlier to the later stages of embryonic development, and in proceeding from the more ancient to the more recent creatures that have succeeded each other in geological time. Man, the highest of the vertebrates, is thus the archetype, representing and including all the lower and earlier members of the vertebrate type. The above are but trite and familiar examples of a doctrine which may furnish and has furnished the material of volumes. There can be no question that the Hebrew Bible is the oldest book in which this principle is stated. In the first chapter of Genesis we have specific type in the creation of plants and animals after their kinds or species, and in the formation of man in the image and likeness of the

Creator; and, as we shall find in the sequel, there are some curious ideas of higher and more general types in the grouping of the creatures referred to. The same idea is indicated in the closing chapters of Job, where the three higher classes of the vertebrates are represented by a number of examples, and the typical likeness of one of these—the hippopotamus—to man seems to be recognised. A late able writer has quoted, as an illustration of the doctrine of types, a very remarkable passage from Psalm cxxxix.:—

"'I will praise Thee, for I am fearfully and wonderfully made.
Marvellous are thy works,
And that my soul knoweth right well.
My substance was not hid from Thee
When I was made in secret,
And curiously wrought in the lowest parts of the earth:
Thine eyes did see my substance yet being imperfect,
And in Thy book all my members were written,
Which in continuance were fashioned when as yet there was none of them.'

"It would too much tax the faith of exegists to ask them to believe that the writer of the above passage, or the spirit that inspired him, actually meant to teach—what we now know so well from geology, that the prototypes of all the parts of the archetypal human structure may be found in those fossil remains of extinct animals which may, in nearly every country, be dug up from the rocks of the earth. No objection need, however, be taken to our reading in it the doctrine of embryonic development according to a systematic type.

"In that spiritual department which is the special field of scripture, the doctrine of type has been so extensively recognised by expositors, that I need only refer to its typical numbers, its typical personages, its typical rites and ceremonies, and lastly, to its recognition of the Divine Redeemer as the great archetype of the spiritual world, as man himself is of the natural. In this last respect the New Testament clearly teaches that, in the resurrection, the human body formed after Adam as its type, is to be sublimated and reformed after the heavenly body of the Son of God, rising to some point of perfection higher than that of the present earthly archetype.

"It is more than curious that this idea of type, so long existing in an isolated and often despised form, as a theological thought in the imagery of scripture, should now be a leading idea of natural science; and that while comparative anatomy teaches us that the structures of all past and present lower animals point to man, who, as Prof. Owen expresses it, has had all his parts and organs 'sketched out in anticipation in the inferior animals,' the Bible points still farther forward to an exaltation of the human type itself into what even the comparative anatomist might perhaps regard as among the 'possible modifications of it beyond those realized in this little orb of ours,' could he but learn its real nature."

The passage given above, even if we cannot go with the author to the full extent of his argument, will shew the suggestive, thought-creating character of Dr. Dawson's work. As such, it will shew also, the value of the work itself to the biblical or theological student, who, shaking off the trammels of a too narrow school, is willing to allow a place in his philosophy to the teachings of the great cosmic harmony which circles around him, and which proclaims through all its changes, I, too, am of God. E. J. C.

SCIENTIFIC AND LITERARY NOTES.

PROFESSOR GEORGE WILSON, M.D., F.R.S.E.

Death has of late thinned the ranks of Edinburgh's men of science and letters. Some of the last veterans of the old *Edinburgh Review*, the foremost of Scottish Metaphysicians, and one eminent in her ranks of native Geologists, have rapidly followed one another to the tomb; but a sense of sorrow not less intense than that which was felt on the painful and sudden loss of Hugh Miller, has been occasioned by the death of Dr. George Wilson, the first Regius Professor of Technology in the University of Edinburgh. Dr. Wilson is widely known as the biographer of Cavendish and Reid; the author of "Researches on Colour Blindness," and other scientific works; besides numerous valuable papers contributed to scientific periodicals, and to the Transactions of the Royal Society and other learned bodies of which he was a member. His researches embraced a great variety of subjects, and included many discoveries of interest and value; among which may be noted his investigations into the history of medical electricity, and his discovery of fluorine in sea-water and in blood.

Dying, however, in his forty-first year, when, to those who knew him best, he seemed only to be ripening for the works of his matured genius: the best of his productions very partially indicate the wide range of thought and the original capacity of his mind. He has left incomplete the biography of his old friend and colleague, Professor Edward Forbes; and many of his papers furnish mere glimpses of the original views in his favourite science of Chemistry which he had purposed to work out in the leisure of later years he was never destined to see.

In addition to his professorship, Dr. Wilson was Director of the Scottish Industrial Museum. Of this national Institution a writer in the *Athenæum*, has justly remarked: "Dr. George Wilson was in no small degree the originator of that museum; he gave to it his heart, his genius, and his hopes of success and fame." It would not, indeed, be unjust to say that his life was in some degree the sacrifice made by his devotion to that favourite object. Of a warm and generous nature, and with the well-tempered enthusiasm of true genius, he threw his whole heart into whatever he did; and his loss is mourned in his native city with demonstrations of public grief rarely manifested with like intensity. His remains were followed to the grave by the City Magistrates, the professors of the University, and the representatives of scientific societies and public bodies: and the day of his funeral was observed as one of public mourning. Such an expression of general grief, was due perhaps even more to the worth of a singularly upright and genial Christian man, than to the admiration excited by his rare eloquence as a lecturer, and the fascination of a peculiarly winning and attractive manner, alike in public and private. To those who knew him in the intimate relations of private life, his loss creates a blank that nothing can replace. To a wider circle it may suffice to say, the world has lost in him,—at the early age of forty-one,—a most faithful and conscientious servant of science, and a singularly honest and painstaking searcher after its truths. What he has done will give his name a place among the honoured ranks of our scientific discoverers,—but what he was capable of doing, had life been granted to him, would have rendered all he has done of little account.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The twenty-ninth Annual *Meeting* of the British Association for the advancement of Science, which opened its proceedings under the presidency of His Royal Highness Prince Albert at Aberdeen, on Wednesday, September 14th, 1859, appears to have fully equalled in general interest the most successful of its predecessors. The attendance was much beyond the average; and so numerous were the papers communicated to the various Sections, that a mere enumeration of their titles, alone, would occupy many pages of our Journal. In the first Section, for example, comprising Mathematical and Physical Science, nearly eighty papers were read; and the total number of communications and Reports brought forward at the Meeting, is not far short of four hundred. Some of these papers are of the highest value: but a considerable number are of merely local interest, and many, indeed, appear to be entirely destitute of any special novelty or importance. Considering the undesirable manner in which really valuable communications, on account of the limited duration of the Meetings, are obliged to be hurried through, and their discussion greatly shortened, it would seem advisable to restrict the reading of the papers to such only as contain new facts or practical demonstrations, or which refer to questions of a debatable nature bearing on the philosophy of Science. Mere details of local geology (however useful in their way), with descriptions of ordinary fossils, analyses of river-waters, ordinary meteorological observations, and other papers of a similar character, *that neither clear up doubtful points nor open out new paths of inquiry*, might surely be forwarded with equal profit to some of the numerous scientific journals, in which, if worthy of regard, they would readily receive insertion. Some plan, at least, will have to be adopted sooner or later, to keep down the formidable array of papers, brought forward, in increasing numbers, at each successive meeting of the Association.

We give below (from copies of the Aberdeen *Herald*, kindly placed at our disposal by Professor Wilson,) a Report of the President's Address, and a few of the more important or generally-interesting papers communicated at this Meeting.

THE PRESIDENT'S ADDRESS.

GENTLEMEN OF THE BRITISH ASSOCIATION,—

Your kind invitation to me to undertake the office of your President for the ensuing year could not but startle me on its first announcement. The high position which science occupies, the vast number of distinguished men who labour in her sacred cause, and whose achievements, while spreading innumerable benefits, justly attract the admiration of mankind, contrasted strongly in my mind with the consciousness of my own insignificance in this respect. I, a simple admirer, and would-be student of science, to take the place of chief and spokesman of the scientific men of the day, assembled in furtherance of their important objects—the thing appeared to me impossible. Yet, on reflection, I came to the conclusion, that, if not as a contributor to or director of your labours, I might still be useful to you, useful to science, by accepting your offer. Remembering that this Association is a popular Association, not a secret confraternity of men jealously guarding the mysteries of their profession, but inviting the uninitiated, the public at large, to join them, having as one of its objects to break down those imaginary and hurtful barriers which exist between men of science and so-called men of practice—I felt that I could, from the peculiar position in which Providence had placed me in this country, appear as the representative of that large public, which profits by and admires your exertions, but is unable actively to join in them; that my election was an act of humility on your part which to reject would have looked like false humility, that is like pride, on mine. But I reflected further, and saw in my acceptance the means, of which necessarily so few are offered to her Majesty, of testifying to you, through the instrumentality of her husband, that your labours are not unappreciated by your Sovereign, and that she wishes her people to know this as well as yourselves. Guided by these reflections, my choice was speedily made, for the path of duty lay straight before me.

If these, however, are the motives which have induced me to accept your flattering offer of the Presidency, a request on my part is hardly neccessary that you will receive my efforts to fulfil its duties with kind indulgence.

If it were possible for anything to make me still more aware how much I stand in need of this indulgence, it is the recollection of the person whom I have to succeed as your President—a man of whom this country is justly proud, and whose name stands among the foremost of the naturalists in Europe for his patience in investigation, conscientiousness in observation, boldness of imagination, and acuteness in reasoning. You have no doubt listened with pleasure to his parting address, and I beg to thank him for the flattering manner in which he has alluded to me in it.

The Association meets for the first time to-day in these regions, and in this ancient and interesting city. The poet, in his works of fiction, has to choose, and anxiously to weigh, where to lay his scene, knowing that, like the painter, he is thus laying in the background of his picture, which will give tone and colour to the whole. The stern and dry reality of life is governed by the same laws, and we are here living, feeling, and thinking under the influence of the local impressions of this northern seaport. The choice appears to me a good one. The travelling philosophers have had to come far, but in approaching the Highlands of Scotland they meet nature in its wild and primitive form, and nature is the object of their studies. The geologist will not find many novelties in yonder mountains, because he will stand there on the bare backbone of the globe, but the primary rocks which stand out in their nakedness, exhibit the grandeur and beauty of their peculiar form, and in the splendid quarries of this neighbourhood are seen to peculiar advantage the closeness and hardness of their mass, and their inexhaustible supply for the use of man, made available by the application of new mechanical powers. On this primitive soil the botanist and zoologist will be attracted only by a limited range of plants and animals, but they are the very species which the extension of agriculture and increase of population are gradually driving out of many parts of the country. On those blue hills the red deer, in vast herds, holds undisturbed dominion over the wide heathery forest, until the sportsman, fatigued and unstrung by the busy life of the bustling town, invades the moor, to regain health and vigour by measuring his strength with that of the antlered monarch of the hill. But, notwithstanding all his efforts to overcome an antagonist possessed of such superiority of power, swiftness, caution, and keenness of all the senses, the sportsman would find himself baffled, had not science supplied him with the telescope, and those terrible weapons which seem daily to progress in the precision with which they carry the deadly bullet, mocking distance, to the mark.

In return for the help which science has afforded him, the sportsman can supply the naturalist with many facts which he alone has opportunity of observing, and which may assist the solution of some interesting problems suggested by the life of the deer. Man also, the highest object of our study, is found in vigorous healthy developement, presenting a happy mixture of the Celt, Goth, Saxon, and Dane, acquiring his strength on the hills on the sea. The Aberdeen whaler braves the icy regions of the Polar Sea, to seek and do battle with the great monster of the deep: he has materially assisted in opening these icebound regions to the researches of Science; he fearlessly aided in the search after Sir John Franklin and his gallant companions, whom their country sent forth on this mission, but to whom Providence, alas! has denied the reward of their labours, the return to their homes, to the affectionate embrace of their families and friends, and the acknowledgments of a grateful nation. The City of Aberdeen itself is rich in interest for the philosopher. Its two lately united Universities make it a seat of Learning and Science. The Collection of Antiquities, formed for the present occasion, enables him to dive into olden times, and, by contact with the remains of the handiwork of the ancient inhabitants of Scotland, to enter into the spirit of that peculiar and interesting people, which has attracted the attention and touched the hearts of men accessible to the influence of heroic poetry. The Spalding Club, founded in this city for the preservation of the historical and literary remains of the north-eastern counties of Scotland, is honourably known by its important publications.

Gentlemen!—This is the 29th Aniversary of the foundation of this Association; and well may we look back with satisfaction to its operation and achievements, throughout the time of its existence. When, on the 27th September, 1831, the Meeting of the Yorkshire Philosophical Society took place at York, in the theatre of the Yorkshire Museum, under the presidency of the late Earl Fitzwilliam, then

Viscount Milton, and the Rev. W. Vernon Harcourt eloquently set forth the plan for the *formation* of a British Association for the promotion of Science, which he showed to have become a want for his country, the most ardent supporter of this resolution could not have anticipated that it would *start* into life full-grown as it were, enter at once upon its career of usefulness, and pursue it without deviation from the original design, triumphing over the oppositions which he had to encounter in common with everything that is new and claims to be useful. Gentlemen, this proved that the want was a real, and not an imaginary one, and that the mode in which it was intended to supply that want was based upon a just appreciation of unalterable truths. Mr. Vernon Harcourt summed up the desiderata in graphic words, which have almost *identically* been retained as the exposition of the objects of the Society, printed at the head of the annually-appearing volume of its Transactions:—" to give a stronger impulse and more systematic direction to scientific inquiry—to promote the intercourse of those who cultivate Science in different parts of the Empire, with one another and with foreign Philosophers—and to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progres."

To define the nature of Science, to give an exact and complete definition of what that Science, to whose service the Association is devoted, is and means, has as it naturally must, at all times occupied the Metaphysician. He has answered the question in various ways, more or less satisfactorily to himself or others. To me, Science, in its most general and comprehensive acceptation, means the knowledge of what I know, the consciousness of human knowledge. Hence, to know, is the object of all Science; and all special knowledge, if brought to our consciousness in its separate distinctiveness from, and yet in its recognised relation to the totality of our knowledge, is scientific knowledge. We require, then, for Science—that is to say, for the acquisition of scientific knowledge—those two activities of our mind which are necessary for the acquisition of *any* knowledge—analysis and synthesis; the first, to dissect and reduce into its component parts the objects to be investigated, and to render an accurate account to ourselves of the nature and qualities of these parts by observation; the second to recompose the observed and understood parts into a unity in our consciousness, exactly answering to the object of our investigation. The labours of the man of Science are therefore at once the most humble and the loftiest which man can undertake. He only does what every little child does from its first awakening into life, and must do every moment of its existence; and yet he aims at the gradual approximation to divine truth itself If then, there exists no difference between the work of the man of Science and that of the merest child, what constitutes the distinction? Merely the conscious self-determination. The child observes what accident brings before it, and unconsciously forms its notion of it; the so-called practical man observes what his special work forces upon him, and he forms his notions upon it with reference to this peculiar work. The man of Science observes what he intends to observe, and knows why he intends it. The value which the peculiar object has in his eyes is not determined by accident, nor by an external cause, such as the mere connexion with work to be performed, but by the place which he knows this object to hold in the general universe of knowledge, by the relation which it bears to other parts of that general knowledge.

To *arrange* and *classify* that universe of knowledge becomes therefore the first and perhaps the most important, object and duty of Science. It is only when brought into a system, by separating the incongruous and combining those elements in which we have been enable to discover the internal connexion which the Almighty has implanted in them, that we can hope to grapple with the boundlessness of His creation, and with the laws which govern both mind and matter. The operation of Science then has been, systematically to divide human knowledge, and raise, as it were, the separate groups of subjects for scientific consideration, into different and distinct sciences. The tendency to create new sciences is peculiarly apparent in our present age, and is perhaps inseparable from so rapid a progress as we have seen in our days; for the acquaintance with and mastering of distinct branches of knowledge enables the eye, from the newly-gained points of sight, to see the new ramifications into which they divide themselves in strict consecutiveness and with logical necessity. But in thus gaining new centres of light, from which to direct our researches, and new and powerful means of adding to its ever-increasing treasures, science approaches no nearer to the limits of its range, although travelling further and further from its original point of departure. For God's world is infinite; and the boundlessness of the universe, whose confines appear ever to retreat before our finite minds, strikes us no less with awe when, prying into the starry crowd of heaven, we find new worlds revealed to us by every increase in the power of the telescope, than when the microscope discloses to us in a drop of water, or an atom of dust, new worlds of life and animination, or the remains of such as have passed away.

Whilst the tendency to push systematic investigation in every direction enables the individual mind of man to bring all the power of which he is capable to bear on the specialities of his study, and enables a greater number of labourers to take part in the universal work, it may be feared that that consciousness of its unity which must pervade the whole of science, if it is not to lose its last and highest point of sight, may suffer. It has occasionally been given to rare intellects and the highest genius, to follow the various sciences in their divergent roads, and yet to preserve that point of sight from which alone their totality can be contemplated and directed. Yet how rare is the appearance of such gifted intellects! And if they be found at intervals, they remain still single individuals, with all the imperfections of human nature.

The only mode of supplying with any certainty this want, is to be sought in the *combination* of men of science representing all the specialities, and working together for the common object of preserving that unity and presiding over that general direction. This has been, to some extent, done in many countries by the establishment of academies embracing the whole range of the sciences, whether physical or metaphysical, historical or political. In the absence of such an institution in this country, all lovers of science must rejoice at the existence and activity of this Association, which embraces in its sphere of action, if not the whole range of the sciences, yet a very large and important section of them, those known as the *inductive sciences*, excluding all that are not approached by the inductive method of investigation. It has, for instance (and, considering its peculiar organisation and mode of action, perhaps not unwisely), eliminated from its consideration and discussions those which come under the description of moral and political sciences. This has not been done from undervaluing their importance and denying their sacred right to the special attention of mankind, but from a desire to deal with those subjects only which can be reduced to positive proof, and do not rest on opinion or faith. The subjects of the moral and political sciences involve not only opinions but feelings; and their discussion frequently rouses passions. For feelings are "subjective," as the German metaphysician has it—they are inseparable from the individual being—an attack upon them is felt as one upon the person itself; whilst facts are "objective," and belong to everybody—they remain the same facts at all times and under all circumstances: they can be proved; they have to be proved; and when proved, are finally settled. It is with facts only that the Association deals. There may, for a time, exist differences of opinion on these also, but the process of removing them and resolving them into agreement is a different one from that in the moral and political sciences. These are generally approached by the *deductive* process; but if the reasoning be ever so acute and logically correct, and the point of departure, which may be arbitrarily selected, is disputed, no agreement is possible; whilst we proceed here by the *inductive* process, taking nothing on trust, nothing for granted, but reasoning upwards from the meanest fact established, and making every step sure before going one beyond it, like the engineer in his approaches to a fortress. We thus gain ultimately a roadway,—a ladder by which even a child may, almost without knowing it, ascend to the summit of truth, and obtain that immensely wide and extensive view which is spread below the feet of the astonished beholder. This road has been shown us by the great Bacon; and who can contemplate the prospects which it opens, without almost falling into a trance similar to that in which he allowed his imagination to wander over future ages of discovery!

From amongst the political sciences it has been attempted in modern times to detach one which admits of being severed from individual political opinions, and of being reduced to abstract laws derived from well-authenticated facts. I mean political economy, based on general statistics. A new Association has recently been formed, imitating our perambulating habits, and striving to comprehend in its investigations and discussions even a still more extended range of subjects, in what is called "social science." These efforts deserve our warmest approbation and good-will. May they succeed in obtaining a purely and strictly scientific character! Our own Association has, since its meeting in Dublin, recognized the growing claims of political economy to scientific brotherhood, and admitted it into its statistical section. It could not have done so under abler guidance and happier auspices than the Presidency of the Archbishop of Dublin, Dr. Whately, whose efforts in this direction are so universally appreciated. But even in this section, and whilst statistics alone were treated in it, the Association, as far back as 1833, made it a rule that, in order to ensure positive results, only those classes of facts should be admitted which were capable of being expressed by numbers, and which promised, when sufficiently multiplied, to indicate general laws.

If, then, the main object of science—and I beg to be understood, henceforth, as speaking only of that section which the Association has under its special care viz., inductive science—if I say, the object of science is the discovery of the laws which govern natural phenomena, the primary condition for its success is:—Accurate observation and collection of facts in such comprehensiveness and completeness as to furnish the philosopher with the necessary material from which to draw safe conclusions.

Science is not of yesterday. We stand on the shoulders of past ages, and the amount of observations made, and facts ascertained, has been transmitted to us, and carefully preserved in the various storehouses of science; other crops have been reaped, but still lie scattered on the field; many a rich harvest is ripe for cutting, but waits for the reaper. Economy of labour is the essence of good husbandry, and no less so in the field of science. Our Association has felt the importance of this truth, and may well claim, as one of its principal merits, the constant endeavour to secure that economy. One of the latest undertakings of the Association has been, in conjunction with the Royal Society, to attempt the compilation of a classified catalogue of scientific memoirs, which, by combining under one head the titles of all memoirs written on a certain subject, will, when completed, enable the student who wishes to gain information on that subject to do so with the greatest ease. It gives him, as it were, the plan of the house, and the key to the different apartments in which the treasures relating to his subject are stored, saving him at once a painful and laborious search, and affording him at the same time an assurance that what is here offered contains the whole of the treasures yet acquired.

While this has been one of the latest attempts, the Association has from its very beginning kept in view that its main sphere of usefulness lay in that concentrated attention to all scientific operations which a general gives to the movements of his army, watching and regulating the progress of his impetuous soldiers in the different directions to which their ardour may have led them, carefully noting the gaps which may arise from their independent and eccentric action, and attentively observing what impediments may have stopped, or may threaten to stop, the progress of certain columns. Thus it attempts to fix and record the position and progress of the different labours, by its reports on the state of sciences published annually in its transactions;—thus it directs the attention of the labourers to those gaps which require to be filled up, if the progress is to be a safe and steady one —thus it comes forward with a helping hand, in striving to remove those impediments which the unaided efforts of the individual labourer have been or may be unable to overcome.

