IX. *On the Skeleton of the Marsipobranch Fishes.*—Part I. *The Myxinoids* (Myxine, *and* Bdellostoma).

By William Kitchen Parker, *F.R.S.*

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[Plates 8–17.]

Introduction.

At present, almost 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 received great attention lately in most of its stages, I have thought that it would be profitable to anatomists to have a detailed account of the structure of the skeleton in these lower, and less known types.

The late Professor Johann Müller left us his inestimable account of the anatomy of *Bdellostoma*, with excellent figures of the skeletal parts; but of *Myxine* he gave very few illustrations. Moreover, the absolutely accurate figures of the skull of *Bdellostoma* are small and uncoloured; they fail to show the various kinds of cartilage of which it is composed, and as this skull is so extremely unlike that of any other known vertebrate, except that of the Hag (*Myxine*), I venture to give my own (new) illustrations on a larger scale and coloured. My figures of the skeletal parts of *Myxine* will be, I believe, almost entirely new to science; and, moreover, the time seems to have arrived in which some *interpretation* of these low generalised skulls may be attempted.

This will be done by the help of what we have lately been learning of the development of the skeleton of the nearest relative of the Myxinoid—the Lamprey,—the subject of Part II. This attempt to explain the Myxinoid type of skull and skeleton generally—nearly all the cartilage in these fishes is *cephalic*—has been done by the help of our growing knowledge of the Lamprey, and also by comparison with what the writer has traced out in the early conditions of the skull in various types of Ichthyopsida, especially in the larva of *Lepidosteus*, and of a large number of Tadpoles of the *Amphibia Anura*.

The light thrown upon the Myxinoid cranio-facial apparatus by the early *chondrocranium* of other and much higher kinds of Ichthyopsida, is much greater than might have been expected, for these show, now here, now there, very remarkable archaic characters; and one kind, the Tadpole of the Nailed Toad of the Cape (*Dactylethra*), has these parts but little more specialised than in the Myxinoids; and, moreover, this type has all its cartilage (which is very copious and wild-growing), even in Tadpoles an inch long, of a peculiarly light and cellular kind—like many parts of the Myxinoid's skeleton. It is evidently *the historic representative* of an exceedingly ancient and generalised sort of Fish.

Most important help to me in this attempted interpretation has been repeated discussion of the subject with one of the very highest intellects ever devoted to Biological research—I allude to the late Professor BALFOUR; that source of light and strength is now, unhappily, lost to me.

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On the Varieties of the Connective-tissue Series found in the Skeleton of the Myxinoids.

There are four kinds of supporting-tissue in these types, namely:—

a. A very solid greenish kind of cartilage, seen in these Fishes and the Lamprey, only, as far as my experience goes; it is formed by special deposits in the softer kind.

b. Soft cartilage; colourless, and with but little inter-cellular deposit; passes insensibly in some places, suddenly in others, into hard cartilage.

c. An elastic, spongy tissue, full of large vacuoli, a degree denser than the tissue of the notochord.

d. White fibrous tissue, often exceedingly compact and strong; it may, for the present, be called *fibro-cartilage.*

On the relation of the Myxinoids to other types: their Zoological position in the "Branchiata," or "Anamniota."

Roughly, this may be expressed as follows: The Hag and *Bdellostoma* are a sort of greatly modified *Ammocœte;* they bear a relation to the Lamprey similar to that which it bears to the Anurous Amphibia. The *secular losses* among these types must have been very great indeed, for although the Marsipobranchs and the Anura—which are Marsipobranchs in their larval state—are akin to each other to a degree in which they are not akin to any other Branchiata, yet they are very far apart from each other, after all. The metamorphosis of the Tadpole lifts it far above the highest of the Marsipobranchii proper, but I feel satisfied that the Anura have only gradually become metamorphosed; and I doubt whether *all the larvæ of Pseudis* undergo that change, even now. Yet when once this change is set up, we see a very generalised and archaic Fish become *almost* a true Reptile. More than this, one kind—*Pipa*—scarcely shows a trace of gills, and all the Anura, during their metamorphosis, develop a "bladder" which is, *apparently,* the rudiment of an "Allantois;" if further research makes this supposition a settled fact, the stride made by these forms, during individual life, will be seen to be very great indeed.

It is better to call the Hag and Lamprey "Marsipobranchs" than *suctorial fishes;* the adult Lamprey, like the Tadpole, is truly suctorial, but the mouth of the *Ammocœte* or larval Lamprey, and the mouth of the Hag and *Bdellostoma,* are not modified into a circular sucking ring, but it remains as a small hooded opening, fringed with short barbels, or oral palpi. There is no cartilage whatever in the mouth of the *Ammocœte* (Plate 19, figs. 4, 5), and in the Myxinoids the only cartilage developed is as a pith to the barbels (Plate 17, figs. 1–3). All this will be explained in the sequel, but we may as well start fairly, looking upon the subjects of the present paper as greatly specialised, but not metamorphised, "Marsipobranchs," a curious variety of arrested "Sand Pride," or *Ammocœte.* In my Second Part I shall show how such a simple type is transformed into a true Sucking Fish, or Lamprey, which may be, in turn, looked upon as a sort of highly specialised, but arrested, Anurous Amphibian.

On the cranio-facial apparatus of the adult Hag-Fish (Myxine glutinosa).

All the cartilage to be found in this Fish is *cephalic,* for even the furthest rudiment of the dorsal part of the branchial basket is, like the rest of that system, supplied by a cranial nerve—the vagus; the spinal region is only supported by membrane, or strong, fibrous tissue.

Properly speaking, these Fishes, although *Craniata,* are not *Vertebrata;* they are *chordato-craniata* like the Lamprey before its metamorphosis, for neither in this, or in the large Cape species (*Bdellostoma*), can I find any cartilaginous rudiments of vertebral arches. Moreover, the *theca vertebralis* is but little enlarged where it passes, insensibly, into the *dura mater*.

The huge notochord (Plates 9 and 10, figs. 1, 2, *nc.*), with its *merely membranous* sheath, suddenly ends in a conical form between the ear capsules, its thick sheath becoming still thicker at the end, and the vacuoles and membranous bands ceasing very close to the hind part of the head, which is not definitely separate from the spinal region.

Hence the parachordal region, or investing mass (*iv.*) is very short, only one-fifth the length of the entire skull; its moieties become the trabeculæ (*tr.*) at the front third of the auditory capsules (*au.*) The right and left bands unite below (Plate 10, fig. 3) but not above (figs. 1, 2); there they do project a little behind the capsules, but, below, this is hardly perceptible. Thus, the basi-occipital cartilage is incomplete. Moreover, it is arrested behind, for there are not only no condyles, but the cartilage stops in front of the place where they would be found. The sides, or ex-occipital region, and the roof or super-occipital, are arrested, entirely; thus there is no occipital ring. At this hind part the *theca cranialis*, or "dura mater" lies on an imperfect floor of cartilage, but for the rest of its extent the trabeculæ lie rather outside than under it, and only meet and unite under the nasal capsule (*na.*) Thus the huge oval "fontanelle" reaches from end to end, and is only separated from the inferior or pituitary fontanelle by the thick lateral (trabecular) bands; yet a secondary cartilaginous part forms a partial floor to the *pro*-chordal part of the skull. The fore part of the skull has a peculiar ox-faced form, ending in two crescentic "horns;" behind these horns it narrows gently, and then widens out in an even, rounded manner, the widening being due to the facial basket-work.

The whole structure is, indeed, a generalised cranio-facial basket-work. There is no proper segmentation, but here and there the cartilage remains soft, and thus certain of the territories are marked out.

That which is so puzzling in this little unossified skull is its primitiveness and simplicity; for we are accustomed to cranial and facial structures that are differentiated from each other, and in which the facial arches are segmented into a number of parts; these can be classified and named, a typical arch being made the measure of the rest.

Here we have unenclosed land, and in such a generalised, common field, any balk, mound, stone, or bush may be useful as a landmark.*

The "horns" are not the *cornua trabeculæ;* these are suppressed in *Myxine*, but they belong to the palatine *region*, and so does at least half of the fore part of the cartilage bounding the narrow cranial cavity. The two trabeculæ are confluent in front, between

* If the reader would follow the description and interpretation here attempted, it would be well for him to have the other papers of the writer before him, especially the following, namely:—"Skull of Batrachia," Part II., Phil. Trans., 1876, Plates 54–62; "Skull of Batrachia," Part III., Phil. Trans., 1881, Part I., Plates 1–44; and "Skull of *Lepidosteus*," Phil. Trans., 1882, Plates 30–38. The nomenclature shall be as uniform as I can make it.

the "prepalatine" horns (*pr.pa.*), and where they unite in front there is a wedge of soft cartilage; also the inner edge of the basal cartilage (*iv.*) behind, under the hind-brain, is soft. As to the lateral bars, the eye seizes upon a landmark; this is the "subocular fenestra" (*s.o.f.*), very familiar to us in the skulls of Tadpoles. Inside this very limited reniform membranous space the bar is purely trabecular. In front of it it is palato-trabecular (*pa., tr.*). Another familiar part can now be seen; it is behind the fenestra, and is composed of soft cartilage; this short tract is the pedicle (*pd.*), for it answers to the dorsal end of the great "suspensorium" or palato-quadrate of the Tadpole, a part always developed continuously with the basis cranii in the Anura. (See "Batrachian Skull," Part II., Phil. Trans., 1876, Plate 35, figs. 1–5, *pd.*). An oblique soft tract may be seen in front of the subocular fenestra in *Myxine;* this marks the junction of the pterygo-quadrate region with the palatine. The pre-palatine horns (*pr.pa.*) remain soft; they are large, rounded, and suddenly apiculated near their end. Now, for a while, the Tadpole's skull will fail us in our interpretation; as long as I kept, slavishly, to that chondrocranium, as my key to the skull of the Marsipobranchs, I was always falling into confusion. The Tadpole's skull, however, just when transformation is taking place, and the skull of the *suctorial larva of Lepidosteus*, greatly enlighten us at this point. (See "Skull of Batrachia," Part III., Plate 4, figs. 5–9, and "Skull of *Lepidosteus*," Phil. Trans., 1882, Plate 30, figs. 3, 7, 8.) Here we have to be cautious; for *Myxine* has its *quadrate region* suppressed at the part where the condyle is formed in the higher kinds, and there are no Meckelian or mandibular rods. Hence that huge, broad, condyle-bearing part of the enormous suspensorium of the Tadpole shown in so many of my figures, and often running up to the front of the face, is not present in *Myxine*. Moreover, I am quite persuaded that the rudiment of the quadrate region (*q.*) which does exist, is not in front, but directly below the pedicle (*pd.*), a position which is only slowly gained in the Tadpole; in *Lepidosteus* it is not far in front of the pedicle, being opposite the pituitary body ("Skull of *Lepidosteus*," Plate 30, fig. 3, *py.*, *q.c.*).

The remarkable position of the distal part of the "pier" (or suspensorium) of the mandible in the Tadpole is quite unique; it exists nowhere else but in the Anura, and depends upon the compromise, so to speak, which in them is made between a jaw-less and a jaw-bearing type. I must return to the arrested jaw-pier and its connexions with the rest of the facial basket-work, when the rest of the cranium has been described.

In the Tadpole the trabeculæ, after a time, become united together beneath the fore brain by a thin lamina of cartilage, the soft tissue gradually becoming cartilaginous; but this posterior intertrabecular tract is not found as a distinct sheet of cartilage. Afterwards, when the trabeculæ of the Tadpole have united in the ethmoidal region, a crest of cartilage appears upon it, which becomes the vertical ethmoid and septum nasi in one high tract ("Batrachia," Part III., Plate 2, fig. 1). In the Green Turtle, I have shown that the intertrabecular cartilage is found as a rounded rod between the rounded paired trabeculæ, and that afterwards they flatten out, and it rises upwards to form the ethmo-septal partition of the nasal region ('Challenger Memoirs,' vol. i., part 5, plate 2, figs. 3–7).

This is the manner of growth seen in all Reptiles above Serpents, in Birds, and in Mammals. Here, in the lowest kind of skull we know of, the median prochordal cartilage appears as two tracts, one before the other, the two quite independent of each other, and very much unlike in form and consistency; so that the skull itself in the Myxinoid is formed of separate segments, although the facial arches are not differentiated (or segmented) from the edges of the paired cranial bars.

The long oval space in front of the short parachordal tracts, reaching from there to the ethmoidal commissure (Plate 10, figs. 1, 2, 3), is imperfectly closed below by a remarkable spoon-shaped cartilage of the soft kind; this is the *hinder intertrabecula* (*p.i.tr.*). Under the proper pituitary region, we see the bowl of the "spoon," which is rostrate and perforate behind; the straight, narrow "handle" runs forwards, touching the ethmoidal commissure: it gently lessens from behind, forwards. The handle leaves a large unfloored space right and left; it is gently scooped above, and the "bowl" considerably; this lamina is of even thickness, and is quite convex below. At some height above the end of the handle, a new cartilage begins, very different from the last; this is the *front intertrabecula* (*a.i.tr.*). This bar is composed of hard cartilage; it is compressed vertically, is as wide as the handle of the "spoon," but higher than wide; it is thickest behind, where it is emarginate and acutely bilobed; and it narrows gently forwards, and is then thickened again. This "front intertrabecula" is one-sixth longer than the other, and more than its hinder fourth lies *on* the ethmoidal commissure, and *under* the long nasal labyrinth (*n.a.*, *e.n.t.*). These structures are quite unlike what is seen in the Lamprey, where the cornua trabeculæ are connate, and abort the front intertrabecula, and where the hind intertrabecula is composed of hard cartilage, and is only distinct for a very short time after metamorphosis (Plate 10, figs. 4, 5, *p.i.tr.*). The state of things seen in *Myxine* is evidently due to the *intense* specialisation of a type, which, on the whole, does not rise above the level (or *platform*) of an *Ammocœte*. Some other "novelties," quite equal to this, will be seen as we proceed.

Below the middle of the auditory capsule (Plate 9, fig. 2, *au.*), there is a round fenestra (*m.h.f.*), half as large as the reniform subocular space (*s.o.f.*); and below this, separated by a thick bar, is another oval space ($l.f^2.$), twice as large as the subocular. These, also, are nascent segmentation lines, arrested and widened out. The bar bounding the little upper space, behind (*h.m.*), is quite similar to, but wider than, the one in front—the pedicle (*pd.*); it is also composed of soft cartilage, whilst the thick bar running backwards from the pterygoid region under the reniform, and round and over the oval, fenestra, is hard cartilage. The narrow end of the oval fenestra looks upwards and forwards, and the hard bar below and in front of it, which lessens, and then widens out again, is the pterygo-quadrate bar, ending below, not in a *quadrate condyle*, but in a thin, inturned edge, somewhat rounded in outline. The hard cartilage ends, above and below, a little behind the large oval fenestra, and at its hind margin, and in the rest of the basket-work, the cartilage is soft. Like the pedicle, the short bar (*h.m.*) behind the small, round fenestra is continuous with the parachordal (*iv.*); it is the "serial homologue" of the pedicle of the suspensorium, and therefore is the head of the hyoid arch (= head of the hyomandibular). Now we begin to feel our way in this *unenclosed field;* we have lit upon some landmarks. One continuous growth of cartilage is seen running sinuously, sub-parallel with the axis, from near the fore-end of the nasal tube (*e.n.t.*) to a point beneath the 3rd spinal nerve (*sp.n.*). The fore part is what I have called the prepalatine "horn," or spike (*pr.pa.*); it is soft; then the hard tract behind it is first palatine (*pa.*), and then becomes the top of the pterygo-quadrate region (*pg.*, *q.*), passing into the "shoulder" of the hyomandibular (*h.m.*), the fore part of which answers to the wide snaggy part of that bone in an Osseous Fish, whilst the hind part corresponds to its "opercular process" for the *os operculare.* The hard cartilage of the pterygoid region is separated from that of the palatine in front, and the quadrate behind and below, by a narrow soft tract. The soft cartilage behind is first inter-hyal (*i.hy.*) then epi-hyal (*e.hy.*), and then forms the top of the 1st epibranchial ($e.br^1.$) The margining cartilage behind the large oval fenestra, sends back a rounded lobe into the hinder fenestra ($l.f^3.$)—a two-horned space; that lobate band is the "symplectic" region (*sy.*); it is soft; but the back of the quadrate region, into which it passes, is hard. The largest or hindmost two-horned fenestra although single below, is broken into two, above, by the main part of the hyoid arch—the inter-, epi-, cerato-, and hypo-hyal regions (*i.hy.*, *e.hy.*, *c.hy.*, *h.hy.*).

This arched band, bending backwards, and growing downwards and forwards, to pass into the huge basal bar, is both wider and thicker than that of an adult Frog, but unlike its counterpart in that type it is continuous with the upper or hyomandibular part of the arch. Nevertheless, its small width here suggests comparison with the hyoid of the adult, and not of the larval Frog, whose broad, short lower hyoid is suspended from the suspensorium, beneath the eye-ball, indeed under the front of the subocular space. Here the hyoid arch is curved backwards so as to lie, in the middle, below the 1st spinal nerve (*sp.n.*) whilst the arrested quadrate tract (*q.*) is directly below the middle of the auditory capsule, a position attained by the quadrate condyle of the Frog soon after metamorphosis. Where the soft cartilage of the hypo-hyal region (*h.hy.*) ends below, there the hard cartilage of the basi-hyal ($b.hy^p.$) begins, but there is no joint.

This continuous hyoid bar, as we have seen, passes over the last, or two-horned fenestra dividing it, above, and then riding over it. Above, this hyoid bar passes directly into the arched cartilage bounding the hind fenestra; below, that boundary of cartilage passes inside the long hyoid bar, and becomes the symplectic region. From its convex margin, behind, this hinder arch gives off two styliform outgrowths. This semicircle of soft cartilage, which forms the hinder half of the boundary of the hinder fenestra, is the 1st epi-branchial; the 1st cerato-branchial is suppressed in *Myxine*, but well-developed and distinct in *Bdellostoma* (Plate 16, figs. 1, 2, *c.br.*).

But the 1st pharyngo-branchial, or pier of the 3rd visceral arch, is well developed in both kinds; here (Plate 10, figs. 1–3; and Plate 17, figs. 1–3, *p.br*^{1}.) it is free from its own proper descending bar, lies obliquely inside it, and is joined to the general thickening of cartilage in the hind part of the *oval* fenestra. Thence it is very thick, and clavato-lobate, filling up nearly half of the fenestra at its inner face; it is there composed of hard cartilage. The rest is a soft, long, sinuous, inbent rod, which ends in a point some distance behind the *epi-branchial rays* (*e.br*^{1}.). Of the 2nd branchial arch only the upper or pharyngeal part is developed; but the relations of this and of the 1st pharyngo-branchial, enable us to determine the nature of these cartilages as to whether they are *extra*-branchials or *intra*-branchials. When the lower part of the throat of *Myxine* is removed, and the pharynx slit open for some distance (Plate 13, fig. 7), then we see that behind the pharyngeal opening of the posterior nasal canal (*p.n.c.*) there is a peculiar hood of membrane, the "pharyngeal velum" (*vl.*); it is pyriform, its narrow end is crenate, and a septum divides it behind, between the terminal folds.

When this is dissected out and examined from below (Plate 15, fig. 6), then we find that the 1st pharyngo-branchials are the supports of its outer margin, and that its swelling part has a skeleton derived from the 2nd pharyngo-branchials. The branchial pouches and clefts, *during growth, retired far away from the skeletal framework* (Plate 9, fig. 1), so that the cleft or opening of the first or *hyo-branchial* pouch lies below the *twentieth spinal nerve* (*sp.n.*); and the middle of the pericardium is below the *fortieth* (*sp.n.*). All these retired parts, pushed back, *so to speak*, by the huge lingual apparatus, are supplied by a cranial nerve, the vagus—a remarkable "prophecy" of what will take place in the retirement of the respiratory organs in the higher Vertebrata. The framework of the branchial region is left in its place, and is largely suppressed, and the parts that are developed are free to form new specialisations. The lower part of the pharyngeal velum, covered by *hypoblastic* cells, is supported by the 2nd pharyngo-branchials (Plate 15, fig. 6, *p.br*^{2}.), which are a pair of nbent, obliquely placed rods, thickish in front and very slender behind. At their middle they are united by a transverse bar, and this bar sends forwards two slender rods, which grow in front into large, pedate lobes. Where the slender hind part turns outwards, in the crenations of the velum, there another transverse rod is formed, thus uniting the right and left bars together; this also sends off, backwards, a small median outgrowth, and two large, lateral, multilobate outgrowths—a curious moss-like structure.

On the *right* side the rays of the 1st epi-branchial (Plate 10, figs. 1, 2, *e.br*^{1}.) are united at their base, and form another fenestra, so that there are *four* visceral fenestræ on the left side, and *five* on the right.

And yet this remarkable basket-work is not homologous with the curiously similar growth in the Lamprey; in that Fish the reticulation is formed outside the head-cavities; in the Hag-Fish they *must have been formed within* them, as they lie close to the hypo blastic lining of the throat.

With regard to the great inferior median bar (*b.hy.*, *b.br.*), there can be but little difficulty; for not only the Lamprey, but the Bony Gar-pike (*Lepidosteus*) also, shows us a similar huge glosso-hyal in front of the common basi-branchial bar. In the latter Fish (Phil. Trans., 1882, Plates 30–38) the basi-hyal is double, composed of two equal rounded rods, which are united along the middle. Moreover (most instructive of all the characters of that remarkable lingual skeleton), the cartilage is cut up into a number of transverse blocks by fibrous septa. This takes place in a Ganoid Fish, whose larva has a suctorial snout.

In the Myxinoids the tongue dominates the whole body; everything else yields to it, and is modified intensely by it. In the Lamprey, as well as in *Lepidosteus*, the basi-hyal becomes double in front, here it is a four-fold bar or plate; the solid cartilage being divided as it goes on expanding from behind forwards, first into two and then into four pieces (Plate 9, fig. 3); these are at once united and separated by tracts of soft cartilage or fibro-cartilage, and even by mere fibrous tissue in some places; and the two inner pieces of the terminal front part have a fenestra between them, behind. Then the bar becomes sub-carinate, but this angular projection is gradually lost, and the cartilage suddenly becomes soft, and a mere thick, *almost* fibrous web, is continued backwards behind the hypo-hyal junctions as an *anterior* basi-branchial (*b.br*^{1}.), which is one-third longer than the basi-hyal region.

Near the middle, this soft *fibro-cartilaginous* bar becomes keeled and alate; it then lessens gradually to a sharp point, which is gently upturned; this hinder part of the huge median bar is scooped on its upper surface; but the scooping becomes deeper and deeper, as we pass forwards to where the great fourfold basi-hyal is carinate below. The two middle pieces, in front, together form an emargination, and the outer pieces are rounded off externally. In front, the great lingual bar is twice as wide as the alate part of the basi-branchial behind. This huge beam is swung from the head, in front of its middle, by those small, soft ropes, the descending hyoid bands (*c.hy.*), which broaden and harden into the hyomandibular region (*h.m.*), above. The broad, emarginate fore-end of the huge lingual cartilage nearly reaches to the tips of the lower barbels, two pairs of which are seen protecting the slit-like mouth; whilst seven more protect the opening of the *nasal proboscis* (Plate 13, fig. 7).

The supra-lingual apparatus of Myxine.

The great basal bar (Plate 9, figs. 1–3, *b.hy.*) is only the coarser part, so to speak, of the lingual dentary apparatus; the two rows of teeth, right and left, themselves are set in a cushion of fibrous tissue, which is supported by a *supra-lingual* cartilage (Plate 12, figs. 7, 8), a *superadded* structure, the rudiment of which only re-appears in the Lamprey with one row of teeth right and left (Plate 14, fig. 9); in both cases these are peculiar to the Marsipobranchs.

When the great lingual cartilage, with the parts carried by it, is dissected out we have the structure shown in Plate 12, fig. 7; and when the teeth are removed, then the "supra-lingual" framework is seen (fig. 8), a curious *apron* with slits in it, and short strings projecting from it; it is composed of hard and soft cartilage, and of fibrous tissue ending, in front, in a horny comb; the figure shows it as considerably outspread, for display;—the sections correct this. In this hollow space lie the lingual teeth (fig. 7, *s.l.t.*); the cartilage had better be described first. This additional skeletal structure is formed in the floor and sides of the oral mucous membrane, and, with the structures it carries, reduces the cavity to a number of narrow chinks. The general outline of the supra-lingual frame-work is heart-shaped, but widely open, with projecting spurs, behind, whilst in front it is transverse, slightly emarginate, and developed into a fine comb of horny spikes. The fore part is membranous, but the cartilage creeps into this membrane, right, left, and in the middle—most there; there the fore margin of the cartilage has a small, toothed emargination in the middle and a large transverse notch, right and left. The whole cartilage tends to break up into a series of three pairs of short arches; within the hinder half there is a median bar between; these, together, form a sort of *intra-visceral* series, mimetic of the proper visceral arches, just as the *extra-visceral* framework of the Lamprey's pharynx is mimetic of such a series.

The first pair of these semi-segmented arches is wing-like, and is half separated by the next pair, which are narrow and feeble; one snag ends both of these behind; a crescentic cleft divides these for three-fourths of their extent; these two first pairs are composed of soft cartilage. The hinder pair ends in a snag, which is soft, and which is continuous in front with the root of the first snag. The side bars are twice as large as those in front of them, and are composed of hard cartilage; the median bar is soft, projects a little into the notch in front of it, and much more behind, where it reaches nearly as far backwards as the second pair of lateral processes. As it lies on the large basal beam, this hinder median part reaches as far back as the hard cartilage, and further than the setting on of the hypo-hyal ends of the hyoid arches (*h.hy.*).

In front, the horny comb helps to fill in the emargination of the basal beam.* The arrangement of the golden-coloured horny supra-lingual teeth is in a double, arched series, with a large notch behind. There are *seven* large teeth and *nine* small ones on each side; the large teeth are in front of, and outside, the others; their points look

* There may seem to be some discrepancy between the figures of the huge basal beam—upper, lower, and lateral, and of the *sections* that illustrate its structure still further. The explanation is this: the *dissections* show the bars as invested with a strong perichondrium, and thus they *look* nearer together than they really are. The colouring of the dissections takes no account of this: the numerous sections, drawn with a *camera*, show the width of the intercartilaginous spaces.

backwards, and inwards, and they are shaped like a lancet blade, but with a slight curve, the convexity being antero-internal. A cavity can be seen in them, and also that they are made of fibres arranged featherwise. The thick horny layer is continuous at the base of the teeth; their form is due to the folding of the lining membrane of the mouth, which undergoes *corneous hypertrophy* of the cells. These structures will be described again, when we come to the *sections.* The only *antagonist* tooth is very large and canine-shaped, attached to the ethmoid below, and pointing backwards (Plate 10, fig. 3, *et.t.*); an arrangement similar to that in "Cyprynoids," where the basi-occipital, horny tooth antagonises the lower pharyngeal, true teeth.

On the branchial pouches of Myxine.

The extraordinary displacement of the branchial pouches in the Myxinoids is correlated with, or even caused by the enormous size of the lingual apparatus, the fore part of the great common basi-branchial bar being retained with the basi-hyal at the hind part of the lingual skeleton (Plate 9, figs. 1–3). But even this only reaches half way along the base of the oblique muscles that work the tongue. There is, however, a second basi-branchial bar (fig. 4, $b.br^2.$), slenderer and flatter by far, and only half the length of the main part; this is composed of hard cartilage, and after a space equal to its own length finishes the skeleton of the apparatus along the basal line.

In *Myxine* there is no skeleton to the *six pairs** of cake-shaped (*placentiform*) branchial pouches, but the whole structure is membranous (see J. MÜLLER, I., plate 7, figs. 10–12; and my figure Plate 9, fig. 1).

Each pouch opens inwards into the narrow pharynx by a wide passage, and outwards by a largish tube which communicates with the opening of each succeeding tube, until they all have a common escape opening, behind. Into this space, on the *left* side, there is a sort of *fistulous passage*—the "ductus œsophago-cutaneus" (*d.œ.c.*) behind the last pouch—a sort of abortive gill-cleft, with no gill structure, the use of which I cannot see, but the morphology of which is self-evident. Behind these is the large heart (*h.*), giving off the arterial arches to the gill pouches.†

On the sense-capsules of Myxine.

For a detailed account of these organs, the reader is referred to MÜLLER'S Memoirs; and for the auditory organs, especially, to Professor RETZIUS'S magnificent volume, just published.‡

* Mr. WELDON informs me that he has found some specimens of *Myxine glutinosa* with *seven* pairs of pouches.

† For details see J. MÜLLER, I., plate 7.

‡ 'Das Gehörorgan der Wirbelthiere,' vol. i., plates 1, 2, pp. 3–12. Stockholm: 1881.

To *me* they are part of the skeleton, and therefore come into my description. The eye-balls are extremely small, and inconspicuous (Plate 13, fig. 1, *e.*, II.). The auditory capsules are very small, but not so small by far as the eye-balls; they are kidney-shaped, and look much larger below than above (Plate 10, figs. 1–3, *au.*). Indeed, below they are oval in form, with the narrow end in front, and, above, the concavity of the inner face, which is largely membranous, gives them their reniform appearance; they are composed of hard cartilage, and look like little light green seeds. They are confluent with the basis cranii and head of the hyomandibular cartilage; I shall show this in my account of the *sections.*

The nasal capsule of the Myxinoids is a unique structure; it is composed of the true olfactory organ and the vestibular region, which is proboscidiform (Plates 9, 10).

The proper olfactory organ is covered with a *grating* of cartilage (*na.*), whose bars run in a longitudinal direction.

The whole capsule is wider than long—wider than the brain cavity—is gently emarginate behind, and apiculate in front. The floor is membranous, and lies over the brain cavity behind, and the "front intertrabecula" in front. The roof and sides are enclosed by the cartilaginous grating, in which there are *nine* sub-equal bars, united fore and aft by a continuous belt of cartilage; the bars and these interspaces are nearly equal. The olfactory nerves enter the *membranous cribriform plate* by five distinct bundles (see in *Bdellostoma,* Plate 17, fig. 4—an anticipation of the Mammalian ethmoid).

The proboscidiform nasal tube is very exactly like a *Mammalian trachea,* being composed of a series of imperfect cartilaginous rings, of which I find *eleven* in *Myxine,* the last being apiculated; it projects forwards above the single narial opening; these parts will be better understood when we come to the *sections.* The upper seven *barbels* or "nasal palpi" protect this opening, and the other four the oral opening; they each have a delicate cartilaginous axis. This type of skull remained an utter enigma to me until lately, even with the great work of MÜLLER before me; and I am not aware that any one, except Professor HUXLEY, has, of late years, attempted to interpret it; nor should I have attempted now, if the task had not been lightened by my fellow workers, and if the early stages of the nearest relatives—the Lamprey, and the "Anura" in their larval stages—had not been mastered.

