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The Cranial Anatomy of the Mail-Cheeked Fishes.

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THE CRANIAL ANATOMY OF THE MAIL-CHEEKED FISHES.

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Introduction.

The mail-cheeked fishes, first grouped together by Cuvier and Valenciennes ('29), are said to be all characterized by the presence of a suborbital stay, that stay being formed by the extension across the cheek, toward or to the operculum, of the third infraorbital bone. In other respects certain families of the group differ greatly from the others, so much so that they have frequently, since Cuvier's time, been widely separated in classificatory schemes. Modern tendency is however to bring the several families together again, Boulenger ('04), the most recent writer on the subject, placing them all in a single division of the Acanthopterygii, which he calls the Scleroparei. Preceding Boulenger, Gill ('88), and, following him, Jordan and Evermann ('98), keep the several families of the group together, but separate them into two suborders, the Loricati and the Craniomi. The latter fishes are said by these authors to be derived from the former and to be distinguished from them, essentially, by the following features only: 1. by the abnormal character of the scapular arch; 2. in that the post-temporal (suprascapular) forms an integral part of the cranium; and 3. that the postero-temporal (supraclavicular) is „crowded out of place by the side of the proscapula above or at the edge of the post-temporal".

Of the numerous fishes of the group I have had specimens of the following species, and they have all been more or less carefully examined in connection with the present work:

Scorpaena scrofa, S. porcus,
Sebastes dactylopterus,
Cottus octodecimospinosus, C. scorpius,
Trigla hirundo, T. gurnardus, T. lyra, T. pini, T. lineata, T. obscura,
Lepidotrigla aspera,
Peristedion cataphractum, and
Dactylopterus volitans.

The three specimens of Cottus octodecimospinosus and the two specimens of Trigla gurnardus that I have had, were kindly sent me, respectively, by the U. S. Fish Commission Station at Wood's Holl, Mass., and by Dr. Allen of the Plymouth Biological Station, England. Of Cottus scorpius I have had only a few embryos and larvae kindly sent me by Prof. W. C. Mc. Intosh of St. Andrews, Scotland. Of Dactylopterus volitans one of the several specimens was obtained from the Naples Zoological Station. The other specimens used in the investigation were all found in the market here (Menton) or at Nice, and, although they are all Mediterranean species, I have not always been able to satisfactorily identify them; for the features given by Günther ('60) as of specific value are often very variable, and there are apparently, in many of those features, an almost perfect series of intermediate types.

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In addition to the investigation of these several mail-cheeked fishes it has been found necessary to carefully examine certain special features in the cranial anatomy of several other fishes, these fishes being mostly obtained here, though certain of them were sent me from America, by one of my assistants, Mr. Wm. F. Allen.

The Scorpaenidae are said by Gill to be the most generalized of the mail-cheeked fishes, and the Scorpaenids to be the most generalized of that family. Because of this, I begin the descriptions with Scorpaena, selecting S. Scrofa because of its being larger than S. porcus. This fish is described with considerable detail, for it is often the apparently unimportant features that are important in comparisons. Each cranial bone is described under its own special heading, and to make the descriptions complete under each of these headings, some repetition has been unavoidable. As the descriptions proceed, comparisons are at once made with fishes other than the mail-cheeked ones, no special sections being devoted to comparative discussions alone. The other mail-cheeked fishes included in the investigation, are, when described, compared, as much as possible, with Scorpaena scrofa only. Scorpaena porcus, the skull of which, though smaller than S. scrofa otherwise closely resembles it, is referred to only where appreciable differences were noticed.

The nomenclature employed differs somewhat from that heretofore employed by me, for it has seemed to me best to adopt, in large part, the current English names of the cranial bones. This will appear in the descriptions of Scorpaena, and needs no special explanation here.

During the investigation, which has been in progress during several years, I have had the continued aid of my three assistants at Menton, Mr. Jujiro Nomura, Mr. G. E. Nicholls and Mr. John Henry, to whom the preparation of the material, the drawings used for illustration and the literature references were largely confided, circumstances obliging me to be frequently absent from the laboratory. The dissections were almost all prepared by Mr. Henry. Mr. Henry also traced the nerve components in the sections of Dactylopterus, controlling also certain of the results obtained by me in the examination of the sections of Scorpaena and Lepidotrigla. The drawings were made by Mr. Nomura from specially prepared specimens, not used for the descriptions, and because of frequently occurring individual variations in different specimens the figures will be found to differ in certain details from the descriptions. The descriptions give the usual conditions.

When the work was nearly finished I received Supino's ('04/06) work on the Triglidae, in which Scorpaena scrofa, Sebastes, Trigla lyra, Cottus, Peristedion and Dactylopterus are all described and figured. But both the descriptions and the figures are so incomplete and so lacking in definite detail that but little reference will be made to them. Garman's ('92) figure of Cottus octodecimospinosus, given in his work on „The Discoboli", is equally indefinite and unsatisfactory.

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I. THE LORICATI.

I. Scorpaena.

1. SKULL.

The complete skeleton of the head, and the skull proper (neurocranium) of Scorpaena scrofa are show in Figs. 1—9. As is well known, the orbits are large; the interorbital wall simple; the dorsal surface of the skull, between the orbits, deeply concave and traversed longitudinally by two prominent ridges; and on the vertex there is a subquadrangular groove which is slightly broader than it is long, and which is bounded on either side, and both anteriorly and posteriorly, by ridges.

The two longitudinal ridges between the orbits mark the course, on either side of the head, of the supraorbital latero-sensory canal. Each of these ridges turns postero-laterally at its hind end and is there joined by the transverse ridge that forms the anterior boundary of the groove on the vertex, the single ridge formed by these two ridges united then immediately turning posteriorly and terminating in a pronounced spine. This spine lies not far from the hind edge of the frontal, at the anterior end of the ridge that forms the lateral boundary of the groove on the vertex, and it projects backward, or backward and laterally above the opening of the seventh, or terminal tube of the supraorbital latero-sensory canal, that opening lying immediately lateral to the lateral bounding ridge of the groove on the vertex. Emery ('85) has called this spine the frontal spine, naming it after the bone on which it lies, and I adopt this term rather than the term tympanic, given by Jordan & Gilbert ('83) to the corresponding spine in Scorpaena porcus.

The tympanic spine of the Scorpaenidae, as defined by Eigenmann and Beeson ('94) in their descriptions of the Sebastinae, is said to always overarch a mucous pore, to always lie near the outer border of the frontal, and to be always present and homologous throughout the group. The coronal spine, as defined by the same authors, is said to be developed in but few species, to lie on the frontal, nearer the mid-dorsal line than the tympanic, and directly in front of the parietal ridge. The frontal spine of Scorpaena scrofa thus has the relations to the supraorbital latero-sensory canal of a tympanic spine, while in other respects it has the position of a coronal spine, as that spine is shown both in Jordan & Gilberts' diagram of the cranial ridges of Sebastodes (l. c. p. 653) and in Cramer's ('95) figures of Sebastodes introniger and Sebastodes auriculatus. The relation to the supraorbital canal is, however, so typical that the spine, in Scorpaena, is certainly a tympanic and not a coronal one. It lies at the hind end of the interorbital ridge on the frontal, that ridge thus appearing as a cranial spinous ridge; but this relation of the spine to the ridge, though apparently usual in the group, is not constant, as will appear when the spine is described in Scorpaena porcus.

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Slightly mesial to the ridge that forms the lateral boundary of the groove on the vertex, near the middle of its length, and at the anterior edge of the parieto-extrascapular bone, another cranial ridge begins. Running at first parallel to the lateral bounding ridge of the groove on the vertex, this other ridge soon curves latero-posteriorly onto the bounding ridge, near its hind end, and so leaves the groove on the vertex at its postero-lateral corner. It then curves again into the direction of the bounding ridge, here lying posterior to the groove on the vertex, and continues either parallel to and slightly mesial to the line prolonged of the bounding ridge of the groove, or as a direct posterior continuation of that ridge. It soon terminates in a spine, this spine rising from the dorsal surface of the parieto-extrascapular slightly postero-mesial to the central point of the body of that bone, and lying directly superficial to that section of the supratemporal latero-sensory canal that is lodged in the bone. This spine is the parietal spine of Jordan & Gilbert's diagram of Sebastodes, and it lies approximately at the hind end of the parietal part of the parieto-extrascapular bone. The ridge to which the spine is related is then the parietal spinous ridge, and this ridge is not the one that forms the lateral boundary of the groove on the vertex, that ridge being an independent one, without related spine.

Immediately posterior to the parietal spine, or immediately lateral to its base, another cranial spinous ridge begins, and running postero-laterally to the hind edge of the parieto-extrascapular there terminates in the nuchal spine; this spine thus lying at the hind edge of the extrascapular part of the parieto-extrascapular.

Emery ('85), in his figure of the skull of Scorpaena scrofa, shows but a single spine on the parieto-extrascapular, the spine and bone both being called by him, the external occipital.

In the several specimens of Scorpaena porcus that were examined in this connection, the anterior end of the parietal spinous ridge, instead of beginning close to the lateral bounding ridge of the groove on the vertex, begins well within the groove, sometimes even near the middle of the corresponding half of the groove. It leaves the groove at its postero-lateral corner, as in Scorpaena scrofa, but it is much taller, relatively to the lateral bounding ridge of the groove, than in that fish. It thus forms the apparent lateral boundary of the posterior portion of the groove, and the groove has not the evenly subquadrangular appearance that it has in Scorpaena scrofa.

The frontal, parietal and nuchal spines of Scorpaena form the three posterior members of a row of four spines, the anterior member of which is the nasal spine, lying at the hind end of the nasal bone. There is thus, in this row, a spine at or near the hind edge of each of the four dermal elements that form the mesial portion of each half of the dorsal surface of the skull; the four spines forming a mesial row of spines.

The remaining spines of Jordan and Gilbert's diagram of Sebastodes are the preocular, supraocular and postocular, all three of which are found in Scorpaena. The preocular spine of this latter fish lies on the free, orbital edge of the ectethmoid, near its dorso-mesial end, and forms the hind end of a ridge on the dorsal surface of the ectethmoid which runs, from in front, upward backward and slightly laterally. The supraocular and postocular spines rise from the dorsal surface of the lateral edge of the frontal, both lying posterior to the middle point of the orbit, and both of them projecting postero-laterally in the direction of the lateral edge of the frontal.

From the base of each of these three ocular spines, a ridge runs postero-mesially, the three ridges converging, approximately, toward the point where the fourth tube of the supraorbital latero-sensory canal leaves that canal to run backward and mesially to unite with its fellow of the opposite side and thus form the supraorbital, or frontal commissure of the latero-sensory system. The point

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where this commissure leaves the main canal lies anterior and slightly mesial to the antero-lateral corner of the groove on the vertex, and the course of the commissure, on either side, is approximately marked by the anterior bounding ridge of the groove. This latter ridge begins at the median opening of the commissure and from there runs antero-laterally, immediately posterior to the commissure, to become confluent with the frontal spinous ridge at the base of the frontal spine, as already described. The frontal and commissural ridges, as well as the three ocular ridges, thus all radiate approximately from the point where the frontal commissure arises from the supraorbital canal. The parietal ridge, also, radiates from this same point; and still another ridge, a slight one, extends from this point, postero-laterally, across the postero-lateral part of the frontal, and leads directly toward but does not quite reach the anterior end of the pterotic spinous ridge, to be later described. There are thus seven ridges radiating approximately from a certain point on the dorsal surface of the skull, all of them apparently in some way related to certain of the cranial spines. But what these relations may be, or what the significance of the ridges, I can not determine, excepting that they would seem to indicate some center of formative action at the point from which they radiate. With the exception of the frontal and parietal ridges they seem not to have heretofore been described. The preocular spine, it is to be noted, has two ridges related to it, one on the frontal and the other on the ectethmoid, the latter being the more important.

In Scorpaena porcus, the comissural ridge runs directly across the hind end of the frontal ridge, this latter ridge abutting against the former one, almost at right angles to it, at a point slightly mesial to the base of the frontal spine and there apparently ending. The commissural ridge and not the frontal ridge thus here bears the frontal spine, the commissural ridge turning sharply backward at its lateral end, and immediately terminating in the backwardly directed spine. This arrangement of ridge and spine is a definite characteristic of all my specimens of Scorpaena porcus, while the former arrangement is equally characteristic of all those of my specimens of Scorpaena scrofa in which there are three postfrontal spines, described below. Where there are, in Scorpaena scrofa, but two of these latter spines, the relations of the two ridges here in question, to each other and to the frontal spine, are intermediate in character.

In addition to the above described spines, all of which are mentioned by Cuvier and Valenciennes ('29, vol. 4, p. 291), there are, on the dorsal surface of the head of Scorpaena scrofa, a certain number of other spines, all of which, excepting two, those on the lateral extrascapulars, are also mentioned by Cuvier and Valenciennes. Three of these spines are small, and lie on the postfrontal bone; one near the antero-mesial corner of the bone, one at the postero-mesial corner and one at the postero-lateral corner. The three spines radiate, in general direction, from the antero-lateral corner of the bone, and on that corner there is a small but pronounced tubercle. Joining this tubercle and the antero-mesial spine there is a small but definite ridge, the other two spines having no related ridges. In Scorpaena porcus, in all the specimens examined, there were in this group of postfrontal spines, but one or two spines; the one spine, where it alone was found, being usually bifid. The presence of the three postfrontal spines thus seems to be a definitive characteristic of Scorpaena scrofa, but in certain of my specimens of this fish there are but two spines, as in Scorpaena porcus. These postfrontal spines must be the bifid spines of Jordan & Evermann's ('98) descriptions.

Postero-mesial to this little group of postfrontal spines, a ridge begins on the pterotic, and running postero-laterally to the hind end of that bone ends in a strong spine. Posterior to, and in the line prolonged of this spinous ridge, a ridge begins on the suprascapular, and running along the

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dorsal surface of the lateral edge of that bone ends in a spine that would seem to be the exoccipital of Jordan & Evermann's descriptions. Posterior to this suprascapular spine, and in line with it, the dorsal edge of the supraclavicular ends in a more or less pointed corner, but there is here no regular spine. Between the pterotic spine and the anterior end of the suprascapular spinous ridge, the lateral edge, or the postero-lateral corner, only, of the lateral extrascapular intervenes; and on that corner there is a small sharp prominence, rather than spine. This prominence forms the postero-lateral end of a small ridge which extends, from there, antero-mesially across the dorsal surface of the bone.

These several additional spines thus form a lateral row on the dorsal surface of the skull, one or more of the spines being found on each of the dermal bones that form the lateral portion of the dorsal surface of the skull, the lateral extrascapular excepted. But it is to be noted that the postfrontal spines lie lateral to the anterior end of the pterotic spinous ridge, and that that ridge is continued anteriorly by the slight ridge, already described, that leads toward the point from which the frontal commissure arises from the supraorbital canal.

Between the hind ends of the lateral and mesial rows of spines, there is a short row of two small spines, one on the hind edge of the lateral extrascapular and the other on the hind edge of the epiotic process of the suprascapular.

Considering, now, the posterior portion only of the dorsal surface of the skull, there are seen to be, on each side, four ridges or lines of ridges diverging approximately from the frontal spine. One of these ridges is the commissural ridge, which extends postero-mesially to the mesial edge of the frontal; and another is the postocular spinous ridge which extends almost directly laterally to the lateral edge of the same bone. Between these two ridges are the parieto-nuchal and pterotic ridges, both extending backward, but diverging. These four ridges thus divide the posterior portion of the dorsal surface of the skull of Scorpaena into three regions which are seen to be strikingly similar to the regions occupied by the supratemporal, temporal and dilatator grooves of Scomber (Allis, '03); and the three grooves of Scomber would arise if the three regions in Scorpaena were to undergo a depression, this depression being accompanied by a diminution in size and a backward translation of the lateral extrascapular, and by a separation of the postfrontal from the underlying bones of the skull.

SUBQUADRANGULAR GROOVE.

The subquadrangular groove on the vertex of Scorpaena is a single median depression, which occupies the position of the two supratemporal grooves, united, of Scomber. Laterally it is bounded, on either side, in part by the parietal spinous ridge, and in part by the ridge that runs backward from the base of the frontal spine immediately lateral to the parietal spinous ridge, this second ridge bearing no spine. The anterior edge of the groove is reëntrant, and is formed, on either side, by the corresponding commissural ridge. Posteriorly the groove is bounded by a transverse ridge on the dorsal surface of the supraoccipital, this ridge being heightened by superimposed, transverse suturating processes of the parieto-extrascapulars. The parietal spine lies at the lateral end of this transverse ridge, and hence at the postero-lateral corner of the groove. The frontal spine lies at the antero-lateral corner of the groove. The floor of the groove is formed mainly by the frontal and parieto-extrascapular bones, but a small median portion of the supraoccipital is exposed near the middle point of the groove. These same three bones, on either side of the head, form the floor of the larger, anterior portion of the supratemporal groove of Scomber, the extreme posterior portion of the floor of the groove, in this latter fish, being formed by the supraoccipital and epiotic. The groove, in

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Scorpaena, thus seems to represent the fused anterior portions only of the supratemporal grooves of Scomber. The posterior portions of the grooves of the latter fish must accordingly be looked for elsewhere in Scorpaena, and they would seem to be represented, in this latter fish, in two small pockets, one on either side, which occupy what is, in appearance, the dorsal portion of the posterior surface of the skull. The pockets lie on a dorsal, shelving portion of the posterior surface of the skull, this shelving portion being separated from the portion ventral to it by a distinct angle, usually produced into more or less of a ridge. This ridge is transverse and nearly horizontal in position, corresponds approximately to the hind edge of the dorsal surface of the skull of Scomber, and appears as that edge of the skull of Scorpaena when the dermal bones are removed (Fig. 7).

There are thus two hind edges to the supratemporal portion of the dorsal surface of the skull of Scorpaena, an antero-dorsal one formed by the dermal bones, and a postero-ventral one formed by the primary bones. The development of these two edges I have not attempted to investigate, but the space between them evidently represents the extent to which the trunk muscles have invaded the dorsal surface of the skull in the supratemporal region. This supratemporal invasion is distinct from the one that enters the temporal fossa, and its extent, which varies greatly in different fishes, seems to be in some way related to the development of the extrascapular bones and the latero-sensory canals they carry. Where the mesial extrascapular elements are strongly developed, meet in the middle line, or are fused with the parietals, the trunk muscles pass dorsal to the hind edges of the bones and stop when, or before, they reach the commissural canal: while where the bones are feebly developed, or not fused with the parietals, the invading muscles seem to push them apart, to pass forward beneath them and the canal they carry, and then onward, dorsal to the more anterior bones. To the first mentioned, and probably more primitive category belong Polypterus, Amia, Lepidosteus, Dactylopterus, and all those teleosts in which the mesial extrascapular elements have fused with the parietals (Allis, '04); while to the second category probably belong the larger number of teleosts, Scomber being typical of the class. The line that marks, in fishes, the anterior limit of the surface of invasion of the trunk muscles, has been called by Sagemehl ('84b) the linea nuchae, and it forms, in many fishes of the first above-named category, the apparent, and is usually there considered as the actual hind edge of the skull. It is, however, in reality, the secondary hind edge of the skull, the primary hind edge underlying it and being formed by the hind edges of the dorsal surfaces of the primary bones of the skull. The possible presence of these two edges must always be borne in mind, for it is of importance in comparisons of the region.

In Scorpaena, the two little pockets, just above described, accordingly lie on what is probably the posterior portion of the dorsal surface of the skull, and not on its posterior surface. The mesial half of the floor of each pocket is formed by a part of the supraoccipital, the lateral half being formed in part by the epiotic, and in part by the dorso-posterior surface of a flange of bone that projects downward backward and mesially from the ventral surface of the parieto-extrascapular, not far from its hind edge. This flange lies on the dorsal surface of the primary skull, and notwithstanding its apparent origin from the ventral surface of the parieto-extrascapular should probably be considered as a part of the dorsal surface of that bone. The apparent hind edge of the parieto-extrascapular, of either side, projecting backward, forms the roof of the corresponding pocket, and the two pockets are separated from each other by the spina occipitalis. A part of the epiotic, together with overlying parts of the suprascapular and parieto-extrascapular, separate each pocket from the dorsal portion of the corresponding temporal fossa.

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TEMPORAL FOSSA.

The temporal fossa of fishes is a hole formed by the more or less complete roofing, by dermal bones, of the temporal groove on the dorsal surface of the primordial cranium. This fossa and groove are both shown in what is considered as the most primitive condition known, in Amia calva, in which fish they have both been described by Sagemehl ('83); but Sagemehl did not recognize, in this fish, an anterior extension, or diverticulum of the groove, to which I later called attention ('89, p. 501), and which becomes incorporated in the groove and fossa in certain other fishes, as shown below.

In Scorpaena scrofa the temporal groove is deep, but short, antero-posteriorly, as compared with that of Scomber, corresponding only to the deeper, posterior portion of my descriptions of the groove in the latter fish. The groove is, in Scorpaena, completely roofed, mainly by the lateral extrascapular and suprascapular bones; but there are, along the edges of the groove, overhanging portions of the pterotic, epiotic and parieto-extrascapular, and between the edges of the parieto-extrascapular and lateral extrascapular, there are narrow spaces spanned by tough fibrous tissue. The groove being completely roofed, becomes a fossa, and opens onto the posterior surface of the skull by a large opening which occupies the dorso-lateral portion of that surface. A small opening between the hind edge of the pterotic and the opisthotic process of the suprascapular, leads into the fossa from the lateral surface of the skull, and through this opening the supratemporal branch of the nervus lineae lateralis, accompanied by certain vagus fibres, passes inward into the fossa. The mesial wall of the fossa is formed by the epiotic; its lateral wall by the pterotic, the opisthotic, and the opisthotic process of the suprascapular. Its floor is formed in part by the sloping side walls of the pterotic and epiotic, but mainly by a relatively wide strip of cartilage which separates those two bones, and which is the temporal interspace of my descriptions of Scomber. Posteriorly this interspace of cartilage is bounded by the dorsal edge of the exoccipital, which bone forms the floor of the posterior opening of the fossa, and, in large specimens, a small part also of the floor of the fossa itself.

The fossa lodges, as in other fishes, an anterior extension of the trunk muscles, and if those muscles were to push forward and upward, through the space covered by the lateral extrascapular, onto the dorsal surface of the skull, they would push forward dorsal to the parietal portion of the parieto-extrascapular and dorsal also to the depressed hind edge of the frontal, and, occupying the region between the mesial and lateral rows of spines, would give rise to the temporal groove of Scomber.

In one specimen, in which the parieto-extrascapular had been removed from the underlying bones, the dorso-anterior end of the temporal groove formed a sort of pocket which is apparently the homologue of the recess in the antero-lateral corner of the groove in Scomber ('Allis, '03, p. 51), and the homologue also of the anterior diverticulum of the groove in Amia. The pocket, in Scorpaena, opened onto the dorsal surface of the primordial cranium by a small and separate opening, which lay immediately anterior to the suturating edges of the superficial portions of the epiotic and auto-pterotic, between those bones and a portion of the chondrocranium, and was covered externally by the parieto-extrascapular.

In the Elopidae and Albulidae, the former of which are said by Ridewood ('04a) to be the most archaic of existing teleosts, and the latter to be in but few respects more highly specialized, the temporal fossa is said to be very extensive. Ridewood calls this fossa the posterior temporal fossa, and says that it extends forward a considerable distance beneath the frontal; apparently extending even

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a certain distance between the orbits, for in addition to the proötic, sphenotic (postfrontal, Ridewood) and supraoccipital, Ridewood says that the alisphenoid, and even the orbito-sphenoid form, in one or other of the fishes described, a part of its floor.

Dr. E. C. Starks, of Stanford University, having most kindly sent me two specimens of Elops and a few specimens of Albula, I have examined the temporal fossa in both of these fishes. In Elops, I find that the posterior portion only of the fossa is the homologue of the entire fossa of Scorpaena. This posterior portion of the fossa is much shorter and much less important than the anterior portion, and is separated from the latter portion by a wide and evenly rounded transverse elevation of the floor of the fossa. This transverse elevation, or saddle, separates the fossa into two portions, which have the appearance of having been primarily more or less independent, and only secondarily united to form a single continuous groove. The anterior portion apparently corresponds to the anterior diverticulum of the temporal groove of Amia, the posterior portion corresponding to the temporal groove itself of that fish.

The lateral wall of the posterior portion of the fossa is formed by the pterotic and opisthotic, its mesial wall by the epiotic and supraoccipital, and its floor by the pterotic, the exoccipital, and the temporal interspace of cartilage. In the mesial wall of this posterior part of the fossa there is a deep depression which is certainly the homologue of the preëpiotic fossa of Ridewood's descriptions of Clupea, though that author does not, in Elops, so define it.

The saddle between the anterior and posterior portions of the fossa is formed, in Elops, mainly by the pterotic, the saddle arching over the subtemporal fossa and forming its roof. On the summit of the saddle the layer of bone separating the two fossae is so thin that a slight further excavating of the bone, on either side, would break down the bony separating wall and either put the two fossae into direct communication, or leave them separated by membrane only. This latter condition is said by Sagemehl ('91, p. 555) to be found in Rasbora and Leptobarbus of the Cyprinidae.

The floor and side walls of the anterior portion of the fossa are formed by the pterotic, proötic, sphenotic and alisphenoid, the part of the alisphenoid here concerned being a part of a well developed flange on the internal surface of the bone together with that part of the internal surface of the bone that lies postero-lateral to that part of the flange. This flange of the alisphenoid is continuous ventrally with a ridge on the internal surface of the proötic, this ridge forming the anterior wall of the labyrinth recess. The anterior semicircular canal, running upward and laterally, lies postero-lateral to the ventral portion of the flange, in a recess in the alisphenoid, and, as this recess is bridged by a narrow bar of bone, the dorso-anterior end of the semicircular canal lies in a short canal in the alisphenoid. The sphenotic comes into no bounding relations to the labyrinth recess, being wholly excluded from it and also from all bounding relations to the cranial cavity, by the deep anterior portion of the temporal fossa. If this condition of the sphenotic is primary, its bounding relations to the anterior semicircular canal are evidently a secondary acquisition, and that the condition is primary would seem to be indicated by its being found in this primitive teleost, in Amia, and also in Esox. In neither of these three fishes does the bone extend through the cranial wall; and it accordingly must have been first developed, wholly independent of the anterior semicircular canal, simply to strengthen the postorbital process of the skull and to give a proper surface of attachment to the muscles that have their origins there. A similar origin is ascribed by Gaupp ('03) to the autopterotic in Salmo.

In the deepest point of the anterior portion of the fossa there is, in the proötic bone, a small circular opening. From this opening a canal runs at first downward in the proötic to the dorsal edge

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of the posterior portion of the trigemino-facialis chamber, and then turns backward in the bone, parallel to that edge of the chamber. At the anterior edge of the subtemporal fossa the canal turns inward in the bounding wall of the fossa, still lying in the proötic, and, on one side of the head of the one specimen sacrificed in this examination, there seemed to end blindly at the hind edge of the proötic. On the other side of the head of the same specimen the canal opened into the subtemporal fossa, but whether this opening was an artifact or not, I could not determine. What this canal is I can not determine, but it may, perhaps, be a persisting remnant of the spiracular canal of Amia.

In Albula the temporal fossa is similar to that in Elops, but its anterior portion is much less extensive; and I find no canal opening into the bottom of the fossa. No special description of it seems necessary.

In Esox, according to Vrolik's ('73) figures of transverse sections of the skull, there is, in the temporal fossa, a mesial pocket which has the position of a preëpiotic fossa. The deeper portion of this pocket is bounded both above and below by portions of the supraoccipital bone, exactly as the preëpiotic fossa is, in Elops. The anterior end of the temporal fossa ends blindly in the thick dorso-lateral edge of the chondrocranium, and is there partly surrounded by a thin layer of perichondrial bone which apparently belongs to the pterotic though this is not so stated. The dorsal portion of the alisphenoid is formed by two plates of perichondrial bone, one of which lines the external and the other the internal surface of the cartilaginous cranial wall. The internal plate is apparently raised into a ridge-like process, but whether it bounds a recess for the dorso-anterior end of the anterior semicircular canal, or not, is not evident. The wall of the cranial cavity, however, quite certainly continues backward, in the line of the ridge-like process, until it joins that flange of the supraoccipital that forms the floor of the preëpiotic pocket, as it does in Elops. A region corresponding to that occupied by the anterior portion of the temporal fossa of Elops is thus, in Esox, included in the cranial wall, and the sphenotic, as in Elops, is excluded from bounding relations to the cranial cavity. Assume that there is, on the dorsal surface of this part of the chondrocranium of Esox, an anterior diverticulum of the temporal fossa similar to the one in Amia: a simple enlargement and deepening of this diverticulum, and its partial confluence with the temporal groove of the fish would produce the conditions found in Elops; and if the enlarged diverticulum did not become confluent with the temporal groove, acquiring, instead, an independent opening to the exterior, on the lateral surface of the skull, it would seem as if it must give rise to the conditions described by Ridewood ('04c, p. 473) in Engraulis.

In the Characinidae, judging from Sagemehl's ('84b) descriptions and figures, the pterotic, and that bone alone, forms the floor of the temporal fossa. This is however not true of Macrodon, which I have examined in this connection. In this fish the fossa has anterior and posterior portions, as in Elops, the two portions being separated by a low saddle. The floor of the posterior portion is formed by the pterotic, as Sagemehl states, but that of the anterior portion is formed by the proötic, the latter bone having a widely spreading dorsal edge. The anterior end of the anterior portion of the fossa abuts against and is bounded anteriorly by the sphenotic. The fossa is thus less extensive than in Elops, but much more extensive than in Scorpaena. It has an extensive preëpiotic pocket, and in this pocket lie those fenestrations of the epiotic that are said to be so characteristic of the Characinidae. The anterior wall of the labyrinth recess is formed by a strong flange that lies mainly on the proötic but extends upwards slightly onto the cerebral surface of the sphenotic. Between this flange and the cerebral wall of the anterior portion of the temporal fossa, in a deep groove, lies the anterior semi-

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circular canal. In the bottom of the anterior portion of the fossa there is, in my specimen, a foramen — if it be not perhaps simply a defect in the bone — which opens into that canal that leads from the cranial cavity to the upper one of the two apertures called by Sagemehl, in his figures of Erythrinus, the facialis foramina. The opening is so inconspicuous that I should not have noticed it had I not been led to look for it, because of the canal here found in Elops. There are also in my specimen, two perforations of the bony partition that separates the temporal fossa from the dilatator fossa, one of the perforations undoubtedly giving passage to the ramus oticus, and the other probably to a venous vessel similar to the one that, in Scorpaena, accompanies the oticus in its backward course, as will be later described. These several foramina are not described by Sagemehl, and furthermore that author's descriptions of the foramina that perforate the lateral wall of the proötic are certainly not wholly correct. The so-called jugular foramen is found, as shown, opening directly into the labyrinth recess, but this opening in the prepared skull must certainly be closed, in the recent state, by membrane, and hence can not transmit the jugular vein. In the anterior edge of this foramen a small canal begins in the wall of the proötic and, running forward, traverses the base of that flange that forms the anterior wall of the labyrinth recess and so enters a recess of the cranial cavity into which the so-called facialis and trigeminus foramina open. This cranial recess probably lodges, as in Cottus, and as will be fully described when describing that fish, the profundus, communis and lateralis ganglia of the trigemino-facialis complex, the trigeminus ganglion probably having an extracranial position. If this be so, the jugular vein, as in Cottus, does not enter the recess, but lies along the outer surface of the skull immediately beneath the extracranial trigeminus ganglion. One of the two foramina marked „fa" in Sagemehl's figures must then transmit the truncus hyoideo-mandibularis facialis, the other one, said by him to transmit a vein, probably transmitting the encephalic branch of the jugular vein. What the little canal in the proötic that I have just above described transmits, I can not tell, and it may perhaps be an artifact.

In Catostomus teres and Moxostoma sucetta, of the Cyprinidae, the axis of the temporal fossa is said by Sagemehl ('91, pp. 550—553) to lie in a frontal (transverse?) position and the fossa is said to open on the lateral instead of on the posterior surface of the skull. The anterior portion only of the fossa is roofed, the roof there being formed by the mesial edge of the dermal portion of the pterotic, the lateral edge of the epiotic (exoccipitale), and, between those two bones, by a portion of the parietal. In the genus Sclerognathus, the roofing portions of these several bones are said to have almost disappeared, and in the genus Diplophysa to have entirely disappeared; the fossa of this latter fish thus becoming a simple pit or groove on the dorsal surface of the skull, the homologue, apparently, of the groove in Scorpaena, and not of that in Scomber. The extrascapular and suprascapular bones are not here considered by Sagemehl as roofing bones of the groove, but they are nevertheless found in all the Cyprinidae (l. c., p. 507), the extrascapular as a small scale-like bone at the hind edge of the pterotic, and the suprascapular as a long, lance-like bone that lies along the hind edges of the pterotic and epiotic and there roofs the posterior entrance of the temporal groove. In certain others of the Cyprinidae, the temporal fossa is said by Sagemehl to be reduced to a simple and narrow canal which opens on the posterior surface of the skull between the pterotic and epiotic. In the genera Nemachilus, Misgurnus, Cobitis and Acanthophthalmus even this narrow canal is said to become almost entirely obliterated.

A temporal fossa, similar to that of Sclerognathus, is said by Sagemehl to be found in very many of the Physostomi and in nearly all the Acanthopterygii and Anacanthini. This I am inclined

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to think is not strictly correct, for the fossa in some of these latter fishes is certainly similar to that in Scomber, which, as above explained, is something more than the equivalent of that in Sclerognathus and Diplophysa. Sagemehl further says that the fossa in the fishes above mentioned has arisen wholly independently of that in Sclerognathus. This also seems to me incorrect. Sagemehl himself says that the fossa in Amia represents a primitive condition. From that fossa, the fossa of Scorpaena is readily and directly derived; and from the fossa of Scorpaena that of Sclerognathus would be directly derived by the simple reduction, which has actually taken place in the latter fish, of the extrascapular and suprascapular bones. And from the condition found in either Scorpaena or Sclerognathus that in Scomber would be produced by the continued anterior prolongation of the muscles that fill the groove, the muscles passing dorsal to the parietal and frontal bones instead of ventral to them. If the muscles passed beneath the parietal and frontal it would give rise to the conditions found in Macrodon and Elops. From the condition found in Sclerognathus, also, that in Nemachilus, Misgurnus, Cobitis and Acanthophthalmus would be derived by a simple constriction of the groove. due to the encroaching ingrowth of the pterotic and epiotic. It seems almost unnecessary to state that the conditions found in these latter fishes is certainly not a primary one, the trunk muscles here being seen in process of excavating the fossa in the solid bones of the skull.

In Gasterosteus, according to Swinnerton ('02), the temporal groove is shallow and wholly uncovered, the extrascapular (supratemporal) being said to lie superficial to the trunk muscles but wholly posterior to the hind edge of the skull. Swinnerton considers the groove in this fish as similar to that in Amia. It is, on the contrary, similar to, but less developed than the groove in Scomber, in which fish the groove also lies wholly external to, instead of internal to, the parietal. A similar groove is also found in all the Clupeoid fishes described by Ridewood ('04c), excepting only Chanos, but there is, in these fishes, a related temporal foramen not found in Scomber or Gasterosteus.

In Gymnarchus the temporal fossa undergoes special development and acquires relations to the auditory organ, as I have recently shown ('04); and, judging from Ridewood's descriptions, the same may be true of the other Mormyridae and of the Notopteridae. In these latter fishes, Ridewood ('04b) does not describe either a temporal fossa or groove, but his figures show such a groove, apparently similar to that of Scomber, this groove being more or less roofed by an extrascapular (supratemporal) bone or bones, and having, in its mesial wall, a large opening. This opening Ridewood describes as a lateral cranial foramen, and he considers it ('04a, p. 61) as the possible homologue of the preëpiotic fossa of his descriptions of Clupea.

In Gonorhynchus, according to Ridewood ('05b), there is no suggestion, even, of a temporal groove; but judging from the figures given, it would seem as if there might there be a very shallow groove of the kind found in Scomber.

It may here be stated that, in Notopterus, Ridewood says that the extrascapular (supratemporal) „does not carry the sensory tube", the supratemporal cross-commissure lying anterior to that bone. Bridge ('00, p. 517) however says that this sensory canal of Notopterus is „strengthened", along its lateral and inner walls, by „two longitudinally arranged, thin, semi-cylindrical bones, or sensory ossicles"; which ossicles must accordingly be, or belong to, the extrascapulars. Be this as it may, the variation seems morphologically unimportant, for the extrascapular does not actually „carry" the canal in Gymnarchus either, the bone lying wholly superficial to the canal.

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DILATATOR FOSSA.

The dilatator fossa of Scorpaena is a small pit that lies directly above the interval between the two articular facets for the hyomandibular, near the dorso-lateral edge of the skull. Its posterior portion is enclosed in the pterotic, its anterior portion in the sphenotic. Between these two bones there is, in the lateral edge of the roof of the fossa, an interval, which leads onto the roof of the primordial cranium but is covered by the purely dermal postfrontal bone. The fossa gives origin to a small superficial bundle of the dilatator operculi muscle, and corresponds to the deeper, posterior portion, only, of the large dilatator groove of my descriptions of Scomber. If the dilatator muscle were here, in Scorpaena, to push upward through the interval between the pterotic and sphenotic, it would lift the postfrontal from the dorsal surface of the primordial cranium, and occupying the region between the pterotic and postocular spinous ridges, give rise to the dilatator groove of Scomber.

In the bottom of the fossa there are two openings. The anterior one opens directly into the oticus canal and transmits a vein which is associated with the ramus oticus. The other transmits a vein that comes from regions median to the oticus, between the primary skull and the overlying dermal bones.

The dilatator fossa and groove of the nomenclature here employed are the lateral temporal fossa or groove of Ridewood's recent descriptions of the teleostean skull. But Ridewood does not call attention to the marked difference between these fossae and grooves, as just above set forth, and doubtless did not recognize it. In both Elops and Megalops, for example, the lateral temporal groove of Ridewood's descriptions would seem to be the homologue of the dilatator groove of Scomber; while in both Albula and Bathythrissa, the lateral temporal fossa would seem to be the homologue of the dilatator fossa of Scorpaena; the lateral temporal grooves and lateral temporal fossae of his descriptions then not being equivalent.

In the Clupeidae, there would seem to be, from Ridewood's descriptions, a dilatator groove similar to the groove in Scomber.

MESETHMOID.

The mesethmoid has a keel-shaped anterior portion, the keel directed dorsally, and a thin tapering posterior portion which is concave longitudinally, on its dorsal surface, and ends posteriorly in a point. Between these two portions, and at about the middle of the length of the bone, two stout prong-like processes arise, one on either side, and project upward and slightly laterally and forward. The hind edge of each process is usually slightly convex, curving upward, forward and laterally, while the ventral half of the anterior edge is slightly concave; the whole process having the appearance of a horn projecting upward, forward and laterally but with the point cut off obliquely, so that a flat surface is presented almost directly forward. This flat surface gives origin to the ethmo-maxillary ligament, while the lateral surface of the process gives support and attachment to the hind end of the nasal bone. This stout and prominent process has long been known and is the homologue of the quite differently appearing dorso-lateral process of my descriptions of Scomber, a fact I did not recognize when describing that fish. It has been called the mesethmoid process in certain descriptions of the Scorpaenidae, a name which I adopt as much preferable to the term employed by me.

The median keel on the dorsal surface of the anterior portion of the mesethmoid forms the thick but low internasal wall of the skull. It extends backward a varying distance between the two mesethmoid processes, and on it the cartilaginous rostral slides backward and forward, the tapering hind end

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of the cartilage passing wedge-like between the processes and its backward motion being arrested by its wedging in between them. That part of the mesethmoid that lies on either side of the median keel, forms part of the floor of the nasal pit, but the nasal sac rests but little upon it, being crowded off it by the rostral. On the dorsal surface of the posterior portion of the mesethmoid, on either side, the frontal rests, the articulating edges of the two bones being often more or less dovetailed together. The frontal of either side extends forward to the base of the corresponding mesethmoid process, the two frontals entirely covering the posterior part of the mesethmoid excepting only a small median portion.

