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# INQUIRY INTO THE PHYSICAL CHARACTERISTICS OF THE ANCIENT AND MODERN CELT OF GAUL AND BRITAIN.

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Among the terms of a distinctive ethnical significance, derived from classical authorities, and applicable to living races, few have been employed more loosely and indefinitely than that of *Celt*. The causes of this arise, in part, from the great antiquity of what appears on many accounts to have a just claim to be ranked as the oldest member of the Aryan family of European nations. The peculiar relations traceable between the various Celtic dialects and any assumed common mother tongue of all the Indo-European languages, appear to indicate that the former separated at an earlier stage than the classical languages. I have assigned reasons in a former paper* for believing that the historic advent of the Gauls, on their invasion of Rome and Central Italy in the fourth century, B. C., so far from indicating their first appearance in Europe, in reality marks the commencement of their decline and decay. They were then beginning,

* *On the Intrusion of the Germanic Races into Europe.* Edin. Philosoph. Jour. N. S. January, 1855.

as I conceive, to be displaced in central Europe, by the movements of the Germanic nations from beyond the Baltic into their later home in the Rhine valley.

In the time of Herodotus, the Greeks knew vaguely of a people called Κέλται, occupying the remotest regions of Europe, bordering on the Atlantic. At later dates allusions are made to them by Xenophon and Aristotle; and the latter indicates an increasing knowledge of them in his day, by the references to their customs and most characteristic traits which occur in his philosophical works. But the very imperfect knowledge of this ancient people manifested by the most observant Greek writers, suffices to illustrate the extreme isolation of the nations within the period of authentic history. Transalpine Europe was still a *terra incognita*; and the Κέλται, whose language is the key to much of the earliest topographical nomenclature of Central Europe, from the Atlantic to the head of the Adriatic Gulf; and who must have been a numerous and powerful people long before they made their hostile incursions into Italy: were, nevertheless, known only to the Greeks through some obscure rumours, probably of Phœnician voyagers. Slight, however, as are the early notices of the Keltai, they reveal to us the presence at the dawn of authentic history of that remarkable people who seem to constitute a link between the prehistoric and the historic nations of Europe. If we do indeed look upon them for the first time in the beginning of their decline, when younger nations were already intruding on the ancient Celtic area, and effecting the first encroachments which finally resulted in their dismemberment and denationalisation: it suffices to illustrate the great age of nations. Upwards of two thousand years have since elapsed; and still the fragments of that once powerful branch of the European family of nations preserve their ancient tongue, and struggle to assert for themselves an independent nationality. To the Romans they had made themselves known as haughty conquerors, while yet the imperial city on the Tiber was but the nucleus of an infantile state; but the earliest authentic details regarding them, as the occupants of what is regarded as their native territory, are derived from the narrative of Cæsar's conquests; and the subsequent reduction of the tribes of Gaul and Britain by the Legionaries of Rome.

Unfortunately the ethnologist has at every step in his researches, to deplore the indefiniteness of nearly all the notices of the barbarian races with which the Greeks or Romans were brought into contact;

and in seeking their aid to determine the physical characteristics of Kelt, Gaul or Briton, the results are little less vague, than when he attempts to fix the ethnical character of the Pelasgi, or to group the Etrusci among indigenous races of Italy. The controversies, moreover, of which the term *Celtic* has furnished the key-note, were long embittered by the narrowest spirit of national prejudice, and exposed thereby to well-merited ridicule.* One recent champion of the Celt, in a communication to the British Association, after characterising the Saxon as "a flaxen-haired, bullet-headed, stupid, sulky boor," proceeds to define the Celtic characteristics recognisable in men who have taken a distinguished place in English or Scottish history, as "a long cranium, high and expressive features, dark or warm complexion, and spare or muscular frame."† Pinkerton the Teutonic partizan,—who, in like fashion, maintained the opposite side in this controversy, by affirming: "What a lion is to an ass, such is a Goth to a Celt;"—assigns to the latter: dark hair and eyes, swarthy complexion, and inferior stature to the large-limbed, red or yellow-haired Goth, with fair complexion and blue eyes. In so far as the form of the head marks the difference between them, the supposed cranial contrast is indicated in the globular or "bullet-head" assigned to the Saxon, and the long cranium and high features ascribed to the Celt. The latter, at least, is an idea maintained, with more or less definiteness, by some of the most observant ethnologists; and so long as the Celt was supposed to belong to an essentially different division of the human race, it was not unnatural to assume that the opposite type of head must pertain to the Saxon. Few points, however, connected with physical ethnology rest on more uncertain evidence than the distinctive form, colour of hair, and other characteristics, not only of the ancient, but of the modern Celt.

The Gauls and Britons are the recognised representatives of that ancient people, who after being long regarded as in the most literal sense European aborigines, are even now commonly assumed to be the originators of all primitive art-traces pertaining to purely archæolo-

* The only occasion where Dr. Prichard is tempted beyond the simple language of the scientific investigator is where, in his *Researches*, he contrasts Pinkerton's views as a man "of clear and strong sense, though somewhat peremptory and wrong headed;" with "the weak and childish dreams of the Celtic antiquarians *who descant with amazing absurdity, through entire volumes, upon their Phœnician, Punic, Scythian, Spanish, and Magogian ancestry!*"

† Mr. John McElheran.

gical, in contradistinction to geological researches. Of this, however, there is not only no proof, but the existence of pre-Celtic races, to whom the implements and arts of the European Stone Period were assignable, had been maintained both on technological and philological grounds, before the traces of Cave-Men, or the Flint-Folk of post-pliocene ages, had been demonstrated by the geologist, from evidence derived to a great extent from the French drift, where it is overlaid by the graves and buried arts of the ancient Gaul and his Roman conqueror.

From the date of Julius Cæsar's conquests, the native population both of Gaul and the British Isles have been made the subjects of descriptive comment by some of the most observant writers. But their notices of the tribes on both sides of the English Channel, suffice to remind us, that in speaking of the Celts we are not dealing with an isolated and homogeneous people, but with diverse nations of a common race, which once filled Central Europe; and which, moreover, in the earliest period of their definite history, were the occupants of a diminishing area, encroached upon by Germanic and other nations, before the Romans stepped in to complete the changes already in progress. There were Gauls or Kelts to the south, and to the east of the Alps, to the south of the Pyrenees, to the north of the English Channel, and—according to archæological evidence,—seemingly even to the north of the Baltic sea. Among the numerous tribes of a common stock thus brought into contact with the most diverse races of Europe, we must anticipate considerable variations from any assignable type. But this contact has been of a far closer and more influential character since the fall of the Roman Empire; so that it is little more difficult to ascertain what were the specific characteristics of the ancient Gaul or Briton, than it proves to be to determine the typical attributes of the modern continental or insular Celt. Few races of European origin, for example, show less indications either of physical or moral affinity than the so-called French and Irish Celts of Lower Canada: the one warm-hearted, but irrascible, pugnacious, and prone to excitement; the other gentle, impassive, and amiable to a fault. How far the common term is applicable to both will be considered on a subsequent page.

Cæsar's account of the Gauls in the sixth book of his *Bellum Gallicum* supplies the most comprehensive details we now possess in reference to their manners and religion; and to him also we owe similar notices of the Belgæ and other continental tribes, seemingly most nearly allied to others of south Britain, the Germanic or Celtic affinities of which have been made the subject of much controversy among modern ethnologists. In the previous book* Cæsar expre sly states that, while the inhabitants of Britain are regarded as aborigines, the sea coast is occupied by tribes derived from the country of the Belgæ, and bearing names corresponding to those of the states they came from. Strabo describes the Britons of about the commencement of the following century, in part from observations made on some of their young men seen by him at Rome; and he discriminates between them and the Gauls, assigning to the latter yellow-hair, a fairer complexion, and smaller stature, than their insular neighbours.* This suggests a comparison with the description of the Caledonians given by Tacitus, in which he notes the huge stature and red hair of the latter, and recognises in them an approximation to the German type.* The Silures, or West Britons, on the contrary, he contrasts both with them and the southern tribes, as *colorati vultus et torti plerumque crines;* they were of florid, or, rather in this case, dark complexion, with abundance of curly locks; and to this Jornandes adds that the hair was black. They thus contrasted very strikingly both with the northern and southern tribes; and Tacitus, in referring to an Iberian origin ascribed to them, adds the probable confirmation arising from the position of their country, standing as it does opposite to Spain. To the southern Britons alone, a common origin with the Gauls was assigned; though Tacitus himself recognises the correspondence between the whole of those insular tribes and the continental Gauls, in customs, language, and religious rites; and obviously attaches more importance to these points of agreement, than to those of physical difference.

The allusions to varieties of physical character, are so far valuable, though deficient in many important details. Virgil, Claudian, and other poets repeat them, but without enlarging their details, or adding to their credibility; and when every reference has been carefully weighed, it is surprising how little that is definite can really be inferred beyond the one important fact that considerable diversity prevailed. So vague is all that can be deduced from such references, that Nieb-

* *Bell. Gall.* lib. v. c. 12.

† *Strabo*, lib. iv.

‡ *Vit. Agricola*, c. xi.

hur, Prichard, Laurence, Latham, and other writers, have debated the questions: were the Gauls xanthous or swarthy; yellow, red, or dark-haired; and blue or black-eyed? and of the Britons, in like manner, it is still a moot point, whether they were fair or dark, and their long shaggy locks were black, brown, red, or yellow. Dr. Beddoe, an intelligent observer, applied the test of personal experience, a few years since, to determine some of the same questions; and found it little less puzzling to arrive at any definite results in reference to their modern representatives, than to reconcile conflicting evidence relative to the Celts or Gauls of two thousand years ago.* Niebhur, confounded by the assurance conveyed to him by an English correspondent, that all modern British Celts have black hair: in the last edition of his Roman History, places this supposed fact in contrast with the yellow hair assigned by Ammianus Marcellinus, a resident in Gaul, to the continental Celts. Dr. Beddoe, on the contrary, was forced at last to the conclusion "that black and red hair are not so diametrically opposed as is generally imagined;" and he ended by assigning to the British Celt:—eyes grey or blue, passing through dark grey into brown and black; hair bright red or yellow, passing through various shades of bright brown, into dark brown and coal black. The Teutonic Briton differed in the red hair being light, and the yellow flaxen; while the brown tints were dull; and neither eye nor hair exhibited the pure black.

Difficult as it thus appears to be to determine the complexional peculiarities of the Gaul or Briton, either of ancient or modern times: it might seem an easier task to define the form of head characteristic of each. The light of their eyes may be quenched in dust, and the bright locks have yielded up their lustre to the grave; but the skull, though not imperishable, has in many cases resisted decay. Of the Roman supplanters of the Gaul and Briton, many skulls are preserved; some of which, recovered from inscribed sarcophagi, not only reveal the race of the deceased, but the name, age, rank, and term of military service or foreign residence of each. When we turn to the contemporary Gaulish or British barrow, we look in vain for information so minute or exact. Nevertheless, the evidence is sufficient for all practical requirements, and it is indisputable that hundreds of Crania have been

* *A Contribution to Scottish Ethnology:* by John Beddoe, B.A., M.D.; London 1853. *On the Ancient and Modern Ethnography of Scotland.* Proceed. Soc. Antiq. Scot. Vol. I. p. 256.

recovered from French and English grave mounds, contemporary with the era of Roman occupation.

It may be assumed as a recognized fact, that the form of the human skull is essentially distinctive of race. The difficulty is to determine the characteristic differentiæ, especially in approximate races; and hence considerable diversity of opinion still prevails as to the methods best fitted to express the ethnical significance of form, proportions, prognathism or orthognathism, and other characteristic diversities. But as the study of craniology, and anthropology generally, continues to receive ever increasing attention, the simple broad distinctions, such as those which satisfied Blumenbach or even Retzius, disappear; and now we have brachycephalic, dolichocephalic, kumbecephalic, scaphocephalic, macrocephalic, sphenocephalic, acrocephalic, and platycephalic skulls, with numerous subordinate modifications. Of those forms, five, at least, occur among ancient British crania; and include types of extreme diversity. To some of these I have already repeatedly referred in former papers; and have indicated in other publications some of the grounds that lead me to infer the existence, at some remote period, of races distinct from the Celtic tribes found in occupation of the British Islands, at the period of Roman invasion.*

Briefly, the evidence already set forth points to a megalithic era, with huge chambered catacombs of cyclopean masonry, and traces of a race remarkable for long, narrow heads, moderately developed zygomata and cheek bones, and small under jaws, as their builders. To this it is objected that by assigning priority to the constructors of the elaborate and massive chambered catacombs over the simpler barrow builders, the probable order in the succession of constructive remains is inverted. This idea, however, proceeds on the assumption that primitive arts must invariably proceed from the rudest to more ingenious and elaborate works. The recently discovered carvings and engravings, found by M. Lartet and Mr. Christie in the Dordogne Caves, of Central France, rude though they are, suffice to prove that artistic ingenuity is no modern acquisition of man. But we are dealing with races nearer the confines of the historic period than the contemporaries of the Reindeer of Central France. The cyclopean cata-

* *Ethnical forms and undesigned artificial distortions of the Human Cranium.* Canadian Journal, Vol. VII. p. 399. *Illustrations of the significance of certain Ancient British skull forms.* Ibid. Vol. VIII. p. 127. *Prehistoric Annals of Scotland.* Sec. Ed. pp. 227–298, &c.

combs of the British Kumbecephali have no claims to a primeval rank among the recovered traces of early human arts. Supposing them to be three, four, or five thousand years old, grave-mounds, barrows, and tumuli of every form and proportion may have preceded them, and been erased. Neither history nor definite archaeology, moreover, confirms any such "natural order." On the contrary, in Egypt, India, Greece, and Italy; in Peru, Central America, and even in some of the islands of the Pacific, the oldest traces of architectural or constructive efforts survive in megalithic remains, ascribed for the most part to unknown and ante-historical races. Less substantial mounds or catacombs, which may have preceded or accompanied them, necessarily experienced the fate of all ephemeral structures; and it is probably mainly due to the cyclopean masonry of the chambered-barrow builders, that any evidence of the physical characteristics of so ancient a race are still recoverable.

But to this race succeeded a short-headed one, the Brachycephali of the later tumuli, which apparently survived in Britain to Roman times. The characteristic skull-form of this period has been repeatedly defined; and the significance of the vertical or obliquely flattened occiput of frequent occurrence, has been repeatedly discussed by me in former communications to the Canadian Institute. The point specially to be noted at present is, that not only considerable variations from any assumed typical British or Celtic cranium occur; but that at least two types of the most striking diversity mark the sepulchres of the megalithic era, and the seemingly later earth-barrows and cists. Their relative chronology is not indeed of permanent importance in the present inquiry. Both undoubtedly occur in ante-Christian and ante-Roman sepulchres. In referring to the doctrine of a pre-Celtic population for the British Islands, maintained in my "Prehistoric Annals of Scotland," Dr. Thurnam remarks: "Previous to inquiry as to the form of the skull in any possible pre-Celtic race, it is necessary to determine the form of the Celtic skull itself. Proceeding from the known to the unknown, we may then hope to trace the form of the skull in races which may possibly have preceded, or been mingled with the early Celtic population of Britain."* If possible, this is unquestionably most desirable; but as Dr. Thurnam here assumes that there is

* *Crania Britannica.* Chap. V. p. 55. The author adds, "such an inquiry is an important object of the present work." But the concluding Decade, with its summary of results from the accumulated evidence is still unpublished.

a specific Celtic skull-form, both the above forms—to the correct knowledge of which he has largely contributed,—cannot be grouped under it. At least two types of extreme diversity belong to the ancient British pagan period: the one, the extremely long skull of the megalithic tombs; the other, the short and broad brachycephalic skull abounding in British barrows of ante-Roman and Roman centuries; while the ovoid dolichocephalic skull of the pagan Saxon is intermediate in form, when compared with the two.

More than one hypothesis is open to us to account for such diversities. There is the probability of an Allophylian, possibly Finnic, Turanian, or other prehistoric race, which was in occupation of Britain before the first Celtic immigration. Retzius from the examination of two Basque skulls was led to the conviction, which accorded with his preconceived opinions, that the Basque head-form is brachycephalic. M. A. d'Abbadie confirmed this opinion by his observations on the living head; and the result has been generally accepted as an established fact. But recently, two members of the Anthropological Society of Paris recovered with their own hands, from a Basque cemetery, in the province of Guipuscoa, sixty crania, which are now deposited in the museum of the Society. Of these, M. Paul Broca remarks, in his address delivered before the Society in 1863: "Of the sixty Basque skulls in your collection, two or three only are really brachycephalous; most of them are altogether dolichocephalous; and, what was quite unexpected, the mean type of the series is much more dolichocephalous than that of the French in the north." Here it is seen M. Broca unhesitatingly styles them "Basque skulls;" but though the old Iberian tongue survives in the Basque district, its race may be, and probably is, not less mixed than the Gaelic speaking people of the Lewes, for example, among whom both Finnic and Norse features and head-forms are affirmed by one recent experienced observer, Captain Thomas, R.N. to predominate.* The unexpected results of the anatomical study of so large a number of crania from a cemetery within the Basque area, are, however, deserving of the most careful study. They help to add to the regret that the abundant dark locks of the Silures prevented Tacitus from reporting on the form of head of the British tribes to whom an Iberian origin was ascribed.

To the comparative proportions of the head-forms of Guipuscoa and the north of France I shall again refer. But, returning meanwhile to

* M.S. Letters to the author. *Prehist. Annals*, Vol. II. p. 208.

the diverse ancient British forms: another opinion specially maintained by Dr. J. Barnard Davis, is, that the brachycephalic head of the barrows is the true Celtic skull-form, and that all others, not Anglo-Saxon,—including even the Kumbecephalic crania of the megalithic tombs,—are mere exceptional deviations, or what he styles "aberrant forms." A third hypothesis may be started, which would receive confirmation from the opinions advocated by one class of ethnologists on philological grounds, that the Cymri and the Gaels are two essentially distinct races;* in which case the two very diverse forms of head may be physical tests of the two races. A fourth idea cannot be overlooked, in reference to some points discussed in subsequent pages, that the head of the Gaul and the British Celt may have undergone modifications in the course of time, wholly apart from any admixture with other races. One other opinion, in special favour among certain purely philological ethnologists, need not be discussed here, viz.: that craniology is valueless for ethnical classification.

Looking meanwhile to the osteological evidence derived from the British Islands, this much appears to be established, that at some remote period, lying beyond the earliest glimpses of any definite British History, the Kumbecephalic, or long headed race, occupied Britain in such numbers as to be capable of the combined labour required in the construction of vast chambered cairns and barrows. These sepulchres I cannot doubt are the mausolea of a royal or priviledged class, and not common receptacles of the dead. They exhibit the laborious but unskilled architecture of a megalithic era, lavished ungrudgingly on the sepulchres of the honoured dead. The only works of art found in them, or at least appearing strictly to belong to their original contents, are bone and flint implements, and rude pottery. This race, as appears from some of the crania recovered from the megalithic chambers, was not altogether ignorant, at some period of its presence in Britain, of another, characterised by an essentially different form of head. The circumstances under which the latter have been met with seem to justify the opinion that this Brachycephalic race occupied a servile relation to the other. When, however, we pass into a later, but still prehistoric era, the long-headed race disappears; and the simple earth-barrow and small cist characteristic of the latter race, reveal almost exclusively the brachycephalic

* *Celtic Language in reference to Race*; by John Crawford, Esq., F.R.S. *On the Gaels and Celts*; by M. Lagneau, &c.

type of skull, with prominent parietal tubers and truncated occiput. This is the form chiefly occurring in native British graves of the Roman period ; and on this, as well as on other grounds, it is assumed by Dr. J. B. Davis and others to be the true type of the British Celt. I have already advanced reasons for thinking that a race of Brachycephali, Turanian or other, to whom the rude stone arts of prehistoric Britain chiefly pertained, intervened between the Kumbecephali of the long chambered barrows and the true Celtæ.* The linguistic affinities between the latter and the great Aryan family of nations, prove that the Celtæ branched off from the parent stock subsequent to the evolution of numbers, the development of metallurgy and many other arts of civilisation. The contents of the earlier cairns, cromlechs, and barrows, do not therefore correspond with their progress; and the very term *cromlech*,—gael. *cromadh*, Wel. *cromen*, a *roof* or *vault*, and *clach*, or *lech*, a stone :—indicates as total ignorance of its sepulchral character, as the English name: Druidical Altar.

In this state of the question it becomes a matter of interest to ascertain what direct evidence is still accessible, and how far it can be made available for throwing light on the physical, and more especially the cranial characteristics of the Celt.

One form of the Anglo Roman period—the historical age of Celtic Britain,—undoubtedly approximates to the brachycephalic type, notwithstanding many aberrations. But on the other hand this is by no means the predominant skull-form of the modern Welchman, the Highlander of the most purely Celtic districts of Scotland, or the seemingly unadulterated native population of south-western Ireland. On this subject Dr. Anders Retzius remarks: "During an excursion in Great Britain in 1855, I was able to satisfy myself anew that the dolichocephalic form is predominant in England proper, in Wales, in Scotland, and in Ireland. Most of the Dolichocephalæ of these countries have the hair black, and are very similar to Celts."† The Anglo-Saxon cannot be affirmed to be a pure race. Apart from later Danish, Norse, and Norman intermixture: it differs mainly, as I conceive, from its Germanic congeners, by reason of a large admixture of Celtic blood, traceable primarily to the intermarriage of Anglish and Saxon

* *Prehistoric Annals of Scotland*, sec. ed., vol. 1. part I., chap. IX. *Canadian Journal*, vol. VII, p. 405.

† *Archives des Sciences Physiques et Naturelles*, Geneva, 1860, *Smithsonian Report*.

colonists with the British women. Such a process of amalgamation is the inevitable result of a colonisation chiefly male, even where the difference is so extreme as between the white and the red or black races of the New World. But the Anglo-Saxon intruder and the native were on a par physically and intellectually; and while the former was pre-eminent in all warlike attributes, the latter excelled in the refinements of a civilisation borrowed both from the pagan Roman and the Christian missionary. There was nothing therefore to prevent a speedy and complete amalgamation. But if this was an admixture of a dolichocephalic with a brachycephalic race, the result should be a hybrid skull of intermediate form; whereas the modern Anglo-Saxon head is essentially longer than the continental Germanic type. This, therefore, seems to me to point to ethnical characteristics of the British Celt according with the indications already suggested by philological evidence; and so to lend some countenance to the idea that the Celtæ intruded on the brachycephalic barrow-builders of Britain, prior to the dawn of history, introduced among them the higher arts of the Aryan races, and themselves underwent the inevitable change consequent on an intermingling of intruding and native races.

