the hyoidean apparatus (fig. 3) two reniform hypo-hyals in cartilage, surmounted by a triple piece of the same material that occupies the usual site of the glosso-hyal. In the median line we have a thoroughly ossified basi-hyal; while curved bony cerato-hyals, with expanded cartilaginous anterior ends, are suspended from the hypo-hyals. Four branchial arches are represented; the first pair being long, curved bones, and the remaining ones cartilage. The gill-clefts open to the rear of the last pair on either side.

The spinal column of an adult Muraenopsis contains one hundred and ten well-ossified vertebrae. The second and third of these have suspended from their transverse processes free ribs, of which the anterior pair is the larger. A strongly marked intercondyloid process is formed between the two concave facets on the anterior aspect of the atlas. As a rule, all these vertebrae, except the first and the extremely rudimentary caudal ones, are of the amphicoelous type, with lofty neural spines,—far-spreading transversed processes that become horizontally broadened in mid-spinal region,—and with well-marked zygapophysial processes to link the series together. None of these vertebrae are modified to form a sacrum in connection with the pelvis in the precaudal region; beyond which, each segment throws down parial hypapophysial processes, which are not lost, as we proceed backwards, until we arrive at the ultimate nodules that complete the tip of the tail.

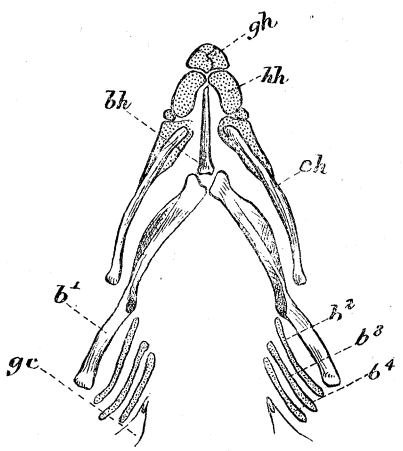



FIG. 3.—Hyoidean and branchial apparatus of Muraenopsis tridactylus; life-size; dotted parts in cartilage; *gh*, rudimentary glosso-hyal; *hh*, hypo-hyal; *ch*, cerato-hyal; $b^1$, $b^2$, $b^3$, and $b^4$, branchial arches; *gc*, gill-cleft.

In my specimen the thirty-third and thirty-fourth vertebrae have coalesced in the most remarkable manner, forming one bone, with nearly all the parts double. The appendicular skeleton is represented by extremely rudimentary shoulder and pelvic girdles, supporting equally feebly developed limbs, with their segments arranged as seen in fig. 4. We find

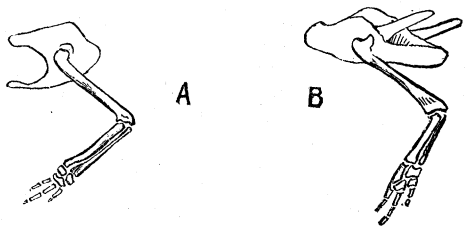



FIG. 4.—A, right fore-limb and rudimentary shoulder-girdle; B, right hind-limb and rudimentary pelvis, both slightly enlarged, of M. tridactylus. From dissections by the author.

the carpus has three cartilaginous elements in its structure,—two in the proximal row, and only one in the distal. This number is increased by an additional segment in the tarsus, which has two elements in each row, articulating with the digits, as shown in the figure.

Osseous tissue of an elementary character may be deposited in the humerus, the femur, and certain points in the pelvis, more particularly the projecting rod that appears to represent the pubic bone; otherwise all this part of the skeleton in our siren remains in cartilage throughout life.

R. W. SHUFELDT.

## *THE GREAT TERMINAL MORAINE ACROSS PENNSYLVANIA.*[1]

AFTER describing the investigations which elsewhere had demonstrated the existence of a true terminal moraine to the glacier covering north-eastern America, the author stated, that having obtained the aid of the geological survey of Pennsylvania, and, during a portion of his work, the assistance of Prof. G. F. Wright, he had been able to follow and define the southern limit of glaciation for the first time in a continuous line four hundred miles in length, and to find that it was everywhere marked by a remarkable accumulation of glaciated material, which, winding across mountains and valleys, from the lowlands of the Delaware to the great Alleghany plateau, was continuous from end to end, and formed a true terminal moraine.

