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(*Concluded.*)

We may also note a fact which I have long ago insisted on,[1] the regular pulsation of the continental areas, giving us alternations in each great system of formations of deep-sea and shallow-water beds, so that the successive groups of formations may be divided into triplets of shallow-water, deep-water, and shallow-water strata, alternating in each period. This law of succession applies more particularly to the formations of the continental plateaus, rather than to those of the ocean margins, and it shows that, intervening between the great movements of plication, there were subsidences of those plateaus, or elevations of the sea bottom, which allowed

[1] *Acadian Geology*, 1865.

the waters to spread themselves over all the inland spaces between the great folded mountain ranges.

In referring to the ocean basins, we should bear in mind that there are three of these in the northern hemisphere—the Arctic, the Pacific, and the Atlantic. De Rance has ably summed up the known facts as to Arctic geology in a series of articles in "Nature," and from which it appears that this area presents from without inwards a succession of older and newer formations from the Eozoic to the Tertiary, and that its extent must have been greater in former periods than at present, while it must have enjoyed a comparatively warm climate from the Cambrian to the Pleistocene period. The relations of its deposits and fossils are closer with those of the Atlantic than with those of the Pacific, as might be anticipated from its wider opening into the former. Blandford has recently remarked on the correspondence of the marginal deposits around the Pacific and Indian oceans,[1] and Dr. Dawson informs me that this is equally marked in comparison with the west coast of America,[2] but these marginal areas have not yet gained much on the ocean. In the North Atlantic, on the other hand, there is a wide belt of comparatively modern rocks on both sides, more especially toward the south and on the American side; but while there appears to be a perfect correspondence on both sides of the

[1] A singular example is the recurrence in New Zealand of Triassic rocks and fossils of types corresponding to those of British Columbia. A curious modern analogy appears in the works of art of the Maoris with those of the Haida Indians of the Queen Charlotte Islands, and both are eminently Pacific in contradistinction to Atlantic.

[2] *Journal of Geological Society*, May 1886. Blandford's statements respecting the mechanical deposits of the close of the Palæozoic in the Indian ocean, whether these are glacial or not, would seem to show a correspondence with the Permian conglomerates and earth-movements of the Atlantic area; but since that time, the Atlantic has enjoyed comparative repose. The Pacific seems to have reproduced the conditions of the Carboniferous in the Cretaceous age, and seems to have been less affected by the great changes of the Pleistocene.

Atlantic, and around the Pacific respectively, there seems to be less parallelism between the deposits and forms of life of the two oceans as compared with each other, and less correspondence in forms of life, especially in modern times. Still in the earlier geological ages, as might have been anticipated from the imperfect development of the continents, the same forms of life characterise the whole ocean from Australia to Arctic America, and indicate a grand unity of Pacific and Atlantic life not equalled in later times,[1] and which speaks of contemporaneity rather than of what has been termed homotaxis.

We may pause here for a moment to notice some of the effects of Atlantic growth on modern geography. It has given us rugged and broken shores composed of old rocks in the north, and newer formations and softer features toward the south. It has given us marginal mountain ridges and internal plateaus on both sides of the sea. It has produced certain curious and by no means accidental correspondences of the eastern and western sides. Thus the solid basis on which the British Islands stand may be compared with Newfoundland and Labrador, the English Channel with the Gulf of St. Lawrence, the Bay of Biscay with the Bay of Maine, Spain with the projection of the American land at Cape Hatteras, the Mediterranean with the Gulf of Mexico. The special conditions of deposition and plication necessary to these results, and their bearing on the character and productions of the Atlantic basin would require a volume for their detailed elucidation.

Thus far our discussion has been limited almost entirely to physical causes and effects. If we now turn to the life history of the Atlantic, we are met at the threshold with the question of climate, not as a thing fixed and immutable, but as changing from age to age in harmony with geographical mutations, and producing long cosmic summers and winters of alternate warmth and refrigeration.

[1] Daintree and Etheridge, 'Queensland Geology,' *Journal Geological Society*, August 1872; R. Etheridge, Junior, 'Australian Fossils,' *Trans. Phys. Soc.*, Edin. 1880.

We can scarcely doubt that the close connection of the Atlantic and Arctic oceans is one factor in those remarkable vicissitudes of climate experienced by the former, and in which the Pacific area has also shared in connection with the Antarctic Sea. No geological facts are indeed at first sight more strange and inexplicable than the changes of climate in the Atlantic area, even in comparatively modern periods. We know that in the early Tertiary, perpetual summer reigned as far north as the middle of Greenland, and that in the Pleistocene, the Arctic cold advanced until an almost perennial winter prevailed half way to the equator. It is no wonder that nearly every cause available in the heavens and the earth has been invoked to account for these astounding facts.

It will, I hope, meet with the approval of your veteran glaciologist Dr. Crosskey if, neglecting most of these theoretical views, I venture to invite your attention in connection with this question chiefly to the old Lyellian doctrine of the modification of climate by geographical changes. Let us, at least, consider how much these are able to account for.

The ocean is a great equalizer of extremes of temperature. It does this by its great capacity for heat, and by its cooling and heating power when passing from the solid into the liquid and gaseous states, and the reverse. It also acts by its mobility, its currents serving to convey heat to great distances or to cool the air by the movement of cool icy waters. The land, ou the other hand, cools or warms rapidly, and can transmit its influence to a distance only by the winds, and the influence so transmitted is rather in the nature of a disturbing than of an equalizing cause. It follows that any change in the distribution of land and water must affect climate, more especially if it changes the character or course of the ocean currents.[1]

At the present time, the North Atlantic presents some very peculiar and in some respects exceptional features, which are

[1] Von Wœickoff has very strongly put these principles in a Review of Croll's recent book, *Climate and Cosmology; American Journal of Science*, March, 1886.

most instructive with reference to its past history. The great internal plateau of the American continent is now dry land; the passage across Central America between the Atlantic and Pacific is blocked; the Atlantic opens very widely to the north; the high mass of Greenland towers in its northern part. The effects are that the great equatorial current, running across from Africa and embayed in the Gulf of Mexico, is thrown northward and eastward in the Gulf Stream, acting as a hot-water apparatus to heat up to an exceptional degree the western coast of Europe. On the other hand, the cold Arctic current from the polar seas is thrown to the westward, and runs down from Greenland past the American shore.[1] The pilot chart for June of this year shows vast fields of drift ice on the western side of the Atlantic as far south as the latitude of 40.° So far, therefore, the Glacial age in that part of the Atlantic still extends; and this at a time when, on the eastern side of the Ocean, the culture of cereals reaches in Norway beyond the Arctic Circle. Let us inquire into some of the details of these phenomena.

The warm water thrown into the North Atlantic not only increases the temperature of its whole waters, but gives an exceptionally mild climate to Western Europe. Still the countervailing influence of the Arctic currents, and the Greenland ice is sufficient to permit icebergs, which creep down to the mouth of the Strait of Belle Isle, in the latitude in the south of England, to remain unmelted till the snows of succeeding winters fall upon them. Now let us suppose that a subsidence of land in tropical America were to allow the equatorial current to pass through into the Pacific. The effect would at once be to reduce the temperature of Norway and Britain to that of Greenland and Labrador at present, while the latter countries would themselves become colder. The northern ice, drifting down into the Atlantic, would not, as now, be melted rapidly by the warm water which it meets in the Gulf Stream. Much larger quantities of it would remain undissolved in summer, and thus an accumulation of

[1] I may refer here to the admirable expositions of these effects by the late Dr. Carpenter, in his papers on the results of the explorations of the *Challenger*.

permanent ice would take place, along the American coast at first, but probably at length even on the European side. This would still further chill the atmosphere, glaciers would be established on all the mountains of temperate Europe and America,[1] the summer would be kept cool by melting ice and snow, and, at length, all Eastern America and Europe might become uninhabitable, except by arctic animals and plants, as far south as perhaps 40° of north latitude. This would be simply a return of the Glacial age. I have assumed only one geographical change; but other and more complete changes of subsidence and elevation might take place, with effects on climate still more decisive; more especially would this be the case if there were a considerable submergence of the land in temperate latitudes.

We may suppose an opposite case. The high plateau of Greenland might subside or be reduced in height, and the North Atlantic might be closed. At the same time, the interior plain of America might be depressed, so that, as we know to have been the case in the Cretaceous period, the warm waters of the Mexican Gulf would circulate as far north as the basins of the present great American lakes. In these circumstances there would be an immense diminution of the sources of floating ice, and a correspondingly vast increase in the surface of warm water. The effects would be to enable a temperate flora to subsist in Greenland, and to bring all the present temperate regions of Europe and America into a condition of sub-tropical verdure.

It is only necessary to add that we know that vicissitudes not dissimilar from those above sketched, have actually occurred in comparatively recent geological times, to enable us to perceive that we can dispense with all other causes of change of climate, though admitting that some of them may have occupied a secondary place.[2] This will give us, in dealing

[1] According to Bonney, the west coast of Wales is about 12° above the average for its latitude, and if reduced to 12° below the average, its mountains would have large glaciers.

[2] More especially, the ingenious and elaborate arguments of Croll deserve consideration; and, though I cannot agree with him in this main thesis, I gladly acknowledge the great utility of the work he has done.

with the distribution of life, the great advantage of not being tied up to definite astronomical cycles of glaciation, which may not always suit the geological facts, and of correlating elevation and subsidence of the land with changes of climate affecting living beings. It will, however, be necessary, as Wallace well insists, that we shall hold to that degree of fixity of the continents in their position, notwithstanding the submergences and emergences they have experienced, to which I have already adverted. Sir Charles Lyell, more than forty years ago, published in his 'Principles of Geology' two imaginary maps which illustrate the extreme effects of various distribution of land and water. In one, all the continental masses are grouped around the equator. In the other, they are all placed around the poles, leaving an open equatorial ocean. In the one case, the whole of the land and its inhabitants would enjoy a perpetual summer, and scarcely any ice could exist in the sea. In the other, the whole of the land would be subjected to an Arctic climate, and it would give off immense quantities of ice to cool the ocean. But Lyell did not suppose that any such distribution as that represented in his maps had actually occurred, though this supposition has been sometimes attributed to him. He merely put what he regarded as an extreme case to illustrate what might occur under conditions less exaggerated. Sir Charles, like other thoughtful geologists, was well aware of the general fixity of the areas of the continents, though with great modifications in the matter of submergence and of land conditions. The union, indeed, of these two great principles of fixity and diversity of the continents lies at the foundation of theoretical geology.

We can now more precisely indicate this than was possible when Lyell produced his 'Principles,' and can reproduce the conditions of our continents in even the more ancient periods of their history. Some examples may be taken from the history of the American continent, which is more simple in its arrangements than the double continent of Europ-asia. We may select the early Devonian or Erian period, in which the magnificent flora of that age—the earliest certainly known to us—made its appearance. Imagine the whole interior plain of North America submerged, so that the continent is reduced to two strips on the east and west, connected by a belt of Laurentian land on the north. In the great Mediterranean sea thus produced, the tepid water of the equatorial current circulated, and it swarmed with corals, of which we know no less than one hundred and fifty species, and with other forms of life appropriate to warm seas. On the islands and coasts of this sea was introduced the Erian flora, appearing first in the north, and with that vitality and colonising power, of which, as Hooker has well shown, the Scandinavian flora is the best modern type, spreading itself to the south.[1] A very similar distribution of land and water in the Cretaceous age gave a warm and equable climate in those portions of North America not submerged, and coincided with the appearance of the multitude of broad-leaved trees of modern types introduced in the early and middle Cretaceous, and which prepared the way for the mammalian life of the Eocene. We may take a still later instance from the second continental period of the later Pleistocene or early Modern, when there would seem to have been a partial or entire closure of the North Atlantic against the Arctic ice, and wide extensions seaward of the European and American land, with possibly considerable tracts of land in the vicinity of the equator, while the Mediterranean and the Gulf of Mexico were deep inland lakes.[2] The effect of such conditions on the climates of the northern hemisphere must have been prodigious, and their investigation is rendered all the more interesting because it would seem that this continental period of the post-Glacial age was that in which man made his first acquaintance with the coasts of the Atlantic, and possibly made his way across its waters.

We have in America ancient periods of cold as well as of

[1] As I have elsewhere endeavoured to show (*Report on Silurian and Devonian Plants of Canada*), a warm climate in the Arctic region seems to have afforded the necessary conditions for the great colonising floras of all geological periods. Gray had previously illustrated the same fact in the case of the more modern floras.

[2] Dawkins, *Popular Science Monthly*, 1873.

warmth. I have elsewhere referred to the boulder conglomerates of the Huronian, of the Cambrian and Ordovician, of the Millstone-grit period of the Carboniferous and of the early Permian; but would not venture to affirm that either of these periods was comparable in its cold with the later glacial age, still less with that imaginary age of continental glaciation assumed by certain of the more extreme theorists.[1] These ancient conglomerates were probably produced by floating ice, and this at periods when in areas not very remote, temperate floras and faunas could flourish. The glacial periods of our old continent occurred in times when the surface of the submerged land was opened up to the northern currents, drifting over it mud and sand and stones, and rendering nugatory, in so far at least as the bottom of the sea was concerned, the effects of the superficial warm streams. Some of these beds are also peculiar to the eastern margin of the continent, and indicate ice-drift along the Atlantic coast in the same manner as at present, while conditions of greater warmth existed in the interior. Even in the more recent Glacial age, while the mountains were covered with snow and the lowlands submerged under a sea laden with ice, there were interior tracts in somewhat high latitudes of America in which hardy forest trees and herbaceous plants flourished abundantly; and these were by no means exceptional 'inter-glacial' periods. Thus we can show that while from the remote Huronian period to the Tertiary, the American land occupied the same position as at present, and while its changes were merely changes of relative level as compared with the sea, these have so influenced the ocean currents as to cause great vicissitudes of climate.