The mesethmoid of Scorpaena, although undoubtedly a so-called primary bone, consists of two distinctly different portions. One of these portions is a thin dense layer of superficial bone. The other portion is a deeper one, of quite different appearance, which underlies the central portion only of the superficial portion, and there replaces portions of the cartilage of the skull. I have made no attempt to study the development of these two components of the bone, or even to determine, other than most superficially, their character. The investigation has however involved the examination of several series of sections of specimens from 45 mm to 55 mm in length, and in these sections the condition of several of the cranial bones was more or less carefully noted. In these specimens the deeper portion of the mesethmoid of the adult, the portion that replaces parts of the cartilage of the skull, has not yet begun to develop. The superficial portion of the bone is represented by a thin plate that lies closely upon the cartilage of the skull, without intervening membrane, and must be primarily wholly of perichondrial origin; but this perichondrial plate receives, at certain places, accretions, or additions, to its outer surface, and these accretions, although they present in sections exactly the same appearance as the perichondrial plate, seem to be of purely membrane origin. This is particularly noticeable, in my specimens, along the lines of the articulation of the mesethmoid with the frontals, and in the mesethmoid processes. These latter processes rise from and are directly and unbrokenly continuous with the layer of perichondrial bone, but they are so important, and so wholly out of all relation to existing cartilage that they must be largely of purely membrane origin. Otherwise, there must be here an important fold in the perichondrial tissues which occupies the place of a cartilaginous process found in other earlier forms, and this tissue must give origin to perichondrial bone without the related development of any cartilage.

The superficial portion of the mesethmoid of the adult, of dermo-perichondrial origin, as above explained, is in direct contact, on either side, with a corresponding portion of the ectethmoid. Anteriorly it is in contact with the dorsal limb of the vomer. The deeper part of the mesethmoid, of endosteal origin, is every where in contact with, and replaces portions of the antorbital cartilage, and does not extend ventrally through that cartilage.

ECTETHMOID.

The ectethmoid, on either side, is the prefrontal of many authors, the parethmoid of Swinnerton's descriptions of Gasterosteus, and the preorbital ossification of my own descriptions of Amia and Scomber. It has, in Scorpaena, a dragon-wing-like appearance, and consists of a wing, an arm that bears that wing, and a small bit of shoulder or body that bears the arm and supports the mesial edge of the wing. The wing is a thin plate of bone, concave posteriorly and convex anteriorly, which projects upward and backward, in a curved line, from the dorsal surface of the arm, and is fused in the basal portion of its mesial edge with a part of the body of the bone. The wing of the bone develops without being

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preformed in cartilage, resembling, in this, the mesethmoid processes of the mesethmoid; but, as in the case of the latter processes, the bone is perhaps of perichondrial origin, developed, in that case, in perichondrial membrane, but without the related development of cartilage. The arm of the bone projects antero-latero-ventrally from a relatively small ossification of the side wall of the skull, this ossification lying immediately in front of the orbit and forming the body of the bone. From the ventro-mesial corner of the anterior surface of the wing, where the arm and wing join the body of the bone, two ridges start, and diverging slightly run upward and backward to the dorso-posterior edge of the wing. The lateral one of these two ridges terminates in the preocular spine, which lies near the dorsal end of the lateral edge of the entire bone. The mesial ridge does not terminate in a spine, but gives support, along its mesial surface, to the lateral edge of the anterior end of the frontal, a pronounced ridge, formed by the two bones, here appearing on the dorsal surface of the skull. The curved lateral edge of the wing turns sharply forward, at its ventral end, to join the outer end of the arm of the bone, a sharp corner, but not a spine, marking this angle in the edge of the wing. In certain of the Scorpaenidae there is said to here be a short, blunt spine. On the dorso-anterior surface of the wing, lateral to the preocular spinous ridge, there is sometimes an eminence, or short spine, which occupies the position of a stout process found on the bone of Cottus, that process there giving support to a lateral process of the nasal bone, as will be later described.

The arm of the ectethmoid is a stout, flat, quadrant-shaped process, which has a slightly curved outer edge presented ventro-laterally, and nearly straight dorsal and mesial edges which are both considerably thickened. The entire arm, in the adult fish, thus looks like two stout processes that arise from a single point, and, diverging, are connected by an intervening portion of thinner bone. In 45 mm specimens the two process-like portions of the arm are of cartilage, enclosed in perichondrial bone, the thinner intervening portion being of bone similar to that that forms the wing of the bone. In the adult, one of the process-like portions of the arm lies in a nearly horizontal position, directed laterally and slightly forward. It forms the dorsal edge of the entire arm, and its dorsal surface forms part of the dorsal surface of the entire skull. Its anterior surface is slightly concave and forms the latero-posterior and part of the posterior wall of the nasal pit. Its outer end is considerably thickened and forms a large articular head, capped with cartilage, which is presented latero-ventrally and but slightly anteriorly, and gives articulation to an articular facet on the dorsal edge of the lachrymal. The other process-like portion of the arm forms no part of the bounding walls of the nasal pit. It is directed almost directly ventrally, and its ventral end forms a small elongated articular head, capped with cartilage, which gives articulation to the posterior ethmoid articular surface of the palatine. Between these two articular surfaces, the outer edge of the arm of the ectethmoid is thin, slightly concave, and not capped with cartilage.

The body of the ectethmoid is an ossification of the ventro-lateral corner of the antorbital process of the chondrocranium, and consists, as the mesethmoid does, of a superficial layer of dense dermo-perichondrial bone, which overlies, but projects everywhere beyond, a deeper endosteal portion which replaces portions of the cartilage. This body of the bone is of less important dimensions than the part that I have described as its arm. It extends but slightly posterior to the point of origin of that arm, but its anterior portion projects considerably anterior to the arm, is gutter-shaped, and embraces the thin lateral edge of this part of the antorbital cartilage. The rounded lateral surface of this anterior portion of the body of the bone is slightly concave, longitudinally, and a deep rounded angle is thus formed between itself and the concave anterior edge of the horizontal, process-like portion

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of the arm of the bone. The space enclosed in this rounded angle is further bounded, latero-anteriorly, by the dorsal edges of the lachrymal and palatine, a large oval or rounded passage thus here being formed, between these several bones, which leads from the dorsal to the ventral surface of the skull immediately lateral to the nasal region.

On the dorsal surface of the skull, the mesial edge of the superficial, dermo-perichondrial portion of the body of the ectethmoid is serrated and articulates, by suture, with the corresponding portion of the mesethmoid, the two bones forming the floor and mesial wall of the nasal pit. On the ventral surface of the skull the body of the ectethmoid everywhere lies directly upon or is in synchondrosis with the antorbital cartilage, and is there overlapped externally, along its mesial edge, by the lateral edge of the parasphenoid. Anteriorly, on the dorsal surface of the skull, an interspace of cartilage separates the body of the ectethmoid from the dorsal limb of the vomer, this interspace being bounded mesially by the mesethmoid. On the ventral surface of the skull, in small and even medium-sized specimens, this same interspace of cartilage intervenes between the anterior portion of the body of the ectethmoid and the postero-laterally presented lateral edge of the body of the vomer; but in large specimens, the interspace may be cut into two portions by the backward growth of a process of the vomer, this process meeting or even overlapping externally the anterior edge of the ectethmoid. The lateral edge of the interspace turns slightly upward, and may present an angle, which then forms a prominence on the lateral edge of this part of the skull. The lateral portion of the ventral surface of the interspace, the part that lies lateral to the process of the vomer, when that process exists, is presented ventrally and slightly latero-posteriorly, and gives articulation to a small articular surface at the base of the maxillary process of the palatine. In Scomber, I described this articular surface of the ethmoid cartilage as the ventro-lateral, or septo maxillary process of the mesethmoid, it being the mesethmoid instead of the ectethmoid that, in Scomber, forms its principal support. In most current descriptions of the teleostean skull, it is called the anterior palatine, or prepalatine articular surface or process, the articular surface on the outer end of the ventral process-like portion of the arm of the ectethmoid being called the posterior palatine or postpalatine articular surface or process.

The posterior surface of the ectethmoid forms the concave anterior wall of the orbit; the wing, the arm, and the body of the bone all contributing to it. At the anterior end of the orbit, and somewhat above its floor, there is a pit-like depression, lying partly in the body of the ectethmoid and partly in the adjoining cartilage. The pit gives insertion to the oblique muscles of the eye, and is accordingly the anterior eye-muscle canal. In it, close to its lateral edge, is the posterior opening of the olfactory canal through the antorbital process, that canal being entirely enclosed in the body of the ectethmoid. Immediately lateral to the pit, a strong ligament has its origin, as in Scomber, and running downward is inserted on a transverse ridge-like process of the palatine cartilage that forms the hind edge of the posterior ethmoid articular surface of that element. This ligament is thickened at either edge, thus seeming to represent two ligaments incompletely fused with each other.

Ridewood says ('04a, p. 56) that the ectethmoid (his prefrontal) is usually formed by the fusion of originally separate ectosteal and endosteal components, and he says (l. c., p. 39) that the bone is „purely ectosteal" in Elops. As, in my work, I have never found a dermal ectethmoid, I have examined Elops carefully in this connection, and the bone, in my specimens, is certainly similar to the bone of Scorpaena: that is, it is formed of a perichondrial layer that has acquired dermal accretions, and these accretions do not represent a separate dermal component that has fused with an underlying perichondrial one. That an independent and purely dermal ectethmoid, related to an underlying

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endosteal bone, may have existed in earlier fishes, I can not contest, but I greatly doubt it; the apparently dermal prefrontal described in certain fishes belonging, in my opinion, to the frontal or nasal series and fusing with one or the other of those bones and not with the ectethmoid.

VOMER.

The vomer caps the pointed anterior end of the antorbital cartilage, and has dorsal and ventral limbs, one of which forms part of the dorsal, and the other part of the ventral surface of the anterior end of the skull. The anterior edge of the bone has the shape of a broad V, the point of the V directed forward in the middle line; and on the ventral surface of this edge of the bone there is a narrow raised surface the anterior portion of which is garnished with small villiform teeth, the band of teeth passing uninterruptedly from one side of the head to the other. This part of the vomer forms the head of the bone. Posterior to this head, the ventral limb, or body of the bone projects backward along the ventral surface of the skull as a thin plate which tapers rapidly to a sharp point. In its anterior portion, the body of the bone lies against the ventral surface of the antorbital cartilage, while posteriorly it fits into a depressed region on the ventral surface of the parasphenoid. The bone has no pronounced lateral processes, such as are found in Scomber, but in the angle between the head and the body of the bone, on either side, there is a slight process which projects toward, and in large specimens may even come in contact with, the anterior end of the ventral plate of the corresponding ectethmoid. This little process has already been referred to, when describing the ectethmoid, this latter bone and the process of the vomer both growing toward and giving support to the anterior palatine articular process of the ethmoid cartilage. Immediately anterior or antero-mesial to this slightly developed lateral process of the vomer, on the ventral surface of the bone, and slightly posterior to the raised portion that bears the villiform teeth, there is a large but shallow depression which gives origin to a strong ligament, the vomero-palatine ligament, which has its insertion on the mesial surface of the palatine.

On the dorsal limb of the vomer there is a median ridge which forms an anterior prolongation of the median ridge on the mesethmoid. A median interspace of cartilage intervenes between the two bones and extends forward a variable distance in a median slit in the hind edge of the dorsal limb of the vomer, this slit separating this limb of the vomer into two parts which may be called the right and left ascending processes of the bone. Near the hind end of the interspace of cartilage, and immediately in front of the mesethmoid, there is a marked angle in the mid-dorsal line of the cartilage, this angle lying not far from the middle of the entire internasal ridge. On either side of the median ridge, there is, on the dorsal surface of each ascending process of the vomer, a depressed region, and in the line of the bottom of this depression, near the anterior edge of the bone, there is a slight eminence which is found much more developed in the Triglidae. With the lateral surface of this eminence, and in the depressed region posterior to it, the postero-ventral portion of the ascending process of the maxillary articulates, as will be later described.

The ascending processes of the vomer are each in sutural contact, posteriorly, with the anterior end of the perichondrial portion of the mesethmoid; and this posterior portion of these processes has, in the adult, strikingly the same appearance as the adjacent perichondrial portions of the three ethmoid bones. The vomer can, however, be removed from the skull, in slightly macerated specimens, without apparently injuring, in the least, the underlying cartilage. Whether, because of this, the entire bone should be considered as of purely membrane origin, or not, I can not decide; but it would

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seem as if it might be partly of perichondrial origin, this perichondrial portion of the bone lying directly upon the underlying cartilage but not yet having acquired endosteal relations to it. In certain specimens, as seen in Figure 10, a bit of cartilage is enclosed in the vomer, near its anterior end, this seeming to indicate that this part of the bone is of perichondrial origin and has surrounded and isolated a bit of the chondrocranium. In sections of young specimens the ascending processes of the bone lie closely against the cartilage but are separated from it by a line of tissue, and this tissue is certainly not a simple perichondrial membrane. Just what it is, I have not sufficient histological experience to determine, but the bone, if by origin a purely membrane one, is certainly here in process of acquiring that direct perichondrial contact with the underlying cartilage that Schleip ('04, p. 351) describes in 29 mm larvae of Salmo. But there is in Scorpaena, even in the adult, no indication of that calcification of the cartilage found in Salmo. It can, however, be positively asserted that the dorsal limb of the vomer, not only of Scorpaena but probably also of all other fishes in which it is developed, has, or may acquire quite different relations to the underlying cartilage than that part of the bone that lies upon the ventral surface of the cartilage and is developed in the mucous membrane of the mouth. And this apparently different origin and character of these two parts of the bone is of importance in the homologies that I shall now seek to establish.

Beginning with Scomber, the two stout condylar processes of the head of the vomer of that fish are evidently the homologues of the ascending processes of the vomer of Scorpaena, the external surface of the processes of Scomber being presented laterally forward and but slightly upward (Allis, '03, p. 68), while in Scorpaena it is presented dorsally; and in Scomber, as in Scorpaena, these processes of the bone seem to be in process of acquiring primary relations with the underlying cartilage. The cartilaginous interspace of the internasal ridge of Scorpaena, partly enclosed as it is between the two ascending processes of the vomer, is thus the homologue of the beak of my descriptions of the chondrocranium of Scomber, and hence of a part of the prenasal process of the chondrocranium of Amia.

In Amia, the so-called posterior process of the premaxillary is, as will be later shown, the probable homologue of the articular process, to be later described, of the premaxillary of Scorpaena. It lies directly upon the dorsal surface of the anterior end of the chondrocranium, and also upon the dorsal surface of the preëthmoid (septomaxillary) bone (Allis, '98); and the anterior, or proximal end of the maxillary articulates with its ventral surface, and also with the anterior edge of the preëthmoid. The vomer lies immediately ventral to the articular end of the maxillary, and, immediately posterior to that bone, against the ventral surface of the preëthmoid. The lateral edge of the preëthmoid encroaches upon the anterior end of the single palatine articular ridge of the ethmoid cartilage, and supports, rather than forms part of, that ridge. Taking all these facts into consideration, it is evident that the preëthmoid of Amia replaces functionally the ascending process of the head of the vomer of Scorpaena, and that if it were to fuse, in Amia, with the underlying vomer, and the vomers of opposite sides were to fuse with each other, a bone functionally the equivalent of the vomer of Scorpaena would arise. But the preëthmoid of Amia is a perichondrial bone that has acquired endosteal relations to the underlying cartilage, while the ascending processes of the vomer of Scorpaena are either purely membrane bones that seem to be in process of acquiring perichondrial relations to the underlying cartilage, or are, perhaps, partly of perichondrial bone that has not yet acquired endosteal relations to the related cartilage. This difference in the character of the bone in the two fishes may however simply indicate that the primary bones develop in a somewhat different manner in Amia and teleosts, being perhaps formed, in Amia, by direct ossification of the cartilage, while in

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teleosts the cartilage is usually first broken down and then replaced by bone developed in relation to perichondrial plates. Be this as it may, the preëthmoid of Amia and the ascending processes of the vomer of teleosts seem to be developed in relation to the same region of the chondrocranium, and this seems sufficient to establish an homology.

In Esox, the preëthmoid, bone 3 of Huxley's ('72) descriptions, is an ossification of the posterior edge of that abruptly widened portion of the anterior end of the ethmoid cartilage that Swinnerton ('02) calls the preëthmoid cornu. This ossification, in young specimens of Esox, I find formed of two thin plates of perichondrial bone, united by a thick outer edge of similar appearance, the two plates lying one on the dorsal and the other on the ventral surface of the chondrocranium. In older specimens ossification extends into the cartilage, beween the two plates, from the outer thickened edge of the bone. A lateral corner of the anterior end of bone 2 of Huxley's descriptions lies directly upon the dorsal surface of the preëthmoid; and on the free, latero-posterior edge of the preëthmoid there is a longitudinal articular head, capped with fibro-cartilage, which articulates with a facet on the mesial surface of the anterior end of the palatine. The maxillary bone articulates, by a condylar surface near its anterior end, with a facet on the anterior end of the palatine, the pointed anterior end of the maxillary very nearly, but not quite, reaching the preëthmoid and being bound to that bone by tough fibrous tissue The lateral corner of the anterior end of the single median vomer rests upon the ventral surface of the preëthmoid. The preëthmoid of Esox, which seems unquestionably the homologue of the preëthmoid of Amia, thus has relations to the other bones that are in accord with the supposition that it finds its homologue in the ascending process of the vomer of Scorpaena, and its manner of development seems intermediate between that of the bone of Amia and that of Scorpaena. The vomer of Esox, as is proper where the preëthmoid is an independent bone, consists of a ventral plate only, as in Amia, without a vestige of a dorsal limb.

The only other fishes in which a preëthmoid has been described, so far as I can find, are certain of the Cyprinidae, and Belone acus. In the Cyprinidae, Sagemehl ('91) shows a preëthmoid (septomaxillary) lying on either side of the anterior end of the internasal ridge, and forming part of the dorsal surface of the anterior end of the snout. Antero-ventrally it closely approaches the anterior end of the vomer, that bone having no dorsal limb. The preëthmoids (septomaxillaries) are said (l. c., p. 510) to each lie upon, or in, a cartilaginous process that gives articulation not only to the palatine but also, through the intermediation of a pad of cartilage, to the maxillary. A fusion of the preëthmoids with the vomer would thus certainly here produce the vomer of Scorpaena.

In the Characinidae the preëthmoids are replaced topographically, as well as functionally, by processes of the mesethmoid (Sagemehl, '84b, p. 30), the vomer reaching, on either side, the base of this process, or even forming part of it. The vomer is said to have acquired pronounced primary relations to the skull, and, in Erythrinus, to even form an important part of the internasal septum. The descriptions and figures are however not definite, and it is impossible to tell whether the preëthmoids are absent or have been absorbed by the mesethmoid or by the vomer.

In Belone acus, Swinnerton ('02) says there is a preëthmoid, and he shows it apparently lying on the dorsal surface of the snout, slightly antero-mesial to his prepalatine articular facet and close to the lateral edge of the mesethmoid. Having several specimens of this fish, I have looked for this bone in three of them, but I have wholly failed to find it.

The frontal, in Belone, has a long, thin, anterior prolongation which lies closely upon the dorsal surface of the cartilage of the snout, exactly as a similar process of the frontal does in Esox. The

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anterior end of this prolongation approaches, or even overlaps, externally the hind end of the mesethmoid. The lateral portion of the prolongation supports, on its dorsal surface, the mesial edge of the posterior portion of the nasal. The nasal is a relatively large, flat, subrectangular bone, traversed its full length by the supraorbital latero-sensory canal. The posterior portion of the bone forms the roof of the nasal pit. The anterior portion of the bone rests in part upon the dorsal surface of the anterior prolongation of the frontal, in part upon the dorsal surface of the mesethmoid, and in part closely upon the cartilage of the anterior end of the snout: and this anterior portion of the nasal presents the appearance of being composed of an underlying membrane component fused with an overlying latero-sensory component. Be this composition of the bone as it may, the two parts may be referred to, for the present descriptive purposes, as the membrane and latero-sensory components of the bone. The membrane component projects slightly beyond the anterior and mesial edges of the anterior end of the latero-sensory component, there resting upon the cartilage of the snout. Along the lateral edge of the bone this membrane component turns downward, and so forms a lamina-shaped process which projects ventrally along the lateral edge of the cartilage of the snout; and this lamina-shaped process would seem to be the homologue of the process, na' described by Swinnerton on the nasal of Gasterosteus. Its ventral edge extends to, or is even more or less interposed between, the anterior end of the palatine and the cartilage of the end of the snout, this process of the nasal thus seeming to form part of the articular surface for the anterior end of the palatine.

In two of my specimens of Belone the membrane component of the nasal was easily detached, in part or in whole, from the overlying portion of the bone; and although this may have been due to a partial disintegration of the bone, due to the fact that my specimens had been long preserved in alcohol and had then been boiled, it would tend to indicate that the part of the bone that so separated was an independent ossification. It is a strictly and evidently ectosteal bone, and hence can not represent, in any part, the bone described by Swinnerton as the preëthmoid, which bone he classes as „undoubtedly endosteal".

Immediately anterior to the anterior end of the palatine, there is, on the lateral edge of the cartilage of the snout, a small but marked eminence not shown or described by Swinnerton, but which must be the preëthmoid cornu of that author's nomenclature notwithstanding that it forms no part of the articular surface for the palatine. The ventral edge of the laminar process of the nasal reaches the base of this little process, but does not extend upon it; and between the cartilaginous process and the lateral surface of the laminar process, there is a groove which receives the dorso-mesial edge of the maxillary bone, the latter bone articulating in part with the cartilage here, and in part with a small articular surface on the laminar process of the nasal. The maxillary thus here articulates with the dorsal surface of the snout, and, furthermore, partly with an apparently membrane component of the nasal bone, which component thus seems to here replace the preëthmoid, and may perhaps represent that bone. This membrane component of the nasal also somewhat resembles bone 2 of Huxley's descriptions of Esox, and it may be the homologue of that bone and not of the preëthmoid; this then applying also to the process na', of the nasal of Gasterosteus. This needs more careful investigation than I have been able to give it, but it is evident that as the vomer has no dorsal limb, the preëthmoid, if not absent, must be elsewhere represented.

The palatine of Belone is said by Swinnerton to articulate with the cranium at its anterior end only, the posterior articulation being said to be wholly absent. This certainly is not true of my specimens. Here the lateral wing of the antorbital cartilage is not entirely occupied by the ectethmoid

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bone, the cartilage extending ventrally beyond the bone, and its ventro-lateral end projecting as a small process which certainly gives articulation to the palatine cartilage at or near its hind end. Between this articular surface and the surface that gives articulation to the anterior end of the palatine, the dorsal edge of the palatine cartilage approaches closely a narrow longitudinal ridge on the ethmoid cartilage, is strongly attached to it by fibrous tissues, and would seem to be in contact with it. The anterior end of the palatine lies against the internal surface of the maxillary, posterior to the articular surface on the dorsal edge of that bone, and posterior also to the little preëthmoid cornu.

Belone, it may here be stated, presents certain peculiarities in the distribution of its latero-sensory canals. There is, in this fish, as is well known, a ventral body line, with a short branch line running upward slightly in front of the pectoral fin. What is not known, so far as I can find, is that there is a canal in the premaxillary, this canal apparently being an anterior and independent section of the infraorbital line, which extends forward, from the base of the bone, through about one third of its length. There is no slightest indication, on the external surface of the premaxillary, of a fusion of latero-sensory ossicles with an underlying tooth-bearing bone; but the evident supposition is that such a fusion has taken place, the latero-sensory ossicles, of either side, together representing the ethmoid of Amia and the supraethmoid of Salmo (Parker, '73), and each ossicle here being fused with the corresponding premaxillary to form the ascending process of that bone. A cartilaginous rostral is held between the hind ends of the premaxillaries, as it is, in Scorpaena and many other fishes, between the ascending processes of those same bones.

A further peculiarity of the latero-sensory system of Belone is, that from the point in the frontal where, in other fishes that I am familiar with, the penultimate tube of the supraorbital canal arises from that canal, the canal in Belone seems to separate into two parts. One of these two parts turns latero-posteriorly, traverses the pterotic, and seems to end at the hind end of that bone. The other part continues posteriorly to the hind end of the frontal, and there runs directly into what seems to be the antero-mesial end of the supratemporal canal, which canal then continues backward as the main canal. If the bone here traversed by the supratemporal canal is an extrascapular bone, as its relations to the canal would indicate, a parietal bone would seem to be lacking. These conditions are so unusual that I am collecting and preparing material for a proper study of them.

Returning now to the vomer, it may be said, that in all cases where an independent preëthmoid bone has been properly identified, the vomer has no ascending processes, and is confined to the ventral surface of the chondrocranium; and that in the Acanthopterygii and Anacanthini, in which fishes a preëthmoid has never been described, the figures and descriptions of the vomer show certainly that it usually has, and it seems probable that it always has, a dorsal limb. In other fishes the descriptions and figures are much too indefinite to warrant a serious attempt at comparison. It may, however, be stated that, in a general way, and so far as can be judged from the rather indefinite existing figures and descriptions, that where the maxillary has the relation to the premaxillary that Sagemehl described as lateral (the maxillary lying as a postero-lateral continuation of the premaxillary), the vomer has no ascending processes, and that where the maxillary has the position described by Sagemehl as posterior (internal) to the premaxillary, the vomer has those processes. The maxillary is found lateral to the premaxillary, according to Sagemehl ('84b, p. 101), only in a few families of the Physostomi, those few families of fishes accordingly probably being the only ones in which the vomer is without ascending processes. The maxillary is, according to Sagemehl, never found toothed excepting in those same few families.

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The term „posterior“, used by Sagemehl to describe the relations of the maxillary to the premaxillary, is confusing; for while the articular end of the maxillary certainly lies posterior (internal) to the premaxillary, the shank of the bone, in all the fishes of which I have specimens, lies dorso-external (that is, anterior or lateral, as the case may be) to the shank of the premaxillary, this relation of the bones being particularly marked when the shank of the premaxillary has a certain dorsal process which I shall describe as the post-maxillary process of that bone.

The dorsal limb of the vomer of teleosts forms an anterior portion of the more or less developed internasal wall, and it is of membrane, or perhaps partly of perichondrial origin. It accordingly does not present the only two conditions that I formerly ('98, p. 458) found unfavourable to the homologization of the preëthmoid (septomaxillary) of Amia with the vomer bone of mammals.

PARASPHENOID.

The parasphenoid of Scorpaena is a nearly straight bone, with well developed ascending processes near the middle of its length. It has a rounded anterior, and a bifurcated posterior end, and the anterior portion of its ventral surface is grooved, as usual, to receive the posterior portion of the body of the vomer. Anterior to its ascending process there is, on the dorsal surface of the bone, a thin longitudinal median ridge which fits into a corresponding depression on the ventral surface of the chondrocranium. Beginning immediately posterior to the ascending processes, there is also, on the dorsal surface of the bone, a median longitudinal ridge, but this ridge is broad and is grooved on its dorsal surface. Anteriorly this groove is shallow, but posteriorly it deepens gradually, until, near the hind end of the bone, it cuts through it, leaving only two pointed processes, one on either side. The groove forms the median part of the floor of the myodome (eye-muscle canal), the ridge lying between the ventral ends of the proötics, and the cartilage that caps those bones abutting, on either side, against its lateral surface.

Swinnerton says ('02, p. 532) that, in Gasterosteus, the ascending process of the parasphenoid, on either side, lies anterior to the exit of the trigeminus nerve, and that it meets and overlaps a process of the frontal sent down immediately in front of the sphenotic. Because of this position, anterior to the trigeminus foramen, he concludes that the process in Gasterosteus can not be the homologue of the similarly named process in Amia, in which fish it lies posterior to the trigeminus foramen. This conclusion is partly correct and partly incorrect, for the bases of the ascending processes, in the two fishes, are homologous, while the dorsal prolongations of those basal portions are not. The entire process lies, in Scorpaena and Scomber, ventral to the trigeminus foramen, and this would seem to be the usual teleostean relation. In Amia, a dorsal prolongation of this basal portion of the process passes posterior to the trigeminus foramen, comes into contact with the sphenotic, and seems to be in some way related to the spiracular canal. In Gasterosteus, a dorsal prolongation of the basal portion passes upward anterior to the trigeminus foramen, there invading and taking possession of the region occupied, in Amia, by the so-called pedicle of the alisphenoid, which latter bone is said by Swinnerton to be absent in Gasterosteus. This arrangement of the parasphenoid, in Gasterosteus, is apparently exactly similar to that found in Cottus, where the process of the bone comes in contact with the alisphenoid as well as with the ventral flange of the frontal, as will be fully described when describing that fish. Here it need only be said that that part of the alisphenoid of Amia that has been described as the pedicle of the bone, is largely or even wholly absent in certain teleosts, there

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being replaced by membrane, which membrane might easily be invaded by outgrowths from a neighbouring membrane bone.

In Gonorhynchus Greyi there is, according to Ridewood ('05b), a process that would seem to be similar to that of Gasterosteus and Cottus, but somewhat more developed, for it is said to come into contact with the sphenotic (postfrontal, Ridewood) as well as with the alisphenoid.

In Osteoglossum formosum, Bridge ('95) describes two processes on the parasphenoid, one of which would seem to be exactly similar to that of Gonorhynchus; for, although its relations to the trigeminus foramen are not given, it is said to come into contact with both the sphenotic and alisphenoid. Bridge considers this process of Osteoglossum as the equivalent of the processes of Amia, Acipenser and Polypterus; but if, as seems so evident, it is simply an exaggerated development of the processes of Gasterosteus and Cottus, it can not be the equivalent of the process of Amia. It is also not the homologue of the process of Polypterus, as is shown immediately below. Whether it is the homologue of the process of Acipenser, or not, I can not determine from the descriptions and figures that I find of that fish.

The second process of the parasphenoid of Osteoglossum is said by Bridge to grow out of the lateral edge of that bone immediately ventral to the root of the ascending process. It projects laterally and slightly upward, and gives articulation to an articular surface on the dorsal edge of the metapterygoid. It is said to have no parallel in any other teleostean fish, but to be represented in Lepidosteus by what is an essentially similar process. This process in Lepidosteus is fully described in the chapter of this work devoted to the myodome, and that it is the homologue of the process of Osteoglossum seems to me, from the figures of this latter fish, very doubtful.

In Polypterus, according to Traquair ('70), the ascending process of the parasphenoid has not only a horizontal portion, or process, which may perhaps be the homologue of the horizontal process of Osteoglossum, but also two dorsal prolongations. One of these dorsal prolongations is apparently the homologue of the sphenotic prolongation of the process of Amia, the other being still a third prolongation, not described in any other fish, which projects dorso-posteriorly, embraces the facialis foramen, and comes into contact with the so-called opisthotic bone.

PREMAXILLARY.

The premaxillary consists of a curved body, often called the horizontal part of the bone, and three processes which rise perpendicularly to that body. The curved body of the bone ends in a blunt point, and its oral surface is covered, nearly its full length, with small villiform teeth, while on its dorsal surface, and extending its full length, there is a slight groove. The three processes of the bone rise from the ental edge of this groove, and the groove lodges the ventral edge of the maxillary.

One of the three processes of the premaxillary is a thin triangular flange that rises, longitudinally, from the distal half of the body of the bone. It projects upward and postero-mesially, perpendicularly to the body of the bone, lies against the internal surface of the maxillary, and, because of this position, may be called the postmaxillary process of the premaxillary. In certain teleosts this process forms the hind end of the premaxillary, the more distal portion of the bone of Scorpaena being represented, in such fishes, by tough gristly connective tissue. This would seem to indicate that the premaxillary primarily extended only to this process, and it would also seem to in-

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dicate that the bone of Scorpaena, up to and including this process, is the equivalent of the entire premaxillary in those fishes in which the maxillary lies, in Sagemehl's terminology, lateral to the premaxillary. This, however, requires investigation.

The other two processes of the premaxillary both arise from the proximal end of the bone, and, in the descriptions of many fishes, are both included under the term ascending process. But one of them only is properly that process, the other being a greatly developed articular process.

The ascending process, properly so-called, is directed dorso-posteriorly, and is a long, thin, pointed, plate-like piece of bone which lies in a plane that crosses obliquely and perpendicularly the extreme proximal end of the premaxillary. Its internal surface is presented ventro-postero-laterally and its mesial and larger part rests upon and is firmly attached by connective tissue to the corresponding half of the grooved dorsal surface of the cartilaginous rostral, its mesial edge touching, throughout nearly its entire length, in the mid-dorsal line, the corresponding edge of its fellow of the opposite side. The external surface of the process is presented antero-dorso-mesially, and so forms, with its fellow of the opposite side, a V-shaped longitudinal groove on the dorsal surface of the anterior end of the snout. This groove is wide antero-ventrally, but tapers dorso-posteriorly to a narrow end. The antero-ventral end of the groove is filled with a pad of tough fibrous tissue which extends downward between the anterior ends of the two premaxillaries and binds them strongly but loosely together. The dorso-posterior end of the groove lodges a similar but smaller pad of tissue, and this pad gives attachment to a stout ligamentous band which here crosses the outer surface of the two ascending processes. This ligament, from here, runs downward and laterally, on either side, passes ventral to the nasal bone, between it and the ethmo-maxillary ligament, and is inserted on the base of the maxillary process of the palatine. A branch of this ligament runs antero-ventro-laterally to the antero-mesial corner of the articular process of the premaxillary and then laterally to the mesial (proximal) end of the ligamentary process of the maxillary, having an attachment at each of these points; while a smaller branch of the ligament runs backward and laterally, and is inserted on the anterior surface of the mesethmoid process. The function of this latter branch of the ligament is evidently simply to fix a limit to that anterior motion of the rostral that accompanies the protrusion of the premaxillaries, the main ligament holding the rostral down upon the dorsal surface of the snout.

The articular process of the premaxillary arises from the bone immediately lateral (distal) to the ascending process. It is a relatively large plate of bone which lies in a plane that begins at the antero-lateral edge of the base of the ascending process, at an acute angle to the plane of that process, and from there runs postero-laterally across the dorsal surface of the body of the bone. At the point where its antero-mesial edge joins the antero-lateral edge of the ascending process, there is a marked but rounded angle in the antero-lateral edge of the latter process. The external surface of the articular process is flat and smooth. On the postero-lateral portion of its internal surface there is a large flat articular eminence which gives articulation to a part of the articular head of the maxillary, in a manner that will be later described.

In an earlier work ('98) I came to the conclusion that the ascending process of the premaxillary of teleosts is primarily an independent bone, and that this independent bone is represented in the median dermal ethmoid of Amia, and probably also in bone 2 of Huxley's descriptions of Esox. This conclusion, in so far as it regards the dermal ethmoid of Amia, seems confirmed by the conditions found in Lophius, Sphyraena, Salmo, Elops, and other fishes that I have been led to examine in this

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connection. Regarding bone 2 of Esox I have made no further investigation, but it would certainly seem to be the homologue of the dermal ethmoid of Amia.

In Lophius piscatorius, the premaxillary has a well-developed articular process, but no attached ascending process. At the place where this latter process would normally arise, there is a transverse facet which gives articulation to the anterior end of a long and tapering bone. This is all seen in Bruhl's ('56) figures of this fish, and the long and tapering bone is considered by that author as the detached ascending portion of the premaxillary (infra-maxillary), which it unquestionably is. It lies close against its fellow of the opposite side, the two bones, united, lying in a large rostral chamber on the dorsal surface of the snout. No rostral cartilage is found, but it is quite unquestionably represented in the tissues that envelope and underlie the two bones. The ascending processes of the premaxillaries thus here have a shape and position that render them easily recognizable as those processes, which the dermal ethmoid bones of Amia and Esox have not, and yet, as in these latter fishes, the two bones are wholly independent of the bodies of the premaxillaries.

In Sphyraena vulgaris the premaxillary has both articular and ascending processes. The ascending process rests against the antero-mesial edge of the articular process, wholly free from it, but flexibly and apparently uninterruptedly connected with the premaxillary immediately antero-mesial to the base of the articular process. The connection is by the intermediation of what looks like gristly tissue, and it is evident that a primarily independent bone is here in process of fusion with the premaxillary. That the bone can not be an outgrowth of the premaxillary that is in process of becoming detached from it, seems self-evident.

In Salmo salar, Parker ('73) shows the premaxillary as a large and somewhat triangular bone, the point of the triangle directed dorso-posteriorly and overlapping the proximal end of the maxillary. At the mesial edge of the bone a short process is shown which might, in the figure, be considered as an ascending process. This is, however, probably an error in the drawing, for I have examined both Salmo trutta and Christivomer namaycush and do not find the process in either. The premaxillary bone, in both these latter fishes, is somewhat triangular, as shown by Parker in Salmo salar, but the dorso-posteriorly directed point of the triangle lies near the middle of the length of the bone and not at its mesial edge, as an ascending process should. The process, moreover, overlaps the proximal end of the maxillary, and gives articulation, on its internal surface, to that bone. It is accordingly a part of the articular process of that bone and not an ascending process. And in all of these three fishes there is an independent so-called supraethmoid.

In Elops saurus the maxillary has the relation to the premaxillary that is designated by Sagemehl as lateral. The premaxillary is without ascending process, and articulates, by its antero-mesial end, with the antero-lateral edge of a bone that Ridewood ('04.a) considers as a mesethmoid firmly united with a vomer. This mesethmoid bone of Elops is said by Ridewood to be separable without much difficulty into two components, „the upper part (supraethmoid of some authors) being a membrane bone, while the lower part, of diminutive size is a cartilage bone". In my two specimens of the fish this membrane component of the mesethmoid bone is traversed by a cross-commissural canal which is in communication, at either end, with the infraorbital latero-sensory canal. It was not possible to establish the presence of sense organs in this canal, but it is, nevertheless, quite unquestionably the homologue of the anterior or ethmoid commissure of the Crossopterygii and Ganoidei Holostei (Allis, '04), and it has never heretofore been found in any teleost. The infraorbital canal, after having traversed the anterior one of the circumorbital bones shown in Ridewood's figures,

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separates into two parts, one of which turns upward and backward, in the posterior one of the two infranasal bones shown in the figures, while the other part traverses the anterior one of those two bones and then enters and traverses the membrane component of the mesethmoid. This latter bone alone, if it lodges two latero-sensory organs on either side, or this bone together with the anterior infranasal bone, if each of the bones lodges but a single organ on either side, is accordingly the homologue of the supraethmoid (median dermal ethmoid) of Amia; and in Elops, as in Amia, the one or two bones have not yet become incorporated in the premaxillary as its ascending process. The posterior infranasal bone alone (or that bone together with the anterior one, if this latter bone be not a part of the median dermal ethmoid) is the homologue of the antorbital bone of Amia, and this antorbital bone, traversed by a latero-sensory canal, has also never heretofore been described in any teleost, so far as I can find, unless it be in certain of the Siluridae (Allis, '98). This antorbital bone of Amia, and hence also the bone of Elops, is represented in Polypterus, as I have already shown ('00b), in the infranasal process of the premaxillary of that fish, and, judging from a recent work by Gaupp ('05), it must be the homologue of the septomaxillary of Amphibia and higher vertebrates. It is of dermal origin, as the septomaxillary is, and so closely resembles that bone in general position and relations to other bones that it seems quite unquestionably to represent it before it has acquired its nasal plate; that plate being a special and secondary acquisition, as Gaupp has shown.