There is a marked distinction between the glaciated portion of Pennsylvania and that region south of glacial action. Although the general topography of the two regions is alike, the varied superficial features due to glacial agencies, the far travelled and scratched bowlders, the smoothed and striated

[1] Abstract of a paper before the American association for the advancement of science, in Montreal, August, 1882. By Prof. H. CARVILL LEWIS.

rock-exposures, the unstratified deposit of till, the many kames, and especially the numerous glacier-scratched fragments and pebbles, — all these deposits are in strong contrast with those south of the moraine, where all the gravels are stratified and the pebbles water-worn, where the rocks are never polished or striated, but, on the other hand, often decomposed to a great depth, and where, except near the seacoast, wide stretches of the more elevated regions are perfectly free from all drift.

The method employed in discovering the line of the moraine was to zigzag along its course from the glaciated into the non-glaciated region, and *vice versa*, going each time far enough on the one side to be fully satisfied of the absence of glaciation, and, on the other, to find undoubted traces of its action.

Nowhere south of the line of the terminal moraine had he found any traces of glacial action, *all statements by other geologists to the contrary notwithstanding.* When typically developed, the terminal moraine is characterized by peculiar contours of its own. A series of hummocks, or low conical hills, alternate with short straight ridges, and enclose shallow basin-shaped depressions, which, like inverted hummocks in shape, are known as *kettle-holes.* Large bowlders are scattered over the surface; and the unstratified till which composes the deposit is filled with glacier-scratched bowlders and fragments of all sizes and shapes. The average width of the moraine is about one mile.

At many places, however, the limit of glaciation is marked merely by an unusual collection of large transported bowlders. This is especially the case in front of a high mountain range which has 'combed out' the drift from the ice.

The general course of the moraine across Pennsylvania was defined as follows: appearing first in Northampton county, a mile below Belvidere, at latitude 40° 49′, it winds in a great curve, first westward and then northward, reaching the base of the Kittatinny Mountain, three miles east of the Wind-Gap.

Ascending to the top of the Kittatinny Mountain, sixteen hundred feet high, the moraine crosses the great valley between the Kittatinny and the Pocono, and then swings sharply back and around Pocono Knob, immediately afterwards to ascend the steep face of the mountain to the wide plateau on top, twenty-one hundred feet above the sea. Crossing this in a fine curve, and heaped up in an immense accumulation, it goes first north and afterwards west, reaching the gorge of the Lehigh River, some ten miles north of Mauch Chunk. It crosses the gorge at Hickory Run, and, without swerving from its general north-western course, ascends mountain range after mountain range, descends to the valley of the east branch of the Susquehanna, and crosses the river at Beach Haven.

