THE COMMON FROG*

VII.

THE skull of the frog presents numerous points of interest, but only four of these can be here referred to, as other matters demand our attention.

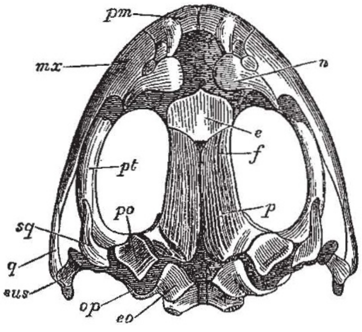

FIG. 37.—Upper Surface of the Skull of a Frog (after Parker). *e*, os en ceinture, or girdle-bone; *eo*, exoccipital; *f*, frontal part of frontoparietal bone; *mx*, maxillary bone; *n*, nasal; *op*, opisthotic; *p*, parietal part of fronto-parietal bone; *pm*, pre-maxilla; *po*, pro-otic; *pt*, pterygoid; *q*, quadrato-jugal; *sq*, squamosal; *sus*, suspensorium of lower jaw.

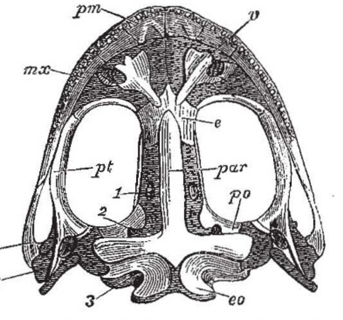

FIG. 38.—Under Surface of the Skull of a Frog (after Parker). *e*, girdle-bone; *eo*, exoccipital; *mx*, maxilla; *par*, parasphenoid; *pm*, pre-maxilla; *po*, pro-otic; *pt*, pterygoid; *q*, quadrato-jugal; *sus*, suspensorium of lower jaw, the lower end of which represents the quadrate bone; *v*, vomer; 1, optic foramen; 2, foramen ovale; 3, condyloid foramen.

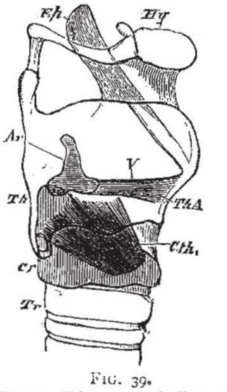

FIG. 39.

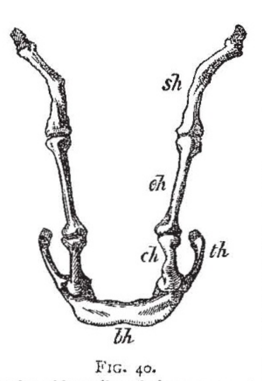

FIG. 40.

FIG. 39.—Diagram of the Larynx of Man, the thyroid cartilage being supposed to be transparent, and allowing the right arytenoid cartilage (*Ar*), vocal ligament (*V*), and thyro-arytenoid muscle (*Th A*), the upper part of the cricoid cartilage (*Cr*), and the attachment of the epiglottis (*Ep*), to be seen. *C th*, the right cricothyroid muscle; *Tr*, the trachea; *Hy*, the body of the hyoid bone. The right lesser cornu appears as a very small process, extending upwards and backwards from the body of the hyoid behind the letters *Hy*, and in front of the Epiglottis. The right great cornu is shown extending backwards from the body of the Hyoid and terminating beneath the letters *Ep*.

FIG. 40—Extracranial portion of hyoidean apparatus of Dog, front views *sh*, stylohyal; *eh*, epihyal; *ch*, ceratohyal (these three constitute the "anterior cornu"); *bh*, basihyal, or "body" of hyoid; *th*, thyrohyal, or "posterior cornu." (From Flower's "Osteology.")

* Continued from p. 110.

The first of these four relates to its mode of articulation with the vertebral column. As has been said the first vertebra presents a pair of concavities to the skull. The skull develops from its hinder (or occipital) region a cor-

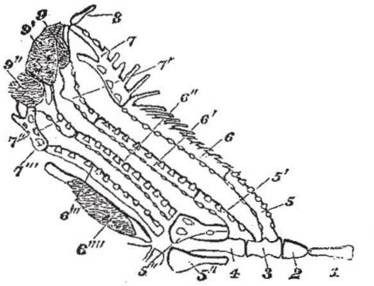

FIG. 41.

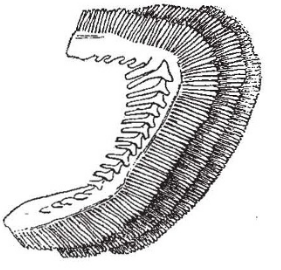

FIG. 42.