The Anglo Saxon is a very modern insular intruder. It is now little more than thirteen centuries since he encroached as a stranger on the home of the native Britons. We may allow the latter an undisturbed occupation for more than double that time, and lengthen the period of their presence in central and north-western Europe, thereby carrying them far back into its prehistoric night; and still ample time will remain for Allophylian precursors. But, so far as the British Islands are concerned, the comparatively recent intrusion of, at least, the Belgæ, probably of the Cantii and Regni, if not also the Durotriges and Damnonii, and even, as some have maintained, of all the tribes to the south of the Brigantes, found in occupation by the first Roman invaders, is more or less clearly indicated. Britain, moreover, had not been so entirely isolated, prior to the era of Roman invasion as to justify any assumption of its undisturbed occupation by a single native race through all previous centuries. To Tacitus, it is obvious no such idea presented itself as the probable theory of British population in the first century, though historical evidence to the contrary was little more available to him than to us.

The revolution recently wrought in the opinions of archæologists and geologists relative to the antiquity of man, renders the idea of the oldest historical races having been preceded by others, not only one of easy reception, but almost a necessary consequence of the evidence. But leaving altogether out of view the traces of the Drift or Cave-Man, and dwelling exclusively on the cranial evidence derived from regular sepulture, the proofs of physical and ethnical diversity are as striking as those which distinguish living races of very diverse character. When, moreover, the craniologist, already familiar with the cranial type of the later pagan barrows, proceeds to determine that of the British Celt of any period subsequent to the Saxon invasion, he is compelled to classify it apart from the brachycephalic type of the Anglo-Roman period. I can scarcely conceive of this being disputed by any experienced observer; whatever inferences may be derived from the fact. It may be (1.) that the brachycephalic skull of the barrows is not the true Celtic type; or (2.) the difference observable in the modern Celtic head may be consequent on altered diet, habits, on cerebral and intellectual development; or (3.) the modern representative may be no pure Celt, but variously affected by intermixture of Roman, (in its widest sense, *i.e.* not merely Italian, but continental,) Saxon, Norse, Danish, and Norman blood; or (4.), all of those causes may have combined to produce the results in question.

In discussing the physical attributes of the Celtic race, Dr. Prichard asks: "Was there anything peculiar in the conformation of the head in the British and Gaulish races?" and thus replies: "I do not remember that any peculiarity of features has been observed by Roman writers in either Gauls or Britons. There are probably in existence sufficient means for deciding this inquiry in the skulls found in old British cairns or places of sepulture. I have seen about half-a-dozen skulls found in different parts of England, in situations which rendered it highly probable that they belonged to ancient Britons. All these partook of one striking characteristic, viz.: a remarkable narrowness of the forehead compared with the occiput, giving a very small space for the anterior lobes of the brain, and allowing room for a large developement of the posterior lobes. There are some modern English and Welsh heads to be seen of a similar form, but they are not numerous."* But not only did Prichard thus recognise the essential disagreement between the brachycephalic head of the barrows and that of the modern British Celt; but he has also indicated his recog-

**Researches into the Physical History of Mankind*: Third Ed. vol. III.

nition of characteristics in the former, which appear to him other than Celtic. In noticing two well known crania recovered from the Knoch-maraidhe tumulus in the Phœnix Park, Dublin, he remarks: "In these, especially in one of them, there is a considerable approximation to the Turanian skull;" and again in view of those from British cairns and cists, he repeats his belief that some of them give reason to suspect that they had somewhat of the Mongolian or Turanian form of head.*

It seems, at first sight, an undertaking sufficiently compatible with the results already achieved by craniology, to determine the typical form at least of the modern Celtic cranium; but the results have hitherto been of a very indefinite character. One source of error is doubtless traceable to the neglect of the important fact that a type is an ideal abstraction embracing the mean of many variations, and is not to be determined by the selection of one or two assumed characteristic examples. Opinions, however, have been advanced on the authority of experienced observers, in favour of one or more specific forms as that of the true Celtic head. Referring to the small anterior region characteristic of the skulls in ancient British graves, Dr. Prichard remarks: "In this particular, the ancient inhabitants of Britain appear to have differed very considerably from the present."† Mr. Wilde, on the contrary, after referring to two ancient races, whose remains are found in Irish cairns and sepulchral mounds, the one "globular headed," and the other having skulls "chiefly characterised by their extreme length from before backwards, or what is technically termed their antero-posterior diameter, and the flatness of their sides;" adds: "we find similar conditions of head still existing among the modern inhabitants of this country, particularly beyond the Shannon, towards the west, where the dark, or Firbolg race may still be traced, as distinct from the more globular-headed, light-eyed, fair-haired Celtic people who lie to the north-east of that river."‡ Here the Irish archæologist describes two essentially distinct ancient skull-forms, and not only recognises the living representatives of both, but finds the diversity of form accompanied by other distinctions in hair, eyes, and complexion.

Nevertheless it has been generally assumed that one well-defined

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* Researches. vol. iii, p. xx.

† Ibid vol i. p. 305.

‡ *Lectures on the Ethnology of the Ancient Irish.*

form of head is recognisable as characteristic of the true Celt. Dr. Morton, in defining the Celtic Family, says: "they have the head rather elongated, and the forehead narrow and but slightly arched. The brow is low, straight, and bushy; the eyes and hair are light, the nose and mouth large, and the cheek-bones high. The general contour of the face is angular and the expression harsh."* Dr. J. Aitken Meigs in discussing the characteristics of the race, as represented in the Mortonian Collection, selects a cast bearing the memorandum: "Descendant of an ancient Irish King, Alexander O'Connor, —original in Dublin." Of this he remarks: "No. 1356,—a cast of the skull of one of the ancient Celtic race of Ireland,—appears to me the most typical in the Irish group. This head, the largest in the group, is very long, clumsy and massive in its general appearance. The forehead is low, broad, and ponderous; the occiput heavy and very protuberant. The basis cranii long, broad, and flat; the orbits capacious; and the distance from the root of the nose to the upper alveolus quite short."† Dr. Kombst also, who, during a residence of some years in Scotland, devoted considerable attention to the determination of the Celtic, as distinguished from the Germanic type, states that "the Celtic skull is elongated from front to back, moderate in breadth and length, and the face and upper part of the skull the exact form of an oval."‡ Professor Retzius after studying the modern Celt both in France and Britain, assigns to the cranium of the common race a form of peculiar length, compressed at the sides, narrow and generally low in the forehead. At the same time he ascribes to the true Celtic type of head greater breadth, though still describing the skull as long, oval, and narrow.§ In his latest matured views he groups the Celts as European orthognathic Dolichocephalæ, under the heads: "Scottish Celts, Irish Celts, English Celts, and Welsh;" and when referring to a skull sent to him by Dr. Prichard, as the first Roman one he had seen, he remarks: "It had been picked up on an ancient field of battle near York, with another skull of different form. The latter was smaller, much elongated, straight and low, and had evidently belonged to a Celt."‖ This judgment, he adds, fully

* *Crania Americana.* p. 16.

† *Indigenous Races of the Earth*, p. 301.

‡ *Johnston's Physical Atlas*, c. 8.

§ *Kraniologisches. Muller's Archiv.*, 1849, p. 575.

‖ *Smithsonian Report*, 1859, p. 253.

satisfied Dr. Prichard. But when commenting on the Ugrians, Turks, and Sclaves of Europe, all of whom he includes in his *Orthognathic Brachycephalæ,* Retzius remarks: "On different occasions I have met with brachycephalic Scots from northern Scotland, and the isles to the north. During my last sojourn in Scotland, I encountered again divers individuals pertaining to this same type, having an expression altogether peculiar, their visage being often short and somewhat large, their hair red, the skin of their faces marked with freckles. Since then I have learned from the reports of travellers, that this type is common in the Highlands, where it is indigenous from a remote antiquity. I suppose it has descended from the Finns, or perhaps the Basques." The observations of Professor Retzius are confirmed by those of my friend, Captain Thomas, R.N., whose experienced eye has detected a peculiar type of form and features both in the Orkneys and the Hebrides, equally distinct, as it appears to him from Celt and Scandinavian, which he also conceives to be Finnic. It is well worthy of note, however, that this globular head-form appears to pertain to the Scoto-Scandinavian districts; for, as will be seen, a similar type prevails in the Gallo-Scandinavian district of Normandy; and the same type predominates, according to Mr. Wilde, in the region to the north-east of the Shannon, where in like manner the influence of the Northmen may account for the distinction he defines between them and the long-headed Firbolgs beyond that river. When, however, Dr. Retzius quotes vaguely, "The reports of travellers, that this (the brachycephalic) type is common in the Highlands," the opinion must be received with caution. My own opportunities of observation led me to an opposite conclusion; but from the great difficulty of arriving at any certain results in reference to the relative proportions of the living head, without actual manipulation and measurement, I feel assured that the reports of ordinary travellers on minute distinctions of the kind in question are valueless. It is of a nearly corresponding type that Dr. Prichard remarks: "There are some modern English and Welsh heads to be seen of a similar form, but they are not numerous." But the significance of this globular, or brachycephalic head-form will again come under review in other geographical relations.

Dr. Beddoe, whose observations on the complexion, eyes, and hair of the modern Celt have been already referred to, in a communication to the Society of Antiquaries of Scotland on the ancient and modern ethnography of the country, states that his deductions relative to the physical characteristics of the Scottish population are based on observations made upon about 20,000 individuals. The complexional character chiefly attracted his attention; but other features were not overlooked. Of the people of Upper Argyleshire and Invernesshire he remarks: "The men have the bony frames, the high cheek bones, prominent brows, and long noses, aquiline, sinuous, or curved upwards towards the point, which I have observed in almost all the more Celtic districts of Scotland;" and he thus indicates the idea he has formed of the Celtic head-form, when referring to the fisher-folk of Buckhaven, St. Monance, Newhaven, and Fisherow: "The narrowness of the crania and faces in many of the women tells against their Teutonic origin, and the family names of the Newhaven and Fisherow folk are just those of the neighbouring counties; some of them indeed, as Caird and Gilchrist, are Gaelic."*

The zeal with which anthropological researches are pursued by the savants of Paris, renders their opinion on this department of ethnical classification, in which they have so peculiar an interest, of the highest value. Unfortunately my access to their published results is greatly more limited than I could desire, though perhaps sufficient for the purpose now in view. M. J. J. D'Omalius D'Halloy, remarks in his *Des Races Humaines*, "It is difficult in the present state of the science to express any positive opinion as to the true characteristics and the actual development of the Celtic Family;" and after referring to the wide area occupied by it in ancient times, and its later intermixture everywhere with encroaching races of conquerors, he adds: "It is probable that the peoples who still speak the Celtic languages are not the pure descendants of the ancient Celts, but that they have resulted from an admixture with the Arameans whom we suppose to have been their precursors in Central Europe, and with the Latins and Teutons, who intruded subsequently. Moreover their characteristics are not uniform; and whilst, for example, the Bas-Bretons have in general their hair and their eyes black, and the stature of the inhabitants of the south west of France, we frequently meet with blond complexions among the Gauls."† Among the scientific anthropologists of Paris, however, the same idea, already referred to, of the elongated skull being the true Celtic type, appears to maintain its

* *Proceedings of Soc Antiq of Scotland*, Vol. I pp. 254, 256.

† *Des Races Humaines, ou Eléments d'Ethnographie*, p. 37.

ground. M. Paul Broca, the learned Secretary of the *Société d'Anthropologie de Paris*, in an ethnological resume addressed to the society in 1863, when contrasting two distinct types of skull—the one brachycephalic and the other dolichocephalic,—recovered from sepulchres of the Burgundian period, affirms of the successive occupants of French soil: "The Celts, the Cymri, and the Germans, were dolichocephali; and so were the Romans in a less degree. There is therefore," he adds, "no question that the brachycephalic type still so prevalent among us, is derived from populations prior to the arrival of the Celts." Again, M. Pruner-Bey, in discussing before the same body the ethnical affinities of the Neanderthal man, characterised by a skull little less remarkable for its great length and narrowness, than for the extreme development of the superciliary ridges, says: "let us try if it is possible to classify the Neanderthal skull. Is it the representative of a lost race, or can it be identified with any of the stocks which are known to us? In my opinion it is undoubtedly the skull of a Celt; it belongs to a large individual; it is capacious and dolichocephalic; it presents the depression on the posterior third of the sagittal suture common to the Celts and Scandinavians; and finally its occipital projection is equally characteristic of these two races." M. Pruner-Bey then produces one Helvetian and two Irish skulls as illustrations of the true Celtic type, and thus proceeds: "Whilst they all present the same general type, these three skulls exhibit slight differences. There even exists a fourth variety, represented in the collection of Retzius by an ancient Belgian, whose skull is more compressed laterally than that of the first Irishman, which is almost cylindrical. In the gallery of the museum there is a sufficiently numerous series of ancient French skulls of the same type in every respect as those before us. . . . Without entering into descriptive details respecting the ancient Celtic skull, you will recognise that all the ancient skulls before us present a very depressed forehead, compared with the enormous facial development; but that which the forehead loses in height it gains in length." He then, in considering the evidence that the skulls produced are really Celtic, refers, among other proofs, to "comparison by the retrogressive or progressive method with skulls of Bretons, French, and modern Irishmen, in which the mass are undoubtedly Celtic;" and adds: "Although the Celtic skull has undergone some secondary modifications, its type is at the present day the same as in the most remote ages. I refer to the beautiful series of modern skulls in the museum, derived from Brittany, and to my own collection of modern Irish skulls." In a letter on the same subject, addressed by M. Pruner-Bey to Mr. C. C. Blake, of the London Anthropological Society, he refers to "the elliptic form (segmental) of the occiput as well as of the coronal as truly characterising the Celtic type."* The crania selected by him as typical Celtic skulls, measure, in centimetres, longitudinally and parietally as follows:

| | | | | |
|---|---|---|---|---|
| Helvetian, | length, | 19.5; | breadth, | 14.5. |
| Irish No. 1, | " | 20.0; | " | 15.0. |
| Irish No. 2, | " | 20.5; | " | 14.3. |

The discussions originating in M. Pruner-Bey's observations on what he finally designates "The long-headed Celt of Neanderthal:" though they elicited opinions at variance with his ethnical classification of the remarkable skull discovered in 1837 in the Neanderthal cave; have not, so far as I am aware, led to any challenge of the typical form thus asserted for the Celtic skull of France, as well as of Switzerland and Ireland.

It accordingly appears thus far, from the various authorities referred to, that considerable unanimity prevails in the ascription of an excess of longitudinal diameter as one of the most marked characteristics of the Celtic cranium. A long but low frontal development, in which, as M. Pruner-Bey defines it, "The forehead of the ancient Celt gains in length what it loses in height;" a flattening of the parietals, and a tendency towards occipital prolongation, are all more or less strongly asserted as characteristic of the same head-form. There are marked exceptions, however, to this apparent unanimity. Professor Nillson —who, in his earlier definitions, had spoken of the Celtic cranium as intermediate in proportions to the true dolichocephalic and brachycephalic skull-forms,—when writing more recently to Dr Thurnam, remarks in reference to that cranium: "I consider nothing more uncertain and vague than this denomination; for hardly two authors have the same opinion in the matter. It would indeed be very desirable if, in England, where it might most conveniently be done, one could come to a proper understanding as to what constitutes the Celtic form of cranium, and afterwards impressions in plaster-of-pari be taken of such a cranium as might serve as a type for this race."† The de-

* *Anthropological Review.* Vol. II. p. 146.

†*Crania Britannica,* Dec. i., p. 17.

mand of the Swedish naturalist is more desirable than easy of accomplishment. What tribunal is to determine the coveted cranium embodying in itself the ideal type? Dr. Spurzheim directed a series of minute observations with this object in view; and other evidence shows that the body of British cranioscopists called into being by the teachings of Dr. Gall and his collaborateurs, systematically aimed at determining this and other leading ethnical types. The collection of the Edinburgh Phrenological Society includes a cast marked as the Celtic type: one of a series described in the Phrenological Journal as "selected from a number of the same tribe or nation so as to present as nearly as possible, a type of the whole in the Society's collection."* It is characterised in the catalogue as a "long Celtic skull;" and as will be seen from its measurements,—No. 16, in the following table of crania, otherwise obtained from ancient Celtic areas under circumstances that afford the greatest presumptive evidence of their truly representing the native race,—it is remarkable for its length and narrowness. It is also characterised by the narrow, elongated frontal region, which French anthropologists appear to recognise as a typical Celtic feature.

An unbiassed judgment, as well as great sagacity and experience, is required to determine such a selection in comparative craniology. Wilde, as we have seen, describes the heads of the Irish beyond the Shannon as distinct from what he calls "the more globular headed, light-eyed, fair-haired Celtic people" to the north of the same river. The former, with long heads, he designates the dark or Firbolg race, the representatives as he conceives of the aboriginal Irish Cromlech-builders. But who the Firbolgs were, and whence their name is derived, are questions still in dispute among Irish antiquaries and historians. They came into Ireland according to the *Annals of the Four Masters*, A.M., 3266. O'Flaherty, in his *Ogygia*, fixes their advent at the still earlier date of A. M., 2657. Keating, Algernon Herbert, and others believe them to have been a colony of Belgæ, or other Gaulish tribe; and the last named authority regards the date of their arrival in any part of the British Isles as little more than a century before Christ.† On this latter theory, it is in no degree remarkable that a comparison of Breton, French, and Irish skulls in Parisian collections, should produce such harmonious results. But Dr. Davis,

* Phrenological Journal. Vol. VI. p. 144.

†*Irish Nennius*, pp 44. xcix.

who assumes the short crania of the barrows to represent "the typical form of cranium of the ancient Britons," describes them as "somewhat short or brachycephalic, not ill-developed, nor remarkable for a small facial angle. The bones of the face, and especially the upper maxillaries, upright or orthognathous, but also rather short. The chin is usually prominent, the exterior surface of the upper maxillaries depressed, the nose abrupt and short, surmounted with a frowning eminence, marking the situation of the frontal sinuses."* Having thus determined the typical Celtic head-form, Dr. Davis disposes of the remarkable class of extreme dolichocephalic crania already referred to as found in Britain, by classing them, along with other variations from his Celtic type, as: "aberrant forms." Here therefore we see to how great an extent the selection of any assumed typical form is liable to be affected by preconceived theories.

But another difficulty meets us when we attempt to select the living representative of the pure Celt. M. D'Halloy classes the French, apart from the Celtic family, under *La Famille Latine*, but he adds: "It is probable that the French derive their origin principally from the Celts; but these submitted during five centuries to the Romans, and not only mingled with them, but have entirely lost the use of the Celtic languages. Subsequent conquests, repeatedly effected by Teutonic people, subjected them to fresh admixture, and they took the name of French; but the descendants of the conquerors lost the use of the Teutonic languages, and the Latin dialects have prevailed. . . . It is probable that the people of Central France are those who remain most thoroughly Celtic; that those of the south have inherited the vivacity of the Basques; and that those of the north have undergone more change from Teutonic races. This influence has been chiefly felt in Normandy, which received its name in consequence of its settlement by Scandinavians in the tenth century."† Turning from France to Britain, the same difficulties are encountered; and even when we confine ourselves to what are commonly designated the purely Celtic districts of Wales, Scotland, and Ireland: the northern and western Highlanders of Scotland differ little less noticeably than the Irish on either side of the Shannon, while the Welsh are distinguishable in many respects from both. In Sir David Wilkie's graphic picture of the "Reading of the Waterloo Gazette," the characteristic

* On the Crania of the ancient Britons. *Proceed. Acad. Nat. Sc. Philadelphia.* Feb. 1857, p 42.

† *Des Races Humaines*, pp. 38, 40.

differences between the English dragoon, the Highland sergeant, and the Irish private, are as obvious as the distinctive features of the Negro who mingles in the same jovial group. M. D'Halloy excludes the region of Brittany from the France assigned by him to its branch of the Latin Family. But even the retention of the Celtic language is no certain test of purity of race; and it is more easy to imagine, than to estimate by any definite scale, the influence which Roman, Frank, Burgundian, Saxon, Dane, Norman, and other foreign blood, have exercised in effecting the diversities referred to. Taking, however, crania derived from Highland districts where the Gælic language still prevails, and from cemeteries of the earliest Columbian and Pictish Christian foundations, we have some reason to anticipate in them an approximation to the true form of the Celtic head subsequent to the Roman invasion. The following table embraces such a selection, illustrating the character of the native population in different parts of the British Islands, at a period when the first Celtic missionaries of Scotland and Ireland were preaching to their converts in their native tongue.* The measurements are *Longitudinal diameter*, *Frontal breadth*, *Parietal breadth*, and *Horizontal circumference*.

BRITISH CELTIC CRANIA.

| | Locality. | | L. D. | F. B. | P. B. | H. C. |
|---|---|---|---|---|---|---|
| 1 | Iona | M | 7.3 | 4.5 | 5.5 | 20.2 |
| 2 | " | M | 7.2 | 4.7 | 5.5 | 20.6 |
| 3 | " | M | 7.4 | 5.0 | 5.6 | 20.9 |
| 4 | " | M | 7 1 | 4 5 | 5.6 | 20.0 |
| 5 | " | M? | 7.3 | 4.6 | 5.7 | 19.9 |
| 6 | " | M | 7.3 | 4.3 | 5.4 | 20.7 |
| 7 | St. Andrews | M | 6.8 | 4.8 | 5.5 | 20.4 |
| 8 | " | M | 7.0 | 4.4 | 5.3 | 20.3 |
| 9 | " | M | 7.3 | 5.0 | 5 8 | 21.5 |
| 10 | " | F | 7.2 | 4.4 | 5.0 | 20.2 |
| 11 | Kintyre | M | 7.7 | 4.8 | 5.0 | 21.2 |
| 12 | Larnahinden | M | 7.5 | 4 6 | 5.1 | 20.2 |
| 13 | Caithness | M | 7.7 | 4.3 | 5.5 | 20.9 |
| 14 | Northampton | M | 7.5 | 4 4 | 5.4 | 20.6 |
| 15 | Longford | M | 7.8 | 5.1 | 5.6 | 21.9 |
| 16 | Celtic Type, E. P. M. | | 7.9 | 4.8 | 5.4 | 21.5 |
| | Mean | | 7.37 | 4.64 | 5.43 | 20.69 |

* For additional measurements, and the circumstances of discovery justifying their Celtic classification, vide *Prehist. Annals of Scotland*, 2nd edit., vol. I., p. 284.