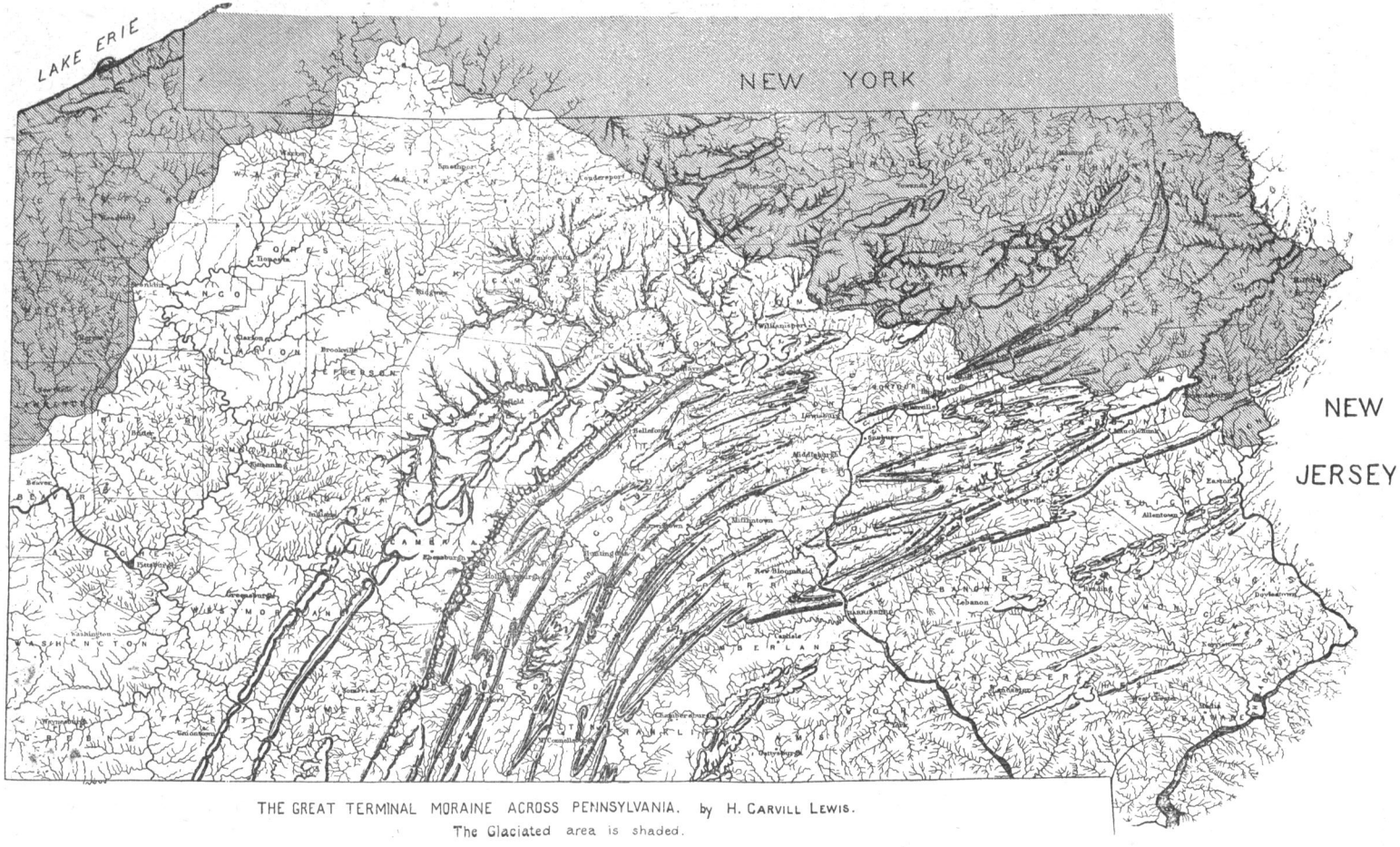
Then, following the base of Huntington or Knob Mountain, it finally ascends it, and crossing its summit, at a height of fifteen hundred feet above the Susquehanna just below, descends the north slope of the mountain to the broad, undulating valley to the north. Taking a northerly course, it follows up on the east bank of Fishing Creek to the North or Alleghany Mountain, enters Lycoming county, passes westward along the base of the mountain, crossing in its course the Muncy and Loyalsock creeks, and then, near the village of Loyalsock, turns at right angles, and ascends the mountain.

Having reached the summit of the Alleghanies, over two thousand feet above the sea, it passes west through a wild, wooded region nearly as far as Pine Creek, where it begins a nearly straight north-westward course through the south-west corner of Tioga county, and the north-west part of Potter. In the high ground of Potter county, the moraine crosses a great continental watershed, from which the waters flow into the Gulf of Mexico, Lake Ontario, and Chesapeake Bay. The moraine is here finely shown at an elevation of twenty-five hundred and eighty feet, being higher than elsewhere in the United States.