Of course, every determination of the nature of parts made now will be subjected to a severe and crucial test when the early stages of a true Myxinoid have been worked out. For those stages I am anxiously looking; but, meantime, this initial work will be something done; a little change of nomenclature, if needed afterwards, will be no great matter; and it is very important that this *scarcely vertebrate* type—it has no *vertebræ*—should be understood. The number of sections drawn is great, but they were all needed to make even *the worker himself* understand what lay before his eyes. The reader will need to keep the figures of the dissections (Plate 9, figs. 1–3, and Plate 10, figs. 1–3; Plate 12, figs. 7, 8; and Plate 15, fig. 6) before him whilst reading the following description of the sections; the figures of the undissected Fish (Plate 8, figs. 7–9) will also be found useful.

Vertically transverse sections of the adult Myxine glutinosa.

Before describing these sections, I may remark that the nasal passage carries the upper lip far in front of the lower; but the lower lip, even in the *Ammocœte*, is far back; whereas, in the adult Lamprey, the lower lip, *when the sucking disc is in action*, projects beyond the "anterior dorsal cartilage," and its enclosing skin, the upper lip.

The end of the external nasal passage is protected by nasal barbels, and the mouth opens further back; there are two pairs of oral barbels, the outer unciform and the inner mammillate. There are three nasal barbels on one side and four on the other; *six* thin sections of this part, one of which was drawn, show this; and, corroborative of this fact, Dr. GÜNTHER, in his 'Study of Fishes' (p. 695, fig. 320, A) gives, in a woodcut, the same number in *Myxine Australis*.

Section 1 (Plate 11, fig. 1).—Here the interior valvular opening of the external nasal duct (*e.n.*) shows four points of cartilage (*n.bb.*) cut through on one side, and three on the other; the lesser barbels are close to the passage, and the larger further out; the fore end of the prepalatine reaches to this point.*

Section 2 (fig. 2).—The nasal canal or passage (*n.p.*) is now complete, and the first ring is cut through in three places, above, and on each side (see also Plate 10, fig. 1); for this imperfect *annulus* has a rostrum. Right and left of the vertically elliptical passage, the largest nasal palpi (*n.bb.*) and the prepalatines are cut across. The median line, below, is concave; this hollow leads to the oral passage further back. The upper outline of this section shows two sub-marginal shallow grooves

Section 3 (fig. 3).—In this the sub-marginal grooves above are nearly obsolete, and the middle part of the top is slightly crested; it is slightly grooved in its broad, lower part. The prepalatine cartilages (*pr.pa.*) are now flatter and wider apart; the section is through their arch in the middle. This shows a wider but lower passage (*n.p.*), widest below, and it is also seen that the annulus just reaches the bottom, and is thickened there. Under the nasal passage, the dilated fore end of the front inter-trabecula (*a.i.tr.*) is cut across; the bend downwards of its edges makes it like a *Chinese bridge*.

Section 4 (fig. 4).—Here, in this larger section, both the upper and lower surfaces are hollow in the middle; the nasal canal is becoming pyriform, with the narrow end below. The annulus is like that of the last section, but larger; but the prepalatine and front intertrabecula (*pr.pa.*, *a.i.tr.*) are both flat in section; here the prepalatine has evidently been cut through very obliquely. The hard front intertrabecular bar is club-shaped in section in this and the next, the thick part being above.

* The lower, larger sections of cartilage are, by mistake in this and the next figure, lettered, with the rest, as nasal barbels (*n.bb.*); they are the free ends of the prepalatine spurs.

Section 5 (fig. 5).—Here the pre-oral groove is deeper, and the front intertrabecula is here at its largest part. The true form of the prepalatine section (*pr.pa.*) is seen here. In this section, and in the 7th and 8th, we get a view of an important character in the nasal passage (*n.p.*), namely, that it has a valvular fold in it, growing down from above, and making it heart-shaped in section.

Section 6 (fig. 6).—This section is much larger than the last, and here we have the upper lip breaking into two large, sharp folds, and the palatal part of the oral vestibule wrought into two rounded folds. The valvular process of the nasal passage was not clear in this section, but we see that here the *annulus* is not thickened below, and that it turns inwards right and left. The front intertrabecula (*a.i.tr.*) is now long-oval in section, and the prepalatine (*pr.pa.*) oval. In the two folds of the upper lip (*u.l.*) we have the oral palpi (*o.bb.*) cut through, the outer longitudinally, and the inner across.

Section 7 (fig. 7).—In this section the two lobes of the upper lip (*u.l.*) are confluent, but the palpi (*o.bb.*) still come into section in a similar manner to the last; there are now five folds of the prepalatal region above, and two below; these latter look upwards, the meaning of which will soon be seen (see figs. 8–11). The valvular fold in the roof of the nasal passage is here clearly shown, and also the lessened depth of the front intertrabecula (*a.i.tr.*). The true thickness of the prepalatines (*pr.pa.*) is here shown, just at their base; and here also (see Plate 10, figs. 1–3) the ethmoidal region of the skull (*eth.*), with its attached conical yellow tooth (*et.t.*), is cut across.* The closed-in, or ethmoidal part of the skull is formed, as we saw, by the coalescence (or continuity) of the palatine bars outside, and the trabeculæ within; here, at the junction of these parts, the cartilage is high above, and gently convex below, where it carries the tooth.

Section 8 (fig. 8).—The section through the dilated hind part of the front intertrabecula (see Plate 10, fig. 2, *a.i.tr.*) was not figured; here, in front of that part, it is nearly circular in section; and because of the sinuous form of the hinder *narial annuli*, this section shows one cut into three pieces (*e.n.t.*); the nasal tube still shows its valvular character up to the proper capsule. The ethmoidal region (*eth.*) is arched; the outer part is palatine, and the middle trabecular. A cushion of fibrous tissue fills the concavity, and to it is attached the great tooth (*et.t.*), which is here cut across obliquely near its apex, showing its internal cavity. The lining of the mouth is sinuous, and the floor of it is now complete; this is the first section through the lower lip (*l.l.*), the ascending fold of which is the fore part of the *supra-lingual apparatus*. Right and left of these folds, not far from the mucous membrane of the mouth, two large hard cartilages have been caught by the razor; these are the outer front basi-hyals (*b.hy*[a].) (see also Plate 9, fig. 3). These bars turn upwards and out-

* The specimen sectioned was older than the one which was dissected, and so the hard cartilage had extended further in the former; this will explain some slight discrepancies between the two sets of figures as to *colour*, and also as to the fineness or coarseness of the *dotting*.

wards, and are sub-pyriform in section, the thick end being uppermost. This 8th section is the first that takes in the lower lip, and we see how truly *Ammocœtine* these Myxinoids are.

Section 9 (fig. 9).—If this section be compared with the dissections we shall see what an elegant structure the nasal capsule (*ol.*) of *Myxine* is; in my Second Part I shall show that in the Lamprey this organ is a complete *wheel* of plates in section; here it is only half a wheel, and the folds only gently converge; this is the most simple structure of the two. Yet on this simpler platform there is a most curious specialisation of the cartilaginous capsule itself, and also of its vestibule. The accuracy of the *grating* is well shown in the sections. The two lowermost of the *nine* parallel bars are the widest; each bar has its own fold of mucous membrane, and these nearly reach to the common cavity below, which is here very large. Supporting this curious framework, we see the palato-trabecular bands (*p.tr.*, see also Plates 9 and 10); these are hard, oval, and tilted outwards, above. Then, for a short distance in front of the cranial cavity, the floor of the cranio-facial framework is open, being only floored by membrane.

A large tract of palatal tissue intervenes between this weak floor and the roof of the mouth (*m.*), the cavity of which is formed of three fissures, the outer and upper pair being semicircular, and the median, or lower, sub-oblong, but widest above, and having its sides running between deep folds. Above, the median line of the mouth is grooved; below, it is gently ridged; the lateral folds are the fore part of the *supra-lingual* framework. The proper lingual cartilages ($b.hy^a.$) are now seen to be *four*, instead of *two*, for the median pair have come into view (see also Plate 9, fig. 3); the *apparent distance* between the bars, here, is due to the fact that only the projecting fore end of each was cut through.

Section 10 (fig. 10).—This section is very similar to the last, but is important as showing the fusion of the two median bars ($b.hy.^a$); in this *old specimen* the fusion is perfect, but in the one dissected there was some appearance of distinctness along the midline, below (Plate 9, fig. 3); here the edges are thicker than the middle, which is gently scooped.

Section 11 (fig. 11).—Several new things come into this section; and here in the middle of the nasal capsule the lower cartilaginous bars are seen to have their own fold, but it is not free, so that there are only seven distinct folds in the sac. The great inferior fontanelle of the cranium bulges gently here, and the tip of the hinder intertrabecula (*p.i.tr.*) is cut across, where it supports the middle of the membranous floor. The bulging of the floor makes a great space for the nasal cavity (*n.c.*).

The palato-trabecular bands (*p.tr.*) are smaller at this part, and evenly oval in section; between the skull and the roof of the mouth there is a considerable web of fibrous tissue.

The form of the mouth cavity here is greatly modified by the horny cheek-teeth—*supra-linguals* (*s.l.t.*)—which are imbedded in a mass of fibrous stroma, and thus the wide mouth becomes a space of three fissures.

The two upper fissures are crescentic, and the form of the median space is a blunted wedge; the floor has two ridges. These sections show that the horny teeth are folds of a continuous epithelium; they are huge *papillæ* with a common horny base, and, distally, have their own cavity.

Under the folds of the mid-line the median part of the supra-lingual skeleton (*s.l.c.*) is cut through; this lies on the fused middle pair of front basi-hyals, which plate is concave under the lesser upper cartilage.

The lateral pairs of the front basi-hyals (*b.hy^a.*) are solid, oval in section, and are further apart from the middle pair than they seem to be in the bird's-eye view. (Plate 9, fig. 3; and Plate 12, fig. 7.)

Section 12 (Plate 12, fig. 1).—This section is through the hind bar of the nasal capsule (*ol.*), and the longitudinal rods of the grating are seen cut across close to the transverse bar. This section is close in front of the membranous cribriform plate, which will be described in my account of *Bdellostoma*, in which (and in *Myxine*) the olfactory nerves, as shown by MÜLLER (II., plate 2, figs. 8–12), pass into the capsule by *five* roots on each side, each root breaking into a pencil of fibres as it enters the capsule; a *Mammalian anticipation.* The palato-trabecular bands (*p.tr.*), and the *handle* of the hinder intertrabecular *spoon* (*p.i.tr.*), are cut through, and are similar to what we saw in the last section. So also are the basi-hyal bars; but, here, the median supra-lingual plate is wider, and the side wings now come into view, to support the cheek-teeth, now showing their distinctness in section.

Section 13 (Plate 12, fig. 2).—This section is very similar to the last, but it is behind the nasal capsule, and through the fore brain (C^1.); a large space is seen between the fore brain and the feeble floor of the skull; this is the posterior nasal (or naso-palatine) canal.

Section 14 (Plate 12, fig. 3).—Here the cranial cavity is at its widest part; the palato-trabecular bands are wider and less tilted at this part, which is in front of the small optic nerves (see Plate 13, fig. 1, *e.*, II.). The hinder intertrabecula (*p.i.tr.*) is cut across in three places, the edges of the *spoon* being caught, laterally. The supra-lingual cartilage (see fig. 8) is here continuous from side to side, being cut through in front of the foremost fissures; it forms a deep trough for the bed of the paired rows of cheek-teeth. Here (see Plate 9, fig. 3) the *four* front bars of the basi-hyal (*b.hy^a.*) are all distinct again, the section being made through the *basi-hyal fontanelle.* In the last *four* sections, the two median bars have been confluent.

Section 15 (Plate 12, fig. 4).—This section is through the fore margin of the subocular fenestra (Plate 10, figs. 1–3, *s.o.f.*), where some soft cartilage divides the *palatine* from the *pterygoid* regions (Plate 9, figs. 1, 2; and Plate 10, figs. 1–3), so that the hard cartilage (*pa.*) here is near the pterygoid; the inner is trabecular (*tr.*). Here the *spoon* of the hind intertrabecula (*p.i.tr.*) is cut across in front of its lateral attachment to the trabeculæ (*tr.*). The area on each side of the naso-palatine canal (*p.n.c.*) is the tissue through which the small optic nerves pass, but they were not caught in this section. The cheek-teeth are cut through nearer their point, and their enclosing cartilage is cut across through the first pair of fissures (fig. 8), so that it is not in *one* piece, as in the last section, but in *three*. The basi-hyal (*b.hy*[a].) shows some soft cartilage where the two pairs of front bars unite again, behind the median fenestra (Plate 9, fig. 3), in front of the merely double part.

Section 16 (Plate 12, fig. 5).—Here we have a section of the hinder intertrabecula (*p.i.tr.*) where it is confluent with the hind part of the trabeculæ; this is for a very short extent (Plate 10, fig. 3), but the actual union is very instructive, for in these Myxinoids this median bar retains that distinctness from the paired bars, which, in other types, is a very temporary condition. (See in the young Lamprey, Plate 10, fig. 5, *tr.*, *p.i.tr.*) At this point the basis-cranii is perfect, and being across the subocular fenestra (Plates 9, 10, *s.o.f.*) the cranium and pterygo-palatine region of the face are distinct for a short distance.

The supra-lingual skeleton (see also fig. 8) shows the depth of the middle part, and the steepness of the two sides further back across the two first fissures. The basi-hyal is now single (Plate 9, fig. 3, *b.hy*[p].), but this is down-bent in the middle, where two pieces have coalesced.

Section 17 (Plate 5, fig. 6).—This is also through the suborbital fenestræ (between *tr.* and *pa.*) behind the junction of the hinder intertrabecula with the trabeculæ (*p.i.tr.*, *tr.*). The pterygo-palatine bar (*pa.*) is dipping more and more towards the quadrate region; the lateral supra-lingual plates are narrower, and the basal part broader and deeper than in the last; the double basi-hyal (*b.hy*[p].) is narrower and deeper.

Section 18 (Plate 13, fig. 1).—In this section, behind the middle of the subocular fenestra (*s.o.f.*), a bundle of fibres is seen emerging from the brain; this is the optic nerve II., with the aborted eye-ball at its extremity. Here the trabecula (*tr.*) is a narrow rod, and the pterygo-palatine (*pa.*) is becoming flat and descending. The naso-palatine canal (*p.n.c.*) is still very wide, but the intertrabecula (*p.i.tr.*) below it is narrowing. This and the two next sections are through the hard cartilage of the hinder bars of the supra-lingual framework; the lateral plates are narrower, and the basi-hyal (*b.hy*[p].) similar to what was seen in the last section.

Section 19 (Plate 13, fig. 2).—This is the last section through the subocular fenestra (*s.o.f.*); it is very similar to the last, but the intertrabecula (*p.i.tr.*) is much narrower, and the pterygoid (*pg.*) is very solid; the basi-hyal (*b.hy*[p].) is becoming narrower, and the supra-lingual (*s.l.c.*) shows soft cartilage below, between the two hard bars (see Plate 12, fig 8).

Section 20 (Plate 13, fig. 3).—This and the next are between the first and second fenestræ, and therefore through the "pedicle" (*pd.*) of the pterygo-quadrate region (Plates 9, 10, *pg.*, *q.*); there is soft cartilage here, but with some hardened cells inside it; the trabeculæ (*tr.*) are widening towards the parachordals, and the inter-trabeculæ (*p.i.tr.*) under the narrowing naso-palatine canal (*p.n.c.*) are becoming small.

The supra-lingual (*s.l.c.*) is cut through where the hard hinder bars run into soft cartilage above; the upper plate is narrow; the basi-hyal (*b.hy*^{p}.) like the last.

Section 21 (Plate 13, fig. 4).—This section was made through the second fenestra, the trabeculæ (*tr.*) are cut across, and the pedicle (*pd.*) in its hind part; the descending pterygo-quadrate bar (*pg.*) is cut through much further down. The naso-palatine canal (*p.n.c.*) is squarish, and the folds of its lining membrane are shown; under it is the fast narrowing intertrabecula (*p.i.tr.*). Here the elbow of each hard hind bar of the supra-lingual (Plate 12, fig. 8) is cut across outside one of the hinder teeth. The basi-hyal (*b.hy*^{p}.) is now in two pieces, below.

Section 22 (Plate 13, fig. 5).—This section is between the pedicle and the head of the hyomandibular, across the mandibulo-hyoid band (*m.hy.*) and the mandibulo-hyoid fenestra (*m.h.f.*) above, and through the quadrate (*q.*) below; the space between these bars is the second lateral fenestra (Plates 9, 10, *l.f*^{2}.). Inside the upper bar the front face of the auditory capsule (*au.*) is shaved off; these organs are confluent with the narrow fore part of the parachordals (Plate 10, figs. 1–3, *au.*, *iv.*), where the trabeculæ begin in front of the notochord; the intertrabecula (*p.i.tr.*) is very narrow here over the square naso-palatine canal (*p.n.c.*). One of the hinder cheek-teeth is cut through on each side, and part of the cartilaginous wall and the two hind snags. The narrowing hinder basi-hyals (*b.hy*^{p}.) are distinct.

Section 23 (Plate 13, fig. 6).—If this section be compared with the dissections (Plates 9 and 10) the great conformity of the two kinds of preparations will be seen. This and the next are the last sections in front of the notochord; the moieties of the investing mass, or parachordals, form here a mere lip to the lower edge of the *auditory shell* (*au.*), which is seen to be reniform in section, and membranous within, the walls being thickish, and composed of hard cartilage. Here the tip of the *bowl* of the intertrabecula (*p.i.tr.*) is perforated, and thus it is seen in section as two points of soft cartilage over the square naso-palatine canal (*p.n.c.*).

The mandibulo-hyoid bar (*m.hy.*) is a small oval section, a considerable distance from the capsule; much further down there is a curious hook of hard cartilage, and below it, but nearer to it, on the outside, another oval section. The hook is the first pharyngo-branchial (*p.br*^{1}.), at its enlarged end, where it partly occludes the second fenestra (Plates 9 and 10), and the bar below is the narrow neck where the pterygoid passes into the quadrate (*q.*), under the second fenestra. The basi-hyal (*b.hy*^{p}.) is like that of the last section.

Section 24 (Plate 14, fig. 1).—This section sheds light upon the dissections, and is also in turn explained by them.* Here, as in the last, the parachordals are very

* I must here repeat the fact that these sections show the cartilage to be hard, in places where in the dissections it was soft, on account of the greater age of the specimen made into sections; where any other apparent want of conformity exists between the two sets of observations, it is due to *compression* of the specimen in cutting, for my best specimens were not well preserved, and at the best the pharynx and its *velum* are very elastic and mobile.

narrow, turned upwards, and confluent with the auditory capsules (*au.*). Under the square naso-palatine canal (*p.n.c.*) the tip of the *bowl* of the intertrabecula (*p.i.tr.*) is cut across, and near the capsule the mandibulo-hyoid bar (*m.hy.*). At a considerable distance down the side of the throat the hooked cartilage or 1st pharyngo-branchial ($p.br^1.$) is cut across, and below it the quadrate region (*q.*). The basi-hyal ($b.hy^b.$) is still double, and deep.

Section 25 (Plate 14, fig. 2).—We have now reached the notochord (*nc.*), a mere point here, and not invested by the investing mass, which is still a mere selvedge to the inner and lower edge of the auditory capsule (*au.*). This section is behind the intertrabecula, and it shows the naso-palatine canal (*p.n.c.*) still closed below. The lateral cartilages cut across are the mandibulo-hyoid band (*m.hy.*), the first pharyngo-branchial ($p.br^1.$), and the quadrate (*q.*); below, the basi-hyal is still double, and composed of hard cartilage. The bracket-shaped fold of membrane (above *vl.*, the pharynx is below *phx.*, the dotted lines are wrong) across the roof of the pharynx is the beginning of the "upper velum."

Section 26 (Plate 14, fig. 3).—This section shows the notochord (*nc.*) and the investing mass increasing, and the cavity of the auditory capsule (*au.*) laid open, and in this part the "anterior canal" is enclosed specially by cartilage. The neck and shoulder of the hyomandibular (*hm.*) is first soft, and then hard cartilage. The investing mass has grown beneath the capsule, as well as along its inner edge, below, and thus the hyomandibular which grows from it *seems to be* a mere outgrowth of the capsule.

Section 27 (Plate 14, fig. 4).—The notochord (*nc.*) is now invested by the parachordals; the hyomandibular (*hm.*) is thinner in the middle, here, than at its fore edge, as seen in the last section.

Section 28 (Plate 14, fig. 5).—This is a very instructive section, for here the naso-palatine canal (*p.n.c.*) is opening below, revealing the diagnostic character of the Myxinoids—("Hyperotreta"). The investing mass (*iv.*) now forms a neat trough for the notochord, and is, in reality, continued as a thin but confluent lamina under the auditory capsule (*au.*) where the cartilage is continuous with the soft head of the hyomandibular (*hm.*) By comparing this section with the side view (Plate 9, fig. 2, *hm.*) it will be seen that in this region the bar is soft in three places and hard in two. Inside the lower or symplectic region of the bar (*sy.*), where it runs into the quadrate region, the neck of the large 1st pharyngo-branchial ($p.br^1.$) is seen as hard cartilage. The basi-hyal ($b.hy^b.$) still retains the same character as in the sections immediately in front of it.

Section 29 (Plate 14, fig. 6).—In this section the notochord (*nc.*, *iv.*) is, *for once*, enclosed in cartilage. In the younger dissected specimen (Plate 10, figs. 1, 2,) the investing mass was not perfect anywhere above the notochord—only below (fig. 3). The auditory capsules (*au.*) are perfectly confluent with the basal plate, and here we are behind the head of hyomandibular, so that there is a space before cartilage is shown. The bar cut through is hyomandibular above (just where the opercular process is given off in Teleosteans), and symplectic (*sy.*), below. Inside the bar the 1st pharyngo-branchial (*p.-br*[1].) is still hard. The opening of the naso-palatine canal into the pharynx (*phx.*) is very wide here, and the round folds right and left are the sides of the "velum" (*vl.*). The basi-hyal (*b.hy*[b].) is beginning now to lose its hard cartilage; the soft cartilage at its edges is the distal part of the descending hyoid bar, the hypo-hyal region.

Section 30 (Plate 14, fig. 7).—The ends of the auditory capsules are here cut through, and the investing mass (*iv.*) is now a thick trough, in which the enlarging notochord lies. The lateral cartilages (*sy.*, *p.br*[1].) are the same as the last, but cut through a little further backwards. The double basi-hyal now passes into the large soft elastic 1st basi-branchial above the hard paired cartilages (*b.hy*[b].). The soft end of each descending hyoid bar (*h.hy.*) is seen cut across.

Section 31 (Plate 15, fig. 1).—This section is very similar to the last, but is behind the auditory capsules, and the investing mass (*iv.*) is lesser, whilst the notochord (*nc.*) is larger. Below, the hard cartilage of the basi-hyals grows for some extent into the 1st basi-branchial (*b.h.br.*), the hypo-hyal end of the cerato-hyal bar (*h.hy.*) is still seen; it is slightly confluent with the basal bar.

Section 32 (Plate 15, fig. 2).—The notochord is now two-thirds of its average *spinal* thickness; it is almost enclosed by cartilage; this and the last are in the occipital region in front of the 1st spinal nerve (Plate 9, figs. 1, 2, *sp.n.*); here the hind brain (C^3.) begins to be *myelon*. The large flat symplectic region (*sy.*) still comes into section; above it is the inter-hyal bar (*i.hy.*), and, within it, the 1st pharyngo-branchial (*p.br*[1].). Below, the hypo-hyal is seen to be distinct from the soft elastic 1st basi-branchial (*b.br*[1].), the section of which is U-shaped and thick. The form of the two-lobed velum (*vl.*) is well shown here, with the open channel in which the naso-palatine canal ends.

Section 33 (Plate 15, fig. 3).—The notochord (*nc.*) has now acquired nearly its full size, and still it has two points of cartilage upon it, the extreme ends of the parachordals (see figs. 1, 2, *iv.*). A good distance down we get the upper band of the branchial basket-work cut through where the outer descending hyoid passes free from the hyo-mandibular region; this is the inter-hyal region (*i.hy.*). This bar re-appears again below at the bottom of the cerato-hyal as the hypo-hyal region (*h.hy.*); in some of the sections not drawn these two points passed into each other, the compression of the head curved the bar so as to make the razor pass through it in two points; and the same cause has forced the "velum" down, so that both in this and the next, the cartilages in it (*p.br*[1]., *p.br*[2].) are lower down than in an undisturbed state. Between these small points we see the leafy part of the symplectic (see Plate 9, figs. 1, 2, *sy.*), still coming into view in section. The 1st basi-branchial (*b.br*[1].) is now a deep trough of *vacuolar* tissue, with the hypo-hyals (*h.hy.*) at its edge.

Section 34 (Plate 15, fig. 4).—This is from a considerable distance back, so that all the cartilage seen in it is mainly that of sections of the terminal rays of the basket-work (*e.br*^{1}., *p.br*$^{1, 2}$.), with the very last part of the hyoid bar (*h.hy.*), and, above, the upper part of the 1st branchial (*e.br*^{1}.) is cut through twice. The 1st basi-branchial almost closes upon the median bands (belonging to the huge lingual muscles) that lie inside it. This section was made between the 1st and 2nd spinal nerves (Plate 9, figs. 1, 2) (*sp.n.*), and here the notochord (*nc.*) is of full size, and has no cartilage around it, whatever; the parachordals are the only *paraxial* cartilages developed; and, as in the larval Lamprey, there are no rudiments, even, of vertebræ; here, for C^3., read *my.*

Beneath the huge lingual muscles, the intra-branchial skeleton breaks out again; there (Plate 9, fig. 4) the 2nd basi-branchial (*b.br*^{2}.) reappears as a band of hard cartilage, broadish in front, and narrower behind, it is ventrally placed in relation to the first two branchial pouches; it does not support them, but lies under the "raphe" of the hinder part of the massive muscular apparatus of the tongue (*l.m.m.*).

The foregoing are all the skeletal parts I can find in this Fish, which in some respects is developed more in conformity with the higher Fishes—Cartilaginous or Bony—than the Lamprey, and in others is so very rudimentary; altogether, it evidently belongs to the *Ammocœtine* type, although greatly specialised in its own way, to its own ends.

The sections just described will be equally useful for both *Myxine* and *Bdellostoma*, for this latter larger Fish differs only in non-essentials from *Myxine;* my description of the former will merely relate to dissections, and to a general longitudinally-vertical section of the Fish.

On the skeleton of Bdellostoma Forsteri.*

On the cranio-facial apparatus of the adult Bdellostoma Forsteri.

The *theca cranialis*, or dura mater, in the hinder half, and the nasal capsule in the front half of the cranium (Plates 16, 17), have to be removed before the proper framework can be seen from above; the lingual apparatus has to be dissected from the lower part of the head before the basal part can be seen. Neither in the adult of these two types, nor in the embryo of the somewhat higher Lamprey, do we see any other explanation of the *pre-pituitary* part of the cranium than that of an outgrowth or foregrowth of the axial part of the skull. And yet the *pro*-chordal part begins

* Dr. Günther informs me that there is but one species of this Fish, and that the kinds called *B. Forsteri* and *B. heterotrema*, by Müller, are merely varieties of the same species. Dr. Günther's description of the two Myxinoid Genera is as follows:—

"Myxine.—One external branchial aperture opening only on each side of the abdomen, leading by six ducts to six branchial sacs.

"Bdellostoma.—Six or more external branchial apertures on each side, each leading by a separate duct to a branchial sac." ('Study of Fishes,' p. 695.)

Müller, I., plate 7, fig. 3, gives a figure of *Bdellostoma* with *seven* pouches on the left side, besides the "ductus œsophago-cutaneous," and only six pouches on the right side. I found only six pouches on each side in my two specimens; for *plans* of these remarkable branchial organs see the same plate in Müller's Memoir.

first, and is larger, often much larger, than the *para*-chordal; moreover, in most low forms the prochordal part is developed first. The notochord is very uniform in bulk along the spinal region in these large long Fishes, only gradually lessening in the caudal region. In the head, this rod (Plates 16, 17, *nc.*) suddenly becomes conical, and ends between the middle of the auditory capsules (*au.*) so that this part of it is only one-tenth the length of the entire skull. Of course in the embryo the relative length was much greater. In the embryo of the Lamprey, as I shall show in my Second Part, it is half as long as the entire skull, and in the youngest chondrocranium figured by me in *Lepidosteus* (Phil. Trans., 1882, Plate 30, fig. 3) it is *three-fifths* the length of the skull.

