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MEETING OF THE BRITISH ASSOCIATION.

PRESIDENT'S ADDRESS: BY JOHN PHILLIPS, M.A., LL.D., F.R.S.*

Professor PHILLIPS having taken the chair, was received with loud applause. He said—

Assembled for the third time in this busy centre of industrious England, amid the roar of engines and the clang of hammers, where the strongest powers of nature are trained to work in the fairy chains of art, how softly falls upon the ear the accent of science, the friend of that art, and the guide of that industry! Here, where Priestley analysed the air, and Watt obtained the mastery over steam, it well becomes the students of nature to gather round the standard which they carried so far into the fields of knowledge. And when, on other occasions, we meet in quiet colleges and academic halls, how gladly welcome is the union of fresh discoveries and new inventions with the solid and venerable truths which are there treasured and taught. Long may such union last; the fair alliance of cultivated thought and practical skill; for by it labor is dignified and science fertilised, and the condition of human society exalted!

Through this happy union of science and art, the young life of the British Association—one-third of a century—has been illustrated by discoveries and enriched by useful inventions in a degree never surpassed. How else could we have gained that knowledge

* Delivered in the Town Hall, Birmingham, September 6, 1865.

of the laws of nature which has added to the working strength of a thousand millions of men the mightier power of steam (*a*), extracted from the buried ruins of primeval forests, their treasured elements of heat and light and color, and brought under the control of the human finger, and converted into a messenger of man's gentlest thoughts, the dangerous mystery of the lightning (*b*)?

How many questions have we asked—not always in vain—regarding the constitution of the earth, its history as a planet, its place in creation; now probing with sharpened eyes the peopled space around—peopled with a thousand times ten thousand stars; now floating above the clouds in colder and clearer air; now traversing the polar ice—the desert sand—the virgin forest—the unconquered mountain; now sounding the depths of the ocean, or diving into the dark places of the earth. Everywhere curiosity, everywhere discovery, everywhere enjoyment, everywhere some useful and therefore some worthy result. Life in every form, of every grade, in every stage; man in every clime and under all conditions; the life that now surrounds us, and that which has passed away;—these subjects of high contemplation have been examined often, if not always, in the spirit of that philosophy which is slowly raising, on a broad security of observed facts, sure inductions, and repeated experiments, the steady columns of the temple of physical truth.

Few of the great branches of the study of nature on which modern philosophy is intent were left unconsidered in the schools of Athens; hardly one of them was or indeed could be made the subject of accurate experiment. The precious instruments of exact research—the measures of time, and space, and force, and motion—are of very modern date. If, instead of the few lenses

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(*a*) The quantity of coal dug in Great Britain, in the year 1864, appears by the returns of Mr. R. Hunt to have been 92,787,873 tons. This would yield, if employed in steam-engines of good construction, an amount of available force about equal to that of the whole human race. But in the combustion of coal not less than ten times this amount of force is actually set free—nine-tenths being at present unavailable, according to the statement of Sir. William Armstrong, in his address to the meeting at Newcastle, in 1863.

(*b*). The definite magnetic effect of an electrical current, was the discovery of Oersted in 1819: Cooke and Wheatstone's patent for an Electric Telegraph is dated in 1837; the first message across the Atlantic was delivered in 1858. Tantæ molis erat.

and mirrors, of which traces appear in Greek and Roman writers (*c*), there had been even the first Galilean or the smallest Newtonian telescope in the hands of Hipparchus, Eratosthenes, or Ptolemy, would it have been left to their remote successors to be still struggling with the elements of physical astronomy, and waiting with impatience till another quarter of a century shall have rolled away, and given us one more good chance of measuring the distance of the sun by the transit of Venus? Had such instruments as Wheatstone's chronoscope been invented, would it have been left to Foucault to condense into his own apartment an experimental proof of the velocity of light, and within a tract of thirty feet to determine the rate of its movement through all the vast planetary space of millions and thousands of millions of miles, more exactly than had been inferred by astronomers from observations of the satellites of Jupiter (*d*)? By this experiment the velocity of light appears to be less—sensibly less—than was previously admitted; and this conclusion is of the highest interest. For, as by assuming too long a radius for the orbit of Jupiter the calculated rate of light-movement was too great; so now, by employing the more exact rate and the same measures of time, we can correct the estimated distance of Jupiter and all the other planets from the sun. We have, in fact, a really independent measure of planetary space; and it concurs with observations of the parallax of Mars, in requiring a considerable reduction of the assumed diameters of the planetary paths. The distance of the earth from the sun must be reduced from above ninety-five to less than ninety-three millions of miles, and by this scale the other space measures of the solar

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(*c*) The effect of lenses or globes of glass or crystal (ὕαλος) in collecting the solar rays to a point, are familiarly referred to by Aristophanes in the Nubes, 766; and the ornamental use of convex and concave reflectors is known by the curious discussions in the Fourth Book of Lucretius.

(*d*) Fizeau performed experiments on the velocity of light between Suresnes and the Butte Montmartre, by means of the oxyhydrogen light, reflected back in its own path. The space was 28,324ft. Engl. Twice this distance was traversed in $\frac{1}{18,000}$ of a second = 167,528 geogr. miles in a second. From observations of Jupiter's satellites, Delambre inferred 167,976 miles, Struve 166,096. The experiment of M. Foucault gives 298,000,000 metres = 160,920 geogr. miles.

system, excepting the diameter of the earth and the distance and diameter of the moon, may be corrected *(e)*.

The light and heat which are emitted from the sun reach the earth without great diminution by the absorptive action of the atmosphere; but the waste of heat from the surface of our planet through radiation into space is prevented, or rather lessened, by this same atmosphere. Many transparent bodies admit freely heat-rays derived from a source of high temperature, but stop the rays which emanate from bodies only slightly warmed. The atmosphere possesses this quality in a remarkable degree, and owes it to the presence of diffused water and vapor; a fact which Dr. Tyndall has placed in the clear light of complete and varied experiment *(f)*. The application of this truth to the history of the earth and of the other planets is obvious. The vaporous atmosphere acts like warm clothing to the earth. By an augmented quantity of vapor dissolved, and water suspended in the air, the waste of surface-heat of the earth would be more impeded; the soil, the water, and the lower parts of the atmosphere would grow warmer; the climates would be more equalized; the general conditions more like what has been supposed to be the state of land, sea, and air during the geological period of the Coal-measures.

Such an augmentation of the watery constituents in the atmosphere would be a natural consequence of that greater flow of heat from the interior, which, by many geologists, mathematicians, and chemists, is supposed to have happened in the earlier periods of the history of the earth.

By the same considerations we may understand how the planet Mars, which receives not half so much heat from the sun *(g)* as

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(e) Estimates of the earth's distance from the sun have varied much. Cassini and Flamsteed, using observations of the parallax of Mars, ascribe to it ten or eleven thousand diameters of the earth=79 or 89 millions of miles. Huyghens estimated it at twelve thousand=95 millions of miles. In 1745, Buffon reported it as the common opinion of astronomers at 30 millions of leagues (Fr.)=90 millions miles (Engl); but after the transit of Venus in 1769, he allowed 33 millions. Such was the effect of that now supposed erroneous experiment on the opinions of astronomers. (Epoques de la Nature.)

(f) Proc. of Roy. Soc. 1861. The Rumford Medal was adjudged to Dr. Tyndall in 1864.

(g) The proportion is about $\frac{100}{231}$ according to the received measure of the mean distance.

the earth does, may yet enjoy, as in fact it seems to enjoy, nearly a similar climate, with snows alternately gathering on one or the other of its poles, and spreading over large spaces around, but not, apparently beyond the latitude of 50 deg. or 40 deg.; the equatorial band of 50 deg. or 40 deg. north or south being always free from snow-masses bright enough and large enough to catch the eye of the observer. Mars may, therefore, be inhabited, and we may see in the present state of this inquiry reason to pause before refusing the probability of any life to Jupiter and even more distant planets.

The history of suns and planets is in truth the history of the effects of light and heat manifested in them, or emanating from them. Nothing in the universe escapes their influence; no part of space is too distant to be penetrated by their energy; no kind of matter is able to resist their transforming agency. Many if not all the special forces which act in the particles of matter are found to be reducible into the general form of heat; as this is convertible and practically is converted into proportionate measures of special energy. Under this comprehensive idea of convertibility of force, familiar to us now by the researches of Joule (*h*), the reasonings of Grove (*i*) and Helmholtz, and the theorems of Rankine (*k*), it has been attempted by Mayer, Waterston, and Thomson (*l*), to assign a cause for the maintenance of the heat-giving power of the sun in the appulse of showers of aerolites and small masses of matter, and the extinction of their motion on the surface of the luminary. By calculations of the same order, depending on the rate of radiation of heat into space, the past antiquity of the earth and the future duration of sunshine have been expressed in thousands or millions of centuries (*m*). In like manner the physical changes on the sun's disk, by which portions of his darkly heated

(*h*) Phil. Mag. 1843; Reports of the British Association, 1845; Trans. of the Royal Society, 1850.

(*i*) Grove on the Correlation of Physical Forces. 1846.

(*k*) Rankine, Trans. of the Royal Society of Edinburgh, 1850-51; Phil. Trans. 1854.

(*l*) Communication to the Royal Society of Edinburgh, 1854.

(*m*) Professor Thomson assigns to the sun's heat, supposing it to be maintained by the appulse of masses of matter, a limit of 300,000 years; and to the period of cooling of the earth from universal fusion to its actual state, 98,000,000 years. These are the lowest estimates sanctioned by any mathematician.

body become visible through the luminous photosphere, have been connected, if not distinctly as a cause, certainly as a coincident phenomenon, with particular magnetic disturbances on the surface of the earth; the solar spots and the magnetic deflections concurring in periods of maxima and minima of ten or eleven years duration. Thus even these aberrant phenomena become part of that amazing system of periodical variation which Sabine and his fellow-laborers, British, French, German, Russian, and American, have established by contemporaneous observation over a large part of the globe (*n*).

With every change in the aspect and position of the sun, with every alteration in the place and attitude of the moon, with every passing hour the magnetism of the earth submits to regular and calculable deviation. Through the substance of the ground, and across the world of waters, Nature, ever the beneficent guide to science, has conveyed her messages and executed her purposes, by the electric current, before the discovery of Oersted and the magical inventions of Wheatstone revealed the secret of her work.

Even radiant light in the language of the new philosophy is conceived of by Maxwell (*o*), as a form of electro-magnetic motion. And thus the imponderable, all-pervading powers, by which molecular energy is excited and exchanged, are gathered into the one idea of restless activity among the particles of matter :—

—æterno percita motu :

ever-moving and being moved, elements of a system of perpetual change in every part, and constant preservation of the whole.

What message comes to us with the light which springs from the distant stars, and shoots through the depths of space to fall upon the earth after tens, or hundreds, or thousands of years? It

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(*n*) Among the interesting researches which have been undertaken on the subject of the spots, may be mentioned those of Wolfe (Compte rendus, 1859), who finds the number and periodicity of the spots to be dependent on the position of Venus, the Earth, Jupiter, and Saturn. Stewart has made a special study of the relation of the spots to the path of Venus (Proc. of the Roy. Soc. 1864); and Chacornac is now engaged in unfolding his conception of the spots as the visible effect of volcanic excitement. The peculir features of the solar surface are under examination by these and other good observers, such as Dawes, Nasmyth, Secchi, Stone, Fletcher, and Lockyer.

(*o*) Proc. of Roy. Soc. 1864. The elder Herschel appears to have regarded the light of the sun and of the fixed stars as perhaps the effect of an electro-magnetic process—a perpetual auora.

is a message from the very birthplace of light, and tells us what are the elementary substances which have influenced the refraction of the ray. Spectral analysis, that new and powerful instrument of chemical research for which we are indebted to Kirchhoff, has been taught by our countrymen to scrutinise not only planets and stars, but even to reveal the constitution of the nebulæ, those mysterious masses out of which it has been thought new suns and planets might be evolved—nursing mothers of the stars. For a time, indeed, the resolution of some nebulæ, by the giant mirror of Lord Rosse, afforded ground for opposing speculation of Herschel and the reasoning of Laplace, which required for their very starting-point the admission of the existence of thin gaseous expansions, with or without points or centres of incipient condensation, with or without marks of internal movement. The latest results, however, of spectral analysis of stars and nebulæ by Mr. Higgins and Professor W. A. Miller, have fairly restored the balance. The nebulæ are indeed found to have in some instances stellar points, but they are not stars; the whole resembles an enormous mass of luminous gas, with an interrupted spectrum of three lines, probably agreeing with nitrogen, hydrogen, and a substance at present unknown (*p*). Stars, tested by the same accurate hands, are found to have a constitution like that of our own sun, and, like it, to show the presence of several terrestrial elements, as sodium, magnesium, iron, and very often hydrogen. While in the moon and Venus no lines whatever are found due to an atmosphere, in Jupiter and Saturn, beside the lines which are identical with some produced in our own atmosphere, there is one in the red, which may be caused by the presence of some unknown gas or vapor. Mars is still more peculiar, and enough is ascertained to discountenance the notion of his redness being due to a peculiarity of the soil (*q*).

To aid researches into the condition of celestial bodies, the new powers of light, discovered by Niepce, Daguerre, and Talbot, have been employed by Bond, Draper, De la Rue, and other astronomers. To our countryman, in particular, belongs the honor of successful experiments on the rose-colored flames which extend from certain points of the sun's border during an eclipse; as well as of valuable contributions through the same agency to that enlarged survey of the physical aspect of the moon, which, since 1852,

(*p*) Proc. Roy. Soc. and Phil. Trans. 1864.

(*q*) Phil. Trans. 1864.

the Association has striven to promote. By another application of the same beautiful art, in connection with clock-work, the momentary changes of magnetic force and direction, the variations of temperature, the fluctuations of atmospheric pressure, the force of the wind, the fall of rain, the proportion of ozone in the air, are registered in our observatories; and thus the inventions of Ronalds and his successors have engaged the solar rays in measuring and comparing contemporaneous phenomena of the same order over large parts of the globe—phenomena some of which are occasioned by those very rays.

As we ascend above the earth, heat, moisture and magnetic force decrease, the velocity of wind augments, and the proportion of oxygen and nitrogen remains the same. The decrease of heat as we rise into the air is no new subject of enquiry, nor have the views respecting it been very limited or very accordant. Leslie considered it mathematically in relation to pressure; Humboldt gave the result of a large enquiry at points on the earth's surface, unequally elevated above the sea; and finally, Mr. Glaisher and Mr. Coxwell, during many balloon ascents to the zones of life-destroying cold, far above our mountain tops, have obtained innumerable data, in all seasons of the year, through a vast range of vertical height. The result is to show much more rapid decrease near the earth, much slower decrease at great elevations; thus agreeing in general with the view of Leslie, and yet throwing no discredit on the determinations of Humboldt, which do not refer to the free atmospheric ocean, but to the mere borders of it where it touches the earth, and is influenced thereby (*s*).

The proportion of carbonic acid gas in the atmosphere at great heights is not yet ascertained; it is not likely to be the same as that generally found near the earth; but its proportion may be more constant, since in those regions, it is exempt from the influence of the actions and reactions which are always in progress on the land and in the water, and do not necessarily compensate one another at every place and at every moment.

Other *information bearing on the constitution* of the atmosphere comes to us from the auroral beams and other meteoric lights known as shooting stars. For some of these objects not only appear at heights of ten, fifty, and 100 or more miles above the earth, but at the height of fifty miles it is on record that shooting stars

(*s*) Reports of the British Association for 1862, 1863, 1864.

or fire-balls have left waving trains of light, whose changes of form were in seeming accordance to varying pressure in the elevated and attenuated atmosphere. (t)

Researches of every kind have so enriched meteorology since our early friend, Professor J. Forbes printed his suggestive reports on that subject; and so great have been the benefits conferred on it by the electric telegraph, that at this moment in M. Leverrier's observatory at Paris, and the office so lately presided over by Admiral FitzRoy in London, the messages are arriving from all parts of Europe to declare the present weather, and furnish grounds for reasonable expectation of the next probable change. Hardly now within the seas of Europe can a cyclone begin its career of devastation, before the warning signal is raised in our seaports, to restrain the too confident sailor. The gentle spirit which employed this knowledge in the cause of humanity has passed away, leaving an example of unselfish devotion, in a work which must not fail through any lack of energy on the part of this Association, the Royal Society, or the Government. We must extend these researches and enlarge these benefits by the aid of the telegraph bringing the ends of the world together. Soon may that thread of communication unite the two great sections of the Anglo-Saxon race, and bring and return through the broad Atlantic the happy and mutual congratulations for peace restored and friendships renewed.

The possible combinations of force, by which, in the view we have been considering the characteristic force and special phenomena of solid, liquid, and gaseous matter are determined, may be innumerable. Practically, however, they appear to be limited, as natural products, to less than one thousand distinguishable compounds, and less than one hundred (u) elementary substances. Of these elements the most prevalent are few on the earth; as of gases, oxygen, hydrogen, nitrogen; of solids, silicon, calcium, magnesium, sodium, iron; and it is interesting to learn by analysis of the light of stars and planets, that these substances, or some of them, are found in most of the celestial objects yet examined, and that, except in one or two instances, no other substances have been traced

(t) This is the result of a careful discussion made by myself of observations on a meteor seen from Rouen to Yorkshire, and from Cornwall to Kent, Jan. 7, 1856.

(u) At the present moment the number of "elementary substances" is sixty-one.

therein. Even the wandering meteoric stones, which fall from their courses, and are examined on the earth, betray only well-known mineral elements, though in the manner in which these are combined, some differences appear, which, by chemical research and the aid of transparent sections, Professor Maskelyne and Mr. Sorby are engaged in studying and interpreting (*x*).

By the labors of Lavoisier and his contemporaries, chemistry acquired a fixed logic and an accurate nomenclature. Dalton and the great physicists of the early part of this century gave that law of definite combination by proportionate weights of the elements which is for chemistry what the law of gravitation is for celestial mechanics. A great expansion of the meaning of the atomic theory took place, when Mitscherlich announced his views of isomorphous, isomeric, and dimorphous bodies. For thus it came gradually to appear that particular forces resided in crystals in virtue of their structure, lay in certain directions, and exhibited definite physical effects, if the chemical elements, without being the same, were combined in similar proportions and aggregated into similar crystals. Some years later, ozone was discovered by Schönbein, and it concurred with a few other allotropic substances in reviving, among philosophic chemists, the enquiry as to the relative situation of the particles in a compound body, and the effects of such arrangements: an idea which had been expressed by Dalton in diagrams of atoms, and afterwards exercised the ingenuity of Exley, MacVicar, and others (*y*).

Everything connected with this view of the modification of physical properties by the arrangement of the particles—whether

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(*x*) Professor Maskelyne has made a convenient classification of the large collection of meteorites in the British Museum, under the titles of "Aërolite or Meteoric *Stone*;" "Aërosiderite or Meteoric *Iron*:" and "Aërosiderolites," which includes the intervening varieties. Mr. Sorby, whose latest results are unpublished, but will be communicated to the Royal Society, is of opinion that the substance of meteorites has undergone changes due to physical conditions in some ancient period not now to be paralleled on our planet, or on the moon, but rather to be looked for only in the immediate neighborhood of the sun. Professor Haidinger has also made a special study of meteorites.

(*y*) Dalton, Chemistry, vol. i. 1808. A clear view of the simpler applications of Dalton's ideas is given by the illustrious author in Daubeny's Treatise on the Atomic Theory, 1850.

Exley, Nat. and Exp. Philosophy, 1829.

MacVicar, Reports of the British Association for 1855.

elementary or compound—is of the highest importance to mineralogy, a branch of study by no means so much in favor even with chemists as its own merits and its collateral bearings might justly deserve. Yet it is in a great measure by help of this branch of study that the opinions now current regarding metamorphism of rocks *in situ*, and the formation of mineral veins, must acquire that solid support and general consent which at present they do not possess. Crystals, indeed, whether regarded as to their origin in nature, their fabrication by art, or their action on the rays of light, the waves of heat and sound, and the distribution of electricity, have not been neglected by the Association or its members. In one of the earliest reports, Dr. Whewell calls attention to the state of crystallographical theory, and to the artificial production of crystals; and in another report, Professor Johnston notices epigene and pseudomorphous crystallisation; and for many years, at almost every meeting, new and brilliant discoveries in the action of crystals on light were made known by Brewster (z), and compared with the undulatory theory by Herschel, MacCullagh, Airy, Hamilton, Whewell, Powell, Challis, Lloyd, and Stokes.

The unequal expansion of crystals by heat, in different directions, first observed by Mitscherlich, has been carefully examined in the cases of sulphate and carbonate of lime, by Professor W. H. Miller (*a*), who has also considered their elasticity, originally measured in different relations to the axis by Savart. These and many other interesting relations of crystals have been attended to; but the Association has not yet succeeded in obtaining a complete digest of the facts and theories connected with the appearance of crystals in nature—in the fissures of rocks, in the smaller cavities of rocks, in the solid substance or liquid contents of other crystals. Such an enquiry, however, it did earnestly demand, and some steps have been taken by our own chemists, mineralogists, and geologists. But more abundant information on this class of subjects is still needed, even after the admirable contributions and recent discoveries of Bischof, Delesse, and Daubrée (*b*).