FIG. 41.—Skeleton of left series of Branchial Arches of a Perch, seen from above. 1, glosso-hyal; 2, 3, and 4, basi-branchials; 5, hypo-branchials; 6, cerato-branchials; 7, epi-branchials; 8, styliform pharyngo-branchials; 9, pharyngo-branchials; 6'''', inferior pharyngeal bone; 9' and 9'', superior pharyngeal bones; 5, 6, 7, and 8, first branchial arch; 5', 6', 7', and 9, second branchial arch; 5'', 6'', 7'', and 9', third branchial arch; 5''', 6''', and 7''', fourth branchial arch; 6'''', fifth branchial arch.

FIG. 42.—First three Branchial Arches from the left side of a Perch. On the outer (convex) side of each branchial arch the series of closely-set gill filaments (or leaflets or lamellæ) are seen to be attached. On the inner (concave) side of the first branchial arch are the series of elongated processes (supporting minute denticles) which help to prevent particles of food, or other foreign bodies, passing from the mouth to the gill chamber.

responding pair of articular convexities or "condyles." Now in this matter the frog differs from both birds and

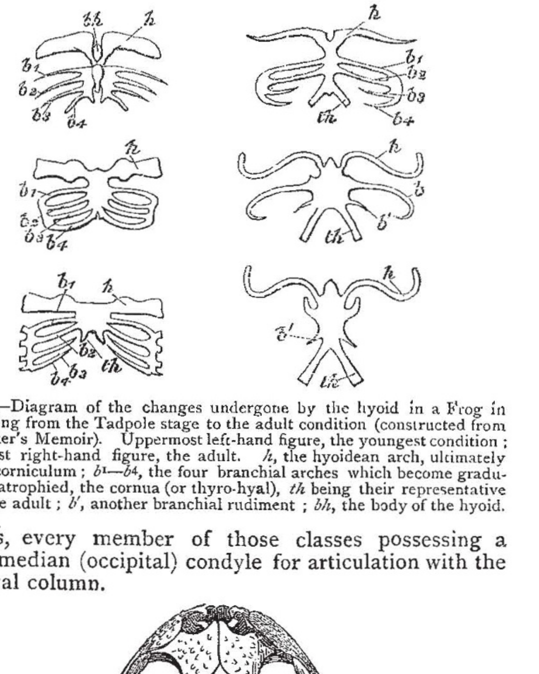

FIG. 43.—Diagram of the changes undergone by the hyoid in a Frog in passing from the Tadpole stage to the adult condition (constructed from Parker's Memoir). Uppermost left-hand figure, the youngest condition; lowest right-hand figure, the adult. *h*, the hyoidean arch, ultimately the corniculum; *b*1—*b*4, the four branchial arches which become gradually atrophied, the cornua (or thyro-hyal), *th* being their representative in the adult; *b'*, another branchial rudiment; *bh*, the body of the hyoid.

reptiles, every member of those classes possessing a single median (occipital) condyle for articulation with the vertebral column.

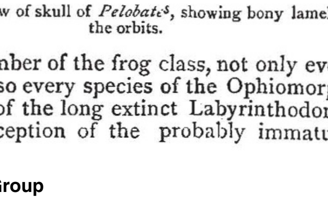

FIG. 44.—Dorsal view of skull of *Pelobates*, showing bony lamellæ behind the orbits.

Yet every member of the frog class, not only every toad and newt, but also every species of the Ophiomorpha, and even every one of the long extinct Labyrinthodons (with the doubtful exception of the probably immature and larval *Archegosaurus*) has a similar pair of occipital condyles. The interesting matter is that man and all beasts have also two occipital condyles. Is this then a mark of affinity, and can we, as it were, reach beasts by a short cut through Batrachians, leaving all the reptiles and birds on one side, as a special outstanding and diverging development?

We shall presently see that other yet more striking facts may be brought forward in support of the latter view. Nevertheless it must be remembered that there are fishes, thongh very few and exceptional, which also possess a pair of occipital condyles, and that in one respect most fishes are more like mammals than are any Batrachians since they, like mammals, have a well ossified median bone at the base of the skull in the occipital region, a structure which all Batrachians, without a single exception, are destitute of.

The second point of interest concerns the lower part, or base, of the skull, which exhibits a striking agreement with the same part as developed in bony fishes.