In Macrodon, which I have examined, the premaxillary has a process similar to that in Salmo, and similar also to that shown by Sagemehl in Erythrinus, where that author considers it as an ascending process. This process in Macrodon articulates by its mesial edge with the lateral edge of the dermal component of the mesethmoid, and is widely separated from its fellow of the opposite side, exactly as Sagemehl's figures show for Erythrinus. On its internal surface there is a raised portion which gives articulation to the lateral surface of the long anterior articular end of the maxillary, and that the process is simply an articular process seems quite unquestionable, the bone then having no ascending process. And this is strictly as it should be, for the dermal supraethmoid is here said by Sagemehl to be fused with the primary mesethmoid to form the median mesethmoid bone of the fish. The supraethmoid of Macrodon would seem, however, to have been developed in relation to the median one only of two ethmoid latero-sensory ossicles on each side, and to represent a membrane component only of those ossicles, no latero-sensory organs here being found. The membrane component of the lateral one of the two ethmoid latero-sensory ossicles may then be here fused with the articular process of the premaxillary; for the outer surface of this process in Macrodon comes to the level of the adjacent dermal bones and has surface markings quite similar to those on those bones. In Elops the anterior infranasal bone, assumed to represent the lateral one of the two ethmoid latero-sensory ossicles on either side, and which is traversed in that fish by a latero-sensory canal, lies directly superficial to and in contact with the articular process of the premaxillary.

It may here be further stated, that I find, in my specimen of Macrodon, the bone called by Sagemehl ('84b, p. 95) the accessory palatine, and that, so far as can be judged from my somewhat dilapidated specimen, it is developed in the maxillary breathing valve of the fish. This, if correct, is important, for it would then be the homologue of the so-called vomer of Polypterus, a bone which I, in an earlier work ('00b), identified as the maxillary breathing valve bone of that fish. It has never heretofore been recognized in any teleost.

In Osteoglossum, according to Ridewood's ('05a) figures, the premaxillary has no ascending process, and Ridewood says that, in this fish, the ,,mesethmoid is a small rhombic bone of ectosteal

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origin". If this bone is of dermal and not of perichondrial origin, it would seem as if it must be a supraethmoid instead of a mesethmoid, and that it must represent the missing ascending processes of the premaxillaries.

In the Cyprinidae, I can not determine whether the ascending processes of Sagemehl's descriptions are those processes or articular processes. In a specimen of Tinca that I have examined, there is but one process on the premaxillary, and it is in contact, in the median line, with its fellow of the opposite side, as an ascending process should be. It seems however highly probable that this process is simply an articular process, or perhaps that process fused with an ascending process. The ascending process would certainly be wanting if, as Sagemehl states, the mesethmoid in the Cyprinidae has, as in the Characinidae, an overlying dermal component fused with it. There is in Tinca, as Sagemehl describes for others of the Cyprinidae, a ligamentous band that connects the process of the premaxillary with the top of the ethmoid bone, and associated with the ligament there is a small median bone, the rostral of Sagemehl's descriptions; and the apparent homologue of this ligament, in Scorpaena, is associated with the articular rather than with the ascending process of the premaxillary.

The ascending process of the premaxillary in Amphibia and higher vertebrates is called by Gaupp the prenasal process of that bone. As this process in fishes quite certainly arises by the fusion of the supraethmoid with the premaxillary, the term supraethmoid process would seem a better one, if a change is to be made. And as the antorbital bones of Amia and Elops, and the septomaxillary of amphibians certainly do not belong, in their origin or development, either to the orbital or maxillary series, either infranasal or extranasal would seem to be the proper term; extranasal being the term proposed by Gaupp for the bone in the Amphibia.

The articular process of the premaxillary has never heretofore been specially described, so far as I can find, excepting by myself in Scomber and by Brooks ('84) in Gadus aeglifinus. It is, however, of very general, if not constant occurrence in the Acanthopterygii and Anacanthini. I find it in all the mail-cheeked fishes that I have examined, and also in Zeus faber, Uranoscopus scaber, Mugil capito, Sphyraena vulgaris, Gobius cruentatus, Trachurus trachurus and Lophius piscatorius, and more or less completely fused with the ascending process in Labrus, Crenilabrus and Chrysophrys aurata. It is also shown, in a more or less definite manner, by Cuvier and Valenciennes ('29) in their figures of Perca, Sciaena and Otolithus; by Bruhl ('91) in his figures of Rhombus and Labrax; by Agassiz ('33/43) in his figures of Ophidium and Vomer; by Shufeldt ('85) in his figures of Micropterus; by Supino ('01/02) in his figures of Pomatomus, Hoplostethus, Ruvettus and Macrourus; by Traquair ('65) in his figures of Hippoglossus; by Girard ('51) in his figures of Triglopsis; and in Gasterosteus, judging from Swinnerton's ('02) figures, it is probably present in much the same condition that it is in Scomber. In the Characinidae, and possibly also in the Cyprinidae, it is found, as I have just above described. In the descriptions that I have of other teleosts I can not positively recognize it. It would seem to be present in Argyropelecus (Supino '01/02), that fish certainly having an important ascending process. In Clupea harengus I find, on the internal surface of the premaxillaries, a small articular eminence that may perhaps be its homologue; but, to definitely determine this, a much more careful study of the bones and ligaments is needed than I have been able to at present give them. In Silurus glanis there is, on the dorsal surface of the premaxillary, at the lateral edge of the mesethmoid, a small process against the lateral surface of which the maxillary abuts, if not articulates. This process is shown in Jaquet's ('98) figure 39, and would seem to be an articular process. In Esox, a

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similar process is found on the premaxillary, there lying immediately external to and covering the antero-mesial end of the maxillary; and this must be the articular process of the bone, if that process is not represented in bone 2 of Huxley's descriptions.

The articular process of the premaxillary of teleosts would thus seem to be as early, or even an earlier acquisition of that bone than the ascending process. This has led me to reconsider the conditions found in Amia, in which fish there is, as is well known, a large posterior process of the premaxillary, but no ascending process. This posterior process I was led, in an earlier work ('98), to consider as an olfactory sensory ossicle fused with the premaxillary, this conclusion being largely based on a description of Gymnarchus that I have since found to be erroneous (Allis, '04). My present work leads me to consider it as a greatly developed articular process of the premaxillary: for the maxillary articulates with its postero-ventral surface (Allis, '98), as it should, and its relations to the nasal sac are such as might be readily acquired by a posterior prolongation of the process of Scorpaena.

ROSTRAL.

The rostral is a median piece of cartilage, longer than it is tall, and about as tall as it is broad. Its external, or dorso-anterior surface, which is slightly concave, gives support and attachment, on either side, to the ascending process of the corresponding premaxillary. Its internal, ventro-posterior surface is considerably wider than the external one, and is grooved its full-length, in the median line, the groove fitting upon and sliding backward and forward upon the median internasal ridge. A short, stout ligament arises from the side of the rostral, and running downward and backward, is inserted on the mesial surface of what I shall describe as the ascending process of the maxillary, near its ventral edge. From the posterior half of the latero-ventral edge of the rostral, and in part, also, from its ventral surface, arises a tough fibrous or ligamentous band, which is in part inserted on the pointed mesial (proximal) end of the maxillary and in part on the shank of that bone. In that part of the band that has this latter insertion is suspended the semi-cartilaginous nodule that is interposed between the articulating surfaces of the vomer and maxillary.

In Gasterosteus, according to Swinnerton, the rostral is a chondrification, in late stages of development, of a mass of densely nucleated tissue, which, in earlier stages, lies chiefly on the underside of the ascending processes of the premaxillaries. In Salmo, Gaupp ('03) finds the rostral arising in exactly the same manner, and as he had not apparently noticed Swinnerton's description he considers the discovery of this development of this cartilage in Salmo as a support to the assumption that the premaxillary is a dermal bone developed in relation to a labial cartilage. But if the ascending process of the premaxillary is not primarily a part of that bone, as I maintain, the cartilage would seem not to have this special significance. In any event the rostral is quite certainly not a detached portion of the primordial cranium.

MAXILLARY.

The maxillary is a curved untoothed bone, with a flat, expanded hind end, and a somewhat complicated anterior end. This latter end of the bone forms its articular head, and may be said to bear two plate-like processes of bone, so placed as to give to the end of the bone a broad and somewhat V-shaped appearance. The antero-mesial (proximal) end of the shank of the bone curves rather sharply mesially and lies directly above the dorsal limb of the vomer, but it is apparently not in sliding

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contact with that bone. On its ventral edge there is a pronounced angular eminence, the dorso-anterior (lateral) surface of which, and the corresponding surface of the shank of the bone above it, bears a condylar thickening which articulates, by the intermediation of a pad of semi-cartilaginous tissue, with the internal (postero-mesial) surface of the articular process of the premaxillary, the pad of tissue being suspended in tissues that are attached to the premaxillary and rostral rather than to the maxillary.

On the dorsal edge of the extreme antero-mesial (proximal) end of the maxillary there is a small bluntly pointed process which projects dorso-mesially and touches, or almost touches, the ventral surface of the rostral, being bound to that cartilage by tough fibrous tissue. Beginning at the base of this little process, a flange-like process rises from the dorsal edge of the maxillary, extends distally a short distance along the shank of that bone, and then turns transversely, almost at right angles, across its dorsal surface. The process thus has longitudinal and transverse portions, the latter of which is much the more important and forms a tall flange-like portion of the entire process which lies perpendicularly to the maxillary and approximately in a vertical longitudinal plane of the body. This right-angled and flange-like process may be called the ascending process of the maxillary. Into the angle between its two portions the postero-lateral edge of the articular process of the premaxillary fits, the ascending process of the maxillary thus embracing and giving articulation, in the angle between its two parts, to the edge of the articular process of the premaxillary. From the mesial surface of the transverse portion of the process, a strong ligament, already referred to, runs upward and backward and is inserted on the lateral surface of the rostral, near its ventral edge.

The transverse limb of the ascending process of the maxillary is longer than the shank of the maxillary is wide, and hence projects anteriorly beyond the lateral edge of that shank. The ventral edge of this projecting portion of the ascending process is fused with the anterior end of another plate-like process of the maxillary, this latter process arising in a longitudinal line from the dorso-anterior (lateral) surface of the shank of the bone, beginning immediately distal to the ascending process. This longitudinal process, which may be called the ligamentary process of the bone, projects downward and forward, eaves-like, along the anterior (lateral) surface of the premaxillary. It gives insertion, on the antero-mesial (proximal) corner of its external, dorso-anterior surface, to the ethmo-maxillary and naso-maxillary ligaments, which ligaments from there run postero-dorso-mesially to their points of origin on the mesethmoid process and the nasal bone respectively; the ligaments, in their course, lying upon and crossing latero-mesially the anterior edge of the ascending process of the maxillary. From the antero-mesial (proximal) edge of the process a wide band of fibrous tissue arises, and, running mesially, crosses the external surfaces of the ascending processes of the two premaxillaries, near their bases, and has its insertion on the antero-mesial edge of the ligamentary process of the maxillary of the opposite side. The cut ends, only, of this band are shown in the figures. This intermaxillary band of tissue, together with the short ligament, on either side, and already described, that extends from the base of the ascending process of the premaxillary to the mesial (proximal) end of the ligamentary process of the maxillary, hold the two maxillaries against the edges of the articular processes of the premaxillaries, the two ligaments being directly opposed to a ligament that arises from the extreme postero-lateral (distal) corner of the ligamentary process. This latter ligament runs postero-ventrally across the dorsal surface of the shank of the maxillary and then onward along the internal surface of that bone, lying in the thin membrane that extends from the inner surface of the maxillary, near its dorsal edge, to the ventro-lateral edge of the palato-quadrate apparatus, and that forms part

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of the lateral wall of the buccal cavity. The ligament here lies along the anterior edge of the superficial division, A_1, of the adductor mandibulae muscle, and separates into a number of ligamentous strings. These strings soon reunite into a broad ligamentous band which passes over the external surface of a tough pad of fibrous tissue that covers the coronoid process of the mandible, and there separates into two parts, both of which continue onward and have their insertions on the external surface of the articular, along a ridge that forms the ventral margin of the articular facet for the quadrate. As the ligament passes over the coronoid pad of fibrous tissue there is apparently an interchange of fibers with that pad. This ligament, in Scomber, gives insertion to a part of the deeper division, A_3, of the adductor mandibulae muscle, and is the tendon A_3mx of my descriptions of that fish.

Between the ventro-anterior (lateral) edge of the ligamentary process of the maxillary and the proximal portion of the shank of that bone, there is a wide V-shaped groove. This groove fits upon the dorsal edge of the premaxillary, immediately distal to the base of the articular process of the bone, and also embraces the basal portion of that articular process itself. The articular process of the premaxillary articulates, however, with the shank and ascending process of the maxillary, in the manner just above set forth, and not with its ligamentary process, although this latter process may have a secondary participation in this articulation.

On the dorsal surface of the ligamentary process, in the angle between it and the lateral (distal) surface of the ascending process of the bone, there is a little pit-like depression which gives support and articulation to the anterior end of the maxillary process of the palatine, that process being firmly but moveably bound to the maxillary. Immediately postero-lateral (distal) to this articular surface, the ligamentary process gives support, on its dorsal surface, and is firmly bound by ligamentous tissue to, the anterior, process-like end of the lachrymal.

On the dorso-posterior (mesial) surface of the shank of the maxillary, opposite the postero-lateral (distal) end of its ligamentary process, there is a depression which gives insertion to a short tendon of the dorsal portion of the superficial division, A_1, of the adductor mandibulae muscle; this insertion of the tendon of this muscle thus differing from that in Scomber, where it is inserted on the inner surface of the lachrymal.

The ascending process of the maxillary is directed dorso-posteriorly, and its summit is thickened to form an even, smooth and slightly curved edge, which is covered, in the recent state, with glistening connective, or semi-cartilaginous tissue. The postero-ventral portion of this curved edge has a sliding articulation, through the intermediation of a pad of tough fibrous or semi-cartilaginous tissue, with the dorsal surface of the dorsal limb of the vomer. The pad of semi-cartilaginous tissue is suspended in that fibrous band that extends from the ventral surface of the rostral to the proximal end of the shank of the maxillary, and that has already been described. The remaining and larger portion of the summital edge of the process, although having the appearance of an articular surface, does not articulate with any structure. It, however, in its motion, rubs against the internal surface of the ethmo-maxillary ligament, against the anterior edge or internal surface of the rostro-palatine ligament, and rubs and pushes against the anterior surface of the nasal sac.

An ascending process of the maxillary is doubtless present in all the Acanthopterygii and Anacanthini; but it is certainly not always developed to the extent, and in the manner that it is in Scorpaena. In Scomber, for instance, the single process of Scorpaena is represented by two separate processes. One of these processes is longitudinal in position, articulates by its dorsal edge with the

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dorsal limb of the vomer, and was described by me as the dorsal articular head of the bone. The other is represented in the little process which not only gives insertion to the ethmo-maxillary ligament, but also articulates, by its antero-mesial surface, with the articular process of the premaxillary. In Amia, the process is not evident, nor is it in Salmo (Parker, '73), Esox, Citharinus (Sagemehl, '84b), Hydrocyon (Sagemehl, '84b), Elops (Ridewood, '04a), Megalops (Ridewood, '04a), Albula (Ridewood, '04a), Mormyrops (Ridewood, '04b), Notopterus (Ridewood, '04b), or Gymnarchus (Erdl, '47). But in several of these fishes there is a bend in the maxillary, near its proximal end, and at this bend there is an eminence on the bone which may quite probably represent the well-developed process of the Acanthopterygii and Anacanthini. This can only be determined when these fishes shall have been much more carefully described than they have been up to the present time.

In Gonorhynchus Greyi, according to Ridewood ('05 b), „There is no articulation between the ethmoid region of the cranium and the maxilla, nor between the ethmoid and the premaxilla". The premaxillary, as shown in Ridewood's figures, is here without either ascending or articular processes, the maxillary is without ascending process, the vomer is apparently without ascending processes, and the preëthmoid (septomaxillary), if present, is apparently fused with the mesethmoid. This all seems to need further examination.

NASAL SAC.

The nasal sac of Scorpaena is large, and has two large diverticula. The posterior surface of the sac lies against the anterior surface of the ectethmoid, occupying the space between the preocular spinous ridge and the lateral edge of the arm of the bone. The posterior nasal aperture lies at the tapering dorsal end of this portion of the sac, immediately lateral to the preocular spinous ridge; the anterior aperture lying slightly anterior to it, approximately between the summit of the mesethmoid process and the dorso-lateral corner of the arm of the ectethmoid. The anterior opening of the olfactory canal through the antorbital process lies in this same region, approximately ventral to the anterior edge of the posterior nasal aperture. As the olfactory nerve issues from its canal, it turns dorsally, at the same time spreading in a postero-anterior direction, and, pushing the floor of the sac upward, forms a stout vertical partition which rises from the floor and anterior wall of the sac and reaches upward nearly to its roof. It bears, on its summit, a rosette of sensory tissue, this rosette lying directly beneath the anterior nasal aperture. The floor of the nasal sac extends forward, on either side of this sensory partition, to the level of the summital edge of the ascending process of the maxillary, which edge abuts against the anterior end of the partition. The floor of the nasal sac is thus here U-shaped. The lateral leg of the U lies directly above the open oval space, already described, that lies between the lateral edge of this part of the skull and the dorso-mesial edges of the lachrymal and palatine, this space being closed, ventrally, by the lining membrane of the mouth cavity.

From each leg of the U-shaped nasal sac, an important diverticulum arises, these diverticula doubtless being the „nasal sacs" or „reservoirs" that Kyle ('00) says are found in the Scorpaenidae, but which I cannot find that he describes. The diverticulum that arises from the lateral leg of the U is the larger one of the two. It passes beyond the lateral edge of the skull, and there lies in the space enclosed between the lachrymal above, and the palatine below. It has a short posterior prolongation and a longer anterior one. The posterior prolongation lies along the ventro-lateral edge of the arm of the ectethmoid, between the two articular surfaces on that edge. The anterior end of

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the anterior prolongation passes along the lateral surface of the maxillary process of the palatine, and then turns mesially beneath that process, between it and the lining membrane of the roof of the mouth cavity, and abuts and terminates against the lateral (distal) surface of the ascending process of the maxillary.

From the mesial or dorso-mesial surface of the mesial leg of the U-shaped sac the mesial diverticulum has its origin, this diverticulum being formed of a noticeably delicate and very flexible membrane. It lies against the lateral surface of the rostral, has a short anterior prolongation between the rostral and the mesial surface of the ascending process of the maxillary, and a longer posterior prolongation which extends around the hind end of the rostral, and there meets, but in the adult, so far as could be determined by dissection, does not communicate with the corresponding diverticulum of the opposite side. In 45 mm specimens the diverticula are apparently here in large and free communication with each other. From the disposition of the diverticula, it is evident that when the mouth is protruded and retruded the capacity of the nasal sac is first considerably enlarged and then diminished, the circulation of the water in it thus being facilitated, as Kyle has stated.

NASAL.

The nasal is a small bone, which, by a downwardly projecting portion of its hind end, fits against and is firmly attached to, the lateral surface of the mesethmoid process. It encloses the nasal portion of the supraorbital latero-sensory canal, and bears, on its hind end, the nasal spine. From its anterior end the naso-maxillary ligament arises, and running forward and downward is inserted on the ligamentary process of the maxillary. On its inner surface, near its hind end, and also on the adjacent ligamentary surface of the mesethmoid process, the ethmo-maxillary ligament and the small rostro-nasal branch of the large palato-rostral ligament both have their attachments.

FRONTAL.

The frontal touches, in the mid-dorsal line, throughout nearly its entire length, its fellow of the opposite side. At its anterior end its lateral edge rests upon the dorsal surface of the ectethmoid, its mesial edge resting upon the dorsal surface of the pointed posterior portion of the mesethmoid. In the anterior half of the orbital region, its mesial edge rests upon the dorsal edge of the interorbital septum, that septum being a thin wall, cartilaginous in its anterior but membranous in its posterior portion. In the posterior half of the orbital region a thin flange-like process has its origin from the ventral surface of the frontal, the line of origin of the process running, at first, backward and but slightly laterally, and then turning laterally, in a rounded angle, toward the postorbital corner of the lateral edge of the bone. From this line of origin the flange projects downward, backward and mesially, beginning at nothing anteriorly, increasing gradually in depth until it reaches the rounded angle of its line of origin, and then diminishing again almost to nothing shortly before it reaches the postorbital corner of the bone. The ventral edge of the anterior half of the flange, that is, up to its deepest point, gives attachment to the dorsal edge of the membranous posterior half of the interorbital septum; the flanges of opposite sides, which touch in the middle line throughout a part of this distance, enclosing an anterior portion of the cranial cavity. Posterior to its deepest point, the flange, turning laterally, overlaps externally and lies closely against the external surface of the dorsal half of the alisphenoid, the base of the flange resting against the external surface of the

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line of cartilage that caps the dorsal edge of that bone, and the body of the frontal, immediately postero-mesial to the flange, resting upon the dorsal surface of this same line of cartilage. Postero-internal to this large flange and slightly postero-lateral to the antero-mesial end of the line of alisphenoid cartilage, a short narrow and pointed process projects downward from the ventral surface of the frontal, lies against the internal, postero-mesial surface of the cartilage, and may even extend ventral to the cartilage, there lying against the corresponding surface of the alisphenoid. This little process of the frontal, and the large flange-like process of the same bone, thus clasp and hold between them the dorsal end of the alisphenoid, in a manner similar to that described by me for these same bones in Scomber. From the hind edge of the little process a delicate ridge runs postero-mesially toward the postero-mesial corner of the frontal. It corresponds to the flange that, in Scomber, forms the lateral boundary of the post-epiphysial cartilage, that cartilage being reduced, in Scorpaena, to a narrow band along the anterior edge of the supraoccipital. Postero-lateral to the alisphenoid, the greatly diminished flange of the frontal overlaps slightly, or abuts against, the dorsal edge of the sphenotic.

The lateral edge of the frontal, at and posterior to its postorbital corner, rests upon the dorsal surface of the sphenotic, the mesial corner of its hind edge resting upon the dorsal surface of the supraoccipital, and the hind edge of the bone articulating by suture with the anterior edges of the pterotic and parieto-extrascapular. Adjacent to the sphenotic and supraoccipital bones the frontals each rest upon small cartilaginous remnants of the chondrocranium; and between these cartilages and the related bones, they form part of the roof of the cranial cavity, covering a large median opening in the roof of the chondrocranium formed by the fusion of the anterior ends of the lateral fontanelles. This median opening is open anteriorly, there being no cartilaginous epiphysial ridge to form its anterior boundary; Sagemehl's statement that this ridge is found in all teleosts thus not being correct.

The frontal is traversed by the supraorbital latero-sensory canal and lodges five organs of that line, two of these organs, the 4th. and 5th. of the line, lying relatively close together, without an intervening primary tube, as will be fully explained when describing the canals. The position of that part of the canal that lies between the orbits is marked by a strong ridge, already several times referred to as the frontal or interorbital ridge. A similar ridge marks approximately the position of the fourth tube of the line; that tube running mesially and slightly backward to meet, in the middle line, its fellow of the opposite side. The hind edge of this ridge forms the anterior boundary of the groove on the vertex.

That part of the cranial cavity that is enclosed between the anterior halves of the ventral flange-like processes of the frontals corresponds to the fore-brain recess of my descriptions of Scomber, but, in Scorpaena, the cranial cavity is so large, relatively to the brain, that the fore-brain lies wholly posterior to the recess, reaching, approximately, only to the anterior edge of the basisphenoid. The olfactory nerves there pierce the membranes that close the orbital opening of the brain case, and, enclosed in a membranous tube, traverse the orbit. The fore-brain recess of the adult Scorpaena thus lodges no portion of the brain, being simply filled with fatty tissue.

POSTFRONTAL.

The postfrontal is a small flat bone which lies directly upon, and is quite firmly bound to, the posterior portion of that part of the dorsal surface of the sphenotic that is not covered by the frontal and pterotic. Along its anterior and lateral edges, narrow strips of the sphenotic appear, and form

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part of the dorsal surface of the skull. The postfrontal forms part of the roof of the dilatator fossa, bears two or three short blunt spines, and is traversed by the main infraorbital latero-sensory canal, lodging one organ of that canal, innervated by the ramus oticus lateralis.

In Scorpaena porcus, the postfrontal is a short, small, tubular bone, and bears but one, or at most two spines.

PARIETO-EXTRASCAPULAR.

The parieto-extrascapular is formed by the fusion of the parietal with the mesial ossicle of the extrascapular latero-sensory series. This fusion, in certain other fishes, of these two usually separate elements was fully discussed by me in a recent work ('04). As further confirmation of the fusion, the conditions in Chanos can be cited, where, according to Ridewood ('04a, p. 58), ,,the parietals are widely separated in the young but by subsequently fusing with the scales of the commissural section of the sensory canal system, they come to meet above the supraoccipital bone".

In Scorpaena, the parieto-extrascapular is a relatively large and very irregular bone, with a much ridged dorsal surface. One of these ridges is the parietal spinous ridge, which has already been described. Another and lower ridge lies immediately lateral to the parietal ridge, is formed, anteriorly, by the lateral bounding ridge of the groove on the vertex, and, posteriorly, by the nuchal spinous ridge; the ridge being interrupted between these two portions. Immediately lateral to this ridge, there is a curved ridge, tall in its middle portion but low at either end, the hollow of the curve presented laterally. The posterior portion of this ridge marks the course of a part of the supratemporal latero-sensory canal. A mesially projecting corner of the bone lies on the posterior portion of the dorsal surface of the supraoccipital, articulates by suture, usually serrate, with its fellow of the opposite side, and forms the summit of the ridge that bounds posteriorly the groove on the vertex. A large reëntrant angle at the postero-lateral corner of the bone receives the antero-mesial corner of the lateral extrascapular, the edges of this part of the parieto-extrascapular overhanging slightly the temporal fossa and forming part of its roof.

The posterior half of the parieto-extrascapular is a stout, broad process-like portion which projects postero-laterally and lies slightly dorsal to the dorsal surface of the suprascapular process of the epiotic; the narrow space between itself and that process of the epiotic receiving the epiotic arm of the suprascapular. From the internal surface of this part of the bone, near its hind edge, a delicate flange projects ventro-posteriorly. The antero-ventral surface of this flange lies upon that part of the dorsal surface of the epiotic that lies immediately anterior to the base of the suprascapular process of that bone. The postero-dorsal surface of the flange forms part of the floor of the supratemporal pocket and thus forms part of the apparent posterior surface of the adult skull, but it lies on a part of the dorsal surface of the primary skull, and not on its posterior surface, as already explained.

The anterior half of the parieto-extrascapular rests in part upon the dorsal surface of the pterotic and supraoccipital, in part upon remnants of the chondrocranium adjacent to those bones, while, in part, it bridges the lateral fontanelle of the skull, there forming part of the roof of the cranial cavity. The anterior edge of the bone articulates by suture with the hind edge of the frontal, the mesial edges of the parieto-extrascapulars not here meeting in the middle line, and a median portion of the supraoccipital being exposed between them. The bone is traversed by the supratemporal latero-sensory canal, the canal usually lodging a single sensory organ, but in one specimen this organ had apparently separated into two parts, lying close together. In 45 mm specimens there is but a

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single organ here, this showing that but a single extrascapular latero-sensory ossicle has here fused with the parietal.

The parietal spine on the dorsal surface of the parieto-extrascapular belongs to the anterior, parietal part of the bone, the nuchal spine belonging to the posterior, extrascapular part.

LATERAL EXTRASCAPULAR.

The lateral extrascapular, the only independent extrascapular element there is in the skull of Scorpaena, is a small plate-like bone that forms the larger part of the roof of the temporal fossa. Its lateral edge rests upon the dorsal edge of the posterior process of the pterotic, and its posterior edge upon the dorsal surface of the suprascapular. Its anterior and mesial edges are almost entirely enclosed in the reëntrant angle in the postero-lateral corner of the parieto-extrascapular, from which bone the extrascapular is separated by a narrow space bridged by fibrous tissue, this tissue holding the extrascapular in place, forming part of the roof of the temporal fossa, and transmitting the supratemporal canal. The bone encloses a section of the main infraorbital latero-sensory canal, and also the lateral portion of the supratemporal canal, lodging one sense organ of each of those canals. The bone bears, on its hind edge, the anterior one of the two spines of the intermediate line.

SUPRASCAPULAR.

The suprascapular has a mesial, or epiotic, and an inferior, or opisthotic process, the epiotic process forming the larger part of the bone and running insensibly into the body of the bone. The body of the bone, which forms the lateral edge of the entire bone, encloses a short section of the main infraorbital canal and lodges one organ of that canal. The epiotic process projects upward forward and mesially, and rests upon the dorsal surface of the suprascapular process of the epiotic, fitting closely into a narrow space between that bone, below, and the ventral surface of the projecting posterior portion of the parieto-extrascapular above. The process of the suprascapular is firmly bound to each of these two latter bones, its position relative to the posterior portion of the parieto-extrascapular being that that it normally has to an extrascapular bone. The opisthotic process of the bone projects ventro-antero-mesially and rests upon and is bound by tissue to a thickened portion of the hind edge of the opisthotic. The process lies along, or internal to, the hind edge of the posterior process of the pterotic, and forms the lateral wall of the posterior opening of the temporal fossa. On the internal surface of the postero-lateral corner of the bone, close to its hind end, there is a small articular eminence, and immediately antero-mesial to this eminence, an articular facet; the two surfaces articulating with corresponding surfaces on the dorso-anterior corner of the supraclavicular. The bone bears, on its hind edge, two spines, one belonging to the lateral row of spines and the other to the intermediate row. It is traversed by the main infraorbital latero-sensory canal and lodges a single organ of that line.

SUPRACLAVICULAR.

The supraclavicular is a triangular bone. It lies along the outer surface of the clavicle, and articulates, by two articular surfaces on its dorso-anterior corner, with the ventral surface of the suprascapular. One of these two articular surfaces is an articular head that rises prominently from the anterior end of the dorsal edge of the bone, the other being an articular facet that lies immediately latero-posterior to the articular head. The dorsal edge of the bone, posterior to these articular surfaces,

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is traversed by the main infraorbital canal, and lodges one organ of that canal. The hind corner of the bone may be either sharp or rounded, and as it forms a slight eminence in the dermis may be considered as the last spine of the lateral row. The occipito-supraclavicular ligament is inserted on the internal surface of the supraclavicular, in the usual manner.

LATERAL SURFACE OF THE BRAIN CASE.

The lateral surface of the brain case of Scorpaena is inclined at an angle of 45°, approximately, to the horizontal plane. Its ventral half is crossed transversely, from above downward and backward, by the elongated, fusiform and prominent swelling of the bulla acustica. Anterior to this swelling, there is, on the ventral half of the lateral surface of the brain case, a depressed region which lies on the proötic and parasphenoid. The posterior and larger part of this depressed surface is filled by and gives attachment to a large tough pad of connective and muscular tissue, which is continuous, across the middle line, with a similar pad on the other side, the two together representing the anterior transversus dorsalis muscle. The lateral border of the pad of either side gives attachment to a short muscle which has its insertion on the epibranchial of the second arch, and is the obliquus dorsalis of that arch; the two short muscles, one on either side, together with the intervening pad, forming a single mass, as in Scomber. The posterior transversus dorsalis is a thin band of muscle extending from the third and fourth epibranchials of one side transversely across to the corresponding bones of the other side.

Anterior to the anterior transversus dorsalis, the infrapharyngobranchial of the first arch is attached to the side wall of the skull; and, anterior to that element, the posterior portion of the adductor arcus palatini has its origin. The surface of origin of this latter muscle begins immediately ventral to the trigeminus opening of the trigemino-facialis chamber, there lying partly on the proötic and partly on the ascending process of the parasphenoid. From there it extends downward and forward along the anterior portion of the latter process, and then turns directly forward, occupying a depressed region along the lateral edge of the body of the parasphenoid and extending forward across the orbit to the antorbital process of the skull. From this long surface of origin the broad and relatively thin muscle extends latero-ventrally and has its insertion mainly on the palato-quadrate arch, as will be later more fully described, its posterior portion, however, having its insertion on the inner surface of the thin flange of bone that forms the anterior edge of the hyomandibular. The muscle thus acts in part as an adductor hyomandibularis, but it is widely and wholly separate, both at its origin and insertion, from the latter muscle, properly so-called.

Immediately dorsal to the anterior end of the bulla acustica is the opening usually called the facial foramen, but this so-called foramen is, as in Scomber, the facialis opening of the trigemino-facialis chamber. Posterior to this opening, and extending across the lateral surface of the skull to its hind edge, there is a large, shallow, and, in certain specimens, distinctly pyramidal depression which lies on the proötic, opisthotic and exoccipital bones. The depression is subtriangular in outline, the base of the triangle being formed by the dorsal edge of the anterior portion of the bulla, the posterior edge by a part of the postero-lateral edge of the skull, and the antero-dorsal edge by a low ridge that runs downward and forward across the lateral surface of the brain case, approximately in the line prolonged of the opisthotic process of the suprascapular. The center of the depression, somewhat pointed in certain specimens, lies within the arch of the external semicircular canal, ventral to that canal, and in this the depression corresponds to the subtemporal fossa of Sagemehl's

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descriptions of the Cyprinidae, but, as described immediately below, it does not correspond with that fossa in the muscles to which it gives origin. The anterior corner of the depression is connected by a shallow groove with the facialis opening of the trigemino-facialis chamber, this groove lodging the nervus sympatheticus and the ramus anterior of the nervus glossopharyngeus. In the postero-ventral corner of the depression is the vagus foramen, and slightly anterior to that foramen, near the ventral edge of the depression, is the glossopharyngeus foramen, both of these foramina perforating the exoccipital.

Dorsal to the subtriangular depression above described, the posterior half or three-fifths of the dorsal half of the lateral surface of the skull is markedly flat. Anterior to this flat portion, there is a large and deep fossa, on the proötic and pterotic bones, the fossa lying immediately antero-ventral to the elongated facet for the posterior articular head of the hyomandibular, and antero-dorsal to the arch of the external semicircular canal. The anterior border of this fossa is formed by a strong flat process of the proötic, this process lying directly dorsal to the facialis opening of the trigemino-facialis chamber and immediately posterior to the rounded oval and relatively deep facet for the anterior articular head of the hyomandibular. Partly in the dorsal portion of this fossa and partly on the process that forms its anterior border, the two internal levators of the branchial arches and the external levators of the first three branchial arches have their origins. The external levator of the first arch was little more than a band of membrane on one side of the head of the single specimen examined in this respect; and on this same side of the head of this one specimen the external levator of the third arch was wholly wanting, while on the other side it was a slender muscle much smaller than any of the others. The several muscles all arise together, as a group, the internal levators arising in a line that lies immediately postero-ventral to the line of origin of the external muscles. The levator internus anterior lies internal to the other muscles, and is a stout one which bellies considerably immediately beyond its origin, the belly of the muscle completely filling that large part of the fossa that lies ventral to the surface of origin of the muscles. This large part of the fossa thus seems to have been formed by the compressive action of this muscle, and not in relation to the points of origin of the several muscles of the group.

On the flat surface of the skull posterior to this fossa, and also partly in the subtriangular depression, the adductor hyomandibularis and adductor operculi have a large surface of origin. These two muscles are not contiguous at their origins, the surface of origin of the adductor operculi lying slightly posterior to and being slightly larger than that of the adductor hyomandibularis. Dorsal to these two muscles, in a long and narrow line along the dorso-lateral edge of the skull, the levator operculi has its origin. Immediately posterior to the surface of origin of the adductor operculi, in a narrow line near the hind edge of the skull, the external levator of the fourth arch has its origin, this fourth levator, in the one specimen examined, having its insertion on the fourth arch and not on the inferior pharyngeal bone. Posterior to this fourth levator, and in contact with it, a flat muscle has its origin, and running posteriorly has its insertion on the dorsal portion of the clavicle, thus corresponding to the fifth levator of my descriptions of Scomber. This fifth levator would seem to be the homologue of the muscle that Herrick considers ('99, p. 117), in Menidia, as the trapezius muscle. It would seem as if it must also be the homologue of the muscle described by Sagemehl ('84 b, p. 49), in the Characinidae, as the Attractor of the shoulder girdle, that muscle being said to arise from the skull and to have its insertion on the supraclavicular. Vetter concluded that a trapezius muscle is wanting in Teleosts, as Herrick himself states.

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There are thus, on the lateral surface of the skull of Scorpaena, two separate depressions in each of which certain of the levator and adductor muscles of the visceral arches have their origins, and the anterior one of the two seems certainly to have been developed in some relation to the muscles that have their origins in it. With the posterior depression, this causal relation is much less evident, and it would seem as if the anterior depression of Scorpaena must be superimposed upon the posterior one to form the subtemporal fossa of Sagemehl's and Ridewood's descriptions of the Cyprinidae. Sagemehl says that this fossa in these latter fishes is formed as the result of the origins of certain of the levator muscles on this particular part of the skull, and he says that, in the Barbidae, the adductor operculi arises in the anterior part of the fossa, and the external levator of the fourth arch in its posterior portion. Of the other Cyprinidae he simply says that the levators of the branchial arches arise from the side walls of the skull below the adductor hyomandibularis and adductor operculi. Ridewood says ('04 a, p. 62) that, in certain of these same fishes, the fossa serves ,,for the lodgment of the great muscles, which by pulling up the inferior pharyngeal bones (fifth ceratobranchials) bring the teeth upon those bones forcibly against the callous pad that is carried on the under surface of the basioccipital bone"; and Vetter says ('78, p. 505) that, in Cyprinus and Barbus, the levatores arc. branch. externi have their origins in part in this fossa, that they are in part inserted on the hind surface of the outer corner of the large inferior pharyngeal bone, and that they press that bone against the bony plate on the under surface of the basioccipital. It seems, accordingly, to be to certain of the external levators alone that the fossa-forming quality is attributed, and when they happen to have their points of origin on the side wall of the skull in the region of the subtriangular depression of Scorpaena, they apparently may cause a deepening of that depression and so give rise to a true subtemporal fossa. The subtriangular depression of Scorpaena would accordingly seem to be a rudimentary fossa, and may be called the subtemporal depression. In the Barbidae and Homaloptera this depression is deepened to such an extent that the epiotic is seen at the bottom of it (Sagemehl, '91, p. 554); while in Elops, according to Ridewood, the supraoccipital also is there exposed.

Immediately ventral to the surface of origin of the adductor hyomandibularis, on the dorsal portion of the bulla acustica, a large bundle of the muscles of the trunk has its origin.

THE ORBIT.

The orbit is large. The interorbital septum is cartilaginous in its anterior and larger portion, but membranous in its posterior portion. The ventral half of this membranous portion is attached posteriorly to the anterior edge of the pedicle of the basisphenoid. Above the dorsal end of that pedicle, the membrane spreads laterally, on either side, and is attached to the anterior edge of the body of the basisphenoid, and, above that bone, to the ventral edge of the alisphenoid and then to the ventral edge of the ventral process of the frontal; the membrane thus closing the orbital opening of the brain case. This membrane is pierced, on either side, and immediately above the basisphenoid, by the optic nerve. Slightly above the optic nerves, the two oflactory nerves enter a small median pocket in the membrane, from which a membranous tube leads forward on either side of the interorbital septum. Having traversed this tube, the olfactory nerve of either side continues forward, in the orbit, lying along the lateral surface of the cartilaginous portion of the interorbital septum and so reaches and then traverses the olfactory canal through the ectethmoid. Lateral to the olfactorius, and along, or enclosed in, the ventral edge of the alisphenoid, the trochlearis enters the orbit.

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ORBITOSPHENOID.

There is no orbitosphenoid.

ALISPHENOID.

The alisphenoid is sub-oval in outline. Its dorso-anterior third or half is overlapped externally by the posterior portion of the ventral process of the frontal. Its dorsal edge is capped with cartilage, and this cartilage rests against the ventral surface of the frontal immediately internal to the ventral process of that bone. The anterior edge of the bone is presented mesially and but slightly forward, and suturates with the ventral flange-like process of the frontal. Its posterior edge is presented laterally and but slightly backward and is bounded, in its dorsal portion, by the sphenotic and the body of the proötic, but is separated from both of those bones by a line of cartilage. The ventro-posterior corner of the bone suturates, without intervening cartilage, with the dorso-anterior edge of the prepituitary portion of the mesial process of the proötic and with the antero-lateral corner of the body of the basisphenoid. Its ventral edge forms part of the boundary of the orbital opening of the brain case and gives attachment to the membranes that, in the recent state, close that opening.