(z) "Sir David Brewster must be considered as in a degree the creator of the science which studies the mutual dependence of optical properties and crystalline forms."—[*Whewell, in Report on Mineralogy, Brit. Association*, 1832, *p.* 336.]

(*a*) Rep. Proc. 1837, pp. 43, 44.

(*b*) Bischof, Chemical Geology (published by the Cavendish Society, 1856.)

Within our Association-period both the nomenclature of chemistry and the conception of the atomic theory have received not indeed a change, but such an addition to its ordinary expression as the more general language and larger meaning of algebra have conferred on common arithmetical values. The theory of compound radicals, as these views of Liebig, Dumas, and Hofmann may be justly termed, embraces the consideration of groups of elements united in pairs by the ordinary law, these groups being for the purpose in hand treated as single elements of combination. The nomenclature which attempts in ordinary words to express these relations grows very unmanageable even in languages more easily capable of polysyllabic combinations than ours; but symbols of composition—the true language of chemistry—are no more embarrassed in the expression of these new ideas than are the mathematical symbols which deal with operations of much greater complexity on quantities more various and more variable. (c) The study of these compound radicals comes in aid of experimental research into those numerous and complex substances which appear as the result of chemical transformations in organic bodies. Thus in some instances the very substances have been recomposed by art which the vital processes are every moment producing in nature; in others the steps of the process are clearly traced; in all the changes become better understood through which so great a variety of substances and structures are yielded by one circulating fluid; and the result is almost a new branch of animal and vegetable physiology, not less important for the health of mankind than essential to the progress of scientific agriculture.

The greater our progress in the study of the economy of nature, the more she unveils herself as one vast whole—one comprehensive plan—one universal rule, in a yet unexhausted series of individual peculiarities. Such is the aspect of this moving, working, living system of force and law: such it has ever been, if we rightly interpret the history of our own portion of this rich inheritance of mind, the history of that earth from which we

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Delesse, Etudes sur le Métamorphisme, 1858, and other works.

Daubrée, sur la Relation des Sources Thermales des Plombières, avec les Filons Metallifères et la formation des Zeolithes, 1858; and other works.

(c) On the Nomenclature of Organic Compounds, by Dr. Daubeny. Reports of British Association, 1851.

spring, with which so many of our thoughts are co-ordinated, and to which all but our thoughts and hopes will again return.

How should we prize this history! and exult in the thought that in our own days, within our own memories, the very foundations of the series of strata, deposited in the beginning of time, have been explored by our living friends, our Murchison and Sedgwick, while the higher and more complicated parts of the structure have been minutely examined by our Lyell, Forbes, and Prestwich (*d*). How instructive the history of that long series of inhabitants which received in primeval times the gift of life, and filled the land, sea, and air with rejoicing myriads, through innumerable revolutions of the planet, before, in the fulness of time, it pleased the Giver of all good to place man upon the earth, and bid him look up to heaven.

Wave succeeding wave, the forms of ancient life sweep across the ever-changing surface of the earth, revealing to us the height of the land, the depth of the sea, the quality of the air, the course of the rivers, the extent of the forest, the system of life and death—yes, the growth, decay, and death of individuals, the beginning and ending of races, of many successive races of plants and animals, in seas now dried, on sand-banks now raised into mountains, on continents now sunk beneath the waters.

Had that series a beginning? Was the earth ever uninhabited, after it became a globe turning on its axis and revolving round the sun? Was there ever a period since land and sea were separated—a period which we can trace—when the land was not shaded by plants, the ocean not alive with animals? The answer, as it comes to us from the latest observation, declares that in the lowest deposits of the most ancient seas in the stratified crust of the globe, the monuments of life remain. They extend to the earliest sediments of water, now in part so changed as to appear like the products of fire. What life? Only the simpler and less specially organised fabrics have as yet rewarded research among these old Laurentian rocks—only the aggregated structures of Foraminifera have been found in what, for the present, at least, must be accepted as the first deposits of the oldest sea. The most ancient of all known fossils, the Eozoon Canadense of Sir W.

(*d*) The investigations of Murchison and Sedgwick in the Cambrian and Silurian Strata began in 1831; the views of Sir C. Lyell on Tertiary Periods were made known in 1829.

Logan, is of this low, we may even say lowest, type of animal organisation.

Then step by step we are guided through the old Cambrian Silurian systems, rich in Trilobites and Brachiopoda, the delights of Salter and Davidson; with Agassiz and Miller, and Egerton, we read the history of the strange old fishes of Devonian rocks; Brongniart, and Göppert, and Dawson, and Binney, and Hooker unveil the mystery of the mighty forests now converted to coal; Mantell and Owen and Huxley restore for us the giant reptiles of the Lias, Oolite, and the Wealden; Edwards and Wright almost revive the beauteous corals and echinodermata; which with all the preceding tribes have come and gone before the dawn of the later periods, when fragments of mammoths and hippopotami were buried in caves and river sediments to reward the researches of Cuvier and Buckland, Prestwich and Christy, Lartet and Falconer.

And what is the latest term in this long series of successive existence? Surely the monuments of ever-advancing art—the temples whose origin is in caverns of the rocks; the cities which have taken the place of holes in the ground, or heaps of stones and timber in a lake; the ships which have outgrown the canoe, as that was modelled from the floating trunk of a tree, are sufficient proof of the late arrival of man upon the earth, after it had undergone many changes, and had become adapted to his physical, intellectual, and moral nature.

Compared with the periods which elapsed in the accomplishment of these changes, how short is the date of those yet standing monoliths, cromlechs, and circles of unhewn-stone which are the oldest of human structures raised in Western Europe, or of those more regular fabrics which attest the early importance of the monarchs and people of Egypt, Assyria, and some parts of America! Yet tried by monuments of natural events which happened within the age of man, the human family is old enough in Western Europe to have been sheltered by caverns in the rocks, while herds of reindeer roamed in Southern France (*d*), and bears and hyenas were denizens of the south of England (*e*). More

(*d*) See the Memoirs of M. Lartet on the Caves of the Dordogne, 1863-4.

(*e*) In the caves of Gower, Devon, and Somerset, flint flakes occur with several extinct animals.

than this, remains of the rudest human art ever seen are certainly found buried with and are thought to belong to races who lived contemporaneously with the mammoth and rhinoceros, and experienced the cold of a Gallic or British winter, from which the woolly covering of the wild animals was a fitting protection.

Our own annals begin with the Kelts, if indeed we are entitled to call by that historic name the really separate nations, Belgian, Iberian, and Teutonic, whom the Roman writers recognise as settlers in Britain (*f*); settlers among a really earlier family, our rudest and oldest forefathers, who may have been, as they thought themselves to be, the primitive people of the land (*g*). But beyond the Κελταί who occupied the sources of the Danube and the slopes of the Pyrenees, and were known to Rome in later days, there was present to the mind of the father of Grecian history a still more western race, the Cynetæ, who may perhaps be supposed the very earliest people of the extreme west of the continent of Europe. Were those the people, the first poor pilgrims from the East, whose footsteps we are slowly tracing in the valleys of Picardy and the south of England, if not on the borders of the lakes of Switzerland? Are their kindred still to be found among the Rhætic Alps and the Asturian cliffs, if not amid the wilds of Connemara, pressed into those mountainous recesses by the legions of Rome, the spear of the Visigoth, and the sword of the Saxon? Or must we regard them as races of an earlier type, who had ceased to chip flints before the arrival of Saxon, or Goth, or Kelt, or Cynetian? These questions of romantic interest in the study of the distribution and languages of the families of man are part of a large circle of enquiry which finds sympathy in several of our sections, especially those devoted to zoology, physiology, and ethnology. Let us not expect or desire for them a very quick, or, at present, a very definite settlement. Deep shadows have gathered over all the earlier ages of mankind, which perhaps still longer periods of time may not avail to remove. Yet let us not undervalue the progress of ethnological enquiry, nor fail to mark how, within the period to which our recollections cling, the revelations of early Egypt have been followed by a chronology of the

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(*f*) Gallic or Belgian on the south-east coast; Iberian in South Wales. German at the foot of the Grampians—(Tacitus, Vita Agricolæ.)

(*g*) "Britannicæ pars interior ab iis incolitur, quos natos in insula ipsa memoria proditum dicunt."—(Cæsar, v. 12.)

ancient kingdoms on the Tigris and Euphrates, through the same rigorous study of language. Thus has our Rawlinson added another page to the brilliant discoveries of Young and Champollion, Lepsius and Rosellini.

Nor, though obtained in a different way, must we forget the new knowledge of a people nearer home, which the philosophic mind of Keller has opened to us among his native mountains. There, on the borders of the Alpine lakes, before the great Roman general crossed the Rhone, lived a people older than the Helvetians; whose rude lives, passed in hunting and fishing, were nevertheless marked by some of the many inventions which everywhere, even in the most unfavorable situations, accompany the least civilised of mankind. Implements of stone and pottery of the rudest sort belong to the earliest of these people; while ornamented iron weapons of war, and innumerable other fabrics in that metal, appear about the later habitations, and correspond probably to the period of the true Helvetii, who quitted their home and contended with Cæsar for richer settlements in Gaul. The people of whom these are the traces on almost every lake in Switzerland are recognised as well in the ancient lake-basins of Lombardy and among the Tyrolean Alps, and farther on the north side of the mountains; and probably fresh discoveries may connect them with the country of the Sarmatians and the Scythians.

Thus at length is fairly opened, for archæology and palæontology to read, a new chapter of the world's history, which begins in the pleistocene periods of geology, and reaches to the prehistoric ages of man. Did our ancestors really contend, as the poets fancied (*h*), with stones and clubs against the lion and the rhinoceros, and thus expel them from their native haunts, or have they been removed by change of climate or local physical conditions? Was the existence of the hyena and the elephant only possible in Western Europe while a climate prevailed there such as now belongs to Africa or India? and was this period of high temperature reduced in a later time for the elk, reindeer, and musk ox, which undoubtedly roamed over the hills of England and France? If we think so, what a vista of long duration stretches before us, for no such changes of climate can be supposed to have occurred except as the effect of great physical changes, requiring a lapse of many thousands of years. And though we may think such changes

(*h*) Lucretius, v. 964—1283.

of climate not proved, and probably careful weighing of evidence may justify our disbelief, still, if the valleys in Picardy have been excavated since the deposit of the gravel of St. Acheul (*i*), and the whole face of the country has been altered about the caverns of Torquay since they received remains of animals and traces of man (*j*)—how can we admit these facts and yet refuse the time required for their accomplishment? First, let us be sure of the facts, and especially of that main fact upon which all the argument involving immensity of time really turns, viz., the contemporaneous existence of man with the mammoth of the plains and the bear of the caverns. The remains of men are certainly *buried* with those of extinct quadrupeds; but did they *live* in the same days, or do we see relics of different periods gathered into one locality by natural processes of a later date, or confused by the operations of men?

Before replying finally to these questions, further researches of an exact kind are desirable, and the Association has given its aid towards them, both in respect to the old cavern of Kent's Hole, and the newly-opened fissure of Gibraltar, from which we expect great results, though the best of our laborers has ceased from his honorable toil. (*k*) When these and many other researches are completed, some future Lyell, if not our own great geologist, may add some fresh chapters to the "Antiquity of Man."

In judging of this antiquity, in counting the centuries which may have elapsed since smoothed flints fitted with handles of wood were used as chisels and axes by the earliest people of Scandinavia or Helvetia, and flakes of flint were employed to cleanse the skins of the reindeer in the caves of the Dordogne, or stronger tools broke up the ice in the valley of the Somme, we must be careful not to take what is the mark of low civilization for the indication of very remote time. In every country, among every race of men, such rude weapons and tools are used now, or were used formerly. On the banks of the Ohio, no less than on the English hills, mounds of earth, rude pottery, and stone weapons occur in abun-

(*i*) Prestwich, Transactions of the Royal Society, 1860, and Proc. of Roy. Inst., Feb., 1864.

(*j*) Pengelly, reports of the British Association, 1864.

(*k*) The late Dr. Hugh Falconer, whose knowledge of the fossil animals of caves was remarkably exact, took a great share in these examinations.

dance; and indicate similar wants, contrivances, customs, ideas, in different races of men living in different periods. Even when in the same country, as in Switzerland, or England, or Denmark, successive deposits of instruments of stone, bronze, or iron; successive burials of pines, beeches, and oaks; successively extinguished races of elephants, elks, and reindeer, give us a real scale of elapsed time, it is one of which the divisions are not yet valued in years or centuries of years.

Toward a right judgment of the length of this scale of human occupation, two other lines of evidence may be thought worthy of notice; one founded on the anatomical study of the remains of early men, the other on the laws of language. If the varieties of physical structure in man, and the deviations of language from an original type, be natural effects of time and circumstance, the length of time may be in some degree estimated by the amount of the diversities which are observed to have happened, compared with the variation which is now known to be happening. This process becomes imaginary, unless we assume all mankind to have had one local centre, and one original language. Its results must be erroneous, unless we take fully into account the superior fixity of languages which are represented in writing, and the greater tendency to diversity of every kind which must have prevailed in early times, when geographical impediments were aggravated by dissocial habits of life. It appears, however, certain that some differences of language, organisation, and habits have separated men of apparently unlike races during periods longer than those which rest on historical facts (*l*).

Ever since the days of Aristotle, the analogy existing among all parts of the animal kingdom, and in a general sense we may say among all the forms of life, has become more and more the subject of special study. Related as all living beings are to the element in which they move and breathe, to the mechanical energies of nature which they employ or resist, and to the molecular forces which penetrate and transform them, some general conformity of structure, some frequently recurring resemblance of function, must be present, and cannot be overlooked. In the several classes this analogy grows stronger, and in the subdivisions of these classes real family affinity is recognised. In the smallest divisions which have this family relation in the highest degree,

(*l*) Max Muller on the Science of Language.

there seems to be a line which circumscribes each group, within which variations occur, from food, exercise, climate, and transmitted peculiarities. Often one specific group approaches another, or several others, and a question arises whether, though now distinct, or rather distinguishable, they always have been so from their beginning, or will be always so until their disappearance.

Whether what we call species are so many original creations or derivations from a few types or one type, is discussed at length in the elegant treatise of Darwin (*m*), himself a naturalist of eminent rank. It had been often discussed before. Nor will any one think lightly of such enquiries, who remembers the essay of Linnæus, 'De Telluris orbis incremento," or the investigations of Brown, Prichard, Forbes, Agassiz, and Hooker, regarding the local origin of different species, genera, and families of plants and animals, both on the land and in the sea. Still less will he be disposed to undervalue its importance, when he reflects on the many successive races of living forms more or less resembling our existing quadrupeds, reptiles, fishes, and mollusca, which appear to have occupied definite and different parts of the depths of ancient time; as now the tiger and the jaguar, the cayman and the gavial, live on different parts of the terrestrial surface. Is the living elephant of Ceylon the lineal descendant of that mammoth which roamed over Siberia and Europe, and North America, or of one of those sub-Himalayan tribes which Dr. Falconer has made known; or was it a species dwelling only in circumpolar regions? Can our domestic cattle, horses and dogs, our beasts of chase and our beasts of prey, be traced back to their source in older types, contemporaries of the urus, megaceros, and hyena on the plains of Europe? If so, what range of variation in structure does it indicate? If not so, by what characters are the living races separated from those of earlier date?

Specific questions of this kind must be answered, before the general proposition, that the forms of life are indefinitely variable with time and circumstance, can be even examined by the light of adequate evidence. That such evidence will be gathered and rightly interpreted, I for one neither doubt nor fear; nor will any be too hasty in adopting extreme opinions or too fearful of the final result, who remember how often that which is true has been found very different from that which was plausible, and how

(*m*) On the Origin of Species, 1859.

often out of the nettles of danger we have plucked the flowers of safety. At the present moment the three propositions which were ever present to the mind of Edward Forbes may be successfully maintained, as agreeing with many observed phenomena; and around them, as a basis of classification, may be gathered most of the facts and most of the speculations which relate to the history of life (*n*). First, it may be admitted that plants and animals form many natural groups, the members of which have several common characters, and are parted from other groups by a real boundary line, or rather unoccupied space. Next, that each of these groups has a limited distribution space, often restrained by high *mountains or deep seas, or parallels of temperature, within which* it has been brought into being. Thirdly, that each group has been submitted to, or is now undergoing, the pressure of a general law, by which its duration is limited in geological time; the same group never re-appearing after being removed from the series.

How important, in the view of this and many other questions, is that never-tiring spirit of geographical and maritime discovery, to which through four hundred years Europe has sent her noblest sons and her most famous expeditions; sent them, alas! too often to an early grave. Alas! for Franklin, who carried the magnetic flag into the Icy Sea from which he had already brought trophies to Science! Alas! for Speke, who came home with honor from the head waters of the Nile! Forgotten they can never be, whenever on occasions like this, we mourn the absence of our bravest and our best; praise, neverending praise be theirs, while men retain the generous impulse which prompts them to enterprises worthy of their country and beneficial to mankind!

If it may be asked, what share in the discoveries and inventions of the last thirty-three years is claimed for the British Association, let us answer fearlessly, We had a part in all. In some of them we took the foremost place by the frequency of our discussions, the urgency of our recommendations, the employment of our influence, and the grant of our funds. For others we gave all our strength, to support the Royal Society and other institutions in their efforts to accomplish purposes which we approve. In all instances our elastic system responds quickly to pressure, and

(*n*) See the remarkable essay of E. Forbes on the distribution of the existing Fauna and Flora of the British Isles, in Memoirs of Geol. Survey of Britain, vol. i, p. 336.

returns the friendly impulse. If we look back on the work of previous years, it is easy to mark the special action of the Association in fields which hardly could be entered by any other adventurers.

Many of the most valuable labors of which we are now reaping the fruits were undertaken in consequence of the reports on special branches of science which appear in the early volumes of our Transactions—reports in which particular data were requested for confirming or correcting known generalisations, or for establishing new ones. Thus, a passage in Professor Airy's report on Physical Astronomy (*o*) first turned the attention of Adams to the mathematical vision of Neptune; Lubbeck's Report on Tides (*p*) came before the experimental researches and reductions, which since 1834 have so often engaged the attention of Whewell and Airy and Haughton, with results so valuable and so suggestive of further undertakings. Among these results may be placed additional knowledge of the probable depth of the channels of the sea. For, before the desire of telegraphic communication with America had caused the bed of the North Atlantic to be explored by soundings to a depth seldom exceeding three miles, there was reason to conclude from the investigations of Whewell on Cotidal Lines (*q*) that a depth of nine miles was attained in the South Atlantic, and from the separate computations of Airy and Haughton that a somewhat greater depth occurred in a part of the course of the tide-wave which washes the coast of Ireland (*r*). The greater portion of the sea-bed is within the reach of soundings directed by the superior skill and greater perseverance of modern scientific navigators; a depth of six miles is said to have been reached in one small tract of the North Atlantic; depths of nine or ten miles in the deepest channels of the sea are probable from considering the general proportion which is likely to obtain between sea-depths and mountain-tops. Thus the data are gradually being collected for a complete survey of the bed of the sea, includ-

(*o*) Reports of the British Association for 1832, p. 154. Laplace had indeed observed that "the planet Uranus and his satellites, lately discovered, give reason to suspect the existence of some planets not yet observed;" thereby encouraging the search for new discoveries, in our own system.—(Exp. du Syst. du Monde, 1799, 4to, p. 350.)

(*p*) Reports of the British Association, 1832.

(*q*) Trans. of Roy. Soc., 1833.

(*r*) Trans. of Roy. Irish Acad., 1855.

ing, among other things, information, at least, concerning the distribution of animal and vegetable life beneath the waters.

Waves — their origin, the mechanism of their motion, their velocity, their elevation, the resistance they offer to vessels of given form: these subjects have been firmly kept in view by the Association, since first Professor Challis (*s*) reported on the mathematical problems they suggest, and Sir J. Robinson and Mr. Scott Russell undertook to study them experimentally (*t*). Out of this enquiry has come a better knowledge of the forms which ought to be given to the 'lines' of ships, followed by swifter passages across the sea, both by sailing vessels and steamers, of larger size and greater lengths than ever tried before. (*u*)

One of the earliest subjects to acquire importance in our thoughts, was the unexplored region of meteorology laid open in Professor J. Forbes' Reports (*x*). Several of the points to which he called attention have been successfully attained. The admirable instruments of Whewell, Osler, and Robinson have replaced the older and ruder anemometers, and are everywhere in full operation, to record the momentary variations of pressure, or sum the varying velocities of the wind. No small thanks were due to Mr. Marshall and Mr. Miller (*y*) for their enterprise and perseverance in placing rain gauges and thermometers amidst the peaks of Cumberland and Westmoreland. These experiments are now renewed in both countries, and in North Wales; and I hope to hear of similar efforts among the mountains of the west of Ireland and the west of Scotland. Our meteorological instruments of every kind have been improved; our system of photographic registration has spread from Kew into other observatories; and our corresponding member, Professor Dove, has collected into systematic maps and tables the lines and figures, which represent annual and monthly climate over every land and sea.