This agreement consists in the fact that the middle of the floor of the skull is not formed as in all beasts, birds, and reptiles, by a deposition of bony substance in pre-existing gristle (ossification of cartilage), to which name *Basi-sphenoid* is applied, but, as in bony fishes, by a great bone called *Parasphenoid*, which shoots forwards and also extends backwards to the hinder end of the skull floor, but is formed by the deposition of bony substance in pre-existing membrane. (Fig. 38, *par.*)

Although this great membrane bone is constant in Batrachians and bony fishes, and is represented, if at all, only by minute rudiments in higher vertebrates; nevertheless in serpents we once more meet with a far-reaching and well-developed parasphenoid.

Yet it can hardly be conceived that serpents have carried off from Piscine ancestors and carefully preserved this peculiarity of structure which all their other class fellows have lost. It seems much more probable that this structure has independently appeared through the action of peculiar conditions, and hence that we have here again a remarkable instance of the independent origin of similar structures.

The third peculiarity of the frog's skull consists in the form and conditions of the bony supports of the tongue.

It would not be easy to find a better example of the need of widely extended observations in order duly to understand structures apparently very simple indeed.

The bone of the tongue in man—the *os hyoides* *—is a small structure, and one to all appearance of little significance. It is placed at the root of the tongue and above the larynx, and consists of a body with a pair of processes on each side, one large (the posterior or great cornu), and one small (the anterior or lesser cornu, or corniculum).

Even in man's own class (mammalia) the relative development of the parts may vary greatly. Thus the cornicula may be large and may each be represented by two or three distinct applications as in the dog and horse.

The cornua also may take on a development very much greater than that existing in man as is the case in some other Mammals. These facts may prepare us to expect much greater divergences in lower forms; and yet throughout the two great classes of birds and reptiles (as well as beasts)—though varying conditions as to the proportions of the parts present themselves—the os hyoides continues essentially the same in structure, and even in the adult frog this bone exhibits nothing but a rather wide "body" with two long and slender "cornicula" and a pair of shorter "cornua."

Let us now pass for a moment to the other end of the vertebrate sub-kingdom. We find in fishes a complex framework for the support of the gills, or structures, by which they effect their aquatic respiration. This framework consists of a number of arches (placed in series one behind another) extending on each side of the throat upwards towards the backbone, and supporting on their outer sides the gills or branchia, on which account they are called the *branchial arches*. In front of these arches and forming as it were the first of the series, is an arch which ascends and becomes connected with the skull.

Turning now to those Batrachians which breathe throughout their lives in the manner of fishes, we find a corresponding system of branchial arches. Thus in the Siren we find a series of gill-supporting branchial arches, placed behind another arch which is connected with the skull.

But the frog passes the first part of its life in a fish-like manner, and in the tadpole accordingly we find an apparatus similar to that of the Siren. There are, in fact, on each side of the throat, four branchial arches, placed behind another arch, which is connected with the skull. As development proceeds these *branchial* arches become gradually absorbed and all but disappear. Relics of them, however, exist even in the adult condition, and thus serve to indicate the true nature of parts which otherwise would be little understood.

The central portion of the structure—that from which arches diverge on each side—increases in relative as well as absolute size, and becomes the "body" of the *os hyoides*. That arch on each side which is connected with the skull and is placed immediately in front of the branchial arches, continues to be so connected and becomes one of the two "cornicula," while the rudimentary relics of the branchial arches which persist become what we have seen in the adult as the cornua of the *os hyoides*.

Thus the anatomy of the tongue-bone of the frog, studied in its progressive changes, reveals to us that otherwise unsuspected relations exist in certain parts of the tongue-bone of man. It exhibits to us the coruna of his *os hyoides* as related to those large and complex branchial arches which play so important a part in the fish and form so relatively large a portion of its skeleton.

The fourth circumstance (the last here to be noticed) connected with the frog's skull concerns the relative position and size of certain of its enveloping bones.

When the skull of the frog is viewed from above, a large vacuity is seen to exist on each side, between the brain-case and the great arch of the upper jaw. In the hinder part of this space is situate the temporal muscle, which by its contraction pulls up the lower jaw and closes the mouth; and the hollow in which this muscle lies is called the temporal fossa.

In a certain frog before noticed, called *Pelobates*, as also in *Calyptocephalus*, a similar view of the skull exhibits no such great vacuity. The reason of such absence is that the temporal fossa in these animals is roofed over and enclosed by the meeting together of bony lamellæ developed from the bones surrounding it, which thus bound the orbit posteriorly, and give to the cranium an altogether false appearance of great capacity.