Let us follow the activity of the Association in these three different directions. The Reports on the state of Science originate in the conviction of the necessity for fixing, at given intervals, with accuracy and completeness, the position at which it has arrived. For this object, the General Committee of the Association entrusts to distinguished individuals in the different branches of science the charge of becoming, as it were, the biographers of the period. There are special points in different sciences in which it sometimes appears desirable to the different sections to have special reports elaborated; in such cases the General Committee, in its capacity of the representative assembly of all the sciences, reserves to itself the right of judging what may be of sufficient importance to be thus recorded

The special subjects which the Association points out for investigation, in order to supply the gaps which it may have observed, are—either such as the philosopher alone can successfully investigate, because they require the close attention of a practised observer, and a thorough knowledge of the particular subject; or they are such as require the greatest possible number of facts to be obtained. Here science often stands in need of the assistance of the general public, and gratefully accepts any contribution offered, provided the facts be accurately observed. In either case the Association points out *what* is to observed. and *how* it is to be observed. The first is the result of the same careful sifting process which the Association employs in directing the issue of special reports. The investigations are entrusted to specially-appointed committees or selected individuals. They are in most cases not unattended with considerable expense, and the Association, not content with merely suggesting and directing, furnishes by special grants the pecuniary means for defraying the outlay caused by the nature and the extent of the inquiry. If we consider that the income of the Association is solely derived from the contributions of its members, the fact that no less a sum than £17,000 has, since its commencement, been thus granted for scientific purposes, is certainly *most gratifying*. The *question how to observe, resolves itself into two,—that of* the scientific method which is to be employed in approaching a problem or making an observation, and that of the philosophical instruments used in the observation or experiment. The Association brings to bear the combined knowledge and experience of the scientific men not only of this but other countries, on the discovery of that method which, while it economises time and labour, promises the most accurate results. The method to which, after careful examination, the palm has been awarded, is then placed at the free disposal and use of all scientific investigators. The Association also issues, where practicable, printed forms, merely requiring the different heads to be filled up, which, by their uniformity, become an important means for assisting the subsequent reduction of the observations for the abstraction of the laws which they may indicate. At the same time most searching tests and inquiries are constantly carried on in the Observatory at Kew, given to the Association by Her Majesty, the object of which is practically to test the relative value of different methods and instruments, and to guide the constantly progressive improvements in the construction of the latter. The establishment at Kew has undertaken the further important service of verifying and correcting to a fixed standard the instruments of any maker, to enable observations made with them to be reduced to the same numerical expression. I need hardly remind the inhabitants of Aberdeen that the Association, in one of the first years of its existence, undertook the comparative measurement of the Aberdeen standard scale with that of Greenwich—a research ably carried out by the late Mr. Baily.

The impediments to the general progress of science, the removal of which I have indicated as one of the tasks which the Association has set for itself, are of various kinds. If they were only such as direction, advice, and encouragement would enable the individual, or even combined efforts of philosophers, to overcome, the exertions of the Association which I have just alluded to might be sufficient for the purpose. But they are often such as can only be successfully dealt with by the powerful arm of the State, or the long purse of the nation. These impediments may be caused either by the social condition of the country itself, by restrictions arising out of peculiar laws, by the political separation of different countries, or by the magnitude of the undertakings being out of all proportion to the means and power of single individuals of the Association, or even the voluntary efforts of the public. In these cases the Association, together with its sister Society, "the Royal Society," becomes the spokesman of Science with the Crown, the Government, or Parliament—sometimes, even, through the Home Government, with Foreign Governments. Thus it obtained the establishment, by the British Government, of magnetic and meteorological observatories in six different parts of the globe, the beginning of a network of stations which we must hope will be so far extended as to compass, by their geographical distribution, the whole of the phenomena which throw light on this important point in our tellurian and even cosmical existence. The Institute of France, at the recommendation of M. Arago, whose loss the scientific world must long deplore, cheerfully co-operated with our Council on this occasion. It was our Association which, in conjunction with the Royal Society, suggested the Antarctic Expedition, with a view to further the discovery of the laws of terrestrial magnetism, and thus led to the discovery of the southern polar continent. It urged on the Admiralty the prosecution of the tidal observations, which that Department has since fully carried out. It recommended the establishment, in the British Museum, of the conchological collection, exhibiting present and extinct species, which has now become an object of the greatest interest.

I will not weary you by further examples, with which most of you are better acquainted than I am myself, but merely express my satisfaction that there should exist bodies of men who will bring the well-considered and understood wants of science before the public and the Government, who will even hand round the begging-box, and expose themselves to refusals and rebuffs to which all beggars are liable, with the certainty besides, of being considered great bores. Please to recollect that this species of bore is a most useful animal, well adapted for the ends for which nature intended him. He alone, by constantly returning to the charge, and repeating the same truths and the same requests, succeeds in awakening attention to the cause which he advocates, and obtains that hearing which is granted him at last for self-protection, as the minor evil compared to his importunity, but which is requisite to make his cause understood. This is more particularly the case in a free, active, enterprising, and self-determining people like ours, where every interest works for itself, considers itself the all-important one, and makes its way in the world by its own efforts. Is it, then, to be wondered at, that the interests of science, abstract as science appears, and not immediately showing a return in pounds, shillings, and pence, should be postponed, at least, to others which promise immediate tangible results? Is it to be wondered at, that even our public men require an effort to wean themselves from other subjects, in order to give their attention to science and men of science, when it is remembered that science, with the exception of mathematics, was, until of late, almost systematically excluded from our school and university education;—that the traditions of early life are those which make and leave the strongest impression on the human mind, and that the subjects with which we become acquainted, and to which our energies are devoted in youth, are those for which we retain the liveliest interest in after years, and that for these reasons the effort required must be both a mental and a moral one? A deep debt of gratitude is therefore due to bodies like this Association, which not only urges the wants of science on the

Government, but furnishes it at once with well-matured plans how to supply them with the greatest certainty and to the greatest public advantage.

We may be justified in hoping, however, that by the gradual diffusion of science, and its increasing recognition as a principal part of our national education, the public in general, no less than the Legislature and the State, will more and more recognise the claims of science to their attention; so that it may no longer require the begging-box, but speak to the State, like a favoured child to its parent, sure of his parental solicitude for its welfare; that the State will recognise in science one of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand.

If the activity of this Association, such as I have endeavoured to describe it, ever found or could find its personification in one individual—its incarnation, as it were—this had been found in that distinguished and revered philosopher who has been removed from amongst us, in his ninetieth year, within these last few months. Alexander von Humboldt incessantly strove after dominion over that universality of human knowledge which stands in need of thoughtful government and direction to preserve its integrity; he strove to tie up the *fasces* of scientific knowledge, to give them strength in unity. He treated all scientific men as members of one family, enthusiastically directing, fostering, and encouraging inquiry, where he saw either the want of, or the willingness for, it. His protection of the young and ardent student led many to success in their pursuit. His personal influence with the Courts and Governments of most countries in Europe, enabled him to plead the cause of science in a manner which made it more difficult for them to refuse than to grant what he requested. All lovers of science deeply mourn for the loss of such a man. Gentlemen, it is a singular coincidence, that this very day on which we are here assembled, and are thus giving expression to our admiration of him, should be the anniversary of his birth.

To return to ourselves, however. One part of the functions of the Association can receive no personal representation—no incarnation. I mean, the very fact of meetings like that which we are at present inaugurating. This is not the thoughtful direction of one mind over acquired knowledge, but the production of new thought by the contact of many minds, as the spark is produced by the friction of flint and steel; it is not the action of the monarchy or a paternal government, but the republican activity of the Roman Forum. These meetings draw forth the philosopher from the hidden recesses of his study, call in the wanderer over the field of science to meet his brethren, to lay before them the results of his labours, to set forth the deductions at which he has arrived, to ask for their examination, to maintain in the combat of debate the truth of his position and the accuracy of his observations. These meetings, unlike those of any other society, throw open the arena to the cultivators of all sciences, to their mutual advantage: the Geologist learns from the Chemist that there are problems for which he had no clue, but which that science can solve for him; the Geographer receives light from the Naturalist, the Astronomer from the Physicist and Engineer, and so on. And all find a field upon which to meet the public at large, invite them to listen to their reports, and even to take part in their discussions; show to them that philosophers are not vain theorists, but essentially men of practice—not conceited pedants, wrapped up in their own mysterious importance, but humble inquirers after truth, proud only of what they may have achieved or won for the general use of man. Neither are they daring and presumptuous unbelievers—a character which ignorance has sometimes affixed to them—who would, like the Titans, storm heaven, by placing mountain upon mountain, till hurled down from the height attained by the terrible thunders of outraged Jove; but rather the pious pilgrims to the Holy Land, who toil on in search of the sacred shrine, in search of truth—God's truth—God's laws as manifested in His works, in His creation.

[A very interesting communication, laid before the Geological Section, by Sir Charles Lyell, "On the Results of some Observations in France, in reference to the Antiquity of the Human Race," appeared in the last number of the *Canadian Journal*, Vol. IV. p. 497. In the present Number we give two additional papers: one of great value, "On Fossil and Recent Reptilia," by Professor Owen; and a communication of much general interest, "On Japan;" by Lawrence Oliphant, Esq.]

ON THE ORDERS OF FOSSIL AND RECENT REPTILIA, AND THEIR DISTRIBUTION IN TIME.* BY PROF. OWEN, F.R.S., ETC.

Professor Owen began by remarking that, with the exception of Geology, no collateral science had profited so largely from the study of organic remains as Zoology. The catalogues of animal species had received immense accessions from the determination of the nature and affinities of those which had become extinct, and much deeper and clearer insight had been gained into the natural arrangement and subdivision of the classes of animals since Palæontology had expanded our survey of them. Of this the class Reptilia, or cold-blooded air-breathing Vertebrates, afforded a striking example. In the latest edition of the 'Règne Animal,' of Cuvier, 1829, as in the 'Elémens de Zoologie' of M. Edwards, 1834–37, and the still more recent monograph on American Testudinata, by Agassiz, 4to, 1857, the quadruple division of the class, proposed by Brongniart in 1802, was adhered to, viz., Chelonia (tortoises, turtles), Sauria (crocodiles, lizards), Ophidia (serpents), Batrachia (frogs, newts); only the last group is made a distinct class by the distinguished Professor of the United States:—"After this separation of the Batrachians from the true Reptiles we have only three orders left in the class of Reptiles proper,—the Ophidians, the Saurians, and the Chelonians." l. c. p. 239. In Prof. Owen's Reports on British Fossil Reptiles, to the British Association, in 1839 and 1841, it was proposed to divide the class into eight orders, viz., Enaliosauria, Crocodilia, Dinosauria, Lacertilia, Pterosauria, Chelonia, Ophidia, and Batrachia, which were severally characterized. Subsequent researches had brought to light additional forms and structural modifications of cold-blooded air-breathing animals now extinct, which had suggested corresponding modifications of their distribution into ordinal groups. Another result of such deeper insight into the forms that have passed away, has been the clearer recognition of the artificiality of the boundary between the classes Pisces and Reptilia of modern zoological systems. The conformity of pattern in the arrangement of the bones of the outwardly well-ossified skull in certain

* From *The Athenæum* of October 1, 1859.

fishes with well developed lung-like air-bladders (Polypterus, Lepidosteus, Sturio), and in the extinct reptiles, Archegosaurus and Labyrinthodon: the persistence of the notochord (*chorda dorsalis*) in Archegosaurus as in Sturio: the persistence of the notochord and branchial arches in Archegosaurus and Lepidosiren: the absence of occipital condyle or condyles in Archegosaurus as in Lepidosiren: the presence of teeth with the labyrinthic interblending of dental tissues in Dendrodus, Lepidosteus, and Archegosaurus, as in Labyrinthodon: the large median and lateral throat-plates in Archegosaurus as in Megalichthys, and in the modern fishes Arapaima and Lepidosteus:—all these characters, as the author had urged in his Lectures at the Government School of Mines (March, 1858), pointed to one great natural group, remarkable for the extensive gradations of development, linking and blending together fishes and reptiles within the limits of such group. The salamandroid (or so-called "sauroid") Ganoids—Lepidosteus and Polypterus—are the most ichthyoid, the Labyrinthodonts the most sauroid, of the great group: the Lepidosiren and Archegosaurus are intermediate gradations, one having more of the piscine, the other more of the reptilian, character. Archegosaurus conducts the march of development from the fish proper to the Labyrinthodont type; Lepidosiren conducts it to the perennibranchiate, or modern batrachian, type. Both forms expose the artificiality of the ordinary class-distinction between Pisces and Reptilia, and illustrate the naturality of the cold-blooded Vertebrates, or "Hæmatocrya" (αιμα, blood, κρυος, frost: the correlative group is the "hæmatotherma.") Reptiles are defined as "cold-blooded, air-breathing Vertebrates;" but the Siren and Proteus chiefly breathe by gills, as did most probably the Archegosaurus. The modern naked Batrachia annually mature, at once, a large number of small ova. The embryo is developed with but a small allantoic appendage, and is hatched with external gills. These are retained throughout life by a few species; the rest undergo a more or less degree of metamorphosis. Other existing reptiles have comparatively few and large eggs; and the embryo is inclosed in a free amnios, and is more or less enveloped by a large allantois. It undergoes no marked transformation after being hatched. On this difference the Batrachia have been by some naturalists separated as a distinct class from the Reptilia. But the number of ova simultaneously developed in the viviparous land salamanders is much less than in the siren, and not more than in the turtle; and, save in respect of the external gills, which disappear before or soon after birth, the salamander does not undergo a more marked transformation, after being hatched, than does the turtle or crocodile.* It depends, therefore, upon the value assigned to the different proportions of the allantois in the embryo of the salamander and lizard, whether they be pronounced to belong or not to distinct classes of animals. This embryonic, or developmental, character, is unascertainable in the extinct Archegosaurus and Labyrinthodon. The affinity of Labyrinthodon to Ichthyosaurus, and those structures which have led the ablest Germans palæontologists to pronounce the Labyrinthodonts to be true Saurians, under the names of Mastodonsaurus, Trematosaurus, Capitosaurus, &c., may well support the conjecture that modifications more "reptilian" than those in Salamandra may have attended the development of their young. Characters derived

* The Cæcilia may probably depart still further from the type-batrachian mode of development, and approach more to the type-reptilian mode.

from the nature of the cutaneous coverings equally fail to determine the class-characters of Batrachia as contra-distinguished from Reptilia. It is true that all existing Batrachia have a scaleless skin, or very minute scales (Cæcilia), but not all existing reptiles have horny scales. The crocodiles and certain lizards show a development of dermal bones similar to that in certain placoid and ganoid fishes. This development is greater, and the resemblance is closer, in those ancient forms of Reptilia which exhibit in their endo-skeleton unmistakeable signs of their affinity to ganoid fishes and Batrachia. In a survey, therefore, of the present known forms of cold-blooded, air-breathing Vertebrates, recent and fossil, Prof. Owen could not define any real and adequate boundary for dividing them primarily into two distinct classes of Batrachians and Reptiles. As little was he able to point out a character dividing the air-breathing from the water-breathing Hæmatocrya—the reptiles from the fishes. In the present communication the author drew an arbitrary line between Lepidosiren and Archegosaurus, and proposed to begin his review of the ordinal groups of Reptilia, or air-breathing Hæmatocrya, with that of which the Archegosaurus was the type.

Order I. *Ganocephala.*—For this group or order he proposed the name of Ganocephala (γανος, lustre, κεφαλη, head), in reference to the sculptured and externally-polished or ganoid bony plates with which the entire head was defended. These plates include the "*postorbital*" and "*supertemporal*" ones, which roof over the temporal fossæ. No occipital condyles. The teeth have converging inflected folds of cement at their basal half. The notochord is persistent; the vertebral arches and peripheral elements are ossified; the pleurapophyses are short and straight; pectoral and pelvic limbs, which are natatory and very small; large median and lateral "throat-plates;" scales small, carinate, sub-ganoid; traces of branchial arches. The above combination of characters gives the value of an ordinal group in the cold-blooded Vertebrata. The extinct animals which manifest it were first indicated by certain fossils discovered in the sphærosideritic clay-slate forming the upper member of the Bavarian coal-measures, and also in splitting spheroidal concretions from the coal-field of Saarsbruck, near Treves; these fossils were originally referred to the class of fishes (*Pygopterus Lucius*, Agassiz.) But a specimen from the "Brandschiefer" of Münster-Appel presented characters which were recognised by Dr. Gergens to be those of a Salamandroid reptile.* Dr. Gergens placed his supposed "Salamander" in the hands of M. Hermann von Meyer for description; who communicated the result of his examination in a later number of the under-cited journal.† In this notice the author states that the Salamander-affinities of the fossil in question, for which he proposes the name of *Apateon pedestris*, "are by no means demonstrated."‡ "Its head might be that of a fish, as well as of a lizard, or of a batrachian." "There is no trace of bones of limbs." M. von Meyer concludes by stating that, "in order

* "Mainz, Oktober, 1843.—In dem Brandschiefer von Münster-Appel, in Rhein-Baiern, habe ich in vorigen Jahre einen Salamander aufgefunden. Gehört dieser Schiefer der Kohlen-formation? in diesene falle wäre der Fund auch in anderen Hinsicht interressant." Leonhart und Bronn, Neues Jahrbuch für Mineralogie, &c., 1844. p. 49.

† Ibid. 1844, p. 336.

‡ "Ob das—Apateon pedestris—ein Salamander-artiges Geschöpf war, ist keineswegs ausgemacht."

to test the hypothesis of the Apateon being a fossil fish, he has sent to Agassiz a drawing, with a description of it." Three years later, better preserved and more instructive specimens of the problematical fossil were obtained by Prof. von Dechen from the Bavarian coal-fields, and were submitted to the examination of Prof. Goldfuss, of Bonn; he published a quarto memoir on them, with good figures, referring them to a Saurian genus, which he calls Archegosaurus, or "primeval lizard,"—deeming it to be a transitional type between the fish-like Batrachia and the lizards and crocodiles.* The estimable author, on the occasion of publishing the above memoir, transmitted to Prof. Owen excellent casts of the originals therein described and figured These casts were presented by the Professor to the Museum of the Royal College of Surgeons, London, and were described by him in his 'Catalogue of the Fossil Reptiles,' in that Museum, (4to. 1854). The conclusions which Prof. Owen formed thereupon, as to the position and affinities of the Archegosaurus in the reptilian class, are published in that Catalogue, and were communicated to and discussed at the Geological Society of London (see the 'Quarterly Journal of the Geological Society,' Vol. iv., 1848). One of the specimens appeared to present evidence of persistent branchial arches. The osseous structure of the skull, especially of the orbits, through the completed zygomatic arches, indicated an affinity to the Labyrinthodonts; but the vertebræ and numerous very short ribs, with the indications of stunted swimming limbs, impressed the writer with the conviction of the near alliance of the Archegosaurus with the Proteus and other perennibranchiate reptiles. This conclusion of the affinity of Archegosaurus to existing types of the reptilian class is confirmed by the subsequently discovered specimens described and figured by M. von Meyer, in his 'Palæontographica' (Bd. vi., 2te Hef. 1857),—more especially by his discovery of the embryonal condition of the vertebral column†—*i. e.*, of the persistence of the notochord, and the restriction of ossification to the arches and peripheral vertebral elements. In this structure the old carboniferous Reptile resembled the existing Lepidosiren, and afforded further ground for regarding that remarkable existing animal as one which obliterates the line of demarcation between the fishes and the reptiles. Coincident with this non-ossified state of the basis of the vertebrate bodies of the trunk is the absence of the ossified occipital condyles, which condyles characterize the skull in better developed Batrachia. The fore part of the notochord has extended into the basi-sphenoid region, and its capsule has connected it, by ligament, to the broad, flat ossifications of expansions of the same capsule, forming the basi-occipital or basi-sphenoid plate. The vertebræ of the trunk in the fully developed full-sized animal present the following stages of ossification. The neurapophyses coalesce at the top to form the arch, from the summit of which was developed a compressed, subquadrate, moderately high spine, with the truncate, or slightly convex, summit, expanded in the fore and aft direction, so as to touch the contiguous spines in the back: the spines are distinct in the tail. The sides of the base of the neural arch are thickened and extended outwards into diapophyses, having a convex articular surface for the attachment

* "Archegosaurus: Fossile Saurier aus dem Steinkohlengebirge die den Uebergang des Ichthyoden zu den Lacerten und Krokodilen bilden," p. 3. 'Beitrage zur vorweltlichen Fauna des Steinkohlengebirges,' 4to. 1847,

† 'Reptilien ausder Steinkohlen Formation in Deutschland,' Sechster Band, p. 61.

of the rib: the fore part is slightly produced at each angle into a zygapophysis looking upward and a little forward; the hinder part was much produced backwards, supporting two-thirds of the neural spine, and each angle developed into a zygapophysis, with a surface of opposite aspects to the anterior one. In the capsule of the notochord three bony plates were developed, one on the ventral surface, and one on each side, at or near the back part of the diapophysis. These bony plates may be termed "cortical parts" of the centrum, in the same sense in which that term is applied to the element which is called "body of the atlas" in man and Mammalia, and "sub-vertebral wedge-bone" at the fore part of the neck in Enaliosauria. As such ventral or inferior cortical elements co-exist with seemingly complete centrums in the Ichthyosaurus, thus affording ground for deeming them essentially distinct from a true centrum, the term "hypapophyses" had been proposed by Prof. Owen for such independent inferior ossifications in and from the notochordal capsule, and by this term may be signified the sub-notochordal plates in Archegosaurus, which co-exist with proper "hæmapophyses," in the tail. In the trunk they are flat, subquadrate, oblong bodies, with the angles rounded off; in the tail they bend upwards by the extension of the ossification from the under to the side parts of the notochordal capsule; sometimes touching the lateral cortical plates. These serve to strengthen the notochord and support the intervertebral nerve in its outward passage. The ribs are short, almost straight, expanded and flattened at the ends, round and slender at the middle. They are developed throughout the trunk and along part of the tail, co-existing there with the hæmal arches, as in the menopome.* The hæmal arches, which are at first open at their base, become closed by extension of ossification inwards from each produced angle, converting the notch into a foramen. This forms a wide oval, the apex being produced into a long spine; but towards the end of the tail the spine becomes shortened, and the hæmal arch is reduced to a mere flattened ring. The size of the canal for the protection of the caudal blood-vessels indicates the powerful muscular actions of that part; as the produced spines from both neural and hæmal arches bespeak the provision made for muscular attachments, and the vertical development of the caudal swimming organ. All these modifications of the vertebral column demonstrate the aquatic habits of the Archegosaurus; the limbs being in like manner modified as fins, but so small and feeble, as to leave the main part of the function of swimming to be performed, as in fishes and perennibranchiate batrachia, by the tail. The skull of the Archegosaurus appears to have retained much of its primary cartilage internally, and ossification to have been chiefly active at the surface; where, as in the combined dermo-neural ossifications of the skull in the sturgeons and salamandroid fishes, *e.g.*, Polypterus, Amia, Lepidosteus, these ossifications have started from centres more numerous, than those of the true vertebral system in the skull of Saurian reptiles. The teeth are usually shed alternately. They consist of osteo-dentine, dentine, and cement. The first substance occupies the centre, the last covers the superficies of the tooth, but is introduced into its substance by many concentric folds extending along the basal half. These folds are indicated by fine longitudinal straight striæ along that half of the crown. The section of the tooth at that part gives the

* "Principal Forms of the Skeleton," Orr's 'Circle of the Sciences,' p. 187, fig. 11.

same structure which is shown by a like section of a tooth of the *Lepidosteus oxyurus*.* The same principle of dental composition is exemplified in the teeth of most of the ganoid fishes of the Carboniferous and Devonian systems, and is carried out to a great and beautiful degree of complication in the old red Dendrodonts. The repetition of the same principle of dental structure in one of the earliest genera of Reptilia, associated with the defect of ossification of the endoskeleton and the excess of ossification in the exa-skeleton of the head, decisively illustrate the true affinities and low position in the Reptilian class of the so-called Archegosauri. For other details of the peculiar and interesting structure of the animals representing the earliest or oldest known order of Reptiles, Prof. Owen referred to the article "Palæontology" in the 'Encyclopædia Britannica.' This order is "carboniferous."