In the same manner, by no sudden impulse or accidental circumstance, rose to its high importance that great system of magnetic observations, on which for more than a quarter of a century the Brit-

(*s*) Reports of the British Association, 1833, 1836.

(*t*) Ibid., 1837 and following years.

(*u*) Ibid., 1840–1843.

(*x*) Reports of the British Association, 1832–1840.

(*y*) Mr. Marshall's observations were made in Patterdale, Mr. Miller's about Wastdale Head. (British Association Reports for 1846, and Royal Society's Transactions, 1850.)

ish Association and the Royal Society, acting in concert, have been intent. First, we had reports on the mathematical theory and experimental researches of magnetism by Christie, 1833, Whewell, 1835, and Sabine, 1835;—afterwards a magnetic survey of the British Islands (*z*); then, the establishment of a complete observatory at Dublin, with newly arranged instruments, by Dr. Lloyd, in 1838. On all this gathered experience we founded a memorial to her Majesty's Government, made a grant of £400 from our funds for preliminary expenses, and presented to the meeting of this Association in Birmingham, in 1839, a report of progress, signed by Herschel and Lloyd. From that time how great the labor, how inestimable the fruits! Ross sails to the magnetic pole of the south; America and Russia co-operate with our observers at Kew, Toronto, and St. Helena; and General Sabine, by combining all this united labor, has the happiness of seeing results established of which no man dreamed—laws of harmonious variation affecting the magnetic elements of the globe, in definite relation to the earth's movement, the position of the sun and moon, the distribution of temperature, and the situation in latitude and longitude (*aa*).

Our efforts have not been fruitless, whether with Mr. Mallet we make experiments on artificial earth-shocks at Dalkey, or survey the devastations round Vesuvius, or tabulate the records of earthquakes since the beginning of history (*bb*); or establish the Kew Observatory as a scientific workshop where new instruments of research are made and proved and set to work (*cc*); or dredge the sea with Forbes, and Brady, and Jeffreys (*dd*); or catalogue the

(*z*) The survey was begun in Ireland in 1835, by Lloyd, Sabine, and Ross; and completed in England, Wales, and Scotland, in 1837, by the same magneticians, assisted by Fox and Phillips. It was repeated in 1857 and following years by Sabine, Lloyd, Welsh, Haughton, Galbraith, and Stoney.

(*aa*) Trans. of the Royal Society for many years; Reports of the British Association, 1840 and following years; Rede Lecture, 1862.

(*bb*) British Association Reports; Experiments at Dalkey, 1853; Report on Earthquakes, 1840–1858. See also the excellent communications of M. Perrey to the Memoirs of the Academy of Dijon.

(*cc*) The Kew Observatory became a part of the system of the Association in 1842.

(*dd*) See reports of the Dredging Committees from 1842 to 1864; Nat. Hist. Trans. of Northumberland and Durham; Jeffrey's British Conchology.

stars with Baily (*ee*); or investigate electricity with Harris, Ronalds, Thomson, and Jenkin (*ff*); or try the action of long-continued heat with Harcourt (*gg*); in these and a hundred other directions, our attempts to gain knowledge have brought back new facts and new laws of phenomena, or better instruments for attaining, or better methods for interpreting them. Even when we enter the domain of practical art, and apply scientific methods to test a great process of manufacture, we do not fail of success, because we are able to join in united exertion the laborious cultivators of science and the scientific employers of labor.

Am I asked to give an example? Let it be iron, the one substance by the possession of which, by the true knowledge and right use of which, more than by any other thing, our national greatness is supported. What are the ores of iron—what the peculiarities and improvements of the smelting processes—what the quality of the iron—its chemical composition—its strength in columns and girders as cast iron; in rails and boiler plate, in tubes and chains, as wrought iron—what are the best forms in which to employ it, the best methods of preserving it from decay? —these and many other questions are answered by many special reports in our volumes, bearing the names of Barlow, Mallet, Porter, Fairbairn, Bunsen, Playfair, Percy, Budd, Hodgkinson, Thomson; and very numerous other communications from Lucas, Fairbairn, Cooper, Nicholson, Price, Crane, Hartley, Davy, Mushet, Hawkes, Penny, Scoresby, Dawes, Calvert, Clark, Cox, Hodgkinson, May, Schafhaeutl, Johnston, Clay, and Boutigny. Beyond a question, a reader of such of these valuable documents as relate to the strength of iron, in its various forms, would be far better informed of the right course to be followed in experiments on armor-plated ships and forts to resist assault, and in the construction of ordnance to attack them, than is likely to be from merely witnessing a thousand trials of the cannon against the target. Any one who remembers what the iron furnace was forty years ago, and knows its present power of work; or who contrasts the rolling mills and hammers of other days, with the beautiful machines which now, with the gentlest motion but irresistible

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(*ee*) British Association Catalogue of Stars, 1845.

(*ff*) The latest result of these researches is an instrumental standard of electrical resistance. (Reports of the British Association, 1863–1864.)

(*gg*) Reports of the British Association, 1846–1860.

force, compel the strong metal to take up the most delicately moulded form, will acknowledge, that within the period since the British Association began to set itself to the task of reconciling the separated powers of theory and experience, there has been a total change in the aspect of each, to the great advantage of both.

Our undertakings have not been fruitless. We attempted what we had well considered, and had the power to accomplish; and we had the more than willing help of competent persons of our own body, the friendly aid of other institutions, and the sanction of the Government, convinced of the sincerity of our purpose and the wisdom of our recommendations.

The same work is ever before us; the same prudence is always necessary; the same aid is always ready. Great, indeed, should be our happiness in reflecting on the many occasions, when the Royal Society in particular, and other institutions older than our own, have readily placed themselves by our side, to share our responsibility and diminish our difficulties. But for this, our wishes might not always have prevailed; and the horizon of science would not have been so clear as now it is. Of late years, indeed, societies formed on our model have taken up special parts of our work, and thus, to some extent, have relieved us of the pressure of communications relating to the practice of particular professions and the progress of some public questions. Not that scientific agriculture, social statistics, or physiology, are neglected in our meetings, but that these and other practical subjects are found to have more than one aspect, and to require more than one mode of treatment. With us, facts well *ascertained, conclusions* rightly drawn, will ever be welcome, from whatever quarter of the horizon of science they make their appearance. Whatever societies cultivate these objects, they are our allies, and we will help them, if we may. With pleasure we receive proofs of the good work done in limited districts by the many admirable Field Clubs formed by our countrymen; whether, like those of Tyne-side and the Cotswolds, and in this immediate vicinity those of Warwickshire, Worcestershire, and Dudley, they explore the minutest recesses of our hills and glens; or, like the rangers of the Alps, bring us new facts regarding glaciers, ancient climates, and altered levels of land and sea.

By these agreeable gatherings natural history is most favorably commended; and in the activity and enlarged views of the officers who conduct them, the British Association recognizes the qualities, by which the vitality of scientific research is maintained, and its benefits diffused among the provincial institutions of the empire.

Such, gentlemen, are 'some of the thoughts which fill the minds of those, who, like our Brewster, and Harcourt, and Forbes, and Murchison, and Daubeny, stood anxious but hopeful, by the cradle of this British Association; and who now meet to judge of its strength, and measure its progress. When, more than thirty years ago, this Parliament of Science came into being, its first child-language was employed to ask questions of nature; now, in riper years, it founds on the answers received further and more definite enquiries directed to the same prolific source of useful knowledge. Of researches in science completed, in progress, or in beginning, each of our annual volumes contains some three hundred or more passing notices, or full and permanent records. This digest and monument of our labors, is, indeed, in some respects, incomplete, since it does not always contain the narrative or the result of undertakings which we started, or fostered, or sustained; and I own to having experienced on this account once or twice a feeling of regret. But the regret was soon lost in the gratification of knowing that other and equally beneficial channels of publication had been found; and that by these examples it was proved how truly the Association kept to the real purpose of its foundation, 'the Advancement of Science,' and how heartily it rejoiced in this advancement without looking too closely to its own share in the triumph. Here, indeed, is the stronghold of the British Association. Wherever and by whatever means sound learning and useful knowledge are advanced, these to us are friends. Whoever is privileged to step beyond his fellows on the road of scientific discovery, will receive our applause, and, if need be, our help. Welcoming and joining in the labor of all, we shall keep our place among those who clear the roads and remove the obstacles from the paths of science; and whatever be our own success in the rich fields which lie before us, however little we may now know, we shall prove, that in this our day we know at least the value of knowledge, and join hearts and hands in the endeavor to promote it.

Sir Roderick Murchison proposed a vote of thanks to the President, for his address, in highly eulogistic terms.

ADDRESS TO THE GEOLOGICAL SECTION

BY SIR RODERICK MURCHISON, K. C. B.

It is now nineteen years since I presided over the British Association; and fifteen years have elapsed since I occupied the geological chair; for, although I have not in the meantime ceased to use my hammer, and though I still cling as keenly as ever to this my own special science, I have, in what I consider its enlarged sense, been led to endeavor to advance, in late years, by every means in my power, the sister science of Geography. I have thus had the happiness to see that, whilst the comparatively new Section of Geography and Ethnology has become very popular, and is always crowded, at all our recent meetings Section C treating, as it does, of the true foundation of geography, has been quite as well attended as ever; and I trust that on this occasion our room will be as well filled as it has ever been in previous years, when this section was presided over by a Buckland, a Sedgwick, a Delabeche, a Lyell, and a Phillips.

Great indeed have been the advances made in geological science in the sixteen years which have elapsed since our last meeting in Birmingham. For although at that time the bases of the classification of the older rocks were then firmly established, still our knowledge of the correlations and contents of the several formations ascending from the oldest stratified rocks in which we could distinguish the remains of life has since been materially extended.

The lowest sedimentary rock, which, with most geologists, I considered to be azoic, or void of life, simply because at that time nothing organic had been discovered in them, have, through the labors and discoveries of Sir William Logan and his associates in Canada been found to contain a zoophyte, which they termed *Eozoon Canadense.* But the rocks containing this fossil were named Laurentian by Logan long before that fossil was detected in them, and simply because they clearly underlie all the rocks of Cambrian and Silurian age. On the same principle of infraposition, it was my good fortune to be able, in 1855, to point out the existence of these same ancient rocks on a large scale in the north-west Highlands of Scotland; and though I at first termed them Fundamental Gneiss, as soon as I heard of Logan's discovery in North America I adopted his name of Laurentian.

In our islands, however, nothing organic has been discovered as yet in these our British fundamental rocks, though they are truly of Laurentian age. For although it was supposed for a moment that the rocks of the Connemara district in the west of Ireland were also of that high antiquity, because it was said that they contained an *Eozoon*, I assert, from my own examination*, as well as from information obtained during a recent visit by Professor Harkness, that the quartzose, gneissose, and calcareo-serpentinous strata of the Bins of Connemara, in which the supposed *Eozoon* was said to exist, are simply metamorphosed Lower Silurian strata. Professor Harkness will explain this point to you, and will further, I believe, endeavor to convince you that there is no organic structure whatever in the serpentinous rock of Connemara. But, whatever may be the decision of microscopists, I must, as a geologist, declare that, inasmuch as zoophytes of a low order (Foraminifera) unquestionably occur in Laurentian rocks, so it was by no means improbable that the same group of low animals, having, as far as we can detect, no antagonistic contemporaries, and having been, therefore, free from any "struggle for existence," might have continued to be the inhabitants of sea shores and cliffs during the long succeeding epoch.

The mere presence of an *Eozoon* is therefore no proof whatever that the rock in which it occurred is of the "Fundamental" or "Laurentian" age, that point being only capable of settlement by a clear infraposition of the rocks to well-known and clearly defined Lower Palæozoic deposits, in the lowest of which, or the Cambrian of the Geological Survey, another form of low zoophyte, and a few worm-tracks have, as yet, alone been detected.

In a word, this discovery of a foraminifer in the very lowest known deposit, instead of interfering with, sustains the truth of that doctrine which all my experience as a geologist has confirmed, that the lowest animals alone occur in the earliest zone of life, and that this beginning was followed through long periods by creations of higher and higher animals successively. Thus through the whole of the vastly long Lower Silurian period, so rich in all the lower classes of marine animals, whether mollusks, crustaceans, or zoophytes, no one has yet detected a vertebrated creature. Fishes first begin to appear in the latest Silurian deposit, from which time to the present day they have never ceased to prevail; and new forms of Vertebrata, adapted to each succeeding

* See 'Siluria,' p. 190.

period, have followed each other. Every geologist knows how, in the overlying Secondary and Tertiary formations, higher and higher grades of animals successively appear; and how the relics of man or his works have been detected in the youngest only of the Tertiary deposits, though certainly at a period long anterior to all history. We now well know that human beings coexisted with quadrupeds which are extinct; and we also know that the physical configuration of the surface has undergone considerable changes since such primeval men lived. This subject, opened out in France by M. Boucher de Perthes, followed by some of his distinguished countrymen, has in our country received much illustration at the hands of Prestwich, Lyell, Falconer, Lubbock, Evans, and others, and is now a well-established doctrine.

But the great feature at the other end of the geological series, to which I revert, is the uncontradicted fact, which has been passed over by many writers, or misrepresented by others, that there were enormously long periods, following that of the primeval zoophytic deposits, during which the seas, though abounding in all other orders of animals, were not tenanted by fishes.

As this is a fact which the researches, during thirty years, of many geologists, amidst the Lower Silurian rocks in all parts of the world, have been unable to invalidate, so it teaches us, in our appeal to the works of nature, that there was a beginning as well as a progress of creation, and that those writers, however eminent, who have announced that fishes, mollusks, and other invertebrata appeared together, have asserted that which is positively at variance with the results of the researches of this century. As I have in various works pointed out this great fundamental principle in the origin of successive faunæ, and as at my age I may probably never again occupy a geological chair, I hope therefore to be excused for looking back with some pride, now that I am on the eastern borders of my Silurian region, to the period when, thirty years ago, I dwelt on the then novel fact, never since contravened, that "the fishes of the Upper Silurian rocks appeared before naturalists as the most ancient beings of their class."* Enormous regions in Europe and America over which these

* See 'Silurian System,' p. 605. Though the work was not published until 1838–39, the Silurian system and its characters were established by me in 1835 (see 'London, Edinburgh, and Dublin Philosophical Magazine,' 3rd series, vol. vii, p, 46, 1835).

Silurian rocks extend have, I repeat, been long harried, with an intense desire on the part of many searchers to find something which would gainsay the datum-line that marks the beginning of vertebrated life; and, as all these efforts have failed, I have some right to insist upon the value of such a vast amount of what those who seek to oppose this view still persist in calling negative evidence. The facts however remain, and on them I rest my belief.

In this short introductory address I cannot attempt to present to you a sketch of the general recent progress of geological science in other parts of Europe or in America. This must be sought in the well-digested recent address of the actual President of the Geological Society, Mr. W. J. Hamilton. I must, for the most part, confine my observations to certain British questions, the more so as I know that our distinguished associates of other countries, who honor us by their presence on this occasion, come to us mainly for the purpose of ascertaining the progress we have made in our isles, and also with the view of visiting those of our typical localities of which they have read.

Among those visitors from abroad, I must first allude to my eminent friend, M. Henri von Dechen, the director of the mines of Prussia. In speaking of him, I turn back to the year 1827 (four years before the foundation of the British Association), when he and his associate Oeynhausen explored our islands, and when it was the good fortune of Professor Sedgwick and myself to examine parts of the Highlands of Scotland in company with those able young German geologists, who have since risen to such high distinction. Of him who is now present, I will only say that the great geological map of the Rhine Provinces, of which he has been the director, is a work of special value to English geologists. In this map are delineated with precision the whole series of the Palæozoic rocks on both banks of the Rhine, from those Devonian limestones of the Eifel which were correlated with our own by Sedgwick and myself, to the Coal-measures and the several Tertiary and superficial deposits, as well as all the rocks of igneous origin; in it are also elaborated in the most skilful manner all the numerous intermediate strata, of Devonian and Mountain-limestone age, which are wanting in the immediate vicinity of Birmingham, but which have to a great extent their equivalent representatives in other parts of our islands. Whilst for the subordinate strata thus delineated M. von Dechen and all Prussian geologists naturally employ local names, I am glad to find that the general groups of the Silurian, Devonian, and Carboniferous are thoroughly recognized by him and his associates according to the divisions established in Britain, and of which our father William Smith set the first example, by his admirable identification of the strata of the Secondary rocks by their fossils and order of superposition.

My veteran German friend is accompanied by another of his countrymen, Professor Ferdinand of Roemer, of Breslau, whose works have justly earned for him a very high position, particularly in palæontology; and whilst one of these is upon Texas, in the United States of America, let me say how fortunate we are in having among us Principal Dawson, of Montreal, in Canada, whose merits are so well known to every reader of the volumes of Lyell and the Quarterly Journal of the Geological Society of London. There may indeed be present several distinguished visitors from distant countries, with whose arrival or intention of coming hither I am unacquainted whilst I write; but in relation to our nearest neighbors, the French, it gave me great pleasure when I learned that our younger Foreign Associates were to be led by M. A. Gaudry, once President of the Geological Society of France. Now, all these visitors will, I doubt not, rejoice in having the opportunity of studying the varied relations of the sedimentary and eruptive rocks in the vicinity of this flourishing hive of human industry. These and other foreign visitors, as well as our associates from different parts of the United Kingdom, will necessarily take a deep interest in comparing the varied rocks and their fossils, which are grouped around our place of meeting, with the sedimentary and eruptive rocks of their own several districts.

Among the recent important additions to our knowledge of the geographical distribution and characters of the Silurian rocks, I cannot but advert to the successful labors of Professor Harkness. He had already shown in the clearest manner, by the evidence of fossils and order of succession, that the lowest of the strata in the Cambrian district of the Lakes, the slates of Skiddaw, are truly of Lower Silurian age, and not older than the Llandeilo group. Recently, in pursuing his labors, he has detected fossils in the "green slates" or volcanic ashes and porphyries which lie intermediate between the Skiddaw strata and the higher Silurian; and he has further found others in the Coniston Flags, which he views as equivalents of the upper part of the Caradoc formation. Further, Professor Harkness has shown, for the first time, that the slaty rocks of Westmoreland, which separate the Carboniferous limestone from the Permian of the Vale of the Eden, contain Lower Silurian fossils similar to those of Cumberland. I hope also to learn from him at this meeting what has been the effect of certain great faults ranging from north to south, which have impressed a grand and picturesque outline on that region, and upon the lines of which are situated the most striking of the lakes of the north-west of England.

Although no Lower Silurian rocks, properly so called, occur near Birmingham, one adjacent tract, the Lickey, offers a characteristic example of the lowest of the Upper Silurian rocks, in the form of quartz-rock; whilst the limestones and shales of Dudley, and their beautiful fossils, surmounted by those of Sedgeley, are very rich and characteristic of part of the overlying Ludlow and Aymestry series. I am glad to find that the members of the Dudley and Midland Geological Society will not only communicate to us papers on the different organic remains of these deposits, but will also point out the relations of these rocks to others in the west, where the whole Silurian system is more fully developed. We shall also, I hope, have fresh illustrations of the effect of the eruptions of the basaltic and igneous rocks of the Rowley Hills, and other similar bosses, upon the Palæozoic strata which they penetrate.

Above all, the mining public and proprietors in the Midland Counties will, I am certain, be well instructed by the evening lecture to be given by my friend and associate Professor Jukes, who so distinguished himself, by his descriptions and maps of this his native district, as justly to entitle him to be placed at the head of the geological Survey of Ireland, which for many years he has conducted with great ability. He can, no doubt, indicate to you the extent to which profitable works in coal are likely to be carried out, by sinkings through that Lower Red Sandstone of the central counties which is now termed Permian, a name proposed by myself in 1841, as taken from a large province in Russia, because I there found sandstones and limestones of the same age, extending over a region much larger than France. The sinkings, which were successfully made through this deposit at Christchurch by the late Earl of Dartmouth, only four miles to the west of Birmingham, induced me, twenty-seven years ago, to write thus:—" It is, indeed, impossible to mention this enterprise, without congratulating geologists on the effects which their writings are now producing on the minds of practical men, since it was entirely owing to inferences deduced from geological phenomena that this work was commenced, whilst its success was derided by many of the miners of the adjacent coal-field."

If that enterprise has not been extensively followed, we must recollect, that, to sink shafts to depths of many hundred feet can in central England scarcely be profitable, so long as coal is found so much nearer the surface, as in the South Staffordshire field; yet, as that field is tending towards exhaustion, it is cheering to know that extensive beds of coal will be worked in future ages under the red lands of the Midland counties and the Magnesian Limestone of Nottinghamshire, under which the great Derbyshire coal-field passes; and hence all present estimates of the duration of our coal-supply must be more or less fallacious, if such high probabilities be left out of the estimate. At the same time it must be admitted that we are consuming this staple of our national greatness at so rapidly increasing a ratio, that the value of the warning voice of Sir William Armstrong at the Newcastle Meeting of the Association, when he told us that, with a continued yearly increase of two and three-quarter millions of tons, our coal-supply would be exhausted in little more than two centuries, is well sustained. Now when this announcement was made, the average total annual produce, as ascertained by the Mining Record Office of the Museum of practical Geology, amounted to eighty-six millions of tons; but by the estimate of last year, as prepared by Mr. Robert Hunt, and to which I have recently affixed my name, the produce has risen to the astounding figure of ninety-three millions of tons. Such is our own natural industry and enterprise that not more than 9½ per cent. of this enormous quantity is exported for the use of foreign countries, among which France receives but 1,400,000 tons per annum.