This very singular structure is found to exist also in the marine turtles, amongst the Chelonians, and here we have another striking resemblance between the Chelonia and the Anoura, apparently reinforcing the argument for the existence of real affinity derived from the presence of such bony dorsal shields in both those two orders. The importance of this character might seem the more unquestionable, since no other reptiles and no birds or beasts whatever were known to exhibit a similar structure.

Quite recently, however, Prof Alphonse Milne-Edwards has described a beast from Africa (*Lophiomys*) belonging to the Rodent (rat, rabbit, and squirrel) order, which has a skull, the temporal fossa of which is similarly enclosed by bony plates.

This unexpected discovery completely destroys any weight which might be attached to this character as an evidence of genetic affinity. It does so because it is inconceivable this Rodent should have directly descended

* So named from its resemblance to the Greek letter υ.

from a common progenitor of frogs and of Chelonians through a line of ancestors which never lost this cranial shield, though the ancestors of all other beasts, all birds, and all reptiles, except turtles, *did* lose it. It is inconceivable, for if it were true a variety of the lowest mammals (Marsupials * and Monotremes †) must have less diverged from the ancient common stock than have the members of the Rodent order, and nevertheless these lowest mammals exhibit no trace whatever of such a cranial shield.

Here then we have an undoubted example of the independent origin of structures so similar that at first sight their similarity might well have been deemed a conclusive evidence of affinity.

Here, also, we have a memorable caution against hasty inferences from structural similarities. If this resemblance and that of the dorsal shields are, when taken together, no signs whatever of special genetic affinity—it is difficult to say what structural likenesses are to be deemed unquestionable evidences of a common ancestry.

Fig. 45.—External form of *Lophiomys*.

Passing now to the skeleton of the limbs, we come to a character of great significance, as it is one which serves to distinguish all the limbed species of the frog's class from lower vertebrates. The character is very significant, because all Batrachians, in spite of their numerous and important fish affinities, differ from all fishes, and agree with all higher classes in that they—if they have limbs at all—have them divided into those very typical segments which exist in man; namely, shoulder-bones, arm-bones, wrist-bones, and hand-bones; and into haunch-bones, leg-bones, ankle-bones, and foot-bones respectively. It is difficult, then, to avoid the belief that in the Batrachian class we come upon the first appearance of vertebrate limbs, differentiated in a fashion which thenceforward becomes universal.

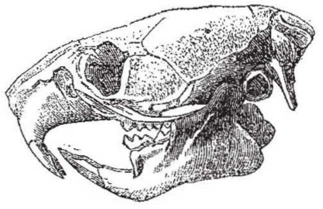

Fig. 46.—Lateral view of skull of *Lophiomys*, showing bony lamellæ behind the orbit.

The bones of the wrist in the frog, again, present a nearer resemblance to those in man than do those of most reptiles, and this is still more the case in some other members of the frog's class, *e.g. Salamandra* and other Efts. Nevertheless, there are certain reptiles, and, strange to say, they are once more Chelonians, which agree in this resemblance—as may be seen in the hand of the tortoise—*Chelydra serpentina*.

* *i.e.* opossums, kangaroos, &c.
† The Ornithorhynchus and Echidna.

The bones of the fingers show, moreover, a greater likeness, in certain respects, to those of beasts than to those of reptiles. No finger has a greater number of joints than three, while, in some lizards, the fourth digit may have as many as five joints.

In the frog the wrist-bones (called respectively the magnum and unciforme) which support the third, fourth, and the little fingers, are formed together into a single ossicle. The same condition, however, sometimes occurs even in the orang. On the other hand, the single bone which in man and beasts supports both the "ring" and the "little" fingers, may be represented by two ossicles in the frog's class (or *e.g.* in *Salamandra*) and in some reptiles (as in *e.g. Chelydra*).

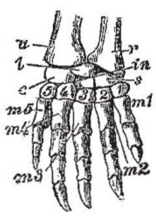

Fig. 47.

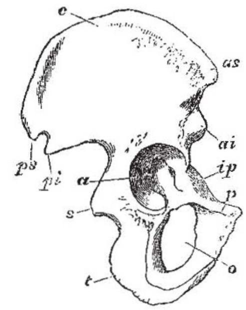

Fig. 48.