On the internal surface of the alisphenoid, near its anterior edge, a ridge runs downward a short distance from the dorsal edge of the bone. This ridge is continuous with a similar ridge on the corresponding surface of the cartilage that caps the bone, and is also continuous with, or is slightly overlapped by, the little ridge and process, already described, on the ventral surface of the frontal. The entire ridge thus formed, forms the posterior boundary of what I have referred to as the fore-brain recess of the cranial cavity, that recess thus lying mainly anterior to the alisphenoid, and the alisphenoid bounding the mid-brain region.

A small foramen is always found perforating the alisphenoid, and the ventral edge of the bone, where it bounds the orbital opening of the brain case, is always notched to form an imperfectly closed and larger foramen. The small foramen transmits a small nerve accompanied by two small arteries; the nerve being a branch of the ophthalmicus lateralis destined to innervate organ 6 of the supraorbital canal, but accompanied by other fibers, probably general cutaneous, and the arteries being, one a branch of the external carotid and the other a branch of a blood vessel to be later described as the vessel x and that would seem to represent, in part at least, the hyo-opercularis artery of my descriptions of Amia. The notch in the ventral edge of the bone transmits the nervus trochlearis. Dorso-anterior to this notch, and close to it, a smaller notch transmits a branch of the orbito-nasal vein. In Amia, this small vein perforates the alisphenoid, and in my descriptions of that fish I called it the anterior cerebral vein. In Scomber a corresponding foramen was found in the alisphenoid, and I assumed that it transmitted a corresponding vein, as it doubtless does. In Ophiodon, Allen ('05) does not describe this vein, but it would seem as if it must there be found for I find it in Cottus, Trigla, Peristedion and Dactylopterus as well as in Scorpaena, but perforating the alisphenoid in all those fishes instead of passing across its anterior edge. It would seem, even, to have a certain morphological importance, though what it may be I can not yet determine. It, or the foramen that transmits the branch of the external carotid, or these two foramina together, may perhaps represent the foramen spinosum of human anatomy.

On the outer surface of the posterior portion of the alisphenoid, and extending to its ventral edge, there are two more or less developed ridges. The postero-lateral one of these two ridges is often wholly wanting, the antero-mesial one being present, more or less developed, in all my specimens. The

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ventral end of each of these ridges projects, as a small process, toward the dorsal end of the ascending process of the parasphenoid, and is connected by fibrous tissue with the dorsal end of that process, this tissue bridging, to reach the parasphenoid, a narrow intervening portion of the orbital surface of the proötic. The tissue related to the antero-mesial ridge is always more strongly developed than that related to the postero-lateral one, being almost ligamentous in character. In one specimen it had even become entirely ossified by invading growths from the alisphenoid and parasphenoid, a complete bony foramen thus being formed which is the homologue of the internal jugular foramen of Allen's ('05, p. 81) descriptions of Ophiodon. When the ligamentous tissue does not ossify, and that is the usual condition in the specimens that I have examined, the foramen becomes an internal jugular notch. The bottom of this notch, or the mesial border of the foramen when there is a foramen, is usually, but not always marked by a slight ridge on the proötic; and this ridge, where there is simply a notch, forms the dorso-lateral corner of the orbital opening of the myodome, and separates that opening from a groove on the posterior wall of the orbit. This groove lies on the orbital surface of the proötic, leads dorso-postero-laterally into the trigeminus opening of the trigemino-facialis chamber, and lodges not only the internal jugular vein, but also the truncus ciliaris profundi. Because of the name given to the foramen (or notch) that forms its antero-mesial boundary, the groove can be called the internal jugular groove. Coming along this groove, the truncus ciliaris profundi passes through the internal jugular notch, mesial to the spanning ligament, and then turns forward, in the orbit; the nerve thus entering the orbit mesial to, and hence morphologically anterior to, the spanning ligament. The oculomotorius traverses a foramen in the proötic the external aperture of which lies immediately antero-mesial to the internal jugular notch, and then runs forward in the orbit, thus also lying mesial and hence morphologically anterior to the band of ligamentous tissue. The trochlearis has similar relations to the band of tissue, while the trigeminus and lateralis nerves issue, and always lie, lateral, and hence morphologically posterior to it. The band of ligamentous tissue and the associated process-like ridge of the alisphenoid, thus together correspond exactly, in their relations to these cranial nerves, to the pedicle of the alisphenoid of Amia; and if, in Scorpaena, the process of the alisphenoid were alone to be prolonged, by ossification of the ligament, its ventral end would rest upon the ascending process of the parasphenoid, and, interno-posterior to that process, upon a portion of the lateral bounding wall of the orbital opening of the myodome, exactly as it does in Amia. The process and band, together, are thus quite certainly the homologue of the pedicle of the alisphenoid of Amia.

That small part of the alisphenoid of Scorpaena that lies ventral to its slightly developed pedicle must then correspond to that flange of the alisphenoid of Amia (Allis, '97a, fig. II) that lies internal to the well-developed pedicle of the bone of that fish. In Amia this flange of the alisphenoid gives attachment to the dorsal edge of the tough membrane that, in that fish, forms the lateral wall of the cranial cavity and the mesial (morphologically anterior) wall of the tall orbital opening of the myodome. Ventrally this membrane is closely attached (Allis, '97a, p.494) to the dorsal surface of the transverse cartilaginous prepituitary bolster of the fish; and in this part of the membrane, or perhaps partly also in tissues that remain after the resorption of the cartilaginous bolster, the body and pedicle of the T-shaped basisphenoid of teleosts are developed. In both Scomber and Scorpaena the ventral edge of the alisphenoid suturates with the lateral edge of the body of the basisphenoid; this showing that a portion of the membrane that forms the antero-mesial wall of the orbital opening of the myodome of Amia is alisphenoid membrane, and potentially a part of the alisphenoid bone.

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The alisphenoid of Amia and teleosts is thus, in principle, an inverted Y-shaped bone, the anterior arm of the inverted Y resting on the lateral edge of the actual or potential basisphenoid, and the posterior leg resting on the lateral and morphologically posterior wall of the orbital opening of the myodome, the ascending process of the parasphenoid there coming into supporting relations with it. The bone thus straddles the orbital opening of the myodome, and through the passage between its legs, in Amia, the oculomotorius, trochlearis, and profundus nerves enter the orbit; the passage not, however, representing the fused foramina of those nerves (Allis, '97b), their true foramina being where they respectively pierce the membrane which, in Amia, forms the entire lateral bounding wall of this part of the cranial cavity. All three of the nerves, in Amia, certainly lie anterior to the parasphenoid leg of the alisphenoid; and the profundus certainly lies posterior to the basisphenoid leg of that bone. What the relations of the trochlearis and oculomotorius are to this latter leg is not evident, for there is nothing in the continuous membrane to in any way indicate the alisphenoid region. In teleosts, where, as in Scorpaena, this membrane of Amia may be replaced by bone, the relations of these two nerves to the basisphenoid leg of the alisphenoid are also not evident; for although, in my descriptions of Scomber, I stated that, in that fish, the trochlearis issued along the antero-mesial edge of the alisphenoid, a reconsideration of the figures makes it evident that the so-designated edge of the bone is, in reality, part of its ventral edge. These two nerves, in teleosts, thus both seem to have been pushed downward, by the growing ventral edge of the alisphenoid, and to lie, in the adult, simply ventral to that bone, without positively evident anterior or posterior relations to it.

In Gasterosteus, where, according to Swinnerton, the alisphenoid is wanting, a dorsal prolongation of the ascending process of the parasphenoid has invaded the region of the parasphenoid leg of the alisphenoid, and there has come into sutural contact with the closely adjacent ventral edge of the ventral process of the frontal. This condition of the parasphenoid is also found in Cottus octodecimospinosus, and will be fully described when describing that fish. It is apparently also found in the Barbidae and Cobitiidae, and in Homaloptera (Sagemehl '91, p. 564).

SPHENOTIC.

The sphenotic (postfrontal, postorbital ossification) is an irregular bone that forms the summit of the postorbital process of the skull. It forms part of the inner as well as part of the outer surface of the brain case. Its outer surface has lateral, dorsal and anterior regions, separated by sharp angles. The anterior surface forms part of the hind wall of the orbit. On it there is a relatively large recess, beneath a thin flange of bone, and from this recess the oticus canal leads upward laterally and backward in a curved course, traversing the bone and issuing on its dorsal surface near its hind end. It transmits the ramus oticus lateralis, accompanied by both communis and general cutaneous fibers, and is the homologue of the similar canal described by me in Scomber. On the lateral surface of the bone there is a large articular facet for the anterior head of the hyomandibular, the ventral portion of the facet being formed by the proötic. Immediately dorso-anterior to this facet there is a roughened surface which gives origin to the levator arcus palatini, and immediately dorso-posterior to the facet there is a depression, open posteriorly, which forms the anterior part of the dilatator fossa. The dorsal surface of the bone, which is flat, gives support to the postfrontal bone and also to the anterior edge of the pterotic and the lateral edge of the posterior portion of the frontal. The internal surface of the bone is relatively small, and presents, as in Scomber, two deep recesses separated by a thin and nearly vertical partition of bone which, projecting backward and mesially into the cranial

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cavity, forms the dorsal portion of the anterior wall of the labyrinth recess. The posterior recess on the internal surface of the bone thus forms part of the labyrinth recess, but it lodges, in the adult, no part of the membranous ear, lying wholly dorso-anterior to the curved anterior edge of the anterior semicircular canal. The anterior recess forms the latero-postero-dorsal corner of that part of the cranial cavity that lies between the labyrinth and fore-brain recesses, and would accordingly seem to be a mid-brain recess.

Ridewood says ('04a, p. 56) that the sphenotic is found distinct from the postfrontal in but a few fishes. I, on the contrary, find these two bones almost invariably distinct and separate. Ridewood further says that the sphenotic is an endosteal ossification „set up in sympathy with" that ossification in the dermal tissues that gives origin to the postfrontal; and he accordingly considers the name sphenotic redundant. This relation of these two bones to each other I do not consider as established.

In the Barbidae, according to Sagemehl ('91, p. 573), the anterior semicircular canal may be enclosed in a canal in the sphenotic. This semicircular canal thus has this relation to the sphenotic in the Barbidae, while in Elops, as I have already stated, it traverses a canal in the alisphenoid.

Swinnerton, in his descriptions of Gasterosteus, uses the term „postorbital process" in a manner that might be confusing. On p. 532 of his work on that fish he says „the postorbital process, which in other teleosts forms part of the alisphenoid, remains unossified". The process of Gasterosteus here referred to is an outgrowth of the auditory capsule which projects forward in the dorsal portion of the hind end of the orbit, and is accordingly more properly an orbital or supraorbital process, than a postorbital one; and it is the lateral corner of its base, alone, that is the postorbital process, as that term is commonly used, and it ossifies in Gasterosteus, as in other fishes, as the sphenotic.

BASISPHENOID.

The basisphenoid is, as usual, T-shaped, the ventral end of its pedicle abutting against a median nodule of cartilage that lies on the dorsal surface of the parasphenoid. The anterior edge of the pedicle is strongly curved, running at first forward and downward, or sometimes even directly forward, and then curving downward, and downward and backward. The dorsal portion of the pedicle is usually expanded into a relatively large median plate, and this part of the pedicle is often independent of the ventral portion, touching and being bound to that portion, but not being continuous with it; the pedicle of the bone thus being in two, and sometimes even in three separate pieces. The pedicle, as usual, separates the anterior opening of the myodome into two parts, and its anterior edge gives insertion to the hind edge of the ventral portion of the membranous posterior portion of the interorbital septum.

The body of the basisphenoid is almost flat, and occupies a nearly horizontal, transverse position. Its posterior edge, on either side, is overlapped ventrally by, and lies against the dorsal surface of a small process of the prepituitary portion of the mesial process of the proötic, these small prepituitary processes of the proötics of opposite sides meeting in the middle line and thus shutting off the basisphenoid from the anterior edge of the pituitary opening of the brain case. In Scomber (Allis, '03), the basisphenoid forms part of the anterior edge of the latter opening. In Amia the anterior edge of the opening is formed by a transverse bolster of cartilage, the actual anterior edge of the pituitary fossa being, however, formed of membrane only.

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In 45 mm Scorpaenas the basisphenoid is just beginning to form, appearing as a thin gutter-shaped lamina of bone in the midst of the dense fibrous tissues which form the floor of this part of the cranial cavity and the roof of the anterior portion of the myodome. Immediately anterior to this little bone there is a small median nodule of cartilage which lies between the extreme hind ends of the recti inferior muscles, imbedded in the anterior end of a median vertical band of tough fibrous tissue which gives origin to those muscles and will be further described when describing the myodome. This little nodule of cartilage is connected, antero-ventrally, by a delicate median line of cartilage, with the nodule of cartilage on which, in the adult, the pedicle of the basisphenoid rests, and this latter nodule is connected anteriorly, also by a delicate line of cartilage, with the cartilage of the interorbital septum. The pedicular line of cartilage together with the dorsal nodule thus form a basisphenoid cartilage which must certainly be the somewhat reduced homologue of the transverse prepituitary bolster of Amia. The basisphenoid bone of the adult Scorpaena is thus probably a perichondrial ossification related to this basisphenoid cartilage of the young Scorpaena, but it certainly extends beyond the cartilage, into the adjacent tissues, these tissues representing, in part at least, parts of the primary membranous cranium that have not chondrified.

PROÖTIC.

The proötic (petrosal) has lateral and orbital surfaces, the former forming a considerable part of the side wall of the brain case, and the latter a small part of the hind wall of the orbit. The bone is bounded dorsally by the sphenotic and pterotic, antero-mesially by the alisphenoid, and posteriorly by the exoccipital and basioccipital; with all of which bones it is either in contact or in synchondrosis. Its hind edge is, in part, slightly overlapped externally by the anterior edge of the opisthotic. Its ventral edge is overlapped externally by the lateral edge of the parasphenoid. The prepituitary portion of its mesial process suturates with the basisphenoid and alisphenoid.

The angle separating the lateral and orbital surface of the bone forms the ventral portion of the postorbital process of the skull, and on the dorsal end of this part of the bone lies the ventral portion of the anterior articular facet for the hyomandibular. The hind edge of this facet is raised to form a ridge which ends, at the dorsal edge of the bone, as a pronounced process, and this process, as already stated, gives origin to certain of the levator muscles of the branchial arches. The process lies between the articular facets for the anterior and posterior heads of the hyomandibular, and abuts against the inners urface of the hyomandibular between its two articular heads, the hyomandibular being often here perforated by a circular opening due doubtless to wear. Immediately posterior to the ridge and process, there is, on the lateral surface of the bone, a marked depression or pit, which, as already described, also gives origin and lodgment to certain of the levator muscles of the branchial arches. In one specimen the pit was unusually deep, and at the bottom of it there was a smaller pit, which gave insertion to one of the levator muscles, doubtless the internus anterior. This smaller pit in this one specimen extended forward into the postorbital process, and perforating the proötic, near its edge, was bounded mesially by the sphenotic, a thin plate only of that bone separating it from the cerebral recess for the anterior semicircular canal.

The angle that separates the lateral and orbital surfaces of the proötic is traversed by a canal which is the homologue of the more extensive trigemino-facialis chamber of my descriptions of Scomber. The nervus facialis issues from the posterior opening of this chamber, and the trige-

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minus, lateralis trigemini and ciliaris profundi nerves from its anterior opening. The chamber lodges the trigeminus portion only of the trigemino-facialis ganglionic complex, together with the associated sympathetic ganglia, a recess on the cerebral surface of the bone lodging the lateralis and communis portions of the ganglionic complex. The chamber might accordingly be more properly called the trigeminus or semilunar chamber, the recess on the cerebral surface of the bone being called the facialis or geniculate recess. But until the manner of development is better known, of this chamber and recess, from a single chamber lodging the entire ganglionic complex, as in Amia, it seems to me best to retain the name already given to the chamber in Scomber, and to call the recess the trigemino-facialis recess. The main sympathetic trunk, the jugular vein, the external carotid artery and the vessel x all traverse the chamber in Scorpaena, the chamber thus representing either the whole or a portion of the upper lateral chamber of the eye-muscle canal of Amia (Allis, '03, p. 94). Into the chamber two to four foramina open; a large trigeminus one, a slightly smaller facialis one, and two small foramina, one or both of which may be included in the large trigeminus foramen. One of the two small foramina, when found, transmits the ramus ophthalmicus lateralis, the other transmitting the truncus ciliaris profundi. The ophthalmicus foramen lies slightly dorso-anterior to the trigeminus foramen, this latter foramen lying anterior to the facialis foramen, while the profundus foramen lies in the internal jugular groove at a variable distance anterior to the trigeminus foramen. The trigeminus foramen transmits the radix trigemini, the ramus buccalis plus oticus lateralis and the encephalic branch of the jugular vein. The oculomotorius traverses a foramen that perforates the proötic anterior to these several foramina, as will be later described, and in one instance this nerve was accompanied, as it traversed its foramen, by the truncus ciliaris profundi.

Sagemehl says ('91, p. 568) that in the Cyprinidae the ramus ophthalmicus superficialis (trigeminus lateralis) always perforates the alisphenoid; and Stannius says ('49, pp. 33 & 36) that this same nerve pierces the alisphenoid (Keilbeinflügel) in most teleosts. Sagemehl further says ('84b, p. 70) that independent foramina for the truncus trigemini and the ramus ophthalmicus superficialis trigemini is a primitive condition, and that a single foramen for these two nerves is exceptional. Neither of these statements is true either for Scomber or Scorpaena, and it would seem as if the foramina referred to must be, as in Amia, the foramina by which the nerves referred to issue from a trigemino-facialis chamber and not those by which they issue from the cranial cavity to enter that chamber. That there is a radical difference in these two sets of foramina was pointed out in my work on Scomber, and will be further discussed in the course of the present work.

The ventral portion of the proötic of Scorpaena, the part that lies ventral to the mesial process of the bone, forms, as usual, the lateral wall of the myodome, and its ventral edge is edged its full length with a broad band of cartilage, this cartilage being held in a deep slit-like groove in the edge of the bone. This groove lies between thin external and internal laminae of the proötic, of perichondrial origin, the anterior edges of these laminae being united along the anterior edge of the bone. The anterior edge of the endosteal bone, thus formed, then receives membranous additions which prolong it anteriorly, especially in its dorsal portion. Ventro-mesial to this edge of the bone, the ventro-anterior corner of the edging band of cartilage is cut away to form a large incisure which bounds the passage for the internal carotid artery. Posterior to this incisure the ventral edge of the edging cartilage forms the lateral boundary of the hypophysial fenestra, the ventral edge of the cartilage being presented ventro-mesially and abutting against the lateral surface of the median ridge on the dorsal surface of the postorbital portion of the parasphenoid.

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The ventral edge of this ventral portion of the proötic is overlapped externally by the lateral edge of the body of the parasphenoid, its anterior edge being in part overlapped externally by, and in part suturating with the hind edge of the ascending process of the same bone. In the angle between the ascending process and the body of the parasphenoid, between that bone and the proötic, is the internal carotid foramen, which leads from the external surface of the skull inward and forward between the parasphenoid and the proötic, and then across the internal carotid incisure, into the myodome. On the external surface of the proötic, and running from the dorsal edge of the internal carotid foramen upward and backward toward the facialis opening of the trigemino-facialis chamber, there is a slight groove which marks the course of the internal carotid artery before it enters the foramen. Immediately anterior to this groove, on the lateral surface of the ascending process of the parasphenoid, the infrapharyngobranchial of the first branchial arch is flexibly attached by strong fibrous tissues.

The mesial process of the proötic forms, as usual, part of the roof of the myodome and part of the floor of the cranial cavity. The angle between it and the ventral part of the bone forms the dorso-lateral angle of the myodome, and in this angle, near its anterior end, there is a deep pit leading upward in the bone almost to the floor of the trigemino-facialis chamber; a remnant, doubtless, of the passage which, in Amia, connects the ventral portion of the myodome with its upper lateral chamber. Immediately anterior to this pit is the ventral opening of the canal for the palatinus facialis, that canal beginning on the cerebral surface of the bone, in what has already been referred to as the trigemino-facialis recess. The canal lies wholly in a part of the bone that is of membranous origin, as will be later explained.

The dorso-lateral angle of the myodome is well rounded, and is continued forward upward and laterally to the internal jugular notch, where, turning backward, it falls into and is continuous with the anterior end of the internal jugular groove. The internal jugular notch, as already fully described when describing the alisphenoid, lies between the dorsal end of the ascending process of the parasphenoid and the ventral, process-like end of the anterior one of the two little ridges on the external surface of the alisphenoid, and the internal jugular groove, beginning there, runs backward and laterally along the orbital surface of the proötic into the ventral end of the trigeminus opening of the trigemino-facialis chamber. The slight ridge on the proötic that forms the ventral edge of the groove is closely applied, in its anterior portion, to the inner surface of the dorsal edge of the ascending process of the parasphenoid, while posteriorly it is continuous with the anterior edge of the lateral wall of the trigemino-facialis chamber. In the dorso-lateral angle of the orbital opening of the myodome, immediately mesial to the internal jugular notch, is the external opening of the oculomotorius foramen, that foramen lying wholly in the proötic. Dorsal to the internal jugular groove, on the orbital surface of the proötic, there is often a slight ridge with a process-like and downwardly projecting ventral end, exactly similar to the two ridges on the alisphenoid. The process-like end of this proötic ridge is, like the processes on the alisphenoid, connected by fibrous tissue with the dorsal edge of the ascending process of the parasphenoid, the process and tissue evidently representing an anterior extension of the lateral bounding wall of the trigemino-facialis chamber.

In Amia the lateral bounding wall of the trigemino-facialis chamber is well developed, being wholly of bone or cartilage, while the mesial wall is wholly of membrane. In Scorpaena, and also in Scomber, it is the mesial wall that is well developed, the outer wall being greatly reduced, while Lepidosteus presents a condition intermediate between Amia and Scorpaena.

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The mesial process of the proötic of Scorpaena has, as it has in Scomber, anterior and posterior portions, the pituitary opening of the brain case lying between the two portions. Immediately posterior to the pituitary opening, a small process of the postpituitary portion of the main process, projecting mesially, suturates with a corresponding process of the opposite side. Posterior to this little suturating process the mesial edge of the main process is connected by synchondrosis, by a median interspace of cartilage, with its fellow of the opposite side. On its dorsal surface, this interspace of cartilage is considerably wider than on its ventral surface, a thin lamina of the ventral layers of the process of the proötic projecting mesially, nearly to the middle line. Posteriorly, the interspace of cartilage is continuous, along the hind edge of the proötic, with the cartilage that caps the ventral edge of the bone, the hind edge of these united bands of cartilage bounding the anterior end of the basioccipital and connecting that bone, by synchondrosis, with the proötic. The anterior boundary of the pituitary opening is formed by a small sharp process of the prepituitary portion of the mesial process of the proötic. This little process lies, as already stated, against the ventral surface of the hind edge of the basisphenoid, and usually extends to the middle line of the skull, where it suturates with its fellow of the opposite side, thus completely cutting off the basisphenoid from all bounding participation in the pituitary opening. Antero-dorsal to this little pituitary process of the prepituitary portion of the entire process, the process suturates with the basisphenoid and the alisphenoid, as in Scomber.

The pituitary opening of the brain case of Scorpaena is closed, in the recent state, by membrane, this membrane being slightly concave on its dorsal surface, and slightly convex on its ventral surface. A slight depression is thus formed in the floor of the cranial cavity, this depression underlying the pituitary body and being the pituitary fossa. The pituitary opening of the brain case of the adult Scorpaena is, accordingly, the functional equivalent of the so-called pituitary fossa (Swinnerton), or pituitary space (Parker) of teleostean embryos: and an opening, similar to this one in Scorpaena, must certainly be found, at some stage, in all fishes the adults of which possess a basisphenoid bone. But the opening, though shown in certain figures of median sections of the teleostean skull, has seldom been particularly described. In Scomber I fully described it, using the word opening in place of fenestra so as to avoid, as much as possible, any suggestion of an homology.

On the internal surface of the proötic, near the sutural corner between this bone, the alisphenoid and the basisphenoid, is the internal opening of the foramen for the nervus oculomotorius. Posterior and slightly lateral to the pituitary opening the mesial process of the bone is perforated by the foramen for the nervus abducens, that nerve passing from the cranial cavity directly into the myodome. Lateral to these two foramina are the internal openings of the trigeminus, facialis, profundus and palatinus foramina; the first three foramina piercing the body of the bone to enter the trigemino-facialis chamber, while the palatinus foramen perforates the base of the mesial process of the bone and so enters the myodome. All four of these foramina lie in what is, in some specimens, a simple depression, but in others a marked recess on the internal surface of the bone. The hind wall of this recess looks postero-laterally and forms part of the anterior wall of the labyrinth recess, that wall being represented, both dorsal and ventral to the pocket, by a low ridge of bone; the dorsal ridge being continuous dorsally with the flange of bone that separates the two recesses on the internal surface of the sphenotic, and the ventral ridge vanishing along the mesial boundary of the saccular groove. The roof of the recess is formed by a nearly horizontal, shelf-like web of bone which extends across the angle that lies between the anterior wall of the labyrinth recess and the body of the proötic

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anterior to that wall. A much smaller but similar web of bone may separate the recess into dorsal and ventral portions, the facialis and palatinus foramina leading, in such cases, from the ventral portion of the recess, and the trigeminus and profundus foramina from its dorsal portion. The recess lodges the profundus ganglion and also the lateralis and communis portions of the trigemino-facialis ganglionic complex. The recess can accordingly be called the trigemino-facialis recess, although, as already stated, geniculate recess might be a more proper designation.

The canal for the ramus palatinus facialis thus perforates, in Scorpaena, the base of the mesial process of the proötic and does not enter the trigemino-facialis chamber in any part of its course; and this is the condition found also in the Characinidae (Sagemehl, '84 b, p. 65) and Cyprinidae (Sagemehl, '91, p. 558). In Scomber, on the contrary, the nerve first enters the trigemino-facialis chamber and then pierces the proötic to enter the myodome (Allis '03). In Trigla Lepidotrigla and Dactylopterus, as will be later shown, the nerve also first enters the trigemino-facialis chamber, but instead of then piercing the proötic by a separate canal, as in Scomber, it simply issues by the trigeminus opening of the chamber and so enters the orbit. In Menidia, the nerve is said by Herrick ('99, p. 176) not to enter the myodome (sub-cranial canal), butto run „along the outer side of the canal, not the inner"; thus apparently being either as in Scomber, or as in Trigla Lepidotrigla and Dactylopterus.

Immediately posterior to the trigemino-facialis recess, the labyrinth recess begins, and in that recess, on the internal surface of the proötic and immediately dorso-postero-lateral to the trigemino-facialis recess, there are two adjoining depressions, the anterior one lodging the ampulla of the anterior semicircular canal, and the posterior one the ampulla of the external canal. Ventro-mesial to these depressions, and immediately posterior to the ventral portion of the trigemino-facialis recess, a large and deep longitudinal groove begins, and, extending backward to the hind end of the proötic, immediately dorsal to the base of the postpituitary portion of the mesial process of the bone, forms the anterior portion of the saccular groove. The bottom of this groove is thin, and this part of the proötic forms, on the outer surface of the skull, the anterior part of the bulla acustica.

The conditions in the proötic region of 45 mm specimens, examined in serial sections, must now be considered. In these specimens, the basisphenoid bone is just beginning to develop, and lies immediately posterior and ventral to the posteriorly directed dorsal end of the basisphenoid cartilage. Excepting only this little bone and cartilage, the floor of the cranial cavity is, at this age, wholly membranous from its anterior end back to the abducens foramina. Immediately posterior to the abducens foramina, the cranial floor is formed by a horizontal bridge of cartilage which corresponds exactly, in extent and position, to the bony bridge formed by the united mesial processes of the proötics of the adult Amia. But the saccus vasculosus lies, both in these 45 mm specimens and also in the adult Scorpaena, on the dorsal surface of this proötic bridge, while in Amia it lies (Allis, '97 a, pp. 494 und 505) ventral to that bridge. As the bridges in these two fishes are unquestionably homologous, this difference in the position of the saccus, if the sacci also are homologous, must be caused by its being, in Scorpaena, pulled out from beneath, and lifted up above the bridge, by the greatly developed hypoaria; the saccus thus being pulled out of the myodome and so losing all relation to that canal.

Those parts of the mesial processes of the proötics of the adult Scorpaena that lie anterior to the abducens foramina are thus not preformed in cartilage, and must accordingly be developed wholly in membrane, as I was led to conclude, in an earlier work ('97), that they must be in all teleosts.

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The membrane in which they develop is, in my 45 mm specimens, a thick layer of coarse fibrous tissue which extends from the opticus to the abducens foramina, passing on either side of the pituitary fossa. This membrane is continuous, on either side, with the side wall of the skull, the ventral and larger portion of that wall here being also of membrane. This latter membrane is attached dorsally to the ventral edge of a cartilaginous process of the auditory capsule which forms the dorso-lateral corner and the dorsal portion of the side wall of this part of the skull. This process is called by Swinnerton ('02), in his descriptions of Gasterosteus, the postorbital process of the auditory capsule; but, as already stated, supraorbital process would seem a better term, for the process extends antero-mesially from the postorbital process of the skull along the dorsal edge of the posterior portion of the orbit. The membranous side wall of the skull ventral to this process is, in my 45 mm specimens, undergoing ossification to form parts of the proötic and alisphenoid bones, and the former bone, or that part of the membrane that will ossify as part of it, is perforated, immediately ventral to the ventral edge of the cartilage, by two foramina. One of these foramina is a large opening which transmits the united trigeminus and lateralis trigemini nerves and also the encephalic branch of the jugular vein, the other transmitting the facialis and lateralis facialis nerves. Ventro-anterior to these two foramina, but still posterior to the slightly developed basisphenoid bone, the membrane is pierced by both the oculomotorius and truncus ciliaris profundi; these two perforations lying relatively close together, the one for the ciliaris profundi slightly dorso-posterior to the one for the oculomotorius.

In the region ventral to the profundus foramen the membranous cranial wall is connected by a bridge of dense, coarse, fibrous tissue, with the dorsal end of the ascending process of the parasphenoid, that part of the latter process that is cut in sections passing through this region, forming the lateral wall of the orbital opening of the myodome and lying anterior to the cartilage that represents the ventral portion of the proötic. The dorsal end of the process of the parasphenoid here lies at a relatively considerable distance from the membranous side wall of the cranial cavity, and from its anterior edge, and continuous with the bridge of fibrous tissue that spans the space between it and the membranous cranial wall, a strong line of tissue runs dorsally, and, separating into two parts, has its attachment to the cranial wall, one part dorsal and the other ventral to the ophthalmic nerves. This line of tissue lies wholly anterior to the truncus maxillo-mandibularis trigemini, and represents, in part, the two little process-like ridges on the external surface of the alisphenoid of the adult, and, in part, the fibrous or connective tissues that extend from those little processes to the dorsal end of the ascending process of the parasphenoid. The line of tissue that has its insertion dorsal, and hence morphologically postero-lateral, to the ophthalmic nerves, represents the postero-lateral one of the two processes of the adult, the line that has its insertion ventral, and hence morphologically antero-mesial to the nerves, representing the antero-mesial process: the two bands of tissue together representing the parasphenoid leg of the alisphenoid, here pierced by the ophthalmic nerves, as the pedicle of the alisphenoid is in Amia. The basisphenoid leg of the alisphenoid is represented in an undefined portion of this part of the cranial wall, that wall being of membrane in its ventral portion, but already ossified in its dorsal portion. The bridge of fibrous tissue that spans the space between these two legs of the alisphenoid, represents that part of the orbital surface of the proötic of the adult that is occupied by the internal jugular groove.

Slightly posterior to the oculomotorius and profundus foramina the lateral edge of the bridge of fibrous tissue above referred to sends a line of tissue downward internal to, and parallel to the

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bony ascending process of the parasphenoid, this line of tissue edging the anterior edge of the plate of cartilage that represents the ventral portion of the proötic and then passing downward along the external surface of that cartilage. From the mesial edge of the bridge of tissue, and from the membranous cranial wall posterior to it, another line of tissue descends, passing along the internal surface of the proötic cartilage. Between the two descending lines of tissue, anteriorly, and between the proötic cartilage and the internal line of tissue posteriorly, a space is left, which, in the 45 mm specimens, is filled with fat globules and loose connective tissue. This space lies immediately beneath the trigemino-facialis chamber, and its dorsal wall ossifies to form the thin bony floor of that chamber. In its anterior portion the space is tall, extending from the floor of the trigemino-facialis chamber downward beyond the line of origin of the mesial process of the proötic; that process here being wholly of membrane, and rising perpendicularly from the membranous mesial wall of the space. Slightly posterior to this, in those sections that cut through the trigeminus foramen, the fat space separates into dorsal and ventral limbs. The dorsal limb continues backward immediately beneath the floor of the trigemino-facialis chamber and extends to the hind end of that chamber. The ventral limb extends backward to the hind end of the proötic cartilage, lying always opposite the line of origin of the membranous portion of the mesial process of the proötic, but passing ventral to the cartilaginous portion of that process and there occupying the dorso-lateral corner of the myodome. The lateral wall of the dorsal limb of the space is always formed of membrane or of membrane bone. The lateral wall of the ventral limb is always of cartilage, this limb of the space lying in a wide and shallow groove on the inner surface of the proötic cartilage, the dorsal edge of the groove being marked by a sharp edge or ridge.

This space in the proötic evidently has some special morphological significance, for, although not evident in the adult Scorpaena, it quite certainly has its homologue in an important vacuity found in the proötic of the adults of certain other teleosts, as will later be shown when describing the myodome in Gadus. It may be referred to as the proötic vacuity. The mesial wall of the anterior part of the vacuity is, in the 45 mm Scorpaena, a direct ventral continuation of the mesial wall of the trigemino-facialis chamber, the lateral wall of this anterior part of the vacuity being similarly related to the lateral wall of that chamber.

Close to the anterior end of the proötic vacuity, in the 45 mm Scorpaena, the ramus palatinus facialis pierces the membrane that later ossifies as the mesial process of the proötic, near the base of that process, and passing internal to the anterior edge of the proötic cartilage enters the myodome. The nerve arises from the intracranial communis ganglion, and does not in any part of its course enter the trigemino-facialis chamber. In the intracranial part of its course, it lies along the cerebral surface of a membranous portion of the cranial wall, imbedded in loose connective tissues, these same tissues also enclosing, mesially, the intracranial portion of the trigemino-facialis ganglion, and being prolonged dorsally as part of the cerebral wall of the labyrinth recess. This tissue may therefore represent the tough glistening membrane that, in Amia, forms the lateral bounding wall of the cranial cavity in the pituitary region, though it seems more probable that that membrane is represented, in Scorpaena, in the membrane that forms the mesial wall of the trigemino-facialis chamber. Following Sagemehl, I ('97) formerly considered the tough glistening membrane of Amia as a specially developed portion of the dura mater. My present work leads me to accept this conclusion only with the proviso that the dura mater is itself a differentiated portion of the membranous tissue that primarily forms the enclosing capsule of the central nervous system.

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MYODOME.

The myodome (eye-muscle canal) of Scorpaena has the shape of a funnel, the body of which is triangular or semicircular in transverse section, while the tubular portion is nearly circular in section. The orbital opening of the canal is approximately an equilateral triangle with rounded corners, the base of the triangle being presented dorsally and the triangle being bisected by the pedicle of the basisphenoid. The opening is bounded ventrally by the body of the parasphenoid, laterally on either side by the ascending process of the parasphenoid, and dorsally mainly by the body of the basisphenoid though partly also by the prepituitary portions of the mesial processes of the proötics. At the extreme dorso-lateral corner of the opening, is the internal jugular notch, that notch lying, as already explained, between the basisphenoid and parasphenoid legs of the alisphenoid. From this notch the internal jugular groove leads postero-laterally into the trigeminus opening of the trigemino-facialis chamber, the notch, groove and chamber all being remnants of the upper lateral chamber of the myodome of Amia.

Immediately internal to its orbital opening the myodome expands abruptly at its dorso-lateral corners, a pocket thus here being formed, on either side, which, as already stated, projects upward and reaches the under surface of the thin floor of the trigemino-facialis chamber. The myodome here has its largest transverse section, and from here contracts rapidly to the hind edges of the proötics, where the long and relatively small tube of the funnel begins. This tube lies wholly in the grooved ventral surface of the basioccipital, the body of the funnel lying wholly between the proötics. Between the ventral edges of these latter bones, and also between the ventral edges of the groove in the basioccipital, there is a long slit-like opening, the hypophysial fenestra. This fenestra extends the full length of the floor of the myodome but is closed, ventrally, by the parasphenoid, excepting at its extreme hind end where the myodome opens onto the ventral surface of the skull. The roof of the body of the myodome is formed in part by the basisphenoid, but mainly by the mesial processes of the proötics, and it is perforated, in its anterior portion, by the median, pituitary opening of the brain case.

The pituitary opening is closed, in the recent state, by membrane, and, arising from this membrane and extending forward to the hind edge of the pedicle of the basisphenoid, there is a vertical band of tough fibrous tissue, attached by its dorsal edge to the ventral surface of the body of the basisphenoid. The anterior end of this tissue gives origin, on either side, to the rectus inferior muscle. The ventral edge of the band spreads, and is firmly attached to the dorsal edges of the recti interni muscles, those two muscles entering the myodome, on either side, ventral to the rectus inferior, along the floor of the myodome and close against the pedicle of the basisphenoid. The attachment of these recti interni to the ventral edge of the mid-vertical membrane seems to be the important origin of the muscles, for although they extend posteriorly considerably beyond the membrane, approximately to the hind ends of the proötics, they are, in this part of their course, simply attached to each other and to loose tissues in the myodome; the attachment of the muscles to each other being strong. The rectus superior, on either side, enters the myodome near the dorsal end of its orbital opening, there passing downward between the rectus inferior, mesially, and the rectus externus laterally. Running downward and but slightly backward it passes lateral to the rectus internus and has its origin on the dorsal surface of the parasphenoid. The rectus externus enters the myodome along the lateral edge of its orbital opening, lying lateral to all the other muscles.

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Turning backward in the myodome it lies at first dorso-lateral to the rectus internus, but it extends posteriorly beyond that muscle, into the basioccipital part of the myodome. Near the hind end of this latter part of the myodome, the muscle becomes tendinous and is inserted on the basioccipital, certain of the fibers of the tendon passing out of the myodome, by its posterior opening, and there arising from the ventral, external surface of the bone. The orbital opening of the myodome is closed by a strong membrane which the recti muscles all perforate to reach their points of origin.

Sagemehl says that, in the Characinidae, the recti inferior and externus arise in the myodome, the internus having its origin in the orbit; and as the myodome, in the Cyprinidae, is said to differ in no important respect from that in the Characinidae, these muscles must there have the same origin. In all of the mail-cheeked fishes that I have examined, and also in Scomber (Allis, '03), it is the externus and internus instead of the externus and inferior that have this origin in the myodome.

CAROTID ARTERIES AND VESSEL X.

The external and internal carotid arteries were traced both in 45 mm specimens and in the adult, and they differ but little from the arteries in the adult Ophiodon elongatus, recently described by Allen ('05). I, however, find, in young specimens of Scorpaena, Trigla, Lepidotrigla and Dactylopterus, a small artery that is not described by Allen, that would seem to be in part the homologue of the hyo-opercularis artery of my descriptions of Amia ('97, p. 497), and that has already been referred to as the vessel x.