Passing from the consideration of these deep-seated subjects to the superficial deposits of the country around Birmingham, I would advise any of my associates who have not witnessed the phenomena to repair to the parishes of Trescott and Trysull, and the adjacent hills to the west of Wolverhampton, there to see a quantity of blocks of granitic and other hard northern rocks, all foreign to the district, which were evidently carried by icebergs floating in the sea which covered this flat and undulating region in the heart of England during that glacial period when Scotland was what Greenland is now—an ice-clad region, whence icebergs, transporting blocks of stone, were floated southwards from great Scottish glaciers which protruded into the sea.

Coming hither in ignorance of what the several associations of local geologists (which rival each other in their researches) have accomplished, I shall be happy to learn that some of them have detected, in this portion of the kingdom, any of those proofs of the existence of man at an early period, when large animals, now extinct, prevailed in our islands, in ages so remote that, since then, the physical configuration of the country has undergone great changes. This inference is, as I have said, founded upon irrefragable evidence collected in different parts of Europe, as well as in our own country. When, however, we come to consider the *modus operandi* by which these great physical changes have been brought about, geologists have different opinions. As one who holds to the belief that in former periods the crust of the earth was from time to time affected by an agency much more powerful than anything which has been experienced in the historic era, I do not believe that the wear and tear due to atmospheric subaërial erosive agency could, even after operating for countless ages, have originated and deepened any of the valleys and gorges which occur in countries as flat as the tract in which we are now assembled.

But whilst I adhere to my long-cherished opinion as to the great intensity of power employed in the production of dislocations of the crust of the earth, and though I cannot subscribe to the doctrine that the ordinary action of deep seas remote from coasts can adequately explain the denudation of the old surface, even by invoking any amount of time, I recognize with pleasure the ability displayed by my able associates, Ramsay, Jukes, and Geikie, in sustaining views which are to a great extent opposed to my own in this department of Theoretical Geology.

Admiring the Huttonian theory, as derived from reasoning upon my native mountainous country, Scotland, and fully admitting that on adequate inclines ice and water must, during long periods, have produced great denudation of the rocks, I maintain that such reasoning is quite inadequate to explain the manifest proofs of convulsive agency which abound all over the crust of the earth, and even are to be seen in many of the mines in the very tract in which we are assembled. Thus, to bring such things to the mind's eye of persons who are acquainted with this neighborhood, I do not apprehend that those who have examined the tract of Coalbrook Dale will contend that the deep gorge in which the Severn there flows has been eaten out by the agency of that river, the more so when the deep fissure is at once accounted for when we see the abrupt severance that has taken place between the rocks which occupy its opposite sides. In that part of Shropshire, the Severn has not worn away the rocks during the historic era, nor has it produced a deeper channel; whilst in its lower parts it has only deposited silt and mud, and increased the extent of land on its banks.

Then, if we turn to the district in which we were last assembled, the valley at Bath is known to be the seat of one of those disturbances to which my eminent friend Sir Charles Lyell candidly applied the term " convulsion" ; the hot waters of that city having ever since flowed out of a deep-seated fissure, clearly marked by the strata on the one side of the valley having been upheaved to a height very different from that which they once occupied in connexion with those of the other side. When, indeed, we look to the lazy-flowing, mud-collecting Avon, which at Bath passes along that line of valley, how clearly do we see that it never scooped out its channel; still more, when we follow it to Bristol, and observe it passing through the deep gorge of Mountain-limestone at Clifton, every one must then be convinced that it never could have produced such an excavation. In fact, we know that, from the earliest periods of history, it has only accumulated mud, and has never worn away any portion of the hard rock.

From such data I conclude that we cannot apply to flat regions, in which water has no abrading power, the same influence which it exerts in mountainous countries; whilst we are also compelled to admit that the convulsive dislocations of former periods produced many of those gorges in which our present streams flow. To pass, indeed, from the environs of Bath and Bristol, and even from the less distant Coalbrook Dale, you have only to contemplate the tract which lies between Birmingham and Dudley, and endeavor to satisfy the mind as to the process by which it has been planed down before the surface was covered by the Northern Drift; for the great dislocations which this tract has undergone, as proved by many subterraneous workings, must have left a highly irregular surface, which was so levelled by some very active causes as to obliterate the superficial irregularities corresponding with the interior disturbances. In short, what was this great power of denudation which took place in a tract where there are no mountains whence powerful streams descended, and in which there are no traces of fluviatile action? Must we not, in candor, admit that such denudation is as difficult to account for as it is to explain by what possible gradual agency the vast interior of the valley of elevation of the Weald of Sussex and Kent, and that of the smaller valley of Woolhope in Herefordshire, have been so absolutely and entirely denuded of every fragment of the enormous masses of débris which must have encumbered these cavities, as derived from the rocks which once covered them? Placing no stint whatever on the time which geologists must invoke to satisfy their minds as to the countless ages which elapsed during the accumulations of sediment, I reject as an assumption which is at variance with the numberless proofs of intense disturbance, that the mechanical disruptions of former periods, and the overthrow of entire formations, as seen in the Alps and many mountain chains, can be accounted for by any length of action of existing causes.

A GEOGRAPHICAL, SKETCH OF CANADA.*

The great basin of the St. Lawrence, in which the province of Canada is situated, has an area of about 530,000 square miles. Of this, including the gulf of St. Lawrence, the river, and the great lakes, to Lake Superior inclusive, about 130,000 square miles are covered with water, leaving for the dry land of this basin an area of 400,000 square miles, of which about 70,000 belong to the United States. The remaining 330,000 square miles constitute the province of Canada. With the exception of about 50,000 square miles belonging to Lower Canada, and extending from the line of New York to Gaspé, the whole of this territory lies on the north side of the St. Lawrence and the great lakes.

On either side of the valley of the lower St. Lawrence is a range of mountainous country. The two ranges keep close to the shores for a considerable distance up the river; but about 100 miles below Quebec, where the river is fifteen miles wide, the southern range begins to leave the margin, and opposite to Quebec is thirty miles distant. From this point it runs in a more southern direction than the river-valley, and opposite to Montreal is met

* The following pages are extracted from a small pamphlet on Canada, prepared by Dr. T. Sterry Hunt, at the request of the Minister of Agriculture, for distribution at the Exhibition held at Dublin in 1865. As containing a brief and popular description of the topography and the soils of the Province they may not be without interest to our readers.

with about fifty miles to the south-east, where it enters Vermont, and is there known as the Green Mountain range, which forms the eastern limit of the valley of Lake Champlain. In Canada, this range, stretching from the parallel of 45° north latitude to the Gulf, is known as the Notre-Dame Mountains, but to its north-eastern portion, the name of the Shickshock Mountains is often given.

The flank of the northern hills, known as the Laurentides, forms the north shore of the river and gulf, until within twenty miles of Quebec. It then recedes, and at the latter city is already about twenty miles distant from the St. Lawrence. At Montreal the base of the hills is thirty miles in the rear, and to the westward of this it stretches along the north side of the Ottawa River for about 100 miles, and then runs southward across both the Ottawa and the St. Lawrence, crossing the latter river a little below Kingston, at the Thousand Islands, and entering New-York. Here the Laurentides spread out into an area of about 10,000 square miles of high lands, known as the Adirondack region, and lying between the Lakes Champlain and Ontario. The narrow belt of hill-country which connects the Adirondacks with the Laurentides north of the Ottawa, divides the valley of the St. Lawrence proper from that of the great lakes, which is still bounded to the north by a continuation of the Laurentides. The base of these from near Kingston runs in a western direction, at some distance in the rear of Lake Ontario, until it reaches the south-west extremity of Georgian Bay on Lake Huron; after which it skirts this lake and Lake Superior, and runs north-westward into the Hudson Bay Territory. This great northern hill-region consists of the oldest known rock-formation of the globe, to which the name of the Laurentian system has been given, and occupies, with some small exceptions, the whole of the province northward of the limits just assigned. We shall designate it as the LAURENTIAN REGION. Over a small portion of this area, along Lakes Huron and Superior, and farther eastward on Lake Temiscaming is another series of rocks, to which the name of the Huronian system is given. But as the country occupied by these rocks is geographically similar to the Laurentian, it is for convenience here included with it.

To the south of this region the whole of Canada west of Montreal, with the exception of the narrow belt of Laurentian country described as running southward across the Ottawa and St. Lawrence Rivers, is very level. The same is true to the eastward of Montreal until we reach the Notre-Dame range of hills, already described as passing southward into Vermont, and in its north-eastern extension as bounding the lower St. Lawrence valley to the south. This valley may be regarded geographically as an extension of the great plains of western Canada and central New York, with which it is connected through the valley of Lake Champlain. This level country to the south of the Laurentides in the two parts of the province is occupied by similar rock formations, and constitutes the CHAMPAIGN REGION of Canada, the surface of which is scarcely broken, except by a few isolated hills in the vicinity of Montreal, and by occasional escarpments, ravines, and gravel ridges farther westward.

The next area to be distinguished consists of the Notre-Dame range on the south side of the St. Lawrence which forms the belt whose course has just been described, with an average breadth of from thirty to forty miles. To the south and east of this, is a district of undulating land, which extends to the boundaries of the province in that direction. These two districts may for convenience in farther description be classed together, and they embrace the region which is generally known as the EASTERN TOWNSHIPS. By this term they are distinguished from the SEIGNIORIES, which bound them to the north and west. To the north-east, however, along the Chaudiere River, some few seigniories are found within the geographical limits of this third region.

The whole of the province is well watered with numerous large and small rivers, and in the mountainous districts there are great numbers of small lakes, more than 1,000 of which are represented on the maps.

We have in the preceding description divided the country into three distinct regions, and have next to consider the geological structure of these as related to the soil and to its agricultural capabilities.

THE LAURENTIAN REGION.—The great tract of country occupied by the Laurentian rocks has for its southern boundary the limits already assigned, and stretches northward to the boundary of the province, which is the height of land dividing the waters of the St. Lawrence basin from those of Hudson's Bay. Its area is about 200,000 square miles, or six-tenths of the whole land of the province. This region is composed exclusively of crystalline rocks, for the most part silicious, or granite-like in character, consisting of quartzite, syenite, gneiss, and other related rocks. These are broken up into ridges and mountain peaks, generally rounded in outline and covered with vegetation. The summits in the neighbor hood of Quebec are some of them from 2,000 to 2,500 feet in hight, and in other parts attain 4,000 feet or more; but the genera level of this region may be taken at about 1,500 feet above the sea, although it is much less in the narrow belt which crosses the province east of Kingston. Through the hard rocks of this region run numerous bands of crystalline limestone or marble, which from their softness give rise to valleys, often with a fertile soil. The hill-sides are generally covered with little else than vegetable mold, which sustains a growth of small trees, giving them an aspect of luxuriant vegetation. But when fire has passed over these hills, the soil is in great part destroyed, and the rock is soon laid bare. In the valleys and lower parts of this region however, there are considerable areas of good land, having a deep soil, and bearing heavy timber. These are the great lumbering districts of the country, from which vast quantities of timber, chiefly pine, are annually exported, and constitute a great source of wealth to the province. These valleys are in most cases along the bands of limestone, whose ruins contribute much to the fertility of the soil. Lines of settled country running many miles into the wilderness are found to follow these belts of soft calcareous rock.

The settlements in this region are along its southern border, and at no great altitude above the sea. In the higher parts, the rigor of the climate scarcely permits the cultivation of cereals, and it is probable that no great portion of this immense region will ever be colonized, but that it will remain for ages to come covered with forests. These, if husbanded with due care, will remain a perpetual source of timber for the use of the country and for exportation; besides affording, with proper facilities for transportation, an abundant supply of fuel to the more thickly settled districts, where the forests have nearly disappeared, and where from the severity of the long winters, an abundant supply of fuel is of the first necessity. There are other reasons why this great forest region should be protected. The vegetation, and the soil which now cover the hill-sides, play a most important part in retaining the waters which here fall in the shape of rain or snow. But for this covering of soil, the rivers and mill-streams which here take their rise, would, like the streams of southern France, and of the north of Italy, be destructive torrents at certain seasons, and almost dried-up channels at others. The effect of this great wooded area in tempering the northern winds, and moderating the extremes of climate is not to be overlooked in estimating the value of the Laurentian region..

THE EASTERN TOWNSHIPS.—Under this head, as already explained, is included the belt of hill-country south of the St. Lawrence, with the region on its south-east side, extending to the frontier, and forming a succession of valleys, which may be traced from the head-waters of the Connecticut north-eastward to the Bay of Chaleurs. It is true that the Eastern Townships, as now known, do not embrace this northeastern extension; but as it belongs to them both geographically and geologically, it may be conveniently included with them.

The area whose limits are thus defined forms about one-tenth of the province. The hills of the range which traverses it are composed, like those of the Laurentian region, of crystalline rocks: but these are softer than the greater part of the rocks on the north shore, and yield by their wearing down a more abundant soil. Some of the hills in this range attain an elevation of 4,000 feet above the sea, and the principal lakes in the valley on the south-eastern side, Memphremagog, Aylmer, and St. Francis, are from 750 to about 900 feet above the sea-level. This region is well wooded, and when cleared is found in most parts to have an abundant soil, generally sandy and loamy in character, and well fitted for grazing and for the cultivation of Indian corn and other grains. Great attention is now paid to the rising of cattle, and the growing of wool, and within the last few years the best breeds of sheep have been successfully introduced from England and from Vermont. Draining and improved methods of farming are in many parts practised, and the agricultural importance of the southern portions of this region is yearly increasing.....................................

THE CHAMPAIGN REGION.—The limits of the great plains of Canada have already been defined in describing those of the two preceding regions. These plains, which may be called the champaign region, occupy about three tenths of the province, and are, as we have seen, divided into two parts by a low and narrow isthmus of Laurentian country, which runs from the Ottawa to the Adirondacks of New-York. To the eastward of this division, the present region includes the country between that river and the St. Lawrence, and all between the Laurentides on the north and the Notre Dame hills on the south-east; while to the westward it embraces the whole of the province south of the Laurentian region, including the great area lying between the Lakes Ontario, Erie and Huron, generally known as the south-western peninsula of Canada. The whole of this region, from east to west, is essentially a vast plain, with a sufficient slope to allow of easy drainage. The distance from Quebec to the west end of Lake Superior is about 1,200 miles, yet this lake is only 600 feetabove the sea-level, while Lake Erie is 565 feet, and Lake Ontario 232 feet above the sea. The land on the banks of the St. Lawrence and its lakes, either near the margin, or not very far removed, generally rises to a height of from fifty to one hundred and fifty feet, and from this level very gradually ascends to the base of the hills which bound the region.

Unlike the two regions already described, these great plains are underlaid by beds of unaltered Silurian and Devonian rocks, consisting of sandstones, limestones, and shales. These are but little disturbed, and are generally nearly horizontal; but over by far the greater part of the region they are covered by beds of clay, occasionally interstratified with or overlaid by sand and gravel. These superficial strata, which are in some parts several hundred feet in thickness, are throughout the eastern division, in great part of marine origin, and date from a time when this champaign region was covered by the waters of the ocean; while throughout the western division the clays are more probably of fresh-water origin. It results from the distribution of these superficial post-tertiary strata, that the soil over the greater part of the region consists of strong and heavy clays, which in the newly cleared portions are overlaid by a considerable thickness of vegetable mould. In the eastern division, a line drawn from Quebec to Ottawa, and two others from these points, converging at the outlet of Lake Champlain, will enclose a triangular area of about 9000 square miles, which is very nearly that occupied by the marine clays. These are overlaid, chiefly around the borders of this space, by more sandy deposits, which are well seen near Three Rivers, and about Sorel. They form a warm but light soil, which yields good crops when well manured, but is not of lasting fertility. The greater part of this area however is covered by a tenacious blue clay, often more or less calcareous, and of great depth, which constitutes a strong and rich soil, bearing in abundance crops of all kinds, but particularly adapted for wheat, and was in former times noted for its great fertility. These clay lands of Lower Canada, have been for a long time under cultivation, and by repeated cropping with wheat without fallow, rotation, deep plowing, or manure, are now in a great many cases unproductive, and are looked upon as worn out or exhausted. A scientific system of culture which should make use of deep or sub-soil ploughing, a proper rotation of crops, and a judicious application of manures, would however soon restore these lands to their original fertility. The few trials which within the last few years have been made in the vicinity of Montreal and elsewhere, have sufficed to show that an enlightened system of tillage, with sub-soil draining, is eminently successful in restoring these lands, which offer at their present prices good inducements to skilled farmers. Besides grain and green crops, these soils are well fitted for the culture of tobacco, which is grown to some extent in the vicinity of Montreal. Notwithstanding the length of the winter season in Canada, the great heat and light of the summer, and the clearness of the atmosphere enable vegetation to make very rapid progress.

To the north-east of Quebec, besides the plains which border the river, there is a considerable area of low-lying clay land, cut off from the great St. Lawrence basin by Laurentian hills, and occupying the valley of Lake St. John and a portion of the Saguenay. Here is a small outlying basin of Lower Silurian rocks, like those about Montreal, and overlaid in like manner by strong and deep clays, which extend over the adjacent and little elevated portion of the Laurentian rocks, and form a soil as well fitted for cultivation as any part of the lower St. Lawrence valley. The valley of this lake is probably not more than 300 feet above the sea; and from the sheltered position the climate is not more rigorous than that of Quebec. Several townships have within a few years been laid out in this valley, and have attracted large numbers of French Canadians from the older parishes in the valley of St. Lawrence.

The western part of the champaign region, commencing near Kingston and including all the southern portion of the western province, is the most fertile and productive part of Canada. Like the plains further eastward, its soil consists chiefly of strong clays, overlaid here and there by loam, sand, and gravel. In the natural state nearly the whole of this region supported a fine growth of timber, in great part of broad-leaved species, but presented however various local peculiarities. Thus, the banks of the Grand River from Galt to Brantford were remarkable for a sparse growth of oaks, free from underwood, and known as oak openings. These are said to have been pasture grounds of the Indians, brought to this condition and kept in it by partial clearing, and by the annual burning of the grass. The object of this was to attract the deer who came to feed upon the herbage* The soil of these plains is a light sandy loam, very uniform in character, and generally underlaid by coarse gravel. Though fertile, and of easy tillage, this and similar soils will not support the long continued cropping without manure, which is often practiced on the clay lands of both Upper and Lower Canada.

The valley of the Thames, together with the rich alluvial flats which extend from it northward to the North Branch of Bear Creek, and southward nearly to the shore of Lake Erie, is remarkable for its great fertility, and its luxuriant forest growth. The soil is generally clay, with a covering of rich vegetable mould, and is covered in the natural state with oak, elm, black-walnut and tulip trees (*Liriodendron tulipifera*) of large size, together with fine groves of sugar-maple. Towards the mouth of the Thames, and on the borders of Lake St. Clair, is an area of natural prairie of about 30,000 acres. It lies but little above the level of the lake, and is in large part overflowed in the time of the spring floods. The soil of this prairie is a deep unctuous mould, covered chiefly with grass, with here and there copses of maple, walnut and elm, and with willows dotting the surface of the plain. Numbers of half-wild horses are pastured here, and doubtless help to keep down the forest growth. The characters of the surface are such as to suggest that it had been at no distant period reclaimed from the waters of the adjacent lake.

In no part of the province have skilled labour and capital been so extensively applied to agriculture as in western Canada, and the result is seen in a general high degree of cultivation, and in the great quantities of wheat and other grains which the region annually furnishes for exportation; as well as in the excellent grazing farms, and the quantity and quality of the dairy produce which the region affords. This western portion of the province, from its more southern latitude, and from the proximity of the great lakes, enjoys a much milder climate than the other parts of Canada. The winters are comparatively short, and in the more southern sections the peach is successfully cultivated, and the chestnut grows spontaneously.

* See on this point, Marsh's *Man and Nature*, page 137.

REVIEW OF THE NORTHERN BUCCINUMS,

AND REMARKS ON SOME OTHER NORTHERN MARINE MOLLUSKS.

PART I.

By Dr. WM. STIMPSON.

Having recently undertaken, at the request of Principal Dawson of McGill College, to make some comparisons of the fossils of the pleistocene deposits of Canada and Maine with recent species, particularly those of the difficult genus *Buccinum*, I am induced to offer the results for publication, the work having become more extended than was at first anticipated.

Genus BUCCINUM Linn.

The group of shells to which the generic name *Buccinum* was originally applied, a century ago, by Linné, has been found by subsequent investigation to contain many heterogeneous forms, and has consequently been greatly subdivided. The name has been retained for the genus typified by *Buccinum undatum*, by common consent, and, I believe, in accordance with the best rules of nomenclature. It is true that Linné's first species—that which is to be selected, as in cases where no type is distinctly specified,—is a *Dolium*. But in the case of Linné's genera, he must be considered to have indirectly specified the type, as he has expressly stated that, in his view, where it becomes necessary to divide a group, formerly supposed to be one genus, the original name must be retained for the subdivision containing the most common species; in other words, that the most common species must be considered as the type of its genus. And he must, therefore, have regarded the *undatum*, the most common of all his Buccinums, as the type of the genus.