It now enters the state of New York in the south-west corner of Allegany county. Passing still north-west, and entering Cattaraugus county, it twice crosses the winding course of the Allegheny River, east and west of Olean; then trending to a point five miles north of Salamanca, in latitude 42° 15′, it forms a remarkable apex, whence to the Ohio line its course is south-west. Turning at right angles to its former course, the moraine passes south-west through the south-east corner of Chautauqua county, and, keeping approximately parallel to the course of the Allegheny River, re-enters Pennsylvania in Pine Grove township, Warren county. It crosses the Conewango River seven miles north of Warren; then trending west, still at a general elevation of nearly two thousand feet above the sea, it crosses one gorge after another, and forms a line separating not only the glaciated from the non-glaciated region, but also the cultivated from the uncultivated and densely wooded region. It crosses the south-east corner of Crawford county, skirts the north-west and west boundary of Venango county, crosses Beaver River eight miles south of New Castle, and, traversing the extreme north-west corner of Beaver county, crosses the Ohio state line in the middle of Darlington township, thirteen miles north of the Ohio River.

The moraine thus leaves Pennsylvania at precisely the latitude at which it entered the state; and, if a straight line were drawn across the state between these two points, the line of the moraine would form with it a nearly right-angled triangle whose apex was a hundred miles distant perpendicularly from its base. The total length of the moraine, as here shown, is about four hundred miles. The moraine crosses the Delaware at an elevation of two hundred and fifty feet, the Allegheny at an elevation of fourteen hundred and twenty-five feet, and the Beaver at an elevation of eight hundred feet, above the sea, or two hundred and twenty-five feet above Lake Erie. Upon the high lands it rises higher by a thousand feet or more.

Coming to the details of the moraine, many of which are of great interest, reference was made to its fine development in Northampton county, west of




THE GREAT TERMINAL MORAINE ACROSS PENNSYLVANIA. by H. CARVILL LEWIS.

The Glaciated area is shaded.

Bangor, where it forms a series of hummocky hills, which, a hundred to two hundred feet in height, and covered with transported and striated bowlders, rise abruptly out of a clayey plain to the west. Glacial striae upon exposed surfaces near Bangor point south-west, or towards the moraine. After following the moraine to the base of the Kittatinny Mountain, it became of great interest to know whether a great lobe of ice descended from New Jersey along the lower side of the mountain, or whether a tongue projected through the Delaware Water-Gap, or whether the glacier, even so close to its southern limit, came bodily over the top of the mountain, unchecked by it, and unchanged in its course. The last, the most improbable of these hypotheses, and certainly the least expected by the author, proved to be undoubtedly the true one. The author had been able to show that the moraine crossed the mountain near Offset Knob; that large bowlders, derived from lower elevations several miles northward, lie perched all along the summit, fourteen hundred feet above the sea; and that, as shown by the numerous striae on the northern slope of the mountain, running *up-hill*, the glacier moved diagonally up and across the mountain, uninfluenced in any way by the presence of the Water-Gap, and finally came to an end in the valley south of the mountain, as marked out by the terminal moraine. Huge bowlders of fossiliferous limestone, sometimes thirty feet long, were torn by the ice from their parent strata in Monroe county, on the north side of the mountain, lifted up a thousand feet, carried across the mountain, and dropped finally in the slate valley of Northampton county. The author had found one of these limestone bowlders upon the very summit of the mountain, where the jagged sandstone rocks had combed it out of the ice during its passage across. The journeys of these bowlders were short; but that of a well-rounded bowlder of Adirondack syenite, which the author had found in the same county, was about two hundred miles.

Another interesting point is in Monroe county, upon the summit of Pocono Mountain, over two thousand feet above the sea, where a great ridge of moraine hills twelve miles long, one mile wide, and a hundred or more feet high, composed of unstratified till, and bearing numerous bowlders of Adirondack gneisses and granites, rises out of the level, sandy plain of the Pocono plateau, and sweeps around from Pocono Knob into Carbon county. Known locally as 'Long Ridge,' its origin had never before been suspected. It encloses remarkable little 'moraine lakes' without inlet or outlet, and is heaped up into just such conical hills as may be seen in the moraine in southern Massachusetts. Nothing can more clearly show the continuity and uniformity of action of the great glacier than the identity of its moraine accumulations at such remote points.