Without entering on any detailed discussion of that last and greatest Glacial period, which is best known to us, and is more immediately connected with the early history of man and the modern animals, it may be proper to make a few general statements bearing on the relative importance of sea-borne and land ice in producing those remarkable

[1] *Notes on Post-Pliocene of Canada.* Hicks, *Pre-Cambrian Glaciers, Geol. Mag.*, 1880.

phenomena attributable to ice action in this period.[1] In considering this question, it must be borne in mind that the greater masses of floating ice are produced at the seaward extremities of land glaciers, and that the heavy field-ice of the Arctic regions is not so much a result of the direct freezing of the surface of the sea as of the accumulation of snow precipitated on the frozen surface. In reasoning on the extent of ice action, and especially of glaciers in the Pleistocene age, it is necessary to keep this full in view. Now in the formation of glaciers at present—and it would seem also in any conceivable former state of the earth—it is necessary that extensive evaporation should conspire with great condensation of water in the solid form. Such conditions exist in mountainous regions sufficiently near to the sea, as in Greenland, Norway, the Alps, and the Himalayas; but they do not exist in low arctic lands like Siberia or Grinnel-land, nor in inland mountains. It follows that land glaciation has narrow limits, and that we cannot assume the possibility of great confluent or continental glaciers covering the interior of wide tracts of land. No imaginable increase of cold could render this possible, inasmuch as there could not be a sufficient influx of vapour to produce the necessary condensation; and the greater the cold, the less would be the evaporation. On the other hand, any increase of heat would be felt more rapidly in the thawing and evaporation of land ice and snow than on the surface of the sea.

Applying these very simple geographical truths to the North Atlantic continents, it is easy to perceive that no amount of refrigeration could produce a continental glacier, because there could not be sufficient evaporation and precipitation to afford the necessary snow in the interior. The case of Greenland is often referred to, but this is the case of a high mass of cold land with sea, mostly open, on both sides of it, giving, therefore, the conditions most favorable to precipitation of snow. If Greenland were less elevated, or if there were dry plains around it, the case would be quite different, as Nares has well shown by his observations on the

[1] These views have been admirably illustrated by Von Wœickoff in the paper already referred to and in previous geographical papers.

summer verdure of Grinnel-land, which, in the immediate vicinity of North Greenland, presents very different conditions as to glaciation and climate.[1] If the plains were submerged, and the Arctic currents allowed free access to the interior of the continent of America, it is conceivable that the mountainous regions remaining out of water would be covered with snow and ice, and there is the best evidence that this actually occurred in the Glacial period; but with the plains out of water, this would be impossible. We see evidence of this at the present day in the fact that in unusually cold winters the great precipitation of snow takes place south of Canada, leaving the north comparatively bare, while as the temperature becomes milder, the area of snow-deposit moves farther to the north. Thus a greater extension of the Atlantic, and especially of its cold, ice-laden Arctic currents, becomes the most potent cause of a glacial age.

I have long maintained these conclusions on general geographical grounds, as well as on the evidence afforded by the Pleistocene deposits of Canada; and in an address, the theme of which is the ocean, I may be excused for continuing to regard the supposed terminal moraines of great continental glaciers as nothing but the southern limit of the ice-drift of a period of submergence. In such a period, the southern margin of an ice-laden sea, where its floe-ice and bergs grounded, or where its ice was rapidly melted by water, and where, consequently, its burden of boulders and other *debris* was deposited, would necessarily present the aspect of a moraine, which by the long continuance of such conditions, might assume gigantic dimensions. Let it be observed, however, that I fully admit the evidence of the great extension of local glaciers in the Pleistocene age, and especially in the times of partial submergence of the land.

I am quite aware that it has been held by many able American geologists,[1] that in North America, a continental glacier extended in temperate latitudes from sea to sea, or at least from the Atlantic to the Rocky Mountains, and that

[1] Report of Mr. Carvill Lewis, in *Pennsylvania Geological Survey*, 1884; also Dana's *Manual*.

this glacier must, in many places, have exceeded a mile in thickness. The reasons above stated appear, however. sufficient to compel us to seek for some other explanation of the observed facts, however difficult this may at first sight appear. With a depression such as we know to have existed, admitting the Arctic currents along the St. Lawrence Valley, through gaps in the Laurentian watershed, and down the great plains between the Laurentian areas and the Rocky Mountains, we can easily understand the covering of the hills of Eastern Canada and New England with ice and snow, and a similar covering of the mountains of the west coast. The sea also, in this case, might be ice-laden and boulder-bearing as far south as 40°, while there might still be low islands far to the north on which vegetation and animals continued to exist. We should thus have the conditions necessary to explain all the anomalies of the glacial deposits. Even the glaciation of high mountains south of the St. Lawrence Valley would then become explicable by the grounding of ice on the tops of these mountains when reefs in the sea. In like manner we can understand how on the isolated trappean hill of Belœil, in the St. Lawrence Valley, Laurentian boulders, far removed from their native seats to the north, are perched at a height of 1,200 feet on a narrow peak where no glacier could possibly have left them. The so-called moraine, traceable from the great Missouri Coteau in the west, to the coast of New Jersey, would thus become the mark of the western and southern limit of the subsidence, or of the line along which the cold currents bearing ice were abruptly cut off by warm surface waters. I am glad to find that these considerations are beginning to have weight with European geologists in their explanation of the glacial drift of the great plains of Northern Europe.

Whatever difficulties may attend such a supposition, they are small compared with those attendant on the belief in a continental glacier, moving without the aid of gravity, and depending for its material on the precipitation taking place on the interior plains of a great continent.

I have elsewhere endeavoured to show, on the evidence found in Canada, that the occurrence of marine shells, land plants, and insects in the glacial deposits of that country indicate not so much the effect of several inter-glacial periods, as the local existence of conditions like those of Grinnelland and Greenland, in proximity to each other at one and the same period, and depending on the relative levels of land and the distribution of ocean currents and ice-drift.[1]

I am old enough to remember the sensation caused by the delightful revelations of Edward Forbes respecting the zones of animal life in the sea, and the vast insight which they gave into the significance of the work on minute organisms previously done by Ehrenberg, Lonsdale, and Williamson, and into the meaning of fossil remains. A little later, the soundings for the Atlantic cable revealed the chalky foraminiferal ooze of the abyssal ocean; still more recently, the wealth of facts disclosed by the Challenger voyage, which naturalists have not yet had time to digest, have opened up to us new worlds of deep-sea life.

The bed of the deep Atlantic is covered, for the most part, by a mud or ooze, largely made up of the *debris* of forminifera and other minute organisms mixed with fine clay. In the North Atlantic, the Norwegian naturalists call this the Biloculina mud. Further south, the Challenger naturalists speak of it as Globigerina ooze. In point of fact it contains different species of foraminiferal shells, Globigerina and Orbulina being in some localities dominant, and in others, other species, and these changes are more apparent in the shallower portions of the ocean.

On the other hand, there are means for disseminating coarse material over parts of the ocean-beds. There are, in the line of the Arctic current, on the American coast, great sand-banks, and off the coast of Norway, sand constitutes a considerable part of the bottom material. Soundings and dredgings off Great Britain, and also off the American coast, have shown that fragments of stone referable to Arctic lands are abundantly strewn over the bottom along certain lines, and the Antarctic continent, otherwise almost unknown, makes its presence felt to the dredge by the abundant

[1] *Notes on Post-Pliocene of Canada*, 1872. One well-marked interval only has been established in the glacial deposits of Canada.

masses of crystalline rock, drifted far from it to the north. These are not altogether new discoveries. I had inferred many years ago, from stones taken up by the hooks of fishermen on the banks of Newfoundland, that rocky material from the north is dropped on these banks by the heavy ice which drifts over them every spring, that these are glaciated, and that after they fall to the bottom, sand is drifted over them, with sufficient velocity to polish the stones, and to erode the shelly coverings of Arctic animals attached to them.[1] If then the Atlantic basin were upheaved into land, we should see beds of sand, gravel and boulders with clay flats and layers of marl and limestone. According to the Challenger Reports, in the Antarctic seas S. of 64° there is blue mud, with fragments of rock, in depths of 1,200 to 2,000 fathoms. The stones, some of them glaciated, were granite, diorite, amphibolite, mica schist, gneiss and quartzite. This deposit ceases and gives place to Globigerina ooze and red clay at 46° to 47° S., but even further north, there is sometimes as much as 49 per cent. of crystalline sand. In the Labrador current a block of syenite, weighing 400 lbs., was taken up from 1,340 fathoms, and in the Arctic current, 100 miles from land, was a stony deposit, some stones being glaciated. Among these were smoky quartz, quartzite, limestone, dolomite, mica schist, and serpentine; also particles of monoclinic and triclinic felspar, hornblende, augite, magnetite, mica and glauconite, the latter no doubt formed in the sea-bottom, the others drifted from Eozoic and Palæozoic formations to the north.[2]

A remarkable fact in this connection is that the great depths of the sea are as impassable to the majority of marine animals as the land itself. According to Murray, while twelve of the Challenger's dredgings, taken in depths greater than 2,000 fathoms, gave 92 species, mostly new to science, a similar number of dredgings in shallower water near the land, gave no less than 1,000 species. Hence arises another apparent paradox relating to the distribution of organic beings. While at first sight it might seem that the chances

[1] *Notes on Post-Pliocene of Canada*, 1872.
[2] *General Report, 'Challenger' Expedition.*

of wide distribution are exceptionally great for marine species, this is not so. Except in the case of those which enjoy a period of free locomotion when young, or are floating and pelagic, the deep ocean sets bounds to their migrations. On the other hand, the spores of cryptogamic plants may be carried for vast distances by the wind, and the growth of volcanic islands may affect connections which, though only temporary, may afford opportunity for land animals and plants to pass over.

With reference to the transmission of living beings across the Atlantic, we have before us the remarkable fact that from the Cambrian age onwards there were, on the two sides of the ocean, many species of invertebrate animals which, were either identical or so closely allied as to be possibly varietal forms.[1] In like manner, the early plants of the Upper Silurian, Devonian, and Carboniferous, present many identical species, but this identity becomes less marked in the vegetation of the more modern times. Even in the latter, however, there are remarkable connections between the floras of oceanic islands and the continents. Thus the Bermudas, altogether recent islands, have been stocked by the agency chiefly of the ocean currents and of birds, with nearly 150 species of continental plants, and the facts collected by Helmsley as to the present facilities of transmission, along with the evidence afforded by older oceanic islands which have been receiving animal and vegetable colonists for longer periods, go far to show that, time being given, the sea actually affords facilities for the migration of the inhabitants of the land, comparable with those of continuous continents.

In so far as plants are concerned, it is to be observed that the early forests were largely composed of cryptogamous plants, and the spores of these in modern times have proved

[1] See Davidson's *Monographs on Brachiopods;* Etheridge, *Address to Geological Society of London;* Woodward, *Address to Geologists' Association;* also Barrande's *Special Memoirs on the Brachiopods, Cephalopods, &c.,:* and Hall, *Palæontology of New York;* Billings, *Reports, on Canadian Fossils;* and Matthews, *Cambrian of New Brunswick. Trans. R. S. C.*

capable of transmission for great distances. In considering this, we cannot fail to conclude that the union of simple cryptogamous fructification with arboreal stems of high complexity, so well illustrated by Dr. Williamson, had a direct relation to the necessity for a rapid and wide distribution of these ancient trees. It seems also certain that some spores, as, for example, those of the Rhizocarps,[1] a type of vegetation abundant in the Palæozoic, and certain kinds of seeds, as those named *Ætheotesta* and *Pachytheca,* were fitted for flotation. Farther, the periods of Arctic warmth permitted the passage around the northern belt of many temperate species of plants, just as now happens with the Arctic flora; and when these were displaced by colder periods, they marched southward along both sides of the sea on the mountain chains.

The same remark applies to northern forms of marine invertebrates, which are much more widely distributed in longitude than those further south. The late Mr. Gwyn Jeffreys, in one of his latest communications to this Association, stated that 54 per cent. of the shallow-water mollusks of New England and Canada are also European, and of the deep-sea forms 30 out of 35; these last, of course, enjoying greater facilities for migration than those which have to travel slowly along the shallows of the coast in order to cross the ocean and settle themselves on both sides. Many of these animals, like the common mussel and sand clam, are old settlers which came over in the Pleistotene period, or even earlier. Others, like the common periwinkle, seem to have been slowly extending themselves in modern times, perhaps even by the agency of man. The older immigrants may possibly have taken advantage of lines of coast now submerged, or of warm periods, when they could creep around the Arctic shores. Mr. Herbert Carpenter and other naturalists employed on the Challenger collections have made similar statements respecting other marine invertebrates, as, for instance, the Echinoderms, of which the deep-sea crinoids present many common species,

[1] See paper by the author on Palæozoic Rhizocarps, *Chicago Trans.* 1886.

and my own collections prove that many of the shallow-water forms are common. Dall and Whiteaves[1] have shown that some mollusks and Echinoderms are common even to the Atlantic and Pacific coasts of North America; a remarkable fact, testifying at once to the fixity of these species and to the manner in which they have been able to take advantage of geographical changes. Some of the species of whelks common to the Gulf of St. Lawrence and the Pacific are animals which have no special locomotive powers even when young, but they are northern forms not proceeding far south, so that they may have passed through the Arctic seas. In this connection it is well to remark that many species of animals have powers of locomotion in youth which they lose when adult, and that others may have special means of transit. I once found at Gaspé a specimen of the Pacific species of Coronula, or whale-barnacle, the *C. reginæ* of Darwin, attached to a whale taken in the Gulf of St. Lawrence, and which had probably succeeded in making that passage around the north of America which so many navigators have essayed in vain.