The external carotid of Scorpaena, after its origin from the short common carotid, runs upward and forward, enters the trigemino-facialis chamber through its facialis opening, and traversing that chamber issues by its trigeminus opening. It then immediately gives off what must be the sclerotic-iris artery of Allen's descriptions, though the artery as I find it has not exactly the distribution given by Allen. It then gives off a branch to the levator arcus palatini muscle and the large facialis-maxillaris artery, as described by Allen in Ophiodon, and itself turns downward and slightly backward in the V-shaped space between two flanges on the hind edge of the metapterygoid, to be later described. At the lower edge of the internal one of these two flanges the artery falls into the arteria hyoidea at a sharp bend in that artery, that part of the carotid that lies between the point where it gives off the facialis-maxillaris and the point where it falls into the arteria hyoidea, corresponding closely in position to the secondary afferent pseudobranchial artery of my descriptions of Amia ('00 c). The hind end of the latter artery, in larvae of Amia, closely approaches the dorsal end of the primary affferent pseudobranchial artery, which artery is the arteria hyoidea, and if the secondary afferent artery should acquire a connection with the arteria hyoidea, and that artery retain its connection with the pseudobranch, the conditions found in Scorpaena would arise. And this is quite certainly the manner in which the teleostean arrangement has actually arisen.

The arteria hyoidea of Scorpaena, coming upward along the ceratohyal, turns dorso-anteriorly along the anterior aspect of the interhyal and traverses a large opening that lies between the preopercular and the posterior process of the quadrate, posteriorly, and the symplectic anteriorly. There it immediately gives off the mandibular artery, which runs downward and forward, along the outer surface of the quadrate, into the mandible. Having given off this artery, the arteria hyoidea turns sharply upward, crosses the external surface of the hyomandibulo-symplectic interspace of cartilage and at the antero-dorsal corner of that cartilage passes inward through a small opening between the cartilage, the metapterygoid and the shank of the hyomandibular. Continuing its upward

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course, the artery passes along the inner surface of the external one of the two flanges on the hind edge of the metapterygoid, there lying along the anterior edge of a part of the levator arcus palatini muscle that here has its insertion, and reaches the ventral edge of the internal one of the two flanges on the metapterygoid. There it turns sharply dorso-posteriorly, crosses the internal surface of the hyomandibular and enters the opercular hemibranch at about its dorsal third. At the bend it fuses with the ventral end of the external carotid, that artery forming, in direction, a direct dorsal continuation of that part of the arteria hyoidea that lies below the bend.

Allen ('05), in his work on Ophiodon, considers the hyoid artery as ending at the point where the mandibular artery is given off, the artery above that point being called by him the external carotid, with an afferent pseudobranchial branch arising from it. This manner of naming these arteries is based on the fact that, in Ophiodon, the so-called external carotid is so large, and the hyoid artery so small, that the flow of blood is said to be largely or wholly downward to the point where the mandibular artery arises, instead of upward from there, toward the hemibranch. In Amia, also, I was led to conclude ('00 c, p. 121) that the flow of blood in the dorsal portion of the arteria hyoidea must be downward, and be derived from the carotid through the pseudobranch. But granting that this be so, the nomenclature seems to me a faulty one, for the artery, up to the hemibranch, is certainly, in its development, the afferent pseudobranchial artery, or arteria hyoidea. Furthermore the course of this so-called part of the external carotid artery, as given by Allen in Ophiodon, is not exactly the same as that of the corresponding artery in Scorpaena, the artery being said by Allen (l. c., p. 51) to pass „over the dorsal edge of the hyomandibular", then, „along the inner side of the metapterygoid" until it receives the hyoid artery, after which it „comes to the outer surface through a foramen between the symplectic, hyomandibular, preopercular, and quadrate bones". In Scorpaena, this part of the external carotid of Allen's nomenclature passes downward between two flanges on the hind edge of the metapterygoid, then comes to the outer surface of the palato-quadrate through a small foramen between the metapterygoid and hyomandibular, and, remaining always on the outer surface of the apparatus, receives the hyoid artery which passes outward through an opening between the symplectic, quadrate and preopercular to join it. And in Cottus, Trigla and Dactylopterus strictly similar or equivalent conditions are found, as will be later described. In Scomber, also, this artery has the same course as in these several fishes: for, the connection of the external carotid and hyoid arteries not being given in my work on Scomber, I have had Mr. Henry examine it, in that fish, and he finds the arrangement exactly as above described for Scorpaena, excepting that the two sharp bends found in the hyoid artery (my nomenclature) of Scorpaena do not exist in Scomber; the artery in the latter fish having a nearly straight course as it runs upward from the hyoid arch toward the opercular hemibranch, and the external carotid falling into it at a right angle. This course of the artery in these several fishes seeming to make its course in Ophiodon exceptional, unless there were some error or misconception of its course in Allen's work, I had Mr. Allen reexamine it — for he was at the time attached to my laboratory — and the sketch sent me by him shows that the conditions in Ophiodon are similar to those in Cottus; the hyoid artery (my nomenclature) passing to the outer surface of the palato-quadrate apparatus between the symplectic and preopercular, then crossing the external surface of the hyomandibulo-symplectic cartilage and passing to the inner surface of the apparatus again between the hyomandibular and metapterygoid. Then the artery, to all appearance, runs upward along the inner surface of the hind edge of the metapterygoid as it does in Cottus; but, in Ophiodon, the two flanges on the hind edge of the metapterygoid

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must lie, as they do in Cottus, and as will be later described, in practically the same plane, the internal flange lying wholly dorsal to the external one and the adjoining edges of the two flanges being fused excepting where they enclose a relatively large foramen which perforates the bone so formed. The hyoid artery, in Ophiodon, when it reaches the inner surface of the palato-quadrate, accordingly lies along the inner surface of what is, in reality, the external flange on the hind edge of the metapterygoid and not along the inner surface of the body of that bone. There it receives the external carotid artery (my nomenclature) which, coming down along the external surface of the internal flange on the hind edge of the metapterygoid, traverses the foramen between the ventral edge of that flange and the dorsal edge of the external flange. This is also the condition found in Cottus, and Allen's description of Ophiodon is here so particularly referred to simply because it is another of the numerous instances that show that when existing descriptions seem to indicate that important structures, in different animals, differ in their relations to each other, reexaminations and a proper understanding of the parts almost invariably show that such is not the case. There are however instances that do not seem capable of this interpretation. In Triton, for example, Coghill ('06) says that the ramus ophthalmicus profundus V passes dorsal to the ramus superior III, while in Amblystoma it passes ventral to that nerve. The supposition that the ophthalmicus V is a superficialis in Triton and a profundus in Amblystoma seems unwarranted, and even this would not explain the conditions found in one specimen of Triton, where Coghill says that the ophthalmicus V passes between two portions of the r. superior III, lying dorsal to one of them and ventral to the other.

In Scorpaena, the internal carotid artery, having separated from the external carotid, runs forward and downward in the groove on the outer surface of the proötic, and, traversing the internal carotid foramen enters the myodome across the internal carotid incisure. There it immediately gives off a branch which, on one side of the 45 mm specimen examined, is small, runs forward in the myodome and could there be traced but a short distance. On the other side of this specimen the branch is large, runs forward in the myodome along the internal surface of the ascending process of the parasphenoid, and, at the anterior edge of that process, sends a branch toward the efferent pseudobranchial artery (arteria ophthalmica magna), apparently joining it, and then continues forward as the orbito-nasal artery of Allen's descriptions of Ophiodon. This connection of these two arteries, if it actually exists, which could not be definitely established, would agree with that found by me in Amia. It was not found by Allen in Ophiodon (l. c., p. 55).

The efferent pseudobranchial artery arises from the opercular hemibranch and, running forward external to the cranium, terminates in the choroid gland of the eye-ball. Immediately anterior to the ascending process of the parasphenoid, and immediately anterior also to the point where, on one side of my specimen, the artery apparently receives a communicating branch from the internal carotid, it sends a branch downward and mesially, across the ventral edge of the rectus internus and dorsal to the parasphenoid, to join, in the middle line, a corresponding branch from the artery of the opposite side; a transverse commissure between the two arteries thus here being formed. The efferent pseudobranchial artery of Scorpaena thus differs in no respect from that in Ophiodon excepting that, on one side of my specimen, it apparently receives a communicating branch from the internal carotid.

In Pleuronectes, Cole and Johnstone ('01, p. 96) say that the two ophthalmic (efferent pseudobranchial) arteries „perforate the proötics together with the superior jugular veins, passing through the jugular foramina". The external carotids are said to break up along the ventral surface of the

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skull, not, accordingly, traversing the so-called jugular foramen, which foramen is the facialis opening of the trigemino-facialis chamber of my descriptions. This course of these two arteries being so unusual, I have had it looked up both in Rhombus and Solea. In both these fishes the efferent pseudobranchial artery runs forward external to the cranium, the external carotid traversing the trigemino-facialis chamber, both arteries thus having exactly the same general course that they have in Scorpaena and that they are known to have in many other teleosts. That Pleuronectes forms an exception to this rule I greatly doubt, the particular specimen examined by Cole & Johnstone doubtless presenting an abnormality in the course of these two arteries, as it apparently does also in the absence of an encephalic artery arising from the transverse commissure that is said to connect the internal carotids of opposite sides.

The internal carotid of Scorpaena, having given off the orbito-nasal artery or the communicating branch to the efferent pseudobranchial artery, as the case may be, runs mesially and but slightly anteriorly along the floor of the myodome, lying immediately beneath the rectus internus muscle. Having reached the middle line of the head, the artery turns upward between the two recti interni muscles, there lying closely pressed against its fellow of the opposite side. Whether there is here an anastomosis of the arteries of opposite sides to form a single median encephalic artery, such as Allen describes in Ophiodon, or not, could not be determined; but there probably is, as, otherwise, there would be no circulus cephalicus in this fish. It may, however, here be stated that the diagrams ordinarily given of this circulus, and as given by Ridewood ('99) for Cottus and Trigla, are misleading, for there is not here a simple transverse commissure, such as there is for the efferent pseudobranchial arteries. There are two arteries, one on either side, which, running upward to enter the cranial cavity, lie close together and fuse in the middle line for a short distance, and then separate again as they enter the cranial cavity. The one or two arteries in Scorpaena, whichever it be, running upward enters the hind end of the median vertical band of fibrous tissue, already described, that arises from the hind edge of the pedicle of the basisphenoid and ends posteriorly in the fibrous tissues that close the pituitary opening of the brain case. Having traversed this tissue, the two arteries become distinct again, perforate separately the membrane that closes the pituitary opening of the brain case, along the hind edge of the basispheniod, and enter the cranial cavity, their further course not being traced.

In Scomber I have stated ('03, p. 93) that the internal carotid enters the cranial cavity along the anterior edge of the basisphenoid, there perforating the membrane that closes the orbital opening of the brain case. This marked difference in the relations of the artery to the basisphenoid, in this fish and in Scorpaena, has led me to reëxamine Scomber, and I find that my statement regarding that fish is an error, the artery there running up posterior to the basisphenoid, as it does in Scorpaena.

The vessel x was examined in sections of young specimens of Scorpaena, Trigla, Lepidotrigla and Dactylopterus, but the results obtained were so unsatisfactory that I am preparing material for a further study of it. It is so small a vessel that it was not looked for in any of the adults. In the sections examined of Scorpaena, Trigla and Lepidotrigla strictly similar conditions were found, while in Dactylopterus the vessel presented a slightly different arrangement.

In Scorpaena, Trigla and Lepidotrigla the vessel is formed by the union of what seem to be small arteries that arise in some sort of relation to the efferent arteries of the first three branchial arches. Running forward parallel and close to the common carotid, the vessel soon separates into two parts which may be called its internal and external branches. The internal branch

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closely accompanies the internal carotid and could be traced as far as the internal carotid foramen, where it either fused with the internal carotid or vanished in the sections. The external branch closely accompanies the external carotid until it reaches the facialis opening of the trigemino-facialis chamber. There it separates slightly from the carotid, but enters and traverses the trigemino-facialis chamber, lying somewhat dorsal to the carotid. Issuing from the chamber, the vessel separates into three branches. One of these branches accompanies the sclerotic-iris branch of the carotid artery and passes into the cranial cavity with that branch of the latter artery that traverses the little foramen in the alisphenoid, already described. A second branch of the vessel closely accompanies that branch of the carotid that goes to the levator arcus palatini. The third branch turns backward and immediately gives off a small branch which accompanies that terminal portion of the carotid that runs downward to fall into the arteria hyoidea. The remainder of this third branch then continues backward along the side wall of the skull, joins the truncus hyoideo-mandibularis facialis and traverses, with that nerve, the facialis canal through the hyomandibular. Slightly before it enters the latter canal it sends a branch backward, this branch joining the ramus opercularis profundus facialis and going to the region of the adductor hyomandibularis and the adductor and levator operculi. The terminal portion of the third branch of the vessel x of these fishes, this branch being given off from the external artery after that artery issues from the trigemino-facialis chamber through its trigeminus opening, thus has a distribution similar to that of a branch of the hyo-opercularis of Amia given off before the artery enters the trigemino-facialis chamber. In Amia, in fact, this latter branch is the important part of the artery, and so led me to call it the hyo-opercularis, the part that enters the trigemino-facialis chamber appearing as a small branch only.

PTEROTIC.

The pterotic (squamosal) forms a small lateral portion of the dorsal surface, and the dorso-posterior portion of the lateral surface of the brain case, and the larger part of the lateral wall of the temporal fossa. The bone is bounded, as usual, by the sphenotic, proötic, exoccipital and epiotic with all of which bones it is in synchondrosis, and by the lateral extrascapular, parieto-extrascapular, frontal and postfrontal, with which bones it is in sutural contact. The opisthotic overlaps externally the outer surface of its postero-ventral portion. On its internal surface there is a large recess which leads into a canal which lodges the outer portion of the external semicircular canal.

On the dorsal surface of the bone, near its lateral edge, there is a prominent longitudinal ridge which ends posteriorly in a short sharp point which forms one of the spines of the lateral row. A thin flat posterior process projects backward from the dorsal half or two-thirds of the hind edge of the bone, and gives insertion to the dorsal end of the fibrous membranes that line the anterior and posterior surfaces of the opercular opening. Degenerate muscle fibers are found in the dorsal ends of these membranes. No portion of the trunk muscles arises from the process. On the dorsal edge of the process the lateral edges of the lateral extrascapular and suprascapular rest, but the process gives no support to the supraclavicular, such as Sagemehl describes in the Characinidae and Cyprinidae. On the lateral surface of the bone, close to its dorsal edge and extending nearly the full width of the body of the bone, there is an oval facet for the posterior articular head of the hyomandibular, the facet lying considerably dorsal to that portion of the bone that lodges the external semicircular canal. Dorsal to the anterior portion of this facet, a depression on the anterior edge of the bone forms the posterior portion of the dilatator fossa. The pterotic is traversed by the

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main infraorbital canal, the canal lying immediately beneath the spinous ridge on the dorsal surface of the bone and lodging but one sense organ of the line, innervated by the ramus oticus. The preopercular canal joins the main infraorbital at the hind end of the section of canal enclosed in the pterotic, the pterotic thus containing no post-preopercular latero-sensory ossicle.

BASIOCCIPITAL.

The basioccipital has, on its dorsal, cerebral surface, two large longitudinal grooves, one on either side, these grooves occupying the entire dorsal surface of the anterior two-thirds of the bone, excepting only the narrow median and lateral portions that form the bounding walls of the grooves. Each groove is continued backward, as a recess, into the posterior third of the bone, the hind end of each recess almost reaching the conical surface of the median vertebra-like depression on the hind end of the bone. The posterior half or two thirds of the uncovered portion of each of these grooves is roofed by a mesial, nearly horizontal process of the exoccipital of its side, the grooves thus becoming large and deep recesses in the cranial floor. Each groove lodges the posterior portion of the sacculus of its side, the anterior portion of the sacculus being lodged in the saccular groove on the cerebral surface of the proötic. On the outer surface of the skull, the bounding wall of the basioccipital portion of the saccular groove forms the posterior portion of the bulla acustica.

On the dorsal surface of the basioccipital, between the hind ends of the saccular grooves, there is a small median pit, sometimes separated into two parts by a thin transverse partition, this partition inclining from the mouth of the pit downward and backward toward its point. The pit, whether simple or double, leads downward and backward almost to the point of the conical vertebra-like depression on the hind end of the bone, approaching that point so closely that it sometimes is separated from it by a thin layer, only, of bone. This small median pit is evidently the homologue of the cavum sinus imparis of Sagemehl's descriptions of the Characinidae and Cyprinidae, but it is, in Scorpaena, wholly uncovered, the hind edges of the mesial processes of the exoccipitals reaching only to its anterior edge and being restricted to roofing, on either side, a portion of the corresponding saccular groove. This latter groove, it may be noted, is relatively small in the Characinidae and Cyprinidae, its anterior end passing but slightly beyond the hind edge of the proötic; and the sacculi of opposite sides are, in those fishes, connected by a canalis communicans, not found in Scorpaena.

Posterior to the cavum sinus imparis, the narrow remaining portion of the dorsal surface of the basioccipital slopes downward and backward to the hind end of the bone, is slightly concave and forms a small bounding portion of the foramen magnum. On either side of the cavum sinus imparis, there is a roughened surface which gives support to a corresponding portion of the ventral edge of the exoccipital, and immediately anterior to this surface, on either side of the anterior end of the cavum sinus imparis, the basioccipital encloses a small nodule of cartilage, a remnant of the chondrocranium, which lies between it and the exoccipital. Anterior to this nodule of cartilage the thin lateral edge of the basioccipital, on either side, is in sutural contact with the ventral edge of the exoccipital; while the median ridge of the bone, which separates the saccular grooves, gives support to the mesial edges of the mesial processes of the exoccipitals, a small remnant of cartilage there intervening.

On the ventral surface of the basioccipital there is a deep longitudinal groove, nearly circular in transverse section. This groove lies between the bottoms of the saccular grooves, tapers gradually to its hind end, and forms the posterior portion of the myodome. It opens on the ventral surface

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of the basioccipital by a narrow median slit-like opening, which extends the full length of the groove and forms the posterior half of the hypophysial fenestra. This fenestra, as already stated, is closed ventrally, excepting in its posterior portion, by the underlying parasphenoid, the hind end of the fenestra remaining uncovered, spreading somewhat, and so forming an opening which leads directly into the hind end of the myodome. On the lateral surface of the hind end of the bone, immediately dorsal to a horizontal plane through the center of the vertebra-like depression on that end, there is, on either side, a slight depression which gives insertion to the occipito-supraclavicular ligament. This ligament of fishes is said by Sagemehl ('84 b, p. 49) to be a differentiation of the perimuscular fascia of the adductor muscle of the shoulder girdle; but this adductor muscle, as described by Sagemehl in the Characinidae, is not found in Scorpaena, and I doubt greatly this origin of the ligament. The only muscle that at all resembles Sagemehl's descriptions of the adductor, is a flat, thin muscle band that arises from the hind edge of the skull and has its insertion on the occipito-supraclavicular ligament near its outer end.

The basioccipital is bounded anteriorly, on either side, by the proötic, with which it is in synchondrosis, and dorsally by the exoccipital with which it is partly in synchondrosis, and partly in sutural contact. Its ventral surface is overlapped externally and largely covered by the parasphenoid. Its hind end is wholly occupied by the deep conical vertebra-like depression.

EXOCCIPITAL.

The exoccipital is an irregular bone which forms part of the lateral surface and part of the posterior surface of the brain case, this latter portion having a medullary prolongation. The angular edge that separates these two portions of the outer surface of the bone has, at about the middle of its length, a pronounced reëntrant and usually well rounded angle. Anterior to this angle the edge extends dorso-anteriorly and, reaching to the level of the floor of the hind end of the temporal fossa, forms the ventral portion of the lateral bounding wall of the posterior opening of that fossa. Posterior to the angle, the edge extends posteriorly and but slightly downward, and is thickened to form, at its hind end, an articular head, which looks posteriorly and slightly ventro-mesially, articulates with a process on the anterior edge of the first vertebra, and may be called the condylar process of the bone. The ventral surface of this condylar process is roughened, and rests directly upon the lateral portion of the dorsal surface of the hind end of the basioccipital, the two bones enclosing, at the anterior end of this suturating surface, the little nodule of cartilage already referred to when describing the basioccipital. Anterior to this part of the exoccipital, the ventral edge of the bone is a thin plate which rests upon and slightly overlaps externally the dorsal edge of the thin lateral portion of the basioccipital, the two bones forming the lateral wall of the saccular recess of the cranial cavity.

That part of the exoccipital that forms part of the posterior surface of the skull is presented dorso-posteriorly and is separated into two parts by a ventral continuation of the epiotic ridge, that ridge forming the mesial boundary of the posterior opening of the temporal fossa. The medullary prolongation of this part of the bone looks dorso-laterally, arches over the canal for the medulla oblongata, and is in contact, in the median line, with its fellow of the opposite side. This contact is by thin external and internal laminae of bone, the space between these laminae being filled with cartilage. Extending obliquely across this part of the bone there is a marked thickening which begins below and extends dorso-posteriorly, presenting a process-like appearance and strongly suggesting a vertebral arch here fused with the exoccipital. The dorsal end of this process-like thickening forms

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the posterior portion of the dorso-mesial edge of the medullary prolongation; and the posterior portion of the ventral edge of the spina occipitalis is wedged in between the ends of the processes of opposite sides. Anterior to these process-like portions of the exoccipitals the ventral edge of the spina occipitalis rests on the external surface of the suturating edges of the exoccipitals. In the hind edge of the medullary prolongation of the exoccipital, there is a large semicircular notch, but it is closed with fibrous tissue and does not give passage to any structure.

From the internal surface of that part of the exoccipital that lies immediately dorsal to the saccular groove, a stout plate-like process projects mesially and slightly downward, and expanding slightly at its mesial end is in synchondrosis, in the middle line of the head, both with its fellow of the opposite side and with the dorsal edge of that thin median ridge of the basioccipital that separates the saccular grooves; a remnant of cartilage intervening between the three bones. The process forms the roof of a considerable portion of the saccular recess, but does not roof any portion of the cavum sinus imparis, as Sagemehl says that it does in the Characinidae and Cyprinidae, the hind edge of the process only reaching to the anterior edge of that pit. Immediately dorsal to the base, or line of origin, of this mesial process, the exoccipital is perforated by two foramina, one of which lies near the anterior edge of the process, and the other near its posterior edge. The anterior foramen opens on the lateral surface of the bone and transmits the nervus vagus, the other opening on the base of the condylar process of the bone, being sometimes double, and transmitting the occipital nerves. Slighty anterior to the vagus foramen the bone is perforated by the glossopharyngeus foramen. On the internal surface of the bone, immediately dorso-anterior to the vagus foramen, there is a recess which lodges the ampulla of the posterior semicircular canal. From this recess two canals start, one running upward and enclosing a portion of the membranous posterior semicircular canal, while the other runs latero-anteriorly and encloses part of the external canal. The canal for the external semicircular canal lies antero-internal to the angular edge between the lateral and posterior surfaces of the bone, the canal for the posterior canal lying in the ridge that forms a ventral prolongation of the epiotic ridge.

The exoccipital is bounded ventrally by the basioccipital, anteriorly by the proötic, dorsolaterally by the pterotic, and dorsally by the epiotic and supraoccipital, from all of which bones it is largely separated by lines of cartilage. The opisthotic overlaps externally the dorsal portion of the lateral surface of the bone, fitting into a depressed region on that surface.

OPISTHOTIC.

The opisthotic (intercalar) is a small plate-like bone, quite unquestionably of purely ectosteal origin, which forms the middle portion of the postero-lateral edge of the skull; there overlapping externally the adjoining edges of the pterotic and exoccipital, and extending forward to, or even slightly overlapping the hind edge of the proötic. Its hind edge is thickened and projects backward beyond the pterotic and exoccipital, there forming part of the lateral wall of the temporal fossa. A small eminence on this edge gives support, and is bound by ligamentous tissue to the ventral end of the opisthotic process of the suprascapular.

EPIOTIC.

The epiotic (exoccipitale) is a somewhat pyramidal bone which caps the dorso-mesial corner of the hind end of the temporal fossa and has dorsal, posterior, lateral and cerebral surfaces. A portion

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of its dorsal surface gives support to the overlying parieto-extrascapular, the remaining part of that surface forming the lateral portion of the floor of the supratemporal pocket; this latter part of the bone, as already explained, lying on and appearing as a part of the posterior surface of the skull. The posterior surface of the bone forms part of the posterior surface of the skull; its lateral surface forming the mesial wall of the temporal fossa. The angle between these two latter surfaces forms a strong, epiotic ridge, which lies in a nearly vertical position near the middle of the corresponding half of the posterior surface of the skull, forms the mesial boundary of the posterior opening of the temporal fossa, and, with its ventral prolongation on the posterior surface of the exoccipital, marks the course of the posterior semicircular canal. The summit of the bone is directed dorso-postero-laterally, and from it a flat, and often sharp and slender process arises, directed postero-laterally and slightly ventrally. On the dorsal surface of this process, between it and the overhanging posterior portion of the parieto-extrascapular, the epiotic process of the suprascapular rests, the two processes roofing the hind end of the temporal fossa. The cerebral surface of the bone is wholly occupied by a deep conical pit which forms part of the labyrinth recess and lodges the dorsal portion of the posterior semicircular canal, that canal piercing the ventro-posterior wall of the recess and from there running downward through the bone, internal to the epiotic ridge.

The epiotic is bounded antero-laterally by the pterotic, ventrally by the exoccipital, and mesially by the supraoccipital, with all of which bones it is in synchondrosis.

SUPRAOCCIPITAL.

The supraoccipital forms part of the dorsal and part of the posterior surface of the skull, these two parts, or limbs of the bone lying at an obtuse angle to each other. From the postero-ventral limb of the bone, and extending its full length, a large thin spina occipitalis projects directly backward, the ventral edge of the spina lying partly upon, and partly being enclosed between, the adjoining dorso-mesial edges of the medullary prolongations of the exoccipitals. The dorsal limb of the bone projects forward between the lateral fontanelles in the roof of the primordial cranium, and is overlapped anteriorly by the frontals, and laterally, on either side, by the parieto-extrascapular. Between these three overlapping bones, a small and variable portion of the supraoccipital is exposed on the dorsal surface of the skull and forms part of the floor of the subquadrangular groove on the vertex. A strong transverse ridge, projecting dorso-posteriorly, crosses the hind edge of the dorsal surface of the bone, and against the anterior surface of this ridge the mesial processes of the parieto-extrascapulars rest. The postero-ventral limb of the bone is crossed, near its dorsal end and on either side of the spina occipitalis, by a more or less prominent transverse ridge, and that part of this limb of the bone that lies dorsal to this ridge forms, on either side, the mesial portion of the supratemporal pocket. The cerebral surface of the bone forms median portions of the roof and hind wall of the cranial cavity. The bone is bounded ventrally by the exoccipitals, and laterally, on either side, by the epiotic, with all of which bones it is in synchondrosis. Anteriorly the bone is edged with a band of cartilage, anterior to which the lateral fontanelles of opposite sides are confluent; the band of cartilage representing all that is found, in this fish, of the large postepiphysial cartilage of Scomber.

CRANIAL CAVITY.

The cranial cavity extends forward to about the middle of the orbit. The mid-longitudinal line of the floor of the cavity slopes downward and backward from its anterior end to the anterior

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end of that thin median ridge-like portion of the basioccipital that separates the saccular grooves, and that supports, on its dorsal edge, the mesial edges of the mesial processes of the exoccipitals. There, the mid-longitudinal line of the floor changes abruptly in level, the immediately posterior portion lying at a slightly higher level, in a nearly horizontal position, on the dorsal surface of the platform formed by the united mesial processes of the exoccipitals. Posterior to this platform the floor slopes into the cavum sinus imparis, posterior to which there only remains the narrow edge of bone that forms the ventral bounding edge of the foramen magnum.

The thin raised platform formed by the united mesial processes of the exoccipitals lies on a level with the pituitary opening of the brain case, and under this platform, on either side, lies the posterior portion of the large saccular groove. Anterior to the exoccipital platform the saccular grooves diverge, on either side, the central portion of the floor of the cavity widening gradually from a thin median line at the edge of the platform, to its widest portion, immediately anterior to the anterior ends of the saccular grooves. At either lateral corner of this widest portion lies the trigemino-facialis recess, in which are the facialis, trigeminus, palatinus and profundus foramina, and approximately between these recesses, in the median line, is the pituitary opening of the brain case. Between the recess of either side and the anterior end of the corresponding saccular groove, there is a thin bony partition which forms the ventro-mesial portion of the anterior wall of the large labyrinth recess, that wall extending from there antero-dorso-laterally across the proötic and sphenotic. In the lateral wall of the labyrinth recess there are four small recesses, all related to the semicircular canals, and all separated from each other, and more or less surrounded by important cartilaginous remnants of the chondrocranium. In the bottom of the anterior one of these four recesses there are two depressions, separated by a low rounded ridge. The ventro-mesial depression lies in the proötic and lodges the ampulla of the anterior semicircular canal, the dorso-lateral depression lying in the sphenotic and being related to the rounded antero-dorsal corner of the anterior semicircular canal, that canal lying wholly exposed in the cranial cavity. The next posterior one of the four recesses also has two portions, one of which lies in the proötic and lodges the ampulla of the external semicircular canal, while the other portion leads into the pterotic and encloses the lateral portion of the same canal. The postero-ventral recess has three portions, a little pit-like depression in the exoccipital, to lodge the ampulla of the posterior semicircular canal, and the cerebral openings of two canals which enclose respectively the hind end of the external canal and the ventral end of the posterior canal. The dorso-posterior recess lies in the epiotic, is large, and has, in its ventro-posterior wall, a small opening which leads into the canal for the posterior semicircular canal, that canal traversing the epiotic. In Amia, the hind wall of the labyrinth recess is formed by an important cartilaginous ridge, membranous in its middle portion, which projects antero-mesially from the lateral cranial wall and separates the labyrinth recess from an important posterior portion of the cranial cavity which I described ('97, p. 703) as the postauditory or occipital chamber. If the membranous ear of Amia, and in particular the sacculus, were to be greatly developed, the labyrinth recess would have to be correspondingly enlarged, and this would necessarily push the posterior wall of the recess backward and mesially, the vagus foramen remaining always posterior to the wall. As the saccular recess was thus pushed backward it would split the dorsal edge of the basioccipital and the ventral edge of the exoccipital each into two parts, one of these parts forming the outer and the other the inner wall of the recess, and so give rise to a saccular groove on the dorsal surface of the former bone and to a mesial process, roofing that groove, on the internal sur-

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face of the latter bone. The mesial process of the exoccipital of Scorpaena is, accordingly, a definite part of the cranial wall and not simply an ossification of the dura mater, as Sagemehl considered it to be ('84 b, p. 85). That part of the process that, in the Characinidae and Cyprinidae, is said by Sagemehl to roof the cavum sinus imparis may however be such an ossification; for this cavum lies in the cranial cavity itself, and not in the walls of that cavity, as the saccular recess does. The true internal, or cerebral surface of these two occipital bones of Scorpaena is accordingly formed by the mesial processes of the exoccipitals and by that small portion of the dorsal surface of the basioccipital that lies between those processes. The nervus glossopharyngeus first perforates the mesial, membranous wall of the labyrinth recess and then the outer, bony wall of the recess, as in Amia, traversing, in its course, a space that is hollowed out of the cranial wall to receive the ear and the ganglion of the nervus acusticus.

The anterior portion of the cranial cavity of Scorpaena is enclosed between the alisphenoids and the ventral flange-like processes of the frontals, and does not, in the adult, lodge any portion of the brain, the brain being small, relatively to the cranial cavity, and its anterior end reaching, approximately, only to the level of the hind edge of the basisphenoid. This part of the cranial cavity, in the dried skull, opens ventrally, by a relatively long and narrow median opening, into the hind end of the orbit, and this opening, bounded posteriorly by the basisphenoid, is the orbital opening of the brain case. In the recent state it is closed by the flaring dorso-posterior edge of the membranous posterior portion of the interorbital septum. Posterior to the hind edge of the basisphenoid, and extending approximately to the hind edge of the proötics, there is, in the recent state, when the brain is removed, a large, nearly round, pit-like depression, formed in the fatty and connective tissues that cover the floor of the cavity. This depression lodges the hypoaria, and has, near the anterior edge of its floor, a small saucer-like depression which lodges the pituitary body and overlies the pituitary opening of the brain case.

2. INFRAORBITAL CHAIN OF BONES.

The infraorbital bones are the three so-called suborbital bones of current descriptions, and a small postorbital bone, which latter bone has, so far as I can find, never been described.

The three so-called suborbital bones are, as is well known, firmly bound together to form a single rigid piece which extends backward across the cheek and abuts against and is firmly bound to the outer surface of the preopercular. The anterior one of these three bones, which I shall call the lachrymal, is an irregular five or six rayed bone, and is called by both Günther ('60) and Boulenger ('04) the preorbital. The several rays of this bone are of varying and unequal proportions, and their bases are connected, excepting between the dorsal and posterior rays, by thin webs of bone in which there may be additional smaller rays. The dorsal ray is a thick stout process, which is concave on its dorsal edge and there articulates with the large articular surface on the outer end of the horizontal arm of the ectethmoid. The anterior ray is a pointed process, and rests upon and is strongly bound by ligamentous tissue to the lateral (distal) portion of the dorsal surface of the ligamentary process of the maxillary. The posterior ray is a sharp or rounded process which fits against, and is rigidly bound to, the outer surface of the anterior end of the second bone of the series. Two of the remaining rays form two of the sharp spines characteristic of the fish, the one directed ventrally and the other antero-ventrally, from the ventral edge of the bone. The sixth ray, when present, lies in the web

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of bone that unites the dorsal and anterior rays, and the anterior pore of the main infraorbital canal lies at the outer end of this ray, there opening on the external surface of the web of bone, close to its dorso-anterior edge. On the internal surface of the bone, opposite or slightly anterior to this latero-sensory opening, a stout ligament has its origin, and, running ventro-mesially, is inserted on the lateral surface of the dorsal edge of the maxillary process of the palatine, opposite and immediately anterior to the surface of insertion of the rostro-palatine ligament. On the ventral edge of the anterior ray of the bone, usually close to its base, and hence between it and the anterior one of the two ventral spines of the bone, is the opening of the second primary tube of the infraorbital canal; and on the ventro-posterior edge of the anterior ventral spine, is the opening of the third primary tube of the same canal. On the posterior edge of the posterior ventral spine, or on the ventral edge of the posterior ray of the bone, the position varying slightly, is the opening of the fourth tube; this tube lying between the lachrymal and the next posterior bone of the series. Along the internal surface of the posterior ray, the main infraorbital canal passes from the lachrymal into the second bone of the chain. The rays of the lachrymal bone thus, all but one, have relations to the primary tubes of the latero-sensory system. The bone lodges three sense organs of the infraorbital line.

The second infraorbital bone, is, in position, a first suborbital bone. It is an elongated bone, traversed by the main infraorbital canal, and has primary tubes of the line at either end. It lodges a single infraorbital sense organ and hence is a single latero-sensory skeletal unit. A short spine arises near the hind edge of the bone, and projects backward above the fifth infraorbital pore. This spine is hardly noticeable in young specimens of Scorpaena scrofa, or in either young or adult specimens of Scorpaena porcus.

The third infraorbital, or second suborbital, is, as Gill ('88) says, ,,hypertrophied and developed as a stay impinging on the anterior wall of the preopercular". It abuts against, and is firmly bound by tissue to, a depressed line on the anterior surface of the outer edge of a strongly developed ridge on the outer surface of the preopercular, opposite the base of the largest and most dorsal preopercular spine. The bone is convex externally and concave internally, and in the middle line of its external surface there is a longitudinal ridge which marks the position of the enclosed latero-sensory canal. Near the posterior end of this ridge, two primary tubes lead from the canal to the outer surface of the bone, one on the ventral surface of the ridge, and the other, slightly posterior to it, on the dorsal surface of the ridge; these tubes being, respectively, the 6 th. and 7 th. primary tubes of the line. The bone lodges two infraorbital sense organs. A short spine projects backward above the seventh infraorbital pore, this spine, like the one on the first suborbital, being unimportant in young specimens and in Scorpaena porcus.

The postorbital bone is a small semi-cylindrical piece of bone that lies in the dermis that forms the hind margin of the orbit, about midway between the dorsal edge of the third infraorbital bone and the postorbital corner of the skull. It lodges a single latero-sensory organ, and is developed in relation to that organ.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The hyomandibular, symplectic, preopercular and palato-quadrate are all united or firmly bound together, and form a single piece which articulates with the skull at its anterior and posterior ends and bears the mandible.

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QUADRATE.

The quadrate is a quadrant-shaped bone with its ventral corner thickened to form an articular surface for the mandible. The dorsal edge of the bone is wavy, and is bounded by cartilage which separates it from the ventral edge of the metapterygoid. Its anterior edge is nearly straight, is bevelled on its internal surface, and overlaps and fits against the external surface of the ventral limb of the ectopterygoid. Its posterior edge is slightly convex, is thickened and grooved, and fits against the anterior edge of the ventral portion of the preopercular. This thick posterior edge of the bone terminates dorsally in a short point, usually longer and sharper than in the specimen used for the figures. This point fits against the inner surface of a thin flange on the anterior edge of the preopercular, and between it and the dorsal edge of the body of the quadrate there is a curved notch. This notch forms the relatively wide dorsal end of a shallow and tapering groove on the inner surface of the bone, the groove running downward and forward to the thickened articular head of the bone, where it ends in a slight recess. The groove lodges the ventral three-fifths of the symplectic and may be said to separate the quadrate into two parts, a body and a posterior process. The groove is everywhere wider than that part of the symplectic that lies in it, a channel thus being left on either side of the latter element. At the upper end of the channel that lies anterior to the symplectic, there is a perforation of the apparatus, through which the mandibularis internus facialis passes from the outer to the inner surface of the palato-quadrate, and then runs downward in the channel along the inner surface of the apparatus. At the upper end of the channel that lies posterior to the symplectic, the mandibularis externus facialis passes, in a similar manner, from the outer to the inner surface of the apparatus, the arteria hyoidea traversing the same opening.

The posterior process of the quadrate of fishes is a feature of some morphological importance. It is not found, as a part of the quadrate, in the bony ganoids, but is found in most, if not all teleosts. It probably is present in all the Acanthopterygii and Anacanthini, for it is shown in all the figures that I can find of the quadrate of those fishes. In Siphonostoma, of the Lophobranchii, it would seem to be certainly present, though Supino's figure ('06) is not very definite in this particular. In Balistes, of the Plectognathi, I find it in normal position, and it is shown by Bruhl ('56) both in this fish and in Diodon. Among the Physostomi, of Günther's classification, it is shown in Belone (Swinnerton, '02), Esox (Swinnerton, '02), Galaxias (Swinnerton, '03), Salmo (Parker, '73), Hyodon (Ridewood, '04 b), Osteoglossum (Ridewood, '05 a), Megalops (Ridewood, '04 a), Alepocephalus (Gegenbaur, '78) and Notopterus (Ridewood, '04 b). In Ameiurus (Mc Murrich, '84), Silurus (Jaquet, '98) and Erythrinus (Sagemehl, '84 b) it seems to be present, in a modified form, as a short process that gives support to the lower end of the preopercular. In Carassius auratus, I find it as a short but normal process, a short groove here lodging a short terminal portion of the symplectic. In Ridewood's figures of the Mormyridae ('04 b) it seems to be wholly absent, as it does also in most of that author's figures of the Clupeoid fishes ('04 c); but Erdl ('47) apparently shows it in Gymnarchus, and I find it perfectly normal, though small, in Clupea harengus. In the Muraenidae, which I am investigating, I am of the opinion that both this process and the symplectic are indistinguishably fused with the quadrate, and it may be that this same fusion has taken place in other fishes where these two structures seem to be wanting. In Erythrinus Sagemehl says ('84 b, p. 92) that the symplectic and quadrate are so closely united that even the lines separating the bones are nearly lost, this evidently representing a stage in the complete fusion of these bones.