So that we see that in these low Myxinoids—the lowest known Vertebrata—the chondrocranium, during development, must have undergone a large amount of change, and we seem to be almost as far off as ever, in these types, in their adult state, from finding an archaic skull. Embryonic chondrocrania, in various *Ichthyopsida*, are our best guides. The investing mass (Plate 17, figs. 2, 3, *iv.*) is complete for a short distance, both above and below, and it projects, as hard cartilage, a little distance behind the auditory capsules, thus forming a rudimentary basi-occipital; but there is no occipital arch or ring. This short parachordal tract is round behind, and deeply notched in front, for the trabeculæ begin opposite the middle of the small auditory capsules. Those bands are only free from surrounding parts for a very short distance, being first (at their parachordal roots) continuous with the infero-internal edge of the auditory capsules, then on the outside with the pedicle, and in front of the short oval subocular fenestra (*s.o.f.*), for the remaining two-thirds of their length, they are continuous with the palatines (*pa.tr.*). This latter essentially compound part is very solid, and for the last sixth of the skull-length the two sides are completely united, so as to form a very solid ethmoidal region (*eth.*). The whole roof is unfinished, being only closed by the dura mater, but the depth of the auditory capsules, and the thickness of the palato-trabecular bars, give a trough-like character to this flat, unfinished skull. Below (Plate 17, fig. 3), the main bulging is formed by the hinder intertrabecula (*p.i.tr.*) and the auditory capsules, which project almost as much below as above; the skull proper is gently convex in the fore part, and in front bends downwards a little. The so-called "pituitary space," or lower cranial fontanelle, reaches from the middle of the auditory capsules to the ethmoid, and is lanceolate, but its narrow fore end is rounded. About half this membranous space is floored by the soft convex hinder intertrabecula (*p.i.tr.*), an additional cartilage, two-thirds the length of the skull, and which reaches from the trabecular roots to the ethmoidal commissure. It is a *ladle*, with its handle dilated in front, and its bowl produced behind, into a short second process or beak; the bowl occupies about a fourth of its length, and is near the hind part. The whole upper part is hollow (Plate 17, fig. 2, *p.i.tr.*), and at the middle of the bowl a short side band runs into the trabecula right and left, these bars being soft for a short space, where the junction takes place, and at this part the trabeculæ bend inwards. Exactly right and left of the *bowl* we see the regularly oval suborbital fenestræ (*s.o.f.*), each about half as large as the bowl, and having its long axis parallel with that of the skull. The front part of the skull is elegantly *ox-faced;* the bovicorn outgrowths are the soft prepalatine bars (*pr.pa.*); they are almost as long as the common palato-trabecular bar next behind them, and their length and distance apart are about equal. They have, hung about them, four pairs of *lesser horns,* three pairs acute, and the fourth double and *cervicorn;* these are the cartilages of the barbels (*n.bb., o.bb.*). The rest of the face is a kind of lattice work, ending behind in free cervicorn processes. The second median element of the skull—the front "intertrabecula" (*a.i.tr.*)—is spindle-shaped and compressed; it is composed of hard cartilage, as in *Myxine;* it overlies the ethmoid in its hind half, and the nasal sac lies over it. The lower margin of the palato-facial growth is convex where the great prepalatine "horn" grows out, then concave, but is obliquely descending in the orbital region; the deepest part of the palato-quadrate tract is directly below the middle of the auditory capsule, and here the quadrate condyle *should* be found; there is none, and no mandibular rod. The lower edge of the cartilage remains soft (Plate 16, fig. 1, *q.*), and so also does the pedicle of the suspensorium (*pd.*); but there is no soft cartilage under the fore part of the subocular fenestra (*s.o.f.*) such as we saw in *Myxine* (Plates 9 and 10). The second lateral fenestra ($l.f^2.$) is nearly twice the size of the one in front of it; it is heart-shaped, having a round process of cartilage growing into its hind margin. A second soft "pedicle," the head of the hyomandibular (*hm.*), is seen under the hind part of the auditory capsules; between these there is a small upper fenestra (Plate 17, fig. 1, *m.hy.f.*), whose lower boundary is a thick bar of hard cartilage (*m.hy.*), the shoulder of the hyomandibular (*hm.*). The fore part of this bar is continuous with the suspensorium (its metapterygoid region), whilst, behind, it ends in soft cartilage, the inter-hyal region (*i.hy.*). The upper part of the hyomandibular in osseous Fishes is mostly very broad, projecting over the short free metapterygoid in front, and growing backwards as the "opercular process." This upper hyoid region finishes the second fenestra, behind, sending inwards a round lobe, and being also sublobate behind in three places. Below and above, the small lobes of hard cartilage pass into the soft kind, above in the inter-hyal region, and below, in the symplectic (*sy.*). From the inter-hyal region the descending epi-cerato hyal band, two-thirds the width of the hard band in front, descends *over* the hinder or third or largest fenestra ($l.f^3.$), the hinder half of which is enclosed by the arcuate and spiked 1st epi-branchial ($e.br^1.$)* There is a notch, below, between the arrested quadrate (*q.*) and the lower part of the symplectic region (*sy.*) The cartilage is all soft here, and above the junction of the two kinds the symplectic region sends a spur backwards partly filling in the lower part of the space. The long hyoid bar (*e.hy., c.hy.*) is sigmoid above, and then slants forwards and downwards to its hypo-hyal region (*h.hy.*), where it is continuous with the basal bar ($b.hy^b.$). The lower boundary of the large posterior membranous space ($l.f^3.$) is

* See Plate 17, fig. 1; in fig. 2, and in Plate 16, fig. 1, this part is lettered *c.br.* by mistake.

formed by the passing of the symplectic into the 1st epi-branchial (*sy.*, *e.br*[1].) ; this bar becomes dilated behind, has a sinuous margin in front, and sends backwards two sharp spikes or rays (non-segmented branchial rays). But this enclosing arcuate spiked bar is only the middle of the large 1st branchial arch ; it has a very long pharyngo-branchial piece above (*p.br*[1].) and a long slender cerato-branchial (*c.br.*) below, both these rods are directed backwards and end in long, sharp styles, and both are *f*-shaped ; the lower is a part *nearly* segmented off from the rest of the basket-work, still it is attached, below, to the basal bar, behind the descending hyoid. The 1st pharyngo-branchial (*p.br*[1].) can be seen from the side filling in the hind and lower part of the middle fenestra, and serving to give " origin" to a fan-shaped series of muscular fasciculi (Plate 16, fig. 1). That part is confluent with the hyomandibular, and is hard ; the rest is soft cartilage and passes upwards a little, and then directly backwards, being enclosed in the edge of the "velum" (Plate 16, fig. 6 ; and Plate 17, fig. 1, *vl.*). These sigmoid rods are continuous on their inside, a little in front of their middle, with the fore end of another pair of rods, similar but smaller, and their serial homologues ; these are the 2nd pharyngo-branchials (Plate 17, figs. 2, 3, *p.br*[2].) ; they have no descending part. Each bar, towards the middle, is bent towards its fellow, like the larger first pair, and the two are twice united by a cross band. The front commissural band sends forwards a pair of three-rayed rods spreading out over the others and looking forwards ; and from its hind margin it gives off a single median rod, which passes directly backwards over the hinder commissure, and then breaks up into two larger sub-terminal and two smaller terminal rays. These four rays, and the points of both pairs of main pharyngo-branchials (*p.br*[1]., *p.br*[2].) end in the transverse crenate hind margin of the great upper pharyngeal "velum" (Plate 17, fig. 1, *vl.*). This structure is much like that seen in *Myxine* (Plate 15, fig. 6), but in that Fish the 2nd is free from the 1st pharyngo-branchial, and the median bar of the former is absent.

The complexity of this reticulation of cartilage suggests the presence of a 3rd pharyngo-branchial rudiment, but I am not certain of its existence.

The huge basal bar is quite like that of *Myxine* (Plate 16, figs. 1, 2, 6, *b.hy.*, *b.br*[1].), the front part, for more than a third of the whole length, being composed of hard cartilage, and the rest of *vacuolar tissue;* this part is the 1st basi-branchial (*b.br*[1].), and the other basi-hyal (*b.hy.*). This is a curious piece of special " hypertrophy," for the normally single basal bar is composed of two bars behind, and four in front, all large, solid bars, oval in section. The outer of the front pieces are the largest ; a small fontanelle is seen where the *six* pieces meet, and they are all connected together by tracts of soft cartilage. Looking at the structure as a whole,—first, quadruple, then double, and then single, and composed of four *varieties* of connective tissue,—we see, at once, that it is merely an enormous development of the common "basi-visceral" element. It is hollow above, all along, as in *Myxine;* in front, to hold the secondary trough-shaped cartilage (supra-lingual), and behind, to receive the tendons of some of the muscles that work the whole lingual machinery.

Close behind the hard cartilage of the basi-hyal, the hypo-hyal end (*h.hy.*) of the descending hyoid bar is there continuous both with the hard and the soft cartilage; and behind it, in its *axil*, the lesser bar, or 1st cerato-branchial (*c.br*[1].) is attached,—semi-confluent. The 2nd basi-branchial (Plate 16, fig. 3, *b.br*[2].), is a thickish rod of hard cartilage serving for the attachment of the oblique muscular mass of the lingual apparatus; it is broad in front and narrow behind, and moderately thick. MÜLLER, *who let nothing escape him*, figures a triradiate tract of soft cartilage on the "œsophago-cutaneous duct" (I., plate 7, fig. 5). I find a similar piece (Plate 16, fig. 7, *d.œ.c.*). This is extremely interesting and instructive, for it is all we have in this type—(I do not find it in *Myxine*)—of the huge "extra-branchial" basket-work of the Lamprey, which can already be seen in embryos one-fifth of an inch in length. Thus, if the Myxinoid is a sort of *Ammocœte*, it is an Ammocœte with a difference.

On the supra-lingual apparatus of Bdellostoma.

In these structures, again, we have a curious *generic* difference between *Bdellostoma* and *Myxine;* this series of intra-visceral arches is, however, only gently modified in the former from that of the latter (see Plate 12, fig. 8; and Plate 16, fig. 5).

Here, there is no differentiation of the median bar; the middle, in front, projects forwards as a triangular tongue of cartilage, but not behind the last lateral bars; the middle, there, is merely a soft narrow tract. The first pair of partly-segmented arches is the largest in this type, only the margin, all round, is soft; it ends in two soft incurved horns. The second pair of bars is soon lost in the third, which are almost as large as the first, and are quite hard, except the middle, or connective tract. I see no horny points in the front part of the common ligamentous tract in front, such as we saw in *Myxine* (Plate 12, fig. 8). A deep fissure divides the first pair of arches from the other two; they are only separated across the middle for one-third of their extent. The richly golden, lanceolate teeth (Plate 16, figs. 4 and 6), show two rows, right and left, of more equal teeth than in Myxine (Plate 12, fig. 7); there are *eleven* in each of the four rows; I counted seven on the outer, and nine on the inner rows in *Myxine*. The single upper tooth attached to the ethmoidal region of the skull is a very large "canine," hooked backwards (Plate 16, fig. 6; and Plate 17, fig. 3, *et.t.*).

On the sense-capsules and barbels of Bdellostoma.

The auditory capsules (Plate 16, figs. 1, 6; and Plate 17, figs. 1–3, *au.*) in this type also are very small, and composed of hard cartilage; they are quite confluent with the contiguous parts of the skull; seen from below (Plate 17, fig. 3, *au.*), they are of a full oval form, and their long axis is almost parallel with that of the skull, but looking a little inwards in front. Above (figs. 1 and 2, *au.*) they are reniform, on account of the deficiency of cartilage in the great "meatus internus;" these figures fail to show the involution of cartilage round the anterior canal as seen in the *sections* of these parts in *Myxine* (Plate 14, fig. 3, *au.*). The "meatus" are seen almost directly from above (fig. 2), and they are margined on their inner edge by the parachordals as they pass into the trabeculæ (*iv.*, *tr.*). The proper olfactory capsule (Plate 16, figs. 1, 6, *na.*; and Plate 17, fig. 1, *na.*) is only gently modified from that of *Myxine;* its fore margin is partly united with the last ring of the outer nasal tube (*e.n.t.*). There are only eleven imperfect annuli in *Myxine* (Plate 10, fig. 1 *e.n.t.*), in this type there are twelve, but these are not quite distinct, as in the Hag Fish; here, the first three are united, and have one small and two large fenestræ; the seventh and eighth are joined in the middle, and the twelfth, partially, with the proper capsule (*na.*). So unlike is the structure of the lips in these, to what is seen in any other types, that nothing but *re-dissection* enabled me to understand MÜLLER's perfectly accurate figures; especially was this the case in the "barbels."

Here (Plate 16, fig. 1; and Plate 17, figs. 1–3, *n.bb.*, *o.bb.*) they are much more modified than in *Myxine* (Plates 9 and 10). The upper pair (1st nasals) are united across the mid-line by a strong commissure which passes under the top of the front intertrabecula (*a.i.tr.*), and the second pair (2nd nasals) are attached to the first where they pass into the cross band.

The upper orals (*o.bb.*) are triradiate, they send an upper curved ray to join the two nasal palpi, and from their proper palpal part which grows forwards they send backwards a lobe over the 4th (or 2nd oral). This latter cartilage is bent forwards, and then sends out three short snags; its upper horn fits into the angle of the 1st oral, and its hinder horn turns backwards and downwards, nearly reaching the front of the "supra-lingual" apparatus. If we turn to the figures of the barbels in their *undissected* state, we shall see reason to believe that they all belong to the *upper lip* (Plate 8, figs. 7–9; Plate 13, fig. 7—*Myxine;* and Plate 15, fig. 5—*Bdellostoma*); in the large kind the 2nd orals are but little produced as barbels, but form an evident fold in front of the lower lip. Thus, in the fullest development of a *Myxinoid's* mouth there is no more promise of what the transformed Lamprey shows in the *lower lip* than in its own larva—the *Ammocœte.* As *Marsipobranchii,* the "Myxinoids" are more specialised, in some important respects, than the "Petromyzoids;" but as *suctorial* Fishes they are altogether below them, bearing to them a sort of *quasi-larval* relation.

Description of a longitudinally vertical section of the head of Bdellostoma.

In this section (Plate 16, fig. 6) we see many things brought into view which may help in the comprehension of this remarkable type of cranio-facial skeleton. Muscular segments and their interseptal fibrous tracts are found running over the brain up to the nasal sac (*na.*, *ol.*); the brain mass (C.) insensibly passes into the *myelon* (*my.*), which latter is supported by the large notochord (*nc.*). This figure shows the *vacuoles* ending some distance behind the thick sheath; this appearance is due to the fact that the section was not quite in the middle: the proper structure of the notochord ends opposite the middle of the ear capsules. The capsule (*au.*) is shown in section near the meatus, so that its thickness appears greater than it is in reality, as the parachordal cartilage thickens it on the inside. The folds of the nasal capsules (*na.*, *ol.*) are brought into view, and the cartilages (*na.*), both of the capsule itself (*ol.*) and of the external nasal tube (*e.n.t.*) are cut through, very near the mid-line. A continuous passage is seen from the external opening (*e.n.*) of the nasal passage (*n.p.*) to the fringed lips of the naso-palatine canal (*p.n.c.*) which opens at the mid-line at the fore part of the velum (*vl.*), here shown in section, with a point of cartilage in it, here and there, caught by the razor. The size of the cavity and the character of the folds inside it, of the fore part of the naso-palatine canal (*p.n.c.*) are seen in this section, and also that these lie *on the floor of the skull*, between the hind intertrabecula (*p.i.tr.*) and the brain (C.) The opening *out of the skull* is behind that median cartilage, between the produced "bowl" of the "spoon" (Plate 17, fig. 3, *p.i.tr.*) and the beginning of the trabeculæ (*tr.*, *iv.*). Another cavity—a space between the hinder intertrabecula and the roof of the mouth—is also seen. This is evidently artificial, and caused by the tearing away of the mucous membrane of the palate from the hinder intertrabecula. A curious coiled valve is seen behind these two openings, under the fore part of the velum, at the beginning of the pharynx; a little in front of this fold, the proper oral cavity (lined with *epiblast*, the pharynx being lined with *hypoblast*) ends. At this part, the entrance of the proper pharynx, the passage is a series of slits or fissures (see the *sections* of the skull of *Myxine*, in Plate 13). Somewhat *left* of the mid-line, this section shows only part of the front intertrabecula (*a.i.tr.*), and thus the whole of the great median tooth (*et.t.*), and the ethmoid (*eth.*), a little to the left, is seen under it. Both the ethmoid and the base of the tooth are enclosed in a special fold of membrane over the oral entrance (*m*). That space would be large, but *two additional lingual masses*, the paired rows of teeth (*s.l.t.*) and their membranous and cartilaginous settings (*s.l.c.*), fill the greater part of the space between the basi-hyal and the palatal membrane. This section being a little to left of the mid-line, shows the inner edge of the *left* bars of the basi-hyal (*b.hy.*), and as the middle bars of the front or quadruple part are shorter than those outside, the cartilage is seen to stop short of the fore end of the under face (lower lip). These cartilages are enveloped in the muscular masses that move the tongue. The upper or ethmoidal tooth (*et.t.*) is seen to turn its point backwards; in the figure it is *in front of* the paired rows of supra-lingual teeth (*s.l.t.*), but the powerful muscular apparatus works so as to make it antagonistic to the lower teeth, generally, which can be made to move backwards and forwards, and from side to side. This whole muscular mass, in my larger specimen, is sub-cylindrical, six inches long, and one inch in thickness. The reader is referred to MÜLLER'S works for a description of the whole apparatus.

On the cranial nerves of Bdellostoma.

For a detailed account of these, and also of the whole nervous system, the same excellent author is referred to; but I have given an outline figure of the skull with the cranial nerves shaded, to help in the determination of the skeletal parts. My own dissection of these nerves was made with the help of MÜLLER's work ('Neurologie,' III.). I made no attempt to find any filaments of the 3rd, 4th, and 6th. The vagus nerve (Plate 10, fig. 4, X.) probably contains the fibres that in higher forms are given off as the separate glosso-pharyngeal. MÜLLER does not figure that nerve as distinct, nor can I find it. But the vagus is very large, and as its proper related structures are removed far backwards, passes directly backwards at right angles to the spinal nerves (*sp.n*$^{1-3}$.). The vagus emerges behind the auditory sac (*au.*), over the short parachordal.

The 8th or auditory nerve is not figured; it passes into the auditory capsule through the great meatus internus.

The 7th nerve (VII.) is shown; it finds its way out of the skull in front of the auditory capsule, between the "pedicle" and the head of the hyomandibular (fig. 2, *pd.*, *hm.*), and turning backwards, burrows under the "shoulder" of the hyomandibular, escaping again behind the *symplectic* region—the hind boundary of the second fenestra —and passes down with, and in front of, the descending epi-cerato-hyal bar (*e.hy.*, *c.hy.*).

The 5th or trigeminal nerve (V.) is immense, and at first sight rather difficult of interpretation. I follow MÜLLER's notation, finding nothing in it to criticise. It is seen emerging in front of the auditory capsule over the pedicle (*pd.*). It then breaks up into three branches, two of which pass *over* the subocular fenestra (*s.o.f.*), whilst one pierces that membrane behind, and passes *under* the palato-quadrate cartilage. The 1st branch, the orbito-nasal (or *ophthalmic,* V^1.), is very large, and soon breaks up into a lesser outer and a larger inner branch. The inner branch then becomes trifid. The "upper maxillary," or second branch of the trigeminal (V^2.) is *considerably less* than either of the three branches of the ophthalmic; it runs over the subocular fenestra, and the palato-quadrate cartilage. The "inferior maxillary," or third branch (V^3.), is as large as the ophthalmic, and as soon as it has passed through the suborbital fenestra it breaks up into four branches, which pass to the lower parts of the head in front.

The optic nerves (II.) are about a fourth the size of the small maxillary nerve; they pass under the ophthalmic (orbito-nasal), and are distributed to the arrested eye-ball (*e.*), enclosed in the much larger *fat body* (*c.a.*).

The olfactory nerves (I.) pass through the membranous "cribriform plate," which is in two divisions and oblique. The huge olfactory lobes give off each *five nerves,** and these, *beginning to bifurcate,* pass in a sub-horizontal row, right and left, to the olfactory folds (*ol.*); here there is a most remarkable anticipation of the Mammalian

* The outer or fifth bundle of the olfactory nerve lies somewhat under the fourth, and is not shown in the figure.

olfactory nerves and *cribriform plate.* If we now compare the diagram (Plate 17, fig. 4), and the meagre description just given of the cranial nerves of this great Myxinoid, we shall find many things become clear that have been for a long time confusing to the students of these types; for there has, apparently, been much *concrescence* and much *suppression* in the development of the cranial nerves in these remarkable Fishes. In the Lamprey, also, there are some very abnormal characters. The right determination of the skeletal parts is largely dependent upon a true knowledge of the cranial nerves, and, *vice-versâ,* they have to be considered in their relation to the supporting skeleton.

MÜLLER II. ("Gehörorgans," plate 3, figs. 3, 4, 5) gives upper, lower, and side figures of the brain of *Petromyzon fluviatilis,* and he enumerates the following nerves going off from it right and left, viz.: I. Olfactory (large and single); II. Optic (moderate size); III. Oculo-motor (very small); IV. Trochlearis (still smaller); V. Trigeminus; VI. Facialis; VII. Acusticus; VIII. Vagus; IX. Hypoglossus.

In the second plate figures are given of the brain of *Bdellostoma* (figs. 8, 9) and *Myxine* (figs. 11, 12).

In these closely related types we have the following cranial nerves given by MÜLLER, viz.:—

I. Olfactory (in five main nerves on each side, and these also each breaking into a small pencil of branches); II. Optic (very small in *Bdellostoma,* but paired; much smaller and only drawn on the *right side* in *Myxine*); III. Trigeminus (very large); IV. Facialis; V. Acusticus; and VI. Vagus (very large).

In his paper (III.) on the 'Neurologie' of the Myxinoids, MÜLLER (plate 2, figs. 4, 5) gives the cranium and its nerves in *Bdellostoma* from above and below. In the upper view the optic nerve is shown passing under the ophthalmic nerve, which is drawn with its first bifurcation. The larger part of the nerve is seen penetrating the suborbital fenestra, and in the lower view this lower part (3rd branch) is seen broken up into four branches, the second of which is re-split. But in the upper view there is also, behind the ophthalmic (1st branch), a small nerve passing over the palato-quadrate cartilage; this he does not name.

But in the next plate (III., figs. 2 and 3) we have this 2nd branch of the trigeminal figured on both sides. In the upper view (fig. 3) it is seen as passing over the cartilage bounding the suborbital fenestra, and in the side view (fig. 2) it is shown as running forwards along the upper surface of the palato-quadrate nearly up to the beginning of the soft "pre-palatine horn." Here it is called "Vorderen ober Ast des Trigeminus," whilst the large branches that grow from the stalk that pierced the fenestra are called "Unter Aeste desselben,"—the lower branches of the same nerve. In the upper view (fig. 3), where the 1st and 2nd branches (only) are drawn, he calls this small nerve "Hinterer oberer Hautast des Trigeminus;" whilst the branches of the great 1st division (Ophthalmic), "Vorderer ober Ast des Trigeminus," he calls "1, Hautast; 2, Nasenast; 3, Oberer Endast; and 4, Unterer Endast."

That there is no mistake here I feel certain; my own dissection shows the same pair of nerves, namely, the *small*, proper, 2nd branch of each trigeminal.*

Now in these Myxinoids we miss the 3rd, 4th, and 6th cranial nerves; also the glosso-pharyngeal or 9th nerve as a separate nerve.

In *Petromyzon*, also, MÜLLER misses the 6th or "abducens" (II., plate 3, figs. 3–5); the "upper maxillary branch" of the trigeminal is small and inconspicuous but quite as large as in *Bdellostoma*. This being the case we have an explanation of what has been a difficulty with us for years; Professor HUXLEY† speaks of "a singular anomaly" in both *Petromyzon* and the Myxinoids, in that "Both the second and third divisions of the trigeminal nerve pass through the subocular membrane, and therefore on the ventral side of the (subocular) arch;" but this error was corrected by him soon afterwards.

That the *arch* and the *membrane* (fenestra) are both the exact counterparts of what we find in the various Batrachian larvæ I cannot doubt; and there is no doubt now, of the existence of a 2nd branch to the trigeminal in *Petromyzon;* and, as we have just seen, such an *upper* branch does exist in *Bdellostoma*, between the huge 1st and 2nd branches.

Summary and conclusion of Part I. (Myxinoids).

In seeking for 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 rudiments 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 which is 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 formed between the "Myomeres" behind the head. Evidently, therefore, the early "Craniata" grew supports to the enlarged and sub-divided front end of the neural axis long before anything beyond strong fibrous septa were developed between the muscular segments of the body. As for the linear growth, and the less or greater extension backwards of the main organs,—circulatory, respiratory, digestive, and uro-genital—that in the variation of the primordial form was a thing to be determined by the life and 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

* See also RETZIUS, plates 1 and 2, and note to p. 42, in Part II.

† See "On the Nature of the Cranio-facial Apparatus of *Petromyzon*" (Jour. of Anat. and Phys. vol. 10, p. 423, a paper to which I am exceedingly indebted in working out these types).

beneath the head; the body and tail, together, forming merely a propelling organ, as is 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,* but the vesicular brain, the suctorial lips, the purse-shaped gills, 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 two of these for them, only, so that these Fishes are chordate and craniate, but are not *vertebrate,* if we stick to the letter. 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 specialised 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 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 "Craniata." For us, *now,* the Myxinoids, Petromyzoids and Anurous 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 types of Fish are evidently the descendants of primordial "Marsipobranchs," notably *Lepidosteus,* the development of which has lately been made out and the results published in the Philosophical Transactions (1882, Part II.).

But the *Chimæroids* and *Dipnoi,* and, what is 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 many such papers.

The Myxinoids keep on the low platform of the larval Lamprey (or *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 cortinuous cornua).

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

d. The last character involves another, 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 hyoidean 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 inter-trabecula.

d. There is a large median cartilaginous olfactory capsule.

The Myxinoids go beyond even the adult Lamprey in the following characters, 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 an equal development of the "*suspensorium,*" but the *suspensorial part* of the hyoid is developed also (it is suppressed in the Lamprey); and there is (in *Bdellostoma*) a large complete 1st branchial arch, and in both kinds pharyngo-branchial rudiments of the 2nd branchial arch.

b. The respiratory pouches are much more specialised, being carried far back under the spine.

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

d. The opening to 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 apparatus, 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 adult Lamprey, and carry only one pair of rows of small recurved teeth, in the Myxinoids are very laige, and carry two pairs of rows of large teeth, with the addition of a median ethmoidal antagonist tooth.

Lastly, the greater development of the intra-visceral 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.

Explanation of the Abbreviations.

The Roman numerals indicate nerves or their foramina.

a.i.tr. Front intertrabecula.
au. Auditory capsule.
bb. Barbels.
b.br[1, 2]. Basi-branchials.
b.c.f. Basi-cranial fontanelle.
b.h.br. Basi-hyobranchial.
b.hy[a]. Front basi-hyal.
b.hy[b, p]. Hind basi-hyal.
b.p. Buccal pouch.
br.a. Branchial artery.
br.c. Branchial canal.
br.d. Branchial duct.
br.p. Branchial pouch.
C[1, 2, 3]. Cerebrum.
c.a. Corpus adiposum.
c.br. Cerato-branchial.
c.hy. Cerato-hyal.
c.tr. Cornu trabeculæ.
cl[1, 2, 3]. Clefts.
d.m. Dura mater.
d.œ.c. Ductus œsophago-cutaneus.
e. Eye
e.br. Epi-branchial.
e.f[2, 3]. External (*lateral*) fenestræ.
e.hy. Epi-hyal.
e.n.t. External nasal tube.
e.pa. Ethmo-palatine.
eth. Ethmoid.
et.t. Ethmoidal tooth.
f. Fenestra.
h. Heart.
h.hy. Hypo-hyal.
hm. (and *h.m.*) Hyomandibular region.
i.vl. Inferior velum.
l.f[2, 3]. Lateral fenestræ.
l.l. Lower lip.
l.mm. Lingual muscles.
m. Mouth.
m.h.c. Mandibulo-hyoid-cartilage.
m.h.f. (*m.hy.f.* and *h.m.f.*) Mandibulo-hyoid-fenestra.
m.hy. Mandibulo-hyoid.
my. Myelon.
na. Nasal capsule.
n.bb. Nasal barbels.
nc. Notochord.
n.c. Nasal cavity.
o.bb. Oral barbels.
ol. Olfactory folds.
pa. Palatine cartilage.
pal. Palatine mucous membrane.
p.br[1, 2]. Pharyngo-branchials.
pg. Pterygoid.
phx. Pharynx.
p.i.tr. Hinder intertrabecula.
p.n.c. Posterior nasal canal.
pr.pa. Pre-palatine cartilage.
p.tr. Palato-trabecular.
q. Quadrate region.
s.l.c. Supra-lingual cartilage.
s.l.f. Supra-lingual folds.
s.l.t. Supra-lingual teeth.
sp.n. Spinal nerve.
s.o.f. Suborbital fenestra.
sy. Symplectic region.
th.v. Theca vertebralis.
u.l. Upper lip.
vl. Velum.

Description of the Plates.