Order II.—*Labyrinthodontia.*—Head defended, as in the Ganocephala, by a continuous casque of externally sculptured and unusually hard and polished osseous plates, including the supplementary "postorbital" and "supertemporal" bones, but leaving a "foramen parietale."† Two occipital condyles. Vomer divided and dentigerous. Two nostrils. Vertebral centra, as well as arches, ossified, biconcave. Pleurapophyses of the trunk, long and bent. Teeth rendered complex by undulation and side branches of the converging folds of cement, whence the name of the order. Osseous scutes in some. The reptiles presenting the above characters have been divided, according to minor modifications exemplified by the form and proportions of the skull, by the relative position and size of orbital, nasal and temporal cavities, &c., into the several genera; as *e. g.* Mastodonsaurus. Trematosaurus, Metopias, Capitosaurus, Zygosaurus, Xestorrhytias. The relation of these remarkable reptiles to the Saurian order has been advocated as being one of close and true affinity, chiefly on the character of the extent of ossification of the skull and of the outward sculpturing of the cranial bones. But the true nature of some of these bones appears to have been overlooked, and the gaze of research for analogous structures has been too exclusively upward. If directed downward from the Labyrinthodontia to the Ganocephali, and to certain ganoid fishes, it suggests other conclusions, which had been worked out by Prof. Owen, in his article on "Palæontology," above referred to. There is nothing in the known structure of the so-named Archegosaurus or Mastodonsaurus that truly indicates a belonging to the Saurian or Crocodilian-order of reptiles. The exterior ossifications of the skull and the canine-shaped labyrinthic teeth are both examples of the Salamandroid modification of the ganoid type of fishes. The small proportion of the fore-limb of the Mystriosaurus in nowise illustrates this alleged saurian affinity; for though it be as short as in Archegosaurus, it is as perfectly constructed as in the Crocodile, whereas the short fore-limb of Archegosaurus is constructed after the simple type of that of the Proteus and Siren. But the futility of this argument of the sauroid affinities is made manifest by the proportions of the hind-limb of Archegosaurus; it is as stunted as the fore-limb. In the Labyrinthodonts it presented larger proportions, which, however, may be illustrated as naturally by these proportions of the limbs in certain Batrachia, as in the Teleosaurus.

* Wyman, 'American Journal of the Natural Sciences,' October, 1843.

† The corresponding vacuity is larger in some ganoid fishes.

Order III.—*Ichthyopterygia.*—The bones of the head still include the supplementary "post-orbitals" and "supra-temporals," but there are small temporal and other vacuities between the cranial bones: a "foramen parietale," a single convex occipital condyle,* and one vomer which is edentulous. Two antorbital nostrils. Vertebral centra, ossified, biconcave. Pleurapophyses of the trunk long and bent the anterior ones with bifurcate heads. Teeth with converging folds of cement at their base; implanted in a common alveolar groove, and confined to the maxillary, premaxillary, and premandibular bones. Premaxillaries much exceeding the maxillaries in size. Orbit very large: a circle of sclerotic plates. Limbs natatory; with more than five multi-articulate digits; no sacrum. With the retention of characters which indicate, as in the preceding orders, an affinity to the higher Ganoidea, the present exclusively marine Reptilia more directly exemplify the Ichthyic type in the proportions of the premaxillary and maxillary bones; in the shortness and great number of the biconcave vertebræ; in the length of the pleurapophyses of the vertebræ near the head; in the large proportional size of the eyeball, and its well-ossified sclerotic coat, and especially in the structure of the pectoral and ventral fins. The skin is naked. The order ranges from the lias to the chalk.

Order IV.—*Sauropterygia.*—No post-orbital and supra-temporal bone:† large temporal and other vacuities between certain cranial bones; a foramen parietale; two antorbital nostrils; teeth simple, in distinct sockets of premaxillary, maxillary, and premandibular bones, rarely on the palatine or pterygoid bones; maxillaries larger than premaxillaries. Limbs natatory; not more than five digits. A sacrum of one or two vertebræ for the attachment of the pelvic arch in some, numerous cervical vertebræ in most. Pleurapophyses with simple heads; those of the trunk long and bent. In the Pliosaurus the neck vertebræ are comparatively few in number, short and flat. The sauropterygian type seems to have attained its maximum dimensions in this genus: the species of which are peculiar to the Oxfordian and Kimmeridgian divisions of the Upper Oolitic system. M. von Meyer regards the number of cervical vertebræ and the length of neck as characters of prime importance in the classification of Reptilia, and founds thereon his Order called Macrotrachelen, in which he includes Simosaurus, Pistosaurus and Nothosaurus, with Plesiosaurus. No doubt the number of vertebræ in the same skeleton bears a certain relation to ordinal groups; the Ophidia find a common character therein; yet it is not their essential character; for the snake-like form, dependent on multiplied vertebræ, characterizes equally certain Batrachians (Cæcilia) and fishes (Muræna). Certain regions of the vertebral column are the seats of great varieties in the same natural group of Reptilia. We have long-tailed and short-tailed lizards: but do not, therefore, separate those with numerous caudal vertebræ as "Macrouran," from those with few or none. The extinct Dolichosaurus of the Kentish chalk, with its procœlian vertebræ, cannot be ordinally separated, by reason of its more numerous cervical vertebræ, from other shorter-necked procœlian lizards. As little can we separate the short-necked and, the big-headed amphicœlian Pliosaur from the Macrotrachelians of Von Meyer-

* This character is retained throughout the rest of the class, save in Batrachia, and will not afterwards be expressed in their characters.

† These bones do not reappear in the subsequent orders.

with which it has its most intimate and true affinities. There is much reason, indeed, to suspect that some of the Muschelkalk Saurians, which are as closely allied to Nothosaurus as Pliosaurus is to Plesiosaurus, may have presented analogous modifications in the number and proportions of the cervical vertebræ. It is hardly possible to contemplate the broad and short-snouted skull of the Simosaurus, with its proportionably large teeth, without inferring that such a head must have been supported by a shorter and more powerful neck than that which bore the long and slender head of the Nothosaurus or Pistosaurus. The like inference is more strongly impressed upon the mind by the skull of the Placodus, still shorter and broader than that of Simosaurus, and with vastly larger teeeh, of a shape indicative of their adaptation to crushing molluscous or crustaceous shells. Neither the proportions and armature of the skull of Placodus, nor the mode of obtaining the food indicated by its cranial and dental characters, permit the supposition that the head was supported by other than a comparatively short and strong neck. Yet the composition of the skull, its proportions, cavities and other light-giving anatomical characters, all bespeak the close essential relationship of Placodus to Simosaurus and other so-called Macrotrachelian reptiles of the Muschelkalk beds. Prof. Owen continued, therefore, as in his Report of 1841, to regard he fin-like modification of the limbs as a better ordinal character than the number, of vertebræ in any particular regoin of the spine. Yet this limb-character is subordinate to the characters derived from the structure of the skull and of the teeth. If, therefore, the general term Enaliosauria may be sometimes found convenient in its application to the natatory group of Saurian Reptiles, the essential distinctness of the orders Sauropterygii and Ichthyopterygii, typified by the Ichthyosaurus and Plesiosaurus respectively, should be borne in mind. The Plesiosaurus, with its very numerous cervical vertebræ, sometimes thirty in number may be regarded as the type of the Sauropterygii, or pentadactyle sea-lizards. Of all existing reptiles, the lizards, and, amongst these, the Old World monitors, (*Varanus*, Fitz.), by reason of the cranial vacuities in front of the orbits, most resemble the Plesiosaur in the structure of the skull; as in the division of the nostrils, the vacuities in the occipital region between the exoccipitals and tympanics, the parietal foramen, the zygomatic extension of the post-frontal, the palato-maxillary, and pterygo-sphenoid vacuities in the bony palate; and all these are lacertian characters as contradistinguished from crocodilian ones. But the antorbital vacuities, between the nasal, prefrontal, and maxillary bones, are the sole external nostrils in the Plesiosaurs. The zygomatic arch abuts against the fore part of the tympanic and fixes it: a much greater extent of the roof of the mouth is ossified than in lizards, and the palato-maxillary and pterygo-sphenoid fissures are reduced to small size. The teeth, finally, are implanted in distinct sockets. That the Plesiosaur had the "head of a lizard" is an emphatic mode of expressing the amount of resemblance in their cranial conformation. The crocodilian affinities, however, are not confined to the teeth, but are exemplified in some particulars of the structure of the skull itself. In the simple mode of articulation of the ribs the lacertian affinity is again strongly manifested; but to this vertebral character such affinity is limited. All the others exemplify the ordinal distinction of the Plesiosaurs from known existing reptiles. The shape of the joints of the centra; the number of vertebræ between the head and tail, especially of those of the neck;

the slight indication of the sacral vertebræ; the non-confluence of the caudal hæmapophyses with each other, are all "plesiosauroid." In the size and number of abdominal ribs and sternum may perhaps be discerned a first step in that series of development of the hæmapophyses of the trunk, which reaches its maximum in the plastron of the Chelonia. The connexion of the clavicle with the scapula is common to the Chelonia with the Plesiosauri; the expansion of the coracoids—extreme in Plesiosauri—is greater in Chelonia than in Crocodilia; but is still greater in some Lacertia. The form and proportions of the pubis and ischium, as compared with the ilium, in the pelvic arch of the Plesiosauri, find their nearest approach in the pelvis of marine Chelonia; and no other existing reptile now offers so near, although it be so remote, a resemblance to the structure of the paddles of the Plesiosaur. Both Nothosaurus and Pistosaurus had many neck-vertebræ, and the transition from these to the dorsal series was effected, as in Plesiosaurus, by the ascent of the rib-surface from the centrum to the neurapophysis; but the surface, when divided betwee the two elements, projected further ou ards than in most Plesiosauri. In both Nothosaurus and Pistosaurus the pelvic vertebra developes a combined process (par- and di-apophysis). but of relatively larger, vertically longer size, standing well out, and from near the fore part of the side of the vertebra. This process with the coalesced riblet indicates a stronger ilium, and a firmer base of attachment of the hind limb to the trunk than in Plesiosaurus. Both this structure and the greater length of the bones of the fore-arm and leg show that the Muschelkalk predecessors of the liassic Plesiosauri were better organized for occasional progression on dry land. The Sauropterygii extend from the Trias to the chalk inclusive.

Order V.—*Anomodontia* (ανομος, lawless, οδους, tooth).—This order is represented by three families, all the species of which are extinct, and appear to have been restricted to the triassic period. Teeth wanting, or confluent with tusk-shaped premaxillaries, or confined to a single pair in the upper jaw, which have the form and proportions of canine tusks. A foramen parietale and two nostrils, tympanic pedicle fixed. Vertebræ biconcave; pleurapophysis of the trunk long and curved the anterior ones with bifurcate heads; a sacrum of four or five vertebræ forming with broad iliac and pubic bones, a large pelvis. Limbs ambulatory.——Family Dicynodontia. A long ever-growing tusk in each maxillary bone; premaxillaries connate, and forming with the lower jaw a beak-shaped mouth, probably sheathed with horn. This includes two genera—Dicynodon and Ptychognathus—all the known species of which are founded on fossils from rocks of probably triassic age in South Africa.——Family Cryptodontia. Upper as well as lower jaw edentulous. The genus Oudenodon closely conforms to the dicynodont type, and the species are from the same rocks and localities.——Family Gnathodontia. Two curved tusk-shaped bodies holding the place of the premaxillaries, and consisting of confluent, dentinal and osseous substance, descending in front of the symphysis mandibulæ. These bodies are homologous with the pair of confluent premaxillary teeth and bones in the existing New Zealand amphicœlian lizard Rhynchocephalus; they are analogous to the tusks in the Dicynodonts, and must have served a similar purpose in the extinct reptiles of the New Red (Trias) Sandstone of Shropshire (Rhynchosaurus), in which alone this structure, with an otherwise edentulous beak-shaped mouth, has hitherto been met with. To this order belongs the Rynchosauroid reptile, from the Elgin sandstone, with palatal teeth, called Hyperodapedon, by Prof. Huxley.

Order VI. *Pterosauria.*—Although some members of the preceding Order resembled birds in the shape or the edentulous state of the mouth, the reptiles of the present order make a closer approach to the feathered class in the texture and and pneumatic character of most of the bones, and in the modification of the pectoral limbs for the function of flight. This is due to the elongation of the antebrachial bones, and more especially to the still greater length of the metacarpal and phalangial bones of the fifth or outermost digit, the last phalanx of which terminates in a point. The other fingers were of more ordinary length and size, and were terminated by claws, the number of their phalanges progressively increasing to the fourth, which had four joints. The whole osseous system is modified in accordance with the possession of wings: the bones are light, hollow, most of them permeated by air-cells, with thin, compact outer walls. The scapula and coronoid are long and narrow, but strong. The vertebræ of the neck are few but large and strong,—for the support of a large head with long jaws, armed with sharp-pointed teeth. The skull was lightened by large vacuities, of which one was interposed between the nostril and the orbit. The vertebræ of the back are small as are those of the sacrum, which were from two to five in number, but combined with a small pelvis and weak hind-limbs, bespeaking a creature unable to stand and walk like a bird; the body must have been dragged along the ground like that of a bat. The vertebral bodies were united by ball-and-socket joints, the cup being anterior, and in them we have the earliest manifestation of the "procœlian" type of vertebra. The Pterosauria are distributed into genera according to modifications of the jaws and teeth. In the oldest known species, from the lias, the teeth are of two kinds: a few, at the fore part of the jaws, are long, large, sharp-pointed, with a full elliptical base, in distinct and separated sockets; behind them is a close-set row of short, compressed, very small, lancet-shaped teeth. These form the genus Dimorphodon, Ow. In the genus Ramphorynchus, V. M., the fore par- of each jaw is without teeth, and may have been incased by a horny beak; but behind the edentulous production there are four or five large and long teeth followed by several smaller ones. The tail is long, stiff, and slender. In the genus Pterodactylus, Cuv., the jaws are provided with teeth to their extremities; all the teeth are long, slender, sharp-pointed, set well apart. The tail is very short. *P. longirostris*, Ok., about ten inches in length. From lithographic slate at Pappenheim, *P. crassirostris.* Goldf., about one foot long, *P. Sedgwickii*, Ow., from the greensand, with an expanse of wing of twenty feet, exemplify the Pterodactyles proper. The oldest well-known Pterodactyle is the *Dimorphodon macronyx* of the lower lias; but bones of Pterodactyle have been discovered in coeval lias of Wirtemberg. The next in point of age is the *Dimorphodon Banthensis*, from the "Posidonomyen-Schiefer" of Banz in Bavaria, answering to the alum shale of the Whitby lias. Then follows the *P. Bucklandi*, from the Stonesfield oolite. Above this come the first-defined and numerous species of Pterodactyle from the lithographic slates of the middle oolitic system in Germany, and from Cirin on the Rhone. The Pterodactyles of the Wealden are, as yet, known to us by only a few bones and bone fragments. The largest known species are the *P. Sedgwickii* and *P. Fittoni*, from the upper greensand of Cambridgeshire. Finally, the Pterodactyles of the middle chalk of Kent, almost as remarkable for their great size constitute the last forms of flying reptile known in the history of the crust of this earth.

Order VII. *Thecodontia.*—Vertebral bodies biconcave: ribs of the trunk long and bent, the anterior ones with a bifurcate head: sacrum of three vertebræ: limbs ambulatory, femur with a third trochanter. Teeth with the crown more or less compressed, pointed, with trenchant and finely serrate margins: implanted in distinct sockets. This order is represented by the extinct genera Thecodontosaurus and Palæosaurus of Riley and Stutchbury, from probably triassic strata, near Bristol: by the Cladyodon of the New Red Sandstone of Warwickshire, with which, probably, the Belodon of the Keuper Sandstone of Wirtemberg is generically synonymous. The Bathygnathus, Leidy, from New Red Sandstone of Prince Edward's Island, North America, is probably, a member of the present order: which seems to have been the forerunner of the next.

Order VIII. *Dinosauria.*—Cervical and anterior dorsal vertebræ, with par- and di-apophysès, articulating with bifurcate ribs: dorsal vertebræ with a neural platform; sacral vertebræ from four to six in number. Articular ends of the free vertebræ, more or less flat; but in the cervical becoming convex in front and concave behind, in some species. Limbs ambulatory, strong, long and unguiculate. Femur with a third trochanter in some. The species of this order were of large bulk, and were eminently adapted for terrestrial life; some, *e. g.*, Iguanodon and, probably, Hylæosaurus, were more or less vegetable feeders; others, *e. g.*, Megalosar, were carnivorous. The Dinosauria ranged, in time, from the lias (Scelidosaurus Ow., from Charmouth) to the upper greensand (Iguanodon). The Megalosaurus occurs in the lower oolite to the Wealden inclusive. The latter formation is that in which the Dinosauria appear to have flourished in greatest numbers and of hugest dimensions.

Order IX. *Crocodilia.*—Teeth in a single row, implanted in distinct sockets, external nostril single and terminal or subterminal. Anterior trunk; vertebræ with par- and di-apophyses, and bifurcate ribs; sacral vertebræ two, each supporting its own neural arch. Skin protected by bony, usually pitted, plates.

Sub-Order Amphicœlia (αμφι, both; κοιλος, hollow; the vertebræ being hollowed at both ends).—Crocodiles, closely resembling in general form the long and slender-jawed kind of the Ganges, called Gavial, existed from the time of the deposition of the lower lias. The teeth of the liassic forms were similarly long slender, and sharp, adapted for the prehension of fishes, and their skeleton was modified for more efficient progress in water, by both the terminal vertebral surfaces being slightly concave, by the hind limbs being relatively larger and stronger, and by the orbits forming no prominent obstruction to progress through water. From the nature of the deposits containing the remains of the so-modified crocodiles they were marine. The fossil crocodile from the Whitby lias, described and figured in the *Philosophical Transactions*, 1758, p. 638, is the type of these Amphicœlian species. They have been grouped under the following generic heads:—Teleosaurus, Mystriosaurus, Macrospondylus, Massospondylus, Pelagosaurus, Acolodon, Suchosaurus, Goniopholis, Pœcilopleuron, Stagonolepis, (?) &c.* Species of the above genera range from the lias to the chalk inclusive.

Sub-Order Opisthocœlia (οπισθος, behind, κοιλος, hollow: vertebræ concave behind, convex in front).—The small group of Crocodilia, so-called, is an artificial one based upon more or less of the anterior trunk vertebræ being united by ball and-socket joints, but having the ball in front, instead of, as in modern crocodiles, behind. Cuvier first pointed out this peculiarity† in a crocodilian from the Oxfordian beds at Harfleur and the Kimmeridgian at Havre. Prof. Owen had described similar Opisthocœlian vertebræ from the Great Oolite at Chipping Norton, from the Upper Lias of Whitby, and, but of much larger size, from the Wealden formations of Sussex and the Isle of Wight. These specimens probably belonged, as suggested by him in 1841,‡ to the fore part of the same vertebral column as the vertebræ, flat at the fore part, and slightly hollow behind, on which he founded the genus Cetiosaurus. The smaller Opisthocœlian vertebræ described by Cuvier have been referred by Von Meyer to a genus called Streptospondylus. In one species from the Wealden, dorsal vertebræ, measuring eight inches across, are only four inches in length, and caudal vertebræ nearly seven inches across are less than four inches in length. These characterize the species called *Cetiosaurus brevis.* Caudal vertebræ, measuring seven inches deep and five and a half inches in length, from the Lower Oolite at Chipping Norton, and the Great Oolite at Enstone, represent the species called *Cetiosaurus medius.* Caudal vertebræ from the Portland Stone at Garsington, Oxfordshire, measuring seven inches nine lines across and seven inches in length, were referred by the author to the *Cetiosaurus longus.* The latter, he remarked, must have been the most gigantic of crocodilians.

