From the second series—

$$1 \text{ B.A. unit} = \cdot 98669 \times 10^9 \text{ C.G.S.}$$

From the third series—

$$1 \text{ B.A. unit} = \cdot 98683 \times 10^9 \text{ C.G.S.}$$

As a mean we take—

$$1 \text{ B.A. unit} = \cdot 986[illegible] \times 10^9 \text{ C.G.S.}$$

With use of the ratio between the mercury unit and the B.A. unit, found by us ("Proc. Roy. Soc." May, 1882) this gives—

$$1 \text{ mercury unit} = \cdot 94150 \times 10^9 \text{ C.G.S.},$$

or, which is the same thing, the ohm is the resistance of a column of mercury at 0° Cent., whose section is one square millimetre, and whose length is—

1062·14 millimetres.

The very close accordance between the result of the present investigation, and that obtained by the method of the revolving coil (·98651), and by Glazebrook (·98665), using another method again, leads us to hope that no error of importance can have escaped detection.

The Appendix is devoted to a record of experiments having for object the determination of the absolute pitch of a certain tuning-fork, which has served as the standard of time throughout all our work upon this subject. It is believed that the method employed is worthy of attention, and may be useful to other physicists.

II. "On the Skeleton of the Marsipobranch Fishes. Part I. The Myxinoids. (*Myxine* and *Bdellostoma.*) By W. K. Parker, F.R.S. Received December 14, 1882.

(Abstract.)

At present nothing is known of the development of these remarkable fishes, but their structure in the adult state is of great interest, and as the other related type—the Lamprey—has had great attention given to it lately, in most of its stages, I have thought it would be profitable to anatomists to have a detailed account of the skeleton in these lower and less known types. I received several specimens of the adult Hag-fish (*Myxine*) from my friends the late Professor Rolleston, F.R.S., and Mr. Frank Buckland; for fine specimens of the gigantic type (*Bdellostoma*) I am indebted to Professor Ray Lankester, F.R.S.

My guide in this work has been the excellent and most accurate Johannes Müller—his four memoirs (well known to anatomists) on

the Myxinoids and related types have been absolutely necessary to me. I shall be proud if this and the next paper are thought worthy of being considered an *appendix* to his incomparable works on these types.

But as regards the Marsipobranchs generally, especially the Lamprey, I am deeply indebted to Professor Huxley's writings and to discussions with him upon these fishes; and in the same way to the late Professor F. M. Balfour, F.R.S.; and I am indebted further to my young friend Mr. W. B. Scott, of Princeston, U.S., who, after Calberla, has worked largely on the early development of the Lamprey.

What I have been able to make out with regard to the skeletal parts of the Lamprey will be offered to the Royal Society very soon, and then the structure of the adult Myxinoids and of the various stages of the Petromyzoids can be compared together.

But the various kinds of the "Anurous Amphibia"—hundreds of species—give us, in their larval state, a sort of temporary generalised Marsipobranch fish; it is not unknown that I have given several years of labour to these types, and I feel now that I may, with caution, attempt to explain the morphology of the skeleton in all these three related groups—the *Myxinoids*, the *Petromyzoids*, and the *Anura*.

However far apart, *now*, these three groups may be, they are seen to be the nearest of kin to each other when we consider the other "Ichthyopsida." Moreover, they form a curious *scale*, so to speak, one rising above the other in a regular order; for the Myxinoids are a sort of arrested *Ammocœte* or larval Lamprey, and the Lamprey in its adult state is quasi-larval if it be compared with the anurous amphibian—Frog or Toad.

The Myxinoids are very anomalous, and this is seen even in their histology; in them, as in the Lamprey, there are two kinds of cartilage —one very dense and almost as hard as bone, and the other soft, like the cartilage of young embryos of higher types.

But in the Myxinoids one very large bar, the great basi-branchial, is formed of a light, elastic, *vacuolar* tissue, but little denser than that of their great persistent non-segmented notochord, and, like it, ensheathed in a very thick web of fibrous or tendinous tissue.

I suspect that this fact will have a meaning for the student of the lower *non-craniate* "Chordata"—*Amphioxus*, the Ascidians, &c.

In the wide-mouthed, *non-suctorial* larvæ of the Cape Toad (*Dactylethra*)—I found the whole chondro-skeleton composed of a peculiar kind of cartilage intermediate between hyaline cartilage and this vacuolar tissue of the Myxinoids; it is more like the pith of a plant than like ordinary cartilage.

In their cranio-facial skeleton the Myxinoids are very remarkable; where segmentation is perfect in other piscine types they only exhibit a lattice-work of continuous growth; in the median region of

the skull-base, where other types show but little or only temporary distinctness of parts, these fishes develop and retain large independent cartilages.

The lamprey has a large superficial basket-work of soft cartilage (*extra-branchial*), and its gill-pouches keep related to this and to the rest of the structures of the mouth and throat. But in the Myxinoids the basket-work is *intra-branchial*, and corresponds to the system of segmented arches of the higher Cartilaginous, the Ganoid, and the Osseous fishes. But these non-segmented arches soon lose all relation to the branchial pouches, which are removed so far backwards that they begin under the *twentieth myotome;* whilst the end of the pericardium is under the *fortieth.*

In seeking light upon the primordial condition of the Vertebrata, one naturally looks to such forms as the Myxinoids. For in these types, even in the adult state, there are neither limbs nor vertebræ, and no distinction between head and body, except the beginning, in the head, of a cartilaginous skull—a *continuous structure*—not showing the least sign of secondary segmentation, and by far the greater part of it in front of the notochord, or axis of the organism. But here our *gradational* work agrees with the *developmental*, for the continuous skull-bars constantly arise *before* the secondary cartilaginous segments that are found between the myotomes behind the head. Evidently, therefore, the early "Craniata" grew supports to the enlarged and subdivided front end of their neural axis, long before any structures beyond strong fibrous septa were developed between the muscular segments of the body. As for the linear growth, the greater or less extension backwards of the main organs—circulatory, respiratory, digestive, urogenital—that, in the evolution of the primary form, was a thing to be determined by the "surroundings" of the type. "Thereafter as *they* may be" was the tentative idea in this case.