In so far as a comparison can be instituted between this group of Crania and those previously referred to, it will be seen that the latter are smaller than the examples of the Helvetian and Irish Celtic head. Nevertheless they agree with all other evidence in confirming the predominance of a head of unusual length, in more than one of the ancient insular races. But a comparison of the results of the above table, in longitudinal and parietal measurements, with the Kumbecephalic and Brachycephalic crania of British megalithic tombs and barrows, as derived from the mean results of examples of each class, is of more importance, from the remarkable amount of diversity it reveals among the ancient insular races.* For the purpose of comparing them with the typical Celtic crania of M. Broca previously referred to, the measurements are given both in inches and in centimetres.

| | | | | | |
|---|---|---|---|---|---|
| Kumbecephalic crania, | length, | 7.44, or 18.897; | breadth, | 5.27, or 13.385 |
| Brachycephalic " | " | 7.12, " 18.084; | " | 5.70, " 14.477 |
| Celtic " | " | 7.37, " 18.719; | " | 5.43, " 13.792 |

I shall now turn to another test, to which I have already repeatedly referred in former papers, as calculated to furnish useful comparative craniological data. The hatter in the daily experience of his business transactions, necessarily tests the prevalent form and proportions of the human head, especially in its relative length, breadth, and horizontal circumference; and where two or more distinct types abound in his locality, he cannot fail to become cognisant of the fact. One extensive hat manufacturer in Edinburgh, states that "the Scottish head is decidedly longer, but not so high as the English. In comparison with it the German head appears almost round." But comparing his scale of sizes most in demand, with others furnished to me from Messrs. Christie, the largest hat makers in England, the results indicate the prevalent Scottish size to be 22⅜ inches; four of this being required for every two of the next larger and smaller sizes; whereas in assorting three dozen for the English trade, Messrs. Christie furnish four of 21½, nine of 21¾, ten of 22, and eight of 22⅜ inches. Mr. Rogers, of Toronto, in assorting three dozen, distributes them in the ratio of five, seven, nine, and five to the same predominant sizes, and allows four for the head of 23 inches in circumference, the remainder being in both cases, distributed in ones and two between the largest and smallest sizes, ranging from 23⅜ to 20¾ inches.

*Vide Ibid, Tables I., II., vol. I., pp. 267, 275.

The summary of inquiries among the principal hatters of Boston is as follows: "Larger hats are required for New England than for the Southern States. To New Orleans we send $20\frac{5}{8}$ to $22\frac{7}{8}$; and to New Hampshire $21\frac{3}{8}$ to 23 inches." One extensive New England manufacturer adds: "New England heads are long and high; longer and higher than any European heads. British heads are longer than Continental. German and Italian heads are round. Spanish and Italian very small."

Let us now see if this experience acquired in the daily observation of the trader and manufacturer will yield any available results in reference to our present inquiries. An ingenious instrument, known by the name of the *Conformiteur*, was brought into use in Paris, I believe about twenty years since, and is now employed by many hatters, on both sides of the Atlantic, for the purpose of determining the form and relative proportions of the human head, so far as required by them. The instrument fits on the head like a hat; and, by the action of a series of levers encircling it, repeats on a reduced scale, the form which they assume under its pressure. By inserting a piece of paper or thin card board, and touching a spring, the reduced copy is secured by the impress of pins attached to the ends of the levers. Owing to this repetition being made on the top by limbs of equal length, acting, within a circle, at right angles to the main levers, the form produced is more or less exaggerated longitudinally in proportion to the length of the head. But this does not interfere with the value of comparative results derived from numerous head-forms taken by the same instrument, and correspondingly affected according to their relative proportions.

Taking advantage of the precise data furnished by the *conformiteur*, I have availed myself of the peculiar facilities which Canada supplies for instituting a comparison between the diverse races composing its population. Upper Canada is settled by colonists from all parts of the British Islands. In some districts Highland, Irish, German, and "Coloured" settlements perpetuate distinct ethnical peculiarities, and preserve to some extent, the habits, and usages, and even the languages of their original homes. But throughout the more densely settled districts and in most of the towns,* the population presents much the same character as that of the larger towns of England or Scotland,

* The exceptions in the Upper Province are where a large coloured population has congregated; as at St. Catharines, Chatham, and Windsor.

and the surnames form in most cases the only guide to their ethnical classification. In Lower Canada the great mass of the population is of French origin, but derived from different departments of the parent country; of which Quebec is the centre of a migration from Normandy while the district around Montreal was chiefly settled by colonists from Brittany. The French language, laws, religion, and customs prevail, preserving many traits of the mother country and its population, as they existed remote from the capital of the Grande Monarque, and before the first French Revolution. The establishment of the seat of the Provincial Government at different times in Montreal and Quebec, and the facilities of intercourse between the two cities, must have helped to mingle the Norman and Breton population in both. Nevertheless, the results of my investigations tend to show that a striking difference is still recognisable in the predominant French head-forms of the two cities.

My first observations, with special reference to the present inquiry, were made at Quebec, in 1863, when, in co-operation with my friend Mr. John Langton, I tested the action of the conformiteur on heads of various forms, and had an opportunity of examining and comparing nearly four hundred head-patterns of the French and English population.* As each of the patterns had the name of the original written upon it, a ready clue was thereby furnished for determining their nationality. Since then, in following out the observations thus instituted, I have carefully examined and classified eleven hundred and four head-shapes; including those of two of the principal hatters in Montreal, and of one in Toronto.† In testing their various differentiæ, I have arranged them by correspondence in form; by common origin, as indicated by French, English, Welsh, Highland, Irish, and foreign names; and by predominant malformations in those markedly unsymmetrical. The first noticeable fact in comparing the head-forms of the Quebec population was that they were divisible into two very dissimilar types: a long ovoid, and a short, nearly cylindrical one: This is so obvious as to strike the eye at a glance. I accordingly arranged the whole into two groups, determined solely by their forms, without reference to the names; and on applying the latter as a test, the result showed that they had been very nearly classified into French

* Mr. J. Ashworth, Quebec.

† Messrs. J. Henderson & Co., and A. Brahadi. Montreal; and Mr. J. Rogers, Toronto.

and English. In all, out of nearly a hundred head-forms marked with French names, only nine were not of the short, nearly round form; and no single example of this short type occurred in one hundred and forty-seven head-forms bearing English names. A more recent examination of patterns from Montreal led to a very different result. There, where out of the first fifty English head-forms I examined, one example of the short globular type occurred; out of seventy French head-forms (classified by names,) only eleven presented the most prevalent French head-type of Quebec. But the French head of the Montreal district, though long, is not the same as the English type. It is shorter, and wider at the parietal protuberances; and with a greater comparative frontal breadth, than what appears to be the Celtic sub-type of the English head: though also including some long heads of the latter form. So far, therefore, it would seem a legitimate inference from the evidence, that the brachycephalic and nearly globular head of the Quebec district is the Franco-Norman type; while the longer French head of the Montreal district is that of Brittany, where the Celtic element predominates.

But again, amid considerable diversity in minute characteristics, the English heads appear to be divisible into two classes, of which one, characterised by great length, and slight excess of breadth in the parietal as compared with the frontal region, appears to be the Anglo-Saxon head; the other, also long, but marked by a sudden tapering in front of the parietal protuberances, and a narrow prolonged frontal region, is the insular Celtic type. These inferences I deduce from the following data. A certain number of the head-forms, marked by the extreme characteristics of great length and nearly uniform breadth, all bear true English or Saxon names, *e. g.*: Anderson, Bell, Booth, Brown, Beard, Blackie, Cosford, Chapman, Dean, Forster, Fisher, Guest, Giles, Mason, Steel, Sanderson, Thompson, Westby, Waddel, &c. Out of upwards of four hundred heads more or less nearly approximating to this type, only two presented the exceptional names: O'Callaghan and Donovan. The form which I distinguish from this as the British Celtic type, is equally long, but otherwise very different, approaching to what may be most fitly designated the pear-shape. Of this I have found representatives of all the insular subdivisions of the Celtic race, *e. g.*: Campbell, Fraser, Grant, McLean, McKenzie, McDonald, McMillan, McLeay, McKay, McLennan, McGregor, Stuart, &c.; Beaven, Davis, Evans, Flynn, Hughes, Jones, Owen, Gwynne, &c.; and Donelly, Flaherty, Flannigan, Kelly, Macguire, McCaul, McLeary, McCollum, O'Brien, O'Calahan, O'Reilly, &c. The subdivisions which such names suggest are scarcely less obvious than those which, in Lower Canada, separate the Browns, Smiths, Hendersons, Thompsons, Masons, Langtons, Fenwicks, Frisbys, &c., from Charlebois, Barbeau, Charpentier, Chartraud, Deslauner, De-Lusingnan, Durocher, Filialreaut, Labelle, Lafontaine, Lemieux, Montigny, Nadeau, Perrault, Robitail, Simard, Saudier, Verrier, &c.

But the Saxon and Celtic names of the British Islands indicate races which have been intermingling for centuries, until many lines of demarcation have been nearly effaced; whereas the French and English populations of Lower Canada are still separated by the clearly defined traces of recent contact. The latter condition of things is illustrated in their head-forms. With few exceptions they can be distinguished from each other at a glance. Whereas, although the two types which I conceive to be the Saxon and Celtic head-forms of the British Islands, are satisfactorily classed apart, by such evidence as I have indicated: yet many modified forms occur, disclosing all intermediate gradations between the two; and occasionally the pure Saxon type bears a Celtic name, or *vice versâ.* Normandy did indeed once furnish its quota of colonists to Britain as well as to Lower Canada. But, if the followers of William of Normandy included those of the brachycephalic type now met with in Canada, they have long since intermingled with, and been absorbed into the common mass. Exceptional forms are traceable at times, where the evidence is accessible, to the miscellaneous sources of intrusive population. One head of peculiar and marked brachycephalic form, with a common English name attached to it, proved to inherit its specialities from a Hindoo mother; another, no less striking for its peculiar length, was that of a "black Douglas." In these cases the names were calculated to mislead; but in general they furnished the desired clue. In arranging a large collection of head-forms according to their shapes, I found on one occasion that I had thrown sundry exceptional patterns aside as failing to classify under any of the determinate types of French and English heads. On returning to examine the names, they read as follows: Kleisen, Lansberg, Rosebrugh, Snider, Kauffman, Kendrick, DeWintol, Bastedo, Hirsch, Levy, Benjamin. The list of names abundantly accounts for the miscellaneous character of their head-forms, if there is any ethnical foundation for such a system of classification.

So far then as this evidence indicates, the French head as found in the Montreal district, with its Breton population, presents a longer type than that of the Quebec district with its colonists from Normandy. This therefore seems to point to the assignment of the longer head to the more Celtic French race. Again, the Celtic head-form of the British Islands appears to be still more dolichocephalic; and so constant is this, that out of ninety-three head-forms bearing Celtic names, I have only met with six approximating to the short or brachycephalic type; and out of five hundred and forty-two with Anglo-Saxon names, only thirteen of short type: and this among a population inter-marrying with their fellow-subjects of French origin, and with no permanent barrier to the ultimate blending of the two races into one. So far as the cranial evidence defines a difference between the two types of head of the French habitans, it accords with the historical data referred to by M. D'Halloy in his *Races Humaines*, wher—after referring to the predominance of Teutonic influence on the population of Northern France classed by him in the LATIN FAMILY, as distinct from the Bas-Bretons and others of the CELTIC FAMILY, he adds: "Cette influence se fait surtout sentir en Normandie, contrée qui doit son nom aux établissements que des Scandinaves y ont formés dans le 10e siècle." The population was distinguished by language as well as name from the Celtic north-west of Neustria, long before the invasion of the Northmen. Romanised Gauls, Franks, and Burgundians were mingled under Merovingian, Carlovingian, and Scandinavian conquerors, by processes very analogous to those which made Celtic Britain Anglo-Saxon. Nor is the character of the Franco-Canadian wholly inconsistent with the idea of a temperament modified by some infusion of Norse or Danish with the older Gaulish and Frankish blood. Instead of what Tennyson calls "the blind hysterics of the Celt," the Canadian Habitant is marked by a docile and kindly temperament, which presents some analogies to that of the Scoto-Scandinavian population of the Orkneys. Sheriff Robertson, of Orkney, after long experience in the exercise of his judicial functions there, illustrated the character of the population by referring me to one of the Islands forming a distinct parish with several hundred inhabitants, who dwelt there without resident justice, magistrate, or constable, and had never given him occasion to bring his judicial services into requisition. This he contrasted with the more irascible fervour of the Celtic population on the neighbouring Scottish mainland. But if the brachycephalic head of the Quebec district is not Celtic, it is not Scandinavian; but rather belongs to the round and short form of cranium, which constitutes one of two marked types, recovered by M. Brullé, of Dijon, from what he believes to be sepulchres of the time of the Burgundians. Specimens of those, and others of the same type, are in the Parisian Society's Gallery; but they appear to be universally assigned there to a pre-Celtic race.

Here again we see the influence of preconceived ideas. The Finnic hypothesis of Arndt and Rask lies at the foundation of the opinions advanced by Prichard, Retzius, D'Abbadie, Pruner-Bey, Broca, Thomas, and others, as to the Finnic type of the Basques, and the pre-Celtic head-form of Denmark, France, England and Scotland. This assumes the Finnic physical type to survive from periods long anterior to the arrival of Celts or other earliest historic races in Europe. But it is possible that we are tempted by the present tendencies of anthropological research, in its alliance with geology, to slight recent for more remote sources. That the Scandinavian nations shared with a Finnic population, their common country, is as certain as that the Franks intermingled with the Gauls, and the Angles and Saxons with the Britons. It can scarcely be doubted, moreover, that the Finns—occupants of a diminishing area within all recent centuries,—formed a larger proportion of the population of Northern Europe in the ninth century than they do now. In that century it was that the Norwegians and Danes commenced their inroads on the British Islands, North Holland, and Normandy; and that Norskmen, Danskermen, and Ostmen, Fion-ghaill and Dubh-ghaill, began to effect settlements in those countries where their traces still abound. But the Finns, who are elsewhere a hypothetical element of the population of prehistoric Europe, occupied the isolated Scandinavian peninsula in common with the Northmen; and are even now to be met with on Norwegian fiords from whence the marauding Vikings were wont to issue forth. Subsequent, however, to A.D. 1000 —the era of St. Olaf,—increasing intercourse with other nations has tended to approximate the Scandinavian to the Germanic type. Seeing, then, the independent concurrence of so much evidence in proof of the predominance of a brachycephalic head-form, approximating to the assumed Finnic type, in the very regions of Orkney and the Scoto-Scandinavian mainland, in the north-east of Ireland, and in Normandy, where Norse influence most abounded: is it logical to ignore this, and seek the source of such ethnical peculiarities wholly among hypothetical precursors of the historic races? Wherever a native population holds its ground as a race in the midst of its conquerors, intermixture in common interests, and in blood, is inevitable. Gaul joined with Frank in the struggle against Rollo and his Northmen: Gael and Saxon fought together for Scottish independence, against the Edwards; Welsh and English shared with the Norman the triumphs of the Black Prince; as the modern Hindoo, Affghan, Red Indian, and Negro, have been enlisted in the service of their Anglo-Saxon masters. The discrepancy of races in most of those instances surpasses that which results from the assumption that the wild hordes of Norse marauders included Finns as well as true Scandinavians. Their intermixture, in recent centuries is no mere assumption; but a well established fact.

The Northman of the ninth century was by the nature of his geographical position more Finnic than the Dane. The Norwegian and Swede are so even at the present day. I have carefully examined a series of Scandinavian and Finnic crania in the collection of the Academy of Sciences of Philadelphia, with a view to this question. The true Norwegian and Swedish head is dolichocephalic, of moderate length and frontal elevation; but the "Swedish Finn," or mixed race,—of which the collection includes three examples,—is short and semi-globular, partaking of the characteristics of the true Finn, with its marked parietal, and short longitudinal development. The Philadelphia collection contains nine pure Finn skulls and a cast, in addition to those of the Scandinavian and mixed races, nearly all selected by Professor Retzius, and highly illustrative of the two distinct types, and the intermediate hybrid form. It seems, therefore, in no degree inconsistent either with scientific or historical evidence, that we should trace a historic, as well as a prehistoric Finnic element in the brachycephalic and semi-globular head-forms of Orkney, the Hebrides, the north-east of Ireland, Normandy, and the Quebec district of Lower Canada. But on any supposition we must not overlook the characteristics of the races with whom the intruders intermingled. Among the Scandinavian crania of the Mortonian collection, are three ancient Swedish skulls of extreme dolichocephalic proportions, which would probably be classed as Celtic by those who regard the elongated cranium as the unvarying characteristic of the latter type, and maintain the preoccupation of Scandinavia by a Celtic race. To assume that the Franco-Roman population of Neustria prior to the Norman invasion was purely Gaulish, would be to ignore all history from Julius Cæsar to Charlemagne. "All the foreign peoples of the Indo-European stock," says M. Broca, when referring to the intermixture of races on the French soil, "who have, one after another, invaded, conquered, or occupied the whole, or a part of our country, the Celts, the Cymri, the Germans, were dolichocephalic, and so were the Romans, though in a less degree. It is, therefore, not doubtful that the brachycephalic type still so prevalent among us, is derived from populations anterior to the arrival of the Celts."

Taking then the known elements as our guide: if all but the Celtic form can be determined, there can be no insurmountable difficulty in ascertaining its type. Assuming the modern German head as a key to the influences of Frank and other Germanic intermixture, it is decidedly shorter and more globular than the Anglo-Saxon head. Indeed my attention was first directed to the hat-gauge as a useful cranial test by a remark of the late Dr. Gustaff Kombst, that he could never procure an English-made hat that would fit his head, owing to the greater length and narrowness of the English head. Leaving out of consideration, then, for the present, any race prior to the Gauls: it is wholly consistent with historical evidence to conceive of them, modified by successive interfusions of trans-Rhenic and other Roman legionaries, the later Franks, and others of Germanic blood; and then of Danes and Northmen, with whatever amount of Finnic element the latter may have been affected. Still the type of head characteristic of the population of Normandy, and of Lower Canada at the present day, requires, either that the undetermined Celtic element modified by all those dolichocephalic foreign influences, must have been brachycephalic; or, that, altogether prior to the first Roman invasion, there existed there a large predominance of such a pre-Celtic element as the Finnic one, assumed as unquestionable by M. Paul Broca, and other French ethnologists. For no permissible augmentation of a Scandinavian-Finnic element would suffice to account for the modern head-form, on the theory of an extreme dolichocephalic Gaulish cranium. Against the conclusion that the Gaulish head resembled the brachycephalic type of the British barrows assigned by Dr. J. B. Davis to the British Celts, two arguments are of considerable weight. (1.) The modern Normandy-head, though brachycephalic, has more affinity with the semi-globular type of the mixed Swedish-Finn, than with that of the British barrows. (2.) The Breton head, in which it cannot be doubted that the Celtic element predominates to a much greater extent than in that of Normandy, instead of approximating more closely to the British brachycephalic type, confirms the idea of a dolichocephalic Celtic head-form. But the analogy of the modern Germanic head, with its numerous sub-types, suggests the probability, that the once widely diffused Celtic nations included variations in physical form, no less definite than those which distinguish the Cymric from the Gaelic subdivisions of their language. The Gaulish and British head-forms must be assumed to have belonged to a common type; but it is probable, if not indeed demonstrable, that they included varieties not less distinct than those of the modern German and Anglo-Saxon. The inquiry, however, is just at that stage when the careful setting forth of the whole evidence—even where it may seem to conflict,—is best calculated to lead to a satisfactory decision. The known, unknown, and undetermined elements of the proposition may, I think, be fairly stated as follows: leaving the Celtic element to be determined by comparison between the modern head-form as the sum of the whole, and the value of the ascertained elements. Thus tested, the weight of evidence appears to be in favor of the Dolichocephalic as the undetermined, and therefore the Celtic element:—

BRETON HEAD-FORM.

| | |
|---|---|
| Pre-Celtic, Turanian or Finnic element | *Brachycephalic?* |
| Frank and other Germanic elements | *Dolichocephalic.* |
| Native Celtic element | ——— ? |

Modern Head:—DOLICHOCEPHALIC.

NORMANDY HEAD-FORM.

| | |
|---|---|
| Pre-Celtic elements | *Brachycephalic?* |
| Germanic elements | *Dolichocephalic.* |
| Scandinavian: Norse element | *Dolichocephalic.* |
| " Finnic element | *Brachycephalic.* |
| Native Gaulish element | ——— ? |

Modern Head:—BRACHYCEPHALIC.

ENGLISH HEAD-FORM.

| | |
|---|---|
| Pre-Celtic element: Megalithic race | Kumbecephalic. |
| Pre-Celtic (?) element: Barrow race | Brachycephalic. |
| Germanic elements: Anglian, Saxon, Frisian | Dolichocephalic. |
| Scandinavian elements: Danish, Norman | Dolichocephalic. |
| Native British element | ——— ? |

Modern Head:—DOLICHOCEPHALIC.

SCOTTISH HEAD-FORM.

| | |
|---|---|
| Pre-Celtic element: Megalithic race | Kumbecephalic. |
| Pre-Celtic (?) element: Barrow race | Brachycephalic. |

| | |
|---|---|
| Germanic elements: Anglian | Dolichocephalic. |
| Scandinavian elements: Norse, Danish | Dolichocephalic. |
| Celtic elements: Gaelic, Erse. British | ——————? |
| Modern Head-Form: | DOLICHOCEPHALIC. |

The results of comparisons instituted from time to time between English and Scottish heads, and confirmed by the practical experience of hatters in both countries, lead me to the belief that they differ in the greater length and less height of the Scottish than the English head. Leaving out of question the pre-Celtic elements in both cases, the others can be defined with tolerable precision. The traces of the Briton in Scotland are as unmistakeable as those of the Gael in Wales. Nevertheless the British is the predominant Celtic element in the South, and the Gaelic in the North. Of the Germanic elements the Saxon is exclusively English; the Anglian, and apparently the Frisian, Scottish. Of the Scandinavian elements, the Danish predominates in England, the Norwegian in Scotland; and the latter was very slightly affected by any Norman element. It is also important to bear in remembrance the relations in which the races stood to each other in the two countries. In England the remnant of Romanised Britons rapidly disappeared before the Saxon and Anglish colonists; so that when the Danes followed in their wake, they found only an Anglo-Saxon people to resist or to intermingle with. In Scotland, on the contrary, a race of Celtic kings occupied the throne of the united kingdom till the death of Alexander III. in 1286. There also the Northmen of the Islands and Sutherland intermingled with a purely Celtic population. In the war of independence the Islesman and the Highlander of the mainland made common cause with the lowland Scot; and the Gaelic and Anglo-Scandinavian races intermingled on perfect political equality: the Gael only exchanging the Celtic for the English tongue, when he passed beyond the Highland line, and merged into the mixed stock of the low country.