Sub-Order Prœlia (προς, front, κοιλος, hollow: vertebræ with the cup at the fore part and the ball behind). Crocodilians with cup-and-ball vertebræ, like those of living species, first make their appearance in the greensand of N. America (*Croc. basifissus* and *C. basitruncatus,* Ow.)‖ In Europe their remains are first found in the tertiary strata. Such remains from the plastic clay of Meudon have been referred to *Crocodilus isorhynchus, C. cœlorhyncus, C. Becquereli.* In the 'Calcaire Grossier' of Argenton and Castelnaudry have been found the *C. Rallinati,* and *C. Dodanii.* In the coeval eocene London clay, at Sheppy Island, the entire skull and characteristic parts of the skeleton of *C. toliapicus* and *C. champsoides* occur. In the somewhat later eocene beds at Bracklesham occur the remains of the Gavial-like *C. Dixoni.* In the Hordle beds have been found the *C.*

* This was referred to the present order by the author, after inspection of the specimens brought to the British Association Meeting, at Leeds, by Sir R. Murchison, but with a note on the greater relative breadth of the coracoid, as shown by the part of the bone then exposed.—(Encyclo. Brit. Art. 'Palæontology'). Prof. Huxley, to whom the specimens were subsequently consigned for description, together with others directly transmitted to him, confirms the general crocodilian character of Stagonolepis. I regard the modifications of the limb-bones as indications of affinity with the Thecodontia; but the structure of the cranium must be ascertained to determine this point. The associated fossils, especially those allied to Rynchosaurus, in the Elgin sandstones, have a triassic character.

† 'Annales du Muséum,' tom. xii. p. 83, pl. x. xi.

‡ 'Report on British Fossil Reptiles,' *Trans. British Association,* for 1841, p. 96.

Quarterly Journal of the Geological Society.

Hastingsiæ, with short and broad jaws; and also a true alligator (*C Hantoniensis*). It is remarkable that forms of procœlian Crocodilia, now geographically restricted, the gavial to Asia and the alligator to America, should have been associated with true crocodiles, and represented by species which lived, during nearly the same geological period, in rivers flowing over what now forms the south coast of Eng land. Many species of procœlian Crocodilia have been founded on fossils from miocene and pliocene tertiaries. One of these, of the gavial sub-genus (*C. crassidens*), from the Sewalik tertiary, was of gigantic dimensions.

Order X. *Lacertilia.*—Vertebræ, in most, procœlian, with a single transverse process on each side, and with single-headed ribs; sacral vertebræ, not exceeding two. Small vertebræ of this type have been found in the Wealden of Sussex. They are more abundant, and are associated with other and more characteristic parts of the species in the cretaceous strata. On such evidence have been based the *Rhapiosaurus subulidens*, the *Coniasaurus crassidens*, and the *Dolichosaurus longicollis*. But the most remarkable and extreme modifications of the lacertian type, in the cretaceous period, is that manifested by the huge species of which a cranium, five feet long, was discovered in the upper chalk of St. Peter's Mount. near *Maestricht*, in 1780. This species, under the name Mosasaurus, is well known by the descriptions of Cuvier. Allied species have been found in the cretaceous strata of England and North America. The Leiodon anceps of the Norfolk chalk was a nearly-allied marine Lacertian. The structure of the limbs is not yet well-understood; it may lead to a sub-ordinal separation of the Mosasauroids from the land lizards, most of which are represented by existing species, in which a close transition is manifested to the next order.

Order XI. *Ophidia.*—Vertebræ very numerous, procœlian, with a single transverse process on each side, no sacrum; no visible limbs. The earliest evidence, at present, of this order is given by the fossil vertebræ of the large serpent (Palæophis, Ow.) from the London clay of Sheppy and Bracklesham. Remains of a poisonous serpent, apparently a Vipera, have been found in miocene deposits at Sansans, south of France. Ophidiolites, from Œningen, have been referred to the genus Coluber.

Order XII. *Chelonia.—The characters of this order, including the extremely* and peculiarly modified forms of tortoises, terrapenes and turtles, are sufficiently well known. The chief modifications in oolitic Chelonia known to Prof. Owen were the additional pair of bones, interposed between the hyosternals and hyposternals of the plastron, in the genus Pleurosternon from the Upper Oolite at Purbeck. It would be very hazardous to infer the existence of reptiles, with the characteristic structure of the restricted genus Testudo, from the foot-prints in the triassic sandstone of Dumfries-shire. But Prof. Owen concurred in the general conclusions based upon the admirable figures and descriptions in the splendid monograph by Sir Wm. Jardine, Bart., F.R.S., that some of those foot-prints most probably belonged to species of the Chelonian order. As enormous species of true turtle (*chelone gigas*), the skull of which measured one foot across the back part, had left its remains in the eocene clay at Sheppy. The terrestrial type of the order had been exemplified on a still more gigantic scale by the Colossochelys of the Sewalik tertiaries.

Order XIII. *Batrachia.*—Vertebræ biconcave (*Siren*), procœlian (*Rana*), or opisthocœlian (*Pipa*): pleurapophyses short, straight. Two occipital condyles and two vomerine bones, in most dentigerous: no scales or scutes. Larvæ with gills, in most deciduous. Representatives of existing families or genera of true Batrachia have been found fossil, chiefly in tertiary and post-tertiary strata. Indications of a perennibranchiate batrachian had recently been detected by Prof. Owen, in a collection of minute Purbeck fossils. Anourous genera (*Palæophrynus*), allied to the toad, occurred in the Œningen tertiaries, and here also the remains of the gigantic Salamander (*Andrias Schewzeri*) were discovered.

Summary of the above defined Orders.

Province—VERTEBRATA.

Class—HÆMATOCRYA.

Sub-Class—REPTILIA.

Orders.

I. Ganocephala.
II. Labyrinthodontia.
III. Ichthyopterygia.
IV. Sauropterygia.
V. Anomodontia.
VI. Pterosauria.
VII. Thecodontia.
VIII. Dinosauria.
IX. Crocodilia.
X. Lacertilia.
XI. Ophidia.
XII. Chelonia.
XIII. Batrachia.

NOTES ON JAPAN. BY LAWRENCE OLIPHANT, F.R.G.S.

The following Notes are the results of personal observation during the recent mission of Lord Elgin to the Empire of Japan.

The three ports of the Empire visited by the mission, and which fell more immediately under our observation, were Nagasaki, situated in the Island of Kinsin; Simioda, a port opened by Commodore Perry on the Promontory of Idsa; and Yeddo, the capital city of the Empire. Of these Nagasaki is the one with which we have been for the longest period familiar. In former times it was a fishing village situated in the Principality of Omura. It is now an imperial demesne, and the most flourishing port in the Empire. It owes its origin to the establishment, at this advantageous point, of a Portuguese settlement in the year 1569; and its prosperity, to the enlightened policy pursued by the Christian Prince of Omura, in whose territory it was situated. Its transference to the Crown property was the result of political intrigues on the part of the Portuguese settlers, in consequence of which the celebrated Tageo Sama included it among the lands appertaining to the Crown. Situated almost at the westernmost extremity of the Empire, at the head of a deep land-locked harbour, and in convenient proximity to some of the wealthiest and most productive Principalities, Nagasaki possesses great local advantages, and will doubtless continue an important commercial emporium, even when the trade of the Empire at large is more fully developed, and has found an outlet through other ports. The town is pleasantly situated on a belt of level ground which intervenes between the water and the swelling hills. These, with their slopes terraced with rice fields; their wooded valleys and gushing streams; and their projecting points crowned with temples or frowning with batteries, form an amphitheatre of great scenic beauty; and the whole aspect of the place produces a most favourable impression on the mind of the stranger visiting Japan for the first time.

The Empire of Japan is stated, according to native authority, to consist of upwards of three thousand islands. The majority of these, however, are uninhabited rocks. The principal island is known to the natives as Dai Nipon. The word Nipon is, doubtless, the origin of the term Japan, now applied to the whole group. The Chinese have called Nipon, "Jipun, the Empire proceeding from the sun." Marco Polo calls it Jypanger, but all these words have clearly a common origin. Yesso, Kinsin, and Sikok complete the group of larger islands, which contain a territorial superficies, roughly estimated at 160,000 square miles. To these must be added the Japanese settlements in the neighbouring island of Tarakai, where the boundary which divides them from Russia, and marks the limit of that spreading Empire in this direction, remains yet undecided.

The city itself contains a population of about fifty thousand, and consists of between eighty and ninety streets, running at right angles to each other—broad enough to admit of the passage of wheeled vehicles, were any to be seen in them —and kept scrupulously clean. A canal intersects the city, spanned by thirty-five bridges, of which fifteen are handsomely constructed of stone. The Dutch factory is placed upon a small fan-shaped island about two hundred yards in length, and connected with the mainland by a bridge. Until recently, the members of the factory were confined exclusively to this limited area, and kept under a strict and rigid surveillance. The old *regime* is now however,rapidly passing away; and the history of their imprisonment, of the indignities to which they were exposed, and the insults they suffered, has already become a matter of tradition.

Kinsin, or "the Island of Nine," in which Nagasaki is situated, is so called because it is divided into nine provinces. It contains an area of about sixteen thousand miles, being in extent nearly equal to Sardinia. The provinces of which it is composed are—Fizen, Tsikuzen, Tsikugo, Buzen, Bungo, Figo, Oosom, Fingo, and Satsuma. I have enumerated these by name, not so much for the purpose of information as to convey some idea of the words and names in the Japanese language. All these provinces are divided among many princes, who are vassals of the empire. The supremacy, however, in each is generally vested in a single family, whose hereditary position among the aristocracy of the country confers upon it a recognized ascendancy.

In Kinsin, the most important of these Principalities, are Fizen and Satsuma. The largest city in the island, Saga, is the capital of Fizen and residence of its

Prince. Attached to this province there are no fewer than 1016 islands. One of these, Firando, is interesting to us, from the fact that, in the year 1613, an English factory was established there, which however, after a brief existence, failed, in consequence of a combination of adverse circumstances to which it is not necesary here to allude, more especially as we have no reason to anticipate that they will again arise to nip in the bud the commerce that is rapidly growing in those regions. Simabarra is another port of this province possessing historical interest. Its siege forms a celebrated but melancholy episode in the history of Christianity in Japan. Thirty-five thousand Roman Catholic Christians, who had taken refuge within its waters were bombarded by the Dutch at the behest of the Japanese Government, and utterly exterminated.

In former days Nagasaki was comprised within the limits of Fisen, and even now the defence of the city, in time of war, devolves upon the prince. The revenue of this high dignitary is stated to amount to about £360,000 a-year. His territory is one of the most productive in the empire, which will account for this enormous revenue. Besides rice, and various descriptions of grain, it produces tea, tobacco, and cotton, with fruit of divers sorts. Among the most important of its products, however, should be mentioned the vegetable tallow, one cargo of which has already reached this country, and been disposed of at a large profit. Among its mineral productions are iron, sulphur, cinnabar, and marble. There is a coal mine at Wukumote which some of the Dutch Mission have descended. They describe the mine as being well and judiciously worked, and the coal as being bituminous in its nature, and made into coke for use. Old Kainipfer tells a story (by way of illustrating the volcanic nature of the country) of a coal mine in this province which, through the carelessness of the miners, took fire, and has been burning ever since. The nearest coal mine is not more than seven miles from Nagasaki. Another very extensive one is situated in Tsekugen, about one hundred miles distant. A very excellent description of porcelain clay is also found here, and the European demand for eggshell China, which is sold in great quantities at Nagasaki, is chiefly supplied by the subjects of the princes of Ligon and Satsuma. The ruler of Ligon is, so far as we could learn from our Dutch informants at Nagasaki, a man of tolerably advanced views, and favourably disposed towards foreigners. He has already adopted many of our wisest inventions, but has not succeeded in thoroughly divesting himself of old prejudices. This was illustrated a short time prior to our visit, by his refusal to allow the Dutch to enter his territory to put up a steam engine which he himself had ordered out from Europe, to pump water out of one of his coal mines. But the Prince who has distinguished himself most notably by his progressive views is his Highness of Satsuma. Unfortunately, since our return to this country, we have received intelligence of the death of this most enlightened nobleman. A man of the highest rank, of enormous wealth, of great political influence, the Prince of Satsuma was ever ready to advance the interests of foreigners, and to introduce into his own State their arts and inventions. I was informed by a Dutch gentlemen who had visited him that he had established an electric telegraph between his castle and Hagosima, the chief city of his province, a distance of about three miles. He has also extensive glass factories, and cannon foundries, in which 800 workmen are employed.

Some idea may be formed of the scale upon which his establishment was conducted, from the fact that he possessed nine town houses in Yedo, and always travelled to that city with an escort of several thousand men. He was nearly connected with the Royal Family, his daughter being married to the late Tycoon, or Temporal Emperor, whose demise took place about the period of our arrival at Yedo.

A former Prince of Satsuma, was the conqueror of the Lewchew Islands. The Province of Satsuma contains great quantities of sulphur, which may form an mportant item in our trade with Japan. At its southern extremity is situated the Island of Loogasina, or Sulphur Island, which is said to burn incessantly. We did not pass within sight of it however. The mines of the island yield the Prince of Satsuma an annual revenue of 200 chests of silver.

The whole of the Island of Kinsin is eminently volcanic, notwithstanding its general fertility and varied products. Parts of it are wild and barren; the aspect of its shores and general character of its mountains would betray its origin, even did not incessant volcanic action exist to put the matter beyond a doubt. There are no less than five volcanoes active in this island—they are, Mitake, in the Province of Satsuma; Kirisima Yamma, in Fingo; Asoyammo, in Figo; Wunzler, in Fizen; and Tsurminyanma, in Bungo.

The most celebrated of these are the Kirisma Yamma and Wunzler, or the "High Mountain of Warm Springs." I find, on referring to the Chinese Repository, that in 1793 the summit of the mountain sunk entirely down; torrents of boiling water issued from all parts of the deep cavity which was thus formed, and the vapour arose like thick smoke. In one of its eruptions, it is recorded to have destroyed the ill-fated city of Simabara, when 35,000 persons are said to have perished There are also many hot and sulphurous springs, which are used as baths, and accounted to have great medical qualities. To some of these, curious superstitions are attached. They are considered departments for punishment in the infernal regions. To one which is covered at the top with a white cream like froth, are consigned pastry-cooks and confectioners who practised adulteration while in life; while deceitful brewers pass a miserable existence in a spring as thick and muddy as the beer and sakee they sold their customers. The Island of Kinsin is well watered; a hardy and industrious population inhabits its fertile valleys; its lofty mountain ranges contain scenes of great grandeur and sublimity, while its shores, indented with deep and secure harbours and feathered with wood, owe much of their picturesque beauty to the numerous islands which stud those inland waters.

It is separated from the Island of Nipon by the narrow Straits of Vander Capellen or Simonerki, which connect the Straits of the Corea with the Purvonadei Sea. It was originally the intention of Lord Elgin to have explored on his return voyage this most remarkable sheet of water, never yet traversed by foreign keel, and which must afford a most interesting field for surveys of scientific character, as also for general observation. Unfortunately, however, our time did not admit of his putting this design into execution. The South sea is thickly covered with islands, and was reported to us by the Japanese as navigable for ships of large draught. The large and important island of Sikok intervenes between it and the North Pacific Ocean with which this sea is connected, by the Straits of Bangon on the west, and the narrow Channel of Kind on the east. Sikok is, as its name implies, divided into four provinces; as, however, we did not even sight its shores we had no opportunity of obtaining any information about it. It is about 150 miles long, with an average breadth of 70 miles, and is computed to contain about 10,000 square miles.

With the Suwonda Sea, however we are more closely interested, for upon its margin is the Port of Hiogo, opened by the late treaty to the commerce of the west.

This port is situated in the Bay of Othosaka, opposite to the celebrated city of that name, from which it is ten or twelve miles distant. The Japanese Government have expended vast sums in their engineering efforts to improve its once dangerous anchorage. A breakwater, which was erected at a prodigious expense, and which cost the lives of numbers of workmen, has proved sufficient for the object for which it was designed. There is a tradition that a superstition existed in connection with this dyke, to the effect that it would never be finished, unless an individual could be found sufficiently patriotic to suffer himself to be buried in it. A Japannese Curtius was not long in forthcoming, to whom a debt of gratitude will be due in all time to come, from every British ship that rides securely at her anchor behind the breakwater.

Hiogo has now become the port of Ghosaken and Miaco, and will in all probability, be the principal port of European trade in the empire. The city is described as equal in size to Nagasaki. When Kainipfer visited it, he found 300 junks at anchor in its bay.

The Dutch describe Ohosaka as a more attractive resort even than Yedo. While this latter city may be regarded as the London of Japan, Ohosaka seems to be its Paris. Here are the most celebrated theatres, the most sumptuous tea-houses, the most extensive pleasure-gardens. It is the abode of luxury and wealth, the favourite resort of fashionable Japanese, who come here to spend their time in gaiety and pleasure. Ohosaka is one of the five Imperial cities, and contains a vast population. It is situated on the left bank of the Jedogawa, a stream which rises in the Lake of Oity, situated a day and a-half's journey in the interior. It is navigable for boats of large tonnage as far as Miaco, and is spanned by numerous handsome bridges.

The port of Hiago and the city of Osaca will not be opened to Europeans until the 1st of January, 1863. The foreign residents will then be allowed to explore the country in any direction, for a distance of twenty-five miles, except towards Miaco, or, as it is more properly called, Kioto. They will not be allowed to approach nearer than twenty-five miles to this far famed city.

As the Dutch have constantly been in the habit of passing through Kioto, it is probable that before very long this restriction will be removed, and Europeans will be permitted to visit, what is, without question, the most interesting spot in the Empire. If Yedo is the London, and Othosaka the Paris, Kioto is certainly the Rome of Japan. It is here that the spiritual Emperor resides, and that enormous ecclesiastical Court by which he is surrounded, and which is called the Dairie, is permanently fixed. It is here that the celebrated tomb of the Great Sayco Sena, the most famous of Japanese temporal Emperors is situated; and here are to be seen the most magnificient and imposing temples of which the Empire can boast. The population of Kioto is said to be half a million, and it has had the reputation of being the principal manufacturing town in the Empire. It is situated as nearly as possible in the centre of Dai Nipon, the largest and most important island in the Japanese group, and which now demands a brief descriptive notice. According to Kainipfer, its length measured along the middle of the island exceeds 900 miles, and its average width may be estimated at more than 100 miles—its surface may, therefore cover an area of about 100,000 square miles. It is traversed in its whole length by a chain almost of uniform elevation, and in many places crowned with peaks covered with perpetual snow. This chain divides the streams which flow to the south and east, and which fall into the Pacific Ocean, from those which pursue a northerly course to the sea of Japan. Very many of its peaks are volcanic—among the most important of these is the Fusyanuner, the highest mountain in Japan. Its elevation is estimated at about 11,000 feet above the sea level. It has been quiescent for upwards of a century; its summit was sheathed with snow when we saw it at midsummer. The volcanoe of Pries, situated on an island under which we passed, was in action. Nipon is divided into upwards of 50 separate provinces, and contains the capital city of the Empire: Yedo. The first point in it at which we touched was the port of Simoda, situated on the promontory of Idsu, and opened to foreign trade by Commodore Perry in 1852.

As this port is under the new treaty to be closed to foreigners, it is scarcely necessary to allude to it. At no time favourably situated for trade, and under all circumstances a dangerous harbour, the anchorage was totally destroyed by an earthquake, which took place in December, 1854. Placed at the extreme end of a mountainous promontory, to pass from which into the interior of the island it is necessary to cross a mountain range 6000 feet high, and inhabited by a poor population of fishermen, Simoda can never offer attractions to the merchant, or give us cause to regret that it is no longer available for commercial purposes. The promontory of Idsu forms the eastern shore of the Bay of Yedo. The distance from Simoda to that city is about eighty miles. At Uraga the opposite shores approach to within ten miles of each other, and the straits which are thus formed afford scenery of much picturesque beauty. Eighteen miles from Yedo, and situated in a curvature of the western shore, lies the new port of Kanagawa, affording secure anchorage within half-a-mile of the land. Connected with Yedo by an excellent road, practicable for wheeled vehicles, and containing a considerable population already, Kanagawa possesses many advantages as a focus of trade. As, however, we did not land here, I do not venture to describe it further, the more especially as it has now been open to Europeans for upwards of two months, and we shall doubtless ere long have a full account of it from some of the pioneers of commercial enterprise who have already gone to establish themselves there. Foreigners are permitted by treaty to go into the interior for a distance of twenty-five miles, except toward Yedo. The Logos river, distant about ten miles from this city, is their limit in that direction.

Fortunately, no such restriction applied to us, and we were enabled, during a residence of ten days in that most interesting capital, to acquire some information with reference to the manners and customs of the singular race who inhabit it, of their mode of government, and of the resources of the country generally.

Situated at the head of a bay, or rather gulf, so extensive that the opposite shores are not visible to each other, Yedo spreads itself in a continuous line of houses along its partially undulating, partially level margin, for a distance of about ten miles. Including suburbs, at its greatest width it is probably about seven miles across, but for a portion of the distance it narrows to a mere strip of houses. Any rough calculation of the population of so vast a city must necessarily be very vague and uncertain; but, after some experience of Chinese cities, two millions does not seem too high an estimate at which to place Yedo.

In consequence of the great extent of the area occupied by the residences of the Princes, there are quarters of the town in which the inhabitants are very scarce. The citadel, or residence of the temporal Emperor, connot be less than five or six miles in circumference, and yet it only contains about 40,000 souls. On the other hand, there are parts of the city in which the inhabitants seem almost as closely packed as they are in Chinese towns.

The streets are broad and admirably drained, some of them are lined with peach and plum trees, and when these are in blossom must present a gay and lively appearance. These which traverse the Prince's quarter are for the most part as quiet and deserted as aristocratic thoroughfares generally are. Those which pass through the commercial and manufacturing quarters are densely crowded with passengers on foot, in chairs, and on horseback, while occasionally but not often, an ox waggon rumbles and creaks along. The houses are only of two stories, sometimes built of freestone, sometimes of sunburnt brick, and sometimes of wood; the roofs are either tiles or shingles. The shops are completely open to the street; some of them are very extensive, the show rooms for the more expensive fabrics being up stairs as with us. The eastern part of the city is built upon a level plain, watered by the Toda Gawa, which flows through this section of the town, and supplies with water the large moats which surround the citadel. It is spanned by the Nipon; has a wooden bridge of enormous length, celebrated as the Hyde Park Corner of Japan, as from it all distances throughout the empire are measured. Towards the western quarter of the city the country becomes more broken, swelling hills rise above the housetops, richly clothed with foliage, from out the waving masses of which appear the upturned gables of a temple, or the many roofs of a Pagoda.