In fact, the course of the moraine, as it winds from the top of the Kittatinny Mountain down to Cherry valley, and then up again on to the Pocono, is a complete vindication of the glacial hypothesis. It is in no sense a water-level, nor could it have been formed by floating ice. No other cause than that of a great glacier could form a continuous accumulation of glaciated material which contains no evidences of water-action, and which follows such a course. Neither on the mountains nor in the valley does the moraine rest against any defined barrier, as would be the case were it a shore-line.

The kames of Cherry valley, fine examples of which appear south of Stroudsburg, are interesting relics of sub-glacial water-action. They are composed of stratified water-worn gravel, having often an anticlinal structure, and as a series of conical hills and reticulated ridges, enclosing 'kettle-holes,' form conspicuous objects in the centre of the valley. They appear to have been formed by sub-glacial rivers, which, flowing from the moraine *backwards*, under or at the edge of the ice, emptied into the Delaware valley. They thus probably differ in origin from the longer kames in New England, and other regions more remote from the edge of the glacier.

The glacier had produced very slight effect upon the topography of Pennsylvania. It neither levelled down mountains nor scooped out cañons. The glacier passed bodily across the sharp edge of the Kittatinny Mountain without having any appreciable effect upon it, the glaciated part of the ridge being as high and as sharp as that part south of the moraine.

In describing the course of the moraine across Luzerne county, the author showed that it crossed several mountain chains in succession, by each of which it was locally deflected northward. At the point where the terminal moraine crosses Buck Mountain, in a line diagonally across the mountain, the moraine was so sharply defined that he was able to stand with one foot upon the glaciated and the other upon the non-glaciated region. It was interesting to find, that in *front* of a mountain chain, such as Huntington Mountain or the Alleghany Mountain, the moraine was poorly developed, as though the mountain had 'combed out' the drift from the ice.

He described an instructive portion of the moraine, where, three and one-half miles north-west of Berwick, it seems to abut against a high slate hill, which furnishes, therefore, a *section* of the end of the glacier. It shows that the extreme edge of the ice was here only about four hundred feet thick, and that, while the moraine and the scratched pebbles were carried along at the base of the ice, sharp fragments of sandstone were carried on top.

In speaking of the apex made by the moraine in New York, and of the high plateau region of Potter county, it was inferred, from the local influence already shown by the author to have been exerted by single mountain chains, that this region of high elevation had a decided influence upon the general course of the moraine.

Certain facts observed as to the gravel-ridges of the Allegheny River rendered it probable that the river flowed under a tongue of the glacier, ten miles broad and two miles long, through a sub-glacial channel, at the time of its greatest extension near Olean. He

described a great natural dam across the valley of the Great Valley Creek, near Peth, where the moraine stretches across the valley from side to side; and he spoke of the contrast between the numerous drainage valleys which drained the waters of the melting ice into the Allegheny River, and those valleys which took their rise south of the moraine, and were free from all drift.

After giving some details of the western lobe of the ice-sheet, and dwelling upon the agricultural significance of the moraine, he spoke of some curious deposits of glaciated material which occurred in a narrow strip of ground immediately in front of the moraine, and which he had named the 'fringe.' These deposits consisted of bowlders of Canadian granite, and other rocks, which he found perched upon the summits of hills, sometimes as far as five miles in front of the moraine, though never farther. This glacial 'fringe,' confined to the western part of the state, was found to increase in width from two miles in Warren county to five miles on the Ohio line, and was at first a puzzling phenomenon. The hypothesis suggested was, that, like breakers on the seashore, the top of the ice overreached the lowest strata by the width of the 'fringe,' and that while the moraine marked the halting-place of the bottom of the ice, by which it was formed, the far-transported bowlders were carried on more rapidly in the top strata of the ice, and were dropped outside of the moraine to form the 'fringe.' It was stated that the striae in the western part of the state all pointed south-east, being at right angles to those in the eastern part of the state, but, like them, pointing always towards the moraine.