The Scandinavian naturalists have generally retained the name *Tritonium* of Mueller for this genus, but Linné's name has priority by many years. *Tritonium*, as proposed, and as frequently used since, would include both the *Murex* and the *Buccinum* of Linné.

The genus is too well known to require particular description here, and few points require special remark. Among the spiral grooves and striæ or ridges with which the shell is always more or less deeply sculptured, two kinds may usually be distinguished, a large and a small kind, those of the latter being by far the more numerous, and distributed upon the surface of the others. These kinds we shall call, for convenience, the primary and secondary grooves, or ridges, as the case may be. The difference between them is very conspicuous in *B. glaciale.* The columella has normally three folds, an upper, middle, and lower one;—the lower one constituting the oblique inferior margin of the columella. These folds are not always distinct, but all of them may be made out in *B. tenue.* The middle fold is obsolete in most of the species, but is very prominent and tooth-like in *B. ciliatum.* The layers of the shell are very distinct in this genus, the outer coat being most frequently of a brownish color. The periostraca is generally ciliated with minute processes along the lines of growth, corresponding to their intersections with the secondary ridges.

The operculum is oval or subcircular, and may have the nucleus near the centre, or more or less approximated to the posterior (outer) margin, according to the species. On the lingual ribbon, as in all the Buccinidæ, we find three teeth in each row, the central one of which is lamelliform, with denticles on its posterior edge; while each lateral tooth has two strong hook-shaped denticles, with smaller ones between them. The denticles of the central tooth are more numerous than in *Neptunea.*

With one or two doubtful exceptions, the genus *Buccinum* is restricted geographically to the temperate and frigid seas of the northern hemisphere. More careful examination, both of the shell and soft parts of the antarctic species* referred to the genus, is required, before deciding upon their actual pertinence to it. Geologically, the history of the genus commences in the Pliocene formation. They are found in the European Tertiary deposits of that age, even as far south as the shores of the Mediterranean. They become very numerous in the Pleistocene deposits both of Europe and North America, but reach their maximum development in the existing seas.

I have endeavored to include in the following review all the species which certainly belong to the genus. As to the *B. Dalei* of Sowerby, and the *B. ovoides* of Middendorff, if we may rely upon the accuracy of the observations of Mr. Alder on the lingual dentition of the former, as detailed in Forbes and Hanley's "British Mollusca," vol. iv, p. 284, these species are not true Buccinums. Mr. Alder says, "Its tongue differs from that of *Buccinum undatum* as well as from those of the allied species of the genus *Fusus*, and makes a slight approach to that of *Mangelia.* It has a single plain

* Such as *B. antarcticum* and *B. zealandicum.*

and slightly-curved tooth on each side, and a very thin non-denticulated plate in the centre." This statement clearly indicates the existence of a distinct generic group, for which we would propose the name *Liomesus* with *Buccinum Dalei* as the type. I have specimens of *L. ovoides* from Behring's Straits.

The shells of the genus *Buccinum* are peculiarly liable to variation both in form and sculpture, and to obsolescence or erosion of the surface-markings. In the following descriptions, the normal form and markings are always given, except when otherwise distinctly stated. The identification of imperfect or worn specimens is extremely difficult in this genus.

Buccinum polare Gray.

Buccinum polaris Gray, Zoöl. of Beechey's Voy. (1839), p. 128.

Shell rather thin, ovate, turreted. Whorls 6–7, strongly and sharply bi-carinated, with the upper carina strongest, forming a prominent shoulder to the whorl. Between these two principal carinæ there are often one or two others much slighter. The longitudinal folds are regular, oblique, and about fourteen in number to each whorl; they are prominent near the suture, but become obsolete below the carina of the shoulder, on which they form tubercles. The primary spiral grooves are about thirty-five in number on the outer whorl, nearly equidistant, deep, sharply and squarely cut, and sometimes double, being divided in two by a sharp and narrow ridge. The primary ridges are flat and even, and covered with very minute secondary grooves, about six to each ridge. Aperture rather narrow, about half as long as the shell, broadest above, and somewhat contracted anteriorly; outer lip not patulous, thin and simple in our specimens. Columellar lip more deeply incurved or excavated above, less oblique and more elongated than in *B. glaciale*, and with its three folds sufficiently conspicuous. Periostraca short-ciliated on the upper whorls; perfectly smooth on the outer whorl.

Length, 2.2; breadth, 1.25 inch.

This description is taken from two specimens, probably immature, dredged by Capt. John Rodgers, of the U. S. North Pacific Expedition, in the Arctic Ocean, north of Behring's Straits. I consider them to be the *B. polare* of Gray;—at least I can find no other form agreeing as well with his description as this. Gray's specimens were from Icy Cape.

The only species with which this is likely to be confounded are

B. glaciale and *B. grœnlandicum.* From the former it differs in its thin structure, shouldered whorls, and narrower aperture. It is larger and broader than *B. grœnlandicum*, and the aperture is comparatively larger and more narrowed anteriorly than in that shell, which, moreover, never has shouldered whorls.

The characters given by Gray for the distinction of this species from *B. glaciale* do not hold good. That species often has whorls as "deeply striated and closely plicated" as occurs in *B. polare.*

BUCCINUM GRŒNLANDICUM Hancock.

Buccinum grœnlandicum Hancock, An. and Mag. Nat. Hist. [1], xviii (1846), 329; v, 8, 9. Reeve, Conch. Icon., iii (1847), Buc., xiv, 118.

Tritonium Hancocki Moerch, in Rink's "Grœnland," Tillaeg. (1857), Aftryk, 84.

Buccinum undatum Dawson, Can. Nat., ii (1857), 415.

Shell rather small, very thin, moderately elongated; spire conical. Whorls six or seven, not shouldered, regularly convex except near the suture, where they are flattened; carinæ of the body-whorl two to four, that commencing at the upper angle of the aperture being the principal one, but less prominent than in *B. glaciale.* Longitudinal folds often obsolete; when present about fifteen in number on the body-whorl, most conspicuous at the middle, where they often form tubercles on intersecting the carinæ. The spiral grooves, both primary and secondary, are much like those of *B. polare*, but are less regular, the ridges being of unequal width. Aperture short, less than one half as long as the shell, and broad, broadest above the middle. Outer lip not sinuated. Columellar lip deeply incurved above, as in *B. polare.* Periostraca thin, smooth.

Length, 1.75; breadth, 0.93 inch. Dimensions taken from a fossil specimen from Montreal.

The species was originally described by Mr. Hancock from specimens dredged in Davis's Straits. It has since been found quite abundantly in the pleistocene beds at Montreal by Prof. Dawson. The fossil specimens appear to be all of the smooth variety, in which the folds are nearly obsolete and the carinæ not tuberculated.

It is very closely allied to *B. polare.* The chief differences are mentioned under that species, but it may be added that the grooving is usually shallower and less distinct in *B. grœnlandicum* than in *B. polare.* It differs from *B. glaciale* in being smaller, much thinner, and less strongly grooved; also in having more rounded whorls and a longer columella.

Moerch changes the name of this species, because he considers the name *grœnlandicum* to have been used by Chemnitz for another species. Chemnitz however was not, in the "Conchylien Cabinet," a binomial writer, and we are not authorised by the laws of priority to take the second word of his descriptive phrase as a specific name.

BUCCINUM GLACIALE Linn.

Buccinum glaciale Linn., Syst., Nat. Ed. 10 (1758). Chemnitz. Schrift. Berlin Gesell. naturf. Freunde, vi (1785), 317; vi, 4, 5. Kiener, Icon. Buc. (1841), 6; ii, 4: Reeve, Conch. Icon., iii (1846), Buc., iii, 18. Gray, Proc. Zool. Soc. 1850, 14.

Tritonium (Buccinum) glaciale Middendorff, Malac. Rossica (1849), 168; iv. 11; excl. synon.

Buccinum carinatum Phipps, Voy.

Tritonium glaciale O. Fabricius, Fauna Groenl. (1780), 397. Moerch, in Rink's Groenland Tillaeg (1857); Aftryk 84.

Shell thick and strong, ovate; spire regularly conical; suture not at all impressed. Whorls six or seven, flattened, usually with a very strong carina commencing at the upper extremity of the aperture and angulating the body-whorl. Sometimes there is another, less conspicuous or obsolete carina above the principal one. Folds ten to twelve, longitudinal, or very little oblique, not very strong, and often obsolete on the body-whorl. Spiral grooves as in *B. polare*. Aperture in the adult patulous, short, a little less than half as long as the shell, and broad, broader than long. Columellar lip very short, shorter than the outer lip, which reaches beyond it below, oblique, almost straight and not incurved above. Outer lip much thickened, reflected, very strongly sinuated at a point usually just above the juncture of the carina, and very much projecting or patulous below. Periostraca not ciliated, generally smooth, sometimes simply wrinkled at the crossings of the lines of growth with the spiral striæ.

Operculum sub-circular, nucleus sub-central.

Length, 3.05; breadth, 1.90 inch.

This species is very common in Behring's Straits and the Arctic Ocean north of it. In the Museum of the Smithsonian Institution there are numerous specimens collected in those seas by the author of this paper while acting as naturalist to the North Pacific Expedition. I have also specimens from Greenland, where it was long since found by that indefatigable observer and most accurate describer, Otho Fabricius. I have a specimen from Spitzbergen, and it has been reported by Gray as having been collected at the mouth of the McKenzie River by Dr. Richardson. Middendorff found it in the Sea of Ochotsk. It is thus circumpolar in its distribution. It has been well named in view of its thoroughly arctic habitat. On the Atlantic Ocean it has never, as far as we are aware, been found south of Greenland on the American shores, nor south of Spitzbergen on those of Europe. In the North Pacific it reaches a notably larger size than in the North Atlantic; and Behring's Straits may be considered as its geographical head-quarters, or "centre of distribution." I am not aware that it has been found in any pleistocene deposit.

It may be distinguished from the other carinated species with flattened spiral ridges by the shape of the aperture, which does not encroach upon the body-whorl within. It is less elongated and more deeply grooved than *B. Donovani.*

Chemnitz' figure in the "Schriften" of the Berlin Society, above cited, is by far the best that has as yet been published of this species, and corresponds exactly with O. Fabricius' description. Kiener's figure represents the two-keeled variety.

BUCCINUM DONOVANI Gray.

Buccinum glaciale Donovan, British Shells, v (1799), pl. cliv. Gray, Appendix to Parry's 1st. Voy. (1824), 240. Brown, Illust. Conch. Gr. Britain (1827), xlix, 12, 13 (not of Linnæus).

Buccinum Donovani Gray, Zool. of Beechey's Voy. (1839), 128. Gould, Inv. Mass. (1841), 304, fig. 208. DeKay, New York Fauna, v (1843); 134, pl. xxxv, 336 : Reeve, Conch. Icon. iii (1846), Buc., i, 2.

Buccinum tubulosum Reeve, Conch. Icon. iii (1847), Buc., xiii, 105.

Tritonium Donovani Moerch, in Rink's 'Groenland' Tillaeg (1857), Aftryk 84.

Shell elongated, thick; spire long and tapering; whorls 8 or 9, convex, with an obtuse carina at the middle of the body-whorl, sometimes obsolete. This carina commences at the upper angle of the aperture. Longitudinal folds about thirteen, most distinct near the sutures, and often obsolete on the body-whorl except at the suture. Primary spiral grooves of the same type as those of *B. polare*, but broader, and always double or triple in fresh and good examples. The primary ridges are less flattened than in the other species of the *glaciale* group; they have the usual number of fine secondary grooves upon them, but the middle groove is often somewhat deeper than the others. Aperture, about two-fifths as long as the shell, and rounded. The columellar lip is more incurved above than in *B. glaciale*, and projects below to the level of the most projecting part of the outer lip. The outer lip is somewhat thickened and reflected, patulous, and broadly sinuated above about half-way between the suture and the juncture of the carina. The periostraca is very thin, and not ciliated in any of the specimens which I have seen.

The dimensions of a typical example from the Banks of Newfoundland are, length, 2.7; breadth, 1.4 inch.

Of this species I have seen several fine examples from the Banks of Newfoundland in the collection of Dr. A. A. Gould, from one of which the excellent figure in the "Invertebrata of Massachusetts" was drawn. There are specimens from the same locality in the Museum of the Smithsonian Institution, presented by the late Gen. J. G. Totten, U. S. A. Moerch mentions the species in his Greenland list.

The *B. Donovani* is a species of very recent origin, and has not, I believe, been found anywhere in a fossil state.

It differs from *B. glaciale* in its elongated form, more convex whorls, more concave columellar lip, and more convex spiral ridges. The uncarinated variety may be distinguished from *B. undatum* by the character of the spiral grooving, the distinction between the primary and secondary grooves being far more strongly marked than in that species.

The *Buccinum Donovani* in Mr. Bell's lists of the Shells of the Gulf of St. Lawrence * is the *Fusus Kroyeri* of Moeller.

Buccinum angulosum Gray.

Buccinum angulosum Gray, Zool. of Beechey's Voy. (1839), 127; xxxvi, 6.

Tritonium (Buccinum) angulosum Middendorff, Malac. Rossica. (1849), 170; iv, 10; and vii, 3, 4 (fig. xix).

Shell very short, almost globose, thick; spire short, conic; whorls five or six, slightly convex; body-whorl more or less angulated, with a carina at the middle, sometimes very strong, sometimes obsolete

* Canadian Naturalist, vol. v, p. 211, and Geol. Surv. of Canada, Report for 1858, p. 253.

Longitudinal folds about nine, not oblique, nearly obsolete at the suture, but very prominent near the middle of the body-whorl, and with broad and deeply concave intervals looking as if the shell had been pinched at these points. The primary and secondary spiral grooves are more alike than in the other carinated species preceding. The primary ridges are like those of *B. polare* and *B. glaciale* as to number and arrangement, but are much more convex; while the secondary grooves upon them are very conspicuous, four or five to each ridge, sharply cut, and nearly as deep as the primary grooves. The grooves are occasionally interrupted or waved by the intersections of the lines of growth, giving the surface a shagreened appearance. The *aperture* is a little more than half as long as the shell; columellar lip much incurved or concave above; columella longer than in *B. glaciale*, and projecting below as far as the outer lip does; outer lip somewhat thickened and reflected, and deeply sinuated just above the angulation of the body-whorl. Periostraca very thin; not ciliated.

Length 1.7; breadth 1.2 inch. Dimensions taken from an uncarinated specimen numbered 1777, in the Smithsonian collection.

The description is drawn up from specimens taken in the Arctic Ocean north of Behring's Straits, by the U. S. North Pacific Exploring Expedition. They occurred at a depth of twenty-five fathoms. None of them are as strongly angulated or carinated as the immature example figured by Gray; but there can be little doubt of their identity, since the polygonal whorls and deep cut grooves give the species a peculiar and unmistakable *facies.* The grooving is especially and constantly characteristic in this species, and must frequently be chiefly relied upon for its identification, since not only the carina but the folds may become obsolete or nearly so, if I have rightly judged the materials at hand.

Gray's figure is a good representation of the young of *B. glaciale*, except in the smaller number of folds, the form being exactly the same; but in his description the grooving is spoken of in such a way that he had undoubtedly before him the shell we have described above. In *B. glaciale* the secondary grooves are never conspicuous, and can scarcely be detected by the unassisted eye. Gray's specimen was from Icy Cape.

Middendorff reports this species as found on the coasts of Nova Zembla and Lapland. But I am by no means certain that his shells were correctly identified with the Behring's Straits species. His description of the grooving does not exactly tally with that seen in my specimens, and I have met with no forms agreeing well with his figures. The question must be decided by direct comparison at some future opportunity.

The *Buccinum angulosum* may, at any rate, be considered as a truly arctic species, found as yet only in the vicinity of the northern coasts of Asia. It has not occurred as a fossil.

BUCCINUM STRIATUM SOW.

Buccinum striatum Sow., 'Records of General Science, i, 134;' Smith, Wern. Mem., viii (1839), 100; i, 9. (Not *B. striatum* of Pennant.)

Tritonium (Buccinum) ochotense Middendorff, Sibirische Reise, Zool. (1851), 235; x, 12; ix, 5.

Shell of moderate size, thick, rather elongated and appressed; whorls seven, not convex, not angulated, but in some (of the same species?) carinated by five or six of the revolving ridges which are more prominent than the others. Longitudinal folds eleven in number, not at all oblique, rather distant, and prominent, especially at the suture. Spiral ridges and grooves as in *B. glaciale*, except that the primaries are more numerous. Aperture a little less than one-half the length of the shell, rather narrow; outer lip scarcely sinuated; columella projecting beyond the anterior extremity of the outer lip.

Length 2; breadth 1 inch.

This species I have never seen. The description is founded upon the accounts given by Smith of *B. striatum* Sow., and by Middendorff of his *B. ochotense*. I have never seen the original description of Sowerby, but can find no essential difference between the form as described and figured by Smith and the *B. ochotense*.

B. striatum has the elongated, appressed form of *B. ciliatum*, with the sculpture of *B. glaciale*. Its longitudinal plications are few, straight, and strong. It differs from *B. angulosum* in its narrow aperture and flat spiral ridges, but the form which we have regarded as a carinated variety may prove to be identical with *angulosum* and not with *striatum*, when the sculpture is more carefully examined.

The shell first occurred as a fossil in pleistocene beds of the Clyde, where it was found by Mr. Smith of Jordan Hill. It has as yet been found living only in the Sea of Ochotsk, by Dr. Middendorff.

The name of this species ought not to be changed on account of its prior use by Pennant, for the *B. striatum* of this latter author is only a variety of *B. undatum*.

BUCCINUM CILIATUM O. Fabr.

Tritonium ciliatum O Fabr., Fauna Groenlandica (1780), 401. Moerch, in Rink's 'Groenland,' Tillaeg (1857), Aftr. 84.

Buccinum ciliatum Moeller, in Kroyer's Tidsskrift, iv (1842), 85. Reeve, Conch. Ic., iii (1846), Buc., v, 29.

Buccinum cyaneum Hancock, An. and Mag. Nat. Hist. [1], xviii (1846), 328. (Not of Bruguière.)

Buccinum Mölleri Reeve, Conch. Ic. iii (1846), Buc., Errata.

Tritonium (Buccinum) tenebrosum, var. *borealis* Middendorff, Malac. Rossic. (1849), 162; iii, 7, 8. (Not *B. tenebrosum* of Hancock.)

Shell rather small and solid, becoming very thick with age, elongated-oval, or sub-elliptical, appressed. Sutures not impressed. Spire short; body-whorl elongated, and constituting seven-tenths of the length of the shell. Whorls not convex, not carinated, plicated; longitudinal folds thirteen to eighteen in number, more or less oblique, variable in number and prominence, but never entirely obsolete at the suture. The primary spiral ridges are narrow and distant, about thirty in number on the lower whorl, but are somewhat variable in strength and distance. They are sometimes double or divided in two by a groove. The secondary ridges alternate with the primaries singly or by groups of two, three, or four; they are only to be distinguished from the primaries by being less prominent, and occupying the depressions constituting the primary grooves. In some specimens the primary and secondary ridges and grooves can scarcely be distinguished from each other. Aperture elliptical, elongated, and narrow, a little more than half the length of the shell, not patulous, but somewhat canaliculated and projecting below; outer lip scarcely at all sinuated. Columella with a distinct tooth or projection near its anterior or lower extremity. This projection corresponds to the second fold of the columella seen in several other species such as *B. tenue* and *B. undatum*, but it is more tooth-like than in any species of the genus, and constitutes an important and easily-recognised specific character. Periostraca ciliated.

Operculum marked on upper surface with regular and prominent lamellæ of growth; nucleus situated at a point half-way between the centre and the outer edge; outer margin sinuated opposite the nucleus; scar of lower surface correspondingly sinuated; marginal limb around the scar considerably thickened.

Length, 1.54; breadth, 0.81 inch. These dimensions are those of a specimen from Behring's Straits.

Although *B. ciliatum* is the most distinct and well marked form in the genus, it is by no means a common species, and, when found, has been frequently referred to other quite different species, for want of attention to its peculiar characters, although these were originally very well described by Otho Fabricius. The appressed form of the shell, narrow, somewhat canaliculated aperture, and the tooth on the columella are its prominent characters. Hancock speaks of the tooth in the description of his *B. cyaneum*, and Middendorff has it distinctly marked in his figure of *tenebrosum;* so that there can be no doubt with regard to the shell meant by those authors.

On the other hand the name *ciliatum* has been applied to a very different species, the *Humphreysianum* of Bennett, by Dr. Gould and others.