It will be some satisfaction to foreigners to know that they are not to be excluded for ever from this most interesting city. By the treaty concluded in it by Lord Elgin, on the first of January, 1862, British subjects will be allowed to reside there, and it is not improbable that a great portion of the trade may be transferred to it from Kanagawa. There is plenty of water and a good anchorage at a distance of about a mile and a half from the western suburb of Linagawa.

The only other port which has been opened by the late Treaty in the Island of Nipon is the Port of Nee-e-gata, situated upon its western coast. As this port has never yet been visited by Europeans, it is stipulated that if it be found inconvenient as a harbour, another shall be substituted for it, to be opened on the first of January, 1860.

It will thus be seen that we have one port in Kinsin, Nagasaki; three in Nipon, Hiogo, Kanagawa, and Nee-e-gata. In the remaining large Island of the Japanese group—viz., Yesso, we have secured Hakodadi. It was opened to foreign trade on the 1st of last July. Our ships of war have recently visited Hakodadi frequently. It is described as a beautiful spot, situated in a country resembling England in its climate, productions, and natural features.

The limits of this paper will not, unfortunately, admit of my adverting, at any length, to the singular political and social institutions of this most remarkable people—otherwise, it might have been interesting to have described the spiritual Emperor passing a sub-celestial existence at Miaco, reminded only of his humanity by twelve wives, who are not spiritual; and the temporal Emperor, confined within the massive walls of his handsome palace, little better than a State prisoner. We cannot now speculate upon the power and influence wielded by the Council of State, composed of five feudal nobles; or discuss the share which an ancient and powerful aristocracy possess in the administration of public affairs. That most striking feature in the social government of Japan, which consists of an elaborate system of espionage, exercised alike upon prince and beggar, and retaining all within the thraldrom of its iron grasp, would be a fertile theme for a paper in itself; while the celebrated Hara Kiri, or happy despatch, already so familiar to all, that it is scarcely necessary to allude to it as the resource alike of the unsuccessful politician, the detected criminal, and the injured member of society. It may not, however, be so well known that the old practice of ripping open the abdomen has been extinguished in favour of a less disgusting method of immolation, by which the duty of terminating the existence of the victim falls not upon himself but upon his friend, who decapitates him in the presence of his family and relations.

Still less can we now venture upon a discussion of the various creeds which obtain in Japan, of the old national religions of the Empire, known as the Sinsyn religion or faith of the gods, or of the extent to which it has become modified by those more recently introduced dogmas of Bhuddism (now a faith widely diffused throughout the Empire,) or of the influence exercised upon both by the more Confucian tenets practised by those who follow Suitoo, or the way of the philosophers.

Having, thus enumerated and briefly discussed, so far as our limited information will admit, the five ports of Japan recently opened by treaty to the commerce and enterprise of the West, it may not be uninteresting to glance at the probable nature and extent of that commerce which is likely to spring up at them.

From the little we know of the internal resources of Japan, it is probable that we shall find a more profitable source of trade in its mineral than its vegetable productions. Unless we have been totally misinformed, these former are of vast extent and great value.

We know that the principal profits of the early Portuguese settlers were derived from the export of gold and silver. So lucrative was it that Kainipfer remarks—"It is believed that, had the Portuguese enjoyed the trade of Japan but twenty years longer, upon the same footing as they did for some time, much riches would have been transported out of this Ophir to Macao, and there would have been such a plenty and flow of gold and silver in that town, as sacred writ mentions there was at Jerusalem in the time of Solomon. At a later period, the Dutch carried on this same traffic to so great an extent that a native political economist, writing in 1708 on the subject, computes the annual exportation of gold at about 150,000 cobaugs, so that in ten years the empire was drained of 1,500,000 cobaugs, or about two millions and a half sterling.

The gold is found in various localities. That procured from Sado has the reputation of being the finest, and it is stated that the ore will yield from one to two oz. of fine metal per 1¼ lb. The copper mines in Garonga are stated to be very rich, the copper ore raised also being impregnated with gold. The ore from Satsuma yields from 4 to 6 oz. per 1¼ lb. These are the principal mines. Gold dust is found in some of the streams. Copper is superabundant, as is evident from the lavish use made of it for ornamental purposes.

For a long period the Dutch received at Nagasaki (in exchange for their merchandize) Japan copper. This however, as well as the sale of gold, has been stopped for many years. The Government allows no more copper to be produced now than is absolutely necessary for home consumption, which is comparatively very small. It will be for us to develope more fully one of the most important elements in the wealth of this vast empire.

By the treaty recently concluded, gold and silver coins may be exported from Japan, but not as cargo; the exportation of copper coin, as well as copper in bars, is prohibited, but the government engages to sell from time to time at public auction, any surplus quantity of copper that may be produced.

Iron abounds in various parts of Japan. The mines of iron are extensively worked, much more so at present than those of copper. Judging from articles of casting of their own construction, the ores must be of excellent quanlity. Specimens of wrought iron, cast and blister steel, have been examined with very satisfactory results. The wrought iron is usually hammered, and in small flat bars varying from 12 to 20 lbs. each. This is probably to be attributed to a want of proper machinery for heavier bars, and its being suited to their purposes. The steel of which the swords were composed which we procured at Yedo, was of admirable temper and quality.

I have already alluded to the coal mines which exist in the Island of Kinsiu—one of them is distant only seven miles from Nagasaki. They are a Government monopoly. Hitherto the coal brought for sale since the opening of trade at Nagasaki has been surface coal, and consequently inferior in quality; it is described as small. It burns slaty, leaving considerable ash, and is very light. There can be little doubt that good coal is to be found in the island, when the mines begin to be properly worked. By the treaty of Yedo, coals, zinc, lead, and tin, are to be exported, at a duty of five per cent.

The vegetable productions of Japan, which are most probably destined to become articles of commerce, are camphor, vegetable tallow, rice, wheat, drugs, seaweed, &c. Among manufactured articles we may mention lacquer ware and porcelain, but it is almost impossible at this early stage of our commercial relations to predict either their character or extent. Immediately on our return from Japan, some merchant ships went out to Nagasaki—not altogether strictly in accordance with international law—to open trade at that port. Since November last we have an actual experience to refer to; but we must beware of drawing conclusions rashly from it. That the result has not equalled the anticipations formed at the commencement is due to the fact that trade has not been carried on under the provisions of the treaty concluded at Yeddo, but under that now obsolete system formerly pursued by the Dutch, in which the foreign merchant was compelled to deal with and through Government alone. The consequence was, that after the first few Government contracts were completed, the trade could only be carried on under those restrictions and disadvantages which have rendered it so little profitable to the Dutch throughout this long course of years. Now, however that those restrictions are removed, and a currency established, which will once more enable merchants to enter upon extensive commercial transactions under favorable conditions, instead of confining them to a paltry barter trade, carried out under Government regulations, I have no doubt that we shall receive very different accounts of our mercantile prospects in this quarter. When we hear that between November, 1858, and March, 1859, no less than 15,000 tons of British and American shipping have left Shanghae for Nagasaki, a port the annual trade of which had been carried on by two Dutch ships, and that upwards of 11,000 tons have returned thence, many of the vessels being announced to go back again, we are driven to suppose either that the British merchant is more than usually blind to his own interest, or that there really is a trade worth engaging in. About fourteen hundred bales of silk in all have been procured and exported at Nagasaki, since the trade began last November. It is expected that the supply of this article will increase materially, the climate being suitable for the growth of the mulberry, and the habits of the people well adapted to the manipulation of silk.

Among the imports into Japan, produce from the Straits and China naturally forms a large proportion. This is for the most part composed of drugs and what is technically termed Chow-chow cargo—viz., spices and condiments of various sorts; also Sandal and Sapan wood. We have contributed damasks, cottons, muslins, velvets, woollens, &c; while American piece goods have found a ready market. As yet, however, our merchants are only feeling their way, and some time must elapse before it will be possible for us to predict with any certainty either the nature or extent of that trade which is capable of being created in this most interesting quarter of the globe. Meantime, a heavy responsibility will rest alike upon the merchants engaged in developing commerial relations in this country, and on our own official agents employed in supporting them and at the same time in protecting the Government to which they are accredited in due exercise of their treaty rights.

We are ignorant of the political considerations which induced the Japanese Government to relinquish that system of exclusiveness which had for many years distinguished it among the nations of the East. We do know, however, that this result was not arrived at without much angry discussion and violent opposition on the part of some of the most influential members of the aristocracy; and we can have little doubt that a strong feeling adverse to intercourse with foreigners or the establishment of commercial relations with them, exists throughout a large important class in Japan.

At present, this party is in the minority, but whether it will remain so or not, must depend upon the skill and tact with which our political relations are conducted, and upon the impression which the foreign mercantile community will create upon the people generally. Of a haughty and independent spirit, the Japanese are also suspicious and vindictive, and it is possible that, unacustomed to contact with Europeans, they may grow restive under the annoyances and evils which follow in the wake of civilization, and manifest a temper calculated to irritate the nation with which they have so recently entered into a friendly compact. It will be at this juncture that we shall be called upon to exercise that forbearance and moderation which it is ever becoming in the strong to display towards the weak

It would be well to remember that while we have achieved a great result in thus opening to the world this prosperous and happy community, we have also incurred serious obligations towards them, and are bound not to take advantage of their ignorance and inexperience in their dealings with western nations. We can only hope to commend our civilization to them by maintaining a high moral standard, both in our commercial and political intercourse. They are sufficiently enlightened to appreciate a policy influenced by higher considerations than those involved in the accumulation of wealth. Unless we follow such a policy, it is not too much to predict that we shall lose alike their confidence and respect, and involve ourselves in complications disastrous to our commerce, and discreditable to our national character. Of all the nations of the east, the Japanese are the most susceptible to civilizing influences, and I quote the words of an eminent Chinese and Japanese scholar in saying that, in one respect, they are far in advance of their ancient neighbours the Chinese, in that their attention is directed to obtain a knowledge of other nations. Their own efforts in this way will form their greatest security. Their soldiers once formed the bodyguard of the King of Siam, their Consuls once examined Spanish ships in Acapulco, their sailors once took a Dutch Governor out of his house in Formosa, and carried him prisoner to their rulers, their princes once sent an embassy to the Pope, their Emperor once defied the vengeance of Portugal, by executing her Ambassadors. The knowledge of these historical events remains among them. We may reasonably hope for a great preponderance of good results from an extension of an intercourse which has recommenced peacefully. Let us indulge in the expectation that the land of the rising sun may not only soon be fitted to take her place among nations, but also among Christian nations, with all the institutions, and liberty, and purity, of the best of these.

ERRATUM.

Vol. IV., page 442, line 10, *for* "procis," *read* "proboscis."

MONTHLY METEOROLOGICAL REGISTER, AT THE PROVINCIAL MAGNETICAL OBSERVATORY, TORONTO, CANADA WEST—SEPTEMBER, 1859.

Latitude—43 deg. 39.4 min. North. Longitude—5 h. 17 min. 33 sec. West. Elevation above Lake Ontario, 108 feet.

Days.	Barom. at temp. of 32°. 6 A.M.	2 P.M.	10 P.M.	MEAN.	Temp. of the Air. 6 A.M	2 P.M	10PM	ME'N	Excess of mean above Average	Tens. of Vapour. 6 A.M	2 P.M	10 P.M.	M'N	Humidity of Air. 6 A.M	2 P.M	10 P.M	M'N	Direction of Wind. 6 A.M.	2 P.M.	10 P.M.	Resultant Direction.	Velocity of Wind. 6 A.M	2 P.M	10PM	Result.	ME'N	Rain in Inches.	Snow in Inches.
1	29.549	29.385	29.390	29.4335	48.0	64.6	55.9	56.52	— 6.52	.287	.404	.288	.323	.86	.66	.64	.70	W N W	S S W	W N W	S 83 W	1.2	9.8	15.4	6.41	8.47	0.075	...
2	.478	.571	.604	.5550	48.7	61.3	52.7	54.83	— 7.90	.234	.208	.298	.256	.68	.37	.75	.61	W S W	W b N	Calm.	N 84 W	10.4	12.6	0.0	7.70	8.77	......	...
3	.481	.329	.474	.4308	56.3	64.6	54.5	58.45	— 3.98	.359	.428	.307	.370	.79	.71	.72	.75	S S E	S S W	N N W	S 44 W	9.5	10.6	8.8	3.75	6.52	0.395	...
4	.634	.731	—	—	46.9	61.7	—	—	—	.263	.265	—	—	.81	.48	—	—	N N W	W N W	NW b N	N 61 W	2.9	8.2	5.0	6.00	6.35	......	...
5	.865	.847	.932	.8895	48.3	58.4	47.2	51.07	—10.77	.275	.320	.258	.289	.82	.65	.79	.77	NW b W	S S W	NW b N	N 76 W	1.5	10.5	0.5	3.84	4.77	0.117	...
6	30.005	.996	30.001	30.0045	44.7	58.8	51.2	52.07	— 8.47	.234	.303	.244	.260	.79	.61	.65	.65	NW b N	S S W	N	N 67 W	4.8	9.8	3.5	2.01	4.79	......	...
7	30.008	.974	29.963	29.9815	47.6	60.6	48.7	53.43	— 7.72	.224	.335	.300	.286	.68	.63	.87	.70	N	S S W	S b W	S 77 W	1.2	7.8	0.2	1.82	3.6[illegible]	......	...
8	30.001	.973	.957	.9758	42.2	62.8	52.3	54.23	— 6.50	.211	.261	.325	.279	.78	.45	.82	.67	W b N	S b E	S S E	S 8 E	0.4	7.5	0.5	1.84	2.14	......	...
9	29.966	.905	.823	.8990	49.4	66.4	58.4	59.10	— 1.25	.202	.258	.389	.317	.82	.39	.80	.65	S E	E b N	E N E	E	4.4	6.0	1.6	3.44	3.81	0.665	...
10	.703	.607	.582	.6217	58.8	67.1	64.2	63.27	+ 3.22	.465	.593	.583	.551	.94	.89	.97	.94	N E	S S W	S W	S 26 W	0.5	4.2	4.4	4.39	4.80	0.100	...
11	.384	.249	—	—	62.8	73..	—	—	—	.542	.415	—	—	.95	.50	—	—	S W b S	W b N	W b N	S 87 W	9.0	23.0	15.0	12.40	13.34	0.038	...
12	.314	.065	.079	.1432	52.3	72.4	.4	63.02	+ 3.78	.319	.334	.396	.367	.81	.42	.70	.65	SW b W	W S W	SW b W	S 64 W	3.5	19.2	6.0	10.67	12.03	......	...
13	.169	.327	.354	.2838	52.7	52.3	46.5	50.52	— 8.33	.197	.243	.212	.211	.48	.61	.66	.57	W N W	N W	S W b S	N 67 W	25.0	21.5	9.6	16.76	18.00	Inap	...
14	.458	.669	.836	.6950	40.4	50.1	37.8	43.17	—15.17	.191	.109	.157	.130	.76	.29	.69	.50	W	NW b W	W N W	N 55 W	11.5	22.0	3.0	12.84	13.82	......	...
15	30.018	.988	.970	.9963	35.7	46.5	44.0	43.08	—14.83	.122	.068	.198	.138	.58	.20	.69	.50	N N E	E	E N E	N 74 E	6.5	6.6	4.2	5.24	5.65	......	...
16	29.842	.770	.653	.7477	45.8	53.4	53.4	51.12	— 6.40	.195	.259	.331	.268	.64	.62	.81	.70	N E b E	E N E	N E b E	N 63 E	8.5	13.0	3.4	8.30	8.46	......	...
17	.639	.591	.650	.6277	53.4	58.4	50.9	53.93	— 3.07	.365	.400	.345	.362	.89	.82	.92	.86	NE b N	E b S	S E b E	N 79 E	3.5	5.8	2.2	1.86	2.62	......	...
18	.666	.641	—	—	46.2	59.9	—	—	—	.242	.379	—	—	.78	.73	—	—	NE b N	E b S	E b N	N 86 E	2.8	8.6	3.[illegible]	2.88	3.15	......	...
19	.419	.351	.357	.3782	50.9	60.3	59.5	57.97	+ 1.85	.345	.423	.470	.422	.92	.81	.89	.87	E N E	E	N N W	N 14 E	3.2	2.5	0.[illegible]	3.80	5.02	0.110	...
20	.510	.608	.676	.6028	51.6	51.9	53.8	52.07	— 3.53	.303	.362	.284	.294	.79	.94	.68	.75	N b E	N E b N	N E b N	N 37 E	13.8	8.0	6.0	7.02	7.18	0.008	...
21	.633	.576	.511	.5740	48.7	53.4	54.8	51.90	— 3.22	.311	.359	.379	.352	.90	.87	.88	.90	NE b N	E N E	E N E	N 64 E	5.6	10.8	19.5	13.66	13.80	1.185	...
22	.509	.522	.612	.5563	55.2	61.0	53.8	56.82	+ 2.18	.407	.482	.381	.425	.94	.90	.92	.92	E N E	E b N	Calm.	N 78 E	12.6	8.5	0.0	3.61	3.69	0.250	...
23	.670	.657	.675	.6662	53.7	62.4	57.7	58.68	+ 4.47	.393	.444	.432	.424	.95	.79	.91	.86	Calm.	Calm.	Calm.	S 35 W	0.0	0.0	0.0	0.15	0.15	Inap	...
24	.644	.630	.664	.6442	57.0	66.2	58.8	60.70	+ 6.95	.436	.457	.431	.447	.94	.70	.86	.85	Calm.	S E b S	E N E	N 16 E	0.0	3.4	3.0	1.25	2.61	......	...
25	.655	.628	—	—	57.0	64.6	—	—	—	.407	.485	—	—	.87	.79	—	—	N b W	S S W	Calm.	S 43 W	4.5	1.0	0.0	0.40	0.65	......	...
26	.646	.593	.571	.5980	51.2	65.0	60.6	58.87	+ 6.13	.341	.473	.455	.428	.90	.76	.86	.86	S S W	S W b S	S S W	S 44 W	0.5	1.2	1.5	1.60	1.76	0.045	...
27	.506	.536	.619	.5573	60.2	65.3	60.2	61.67	+ 9.45	.465	.496	.490	.477	.89	.79	.96	.87	S b W	N W	N N W	N 21 W	0.5	6.5	9.2	5.30	7.62	0.007	...
28	.744	.818	.910	.8300	57.0	64.9	50.1	57.47	+ 5.63	.441	.424	.334	.393	.95	.69	.92	.83	N b W	W N W	S W	N 2 E	8.0	4.0	3.0	3.48	5.88	......	...
29	.934	.993	.926	.9582	50.9	54.8	49.1	51.23	— 0.08	.202	.270	.285	.290	.77	.63	.81	.77	E b N	S E b S	N E b E	N 85 E	5.8	6.0	2.0	4.08	4.25	......	...
30	.864	.749	.624	.7347	48.3	61.0	62.4	58.62	+ 7.80	.316	.389	.470	.413	.93	.69	.84	.83	E	E	S E	S 88 E	1.5	10.4	6.2	3.16	7.02	0.530	...
M	29.6761	29.6550	29.6717	29.6680	50.35	60.18	53.88	55.18	— 2.31	.308	.350	.348	.337	.82	.65	.81	.75	....	....	....	....	5.44	8.97	4.57	.....	6.36	3.525	...

REMARKS ON TORONTO METEOROLOGICAL REGISTER FOR SEPTEMBER.

Highest Barometer.......................... 30.049 at 8 a. m., on 15th } Monthly range=
Lowest Barometer .... 29.038 at 4 p. m. on 12th } 1.011 inches

Self-registing Thermom.
- Maximum Temperature .... 75°4 on p. m. of 11th } Monthly range=
- Minimum Temperature .... 35°7 on a. m. of 15th } 39°7
- Mean maximum Temperature .... 62°68 } Mean daily range=
- Mean minimum Temperature .... 49°32 } 13°36
- Greatest daily range .... 22°8 from a. m. to p. m. on 1st.
- Least daily range.................. 4°6 from a. m. to p. m. on 13th.

Warmest day......... 10th ... Mean temperature......... 63.27 } Difference = 20°19.
Coldest day........... 15th ... Mean temperature......... 43°08 }
Maximum { Solar.................................. 89°8 on p. m. of 11th } Monthly range=
Radiation. { Terrestrial......................... 23°1 on a. m. of 15th } 66°7.
Aurora observed on 8 nights, viz., on 1st, 2nd, 3rd, 4th, 5th, 14th, 27th, and 28th.
Possible to see Aurora on 17 nights; impossible on 13 nights.
Raining on 15 days,—depth 3.525 inches; duration of fall 36.4 hours.
Mean of cloudiness = 0.65.
Most cloudy hour observed, 4 p. m., mean = 0.72; least cloudy hour observed, 6 a. m., mean, = 0.61.

Sums of the components of the Atmospheric Current, expressed in miles.

North.	South.	East.	West.
1607.37	784.62	1305.27	2110.21.

Resultant direction N. 41° W.; Resultant Velocity 1.60 miles per hour.
Mean velocity.......................... 6.36 miles per hour.
Maximum velocity .... 31.0 miles, from 1 to 2 a. m. on the 14th.
Most windy day...................... 13th...Mean velocity 18.00 miles per hour.
Least windy day .... 23rd...Mean velocity 0.15 ditto.
Most windy hour......noon to 1 p. m............ Mean velocity 9.36 ditto. } Difference
Least windy hour ....9 to 10 p. m............ Mean velocity 4.15 ditto. } 5.21 miles.

1st. Double Rainbow at 5 p. m.
3rd. Great magnetic disturbance and brilliant auroral display from 7 p. m. to 3 a. m. of 4th.
6th. Hoar Frost at 5.30 a. m., (first of the season.)
10th. Fog 7 to 11 a. m. Thunderstorm from 11.30 p. m.
13th. Corona round the moon at midnight.
15th. Thin Ice at 6 a.m., (first of the season.) Solar Halo 8 to 9.30 a. m.
17th. Dense ground Fog from 7 p. m.
18th. Ground Fog and very heavy Dew at 6 a. m.
19th. Very heavy Dew 6 a. m. Slight Thunderstorm 8.30 to 10 p. m.
24th. Distant Thunder at 4 p. m.
28th. Ground Fog at 7 p. m.
30th. Ground Fog at 6 a. m.