Plate.	Fig.		Number of times magnified.
8	1	Embryo of *Petromyzon planeri*, 7·8 millims. long; side view	33
,,	2	The same; part of upper view	33
,,	3	The same; part of lower view	33
,,	4	Larva of *Petromyzon fluviatilis*, 2 inches long (nearly); side view	5
,,	5	The same; part of upper view	5
,,	6	The same; part of lower view	5
,,	7	Adult *Myxine glutinosa;* side view	Natural size
,,	8	The same; part of upper view	Natural size
,,	9	The same; part of lower view	Natural size
,,	10	Adult *Petromyzon marinus;* lower view of head	Natural size
,,	11	Adult *Petromyzon fluviatilis;* lower view of head	2
,,	12	The same; side view of head	2
,,	13	The same; upper view of head	2
,,	14	Adult *Petromyzon planeri;* side view of head	2
,,	15	The same; lower view of head	2
,,	16	The same; upper view of head	2
9	1	Adult *Myxine glutinosa;* dissection of fore part; side view	$2\frac{1}{2}$
,,	2	The same dissection (part)	5
,,	3	The same; lower view	5
,,	4	The same; further back; lower view	5
10	1	Adult *Myxine glutinosa;* skull, upper view	5
,,	2	The same, with base exposed	5
,,	3	The same; lower view	5
,,	4	Newly transformed *Petromyzon marinus* (4 inches long); skull, upper view	$12\frac{1}{2}$
,,	5	The same; lower view	$12\frac{1}{2}$
,,	6	The same; inferior labials; lower view	$12\frac{1}{2}$
,,	7	The same; framework of "inferior velum"	15

Plate.	Fig.		Number of times magnified.
11	1–11	Adult *Myxine glutinosa;* first eleven of a series of transversely-vertical sections through cephalic region	10
,,	12	The same; fore part of supra-lingual cartilage; upper view	18
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14	1–7	Adult *Myxine glutinosa;* twenty-fourth to thirtieth of the vertically-transverse sections	10
,,	8	Adult *Petromyzon fluviatilis;* lower velum, and fore part of branchial region; upper view	$7\frac{1}{2}$
,,	9	Adult *Petromyzon fluviatilis;* tongue, with anterior and supra-lingual teeth	$7\frac{1}{2}$
,,	10	The same; vertical section showing supra-lingual and fore part of basi-hyal cartilages	$7\frac{1}{2}$
15	1–4	Adult *Myxine glutinosa;* thirty-first to thirty-fourth of the vertically-transverse sections	10
,,	5	*Bdellostoma Forsteri* ($1\frac{1}{2}$ foot long); from snout to cardiac region; lower view	$\frac{3}{4}$ natural size
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,,	9	The same; another similar section at mid line . . .	4

Plate.	Fig.		Number of times magnified.
16	1	Adult *Bdellostoma Forsteri*, large specimen ($2\frac{1}{2}$ feet long); skull, side view of skull	2
,,	2	The same (large specimen); basi-hyobranchial and supra-lingual cartilages ; lower view	$1\frac{1}{2}$
,,	3	The same (large specimen); hinder part of lingual muscular mass with 2nd basi-branchial	$1\frac{1}{2}$
,,	4	The same (large specimen); supra-lingual apparatus, with teeth	2
,,	5	The same (large specimen), with teeth removed . . .	2
,,	6	*Bdellostoma Forsteri*, small specimen ($1\frac{1}{2}$ foot long); vertical section of head and throat	3
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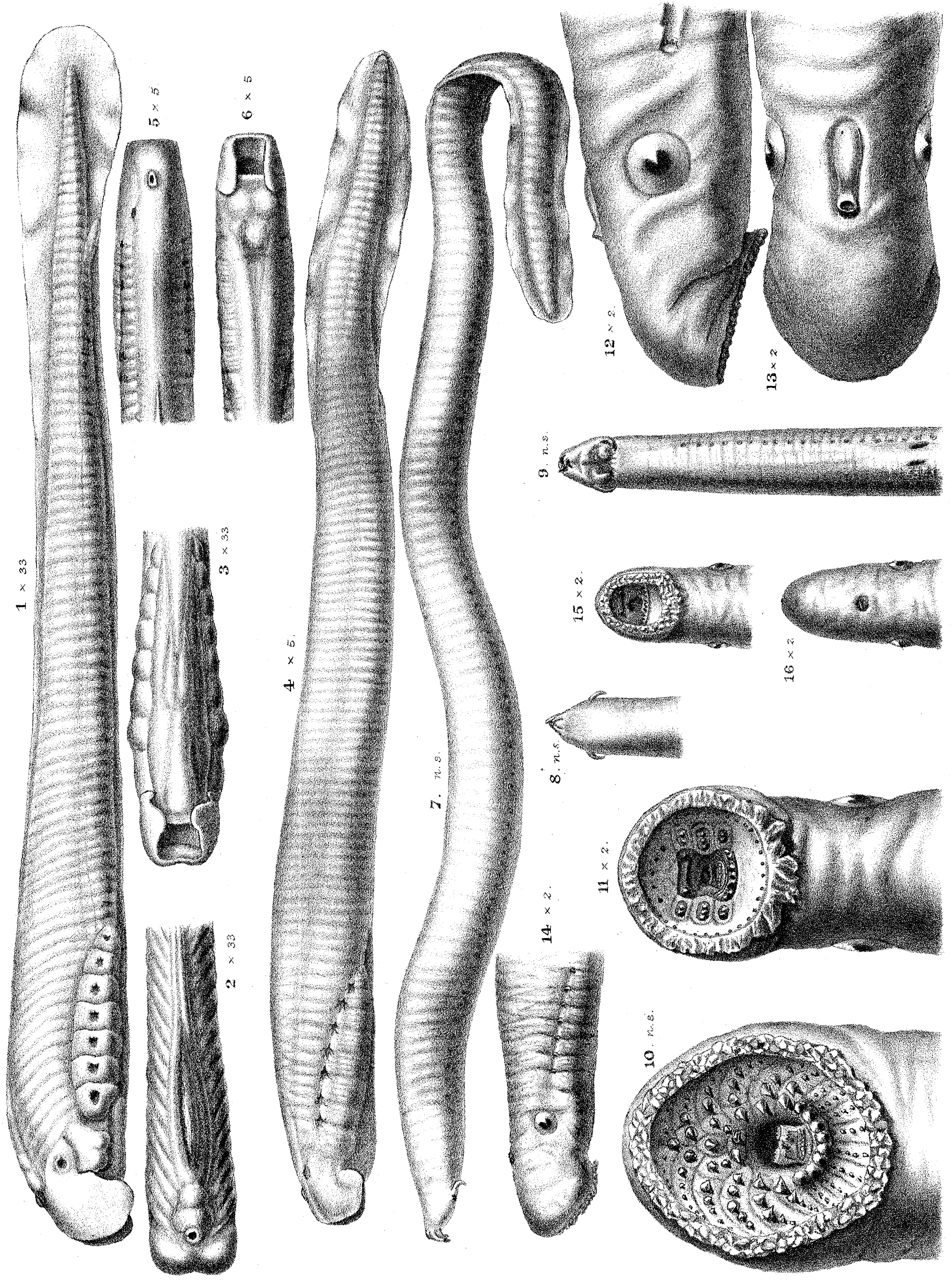
17	1	Adult *Bdellostoma Forsteri* ($2\frac{1}{2}$ feet long); skull, upper view	2
,,	2	The same, with base of skull exposed	2
,,	3	The same ; lower view	2
,,	4	The same ; outline, with cranial nerves ; upper view .	2



W.K.P. del. ad nat.
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MARSIPOBRANCH FISHES.

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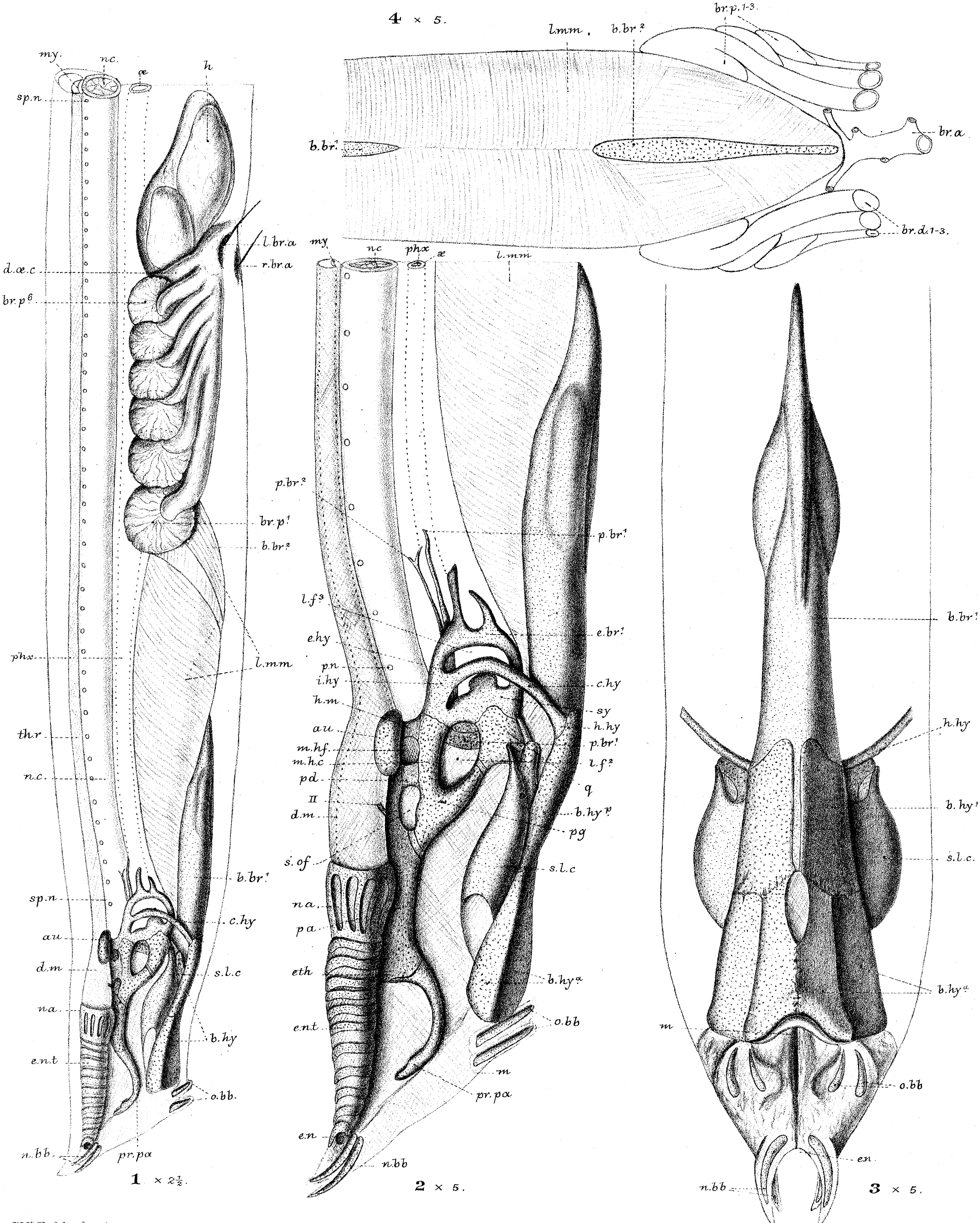
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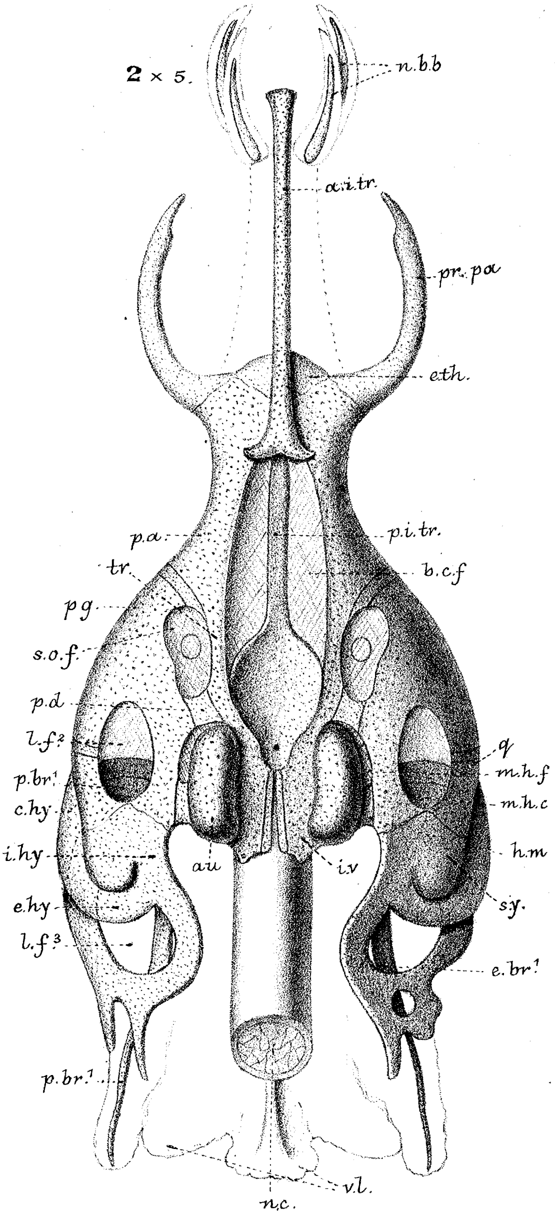
b.br.¹
h.hy
b.hy.¹
s.l.c.
b.hy.ᵃ
m
o.bb
en.
n.bb.
3 × 5.

2 × 5.



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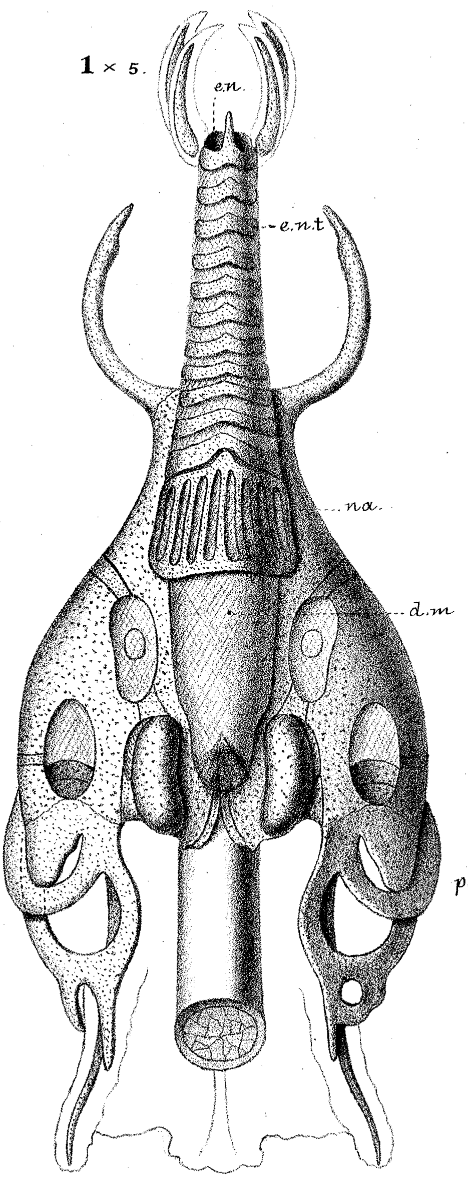

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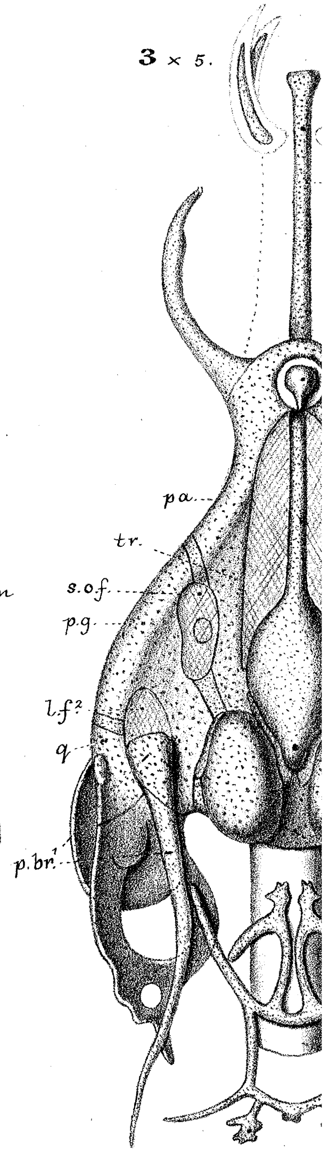
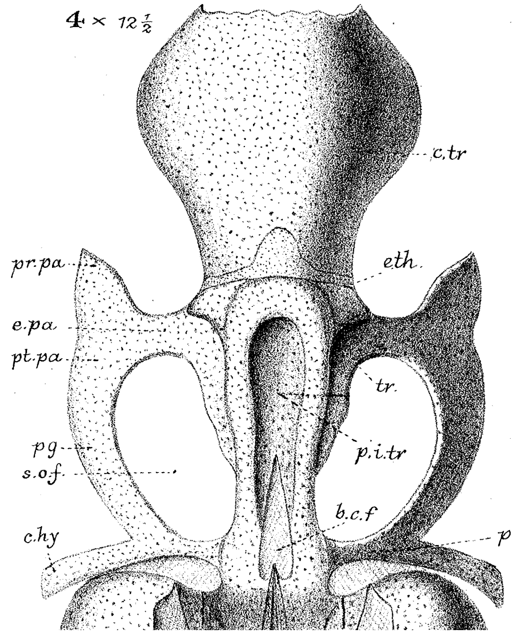
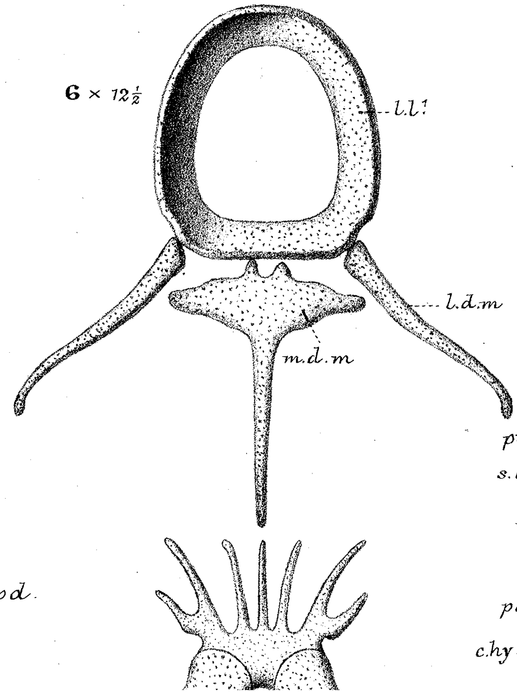


4 × 12½



6 × 12½



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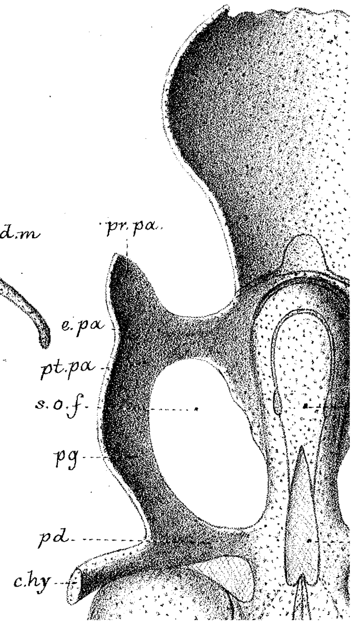

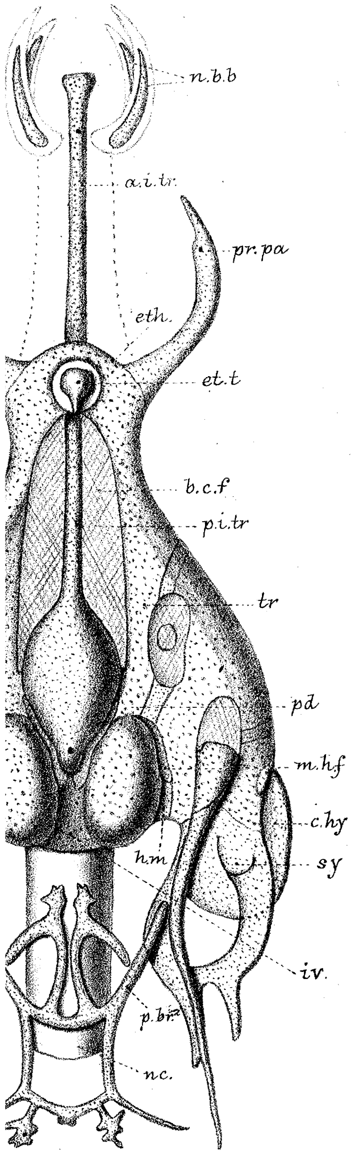
n.b.b
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eth.
et.t
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p.i.tr
tr
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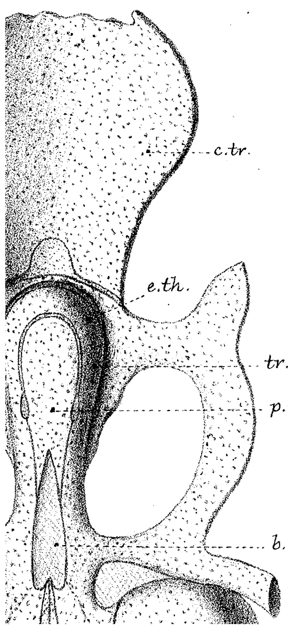
m.hf
c.hy
h.m
sy
iv.
p.br.
nc.

5 × 12½.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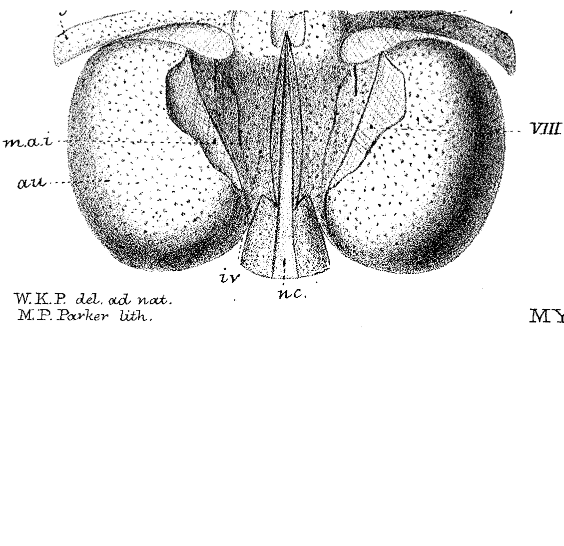
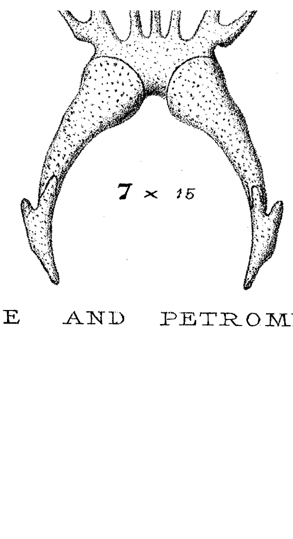
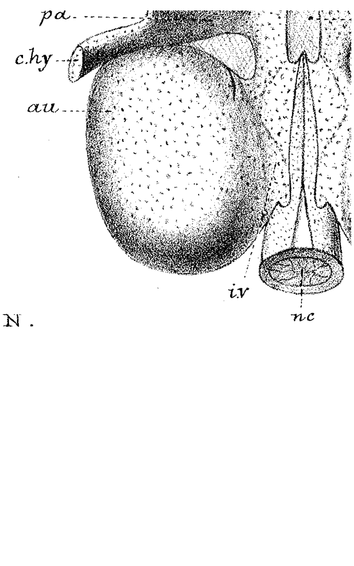
e.th.
tr.
p.i.tr.
b.c.f

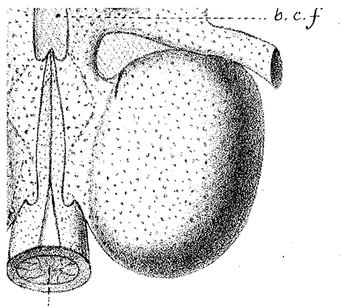




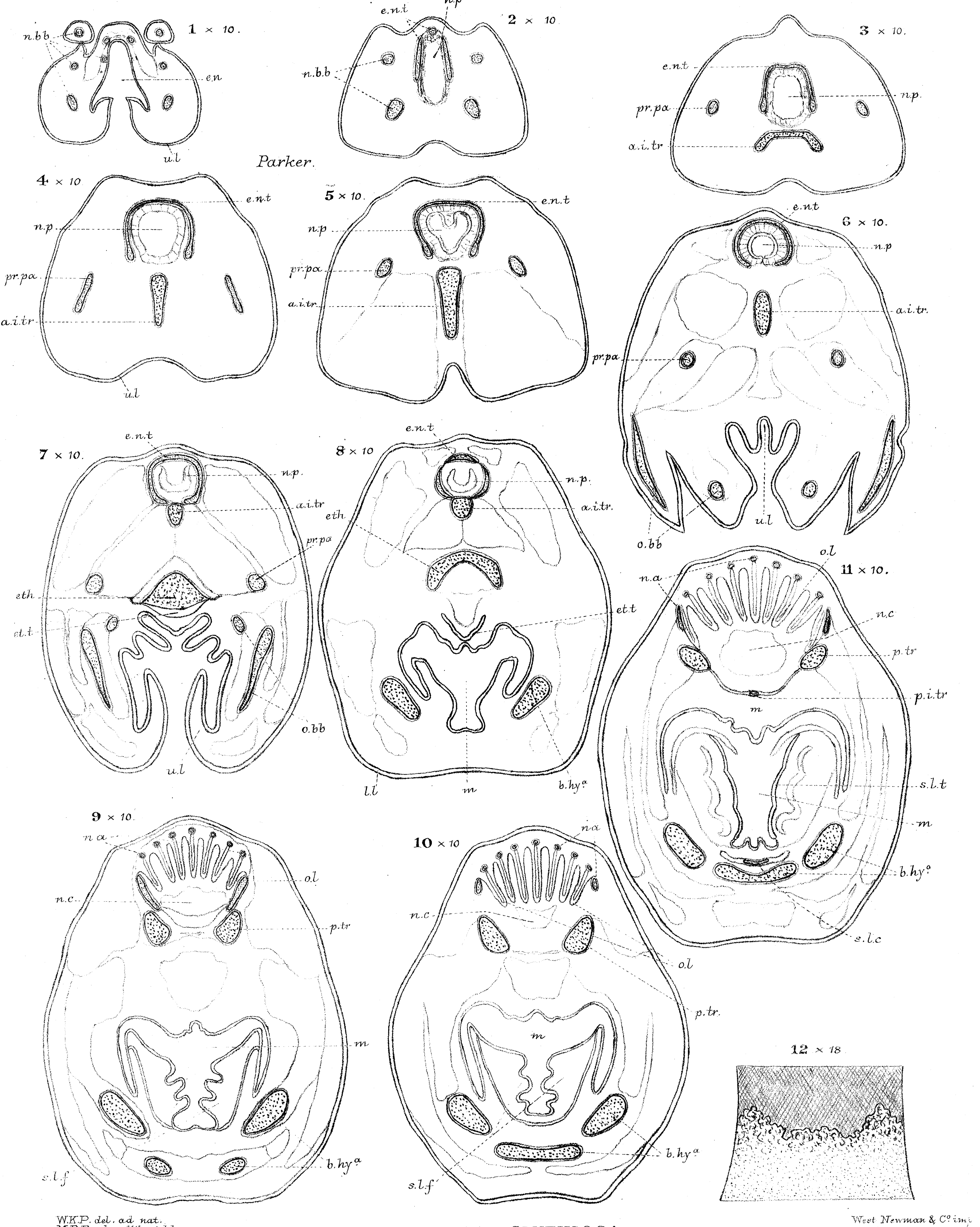


W.K.P. del. ad nat.
M.P. Parker lith.

MYXINE AND PETROMYZON.



West Newman & C°. imp.

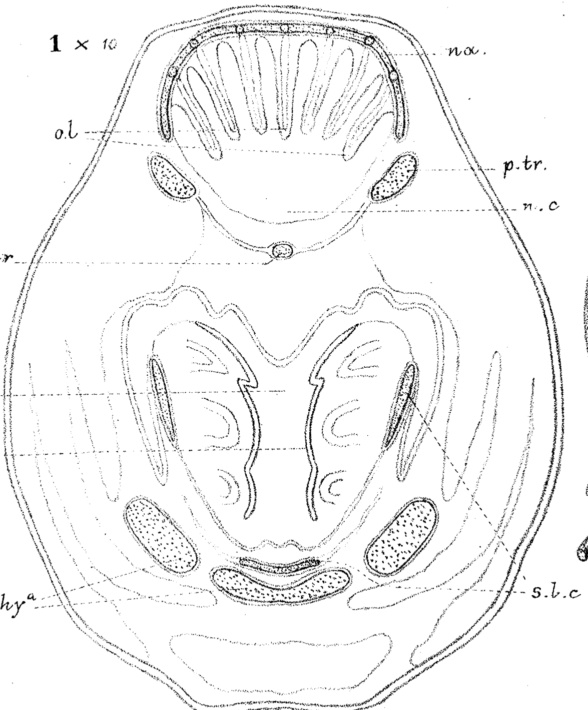


W.K.P. del. ad nat.
M.P. Parker lith. et del.

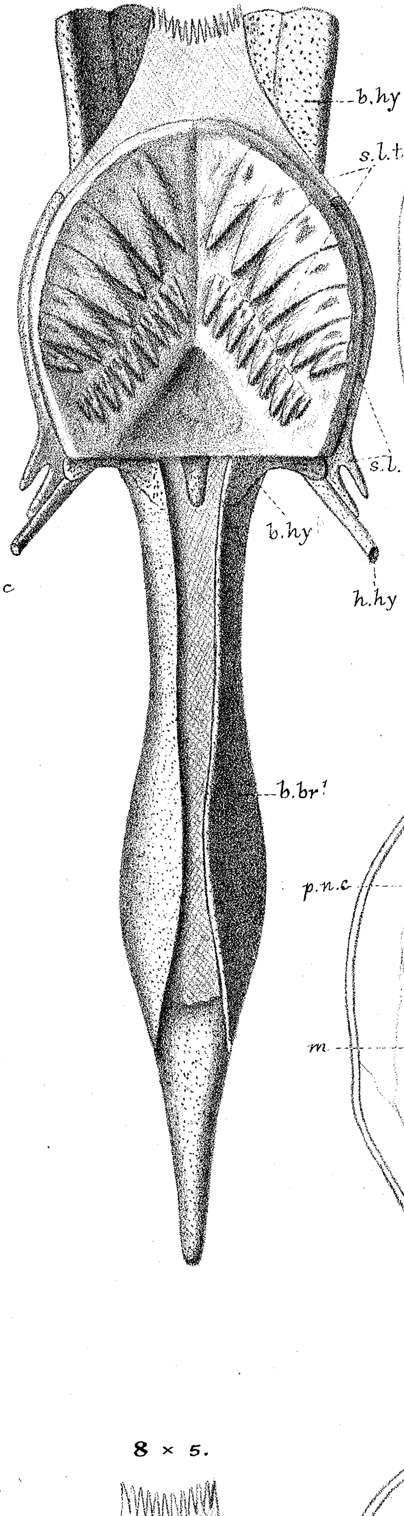
MYXINE GLUTUIOSA.

West Newman & Co. imp.

1 × 10

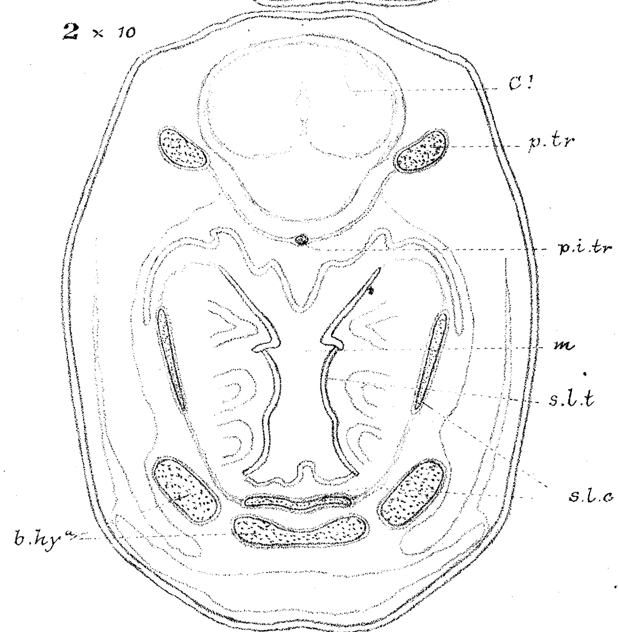


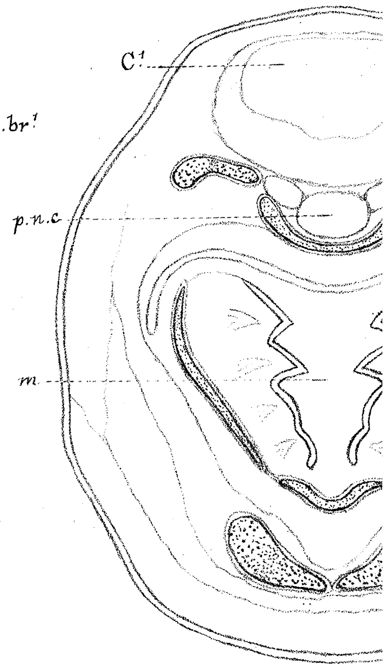
7 × 5.