But it is to be remarked that while many plants and marine invertebrates are common to the two sides of the Atlantic, it is different with land animals, and especially vertebrates. I do not know that any palæozoic insects or land snails or millipedes of Europe and America are specifically identical, and of the numerous species of batrachians of the Carboniferous and reptiles of the Mesozoic all seem to be distinct on the two sides. The same appears to be the case with the Tertiary mammals, until in the later stages of that great period we find such genera as the horse, the camel, and the elephant appearing on the two sides of the Atlantic; but even then the species seem different, except in the case of a few northern forms.

Some of the longer-lived mollusks of the Atlantic furnish suggestions which remarkably illustrate the biological aspect of these questions. Our familiar friend the oyster is one of these. The first known oysters appear in the Car-

[1] Dall, *Report on Alaska;* Whiteaves, *Trans. R. S. C.*

boniferous in Belgium and in the United States of America. In the Carboniferous and Permian they are few and small, and they do not culminate till the Cretaceous, in which there are no less than ninety-one so-called species in America alone; but some of the largest known species are found in the Eocene. The oyster, though an inhabitant of shallow water, and very limitedly locomotive when young, has survived all the changes since the Carboniferous age and has spread itself over the whole northern hemisphere.[1]

I have collected fossil oysters in the Cretaceous clays of the coulées of Western Canada, in the Lias shales of England, in the Eocene and Cretaceous beds of the Alps, of Egypt, of the Red Sea coast, of Judea, and the heights of Lebanon. Everywhere and in all formations they present forms which are so variable and yet so similar that one might suppose all the so-called species to be mere varieties. Did the oyster originate separately on the two sides of the Atlantic, or did it cross over so promptly that its appearance seems to be identical on the two sides? Are all the oysters of a common ancestry, or did the causes, whatever they were, which introduced the oyster in the Carboniferous act over again in later periods? Who can tell? This is one of the cases where causation and development—the two scientific factors which constitute the basis of what is vaguely called evolution—cannot easily be isolated. I would recommend to those biologists who discuss these questions to addict themselves to the oyster. This familiar mollusk has successfully pursued its course and has overcome all its enemies, from the flat-toothed selachians of the Carboniferous to the oyster-dredgers of the present day, has varied almost indefinitely, and yet has continued to be an oyster, unless indeed it may at certain portions of its career have temporarily assumed the guise of a Gryphæa or an Exogyra. The history of such an animal deserves to be traced with care, and much curious information respecting it will be found in the report which I have cited.

But in these respects the oyster is merely an example of

[1] White, *Report U.S. Geol. Survey*, 1882-83.

many forms. Similar considerations apply to all those Pliocene and Pleistocene mollusks which are found in the raised sea-bottoms of Norway and Scotland, on the top of Moel Tryfaen in Wales, and at similar great heights on the hills of America, many of which can be traced back to early Tertiary times, and can be found to have extended themselves over all the seas of the northern hemisphere. They apply in like manner to the ferns, the conifers, and the angiosperms, many of which we can now follow without even specific change to the Eocene and Cretaceous. They all show that the forms of living things are more stable than the lands and seas in which they live. If we were to adopt some of the modern ideas of evolution we might cut the Gordian knot by supposing that, as like causes produce like effects, these types of life have originated more than once in geological time, and need not be genetically connected with each other. But while evolutionists repudiate such an application of their doctrine, however natural and rational, it would seem that nature still more strongly repudiates it, and will not allow us to assume more than one origin for one species. Thus the great ques tion of geographical distribution remains in all its force, and, by still another of our geological paradoxes, mountains become ephemeral things in comparison with the delicate herbage which covers them, and seas are in their present extent but of yesterday, when compared with the minute and feeble organisms that creep on their sands or swim in their waters.

The question remains: Has the Atlantic achieved its destiny and finished its course, or are there other changes in store for it in the future? The earth's crust is now thicker and stronger than ever before, and its great ribs of crushed and folded rock are more firm and rigid than in any previous period. The stupendous volcanic phenomena manifested in Mesozoic and early Tertiary times along the borders of the Atlantic have apparently died out. These facts are in so far guarantees of permanence. On the other hand, it is known that movements of elevation along with local depression are in progress in the Arctic regions, and a great weight of new sediment is being deposited along the borders of the Atlantic, especially on its western side, and this is not improbably connected with the earthquake shocks and slight movements of depression which have occurred in North America. It is possible that these slow and secular movements may go on uninterruptedly, or with occasional paroxysmal disturbances, until considerable changes are produced.

It is possible, on the other hand, that after the long period of quiescence which has elapsed, there may be a new settlement of the ocean-bed, accompanied with foldings of the crust, especially on the western side of the Atlantic, and possibly with renewed volcanic activity on its eastern margin. In either case, a long time relatively to our limited human chronology may intervene before the occurrence of any marked change. On the whole, the experience of the past would lead us to expect movements and eruptive discharges in the Pacific rather than in the Atlantic area. It is therefore not unlikely that the Atlantic may remain undisturbed, unless secondarily and indirectly, until after the Pacific area shall have attained to a greater degree of quiescence than at present. But this subject is one too much involved in uncertainty to warrant us in following it farther.

In the meantime the Atlantic is to us a practically permanent ocean, varying only in its tides, its currents, and its winds, which science has already reduced to definite laws, so that we can use if we cannot regulate them. It is ours to take advantage of this precious time of quietude, and to extend the blessings of science and of our Christian civilisation from shore to shore until there shall be no more sea, not in the sense of that final drying-up of old ocean to which some physicists look forward, but in the higher sense of its ceasing to be the emblem of unrest aud disturbance, and the cause of isolation.

I must now close this address with a short statement of some general truths which I have had in view in directing your attention to the geological development of the Atlantic. We cannot, I think, consider the topics to which I have referred without perceiving that the history of ocean and continent is an example of progressive design, quite as much as that of living beings. Nor can we fail to see that, while in some important directions we have penetrated the great secret of nature, in reference to the general plan and structure of the earth and its waters, and the changes through which they have passed, we have still very much to learn, and perhaps quite as much to unlearn, and that the future holds out to us and to our successors higher, grander, and clearer conceptions than those to which we have yet attained. The vastness and the might of ocean and the manner in which it cherishes the feeblest and most fragile beings, alike speak to us of Him who holds it in the hollow of His hand, and gave to it of old, its boundaries and its laws; but its teaching ascends to a higher tone when we consider its origin and history, and the manner in which it has been made to build up continents and mountain-chains, and, at the same time, to nourish and sustain the teeming life of sea and land.

On the Canadian Rocky Mountains, with special reference to that Part of the Range between the Forty-ninth Parallel and the Head-waters of the Red Deer River.[1]

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The term Rocky Mountains is frequently applied in a loose way to the whole mountain region bordering the west coast of North America, which is more appropriately—in the absence of any other general name—denoted as the Cordillera belt, and includes a number of mountain systems and ranges which on the 40th parallel have an aggregate breadth of about one thousand miles. Nearly

[1] Read before Section C, British Association, Birmingham Meeting, 1886.

coincident, however, with the latitude of the head-waters of the Missouri, a change occurs in the character of this Cordillera region. It becomes comparatively narrow, and runs to the 56th parallel or beyond, with an average width of about four hundred miles only. This narrower portion of the Cordillera comprises the greater part of the Province of British Columbia, and consists of four main ranges, or more correctly speaking, systems of mountains, each composed of a number of constituent ranges. These mountain systems are, from east to west, (1) The Rocky Mountains proper. (2) Mountains which may be classed together as the Gold Ranges. (3) The system of Coast Ranges sometimes improperly regarded as a continuation of the Cascade Mountains of Oregon and Washington Territory. (4) A mountain system which in its unsubmerged parts constitutes Vancouver and the Queen Charlotte Islands. This last is here actually the bordering range of the continent, as beyond it, after passing across a submarine plateau of inconsiderable width, the bottom shelves very rapidly down to the abyssal depths of the Pacific. The Tertiary coast ranges of the south are here entirely wanting.

Between the second and third of the above mountain systems is the Interior Plateau of British Columbia, with an average width of about one hundred miles, a mean elevation of about 3500 feet and peculiar character and climate. The present paper refers more particularly to a portion of the Rocky Mountains proper. This system of mountains has, between the 49th and 53rd parallels, a mean breadth of about fifty miles, which, in the vicinity of the Peace River, decreases to forty miles, the general altitude of the range, as well as that of its supporting plateau, at the same time becoming less. Beyond the Peace River region, these mountains are known only in the most general and unsatisfactory way. The portion of the Rocky Mountains which has been explored, is bordered to the eastward by the Great Plains, which break into a series of foot-hills along its base, and to the westward by a remarkably straight and definite valley which is occupied by portions of the Columbia, Kootanie and other rivers, and is known to preserve its general direction and character for over six hundred miles.

Since the early part of the century, the trade of the great fur companies has crossed the Rocky Mountains chiefly by the Athabasca and Peace River Passes, the first complete traverse of the continent having, in fact, been accomplished by the latter route by that most adventurous of travellers Sir Alexander MacKenzie, thirteen years before the same feat was performed further south by the much advertised Lewis and Clark expedition. Posts once established to the west, these routes became familiar to the traders and voyageurs of the Companies, who in their modest records speak with as much indifference of starting from the mouth of the Columbia or Vancouver Island for Montreal—a journey occupying, under the most favourable circumstances, almost an entire season—as might the modern traveller who makes the traverse by rail in a few days. With the exception, however, of the geographer David Thompson, these adventurers gave little or no information as to the geography of the mountains, which were mapped for them only in days' journeys, and till the date of the explorations carried out under Captain Palliser in this region in 1858 and 1859, nothing was known in detail of the features of the Rocky Mountain Range within the British Possessions. At the inception of explorations for the Canadian Pacific Railway, Palliser's map was still the only one on which any reliance could be placed, and it applied merely to that portion of the range south of the Athabasca Pass. During the progress of the railway explorations a number of passes were examined more or less in detail, including in fact all those which appeared likely to be of service, between the International Boundary on the 49th and the Peace River Pass on the 56th degree of latitude, and the general fact was developed that the gaps became lower toward the north, the Peace River, where it breaks across the range, being, in fact, 2000 feet only above the sea-level. Directness of route and other considerations, however, led finally to the adoption of the Kicking Horse Pass, by which the watershed is crossed at an elevation of 5300 feet. Had it been anticipated by Dr. Hector, who when attached to Palliser's expedition discovered and named this pass, that it would have been traversed by a railway, he might possibly have endeavored to bestow on it some more euphonious name.

In 1874, I examined the South Kootanie Pass in connection with H. M. North American Boundary Commission, and in 1883 and 1884 that portion of the Rocky Mountains between the parallels of 49° and 51° 30′, was explored and mapped in some detail by myself and assistants, in connection with the work of the Canadian Geological Survey. Access to this, the southern portion of the Rocky Mountains in Canadian territory, being now rendered easy by the completion of the railway, its mineral and other resources are receiving attention, and the magnificent alpine scenery which it presents is attracting the notice of tourists and travellers generally. This portion of the mountains, including a length of about one hundred and seventy-five miles, measured along the axis of the range, may be taken as a type of that which is not yet so well known, and some of the main results of the reconnaissance work so far accomplished are here presented.

With certain local exceptions, the geological structure of these mountains is as yet very imperfectly known. In a report of the Geological Survey, shortly to be issued, it is intended to publish such detail as has been worked out. It will here be necessary only to give the main facts, which form the structural basis of the actual surface features. The old crystalline rocks form no part of the Rocky Mountains, either in the district here specially mentioned or northward as far as the Peace River. The lowest rocks here represented are quartzites, slates and shales more or less indurated, with occasionally true schists of a subcrystalline character, forming a series several thousand feet in thickness and referable, so far as the scanty fossil evidence shows, to the Cambrian. Overlying these, with no very marked unconformity, is a great limestone series of Devonian and Carboniferous age, which occasionally holds massive quartzites, and may prove, in the western part of the range, to pass down into Silurian or Cambro-Silurian. Triassic or Permo-Triassic red sandstones appear in some places near the forty-ninth parallel.

In the earliest Cretaceous times, this portion of the Rocky Mountains appears to have been an area of subsidence in which several thousand feet of shales and sandstones were deposited. These contain a characteristic early Cretaceous or Cretaceo-Jurassic flora and have been named the *Kootanie Series.* The conditions at this time appear to have been different from those obtaining in the Western States, as the equivalents of these oldest Cretaceous beds have not there been detected. Deposition, accompanied by some evidence of denudation of the older rocks, continued, over the greater part of the area, till the close of the Cretaceous, and the still later beds of the Laramie are yet found in a few places in the mountains. Throughout the whole of these periods, no evidence of great disturbance is found, and the region was not a mountainous one. For the next ensuing period, however, no representative strata are met with, and it is to this time, coeval with the earliest Tertiary, that the profound changes producing this mountain system are due. The beds were then thrown into a series of parallel folds trending north-north-west by south-south-east, and these, by a continuance of pressure from the west, were closely pressed together, and in many cases—particularly on the eastern side—completely overturned eastward. The subsequent action of denudation on the higher and more ample folds of this corrugated area has almost completely removed from them the whole of the Mesozoic rocks, while along the eastern margin of the disturbed region, in which the folding has been in many places scarcely less severe, the newer rocks still form the actual surface. This eastern belt, with an average width of about fifty miles, forms the foot-hills; while the western portion, with a width of about fifty miles, constitutes the mountains proper, the rugged character of which is almost as much due to the nature of the older rocks there brought to the surface as to its superior elevation.