Heavy dew recorded on 9 mornings during the month.
The Resultant Direction and Velocity of the Wind for the month of September, from 1848 to 1859 inclusive, were respectively N 59° W, and 0.99 miles.
The month of September, 1859, was comparatively cold, dry, and windy; the Mean Temperature was 2°.80 below the average of 20 years, being the coldest September save two (1840 and 1848) during that period. The depth of rain recorded was 0.574 inches on the surface less than the average of 19 years, and the mean velocity of the wind 0.95 miles per hour above the average of 12 years.

COMPARATIVE TABLE FOR SEPTEMBER.

YEAR.	Temperature.					Rain.		Snow.		Wind.		
	M'n.	Diff. from Aver.	Max ob'd.	Min. ob'd.	Range.	No. of days.	Inch's.	No. of days.	Inch's.	Resultant Direction.	Resultant V'y.	Mean Force or Velocity.
	°	°	°	°	°							
1840	54.0	—4.0	70.2	29.4	40.8	4	1.380	...	...	...	...	....
1841	61.3	+3.3	79.9	37.5	42.4	9	3.340	...	...	...	...	0.26 lbs.
1842	55.7	—2.3	83.5	28.3	55.2	12	6.160	...	...	...	...	0.45
1843	59.1	+1.1	87.8	33.1	54.7	10	9.760	...	...	...	...	0.57
1844	58.6	+0.6	81.5	29.6	51.9	4	*	...	...	...	...	0.26
1845	56.0	—2.0	78.8	35.3	43.5	16	6.245	...	...	...	...	0.34
1846	63.6	+5.6	84.0	39.0	45.0	11	4.595	...	...	...	...	0.33
1847	55.6	—2.4	74.8	38.1	36.7	15	6.665	...	...	...	...	0.33
1848	54.2	—3.8	80.9	29.5	51.4	11	3.115	...	...	N 71° W	2.38	5.81 mls.
1849	58.2	+0.2	80.6	33.5	47.1	9	1.480	...	...	N 75° W	0.69	4.23
1850	56.5	—1.5	76.0	31.7	44.3	11	1.735	...	...	S 65° W	1.02	4.78
1851	60.0	+2.0	86.3	33.4	52.9	9	2.665	...	...	N 14° E	1.03	5.45
1852	57.5	—0.5	81.8	36.1	45.7	10	3.630	...	...	N 77° W	0.53	4.60
1853	58.8	+0.8	85.4	36.1	49.3	12	5.140	...	...	N	1.06	4.33
1854	61.0	+3.0	93.1	36.3	56.8	14	5.375	...	...	N 22° W	1.33	4.04
1855	59.5	+1.5	81.7	36.1	45.6	12	5.585	...	...	N 20° E	1.29	7.61
1856	57.1	—0.9	77.3	37.4	39.9	13	4.105	...	...	S 70° W	1.98	6.53
1857	58.6	+0.6	81.4	34.1	47.3	11	2.640	...	...	N 68° W	1.61	5.55
1858	59.1	+1.1	80.1	36.8	43.3	8	0.735	...	...	S 74° W	1.53	5.69
1859	55 2	—2.8	73.8	35.7	38.1	15	3.525	...	...	N 41° W	1.60	6.36
M	57.98	...	80.94	34.35	46.59	10.8	4.099	...	...	....	...	5.41 Mls.

MONTHLY METEOROLOGICAL REGISTER, AT THE PROVINCIAL MAGNETICAL OBSERVATORY, TORONTO, CANADA WEST,—OCTOBER, 1859.

Latitude—43 deg. 39.4 min. North. Longitude—5 h. 17 m. 33 s. West. Elevation above Lake Ontario, 108 feet.

Day.	Barom. at temp. of 32°.				Temp. of the Air.				Excess of mean above Average	Tens. of Vapour.				Humidity of Air.				Direction of Wind.			Result't. Direction.	Velocity of Wind.					Rain in inches.	Snow in inches.
	6 A.M.	2 P.M.	10 P.M.	Mean.	6 A.M	2 P.M	10 PM	ME'N		6 A.M.	2 P.M.	10 P.M.	M'N	6 A.M.	2 P.M.	10 P.M.	M'N	6 A.M.	2 P.M.	10 P.M.		6 A.M.	2 P.M.	10 P.M.	Re-sult'.	ME'N		
1	29.685	29.663	29.641	29.6493	° 55.9	° 59.2	° 56.3	° 56.95	+ ° 6.53	.398	.395	404	.388	.89	.78	.89	.84	N W	S S W	S W	S 37° W	3.5	12.4	5.0	6.61	6.93	...	...
2	.482	.560	—	—	52.7	54.8	—	—	—	.299	.199	—	—	.75	.46	—	—	S W b S	W N W	W N W	N 78 W	12.0	31.0	3.5	10.57	10.97	inap.	...
3	.714	.542	.478	.5663	40.4	62.8	63.5	56.33	+ 6.80	.234	.413	.369	.336	.95	.72	.62	.73	W b S	S S W	S W	S 30 W	0.5	15.5	7.5	7.46	7.70	...	...
4	.526	.538	.562	.5463	57.9	68.0	55.5	60.40	+11.37	.377	.461	.404	.408	.78	.67	.92	.78	S W	S b W	S W	S 30 W	3.0	4.8	0.5	4.14	4.20	...	...
5	.516	.409	.657	.5373	51.6	68.4	44.0	53.70	+ 5.08	.356	.410	.263	.333	.93	.59	.91	.81	S W b S	W N W	N W b W	N 80 W	0.5	17.5	4.2	8.08	11.72	...	...
6	.678	.677	.722	.7020	36.8	51.9	43.3	44.35	— 3.87	.196	.268	.180	.217	.89	.69	.63	.74	W N W	W b N	W b N	N 78 W	3.2	22.0	5.8	8.06	8.44	inap.	...
7	.696	.602	.648	.6420	40.0	55.9	42.5	44.95	— 2.90	.197	.309	.218	.235	.79	.70	.80	.78	N W	N b W	N b E	N 2 E	2.0	7.2	1.0	4.82	5.99	0.115	...
8	.611	.664	.766	.6900	40.4	43.3	37.5	39.88	— 7.57	.208	.216	.144	.178	.83	.77	.64	.72	N E b N	N E	N	N 22 E	10.0	8.5	7.8	7.95	8.53	0.050	...
9	.870	.834	—	—	32.1	45.8	—	—	—	.111	.156	—	—	.61	.50	—	—	N	S b E	S b E	N 50 E	12.0	5.8	3.0	0.81	4.53	...	...
10	.824	.772	.772	.7897	32.1	52.7	44.3	44.07	— 2.60	.142	.238	.230	.208	.78	.59	.79	.71	W N W	S	S W	S 21 W	2.0	9.5	0.6	3.93	4.60	...	...
11	.808	.823	.940	.8678	40.7	55.9	44.7	47.50	+ 1.25	.223	.319	.179	.220	.87	.71	.60	.67	S W	W N W	N b W	N 34 W	3.2	4.2	5.2	3.58	4.56	...	...
12	.958	.844	.695	.8228	36.4	51.6	50.1	46.58	+ 0.62	.167	.230	.312	.251	.77	.60	.86	.77	N	E	E	N 72 E	6.0	5.2	2.0	2.19	2.69	...	...
13	.619	.463	.417	.4933	48.0	63.1	58.4	57.42	+11.85	.300	.380	.400	.367	.89	.65	.82	.78	E	S S W	S W	S 32 W	0.4	20.4	9.6	8.48	10.09	0.397	...
14	.425	.403	.591	.5053	51.9	59.2	43.3	50.73	+ 5.47	.362	.184	.216	.246	.94	.35	.77	.68	N b W	W b N	W	N 77 W	3.8	18.5	8.0	10.98	11.37	...	...
15	.682	.753	.892	.7922	37.5	45.4	33.5	38.92	— 5.93	.177	.188	.170	.178	.79	.62	.88	.76	W N W	N b W	Calm.	N 57 W	7.2	6.2	0.0	4.35	4.58	inap.	...
16	.962	.902	—	—	34.1	49.8	—	—	—	.170	.205	—	—	.87	.56	—	—	Calm.	E b S	E b S	S 71 E	0.0	10.5	4.0	5.15	5.65	inap.	...
17	.623	.472	—	—	50.9	52.3	—	—	—	.271	.352	—	—	.73	.89	—	—	S E b S	S S W	S W b S	S 40 W	3.5	9.8	2.3	6.43	7.31	0.318	...
18	.018	.446	.651	.4132	58.8	46.2	37.9	46.37	+ 2.83	.362	.160	.147	.198	.72	.50	.65	.59	W	W	W	N 84 W	29.0	27.0	10.2	20.49	20.73	0.010	...
19	.666	.560	.489	.5652	35.3	41.5	33.9	37.43	— 6.35	.138	.151	.180	.158	.67	.57	.92	.71	W N W	N W b N	N	N 36 W	4.6	5.8	3.8	6.56	7.43	0.040	inap.
20	.587	.638	.690	.6523	29.5	37.8	31.7	32.12	—11.45	.121	.106	.095	.105	.74	.47	.53	.59	N N W	N N W	N W b N	N 36 W	12.6	28.2	15.6	18.63	18.90	...	inap.
21	.720	.630	.600	.6477	26.3	39.1	29.5	31.82	—11.43	.123	.075	.136	.119	.86	.30	.83	.70	N W b N	N W	W b S	N 49 W	10.5	19.8	8.0	11.88	12.25	...	...
22	.514	.479	.563	.5255	20.5	37.1	33.5	33.75	— 9.22	.129	.192	.176	.163	.78	.86	.92	.83	W N W	Calm.	W N W	N 73 W	1.2	0.0	4.0	1.73	1.73	...	inap.
23	.695	.786	—	—	27.7	43.3	—	—	—	.113	.197	—	—	.74	.70	—	—	W N W	S S W	S W b W	S 55 W	1.5	6.5	5.0	4.22	4.73	...	...
24	.729	.650	.572	.6418	37.1	46.5	44.0	42.73	+ 0.23	.209	.220	.252	.223	.94	.69	.88	.81	S W b W	W b S	W S W	N 88 W	5.4	13.8	4.0	5.93	7.13	0.010	melt-
25	.509	.426	.547	.4948	38.2	41.5	32.4	37.18	— 5.10	.151	.118	.109	.131	.65	.44	.58	.59	N W b N	N N W	N	N 23 W	3.5	11.8	16.0	10.61	11.31	...	ing
26	.514	.365	.338	.3987	22.7	30.3	29.5	27.87	—14.12	.103	.103	.144	.111	.85	.61	.87	.72	N b E	E b N	N	N 8 E	2.0	3.8	5.5	3.23	4.11	...	as it
27	.356	.344	.386	.3703	22.3	38.2	33.2	32.37	— 9.42	.085	.117	.166	.128	.71	.50	.87	.69	N b W	N W	W b N	N 62 W	4.4	19.5	10.0	10.68	11.27	...	fell.
28	.404	.438	.560	.4828	31.7	44.5	36.4	37.52	— 3.97	.139	.118	.148	.139	.77	.37	.69	.63	W	W N W	N W b W	N 53 W	5.0	17.8	10.2	12.53	12.73	...	...
29	.652	.720	.836	.7458	33.9	40.6	35.3	36.52	— 4.75	.143	.137	.170	.146	.74	.54	.83	.68	N W b W	N W	N W	N 44 W	6.6	12.5	9.0	8.36	8.51	...	...
30	.883	.853	—	—	31.4	40.6	—	—	—	.135	.146	—	—	.76	.57	—	—	W N W	W b N	N W	N 58 W	3.0	10.0	1.5	4.40	4.52	...	...
31	.826	.800	.841	.8220	34.6	40.7	37.5	37.25	— 3.[illegible]0	.190	.136	.186	.169	.95	.53	.83	.77	N W	W N W	W	N 77 W	7.5	12.0	8.4	6.22	6.30	...	...
M	29.6095	29.5888	29.6342	29.6146	38.78	48.86	41.27	42.99	— 2.05	.209	.226	.216	.214	.82	.59	.78	.72	......	......	......	......	5.47	12.82	5.85	......	8.12	0.940	inap.

REMARKS ON TORONTO METEOROLOGICAL REGISTER FOR OCTOBER, 1859.

Highest Barometer	29.962 at 6 a. m. on 16th,	Monthly range=
Lowest Barometer	29.018 at 6 a. m. on 18th,	0.944 inches.
Self-registering Ther. — Maximum temperature	69°8 on p.m. of 4th	Monthly range=
Minimum temperature	22°3 on a.m. of 27th	47°5
Mean maximum temperature . .	50°38	Mean daily range = 13°33.
Mean minimum temperature . .	37°05	
Greatest daily range	26°0 from a. m. to p.m. on 3rd.	
Least daily range	4.7 from a. m. to p. m. on 25th.	
Warmest day . . 4th ... Mean Temperature . . .	60°40	Difference=32°53.
Coldest day. . . . 26th ... Mean Temperature . . .	27°87	
Maximum Radiation — Solar	81°8 on p. m. of 4th	Monthly range=
Terrestrial	12.0 on a. m. of 27th	69°8.

Aurora observed on 5 nights, viz.: 2nd, 3rd, 18th, 20th, and 21st; possible to see Aurora on 18 nights; impossible on 13 nights.
Snowing on 4 days; depth inappreciable: duration of fall 4.0 hours.
Raining on 11 days; depth, 0.940 inches; duration of fall, 25.8 hours.
Mean of cloudiness=0.64; most cloudy hour observed, 8 a. m., mean=0.77: least cloudy hour observed, midnight, mean=0.48.

Sums of the components of the Atmospheric Current, expressed in Miles.

North.	South.	East.	West.
2449.20	1072.30	349.17	3837.12

Resultant direction, N 68° W; Resultant Velocity, 5.04 miles per hour.
Mean velocity of the wind 8.12 miles per hour.
Maximum velocity . . . 35.2 miles per hour, from 11 a.m. to noon on 18th.
Most windy day . . 18th—Mean velocity, 20.73 miles per hour. } Difference
Least windy day . . 22nd—Mean velocity, 1.73 do } 19.00 miles.
Most windy hour, 2 to 3 p. m.—Mean velocity, 13.45 do } Difference
Least windy hour, 1 to 2 a.m.—Mean velocity, 5.08 do } 8.37 miles.

7th. Solar Halo during the forenoon.
11th. Lunar Halo from 10.30 p. m.
15th. Slight Rain and Hail at 4 p. m.
17th. Sheet Lightning in N. W. 7.50 to 8.30 p. m.
18th. Very Stormy day, and rapid descent of temperature from 6 a. m.
19th. First Snow of the season, from 10 p. m. Depth inappreciable.
20th. 22nd. and 24th. Slight particles of Snow, melting as it fell.

Great change of temperature, from 4 p. m. of 5th = 68°5 to a. m. of 6th = 36°5 Range in 14 hours = 32°0.
Fog on 5th, at 6 a. m., and 13th at 6 a. m. Heavy Dew on 2nd and 11th at 6 a. m. Hoar Frost recorded on 6 mornings. Thin Ice registered on 10 mornings.

The Resultant Direction and Velocity of the Wind for the month of October from 1848 to 1859 inclusive, were respectively N. 60° W., and 1.76 miles.

The mean Temperature of October, 1859, was 2°28 below the average of 20 years. The depth of Rain, 1.617 inches on the surface, also less than the mean of 20 years. The mean velocity of the Wind. 2.36 miles per hour greater than the average of 12 years, and the depth of Snow which averages about one inch, was recorded inappreciable. The month was therefore, comparatively cold, dry, and windy.

COMPARATIVE TABLE FOR OCTOBER.

YEAR.	TEMPERATURE.					RAIN.		SNOW.		WIND.		
	Mean.	Difference from Average.	Maximum observed.	Minimum observed.	Range.	No. of days.	Inches.	No. of days.	Inches.	Resultant Direction.	Resultant Velocity.	Mean Velocity
	°	°	°	°	°					°		
1840	44.4	— 0.9	68.5	23.9	44.6	13	1.860	3	...	...	...	...
1841	41.6	— 3.7	58.3	20.3	38.0	6	1.360	2	...	...	...	0.41 lbs
1842	45.1	— 0.2	68.5	30.0	38.5	8	5.175	0	...	...	...	0.35 "
1843	41.8	— 3.5	65.7	24.5	41.2	12	3.790	4	2.5	...	...	0.54 "
1844	43.3	— 2.0	69.6	17.8	51.8	7	imper	4	12.0	...	...	0.43 "
1845	46.4	+ 1.1	62.7	20.0	42.7	11	3.760	1	inap.	...	...	0.26 "
1846	44.6	— 0.7	69.7	20.7	49.0	14	4.180	2	inap.	...	...	0.45 "
1847	44.0	— 1.3	65.0	20.3	44.7	13	4.390	2	inap.	...	...	0.19 "
1848	46.3	+ 1.0	62.2	26.4	35.8	11	1.550	0	0.0	N 54 W	1.24	4.60ms.
1849	45.3	0.0	59.2	25.5	33.7	13	5.965	1	inap.	N 12 W	1.27	4.76 "
1850	45.4	+ 0.1	66.6	24.8	41.8	10	2.085	0	0.0	N 66 W	1.10	5.30 "
1851	47.4	+ 2.1	66.1	25.0	41.1	10	1.680	2	0.3	S 72 W	1.06	4.39 "
1852	48.0	+ 2.7	70.7	20.8	40.9	12	5.280	0	0.0	N 5 E	1.10	4.47 "
1853	44.4	— 0.9	64.7	25.5	39.2	10	0.875	2	inap.	S 88 W	1.74	4.77 "
1854	49.5	+ 4.2	74.2	29.8	44.4	15	1.495	3	inap.	N 45 W	1.52	4.57 "
1855	45.4	+ 0.1	64.3	28.0	36.3	14	2.485	5	0.8	N 82 W	4.91	9.88 "
1856	45.3	0.0	70.1	23.3	46.8	10	0.875	2	0.1	N 76 W	2.15	6.07 "
1857	45.4	+ 0.1	63.5	27.7	35.8	10	1.040	2	0.2	N 19 W	2.93	6.24 "
1858	48.8	+ 3.5	76.3	34.2	42.1	17	1.797	1	inap.	N 34 W	0.36	5.96 "
1859	43.0	— 2.3	68.4	22.3	46.1	11	0.940	4	inap.	N 68 W	5.04	8.12 "
Mean	45.27	...	66.71	24.09	41.72	11.3	2.557	2.0	0.94	...	...	5.76

MONTHLY METEOROLOGICAL REGISTER, AT THE PROVINCIAL MAGNETICAL OBSERVATORY, TORONTO, CANADA WEST,—NOVEMBER, 1850.

Latitude—43 deg. 39.5 min. North. Longitude—5 h. 17 min. 33 sec. West. Elevation above Lake Ontario, 108 feet.