We have the true *B. ciliatum* in the Smithsonian Collection, from Greenland, where it was originally found by O. Fabricius. Hancock reports it from Davis' Straits; a specimen from the Newfoundland Banks is in the collection of Dr. Gould; and I have received it from the coast of Nova Scotia through the kindness of my friend, Mr. J. R. Willis of Halifax. I have it also from Behring's Straits and the Arctic Sea north of it, collected by Capt. John Rodgers of the North Pacific Expedition; and specimens from the mouth of McKenzie's River were sent to the Institution by Mr. R. W. McFarlane. I am not aware that it has ever been found in a fossil state.

Buccinum plectrum, nov. sp.

Shell rather large and thin, elongated; spire produced; sutures less deep than in *B. tenue*; whorls seven or eight, regularly convex, or slightly appressed, less gibbous or shouldered at the sutures than in *B. tenue*, and not carinated. Longitudinal folds very numerous, about nineteen, as broad as their interspaces, and most prominent near the suture;—they are curved in a somewhat sigmoid form, and are sometimes, though rarely, interrupted, or have an intervening fold about the middle of the whorl. The striation of the surface has considerable resemblance to that of *B. glaciale*, the primary grooves being deep cut, with the intervening ridges depressed. But the grooving is far less regular than in that species; the primary grooves are more crowded near the suture, and the ridges less flattened. The secondary grooves, on the surface of the primary ridges, are usually as fine as in *B. glaciale*, but often one or more of them becomes deeper, making the sculpture resemble more that of *angulosum*. Aperture oval, less than one half the length of the shell, and narrower than in *B. tenue*. The columella does not project beyond the level of the anterior part of the outer lip, but rather falls short. The columella shews the usual three folds, but the middle fold being nearly longitudinal and parallel to the lowermost fold, the latter cannot be seen in a front view, but it is easily seen in an edge view of the columella, (in broken specimens of the shell,) separated from the marginal middle fold by a longitudinal sulcus. The first and second (uppermost and middle) folds are separated by a broad deep sinus. Periostraca thin, smooth, not ciliated.

Length, 2.23; breadth, 1.2 inch. Another specimen is 2.5 inches long, proportionally more slender.

It may be described in brief language by saying that it has nearly the form and plaits of *B. tenue* with a striation of the *glaciale* type. It evidently approaches nearest to *tenue*, but besides the difference in the striation, the much greater regularity of the longitudinal plaits will serve to distinguish it.

Of this species there are two specimens in the museum of the Smithsonian Institution, which were dredged alive in twenty to thirty fathoms in the Arctic Ocean north of Behring's Straits, by Capt. John Rodgers, U. S. N., while on the North Pacific Exploring Expedition.

I have, among a number of fossil Buccinums kindly loaned by Dr. Packard, two imperfect specimens, probably of this species, from the pleistocene beds of Portland, Me. They differ from the Behring's Straits specimens only in the following particulars. The shell is broader and thicker, with fewer (thirteen) longitudinal folds, none of which are interrupted;—thus approaching *B. undulatum* in these respects. The primary ridges are more convex, and are alternately wider and narrower. The secondary grooves are rather less numerous.

These differences may prove to be specific, when perfect specimens of both forms can be obtained in sufficient numbers. If so, I would suggest the name *Buccinum Packardi* for the Portland form. It is easily distinguished from *B. undulatum* by the flattening and finer striation of the primary ridges, which are also much broader than the corresponding grooves.

I have also a fragment of the form *Packardi* from the Pleistocene of New Brunswick, sent by Mr. G. F. Matthew.

Buccinum tenue Gray.

Buccinum tenue Gray, Zool. of Beechey's Voy. (1839), 128; xxxvi, 19. Reeve, Conch. Ic. iii (1846), Buc., iv, 27.

Buccinum scalariforme Beck, in Kroyer's Tidsskrift, iv (1842), 84. Moerch, in Rink's 'Groenland,' Tillaeg, (1857), Aftr. 84. Packard, Canadian Naturalist, viii (1863), 417. Dawson, Canadian Naturalist [2], ii (1865), 88.

Tritonium (Buccinum) tenue Middendorff, Malac. Rossica (1849), 172; vi, 5, 6.

Buccinum tortuosum Reeve, Conch. Ic., ii (1847), Buc., xiv., 115 (malformation).

Shell of moderate size, thin or only moderately thick, elongated, turreted; spire produced; suture deep; whorls subcylindrical, not carinated, but convex or shouldered near the suture. Longitudinal folds very numerous, more so than in any other species, between twenty-five and thirty in number, mostly arising at the suture, but sometimes interpolated at the middle of the whorl. The folds, between which the interpolated ones occur, are often interrupted before completing their normal length. There are no primary ridges or grooves. The secondary grooves are exceedingly numerous, almost microscopic, but plainly conspicuous, evenly distributed and crowded, sharp-cut, and minutely waved or shagreened by the lines f growth. Sometimes deeper and shallower grooves alternate with each other, either singly, or by two or three of the shallow ones to one of the deeper kind; the difference never, however, being so great as to suggest a division of the grooves into primaries and secondaries. Aperture a little more than two-fifths the length of the shell, short and broad. Columella projecting beyond the outer lip, and having its three folds rather conspicuous, the middle one being generally quite prominent, more so than the upper one, but not tooth-like. Outer lip thickened, slightly patulous and projecting below in full grown specimens; and very little sinuous, the sinus being also very near to the suture. The whorls are pretty sharply contracted below as well as above, so that the siphonal canal at the anterior extremity of the shell projects from the whorl with more than usual abruptness. Periostraca very thin, never ciliated.

Operculum oval, nucleus close to the outer *margin*.

Length, 2.1; breadth, 1.05 inch: from a pleistocene specimen from Hudson's Bay. A recent specimen, from Disco Island measures 2.5 inches in length.

A young individual from Behring's Straits, No. 1775 of the Smithsonian Collection, varies from the type in form, being somewhat appressed, with a much narrower aperture.

The species is easily distinguished from all others by its numerous and frequently interrupted or interpolated plaits, and its minute and crowded but distinct transverse grooves.

This is a common Greenland species, and is reported from the coasts of Nova Zembla and Lapland by Middendorff. I have before me specimens from Spitzbergen; from the vicinity of Behring's Straits, collected by the U. S. North Pacific Expedition; from the north-western coast of Greenland, and from Disco Island, collected by Dr. Hayes; and from Labrador by Dr. A. S. Packard. As a pleistocene fossil, I have it from the eastern coast of Hudson's Bay collected by Mr. Drexler, from Labrador by Dr. Packard, and from Rivière du Loup, Lower Canada, by Professor Dawson. At the present epoch it is a circumpolar species, rarely if ever found living south of the Arctic circle.

BUCCINUM UNDATUM Lin.

Buccinum undatum Lin., Syst. Nat. Ed., x (1758). Forbes & Hanl., Brit. Moll., iii (1853), 401; cix, 3-5 and L.L., fig. 5. Reeve, Conch. Icon. iii (1847), Buc., i, 3.

Tritonium undatum Mueller, Zool. Dan., ii (1788), 12; pl. 1.

Buccinum striatum Pennant, Brit. Zool., 4th Ed., iv, 121; lxxiv, 91.

Shell large, thick, ovate; spire of moderate length; suture not impressed, or, rarely, slightly impressed. Whorls seven, not carinated. Longitudinal folds about fourteen, oblique, sometimes obsolete, but always distinct in young specimens. Primary spiral ridges usually about twenty in number, prominent, rounded, and narrower than the intervening broadly concave primary grooves;—they are generally equidistant in one and the same specimen, except where they become gradually more crowded on the lower part of the lower whorl; but they vary considerably in the distance apart, in different specimens. Sometimes the primary ridges become much more numerous, and are unequal,—alternately larger and smaller. Secondary ridges somewhat variable in size, but uniformly distributed over the primary ridges and grooves,—about six to eight to each ridge and its corresponding groove. The striation and grooving varies much in prominence, but the normal characteristics and relative proportion can always be traced, even in specimens somewhat worn. Aperture nearly one-half as long as the shell; columellar lip not incurved or very little excavated into the whorl; columella usually projecting beyond the level of the anterior part of the outer lip. Periostraca ciliated; hair-like processes long in good half-grown specimens, longest in those specimens which have less prominent folds and striæ. On some specimens the periostraca is smooth, or scarcely ciliated.

Operculum oblong-oval, with the nucleus very near to the outer margin.

Length, 4.1; breadth, 2.15 inch, from a specimen from the east coast of England.

The differences between this and the *B. undulatum* will be noticed under that species.

As an existing species, the *Buccinum undatum* has a more restricted geographical range than most others of the genus, being found only on the Western coasts of Europe, from Southern Norway to Portugal. * Like its intimate representative, the *B. undulatum*, it does not extend into the Arctic regions, and is entirely wanting in the North Pacific fauna. Certain Asiatic shells, referred to it by Middendorff, belong properly to other species, though much resembling this in some of their characters. The species of *Buccinum* when appearing under diseased, abnormal or imperfect conditions, are very apt to simulate each other.

The *Buccinum undatum* is reported to occur in the pliocene and pleistocene tertiaries of many localities in Europe. It will require, however, much more critical study to determine whether the shells so occurring are correctly referred to this species. There is little doubt however that some of the shells found in the English crag belong to it.

* Moerch includes the *undatum* in his list of Greenland shells, but refers to Middendorff's "Beiträge zur einer Malacologia Rossica," p. 482, pl. iv, fig. 3. This figure seems rather to represent the *undulatum*

I have not had an opportunity of examining a specimen of the *Buccinum acuminatum* of Broderip, described and figured in the "Zoological Journal," vol. v (1850), p. 44; pl. iii, figs. 1, 2. Forbes and Hanley, in their "British Mollusca," consider it to be an abnormal form of *B. undatum.*

Buccinum undulatum Moeller.

Buccinum undatum Greene, Catalogue of the Shells of Massachusetts (1833). Gould Inv. Mass. (1841), 305. DeKay, New York Fauna, v (1843) 130; pl. vii, 161. Dawson, Can. Nat. [2], ii (1865), 88.

Buccinum undulatum Moeller, in Kroyer's Tidsskrift, iv (1842), 84.

Buccinum labradorense Reeve, Conch. Icon., iii (1846), Buc., i, 5. Packard, Can. Nat., viii (1863), 416.

? *Tritonium undulatum* Moerch, in Rink's 'Grœnland' Tillaeg (1857), Aftr. 84.

It is not often that two species of shells can be found, the differences between which are more difficult to define than those of the common whelks of the European and North American shores of the Atlantic. Existing as they both do in vast numbers and occupying a very extensive range in station,—from between tidemarks to a depth of more than fifty fathoms on all kinds of ground,—it is not surprising that we find considerable variation among the very numerous specimens which come under our notice, and that the varieties of the two forms, which occur under similar conditions should approach each other closely. Yet it is not at all difficult in most cases, for one familiar with these forms to tell at a glance whether an adult specimen came from the eastern or western side of the ocean. There is a *facies*, difficult to describe, which makes the forms easily recognizable. But specific, tangible differences are hard to find. After careful comparison, I have detected none in the soft parts, nor in the lingual dentition, the central tooth in both having six denticles, and the lateral tooth four. Nor can we find differences in the younger half grown shells. With the adult shells I have met with more success, and will endeavor to describe the distinctive features.

The whorls are more convex next to the suture in *undulatum* than in *undatum*, and the suture is consequently deeper. In *undulatum* also the body-whorl is proportionally broader, and the spire usually shorter; the aperture is smaller, more circular, and conspicuously more arched within or excavated into the body-whorl at the upper part of the inner lip. In *undulatum* the sinus of the outer lip is rather narrow, deep, and near the suture; while in *undatum* it is broader, shallower, and further forward, nearer the middle of the lip. In *undatum* the surface within the aperture is always white or chocolate-colored, while in the American species, as Dr. Gould* has already pointed out, it is often saffron colored. The columella is shorter (less projecting below) in the American shell than in the European. Finally the ciliation of the periostraca in *undulatum* is short and sparse, never long and furry as is commonly the case in good specimens of *undatum*.

Our shell never reaches the size nor the number of whorls of the European form. I have one specimen from Labrador four inches in length, but the average size of adults is much less than the average of foreign shells. A good example from Maine measures 3 inches in length, and 1.8 inch in breadth.

From President Dawson, I have received specimens from the St. Lawrence River, which were taken from water somewhat *brackish*. The influence of an uncongenial element is plainly perceptible in them. They are much thinner and smoother than normal examples, but would not be confounded with any of the smooth species described elsewhere in this paper, such as *B. cyaneum*; for the character of the striation, though but faintly indicated in these specimens, is still the same as that of the typical examples.

There can be but little doubt that our shell is the same as the *undulatum* of Moeller, as it agrees in all respects with that author's description. The figure of Reeve is good, but his description is erroneous in the expression " whorls tranversely very finely striated." Our shell ranges further north than the European *undatum*, being adapted to a colder climate. Its northern limit is Southern Greenland, where, however, it is rare. Its southern limit, as far as ascertained, is on the sea-bottom off the coast of New Jersey, in N. lat. 40°, W. long 73°, where it was dredged by Capt. Gedney, U. S. N., in thirty-two fathoms, sandy bottom. Like many other cold-water species it lives there in the polar undercurrent which flows beneath the gulf stream, and in a contrary direction. I have also specimens from Labrador, Newfoundland, the Gulf and River of St. Lawrence, Nova Scotia, Grand Manan, the coast of Maine, Massachusetts Bay, Cape Cod, and Nantucket.

* "Its golden mouth, too, which, is not found in foreign shells, renders it a beautiful shell." Gould, Inv. Mass., p. 306.

As a pleistocene fossil we have it from Maine, collected by Dr. Packard; from Rivière du Loup, Canada, by Principal Dawson; and from Labrador, by the students of William's College.

Certain figures of Middendorff are good representations of our shell. But I am unwilling to regard it as an inhabitant of Lapland and the sea of Ochotsk, without actual comparison of specimens.

The great variety of station inhabited by this species has been already alluded to.

In conclusion, it may be remarked that although we have good grounds for considering the common whelks of Europe and North America, as they exist at the present day, to be good and distinct species, it is by no means improbable that evidence may be found in the more recent tertiary deposits to prove them to have been derived from a common ancestry. At a former geological epoch, it is not improbable that, owing to the different geographical conditions, the climates of the two sides of the North Atlantic were far less diverse than at present, when we find a very equable water temperature on one side, and a variable one on the other,—causes which must have their effect upon animal life in the lapse of centuries. The question with regard to these Buccinums will probably be settled with greater ease than in most other cases, since the material is abundant, and only requires to be collected with the object in view. Specimens from the pleistocene deposits of Greenland, Iceland, the Faroe Islands, etc., will have special interest.

At present it seems proper to regard all forms as specifically distinct which present constant differences, whatever may have been the origin of these differences.

Buccinum cyaneum Brug.

Tritonium undatum O. Fabr., Fauna Groenlandica (1780), 395 (not of Mueller).

Buccinum cyaneum Bruguière, Encyc. Meth., Vers., i (1792), 266. Beck, in Kroyer's Tidsskrift, iv (1842), 84. Reeve, Conch. Icon., iii (1846), Buc., ix, 69.

Buccinum boreale Leach, Jour. de Phys., etc., lxxxviii (1819), 464. Gray, Zool. of Beechey's Voy. (1839), 128; Brod. & Sow., Zool. Journ., iv (1829), 375.

Buccinum Humphreysianum Moeller, in Kroyer's Tidsskrift, iv (1842), 85 (not of Bennett).

Buccinum hydrophanum Hancock, Ann. & Mag. Nat. Hist. [1], xviii 1846), 323; pl. v, 7. Reeve, Conch. Icon., iii (1847), Buc., xiii, 103.

Buccinum sericatum Hancock, Ann. & Mag. Nat. Hist. [1], xviii (1846), 328; pl. v, 6.

Buccinum tenebrosum Hancock, Ann. & Mag. Nat. Hist. [1], xviii (1846), 327; pl. v, 1, 2. (?)

Buccinum undulatum Hancock, Ann. & Mag. Nat. Hist. [1], xviii (1846), 327 (not of Moeller).

Tritonium (Buccinum) tenebrosum Middendorff, Malac. Rossic. (1849), 160; vi, 9, 11.

Tritonium groenlandicum Moerch, in Rink's 'Groenland' Tillaeg (1857), Aftr. 84.

Buccinum undatum Dawson, Canadian Naturalist [2], ii (1865), 88 (not of Linn.)

Shell of moderate size, rather slender when full grown, thin and usually of a light, fragile structure; spire regularly tapering, pointed, and produced in old specimens; suture not deep. Whorls six to eight, not very convex, flattened near the suture, and generally much smoother than in any other species;—they are neither carinated nor angulated except in occasional instances by the prominence of certain ones of the primary striæ. Longitudinal folds, when they exist, straight, not oblique, ten to fifteen in number, extending very little below the suture. Primary spiral ridges rounded, not flattened, very narrow and distant, about fourteen in number on the lower whorl, often entirely obsolete, but sometimes sufficiently prominent to form slight carinae, in which case they do not project considerably from the proximate surface of the shell, but seem to form angles rather than ridges. Secondary ridges, when present, one-third as broad as the primaries, and distributed upon them and upon their interspaces by about five to each ridge and groove taken together. *On the upper whorls in old specimens we* sometimes see the secondary striæ regularly and closely arranged with no trace of the primaries. But the characteristic primary ridges as well as the secondaries, may almost always be perceived on the body-whorl in adult specimens. Occasionally, in young individuals, the primary ridges are much more numerous than in the ordinary form, and may be even broader than the interspaces. Aperture two-fifths as long as the shell in the adult, (half as long in immature specimens,) and rather narrower than in *B. undatum;* columella rather short, smooth; outer lip generally neither thickened nor reflected, and with but a very slight sinus above the middle. The outer lip is sometimes thickened in old and heavier specimens, but never reflected. Colors bright but variable, usually bluish with chestnut-brown revolving lines, or series of spots, or patches; sometimes brown with white spots. Periostraca smooth or short-ciliated.

Operculum elliptical; nucleus distant from the outer margin about a fifth of the total width. Central tooth of the lingual ribbon with five equal denticles; lateral tooth with three.

The dimensions of an adult specimen from Northern Greenland are, length, 2.3; breadth, 1.3 inch. The species is however very variable in size, dwarf specimens with the full number of whorls frequently occurring. There is a slender dwarf form (*Humphreysianum* Moell., non Bennett) occurring in the Greenland seas, which, with six whorls, is only one inch in length. The specimens of the ordinary form, of that length, would have but four whorls. Yet all the dwarfs have the characteristic striation, and must, with little doubt, be referred to the same species.

B. cyaneum may be distinguished from the young of *B. undatum* and *B. undulatum* by the delicacy of the primary transverse ridges and especially by the absence or obsolescence of the folds on the columella; from *B. plectrum* by the shortness of the longitudinal folds, and the coarser secondary ridges; from *B. Humphreysianum*, by the more slender shell, less convex whorls, and less numerous and less crowded primary ridges; and from *B. groenlandicum* by want of the regular, parallel and sharp cut primary grooves which characterise that species in common with others of the *glaciale* group. I have mentioned the *B. groenlandicum*, though not an allied species, because the primary ridges of the *cyaneum* in some specimens might be mistaken at the first glance for the carinæ of that species, both shells being of a thin and delicate structure.

The *cyaneum* is a North Atlantic species, ranging as far into the arctic regions as exploration has yet extended. Southwardly its geographical limits reach but little beyond the Arctic circle on the shores of either continent. It is abundant in all parts of the seas of Greenland, even to Port Foulke on the north-western coast, from which place I have specimens brought home by Dr. I. I. Hayes of the American Arctic expedition. Hancock reports it from Davis Straits, its southern limit, as an existing species, on our coast. It is common on the northern coast of Norway and Lapland. As a fossil it occurs in the Pleistocene of Rivière-du-Loup, Canada, in fine condition, and as large as the specimen from northern Greenland, the dimensions of which are given above.

For several of these fossil specimens I am indebted to President Dawson.

Moerch considers the species to be the '*Buccinum novum groenlandicum*' of Chemnitz, and has adopted the name *groenlandicum* for it, as already mentioned under the head of *B. groenlandicum* Hancock.

Buccinum simplex Midd.

Tritonium (Buccinum) simplex Middendorff, Sibirische Reise, Zool., i, 234.

As I have never seen a specimen of this unfigured species, which appears to be distinct, I can do no better than quote Middendorff's description, which is as follows:

"Testa purpureo-fusca, solida, ovato-conica; anfractibus convexis, striolis æqualibus longitudinalibus minutissimis, oculo nudo vix conspicuis, undulatis, confertissime ornatis; columella distincte voluta, rugositate spirali externe munita; canali brevi, incurvo, apice truncato; epidermide tenui, tenace, fusco-viridescente. Anfract. numer. 6 ad 7."

Middendorff further remarks that the species is very similar to "*Trit. tenebrosum*" (*cyaneum ?*)* in form and color, but is as thick and heavy as perfect specimens of *B. undatum;* and that it is especially characterised by the uniformly crowded transverse striæ which cannot well be distinguished by the naked eye, and of which there are from forty to ninety on the penultimate whorl. And that the entire want of ciliation on the periostraca, the crooked canal, and the unplicated whorls will give us the means of distinguishing it. "The outer lip is thick, and often reflected, with a somewhat expanded margin. The columella and inner lip are entirely analogous to those of *Tritonium undatum* and *tenebrosum.*"

The dimensions given are, length sixty-one; breadth thirty-two millimetres.