3 × 10

2 × 10





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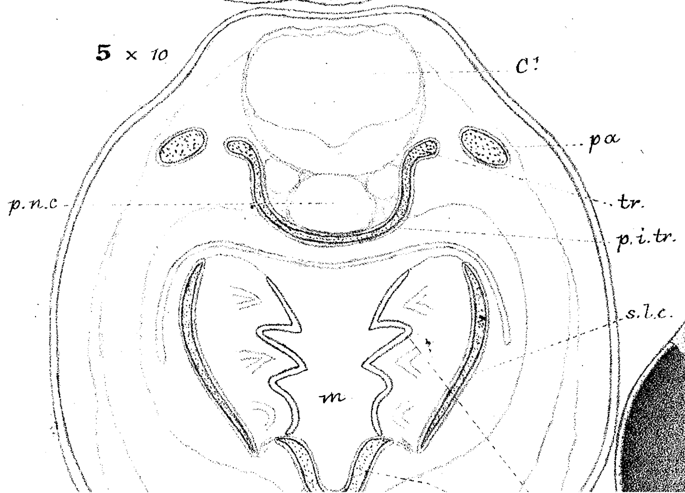
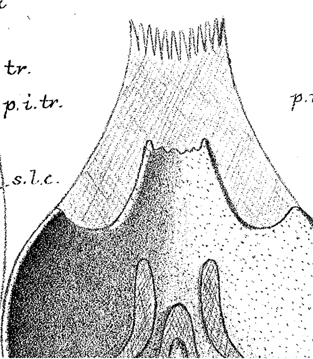
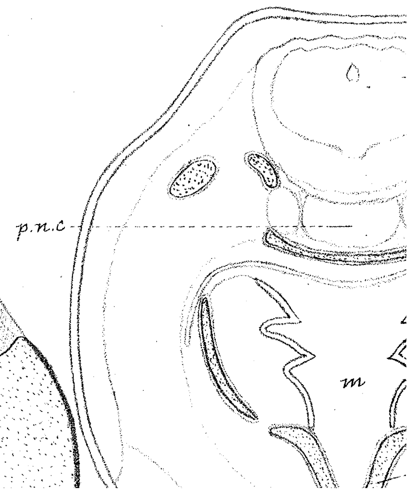
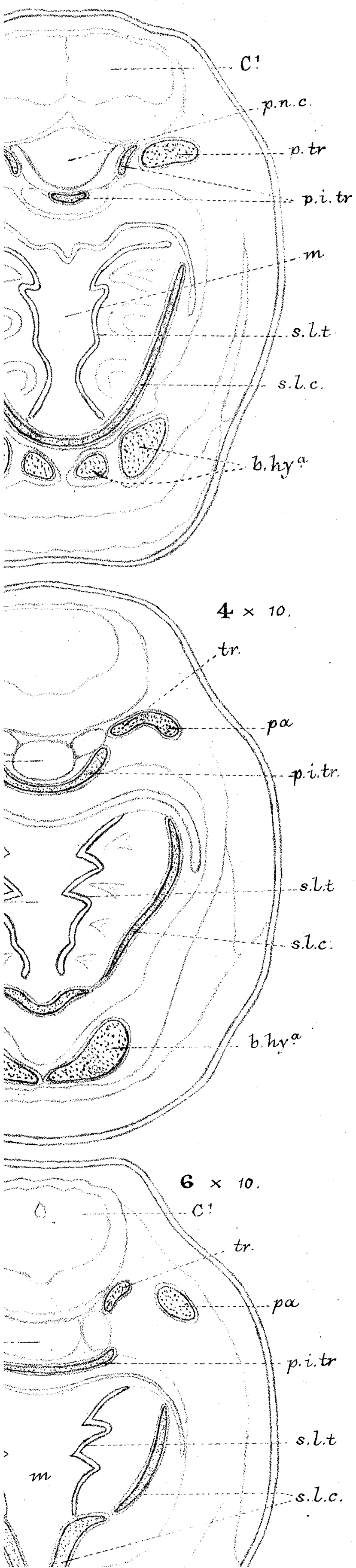


8 × 5.






C¹
p.n.c.
p.tr
p.i.tr
m
s.l.t
s.l.c.
b.hy^a
4 × 10.
tr.
pα
p.i.tr.
s.l.t
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b.hy^a
6 × 10.
C¹
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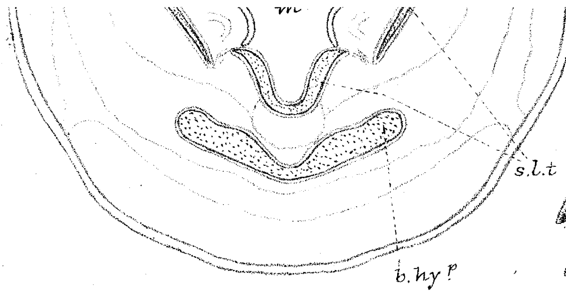
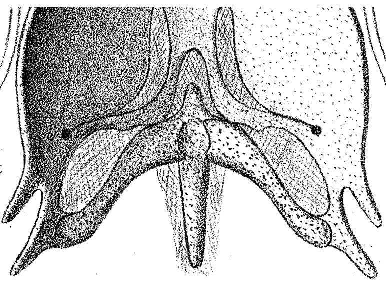
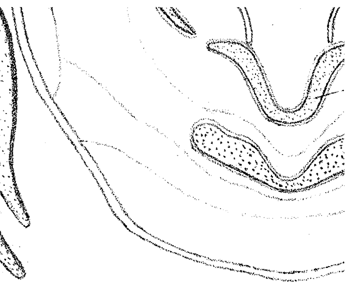
p.i.tr
s.l.t
m
s.l.c.

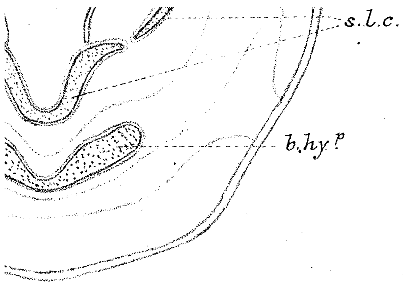




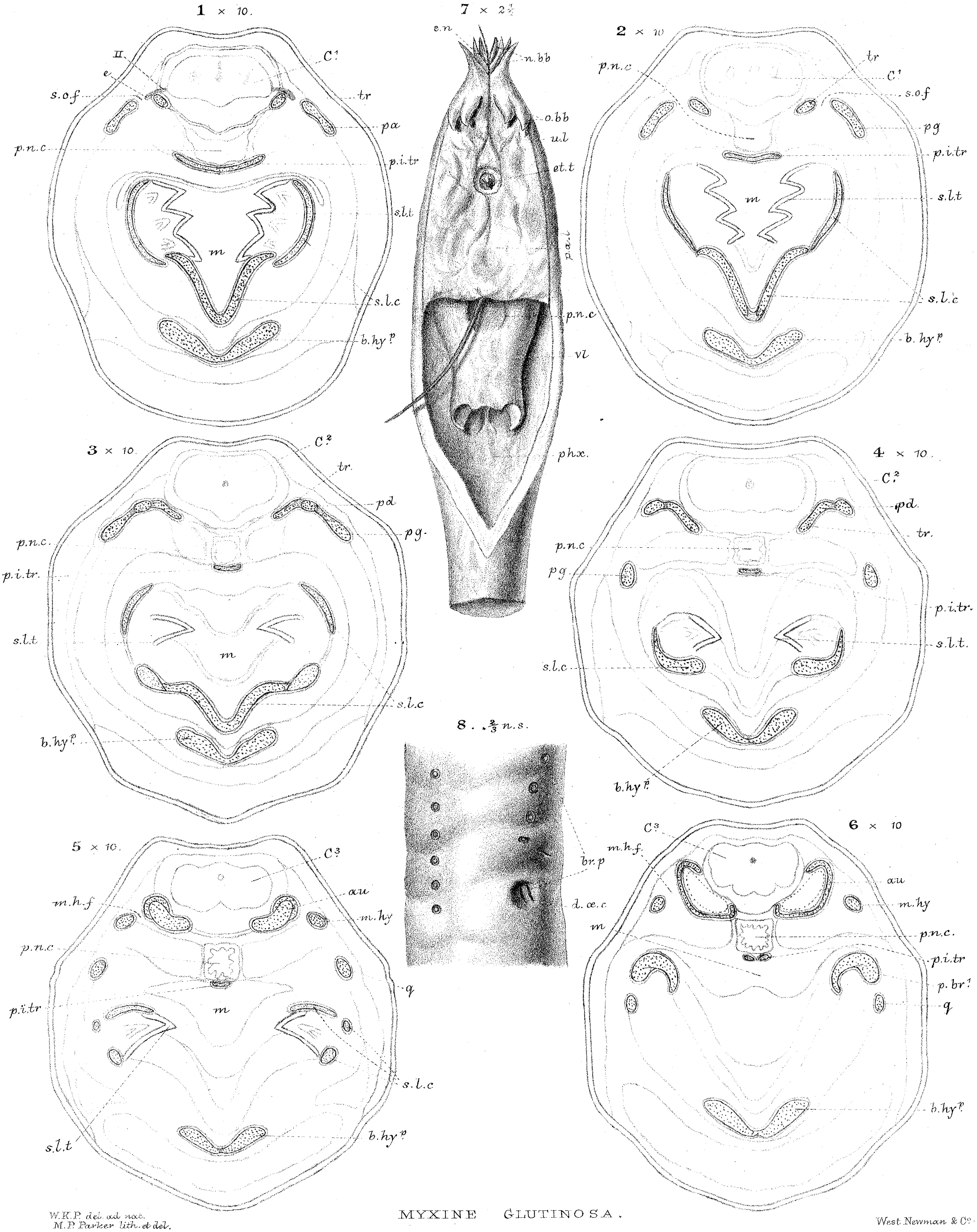


W.K.P. del. ad nat,
M.P. Parker lith. et del.

MYXINE GLUTINOSA.



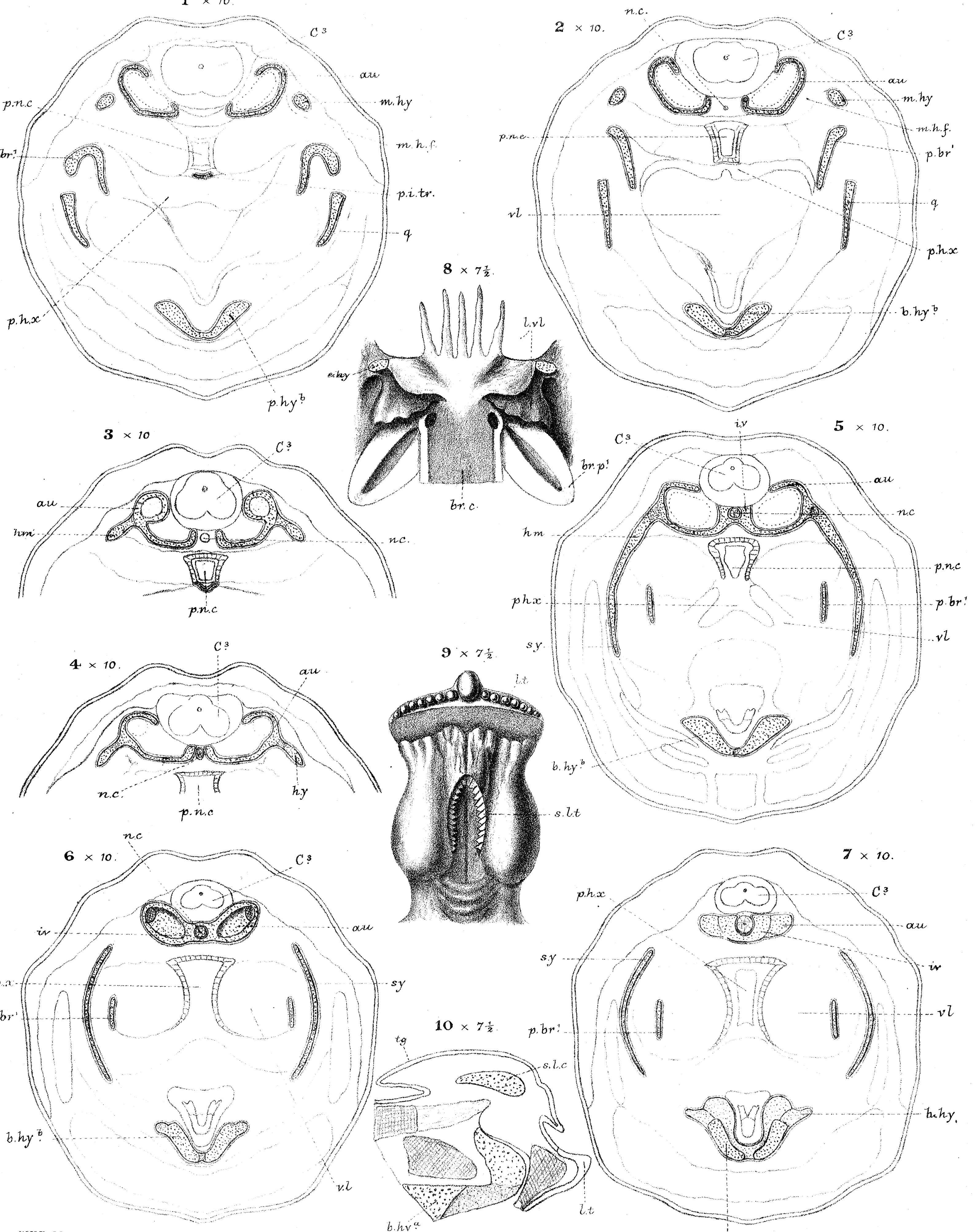
West Newman & Co. imp.



W.K.P. del. ad nat.
M.P. Parker lith. et del.

MYXINE GLUTINOSA.

West Newman & Co.


1 × 10.
C³
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m.h.f.
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p.i.tr.
q
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p.hy.ᵇ
2 × 10.
n.c.
C³
au
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m.h.f.
p.n.c
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8 × 7½.
l.vl
e.hy
br.p.¹
br.c.
3 × 10
C³
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hm
n.c.
p.n.c
5 × 10.
i.v
C³
au
n.c
hm
p.n.c
p.h.x
p.br.¹
s.y
vl
b.hy.ᵇ
4 × 10.
C³
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n.c.
hy
p.n.c
9 × 7½.
l.t.
s.l.t
6 × 10.
n.c
C³
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p.h.x
sy
p.br¹
b.hy.ᵇ
v.l
7 × 10.
p.h.x
C³
au
s.y
iv
vl
p.br.¹
b.hy.
b.hy.ᵇ
10 × 7½.
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l.t
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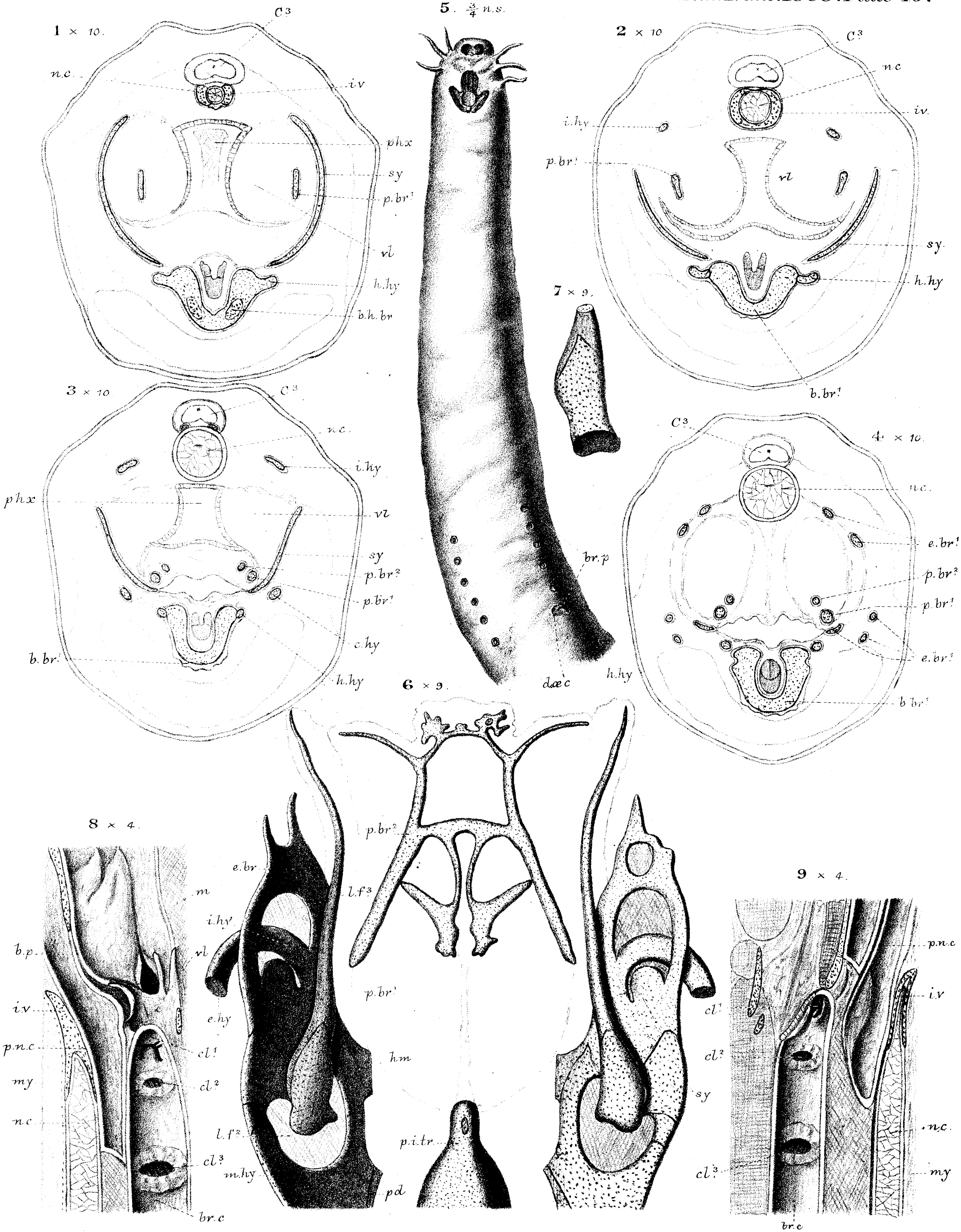
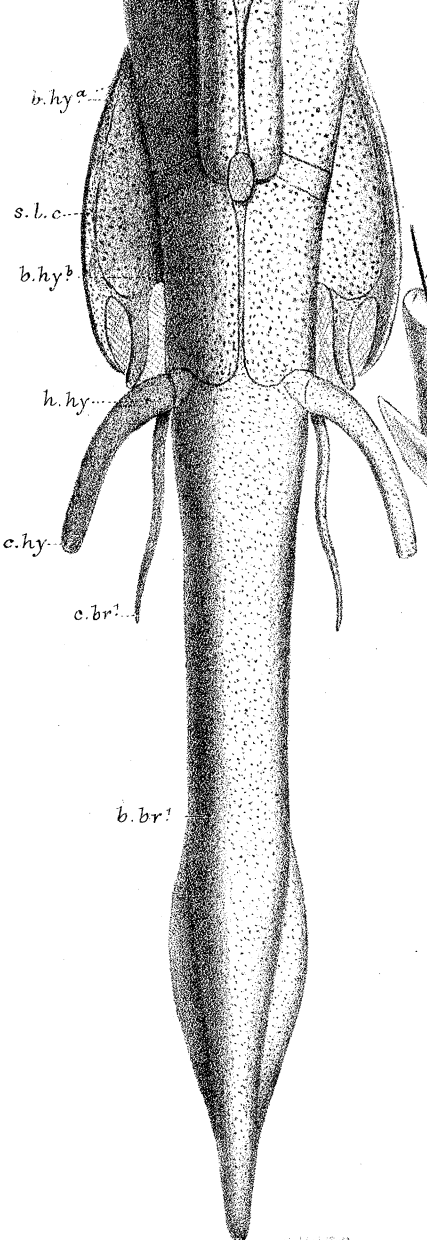


W.K.P. del. ad nat.
M.P. Parker lith. et del.

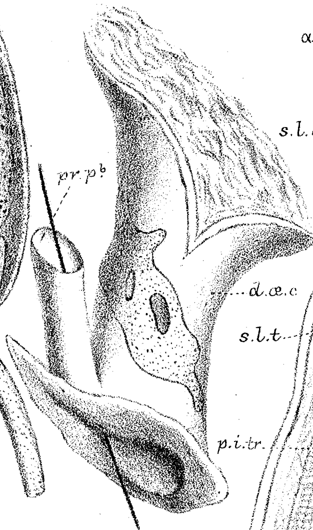
BDELLOSTOMA, MYXINE, AND PETROMYZON.

West Newman & Co. imp.

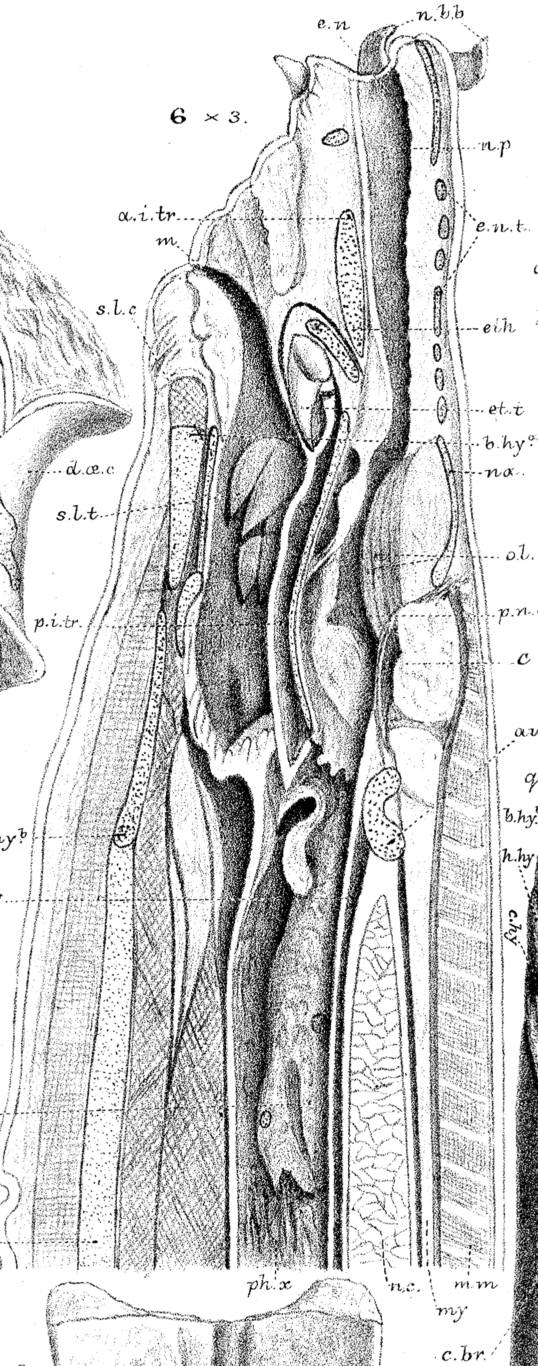
2 × 1½



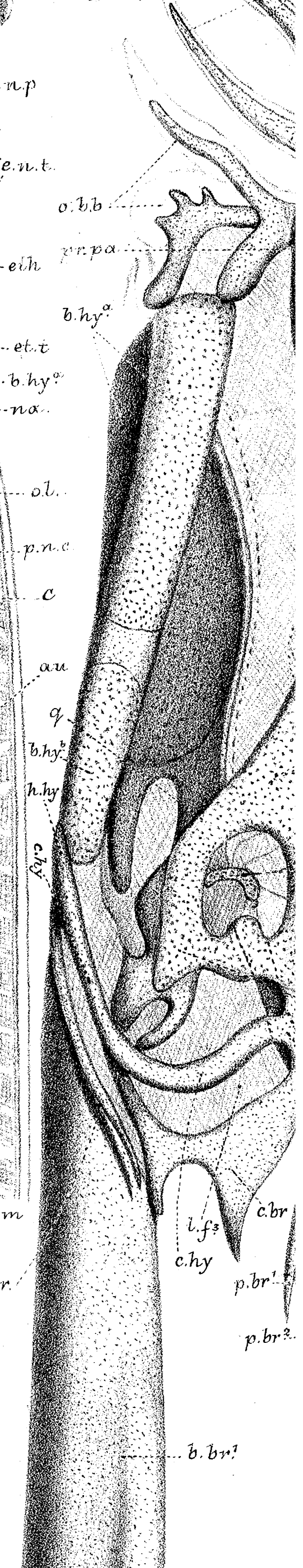
7 × 3



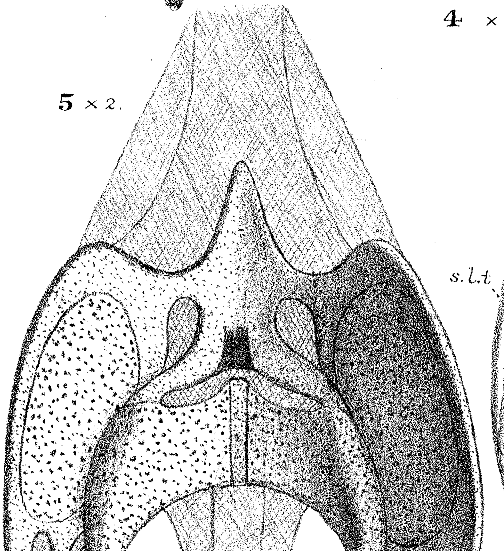
6 × 3.



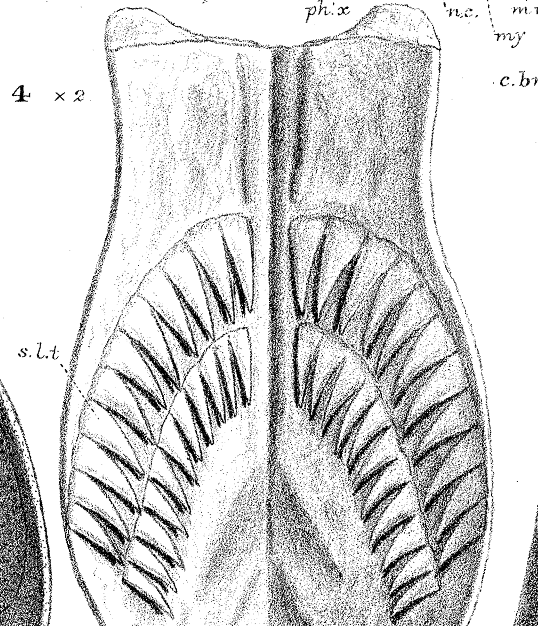
1 × 2.



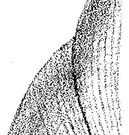
5 × 2.

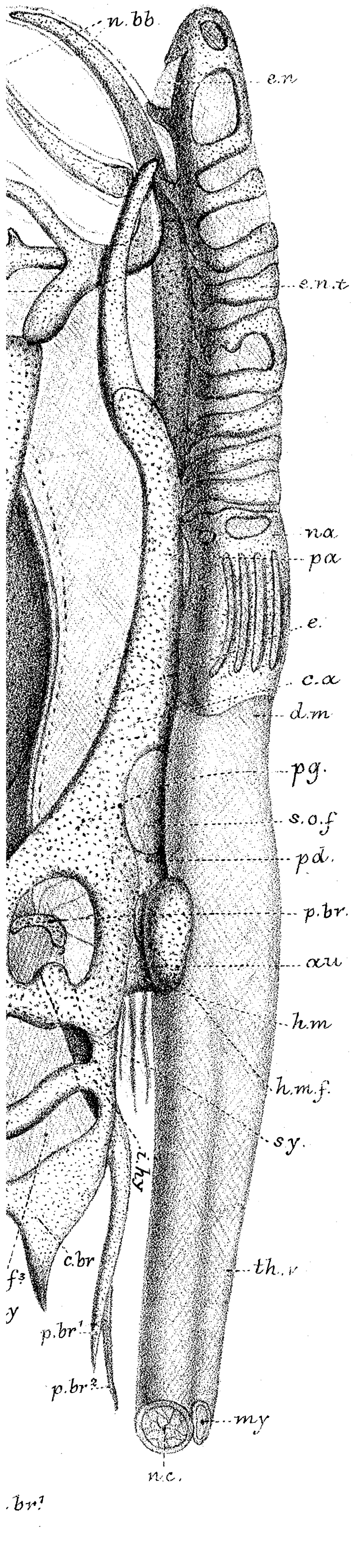


4 × 2

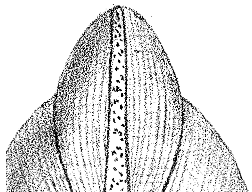


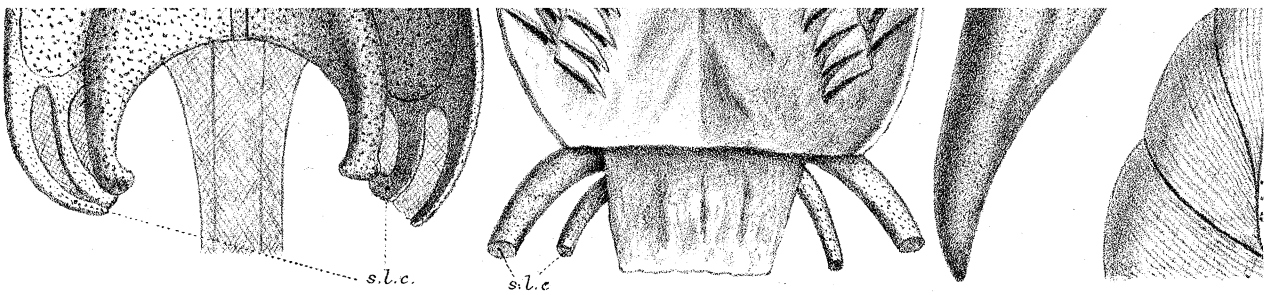
3




n.bb
e.n
e.n.t
n.a
p.a
e.
c.a
d.m
p.g.
s.o.f
p.d.
p.br.
au
h.m
h.m.f.
sy.
t.hy
c.br
p.br^{1}
p.br^{2}
my
n.c.