In conclusion, the author reviewed the more important facts discovered during his exploration of the line of the moraine, dwelling upon the character of the moraine where crossing river-valleys, the absence of proof of any tongues of ice down such valleys, the absence of glacial drift south of the moraine, the very slight erosion caused by the passage of the glacier, and especially upon the deflections, large and small, in the line of the moraine, which were inexplicable on any other hypothesis than that the moraine now described was pushed out at the foot of a continuous ice-sheet of immense extent.

## *LETTERS TO THE EDITOR.*

### Change of birds' notes.

FOR some years it has been known to many about here, that in one locality the cardinal bird (Cardinalis virginianus) has been in the habit of imitating the notes of the whippoorwill (Antrostomus vociferus). From articles I have read from time to time in various scientific journals, I infer that it is not generally known that birds ever, in the wild state (especially cardinalis), change their song. I therefore thought it well to report this case. I have in several instances known this bird to change its song, under confinement, for one entirely different; but this is the only case I have ever known where such a thing has occurred in the wild state. I have known of this case for about ten years.

F. O. JACOBS.

Newark, Licking county, O.

### St. David's rocks and universal law.

The article with the above heading in SCIENCE of June 15, by Dr. M. E. Wadsworth, has just come under my observation; and, as it refers to questions which have arisen chiefly in consequence of my researches among those rocks, I shall deem it a favor if you will allow me space in SCIENCE for a few remarks in explanation. Professor Geikie's paper was written with, as he states, 'a sense of duty' to 'defend the views of his predecessors;' and it is perfectly certain, from the hasty manner in which the work was gone over by Professor Geikie and his two assistants, that the object was to vindicate the work of the Geological survey of thirty or forty years ago, rather than to apply the knowledge gained by the work of many independent observers since that time to correct the errors well known to have been committed by the surveyors, which remain as blots on the maps even now issued by the Geological survey. In the district of St. David's, these maps show a great intrusive mass passing under the city of St. David's, about eight miles in length, and with an average width of about a mile. The southern portion is called syenite, and the other felstone. The rocks lying along the north-western edge for about a mile in width are colored as altered Cambrian, presumably as the result of the intrusion; but on the south-east the rocks of the same age are supposed to be in contact with the mass in an unaltered condition, and without even a line of fault to separate them. These appearances were curiously anomalous if true: hence I felt it necessary to go very carefully into the question. My large acquaintance with the district, and the knowledge I had obtained in my explorations among the lower fossiliferous rocks of the area, enabled me to do this with some advantage. I had also, from time to time, much valuable assistance from Professors Harkness, Hughes, and Bonney, and from Mr. T. Davies of the British museum, Mr. Tawney, etc.

I found that under the same name, rocks of very different characters had been grouped together. The so-called syenite ridge was seen to consist in part of granitoid rocks, but also of quartz-felsites, of hälleflintas, of breccias, and of porcellanites freely traversed by intrusive dikes of various kinds. The so-called metamorphic Cambrian on the north-west was soon discovered to be an entirely distinct series from any Cambrian rocks known in the district, or, indeed, anywhere in Wales, and to be largely made up of volcanic rocks; and the basal Cambrian conglomerate, as marked on the survey-maps, was shown to overlie the granitoid, the quartz-felsite, hälleflinta, and the volcanic schistose and brecciated series unconformably, and to be mainly made up of fragments derived from those series. From the examination of the conglomerates also, it was seen that there were distinct evidences of their having been deposited along old coast-lines, and that their materials varied with the rocks upon which they reposed; also that these pre-Cambrian rocks must have been much in the condition in which they are now found, before the Cambrian conglomerates were deposited upon them. Curiously, also, I found that many of the masses colored as intrusive greenstones on the survey-maps were highly *acid* rocks, and others indurated volcanic ashes of pre-Cambrian age. Indeed, nearly all the so-called intrusive masses marked so abundantly on the survey-map among the older rocks in the St. David's area have been proved beyond doubt to be the result of erroneous observation; and yet we are told by the present director-general that little or no change is required in these maps, and that he