Fig. 47.—Dorsal surface of skeleton of right hand of the Tortoise, *Chelydra* (after Gegenbaur). *c*, cuneiforme; *in*, intermedium (or centrale); *l*, lunare; *m*1—*m*5, metacarpals; *r*, radius; *s*, scaphoides; *u*, ulna; 1—5, the five distal carpals, namely—1, trapezium; 2, trapezoides; 3, magnum; 4 and 5, divided unciforme.

Fig. 48.—Outer side of right os innominatum of Man. *a*, acetabulum; *ai*, anterior inferior spinous process of the ilium; *as*, anterior superior spinous process of the ilium; *c*, crest of the ilium; *ip*, ilio-pectineal eminence; *o*, obdurator foramen; *p*, pubis—its horizontal ramus; posterior inferior spinous process; *ps*, posterior superior spinous process; *s*, spine of the ischium; *t*, tuberosity of the ischium.

No member of the frog's class which has an arm at all, bears less than two fingers (as does *Proteus*) upon it. Thus we meet with a number as small as that which is developed amongst beasts in ruminants, but not so small a number as in the horse.

In the rudimentary condition of its thumb the frog participates in a very common defect, since this member is absent in very many forms. It is so even in creatures as highly organised and as like man in bodily structure as monkeys, since both the spider-monkeys of America and certain long-tailed monkeys (*Colobi*) of Africa, are thumbless.

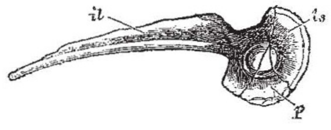

Fig. 49.

Fig. 50.

Fig. 49.—Right side of Pelvis of Frog. *il*, ilium; *is*, ischium; *p*, pubis The three bones meet at the uppper margin of the acetabulum.

Fig. 50.—Dorsal view of pelvis of Frog, showing the narrow ends of the ilia for attachment to the backbone, and also the close approximation of the acetabula.

In man, when standing, the weight of the body is transferred to the limbs by a large bony girdle, which, from its basin-like shape, is called the *pelvis*, This basin consists of the two haunch bones which meet together in front, but behind are separated by the lower part of the backbone (called the sacrum), to which the haunch bones are attached, and which forms the hinder portion of the pelvis. The pelvis has a depression, or "socket," on each side, into which fits the head of one of the thigh bones. Each "haunch bone" consists of three parts, which are, in man, primitively distinct, but afterwards anchylose together, and all three elements (in each haunch bone) take a share in the formation of the bony thigh-socket, or *acetabulum*. These three elements are named—1, *ilium*; 2, *ischiam*; and 3, *pubis*. It is the ilium which is adjoined to the sacrum. The pubis, in man, meets its fellow of the opposite side in the middle line in the front of the body. The two ischia (one to each haunch bone) support man's body when in a sitting posture.

The pelvis of man is often quoted as one of the most peculiar and characteristic parts of his skeleton, and its shape in him *is* very peculiar. Nevertheless the pelvis as it exists in frogs and toads is a far more exceptional structure. It is so in the extraordinary elongation, yet small vertebral attachment, of the haunch bones *ilia*, as also in the fact that these bones as well as the other pelvic elements (*ischia* and *pubes*) are all closely applied to each other in the middle line of the body. Thus these elements form a bony disc, and the two sockets (*acetabula*) destined, respectively, for the heads of the two thigh bones, come to be closely approximated one against the other. The great elongation and small attachments of the ilia allow the pelvis as a whole to be bent upon the backbone. Thus the hinder part of the body is moveable and forms as it were an additional common root segment for the two limbs.

ST. GEORGE MIVART

(*To be continued.*)

SOUNDINGS IN THE NORTH PACIFIC

OVER a year ago the United States Congress authorised preliminary measures for laying a submarine cable from the west coast of America to Japan. The United States steamer *Tuscarora*, then on duty off the Isthmus of Darien, was despatched on this business, and started September 22, 1873, from San Francisco for the Straits of Juan de Fuca. Reconnaissances off Victoria, Vancouver's Island, discovered a gradually shelving bottom in all respects suitable for a cable landing. The steamer coaled at Nanaimo. Coal is also found at Newcastle Island, which is not far distant. It may be mentioned that the coal of this region is semi-bituminous, and that recent discoveries have largely increased its product.