3 × 1½

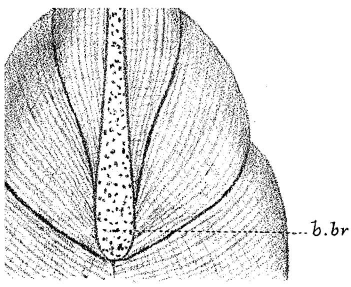




W.K.P. del. ad nat.
M.P. Parker lith.

BDELLOSTOMA FORSTERI.

We



West Newman & C° imp.

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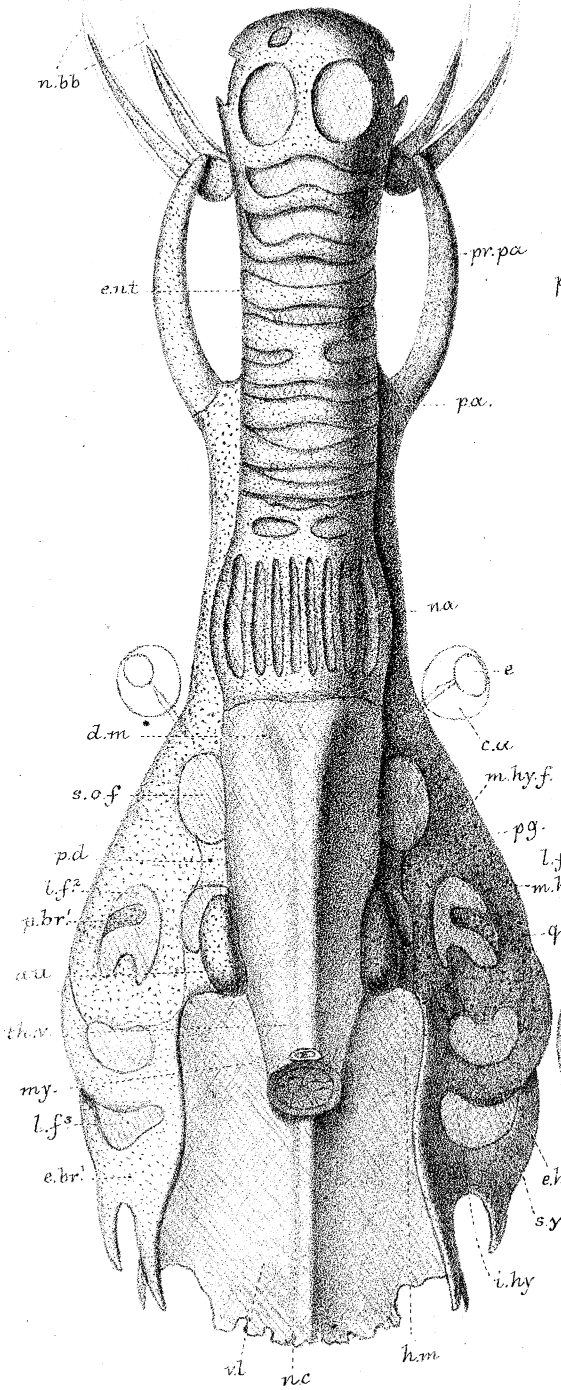
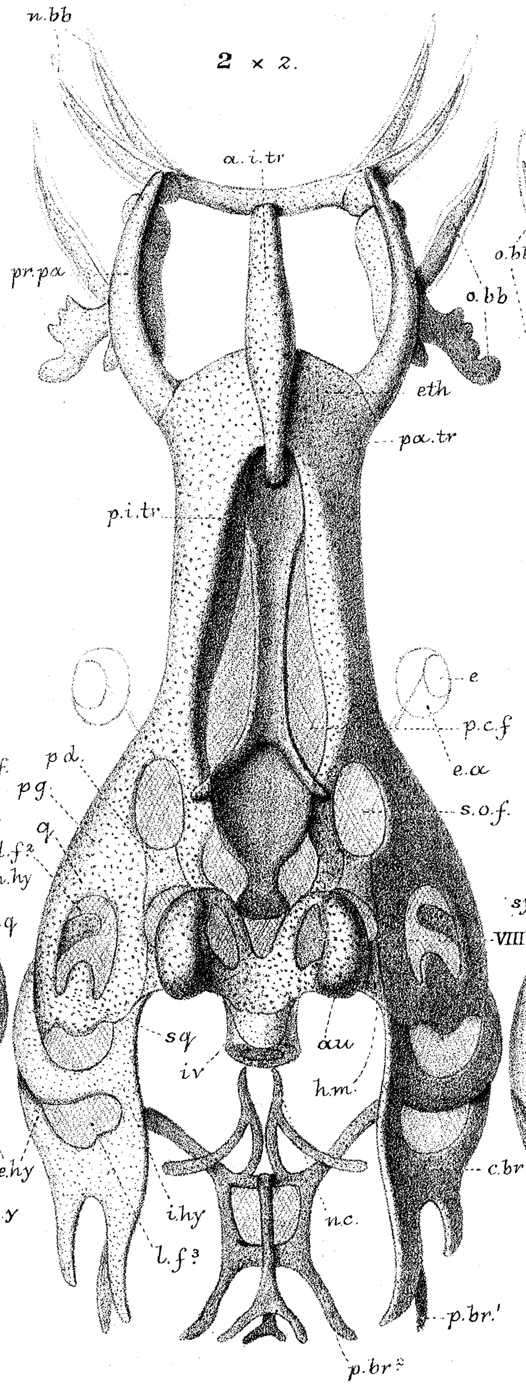


2 × 2.



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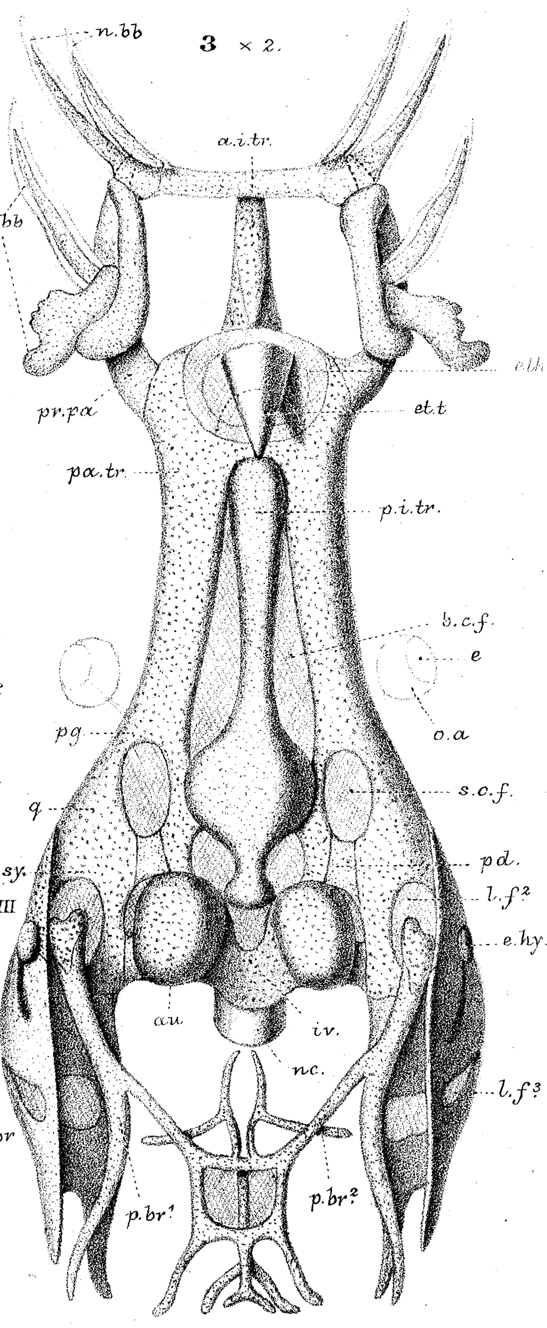
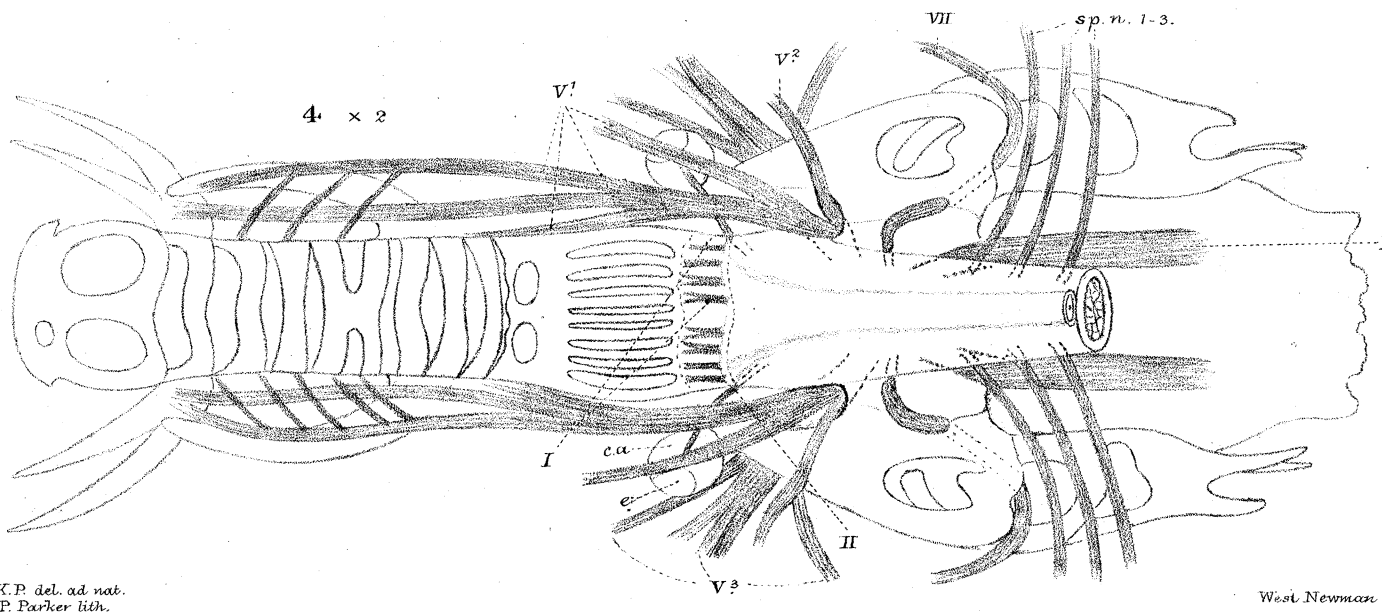


4 × 2

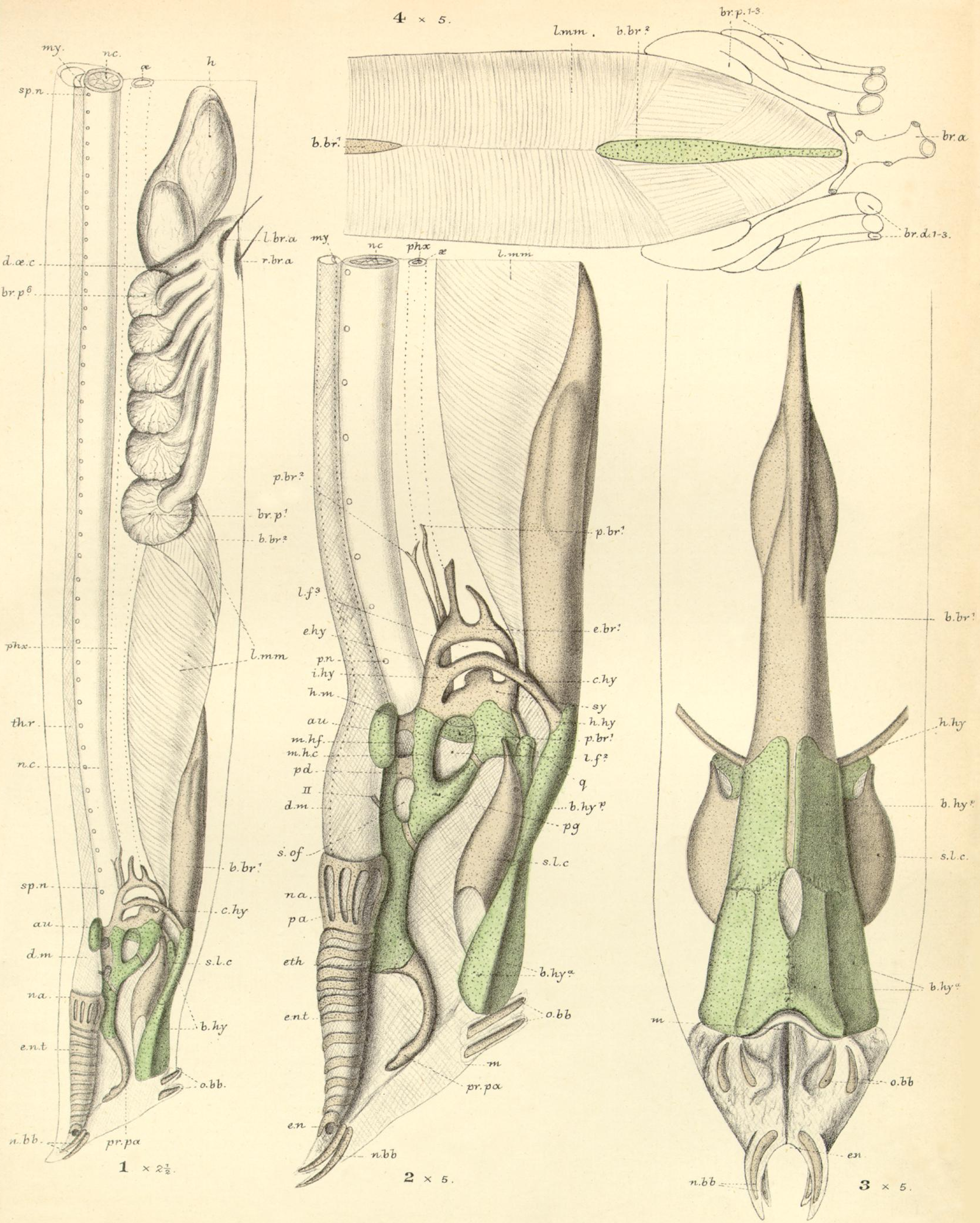


W.K.P. del. ad nat.
M.P. Parker lith.

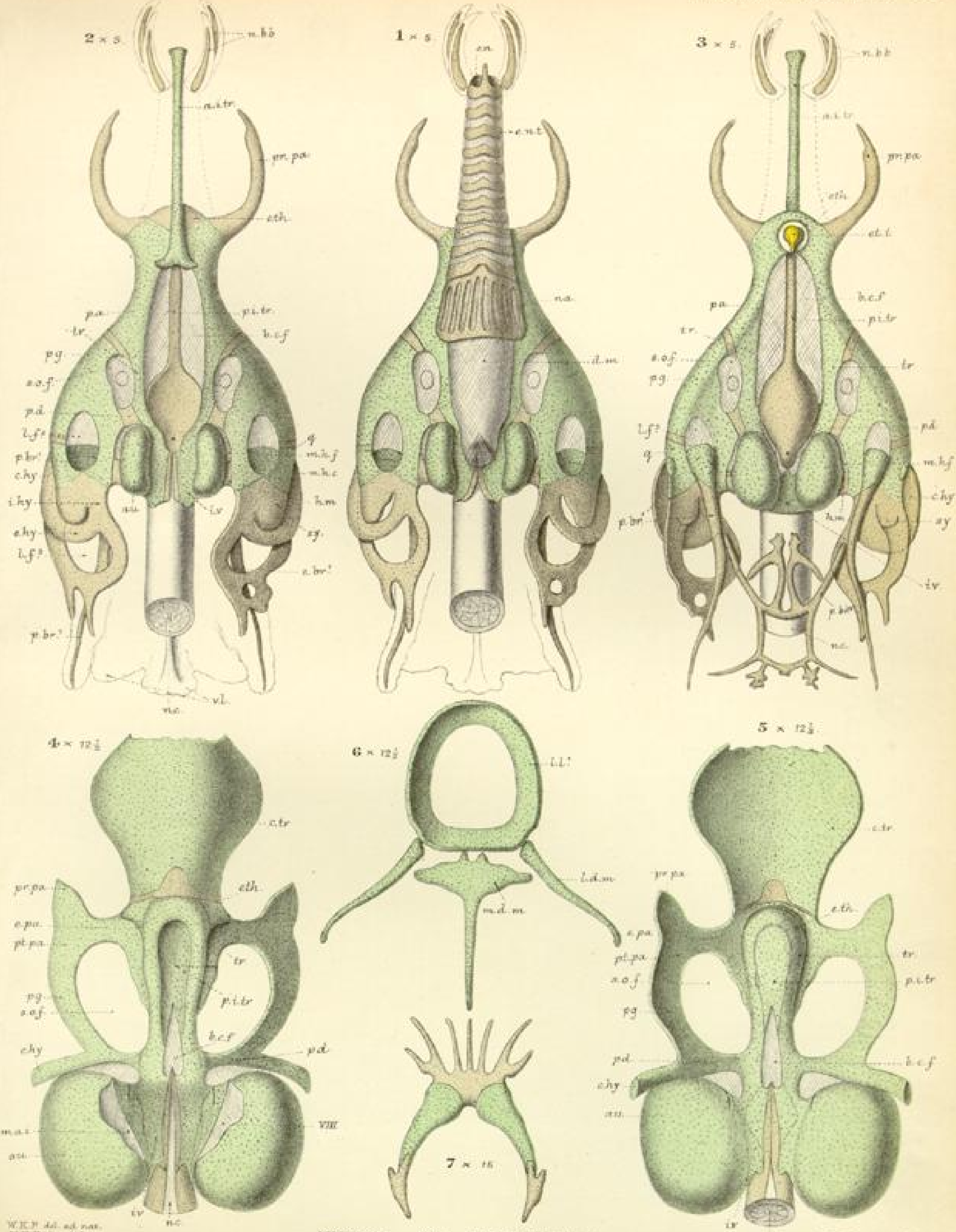
West Newman & Cº imp.

BDELLOSTOMA FORSTERI.

MARSIPOBRANCH FISHES.



MYXINE GLUTINOSA.


2 × 5.
1 × 5
3 × 5.
4 × 12½
6 × 12½
5 × 12½
7 × 15
n.bb
cn
a.i.tr
e.n.t
pr.pa
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et.i.
na
pa
p.i.tr
b.c.f
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pg
s.o.f.
d.m
p.d.
l.f.?
p.br.'
c.hy
i.hy
e.hy
q
m.h.f
m.h.c
h.m
au.
i.v
s.y.
e.br.'
n.c.
v.l.
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l.d.m
m.d.m
c.tr
e.pa
pt.pa
m.a.i.
VIII


2 × 5.
1 × 5.
3 × 5.
n.b.b
a.i.tr.
pr. pa
e.th.
p.a.
p.i.tr.
tr.
b.c.f
p.g.
s.o.f.
p.d.
l.f.²
q
p.br.¹
m.h.f
c.hy.
m.h.c
i.hy.
au
i.v
h.m
e.hy.
sy.
l.f.³
e.br.¹
p.br.¹
v.l.
n.c.
e.n.
e.n.t
n.a.
d.m
p.a.
tr.
s.o.f.
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l.f.²
q.
p.br.¹
4 × 12½
6 × 12½
5 × 12
l.l.¹
c.tr
l.d.m
pr.pa.
eth.
m.d.m
e.pa
pt.pa
tr.
p.i.tr
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b.c.f
c.hy
pd
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pt.pa
s.o.f.
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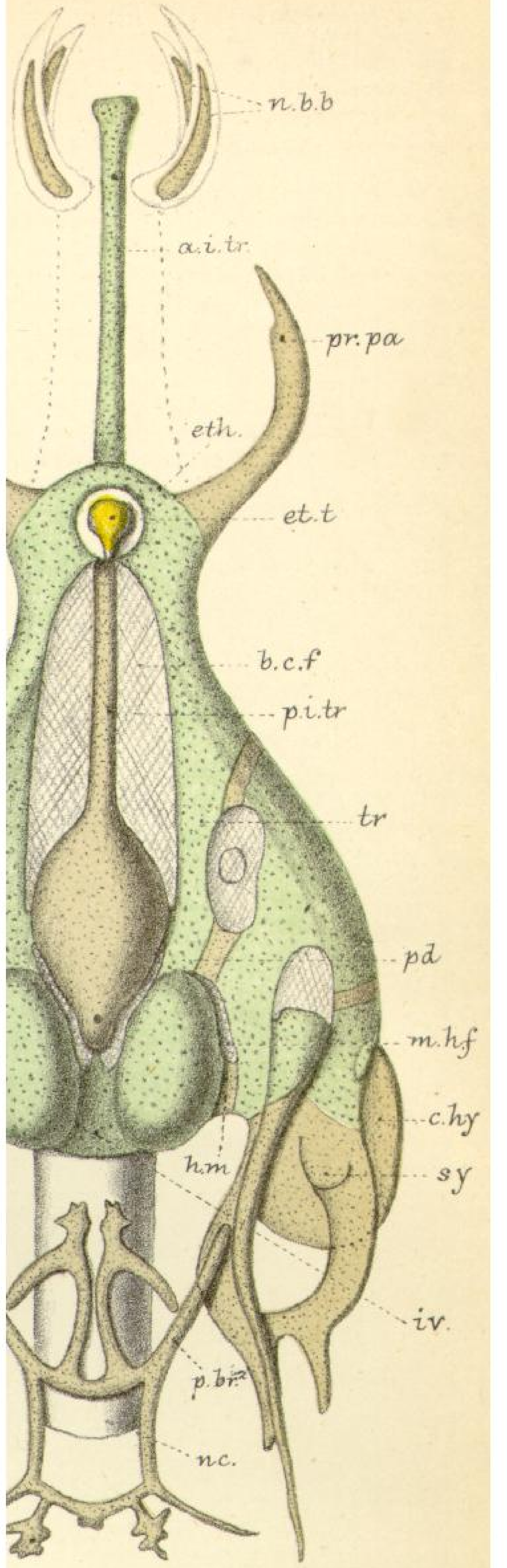
c.hy


n.b.b
a.i.tr.
pr.pa
eth.
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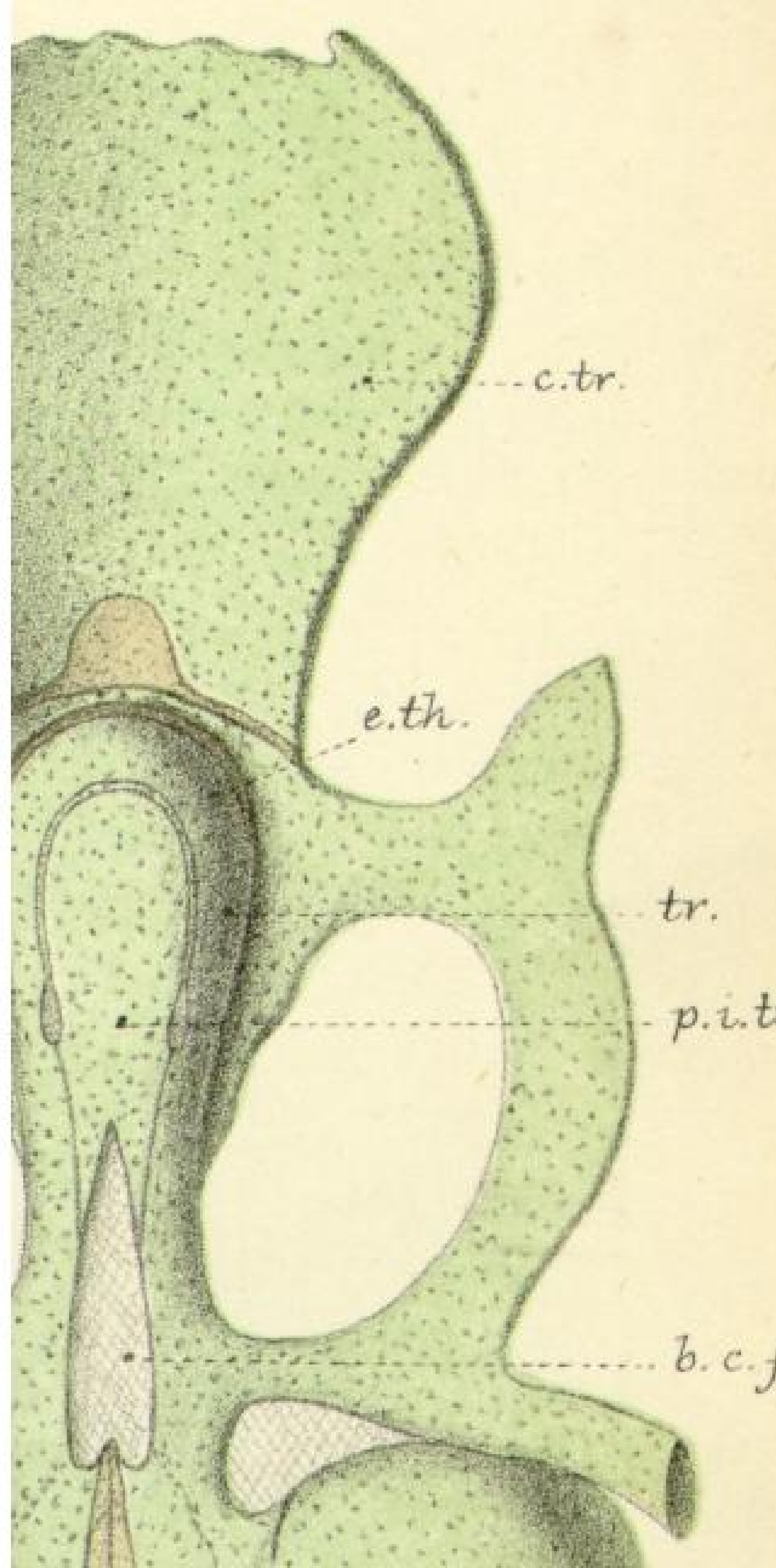
iv.
p.br.
nc.

5 × 12½.


c.tr.
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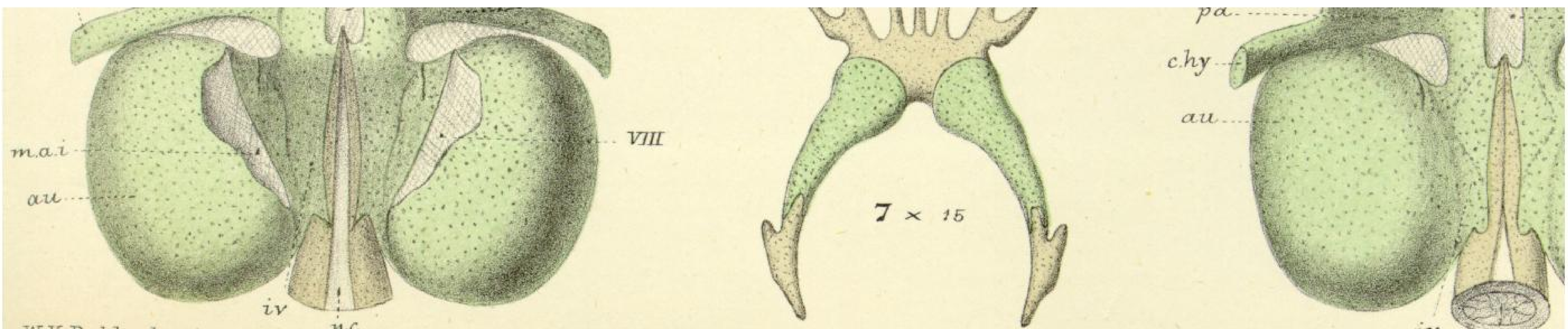
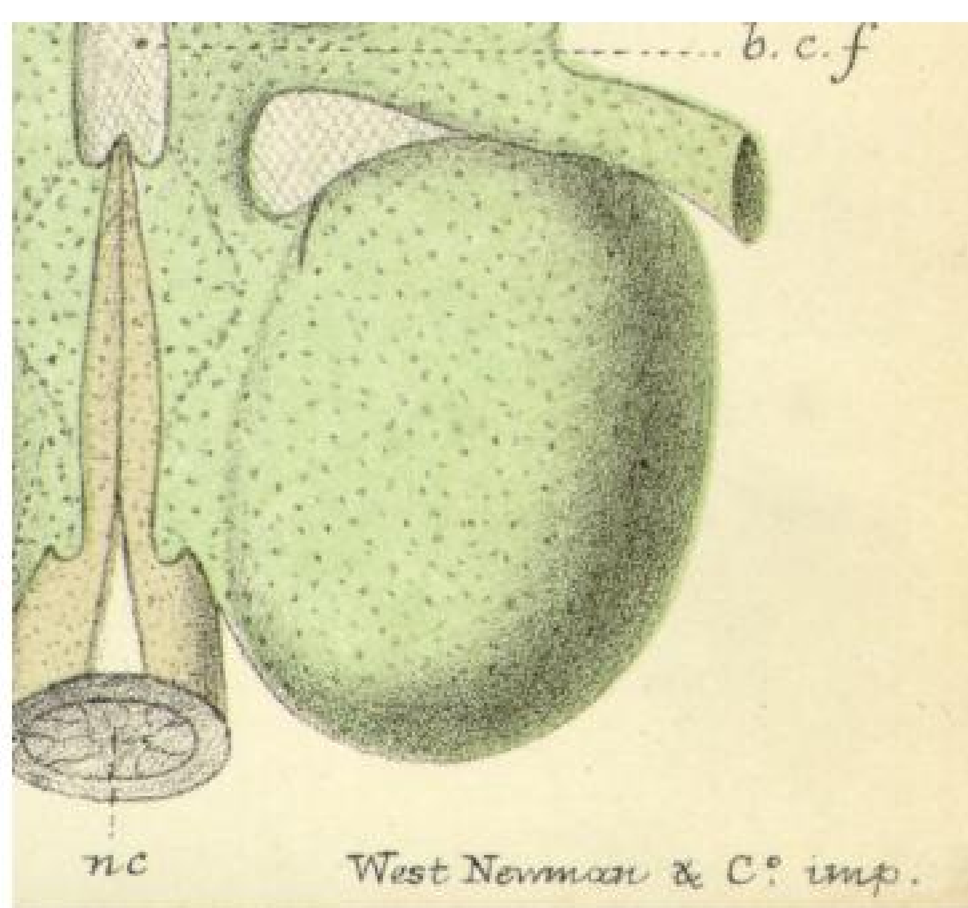
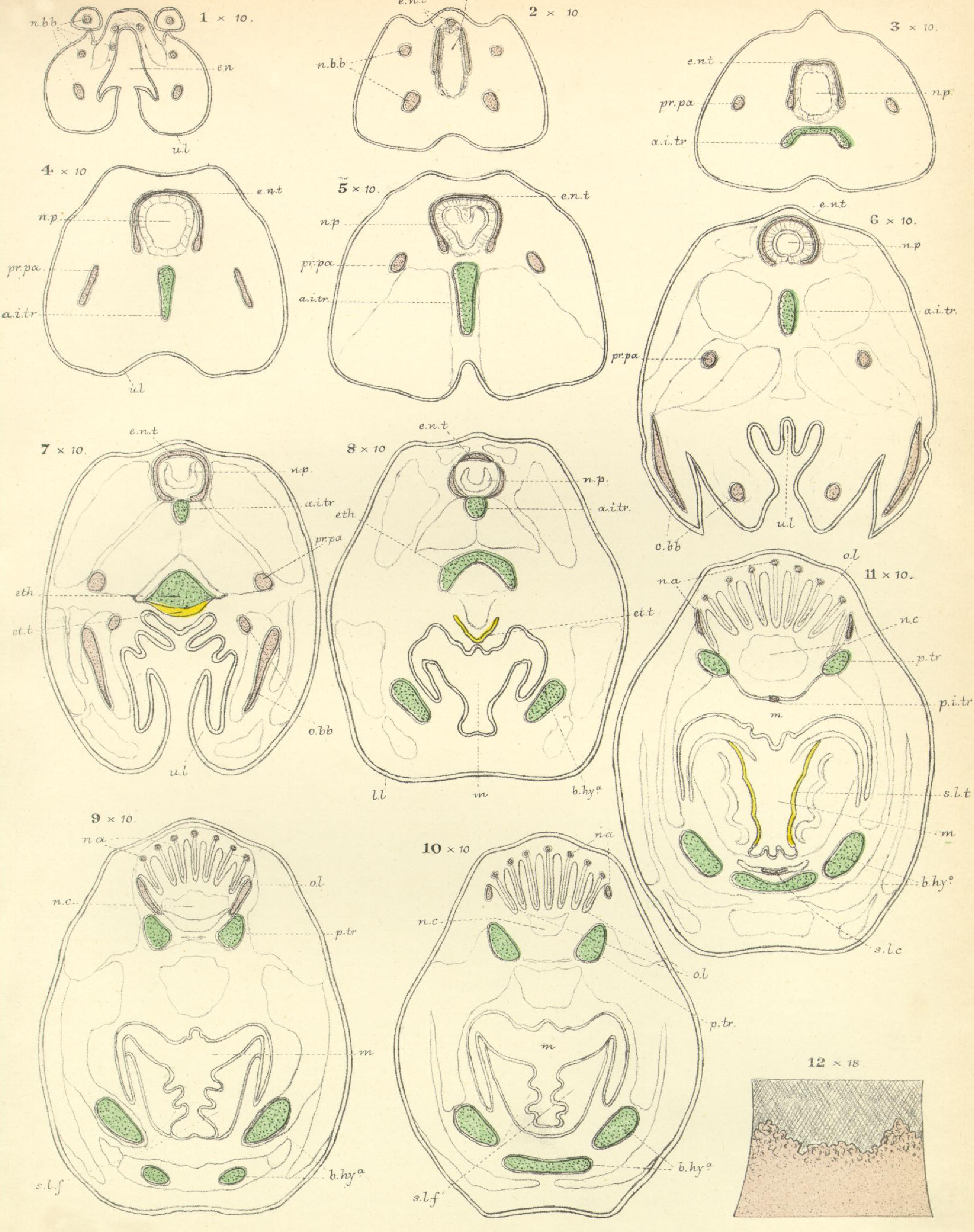
b.c.f