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In the bony ganoids, as stated above, the process is not found as a part of the quadrate. It is, however, elsewhere represented in both Amia and Lepidosteus. In Amia, it has fused with the symplectic and forms an irregular articular head of that bone (Allis, 97 a, pl. 20, Fig. 4); while in Lepidosteus it is the preoperculum of Parker's ('82 b) descriptions, and the interoperculum of Collinge's ('93) descriptions. In Amia the relations are all too evident to leave any doubt as to this homology; and comparison of Lepidosteus with Amia leaves no doubt as to this latter fish. The bone, in Lepidosteus, is not properly shown by either Parker or Collinge; the important features omitted being that the bone has an articular head smaller but similar to that in Amia, and that this head articulates with a facet on the posterior surface of a ventrally projecting portion of the articular head of the quadrate. The disappearance of a relatively small intervening wall of quadrate bone, or a slight shifting of the parts together with a concomitant fusion of the bone with the adjoining symplectic, would produce the conditions found in Amia; while a fusion of the bone with the quadrate, instead of with the symplectic would produce the usual teleostean quadrate. A further fusion of the symplectic with the quadrate would apparently produce the conditions found in the Siluridae and those others of the Physostomi in which the process of the quadrate seems absent; thus leaving only the Lophobranchii as apparent exceptions to the general rule. The bone would seem to be, judging from the conditions found in Lepidosteus, a branchiostegal ray related either to the quadrate or to the mandible.

In Polypterus this process of the quadrate is neither shown nor described, so far as I can determine, and in this fish there is also, according to Traquair ('70), no symplectic.

It may here be stated that Gymnarchus, in the fusion of the symplectic, the posterior process of the quadrate and the body of the latter bone into a single piece, and in the intimate and rigid nature of the attachment of the entire suspensorial apparatus to the cranium, approaches the amphibian condition, as it does also, as I ('04) have lately shown, in the possession of an auditory apparatus resembling the amphibian ear.

METAPTERYGOID.

The metapterygoid consists of a thick quadrant-shaped endosteal portion, and three thin but extensive flanges that appear to be of purely membrane origin. The curved ventral edge of the quadrant-shaped portion is directed ventro-anteriorly and is everywhere bounded by cartilage, a narrow band of which separates it from the dorsal edge of the quadrate. The angle of the quadrant is directed dorsally, and this angle is apparently the centre of ossification for the endosteal body of the bone and also for the apparently membrane flanges. From this angle a slender process arises, and projects dorso-anteriorly in the line prolonged of the hind edge of the body of the bone. This process is more than one half as long as the hind edge of the bone, and has the same general appearance and color as the body of the bone. It may, therefore, also be of endosteal and not of membrane origin. One of the three membrane flanges is a thin web of bone that fills the angle between the anterior edge of this slender process and the dorso-anterior edge of the body of the bone. The other two flanges arise from the full length of the hind edge of the bone, that hind edge including the slender process as well as the body of the bone. The two flanges project dorso-posteriorly, and, spreading somewhat, enclose between them a V-shaped space. This space lodges and gives insertion to a deeper portion of the levator arcus palatini, the superficial portion of that muscle lying external to the external flange. The V-shaped space also lodges that terminal portion of the external carotid

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that runs downward and backward to fall into the arteria hyoidea, as already described. The hind edge of the external one of these two flanges abuts against, and is firmly bound to, the anterior edge of the ventral half of the shank of the hyomandibular, the dorsal portion of the corresponding edge of the internal flange being similarly connected with, but not abutting against, the anterior edge of that thin portion of the hyomandibular, apparently of membrane origin, that lies between the anterior articular process and the shank of the bone. The external flange is quite undoubtedly an ossification of the metapterygoid membrane of Amia, the thickened, process-like portion of the flange being the homologue of the metapterygoid process of that fish (Allis, '97, p. 557).

Across the anterior one third to two-thirds of the internal surface of the body of the metapterygoid, at about the middle of its length, the entopterygoid extends, that bone lying at an angle to the metapterygoid. The V-shaped space between the two bones is filled by, and gives insertion to, a portion of the adductor arcus palatini.

ECTOPTERYGOID.

The ectopterygoid is a slender bone, with two sharply pointed limbs lying at an obtuse angle to each other. From the angle between the two limbs a thin and irregular process projects dorso-posteriorly, lying against the internal surface of the palato-quadrate cartilage, and, beyond that cartilage, against the internal surface of the metapterygoid. The ventro-posterior limb of the bone is the shorter of the two, is bevelled and fits against the internal surface of the anterior edge of the quadrate. The dorso-anterior limb fits upon the dorsal edge of the posterior portion of the ventral, ectosteal flange of the palatine, and although but a thin and slender bone is grooved its full length, on its dorsal surface. This little groove lodges the ventral edge of a slender and rod-like portion of the palato-quadrate cartilage, which connects the cartilages of the palatine and quadrate regions, and, mesial to that rod of cartilage, lodges the ventro-lateral edge of the anterior portion of the entopterygoid.

ENTOPTERYGOID.

The entopterygoid is a V-shaped bone, one limb of the V being small and the other large, the point of the V directed ventro-laterally. The small lateral limb lies against the internal surface of the anterior portion of the metapterygoid, and against the same surface of the adjoining portion of the palato-quadrate cartilage. The larger mesial limb is a thin smooth and delicate, but relatively large plate of bone, the ventral edge of the anterior portion of which lies in the groove on the dorsal surface of the dorso-anterior limb of the ectopterygoid, and there rests against the inner surface of the palatine bone and the same surface of the rod-like remnant of the palato-quadrate cartilage. Posterior to the latter cartilage, the ventral edge of this plate rests against, and is bound by tissue to, the internal surface of the metapterygoid. This mesial limb of the entopterygoid is closely applied to the ventral surface of the anterior portion of the adductor arcus palatini muscle, and its dorso-mesial edge is connected, by the lining membrane of the mouth cavity, with the ventral surface of the parasphenoid.

The adductor arcus palatini has, as already stated, a long surface of origin, this surface beginning on the lateral surface of the ascending process of the parasphenoid and on adjacent portions of the proötic and from there extending forward along the lateral surface of the body of the parasphenoid as far as the antorbital cartilage. From this long surface of origin the broad muscle runs

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latero-ventrally and has a correspondingly long surface of insertion on the palato-quadrate. The ventro-lateral edge of this surface of insertion forms a long line which begins anteriorly at the anterior end of the mesial plate of the entopterygoid, extends the full length of the line of attachment of that plate to the palatine, ectopterygoid and metapterygoid, lying in the V-shaped space between the two limbs of the bone, and then, beyond the entopterygoid, crosses the inner surface of the metapterygoid to the hind edge of the body of that bone. There it turns upward along the hind edge of the internal one of the two membrane flanges on the hind edge of the metapterygoid, crosses onto the inner surface of the thin web of bone that fills the angle between the anterior articular head and the shank of the hyomandibular, and turning dorso-anteriorly follows the line of origin of that web its full length. The muscle thus has its insertion partly on the hyomandibular, but mainly on the palato-quadrate.

PALATINE.

The palatine contains endosteal and ectosteal components, indistinguishably fused. The endosteal component forms the thickened body of the bone, and its curved, relatively long and rod-like anterior end. The ectosteal component is a plate-like portion which projects ventro-laterally from the ventral edge of the endosteal component. The anterior portion of this ectosteal component is thicker than its posterior portion, and the ventral edge of this thickened anterior portion is garnished with small villiform teeth. The curved, anterior, rod-like portion of the bone is capped with cartilage, articulates with the dorsal surface of the maxillary, as already fully described, and is the maxillary process of the bone. At the base of this maxillary process there is a small but sharp transverse ridge, the anterior surface of which is capped with cartilage and articulates with the inferior surface of the anterior palatine process of the ethmoid cartilage. Immediately anterior to this articular process of the palatine, on the dorso-mesial surface of the maxillary process of the bone, a little flattened surface gives insertion to the rostro-palatine ligament. Directly opposite this little surface, on the dorso-lateral surface of the bone, a similarly flattened surface gives insertion to the ventro-mesial end of the lachrymo-palatine ligament. On the mesial surface of the body of the bone, on a ridge that lies immediately postero-ventral to the base of the maxillary process, the strong broad vomero-palatine ligament has its insertion; the ligament running antero-mesially to its surface of origin on the ventral surface of the vomer.

Posterior to the base of the maxillary process, the body of the palatine expands rapidly and soon ends abruptly, this part of the bone being somewhat demicone-shaped, with its flat surface presented ventro-mesially. Its hind end connects by synchondrosis with the anterior end of a block of cartilage that corresponds to the middle cartilaginous remnant of my descriptions of the palato-quadrate of Scomber. This cartilage falls away rapidly, posteriorly, and soon becomes a rod-like and frequently imperfect and discontinuous piece of cartilage which extends backward from the ventro-lateral portion of the hind end of the body of the palatine. Against the flat ventro-mesial surface of this cartilage, and against the corresponding surface of the hind end of the body of the palatine, anterior to it, the anterior end of the entopterygoid rests.

The hind end of the body of the palatine, together with the cartilage immediately posterior to it, forms a pronounced tranverse ridge on the dorso-lateral surface of this part of the palato-quadrate apparatus, near its dorso-mesial edge. The dorso-anterior surface of this ridge, a surface formed partly of bone and partly of cartilage, articulates with the articular surface at the mesial

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end of the curved ventral edge of the arm of the ectethmoid. The articular ridge accordingly forms the posterior ethmoid articular surface of the palatine. Its summit, which is wholly cartilaginous, gives insertion to the strong ethmo-palatine ligament, which ligament is usually double and has its origin on the posterior, orbital surface of the ectethmoid.

HYOMANDIBULAR.

The hyomandibular is an irregular cross of primary bone, with the cross-piece placed obliquely across the shank, and with the four angles between the cross-piece and the shank filled by thin webbing laminae of what is apparently membrane bone.

The dorsal end of the shank of the cross forms the posterior articular head of the bone, this head articulating with the pterotic. The cross-piece has articular heads at either end, the posterior one articulating with the opercular, and the anterior one with the articular facet on the sphenotic and proötic. The thin web of bone that fills the angle between the two cranial articular heads of the bone is frequently perforated by a large foramen, due to the wear, against its inner surface, of that process of the proötic that gives origin to certain of the levator muscles of the branchial arches. A relatively tall ridge of bone begins at the point where the cross-piece crosses the shank of the bone, and runs downward and backward on the external surface of the shank. The dorsal end of the preopercular fits against the hind surface of this ridge, and also against the outer surface of the hyomandibular posterior to the ridge, the dorsal end of the preopercular projecting dorsally across the opercular arm of the hyomandibular, and there leaving a space between itself and that bone. Through this little space, that small superficial portion of the dilatator operculi muscle that arises in the dilatator fossa passes, the remaining and larger portion of the muscle having its origin from the preopercular and from the external surface of the hyomandibular internal to and posterior to that bone.

The ventro-anterior edge of the web of bone that fills the space between the anterior articular arm and the shank of the hyomandibular is bound by a wide but strong band of fibrous tissue to the dorsal portion of the internal one of the two posterior, membrane flanges of the metapterygoid. Ventral to this latter flange, and ventral also to the related web of bone on the hyomandibular, the ventral half of the external one of the two metapterygoid flanges abuts against and is firmly bound by tissue to the anterior edge of the shank of the hyomandibular. At the ventral edge of this latter flange, between the metapterygoid, the hyomandibular and the hyomandibulo-symplectic interspace of cartilage, there is an oval space which transmits the arteria hyoidea.

The ventral end of the shank of the hyomandibular is in synchondrosis with the symplectic, the two bones being separated by a relatively large interspace of cartilage which gives articulation, on its postero-internal surface, to the small and rod-like interhyal. The interhyal lies, in its position of rest, in the line produced of the shank of the hyomandibular; lying internal to the preopercular and interopercular, and being bound by fibrous tissues to both those bones, the attachment to the interopercular being particularly strong.

The facialis canal through the hyomandibular enters the bone by a large pit-like opening on its internal surface, this opening lying in the endosteal part of the bone, close to the angle between the anterior articular arm and the shank of the bone. From this pit two canals arise. One runs downward in the shank of the bone, opens on its outer surface, anterior to the ridge that gives support to the preopercular, and transmits the truncus hyoideo-mandibularis facialis. The other runs downward and backward and separates into two parts, one of which opens on the outer surface of

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the hyomandibular in the angle between the opercular arm and the shank of the bone, and the other close to the hind edge of the web of bone that fills the space between the same two arms of the bone. This second and branching canal transmits the two branches of a nerve that supplies the two dorsal latero-sensory organs of the preopercular canal.

The ramus hyoideus separates from the truncus hyoideo-mandibularis as that nerve reaches the external surface of the hyomandibular, passes downward and backward through a small passage between the hind edge of the hyomandibular and the anterior edge of the preopercular, and so reaches the internal surface of the latter bone.

SYMPLECTIC.

The symplectic is a slender curved bone, the dorsal two-fifths of which lie along the hind edge of the cartilage that separates the metapterygoid and quadrate, while the ventral three-fifths lie in the symplectic groove on the internal surface of the quadrate. The ventral end of the bone is tipped with cartilage. Its dorsal end is bounded by the interspace of cartilage that lies between itself and the hyomandibular. This interspace of cartilage is in close contact with the hind edge of the palato-quadrate cartilage, but is not continuous with that cartilage. A part of the hind edge of the interspace of cartilage is overlapped externally by a thin web of bone on the anterior edge of the preopercular, near the middle of its length, and the hind edge of this part of the cartilage bears the articular facet for the proximal end of the interhyal. Between the hind edge of the dorsal portion of the symplectic, anteriorly, and the anterior edges of the preopercular and the posterior process of the quadrate posteriorly, there is a long oval space which transmits the ramus mandibularis externus facialis and the arteria hyoidea. Along the anterior edge of the symplectic, between it and the hind edge of the dorsal portion of the body of the quadrate, there is a small opening which transmits the ramus mandibularis internus facialis.

PREOPERCULAR.

The preopercular is a curved bone, traversed its full length by the preopercular latero-sensory canal. It has, on its hind edge, five so-called spines, the two ventral ones being blunt or pointed eminences, rather than spines. The dorsal spine is by far the longest and is always double, a small spine, almost completely fused with it, arising on the external surface of its base. At the ventral edge of the base of this small spine, and hence on the external surface of the base of the large spine, there is the opening of a primary latero-sensory tube; and similar openings are found at the ventral edges of each of the three next distal spines. The fifth spine lies at the distal end of the bone, is an eminence rather than a spine, and immediately distal to it there is a primary tube which arises from the sensory canal as it passes from the preopercular into the mandible. The spines, thus here, as on the lachrymal, have definite relations to the primary tubes of the latero-sensory system; but there is not a spine for every tube, for dorsal to the most dorsal spine there is, in the preopercular, still another opening of the latero-sensory canal, but without related spine. The bone lodges six latero-sensory organs, one between each two adjoining tubes.

At the middle of the anterior edge of the preopercular, spanning the hollow of the curve of the bone, there is a thin web of bone which bears, on its internal surface, a small cup-like depresion, this depression receiving the lateral surface of the proximal articular head of the interhyal and to that extent forming part of the articular cup for that element. Lateral to this web of bone, or

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slightly dorsal to it, on the raised and ridge-like external surface of the preopercular, there is a shallow groove which marks the line of insertion of the hind end of the third bone of the infraorbital chain.

OPERCULAR BONES.

The three opercular bones have the shapes shown in the figures. On the external surface of the opercular, three pronounced ridges radiate from the articular facet of the bone. One of these ridges forms the ventral edge of the bone, which edge is presented anteriorly and but slightly ventrally; the other two ridges lying on the dorsal portion of the bone and both of them terminating in free spines. The internal surface of the bone, dorsal to the dorsal one of the three spinous ridges, is depressed, and in this depression the adductor operculi has its insertion; the thin and almost membranous levator operculi being inserted along the dorsal edge of the bone. The deep indentation in the hind edge of the bone, between the two dorsal spines, corresponds to the indentation, without related spines, in the hind edge of the bone of Scomber.

The angular-shaped subopercular overlaps internally, and embraces the ventral corner of the opercular, extending upward one half to two-thirds the length of its anterior edge, but along its entire posterior edge; usually projecting upward slightly beyond the dorsal edge of the bone. It is a thin, flat bone, its long dorso-posterior arm, in particular, being so thin that it is flexible and easily torn.

The dorso-posterior edge of the interoperculum is slightly concave, and lies in a nearly horizontal position. The posterior corner of this edge slightly overlaps externally, and is strongly bound by tissue to the ventral corner of the subopercular, while the anterior corner lies external to the interhyal, and is strongly bound to it by tissue. The lateral surface of the ventral half of the interhyal here fits into a large but shallow depression on the internal surface of the interopercular, this depression having a raised dorsal edge which gives it the appearance of an articular facet. The interopercular is thus here related to the interhyal somewhat as the branchiostegal rays are to the ceratohyal, suggesting it being such a ray. Between its concave postero-dorsal edge and the anterior edge of the subopercular there is a large triangular space, spanned by a sheet of tough fibrous tissue which connects the bones. The ventral end of the interopercular is directed antero-ventrally and gives attachment to a short strong ligament which has its origin on the hind end of the angular.

In Phractolaemus Ansorgii, Ridewood says ('05 a, p. 279) that the interopercular is traversed by a portion of the preopercular latero-sensory canal, adding that this is the only instance of the kind known to him. If the section of canal enclosed in the bone lodges a latero-sensory organ, the bone can not be a simple interopercular.

MANDIBLE.

The mandible has, on its outer surface, a large rounded longitudinal ridge which extends from the ventral edge of the articular facet for the quadrate forward across the articular and then across the dentary, nearly to the anterior end of the latter bone. On the inner surface of the articular and dentary there is a corresponding hollow, which lodges, in its ventral portion, the rod-like Meckel's cartilage. Immediately ventral to the ridge, the mandibular latero-sensory canal traverses the dentary and articular, entering the dentary near its anterior end and leaving the articular at the base of the process that forms the posterior half of the articular facet for the quadrate. The

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dentary lodges four organs of the sensory line and the articular, one. Primary tubes leave the canal at either end of the angular, and four tubes leave it as it traverses the dentary, one of these tubes being the anterior terminal tube of the line.

The dentary has the usual dorsal and ventral limbs, separated by a deep V-shaped reëntrant angle. The dorsal edge of the dorsal limb is lined its full length with villiform teeth. Immediately ventral to this edge, on the outer surface of the bone, and at about the middle of its length, there is a large and deep depression which lodges and gives insertion to the base of a tapering gristly structure which projects posteriorly and forms the core of the mandibular labial fold. This gristly, semi-cartilaginous structure is attached, at its hind end, by dermal tissues to the inner surface of the hind end of the maxillary, and would seem to be the homologue of the labial cartilage of Swinnerton's descriptions of Gasterosteus.

The angular is a small bone which forms the postero-ventral corner of the mandible. Its dorsal end is united by synchondrosis with the articular, immediately ventral to the articular facet for the quadrate, a small interspace of cartilage here being visible on the inner surface of the mandible. The angular gives insertion to a short but strong ligament which has its insertion on the ventral end of the interopercular, and also gives insertion to certain of the ligamentous articular tissues that bind the mandible to the quadrate. There is, as in Scomber, no evident ligamentum mandibulo-hyoideum.

The articular has a stout coronoid process, the base of which forms the anterior portion of the articular facet for the quadrate. The dorsal end of the process lies slightly postero-ventral to the hind end of the dorsal limb of the dentary, and the two bones are here connected by a pad-like structure of tough fibrous tissue which extends forward a short distance along the lateral and dorsal surfaces of the hind end of the dorsal limb of the dentary. This pad forms, in the recent state, a pronounced feature of the mandible, and the inner surface of the maxillary slides against it as the mouth is opened and closed. The maxillo-mandibular ligament, as already described, runs across the external surface of this pad of tissue, with apparent interchange of fibers, and has its attachment to the external surface of the base of the coronoid process and the adjoining portions of the articular. On the hind edge of the articular a stout curved process, projecting dorsally, forms the posterior half of the articular facet for the quadrate. The dorsal end of this process gives insertion to a short stout ligament which extends anteriorly and has its origin on the adjacent lateral edge of the articular head of the quadrate. The mesial or postero-mesial surface of the process is smooth and slightly convex, is covered with a thin layer of fibrous or fibro-cartilaginous tissue, and, when the mouth is opened and shut, slides upon a part of the hind edge of the quadrate immediately dorso-posterior to the articular head of that bone; the outer, dorso-posterior end of the process finally abutting against a part of the quadrate, and so limiting the opening movement of the mandible. This sliding articulation of this process of the articular is with the posterior process of the quadrate, and not with the body of that bone, and manifestly recalls the mandibulo-symplectic articulation of Amia, to which reference was made when describing the quadrate. In Scomber a similar sliding articulation doubtless exists, but, when describing that fish ('03, p. 157) I did not recognize it, or its probable homology.

On the internal surface of the articular, the hind end of Meckel's cartilage is continued backward, for a short distance, as a bony ridge which presents the appearance of a posterior and ossified continuation of that cartilage. On the dorsal surface of this ridge, and partly immediately anterior to it, the tendon of the deeper part of the adductor mandibulae has its insertion.

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4. ADDUCTOR MANDIBULAE AND LEVATOR ARCUS PALATINI MUSCLES.

The adductor mandibulae is completely separated into dorsal and mandibular portions. The dorsal portion is a large muscle, almost completely separated into two divisions, a superficial and a deeper one. The superficial division is apparently the homologue of the muscle A_1 of Vetter's descriptions of other teleosts, the deeper division representing the two muscles A_2 and A_3 of the same descriptions. The mandibular portion of the muscle is the muscle A_ω of Vetter's nomenclature, and lies wholly in the mandible. The mandibular branch of the nervus trigeminus, in its course to enter the mandible, passes between the muscles A_1 and $A_2 A_3$.

The muscle A_1 arises from the outer edge of the preopercular, there lying, in its dorsal portion, directly external to the levator arcus palatini, and in its ventral portion directly external to a portion of $A_2 A_3$. The fibers of the dorsal two-fifths, approximately, of the muscle do not reach the preopercular, being inserted on a broad thin tendinous band which crosses the outer surface of the levator and has its insertion on the preopercular. The fibers of the muscle all run forward in a nearly parallel course, and are inserted on a tendinous band that extends the full length of the anterior edge of the muscle. The dorsal end of this band becomes a short stout tendon which has its insertion on the mesial surface of the shank of the maxillary, the ventral end of the band joining the tendon of the muscle $A_2 A_3$. The anterior edge of the tendinous band gives attachment to the fibrous tissues that line the lateral surface of the mucous membrane that extends from the ventral edge of the palato-quadrate to the internal surface of the maxillary, and it is in this fibrous tissue that the maxillo-mandibular ligament, already described, has its course, lying close along the anterior edge of the muscle A_1. This maxillo-mandibular ligament must accordingly be acted on by the muscle A_1, and hence serves in part as its tendon of insertion; a contraction of the ventral fibers of A_1 rotating the maxillary. In Scomber the tendon of A_1 is inserted on the internal surface of the lachrymal, the maxillo-mandibular ligament in part giving insertion to the deeper portion, A_3, of the adductor (Allis, '03, p. 192).

The muscle $A_2 A_3$ is much thicker and stouter than A_1, and has its origin on the external surface of the body of the metapterygoid, near its hind edge, and, ventral to the metapterygoid, on the anterior surface of the preopercular. The muscle is incompletely separated into dorso-internal and ventro-external portions which may represent A_3 and A_2 respectively, the fibers of A_3 all passing internal to the external bundle of the levator arcus palatini, while the fibers of A_2 pass external to or lie wholly ventral to that muscle. The fibers of both portions of the muscle at first converge slightly forward, and then contract rapidly, and are all, or nearly all inserted on a large tendon which passes into the mandible. The few fibers that are sometimes not so inserted form a broad, thin superficial sheet, the fibers of which separate from the deeper fibers of the muscle and have their insertion in a tendinous formation on the inner surface of the muscle A_1. The large tendon $A_2 A_3$ separates into three parts. The middle one of these three parts arises mainly in relation to the fibers of A_3, the other two arising mainly in relation to the fibers of A_2 and A_1 these two tendons lying the one postero-ventral and the other antero-dorsal to the middle tendon. The middle tendon runs downward and forward, and has its insertion on the mesial surface of the articular immediately dorsal to the hind end of Meckel's cartilage. The postero-ventral tendon runs forward and downward across the lateral surface of the middle tendon, and then turns rather sharply downward, passes

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across the mesial surface of the hind end of Meckel's cartilage and is inserted on the mesial surface of the articular ventral to the cartilage. The antero-dorsal tendon turns forward and is inserted on the tendinous formation that covers the mesial surface of A_ω.

The mandibular portion, A_ω, of the adductor muscle, arises wholly on the mesial surface of the mandible, its fibers converging toward and having their insertions on a tendinous formation which largely covers the mesial surface of the muscle. A part of the fibers of this tendinous formation are collected and separated to join the antero-dorsal tendon of $A_2 A_3$, the remaining fibers running directly backward, mesial to all the tendons of the muscle, and having their insertions, as a broad tendinous band, on the preopercular, near its ventral end. In Scomber this latter tendon is inserted by two heads, one on the preopercular and the other on the quadrate, the rami mandibularis externus and internus passing between the two heads of the tendon (Allis, '03, p. 194).

The levator arcus palatini arises from the roughened lateral corner of the sphenotic. Running downward from there, and spreading slightly forward and backward, it separates into superficial and deeper portions. The superficial portion passes internal to the superficial division, A_1, of the adductor mandibulae, between it and A_3, and then between A_2 and A_3, and has its insertion on the external one of the two flanges on the hind edge of the metapterygoid, and on adjacent portions of the hyomandibular and preopercular. Some of its fibers are also apparently inserted in the membrane that covers the external surface of the muscle A_3. A strong tendon is imbedded in this superficial portion of the levator, extends from the sphenotic to the metapterygoid, and gives insertion or origin to certain of the fibers of the muscle. The deeper portion of the muscle passes between the two flanges on the hind edge of the metapterygoid and has its insertion on those flanges and on the two membranes that connect the flanges with the anterior edge of the hyomandibular. The ventral end of the internal one of these two membranes has a strong attachment to the internal surface of the dorsal end of the interhyal, and it would seem as if the muscle must have some action on that bone. The two portions of the levator correspond respectively to the superficial and deeper portions of the muscle of Amia.

5. LATERO-SENSORY CANALS.

The primary tubes of the latero-sensory canals of Scorpaena, in every case examined, leave the bones to which they are related as simple and single tubes, but, in the overlying dermal tissues, most of them branch repeatedly giving rise to large and often complicated dendritic systems which open on the outer surface by small and often numerous pores. Certain of these dendritic systems, belonging to different canals, interanastomose, thus secondarily connecting primarily independent canals, and giving rise to conditions that might, in a superficial examination, be considered as marked irregularities in the course of those canals.

The main infraorbital canal begins at a group of pores that lies ventro-lateral to the interval between the two nasal apertures. In the two specimens that were carefully examined in this connection, this group was subcircular in outline and contained from 15 to 18 pores; and on one side of one of these two specimens certain of the pores of the group seemed to have anastomosed with certain pores of the second dendritic system of the supraorbital canal, thus apparently establishing a communication between those two canals, the communicating canal passing between the nasal apertures. The group of pores belongs to the first dendritic system of the line, and the trunk of the system enters

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the lachrymal bone by the single large aperture on the dorso-anterior edge of that bone. The canal then traverses the lachrymal, giving off two primary tubes in its course, these tubes opening on the outer surface by small groups of pores which lie one between the anterior and next posterior spine of the bone, and the other between this latter spine and the next posterior one. The fourth tube of the line leaves the canal as it passes from the lachrymal into the first suborbital, and the fifth tube as it passes from that bone into the second suborbital, these tubes both opening on the outer surface by small groups of pores that lie ventral to the canal.

In the second suborbital (third infraorbital) the canal runs backward nearly to the hind edge of the bone, where it issues from the bone on its external surface and ends, having given off one primary tube in its course. This latter tube is the 6th. tube of the line, the canal ending in a terminal tube which represents one half of the 7th. tube of the line, as will be further explained below. These two tubes lie rather close together, near the hind edge of the bone, the 6th. tube directed postero-ventrally and the 7th. one postero-dorsally. Both tubes open on the outer surface by a group of pores, and certain pores of the 7th. group had secondarily fused, in all the several specimens examined, with certain pores of the penultimate dendritic system of the preopercular canal, a dermal communication between the hind end of the suborbital section of the main infraorbital canal and the preopercular canal thus here being established. This communication is large and important, and one not thoroughly conversant with this subject might naturally be led to say, as Garman ('99) has said of Ectreposebastes imus, that the postorbital portion of the main infraorbital canal and the dorsal portion of the preopercular canal were here „reduced to a single canal". This however would certainly be, if said of Scorpaena, and must also be of Ectreposebastes, a most misleading statement of the case, for the two main canals themselves do not in any sense here run into each other, a certain pore or pores of a dendritic system of one of them simply anastomosing, secondarily, with a certain pore or pores of a dendritic system of the other.

Beyond the 7th. primary tube, the main infraorbital canal is interrupted, the next posterior section of the canal being enclosed in the little postorbital ossicle, and not having any direct connection with the suborbital portion of the line. The 7th. tube of the line is thus the terminal tube of an anterior, suborbital portion of the line, and is the anterior half, only, of what would be the 7th. primary tube of a continuous canal. The other half of this primary tube lies directly behind the eye, at the ventral edge of the little postorbital ossicle, and forms the anterior tube of the postorbital section of the canal. In some specimens the dendritic system formed by the repeated subdivisions of this posterior half of the 7th. primary tube seemed to be in secondary communication with the penultimate system of the preopercular canal, but, in the one wholly satisfactory preparation made, this connection did not exist. The dissection necessary to establish this is a difficult and delicate one, and the use of injecting fluids is usually misleading, for the delicate walls of the tubes are easily broken down and artificial connections thus established.

Starting from the posterior half tube of the 7th. primary system of the line, the canal runs upward through the postorbital ossicle and then traverses the relatively wide interval between this ossicle and the postfrontal bone, there lying immediately beneath the thin dermis. From this part of the canal the 8th. primary system of the line arises, this system being a large and complicated one, and having much more the appearance of two half systems that have secondarily anastomosed than of two half tubes that have completely fused to form a single tube and system. The branches of this system extend backward across the cheek, and one of them anastomosed, in all of the spec-

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imens examined, with the double dendritic system formed where the terminal tube of the preopercular canal anastomoses with the main infraorbital; a second, or third secondary connection thus here being established between these two canals.

Beyond the 8th. dendritic system the canal enters and traverses the postfrontal, at the hind end of which bone it anastomoses with the penultimate tube of the supraorbital canal, a small double system here arising from the canal. The canal then turns backward and traverses the pterotic, at the hind end of which bone it anastomoses with the dorsal end of the preopercular canal, giving rise to a double system, 10 inf.-12 pmd. This double system had, in the one satisfactory dissection made, separated into two parts, one lying dorsal and the other ventral to the main infraorbital canal. The dorsal one of these two portions was small, and opened on the outer surface in a small group of pores, the ventral one being large and undergoing anastomosis not only with the 8th. infraorbital system, as above described, but also with the 11th. system of that same line. This last anastomosis gives rise to a large and complicated system which spreads backward in the dermis that covers the levator operculi muscle, extending even beyond that muscle onto the dorsal portion of the outer surface of the opercular.

Posterior to the 10th. tube of the line, the main infraorbital canal traverses the lateral extrascapular and then the suprascapular and supraclavicular, the 11th. tube of the line being given off between the first two bones, the 12th. tube between the last two, and the 13th. tube at the hind end of the supraclavicular. The 11th. tube gives rise, as just above stated, to a large dendritic system which anastomoses with the ventral half of the double system 10 inf.-12 pmd. The 12th. and 13th. systems are small.

In the full length of the main infraorbital canal there are twelve sense organs, one organ thus being found between each two consecutive primary tubes. Three of these organs lie in the lachrymal, one in the first suborbital, two in the second suborbital, one in the postorbital ossicle, and one each in the postfrontal, pterotic, lateral extrascapular, suprascapular and supraclavicular. The first six organs of the line are each innervated by consecutive and independent branches of the ramus buccalis facialis. The eighth (postfrontal) and ninth (pterotic) organs are innervated by branches of the ramus oticus facialis. The innervation of the 7th., or postorbital organ could not be determined either in the sections or the dissections, but it is quite unquestionably innervated by a nerve that corresponds to that somewhat independant branch of the buccalis that innervates, in Amia, the posterior group of buccal organs of that fish. If this be so, the postorbital break in the main infraorbital canal occurs between two groups of organs of the line, and is strictly similar to the break found in this same line in Batrachus tau (Clapp, '98) and Chimaera monstrosa (Cole, '96), and to which I have made full reference in several of my works.

The 10th. (extrascapular) and 11th. (suprascapular) organs are innervated by branches of the supratemporal branch of the nervus lineae lateralis vagi; the 12th. (supraclavicular) organ being innervated by the first single branch of the latter nerve.

The supratemporal canal arises from the main infraorbital canal as that canal traverses the lateral extrascapular. Running mesially it traverses the lateral extrascapular and then the parieto-extrascapular, and then unites, in the mid-dorsal line, with its fellow of the opposite side, thus forming a complete cross-commissure. As the canal passes from the lateral extrascapular into the parieto-extrascapular it gives off a primary tube which separates into two parts one directed anteriorly and the other posteriorly and both giving rise to relatively important dendritic systems. A similar

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system arises where the canals of opposite sides anastomose in the mid-dorsal line. The canal contains two sense organs, one lying in the lateral extrascapular and the other in the parieto-extrascapular; both organs being innervated by branches of the supratemporal branch of the nervus lineae lateralis vagi.

The supraorbital canal begins at the anterior end of the nasal, traverses that bone, and then runs backward in the frontal nearly to its hind edge. The anterior dendritic system of the line lies at the anterior end of the nasal and is represented by a small and somewhat scattered group of pores. The 2nd. system of the line arises from the canal as it passes from the nasal into the frontal. It is larger than the first system and sends a long branch laterally and downward in the dermal bridge between the two nasal apertures. This branch opens on the outer surface by several pores, and in one specimen, as already stated, one of these pores seemed to have anastomosed with a pore or pores of the anterior dendritic system of the main infraorbital line, thus here establishing a connection between these two lines. The 3rd., 4th. and 6th. systems all arise from that part of the canal that lies in the frontal, the canal then ending while still in that bone, in the 7th. or terminal system of the line. The 5th. system, which should normally be formed between the 4th. and 5th. organs of the line, is wholly wanting even in the young specimens examined in sections. The trunk of the 3rd. system is directed forward, and branching gives rise to an elongated group of from twelve to eighteen pores. The trunk of the 4th. system is directed postero-mesially and traverses the frontal to its mesial edge, where it anastomoses with its fellow of the opposite side to form the frontal (supraorbital) cross-commissure. The single median pore here first formed by the fusion of the single primary pores of opposite sides has, by subsequent division, given rise to a small median group of pores. The trunk of the 6th. system runs postero-laterally in the frontal, to its lateral edge, where it anastomosed with the 9th. trunk of the main infraorbital to form a double system. Having given off this trunk, the canal turns posteriorly and issues from the frontal beneath the frontal spine, the 7th. or terminal system of the line being represented by a circular group of some ten to fifteen pores.

The supraorbital canal contains six sense organs, this being one more than is warranted by the number of dendritic systems actually found in the fish. One of these organs lies in the nasal, and five in the frontal. The organ in the nasal is normal in its relations to the trunks of the dendritic systems, as are also the first two organs in the frontal; one of these latter organs lying between the trunks of the 2nd. and 3rd. systems of the line and the other between the trunks of the 3rd. and 4th. systems. The fourth organ lies partly opposite and partly posterior to the trunk of the 4th. system, the fifth organ being similarly related to the trunk of the 7th. or terminal system. The sixth organ is a small one lying in the trunk of the 7th. or terminal system of the line. Between the fourth and fifth organs there is no primary tube in Scorpaena, but both in Cottus scorpius and Cottus octodecimospinosus there is here a small tube. As, otherwise, the organs and tubes are exactly similar in the three fishes, a tube has certainly either aborted or never been developed, in Scorpaena, between the fourth and fifth organs of the line. These two organs lie quite close together and are innervated by branches of a single branch of the ophthalmicus lateralis, the other organs of the line all being innervated by independent branches of the same nerve. The nerve that innervates organs 4 and 5 perforates the frontal, at the base of its ventral flange, to reach the organs it supplies, sometimes separating into its two parts external to the frontal and sometimes while traversing that bone. In one young specimen examined in serial sections the branch to organ 5 separated

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from the branch to organ 4 after the main branch had entered the main infraorbital canal itself, and then continued its course inside that canal. This all certainly indicates that organs 4 and 5 lie so close together at the time that they become enclosed in the canal that no primary tube can be developed between them, this tube thus never being formed. In Menidia also these two organs lie close together (Herrick, '99, p. 198), but there is a primary tube between them as there is in Cottus. In Gadus (Cole '98) there is, as in Scorpaena, no primary tube between the 4th. and 5th. organs of the supraorbital canal, but Gadus differs from Scorpaena in that there is no 6th. supraorbital organ and related primary tube.

Organ 6 of Scorpaena differs from the other organs of the line in being much smaller than any of them. It is innervated by the first branch of the ophthalmicus lateralis, this branch perforating the alisphenoid from its lateral surface and then running upward inside the cranial cavity to perforate the frontal immediately beneath the organ it supplies.

The preoperculo-mandibular canal begins near the symphysis of the mandible, and, running posteriorly, traverses the dentary, articular and preopercular, and then anastomoses with the main infraorbital canal at the hind end of the squamosal. The canal lodges eleven sense organs, four lying in the dentary, one in the articular and six in the preopercular, all of them innervated by branches of the ramus mandibularis externus facialis. A primary tube arises from the canal between each two consecutive organs, this making, with the two terminal tubes, twelve tubes in all. The eleventh tube anastomoses secondarily, as already stated, with the seventh tube of the main infraorbital canal, the twelfth tube anastomosing primarily with the tenth infraorbital tube and secondarily with the eighth and eleventh tubes of the same line.

6. NERVES.

The investigation of the nervous system of the several fishes of the group has been mainly limited to the adult of Scorpaena scrofa, and to serial sections of small specimens of that fish and of Lepidotrigla aspera; but certain features of the innervation in the adults of Cottus octodecimospinosus and Trigla hirundo, in small specimens of Dactylopterus volitans, and in embryos of Cottus scorpius have been also somewhat carefully examined. The intention at first was to simply determine the relations of the roots, ganglia and proximal portions of the cranial nerves to the skeletal elements, the study of the skeleton being the principal object of the research; but as certain of the series of sections examined permitted the tracing, with comparative accuracy, of the components of the several nerves, these results, so far as obtained, are given. There was however no attempt whatever to make these results complete. So far as given they are intended to be correct.

In recent English and American works on the cranial nerves of the lower vertebrates there is a marked tendency to consider the central origin of a given cranial nerve of much more importance for the determination of its segmental position than the course of the nerve and its general relations to the skeletal elements. Underlying this manner of considering the subject, is the implied acceptance of the neurone theory of the nervous system, according to which theory all nerve fibers grow either centrifugally or centripetally between two primarily disconnected points, choosing always the path of least resistance. Directly opposed to this manner of considering the subject is the earlier conception of the nervous system, recently re-presented by Gaskel ('05), according to which the peripheral and central cells are from the very beginning, and as soon as they begin their separate exis-

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tence, always connected by nervous tissue. While my own work has never yet led me to investigate, or even to seriously consider, the manner in which the cranial nerves develop, it has led me to conclude, as I have already had occasion to state, that; (I) the relations of the nerves to the skeletal elements are so remarkably constant that if the nerve itself does not exist from the very beginning, some tissue or condition of tissue, defining its path, or some markedly strong inherited tendency must certainly so exist; and (2), that whenever a nerve is deflected from its accustomed and apparently predetermined path, careful examination and consideration will almost always show that it has simply been pushed or pulled one way or the other, surrounded to a different extent or in a different manner by the encroaching and enveloping growth of adjacent tissues, or even actually displaced relative to certain tissues or structures by a variation in the relative time, or in the relative degree of development of the nerve and those other tissues. That there are certain apparently inexplicable exceptions to this rule, I know full well.

According to the latter of these two conceptions of the nervous system, the general course of a nerve and its relations to the skeletal and other elements, properly determined, definitely define the segmental position of the nerve, and its centers of origin must be in accord with those determinations.