Though thus, structurally considered, the district of the foot-hills may be regarded as a portion of the folded mountain region, it has characters of its own.

This district presents long ridges, or hills arranged in linear series, the positions of which have been determined by those of the harder sandstone beds. Between these are wide valleys in which the smaller streams course, while the larger rivers, with their sources in the mountains, generally cut across nearly at right angles. Though very well marked south of the Old Man River, these ridges are there generally rather low, and the prairie may be said to spread up to the very base of the mountains, the proportion of wooded country being quite small. North of the North Fork of the Old Man River, however, the hills and ridges are higher and more abrupt, and the wooded areas become more considerable, till about the Highwood River and Sheep Creek, extensive forests, interspersed with tracts of burnt woods, render the foot of the mountains well nigh unapproachable, except along the river valleys. The increased height of the foot-hill region in this vicinity is co-ordinate with a greater elevation in the base-level of the mountains, which here attains its maximum—the levels at which the Highwood and Elbow Rivers emerge from the mountains being approximately 4780 and 4800 feet respectively. The streams which leave the mountains at the lowest levels, are the South and Middle Forks of the Old Man, and the Bow River. The two first may be considered as together occupying a structural break in the front of the range, and have a level at this point of little over 4150 feet. The Bow River, but for its greater size and erosive power, which have enabled it to produce a great valley, would probably have had a much greater elevation at its exit from the mountains. Its actual height at this point is 4170 feet.

Where the summits of the foot-hills are not crested by outcropping ledges of sandstone, their outlines are generally rounded and flowing. The parallel valleys contain a deep, rich, black soil, and under the influence of a sufficiently abundant rainfall, the vegetation is wonderfully luxuriant. Few regions in a state of nature can compare with the southern portion of the foot-hills in beauty.

The base-level of this part of the Rocky Mountains is much higher on the eastern than on the western side. On the east, as ascertained by taking the average level at which the larger streams leave the mountains, it is about 4360 feet, while on the west, the mean elevation of the corresponding portion of the Columbia-Kootanie Valley is about 2450 feet. It is in consequence of this difference that the profiles of the various passes show sudden, steep descents to the west, and the streams flowing westward are also, as a rule, more actively engaged in erosion. The abrupt dip from the watershed, on the west side, was the greatest obstacle in the selection of a practicable railway route, and constituted the most formidable engineering difficulty in the pass actually adopted.

The general trend of this portion of the mountains has already been given as N. N. W.—S. S. E., but when more closely examined it is found actually to include three subordinate directions. That portion of the range which extends on the east side from the forty-ninth parallel, to the South Fork of the Old Man River, has a general bearing of N. 35° W. Thence northward to the Highwood River, the general trend is about N.12° W., after which, the bearing again becomes about N. 35° W., and so continues to beyond the Red Deer River. The portion of the range which runs nearly north and south, is considerably wider than the rest (being about sixty miles in width) and includes a remarkable series of infolds of Cretaceous rocks. The constituent ranges and ridges of both the mountains and foot-hills conform throughout very markedly, to the directions above given; and while the three trends are most clearly shown by the outer, eastern range, they are scarcely less evident on the western border. The least regular, and most tumultuous portion of this mountain region is that in the vicinity of the forty-ninth parallel.

In common with most mountain ranges (and here specially marked, in consequence of the regular parallel folding of the rocks) the ruling features are parallel ridges and valleys, crossed nearly at right angles by a system of transverse breaks. The cause of these cross valleys is not very apparent from a geological point of view, as they do not appear to coincide with any important lines of faulting. The general plan of the foot-hills is repeated in the mountains, on a large scale, and some of the cross valleys are continued quite through the foot-hills to the eastern plains, while others again are found in the foot-hills, which do not effect the mountains proper. It is probable that lines of comminuted fracture or shattering of the rocks may have originated these cross valleys, and it is possible that they constituted an original drainage system for the axis of elevation of the mountains, at a time anterior to that at which the longitudinal valleys became deeply excavated, and that some of them, by drawing to themselves the waters of a number of the longitudinal streams, have succeeded in maintaining their position as main waterways to the present time. The great permanence of these main, transverse drainage valleys is shown by the fact that the heights of land between them, in the mountains, are often equal in altitude to that of the main watershed. In no case, however, in the region now described, does such a cross valley preserve its characters so definitely across the entire range as to form throughout a direct pass, or practicable route of travel, though a near approach to this occurs in the North-Kootanie Pass. The routes offering the greatest facility for crossing the mountains, generally follow zig-zag courses, partly along the longitudinal valleys, and seeking the lowest points at which to cross the intervening mountain ridges. In consequence of this, the lengths of the various transverse passes are often considerably greater than the actual width of the mountains. The following list enumerates the passes known in this part of the range, with the length of each along the direction of the trail, from the eastern to the western base of the mountains. The altitude of each at the watershed or main summit is given in the second column.

	Miles.	Elevation of watershed.
1. South Kootanie or Boundary Pass,	66	7,100
2. North Kootanie Pass,................	48	6,750
3. Crow Nest Pass........................	56	4,830
4. North Fork Pass (1)................	46	6,773

	Miles.	Elevation of watershed.
5. Kananaskis Pass.............	85 (about)	6,200
6. White Man's Pass (2)...............	70	6,807
7. Simpson Pass (3)..	70 (about)	6,670
8. Vermilion Pass (4)	88	5,264
9. Kicking Horse Pass (5)............	104	5,300

It is probable that even within this district there are other passes across the watershed range in addition to these here named. The Indians, in the course of their hunting expeditions, travel on foot in every direction across the mountains, but designate as passes only those routes which are not too steep or rough for horses.

Most of the passes above enumerated cross subsidiary summits of some height west of the main watershed. The South and North Kootanie Passes have long been in regular use by the Indians, and both these, after descending into the Flathead Valley, in the centre of the mountain region, cross a second high "divide" between this river and the Kootanie Valley. The Crow Nest Pass was little used by the Indians owing to the thick forest prevailing along parts of it, but was some years ago chopped out, and rough bridges thrown across a couple of streams, to provide a route for taking horses and cattle eastward across the range. The North Fork Pass was not known, except by Indians, till crossed by myself in 1884. The Kananaskis Pass was traversed by Captain Palliser in 1858, and has been much used by the Indians. The White Man's Pass is probably that taken by a party of emigrants, spoken of by Sir George Simpson, in 1841. Sir George Simpson himself, in the same year, crossed the mountains by the pass to which his name is now attached. The Vermilion Pass

1. Measured from the Elk River Crossing in a straight line to the Kootanie Valley; the western continuation of this pass not having been explored,

2. Measured up the Bow River valley on the east, and to the west crossing the Brisco Range by Sinclair Pass.

3. Measured up the Bow Valley on the east and across the Brisco Range in a direct line by a reported pass.

4. The eastern and western ends of this pass are identical with the last.

5. By the railway line 111 miles.

has long been a much travelled Indian route, and takes its name from copious chalybeate springs, which deposit large quantities of ochre. The Kicking Horse Pass was little known and scarcely used by the Indians, probably on account of the thickness of the woods and rough character of parts of the valley for horses. About fifty miles north of the last named pass is the Howse Pass, and thence to the Athabasca Pass, a further distance of sixty-three miles, no practicable route is known across the axis of the range. In 1884 I learned from the Stoney Indians that a hunting party, having heard reports of abundance of game in the region, had during the summer tried every valley between the Athabasca and Howse Passes, but had been unable to get their horses over, being repulsed either by impassible rocky mountains or by glaciers and snow-fields which filled the intervening valleys. It is in this part of the range that Mounts Brown and Murchison occur, with reputed altitudes of 16,000 and 13,500 feet respectively, and Mount Hooker, also reported to be very lofty. This is probably the culminating region of the range, but as yet we have no accurate or detailed knowledge of it.

In the region here particularly described, Mount Lefroy (of Hector), with an altitude of 11,658 feet above the sea, appear to be the highest peak, but Assiniboine Mountain, the height of which, as seen from a considerable distance, I estimated at 11,500 feet, may prove to be higher. A number of the mountains, however, are known to exceed 10,000 feet in elevation, and whole ranges and groups of peaks surpass 8000 feet. Considerable as such elevations are, the height of the adjacent plains and the yet greater altitudes of the valleys within the range, reduces the apparent dimensions of the mountains, which seldom rise much more than about 5000 feet above the point of view. Though thus lacking in the impressive magnitude characteristic of some other mountain ranges, the scenery has a character of its own, and what it may want in actual size is compensated by its extreme ruggedness and infinite variety, its massive, broken escarpments and bare cliffs, which rise often from valleys densely filled with primaeval forest.

The contrast in respect to form is very marked, as between the Rocky Mountains and the Purcell and Selkirk Ranges west of the Columbia-Kootanie Valley, along the eastern side of which the outer range of the Rocky Mountain system forms an almost continuous wall of bare and shattered, though not very lofty, limestone peaks—a character which the opposite ranges only begin to assume toward their axis, rising at first from the valley in long and rounded slopes thickly covered with forest.

The Columbia-Kootanie Valley has already been referred to as an orographic feature of the first importance. Its general features are those of a strike-valley cut out along the outcropping edges of the massive eastward-dipping limestone formation. Its width, however, is much greater than that of other similarly situated valleys of the region, averaging about five miles in the length of 185 miles between the forty-ninth parallel and mouth of the Kicking Horse River. Circumstances, which need not here be detailed, tend to show that the river which excavated this valley originally flowed southward, throughout its whole length, that during the glacial period it became deeply filled with moraine matter and terraced drift, and that subsequently a southward-flowing river again occupied it. At a still later period, however, partly as an effect of the blocking of the valley by debris brought down by the Kootanie at the point at which that river enters it, but probably also in part as a consequence of a relative decrease in elevation to the north, the present remarkable water-parting was formed. The Columbia now rises in two large lakes in this great valley, and flows northward with a comparatively sluggish current, while the Kootanie—already a large river—enters the valley at right angles, at a short distance from the head of the upper lake, from which it is separated by a narrow neck of gravelly terrace-flat, and flows rapidly southward.

On Wild Horse Creek, a tributary of the Kootanie, placer gold mining has been carried on for about twenty years and the camp is still a moderately productive one. Other streams tributary to the Columbia-Kootanie Valley are known to yield alluvial gold, and additional discoveries are probable. No gold has yet been found on the eastern slopes of the range, but here the infolded rocks of the Kootanie (Cretaceous) series contain numerous seams of coal, some of which are of excellent quality. The coal is generally bituminous, but in the Cascade and Bow River basin becomes an anthracite, and mining operations are here already in progress on the line of the railway. Copper ores and galena are also known to occur in somewhat important deposits, and in 1884, we discovered, on a tributary of the Beaverfoot, in veins in an extensive intrusion of nepheline-syenite, a very beautiful blue sodalite which may prove of value for ornamental purposes.

Throughout the whole of this portion of the Rocky Mountains, large patches of perennial snow are frequently met with at elevations surpassing 6000 feet, and in sheltered localities, even at lesser heights. In the high mountains near the forty-ninth parallel, masses of hard snow and ice exist which appear to have a certain amount of proper motion and might be denominated glaciers, but further north, true glaciers, with all the well known characters of those of the Alps and other high mountain regions, occur. Such glaciers may be seen on the North Branch of the Kicking Horse, at the head-waters of the Red Deer, and elsewhere, and these are fed by snow-fields, the areas of which, though not accurately known, must be, in a number of cases, very considerable. Above a height of 6000 feet, snow falls more or less frequently in every month in the year, and about the first of October, it may be expected to occur even in the lower valleys within the mountain region.

In respect to the total amount of precipitation, the circumstances differ remarkably in the different portions of this comparatively limited tract of mountains, being quite small in the Columbia-Kootanie Valley, heavy on the adjacent western slopes of the range, and again inconsiderable on the eastern slopes. The position of the Columbia-Kootanie Valley, with reference to the prevailing westerly air currents, in the lee of the Selkirk and Purcell Ranges, explains its dry climate. Meeting the western slopes of the Rocky Mountains, the air is still sufficiently moist to afford the relatively abundant precipitation of that region; but on passing still further eastward, across the summit elevations, the conditions are unfavourable to further rainfall. Superimposed, however, on these main features, is a tendency to greater rainfall toward the north, which is specially noticeable—whether from a lessened elevation in the mountain barriers to the west, or other causes—in comparing the conditions in different parts of the Columbia-Kootanie Valley. The total amount of precipitation is evidently least in that part of this valley near the forty-ninth parallel, which is known as the Tobacco Plains. Much of the surface is there open, covered with bunch-grass and dotted with open groves of yellow pine (*Pinus ponderosa*), interspersed with the western larch (*Larix occidentalis*) and Douglas fir (*Pseudotsuga Douglasii*), while the herbaceous plants are of a drought-loving character. Northward in the valley these gradually disappear, the yellow pine and western larch cease abruptly at the head of the Upper Columbia Lake, and the black pine (*Pinus Murrayana*) and Engelmann's Spruce (*Picea Engelmanni*) form the chief part of the forest, which becomes relatively dense. Such small efforts at cultivation as have been made, prove that irrigation is necessary for the successful growth of crops in all the southern part of this valley.

In the lower parts of the eastern foot-hills and the larger valleys in the eastern part of the range, the dry conditions of the Columbia-Kootanie Valley are again to some extent repeated; and even within the range, rather extensive patches of dry prairie and slopes clothed with bunch-grass are found in the mouths of the depressions leading to the passes. The open, prairie character of the southern foot-hills has already been alluded to.

Neither the western larch nor the yellow pine recur on the eastern slopes of the mountains, and the Douglas fir, though abundant in the foot-hills, does not extend within the mountains beyond the larger valleys.