It thus appears that where the Celtic element most predominates, the longer form of head is found. It is also noticeable that there are indications of the Gaelic and Erse type of head being longer than the British. The results, as a whole, of the classification of the known and unknown elements in tabular form, appear to involve the assignment of dolichocephalic characteristics to the undetermined Celtic element both of the French and English head.

The question invites further research, in all its bearings; and as one subsidiary source of information, the population of Lower Canada furnishes materials valuable alike to the ethnologist and the historian. There a people of French origin has been isolated from the great revolutions which have wrought such changes on their European congeners. Their physical, moral and intellectual development, all admit of curious comparison with those of the modern Frenchman. The first has been subjected to novel climatic influences for upwards of two centuries; the latter have been moulded by political and religious institutions, brought with them from their old home by the colonists of Louis XIII.; whose descendants have only recently emancipated themselves from seignorial tenures and other shackles of a feudal system of centralization. Those, with the habits of life incident to a climate so diverse from that of northern France, may account for some characteristic traits. Others may be still found among the kindred population of Normandy or Brittany. But, assuredly the summary way in which Dr. Knox has dealt with this element of the European population of the New World, as "The French Celts of the Regency," is wholly unworthy of acceptance.*

Apart, however, from all theory or inductive reasoning, the following facts appear to be indicated in reference to the colonists of Lower Canada: 1st. That the French Canadian head-forms are, as a rule, shorter and relatively broader than the British; 2nd. That the former are divisible into two classes, of which the short globular, or brachycephalic head occurs chiefly in the Quebec district, settled from Normandy;† while the longer type of head predominates in the Montreal district, originally colonised by a population chiefly derived from Brittany and the Department of Charente Inferieure. The mode of investigation thus indicated yields certain definite results, and admits of wide application. Should the anthropologists of Paris be induced to turn their attention to it, the means of comparison supplied by a similar determination of the head-forms of regiments composed of conscripts from Bretagne, Normandie, Franche Compté, Languedoc, and Gascoigne, might go far towards eliminating the true Gaulish

* *Races of Men:* p. 75.

†In the summer of 1863, immediately after examining the Canadian head-forms of the Quebec district, I made a tour through Normandy, and specially directed my attention to the head forms of the peasantry. A short form of head appears to prevail; but without positive measurement no precise results can be attained.

type; and could not fail to supply other information no less acceptable to the ethnologist.

But there is another aspect of the inquiry into the significance of cranial forms which derives striking illustration from the mode of investigation now referred to. When treating in a former communication,* of the various causes tending to produce unsymmetrical cranial development, I remarked: The normal human head may be assumed to present a perfect correspondence in its two hemispheres; but very slight investigation will suffice to convince the observer that few living examples satisfy the requirements of such a theoretical standard. Not only is inequality in the two sides of frequent occurrence, but a perfectly symmetrical head is the exception rather than the rule. The examination of the head-forms already described amply confirms this opinion. Examples of extreme dissimilarity between the two sides, and of abrupt inequalities of various kinds are far from rare. Of one group of 373 head-forms carefully tested for their unsymmetrical characteristics, only 48 could be set apart as uniform, or only slightly unsymmetrical, and not decidedly developed in excess on one side or the other. Of the French heads 67 exhibited a decided development towards the left, with a flattening or depression on the opposite side; and 20 were correspondingly affected towards the right side. Of the British heads, including those with Celtic and other patronymics, 116 exhibited a decided bulging to the left side, and 31 a less decided development in the same direction; while 63 had the same characteristic feature no less strongly on the right side, and 23 a less decided bulging to the right. In all, the results on this point were, that out of eleven hundred and four British and French head-forms, four hundred and forty-two were developed in excess to the left, and three hundred and eighteen to the right; leaving three hundred and forty-four nearly symmetrical. It thus appears that the tendency to unsymmetrical deformity is nearly as three to one; and that in the abnormal head the tendency towards excess of development towards the left, is upwards of two to one. But so far as my opportunities of investigation have extended, this tendency is more decidedly expressed in the brachycephalic (French) heads than in the dolichocephalic, and in those the sinistral is to the dextral excess fully in the ratio of three to one. I

**Ethnical forms and undesigned artificial distortions of the human skull. Canadian Journal*, vol. vii., p. 414.

have discussed the probable causes of such deformations in former papers, and need not resume the subject here.

Another slight, but curious, indication of the unsymmetrical arrangement of the two sides of the head is shown by the position of the ears. To this my attention was drawn by my friend, Mr. Langton, when examining the French head-forms at Quebec. By attaching a paper frame to the rim of a hat, and marking a line corresponding with the centre of each ear, the oblique distortion, which is best observed by looking on the base of the skull, is readily detected in the living head. The extent to which the ears diverge from the opposite points of a line drawn at right angles to the longitudinal diameter is frequently startling to those whose attention is directed to it for the first time. No ethnical significance can be attached to such irregularities in cranial conformation. The same, I doubt not, will be found among all races; and the habits of civilized nations tend no less to their production, than the undesigned usages of savage tribes. One of the most remarkable examples of an unsymmetrical skull which has recently come under my notice, is that of a Chinese, in the collection of Dr. Warren, at Boston, which is distorted obliquely, with predominant development on the left side.

One other question, which may receive illustration from a sufficiently extensive series of observations, is that already referred to, of the possible changes of head-form by mere lapse of time, with the accompanying modifications of diet, climate, and habits of life. Among the short head-forms occurring as exceptions to the general Anglo-Saxon type, is that of my friend, Dr. T. Sterry Hunt, F.R.S., the descendant of a New England family dating back nearly to the first voyage of the "May Flower." It suggests the desirableness of a minute comparison of head-forms of the old New England families. The experience of the New England hatters points, as we have seen, to the prevalence there of an unusually long and high type of head. But the percentage of native Americans of old descent even in the longest settled States must be small, situated as these are on the seaboard, and receiving the annual influx of emigration to fill up the gaps caused by wanderings of their own population into the new West. Indications of the development of a New England type, or variety of the Anglo-Saxon colonist have long been noted with interest; and minute data relative to the cranial type of the pure descendants of the earliest settlers would be of great value in their bearing on this subject. So far, however, the diverse forms still clearly distinguishing the French colonists of the Quebec and Montreal districts of Lower Canada, rather indicate the permanency of the cranial race-forms, and their consequent value as a clue even to minute sub-divisions of the same nation, though severed for centuries from the parent stock.

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## THALLIUM.

The discovery of voltaic electricity by Galvani, and the application of this new power to the decomposition of chemical bodies by Sir Humphrey Davy, led to the recognition of a large number of elementary substances, the existence of which had been until then unsuspected. The preparation of the metallic bases of the alkalies, the alkaline earths, and the earths proper, is due either directly or indirectly to the application of galvanism, and no other force, no other method of analysis has been so productive of interesting discoveries as regards the ultimate constitution of matter. Recently, however, another branch of science, that of spectrum analysis, has bidden fair to be equally prolific in results, for although its birth dates but from a few years back (neglecting Talbot's experiments as not having led to any practical results) no less than three new metals, Caesium, Rubidium, and Thallium have already through its means been added to the list of the known elements.

The first two must often have been under the chemist's hands, but from similarity, especially in the platinochlorides, to potassium, have constantly escaped observation ; indeed the rare mineral Pollux, found in Elba, and supposed to be and described as a silicate of alumina and potassa has recently been proved by Pisani to be essentially a silicate of alumina and cœsium.

Cœsium and Rubidium exist only in exceedingly minute traces in the waters and minerals from which they are extracted, and although from their constant occurrences in certain vegetables, especially the beet-root, they cannot but be considered as essential to the growth of those plants, yet at present their investigation is by no means complete, and no useful applications have as yet been discovered for the metals or any of their salts. Thallium on the other hand, which was discovered much later than the two last mentioned, is now manufactured in large quantities, has been tolerably well investigated and promises to be of considerable use in some of the industrial arts.

It is curious to remark that two if not three of these metals for the discovery of which we are indebted to spectrum analysis, should be found to belong to the class of the alkalic metals, for cœsium and rubidium are so similar as to be with difficulty distinguished from potassium, and thallium which was at first ranked with lead, is now by many associated with the alkalies or rather forms a connecting link between two groups, exhibiting some of the characteristic properties of both.

On this account thallium is one of the most interesting metals, and as the different papers describing its combinations are scattered through various journals, the following resumé may not be without interest to our chemical readers.

The new metal seems to have been discovered independently both by Mr. Crookes and M. Lamy, but the priority is due to the former, who discovered the element in March 1861, and had prepared several of its compounds as early as January 1862, and at the time of the exhibition in 1862 was quite aware of its metallic character, although M. Lamy had succeeded in obtaining it in a denser form exhibiting completely its claim to the character of a metal.

Both chemists obtained it originally from some seleniferous deposits from the chambers of a sulphuric acid factory, and as it will be recollected that Berzelius discovered selenium in his examination of such a deposit from Gypsholm it became interesting to ascertain whether that substance had contained thallium as it would not in all probability have escaped detection under the hands of so acute a chemist as the Swedish philosopher. Fortunately, Mr. Crookes was enabled to examine some of the original Gypsholm deposit, and found it to contain no trace of thallium.

The new metal seems to be very widely distributed, existing in native sulphur and in most pyrites, and in many other ores and commercial products. It has also been detected in the mineral water of Nauheim and in lepidolite and mica, although it has been objected that possibly the thallium may have been contained in the reagents employed, as was proved to be the case with arsenic some years since.

The principal source of thallium appears to be the different kinds of pyrites, either iron or copper, and hence we find it both in the sulphur obtained from the first, and hence in many bodies derived from sulphur, and also in the copper obtained from the latter. Spanish copper seems to be especially rich in thallium. The richest pyrites examined was found to yield about 10 ounces to the ton, and the sulphur obtained from the ore about 10 grains to the pound. The sulphur is digested in caustic potassa till dissolved, the dark residue dissolved in sulphuric acid, precipitated by hydrochloric acid, again converted into sulphate, and the metal separated either by zinc or electricity. The easy solubility of the sulphate and the insolubility of the chloride render the separation of the metal on the large scale an easy operation.

In sulphuric acid factories, the thallium is carried away with the sulphurous acid, but is partly deposited in the flues, and much more might be obtained if the flues were made longer. This flue-dust seems to be the most convenient source of the metal, the quantity however is not large, as Mr. Crookes found only 1 grain in a pound of a seleniferous deposit.

Thus the thallium may make its appearance in common oil of vitriol and in hydrochloric acid; five grains have been obtained from a hundred weight of the latter. It may be detected in less than a pound of some kinds of hydrochloric acid by neutralising with ammonia, digesting with sulphide of ammonium, dissolving the dark precipitate in nitric and hydrochloric acid, reducing by sulphite of soda, and adding a few drops of iodide of potassium; a yellow colour or precipitate will be produced.

Thallium has also been detected in some dark coloured varieties of sulphide of cadmium, and in some salts of copper and bismuth. It has also been detected in tellurium.

Thallium has a perfect metallic lustre, but tarnishes rapidly in the air, the coating of oxide is readily removed by water, as in the case of most other metals by acids. It softens at a temperature of 100° C., and if kept at that heat, exhibits a crystalline structure, similar to that produced by the continued action of water.

Heated before the blowpipe, it melts and oxidises, giving off fumes of a white colour with a tint of red, the fumes continue to form after the heat is removed, as in the case of antimony. If a button of the metal be heated in a cupel, and introduced into oxygen, it will burn, the oxide being absorbed into the cupel as with lead. It is slowly acted on by hydrochloric acid, rapidly by nitric and sulphuric, differing in this respect from lead. The metal is quite soft, and can be even scratched with the nail, when precipitated from its sulphate or nitrate by means of zinc, it forms crystalline plates. When thallium solutions are decomposed by electricity, brown peroxide is precipitated in which respect again it resembles lead, but the deposited oxide dissolves again.

The equivalent appears to be 204; this fact cannot be taken as any argument against the propriety of ranking thallium among the alkalic metals, as the equivalents of lithium, sodium, potassium, rubidium and cœsium are respectively 7, 23, 39, 85, 123. The position of the bright green thallium line does not correspond with any dark line of the spectrum, and hence we may conclude that this new element does not exist in the solar atmosphere.

By electrolysis it can be obtained in beautiful metallic crystals which if required in mass, can be squeezed and fused under cyanide of potassium. It is very malleable, but not very ductile, wires must be formed by squeezing the metal through tubes. The specific gravity is 11.9, which would certainly tend to separate it from the alkalic metals. The metal will mark paper like lead, but the marks soon become obliterated from the formation of the oxide, they may be reproduced by washing with sulphide of ammonium, when black sulphide of thallium is formed, which however also oxidises rather readily to sulphate; another point in which there is a certain resemblance to lead, and not to potassium.

Thallium may be ranked next to bismuth, as regards its diamagnetic properties.

It fuses at 550 F. (287 C.) and distils at a red heat. The crust formed on the metal by exposure is first yellow and then becomes dark, easily removed by water, and communicating to it a strong alkaline reaction, and a caustic biting taste. Owing to the same cause, the metal makes marks on turmeric paper, which soon become brown.

As regards its power of conducting electricity, thallium stands between lead and tin, the relative powers being respectively 7.77, 8.64, 11.45.

*Quantitative Determination.* If the thallium is present in the form of protoxide, it can be precipitated from its solution by bichloride of platinum, but this method is objectionable, inasmuch as the yellowish white double chloride is in such a fine state of division as to pass through the filter. The best method is to precipitate the metal as iodide from strongly ammoniacal solution, it is best to precipitate at a temperature of 100°, to use solutions not too dilute, to allow the mixture to cool before filtering, and to wash out with ammoniated water. Werther denies that the iodide is soluble in excess of iodide of potassium, and only to the extent of $\frac{1}{4000}$ in water.

If the thallium is present in the form of teroxide, it can be precipitated by ammonia, the solution must be cold, and the washing continuous, otherwise a portion of protoxide is formed. The teroxide may also be reduced by sulphurous acid, and the metal precipitated as iodide.

Thallium and all its compounds communicate a brilliant green colour to the flame of a spirit or gas lamp, and if obtainable in sufficient quantity will doubtless be used hereafter for pyrotechnic purposes.

*Protoxide* is obtained by the action of baryta on the sulphate; it is easily soluble in water, attracts carbonic acid from the air, dissolves silicic acid, and hence cannot be kept long in glass vessels; the solution is strongly alkaline.

*Peroxide* is obtained by the action of ammonia on the perchloride, and is insoluble in water, and of a brown colour.

*Protochloride* is white, slightly soluble in water, fuses to a horny mass like chloride of silver, unchanged by exposure to light.

Apparently there are some other chlorides standing between this and the following compound :—

*Terchloride* is obtained by the action of chlorine on thallium under water, or by the long continued action of the same on the protochloride. The action must be continued until bichloride of platinum gives no precipitate. The chlorine is then driven out by carbonic acid, and the solution evaporated in vacuo. It cannot be produced by the action of aqua regia on the metal, as mixtures are formed of the proto and terchloride. The solution, when evaporated, deposits long colourless thick prisms, very easily soluble and deliquescent. The composition is $TlCl^3 + 2HO$, but the water cannot be determined by heating as a portion of protochloride is formed.

*Iodide* is precipitated by iodide of potassium, either of an orange-red colour or citron-yellow, according as the solutions are concentrated and hot, or dilute and cold. From a solution of acetate of potassium it is precipitated of an orange-red colour, and in small cubical crystals; they contain no water, fuse into a blackish-red liquid, and partly sublime. Soluble in 20,000 parts of cold water. Iodide of potassium added to a solution of the terchloride forms iodide and iodine.

*Bromide* is similar to the lead salt.

*Sulphide* is precipitated perfectly from alkaline, only slightly from acid solutions; insoluble in alkalic sulphides, oxidises readily in the air to sulphate. The cyanide and ferrocyanide are insoluble in water, and apparently there are two carbonates, one soluble, the other insoluble.

*Sulphate* is obtained by dissolving the metal in sulphuric acid, or by acting on the chloride or nitrate with the same acid. It is anhydrous, easily soluble in water, and forms with sulphate of alumina an alum, crystalising in regular octohedra.

Apparently there are several phosphates, some soluble and others insoluble; the nitrate is soluble, the chromate yellow and insoluble.

The compounds of oxide of thallium with organic acids are in general very similar to the salts of potassa, and of these Kuhlman has examined the oxalates, tartrates, racemates, acetates, malates, citrates, benzoates, urates, valerianates, and several others. A double salt containing antimony has been obtained corresponding to tartar emetic.

*Double Sulphates.*—By mixing sulphate of thallium with excess of sulphate of nickel, zinc, iron, or magnesium, double salts may be obtained having the same formula and the same crystalline form as the other magnesian double sulphates, a fact which is certainly a a strong argument in favor of ranking thallium among the alkalies.

The iron salt decomposes readily by absorption of oxygen; the magnesium salt is also decomposed by repeated solutions; but the zinc and nickel compounds correspond most closely with those containing potassium instead of thallium. The formulas are :—

$$NiO.SO^3 + TlO.SO^3 + 6HO$$
$$ZnO.SO^3 + TlO.SO^3 + 6HO$$
$$FeO.SO^3 + TlO.SO^3 + 6HO$$
$$MgO.SO^3 + TlO.SO^3 + 6HO$$

*Double Hyposulphite.*—When chloride of thallium is dissolved in a boiling solution of hyposulphite of sodium, and the solution allowed to cool, long silky shining crystals separate, which can be washed with water and recrystalised. The formula was found to be

$$3\,NaO.S^2O^2 + 2\,TlO.S^2O^2 + 10\,HO.$$

*Silico-fluoride* has been obtained in distorted octohedra by digesting carbonate of thallium in hydrofluoric acid containing much silicic acid. The salt is very soluble, and the formula has not been accurately ascertained.

From the above it will be seen that thallium well deserves the name given by Dumas—the "Ornithorhyncus of Metals," exhibiting about equally the characters of lead and potassium. The solubility of the oxide would lead to its being ranked among the alkalies, but it must be remembered that oxide of lead is not quite insoluble; and magnesia is ranked with baryta although virtually insoluble in water.

The solubility of the sulphate would tend to rank it with the alkalies, bnt the opposite character of the haloid salts and of the chromate would point to its classification with lead and silver. The existence of an octohedral alum would be greatly in favour of the first view, were it not that a silver alum has been prepared, but the existence of the magnesian sulphate containing thallium instead of potassium or ammonium is perhaps the strongest fact yet discovered in favour of its alkalic nature.

Thallium may be said to form one of the most curious connecting links between different classes of metals, standing between the lead group, to which it assimilates in its physical and many chemical properties, and the potassium group to which it is evidently closely related.

For analytical purposes it must be ranked in the second division of the second group, among the metals precipitated by hydrosulphuric acid from alkaline solutions, and forming sulphides insoluble in sulphide of ammonia.

H. C.

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*Almanaque para el año de* 1863, *calculado para los Estados Unidos de Colombia por Indalecio Lievano, Encargado del Observatorio Astronomico de Bogota.* Imprenta de echeverria Hermanos. Bogota. 1862.

A thin duodecimo of 64 pages bearing the imprint "Bogota." Perhaps some of our readers would be puzzled to tell at a word where or what Bogota may be. Our pamphlet might inform them that it is a place where books are printed and sold, that it has an astronomical observatory and a military college, and that it lies in the United States of Columbia, a Republic of which the President for the year 1863 was *Tomas C. de Mosquera.* For further information the Gazetteer may be consulted. But before proceeding to examine our little volume inside, let us notice what knowledge we may pick up from the cover; accordingly here we read "*en esta imprenta se han dado a luz*"—notice the elegance of this little phrase, "*i se hallan de venta, las siguentes obras,*" and then follows a list of books, commencing with a "Grammar of the Castilian Language," —price in hard cash, $3.00; and including books of poetry, religion, law, commerce, a manual of politeness (*urbanidad i buenas maneras*), novels, dramas, a code of morals "founded on the nature of man," *juguete filosófico,* and winding up with a "Code of Love, or complete course of definitions, laws, rules and maxims applicable to the art of loving and being loved; by Agapito Canelon, Esquire,"—price $0.40. Thus we see the human insect

"Spins, toiling out his own cocoon,"

in Columbia much the same as in places better known to us. The concluding line of these advertisements is interesting to "us Britishers" as expressing in large capitals "Articulos de escritorio, manufactura *Inglesa.*"

Opening now our almanac, we find ourselves at once in a land of the "historic" faith, for we see that the first page contains the "ecclesiastical reckoning," the four *temporas,* or fasts, and the moveable feasts of the Church. Curiously enough, under the first heading are included the dates of the Jewish and Mahomedan eras, and the Turkish fast or Ramadan, reminding us how closely connected were these races with the Spaniards of old. Then follow "chronological notices," giving an account of the origin and calculations of the dominical and golden letters, the epact, &c., and, we must acknowledge, with a fulness and clearness which we have never met with in any English work. A few important dates in the world's history are added and we are told that "good chronologists count five epochs for the understanding of history, sacred and profane." Students might guess long what these five were, before they lighted on the following:—The taking of Troy, the foundation of Rome, the conquest of Carthage by Scipio, Constantine or the peace of the Church, Charlemagne or the re-establishment of the Empire. Then we have the usual astronomical notices of eclipses, and an extremely well-written and correct article on the different kinds of solar time, and then to the calendar proper, each month being headed by a rude wood-cut of its proper constellation, and each day connected with some saint or martyr, or with ecclesiastical regulations, and the moon's ages and sun's signs interspersed.

A table of meteorological observations at the observatory of Bogota, for the months of October and November, 1862, gives some interesting results. In October the mean temperature of the air was about 60½ degrees Fahrenheit, which is about twelve degrees higher than at Toronto for the same period, though it must be remarked that the observations at Bogota were taken in the daytime and are thus unduly exalted above the Toronto ones, which include 6 A.M. and midnight; but Bogota seems less subject to those sudden changes which make the climate of Toronto so trying—the extreme deviation in the former place being about 9 degrees while in the latter it is no less than 44. The amount of rainfall was 6·36 inches, while at Toronto it was about 2½, but at Bogota nearly the whole fell between the 20th day and the end of the month. Similarly, the mean temperature for November was 59°.8, contrasting with 35°.6 for Toronto, and while the extreme range for Bogota appears to be about 5 degrees, that of Toronto is nearly 40. The rainy season continues during this month, the fall being upwards of nine inches, with only four fair days throughout, while at Toronto the fall (including snow) was under three inches, and there were fifteen days without either snow or rain. The mean height of the barometer is about twenty-two inches, and Bogota must therefore be situated at an immense height, some eight or nine thousand feet, above the sea-level; our author in conjunction with *el Señor William Chandless, illustrado viajero* (the rough Saxon vocables sound oddly amidst the smooth Castilian) has determined the height above Honda to be 2439 metres, but he says that he waits for the observation of the Señor Chandless at Carthagena, in order to determine the height of his observatory above the sea.