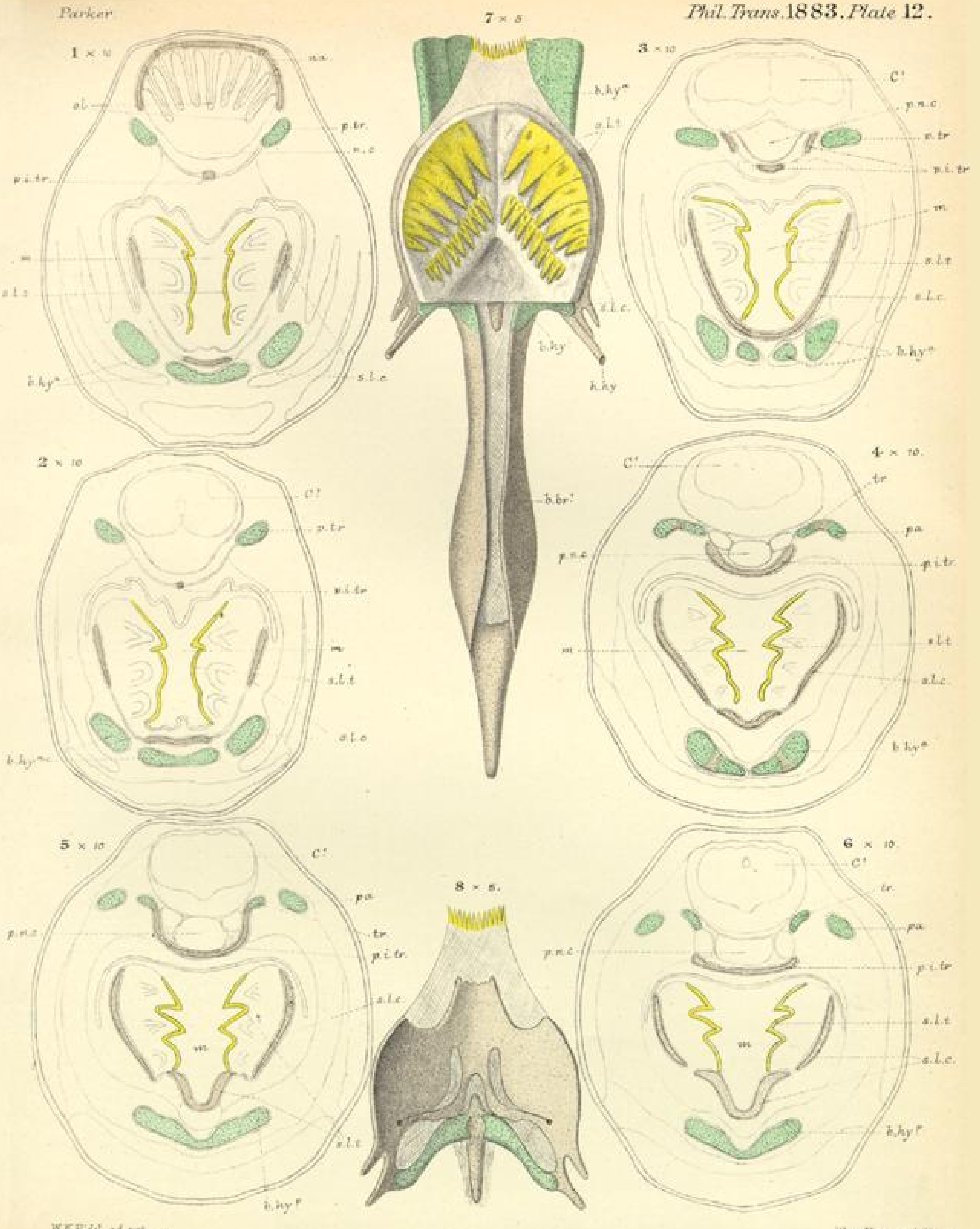
W.K.P. del. ad nat.
M.P. Parker lith.

MYXINE AND PETROMYZON.


b. c. f
nc
West Newman & C° imp.



MYXINE GLUTUIOSA.



W.K.P. del. ad nat.
M.P. Parker lith. et del.

MYXINE GLUTINOSA.

West Newman & Co. imp.


1 × 10
n.a.
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m
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2 × 10
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m
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s.l.c
b.hy^a
5 × 10
C¹
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7 × 5.
b.hy^a
s.l.t
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b.br¹
8 × 5.
3 × 10
C¹
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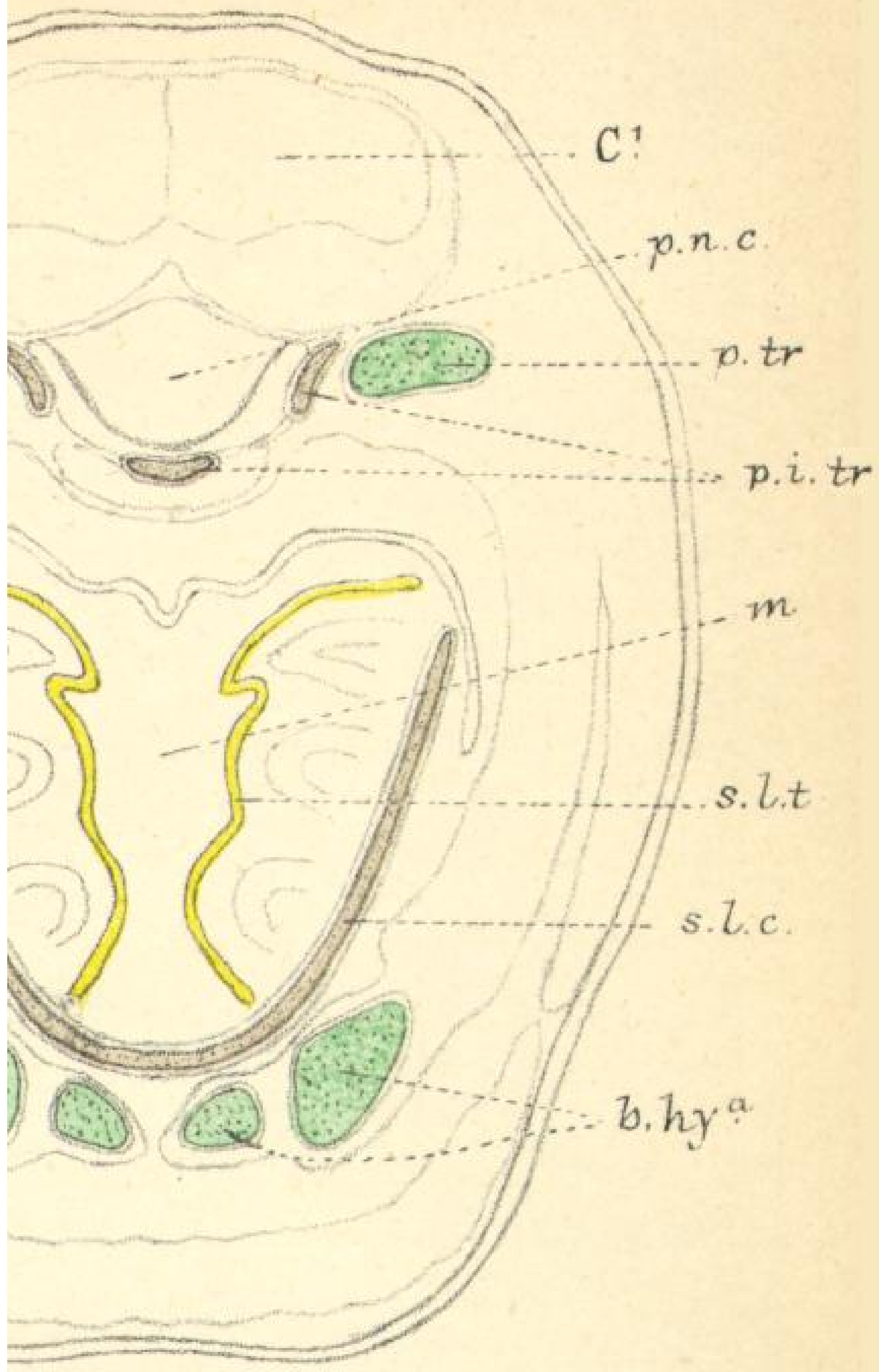
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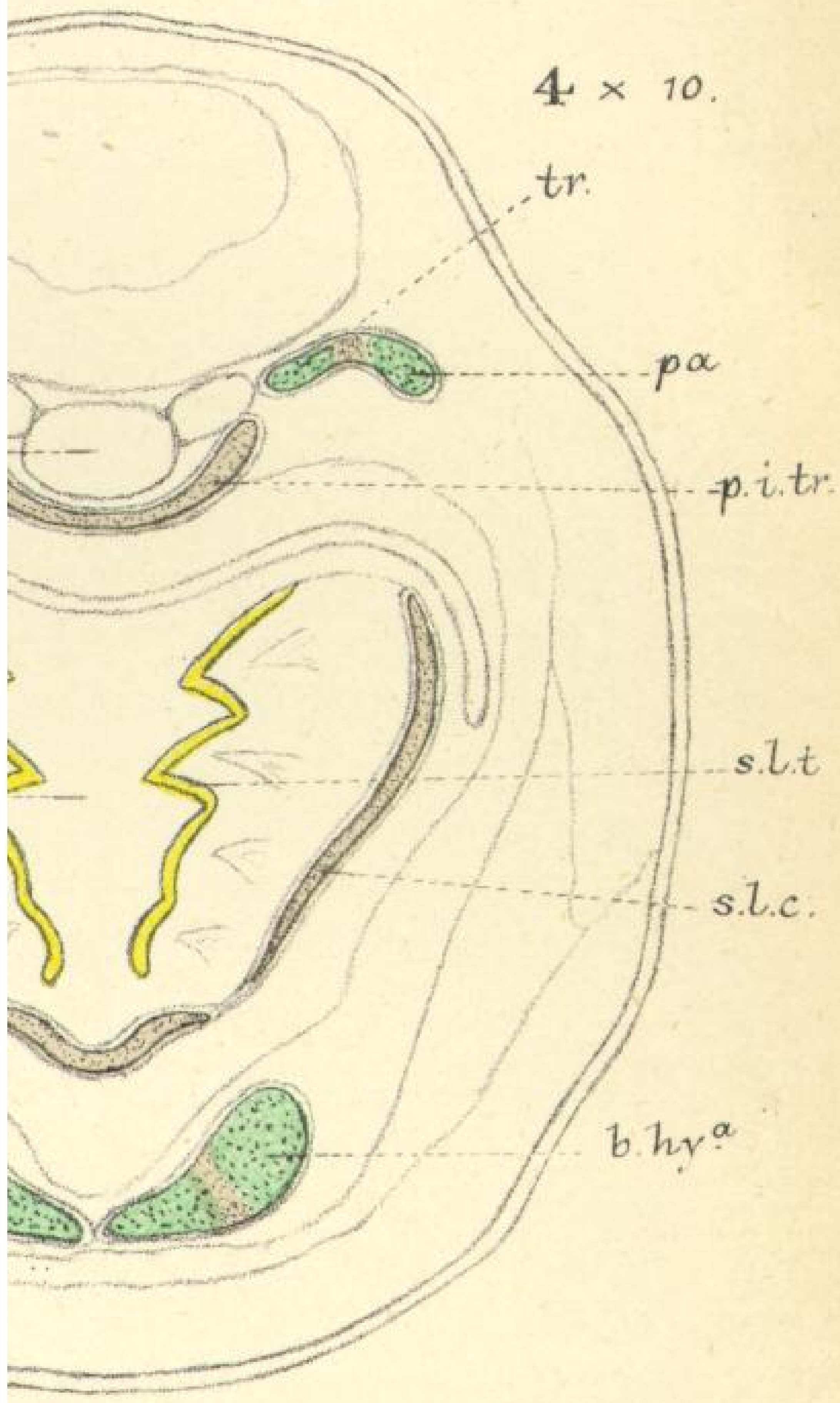
4 × 10.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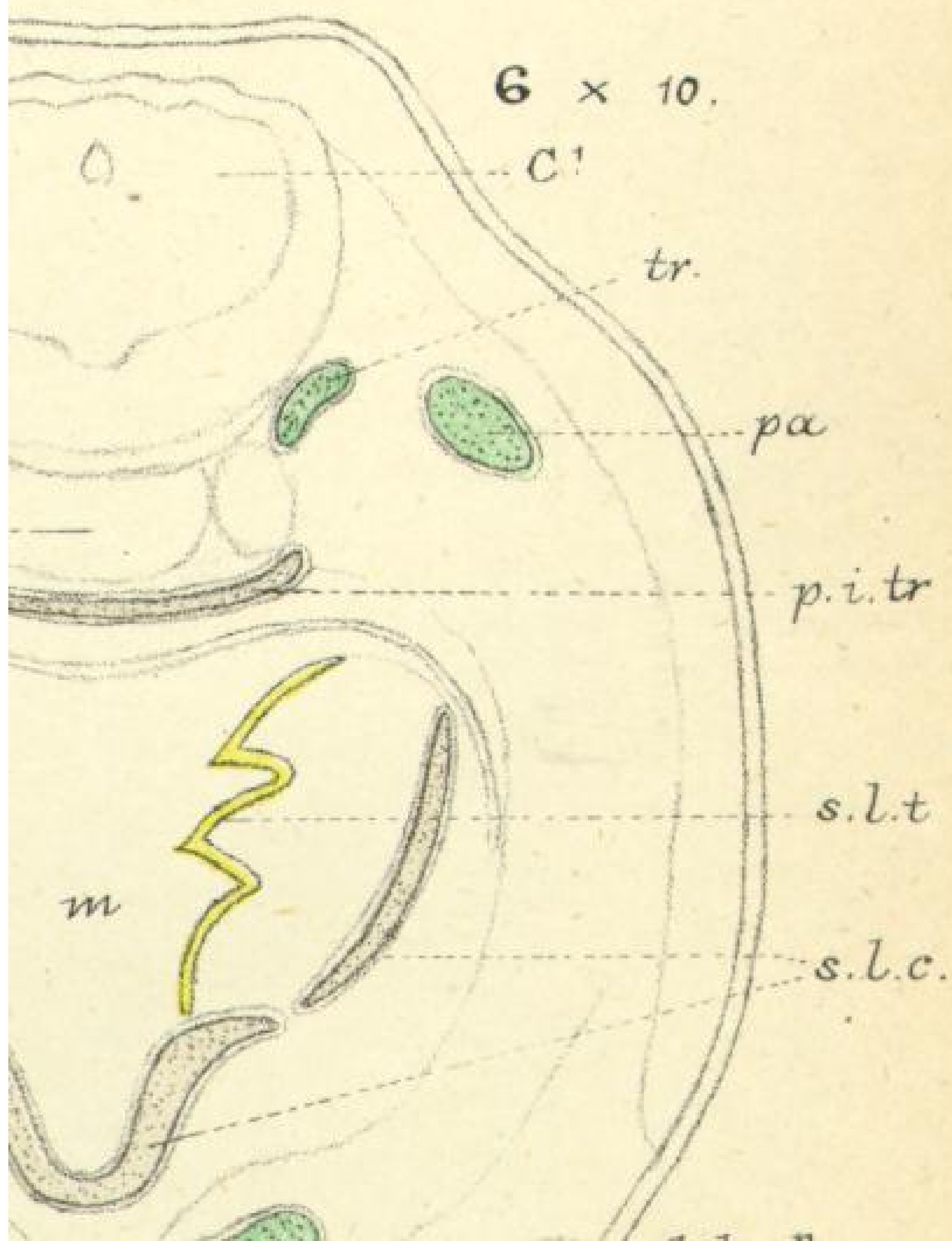
b.hy.a

6 × 10.


C'
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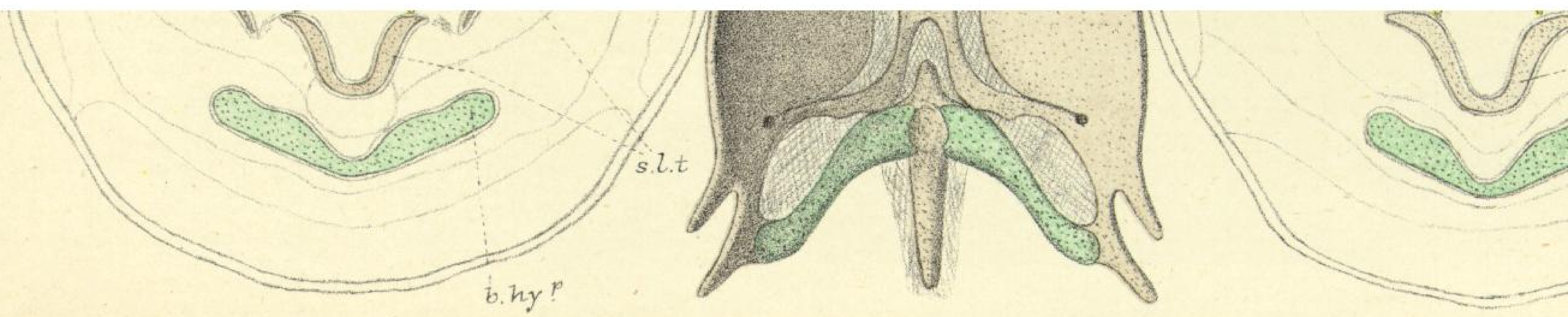
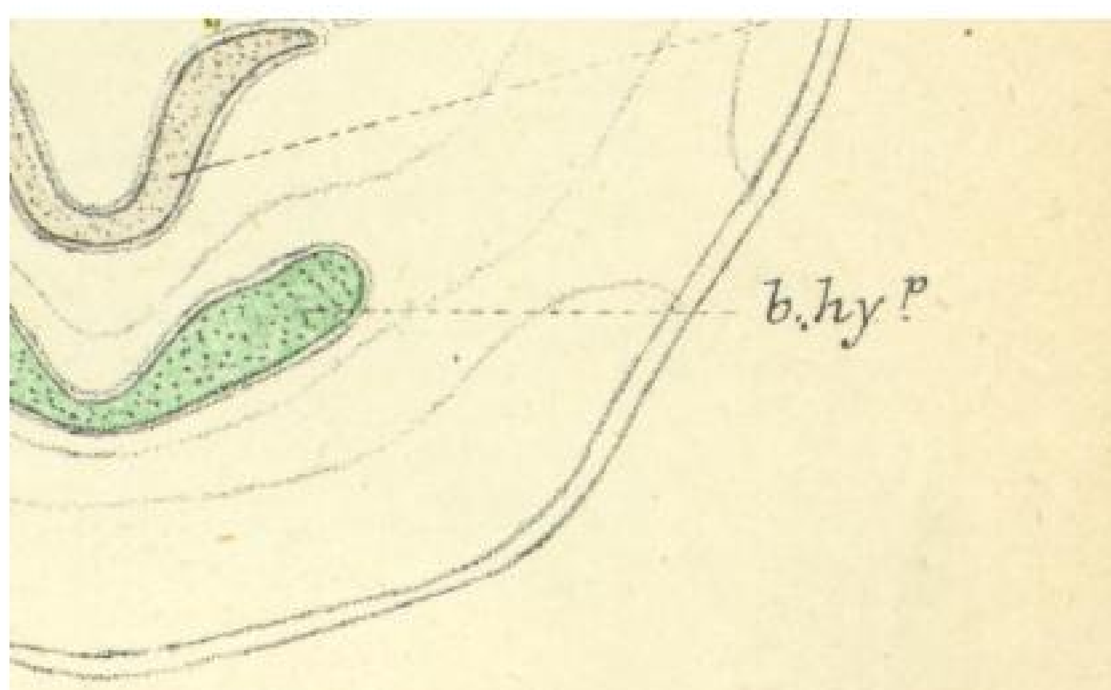
m
s.l.c.

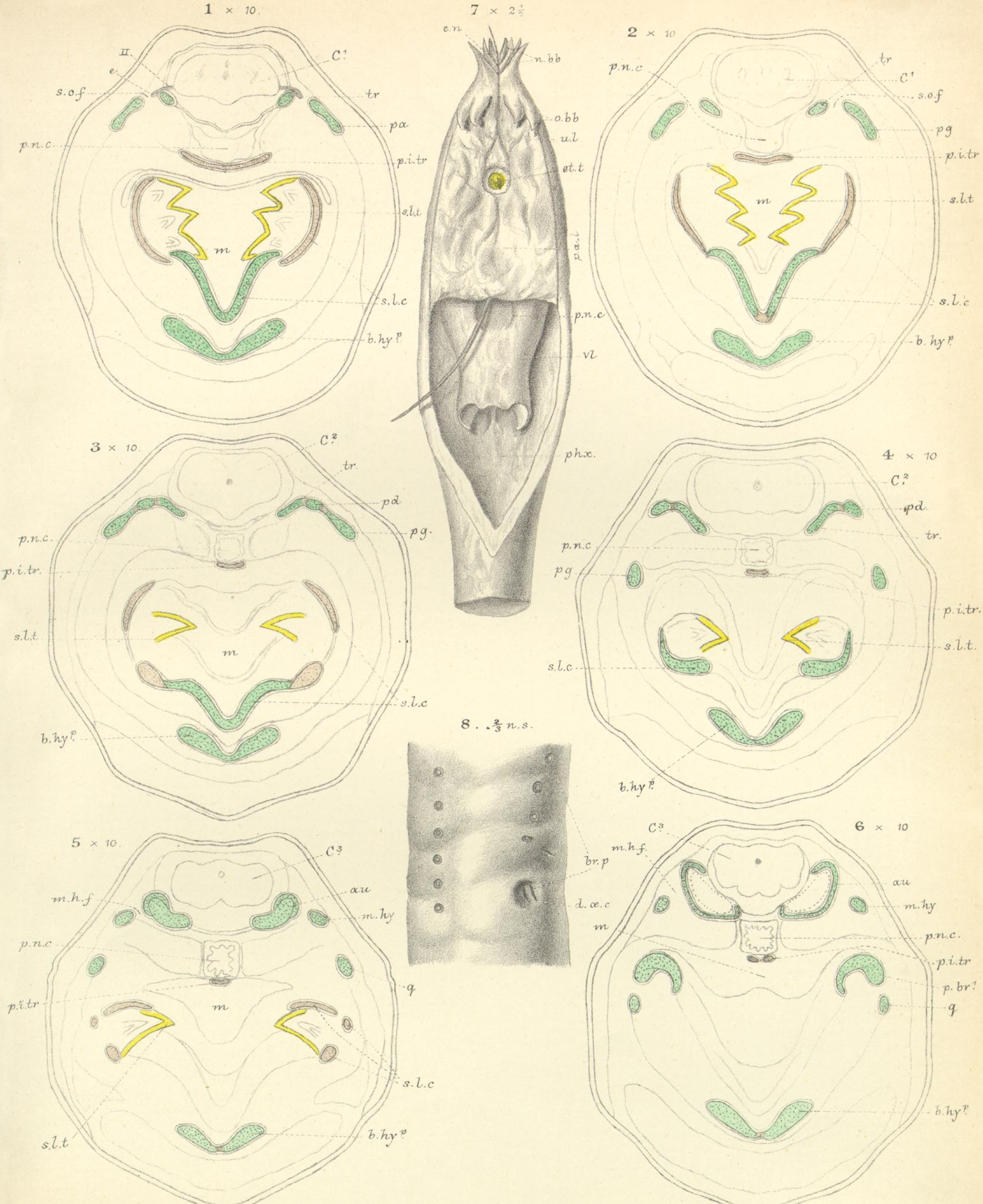


W.K.P. del. ad nat.
M.P. Parker lith. et del.

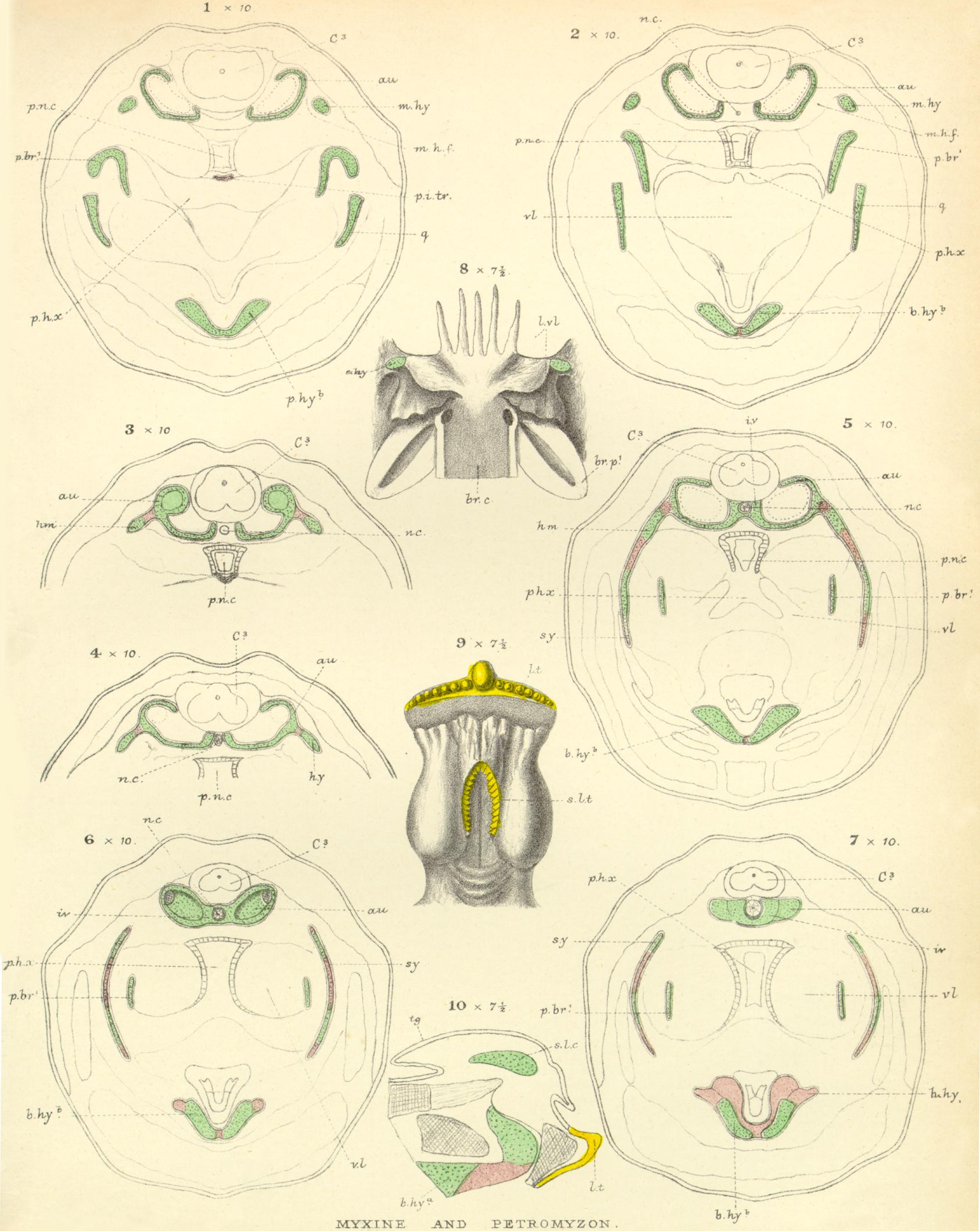
MYXINE GLUTINOSA.