The tree most characteristic of the valleys of the western well-watered slopes, though not abundant in this part of the Columbia-Kootanie Valley, is the western "cedar" or arbor-vitæ (*Thuya gigantea*). Its absence in the eastern valleys is probably due to the want of a sufficiently moist atmosphere rather than to the somewhat more rigorous climate. Lyall's larch (*Larix Lyallii*) forms an open fringe along the upper limit of forest growth in these mountains, or at about 7000 feet, above which arboreal vegetation is scarcely observed. When the leaves of this little larch become yellow, in September, its zone of growth may often be traced, from a distance, with the regularity of a contour-line.

Leaving out of consideration the arbor-vitae, which, as before stated, affects a peculiar station, together with other trees of rarer occurrence, the common conifers may be arranged in a regular series from those tolerant of the most alpine conditions to those which require a high degree of summer heat combined with a dry atmosphere, as follows:—

Larix Lyallii. Strictly alpine.

Abies subalpina. Alpine and sub-alpine and extending to high and cool valleys on both slopes.

Picea Engelmanii. Sub-alpine and extending downward wherever the soil is sufficiently moist, on both slopes.

Pseudotsuga Douglasii. Lower valleys on both slopes.

Larix occidentalis. Base of Mountains on west slope only.

Pinus ponderosa. Base of mountains on west slope only.

Prof. Macoun has made extensive collections of plants in the mountains adjacent to the railway line, and it may be of interest from a botanical point of view to note his observation that a number of mountain plants obtained by myself in the southern part of the region, appear to reach their northern limit there, and do not recur even in the high mountains in the vicinity of the Bow and Kicking Horse valleys. This circumstance is doubtless in connection with the partial break in the continuity of the higher ranges about the head-waters of the Old Man River, and the species wanting are probably those which require relatively dry as well as alpine conditions.

The Indians hunting on the western slopes of this part of the mountains are the Kootanies, (*Kootenuha* or upper Kootanies) with their headquarters in the valley of the same name, together with a small colony of the Shuswap Indians of the Selish stock, with a village near the Columbia Lakes and regarded as intruders by the Kootanies. The Kootanies claim, in theory, all the mountains west of the watershed, as their peculiar hunting-grounds, and in former days made annual excursions for the purpose of hunting the Buffalo, across the range to the Great Plains, where they came into frequent collision with the Blackfoot tribes. The latter in turn occasionally carried retaliatory raids across the mountains to the Kootanie Valley, for the purpose of stealing horses, and many are the tales still told among them of these forays. The eastern slopes of the range and adjacent foothills are now hunted over by the Mountain Stoneys, a branch of the Assiniboines. These people are comparatively recent immigrants, dating their connection with the district about forty years back only. They intermarried with a tribe of Rocky Mountain Crees, who formerly maintained themselves here, but have since lost their identity among the Stoneys, though both languages are still commonly spoken. The extraordinary paucity of local names, whether Cree or Assiniboine—even in the case of important streams and mountains—in this part of the region, leads me to believe that the Crees themselves had not very long possessed these mountains, which, it seems highly probable, at no very distant date, were frequented only by the Kootanies. The Blackfoot tribes, being essentially plain Indians, can scarcely be supposed to have inhabited this wild, and to their ideas, naturally repulsive mountain country. The Crees may probably have penetrated to it about the date when they were first supplied with fire-arms by the Hudson's Bay Company, when they are known to have been very formidable and aggressive.

In addition to the buffalo, the foot-hills formerly abounded in other game, particularly the mule deer, wapiti and white-tailed or jumping deer. With the exception of the buffalo, all these animals are still to be found, but in much diminished numbers. The mountains themselves yet afford sustenance to the Indian hunter, the Rocky Mountain sheep or bighorn and the mountain goat being moderately abundant. Black and grizzly bears are also frequently met with, and the puma or mountain lion—held in great dread by the Indians—is occasionally found. The moose is sometimes shot by the Indians, but the cariboo is scarcely, if at all, found within the district here described, requiring more extensive alpine plateaus than those afforded by this part of the mountains. Smaller fur-bearing animals are numerous where they have not been too assiduously trapped. Trout are abundant and large in most of the streams, and the white-fish and lake-trout, are procured from the larger lakes.

No insuperable obstacles to travel exist in these mountains. Many of the passes and trails are open and easily traversed, and the field for mountain climbing and exploration is unlimited, few of the higher peaks having yet been scaled. Starting from the line of railway, or from the vicinity of Fort MacLeod, with a few pack-animals and a small camping outfit, much may now be accomplished in a comparatively short time, the months of July or August being the best, on account of the lowness of the rivers and mountain torrents, which at other seasons constitute formidaable barriers. If fine scenery, combined with adventure of the less hazardous kind, and the pleasure of exploring tracts which yet appear as blanks on the map, will compensate for the minor discomforts attending such an expedition, I can promise that the enterprising traveller will not be disappointed.

SYNTHESIS OF DIETHYL TRIMETHYL AMIDO-BENZENE.

By R. F. RUTTAN, B.A., M.D.,
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The general reaction on which this synthesis is based was discovered by Prof. A. W. Hofman in 1872.* This eminent observer found that at high temperatures the halogen salts of secondary, tertiary or even quaternary bases of the aromatic series are converted into the salts of their isomeric primary bases by a transfer of the fatty radicles from the side chain to the nucleus. Thus the hydriodide of monomethyl aniline at a high temperature becomes converted into the corresponding salt of toluidine,

$$C_6\ H_5,\ NH\ CH_3 = C_6\ H_4\ CH_3,\ NH_2.$$

This reaction has since found its way into chemical industry, and is largely employed in the Berlin Aniline Factory for the preparation of the higher homologues of aniline, especially of Pseudo-cumidin, which is prepared from dimethyl toluidine according to the following reaction:

$$C_6\ H_4\ CH_3\ N\ (CH_3)_2 = C_6\ H_2\ (CH_3)_3,\ NH_2.$$

It seemed a matter of much theoretical interest to test the reaction still further, and by it to obtain, if possible, a homologue of aniline in which *all* the hydrogen atoms of the phenyl nucleus were replaced by radicles of the fatty series. Taking as a starting point this pseudo-cumidine, in which three atoms of hydrogen out of the five are already replaced by methyl, a modification of Hofmann's method was employed to replace the other two hydrogen atoms by ethyl groups, giving rise to the interesting primary base trimethyl diethyl amido-benzene:

$$C_6\ (CH_3)_3\ (C_2H_5)_2\ NH_2.$$

How far the presence of methyl groups in the benzene ring will retard or promote the introduction of further radicles of another composition, has not yet been determined. This synthesis is the first of a series of experiments designed to

* Berichte der Deutschen Chemischen Gesellschaft, v., 720.

decide this question, which were suggested to me by Prof. Hofmann of Berlin.

In the production of this new base, the first step is the preparation of diethyl cumidine.

For this purpose, carefully dried cumidine hydrochlorate was mixed with somewhat more than the theoretical quantity of ethyl alcohol, and the mixture heated in a closed tube to 120°–130° for four hours, when the following reaction—nearly quantitative—occurs:

$$C_6 H_2 (CH_3)_3 NH_2, HCl + 2 C_2 H_6 O = C_6 H_2 (CH_3)_3 N (C_2 H_5)_2, H Cl + 2 H_2 O.$$

Besides the hydrochlorate of the ethylated cumidine, the product was invariably found to contain some ether. Excess of alkali, added to the contents of the tubes, caused he ethylated cumidine to rise with the ether to the surface, whence they could be easily removed and separated. Distillation very readily removes the ether and water, leaving the basic residue which comes over between 220°–230°.

It is worthy of note that this method of ethylating yielded better results than the usual one of digesting the base with a haloid ether and then separating the secondary base by excess of alkali; moreover, the employment of the more expensive alcoholic iodide is thus avoided.

The ethylated cumidine, again sealed up in tubes with about an equal weight of ethyl iodide, is now heated to a temperature of between 280° and 300° for 8 or 10 hours. If the operation be successful, the tubes on cooling contain a dark jelly-like mass that cannot be poured out. This consists of the hydriodide of the new base mixed with other bases, a small quantity of some fluid, aromatic hydrocarbons and a tarry residue.

The hydrocarbons are driven over by steam, and the residue filtered and treated with caustic potash, when there rises to the top a thick reddish, strongly basic oil.

This oil is separated and fractionated; the greater part distils over between 285° and 290; this is retained and treated with hydrochloric acid. There is formed at once a very insoluble hydrochlorate, crystallising in groups of needles. These are not soluble in cold water to any appreciable extent, very slightly soluble in boiling water, but easily soluble in alcohol. After one or two recrystallizations, this salt was obtained in a state of purity, and proved to be the hydrochlorate of trimethyl diethyl amido-benzene:

$$C_6\,(CH_3)_3\,(C_2\,H_5)_2\,NH_2,\ HCl,$$

which requires the following values—

Theory.			Experiment. I.	II.	III.	IV.
C_{13}	67.20	....	66.82	—	—	—
H_{22}	9.65	....	9.72	—	—	—
N	7.47	....	—	7.61	—	—
Cl	15.68	....	—	—	15.6	15.57

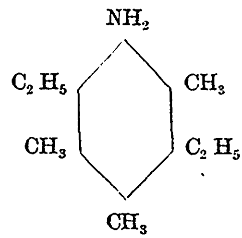
The free trimethyl diethyl amido-benzene obtained from this salt by addition of an alkali, is a liquid boiling between 288° and 290°. It has a specific gravity of .971, and is quite colorless when first set free, but darkens and becomes too thick to pour on standing exposed. The hydrochlorate does not yield a well crystallized double platinum salt, but with palladium chloride it forms a beautiful green double salt in feathery crystals.

The acetate and sulphate crystallize in needles, and are very soluble. The oxalate is very difficultly soluble, and crystallizes in prisms.

The Acetyl compound, $C_6\,(CH_3)_3\,(C_2\,H_5)_2\,NH\,(C_2\,H_3\,O)$, is easily obtained by the action of acetic anhydride; it crystallizes in rosettes of needles, and melts at 182°.

The Isonitril, $C_6\,(CH_3)_3\,(C_2\,H_5)_2\,NC$, is best prepared by mixing the base with an alcoholic solution of caustic potash and chloroform in a small flask fitted with a reversed condenser. A violent re-action ensues, and the pungent isonitril odour is quite marked, thus proving the primary character of the base. After neutralizing the excess of base present with sulphuric acid, the isonitril is extracted with ether, which extract yields on evaporation a thick oil which soon crystallises in short prisms, melting between 190 and 192°.

According to the researches of Froelich,* the methyl groups in pseudo-cumidine, occupy the positions 2, 4 and 5, the amido group being 1. There are thus only the positions 3 and 6 left for the ethyl groups to fill. The constitutional formula for the base is therefore—



On the occurrence of Scolithus in Rocks of the Chazy Formation about Ottawa, Ontario.

By Henry M. Ami, M.A., F.G.S.

For years past, the occurrence of *Scolithus* in the lower portion of the Cambro-Silurian or Ordovician strata, as it is developed in the St. Lawrence and Ottawa Valleys, as well as in the State of New York and elsewhere, was almost invariably taken as the best indication of the presence of the Potsdam formation.

Scolithus Canadensis, as described by the late Mr. E. Billings in his first volume of the Palæozoic Fossils, p. 96, was shewn to be eminently characteristic of the Potsdam formation, its occurrence in a number of localities having been recorded by him. Since then it has also been found in rocks of the same horizon in various other localities, and well recognized by geologists in general.

The form *Scolithus linearis*, of Hall, is also referred to by Mr. Billings, as occurring in the measures of the Potsdam, as seen at L'Anse au Loup (*loc. cit.* p. 2), but in no other Cambrian or Ordovician formation have the remains of *Scolithus* been recognised as yet, as far as the writer is aware.

* Berichte, xvii, 2573.

In the examination of the measures of the Chazy formation about Ottawa, however, the writer has observed numerous scolithoid remains from strata newer than those at L'Anse au Loup or at Ste. Anne's, Beauharnois, &c.

At the Hog's Back, Nepean, in the county of Carleton, Ont., about three miles from Ottawa city, the Chazy formation crops out in the shape of a partially denuded anticlinal, exhibiting on the eastern side of its axis a considerable thickness of strata consisting of sandstones, sandy shales with calcareous matter, and limestones, given in their natural and stratigraphical sequence from the base up. Some of the shales in the exposure are decidedly argillaceous in character, and hold abundance of a species of Lingula—the *L. Belli* (Billings). This band marks a well defined zone in our Chazy formation, and is referred to as the zone of Lingula Belli (see Geol. Rep. Trans. O. F. N. C., 1885-1886.) Above this zone, and a few feet above the *Scolithus* horizon, the "Leperditia band" occurs here in its normal condition, as described by Sir William Logan and Mr. Billings in the publications of the Geological Survey of Canada at various dates, so that the intermediate beds of an arenaceous nature, on careful examination, are seen to contain abundance of a species of *Scolithus* differing but little, if any, from the true *S. Canadensis* (Billings). The characters of this last agree admirably with the form of those from Hog's Back, although there is no doubt whatever as to the age of the series in question being Chazy.

The second place where the genus in question has been observed is at Britannia, Ont., near the southern shores of Lake Dės Chênes, on the Ottawa River, six miles west of Ottawa city. There at Brittannia, some four hundred yards south-west of the railroad crossing or station, numerous remains of a species of *Scolithus* were collected on the occasion of the excursion of the Field Naturalists' Club, in September, 1885. On finding it, the question arose, and has since formed the subject of a slight controversy, as to whether or not the rocks there were really Chazy, or that on account of the occurrence of these annelid (?) burrows, the rocks ought to be ascribed to the age of the Potsdam formation. Fortunately, the occurrence of a similar form in the Chazy of Hog's Back had been previously ascertained so that this fact, coupled with the one that the almost perfectly horizontal strata on the Quebec side of the Ottawa, were truly Chazy, and characterised by the prevalence of such types as *Orthis imperator* (Billings), and a Rhynchonella not distinguishable from the *R. plena* of Hall —which measures extended across the river to the Ontario side, beneath the waters of the lake and rapids, without a fault or dislocation in well-nigh horizontal beds—make it beyond doubt that these rocks at Britannia are truly Chazy.