According to the other conception, carried to its legitimate extreme, the course of nerve fibers is not necessarily segmental, and, the terminal distribution of sensory fibers also not being necessarily segmental, the only positive criterion of the segment or segments to which the component fibers of a certain nerve belong is their points of origin in the central nervous system. Furthermore, the cranial segment to which it is assumed that certain fibers must necessarily belong having been determined by their central origin, the elements of accident, individual experience, or even a sort of elective selection are introduced as natural and constant occurrences to explain the apparently unsegmental peripheral course of certain of those fibers; and where certain sensory fibers are assumed, in the wording of the descriptions, to grow centripetally from certain sense organs to the brain, the same elements of accident, experience or elective selection may determine their peripheral course in one segment and their central origin in another. It is needless to refer to the many expressions and statements that seem to lead legitimately to these conclusions, and while these statements definitely impress the reader it is possible that they may not always give correctly the definite opinions of the authors making them.

These two radically different conceptions of the origin and development of the peripheral nervous system lead, frequently, to totally different interpretations of the facts of distribution, this being especially marked in relation to the branches of the trigemino-facialis complex. Stannius, apparently an advocate of the earlier conception of the nervous system, assigned the fibers of this complex to the trigeminus or facialis nerves according as they issued from the skull by one set of foramina or another, or had a distribution to what he considered as trigeminus or facialis regions; and he accordingly considered the roots of the complex as partly trigeminus, partly facialis, and partly mixed. Later authors first assigned all the lateralis fibers of the complex to the facialis, irrespective of their course and distribution, and now, still later, recent advocates of the component theory assign all the communis fibers also to that same nerve. I, myself, have accepted and advocated the assigning of the lateralis fibers of the complex to the facialis, but as I am not prepared to accept the assigning of the communis fibers to that nerve, I begin to doubt the justice of so assigning the lateralis ones. This will be further discussed when describing certain of the branches of the complex. To avoid confusion I still adhere to the nomen-

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clature heretofore adopted in my works, excepting only as it relates to the lateralis nerves. In referring to these nerves I shall replace facialis by lateralis, and refer to the so-called dorsal and ventral lateralis roots of the trigemino-facialis complex as the lateralis trigemini and lateralis facialis respectively. The brain is not described, as no special examination of it was made.

NERVUS OLFACTORIUS.

The nervus olfactorius arises in Scorpaena from the anterior end of a lobus olfactorius which, as Stannius ('49) has said for Cottus and Trigla, lies beneath the anterior end of the cerebral hemisphere. The nerve is long and relatively slender, and the two nerves run forward, close together, a certain distance in the cranial cavity, there lying immediately dorsal or dorso-mesial to the nervi optici. The two nerves then enter a small median recess in the membrane that closes the orbital opening of the brain case. From this recess a membranous tube leads forward on either side of the posterior, membranous portion of the interorbital septum, each tube conducting the corresponding nervus olfactorius into the orbit. There the nerve continues forward along the lateral surface of the cartilaginous portion of the interorbital septum, passes dorsal to both of the oblique muscles, close to their origins, and traversing the olfactory canal in the antorbital process reaches the nasal pit.

In Menidia the olfactorius is said by Herrick ('99, p. 239) to be „crowded under the m. obliquus superior near its origin", which if it means that the nerve passes ventral to the muscle, must be exceptional for fishes (Stannius, '49, p. 7).

No indication of Locy's ('05) nervus terminalis could be found in any of the fishes of the group.

NERVUS OPTICUS.

The nervi optici are large and much pleated in all of the fishes of the group, as Stannius has already stated for Cottus and Trigla. In Scorpaena, as well as in Cottus, Sebastes and Trigla (Stannius), the chiasma is a simple crossing of the nerves, the left nerve lying dorsal to the right one in all the specimens examined, excepting in one specimen of Scorpaena. In that one specimen the right nerve was the dorsal one.

Beyond the chiasma the nerve of either side, in Scorpaena, runs almost directly forward in the cranial cavity until it reaches the anterior edge of the basisphenoid, where it turns antero-laterally, pierces the membrane that closes the orbital opening of the brain case and, entering the orbit, courses onward to the eyeball.

NERVUS OCULOMOTORIUS.

The nucleus of the nervus oculomotorius lies near the median line, mostly ventral to the fasciculus longitudinalis dorsalis, but, as in Menidia, partly dorsal to it. The fibers from the dorsal portion run downward mesial to the fasciculus and, joining the other fibers, turn ventro-laterally and issue from the base of the brain dorsal to the hind end of the lobus inferior. From there the nerve runs forward along the lateral surface of the dorsal portion of the lobus inferior, lying at first ventro-mesial to the nervus trochlearis and then in similar relation to the profundus ganglion and truncus ciliaris profundi. In one instance the nerve was, in part of its course, closely applied to the mesial surface of the communis ganglion of the trigemino-facialis complex. While still in the cranial cavity it separates into its superior and inferior divisions, both of which issue through the oculomotorius foramen in the proötic, usually alone, but in one 55 mm specimen, and on one side of the adult specimen used for figure No. 28 accompanied by the truncus ciliaris profundi.

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Issuing from its foramen the nerve lies antero-dorsal to the rectus externus and postero-ventral to the rectus superior, to which latter muscle the superior division of the nerve immediately passes. The inferior division of the nerve then comes into close contact with the ciliary ganglion, and there immediately separates into two portions, the larger one of which is the branch for the recti inferior and internus and the smaller one the branch for the obliquus inferior. The larger branch immediately separates into its two parts, both of which run forward postero-ventral to the rectus superior, the branch to the rectus inferior immediately entering its muscle, while the branch to the rectus internus passes dorsal to the rectus inferior to reach its muscle. The ciliary ganglion lies upon the branch that goes to the recti internus and inferior and is connected with it by fibers which represent the radix brevis. The branch to the obliquus inferior turns downward and forward anterior to the rectus externus but postero-ventral to the other three recti muscles, and so reaches its muscle.

The branches of the oculomotorius and their relations to the recti muscles and the nervus opticus, are thus exactly as in Scomber.

In Lepidotrigla and Cottus the same arrangement is found; and Dactylopterus differs only in that the oculomotorius separates into three parts while still inside the cranial cavity, one branch destined to the rectus superior, one to the obliquus inferior, and the other to the recti inferior and internus. In Cottus, there being no basisphenoid, the nerve, as it issues from the cranial cavity, pierces the membrane that closes the orbital opening of the brain case, instead of there being enclosed in bone.

NERVUS TROCHLEARIS.

The trochlearis has a central origin and intracerebral course similar to that given by Herrick for this nerve in Menidia, and it issues from the brain along the ventral margin of the lobus opticus. Running forward in the cranial cavity it does not come into close relations with any of the roots of the trigeminus, or with nerves arising from those roots, differing, in this, from the nerve in Menidia. This is also true of Lepidotrigla, Cottus and Dactylopterus.

The nerve issues from the cranial cavity either along or through the edge of the alisphenoid, and running dorsal to all the muscles of the eyeball enters and supplies the obliquus superior.

NERVUS ABDUCENS.

The abducens issues from the ventral surface of the medulla oblongata slightly posterior to the lobus inferior, and between or slightly anterior to the anterior roots of the nervi acustici of opposite sides. In all the young specimens of Scorpaena examined, it arose by a single root, but in the adult specimen used for figure 28 it arose by two roots. In all of the specimens of Lepidotrigla examined it arose by two roots, one slightly posterior to the other, as Stannius has said for Trigla and Cottus. The one or two rootlets have their origin in a nucleus which lies, as in Menidia, at some distance from the median line and at about one third the distance from the ventral surface of the medulla to the floor of the overlying ventricle. A strong tract of fibers crosses transversely between the nuclei of opposite sides, but my sections did not give any indication either of the tract or the bundle of fibers, described by Herrick in Menidia, that runs from the nucleus or root of the nerve of either side dorsally into the fasciculus longitudinalis dorsalis.

The abducens, having issued from the medulla oblongata, runs forward beneath the hypoarium and, in the sections both of Scorpaena and Lepidotrigla, turns downward over the anterior

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edge of the cartilaginous proötic bridge and then runs backward beneath that bridge to enter and supply the rectus externus. In the adults both of Scorpaena and Trigla, the nerve perforates the bony proötic bridge to reach its muscle. In Cottus octodecimospinosus it runs over the anterior edge of the bony bridge. In small specimens of Dactylopterus it enters the trigemino-facialis chamber through the facialis foramen, and traversing that chamber ventral to all the other nervous structures issues by the trigeminus opening of the chamber and then immediately enters its muscle.

TRIGEMINO-FACIALIS COMPLEX.

This complex has, in Scorpaena, five apparent roots, as Stannius has stated that it has in Trigla, but two of these roots, the lateralis roots, may issue as a single root from the medulla and then immediately separate. These two lateralis roots and the motor facialis root are so closely applied, at their origin, that they appear almost as a single root, and are so shown in figure 28. In that figure, furthermore, the communis root appears crowded down between the trigeminus and the lateralis and motor facialis roots, this not being its position in sections of young specimens.

My sections did not permit of more than a very general determination of the central origin and peripheral distribution of the fibers of the several roots, but comparison with Menidia will show that these determinations are probably correct.

a. Roots and Ganglia of the Complex.

The anterior one of the five roots of the complex is the so-called root of the trigeminus, and it contains both motor and general cutaneous fibers. The motor fibers lie on the dorso-mesial aspect of the root as it emerges from the medulla. The fibers of the deep sensory root lie lateral to these motor fibres, the two bundles of fibers extending dorso-mesially into the medulla, lying close together, and certainly having their principal origins in groups of cells that represent respectively the chief sensory and motor nuclei of the trigeminus. The remaining, ventral fibers of the root enter the spinal V tract. The motor fibers, having issued from the medulla, soon cross, as in Menidia, to the ventral surface of the root, and so continue during their intracranial course. The entire root, running forward and laterally, lies at first, in sections, mesial to the other roots of the complex and then between the lateralis trigemini and lateralis facialis roots, ventral to the former and dorsal to the latter. While still in the cranial cavity it gives off the profundus root. It then traverses the trigeminus foramen, enters the trigemino-facialis chamber, and there immediately swells into the large trigeminus ganglion, which, in my young specimens, seems wholly distinct and separate from any other portion of the ganglionic complex excepting only the large related sympathetic ganglion. The ganglion lies almost wholly in the trigemino-facialis chamber, a small collection, only, of cells being found on the ventral surface of the root just before it issues through its foramen; these cells being connected with the main ganglion by a small ganglionic strand which traverses the foramen. The ganglion thus lies almost entirely in the cranial wall and not in the cranial cavity, all the other ganglia of the complex, excepting only the related sympathetic ganglion, lying in the cranial cavity itself.

The profundus root arises from the sensory portion of the trigeminus root, on its antero-mesial aspect, and running antero-laterally enters the intracranial profundus ganglion which lies slightly antero-mesial to the large stalk formed by the other roots of the complex.

The next posterior root of the complex is the motor root of the facialis. This root emerges from the medulla close to the anterior root of the nervus acusticus, almost as a part of that root,

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and directly anterior to the low swelling of the acusticus part of the tuberculum acusticum; the anterior root of the acusticus spreading, and entering the medulla both dorsal and ventral to the level of the point of exit of the motor root of the facialis. After the root emerges from the medulla it lies dorso-anterior to the anterior root of the acusticus, between it and the overlying lateralis facialis root, but it soon passes up along the lateral surface of the latter root and reaches its dorsal surface. There it continues forward closely applied to the lateralis facialis and issues, with that nerve, through the facialis foramen. As the two nerves pass through the foramen, of shortly before, they receive a large bundle of fibers from the communis ganglion, the three components together forming the truncus facialis. This truncus does not traverse the trigeminus ganglion, passing postero-ventral to that ganglion. As in Menidia, it contains no general cutaneous component.

The next posterior root is the communis root. This root leaves the medulla almost directly dorsal to the motor facialis root, its point of origin lying immediately dorsal to the low, acusticus swelling of the tuberculum acusticum, and immediately anterior to the low, lateralis swelling of the same structure. Immediately after issuing from the medulla it lies wedged in between the lateralis trigemini and lateralis facialis roots, and, anterior to that point, lies lateral and then ventral to the trigeminus root as that root passes between the two lateralis roots. It then swells into a large pear-shaped intracranial ganglion, the large end of the pear directed antero-laterally, and the ganglion occupying the ventral or ventro-mesial portion of the large root-stalk of the complex. From the anterior portion of this ganglion, three bundles, or groups of sub-bundles of fibers arise, their arrangement being somewhat different on the two sides of the one specimen in which they were traced. One of these bundles is the ramus palatinus facialis which runs downward in the cranial cavity and, perforating the base of the proötic bridge, enters the myodome. A second one of the three bundles is a group of sub-bundles which traverses the trigeminus foramen; containing two separate sub-bundles on one side of the specimen and three on the other. One of these sub-bundles enters and traverses the trigeminus ganglion, going mainly if not entirely to the ramus oticus; the other one or two sub-bundles traversing the ganglion to enter the truncus maxillo-mandibularis trigemini. The third bundle that arises from the main ganglion traverses the facialis foramen and it was single on one side of my specimen but double on the other. On the single side the entire bundle entered the truncus facialis, a small branch being immediately sent to Jacobson's anastomosis. On the double side, one of the two sub-bundles went to the truncus facialis and Jacobson's anastomosis, the other sub-bundle running upward in the trigemino-facialis chamber and entering the truncus maxillo-mandibularis. This latter arrangement was also found on one side of the adult specimen used for figure 28, and hence is probably not unusual.

The communis root of Scorpaena thus differs from that of Menidia only in that two separate bundles of fibers, instead of a single one, go to the truncus maxillo-mandibularis. Whether both bundles go to the ramus maxillaris, or one to that ramus and the other to the ramus mandibularis, I could not determine. Scorpaena further differs from Menidia in the absence of any intracranial recurrent communis nerves, and Trigla, Lepidotrigla and Dactylopterus all agree with Scorpaena in this respect. In Cottus, on the contrary, there is an important intracranial recurrent branch.

The next two roots of the complex, in Scorpaena, the two that have the most posterior apparent origin from the medulla, are the roots of the lateralis trigemini and lateralis facialis nerves. These two roots arise as a single root from the tuberculum acusticum immediately posterior to the communis root and immediately dorso-posterior to the anterior root of the acusticus, between that root and

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the posterior root of the same nerve. Running forward, and soon separating, each root swells slightly into an elongated intracranial ganglion, from which the lateralis trigemini and lateralis facialis nerves respectively arise.

In the other fishes of the group the roots and ganglia of the complex conform closely to those in Scorpaena, excepting only in the number and arrangement of the bundles of fibers that arise from the communis ganglion. In the one specimen of Lepidotrigla that was examined, all of these latter fibers arose from the ganglion as a single bundle which immediately separated into two parts, both of which traversed the facialis foramen and entered the trigemino-facialis chamber. One of these two parts is the palatinus facialis which turns forward in the trigemino-facialis chamber and issues through the trigeminus opening of that chamber. The other part separates into two bundles as soon as it enters the chamber, one of these bundles joining the trigeminus nerves and containing all the communis fibers destined to those nerves, while the other bundle contains the fibers destined to Jacobson's anastomosis and the truncus hyoideo-mandibularis facialis. In Dactylopterus one bundle of fibers traverses the trigeminus foramen, and another the facialis foramen, the latter bundle separating into three parts, the facialis branch to Jacobson's anastomosis, the ramus palatinus and the communis component of the truncus hyoideo-mandibularis facialis.

The fact that all of the communis fibers destined to the nervus trigeminus issue from the cranial cavity, in Lepidotrigla, by the facialis foramen might be considered as evidence in favor of the assumption that the communis fibers of the V—VII complex of that fish all belong to the nervus facialis; but it must not be overlooked that the fibers destined to the trigeminus all issue from the trigemino-facialis chamber by the trigeminus opening of that chamber, the fibers that issue through the facialis opening of the chamber all going to the nervus facialis. It is also to be noted that on one side of the 55 mm Scorpaena, and also on one side of the adult Scorpaena used for figure 28, a condition is found that is intermediate to that found on the other side of those two specimens and to that found in Lepidotrigla. These differences in the course of these fibers would all be explained by the assumption that the entire trigemino-facialis ganglionic complex was, in the immediate ancestor or ancestors of all teleosts, enclosed in a trigemino-facialis chamber in the cranial wall, as it actually is in Amia, and that the perforations of the inner wall of this chamber are not necessarily of segmental importance. But while there is much in favor of these assumptions it is to be noted: that in the Plagiostomata, according to Stannius, ('49, p. 32), the ganglion of his third root of the trigemino-facialis complex is always extracranial, while the ganglion of his first root, is intracranial; and that in Petromyzon, according to Johnston ('05 b), the ganglion of the facialis has its general cutaneous and communis components intracapsular, but its lateralis components extracapsular in position; and that the descriptions lead one to conclude, although it is not definitely so stated, that the ganglion of the trigeminus is extracapsular.

b. Truncus Ciliaris Profundi.

The truncus ciliaris profundi is the only nerve that arises from the profundus ganglion. Running forward in the cranial cavity it usually issues, in Scorpaena, through a special foramen in the proötic, but in two instances it was found traversing the oculomotorius foramen with the oculomotorius. In Cottus, Trigla and Lepidotrigla, in all the specimens examined, it issued through a foramen that lies close to the trigeminus and facialis foramina, these two latter foramina lying, the former dorso-anterior to the latter and the profundus lying between and immediately anterior to them.

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In small specimens of Dactylopterus the ciliaris profundi issues through the large trigeminus foramen.

According to Stannius ('49, p. 38), the ciliaris profundi of teleosts perforates the „Keilbeinflügel" (alisphenoid), but this certainly is not true of any of the mail-cheeked fishes I have examined, nor of Scomber, in all of which fishes it perforates the proötic.

In Cottus, Trigla and Lepidotrigla, as in Ophiodon (Allen, '05), the truncus ciliaris profundi is accompanied, in its passage through its foramen, by the encephalic branch of the jugular vein. In Dactylopterus and Scorpaena, that vein traverses the trigeminus foramen, associated with the truncus profundi in Dactylopterus, but not in Scorpaena.

In Scorpaena, the ciliaris profundi receives, immediately after issuing from the skull, a branch from the large sympathetic ganglion associated with the trigeminus, and then separates into its two parts, the ciliaris longus and the radix longa. The ciliaris longus is much the thicker nerve of the two, and running upward and forward, dorsal to the rectus externus and posterior and somewhat parallel to the rectus superior, pierces the eyeball between that muscle and the rectus externus. The radix longa continues onward near the nervus oculomotorius and soon enters the ciliary ganglion; this latter ganglion also receiving, on both sides of the adult specimen used for figure 28, an independent sympathetic strand coming from the trigeminus sympathetic ganglion. This latter strand was not evident in the sections. The ciliary ganglion is connected with the oculomotorius by the radix brevis, and from it a single nerve arises, the ciliaris brevis, which joins and accompanies the nervus opticus and pierces the eyeball not far from that nerve.

In Lepidotrigla the ciliaris profundi, after issuing from its foramen with the encephalic vein, turns downward and forward close against the outer surface of the cranial wall, closely accompanying the internal jugular vein and lying, with that vein, immediately beneath the anterior portion of the trigeminus sympathetic ganglion. From the latter ganglion it receives a strand, and then, joining and accompanying the nervus oculomotorius, separates into its two portions shortly before it reaches the ciliary ganglion. In both Cottus scorpius and Cottus octodecimospinosus, and also in Dactylopterus, strictly similar conditions are found.

The profundus ganglion and its root, and the ciliaris longus and radix longa, are all described by Stannius in Trigla gurnardus and Trigla hirundo, these two teleosts being the only ones in which that author found an independent profundus ganglion. Of Cottus (species not given) Stannius says ('49, p. 38), that the ramus ciliaris arises from the trigeminus ganglion, close to the ramus ophthalmicus trigemini; a statement certainly not true of either of the two species of Cottus that I have examined.

In Menidia, the radix ciliaris longa of Herrick's descriptions is simply the sympathetic strand sent from the trigeminus sympathetic ganglion to join the true radix longa, this latter radix being his ramus ophthalmicus profundus.

In Petromyzon, the root of the profundus is said by Johnston ('05 b, p. 186) to contain some lateralis fibers.

c. Nervus Trigeminus.

The several motor and general cutaneous branches of this nerve all have, in all the fishes of the group, their apparent origin from the trigeminus ganglion, that ganglion lying in the trigeminofacialis chamber.

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The lateralis fibers destined to the rami buccalis and oticus enter the trigeminus ganglion as a single bundle, and while traversing the ganglion separate into two bundles, one destined to each of the two nerves. The fibers that go to the ramus ophthalmicus lateralis do not traverse the ganglion, lying, in sections, either wholly separate and immediately dorsal to the ganglion or partly embedded in its dorsal surface. This ophthalmicus bundle of lateralis fibers always traverses the skull either through a partly separate part of the trigeminus foramen or through a wholly separate but closely adjacent foramen.

From the trigeminus ganglion, in Scorpaena, the ramus ophthalmicus trigemini, the truncus maxillo-mandibularis trigemini, the ramus communicans ad truncus hyoideo-mandibularis facialis, and two independent branches arise; all of these branches issuing from the trigemino-facialis chamber by its trigeminus opening excepting only the ramus communicans ad nervus facialis, which latter nerve issues through the facialis opening of the chamber. Two or three bundles of communis fibers traverse the ganglionic mass, one or two bundles going to the truncus maxillo-mandibularis and the other one going toward the ramus ophthalmicus, but, so far as could be determined in my quite unsatisfactory sections, going wholly to a branch that accompanies the ramus oticus lateralis.

The ramus ophthalmicus trigemini arises from the anterior end of the trigeminus ganglion by two strands in all the sections of Scorpaena, Cottus and Lepidotrigla, one of these strands running forward dorsal and the other ventral to the ophthalmicus lateralis. From the dorsal one of the two strands, in Scorpaena and Lepidotrigla, a small branch, apparently a purely general cutaneous one, is soon sent through the alisphenoid with the lateralis branch that goes to the small sixth organ of the supraorbital canal, the two nerves being accompanied by a branch of the external carotid and also by a branch of the vessel x. The general cutaneous component of this small nerve would seem to be the homologue of one or both of the two meningeal nerves said by Herrick ('99, p. 205) to have an extracranial origin in Menidia; and it may be added that no intracranial meningeal nerves were evident in Scorpaena. Of these two nerves in Menidia, Herrick says, ,,I regard them as primarily general cutaneous nerves" but ,,doubtless accompanied by sympathetic or other visceral fibers." They are said to be ,,destined chiefly at least, for the skin of the top of the head", which would seem to exclude them largely from the meningeal category. In embryos of Cottus this small reëntrant branch of Scorpaena and Lepidotrigla was not traced.

After giving off this small reëntrant branch, the two ophthalmic nerves of Scorpaena and Lepidotrigla, accompanied by the ophthalmicus lateralis, run forward dorsal to all the nerves and muscles of the orbit, give off several branches while in the orbit, and then pass through the canal between the frontal, mesethmoid and ectethmoid to reach the dorsal surface of the snout; their further course not being investigated. In Ameiurus, Herrick ('01) says that the ramus ophthalmicus, his supraorbital trunk, contains communis as well as general cutaneous fibers, which seems certainly not true of the mail-cheeked fishes. According to Sagemehl ('84b, p. 71) the ramus ophthalmicus, in the Characinidae, perforates the ectethmoid by a special canal; which is also not true of any of the mail-cheeked fishes I have examined, nor of Scomber either.

The truncus maxillo-mandibularis separates, as usual, into maxillary and mandibular portions. the former being accompanied by the buccalis lateralis. A small branch is given off before the truncus separates into its two parts, and running upward and backward innervates first the levator arcus palatini and then the dilatator operculi. The further course and distribution of the nerve was not investigated.

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The ramus communicans ad truncus hyoideo-mandibularis facialis, in Scorpaena and Lepidotrigla, is entirely of general cutaneous fibers, and running postero-laterally through the facialis opening of the trigemino-facialis chamber joins the truncus facialis immediately beyond the motor branches to the adductor arcus palatini and adductor hyomandibularis. In Cottus a corresponding branch is found, and it is doubtless a general cutaneous one though this could not be determined in my sections.

The two independent branches that arise from the trigeminus ganglion in Scorpaena, arise from its anterior end. One runs upward and laterally across the anterior edge of the levator arcus palatini, and is distributed to the skin along the hind margin of the orbit. The other branch apparently contains both general cutaneous and communis fibers, and as it joins and accompanies the oticus lateralis it will be described with that nerve. In Lepidotrigla the first one of these two branches is found, but there is apparently no branch joining the oticus lateralis.

In Dactylopterus two general cutaneous branches arise from the anterior end of the trigeminus ganglion. One of these branches joins and accompanies the ophthalmicus lateralis and is the ramus ophthalmicus trigemini. The other separates into two parts, one of which joins the oticus lateralis, the other traversing the alisphenoid by an independent foramen, accompanied by a blood vessel which is apparently the anterior cerebral vein of my descriptions, but not accompanied by lateralis fibers; the lateralis branch to the posterior supraorbital organ not perforating the alisphenoid in this fish and not having a partly intracranial course, as in the other fishes of the group. Dactylopterus differs also from the other three fishes examined in this connection, in that there are two instead of one communicating branches from the trigeminus ganglion to the nervus facialis, both of them containing general cutaneous fibers only. One of these branches arises from the posterior end of the ganglion, and passing backward through the facialis opening of the trigemino-facialis chamber joins the nervus facialis internal to the hyomandibular. The other branch arises further forward from the ganglion, passes outward through the trigeminus opening of the chamber and then runs postero-ventrally, external to the hyomandibular, to join the truncus mandibularis facialis after it issues from the facial canal in the hyomandibular. This condition in Dactylopterus is somewhat similar to that described by Herrick in Menidia, where there are also two communicating branches, one quite undoubtedly issuing through the facialis and the other through the trigeminus opening of a trigemino-facialis chamber, although this chamber is not described and the references to the related foramina are perplexing. But the two branches in Menidia differ from those in Dactylopterus in that they unite to form a single nerve which passes internal to the hyomandibular to join the truncus hyoideo-mandibularis, no portion of either of them joining the nerve external to that bone. Stannius says ('49, p. 47) that this communicating branch from the trigeminus to the facialis is found in nearly all teleosts, and that it issues from the skull with the truncus maxillaris trigemini; the latter part of the statement being an evident error as regards certain teleosts.

d. Nervus Facialis.

This nerve includes, according to the component theory, all the fibers that are contained in the lateralis and communis roots of the trigemino-facialis complex, as well as those of the motor facialis root.

The dorsal one of the two lateralis roots, which I have called the lateralis trigemini, separates, while still in the cranial cavity, into ophthalmicus and buccalis portions.

The ophthalmicus lateralis almost always, in the adult of Scorpaena, traverses a separate foramen which lies directly above the trigeminus foramen, and the nerve lies upon the dorsal surface

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of and does not traverse the trigeminus ganglion. Immediately after issuing from the skull it gives off a small branch which turns upward and inward and, perforating the alisphenoid, enters the cranial cavity. There it runs upward along the inner surface of the skull, lying in the membranous tissue that lines that surface, and, piercing the frontal, reaches the small sixth organ of the supraorbital canal, which it innervates. It is accompanied by a delicate branch of the trigeminus, apparently of general cutaneous origin, as already stated, but this branch could not be separately traced in the cranial cavity. In Lepidotrigla the same mixed nerve is found. In Cottus scorpius a similar nerve is also found; but in the sections of this fish the nerve is lost beneath the terminal tube of the supraorbital canal, and no organ is evident in that tube. In the adult Cottus octodecimospinosus the nerve is found innervating the terminal organ of the supraorbital canal, as in Scorpaena and Lepidotrigla. Slightly posterior to this nerve, in Cottus, and having a closely parallel course, there is a communis nerve which has an intracranial origin from the communis ganglion, and from there runs upward and then backward along the side wall and roof of the cranial cavity. Whether or not this nerve anastomoses with an intracranial branch of the vagus could not be determined in Cottus scorpius, but in Cottus octodecimospinosus it does anastomose with such a branch and then issues near the hind end of the skull; this seeming to indicate that it must form the anastomosis in Cottus scorpius also. The nerve is accordingly the ramus lateralis trigemini of Stannius's descriptions, called by Herrick, in his descriptions of Menidia, the facialis root of the ramus lateralis accessorius. It is said by Stannius not to be found in Trigla, which I confirm. It is also not found in Scorpaena or Dactylopterus.

In the Cod, the facialis root of the lateralis accessorius is said by Herrick ('00) to be present and to be accompanied by a few coarse fibers from the lateral line ganglion, which fibers would accordingly seem to correspond to the branch to organ 6 supraorbital in Scorpaena. Whether or not this latter branch of Scorpaena is represented in Pleuronectes by any part of Cole & Johnstone's ('01, p. 128) ramus lateralis accessorius facialis, I can not decide. In Ameiurus it is represented in Herrick's ('01) branch N. 5, which has a wholly intracranial course until it pierces the frontal to reach its organ; a branch of the nerve going to the anterior head line of pit organs.

The ophthalmicus lateralis, in Scorpaena, having given off the branch to organ 6 supraorbital, runs forward between the two strands of the ophthalmicus trigemini and soon gives off a branch which, running upward, separates into two parts and supplies the fourth and fifth organs of the supraorbital canal. This branch, in the several specimens of Scorpaena examined, and as already stated, sometimes separated into its two parts before it pierced the frontal, sometimes so separated while in its canal in the frontal, and, in one specimen, entered the supraorbital canal as a single nerve which then, lying in the canal, supplied, first, organ No. 4 and then organ No. 5. After giving off this branch the ophthalmicus lateralis continues forward, sends branches in succession to the third and second supraorbital organs, and then supplies and terminates in the first organ of that line.

The ramus oticus, in Scorpaena, separates from the buccalis while that nerve is traversing the trigeminus ganglion, and issues from the ganglion as an independent lateralis branch but accompanied by two bundles of fibers one of which is of general cutaneous and the other of communis origin. This latter bundle issues from the cranial cavity through the trigeminus foramen, and, so far as my quite unsatisfactory sections show, contains all the communis fibers that go to the trigeminus excepting those that accompany the truncus maxillo-mandibularis. These three bundles of fibers, united to form a single nerve, run upward and laterally along the hind wall of the orbit and, traversing the

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oticus canal in the sphenotic, issue on the dorsal surface of the skull beneath the frontal bone. A lateralis branch is then sent to the infraorbital organ in the postfrontal, and a second branch to the organ in the pterotic, these two branches apparently containing all the lateralis fibers of the nerve. The remainder of the nerve then runs backward beneath the dermal bones of the top of the skull, enters the temporal fossa and there runs into and anastomoses with the supratemporal branch of the vagus, branches being sent backward, from the united nerves, along the dorsal surface of the trunk. As the main nerve passes dorso-mesial to the dilatator groove, it lies very close to that groove, and may even be exposed in the bottom of it. A venous vessel, a branch of the external jugular, here perforates the bottom of the groove and joins the nerve, accompanying it in its further course toward the hind end of the skull.

In Lepidotrigla the ramus oticus is a purely lateralis nerve, and is not continued posteriorly beyond the second organ in the pterotic, the pterotic in this fish lodging two organs innervated by the oticus, without an intervening primary tube. This condition of these two organs in this fish would seem to represent a stage in the reduction of the two organs here found normally developed in Amia and certain other fishes to the one organ found in Scorpaena and still other fishes; a reduction strictly similar to that that is taking place in the 4 th. and 5 th. supraorbital organs both of Lepidotrigla and of Scorpaena. In Lepidotrigla, the general cutaneous and communis fibers that accompany the oticus in Scorpaena are represented (or replaced) by fibers that do not traverse the oticus canal; and this is also the condition in Amia, in which fish the ramus oticus is also a purely lateralis nerve while the ophthalmicus lateralis branch that supplies the anterior head line of pit organs is accompanied by fibers the character of which was not determined in my work on that fish, but which have an apparent origin and distribution similar to that of the fibers that accompany the oticus in Scorpaena.

In Dactylopterus the oticus lateralis is accompanied by a bundle of general cutaneous fibers, and apparently by those fibers only.

In Ameiurus, the ramus oticus is said by Herrick ('01) to contain lateralis, general cutaneous, and communis fibers, to have an intracranial origin, and, running upward, to pierce the roof of the skull; which would seem to mean that it does not first issue in the hind end of the orbit before entering and traversing the oticus canal. In Menidia the ramus oticus is said by Herrick ('99) to contain lateralis and general cutaneous fibers, and to correspond to the ramus oticus plus the external buccal of Cole's descriptions of Gadus: that is, its lateralis fibers innervate not only the latero-sensory organs in the postfrontal and pterotic sections of the main infraorbital canal but also the organ in the dorsal postorbital bone. The ramus oticus of Menidia, minus the external buccal portion, is said to traverse a canal in the sphenotic and, as just above stated, it contains both lateralis and general cutaneous fibers. This intimate association, in this nerve, of fibers that are considered by the author to have a central origin in the facialis and trigeminus segments, respectively, leads Herrick to conclude that the oticus ,,was probably originally the dorsal ramus of the facial nerve to which lateralis elements have been secondarily added and whose general cutaneous portion has, like that of the profundus nerve, been cenogenetically fused with the Gasserian ganglion". That is, it is assumed, in this statement, that general cutaneous fibers that originally issued from the brain by three distinctly different apparent roots, and that belonged to three distinctly different but adjacent metameric segments, have come, in Menidia, to issue by a single apparent root and from a single, unsegmented cerebral center; this being the result of a central condensation so complete that all traces of the ori-

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ginal subdivisions of the root and center have been lost. The equally evident assumption that all the lateralis fibers associated with trigeminus nerves are trigeminus ones cenogenetically fused with the lateralis fibers of the facialis segment, is not made; and yet this assumption has apparently much more evidence in fact, for the lateralis trigemini and lateralis facialis fibers here, and in many other fishes also, arise by separate apparent roots and each have an independent ganglion. Johnston, in a recent work ('05 a, p. 222), does make what is practically the equivalent of this assumption, for he there says that it seems probable to him that the supraorbital, infraorbital and hyomandibular latero-sensory lines belong respectively to the profundus, trigeminus and facialis segments. He does not, however, say that the nerves innervating the three lines must also belong to those same segments, and such may not be his meaning.

One other point relating to this same subject can here be mentioned. In many teleosts, as already stated, a strand of general cutaneous fibers, arising from the Gasserian ganglion, joins the truncus hyoideo-mandibularis facialis. These fibers join that nerve extracranially in Scorpaena, Menidia and many other fishes, but intracranially in Pleuronectes (Cole & Johnstone, '01, p. 124). Here then is another instance in which the cenogenetic fusion of fibers belonging originally to the trigeminus and facialis segments might be suggested, but neither Herrick nor Johnston ('05 a) even intimate it; and yet, in Amia, Kingsbury ('97), before the publication of Herrick's work, had stated that general cutaneous fibers issue from the brain in the root of the facialis in all the specimens of that fish that he had examined, and Johnston ('05 b), since the publication of Herrick's work, says that they also issue in that root in Petromyzon.

And if the assumption of cenogenetic fusions can be made either for the general cutaneous or lateralis fibers of the complex, why can it not also be made for the communis fibers? Those fibers then would, in large part at least, normally belong to the nerves with which they are associated, certain juxtapositions perhaps being possible where there are no skeletal elements to prevent them; and the varying quantity of communis fibers in the several trigeminus and facialis nerves would be due to a corresponding variation in the development of the terminal organs innervated by either nerve.

Returning now to the descriptions, the buccalis facialis traverses, in all the fishes examined, the trigeminus ganglion, and, accompanying the ramus maxillaris trigemini, supplies the organs of the post- and sub-orbital portions of the main infraorbital canal.

The truncus facialis, in Scorpaena, Lepidotrigla and Dactylopterus contains motor, lateralis and communis fibers, the latter fibers, in all these fishes, traversing the facialis foramen and joining the other fibers of the truncus either as they are traversing, or after they have traversed the same foramen.

The ramus palatinus contains communis fibers only, and in Scorpaena it usually has an independent origin from the communis ganglion. In the 55 mm Scorpaena, it had such an origin on one side of the head, while on the other side it arose from the base of the bundle of communis fibers sent to the trigeminus ganglion. Turning downward in the cranial cavity, the nerve traverses the palatine canal in the proötic, enters the myodome, and, turning forward, enters the orbit along its floor; its further course not being traced. In Cottus, the palatinus has a course similar to that in Scorpaena, but in Trigla, Lepidotrigla and Dactylopterus it does not separate from the other communis fibers until after those fibers have traversed the facialis foramen. There it turns forward and downward along the floor of the trigemino-facialis chamber, issues through the trigeminus opening of that chamber, and, traversing the myodome of the fish, enters the orbit.

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The next branch of the truncus facialis, in the 55 mm Scorpaena, is given off as the truncus traverses its foramen, and contains communis fibers only. Turning downward and backward it issues through the facialis opening of the trigemino-facialis chamber and then almost immediately joins and anastomoses completely with the ramus anterior of the nervus glossopharyngeus. The nerve so formed is Jacobson's nerve. It runs antero-ventrally along the dorso-anterior aspect of that part of the hyoid cleft that lodges the opercular hemibranch, and is distributed to that hemibranch and to the adjacent tissues on the anterior surface of the cleft, delicate branches of the nerve accompanying both the efferent and afferent arteries of the hemibranch. In both Cottus and Lepidotrigla this nerve is found in almost identical conditions, and it doubtless also is in Dactylopterus, but in this latter fish it was not traced beyond the point of its anastomosis with the glossopharyngeus. The fibers of the glossopharyngeus all run distally with the facialis fibers, none of them turning proximally along the facialis nerve, as I was led to suppose might be the case in Scomber.

Immediately before or after the facialis branch to Jacobson's nerve arises from the truncus facialis, that truncus receives, in both Scorpaena and Lepidotrigla, a communicating branch or branches from the facialis sympathetic ganglion, this connection doubtless existing also in the other fishes of the group but not there being traced.

After giving off the nerve to Jacobson's anastomosis, the facialis, in Scorpaena and Lepidotrigla, sends a motor branch to the adductor arcus palatini, and then a branch to the adductor hyomandibularis; this latter branch also innervating the adductor and levator operculi. These two nerves together form the ramus opercularis profundus of Herrick's nomenclature. The branch that goes to the adductor hyomandibularis is joined posteriorly by and anastomoses with a branch of the supratemporal branch of the nervus vagus, certain of the fibers of the vagus running proximally along the fibers of the opercularis profundus and the two nerves thus appearing as a complete and uninterrupted circuit. In Cottus and Dactylopterus the opercularis profundus is also found, but its anastomosis with a branch of the vagus was not traced.

The truncus facialis, in Scorpaena and Lepidotrigla, is then joined by the communicating branch from the trigeminus ganglion and becomes the truncus hyoideo-mandibularis of Stannius' nomenclature. This nerve continues laterally and slightly downward and enters the facialis canal in the hyomandibular, lying, in its course, postero-dorsal to the adductor arcus palatini and anterior to the adductor hyomandibularis and to all of the levator muscles of the branchial arches. As it enters its canal in the hyomandibular, a branch is sent backward in the small branch canal in the hyomandibular, and, separating into two parts, innervates the two dorsal latero-sensory organs in the preopercular canal. This small branch is the ramus opercularis superficialis of Herrick's nomenclature, and it was traced in the dissections and not in the sections of Scorpaena; the sections here being quite imperfect. In the dissections no branch could be found distributed to the outer surface of the operculum, such as Herrick describes in Menidia, but in Lepidotrigla this branch was found, though the character of its fibers could not be determined. In Menidia these fibers of the nerve are said by Herrick to be partly general cutaneous and partly lateralis. These latter fibers are said to supply certain naked cutaneous sense organs lying on the outer surface of the operculum, these organs being of that intermediate type between pit-organs and terminal buds which are always puzzling to every observer. Herrick concludes that these organs must, because of their innervation, belong to the lateral line rather than the communis system, a conclusion I am not prepared, from the facts so far presented, to accept. In the Cod the corresponding fibers of this nerve are said by Herrick ('00) to probably be wholly

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lateralis ones, and they are said to have been definitely traced to certain opercular pit organs. In Pleuronectes, Cole and Johnstone ('01, p. 132) also find the nerve a purely lateralis one, its terminal branches supplying an opercular line of pit organs.