The line of soundings extended along a great circle drawn from Cape Flattery to Oonalaska Island. At lat. 53° 58′ N., long. 153° W., within about 400 miles of Oonalaska, the coal was exhausted, and the vessel returned to Victoria. The ocean bed sank rapidly from Cape Flattery to lat. 48° 54′ N., long. 126° 21′ W., then rapidly and steadily to lat. 49° 26′ N., long. 128° 37′ W., then more rapidly to lat. 49° 46′ N., long. 129° 27′ W., at which point the depression was 1,452 fathoms. Thence a peak rose in the sea bottom, with a summit at 1,007 fathoms depth, in lat 51° 40′ N. long, 137° 32′ W. Its rise was fully as rapid as the depression preceding it, and the depression beyond it, the side being equally steep, was somewhat greater. The slope after the western bottom of this submarine mountain was reached was exceedingly gradual, and somewhat undulating. Perhaps the following estimates, roughly made from a sketch, will give a clearer notion of the ground surveyed. At about 100 miles from Cape Flattery, depth about 400 fathoms; at 150 miles, 1,000 fathoms; 170 miles, 1,400 fathoms; 200 miles, 1,000 fathoms; 300 miles, 1,600 fathoms; 400, 1,900 fathoms; 500, 2,000 fathoms; 600, 2,000 fathoms; 700, 2,100 fathoms; 800, 2,200 fathoms; 900, 2,300 fathoms; 1,000, 2,300 fathoms; 1,100, 2,500 fathoms.

During soundings on the return voyage to San Francisco, another submarine mountain was discovered in lat. 41° 30′ N., long. 127° 11′ W., the depth at its summit, which the sounding instruments showed to be of a rocky character, being only 996 fathoms. Around it, at distances of 20 miles, the depth was between 1,600 and 1,700 fathoms.

The water temperatures along the line of soundings for the cable, at depths of over 1,000 fathoms, varied from 0° 45′ C. to 2° 43′ C.; surface, 10° 35′ C. to 14° 15′ C. In lat. 53° 58′ N., long. 153° 00′ W., the increase from 50 fathoms to surface, was gradual; but at 50, 100 and 200 fathoms the same temperature was found as at 2,500 fathoms.

The conclusion has been reached in the course of a series of observations made during the return voyage, and subsequently, that what is known as the "California coast current," is really a warm, and not as hitherto supposed, a cold stream. The observations determined the existence of a warm current, presumably a continuation of the "Great Japanese Circle Current," setting toward the south and east, of a surface temperature averaging 15° C., between the positions lat. 48° 36′ N., long. 126° 36′ W., and lat. 50° 34′ N., long. 131° 38′ W. Outside of this current the temperature was but 10° C. Its width, between what is known as "Fleurier's Whirlpool" and the coast of California, is about 700 miles; its depth in lat. 44° 54′ N., long. 125° 13′ W. is about 200 ft.; its speed, one to two knots per hour. Under-currents below this stream have been determined, setting to the north and west. The counter-current does not appear to extend more than 30 to 35 miles from shore, moving at a half to one knot per hour, with a depth of 200 to 300 fathoms.

The expedition was equipped with a great variety of sounding apparatus, of which only a few instruments gave perfect satisfaction, and several proved quite useless. The vessel carried 32,000 fathoms line, of which 21,000 were 1¼ in., carbonised. Among the satisfactory instruments, Prof. Thomson's is mentioned. This is worked by hand, winding No. 22 piano wire, capable of resisting a strain of 200 pounds. It has a registering indicator and a dynamometer attached. For bringing up material from the bottom, Belknap's cylinder, No. 2, gave the best results, the lower half of the cylinder being usually filled with about three ounces of sea-bottom material, and the upper half with water that had rested on the sea-bottom. The material is brought up secured in the case of a "Sand's cup" by a cylindrical sleeve. The latter is held by a spiral spring, in a position just covering a small orifice in the hollow cylindrical case. On striking bottom, the sleeve is forced up, permitting the material of the ocean bottom to enter the orifice. The instrument is driven into the bottom material by a weight which carries it down with great velocity. This weight, consisting of two hemispheres of iron attached just above the spring, is automatically detached when bottom is struck, by the slackening of the line. Upon drawing up the line, the spiral spring again forces the sleeve down, covering the orifice. The material drawn from the greatest depths was the usual chalky, pasty mud, smooth and homogeneous, rarely containing sand, chiefly composed of casings of diatoms and foraminifers, with here and there the spiculæ and siliceous skeletons of the smaller sponges and *polycystina*.

Although the expedition met for the most part with unsettled and unfavourable weather which interfered with its work, that which it has accomplished is regarded as eminently satisfactory. There is little doubt but that the route upon which the soundings have been made, will be the one selected for the cable; and next spring the work will be extended from the point at which it was discontinued.