Days.	Barom. at temp. of 32°.				Temp. of the Air.				Excess of mean above average.	Ten. of Vapour.				Humidity of Air.				Direction of Wind.			Result' Direction.	Velocity of Wind.					Rain in inches.	Snow in inches.
	6 A.M.	2 P.M.	10 P.M.	MEAN.	6 A.M.	2 P.M.	10 P.M.	ME'N		6 A.M.	2 P.M.	10 P.M.	M'N	6 A.M.	2 P.M.	10 P.M.	M'N	6 A.M.	2 P.M.	10 P.M.		6 A.M.	2 P.M.	10 P.M.	Result'.	ME'N		
1	29.813	29.690	29.704	29.7327	34.2°	40.7°	36.0°	37.27°	−3.20°	.177	.136	.180	.159	.89	.53	.85	.72	W b N	S W b S	W S W	N 65° W	1.8	12.5	9.0	6.72	7.21	...	inapp.
2	.730	.698	.908	.7882	31.0	43.3	30.3	35.03	−5.23	.155	.148	.150	.145	.89	.52	.89	.73	W	N W	W b N	N 71 W	3.2	21.5	1.8	8.68	8.95	...	...
3	30.069	30.084	.932	30.0257	27.7	41.5	41.8	37.00	−3.00	.127	.182	.190	.167	.84	.68	.72	.75	W b N	S b E	E	S 74 E	2.8	6.6	10.8	3.59	5.41	...	inapp.
4	29.751	29.626	.627	29.6713	41.1	58.4	53.4	51.15	+11.38	.199	.400	.239	.279	.77	.82	.58	.72	E b N	S W b S	S W	S 41 W	1.6	11.4	8.0	7.21	7.41	...	...
5	.611	.736	30.084	.8373	53.4	61.0	37.1	49.07	+9.58	.210	.189	.115	.170	.53	.35	.52	.49	S W	W b N	N W b W	N 65 W	10.6	20.0	10.5	10.37	11.98	...	...
6	30.208	30.221	—	—	30.3	37.8	—	—	—	.127	.113	—	—	.75	.50	—	—	N b E	E	E	N 74 E	3.9	7.5	11.0	7.82	8.73	...	...
7	30.048	29.940	29.901	.9630	38.6	45.4	40.4	41.05	+2.05	.180	.189	.200	.194	.80	.62	.80	.75	E N E	E b N	E b N	N 80 E	8.4	3.8	2.0	3.13	3.14	inap	...
8	29.836	.787	.711	.7008	36.8	51.6	45.4	44.90	+6.22	.203	.273	.253	.242	.93	.71	.83	.81	E b N	E b N	E b S	S 78 E	3.5	4.0	3.4	2.40	2.47	...	...
9	.662	.679	.635	.6587	45.4	49.0	42.6	45.90	+7.50	.234	.292	.234	.249	.77	.84	.85	.80	Calm.	N N W	N b W	N 1 W	0.5	6.0	10.4	6.98	7.97	0.360	...
10	.462	.261	.346	.3523	38.9	36.8	32.8	35.72	−2.37	.216	.191	.171	.191	.91	.87	.91	.91	N E	N b E	N N W	N 14 W	9.2	6.2	10.2	6.61	8.58	0.405	0.2
11	.653	.712	.657	.6810	29.2	29.9	33.5	30.80	−6.08	.132	.124	.156	.134	.81	.74	.81	.78	N W b N	N	E	......	3.0	2.2	20.0	—	—	...	0.2
12	.419	.212	.067	.2307	36.0	41.8	48.0	41.82	+4.32	.206	.241	.320	.250	.97	.90	.95	.93	E b N	E	S W b S	......	15.0	7.0	11.5	—	—	1.135	...
13	.138	.199	—	—	36.8	29.9	—	—	—	.203	.096	—	—	.93	.57	—	—	W S W	W b S	W b S	S 72 W	9.7	23.5	11.5	18.31	18.80	inap.	0.1
14	.475	.632	.762	.6415	29.2	33.5	28.8	29.83	−7.07	.116	.125	.144	.123	.72	.65	.89	.74	S W b W	W b S	Calm.	S 72 W	[illegible]	20.0	0.0	9.76	9.84	...	inapp.
15	.835	.913	.945	.9157	29.2	36.1	35.7	33.70	−2.80	.147	.153	.159	.154	.90	.73	.76	.80	N W b W	N W b W	S E	S 59 E	2.2	2.0	2.0	1.82	2.77	...	...
16	.894	.817	.738	.8162	36.4	44.7	[illegible]	41.73	+5.53	.183	.207	.209	.195	.85	.69	.71	.73	S S E	E b S	Calm.	S 43 E	5.0	3.8	0.0	1.69	1.82	...	...
17	.721	.706	.773	.7417	41.5	48.7	46.3	45.23	+9.43	.212	.239	.260	.238	.80	.69	.83	.78	S S E	S S W	S S W	S 20 W	0.4	10.2	1.2	4.11	4.15	...	...
18	.744	.676	.540	.6385	41.8	49.4	50.5	46.62	+11.13	.208	.281	.328	.269	.78	.79	.90	.83	S b E	E S E	N E b N	N 33 E	3.0	4.2	11.4	7.67	9.16	1.470	...
19	.225	.047	.366	.2235	47.6	42.5	32.8	39.82	+4.73	.315	.244	.134	.222	.95	.89	.72	.86	N b E	N b W	N W	N 29 W	18.0	15.6	27.2	17.38	18.79	0.435	inapp.
20	.712	.849	—	—	27.7	32.4	—	—	—	.139	.138	—	—	.92	.75	—	—	N W b N	N W	N E b N	N 10 W	11.4	11.6	4.6	7.52	9.15	...	...
21	.956	.756	.544	.7270	28.8	32.4	37.8	33.14	−1.25	.144	.169	.208	.173	.90	.91	.91	.90	E N E	E b N	E	E	11.2	22.2	21.4	15.60	17.28	0.570	...
22	.384	.478	.612	.4995	43.6	44.0	39.3	41.95	+7.87	.248	.202	.219	.220	.88	.70	.91	.83	S	W b S	W	S 80 W	5.0	22.0	12.6	12.85	13.43	0.038	...
23	.779	.837	30.034	.9025	36.4	39.3	30.3	34.73	+1.07	.183	.179	.135	.163	.85	.75	.79	.80	W	W b N	N N W	N 60 W	12.4	21.2	15.4	12.93	14.81	...	...
24	30.154	30.166	30.156	30.1557	27.4	30.3	24.1	27.37	−5.90	.131	.148	.100	.127	.88	.88	.77	.84	N b W	N b E	N E b N	N 26 E	4.8	9.0	4.5	4.09	6.59	...	...
25	29.965	29.534	29.030	29.4635	30.6	33.2	43.6	36.35	+3.38	.152	.166	.252	.196	.89	.87	.90	.89	E S E	E b S	S E b E	S 42 E	14.5	18.2	8.4	7.33	17.39	0.410	0.1
26	.186	.335	.484	.3605	41.8	42.2	37.5	40.12	+7.55	.166	.156	.203	.172	.61	.57	.90	.69	W b S	W S W	W	S 77 W	20.6	15.0	23.2	17.31	17.50	inap.	...
27	.579	.478	—	—	33.2	37.5	—	—	—	.151	.161	—	—	.80	.71	—	—	S W b W	S W	S	S 75 W	7.5	13.2	5.0	9.07	9.98	...	inapp.
28	.547	.534	.667	.5893	30.6	35.0	32.4	32.30	+0.42	.152	.142	.095	.131	.89	.70	.51	.72	W N W	W	W b N	N 86 W	11.5	22.0	11.5	12.09	12.32	...	...
29	.698	.570	.530	.5945	31.4	38.2	38.2	36.30	+4.80	.139	.168	.165	.161	.78	.73	.71	.74	W S W	S W	S W b W	S 45 W	3.4	11.6	6.8	8.15	8.37	...	...
30	.490	.536	.568	.5392	38.6	47.6	41.8	42.43	+11.35	.197	.234	.236	.218	.84	.71	.89	.80	W S W	S W b W	S W	S 54 W	9.8	8.8	1.0	6.16	6.30	0.370	...
M	29.6995	29.6527	29.6683	29.6746	36.43	42.17	38.63	38.90	+2.75	.183	.199	.194	.190	.83	.72	.80	.78	...	...	...	......	7.23	12.09	9.21	...	9.65	3.193	0.6

REMARKS ON TORONTO METEOROLOGICAL REGISTER FOR NOVEMBER, 1859.

Highest Barometer .... 30.252 at 10 a. m. on 6th } Monthly range=
Lowest Barometer .... 28.881 at 0.30 a. m. on 26th } 1.371 inches.

Self-registering Thermometer:
- Maximum temperature.............. 62°6 on p. m. of 5th } Monthly range =
- Minimum temperature.............. 21°8 on a. m. of 21st } 40°8.
- Mean maximum temperature...... 43°93 } Mean daily range = 11°10.
- Mean minimum temperature...... 32°77 }
- Greatest daily range .... 32°4 from p.m. of 5th to a.m. of 6th.
- Least daily range .... 2°4 from a.m. to p.m. of 10th.

Warmest day 4th; Mean temperature..................... 51°15 } Difference = 23°78.
Coldest day 24th; Mean temperature..................... 27.37 }

Maximum { Solar...................................... 69°8 on p.m. of 4th } Monthly range=
Radiation { Terrestrial.............................. 14.0 on a.m. of 26th } 55°8

Aurora observed on 2 nights, viz.: 5th and 13th; possible to see Aurora on 9 nights; impossible on 21 nights.

Snowing on 9 days; depth 0.6 inches; duration of fall 12.8 hours.
Raining on 12 days; depth 5.103 inches; duration of fall 94.1 hours.

Mean of cloudiness = 0.81; most cloudy hour observed 2 p.m., Mean = 0.80; Least cloudy hour observed 8 a.m., Mean = 0.78.

Sums of the components of the Atmospheric Current, expressed in Miles.

North.	South.	East.	West.
1732.22	1331.07	1402.78	3650.46

Resultant direction, N 81° W; Resultant velocity, 3.30 miles per hour.
Mean velocity 9.65 miles per hour; Maximum 31.2 miles, from 3 to 4 a.m. on the 25th.
Most windy day 13th: Mean velocity 18.80 miles per hour. } Difference 16.98 miles.
Least windy day 16th; Mean velocity 1.82 miles per hour. }
Most windy hour 2 to 3 p.m.; Mean velocity 12.86 miles per hour. } Difference
Least windy hour 5 to 6 a.m.; Mean velocity 7.60 do do } 5.26 miles.

Indian Summer, from 3rd to 9th inclusive (well marked).
Large Meteor on 5th at 7 h. 50 m., p.m., falling from 10° W. of zenith to within 15° of western horizon.
First measurable Snow of the season, a.m. of 11th.
Solar Halos on 16th during the forenoon, and on the 17th during the forenoon (imperfect).
Lunar Halos on 4th from 8 p.m., on 7th from 10 p.m., and 8th from 7.30 p.m.
Lunar Corona on 4th from 8.30 p.m.

The Barometer at 6 a.m. on 25th, corrected.......................... 29.965
at midnight do 28.903

Range in 18 hours 1.062

The resultant direction and velocity, and mean velocity of the wind on the 11th and 12th, are not complete, the Anemometer having been out of repair.

The resultant direction and velocity of the wind for the month of November from 1848 to 1859 inclusive, were respectively, N. 75° W., and 2.13 miles.

November, 1859, was comparatively *Dark, Mild, Wet* and *Windy*. The mean temperature having been 2°25. The rain 2.084 inches on the surface. The wind 2.45 miles per hour, and the clouded sky .08; each in excess of their respective averages.

COMPARATIVE TABLE FOR NOVEMBER, 1859.

YEAR.	TEMPERATURE.					RAIN.		SNOW.		WIND.		
	Mean	Difference from Average.	Maximum observed.	Minimum observed.	Range.	No. of d'ys	Inches.	No. of days	Inches.	Resultant. Direction.	Resultant. Velocity.	Mean Velocity
	°	°	°	°	°					°		
1840	35.9	— 0.7	54.4	20.5	33.9	5	1.220	8	...	...	...	...
1841	35.0	— 1.6	63.2	7.6	55.6	8	2.450	5	...	...	...	0.01lbs
1842	33.3	— 3.3	50.6	7.6	43.0	9	5.310	10	...	...	...	1.22 "
1843	33.5	— 3.1	51.2	14.4	36.8	10	4.705	7	1.2	...	...	0.50 "
1844	34.9	— 1.7	49.8	12.0	37.8	8	...	4	8.0	...	...	0.48 "
1845	36.8	+ 0.2	58.8	7.6	51.2	7	1.105	4	5.0	...	...	0.53 "
1846	41.3	+ 4.7	55.5	18.2	37.3	12	5.805	2	0.4	...	...	0.64 "
1847	38.6	+ 2.0	58.2	7.8	50.4	14	3.155	3	inap	...	...	0.36 "
1848	34.5	— 2.1	49.3	16.5	32.8	9	2.020	3	1.4	N 81 W	1.81	4.81ms.
1849	42.6	+ 6.0	56.7	28.4	28.3	10	2.815	2	1.0	N 39 W	1.55	4.78 "
1850	38.8	+ 2.2	62.3	18.1	44.2	7	2.955	1	inap.	N 42 W	1.43	5.27 "
1851	32.9	— 3.7	50.1	16.5	33.6	5	3.885	6	6.7	N 50 W	1.25	4.70 "
1852	36.0	— 0.6	50.4	18.7	31.7	7	1.775	3	2.0	N 59 W	1.53	6.50 "
1853	38.7	+ 2.1	54.1	14.4	39.7	15	2.425	6	2.7	N 9 W	0.55	5.52 "
1854	36.8	+ 0.2	54.0	15.1	39.8	13	1.115	4	1.3	W	3.44	7.54 "
1855	38.6	+ 2.0	54.1	18.7	35.4	8	4.590	6	3.0	N 66 W	3.18	10.81 "
1856	37.4	+ 0.8	56.4	22.8	33.6	10	1.375	9	9.5	S 85 W	2.95	8.75 "
1857	33.5	— 3.1	57.8	-2.3	60.1	14	3.235	9	6.9	S 61 W	5.45	9.25 "
1858	34.2	— 2.4	52.0	20.5	31.5	12	3.879	13	4.0	N 25 W	3.14	8.87 "
1859	38.9	+ 2.3	61.0	24.1	36.9	12	5.193	9	0.6	N 81 W	3.39	9.65 "
MEAN	36.65	...	55.04	15.36	39.68	9.2	3.109	5.7	3.16	...	...	7.20

MONTHLY METEOROLOGICAL REGISTER, ST. MARTIN, ISLE JESUS, CANADA EAST—AUGUST, 1859.

(NINE MILES WEST OF MONTREAL.)

BY CHARLES SMALLWOOD, M. D., LL.D.

Latitude—45 deg. 32 min. North. Longitude—73 deg. 36 min. West. Height above the Level of the Sea—118 feet.

Day.	Barom. corrected and reduced to 32°			Temp. of the Air.			Tension of Vapor.			Humidity of Air.			Direction of Wind.			Velocity in miles per hour.			Mean direction of Wind.	Rain in Inches.	Snow in Inches.	WEATHER, &c. A cloudy sky is represented by 10; A cloudless sky by 0.		
	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.				6 A.M.	2 P.M.	10 P.M.
1	29.710	29.780	29.784	66.1	72.3	69.0	.536	.631	.642	.84	.81	.92	S E	S E	S	0.05	4.81	1.30	...	Inap	...	Cu. Str. 8	Cu. Str. 10.	Str.2. Dst. Lg.
2	890	705	824	63.8	86.2	66.3	548	561	536	79	46	84	S S W	S S W	S S W	4.47	4.42	1.98	...	...	...	Clear.	Clear.	Clear.
3	827	779	752	68.8	90.6	75.1	550	616	690	82	43	83	S	S E b E	S E b E	0.11	0.05	0.01	...	...	...	Do.	Do.	Cu. Str. 10.
4	543	491	601	62.0	70.6	70.3	649	638	688	95	92	92	S E b S	W N W	S S W	0.26	5.13	1.11	...	4.223	...	Rain.	Cu, Str.8. Th.	Clear.
5	636	569	650	69.1	78.6	59.7	606	530	430	88	58	88	W S W	W S W	W S W	3.51	6.97	6.26	...	0.180	...	Light Cir. 2.	C. C. Str. 9.	Cu. Str. 8.
6	771	700	791	59.0	70.4	67.2	358	323	406	73	41	77	W N W	W S W	S W	8.82	9.80	7.35	...	...	...	Clear.	Cirr. 4.	Do. 9.
7	506	535	684	68.3	67.0	58.2	516	310	423	77	48	88	S W	W	W N W	14.42	12.12	12.56	...	0.070	...	Cu. Str. 8.	C. C. Str. 8.	Do. 6.
8	775	781	703	60.1	74.7	61.0	403	463	410	79	50	80	S W b W	S W b W	S	1.26	0.60	0.33	...	...	...	Clear.	Clear.	Clear.
9	990	946	30.011	63.2	84.6	66.8	616	590	620	88	51	82	S W b S	S W b S	S	0.15	1.08	0.01	...	...	...	Do.	Do.	Do.
10	900	887	29.892	62.0	90.5	72.3	523	671	631	94	48	81	S S E	S S W	S E	0.18	0.18	0.00	...	...	...	Do.	Do.	Do.
11	866	748	778	64.0	89.4	71.6	563	650	572	93	47	76	S E	S b E	S b E	0.22	0.07	1.72	...	...	...	Do.	Do.	Do.
12	723	814	871	70.0	81.4	70.4	665	664	695	92	62	95	S b E	S S W	S W	1.08	1.75	0.73	...	Inap	...	C. C. Str. 10.	Cu. Str. 10.	C Str. 10. thun
13	741	530	720	68.7	86.2	69.6	648	719	690	95	85	95	W S W	S S W	S W b W	0.36	1.01	3.80	...	0.186	...	Do. 10.	Do. 4.	Clear.
14	707	696	890	70.0	87.7	69.1	523	623	571	72	48	82	E b S	E S E	S E b E	0.20	1.91	0.21	...	...	...	Clear.	Clear.	Cirri 4.
15	917	896	903	63.0	85.1	69.0	510	570	599	88	47	85	N E b E	E b N	E	4.00	6.18	5.21	...	...	...	Do.	Do.	Clear.
16	910	977	920	63.2	82.9	65.9	510	721	509	89	53	81	N E b E	N E b E	N E b E	6.54	4.02	4.05	...	...	...	Do.	Do.	Do.
17	939	916	845	65.0	89.7	63.8	483	637	509	78	47	81	N E b E	S E b E	S E	0.20	1.65	0.06	...	...	...	Do.	Do.	Do.
18	864	633	623	60.1	87.6	67.0	450	661	529	88	52	82	S E b E	S S W	S W b W	0.00	0.65	0.80	...	...	...	Do.	Do.	Do.
19	632	645	703	56.2	72.0	60.5	420	462	333	94	60	65	N N E	N N E	N	0.53	6.30	4.02	...	0.590	...	Rain.	Cumulus 4.	Cl. Ft. Au. Bo.
20	815	851	877	62.0	70.4	60.3	376	405	433	69	47	85	W S W	W	S W	2.15	0.67	0.66	...	...	...	Clear.	Clear.	Clear.
21	832	840	910	64.4	85.0	68.0	461	691	542	77	77	87	W S W	W S W	W S W	1.07	5.33	3.01	...	...	...	Do.	Do.	Str. 2. Dst. Lg.
22	901	835	809	63.6	84.5	68.2	549	590	612	89	51	90	N E	N E b E	N E b E	2.00	1.50	3.36	...	...	...	C. C. Str. 8.	Cu. Str. 8.	Clear.
23	932	844	894	63.8	84.3	67.0	410	545	502	72	47	78	N E b E	S E b E	S E	4.97	5.50	2.41	...	...	...	Clear.	C. C. Str. 6.	Cl. Ft. Au. Bo.
24	806	731	706	60.0	65.5	63.1	606	549	543	88	80	94	S E b E	S E b E	S W b S	2.03	8.78	0.70	...	1.100	...	C. C. Str. 8.	Rain.	Cu. Str. 4.
25	643	604	690	64.7	77.9	68.4	568	671	577	92	71	85	S S W	S W	S S W	0.05	0.02	3.11	...	...	...	Cu. Str. 10.	Cu. Str. 6.	Do. 4.
26	716	650	688	64.2	78.1	66.1	471	588	570	81	62	89	S W	S W	W S W	1.32	5.70	2.33	...	...	...	Do. 10.	Cirri Str. 4.	Cu.St.4.Dt. lg.
27	614	600	739	63.0	71.1	57.0	485	429	329	86	55	72	W S W	W b N	W N W	0.00	0.20	12.80	...	...	...	Clear.	Cirr. Cum. 4.	Cu. Str. 6.
28	737	639	753	50.7	59.2	51.7	290	212	302	82	48	82	W N W	W N W	W N W	11.63	5.06	10.31	...	...	...	Cu. Str. 6.	Do. 4.	Cu.St.10.Sp.A.
29	700	714	701	50.6	66.4	50.1	301	431	255	71	66	71	W	W	W	25.11	6.30	20.26	...	...	...	Str. 2. Frost.	Clear.	Clear. Aur.Bo.
30	730	701	670	41.4	59.7	50.0	169	235	385	65	46	84	W S W	W S W	S b W	1.29	1.80	0.82	...	0.076	...	Clear.	C. Str. 6.	Rain.
31	540	517	590	57.0	59.9	54.0	400	354	355	84	68	89	S b W	N W	W b S	12.13	5.90	0.87	...	0.231	...	Cu. Str. 10.	Do. 4.	Cu. Str. 2.

MONTHLY METEOROLOGICAL REGISTER, ST. MARTIN, ISLE JESUS, CANADA EAST—SEPTEMBER, 1859.

(NINE MILES WEST OF MONTREAL.)

BY CHARLES SMALLWOOD, M. D., LL.D.

Latitude—45 deg. 32 min. North. Longitude—73 deg. 36 min. West. Height above the Level of the Sea—118 feet.

Day.	Barom. corrected and reduced to 32°			Temp. of the Air.			Tension of Vapor.			Humidity of Air.			Direction of Wind.			Velocity in miles per hour.			Rain in Inches.	Snow in Inches.	Weather, &c. A cloudy sky is represented by 10; A cloudless sky by 0.		
	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.			6 A.M.	2 P.M.	10 P.M.
1	29.660	29.698	29.403	40.8	65.9	55.1	.265	.319	.376	.75	.47	.87	W S W	W S W	S b E	5.83	4.46	2.30	...	...	Clear.	Cu. Str. 4.	Rain.
2	347	484	680	50.1	59.6	52.3	335	342	323	93	78	85	W S W	W N W	W S W	14.01	15.13	14.95	0.136	...	Rain.	Do. 6.	Clear. Aur.Bo.
3	738	667	623	50.0	57.0	52.9	309	330	361	85	75	93	S W	S b W	S E	5.41	1.96	3.64	0.301	...	C. Cum. 4.	Rain.	Rain.
4	658	713	876	50.4	60.9	51.2	309	325	296	85	61	79	W S W	W b S	W S W	8.01	12.21	10.05	0.800	...	Cu. Str. 8.	C. C. Str. 6.	Cu. Str. 3.
5	837	968	987	50.6	61.0	53.0	328	310	349	89	60	86	S W	W	W S W	3 63	2.08	4.17	Inap	...	C. C. Str. 4.	Cu. Str. 9.	Clear.
6	30.030	30.064	30.113	50.8	58.2	49.1	265	255	207	75	53	85	N W	N W	S W b S	0.61	6.26	4.53	...	...	Clear.	C. C. Str. 6.	Do.
7	034	000	077	45.7	65.0	54.6	211	296	335	72	44	80	S S W	W S W	S W b W	0.21	4.00	1.77	...	...	C. C. Str. 4.	Cu. Str. 4.	Cir. Cum. 4.
8	072	067	092	47.2	69.4	54.0	201	529	335	89	75	80	W S W	S S W	S S W	0.00	1.31	2.15	...	...	Cirr. 4.	Clear.	Clear.
9	124	006	001	58.9	76.4	68.2	275	498	571	56	55	85	S W	S W	S	5.07	2.90	1.51	...	...	C. C. Str. 4.	Do.	Do.
10	29.922	29.821	29.754	52.9	61.5	61.2	354	498	590	90	91	97	S E	S S E	S	0.27	0.51	2.85	0.330	...	C. Str. 8.	Rain.	Rain.
11	546	243	339	64.8	64.6	61.3	590	529	478	97	89	88	N	N E	S W	1.27	8.57	3.98	3.890	...	Rain and th.	Do.	Clear.
12	314	138	167	60.3	74.1	63.3	489	568	453	90	67	80	S W	S W	S W	3.30	2.80	7.55	...	...	Cu. Str. 9.	C. C. Str. 6.	Cu. Str. 9.
13	214	262	319	60.8	59.0	46.1	396	289	262	76	57	84	W	W	W	10.27	20.16	19.26	...	...	Do. 10.	Cu. Str. 10.	Do. 4.
14	267	504	850	39.5	47.8	38.1	180	150	186	77	45	81	W	W N W	W	11.98	19.13	17.01	0.773	...	Sw. with hail.	Do. 4.	Clear. Aur.Bo.
15	30.083	30.107	30.154	37.2	50.0	38.4	178	139	165	81	39	72	W N W	W b N	S W	24.86	14.15	3.70	...	...	Clear Frost.	Clear.	Cirri 4.
16	120	044	29.998	34.2	61.3	44 6	144	249	241	75	47	81	S E	E S E	E S E	0.01	0.78	0.66	...	...	C. C. Str. 8.	Do.	Clear.
17	29.856	29.789	834	42.0	58.2	52.2	228	387	361	87	80	93	E	E b N	N E b E	0.40	1.30	4.38	...	...	Cu. Str. 10.	Cu. Str. 10.	Cu. Str. 10.
18	840	862	848	48.0	75.7	50.4	303	574	290	89	70	82	W	S	S b W	1.92	0.07	0.01	...	...	Do. 10.	Clear.	Cl. Ft. Au. Bo.
19	640	629	610	45.2	77.0	61.7	211	534	442	72	50	83	E	S b E	S E b E	0.00	0.17	0.15	...	...	Clear.	Do.	Cu. Str. 9.
20	632	814	973	55.5	62.4	46.3	405	420	238	94	77	77	N	N E	E N E	3.92	7.61	11.66	0.930	...	Rain.	Cu. Str. 10.	Clear. Aur.Bo.
21	30.008	913	986	43.0	47.0	48.0	215	201	316	79	89	96	E N E	N E b E	N E b E	17.87	2.26	17.18	0.771	...	Do.	Rain.	Slight rain.
22	29.940	880	837	45.2	54.3	53.6	294	306	307	99	96	95	N E b E	N E b E	N E b E	15.76	7.65	9.18	1.409	...	C. Str. 8.	Do.	C. Str. 10.
23	840	844	837	50.0	55.2	52.6	341	383	361	96	90	93	N E b E	N E b E	N E b E	15.17	11.13	4.92	1.970	...	Rain.	Do.	Do. 10.
24	834	800	791	50.9	63.2	55.2	348	429	383	92	77	90	N	N E b E	N E b E	0.25	0.43	1.26	Inap	...	Cu. Str. 9.	Cu. Str. 6.	Cu. Str. 10.
25	870	864	869	53.0	62.3	59.6	354	436	462	90	80	90	E S E	E S E	S S W	0.36	3.16	0.01	...	...	Do. 10.	Do. 9.	Do. 10.
26	739	810	792	56.0	71.1	61.5	413	544	498	90	73	91	S S W	S W	S W	0.70	0.50	0.09	...	...	Do. 4.	Do. 4.	Do. 8.
27	761	749	765	57.8	68.2	62.3	436	543	534	90	79	92	S S W	S W	S W	0.35	2.43	1.83	Inap	...	C. C. Str. 6.	Do. 8.	Do. 10.
28	874	972	30.021	56.7	56.2	50.8	336	357	283	75	78	78	N E b E	N N E	N b W	8.80	6.12	4.04	Inap	...	Cu. Str. 8.	Do. 9.	Do. 10.
29	30.179	30.169	201	42.7	62.0	43.2	239	311	248	80	56	88	N E b E	E	E S E	1.95	4.67	0.09	...	...	Clear.	Cirr. 2.	Cl. Ft. Au. Bo.
30	179	003	29.961	40.3	70.6	53.2	225	423	348	91	59	86	E b N	S E	S S E	0.57	1.67	2.60	...	...	Cu. Str. 4.	Clear.	Clear.