In a page surrounded with black lines our Almanac mourns the *perdida irreparable*—the irreparable loss—caused by the death of the illustrious and modest Señor Lino de Pombo (who appears to have been a mathematical Professor in the military college of Bogota) and in eloquent language, replete with the courtesy and pomp of the old Spaniard, expresses his sorrow :—

"Si en las naziones que van a la vanguardia de la civilizacion i del progreso, i que cuentan con multitad de individuos versados in las ciencias, es siempre mui sensible i lamentable la pérdida de uno de ellos, qué no será en la naciente Colombia la pérdida de un sabio, i de un sabio como el Señor POMBO!—Mútis, Caldas i Pombo!! . . existencias preciosas!! . . Tres veces hase viso eclipsado el horizon de Colon . . ; en la tercera, es el Sr. POMBO que nos deja para volar a la mansion eterna!!"

Three articles remain to be noticed, still by the same author, two of which are mathematical, dedicated to the College of Engineers of the Republic of Venezuela. In the former of these, the subject of incommensurables is attempted to be treated in an elementary manner, reference being made to "mi aritmética," and in the latter a "rigorous demonstration" is given of the formula for compound interest (which question is treated in "mi áljebra autógrafa") by proving it in the cases when the index is fractional or incommensurable (though the case of it being negative is omitted); but the remaining article is remarkable enough to claim a translation. It is entitled "a rigorous demonstration of the existence of the deity, given by Indalecio Liévano in the year 1856," and we must crave the author's indulgence for the inevitable defects which accompany a transmutation of the delicate Spanish auxiliaries into our own limited English. He sets out with the axiom that "what is evident is true" —*(lo evidente es vesdadero)*—from this, he says, comes the existence of the *ego (del yo)* because even if all which is presented to my thoughts were a vain play of my imagination, yet I could not doubt of my own existence—it is *evident* to me. This being laid down, the following series of propositions is thus enunciated and proved :—

PROP. I.—*Something has always existed.*

For, if at some time nothing existed, since from pure nothing, nothing can proceed or begin to be, there never could have existed anything; but since something (namely—*el yo*—the *ego*) does now exist, therefore something has always existed.

PROP. II.—*It is necessary that at some time something has existed.*

Because the possibility of non-existence requires a beginning for being able to be or not to be; therefore, something having always existed, the possibility of the nothing (or absence of existence) ceases, and there remains the *necessary* existence of something.

PROP. III.—*A being which has in another distinct being the cause of its existence, might have not existed.* (*Ha podido no existir.*)

Because if its existence were *necessary*, it would exist as a necessary consequence of the other being, and would then be a necessary part of it, and not a distinct being, which is contrary to supposition.

PROP. IV.—*Some being has existed which has had in itself the cause of its existence.*

In effect, if no being had had in itself the cause of its existence, every being would have had in another distinct being the cause of its existence; but since a being which has had in another distinct being the cause of its existence might have not existed (*Prop.* 3.), it follows that the existence of something would not be *necessary*, which is contrary to Prop. 2; therefore it is false that no being has had in itself the cause of its existence; and therefore some being has existed which has had in itself the cause of its existence.

PROP. V.—*A being which has had in itself the cause of its existence*

(1). . . . *Cannot have had a beginning* :—

For if at any time it did not exist, then in passing from non-existence to existence, it must have had in another being the cause of its existence, which is contrary to supposition.

(2). . . . *Is a necessary being* :—

Because if it were not so, then since the remaining beings, which have had in another distinct being the cause of their existence, might have not existed (Prop. 3), it would follow that it was not *necessary* that at some time some being should have existed, which is contrary to Prop. 2.

(3). . . . *Cannot have an end* :—

Because its existence having been *necessary*, there is no reason why the prolongation of its existence should cease to be *necessary*.

(4). . . . *Is infinitely wise* :—

Because, from having in itself absolutely the cause of its existence, it is plain that it has an exact knowledge of its own essence; this knowledge requires an exact knowledge of all the remaining essences because they all have some relation among each other, and one of them cannot be exactly known without knowing in the same manner all the rest.

(5). . . . *Is infinitely powerful:—*

Because being infinitely wise, it knows all the means of effecting all that is possible, (*de realizar los posibles.*)

CONCLUSION.—*A being, necessary, eternal in both senses, omnipotent and omniscient, and which we call the Deity, therefore exists.*

With the quasi-mathematical form of this reasoning, readers of metaphysics are familiar, from the days of Descartes and Spinoza down to the late lamented Ferrier, but the substance of the above is remarkable as being almost a reproduction of the argumentation of Dr. Samuel Clarke, in his "Demonstration of the Being and Attributes of God," a work which is unsurpassed for acuteness, depth, and we may add, difficulty. That our readers may judge of the parallelism, we append part of the chain of propositions which Clarke sets out to establish. Prop. 1. *Something has existed from eternity.* Prop. 2. *There has existed from eternity some one immutable and independent Being.* Prop. 3. *That immutable and independent Being, which has existed from eternity, without any external cause of its existence, must be self-existent, that is, necessarily-existing.* These latter two propositions are identical with Props. 2–4 of our author. In Clarke's Prop. 2. "some one" must be interpreted as "some one at least." Prop. 6. *The self-existent being must of necessity be infinite and omnipresent.* Against the demonstration of the latter part of this proposition, an ingenious objection was urged by Butler, who afterwards was the famous author of the Analogy, and it is said by Prof. Boole that "it does not appear that Dr. Clarke was ever able to dispose effectually of this objection." This however is a mistake, as Butler acknowledges himself satisfied on this head in his Letter IV. It was to an objection made by Butler against the subsequent proposition that Dr. Clarke does not appear to have made a satisfactory reply. Prop. 7. *The self-existent being must of necessity be but one.* Prop. 8. *That the self-existent and original cause of all things must be an intelligent being.* Prop. 9. *Is not a necessary agent, but a being endowed with liberty and choice.* Prop. 10. *Must of necessity have infinite power.* Prop. 11. *Must be infinitely wise.* Prop. 12. *Must have all moral perfections, such as become the Supreme Governor and Judge of the World.*

It will thus be seen that Señor Lièvano can hardly be credited with originality in his demonstration, but the manner in which he has condensed Clarke's reasoning is very remarkable. With regard to the sufficiency of these and all similar arguments *à priori*, it is difficult to express an opinion, so much depending on the use of words, to which no distinct idea appears to be attached, and on grasping the forms of ideas of which the outlines seem to be in constant fluctuation. Hallam confesses that he was never able permanently to satisfy himself whether the celebrated argument of Descartes on necessary existence was sound, or merely a play on words. And a distrust of such arguments is still more forced upon us when we see how they issue when applied to physical subjects: no philosopher of the present day but would smile at Clarke's discussion of the nature of *motion* and his proof of the necessary existence of a vacuum, and yet it would be hard to draw a line between his reasoning in these cases, and that used in other parts of his demonstration. Prof. Boole writes (Laws of Thought, p. 216) "It is not possible, I think, to rise from the perusal of the arguments of Clarke and Spinoza without a deep conviction of the futility of all endeavours to establish, entirely *à priori*, the existence of an Infinite Being, His attributes, and His relation to the universe. The fundamental principle of all such speculations, viz., that whatever we can clearly conceive must exist, fails to accomplish its end." And though it may be doubted whether Boole has here laid his finger on the precise cause of the futility, yet it would seem that even metaphysicians in the present day virtually accept the result, and rely on the *à posteriori* arguments which depend on the sober procedure of analogy and probable induction. All these may be summed in the dictum of Newton at the close of his immortal *Principia*—"Deum summum necessario existere in confesso est; et eadem necessitate *semper* est et *ubique*"—remembering that this *confessio* is derived from a contemplation of the harmony which pervades the celestial system and which "could not spring from any thing than the design and government of an intelligent and powerful being."

We cannot help remarking the singularity of the fact that an argument so profound as this of Señor Lièvano, and apparently so little calculated for popular appreciation should appear in a mere everyday hand-book such as this calendar is, and adapted for circulation among a people to whom we are not generally inclined to ascribe a high degree of civilization. Neither can we omit to remark the combination in our author of metaphysical and mathematical attainments, a combination in old times so common, now-a-days so rare, and to which rarity may possibly be assigned the depreciation of the former study, now too general, yet hardly to be wondered at, when we see the hopeless floundering of metaphysicians of the Hamilton kind over problems which a sprinkling of mathematics would at once dissolve. In conclusion, Señor Liévano will permit us to stretch a hand to him across the equator, and greet him heartily and with all good wishes for success, as a fellow-laborer in the field of knowledge.

J. B. C.

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## PLANTS AND THE ATMOSPHERE.

BY M. J. JAMIN.

(*Translated from the "Revue des deux Mondes," Sept.* 15, 1864.)

Those who have not devoted themselves to the physical sciences will pardon me if I take the liberty of reminding them that the air, in the midst of which plants and animals live, is a mixture of two very different gases. One, almost inert and without any appreciable influence upon natural phenomena, is called nitrogen. The other, on the contrary, possesses most active properties and plays the foremost part in the maintenance of life upon the globe: this is oxygen. Among other properties, it has that of forming an intimate union with carbon, and during this union, or to employ the scientific term, while this combination is being effected, a considerable quantity of heat and light is evolved. We say that carbon *burns*; and it might, at first sight, be thought to be annihilated; but really it only transforms itself into a gas, which mingles with the atmosphere, in which latter chemistry recovers, at the same time, all the carbon which has been burnt and all the oxygen which has united with it. The name of carbonic acid has been given to this compound gas, in order to recall its origin and composition.

Wood, which is essentially composed of carbon and water, burns in the same manner by abandoning the water, which evaporates, and by transforming the carbon into carbonic acid. Fruit, vegetables, bread, all nutritive substances having a chemical composition analogous to that of wood may, like it, be burned in a furnace, and Lavoisier informs us that the substance of these articles of nutrition undergoes a real but slow combustion in the respiratory system of the animals which feed upon them. Every animal, then, is a furnace; every nutritive substance, a combustible; in respiration, oxygen is absorbed from the air, it is replaced by carbonic acid and the water is rejected either by natural channels or by exhalation.

Since carbonic acid is necessarily generated by animal life, it ought, undoubtedly, to form an integral part of our atmosphere. Accordingly, chemists find it there, but in the minute proportion of from four to five in ten thousand. It is a gas which is incapable of maintaining either life or combustion, being, on the contrary, the effect of both. Thus, all animals placed in a receiver filled with air rapidly exhaust the oxygen which they replace by carbonic acid and soon die, not by a poisonous effect of the gas, but from want of respiratory nourishment.

Having thus recalled these facts, I shall now proceed to describe a famous experiment, which, without our knowledge, plants are unobtrusively performing among us; which is accomplished upon an immense scale; and which may rightly be considered one of the most essential phenomena in the world: an experiment otherwise so simple that every one is able and must be willing to repeat it. In order to succeed, take a fresh and sound leafy stem of the aquatic plants which are to be found growing submerged in ponds and rivers, place it in a white glass decanter filled with spring water or better still, with diluted Seltzer water which, as we are aware, contains a great proportion of carbonic acid in solution. Having corked the filled decanter, invert it, so as to introduce the neck into a vessel filled with water. The cork may then be withdrawn, the water remaining undisturbed and continuing to fill the inverted decanter. The apparatus being thus prepared, remove it to an open place where it may receive the rays of the sun.

As soon as the light strikes directly upon the leaves of the immersed plant, they will be seen covered with a multitude of bubbles which rapidly increase in size, unite, and rise to the top of the vessel where they accumulate. Whenever the light is intercepted by an opaque screen, this disengagement ceases, and by alternately covering the apparatus with light or shade, even at a distance, the current may be reproduced or stopped, at will. After several hours of continuous action, the decanter is filled with this gas. It resembles air but has not the properties of air, for if the vessel being returned to its original position, a slender wax taper, just extinguished and still retaining at the end of the wick some red points, be immediately introduced, it will, at once, rekindle and continue to burn with unusual brilliancy. This gas, then, is not air but oxygen. The same experiment may be reproduced with aerial plants, and, in order not to change their habitual condition, they should be exposed to the sun under glass receivers filled with carbonic acid. After a day this gas will disappear and will be found to be replaced by nearly pure oxygen. Whatever the plant may be, whatever the experimental process, the action always remains identical, and the explanation of this important fact is evident. The green parts of plants decompose carbonic acid; they extract from it the carbon which they retain, and reject the oxygen which they return to the atmosphere. In darkness and during the night, their action changes. Far from absorbing carbonic acid they exhale it; but this nightly reaction being inferior to the diurnal action, plants finally accomplish a part diametrically opposed to that performed by animals. They destroy the carbonic acid which they form, they generate anew the oxygen which they absorb and thus reproduce the organic matter which they consume.

At the sight of so perspicuous an experiment and of so simple an explanation, it seems that scientific men ought to have discovered them from the very first. It would, however, be a strange delusion to believe that such was the case. No great discovery is made without cost to humanity. At first, all is obscurity and impotence; it is only after long investigation that, amid much hesitation, a glimpse of some scattered truth is caught, and, until the moment when a serene light comes to clear up all obscurities, there is need for the collected labors of several generations and the co-operation of many men of genius. It is not uninteresting to study the history of these great discoveries, and I here undertake the recital of the successive experiments which have determined the relations existing between plants and the atmosphere ; I shall continue it as far as the recent labors which have recalled attention to the subject of which I treat.

I.

Charles Bonnet, a physician of Geneva, towards the middle of the 18th century, was the first to enter, experimentally, upon the problem which occupies us. It was the reading of a then celebrated work "Le spectacle de la Nature" by Pluche which decided his profession. He, at first, occupied himself with the subject of spontaneous generation, a question already debated at that period and of which, time has but served to inflame the discussion. He relinquished this subject in order to treat of another, of which, perhaps, he did not foresee the prolific nature; he asked himself what is the function of leaves, and made two experiments that have since remained classic. By the first, he proved that light exercises upon the green parts of plants so lively an attraction that, being placed in darkness, they direct and incline themselves towards the least openings which bring daylight to them. The second demonstrated that, on being plunged into water, plants give forth, under the influence of the sun, a great quantity of air; but at this point the discoveries of Bonnet were stopped; he did not know what that air was and could not know it, since, at that period, the world was in utter ignorance of the first principles of modern chemistry.

Priestley, who was the rival, and, in some respects, the predecessor of Lavoisier, was brought, by the very results of his discoveries, to study the action of plants upon the atmosphere. He had just isolated the remarkable gas which energetically maintains the combustion of candles and the respiration of animals, and, for this reason, he had called it "vital air." He had, besides, discovered that small animals shut up either in this or in atmospheric air, soon changed the properties of these to such an extent that the animals ceased to live and that candles were extinguished by the gases. But in reality, Priestley was not aware of the true nature of oxygen, and, by a blind feeling of rivalry, refused all his lifetime to adopt the theory of respiration just published by Lavoisier; but he knew, nevertheless, how to deduce from his experiments a logical conclusion of the greatest importance. Observing that these little animals vitiated the confined air by their exhalations, he concluded that every individual of the animal kingdom produced, in a continuous manner, the same effect upon the entire atmosphere, and that they would infallibly die in it were there not in the play of natural forces an inverse continuous action tending to restore the air to its original purity, in proportion as it is vitiated by animal respiration. This counterbalance, this regenerating action he sought and found in plants. Under an air tight bell glass filled with air he placed an animal and a plant. The former corrupted the air and died; but at the end of a certain time Priestley discovered that the latter had restored to the air its vital property or the purity necessary for the support of life. It was one of the most important facts in the world's mechanism. From this moment it was known, without as yet entering into the details, that plants and animals perform opposite functions, the latter rendering air unsuitable for the support of their life, the former repairing this evil. The Royal Society of London, in 1773, offered Priestley the Copley medal, and, in presenting him with it, the president of this famous body thus characterized Priestley's discovery: "Plants do not grow in vain; each individual in the vegetable kingdom, from the forest oak to the grass in the meadows, is useful to mankind. All plants preserve our atmosphere in a degree of purity necessary to animal life. Even the forests of the most distant countries contribute towards our preservation by feeding upon the exhalations from our bodies which have become injurious to ourselves." The glory of Priestley was, however, doomed to be obscured. After such noble exertions, views so great and so general, after these public rewards and eulogiums, Priestley, one day, took it into his head to repeat his first experiments and obtained results diametrically opposite, that is to say, that plants, instead of purifying the air, seemed to him then to render it more impure. Astonished at this inexplicable contradiction between the past and the present, he multipled his tests by varying them and the only thing that he was thereby enabled to affirm was, that plants exhibit, alternately, the property of purifying and that of vitiating the atmosphere. The law, therefore, which had won for him the Copley medal was not a general one, and the consequences which he had drawn from it were liable to dispute. Seeking refuge in America, Priestley died in 1801, after a life agitated by religious discussions, having made great discoveries in chemistry which he had not understood, and in vegetable physiology, contradictory experiments that he was unable to reconcile. Priestley, however, was noway mistaken; plants do, in reality, perform alternately the two functions which he had assigned to them, and the only thing that he had not discovered was the condition which determines the occurrence, often, of the one, the repairing function, and sometimes, of the other, the deleterious action; a condition of which Bonnet had caught a glimpse and which Ingen-Housz was about to make perfectly clear. Ingen-Housz was born at Breda, in 1730; he was a physician, and went to England to study inoculation for small pox which was then beginning to draw attention. It was in this voyage that he placed himself upon the track of Priestley's labors and that he resolved to explain their contradictions; he found the cause of them in 1779, and here is how he sums up his own discovery: "Hardly was I engaged in these researches before the most interesting scene opened up before my eyes. I observed that plants have, not only the power of correcting the impurity of air in six or more days as the experiment of Mr. Priestley seemed to indicate, but that they acquit themselves of this important duty in the most complete manner within a few hours; that this wonderful operation is not in any way due to vegetation, but to the influence of the sun's light upon plants; that it only commences some time after the sun rises above the horizon and that it is entirely suspended during the darkness of night; that plants shaded by high buildings or by other plants do not acquit themselves of this duty, that is to say, do not ameliorate the atmosphere, but, on the contrary, exhale noxious air and spread veritable poison in the atmosphere which surrounds us; that the production of good air begins to languish towards the close of the day, and entirely ceases with sunset; that all plants corrupt the surrounding air during the night; that all the parts of plants are not employed in purifying the air but only the leaves and green branches; that acrid, fetid and even poisonous plants acquit themselves of this office equally with those which give forth the sweetest odors and are the most wholesome, etc.*"

Ingen-Housz attained also to the discovery of the force which determines the respiration of plants; this force, which had not even been guessed at, comes from the sun; it is light. It diffuses itself in leaves, which absorb it, and accomplishes the immense work of regenerating the atmosphere. Henceforward, the most important as well as the most difficult step was taken; but there still remained fully as much to be performed. The sciences may be compared to the tub of the daughters of Danaus; each labors to fill it and none succeed, because every discovery unveils a new horizon and removes farther away an end which is never attained. According to Ingen-Housz, the question ought to be asked and was indeed asked; what is this change, determined in the atmosphere by animals, and in what does the remedy which plants apply to it consist? It is the duty of chemistry to reply, and, although he had not specially devoted himself to that science, it was Lavoisier who gave the solution of this new problem. He found it, the day on which he demonstrated that animals absorb oxygen, slowly consume the organic substances on which they feed, and give forth, by expiration, a quantity of carbonic acid containing all the carbon which they have consumed. Vitiated or corrupted air, as Priestley and Ingen-Housz called it, was, therefore, air deprived of oxygen and charged with carbonic acid, and, since plants purify it, this fact seemed incontestably to show that they decompose carbonic acid, retaining the carbon and restoring the oxygen to the atmosphere.

Judging from the point to which chemistry had then attained it would seem that everybody might have divined and made public this explanation. It was not so however, and new experiments were still necessary in order to its discovery. It was a Genevese who had commenced this long campaign and it was another Genevese who had the honor of terminating it. His name was Sennebrier; he had been the friend of Charles Bonnet; it was owing to his example that he had embraced science, and, to his counsels that he studied the relations of plants to the atmosphere. He found that plants placed in water which had been boiled do not evolve any gas to the sun, but that they develope an abundant supply of oxygen when this water has, beforehand, been charged with carbonic acid. He thence concluded that this gas is necessary to the respiration of plants, that it is decomposed by them, and thus he had the glory of giving a formula to the law already prepared and discovered by his predecessors. The question might then rightly be considered as solved; but, during these researches, which had lasted for more than half a century, many errors had crept in among the truths acquired, and contradictory assertions still left ample field of doubt upon various points of detail. A review of all these phenomena was necessary; this was undertaken by Th. de Saussure, who, without adding any crowning fact to the pile of former acquisitions, succeeded in giving to them an experimental confirmation that has not since been contested. After these celebrated experiments there was a long

* Expériences sur les végétaux, par T. Ingen-Housz, 1780.

repose. Physicists and naturalists seemed to regard the question as exhausted and withdrew their special attention to subjects which they considered more fertile. However, the more recent labors of Messrs. Daubeny, Draper, Cloes and Gratiolet, and above all of M. Boussingault have successively been undertaken to remove disputes undecided to the present day; but I desire to omit all that is not specially connected with the general theory; I shall treat neither of nitrogen, which plants seem always to give forth at the same time as oxygen, nor of certain deleterious gases such as carbonic oxide and carburetted hydrogen which M. Boussingault has just found among the products of their exhalations, nor, finally, of the experiments made without much success in order to estimate the special influence of different solar rays. What I desire to shew is, that, after the early studies just alluded to, we find ourselves face to face with a second series much more vast and complicated, upon which we must now enter. We must endeavor to find what becomes of the carbon that remains in plants after the decomposition of carbonic acid.

II.