From these two instances, it follows that the occurrence of *Scolithus* remains does not necessarily indicate the existence of Potsdam rocks, but that the beds may possibly be newer or higher up in the series. These cases also indicate the necessity of obtaining collateral evidence of every nature, whether palæontological or stratigraphical, in order to ascertain with any degree of accuracy the precise geological horizon of strata.

The Rhythm and Innervation of the Heart of the Sea-Turtle.*

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The present paper is intended in part as a continuation of a shorter one which appeared in Nos. 4, 5, 6, of vol. v. of the *Journal of Physiology* on the same subject; but more especially as a continuation of my work on Chelonian heart physiology in general. So far as I know there does not exist in physiology a *systematic* comparison of the resemblances and differences of any one family or genus. I propose therefore to do for the Chelonians in physiology, to some extent at least, what has been done for them in morphology.

It has hitherto been believed that animals resembling

* This paper has also very recently appeared in the *Jour. of Anat. and Phys.*, Edinburgh.

each other in structure closely were similar in physiological behaviour. Such however, has been rather assumption than the outcome of careful comparison.

With the view of discharging this task of systematic physiological comparison, I have, during this past summer, made a large number of experiments on various species of sea-turtles at the Marine Laboratory of the Johns Hopkins University at Beaufort in N. Carolina; and also a limited number of experiments on the land-turtle. I desire to express my thanks to Dr. Brooks, professor of morphology in the Johns Hopkins University for his kindness in facilitating my work.

The marine turtle has much less vitality than other Chelonians, and suffers, when kept for a few days out of the water or deprived of its proper food. In order that my animals should be in the best possible condition, a matter of special importance in connection with the subject of spontaneous rhythm, a structure known locally as a "turtle pen" was constructed on the sea shore, of dimensions 12 × 8 × 8 feet, admitting water freely, and so placed that the animals were never without a certain amount of water at the lowest tide. As learned from a fisherman who made a specialty of catching sea-turtles, their principal food consists of crabs. Upon such those kept for a few days in confinement were regularly fed. Most of the animals upon which I have worked were not kept in the pen for longer than two to four days.

According to Holbrook's work on American Reptilia the three species of marine turtle used in my experiments were *Chelonia caretta* or the Loggerhead, *Chelonia imbricata* or Hawksbill, and *Chelonia mydas* or the Green Turtle.

The conclusions and observations of this paper are based upon prolonged and careful experiments by the direct method on twenty specimens of the marine turtle.

As in my paper on the heart of the Terrapin, the literature of the subject is pretty fully considered, that part will be omitted in this paper, so that it may be kept as short as possible.

For stimulation, as in my work on the Terrapin, a Du Bois inductorium, fed by one Daniell's cell, was employed.

I. *Spontaneous Rhythm of the differents Parts of the Heart.*

The subject is so interesting, and such important conclusions have been drawn regarding it, that I shall give a condensed account of a large number of experiments on this subject.

Exp. I.—*Chelonia imbricata;* caught only twenty-nine hours.

At 10.25 A.M. a ligature placed around the auriculo-ventricular junction; ventricle not arrested till ligature is drawn very tight.

10.28 A.M., 1st beat of ventricle.
10.30 " 2nd "
10.32 " 3rd "
10.34 " 4th "
10.36 " 5th "
10.38½ " 6th "

The rhythm never got faster, but gradually subsided.

Exp. II.—*Chelonia imbricata.*

At 11.35 A.M. ligature drawn tightly at junction of sinus with auricle; complete arrest of all parts posterior to the ligature.

1 P.M. After several pricks with a seeker, a succession of beats but no spontaneous rhythm; sinus beats regularly from the first.

2.15 P.M. Ventricle became rigid throughout almost its whole extent. Right auricle much more vitality than left auricle.

3.30 P.M. Not possible by mechanical excitation to call forth a beat in left auricle; right auricle still somewhat excitable.

Exp. III.—*Chelonia mydas*, most lively specimen of any marine turtle I have seen.

At 12.30 A.M. animal bled freely after destruction of brain. Greater part of auricles proper ("bulged" part) cut away; they continue to beat in harmony with the sinus and sinus extension ("basal") or "flattened" portion of Gaskell.

Soon ventricle cut clearly free from the rest of the heart, *i.e.*, no sinus extension adhering. Sinus and auricles act together in sequence and maintain the original rhythm of 32.

12.45 P.M.–12.48 P.M. Ventricle 3 beats.
12.54 " Ventricle 14 beats in 1 minute.
12.58 " " 17 "
12.58 P.M.–1.02 P.M. Several small groups of beats.
1.03 " Ventricle 8 beats in 1 minute, all grouped.

1.09 P.M.–Ventricle a rhythm	of	7 beats 1 minute.	
1.10 "	"	7	"
1.11 "	"	5	"
1.13 "	"	16	"
1.14 "	"	11	"
1.15 "	"	12	"
1.20 "	"	12	"
1.25 "	"	8	"
1.30 "	"	8	"
2.25 "	"	4–6 and irregular.	

N.B.—2.50 P.M. After a previous pause of several minutes. rhythm began again, at first, only at the edges of the ventricles, then grows gradually stronger and spreads over more of the ventricle, but never involves the whole of it.

The last observation is important, as it shows how contraction of certain fibres of the ventricle tend to call into action others, and strengthen those already acting, but weak. Similar cases have been reported for the Terrapin.

The above cited experiment furnishes the best-marked case of spontaneous rhythm I have met.

Exp. IV.—*Chelonia caretta,* about 3 feet long; out of water two days.

1.05 P.M. Ligature between sinus and auricle and sinus extension does not arrest rhythm of auricles and ventricle, *till it is drawn very tight.*

No spontaneous rhythm of any part posterior to the ligature.

N.B.—1.30 P.M. On attempting to get the ventricle to pulsate in response to a prick from a seeker, it *passes into fibrillar action.* This case presents a great contrast to the previous one, but the animal in the latter case had been out of the water two days, while the other specimen was quite fresh.

Exp. V.—*Chelonia mydas.*

11.10 A.M. Ligatured between ventricle and parts just above; former arrested at once.

12.10 P.M. Ventricle a beat now and then, on an average I in the minute, auricles and sinus a rhythm of 30.

1.10 P.M. Ventricle 5 beats in 3 minutes at irregular intervals.

1.50 P.M. Ventricles 3 beats in 4 minutes.

2.50 P.M. Auricles irregular; right beats before left; ventricle 5 beats in 5 minutes.

4 P.M. Ventricle has almost ceased to pulsate, but a touch of the

finger suffices to start the ventricle into a rhythm of 24, lasting for two minutes.

This latter observation illustrates well the great *sensitiveness* or excitability of the ventricle of the sea-turtle.

EXP. VI.—*Chelonia mydas;* animal bled to death; after destruction of brain.

1.30 P.M. Cut away sinus from auricles, sinus extension, and ventricle; very soon a rhythm arises in the latter parts.

2.10 P.M. Right auricle beats slightly before the left.

2.40 P.M. Left auricle beats only feebly; ventricle getting rigid.

3.10 P.M. Ventricle wholly rigid; right auricle beating at rate of 12: left auricle quiescent; vertical section made between the auricles, &c.; right auricle continues to beat.

EXP. VII.—*Chelonia imbricata.*

10 A.M. Cut away side ventricle from rest of heart; then the auricles proper from the sinus extension and the ventricle free from the parts above it. This gives rise in the ventricle to a rapid rhythm of excitation for a very short time, followed by a rhythm of 1–2 in the minute for 3–4 minutes; rhythm of heart at time of section, 20.

10.15 A.M.	Sinus extension a	rhythm of	19, and irregular.
10.30 A.M.	"	"	13.
10.45 A.M.	"	"	12.

Ventricles no pulsation throughout.

12 noon. Ventricle rigid; sinus extension a rhythm of 15, and irregular; auricles proper die much later than ventricles, but have no spontaneous rhythm whatever.

This experiment clearly demonstrates the greater tendency to, and capacity for, spontaneous rhythm of the sinus extension (or "basal" or flattened portion of the auricle) than any other part, including the auricles proper.

To state the results of the rest of my experiments would be very much of a repetition of the above; the experiments have been numerous and occupied much time, and justify, I think, the following conclusions for the sea-turtle:—

1. The power of originating spontaneous rhythm is in the order: sinus, sinus extension, auricle, ventricle; that of the sinus being much the best marked.

2. The degree of spontaneous rhythm of the ventricle varies with the species (and individual) and the state of nutrition and general vitality of the animal. This probably applies also to the rest of the heart, but is most conspicuous

in the ventricle. *C. mydas* has shown much the greatest capacity for spontaneous cardiac rhythm of the species of marine turtles examined by me.

3. The spontaneous rhythm of the ventricle never equals that of the original rhythm of the ventricle, in fact, usually remains very slow indeed.

An examination of the cases reported from my experiments above will show that the ventricle has a purely spontaneous rhythmic tendency, but that this tendency is after all rather feeble.

In all the experiments, the heart was left *in situ*, surrounded either by pericardial fluid, blood plasma, or serum, so that its nutrition was provided for.

When ligatures were used, a certain quantity of blood was imprisoned necessarily within the cavities thus shut off.

A glass vessel was also placed over the heart, thus forming a moist chamber.

The heart of the marine turtle is much more sensitive to conditions of nutrition than that of either the land tortoise or the Terrapin, which is, of course, an obstacle in the way of the development of spontaneous rhythm.

I have found that unless the ligatures used are somewhat fine and *drawn very tight*, a rhythm may arise possibly not equal to the original one, nor to that of the part of the heart usually dominating the rhythm in question (*e.g.*, auricle the ventricle), thus imitating a genuine spontaneous rhythm; while in reality it is in part due to stimulation from the wave of contraction of the part above, the ligature causing a sort of marked "block" only.

With so sensitive a ventricle as that of the marine turtle, I am satisfied the attachment of a lever and the effects of the same on the rhythm would be considerable. If feeding the heart could be so regulated that the pressure within its own special arterial system did not exceed the normal, it might be unobjectionable; but it is difficult or impossible to ascertain what this *norme* is. I therefore regard results obtained with the attachment to the heart of a recording lever, suspension of the heart and feeding it through its own vessels, except under the conditions defined above, as not those of spontaneous rhythm, but as in part due to excitation; and for these reasons it seems to me my experiments really indicate the amount of genuine spontaneous rhythm of the heart of the Chelonians more nearly than those of Gaskell, in which he has employed suspension, recording levers, and feeding.

At the same time I am inclined to believe that in the land tortoise the ventricle has greater tendency to spontaneous rhythm than in some other kinds of Chelonians.

Since the part of the heart, not sinus proper and not constituting the more prominent part of the auricles, is different in appearance, in structure to some extent, and in function, especially in its spontaneous rhythmic power, as well as conductivity, &c., and inasmuch as it, in these respects, approximates more closely to the sinus than to the auricle proper, it would, I think, conduce to clearness, if this part were considered and called the *sinus extension*. This seems the more natural, seeing that a similar structure, manifestly more like the sinus than the auricle, exists in the fish.*

Though this division was not clearly defined in my paper on the Terrapin, "auricle" is used in the sense of the auricle proper, or bulged part between sinus and ventricle.

II. *Reflex Cardiac Inhibition.*

The results of my experiments on this subject may be shortly stated as follows :—

1. Prolonged gentle tapping with a forceps over the abdominal organs had less effect than a pushing down movement with a seeker, and still less than a single sharp blow with the forceps.

2. Stimulation of the brachial plexus, with a strong interrupted current, has not, in general, produced much slowing of the rhythm. In one case it seemed to quicken it.

3. Sponging over the peritoneum vigorously has generally produced cardiac slowing or arrest.

Peculiar Effects.—1. In certain cases, electrical stimula-

* "On the Structure and Rhythm of the Heart in Fishes," &c., vol. vi. No. 4 and 5, *Journal of Physiology.*

tion of the anus has caused marked arrest of tho heart; but in others, a preliminary slowing, followed by an accelerated rhythm, while the current is still passing.

2. In certain cases, stimulation of the liver has led to the usual cardiac arrest; but in others, acceleration has been the first result and the only one; while in still others, acceleration has followed and preceded slowing.

It is to be understood that, in all these cases, the spinal cord and medulla oblongata were intact.

The significance of such results as those cited aboved are discussed in my paper on the Alligator.*

Upon the whole, it may be said that, while in the matter of cardiac arrest by reflex agency, there is much similarity among the different genera and species of Chelonians, the *Chelonia mydas* is the most susceptible of the three species examined by me; and the Slider Terrapin, is almost if not quite equal to it in this respect, and in advance of the other marine turtles. The condition of the animal at the time of experiment is also a most important factor.

III. *Stimulation of the Vagi.*

The possible effects of stimulation of the vagi in the marine turtles are:—

1. Preliminary weakening of the beat, most marked in the auricles, without arrest of the heart's action or change in the rate of beat. This may occur with a very weak current; but more frequent is—

2. Arrest of the auricles; the rest of the heart continuing either with unchanged or a slowed rhythm and weakened beat. Gaskell† has stated in his paper on *Testudo Græco* that he had never seen any evidence that an excitation wave is able to travel from the sinus to the ventricle and cause a ventricular contraction independently of a wave of contraction over both parts of the auricle. The latter statement is at variance with my observations on the Terrapin and still more frequently on the marine turtles. Often, when both auricles proper are arrested by stimulation of

* *Journal of Anat. and Phys.*, vol. xx.