Certainly, in the Marsipobranchs, and in their relations, the larval "Anura," we have the most archaic "Craniata" now existing; in these the organs may be extended far backwards in a vermiform creature, as in these low fishes, or kept well swung beneath the head —the body and tail together forming merely a propelling organ, as seen in Tadpoles, especially the gigantic Tadpole of *Pseudis.*

Thus we see that in low limbless types there is no necessity for the development of more than fibrous "metameres" in the spinal region; but the vesicular brain, the suctorial lips, the branchial pouches, and the special organs of sense—these all call for support from some tissue more dense than a mere fibrous mat or web. In the *Myxinoids* we see that *four* special modifications of the connective tissue series are developed for the support of the properly *cephalic* organs, and for them only; thus these fishes are *Craniata*, but are not *Vertebrata;* that is, if we stick to the letter, which, of course, we do not.

At first some disappointment is felt, after careful study of these types, for, notwithstanding the low level in which they remain—they are mere specialised *Ammocœtes*, keeping on the same "platform" as the larval Lamprey;—yet some parts of their organisation do undergo a marvellous amount of transformation, and are, indeed, as much specialized in conformity with their peculiar habits of life *as any Vertebrates whatever, the highest not excepted.*

Yet, on the whole, the Myxinoids are a sort of *Ammocœtine* type, whilst the transformed Ammocœte, the adult Lamprey, comes nearest to the untransformed Frog or Toad—the *Tadpole.* But the mere putting of this shows (suggests at any rate) what *losses* the Fauna of the world has sustained during the evolution of the Craniate forms; *now*, the Myxinoids, Petromyzoids, and numerous Amphibia must all be kept "within call" of each other; but the types that have been culled out between them cannot be numbered. Some other kinds of fish are evidently the descendants of primordial "Marsipobranchs," notably *Lepidosteus*, the development of which has been lately studied, and the results of which are being published in the "Philosophical Transactions." But the *Chimœroids*, *Dipnoi*, and, still more important, the *Myxinoids*, themselves, have still to be followed through their early stages. If the present paper is of any value to the morphologist, one on the embryology of these low forms would be worth much more.

The Myxinoids keep on the low "platform" of the larval Lamprey (*Ammocœte*) in the following particulars, namely:—

a. The notochord has no paired cartilaginous vertebral rudiments in the spinal region.

b. The trabeculæ end in the ethmoidal region without growing forwards into a cornu (or *two continuous* cornua).

c. There are merely "barbels" round the mouth; no *labial cartilages.*

d. The last character involves this, namely, that the special armature of horny teeth, attached to the labials in the adult *Petromyzon*, is absent.

e. The organs of vision are very feeble, and probably almost useless; in the *Ammocœte* they are arrested for a time.

f. The cranium is a mere *floor*, without side-walls or roof.

The Myxinoids come near to the adult Lamprey in the following particulars, namely:—

a. There are developed outside the skull proper, but not segmented from it, palato-quadrate and hyoid cartilages.

b. There is a very large median cartilage belonging to both the hyoid and branchial regions.

c. The cranium acquires a floor by the development of a special "hinder intertrabecula."

d. There is a large median cartilaginous olfactory capsule.

The Myxinoids go beyond even the adult Lamprey in the following particulars, namely :—

a. The facial basket-work is much more perfect; and as this is a generalised condition of the true *intra-visceral* system of cartilages, it is a very important character; there is not only a development of the "suspensorium," equal to that of the Lamprey, but the *suspensorial part* of the hyoid is developed also (it is suppressed in the Lamprey); and there is, in *Bdellostoma*, a large complete first branchial arch, and in both kinds pharyngo-branchial rudiments of the second branchial arch.

b. The respiratory (branchial) pouches are much more specialised by being carried far back under the spine.

c. There is not only a distinct sub-cranial intertrabecula, but also a large pre-cranial or nasal median cartilage of the same nature.

d. The opening of the median olfactory sac is not a mere short membranous passage, but a long tube, encased in a series of cartilaginous (imperfect) rings.

e. Correlated with the non-development of the suctorial labial cartilages, there is an enormous development of the lingual, this basal bar becoming not only double, but in front quadruple, and the "supra-lingual" cartilages, which are very small in the Lamprey, and carry only one pair of rows of small second teeth, are in the Myxinoids very large, and carry two pairs of rows of large teeth, with the addition of a median antagonistic "ethmoidal tooth."

Lastly, the greater development of the intra-visceral (= "intra-branchial") cartilages is correlated with the suppression of the extra-visceral basket-work seen both in the larval and adult Lamprey, and also in the larvæ of the "Anura," generally.

Morphologists must kindly accept this piecemeal work of mine; it will take on a form, or frame, some day; but much of the materials for its completion are still wanting, and, when obtained, the working of them out must not be done hurriedly.

I may remark, that having just now to work at "the extremity of both ends" of the Vertebrata—the Marsipobranchs and Mammalia—I find the former very excellent as carriers of light to the latter. Everyone will see that by far the greater bulk of the existing Vertebrata are very specialised, each order and class on its own lines, and that any creature to be like a primordial mammal must be very generalised or archaic.