Found at Schantar Island, in the sea of Ochotsk.

Judging from the description, this shell must be closely allied to the large thick and smooth variety of *B. cyaneum.* But the transverse striæ, which are evidently of the secondary kind, are

* Middendorff includes two species in his *T. tenebrosum*, viz. *B. cyaneum* and *B. ciliatum.*

apparently much more numerous than in that species, the mouth more patulous, and the columella more distinctly folded.

BUCCINUM TOTTENII, nov. sp.

Buccinum ciliatum Gould, Inv. Mass. (1841), 307 (in part). Dawson, Can. Nat., ii (1857), 415, pl. vii, fig. 5 (not of O. Fabr).

Shell of moderate size, white, of a light and thin structure; spire acute; suture impressed, whorls seven, regularly convex, neither carinated nor angulated. Longitudinal folds about twenty-two in number to each whorl, very regular, straight, not at all oblique, and about equaling their interspaces in width. These folds are prominent on the spire, but usually obsolete on the body-whorl, except occasionally at the suture. The transverse striation is somewhat as in *B. undatum*, but sharper and more regular, and the grooves are narrower and more deeply cut. The primary ridges are very numerous and crowded, less projecting than in *B. undatum*, but differing among themselves in strength, the narrower and less prominent ones usually alternating by threes or fours with the stronger ones. The primary grooves are much narrower than the corresponding ridges. The secondary grooves are few in number, occurring for the most part only on the greater ridges, and, as usual in the *undatum* group; they are not easily distinguished from the smaller primaries. Aperture rather broad, and half as long as the shell; outer lip thin, effuse, and projecting below, and with its superior sinus very broad and shallow, or obsolete; folds of the columella little prominent. Color within the aperture white or pale yellowish. Periostraca light yellowish, short-ciliated with triangular fimbriæ at the intersections of the lines of growth with the transverse striæ.

Length, 2.12; breadth, 1.3 inches.

Several specimens of this species, from the Banks of Newfoundland, are in the museum of the Smithsonian Institution, donated by the late Gen. Totten of the United States Engineer corps, to whom I have dedicated it, in recognition of his early investigations in the conchology of our Eastern coast. According to Principal Dawson, this species occurs in the Pleistocene beds of Montreal.

It is allied to *B. Humphreysianum*, but differs in its plicated and more convex whorls, deeper transverse sculpture, and want of color. It might be taken for a thin and delicate form of *B. undulatum*, but is easily distinguished by the number and straightness of the longitudinal plications of the spire-whorls, the more numerous and sharply-cut transverse ridges, and the wider mouth. From *B. ciliatum* it differs very much, both in shape, and in the want of a tooth-like fold on the columella.

BUCCINUM HUMPHREYSIANUM Bennett.

Buccinum Humphreysianum Bennett, Zoöl. Journ., London, i (1825), 398, pl. xxii, upper figures. Forbes and Hanley, Brit. Moll., iii, 410; pl. cx, 1.

Buccinum ventricosum Kiener, Iconography, Buc. (1841) 4, pl. iii. 7, (not of Lam.)

Buccinum ciliatum Gould, Inv. Mass. (1841), 307; fig. 209. Reeve, Conch. Icon. iii (1846), Buc. i. 1 (not of O. Fabr.)

Tritonium (Buccinum) Humphreysianum Middendorff, Malac. Rossic. (1849), 163 (syn. partim excl.)

Tritonium Humphreysianum ? Moerch, in Rink's 'Groenland' Tillæg, (1857) Aftr. 84.

Shell rather below the medium size, very thin, translucent, pale, brownish, with fulvous or reddish markings sometimes obsolete. Spire conic; whorls 7, somewhat flattened above and regularly convex below, so as to be faintly shouldered above the middle. They are neither plicated, carinated nor angulated, and the surface is much smoother than in most species of the genus. The transverse striation is of the same type as that seen in *B. undatum*, etc., but far less prominent. The primary ridges are to be distinguished from the secondaries only at the obsolete angle or shoulder of the whorl, where there are generally two or three small ridges on each side of the more prominent ones and the corresponding sulcus. On the middle and lower part of the body-whorl, where the transverse ridges are for the most part equal in size and strength, and equal to the intervening grooves, the grooves are crossed by well-marked though microscopic lines of growth.

The aperture is almost one-half the length of the shell, and about three-fifths as broad as long. The outer lip is very little thickened and scarcely at all projecting below, and it has no sinus at the middle. Columella like that of *B. undulatum*. Periostraca ciliated.

The dimensions of a specimen from the Newfoundland banks are, length, 1.45; breadth, 0.82 inches.

This species is reported from the seas of Ireland, by Bennett; Zetland, by Forbes and Hanley; Lapland, by Middendorff; Greenland, with a query, by Moerch; Newfoundland banks, by Gould;

and the gulf of St. Lawrence, by Mighels. In the Smithsonian museum there are some bleached specimens, found in the Arctic ocean, near the mouth of the McKenzie river, by Mr. R. W. McFarlane.

It may be recognised by its thin structure, superiorly flattened whorls, and the total absence of plications in connection with an obsolescent transverse striation of the type seen in the *undatum* group.

In the following table I have endeavoured to present an analytical synopsis of the species of *Buccinum* here treated of, * as an aid to their determination. In a genus where almost every specific character is subject to great variation, and where the species must be recognized rather by the gross amount of the characters than by the prominence of particular ones, this is, as may be easily understood, a very difficult matter. Such a synopsis is here only useful for the determination of the specific relations of perfect and well characterised specimens,—normal or typical examples of the species. Abnormal forms, imperfect specimens, etc., must be compared with the full descriptions preceding.

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* Of the various Arctic Buccinums which were described during the early part of the present century (1819 to 1839), by the English writers, Leach, Gray and others, without much critical comparison or reference to each other's labors, I believe I have correctly identified and placed in the synonyme all but the *B. boreale* of Broderip and Sowerby, in the "Zoological Journal" of London, vol. iv. (1829), p. 375, which has baffled all my attempts at proper reference. It may be a variety of *B. angulosum* or of *B. cyaneum*. The following is their description in full:

"B. t. tenui, ovato-fusiformi, anf. ventricosis striatis; ultimo sutura simplici; caeteris suturam versus plicatis; apertura patula, labio superne sublobato; epidermide fuscâ, crassâ; long 2.6; lat. 1.6 poll.

Habitat in Oceano Boreali.

The habit of the shell is not unlike that of *B. undatum*, but it differs from it in many points, especially in the form of the aperture and thinness of the shell. In young specimens the epidermis is so strong, that in drying it breaks the delicate edge of the lip. From Kamtschatka."

SYNOPTIC TABLE OF THE SPECIES OF BUCCINUM.

A. Body: whorl angulated or carinated.	
a. Primary transverse ridges flat; secondary ridges inconspicuous.	
1. Shell thin; aperture not patulous; outer lip not sinuated.	
* Whorls shouldered; aperture broadest above.	B. POLARE.
** Whorls scarcely shouldered; aperture broadest below.	B. GRŒNLANDICUM.
2. Shell thick and strong; aperture patulous; outer lip sinuated.	
* Shell elongated.	B. DONOVANI.
** Shell ovate.	B. GLACIALE.
b. Primary transverse ridges convex; secondary grooves very distinct.	B. ANGULOSUM.
B. Body: whorl not angulated.	
a. Aperture narrow.	
1. Primary ridges flat.	B. STRIATUM.
2. Primary ridges convex; a strong, tooth-like plait on the columella.	B. CILIATUM.

b. Aperture broad.
1. Longitudinal folds numerous, often interrupted, or interposed.
  * Primary ridges flat. — B. PLECTRUM.
  ** Primary ridges obsolete; secondaries conspicuous, crowded. — B. TENUE.
2. Longitudinal folds not interrupted or interposed.
  * Shell thick and coarsely striated.
    † Sinus of outer lip near the suture, columella short. — B. UNDULATUM.
    †† Sinus of outer lip near the middle, columella projecting. — B. UNDATUM.
  ** Shell finely striated, usually thin.
    † Secondary ridges easily distinguished from the primaries, which are often obsolete.
      || Columella distinctly folded. — B. SIMPLEX.
      || || Columella smooth, not distinctly folded. — B. CYANEUM.
    †† Secondary ridges confounded for the most part with the primaries.
      || Longitudinal folds conspicuous. — B. TOTTENI.
      || || Longitudinal folds obsolete. — B. HUMPHREYSIANUM.

A PROVISIONAL CATALOGUE OF CANADIAN CRYPTOGAMS.

The Editor of this journal is collecting material towards the compilation of an annotated catalogue of Canadian plants which he hopes to be able to publish in the next volume. With a view to direct attention to the subject, he now prints so much of that material as relates to cryptogams ; and takes opportunity to invite contributions towards the proposed work from all the botanical readers of the *Naturalist.* In all orders, save ferns and allied plants, these lists are of course very incomplete, in view of which, and to facilitate reference, the genera and species have been arranged alphabetically. Should sufficient material accumulate, it is intended hereafter to treat the fungi, lichens, mosses, and liverworts, as well as the phenogams, after the same manner as the ferns, and to add descriptions to those few Canadian plants which are not included in the last edition of Gray's Manual.

Cryptogamic plants are classified in Rev. J. M. Berkeley's "Introduction to Cryptogamic Botany," as follows:

CLASS I. THALLOGENS, (Lindley,) comprising ALLIANCE I. ALGALES (*Seaweeds*), ALLIANCE II. MYCETALES, including *A* Fungales (*Fungi*), *B* Lichenales (*Lichens*). CLASS II. ACROGENS, (Lindley), comprising ALLIANCE III. CHARACEALES (*Charas*), ALLIANCE IV. MUSCALES (*Liverworts and Mosses*), ALLIANCE V. FILICALES (*Filicoid plants*).

ALLIANCE I. ALGALES, Lindley.

Having little to add to what has already appeared in the *Naturalist*, the editor would for the present merely refer to the contributions of Rev. A. F. Kemp:—those on fresh-water algæ, in vol. iii, 1858, and on marine algæ, in vols. v, 1860, and vii, 1862.

ALLIANCE II. MYCETALES, Berkeley. A *Fungales*, Lindley.

This list of fungi is very imperfect, and is capable of almost indefinite extension. It comprises the collections of Dr. W. P. Maclaggan, whose species were determined by Rev. J. M. Berkeley, and those of the Editor, most of whose passed under the eye of Rev. Dr. Curtis of North Carolina. Both collectors confined themselves chiefly to the microscopic forms. Mr. Berkley estimates the number of good species in Britain at nearly 2500.

Æcidium cimicifugatum.
Æcidium Claytoniatum.
Æcidium Compositarum.
Æcidium crassum.
Æcidium Draconturatum.
Æcidium hypericifoliæ.
Æcidium Geranii.
Æcidium Grossulariæ.

Æcidium laceratum.
Æcidium laminatum.
Æcidium lauratum.
Æcidium leucospermum.
Æcidium Orobi.
Æcidium Pini.
Æcidium podophyllatum.
Æcidium Ranunculacearum.
Æcidium sambuciatum.
Æcidium Thalictri.
Æcidium Violarum.
Agaricus salignus.
Agaricus variabilis.
Arcyria punicea.
Aregma mucronatum.
Aregma obtusatum.
Ascobolus Trifolii.
Asteroma pomigena.
Bovista plumbea.
Calvaria cristata.
Calvaria abietina.
Cantharellus crispus.
Capnodium elongatum.
Cenangium triangulare.
Coryneum pulicucitum.
Cladosporium herbarum.
Clavaria abietina.
Corticium mearnatum.
Cryptosporium Caricis.
Cystopus candidus.
Dædalea betulina.
Dædalea unicolor.
Depazea cruenta.
Didymium clavus.
Diplodia Buxi.
Dothidea culmicola.
Dothidea gentianæ.
Dothidea Solidaginis.
Dryophilum Perizoideum.
Erineum fagineum.
Erineum luteolum.
Erineum purpureum.
Erineum quercinum.
Erineum roseum.
Erysiphe adunca.
Erysiphe communis.
Erysiphe guttata.
Erysiphe Mors-Uvæ.
Erysiphe myrtellum.
Erysiphe penicillata.
Fistulina hepatica.
Fusarium roseum.
Geaster fimbriatus.
Hydnum aurantiacum.
Hydnum coralloides.
Hysterium Pinastri.
Irpex sinuosus.
Lenzites Cratægi.
Lycoperdon pyriforme.
Macrosporium Cheiranthi.
Næmaspora crocea.
Nectria polythalama.
Oidium erysiphoides.
Oidium Leucoconium.
Oidium monilioides.
Peziza æruginosa.
Phyllactinia Candollei.
Pileolaria brevipes.
Polyporus cinnabarinus.
Polyporus merandianus.
Polyporus mucidus.
Polyporus squamosus.
Polyporus betulinus.
Polyporus sulphureus.
Polyporus versicolor.
Polyporus zonatus.
Polythrincium Trifolii.
Puccinia aculeata.
Puccinia Amorphæ.
Puccinia asteris.
Puccinia Circææ.
Puccinia compositarum.
Puccinia Graminis.
Puccinia hyssopi.
Puccinia Menthæ.
Puccinia Polygonorum.
Puccinia Saniculæ.
Puccinia Saxifragarum.
Puccinia striola.
Puccinia Vaginalium.
Puccinia Violæ.
Puccinia Xanthii.
Rhytisma Andromedæ.
Rhytisma punctatum.

Schizophyllum commune.
Sclerotium clavus.
Sphæria Andromidarum.
Sphæria argillacea.
Sphæria Coryli.
Sphæria fragiformis.
Sphæria Graminis.
Sphæria marginata.
Sphæria picea.
Sphæria polymorpha.
Sphæria punctiformis.
Sphæria Trifolii.
Sphæria ulmea.
Sphæria verrucosa.
Sphæria Yuccæ.
Sphæronema consors.
Spilocœa Pomi.
Stemonitis fusca.
Stereum fasciatum.
Stereum hirsutum.
Thelephora caryophyllæa.
Trichoderma viride.
Trichothecium roseum.
Tubercularia minor.
Tubercularia vulgaris.
Triphragmium clavellosum.
Uredo agrimoniæ.
Uredo apiculoso.
Uredo Arcœœ.
Uredo Asterum.
Uredo candida.
Uredo caprœarum.
Uredo caryophyllaceænum.
Uredo cylindinia.
Uredo effusa.
Uredo epilobii.
Uredo epitea.
Uredo Filicum.
Uredo labiatarum.
Uredo mixta.
Uredo ovata.
Uredo petroselini.
Uredo polygonorum.
Uredo pyrolæ.
Uredo Rosæ.
Uredo Rubigo.
Uredo ruborum.
Uredo Solidaginis.
Uredo Toxicodendrii.
Uredo vitellinæ.

ALLIANCE II. MYCETALES, Berkeley. B *Lichenales*, Berkeley.

Whatever value attaches to this very complete list of lichens is due to the care and industry of Mr. A. T. Drummond of Ottawa, C. W., whose determinations have all been verified by Prof. Tuckerman. The collections of Mr. Billings, Mr. Macoun, and of the Editor, have confirmed Mr. D.'s observations, but have added very little to them. The nomenclature is that of Tuckerman's Synopsis, such species as are not therein described have the authority added.

Arthonia spectabilis, Flot.
Bæomyces roseus.
Biatoria aurantiaca.
Biatoria Byssoides.
Biatoria icmadophila.
Biatoria decolorans, *var.* lignicola.
Biatoria ocrophæa.
Biatoria rufo-nigra.
Biatoria Schweintzii, Fr.
Biatoria suffusa, Fr.
Biatoria vernalis.
Calicium lenticulare.
Calicium phæocephalum.
Calicium subtile.
Calicium trachelinum.
Calicium turbinatum.
Cetraria aurescens.
Cetraria ciliaris.
Cetraria glauca.
β sterilis.
Cetraria Islandica.
γ crispa.
Cetraria lacunosa.
a Atlantica.
Cetraria nivalis.
Cetraria Oakesiana.

Cetraria pinastri.
Cladonia amaurocræa.
Cladonia cornucopioides.
Cladonia cornuta.
Cladonia cristatella, Tuck.
Cladonia deformis.
Cladonia degenerans.
Cladonia digitata.
Cladonia fimbriata.
α junior.
Cladonia Floerkiana.
Cladonia furcata.
δ subulata.
Cladonia gracilis.
α verticillata.
β cervicornis.
γ hybrida.
Cladonia macilenta.
Cladonia parasitica.
Cladonia pyxidata.
Cladonia rangiferina.
β sylvatica.
γ alpestris.
Cladonia squamosa.
Cladonia turgida.
var. grypa, Tuck.
Cladonia uncialis.
γ turgescens.
α adunca.
Collema nigrescens.
Collema saturninum.
Collema—N. sp., Tuck. MSS.
Conotrema urceolatum.
Endocarpon miniatum.
β complicatum.
Endocarpon manitense, Tuck.
Evernia furfuracea.
Evernia jubata.
β chalybeiformis.
δ setacea.
γ implexa.
Evernia ochroleuca.
Evernia prunastri.
Lecidea albo-cœrulescens.
Lecidea atro-alba.
Lecidea contigua.
Lecidea enteroleuca.
Lecidea geographica.
Lecidea melancheima.
Lecidea parasema.
Lecidea petræa, Tuck.
Lecidea premnea.
Lecidea rubella, Tuck.
Lecidea sabuletorum.
Leptogium lacerum.
Leptogium tremelloides.
Nephroma arcticum.
Nephroma Helveticum.
Nephroma resupinatum.
Opegrapha atra.
Opegrapha inusta.
Opegrapha scripta.
β recta.
γ serpentina.
Opegrapha varia.
Parmelia albella.
Parmelia aleurites.
Parmelia badia.
Parmelia Borreri.
β rudecta.
Parmelia calcarea.
Parmelia caperata.
Parmelia centrifuga.
Parmelia cerina.
Parmelia chrysoleuca.
Parmelia chrysophthalma.
Parmelia ciliaris.
Parmelia cinerea.
Parmelia colpodes.
Parmelia conspersa.
Parmelia crinita.
Parmelia detonsa.
Parmelia elegans.
Parmelia hypoleuca.
Parmelia lanuginosa.
Parmelia lævigata.
Parmelia maritima?
Parmelia microphylla.
Parmelia obscura.
β ulothrix.
var. ciliata.
Parmelia olivacea.
Parmelia oreina.
Parmelia pallescens.

Parmelia pallescens, β Parella.
Parmelia parietina.
var. stellata, Nyl.
γ rutilans.
δ laciniosa.
ε polycarpa.
Parmelia perforata
Parmelia perlata.
β olivetorum.
Parmelia physodes.
β enteromorpha.
Parmelia pulverulenta.
Parmelia rubiginosa.
Parmelia saxatilis.
Parmelia saxicola.
Parmelia scruposa.
Parmelia sophodes.
Parmelia sorediata.
Parmelia speciosa.
Parmelia stellaris.
α stellari-expansa.
β hispida.
γ tribracia.
Parmelia subfusca.
β distans.
var. crenulata, Schaer.
Parmelia tartarea, β frigida.
Parmelia terebrata.
Parmelia tiliacea.
Parmelia triptophylla.
Parmelia varia.
γ sepincola.
β aitema ?
Parmelia vitellina.
Peltigeria aphthosa.
Peltigera canina.
Peltigera horizontalis.
Peltigera polydactyla.
Peltigera rufescens.
Peltigera venosa.
Pertusaria pertusa.
Pertusaria faginea.
Ramalina calicaris.
β fastigiata.
δ farinacea.
α fraxinia.
γ canaliculata.
Solorina saccata.
Sphærophoron compressum.
Sphærophoron coralloides?
Stereocaulon denudatum.
Stereocaulon paschale.
Stereocaulon tomentosum.
Sticta crocata.
Sticta glomerulifera.
Sticta linita, Ach.
Sticta pulmonaria.
Sticta scrobiculata.
Umbilicaria Dillenii.
Umbilicaria hirsuta.
Umbilicaria Muhlenbergii.
Umbilicaria Pennsylvanica.
Umbilicaria polyphylla.
β deusta.
Umbilicaria pustulata.
β papulosa.
Usnea angulata.
Usnea barbata.
α florida.
β strigosa.
δ hirta.
ζ dasypoga.
var. pendula.
Usnea cavernosa, Tuck.
Usnea longissima.
Usnea trichodea.
Verrucaria alba.
Verrucaria Drummondii, Tuck.
Verrucaria epidermis.
Verrucaria nigrescens.
Verrucaria nitida.
Verrucaria rupestris.

ALLIANCE III. CHARACEALES, Berkeley.

Chara vulgaris, Linn.
Chara flexilis, Linn.

And several other forms not yet determined.

ALLIANCE IV. MUSCALES, Berkeley.