While the atmosphere furnishes leaves with carbon, the branches supply them with water, which has been drawn up from the soil, and it is natural to think that these two bodies meeting one another, would mutually combine; they do, in fact, combine, but in very variable proportions; let us cite a few examples. If 12 atoms of carbon unite with 10 atoms of water, they may give birth, either to cellulose, which at the same time constitutes the cells and the whole skeleton of the plant, or to starch, with which everybody is acquainted, or, finally, to dextrin, which is valuable, and of which syrups are sometimes made; but, according to circumstances and organs, the proportion of two bodies may change, and with that the chemical products to which they give rise. Thus, 12 atoms of carbon combined with 12 atoms of water constitute glucose or grape sugar, which is found in ripe grapes, and if, from this glucose, two atoms of water be taken away, the result will be cane or beet sugar. In a word, by processes unknown to us, water and carbon meeting in leaves, form a chemical union, and produce an infinite variety of compounds, according to the position, organs, nature, age and exterior conditions of the plant.

Besides the substances just mentioned, and which are composed of carbon and water, plants create another class characterised by an excess of hydrogen. These are fats, oils, resins, balsams, volatile oils, &c. Whence comes this hydrogen? They also form compounds in which appears a fourth element, nitrogen; does it come from the atmosphere? Is it imbibed from the soil? These are questions directly affecting agriculture, and upon which it is obliged to consult chemistry.—The first and the best treatment of these questions is due to M. Boussingault, who found himself most happily situated for the purpose, being at once placed at the head of a great agricultural commission, and habituated to the most delicate operations of chemical analysis. The method employed by him is peculiar to himself; it is so general and fruitful as to apply to the requirements of all individual cases. Here is what it consists in. In soil analysed beforehand is sown a small number of seeds, of which the chemical composition has been determined, and these are sprinkled with pure water. The latter disappears almost entirely by evaporation, a very small quantity only remaining behind. The plant increases in size. and gains in weight since it receives nourishment from the air, and also because it takes it from the soil. At the end of a certain period of growth, it is gathered, and then measured by new chemical analysis; first as to how much carbon, oxygen, hydrogen, and nitrogen it has gained; secondly, as to how much of these substances the soil has lost, that is, how much it has given to the plant. The difference is due either to the air or to the water. This comes in to equalize the account, and in fine, to settle the balance of profit and loss.

The application of this method, as vigorous in conception as it is difficult in application, has revealed a primary fact of the same order as the decomposition of carbonic acid. All plants have acquired an excess of hydrogen that comes neither from the soil, nor from the air which does not contain it; of necessity, therefore, it must have been derived from the water. Plants therefore do not limit their action to the separation of oxygen from carbon, they also disunite hydrogen and oxygen, retaining the former and rejecting the latter. The water was hydrogen burned, just as the carbonic acid was carbon consumed; in both cases plants have destroyed the effect of combustion by restoring the combustible bodies to the state in which they were before being burned. In establishing this action finally exercised upon water, no success has yet been attained in the knowledge of when it is effected, and in what organs it is accomplished.

A second consequence follows from the analyses of M. Boussingault, namely, that every plant at maturity has gained some nitrogen which betakes itself principally to the seeds; as this nitrogen may come either from the air, which holds it in a free state, or from the manures mixed with the soil, it was necessary to inaugurate special experiments in order to determine its origin. M. Boussingault set to work in the following manner: at first he sowed some clover in soil exclusively constituted of calcined sand, which alone was intended to furnish the growing plant with mineral matter, and with pure water by which the sand was moistened; as for nitrogen, none was contained in it. Under these exceptional conditions the clover, nevertheless, accomplished all the stages of its growth, and finally acquired a feeble but certain proportion of nitrogen which necessarily must have come from the atmosphere. Artichokes gave the same result with greater degree of nicety. When ripe they contained twice as much nitrogen as the seeds from which they sprung; but when it was attempted to reproduce the experiment with cereals, and especially with wheat, the result was that the nitrogen of the seed was tenaciously preserved, but in no degree augmented.

In every case the growth of the plant was extremely difficult, none of them having that healthy aspect exhibited by them in a rich soil; the artichokes, however. suffered less than the clover, and it again less than the wheat which could not even develope ripe grains. The reason of this is evident, nitrogen was wanting; all plants require it, wheat must have it, and when they do not find it in the soil they languish and frequently die. Finally to confirm this conclusion, M. Boussingault subjected to a comparative test three plants of the Sunflower (Helianthus) set in three similar pots filled with pure sand and moistened with pure water. To the first no manure was given, to the second 8 centigrams (1.2344 of a grain), and to the third 16 centigrams (2.4688 of a grain) of nitrate of potassa. From the very first the three plants betrayed the difference in treatment to which they had been subjected: the first languished and died, the second developed itself, although stunted, but the third was remarkable for its healthy condition. At maturity the second had taken from the soil 4 centigrams of nitrate of potassa, and the third 8. But what was especially remarkable was, that, during its existence, the latter decomposed twice as much carbonic acid as the former. Thus did the nitrogen perform the office of stimulating the other functions, and of giving to the subject which received it, or of taking away from that which was deprived of it, the vitality, without which it would not act upon the atmosphere.

Now, let it be observed that a plant contains more than half its weight of carbon, and only some thousandth parts of nitrogen. What purpose, then, in vegetation does this substance serve, being necessary to it, and yet introduced into it only in so small a quantity? M. Payen will inform us. According to this skilful chemist, all vegetable organs originate in a nitrogenous substance analogous to fibrine, to which, little by little, are added the fibrous and cellular tissues which, expanding, produce the whole plant. This fibrine is never destroyed, is formed in all the organs of the plant, and must thus be the rudiment of all its parts which could not be developed without it, and, consequently, without nitrogen which is its essential basis. To recapitulate, plants are composed of carbon, water and an excess of hydrogen; they contain, besides, a fourth simple body, nitrogen, found in a very small proportion, but the presence of which is necessary to life. The atmosphere furnishes carbon abundantly; water, that is to say oxygen and hydrogen, is contributed by rains; nitrogen is required from the soil, and since it is rarely to be found there it must be introduced in the form of manures; this is the great business of the agriculturist, the largest, most unavoidable and most productive of his outlays.

III.

In spite of the solid information which we possess upon the subject that occupies us, we cannot but declare upon many points the inadequateness of our knowledge. One of the most inexplicable facts, and one that ought most to awaken our curiosity and to demand our investigation, is the great physiological fact, the discovery of which I have narrated. Chemists have admirably studied carbonic acid; they know all the properties it possesses, they are able to foresee all the reactions it occasions or undergoes under every condition in which they please to place it; they are ignorant of none of the circumstances which give birth to or destroy it. However, they have never seen it decomposing in a cold state, under the influence of light, in the presence of any inorganic matter whatever, and what they are unable to do, the smallest leaf exposed to the sun performs immediately with a rapidity and an abundance that fill the naturalist with admiration. In ten hours, an aquatic plant gives forth fifteen times its volume of oxygen: a single leaf of the water-lily (*Fr. nénufar*) exhales 300 litres (a litre being 1·760 pint) every summer, and M. Boussingault, having poured into a vase, filled with vine leaves, exposed to the sun, a current of carbonic acid, collected at its exit only pure oxygen. Ah well! we must just confess that this fact so common, so easily accomplished by leaves, every hour of the day, is one which chemistry can neither understand nor imitate.

If we cannot succeed in seizing and imitating the conditions of a fact relatively so simple and so well defined, what must be our embarrassment when we would analyze the chemical and physiological phenomena which result from it? We see in fact three simple bodies, rarely four, combining in indefinitely variable ratios, and giving rise to the most numerous and most different compounds; wood, starch, sugars, oils, wax, balsams, essential oils of agreeable odors, and infectious matters, delicious fruits, and violent poisons, acids such as vinegar, and alkalies as quinine or strychnine, substances coloring and colorless, and, in general, substances of which the infinite variety surpasses all that the imagination can conceive of. It is not without dismay that we measure the depth of our ignorance in the presence of such multiplied phenomena, the mechanism of which altogether escapes our grasp.

There are, however, certain ill-disciplined minds that would explain everything, and above all, matters of which they are most ignorant. It has been said that plants probably contain compounds of carbonic acid and nitrogen, forming during the night and decomposing under the influence of light; it has also been stated that there exists in green leaves a sort of fermentation deriving its activity from the sun and having for its special function the decomposition of carbonic acid. These explanations have not only the defect of being illusory and conjectural, they are also false, for, according to them, pounded leaves preserving the same composition ought to continue the same functions, which is not the case. There is also a whole school of naturalists who content themselves with attributing the vegetable functions to what they call *life*, a kind of inaccessible force which should suffice to explain everything by the sole virtue of its name: these appear to me to renounce every description of scientific progress, like the ignorant bigots who explain all phenomena by saying that it is God who makes them. Without doubt God regulates the world, but He allows us sometimes, to contemplate the machinery. Undoubtedly, also, it is life that regulates the functions of beings; but before proposing it as the final cause and ultimate explanation of facts we must know a little more what it is and what are the means it employs. It is easily seen to what feebleness we are reduced as soon as the ground of experiment fails us, when to fill up the vacuum in our knowledge we take refuge in hypotheses, in unexplained and unexplanatory forces. Let us be true: we are ignorant; let us confess it, and gird up our loins and search!

To console ourselves for this avowal, which might be painful to our self-love, to encourage us in our labors of the morrow, let us, in dwelling upon their results, measure the importance of the discoveries actually made. If plants give forth oxygen, animals absorb it, and compensation is thus established between these inverse functions. This might be experimentally demonstrated by enclosing under a bell glass an animal and a plant. Separately, each of them would die the first by drowning itself in the carbonic acid it would exhale, the second, because deprived of this gas which nourishes it. Brought together in darkness, the animal and the vegetable would injure instead of assisting one another; but, under the influence of the sun, the life of the one would support that of the other;

the animal consuming its nourishment would furnish carbonic acid to the plant, and the latter would restore to the animal the oxygen necessary for it. This experiment would be a small model of the world, and it is thus that Priestley understood its eternal equilibrium. Nothing is greater or more beautiful than this thought, but it requires completion. If the bell glass of which I have just spoken were very small, the least excess arising in the respiration of the animal or the least interruption in the action of the sun would so augment the quantity of carbonic acid as to cause first the animal and afterwards the plant to perish. Are we then exposed on the earth to a similar danger and are plants so necessary, to us that we should cease to live as soon as they cease to act? This cannot be, and I am about to show that the fear of it is vain. The human population of the globe may be approximately estimated at a thousand millions of individuals, and it would not be far from the truth to admit that all other animals taken together exercise upon the atmosphere, by their respiration, an effect equal to three thousand millions of adult men. That makes for the entire animal kingdom a population equivalent to four thousand million human beings. The average quantity of oxygen consumed by an adult daily, being measured, it would be easy to calculate that consumed by the whole population of the globe. It is without doubt very great, but, on the other hand, the supply of oxygen in the atmosphere is greater still. It is so far beyond the consumption of animals that it would require eight thousand million years to exhaust it. In eight centuries the thousandth part only would be wanting, and, if plants were to cease their action, it would require at least two thousand years for the most precise chemical analysis to succeed in perceiving a change in the composition of the atmosphere. The service, therefore, which plants render is much less immediate than Priestley thought; it is a service with a long date, and we may without ingratitude bequeath our thankful acknowledgment to posterity.

But the earth is very old and it is not impossible that its atmosphere may have undergone since the creation progressive changes, which by the long addition of bygone ages must have become very considerable. This is a curious question that has been treated of by M. Adolphe Brongniart and which we are now about to study with him. The earth conceals enormous and so to speak inexhaustible masses of carbon under the form of coal, anthracite, lignite and peat, and it cannot be doubted, for a single moment, that these deposits are the accumulated fossil remains of innumerable plants. Since there is but one way in which a plant can acquire carbon, that is, by taking it from the carbonic acid in the atmosphere, it follows that all the masses of coal, which cover Belgium, England, and a great part of America and which are found in every corner of the globe, were formerly diffused throughout the atmosphere in a gaseous state; they were there combined with oxygen, and the globe at its creation was enveloped in an aeriform stratum containing some nitrogen, a great quantity of carbonic acid and little or no oxygen. Add to this the fact that at that period the earth was incandescent, and it is manifest that all the carbon which it contained would certainly have been consumed at this temperature by contact with oxygen.

Thus constituted the earth cooled down; but the composition of its atmosphere made it uninhabitable by animals, since they require oxygen which it did not possess, and because they would have been suffocated by the carbonic acid and nitrogen which were then in the ascendency. Thus the primary strata of sedimentary rocks contain no animal remains. As a compensation, however, the earth was as favorably situated for the production of plants as it was unfavorably for the support of animals; soon it became covered with luxuriant forests, of which the accumulated remains have formed coal. In that mineral are found all the species which then existed. They were gigantic Equisetaceae, tree-ferns worthy of comparison with our oaks, and Cycadaceae surpassing in height the most magnificent objects which the vegetable kingdom has now to exhibit. While these immense deposits were being made, the oxygen, disengaged little by little by the action of the sun, enriched the atmosphere and prepared for the birth of the Animal Kingdom. Soon these early forms varying from age to age, made their appearance. At the period when coal beds were forming, the forests were populated by great reptiles, cold blooded animals requiring little oxygen; but it was not till after the almost entire disappearance of the carbonic acid that mammals which had waited for a richer atmosphere came upon the scene.

There are certain timorous ignoramuses who ask in all sincerity, what will become of the earth and of themselves, when man has burned out all the coal fields? What will become of us, good people? I am about to tell you: coal will have again become carbonic acid, oxygen will have disappeared, and monster vegetation will return: but if it is true, as certain people would have us believe, that animal species developing little by little, rise from primitive forms up to man, the return of the elements to their starting point should bring man back to his origin by an inverse degeneracy. The fact of having had crocodiles among our ancestors might be allowed; but to see in prospective a posterity composed of ichthyosaurians is the most dreadful of all metempsychoses!

To return to graver matters. If we are ignorant of the mechanism of living organs, we at least know the functions which they fulfil, and can clearly express the part which they play in the physical world. With the water and nitrogenous matter which they take from the soil, with a gas which they collect in the atmosphere, plants compose the organic matter which they accumulate in their tissues, and hold in those for the use of animals. The vegetable kingdom seems to be a great laboratory, a producing workshop (Fr. *atelier de production* in opposition to *atelier de construction, factory*), in which every plant has the same function of constituting substances as varied in their composition as the plants themselves are in form. To this common character we must add another, which is, that receiving as primary materials, carbonic acid and water (substances which have been burned) plants are able to expel the oxygen and extract the carbon and hydrogen to which they restore the power of again being burned. These chemical actions take place in their organs, which are, however, only the seat of them; the *cause* is external, it comes from the sun. Animals have a mission of a diametrically opposite character. They do not create, but destroy: in place of solidifying gases and liquids, they separate and return them to the atmosphere; finally, far from restoring bodies to a combustible state, they burn them. Herbivorous animals extract all their nourishment from plants: they transform a part of it into carbonic acid and water, and stow away the remainder in their proper organs. The carnivorous profit by these stores and complete the return to the atmosphere of that which plants have extracted from it, and herbivorous animals have preserved of it, and every animal, whatever may be the class to which it belongs, rejects, by natural channels, an abundant supply of nitrogenous matter, which it distributes over the soil. It is precisely this matter which plants take up again, without which they could not live, which they are able to elaborate, change, store away, and return to animals after having restored the nutritive qualities it had lost. Thus is completed this admirable circle of opposite transformation and mutual services, in which we see animal and vegetable unceasingly exchanging the same matter, the latter collecting it in a gaseous state, deoxydising and solidifying it, the former receiving it as a combustible, and giving it forth again after consumption. Priestley saw in plants predestined servants whose duty it is to purify the atmosphere; they have another function far more direct, and render a service which affects us far more closely, that of extracting and preparing our food. Their action upon the air would only be felt after a long series of ages; but if a single year of drought should annihilate the fruits of the soil, a frightful famine would, in a few months, destroy all the animals that the earth supports.

From the sun come daily food, life, strength and all our powers. Light, the chemical emanations, all the rays which that orb sends us, are extremely rapid vibrations analogous to those which produce sound: here is motion, and therefore *force*: as soon as this force strikes upon plants, it is absorbed, disappears and is destroyed. But no force is destroyed, except under the condition of having produced an effect, and of having executed some work which is an equivalent for it. Now the work which the light absorbed by leaves accomplishes is that of decomposing carbonic acid. Thus, remembering that it requires a given amount of force to disunite a given quantity of oxygen and carbon, this required force is furnished hourly and gratuitously by the sun.

If now, we place before ourselves this oxygen and carbon, and, by an inverse operation, combine them by burning the carbon, they will in reuniting produce all the force which was expended in order to separate them, that is to say, all that the sun had furnished. This will be, as experience shows, heat and light, and it will also be the force which can be collected by engines worked by fire, and employed for man's service. And, let this be well reflected upon, it is the sun which has prepared for us this heat, this light, and this force; that which it furnished to the forests of the coal measures at an epoch when man was yet uncreated, man discovers and makes use of to-day.

And, what is true of inanimate furnaces appears also, and may be repeated in these living furnaces called animals. They also consume organic matter, produce heat, raising their temperature, and develope force and motion: a force which they do not create, which they owe to this same combustion, and hold by the same right as do steam engines: a force previously poured into plants by the sun, absorbed by them, virtually preserved in their products, which constitute our food, which we set free by respiration, and which our muscles apply at will, according to our varied requirements. The whole of this great generalization of the world's phenomena is the work of chemists and modern physicists. Messrs. Dumas and Boussingault were the first to detect it; the mechanical theory of heat completed and demonstrated it; but the whole of it already lay in the thought of Lavoisier, when he wrote: "Organisation, spontaneous motion, life, only exist on the surface of the earth, in places exposed to light. It might be said that the fable of the torch of Prometheus was the expression of a philosophical truth that had not escaped the ancients. Without light, nature was without life: she was dead and inanimate; a benevolent God, by bestowing light, has spread over the surface of the earth organization, feeling and thought."

IV.

Although, during the regular course of its existence, a plant accumulates organic matter, there are, however, two periods when it loses this essential characteristic and in which it conducts itself as do animals: these are at the commencement and at the end of its life, when it germinates and when it reproduces itself. Every seed, besides the embryo which maintains during long years the principle of life, encloses a supply of organic matter destined for the early nourishment of the growing plant. Thrown upon a warm moist soil it sprouts; its radicle seeks in the soil a point of support and liquid nourishment; the bud rises; the seminal leaves or cotyledons develope themselves, and the rudimentary plant is constituted in virtue of its intrinsic and transmitted life. But, during this primary period, the supply of matter accumulated consists of two parts; one is burned by a species of respiration; the other, undergoing complicated chemical actions, is carried into the organs and fixed there by being made a constituent part of them. Every thing takes place nearly as in an animal, and without any intervention of light: but, after this primitive phase, when the respiratory organs have gained their first development, the plant waits for the rays of the sun in order to continue its evolution, and as soon as these rays come to it, it turns towards them as if eager to collect them, becomes green and begins, to end only with death, that decomposition of carbonic acid and that accumulation of matter which is its function, and so to speak its predestination.

In order better to study this period of the intrinsic life of the seed, M. Boussingault formed the happy thought of prolonging it, by indefinitely retarding the action of light. The experiment was made upon peas in a soil destitute of manure. After having germinated they continued to grow, giving birth to a blanched, thin, and prostrate stem which perished without bearing seed. During all this time they made use of the organic matters primitively contained in the seed, and, as they dragged on their painful existence, gave these forth, little by little, in order to prolong life. Finally, each plant had lost more than half the carbon originally contained in the seed. While this experiment was going on in darkness, other peas sown at the same time were successively brought to the light. Thenceforward, everything was changed, true life was developed, and the vegetable, able at last to make use of the nourishment contained in the air, gained daily, in the sun, nearly as much carbon as it had before lost in darkness.

Everything in nature has its analogue; plants in the seed and animals in the egg appear to accomplish the same actions, and are formed in the same condition. In both cases a mass of organic matter accompanies the germ; the egg and the seed may preserve, for a longer or shorter period, the essential principle of life. A little heat commences the evolution, and from that moment organic matter, absorbed by the infant tissues and borne thither by cells which are then formed, takes its place in the organ which it constitutes. During all this time, the plant and the animal live upon their own private store, taking nothing from without, and, to complete the analogy, consume a portion of their own substance. Soon, when all this is exhausted, the animal being formed is ready to live, as the plant assuming a shape is to vegetate, and at the same instant, a necessity common to both is apparent; that, namely, of finding nourishment from without. From this time, however, all analogy ceases, and the separation of the two kingdoms commences. The plant creates and reduces, the animal destroys and oxydizes.

Let us pursue these analogies. In every expanding flower, botany points out to us the organs of the two opposite sexes which contribute, each in its own character, to the fertilization of the ovary. Now, at the very moment when the flower seems to borrow the sexual function of reproduction which was considered to be the exclusive privilege of animals, it imitates them still more in consuming organic substances by active respiration. "All flowers," said Priestley, "constantly exhale a deadly gas during the day as well as at night, both in light and darkness." Daily experience confirms this assertion, and De Saussure has shown that this poisonous gas is carbonic acid. Finally, one of our most justly celebrated chemists, M. Cahours, has, in a recent and complete work, studied all the circumstances of this respiration of flowers and fruits.

If it be true that this combustion of organic matter, this expenditure and loss of force, are necessary to accomplish the act of fertilization in itself, it is, above all, in the sexual organs that they ought to be produced. Experience, in fact, has confirmed this view, and it has been discovered that the stamen or male organ is most active in its expenditure. This important fact does not stop there. All combustion evolves heat: it is to their respiration that animals owe their high temperature, and it is of the utmost necessity that the stamens and carpels should become heated since they breathe. The question was, to find thermometers sensible enough and a suitable plant. The first plant to permit of the height of temperature being ascertained, was the pumpkin which had never been suspected of preserving such heat. Its flowers being large, air-thermometers are easily introduced into them; some of them are male and others female flowers, the latter of which shewed themselves much more cold than the former.

However, gourds, melons and pumpkins become warm to a very small extent, and may be said to resemble cold-blooded animals; the plants that imitate warm blooded animals are those of the Arum family. One of them, the *Arum maculatum*, found abundantly in the hedgerows, is enveloped by a folded leaf which encloses the flower within a small compass and hinders the heat from being dispersed in space. This is the singular phenomenon observed by Lamarck, Sennebier, Bory de Saint Vincent, and by Saussure himself. Habitually, the Arum is cold, but, at a given moment, which must be watched for and which the experimenter must know how to take advantage of, the plant rises from 7 to 8 degrees above the temperature of the atmosphere. Hubert, a very sagacious observer, succeeded in introducing a small and very sensitive thermometer, first among the stamens which were heated 22 degrees, and afterwards among the carpels which produced an action only half as great. The other parts of the plant did not betray any special action. By dint of care and watchfulness, Sa...sure surprised four Arums at the moment of their rise in temperature, and placed them under a bell glass filled with air. Immediately, the sides of the glass became covered with mist, and a great absorption of oxygen, with a corresponding production of carbonic acid, took place. Both in its chemical action, and in the energy of that action, the plant might have been compared to a rat. Another time, Saussure dissected the plant into its different parts which he studied separately: the sexual organs consumed 132 parts of oxygen and the rest of the flower only 30.