† *Journal of Physiology*, vol. iii. Nos. 5 and 6.

the vagi, the rest of the heart, including sinus extension, may beat as usual; and this holds equally well, as I have observed, for the Alligator and the Fish.

3. Arrest of the heart by diminution of the force of the contractions to zero, as often occurs in the Frog, does *not*, so far as my observations go, occur in any Chelonian.

4. The ventricle with the auricles may cease, the sinus and sinus extension continuing to beat. But such stop is likely to be very brief, the wave of contraction soon passing on.

5. Preliminary acceleration, which is very rare in the S. Terrapin, occurs more frequently in the sea-turtle, but never except with the stimulation of a weak current.

I have noticed brief preliminary acceleration soon followed by slowing, the strength of the current remaining the same, when the heart's powers have been much enfeebled.

Arrest of the sinus, auricles and ventricles continuing to beat, is unknown.

Diastolic relaxation during stimulation is, perhaps, in the marine turtle rather less marked than in the Terrapin; but it does occur, and equally well in the bloodless heart.

The After-Effects of Vagus Stimulation.—These are very similar in all the Chelonians; in all, stimulation of the vagus may be followed by a rhythm without increase; a rhythm with slight increase or with marked increase; and the same law holds equally well in the sea-turtle as in the Terrapin that *the rate of increase in the force and frequency of the beats of the heart is in inverse proportion to those prevailing at the time of stimulation;* from this it follows that a weak heart, one needing help most, is the one the vagi nerves can actually improve most effectually. This has been illustrated to me over and over again when working on the marine turtles; thus, when, as the heart is getting weak, the left auricle, as is the rule, falls into a condition of great enfeeblement, while the right is comparatively strong, the stimulation of the vagus will restore the left, for a time at least, to harmony of rhythm with its fellow, and produce marked improvement in the strength of the beats.

The after acceleration in the sea-turtles, especially in *C.*

caretta and *imbricata* seems to reach its maximum sooner than in the Terrapin. This does not apply equally to C. *mydas*, I think. Further, when the heart is enfeebled in all kinds of Chelonians, the maximum is more rapidly attained, and this remark applies with especial force to the marine turtles.

The beat may recommence after standstill from vagus stimulation, in the order: sinus (always), sinus extension, ventricle, auricles; or in the order: sinus, sinus extension and auricles, ventricle; and the same holds for the Alligator and the Fish.

Unilateral Effects of Vagus Stimulation.—These have been referred to in my paper on the Terrapin (pp. 249, 250), and relate especially to greater dilation of one auricle, than the other during stimulation of its corresponding nerve. While such dilating effects have been noticed for the sea-turtle, arrest of an auricle answering to the vagus stimulated, has been more frequently observed than in the Terrapin; in several cases this phenomenon has been very pronounced, and has followed on every stimulation of the nerve with a sufficiently *weak current*.

Stimulation of the Central End of one Vagus, the Medulla and the other Vagus being intact.—The results may be stated briefly as follows:—

1. In all the specimens of the sea-turtle examined in this way (with one exception, in which there was doubt as to the soundness of the medulla) either arrest or slowing of the rhythm has followed.

2. In most cases this could be repeated 3 to 6 times at short intervals, but with less and less effect on each occasion. Considering the great vital tenacity of the nerves in the Chelonians, this seems to point to exhaustion of the inhibitory centre.

3. In a certain proportion of cases there is decided after-acceleration (*e.g.*, from 33 to 38 beats).

4. As was seen with the Slider Serrapin, there are great differences in capacity for this form of inhibition in different specimens of the same species.

C. mydas gave much the most pronounced and certain results in my experiments on the marine turtles.

In one instance, with a weak current, preliminary increase in the rhythm occurred, followed by slowing and even short stops of the heart.

Prolonged alternate Stimulation of the Vagi.—The following account of an experiment on this subject furnishes the case of longest cardiac inhibition yet published :—

Exp.—*Chelonia imbricata*, 2 feet long.

12.32 P. M. 1. Stimulation of left vagus for 30 minutes, maintains constant standstill; then current withdrawn; after a latency of 14 seconds, rhythm re-established after 1-2 minutes. (First stimulation from 12.32 to 1.3 P. M.)

2. At 1.5 P. M. Stimulation of right vagus till 2.10 P. M.; after the current withdrawn, a latency of 16 seconds before rhythm began.

3. Stimulation of left vagus till 3.32 P. M.; when current shut off.

4. At 3.35 p. m. Stimulation of right vagus till 4.25 p. m.; latency 30 seconds.

5. Stimulation of left vagus, from 4.25 P. M. till 5.30 P. M., when beats began to appear.

Thus in all there was *continuous inhibition of the heart for more than six hours;* for the periods between the stimulation of the right and left vagi were only of sufficient length to ascertain that the heart would still beat, and in none of these cases did the heart begin to pulsate while the current was passing. It was, in fact, evident that the power of the vagus was not exhausted. To this remark, the right vagus at 4.26 p. m. is an exception, but in that case, the electrodes were at once, on the appearance of a beat, transferred to the opposite vagus.

It will also be noted that the periods of latency, after the stimulation ceases before a beat appears, lengthens with each stimulation.

Comparative inhibitory power of the two vagi.—The following is the statement of the results in 8 cases:—

Arrest of the heart with the induced current:

Specimen I.	Left vagus,	secondary coil	½	over primary.
"	Right "	"	¾	"
" II.	Left "	"	at 10 cm.	from primary.
"	Right "	"	5 "	"

Specimen III.	Left vagus,	secondary coil at 4 cm. from primary.
"	Right "	" 1 " "
" IV.	Right "	equal in power.
"	Left "	
Specimen V.	Right vagus	equal in power.
"	Left "	
" VI.	Left "	inhibits with 2 c. at 3 cm.
"	Right "	" " 5 "
" VII.	Right "	" " 6 "
"	Left "	requires the strongest current.
" VIII.	Left "	both at 4 cm.
"	Right "	

A comparison of these results with those reported for the Terrapin (pp. 247, 248, 249) will show a great resemblance. In by far the larger number of cases, the right vagus has greater inhibitory power than the left, exceptions to this, though few, sometimes occurring. In the marine turtle, no case in which the left vagus was wholly without effect on the rhythm was found.

This difference between the two vagi, which does not seem to be confined to the Chelonians, but is seen also, as I have shown, in the Alligator, calls for explanation. Meyer's[1] explanation, that there were certain cases in which there were no inhibitory fibres in the left vagus, does not agree with facts; for in all cases, the left vagus has some effect either on the force or the rate of the beat. It has been seen that in the Chelonians and Alligator, arrest of the sinus leads almost invariably to arrest of the rest of the heart, whether that arrest be brought about by the vagus or by a ligature placed between the sinus and auricle; and in those cases in which one vagus is unable to maintain the rest of the heart in standstill, it is always because the sinus is not controlled.

Gaskell[2] has shown that the part of the vagus known as the "coronary" nerve is that which influences the force of the beat of the auricle and ventricle while the rate depends on the sinus.

The peculiar unilateral vagus effects, pointed out in my paper on the Terrapin, and in this one, seem to me to throw new light on this question.

[1] *Hemmungsnerven System des Herzens*, Berlin, 1869.

[2] *Journal of Physiology*, vol. iii. Nos. 5 and 6.

Beating in harmony with the sinus proper are the terminations of the great veins leading into the sinus. It is easy to see that their conjoined power, which, so to speak, is the *governing* propelling force of the whole heart, is greater, *i.e.*, there is a larger wave of contraction, on the right side than on the left. Now, it is to be observed, that in all those cases in which the left vagus, under the influence of a weak current, can arrest the left auricle and perhaps the left part of the sinus and its associated veins, that inasmuch as the right part of the sinus keeps pulsating, sooner or later the left part is overcome; whereas, when the right part is arrested, its wave is so large, its controlling force so great, the left is of itself so weak, that its wave (also weakened) may not be able to pass on to the sinus extension and auricles; moreover, this left part and its veins, as I have often noticed when the heart is dying, ceases to pulsate before the right part of the sinus and its veins. I would then explain the greater effect of the right vagus as a rule by the character of the contraction wave, associated with the right part of the sinus and its associated veins, and by the fact that the nervous supply to this seems to be chiefly from the right vagus, rather than to any deficiency in the kind or number of the inhibitory fibres in the left vagus; both may supply an equal number of such fibres, but if the supply be even partially unilateral, then the results follow as I have endeavoured to explain.

Inasmush as the force of the auricles is very much lessened by vagus stimulation, great weakening of the beat of the sinus may suffice to arrest the auricles and ventricle without complete arrest of the sinus; in such cases, sinus arrest is not the sole cause of the stop of auricles and ventricle, nor absolutely essential to it.

Intracranial Stimulation of the Vagus.—The peculiar inner conformation of the skull of the sea-turtle, and its great thickness and hardness, make examination of the roots of nerves intracranially very difficult. One such examination gave the following results :—

Exp.—Rhythm 5-6.

Stimulation of nerve roots from the medulla led to very prolonged inhibition, followed by an accelerated after-rhythm of 7-8.

IV. *Faradisation of the Heart.*

As in the Terrapin, Alligator, and Fish, the result obtained depends on the strength of the current and the condition of the heart.

The sinus being in good condition, and the current sufficiently strong, it is arrested, but if the heart be much exhausted, no arrest may follow; arrest of the sinus, of course, leads to stoppage of the rest of the heart, unless, as often happens, there is escape of current.

The same arrest of auricles occurs on stimulation, unless the heart be very much exhausted.

Dilation is less prominent in the ventricle of the sea-turtle than in that of the Terrapin; but the bluish appearance accompanying it, and the light points where the electrodes are applied, are manifest

I have never obtained, in the sea-turtle, arrest of the ventricle by stimulation of this part of the heart with the interrupted current; on the contrary, stimulation of the ventricle gives rise to a more rapid pulsation; or, especially if the nutrition be imperfect, a peculiar form of contraction, which, as it does not exactly resemble that denoted by such terms as fibrillar, peristaltic, &c., I have called intervermiform, which seems preferable to peristaltic, inasmuch as the latter has acquired a very definite physiological meaning, which it is not well to extend.

With a very weak current in all but the freshest hearts, the dilation following the stimulation is much more local, and there may be no marked effects as far as rhythmic variation is concerned.

But in a heart very much exhausted it is often quite impossible to arrest the sinus or any part of the heart with the strongest current.

That the white dots seen at the points of application of the electrodes are due to marked contraction of the heart muscle, the behaviour of the Alligator's heart renders extremely probable; but that the other effects are due, not to the influence of the current directly on the muscle itself, but indirectly through the nervous mechanisms of the heart, several considerations render highly probable.

1. The effects of the current are very like those of stimulation of the vagus nerve itself, as illustrated above (arrest, dilation, &c.)

2. When the nutrition of the heart is impaired (and its nerves have probably suffered the most), it is impossible to produce the usual effects, arrest of the sinus, auricle, &c.; while at the same time it is possible to send the ventricle into the peculiar intervermiform action referred to above. This and many other things I have seen, such as the readiness with which even the mammalian heart, long under experiment, &c., goes into a similar action known as the Kronecker-Schmey phenomenon, leads me to believe that this latter also is to be explained, at least in some cases, by peculiar qualities of the muscle rather than through nerve influence; further, in the case of the mammal, this phenomenon and the intervermiform action referred to in the Chelonians, are alike wholly uninfluenced by vagus stimulation.

3. Sponging over the heart, arrests it when fresh, while later it may give rise only to intervermiform action in the ventricle; this seems to me a very strong argument in favor of nervous influence.

4. After the free application of atropine to the Fish's heart *in situ*, it is impossible to arrest it either by sponging it over or by the application of the electrodes to the sinus; but it is possible to initiate the intervermiform action by this procedure.

V. *Evolution of Function and Cardiac Death.*

In all the Chelonians, the invariable order in which the different parts of the heart die is: (1) ventricle, (2) auricles proper, (3) sinus extension, (4) sinus.

I have studied this subject especially in the sea-turtle, and find that invariably the right auricle outlives the left; and, as has been before indicated, the right moiety of the sinus, and its pulsating venous extensions, tend to outlive the left moiety and its corresponding venous parts.

The death of the ventricle also takes place in a certain segmental order, which is virtually the same in all cases, and which is indicated by dotted lines and numbers (Plate, fig. 5).*

It will be seen from the above figure that the left side of the ventricle dies before the right, and that the last segments to die are a superficial one, extending from the vessels downwards, and another, involving the apex and a portion extending obliquely upwards to the right of it; speaking generally, the *cavum venosum* is the last part of the ventricle to die. From what has been said, it appears that as the heart's vitality is being lowered, a more primitive condition of things is reached, *i.e., the heart comes to consist of the sinus, the auricle, and a simplified ventricle;* or to put it otherwise, the parts least dependent on the constant supply of nourishment are those that are oldest in the development of the heart, as those also of greatest independent rhythmic power; so that observation on the order in which any heart dies may be a means of reading its developmental history. It is more difficult to study this subject on the mammalian heart, but Harvey long ago pointed out that the right auricle was the last to die, and that the left ventricle was the first, though he does not seem to have emphasized the significance of this fact.

When in the animal scale among vertebrates a second auricle is acquired, as it is first among the Dipnoi, it is small and of comparatively much less functional importance than the right.

In the sea-turtle, not only is the right auricle endowed with greater vitality than its fellow, but it is conspicuously larger, the left, however, making a certain degree of advance, as to size, on the condition existing in the Dipnoi.