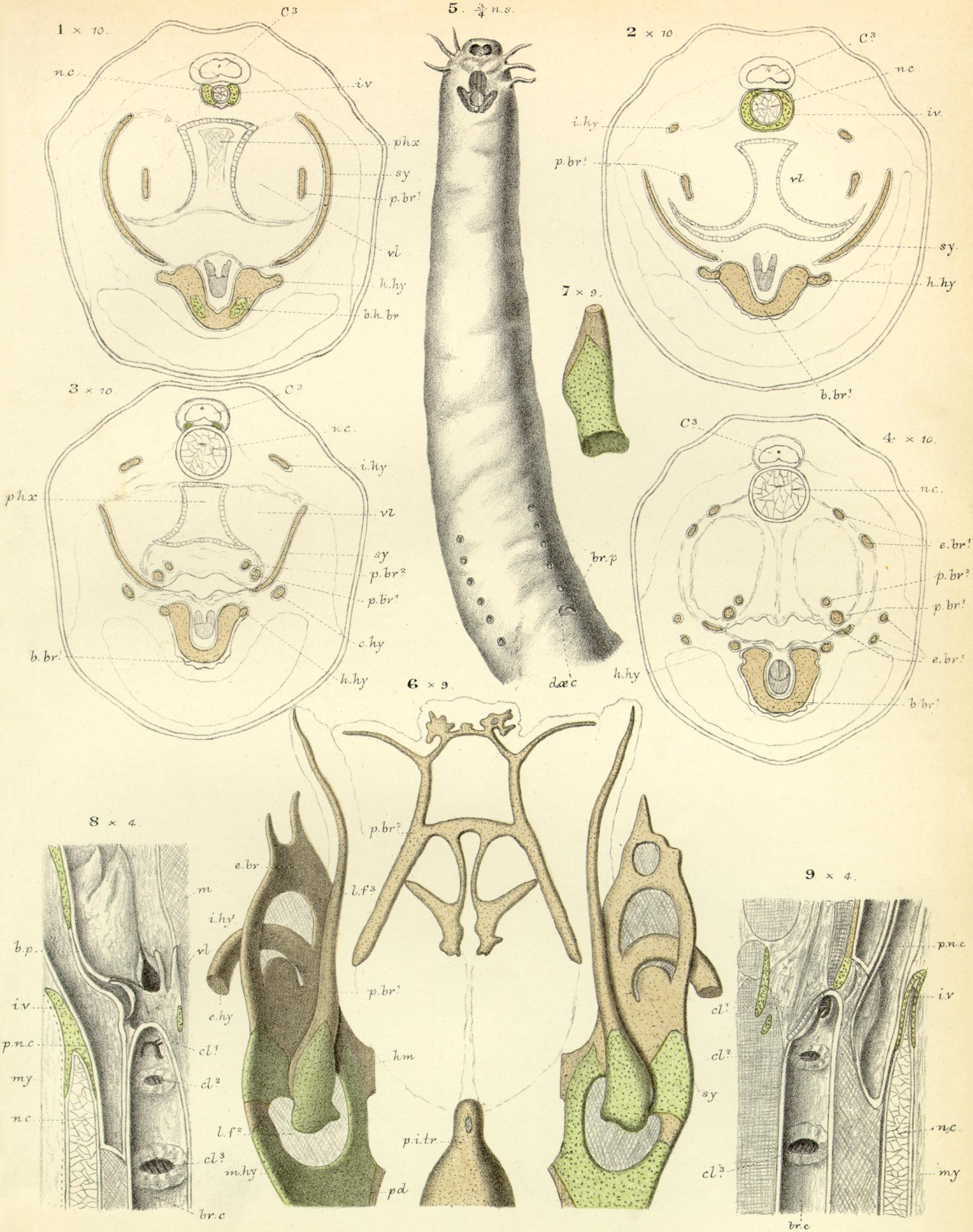
West Newman & Co. imp.



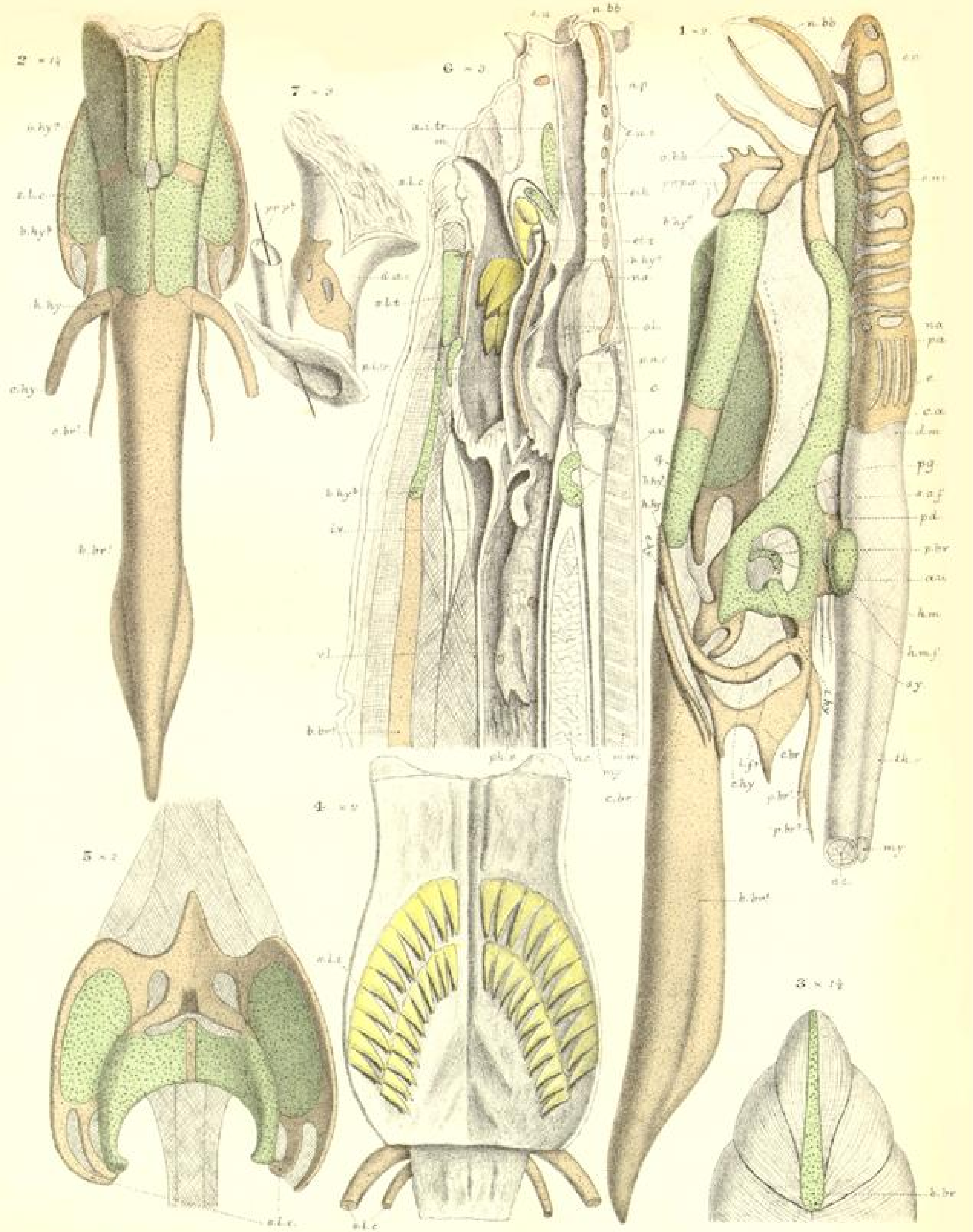
MYXINE GLUTINOSA.



MYXINE AND PETROMYZON.



BDELLOSTOMA, MYXINE, AND PETROMYZON.

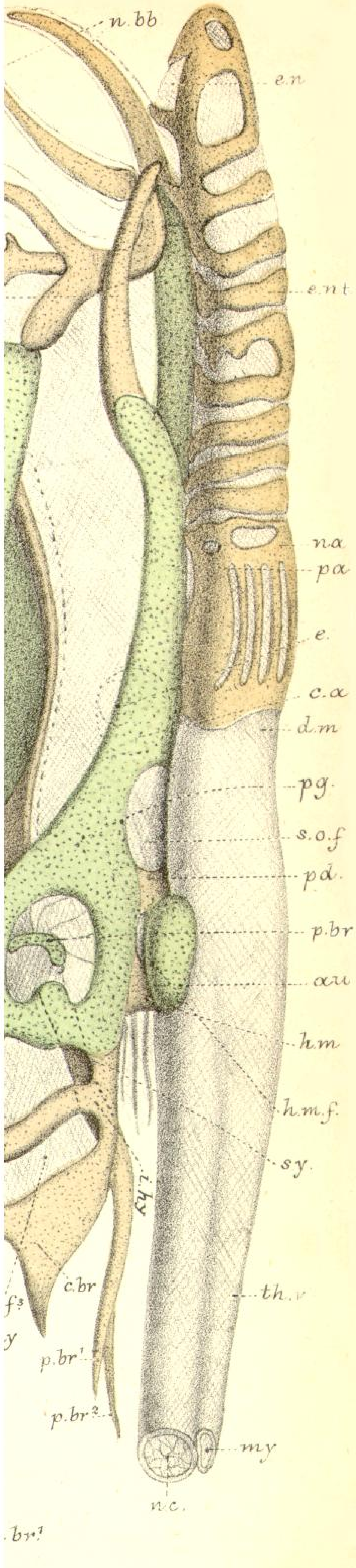


W.K.P. del. ad. nat.
M.P. Parker lith.

BDELLOSTOMA FORSTERI.

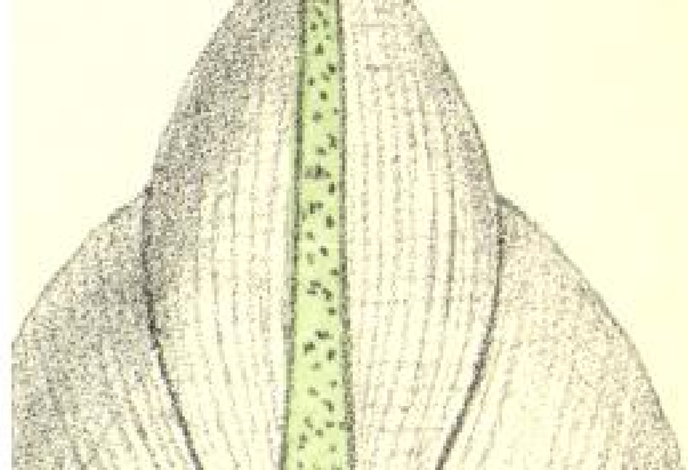
West Newman & Co. imp.

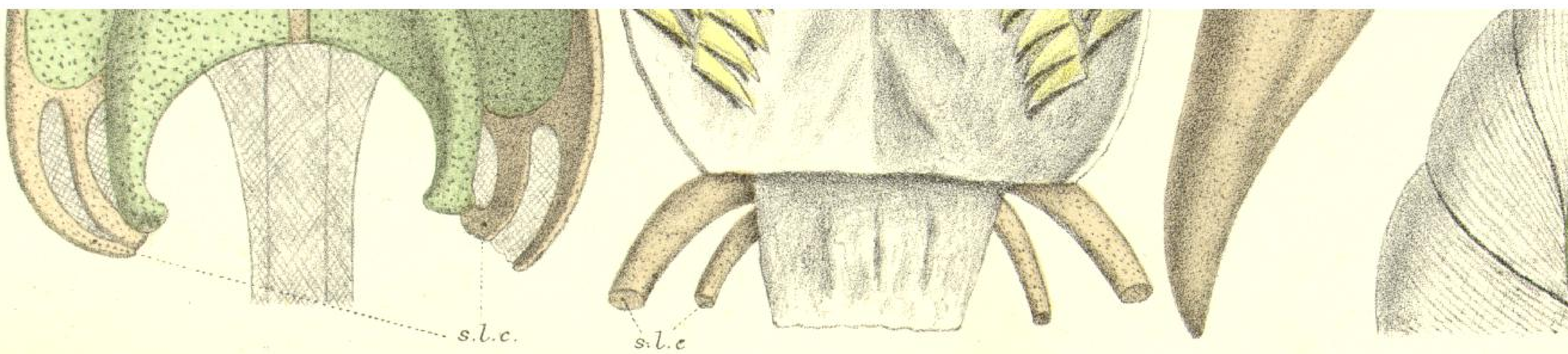
2 × 1½
b.hy^a
s.l.c
b.hy^b
h.hy
c.hy
c.br^1
b.br^1
7 × 3
pr.p^b
d.œ.c
s.l.t
p.i.tr
6 × 3
e.n
n.bb
n.p
α.i.tr
m
e.n.t
s.l.c
eih
et.t
b.hy^c
na
ol
p.n.c
c
au
b.hy^b
i.v
v.l
b.br^2
ph.x
n.c
m.m
my
c.br
1 × 2
o.b.b
pr.pa
b.hy^a
q
b.hy^b
h.hy
c.hy
l.f^3
c.br
p.br^1
p.br^2
b.br^1
4 × 2
s.l.t
5 × 2
3



n.bb
e.n
e.nt
na
pa
e.
c.a
d.m
pg.
s.o.f
pd.
p.br
au
h.m
h.m.f.
sy.
i.hy
th.v
c.br
f³
p.br¹
p.br²
my
n.c.
br¹

3 × 1½

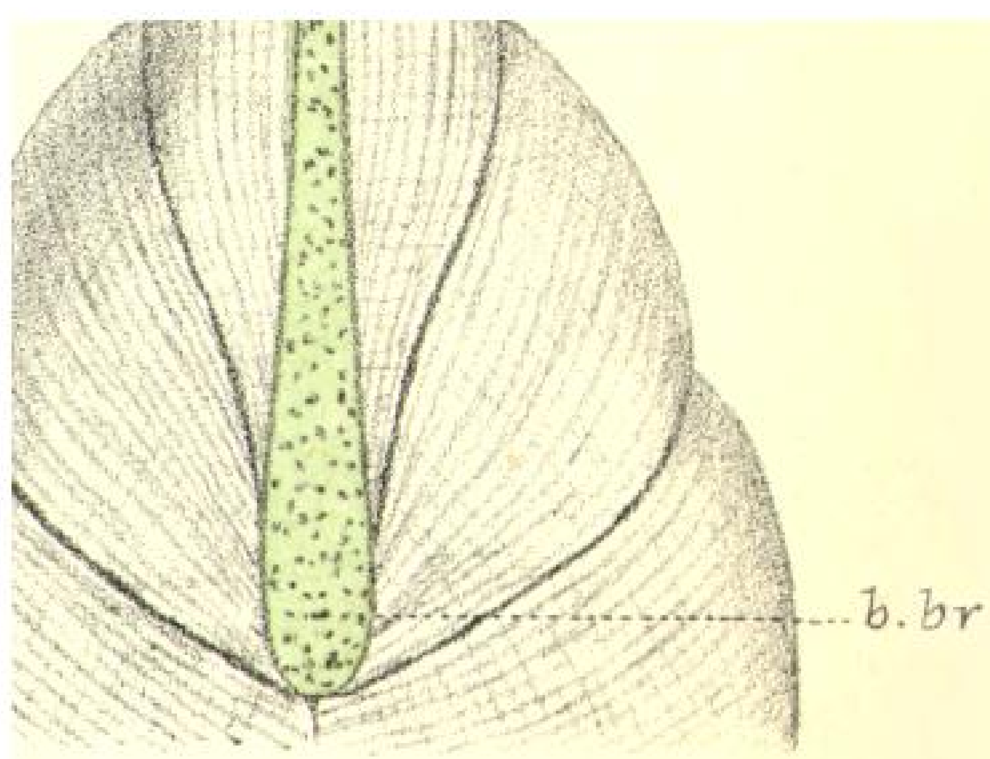




W.K.P. del. ad nat.
M.P. Parker lith.

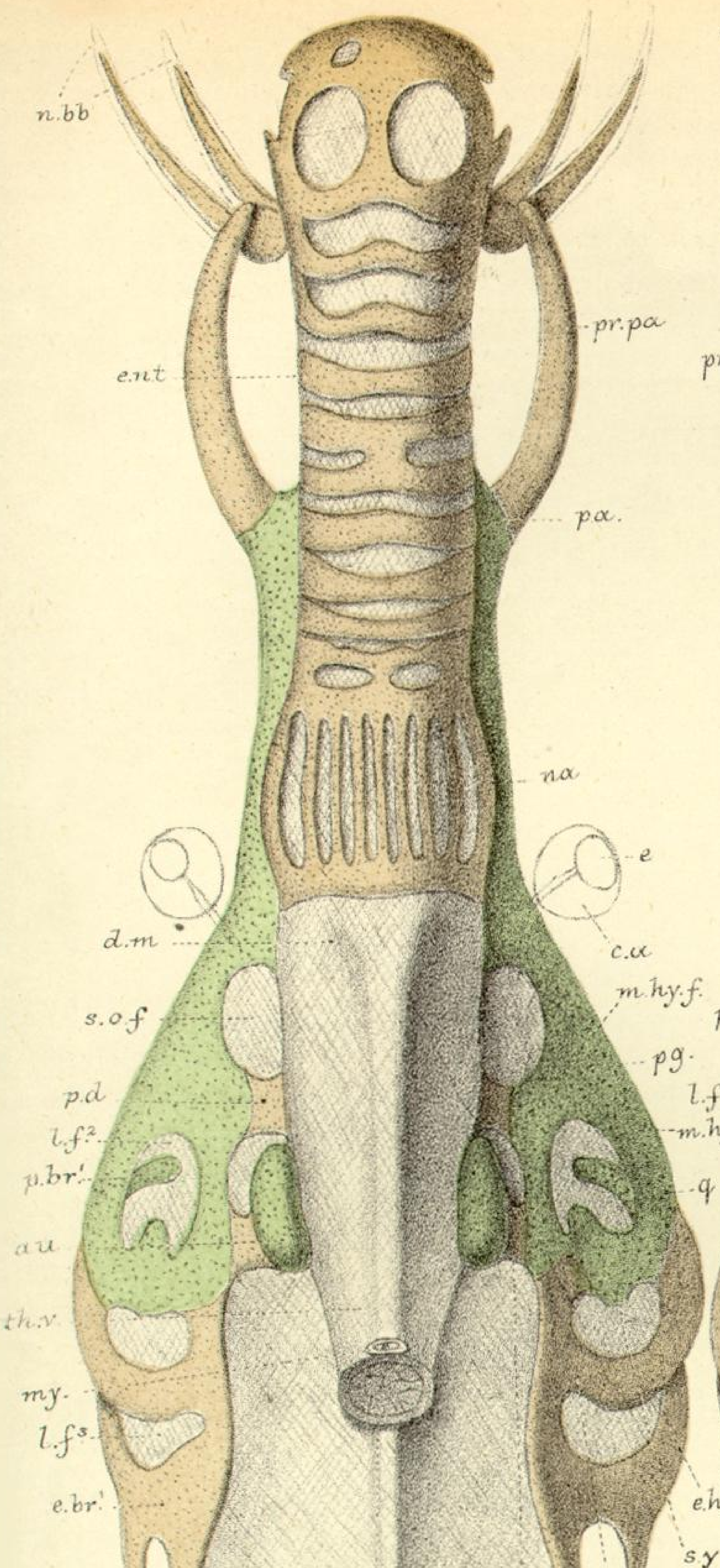
BDELLOSTOMA FORSTERI.

We

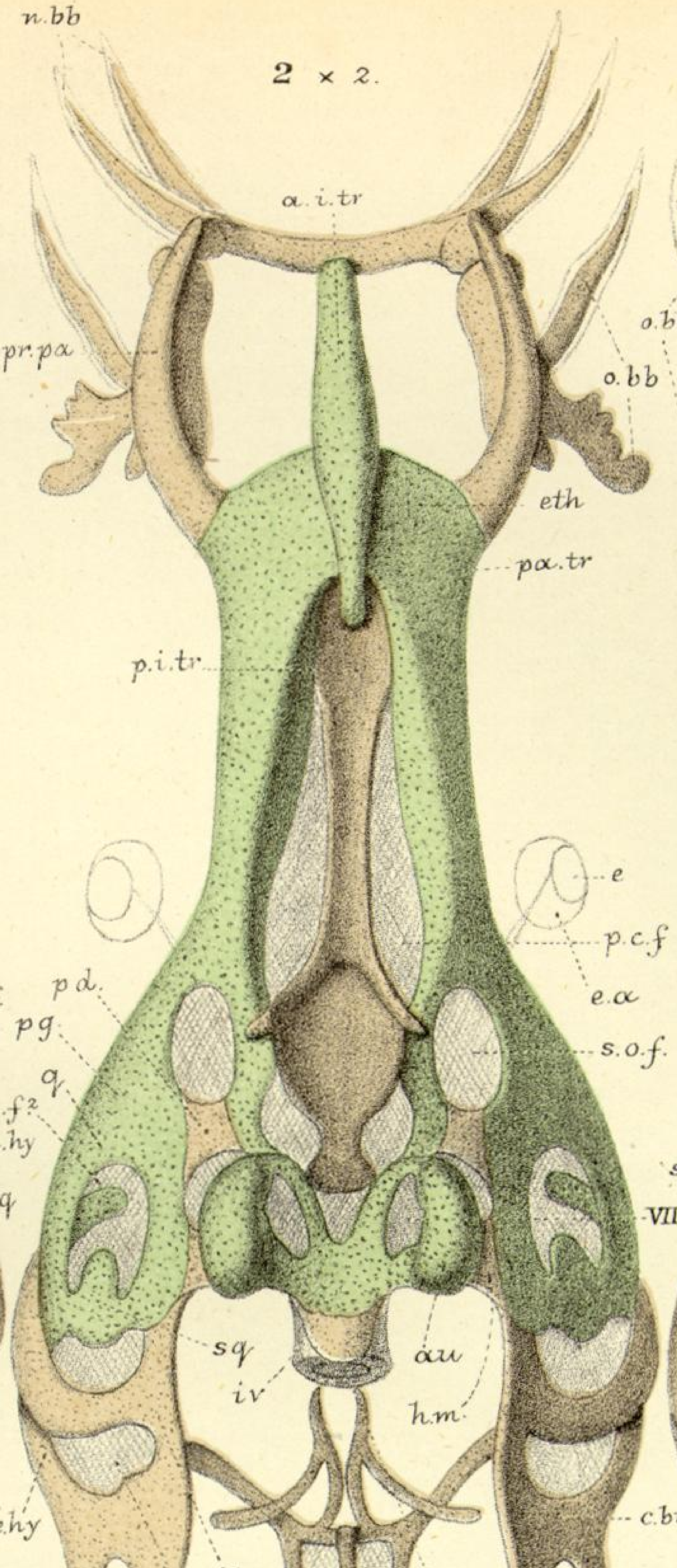


West Newman & C° imp.

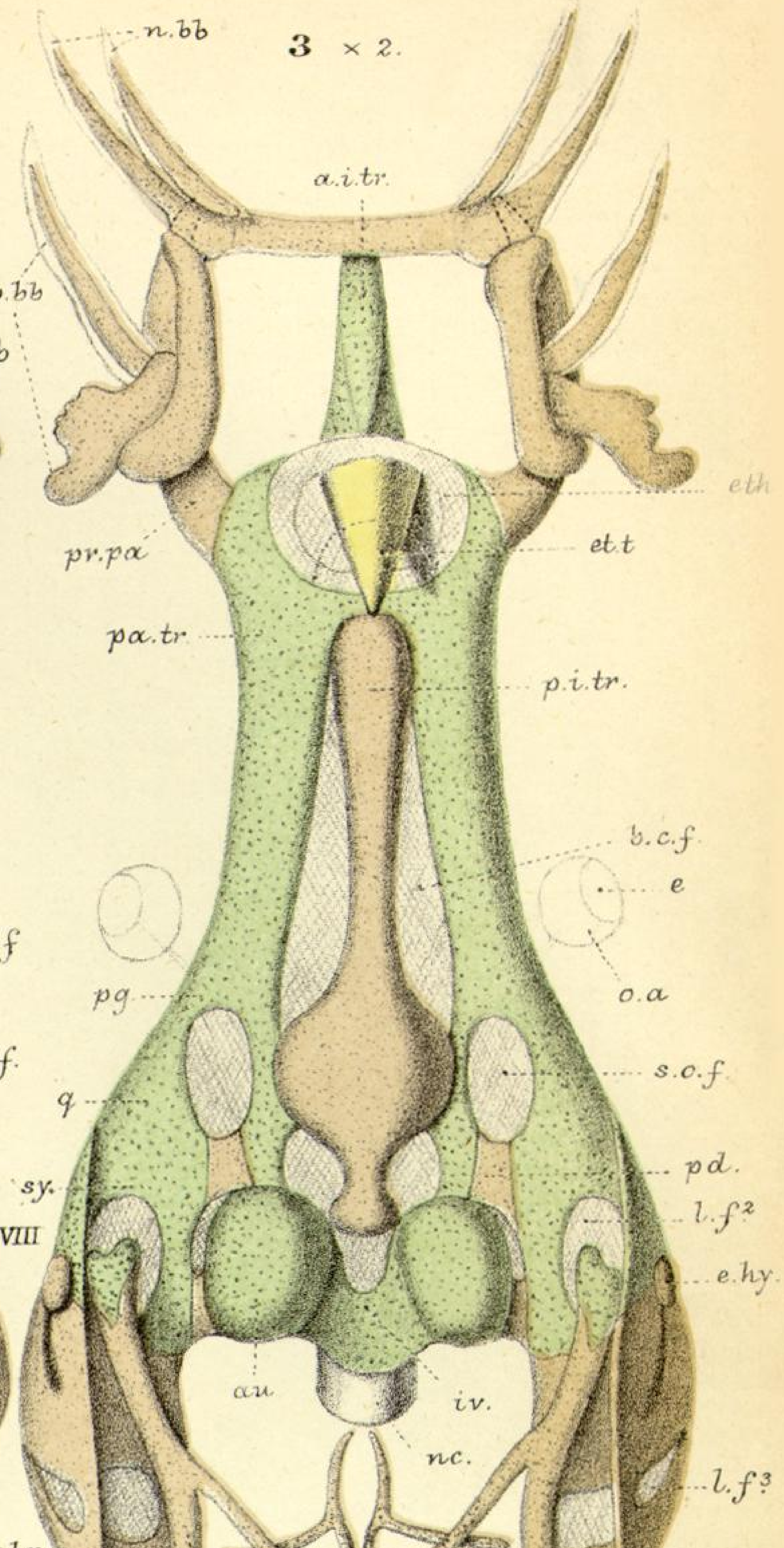
1 × 2.



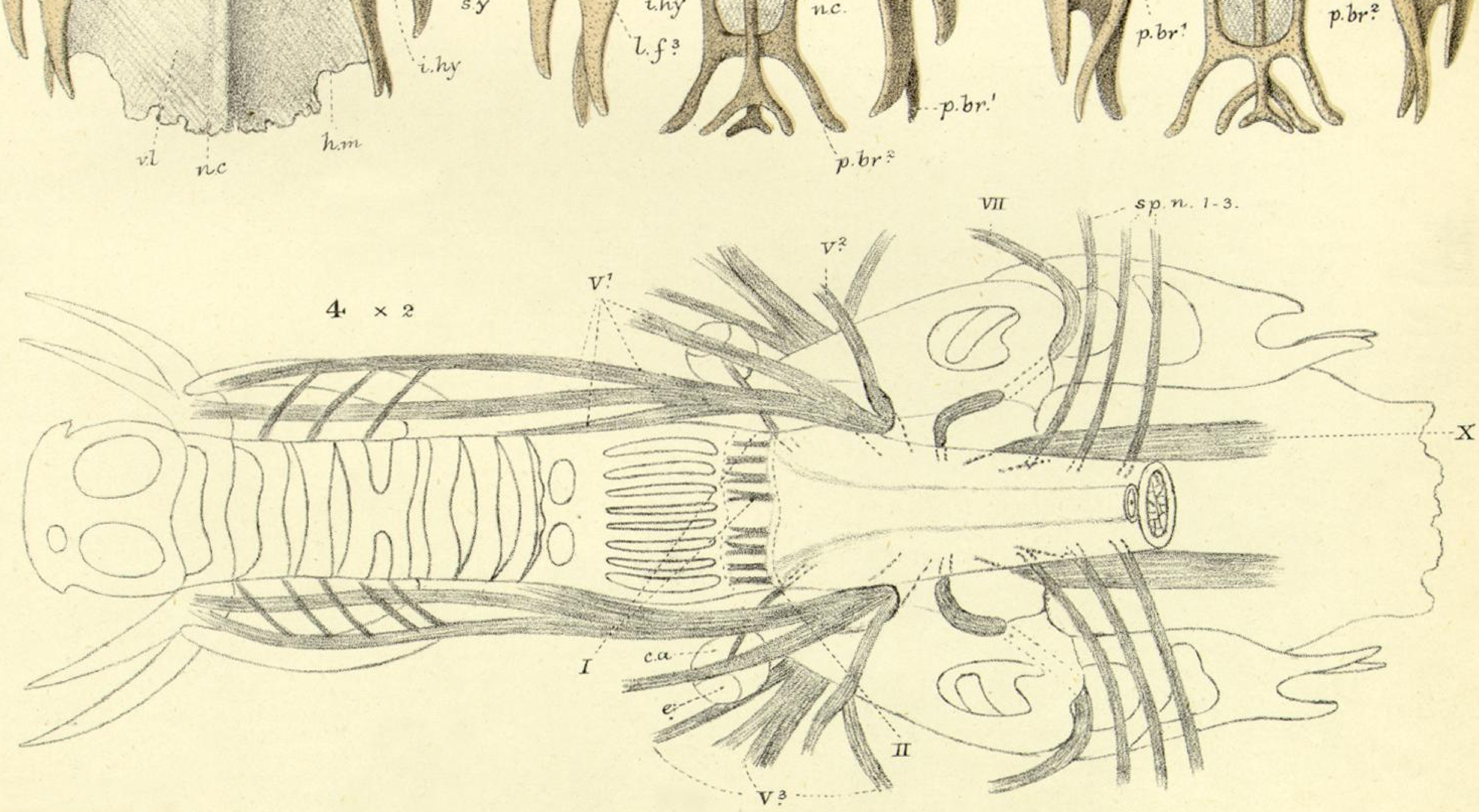
2 × 2.



3 × 2.



4 × 2



BDELLOSTOMA FORSTERI.