REMARKS ON THE ST. MARTIN, ISLE JESUS, METEOROLOGICAL REGISTER FOR AUGUST, 1859.

Barometer	Highest, the 9th day	30.011
	Lowest, the 4th day	29.481
	Monthly Mean	29.760
	Monthly Range	0.530
Thermometer	Highest, the 3rd day	90°9
	Lowest, the 30th day	36°2
	Monthly Mean	68°72
	Monthly Range	54°7

Greatest intensity of the Sun's Rays .... 110°8
Lowest point of Terrestrial Radiation .... 25°2
Amount of evaporation .... 3.17 inches.
Mean of Humidity .... .742
Rain fell on 10 days amounting to 6.666 inches; it was raining 42 hours 55 minutes, and was accompanied by thunder and lightning on 2 days.
Most prevalent wind, S. W.
Least prevalent wind, N.
Most windy day the 29th day; mean miles per hour 17.22.
Least windy day the 10th day; mean miles per hour 0.12.
Frost occurred on the 30th day.
Aurora Borealis visible on 4 nights.
The electrical state of the atmosphere has indicated high intensity.
Ozone was present in rather large quantity.

REMARKS ON THE ST. MARTIN, ISLE JESUS, METEOROLOGICAL REGISTER FOR SEPTEMBER, 1859.

Barometer	Highest, the 29th day	30.201
	Lowest, the 12th day	29.138
	Monthly Mean	29.771
	Monthly Range	1.063
Thermometer	Highest, the 9th day	78°4
	Lowest, the 16th day	29°2
	Monthly Mean	54°31
	Monthly Range	49°2

Greatest intensity of the Sun's Rays .... 101°6
Lowest point of Terrestrial Radiation .... 18°2
Mean of Humidity .... .799
Amount of evaporation .... 1.42 inches
Rain fell on 14 days, amounting to 11.310 inches; it was raining 112 hours 17 minutes, and was accompanied by thunder on 1 day.
Most prevalent wind, N. E. b E.
Least prevalent wind, N.
Most windy day, the 14th day; mean miles per hour, 16.04.
Least windy day, the 19th day; mean miles per hour, 0.10.
Aurora Borealis visible on 5 nights.
The electrical state of the atmosphere has indicated rather feeble intensity.
Ozone was present in rather large quantity.

MONTHLY METEOROLOGICAL REGISTER, ST. MARTIN, ISLE JESUS, CANADA EAST—OCTOBER, 1859.

(NINE MILES WEST OF MONTREAL.)

BY CHARLES SMALLWOOD, M. D., LL.D.

Latitude—45 deg. 32 min. North. Longitude—73 deg. 36 min. West. Height above the Level of the Sea—118 feet.

Day.	Barom. corrected and reduced to 32°			Temp. of the Air.			Tension of Vapour.			Humidity of Air.			Direction of Wind.			Velocity in miles per hour.			Rain in Inches.	Snow in Inches.	WEATHER, &c. A cloudy sky is represented by 10; A cloudless sky by 0.		
	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A. M.	2 P. M.	10 P. M.	6 A.M.	2 P.M.	10 P.M.			6 A. M.	2 P. M.	10 P. M.
1	29.894	29.758	29.786	50.6	60.4	55.7	.328	.487	.405	.89	.94	.94	S	S b W	S W	0.46	0.76	2.16	0.187	...	Rain.	Rain.	Cu. Str. 8.
2	642	525	616	51.1	52.3	47.2	348	375	298	93	93	92	S S W	S b W	S b W	2.35	10.22	8.11	0.556	...	Clear.	Cu. Str. 8.	Str. 4. Aur. B.
3	800	701	620	40.3	52.9	51.6	208	354	321	82	90	86	W S W	S W	S W	15.81	12.27	6.30	...	...	Do.	Do. 10.	Cu. Str. 2.
4	581	686	807	54.8	71.1	55.8	362	544	335	87	73	80	S W	W	E	1.53	7.61	1.48	...	...	Do.	Clear.	Clear.
5	748	613	520	45.1	79.2	67.2	275	574	302	92	58	89	N E	S W b W	W S W	4.51	1.50	7.53	...	...	Do.	Do.	C. Str. D. Ltg
6	722	633	764	41.9	48.6	40.0	197	165	188	78	49	77	W b S	W b N	W	10.48	3.45	15.02	Inap.	...	Rain.	C. C. Str. 6.	Clear.
7	776	758	846	34.1	50.2	42.0	175	309	184	89	85	70	S W	W b S	W	7.51	7.12	0.11	...	...	Clear.	Cu. Str. 4.	Cu. Str. 4.
8	900	851	916	30.6	48.7	36.2	130	165	170	78	49	80	N b W	E S E	N E b E	0.06	1.43	0.51	...	...	Cu. Str. 6.	Clear.	Clear. L. Halo.
9	30.005	30.006	30.129	34.0	51.0	36.3	126	123	170	65	30	80	N E	N N W	S S E	7.43	13.70	1.52	...	...	Clear.	Do.	Clear.
10	060	29.942	29.963	28.9	55.1	40.9	111	168	197	71	39	78	N N E	W b S	S b W	0.06	1.00	1.73	...	...	Do.	Do.	Do.
11	29.920	997	30.085	39.4	60.1	40.3	216	338	182	91	65	73	S W b W	W S W	W N W	16.01	0.62	0.63	...	...	Do.	Cu. Str. 3.	Do.
12	30.160	30.082	29.984	31.1	56.1	41.9	185	211	206	89	48	78	N N W	S W	S b E	0.83	1.17	1.48	...	...	Do.	Cirri 2.	Clear. L. Halo.
13	29.789	29.668	622	42.7	68.8	62.9	237	443	392	87	68	69	S S E	S W	S W	3.03	5.73	4.33	...	...	C. C. Str. 8.	C. C. Str. 8.	Rain.
14	514	466	562	51.5	59.7	49.8	341	323	290	59	68	82	S W	W S W	W S W	14.00	22.60	2.11	0.406	...	Ni. 10.	Cu. Str. 4.	Cu. Str. 10.
15	694	799	940	34.2	54.2	32.1	169	256	143	84	61	79	N N E	N W	N W	0.93	5.57	17.21	...	...	Sleet.	Do. 4.	Clear.
16	30.134	30.148	977	25.7	43.0	37.8	111	137	151	81	48	67	W b N	S W b W	S S W	3.35	12.86	0.71	...	...	Clear.	Do. 8.	Cu. Str. 2.
17	29.901	29.806	708	36.2	59.4	52.1	184	296	282	87	59	73	S E b E	S S W	S S W	0.10	0.57	0.01	...	...	Str. 2.	Do. 10.	C. Str. 10.
18	405	241	419	50.2	57.0	38.0	335	413	201	93	77	86	S	W S W	N W	0.21	1.10	11.45	0.580	...	Cu. Str. 10.	Do. 10.	Clear. Au. Bo.
19	654	669	700	31.0	44.6	32.2	130	189	107	74	64	56	W N W	W N W	N W	11.61	21.23	32.61	...	...	Clear.	Do. 4.	Str. 4. Aur. Bo.
20	510	500	601	29.8	35.0	29.0	136	162	123	83	80	77	W N W	W b N	W N W	19.00	26.81	14.81	...	0.50	Cu. Str. 10.	Do. 10.	Snhw.
21	487	484	520	24.2	30.5	28.2	111	142	135	87	84	86	W N W	W b N	W b N	27.00	17.17	8.00	...	2.30	Snow.	Snow.	Snow.
22	564	571	701	30.0	42.9	34.1	136	209	175	83	78	89	W b N	W b N	W S W	5.68	15.26	3.41	...	...	Cu. Str. 10.	Str. 4.	Str. 2. Ft. A.B.
23	781	799	870	30.0	45.0	38.2	142	101	186	84	34	81	W S W	W S W	W b S	1.35	6.80	9.52	...	...	C. C. Str. 6.	Clear.	C. Str. 10.
24	774	710	760	30.2	40.2	29.3	102	160	128	82	64	77	S S W	W N W	N E b E	0.00	11.02	8.61	Inap.	...	Do. 10.	Cu. Str. 8.	Do. 4.
25	764	650	647	24.1	31.8	25.0	094	130	094	73	74	68	S E	W	W N W	3.35	0.70	16.21	...	Inap.	Cirri Str. 4.	Do. 10.	Snow.
26	674	450	480	21.0	32.0	27.2	069	110	111	63	64	78	W N W	W N W	W	6.90	12.30	8.60	...	...	Clear.	Do. 2.	Cu. Str. 4.
27	254	251	320	23.9	33.2	32.2	089	131	143	72	70	79	W b N	W N W	W	10.16	4.60	14.36	...	...	C. C. Str. 4.	Dc. 10.	Do. 10.
28	351	397	554	34.1	39.1	31.2	158	178	149	79	73	84	W	W	W b N	19.23	13.50	32.30	...	...	Cu. Str. 6.	Do. 10.	Clear.
29	660	710	860	31.5	41.0	36.1	136	147	177	78	57	85	W N W	W N W	N W	7.96	14.41	10.82	...	...	Do. 8.	Do. 6.	C. Str. 9.
30	900	807	926	32.6	41.9	36.2	156	190	170	85	74	80	W b N	W b N	W S W	8.02	2.32	6.20	...	...	Do. 8.	Do. 4.	Do. 10.
31	900	874	960	31.6	38.9	34.1	149	180	158	84	77	79	W N W	W N W	W	0.56	14.40	2.47	...	...	Do. 10.	Do. 6.	Do. 10.

MONTHLY METEOROLOGICAL REGISTER, ST. MARTIN, ISLE JESUS, CANADA EAST—NOVEMBER, 1859.

(NINE MILES WEST OF MONTREAL,)

BY CHARLES SMALLWOOD, M.D., LL.D.

Latitude—45 deg. 32 min. North. Longitude—73 deg. 36 min. West. Height above the Level of the Sea—118 feet.

Day.	Barom. corrected and reduced to 32°			Temp. of the Air.			Tension of Vapour.			Humidity of Air.			Direction of Wind.			Velocity in miles per hour.			Rain in inches.	Snow in inches.	WEATHER, &c. A Cloudy sky is represented by 10; A cloudless sky by 0.		
	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.	6 A.M.	2 P.M.	10 P.M.			6 A.M.	2 P.M.	10 P.M.
1	30.004	29.901	29.924	32.0	41.0	38.1	.142	.190	.186	.84	.74	81	S W	S S W	S W	0.36	1.03	4.05	...	...	Cu. Str. 9.	Cu. Str. 10.	Cu. Str. 10.
2	29.870	864	860	37.0	46.2	33.3	199	238	168	90	77	89	W S W	S W	E b S	5.95	3.12	0.90	Inap.	...	Do. 10.	Do. 2.	Ni. 10.
3	30.124	30.249	30.304	28.1	33.8	24.2	117	126	094	76	75	73	N W	N W	N E b E	4.80	37.96	26.42	...	0.53	Do. 10.	Do. 4.	Cirri 4.
4	312	29.925	29.930	30.5	32.1	31.6	142	162	168	84	89	94	S S E	E N E	E N E	1.54	6.36	3.11	0.297	1.80	Snow.	Rain.	Verglose.
5	29.820	768	951	31.0	34.3	42.0	155	190	177	89	97	66	E S E	S E	W N W	11.05	0.00	5.40	Inap.	...	Cu. Str. 10.	Cu. Str. 10.	Clr. Dst. th. n.
6	30.374	30.382	30.434	26.1	37.0	26.2	099	157	094	69	70	69	W N W	W N W	W	17.93	3.42	1.05	...	...	Clear.	Clear.	Clear.
7	439	324	270	22.0	34.2	28.1	084	125	135	71	69	88	E	N E b E	N E b E	2.31	4.27	9.46	...	...	Cu. Str. 10.	C. C. St. 10.	Cu. Str. 10.
8	183	009	042	30.0	52.5	36.0	148	257	191	88	66	89	E	S	S	6.43	0.20	0.32	...	...	Do. 8.	Hazy.	Hy. L.H. 8p.m
9	29.901	29.804	29.824	33.0	53.2	47.5	144	304	290	70	76	82	S E b E	W	S S W	0.21	0.57	3.80	0.100	...	Hrzy.	Cu. Str. 10.	Rain.
10	800	521	499	33.4	33.7	30.2	182	182	154	95	94	94	N E b E	N E b E	N E b E	15.90	8.40	20.91	0.630	...	Rain.	Verglose.	C. Str. 10.
11	634	984	30.100	24.0	31.9	19.2	100	144	087	79	80	85	N W	N W b W	N E b E	14.15	8.02	0.00	...	0.70	Cu. Str. 10.	Cu. Str. 4.	C[illegible]r.
12	30.114	701	29.600	20.0	32.1	33.4	091	143	184	85	79	96	N E b E	N E b E	N E b E	0.00	7.06	5.51	...	3.70	Clear.	Snow.	Rain.
13	29.230	180	220	33.0	34.9	31.2	174	190	142	94	95	84	N E b E	S W	W S W	4.75	2.77	18.37	2.157	...	Rain.	Cu. Str. 9.	C. Str. 2.
14	559	520	827	24.0	30.1	22.1	111	130	064	87	78	86	S S W	W S W	W S W	24.70	1.52	23.88	...	...	C. Str. 2.	Do. 2.	Clear.
15	30.132	30.229	30.317	17.0	23.0	21.0	068	089	085	75	72	78	N E b E	E N E	S E	0.82	1.28	0.00	...	...	Do. 10.	Do. 10.	C. C. 2.
16	341	260	239	16.0	28.2	22.3	065	129	195	74	32	79	N E b E	N E b E	N E b E	6.41	4.92	4.72	...	...	C. C. 9.	Clear.	Clear.
17	081	048	090	30.1	49.1	12.2	136	278	206	84	81	78	S E	S E	E S E	0.81	2.90	8.23	...	...	Cu. Str. 9.	Cu. Str. 9.	Cu. Str. 10.
18	092	29.952	29.989	40.0	54.5	42.5	210	328	244	86	77	91	E S E	S E b E	N E b E	2.87	0.08	0.89	0.262	...	C. C. Str. 9.	Do. 10.	Do. 10.
19	29.611	406	219	41.4	42.3	40.6	251	261	241	96	98	96	N E b E	N E b E	N E b E	4.72	15.60	9.81	3.746	...	Rain.	Rain.	Do. 10.
20	700	901	30.232	28.2	27.1	20.1	241	093	075	98	68	72	W	N W b N	N	26.56	11.63	14.91	0.630	Inap.	Cu. Str. 10.	Cu. Str. 9.	Do. 10.
21	30.435	30.301	224	16.3	25.0	23.2	074	100	186	85	74	86	N E b E	N E b E	N E b E	7.22	6.35	6.21	...	...	Do. 9.	Do. 4.	Do. 8.
22	29.904	29.840	29.750	33.1	32.9	31.4	107	168	168	87	89	96	N E b E	N E b E	N E b E	21.66	7.20	6.90	...	4.10	Snow.	Snow.	Do. 10.
23	842	909	30.054	25.2	31.0	25.2	113	161	129	84	85	98	W	S W	W S W	7.80	2.01	8.93	...	2.70	Do.	Do.	Snow.
24	30.254	30.270	378	22.2	26.9	17.3	102	117	063	98	82	67	S W	W S W	W S W	9.86	6.66	6.00	...	0.50	Do.	Cu. Str. 10.	Do.
25	345	224	29.910	7.1	22.4	21.5	042	079	196	66	68	88	W S W	E b N	N E b E	4.03	0.36	6.63	...	1.40	Clear.	Do. 10.	Clear.
26	29.214	29.462	464	34.2	42.0	31.8	190	199	162	95	74	89	N E b E	S b W	S W	15.44	10.31	13.00	0.114	2.10	Snow.	Do. 8.	Snow.
27	661	679	600	30.6	35.6	30.0	148	162	154	88	84	89	S W	S W	S S E	2.80	0.00	2.23	...	...	Cu. Str. 4.	Do. 10.	Cu. Str. 6.
28	678	720	657	21.1	27.4	27.1	080	105	126	74	70	88	S	S W	S S W	11.17	2.28	3.92	...	Inap.	Do. 10.	Snow.	Clear.
29	30.104	30.019	30.047	8.0	22.0	11.0	018	084	060	77	71	80	N E b E	N E b E	N E b E	8.36	1.90	2.03	...	0.50	C. Str. 8.	Su. Str. 6.	Cu. Str. 8.
30	29.814	29.800	29.804	12.1	31.1	21.0	061	118	075	81	68	73	N N W	E	S S E	10.61	0.57	0.00	...	...	Do. 10.	Cirri 2.	Snow.
																							Clear.

REMARKS ON THE ST. MARTIN, ISLE JESUS, METEOROLOGICAL REGISTER FOR OCTOBER, 1859.

Barometer	Highest, the 12th day	30.160
	Lowest, the 27th day	29.251
	Monthly Mean	29.779
	Monthly Range	0.909
Thermometer	Highest, the 5th day	83°1
	Lowest, the 25th day	19°4
	Monthly Mean	42°42
	Monthly Range	63°7

Greatest Intensity of the Sun's Rays .... 105°8
Lowest point of Terrestrial Radiation .... 14°2
Mean of Humidity .... .754
Amount of evaporation 1.27
Rain fell on 6 days, amounting to 1.629 inches; it was raining 20 hours and 15 minutes, and was accompanied by thunder on 1 day.
Snow fell on 3 days, amounting to 2.30 inches; it was snowing 24 hours.
First snow of the season fell on the 20th day.
Most prevalent wind, the W. N. W.
Least prevalent wind, E.
Most windy day, the 19th day; mean miles per hour, 21.81.
Least windy day, the 17th day; mean miles per hour, 0.29.
Aurora Borealis visible on 4 nights.
Lunar Haloes visible on 2 nights.
The electrical state of the atmosphere has indicated high and constant tension.
Ozone was present in moderate quantity.

REMARKS ON THE ST. MARTIN, ISLE JESUS, METEOROLOGICAL REGISTER FOR NOVEMBER, 1859.

Barometer	Highest, the 7th day	30.439
	Lowest, the 13th day	29.180
	Monthly Mean	29.940
	Monthly Range	1.259
Thermometer	Highest, the 18th day	57°6
	Lowest, the 25th day	4°6
	Monthly Mean	29°38
	Monthly Range	43°0

Greatest intensity of the Sun's rays .... 98°7
Lowest point of terrestrial radiation .... 5°1
Mean of Humidity .... .819
Rain fell on 10 days, amounting to 7.936 inches; it was raining 76 hours 55 minutes.
Snow fell on 12 days, amounting to 17.83 inches; it was snowing 76 hours 20 minutes.
Most prevalent wind, N. E. by E.
Least prevalent wind, E.
Most windy day, the 3rd day; mean miles per hour, 23.06.
Least windy day, the 27th day; mean miles per hour, 1.72.
Aurora Borealis visible on — nights.
Snow Birds ("Phlectorphanes nivalis,") first seen on 3rd day.
Lunar Halo visible on 1 night.
The Electrical state of the atmosphere has indicated moderate intensity.
Ozone was present in large quantities.