The ventricle in the sea-turtle is much more sensitive to a stimulus than that of other Chelonians; it also has much less vitality, can bear deprivation of its regular nourishment

* The plate referred to will appear in the continuation of this paper in the next No. of this Journal.

less successfully, as the sea-turtle has less vital tenacity than other genera of this family; indeed, there often seems to be associated great vital tenacity of the animal with a corresponding resisting power of the heart, as evinced in the case of *Batrachus tau*, the fish on which my experiments were chiefly made.

VI. *Nerves with Peculiar and Inconstant Influence.*

Reference is made in my earliest communication on the Chelonians* to a fine nerve which on the first stimulation produced cardiac arrest followed by acceleration, but the later stimulation of which seemed to be without effect on the rythm.

I have described what seemed to be accessory vagi in the Alligator.

In the sea-turtle, I have met with fine nerves traceable upwards towards the superior cervical ganglion and downwards to the heart, which have acted in a somewhat inconstant manner. Thus sometimes such a nerve has given purely vagus effects; again, a first stimulation has caused slowing, and all later stimulations only acceleration; while others again have shown no action beyond the first one, on repeated stimulation. But this I have also noticed to hold for the small accelerating branch from the middle cervical ganglion in the Terrapin. Of course, such fine nerves die readily, and are easily exhausted by stimulation, and it may be that the inhibitory fibres in some cases are fewer and are exhausted sooner than the accelerating ones: however, such phenomena, in the present state of our knowledge, are rather puzzling.

Is there a Physiological Depressor Nerve in the Chelonians? The question has been already answered in the negative by my experiments on the Terrapin. After making two tests on the sea-turtle, the latter of which was in everyway satisfactory, the variations in blood-pressure being indicated in a rather sensitive way by a simple contrivance, it was impossible to find any fine nerve which produced marked lowering

* *Journal of Physiology*, vol. v. Nos. 4, 5 and 6.

of the blood-pressure when stimulated, although very many were tried. Some of the nerves that might be suspected as depressors had a function (peripheral end) which is referred to in the preceding section.

It may then be said that *there is no nerve with the functions of a physiological depressor in the Chelonians.*

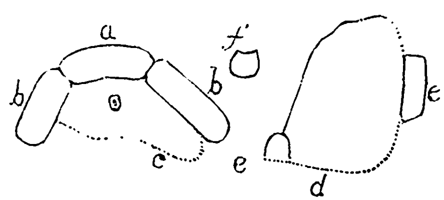
(*To be continued.*)

Additional Note on the Pteraspidian Fish found in New Brunswick.

By G. F. Matthew, F.R.S.C.

Since writing my former communication in reference to the above organism, I have had opportunity for a further examination, and add a few remarks herein to those published in the October number of the *Record*.

On comparison of the plates of this fish with those of the Placoganoids of the Devonian Age, which alone of the earliest fishes are, at the present time, reputed to have been armoured above and below, it seemed probable that the



hexagonal plate (*c* in the above figure) in the Acadian fossil was the ventral plate, corresponding as it does in form to the large ventral plate of Pterichthys; and this view seemed the more probable as this was the flatter, and apparently the thinner of the two large plates of this fish.

A careful comparison with the known genera of Pteraspidian fishes, however, makes it probable that this is not the correct view to take of the position of these plates relative to the dorsal and ventral sides of the creature which they covered.

In *Pteraspis* (Kner) which, however, is a Devonian and not a Silurian genus, there is a considerable resemblance in the ornamentation of the test, and generally in the dorsal armature, to the covering plates of the Acadian fish; but if we attempt to compare the different plates of which the shield of our Pteraspidian fish is composed, with those of Pteraspis, they will be found to differ widely from that genus. On the other hand, if the plates *a, b* and *c* be compared with those of the genus *Cyathaspis* (Lank.), the correspondence of parts is striking.

In Prof. E. Ray Lankester's monograph on the fishes of the Old Red Sandstone,* we appear to have only one example of this genus described, for although *Cyathaspis* (?) *Symondsi* is described under this head, it seems very doubtful whether it should be so referred. The typical species *C. Banksii* (H. & S.) is Silurian, and possesses a set of plates quite analogous to those of the Acadian fish. There is also on the central plate ("dorsal scute") a tubercle, indicated in Prof Lankester's figures, which holds the place of a similar circular elevation on the shield of the Acadian fossil (see fig. *c*). In Prof. Lankester's examples of *C. Banksii*, the surface markings appear to have been obscure, except on the rostral and lateral plates; we do not know, therefore, how far the markings on the main plate of each of these two fishes were similar. In the Acadian species the triangular space between the tubercle above referred to and the front of the chief hexagonal plate *c* possessed a group of sinuous and looping, mostly transverse, striæ, differing in direction from the longitudinal striæ that mark the rest of the plate.

Curiously enough, the plate *d* possesses characteristics analogous to those of the scute of the genus *Scaphaspis* (Lank.). The markings on the surface of this plate are almost exactly parallel to those of the "dorsal" scute of

* Memoirs of the Palæontographical Society, London, vol. xxi.

Scaphaspis truncata (H. & S.), in the fine example figured by Prof. Lankester (plate ii. fig. 3, Memoirs cited), and the plate is similarly a little asymmetrical.

The association of these two types of fish plates at several localities may not be altogether without significance. Thus in the Downton Sandstones of England there are *Cyathaspis Banksii* and *Scaphaspis truncata.* In the Onondaga variegated shales of Pennsylvania, Prof. Claypole has found *Palæaspis** *bitruncata* and *P. Americana*.. So far as form goes, it may be seen that the former is comparable with the "dorsal scute" of *Cyathaspis,* as Prof. Claypole has observed, while the latter in outline is not unlike the shield of *Scaphaspis.* It should be remarked, however, that in the course of the surface markings, as figured by Prof. Claypole, *Palæaspis Americana* differs both from the Scaphaspis of the Downton Sandstone and f. om plate *d* of our Acadian species.

Before closing this note, I may refer to a few other characteristics of the Acadian fish. The plates *c* and *d* possess the two ranks of striæ which, according to Prof. Lankester, distinguish the Silurian from the Devonian Pteraspidians; the contrast between the larger set and the smaller intermediate set of striæ is more marked on plate *d* than on *c*; and the borders of both of these plates, as also the whole of the lateral and rostral plates differ in having striæ of uniform size. The superior prominence of certain of the striæ therefore belongs only to the two larger plates of the dermal covering, but it is a useful character in distinguishing these older fish from the more typical Pteraspids of the Devonian system, in which no part of the dorsal scute presents these strikingly unequal striæ or ridges.

The fineness of the striæ in the plates of the Acadian fish is quite up to the highest standard of tenuity in the fish plates of Prof. Lankester's Memoir, there being from 150 to 200 of them in the width of an inch. The plate *c* is abundantly dotted with minute pits apparently marking the

* *Quart. Jour. Geol. Soe.*, London, Feb., 1885. This genus is separated from the other Pteraspids on account of organic differences in the structures of the plates, not because of difference in form.

sites of mucous glands, which Prof. Lankester mentions as a feature of shields of the genus *Pteraspis*: from this he infers that a secreting membrane probably covered the surface of the calcareous plates in Pteraspis. If his reasoning is correct, the plates of the Acadian fish were also probably clothed with a similar covering.

St. John, N.B., Dec., 1886.

MISCELLANEOUS.

RADIATION FROM PLANTS.—Acting upon the suggestions contained in Darwin's well-known experiments relative to the protection against excessive radiation from leaf surfaces, and so against injury, afforded by the various positions which certain leaves are known to regularly assume at night, Rev. G. Henslow seeks a more general application of the law than had previously been observed. He finds that even in those plants, the leaves of which are not so hypnotic in the mature state, there is usually well-defined hypnotism in the young leaves, and that in any case, the vernation bears a most important relation to the protection of leaves against radiation from their upper surfaces, and also against dessication through the action of dry winds passing ever them. In the latter case, he shows by experimental determination, that in many cases, the loss of moisture in weight, from young leaves artificially extended, exceeds that from leaves which maintain their normal form of vernation, several times. Of the examples which he cites, the ratios of loss between the naturally and artificially exposed leaves, vary from 1 : 5·1 to 1 : 1·2.—*Jour. Lin. Soc.*, xxi.

DEVELOPMENT IN SEPTIC ORGANISMS.—The Rev. W. H. Dallinger, in his presidential address to the Royal Microscopical Society, in February, 1866, traced in a masterly manner the development of certain forms found in septic fluids, requiring for their study at once the very best instruments and the greatest skill. This unrivalled investigator modestly left out of account the skill, and dwelt the great improvements in microscopes within the last few years. An outline of what takes place cannot better be sketched than in Dallinger's own words. The creature (monad) he describes as a protoplasmic cell with nucleus, and having a pair of flagella projecting from the pointed end. "The nucleus is the centre of all the higher activities of these organisms. The germ itself appears but an undeveloped nucleus; and when that nucleus has attained its full dimensions in size, there is a pause in growth, in order that its internal development may be accomplished. When this is the case, it becomes manifest that the body sarcode is, so to speak, a vital product of the nucleus. Moreover, it is from it that the flagella originally arise. In the same way, it is only by a complicated and beautiful series of delicate activities in the nucleus that the wonderful act of fission is initiated, and in all probability carried to the end. So, too, all the changes that go with fertilization and the production of germs are a series of correlated activities, due, at the beginning at least, wholly to the nucleus." All the stages are figured, from the bare nucleus (original germ) down to the amœboid form prior to conjugation with another individual, and the conjoint formation of a quiescent mass of protoplasm, which finally gives rise to a cloud of protoplasmic dust, as it were, which represents the germs or nuclei of yet undeveloped individuals, thus completing the entire cycle.—*Jour. of Roy. Mic. Soc.*

The Digestive Process in some Rhizopods.—Physiology, as a field for original investigation, has been recently entered by ladies. Miss Greenwood, Demonstrator of Physiology, Newnham College, Cambridge, has published a paper on the above subject. Her investigations were confined chiefly to the two interesting forms Amœba and Actinosphærium. The latter, as is well known, has a spherical protoplasmic body, honeycombed with numerous vacuoles, and with filiform pseudopodia protruded from its surface. Her method of work may be described as chemico-microscopical. The digestive process is considered under the heads: (*a*) Ingestion, (*b*) Digestion, (*c*) Egestion. In these two forms, no digestive *ferment* has as yet been found. Many accounts of intra-cellular digestion in invertebrates have been published, but not a few of them are mere fragments. Miss Greenwood draws the following conclusions in regard to the above-mentioned two forms:—1. They show constant and promiscuous enclosure of solid matter, which is received in the vacuole of ingestion. The nature of the latter is doubtful. The formation from the surrounding medium points to its aqueous character; but the rapid death of the enclosed prey, in Amœba at least, argues some influence or secretion from the enclosing animal. 2. Starch grains are not digested by Rhizopods. 3. Fat globules are not digested by Amœba; a slow digestion of them probably takes place in Actinosphærium. 4. The fate of digested matter depends on its character. If it is innutritious, the vacuole of ingestion disappears; if nutritious, it undergoes change not effected by direct contact with the acting protoplasm, but by something passed out of the protoplasm into what has become the *vacuole of digestion*, in fact, a secretion. This case resembles that of the higher animals, in so far that the secretion is passed into a cavity—the cavity in this case being intracellular. 5. This secretion is probably not acid. It cannot apparently act on cellulose walls, but *diffusing* through the coats of cellulose clothing organisms, acts on the contained protoplasm. There is thus some evidence for the view that Rhizopods normally derive fat and carbohydrate from the splitting up of solid proteid—in which they would resemble the highest mammals. They can also probably utilise matter already in solution. 6. The formation of the digestive secretion is not stimulated by bodies incapable of digestion or unsuitable for nourishment. 7. At a certain stage of digestion, there may be temporary loss of fluid around the food; later, the *vacuole of ejection* succeeds the digestive vacuole; and by the outward opening of this vacuole all remains of former food are expelled from the body (excretion). The crystals found in Amœba Proteus and the *contractile* vacuole seem to have no direct connection with digestion. After the ingestion of food, the "proper" granules gather around it; this may have a digestive significance, but such cannot be positively asserted. Observation of the behaviour of these two forms in relation to the digestive process have led to the belief that there are *differences* of a non-essential character.—*Jour. of Physiology*, Eng.

The Liver Ferment.—Miss Florence Eves, B.Sc., of Newnham College, has published a research bearing on this question: Is there a liver ferment which converts glycogen into sugar or not? An affirmative answer to this question has been given since the time of Bernard, but the existence of such ferment was rather an assumption than a demonstrated fact. Miss Eves treated the livers of various animals, especially of the sheep, according to approved methods, with a view of extracting a ferment. The results of her work may be summarised about as follows:—1. There is evidence of the existence of an amylolytic ferment in the (dead) liver, but the amount is very small; a portion of this may be fairly assumed to have been derived from the blood remaining in the unwashed liver, since an amylolytic ferment can be extracted from blood. 2. The sugar formed *post-mortem* in the liver is true dextrose, as had been previously shown. 3. The sugar formed by the isolated liver-ferment is *not* dextrose. It is of smaller reducing power, and may be possibly maltose. It seems natural, therefore, to conclude that the *post-mortem* conversion in the liver is *not* due to ferment action. The *rapid* appearance of sugar in the liver after death is rather to be attributed to the "specific metabolic activity of the dying cells." The same cause suffices to explain the more gradual production. This conclusion would relieve physiology of at least one ferment, and it must be confessed that ferment action seems to be bearing a large share—an undue share in the physiological explanations of the day.—*Jour. of Physiology*, Eng.