After fertilization the fruit begins to develope itself and the plant to nourish it. Not only does the latter furn' ' it with the matter accumulated in its tissues, but also gives it a still greater ( .:ntity which the fruit consumes, by a species of respiration peculiar to itself. The whole of plant life thus seems to be exclusively devoted to the accomplishment of this last duty, namely, that of nourishing the fruit. By this labor, it impoverishes itself; beet and sugar-cane expend all the sugar which they contain, all plants exhaust the stores they have accumulated from the time of their youth, and when the fruit is ripe, the plant, if an annual, is reduced to a dried up skeleton, and, if perennial, remains torpid during the quiet of winter so as to recover strength and begin next year its provident function. The survey which has now been made, contains, besides the questions of detail which I desired to examine, a great truth with which I would conclude, namely, that our earth is not adequate to itself, since force is wanting to it; but it receives this from the sun, which pours the active principle upon it in the form of rays. Thanks to this gift, life is transmitted to the globe under two antagonistic forms, vegetable life, which accumulates force by creating organic matter, and animal life, which expends and dissipates what the sun furnishes and what plants absorb and preserve.

J. C.

# CANADIAN INSTITUTE.

THIRTEENTH ORDINARY MEETING.

19*th March*, 1864.

In the absence of the President and Vice-Presidents, and on motion of Prof. Cherriman, Dr. Daniel Wilson was called to the Chair.

I. *The following donation to the Library was announced.*

"A popular and practical exposition of the minerals and geology of Canada, by E. J. Chapman, Ph. D." The thanks of the Institute were voted to Prof. Chapman for his donation.

II. *The following Papers were then read:*

1. By Prof. Kingston, M.A.:
"On the relative directions of different winds during rain or snow derived from the Toronto observations, in the years 1853 to 1859 inclusive."
2. By Rev. Prof. Hincks, F.L.S., &c.:
"Additions to Canadian Flora."
3. By Prof. Cherriman, M.A.:
"A verbal communication on the Geometrical trisection of an angle."

The thanks of the Institute were voted to the Professors for their Papers.

FOURTEENTH ORDINARY MEETING.

2*nd April*, 1864.

The President, The Rev. J. McCaul, LL.D., in the Chair.

I. *The following donations for the Library since last meeting were announced:*

From the Halifax Institute of Science, &c.

Journal and proceedings of the House of Assembly of the Province of Nova Scotia.................................................. 1*

From the Secretary of State for India.

Magnetical and meteorological observations made at Bombay in the year 1861.

From the Society, Edinburgh.

Proceedings of the Royal Physical Society, Session 1858—1862.

From the Nova Scotia Institute.

Transactions of .................................. Vol. 1, Part 1

From the Historical Society, Chicago.

Transactions of the Illinois State Agricultural Society, Vols. 3, 4, and abstract of a report on Illinois coals, by the state geologist.

From E. Allen, Esq., London.

Catalogue of old and rare works.

II. *The following Paper was read:*

By the Rev. Dr. Scadding;

"On Errata Recepta, written and spoken." A lengthened conversation followed at the conclusion of which the thanks of the Institute were on motion of Dr. Campbell, voted to Dr. Scadding.

FIFTEENTH ORDINARY MEETING.

*9th April*, 1864.

The Vice-President S. FLEMING, Esq , C.E., in the Chair.

I. *The following Gentlemen who were duly proposed at the last meeting as members of the Institute were balloted for, and declared unanimously elected,—viz.*

JOHN L. BLAIKIE, ESQ. Toronto.
WILLIAM ALEXANDER, ESQ.. Toronto.
B. MCMURRICH, ESQ., B.A., Toronto.

II. *The following donations for the Library and Museum received since last meeting were announced.*

FROM THE REGENTS OF THE UNIVERSITY OF NEW YORK STATE.

Appendix.................................................. 1

*For which the thanks of the Institute were voted.*

FOR THE MUSEUM FROM S. FLEMING, ESQ., C.E.

"Specimen of Gypsum obtained by him on the banks of the Tobique River, New Brunswick."

*The thanks of the Institute were voted to Mr. Fleming.*

III. *The following Paper was then read:*

By W. Ogden, Esq., M.D.:

"On Quackery, and a novel remedy for the treatment of certain chronic diseases."

A conversation on the subject followed in which Dr. Tucker, Prof. Croft and Dr. Wright took part. The thanks of the Institute were voted to Doctor Ogden.

SIXTEENTH ORDINARY MEETING.

*16th April*, 1864.

The President, The REV. J. MCCAUL, LL.D., in the Chair.

I. J. T. Gilbert, Esq., was proposed a member of the Canadian Institute by J. McCaul and Daniel Wilson; it being the last meeting of the session, on motion of Doctor Wilson a ballot took place and Mr. Gilbert was declared elected.

II. Doctor Roseburgh presented to the Institute an opthalmoscope.

III.—1. A paper was read by Doctor Tucker:

"On Secluded tribes of Uncivilized Men."

2. Doctor Barrett read Dr. Rosebrugh's Paper:

"On the opthalmoscope as modified lately introduced by him."

3. Doctor Wilson Read a Paper:

"Canadian Type of the French Skull."

This being the last meeting of the Session, and in accordance with the Rules and Regulations of the Institute the auditors were appointed for the year.

The President Nominated Mr. G. H. Wilson, and on motion of Doctor Wilson seconded by Mr. Wood, Mr. S. Spreull was elected.

# MONTHLY METEOROLOGICAL REGISTER, AT THE PROVINCIAL MAGNETICAL OBSERVATORY, TORONTO, CANADA WEST,—AUGUST, 1864.

*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 Normal. | Tens. of Vapour. | | | | Humidity of Air. | | | | Direction of Wind. | | | Resul't. Direc-tion. | 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. | Re-sul't. | ME'N | | |
| | | | | | ° | ° | ° | ° | ° | | | | | | | | | | | | ° | | | | | | | |
| 1 | 29.435 | 29 382 | 29.416 | 29.4088 | 71.7 | 80.0 | 74.6 | 75.95 | + 8.08 | .640 | .662 | .733 | .674 | .84 | .61 | .86 | .76 | S W b S | S W b S | N b W | S 42 W | 0.5 | 12.4 | 1.4 | 5.24 | 6.32 | 0.930 | ... |
| 2 | .446 | .438 | .533 | .4912 | 68.8 | 74.2 | 67.0 | 70.07 | + 3.22 | .627 | .598 | .553 | .571 | .80 | .71 | .83 | .78 | N b W | E S E | E b N | N 41 E | 7.2 | 3.4 | 4.5 | 3.68 | 5.57 | Inp. | ... |
| 3 | .516 | .407 | .402 | .4920 | 65.0 | 71.0 | 64.1 | 66.35 | — 0.50 | .420 | .460 | .490 | .459 | .67 | .60 | .83 | .71 | N | E b S | N W b N | N 14 E | 12.0 | 7.0 | 1.0 | 4.86 | 5.85 | Inp. | ... |
| 4 | .434 | .412 | .457 | .4347 | 62.7 | 73.8 | 65.6 | 68 02 | + 1.22 | .478 | .546 | .531 | .517 | .84 | 65 | .84 | .76 | N b W | S S W | S S W | S 35 W | 6.5 | 6.2 | 0.8 | 1.03 | 2.55 | ... | ... |
| 5 | .523 | .598 | .652 | .5967 | 62.7 | 77.5 | 67.0 | 70.37 | + 3.57 | .454 | .568 | .553 | .550 | .79 | .60 | .83 | .74 | N W b W | S E b S | Calm. | S 53 E | 0 2 | 4.0 | 0.0 | 0.87 | 1.08 | ... | ... |
| 6 | .693 | .706 | .713 | .7030 | 65.2 | 79.6 | 69.9 | 71.38 | + 4.62 | .510 | .590 | .570 | .543 | .81 | .58 | .77 | .71 | Calm. | S S E | S S E | S 18 E | 0.0 | 7.0 | 0.5 | 1 43 | 2.35 | ... | ... |
| 7 | .749 | .730 | — | — | 62.3 | 80.3 | — | — | — | .484 | .560 | — | — | .86 | .54 | — | — | N N W | S S W | S W b W | S 87 W | 2.2 | 10.0 | 3.5 | 2.75 | 3.95 | ... | ... |
| 8 | .737 | .611 | .509 | .6453 | 66.6 | 92.6 | 75.3 | 78.77 | +12 10 | .518 | .589 | .569 | .563 | .79 | .39 | .65 | .60 | N W | N W | N W | N 68 W | 2.2 | 10.2 | 3.0 | 4.99 | 6.18 | ... | ... |
| 9 | .595 | .474 | .448 | .4997 | 68.1 | 84.3 | 75.3 | 77.33 | +10.78 | .524 | .653 | .513 | .537 | .77 | .54 | .58 | .58 | W N W | S S W | S W | S 58 W | 0.8 | 7.8 | 2 2 | 4.92 | 5 46 | ... | ... |
| 10 | .457 | .409 | .433 | .4316 | 72.5 | 89.4 | 77.1 | 80.18 | +13.67 | .607 | .783 | 650 | .685 | .76 | .57 | .70 | .66 | W | S W | W S W | S 55 W | 6.0 | 7.0 | 2.5 | 3.32 | 3.85 | ... | ... |
| 11 | .487 | .472 | .539 | .4942 | 73.8 | 85.0 | 71.7 | 76.60 | +10.17 | .682 | .692 | .588 | .634 | .82 | .57 | .76 | .70 | Calm. | Calm. | N N E | N 39 E | 0.0 | 0.0 | 4.5 | 1.95 | 2.38 | 0.210 | ... |
| 12 | .583 | .533 | .508 | .5313 | 68 4 | 73.5 | 73.1 | 72.77 | + 6.43 | .518 | .667 | .582 | 614 | .79 | .81 | .72 | .76 | W N W | S W b S | S S W | S 73 W | 3.0 | 3.5 | 4.4 | 2.19 | 3.11 | 0.320 | ... |
| 13 | .454 | .395 | .512 | .4550 | 73.5 | 73.5 | 68.8 | 71.93 | + 5.75 | .716 | .716 | .612 | .676 | .87 | .87 | .88 | .85 | S W b S | W b S | N W | S 77 W | 5.2 | 10.8 | 3.8 | 4.65 | 5.68 | 0.905 | ... |
| 14 | .610 | .624 | — | — | 63.7 | 81.8 | — | — | — | .491 | .637 | — | — | .83 | .58 | — | — | N W b N | N N W | W S W | N 51 W | 3 0 | 13.0 | 2.0 | 3.64 | 4.19 | ... | ... |
| 15 | .685 | .635 | .623 | .6428 | 61.9 | 77.8 | 68.4 | 70.28 | + 4.13 | .436 | .519 | .533 | .495 | .79 | .55 | .77 | .68 | N N W | S E b S | E b S | S 89 E | 0.8 | 3.0 | 1.5 | 2.83 | 3.91 | ... | ... |
| 16 | .619 | .588 | .602 | .6015 | 65.9 | 79.3 | 70.6 | 71.93 | + 5.90 | .527 | .688 | .561 | .594 | .83 | .68 | .75 | .76 | Calm. | Calm. | Calm. | N 28 W | 0.0 | 0.0 | 0.0 | 1.35 | 1.19 | ... | ... |
| 17 | .576 | .694 | .645 | .6100 | 69.1 | 77.8 | 65.6 | 70.40 | + 4.43 | .580 | .408 | .340 | .442 | .81 | .42 | .53 | .60 | N W b N | N | N N W | N 7 W | 3.2 | 8.0 | 9.8 | 8.41 | 8.78 | Inp | ... |
| 18 | .691 | .726 | .793 | .7417 | 59.4 | 70.2 | 58.3 | 63.43 | — 2.40 | .434 | .404 | .367 | .405 | .80 | .54 | .75 | .69 | N N E | S E b S | Calm. | N 47 E | 6.0 | 3.8 | 0.0 | 0.98 | 2.15 | ... | ... |
| 19 | .831 | .817 | .791 | .8143 | 59.4 | 69 9 | 64.8 | 64.52 | — 1.25 | .275 | .487 | .450 | .416 | .54 | .67 | .73 | .67 | N b W | S S E | S E b S | N 50 E | 5.2 | 2.5 | 3.0 | 1.44 | 2.70 | 0.005 | ... |
| 20 | .795 | .769 | .675 | .7413 | 65.2 | 60.1 | 61.6 | 62.42 | — 3.13 | .577 | .463 | .428 | .471 | .92 | .89 | .78 | .83 | N E b E | E b N | N E b E | N 88 E | 1.2 | 14.5 | 12.0 | 9.51 | 10.29 | 3.905 | ... |
| 21 | .590 | .564 | — | — | 65.2 | 67.0 | — | — | — | .619 | .608 | — | — | .99 | .92 | — | — | S E b E | E b N | S b E | S 83 E | 3.2 | 5.6 | 1.5 | 2.90 | 3.42 | 0.300 | ... |
| 22 | .556 | .531 | .565 | .5505 | 68 6 | 67.7 | 63.4 | 65.87 | + 0.52 | .614 | .557 | .494 | .538 | .93 | .82 | .85 | .84 | Calm. | N | N W b N | N 39 W | 0.0 | 0.2 | 11.5 | 3.89 | 4.02 | Inp. | ... |
| 23 | .656 | .645 | .633 | .6377 | 65.5 | 71.0 | 63.4 | 64.25 | — 0.88 | .404 | .541 | .533 | .500 | .92 | .71 | .91 | .83 | N W b W | S S W | Calm. | S 57 W | 0 8 | 6.5 | 0.0 | 1 69 | 2.16 | .. | ... |
| 24 | .599 | .488 | .463 | .5090 | 65.9 | 76.7 | 68.8 | 70.83 | + 5.58 | .567 | .656 | .569 | .605 | .89 | .71 | .81 | .81 | S b W | S S E | Calm. | S 11 W | 1.0 | 4.0 | 0.0 | 2.18 | 2.27 | ... | ... |
| 25 | .410 | .260 | .405 | .3528 | 65.2 | 76.7 | 66.3 | 69.27 | + 4.53 | .577 | .739 | .394 | .582 | .92 | .80 | .61 | .78 | Calm. | S S W | N W b W | S 40 W | 0.0 | 12.8 | 2.0 | 4.76 | 5.75 | 0.030 | ... |
| 26 | .466 | .311 | .164 | .2892 | 55.8 | 69.9 | 62.3 | 63.27 | — 1.27 | .355 | .501 | .522 | .479 | .80 | .68 | .93 | .82 | Calm. | S S W | S S E | S 53 E | 0.0 | 1.2 | 9.0 | 2.43 | 5.10 | 1.325 | ... |
| 27 | .120 | .115 | .216 | .1493 | 59.0 | 68.8 | 67.8 | 61.58 | — 2.77 | .462 | .451 | .381 | .425 | .93 | .61 | .80 | .79 | W b S | W S W | W b N | S 83 W | 2.2 | 14.5 | 9.0 | 9.46 | 9.72 | 0.010 | .. |
| 28 | .242 | .286 | — | — | 57.0 | 67.0 | — | — | — | .399 | .423 | — | — | .84 | .63 | | — | W S W | W b N | W | N 82 W | 6.2 | 13.0 | 8.0 | 7.07 | 7.32 | 0 105 | ... |
| 29 | .408 | .423 | .520 | .4577 | 55.1 | 64.5 | 56.2 | 59.73 | — 4.08 | .377 | .404 | .360 | .391 | .87 | .66 | .80 | .76 | W b S | N W | Calm. | N 70 W | 1.8 | 12.8 | 0.0 | 8.05 | 8.28 | ... | ... |
| 30 | .593 | .625 | .704 | .6470 | 54.9 | 64.5 | 52.9 | 57.02 | — 6.60 | .335 | .251 | .216 | .264 | .80 | .41 | .52 | .57 | N W | N N W | N W b N | N 27 W | 7.0 | 10.8 | 7.5 | 7.35 | 7.67 | 0.015 | ... |
| 31 | .780 | .791 | .787 | .7877 | 48.6 | 63.4 | 58.7 | 57.18 | — 6.13 | 241 | .356 | .304 | .308 | .69 | .61 | .62 | .66 | N | S W b S | N b W | S 78 W | 2.5 | 9.5 | 4.0 | 1.14 | 3.75 | ... | ... |
| M | 29.5604 | 29.5300 | 29 550 | 29.5450 | 63.93 | 74.54 | 66.23 | 68.58 | + 2.82 | .500 | .554 | .406 | .516 | .82 | .64 | .70 | .73 | ........ | ........ | ........ | ........ | 2.00 | 7.26 | 3.64 | ...... | 4.75 | 5.060 | 0.0 |

# REMARKS ON TORONTO METEOROLOGICAL REGISTER FOR AUGUST, 1864.

NOTE.—The monthly means do not include Sunday observations. The daily means, excepting those that relate to the wind, are derived from six observations daily, namely, at 6 A.M., 8 A.M., 2 P.M., 4 P.M., 10 P.M., and midnight. The means and resultants for the wind are from hourly observations.

Highest* Barometer . . . . . . . 29.863 at 8 a.m. on 19th. } Monthly range=
Lowest Barometer . . . . . . . 29.099 at 10.20 a.m. on 27th. } 0.764 inches.

Self-registering Ther.:
- Maximum temperature . . . . 91°0 on p.m. of 8th } Monthly range=
- Minimum temperature . . . . 47°0 on a.m. of 31st } 47°0
- Mean maximum temperature . . 77°24 } Mean daily range=15°83
- Mean minimum temperature . . 61°41 }
- Greatest daily range . . . . . . . 29°2 from a. m. to p. m. of 8th.
- Least daily range . . . . . . . . 3°8 from a. m. to p. m. of 22nd.

Warmest day . . . 10th ...Mean Temperature . . . 80°18 } Difference=23°.16
Coldest day . . . 30th...Mean Temperature . . . 57°02 }

Maximum Radiation { Solar (Vacuum) . . . . 127°0 on p. m of 1st } Monthly range=
{ Terrestrial . . . . . . . . 74°0 on a. m. of 20th } 53°.0

Aurora observed on 6 nights, viz.:—on 13th, 24th, 25th, 28th, 30th and 31st.
Possible to see Aurora on 12 nights; impossible on 19 nights.
Raining on 16 days; depth 5.060 inches; duration of fall, 57.8 hours.
Mean of cloudiness=0.70; above average, 0.23. Most cloudy hour observed, 4 p.m; mean=0.73; least cloudy hour observed, 10 p.m; mean=0.63.

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

| North. | South. | East. | West. |
|---|---|---|---|
| 1262.51 | 903.32 | 661.61 | 1626.71 |

Resultant direction, N. 70° W.; Resultant Velocity, 1.38 miles per hour.
Mean velocity 4.75 miles per hour.
Maximum velocity 20.2 miles, from 4 to 5 p.m. on 27th.
Most windy day 20th—Mean velocity 10.29 miles per hour. } Difference 9.21.
Least windy day 5th—Mean velocity 1.08 miles per hour. }
Most windy hour, noon to 1 p.m.—Mean velocity, 8.02 miles per hour. } Difference
Least windy hour, 3 to 4 a.m.—Mean velocity, 2.87 miles per hour. } 5.15 miles.

1st. Thunder and slight rain, 1 to 2 p.m.; sheet lightning and constant rain from 9 p.m.—6th. Distant thunder in W. 4 to 5 p.m.—8th to 13th, inclusive, very sultry days.—10th. Sheet lightning in S.W. at midnight.—11th. Thunder, lightning, and rain nearly all day.—12th. Thunderstorm, lightning, and rain, 10.50 to 11 30 a.m.—13th. Thunderstorm 3 to 5.30 a.m., and again from 10.30 a.m. to 4 p.m.; auroral arch, patches and streamers at midnight.—21st. Thunder in S.W. 11 30 a.m. to 2 p.m.—24th. Loud thunder and vivid lightning, 5 to 6 p m.; 9.50 to 10 30 p.m., a beautiful and well defined auroral band, extending from horizon in W.N.W. to E.S.E., being about 2° in breadth, and passing the meridian considerably to S. of Zenith.—25th. Fog at 6 a m.; thunderstorm 11 30 a.m. to 12.30 p.m.; faint aurora in N. from 8 p.m. to midnight.—26th. Thunderstorm, lightning, and rain, 3 p.m. to midnight.—28th, 30th, and 31st.—Faint auroral light in N. at midnight.

Heavy Dew recorded on 9 mornings during this month.