In addition to the lists which have already appeared in the *Naturalist*, the Editor is under obligations to Mr. Barnston, Mr. Drummond, Mr. B. Billings, and Mr. Macoun for very complete lists of the collections made by them. Mr. Drummond's list included the collections of Mr. John Bell. Mr. Macoun's Liverworts were determined by Mr. C. F. Austin, of New York, and his more obscure Mosses by Mr. Sullivant, whose nomenclature has been followed, (*Vide* Gray's Manual, Ed. 2,) such plants as are not there described having the authority attached.

HEPATICÆ, Linn.

Aneura palmata.
Calypogeia trichomanis.
Fegatella conica.
Fimbriaria tenella.
Frullania æolitis.
Frullania Eboracensis.
Frullania Grayana.
Frullania saxatitis.
Frullania Tamarisci.
Frullania Virginica.
Geocalyx graveolens.
Jungermannia albicans.
Jungermannia barbata.
Jungermannia bicuspidata.
Jungermannia connivens.
Jungermannia curvifolia.
Jungermannia divaricata.
Jungermannia exsecta.
Jungermannia excisa, Dicks.
Jungermannia Francisci, Hook.
Jungermannia Michauxii.
Jungermannia minuta, Crantz.
Jungermannia Schraderi.
Jungermannia setacea.
Jungermannia Taylori.
Jungermannia trychophylla.
Jungermannia ventricosa.
Lejeunia supyllifolia.
Lepidozia reptans.
Lophocolea bidentata.
Lophocolea heterophylla.
Madotheca platyphylla.
Madotheca porella.
Marchantia polymorpha.
Mastigobryum trilobatum.
Plagiochila asplenioides.
Plagiochila porelloides.
Preissia commutata.
Ptilidium ciliare.
Radula complanata.
Reboulia hemisphærica.
Riccia fluitans.
Riccia lutescens.
Riccia natans.
Scapania undulata.
Sphagnæcetis communis.
Steetzia Lyellii.
Trichocolea Tomentella.

MUSCI, Jussieu.

Anomodon apiculatus.
Anomodon attenuatus.
Anomodon obtusifolius.
Anomodon viticulosus.
Atrichum angustatum.
Atrichum undulatum.
Aulacomnion heterostichum.
Aulacomnion palustre.
Barbula convoluta.
Barbula mucronifolia.
Barbula ruralis.
Barbula tortuosa.
Barbula unguiculata.
Bartramia fontana.
Bartramia Marchica.
Bartramia Œderi.
Bartramia pomiformis.
Bryum argenteum.
Bryum bimum.
Bryum cæspiticium.
Bryum capillare.
Bryum crudum.
Bryum Duvalii.

Bryum inclinatum, Bry. Eur.
Bryum pallescens.
Bryum nutans.
Bryum pseudo-triquetrum.
Bryum pyriforme.
Bryum roseum.
Bryum turbinatum.
Bryum Wahlenbergii.
Buxbaumia aphylla.
Ceratodon purpureus.
Climacium Americanum.
Climacium dendroides.
Cryphæa glomerata.
Cylindrothecium cladorrhizans.
Cylindrothecium seductrix.
Dichelyma capillaceum.
Dichelyma pallescens.
Dicranum congestum.
Dicranum Drummondii.
Dicranum elongatum.
Dicranum flagellare.
Dicranum fulvum, Lind.
Dicranum heteromallum.
Dicranum interruptum.
Dicranum longifolium.
Dicranum montanum.
Dicranum polycarpum.
Dicranum Schraderi.
Dicranum scoparium.
Dicranum Scottianum, Turn.
Dicranum undulatum.
Dicranum varium.
Dicranum virens.
Didymodon luridus.
Didymodon rubellus.
Diphyscium foliosum.
Distichium capillaceum.
Distichium inclinatum.
Drummondia clavellata.
Encalypta ciliata.
Encalypta rhabdocarpa.
Fissidens adiantoides.
Fissidens bryoides.
Fissidens grandifrons.
Fissidens osmundioides.
Fissidens polypodoides.
Fissidens subbasilaris.
Fontinalis antipyretica.
Fontinalis biformis.
Fontinalis Frostii, Sulliv.
Funaria hygrometrica.
Grimmia trichophylla, Grev.
Gymnostomum curvrostrum.
Hedwigia ciliata.
Homalothecium subcapillatum.
Hypnum abietinum.
Hypnum acuminatum.
Hypnum adnatum.
Hypnum aduncum.
Hypnum albulum.
Hypnum Alleghaniense.
Hypnum Blandovii, W. et M.
Hypnum confervoides, Schw.
Hypnum cordifolium.
Hypnum Crista-castrensis.
Hypnum cupressiforme.
Hypnum curvifolium.
Hypnum cuspidatum.
Hypnum delicatulum.
Hypnum denticulatum.
Hypnum deplanatum.
Hypnum elegans.
Hypnum eugyrium.
Hypnum fluitans.
Hypnum giganticum, Schimp.
Hypnum gracile.
Hypnum Haldanianum.
Hypnum hians.
Hypnum imponens.
Hypnum lætum.
Hypnum minutulum.
Hypnum molluscum.
Hypnum nitens.
Hypnum orthocladon.
Hypnum paludosum.
Hypnum polygamum.
Hypnum polymorphum.
Hypnum pulchillum, Dicks.
Hypnum radicale.
Hypnum recurvans.
Hypnum reptile.
Hypnum revolvens.

Hypnum riparium.
Hypnum rusciforme.
Hypnum rutabulum.
Hypnum salebrosum.
Hypnum Schreberi.
Hypnum scitum.
Hypnum scorpioides.
Hypnum serpens.
Hypnum serrulatum.
Hypnum splendens.
Hypnum squarrosum.
Hypnum Starkii.
Hypnum straminium.
Hypnum strigosum.
Hypnum subtile.
Hypnum sylvaticum.
Hypnum tamariscinum.
Hypnum triquetrum.
Hypnum trifarium.
Hypnum umbratum.
Hypnum uncinatum.
Hypnum velutinum, Linn.
Leptodon trachomitrion.
Leskea obscura.
Leskea polycarpa.
Leskea rostrata.
Leucobryum glaucum.
Leucobryum minus.
Leucodon julaceus.
Meesia longiseta.
Meesia uliginosa.
Mnium affine.
Mnium cuspidatum.
Mnium Drummondii.
Mnium hornum.
Mnium orthorhynchum.
Mnium punctatum.
Mnium rostratum.
Mnium serratum.
Mnium spinulosum.
Mnium stellare.
Myurella apiculata, Bry. Eur.
Neckera Macounii, Sulliv.
Neckera pennata.
Omalia trichomanoides.
Orthotrichum affine.
Orthotrichum anomalum.
Orthotrichum Canadense.
Orthotrichum crispulum.
Orthotrichum *crispum*.
Orthotrichum cupulatum.
Orthotrichum Hutchinsiæ.
Orthotrichum leiocarpum.
Orthotrichum Ludwigii.
Orthotrichum Rogeri.
Orthotrichum speciosum.
Orthotrichum strangulatum.
Phascum cuspidatum.
Phascum Sullivantii.
Physcomitrum pyriforme.
Platygyrium repens.
Pogonatum alpinum.
Pogonatum capillare.
Polytrichum commune.
Polytrichum formosum.
Polytrichum gracile.
Polytrichum juniperinum.
Polytrichum piliferum.
Pylaisæa intricata.
Pylaisæa polyantha, Bry. Eur.
Racomitrium canescens.
Racomitrium fasciculare.
Racomitrium microcarpon.
Racomitrium Sudeticum.
Schistidium apocarpum.
Sphagnum acutifolium.
Sphagnum contortum.
Sphagnum cuspidatum.
Sphagnum cyclophyllum.
Sphagnum cymbifolium.
Sphagnum fimbriatum.
Sphagnum squarrosum.
Tetraphis pellucida.
Tetraplodon angustatus.
Thelia hirtella.
Timmia megapolitana.
Trematodon ambiguus, Bry. Eur.
Trichostomum glaucescens.
Trichostomum pallidum.
Trichostomum rigidulum, Smith.
Trichostomum tortile.
Trichostomum vaginans.
Weisia viridula.
Zygodon Lapponicus.

ALLIANCE V. FILICALES, Berkeley.

The Editor is indebted to Rev. Mr. Brunet, Rev. Prof. Hincks, Dr. Thomas, Mr. Macoun, Mr. Drummond, Judge Logie, Mrs. Traill, and Mr. Barnston, for local fern lists and other information; he has also availed himself of all the published information within his reach. His personal observations extend through the greater part of Lower Canada as far east as Mingan and Gaspé. The nomenclature is that of Prof. Gray, in the second edition of his Manual of Botany, the varieties being omitted.

EQUISETUM (The Horsetails).

arvense (*Field Horsetail*).

Common everywhere in damp places; a weed.

eburneum (*Great Horsetail*).

In moist places. Belleville, Mr. Macoun; Quebec, Abbé Brunet; probably general.

pratense (*Blunt-topped Horsetail*).

On wet sandy river banks, and elsewhere. General and not uncommon.

sylvaticum (*Wood Horsetail*).

In moist woods, &c.; general, and not uncommon.

limosum (*Smooth Horsetail*).

Usually in water; general, and common.

palustre (*Swamp Horsetail*),

In wet places. Lotbinière, Abbé Brunet; near Toronto, Prof. Hincks; Belleville, Mr. Macoun; probably general. This (E. palustre of Linn.) is a common European plant; it is not in Gray's Manual.

robustum (*Stout-stemmed Horsetail*).

In woods and moist places. Dr. Lawson's station, near Toronto, is the only one known to the Editor.

hyemale (*Rough Horsetail*).

In wet places; general, and common.

variegatum (*Variegated Horsetail*).

In wet sandy places. Abundant along the sandy shores of Lake Ontario, Mr. Macoun; Anticosti, Abbé Brunet —probably general.

scirpoides (*Smallest Horsetail*).

In moist rocky woods and swamps; general, and common.

POLYPODIUM (The Polypodies.)

vulgare (*Common Polypody*).

On mossy rocks; general, and common.

Phegopteris (*Mountain Polypody*).

In moist woods; general, and common. A variable fern sometimes running into var. (?)

hexagonopterum (*Winged Polypody*),

which is generally distributed from Montreal westward, but is not common.

Dryopteris (*Three-branched Polypody*).

In rocky woods; general, and very common.

STRUTHIOPTERIS

Germanica (*Ostrich-fern*).

In rich moist grounds; general; common near Montreal and westward—apparently less so eastward. [More properly *Onoclea Struthiopteris*].

ALLOSORUS (The Rock-Brakes.)

gracilis (*Slender Rock-brake*).

In clefts of rocks; general, and not uncommon northwards.

atropurpureus (*Purple-stalked Rock-brake*).

In the counties of Wentworth, Lincoln, and Welland; rare. As this fern occurs in Vermont near the boundary-line, it is to be sought for in the Eastern Townships.

acrostichoides (*Crisped Rock-brake*).

On rocky lake-shores; Lake Winnipeg, 1854, Mr. Barnston. (Lake Superior to the Rocky Mountains, according to Prof. D. C. Eaton.)

PTERIS

aquilina (*Bracken*).

In woods, &c. Generally distributed, and everywhere common; a weed.

ADIANTUM

pedatum (*Maiden-hair*).

In moist woods; generally distributed from Kamouraska westwards, and usually common. A most graceful fern.

WOODWARDIA

Virginica (*Virginian Chain-fern*).

In swampy ground. General in Canada West, but not common.

CAMPTOSORUS

rhizophyllus (*Walking-leaf*).

On shady rocks; somewhat generally distributed from Montreal westwards, but usually rather rare.

SCOLOPENDRIUM

officinarum (*Hound's-tongue*).

On limestone rocks at Owen Sound, C.W., 1857, Rev. Prof. Hincks University College Toronto. Since found in several adjacent localities.

ASPLENIUM (The Spleenworts.)

Trichomanes (*Common Spleenwort*).

On cliffs and rocky banks, general from Quebec westwards, but not common.

viride (*Green Spleenwort*).

In the fissures of moist rocks. General from near Quebec eastwards. (Newfoundland, New Brunswick, and eastern Lower Canada to the Rocky Mountains, and northward to Greenland.) This fern—the *A. viride* of Hudson and all modern botanists,—is common in the Highlands of Scotland, and other alpine localities in Europe. It is not in Gray's Manual.

ebeneum (*Screw-fern*).

Rocky open woods. General (apparently only) in Canada West; rather rare. To be sought for in the Eastern Townships, as it occurs in Vermont and Maine.

angustifolium (*Narrow-leaved Spleenwort*).

In rich woods; general from Montreal westwards, but rather rare.

thelypteroides (*Silvery Spleenwort*).

In moist rich woods. A variable fern; general from Quebec westwards, and sometimes common.

Filix-fœmina (*Lady-fern*).

In moist woods. A very variable fern; generally distributed, and very common.

DICKSONIA

punctilobula (*Gossamer-fern*).

In moist woods; general from near Montreal westwards, and in some localities common.

WOODSIA* (The Hair Ferns).

Ilvensis (*Downy Woodsia*).

On rocks; general; a variable, and often common fern. Very luxuriant near the river Saguenay, with fronds sometimes over a foot long.

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* After a somewhat imperfect examination of numerous specimens of our Canadian plants belonging to this genus—imperfect chiefly owing to the limited range of fern literature available in Montreal—I would temporarily re-arrange the species as follows:

alpina (*Blunt-leaved Woodsia*).

Woodsia alpina Newman, Hist. of Br. Ferns, ed. 3, p. 79; 'Moor, Nature-printed Br. Ferns, pl. cvi; (Not of S. F. Gray, who included *W. Ilvensis* under this name); *Woodsia hyperborea*, R. Br., Hooker's Br. Ferns, t. 7. Being in doubt as to the relation which the plants hitherto placed here, bear to the preceding and succeeding species, I omit further notice of them for the present.

glabella (*Hairless Woodsia*).

In clefts of moist rocks. General from near Quebec eastwards, but scarce.*

CYSTOPTERIS (The Bladder Ferns).

bulbifera (*Common Bladder-fern*).

In moist rocky woods, sometimes in swamps; general, and very common.

fragilis (*Slender Bladder-fern*).

On rocky banks, &c. A very variable fern; general, and common.

ASPIDIUM (The Shield Ferns).

Thelypteris (*Meadow Shield-fern*).

In swamps. A variable fern; general from Quebec westwards, and common.

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1. WOODSIA RUFIDULA=*Nephrodium rufidulum* Michx.=*Acrostichum Ilvense* Linn.?=*Woodsia Ilvensis* of Gray's Manual. General throughout Canada and often common.

2. WOODSIA ALPINA=*Acrostichum alpinum* Bolton=*Woodsia hyperborea* Hook., Br. Ferns, t. 7.=*W. alpina* Moor, nat. pr. Br. Ferns, pl. cvi; (not of Newman). May prove not to be specifically distinct from No. 1, though the aspect of the plant is different. Occurs occasionally in eastern Lower Canada, mostly in the neighborhood of waterfalls.

3. WOODSIA HYPERBOREA=*Acrostichum hyperboreum* Liljeblad. Not yet found in Canada.

4. WOODSIA GLABELLA R. Brown, Hook. Fl. Bor. Am. t. ccxxxvii.=*W. alpina* Newman, Br. Ferns, ed. 3, p 79. Doubtfully distinct from No. 3. General in Lower Canada from near Quebec eastwards.

Mr. Bentham would probably reduce all these to varieties of No. 1. I incline to recognize two species, Nos. 1 and 3; while some Pteridologists would recognise all four.

* I collected this fern in the month of August last near the River Saguenay, and elsewhere in eastern Lower Canada; I have also received from Dr. Thomas specimens collected by him at Rivière-du-Loup. Our Canadian plants are very closely allied to, if specifically distinct from *Woodsia hyperborea* (Leljeblad), as exemplified by a Lapland specimen (legit R. F. Frishot) in the Herbarium of McGill University.

Nov-Eboracense (*New-York Shield-fern*).

In wet rocky woods. Range same as last species, but apparently not so common.

spinulosum (*Common Shield-fern*).

In woods. One of our most variable ferns; generally distributed, and very common.

cristatum (*Crested Shield-fern*).

In wet woods. As generally distributed, but not so common as the last species. Somewhat variable.

Goldianum (*Goldie's Shield-fern*).

In rich woods. A stately, fern; generally distributed from Montreal westwards, but not common. Slightly variable.

marginale (*Marginal Shield-fern*).

In rocky woods. General and very common. A variable fern.

fragrans (*Sweet-scented Shield-fern*).

In clefts of rocks, &c. Kamouraska to Lake Superior and northwards; occurs sparingly as far south as 45° (Rigaud mountain, near Montreal; also Falls of the St. Croix, U. S., *vide* Gray's Manual).*

aculeatum (*Prickly Shield-fern*).

In rich mountainous woods. Northern shore of Lake Huron (Abbé Brunet) to Kamouraska, eastward and northwards; not common. The North American form is var. *Braunii* of Gray.

acrostichoides (*Terminal Shield-fern*).

In rocky woods. Varies by having its pinnæ more or less incised. General, and usually common.

Lonchitis (*Rough Shield-fern*).

On limestone rocks at Owen Sound in 1857; Rev. Prof. Hincks of University College, Toronto. Since found in several adjacent localities. Varies as the preceeding species.

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* This interesting fern was this year found in some abundance by Dr. Thomas at Rivère-du-Loup, and by myself near the River Saguenay, where it was sometimes very luxuriant, having fronds fifteen inches long: perfectly fruiting fronds from one to two inches long were not uncommon; five to ten inches was the average size. It is the *Polypodium fragrans* of Linn., and is distantly allied to the *Aspidium rigidum* of Europe. It was most probably this fern Prush had in view for his *Aspidium rufidulum*,—his synonym *Nephrodium rufidulum* Michx. (which =*Woodsia Ilvensis* (Linn.) of Gray's Manual) being a manifest error.

ONOCLEA

sensibilis (*Sensitive Fern*).

In wet shady places. The sterile fronds extremely variable; general and very common.

OSMUNDA (The Flowering Ferns.)

regalis (*Royal Fern*).

In moist woods and swamps; general and very common. The American plant differs slightly from the European, and is known as var. spectablis.

Claytoniana (*Interrupted Flowering-fern*).

As the last; equally general and abundant.

cinnamomea (*Cinnamon-fern*).

As the last; general and common.

BOTRYCHIUM (The Moonworts.)

lunarioides (*Tall Moonwort*).

In dry woods and clearings. A very variable plant; generally distributed from Quebec westward, but not plentiful.

Virginicum (*Rattlesnake-fern*).

In rich woods. A variable plant; generally distributed and common.

Lunaria (*Common Moonwort*).

In open woods. A northern plant. General from Hastings (Mr. John Bell) eastwards, but apparently rare; being inconspicuous it may have escaped observation. This plant—the *B. Lunaria* (Linn.) of Swartz and all modern authors—is common in many parts of Europe. It is not in Gray's Manual.

simplex (*Dwarf Moonwort*).

In woods. As the last, of which it may possibly be only a variety.

OPHIOGLOSSUM

vulgatum (*Adder's-tongue*).

In bogs and wet woods. General and probably not uncommon. A variable plant.

LYCOPODIUM (The Club Mosses.)

lucidulum (*Shining Club-moss*).

In cold swampy woods. General, and usually common.

inundatum (*Marsh Club-moss*).

River Mistassini and northward, Michaux, MSS., per Abbé Brunet; Hastings, Mr. Macoun; probably general.

annotinum (*Interrupted Club-moss*).

In woods. A somewhat variable plant; general, and common.

LYCOPODIUM

dendroideum (*Ground-Pine*).

In woods; general, and not uncommon.

clavatum (*Common Club-moss*).

In moist woods; general; very common eastward—apparently less so westward.

complanatum (*Festoon Ground-Pine*).

In woods. A variable plant; very general, and not uncommon.

SELAGINELLA

selaginoides (*Prickly Club-moss*).

Lake Superior, Agassiz; Swan Lake and northward Michaux; Anticosti, Abbé Brunet.

rupestris (*Rock Club-moss*).

On dry cliffs. General and sometimes rather common.

apus (*Moss-like Selaginella*).

On moist shady ground. General in Western Canada, and in some localities plentiful.

ISOETES

lacustris? (*Quillwort*).

Grows profusely on bottom of muddy shallow ponds and sluggish streams; seemingly general; apparently rare, but probably overlooked.

EDITOR'S NOTE.—In the foregoing catalogue an attempt has been made to indicate the local distribution of Canadian ferns so far as at present known to me. Some of the species may hereafter prove to have a much wider range than is here accorded to them. Numerous localities are given in detail in the last volume of this Journal,—by Dr. Lawson, at page 262, and by Mr. McCord, at page 354. Descriptions of such as are not in Gray's Manual will be found in Dr. Lawson's article.

I have been unable to authenticate the occurrence of *Polypodium Robertianum* or of *Asplenium marinum* in any part of North America. *Aspidium Filix-mas* and *Asplenium septentrionale* have been found on the Rocky Mountains, and are to be looked for in Canada; *Asplenium Ruta-muraria*, *Lygodium palmatum*, *Botrychum lanceolatum*, *Lycopodium Selago*, *Azolla Caroliniana* and *Marsilea mucronata* are also to be looked for, as they occur close to our southern borders. D. A. WATT.

Montreal, October, 1865.