## COMPARATIVE TABLE FOR AUGUST.

| YEAR. | TEMPERATURE. Mean | Excess above Average (45°5). | Maximum observed. | Minimum observed. | Range. | RAIN. No. of days. | RAIN. Inches. | SNOW. No. of days. | SNOW. Inches. | WIND. Resultant. Direction. | WIND. Resultant. Velocity. | WIND. Mean Force or Velocity. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | ° | ° | ° | | | | | | | |
| 1840 | 64.7 | — 1.5 | 80.1 | 47.4 | 32.7 | 12 | 2.905 | ... | ... | ... | ... | ... |
| 1841 | 64.4 | — 1.8 | 83.5 | 46.7 | 36.8 | 9 | 6.170 | ... | ... | ... | ... | 0.19lbs |
| 1842 | 65.7 | — 0.5 | 80.7 | 45.3 | 35.4 | 6 | 2.600 | ... | ... | ... | ... | 0.30 " |
| 1843 | 66.4 | + 0.2 | 85.5 | 44.4 | 41.1 | 4 | 4.850 | ... | ... | ... | ... | 0.12 " |
| 1844 | 64.3 | — 1 9 | 82.5 | 44.3 | 38.2 | 17 | Imp | ... | ... | ... | ... | 0.16 " |
| 1845 | 67.9 | + 1.7 | 82.5 | 44.4 | 38.1 | 9 | 1.725 | ... | ... | ... | ... | 0.19 " |
| 1846 | 68.4 | + 2.2 | 86.3 | 50.4 | 35.9 | 9 | 1.770 | ... | ... | ... | ... | 0.17 " |
| 1847 | 65.1 | — 1.1 | 83.1 | 44.9 | 38.2 | 10 | 2.140 | ... | ... | ... | ... | 0.19 " |
| 1848 | 69.2 | + 3.0 | 87.5 | 49.3 | 38.2 | 8 | 0.853 | ... | ... | S 21 E | 0.98 | 4.55 ms |
| 1849 | 66.3 | + 0.1 | 79 5 | 51.4 | 28.1 | 10 | 4.970 | ... | ... | N 71 W | 0.60 | 3.76 " |
| 1850 | 66.8 | + 0.6 | 84.2 | 43.0 | 41 2 | 13 | 4.355 | ... | ... | N 15 E | 0.35 | 4.46 " |
| 1851 | 63.6 | — 2.6 | 79.8 | 43.6 | 36.2 | 10 | 1.360 | ... | ... | N 63 W | 0.40 | 4.63 " |
| 1852 | 65.9 | — 0.3 | 81.2 | 46.7 | 34.5 | 9 | 2.695 | ... | ... | N 70 E | 0.56 | 3.30 " |
| 1853 | 68.6 | + 2.4 | 91.6 | 47.6 | 44.0 | 11 | 2.575 | ... | ... | S 36 E | 0.30 | 4.26 " |
| 1854 | 68.0 | + 1.8 | 98.1 | 47.0 | 51.1 | 5 | 0.455 | ... | ... | N 64 W | 1.76 | 4.60 " |
| 1855 | 64.1 | — 2.1 | 82.1 | 44.9 | 37.2 | 7 | 1.455 | ... | ... | N 63 W | 1.04 | 6.97 " |
| 1856 | 63.6 | — 2.6 | 81.3 | 44.0 | 37.3 | 12 | 1.680 | ... | ... | N 50 W | 2.88 | 7.03 " |
| 1857 | 65.3 | — 0.9 | 85.3 | 50.1 | 35.2 | 13 | 5.265 | ... | ... | N 77 W | 1.51 | 6.36 " |
| 1858 | 67.6 | + 1.4 | 83.4 | 45.4 | 38.0 | 11 | 3.890 | ... | ... | N 69 W | 1.57 | 6.50 " |
| 1859 | 66.6 | + 0.4 | 81.4 | 46.2 | 35.2 | 11 | 3.900 | ... | ... | N 36 W | 1.62 | 5.96 " |
| 1860 | 64.5 | — 1.7 | 81.8 | 47.1 | 34.7 | 14 | 3.405 | ... | ... | N 70 W | 1.83 | 5.80 " |
| 1861 | 65.5 | — 0.7 | 82.5 | 48.2 | 34.3 | 15 | 2.933 | ... | ... | N 8 E | 0.46 | 4.21 " |
| 1862 | 67.6 | + 1.4 | 87.6 | 47.7 | 39.9 | 15 | 3.483 | ... | ... | N 78 W | 1.67 | 5.96 " |
| 1863 | 66.6 | + 0.4 | 87 2 | 43.9 | 43.3 | 12 | 2.208 | ... | ... | S 61 W | 1.80 | 4.89 " |
| 1864 | 68.6 | + 2.4 | 92.6 | 48.6 | 44.0 | 16 | 5.060 | ... | ... | N 70 W | 1.38 | 4.75 " |
| Results to 1864. | 66.21 | ... | 84.45 | 46.50 | 37.95 | 10.7 | 3.026 | ... | ... | N 67 W | 0.93 | 5.18 |
| Exc. for 1864. | +2.37 | ... | +8.15 | +2.10 | +6.05 | + 5.3 | + 2.031 | ... | ... | ... | ... | —0 43 |

# MONTHLY METEOROLOGICAL REGISTER, AT THE PROVINCIAL MAGNETICAL OBSERVATORY, TORONTO, CANADA WEST,—SEPTEMBER, 1864.

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

| Day. | 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. | 10 PM | ME'N | Excess of mean above Normal | 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 | 10 PM | Result't. | ME'N | Rain in Inches | Snow in Inches. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ° | ° | ° | ° | ° | | | | | | | | | | | | | | | | | | | |
| 1 | 29.823 | 29.776 | 29.741 | 29.7727 | 47.2 | 67.0 | 59.8 | 59.50 | — 3.53 | .270 | .416 | .334 | .362 | .86 | .63 | .65 | .71 | N b W | S W b S | Calm. | S 47° W | 1.8 | 3.5 | 0.0 | 1.02 | 1.55 | ... | ... |
| 2 | .691 | .630 | .610 | .6407 | 57.2 | 65.2 | 60.5 | 61.63 | — 1.10 | .358 | .421 | .458 | .425 | .76 | .67 | .87 | .77 | S W b S | E | E | N 65 E | 3.5 | 6.0 | 2.2 | 1.95 | 2.80 | Inp. | ... |
| 3 | .538 | .508 | .500 | .5188 | 59.4 | 67.0 | 56.9 | 61.75 | — 0.35 | .434 | .460 | .374 | .416 | .86 | .70 | .80 | .76 | N N E | E b S | Calm. | N 72 E | 1.5 | 5.0 | 0.0 | 2.57 | 3.82 | ... | ... |
| 4 | .496 | .508 | — | — | 54.7 | 68.8 | — | — | — | .403 | .537 | — | — | .94 | .79 | — | — | N | E S E | E N E | N 62 E | 1.5 | 6.0 | 7.5 | 4.94 | 5.46 | 0.005 | ... |
| 5 | .665 | .688 | .747 | .7023 | 55 8 | 58.7 | 59.0 | 57.90 | — 3.93 | .422 | .373 | .335 | .366 | .95 | .75 | .67 | .76 | N E | E | N E b E | N 59 E | 7.5 | 11.2 | 10.2 | 9.43 | 9.65 | .. | ... |
| 6 | .820 | .862 | .895 | .8683 | 55.8 | 63.7 | 64.4 | 58.27 | — 3.17 | .365 | .352 | .308 | .336 | .82 | .60 | .73 | .69 | N E | E b S | E | N 72 E | 8.8 | 11.5 | 5.2 | 6.87 | 7.62 | ... | ... |
| 7 | .966 | .949 | .876 | .9260 | 51.5 | 64.8 | 61.2 | 59.03 | — 1.22 | .283 | .361 | .374 | .354 | .74 | .59 | .69 | .68 | N N E | E | E S E | S 80 E | 3.4 | 12.8 | 9.8 | 7.95 | 8.59 | 0.040 | ... |
| 8 | .827 | .779 | .735 | .7725 | 57.6 | 59.2 | 59.4 | 58.47 | — 2.27 | .364 | .413 | .461 | .426 | .76 | .82 | .92 | .87 | S E | S S E | S S W | S 7 E | 5.8 | 5.8 | 1.5 | 3.12 | 3.58 | 0.005 | ... |
| 9 | .677 | .534 | .507 | .5647 | 60.5 | 72.4 | 62.3 | 65.37 | + 5.02 | .470 | .530 | .484 | .519 | .89 | .69 | .86 | .83 | S W b S | S W b S | N W | S 70 W | 7.6 | 14.0 | 1.5 | 3.36 | 4.94 | ... | ... |
| 10 | .534 | .514 | .483 | .5072 | 52.9 | 65.9 | 60.1 | 60.50 | + 0.45 | .351 | .461 | .425 | .434 | .95 | .72 | .81 | .82 | N W | S S E | S b E | N 88 E | 0.5 | 4.6 | 2.2 | 0.97 | 3.76 | 0.025 | ... |
| 11 | .518 | .534 | — | — | 55.8 | 62.7 | — | — | — | .338 | .287 | — | — | .87 | .50 | — | — | N N E | N W b N | N N W | N 23 W | 0.5 | 12.8 | 7.8 | 8.95 | 9.36 | ... | ... |
| 12 | .653 | .675 | .711 | .6705 | 47.5 | 61.6 | 56.5 | 55.62 | — 3.62 | .294 | .289 | .281 | .277 | .89 | .53 | .61 | .64 | N b W | N b E | N b W | N 3 W | 12.5 | 11.4 | 5.5 | 7.59 | 8.70 | ... | ... |
| 13 | .685 | .550 | .547 | .5872 | 47.9 | 67.7 | 54.7 | 57.13 | — 1.72 | .278 | .243 | .251 | .251 | .84 | .35 | .58 | .56 | N b W | N W b N | N b W | N 24 W | 5.5 | 9.0 | 12.0 | 7.42 | 7.66 | ... | ... |
| 14 | .432 | .238 | .306 | .3133 | 49.7 | 57.2 | 55.1 | 55.20 | — 3.13 | 287 | .439 | .386 | .394 | .80 | .94 | .89 | .90 | W b W | S | S b W | S 47 W | 2.9 | 9.4 | 4.5 | 5.27 | 7.03 | 0.290 | ... |
| 15 | .255 | .374 | .499 | .3817 | 54.7 | 59.8 | 49.3 | 55.63 | — 2.28 | .380 | .292 | .293 | .332 | .89 | .56 | .83 | .75 | W S W | W N W | W | N 76 W | 11.2 | 22.0 | 4.2 | 13.49 | 13.88 | ... | ... |
| 16 | .540 | .586 | .652 | .5950 | 47 5 | 61.6 | 49.3 | 52.73 | — 4.78 | .283 | .257 | .274 | .262 | .86 | .46 | .77 | .67 | W | N N W | N N W | N 40 W | 3.5 | 11.0 | 1.2 | 5.14 | 5.41 | ... | ... |
| 17 | .688 | .605 | .501 | .5893 | 41.0 | 60.5 | 54.4 | 53.40 | — 3.60 | .218 | .303 | .385 | .310 | .85 | .58 | .91 | .76 | Calm. | S S E | E | S 69 E | 0.0 | 3.0 | 2.0 | 2.04 | 2.94 | ... | ... |
| 18 | .412 | .283 | — | — | 56.5 | 69.9 | — | — | — | 323 | .461 | — | — | .71 | .63 | — | — | E | S b W | N W b W | S 51 W | 3.0 | 14.0 | 11.5 | 5.63 | 8.03 | 0.835 | ... |
| 19 | .530 | .593 | .658 | .6063 | 45.0 | 56.2 | 49.7 | 51.13 | — 4.98 | .249 | .264 | .267 | .264 | .83 | .58 | .75 | .71 | W S W | W b N | Calm. | N 81 W | 4.0 | 12.0 | 0.0 | 4.55 | 4.67 | ... | ... |
| 20 | .643 | .602 | .680 | .6463 | 42.8 | 68.1 | 53.6 | 55.45 | — 0.15 | .250 | .261 | .246 | .259 | .90 | .38 | .59 | .62 | W S W | W b S | W | S 82 W | 0.6 | 16.8 | 4.0 | 6.64 | 6.85 | ... | ... |
| 21 | .693 | .636 | .711 | .6815 | 47.9 | 60.9 | 54.0 | 55.28 | + 0.17 | .301 | .343 | .357 | .325 | .90 | .64 | .85 | .75 | W b N | N | N N E | N 45 E | 2.8 | 12.8 | 4.2 | 4.52 | 6.40 | ... | ... |
| 22 | .700 | .603 | .517 | .5925 | 47.2 | 55.1 | 55.1 | 52.22 | — 2.42 | .220 | .358 | .409 | .334 | .71 | .83 | .95 | .84 | N E b E | E N E | E N E | N 66 E | 11.5 | 6.8 | 5.0 | 6.65 | 6.69 | ... | ... |
| 23 | .458 | .386 | .306 | .3770 | 54.4 | 67.7 | 63.7 | 63.25 | + 9.03 | .418 | .557 | .491 | .510 | .99 | .82 | .83 | .87 | E | S S W | S W b S | S 30 W | 2.2 | 10.2 | 4.5 | 5.97 | 6.86 | 0.078 | ... |
| 24 | .230 | .276 | .309 | .3142 | 60.1 | 64.8 | 50.8 | 57.23 | + 3.48 | .489 | .351 | .233 | .329 | .94 | .56 | .63 | .68 | S W | W | W N W | N 80 W | 8.0 | 17.8 | 20.0 | 13.90 | 14.55 | ... | ... |
| 25 | .587 | .645 | — | — | 43.5 | 54.0 | — | — | — | .214 | .282 | — | — | .75 | .67 | — | — | W N W | W N W | W b N | N 63 W | 9.5 | 18.5 | 0.5 | 9.44 | 9.51 | ... | ... |
| 26 | .722 | .620 | .493 | .5982 | 45.4 | 53.3 | 50.8 | 49.70 | — 3.03 | .263 | .312 | .313 | .295 | .86 | .76 | .84 | .82 | W b N | E b N | N E | N 75 E | 1.0 | 10.0 | 2.2 | 4.17 | 5.65 | Inp. | ... |
| 27 | .491 | .357 | .436 | .4272 | 55.1 | 66.3 | 58.7 | 60.38 | + 8.17 | .386 | .419 | .442 | .416 | .89 | .64 | .90 | .80 | S W b S | S W b S | S W | S 58 W | 7.6 | 20.5 | 2.5 | 9.26 | 12.72 | 0.080 | ... |
| 28 | .664 | .797 | .857 | .7850 | 40.7 | 59.1 | 47.2 | 52 03 | + 0.20 | .349 | .322 | .219 | .287 | .98 | .65 | .67 | .74 | N W | S W b W | N | N 38 W | 9.5 | 7.0 | 6.0 | 3.63 | 6.77 | ... | ... |
| 29 | .715 | .353 | .612 | .5555 | 47.5 | 57.6 | 46.8 | 50.93 | — 0.38 | 294 | .446 | .273 | .331 | .89 | .94 | .85 | .86 | N E b E | S S E | N W | N 20 W | 9.8 | 2 0 | 14.2 | 6.20 | 11.06 | 1.150 | ... |
| 30 | .786 | .839 | .909 | .8500 | 41.4 | 46.8 | 45.3 | 44.62 | — 6.20 | .214 | .206 | .217 | .214 | .81 | .64 | .71 | .73 | N W b N | N b E | N E b N | N 14 E | 4.8 | 7.8 | 1.5 | 4.85 | 5.20 | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | .. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| M | 29.6328 | 29.5902 | 29.6114 | 29.6097 | 50.87 | 61.85 | 54.95 | 56.36 | — 1.13 | .328 | .364 | .342 | .347 | 86 | .65 | .78 | .75 | ........ | ........ | ........ | ........ | 5.08 | 10.51 | 5.11 | ...... | 7.06 | 2.508 | ... |

## REMARKS ON TORONTO METEOROLOGICAL REGISTER FOR SEPTEMBER, 1864.

NOTE.—The monthly means do not include Sunday observations. The daily means, excepting those that relate to the wind, are derived from six observations daily, namely at 6 A.M., 8 A.M., 2 P.M., 4 P.M., 10 P.M., and midnight. The means and resultants for the wind are from hourly observations.

Highest Barometer..........................29.975 at 8 a.m. on 7th } Monthly range =
Lowest Barometer..........................29.230 at 6 a.m. on 24th } 0.745 inches.

Self-registering Thermom.:
- Maximum Temperature ..............73°0 on p.m. of 9th } Monthly range =
- Minimum Temperature ..............37°8 on a.m. of 17th } 35°2
- Mean maximum Temperature ...................... 63°94 } Mean daily range=
- Mean minimum Temperature ...................... 48°96 } 14°98
- Greatest daily range ......27°0 from a.m. to p.m. of 20th.
- Least daily range........... 4°5 from a.m. to p.m. of 8th.

Warmest day ........ 9th... Mean temperature.......... 65°37 } Difference = 20°75.
Coldest day ......... 30th... Mean temperature ......... 44°62 }

Maximum Radiation. { Solar.............................. 115°0 on p.m. of 9th } Monthly range =
{ Terrestrial......................... 29°8 on a.m. of 17th } 85°2

Aurora observed on 4 nights, viz.,—on 20th, 21st, 22nd and 24th.
Possible to see Aurora on 14 nights; impossible on 16 nights.
Raining on 11 days, depth 2.508 inches; duration of fall 31.0 hours.
Mean of cloudiness = 0.58; above average .08.
Most cloudy hour observed, 2 p.m.; mean = 0.67; least cloudy hour observed, 6 a.m.; mean, = 0.50.

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

| North. | South. | East. | West. |
|---|---|---|---|
| 1070.72 | 902.38 | 1364.93 | 2205.17 |

Resultant direction N. 38° W.; Resultant velocity 1.89 miles per hour.
Mean velocity ..........................7.06 miles per hour.
Maximum velocity .................. 27.4 miles, from 2 to 3 p.m. on 15th.
Most windy day ......24th...........Mean velocity, 14.55 miles per hour. } Difference=
Least windy day ......1st............Mean velocity, 1.55 ditto } 13.00 miles.
Most windy hour ...... 2 to 3 p.m.........Mean velocity, 10.94 ditto. } Difference=
Least windy hour ...... 8 to 9 p.m.........Mean velocity, 4.77 ditto. } 6.17 miles.

7th. Imperfect solar halo at 4 p.m.—9th. Sheet lightning in N.W. at 10 p.m. and midnight.—10th. Fog at 6 a.m.; solar halo at 2 p.m.—17th. Hoar Frost 5.30 to 6.30 a.m. (first of the season.)—18th. Thunderstorm 3 to 6 p.m.; imperfect rainbow at 6 p.m.—20th. Auroral arch and streamers, 6.45 p.m. to midnight.—21st. Auroral light and faint streamers at 10 p.m.—22nd. Auroral light and streamers, 10 p.m. and midnight; fog at midnight.—23rd. Ground fog, 6 a.m.; sheet lightning and distant thunder from 10 p.m.—24th. Thunderstorm 12.30 to 2 a.m.; faint auroral light at 9 p.m.—26th. Thunderstorm, vivid lightning and slight rain, 7 p.m. to midnight.—29th. Thunderstorm 8.30 to 11 a.m.

Heavy dew recorded on 10 mornings during this month.

### COMPARATIVE TABLE FOR SEPTEMBER.

| YEAR. | TEMPERATURE. | | | | | RAIN. | | SNOW. | | WIND. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | Excess above aver'ge (26 1) | Max. ob-served. | Min. ob-served. | Range. | No. of days. | Inches | No. of days. | Inches | Resultant. Direction. | Resultant. V'y. | Mean Force or Velocity. |
| 1840 | 54.0° | — 3.8° | 70.2° | 29.4° | 40.8° | 4 | 1.380 | ... | ... | ... | ... | ......... |
| 1841 | 61.3 | + 3.5 | 79 9 | 37.5 | 42.4 | 9 | 3.340 | ... | ... | ... | ... | 0.26 lbs. |
| 1842 | 55.7 | — 2.1 | 83.5 | 28.3 | 55.2 | 12 | 6.160 | ... | ... | ... | ... | 0.45 |
| 1843 | 59.1 | + 1.3 | 87.8 | 33.1 | 54.7 | 10 | 9.760 | ... | ... | ... | ... | 0.57 |
| 1844 | 58.6 | + 0.8 | 81 5 | 29.6 | 51.9 | 4 | Imp. | ... | ... | ... | ... | 0.26 |
| 1845 | 56.0 | — 1.8 | 78.8 | 35.3 | 43.5 | 16 | 6 245 | ... | ... | ... | ... | 0.54 |
| 1846 | 63.6 | + 5.8 | 84.0 | 39 0 | 45.0 | 11 | 4.59[illegible] | ... | ... | ... | ... | 0.33 |
| 1847 | 55.6 | — 2.2 | 74.8 | 38.1 | 36.7 | 15 | 6.665 | ... | ... | ... | ... | 0 33 |
| 1848 | 54.2 | — 3.6 | 80.9 | 29.5 | 51.4 | 11 | 3.11[illegible] | ... | ... | N 71° W | 2.38 | 5.81mls. |
| 1849 | 58.2 | + 0.4 | 80.6 | 33.5 | 47.1 | 9 | 1.480 | ... | ... | N 75° W | 0.69 | 4.23 |
| 1850 | 56.5 | — 1.3 | 76.0 | 31.7 | 44.3 | 11 | 1.735 | ... | ... | S 65° W | 1.02 | 4.78 |
| 1851 | 60.0 | + 2.2 | 80.3 | 33.4 | 52.9 | 9 | 2.665 | ... | ... | N 14° E | 1.03 | 5.45 |
| 1852 | 57.5 | — 0.3 | 81.8 | 36.1 | 45.7 | 10 | 3.630 | ... | ... | N 77° W | 0.53 | 4.60 |
| 1853 | 58.8 | + 1.0 | 85.4 | 36.1 | 49.3 | 12 | 5.140 | ... | ... | N | 1.06 | 4 33 |
| 1854 | 61.0 | + 3.2 | 93.1 | 36.3 | 56.8 | 14 | 5.37[illegible] | ... | ... | N 22° W | 1 33 | 4 04 |
| 1855 | 59.5 | + 1.7 | 81.7 | 36.1 | 45 0 | 12 | 5.58[illegible] | ... | ... | N 20° E | 1.29 | 7.61 |
| 1856 | 57.1 | — 0.7 | 77.3 | 37.4 | 39.9 | 13 | 4.10[illegible] | ... | ... | S 79° W | 1.98 | 6.53 |
| 1857 | 58.6 | + 0.8 | 81.4 | 34.1 | 47.3 | 11 | 2.640 | ... | ... | N 68° W | 1.61 | 5.55 |
| 1858 | 59.1 | + 1.3 | 80.1 | 36.8 | 43.3 | 8 | 0.735 | ... | ... | S 74° W | 1.53 | 5.69 |
| 1859 | 55.2 | — 2.6 | 73.8 | 35.7 | 38.1 | 15 | 3.52[illegible] | ... | ... | N 44° W | 1.60 | 6.36 |
| 1860 | 55.3 | — 2.5 | 74.2 | 28.7 | 45.5 | 14 | 1.95[illegible] | ... | ... | N 71° W | 2.63 | 5.79 |
| 1861 | 59.1 | + 1.3 | 78.2 | 37.1 | 41.1 | 17 | 3.60[illegible] | ... | ... | N 71° W | 1.39 | 4.81 |
| 1862 | 59.6 | + 1.8 | 78.9 | 41.0 | 37.9 | 9 | 2.344 | ... | ... | N 59° W | 1.07 | 5.11 |
| 1863 | 55.9 | — 1.9 | 78.2 | 31.6 | 46.6 | 8 | 1.23[illegible] | ... | ... | N 16° W | 0.92 | 6.46 |
| 1864 | 56.4 | — 1.4 | 72.4 | 41.0 | 31.4 | 11 | 2.508 | ... | ... | N 38° W | 1 89 | 7.06 |
| Results to 1864. | 57.84 | ... | 80.03 | 34.66 | 45.38 | 11.0 | 3.730 | ... | ... | N 57° W | 1.15 | 5.54 |
| Exc for 1864. | — 1.48 | ... | — 7.63 | + 6.34 | — 13.98 | 0.0 | — 1.222 | ... | ... | ......... | ... .. | + 1.52 |

# INDEX.