Having given off this small branch the main truncus, in Scorpaena and Lepidotrigla, traverses the facialis canal in the hyomandibular and issues on the external surface of the shank of that bone. There it separates into its two parts, the ramus hyoideus and truncus mandibularis, the latter of which soon separates into the rami mandibularis externus and internus. The ramus hyoideus runs downward and backward through the opening between the hyomandibular and the preopercular and so reaches the hyoid arch, its further course not being traced. The rami mandibularis externus and internus run downward and forward across the hyomandibulo-symplectic interspace of cartilage, and then pass, respectively, through the openings on the posterior and anterior side of the symplectic, as already fully described, and so reach the inner surface of the palato-quadrate apparatus and then the mandible. The externus sends branches, as usual, to the latero-sensory organs of the preoperculo-mandibular line, and certain branches also to the general tissues, the nerve thus not being a simple latero-sensory nerve. The internus goes to the inner surface of the mandible, its special distribution and relations to the other nerves not being investigated. Whether it contains communis fibers, and those fibers only, as in Menidia, could not be determined, but, whatever its composition may be, it is a true ramus mandibularis internus as that nerve is defined by Stannius. Herrick ('99, p. 171) takes the position, and it may be correct, that a nerve can not be a mandibularis internus unless it contains communis fibers; and the inference is that it must contain those fibers alone, for he says that the nerve is absent in Gadus notwithstanding that both Stannius and Cole describe a nerve in that fish that is said to have the topographical position of an internus. Neither Stannius' nor Cole's descriptions of the course of the nerve being very definite, I have had the nerve looked for in dissections of Gadus merlangus, but it could not be found; which would seem to confirm Herrick's conclusion that the nerve, when present, contains communis fibers only.

In Dactylopterus the truncus hyoideo-mandibularis facialis does not traverse a single canal in the hyomandibular and issue on the external surface of that bone, as it does in Scorpaena, Cottus, Trigla and Lepidotrigla. When it reaches the internal surface of the hyomandibular the nerve, in Dactylopterus, separates into its two portions, the ramus hyoideus and the truncus mandibularis, the latter of which alone traverses the facialis canal through the bone and issues on its external surface. The ramus hyoideus simply passes beneath a bridge of bone on the internal surface of the hyomandibular and reappears on the internal surface of that bone. This will be further discussed when describing the bones in this fish. From the truncus mandibularis, as it enters its canal in the hyomandibular, a lateralis branch, accompanied by what are apparently wholly general cutaneous fibers, passes backward through a small branch canal in the bone, this nerve supplying the two dorsal organs of the preopercular canal and the tissues on the outer surface of the opercular. The truncus mandibularis contains communis fibers and is joined, after it reaches the outer surface of the hyomandibular, and as already stated, by the communicating general cutaneous branch that issues through the trigeminus opening of the trigemino-facialis chamber. After being joined by this communicating branch, the entire truncus mandibularis passes to the internal surface of the palato-quadrate through an opening that lies posterior to the symplectic, no evident branch passing inward anterior to that bone. There is thus no evident ramus mandibularis internus in this fish. The mandibularis externus, after it reaches the internal surface of the palato-quadrate, certainly con-

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tains fibers other than lateralis ones, but whether they are all general cutaneous ones, or partly communis, could not be determined. If they are all general cutaneous ones, Dactylopterus would resemble Ameiurus (Herrick, '01) in this respect, the communis fibers that form part of the ramus mandibularis facialis in that fish all being distributed to regions external to the palato-quadrate.

NERVUS ACUSTICUS.

The nervus acusticus has, in sections of Scorpaena and Lepidotrigla, two roots, which enter the tuberculum acusticum close together, the slight swelling at their point of entrance lying immediately ventral to the swelling for the lateralis nerves. The anterior root belongs to the anterior division of the nervus, the posterior root to its posterior division.

The anterior division, or ramus vestibularis, running forward sends, in my 55 mm Scorpaena, two branches to the macula acustica sacculi. In the 63 mm Lepidotrigla, one of the two branches that go to this organ has a separate origin from the medulla, between the anterior and posterior roots of the nervus, the second branch arising from the posterior root. In both fishes, the ramus vestibularis then sends a branch to the macula acustica utriculi, another branch to the crista acustica in the ampulla of the external canal, and then ends in the crista acustica of the ampulla of the anterior canal. All of these several branches separate distally into two parts, the two parts of the two nerves that go to the ampullae supplying two separate and distinct organs in each of the ampullae, but the nerve that goes to the utriculus supplying different parts, only, of the large and continuous utricular macula.

The posterior division of the nervus, or ramus cochlearis, runs backward and separates into two parts one of which passes dorsal to the root of the glossopharyngeus and the other ventral to that root. The dorsal branch supplies the two organs of the crista acustica in the ampulla of the posterior canal, the ventral one supplying the two organs of the macula neglecta and also the papilla acustica lagenae. The lagena is partially differentiated as a diverticulum arising from the dorsal surface of the hind end of the sacculus.

The papilla lagenae and the maculae sacculi and utriculi each have related otoliths.

There was no indication of a ductus endolymphaticus in the dissections of Scorpaena, but in sections, both of embryos and of the adult, a small remnant of the ductus is evident. In Trigla hirundo the ductus is two or three times as large as in Scorpaena, being evident even in dissections. Retzius ('81) shows the ductus in Trigla gurnardus.

NERVUS GLOSSOPHARYNGEUS.

The nervus glossopharyngeus of Scorpaena arises by a single apparent root, composed, as in Menidia, of two bundles of fibers, a motor and a communis one.

After issuing from the medulla the root runs at first posteriorly, then turns outward between the dorsal and ventral branches of the ramus cochlearis acustici, and then forward and laterally to its foramen, passing between the sacculus and the sinus utriculi posterior. At the bend in the root there is an important collection of ganglion cells lying on the posterior aspect of the nerve, and from this ganglion, in the adult, an intracranial communicating branch was found, going to the root of the vagus. In the 55 mm specimen this branch could not be satisfactorily traced. In the 63 mm Lepidotrigla two branches arise from the ganglion, one of which joins the root of the vagus, the other one entering the intracranial vagus ganglion. The dorsal one of the two branches receives, on one side of

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the specimen, but not on the other, a relatively important branch from the dorsal branch of the ramus cochlearis acustici.

Having traversed its foramen the nerve turns forward along the outer surface of the skull and swells into an elongated ganglion, which has a sympathetic ganglion associated with it. From this ganglion two nerves arise. One of these nerves is the ramus anterior of the nervus, which, running forward, anastomoses with the communis branch from the facialis to form Jacobson's nerve, as already described. The other branch is the ramus posterior of the nervus and was not further traced.

NERVUS VAGUS.

a. Nervus lineae lateralis vagi.

The root of the nervus lineae lateralis vagi issues from the tuberculum acusticum directly dorsal and slightly posterior to the root of the glossopharyngeus. In the 63 mm Lepidotrigla it arises by two roots, a small anterior and a large posterior one. It runs posteriorly in the cranial cavity and issues through the vagus foramen, there lying directly upon the dorsal surface of the root of the vagus. A supratemporal branch is immediately given off, and running upward innervates the latero-sensory organs of the supratemporal commissure and also those of the extrascapular and suprascapular sections of the main infraorbital canal; this branch having a separate extracranial ganglion. The main nerve then enters its own ganglion, and was not further traced. No ganglion cells are found in the main nerve before it issues from the cranial cavity, and there is no branch of the nerve accompanying the nervus glossopharyngeus.

b. Nervus Vagus.

The roots of this nerve could only be properly traced in the 63 mm Lepidotrigla. In this fish, and also in the small specimens of Scorpaena and Dactylopterus, three small rootlets arise from the medulla anterior to the main root of the nervus. These rootlets, in Lepidotrigla, arise one anterior to the other, in the line of the main root, at intervals of about 80 μ. They pierce what is apparently a two layered cranial membrane, richly supplied with blood vessels, the anterior rootlet then joining the main vagus root, while the other two traverse the intracranial vagus ganglion, as will be later described. The anterior rootlet seems to be a purely motor one, the other two apparently containing communis fibers only; but of these determinations I am not at all certain.

The main root of the nervus contains motor, communis and general cutaneous fibers, most of these latter fibers arising from the spinal V tract while some seem to have a superficial origin, coming down from above. The three bundles issue from the medulla, in Lepidotrigla, close together, as a single large stalk which is joined by the anterior one of the three anterior rootlets, and also by one of the two communicating branches from the intracranial ganglion at the bend in the root of the glossopharyngeus. On or in connection with the general cutaneous portion of the root, an important intracranial ganglion is formed, and this ganglion is joined by one of the branches from the glossopharyngeus and is traversed by two of the anterior rootlets of the vagus itself. From the ganglion a stout intracranial branch is sent upward in the cranial cavity and issues on the dorsal surface of the skull near its hind end, this nerve apparently receiving all its fibers from the two anterior rootlets of the vagus, and the nerve accordingly quite probably being largely if not entirely of communis origin. In the sections of Lepidotrigla it could not be determined whether or not this nerve anastomosed with the recurrent component that accompanies that branch of the lateralis facialis that innervates

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organ 6 supraorbital; but in dissections of Trigla hirundo, where this intracranial branch is also found, the anastomosis of the nerve with the branch of the facialis was readily established. Stannius ('49, p. 85) says that this anastomosis is not found in Trigla gurnardus, and he also says that, in that fish, the nerve arises partly from the root of the nervus lineae lateralis. This last statement is certainly an error.

In Scorpaena no intracranial branch of the vagus could be found either in the sections or in the adult.

The main root, in Lepidotrigla, traverses the vagus foramen, there being distinctly separable into two bundles, one of which contains the motor and communis fibers, and perhaps also certain of the general cutaneous fibers, while the other arises directly from the intracranial ganglion and must be largely, if not entirely, composed of general cutaneous fibers. This latter bundle immediately turns upward, accompanying the supratemporal branch of the nervus lineae lateralis; but it soon leaves that nerve, and turning laterally and forward passes onto the external surface of the levator and adductor operculi muscles and is there in large part distributed to the inner and outer surfaces of the operculum, one branch of it, however, joining and anastomosing with the terminal fibers of the ramus opercularis profundus facialis. Whether any fibers of this nerve accompany the supratemporalis lateralis, or not, could not be positively determined, but none of them seemed to.

The remaining fibers of the root of the vagus soon swell into the large ganglionic mass of that nerve and were not further investigated.

OCCIPITAL NERVES.

The occipital nerves were not carefully traced, none of the series of sections prepared extending far enough to permit it. They are shown in figure 28 as found in the adult Scorpaena. They unite to form a single trunk which issues through the foramen in the exoccipital.

NERVUS SYMPATHETICUS.

A large sympathetic ganglion, the anterior cerebral sympathetic ganglion, lies in the trigemino-facialis chamber. Anteriorly this ganglion lies immediately ventral to, and is in contact with, the anterior portion of the trigeminus ganglion, but posteriorly it is separated from that ganglion by the jugular vein, the two ganglia being connected by several bundles of fibers. From the anterior end of the ganglion a branch is always sent to join the radix longa of the ciliary ganglion, and, in the one adult specimen of Scorpaena that was examined, a second branch is sent direct to the ciliary ganglion, as already fully described.

A second sympathetic ganglion lies ventral to the truncus facialis and is connected with that truncus by one or two strands; this ganglion sometimes being an independent ganglion and sometimes simply an enlargement of a posterior prolongation of the anterior ganglion. From the hind end of this second ganglion, the sympathetic trunk runs posteriorly along the side wall of the skull and swells into a ganglion beneath the glossopharyngeus ganglion, and then into another beneath the vagus ganglion; these sympathetic ganglia both being connected by fibers with the related ganglia of the cranial nerves.

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II. Sebastes dactylopterus.

The skull of Sebastes dactylopterus is relatively taller and shorter than that of Scorpaena scrofa; the orbits being relatively larger, the interorbital region narrower, the antorbital region shorter, and the mid-dorsal line considerably more convex than in the latter fish. The space between the eyes is concave.

The ventral surface of the skull, starting immediately posterior to the dentigerous ridge on the ventral surface of the anterior end of the vomer, is slightly convex, the summit of the convexity lying beneath the foot of the basisphenoid.

The internasal ridge is similar to that in Scorpaena, but the mesethmoid processes are smaller and project almost directly forward instead of forward and upward. The bases of these processes are connected by a curved transverse ridge, concave anteriorly, against the anterior surface of which the hind end of the internasal ridge abuts and ends. Against the wide and slightly concave lateral surface of each process the corresponding nasal rests, that bone being firmly bound to the process and bearing, on the dorsal surface of its hind end, the nasal spine.

Immediately lateral to the base of the mesethmoid process, there is a large aperture which lies between the ectethmoid below and the anterior end of the frontal above. This aperture is the anterior opening of that section of the supraorbital latero-sensory canal that lies in the frontal, combined with the anterior opening of a small canal, between the ectethmoid and the frontal, that transmits the rami ophthalmicus lateralis and ophthalmicus trigemini. Starting from this aperture, a large rounded ridge runs backward between the orbits, curving at first slightly toward the middle line and then diverging slightly from it, and marking the course of the supraorbital latero-sensory canal. Beginning slightly posterior to its anterior end, the ridge bears on its dorsal surface a narrow ridge that runs posteriorly, concentric with the dorsal edge of the orbit, and, gradually increasing in height, terminates in a spine. This spine lies posterior to the transverse commissure formed by the fusion, in the middle line, of the fourth primary tubes of the supraorbital canals of opposite sides, and overhangs the seventh or terminal tube of the supraorbital canal. It is accordingly the frontal spine of the fish, and the narrow ridge that terminates in it is the frontal spinous ridge. The third primary tube of the supraorbital canal opens on the dorsal surface of the frontal, lateral to this frontal ridge, at about the middle point of the orbit.

The hind border of the supraorbital commissure is marked by a slight ledge, that part of the dorsal surface of the skull that lies posterior to the ledge lying at a slightly deeper level than the part that lies anterior to it. The frontal spinous ridge, curving postero-laterally, crosses the lateral end of the transverse ledge, and at this point, or from the mesial surface of the frontal ridge slightly posterior to it, the parietal spinous ridge begins. Running backward and slightly laterally from there, the parietal ridge terminates in the parietal spine, that spine lying directly above the supratemporal cross-commissural canal. The anterior end of the parietal ridge lies on the hind edge of the frontal, the remaining and larger part of it lying on the parieto-extrascapular. Immediately posterior to the parietal spine, a short ridge begins on the dorsal surface of the extrascapular part of the parieto-extrascapular, and, continuing the line of the parietal ridge, terminates, at the hind end of the skull, in the nuchal spine.

The nasal, frontal, parietal and nuchal spines of Sebastes thus form a row of spines on the dorsal surface of the skull that is strictly comparable to the middle row of spines in Scorpaena, but, as will

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be explained below, the frontal spine has been displaced laterally to such an extent that it might be mistaken for one of the lateral row of spines.

The parietal spinous ridge and the transverse commissural ledge bound laterally and anteriorly a flat smooth median portion of the dorsal surface of the brain case, this surface lying at a slightly lower level than the anterior part of the dorsal surface of the skull. This flat and slightly depressed surface thus certainly represents a slightly developed subquadrangular groove on the vertex of the skull of the fish, notwithstanding that Günther ('60, vol. 2, p. 95) says that all members of this family are without that groove. Posteriorly, this slightly developed groove is bounded by a slight transverse ridge which lies on the dorsal surface of the parieto-extrascapular of either side, near its hind edge. This ridge extends to the mesial edge of either parieto-extrascapular, but as these bones do not meet in the middle line, the ridge does not extend entirely across the hind edge of the skull. The ridge marks the course of a portion of the supratemporal commissure, the median portion of that commissure lying in the dermal tissues, between the ridges of opposite sides, in a slight groove on the flat dorsal surface of the supraoccipital. The slightly depressed surface that represents the subquadrangular groove is thus not bounded posteriorly by a complete ridge, as in Scorpaena, simply because the median portion of the supratemporal commissure is not here enclosed in bone.

The lateral row of spines is represented by five spines. The anterior spine of the row is the preocular spine, lying on that edge of the ectethmoid that forms the anterior portion of the roof of the orbit. The next two spines of the row are the supraocular and postocular ones, both of which lie close together, one directly behind the other, on the dorsal surface of the roof of the orbit, near its lateral edge, and immediately anterior to the frontal spine. In the specimen used for illustration the postocular spine is bifid on one side of the head, and, anterior to the supraocular spine, there is a small additional spine. The supraocular and postocular spines, as normally found, together with the frontal spine form a short line of three spines lying close together and equidistant one from the other, and they correspond in position to the supraocular, postocular and tympanic spines of Jordan & Gilbert's diagram of the spines in Sebastodes. The frontal spine however belongs, as just above described, to the middle row of spines and not to the lateral one. The remaining two spines of the lateral row are small ones that hardly rise above the outer surface of the body, one of them lying on the hind edge of the suprascapular and the other on the hind edge of the supraclavicular. On the pterotic there is a ridge, but it does not end in a spine.

The intermediate row of spines is represented by a small spine on the hind edge of the epiotic process of the suprascapular, this spine lying slightly mesial to the suprascapular spine of the lateral row.

The bones of the snout of Sebastes differ in no important respect from those of Scorpaena scrofa. The mesethmoid processes, as already stated, are shorter than in Scorpaena, and are directed forward instead of upward and forward. The nasals are traversed by the supraorbital latero-sensory canal, and are relatively larger than in Scorpaena. The lateral arm of the ectethmoid is not differentiated from the wing of the bone, as it is in Scorpaena, the ventral edge of the wing being simply thickened and giving articulation, by two articular surfaces, to the lachrymal and palatine. The vomer has, on either side, an ascending process, which gives articulation, as in Scorpaena, by the intermediation of a disk of semi-cartilaginous tissue, to the ascending process of the maxillary. The maxillary has a right-angled ascending process and a ligamentary process, the former articulating both with the premaxillary and the vomer, and the latter giving support to the lachrymal and palatine, as in Scorpaena. The rostral is more deeply grooved on its ventral surface than in Scorpaena.

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There are naso-maxillary, ethmo-maxillary, intermaxillary, rostro-palatine, rostro-nasal, rostro-maxillary, vomero-palatine, lachrymo-palatine and maxillo-mandibular ligaments, as in Scorpaena. And, in addition to these ligaments, there were, in the large specimen of Sebastes that was particularly examined, other well-developed ligamentous or fibrous bands that were not evident in the fibrous and connective tissue that, in the smaller specimens of Scorpaena that were examined, connected the several bones. One of these fibrous bands extended from the dorso-anterior edge of the ascending process of the maxillary to the mesial surface of the maxillary process of the palatine; and, lying on the dorsal surface of this wide band, a flat ligament extended from the same point to the anterior edge of the lachrymal. Another ligament extended from the proximal end of the shank of the maxillary into the angle between the ascending and maxillary processes of the premaxillary, binding these two bones together in the region of their articular surfaces. The naso-maxillary ligament, in this fish, spreads at its anterior end, and is there inserted partly on the anterior edge of the lachrymal as well as on the ligamentary process of the maxillary.

The frontal has a ventral flange as in Scorpaena.

The alisphenoid has slight ridges on its outer surface which represent those two little processes of the bone of Scorpaena that form, in that fish, ossified portions of the parasphenoid leg of the bone. The bone is traversed by a canal which transmits the nerve that innervates the terminal or sixth organ of the supraorbital canal, this canal beginning on the outer surface of the skull in the sutural line between the alisphenoid and proötic, and from there running upward in the alisphenoid to about the middle point of the bone, where it opens into the cranial cavity.

The trigemino-facialis chamber and related nerves are as in Scorpaena. On the outer surface of the proötic, immediately ventral to the trigemino-facialis chamber, the dorsal end of the first infrapharyngobranchial is strongly attached by fibrous tissues. The pedicle of the basisphenoid is straight, instead of being strongly curved. The myodome has proötic and basioccipital portions, and opens posteriorly onto the ventral surface of the basioccipital. The sphenotic is perforated, from its orbital face, by the oticus canal, this canal crossing the mesial end of the dilatator fossa and transmitting the oticus lateralis accompanied by a more slender nerve which runs backward into the temporal fossa. The dilatator fossa is relatively larger than in Scorpaena, but has no appreciable roof excepting along its anterior edge where it is roofed by the small postfrontal bone.

The dorsal surface of the pterotic is deeply excavated by the main infraorbital canal, the section of canal that is related to it being roofed only by a single narrow and delicate bridge of bone. Anterior to this bridge, and lying partly on the sphenotic and partly on the frontal, there is a large groove which lodges those portions of the main infraorbital and supraorbital canals that adjoin their point of anastomosis. Posterior to the pterotic bridge, between it and the anterior edge of the lateral extrascapular, there is a smaller, but still relatively large opening which is the latero-sensory opening between the pterotic and lateral extrascapular. The narrow pterotic bridge, and the narrow pterotic edges of the large groove that lodges the main infraorbital canal represent all there is of the outer, dorsal surface of the dermo-pterotic.

The lateral extrascapular is a delicate bone that covers a part only of the temporal fossa. It is traversed by the main infraorbital and supratemporal canals, both of which canals are large. The main infraorbital canal lies mainly in a deep groove on the lateral edge of the bone, the canal being wholly enclosed, at one point only, by a narrow bridge of bone. The anterior corner of the bone rests on the dorsal surface of the pterotic, and its posterior corner on the dorsal surface of the

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suprascapular. Elsewhere the bone is entirely suspended in dermal tissues. Between its anterior edge and the adjoining edges of the pterotic and parieto-extrascapular, there is a large circular opening which leads directly into the anterior end of the temporal fossa.

The suprascapular has opisthotic and epiotic processes, the former process resting on and being bound by tissues to an eminence on the hind end of the opisthotic. The epiotic process rests on the dorsal surface of the suprascapular process of the epiotic, its anterior end apparently coming into contact with, but not being completely overlapped dorsally by the hind end of the parieto-extrascapular. The lateral edge of the bone is traversed by the main infraorbital canal, and gives articulation, on its ventral surface, to the dorso-anterior corner of the supraclavicular; there here being, as in Scorpaena, two articular surfaces, an articular head, and a closely adjacent articular facet.

The supraclavicular resembles the bone of Scorpaena. Its dorsal edge is traversed by the main infraorbital canal. Near its anterior edge, at or about its ventral third, it gives insertion to the occipito-supraclavicular ligament.

The parieto-extrascapular, in the two specimens examined, did not meet, in the mid-dorsal line, its fellow of the opposite side. In one of these two specimens the two bones were widely separated: in the other, a much smaller specimen, they approached each other closely at their antero-mesial corners. A considerable, but varying portion of the dorsal surface of the supraoccipital thus here comes to the dorsal surface of the skull, and on its hind edge the median portion of the supratemporal commissure lies, enclosed in dermal tissues only. The hind edge of the parieto-extrascapular overhangs but slightly the posterior surface of the skull, giving rise to a shallow supratemporal pocket.

The supraoccipital has a spina occipitalis similar to that of Scorpaena, its ventral end being held, as in Scorpaena, but to a less extent than in that fish, between thickened process-like portions of the exoccipitals. The posterior surface of the bone is crossed, as in Scorpaena, by what I there described as the hind edge of the primary skull, this edge being represented in its lateral portion by a strong ledge, but in its median portion by a low and rounded ridge.

The temporal fossa is large, and similar to that in Scorpaena; but a large circular opening between the pterotic, lateral extrascapular and parieto-extrascapular leads from it onto the dorsal surface of the skull.

The epiotic, opisthotic, exoccipital, and basioccipital are similar to those bones in Scorpaena. The exoccipital has a mesial process on its cerebral surface, as in Scorpaena. The proötic, in the specimen used for illustration, was perforated, on one side, by two small foramina lying immediately beneath the trigemino-facialis chamber, due doubtless to wear or to defects in the bone.

The bulla acustica is large, and in the angle that marks its dorsal boundary there are separate glossopharyngeus and vagus foramina, the glossopharyngeus foramen lying in the exoccipital on one side of the specimen examined in this connection, but in the sutural line between that bone and the proötic on the other side of the specimen. Posterior to the vagus foramen, the exoccipital is pierced by a foramen for the occipital nerves, as in Scorpaena.

The infraorbital chain of bones includes a lachrymal, two suborbitals and two postorbitals. The lachrymal and two suborbitals correspond to the sames bones of Scorpaena, but they are much narrower and more delicate than in that fish. The two postorbitals are delicate semicylindrical bones that extend from the dorsal edge of the second suborbital to the ventral edge of the postfrontal and bound the hind edge of the orbit. They transmit the main infraorbital canal from the second sub-

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orbital to the postfrontal, the canal here forming a continuous suborbital ring, instead of being interrupted as in Scorpaena. The orbital edges of the lachrymal and two suborbitals are broadened to form a flat, curved and delicate suborbital shelf.

The lachrymal articulates, by its dorsal edge, with the ectethmoid. Its ventro-anterior corner rests upon, and is firmly bound to the ligamentary process of the maxillary, the dorso-mesial portion of its anterior edge resting upon the dorsal surface of the maxillary process of the palatine. At the hind end of this surface of contact with the palatine a short stout ligament connects the two bones. Posterior to the point of attachment of this ligament, between it and the articular surface for the ectethmoid, the large anterior primary tube of the main infraorbital canal opens on the external surface of the bone. The second and third tubes of the main infraorbital canal issue from that canal as it traverses the lachrymal, the fourth tube issuing between the lachrymal and first suborbital, as in Scorpaena. The anterior edges of the second and third tubes, one or both, are produced in short sharp spines, these being the only spines on the infraorbital chain of bones. The fifth tube opens on the lateral surface of the second suborbital bone, and the prolonged hind end of the dorsal edge of this tube reaches and is bound to the preopercular. The sixth tube lies between the dorsal edge of the second suborbital and the ventral end of the first postorbital, the seventh tube lying between the two postorbitals, and the eighth tube between the second postorbital and the postfrontal.

The hyomandibulo-palato-quadrate apparatus does not differ in any important respect from that of Scorpaena. The opercular process of the hyomandibular is not so long as in Scorpaena. The preopercular has five spines on its hind edge; but the second spine from the dorsal edge of the bone, instead of the first one, is the longest, and there is no supplementary spine either at the base of this spine or at the base of the dorsal spine, as there is in Scorpaena. The quadrate has a posterior process, the posterior surface of which is applied against and firmly bound to the ventral end of the preopercular. On the inner surface of the quadrate there is a symplectic groove which lodges the ventral portion of the symplectic. The metapterygoid has lateral and mesial flanges on its hind edge, both of which are connected with the anterior edge of the hyomandibular, as in Scorpaena: but these flanges of Sebastes do not meet to form a dorsal prolongation of the hind edge of the bone, and there is no continuation of the flanges along the dorso-anterior edge of the bone, as in Scorpaena. The ectopterygoid and entopterygoid differ but little from those of Scorpaena. The palatine is relatively shorter than in Scorpaena, and its ventral process is not so tall as in that fish. The opercular, subopercular and interopercular are as in Scorpaena.

The mandible has articular, angular and dentary elements, closely resembling those of Scorpaena.

III. Cottus octodecimospinosus.

The skeleton of the head of Cottus octodecimospinosus differs considerably, in several important respects, from that of Scorpaena and Sebastes.

1. SKULL.

The skull as a whole is relatively low and flat, and the brain case is relatively long, occupying nearly one half the length of the skull. The bones of the skull are all much thinner and more delicate than those of Scorpaena and Sebastes, the brain case being little more than a thin shell of bone.

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The postorbital process of the skull is a short broad pyramidal process which lies at the anterior two-fifths, approximately, of the length of the brain case, and in the dorsal two-fifths only of the lateral surface of the skull. The process, as always, separates the orbital and lateral surfaces of the brain case, but these two surfaces here lie in nearly the same plane, the postorbital process forming simply a large ridge and not a marked angle between them, as it does in Scorpaena. Because of the position of the orbital surface of the brain case, so slightly inclined to its lateral surface, and because, also, of the absence of a basisphenoid, the orbital opening of the brain case is very large. The postorbital corner of the frontal lies in the transverse plane of the lateral bounding edges of the orbital opening of the brain case, considerably anterior to the postorbital process of the skull.

The postorbital process is formed, as usual, by portions of the proötic and sphenotic bones, and it bears a large circular facet for the anterior head of the hyomandibular. Starting from the base of the process, an angular edge runs antero-laterally toward the antero-ventral corner of the brain case, another but much more rounded edge running postero-ventrally toward the hind end of the brain case. Between these two edges and the base of the skull there is a flat smooth and raised portion of the lateral surface of the brain case, the flat bulla acustica forming the rounded dorso-posterior edge of the surface.

Anterior to this flat surface and to the postorbital process, there is a depressed region which forms the orbital surface of the brain case. Dorso-posterior to the flat surface there is, on the lateral surface of the brain case, a large triangular subtemporal depression, similar to but more extensive than the one in Scorpaena, the depression here reaching almost to the dorsal edge of the lateral surface of the skull. Anterior to this subtemporal depression, between it and the postorbital process, there is a shallow groove, which apparently represents the fossa there found in Scorpaena. In the postero-ventral corner of the subtemporal depression is the vagus foramen, the glossopharyngeus foramen lying slightly anterior to it at the ventral edge of the depression; both foramina perforating the exoccipital. The anterior corner of the subtemporal depression is shut off from the orbital surface of the brain case by the base of the postorbital process, and does not, as in Scorpaena, connect, by a groove, with the facialis opening of a trigemino-facialis chamber. Dorsal, or dorso-anterior to the dorsal corner of the subtemporal depression is the small oval facet for the posterior articular head of the hyomandibular, this facet lying wholly on the pterotic.

The DILATATOR FOSSA is small, lies directly anterior to the posterior articular facet for the hyomandibular, and almost directly dorsal to the anterior articular facet for that bone. The fossa lies partly in the sphenotic and partly in the pterotic, and is roofed by the pterotic alone, the postfrontal here lying wholly anterior to it.

The TEMPORAL FOSSA is small, and five of the six fossae in my three specimens open mainly on the lateral surface of the skull, between the opisthotic leg of the suprascapular and the posterior process of the pterotic. The usual opening, on the posterior surface of the skull, between the opisthotic leg of the suprascapular and the epiotic, is, in four of these five instances, reduced to a small opening, and in one instance almost entirely closed.

This reduction of this opening is due to the encroaching ingrowth of both the epiotic and the opisthotic leg of the suprascapular, but mainly to the marked broadening of the latter leg. When the suprascapular is removed the hind end of the fossa is found to be fairly large, and to lie at the extreme dorso-lateral corner of the hind end of the skull. The fossa, thus exposed, seems short when

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viewed from above, but this is largely due to the marked elongation of the brain case; for the fossa extends from the hind end of the skull about halfway to the postorbital process, which is about its normal length. At about the middle of its length the fossa is bridged by the narrow and tubular, mesial one of the two lateral extrascapular ossicles found in this fish. Posterior to this bridge, the central portion of the fossa is without roof, its mesial edge being slightly overhung by the lateral edge of the epiotic, and its lateral edge being roofed by the lateral one of the two lateral extrascapular ossicles. Anterior to the bridge, the fossa is wholly without roof. The posterior opening of the fossa is roofed, as usual, by the suprascapular and the suprascapular process of the epiotic. The fossa thus opens on the dorsal surface of the skull by two large openings. In the mesial wall of the posterior portion of the fossa there is a pronounced preëpiotic recess.

The SUPRATEMPORAL FOSSA is as in Scorpaena, but much smaller.

There are, as is well known, three SPINES on either side of the dorsal surface of the skull, and one on the supraclavicular. The three spines on the dorsal surface of the skull form a row that corresponds to the mesial row of spines of Scorpaena, the supraclavicular spine being the only one of a lateral row.

Of the three spines that form the mesial row, the anterior one lies on the dorsal surface of the hind end of the nasal, and, projecting backward, overhangs the opening of the second primary tube of the supraorbital latero-sensory canal. The next posterior spine of the row lies on the dorsal surface of the frontal, and its relations to the supraorbital canal show that it is a frontal spine. It lies, however, near the postorbital corner of the frontal, considerably anterior to its hind edge, this position thus differing considerably from that of the frontal spine in either Scorpaena or Sebastes.

The base of the spine, in Cottus, overlies that part of the supraorbital canal that lies between the fifth and sixth tubes of that line, and projects backward toward the seventh tube or between that tube and the fifth tube. The sixth tube anastomoses with the main infraorbital canal, and it was double in each of the two specimens examined, the fifth tube being also double in one specimen. There is no spinous interorbital ridge related to the frontal spine.

From the base of the frontal spine a strong ridge begins, the occipital ridge of Jordan and Evermann's ('98) descriptions, and running backward in a curved course across the posterior portion of the frontal and then across the parieto-extrascapular, ends, at the hind end of the latter bone, in a stout spine. This spine lies partly above but mostly posterior to the supratemporal canal, its position thus not definitely indicating whether it is a parietal or a nuchal spine. It is however, in all probability, a spine developed in relation to the parietal bone, and hence a parietal spine, the ridge that terminates in it then being a parietal ridge.

The parietal ridges of opposite sides lie relatively widely apart, and that part of the dorsal surface of the skull that lies between them is flat, and corresponds to the subquadrangular groove on the vertex of Scorpaena; but here, in Cottus, there is, aside from the presence of parietal spinous ridges, no indication whatever of a groove; for the region is not depressed and there are no anterior and posterior bounding ridges whatever.

The supraclavicular spine projects posteriorly from the dorso-posterior corner of the supraclavicular, ventral to the section of latero-sensory canal that traverses the bone.

The MESETHMOID is, in all my specimens, a relatively delicate bone that extends but slightly into the underlying cartilage. It has, on either side, a short stout mesethmoid process which is directed

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antero-laterally and gives attachment, on its outer end, to the ethmo-maxillary ligament. The latero-posterior, or ventro-latero-posterior, surface of the process gives support to a process on the hind end of the nasal bone, the latter bone being strongly bound to the mesethmoid process by fibrous tissues.

The ECTETHMOID has a body of delicate perichondrial bone, and a stout lateral process which corresponds to the wing and arm together of the bone in Scorpaena. On the ventral edge of this lateral process there is a single large condylar eminence, which gives articulation to the lachrymal alone, the palatine not anywhere coming into articular relations with the ectethmoid. Lateral to this articular eminence, the ventro-lateral corner of the lateral process is free. On the antero-dorsal surface of the bone there is a short but relatively large process which projects antero-mesially and gives support, on its summit, to the lateral end of a lateral process on the hind end of the nasal, this process of the nasal being strongly bound to the ectethmoid process by fibrous tissues. Between this ectethmoid process and the mesethmoid process, the lateral process of the nasal bridges the hind end of the olfactory depression, lying between the two nasal apertures. In Scorpaena scrofa, as already stated, this nasal process of the ectethmoid of Cottus is apparently represented by an eminence, or short spine, sometimes but not always found on the ectethmoid of that fish.

The VOMER has a short dorsal limb formed of thin bone, of perichondrial appearance, which comes into contact posteriorly with the perichondrial portions of the three ethmoid bones. A raised portion on the ventral surface of the anterior end of the bone bears a band of villiform teeth which extends, uninterruptedly, from one side to the other.

The PREMAXILLARY has large ascending and articular processes, the former resting on the dorsal surface of the rostral, and the latter articulating with the maxillary, as in Scorpaena. The body of the bone is shorter than in Scorpaena, extending but half the length of the maxillary and ending practically at the hind edge of its own postmaxillary process; the posterior half of the body of the bone of Scorpaena being represented, in Cottus, by tough gristly tissue. The oral surface of the bone of Cottus is furnished nearly its full length with small villiform teeth.

The MAXILLARY has a stout, right-angled ascending process which articulates with the premaxillary and, through the intermediation of a pad of semi-cartilaginous tissue, with the dorsal limb of the vomer. The antero-mesial (proximal) end of the ligamentary process is well-developed and gives insertion to the ethmo-maxillary ligament. The postero-lateral (distal) end of the process is represented by a slight eminence which gives insertion to the maxillo-mandibular ligament, this ligament having a course, and an insertion on the articular, similar to that in Scorpaena. Between these two ends the ligamentary process is but slightly if at all developed, but the dorsal surface of the shank of the bone here gives articulation to the enlarged anterior end of the maxillary process of the palatine. The ventral edge of the anterior end of the lachrymal here also comes into slight contact with the maxillary, but the lachrymal is here bound to the palatine alone, and is not supported by, and bound to the maxillary, as in Scorpaena.

The NASAL has, as already stated, a lateral process on its hind end, this process giving to the hind end of the bone an expanded appearance. This expanded hind end of the bone is bound mesially to the mesethmoid process, and laterally to the nasal process on the dorso-anterior surface of the ectethmoid, thus bridging a part of the nasal pit. The bone is traversed by the supraorbital latero-sensory canal and lodges one organ of that line. No part of the canal traverses the process that bridges the nasal sac.

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The FRONTAL has a well developed ventral flange which comes into contact with the alisphenoid and sphenotic, and possibly also, in some specimens, with the dorsal end of the ascending process of the parasphenoid; but the exact relations of the bones here could not be determined, for their outlines were not distinct in either of my three skulls, and I could not disarticulate the bones in the one skull that I could spare for the purpose. Posterior to this ventral flange, there is a smaller flange on the ventral surface of the frontal, the two flanges embracing the dorsal edge of the alisphenoid, and the small posterior flange forming the dorsal portion of a partition between the fore and midbrain recesses of the cranial cavity. The ventral flanges of the frontals of opposite sides are relatively widely separated from each other and form the lateral boundaries of the dorsal portion of the wide orbital opening of the brain case.

The frontal is bounded posteriorly by the parieto-extrascapular and supraoccipital. Anterior to the latter bone it rests directly upon the postepiphysial cartilage, this part of the bone, and also the part that lies immediately anterior to it, being so thin as to be almost transparent. The hind end of the lateral edge of the bone is bounded by the pterotic, and anterior to that bone is in contact with a corner of the postfrontal.

The bone is traversed by the supraorbital canal and lodges five organs of that line, a primary tube leaving the canal between each adjoining two of the five organs. There is thus one tube more in this fish than in Scorpaena, this seeming to confirm the conclusion that a tube has disappeared in the latter fish, as already explained. The fifth frontal organ of Cottus, the sixth one of the line, lies in the small terminal tube of the canal, is well developed, and is innervated by a branch of the ophthalmicus lateralis that pierces the skull from the outside and has an intracranial course, as in Scorpaena. The penultimate, or sixth tube of the line anastomoses with that tube of the main infraorbital canal that lies between the postfrontal and pterotic.

The POSTFRONTAL has a postorbital position, and is, in appearance, the dorsal one of two postorbital bones. This bone, however, lodges the anterior one of the two infraorbital sense organs that are innervated by the ramus oticus, this definitely identifying it as a postfrontal. The hind end of the dorsal edge of the bone lies on the dorsal surface of the sphenotic, the anterior and larger part of this edge of the bone abutting against the lateral edge of the postorbital part of the frontal.

The PARIETO-EXTRASCAPULAR is traversed, near its hind edge, by the mesial section of the supratemporal latero-sensory canal, and bears at its hind edge the parietal spine. It lodges one organ of the supratemporal commissure.

The LATERAL EXTRASCAPULAR is usually represented by two ossicles, one traversed by the main infraorbital latero-sensory canal, and the other by the lateral section of the supratemporal canal, but in one of the two fishes examined, the two ossicles were fused to form a single bone. The ossicle that lodges the lateral section of the supratemporal canal bridges the temporal fossa, the other ossicle roofing the lateral portion of the postcommissural portion of the same fossa; the commissural ossicle lying at the anterior end of the infraorbital ossicle. Each ossicle lodges a single organ of the related latero-sensory line.

The SUPRASCAPULAR has a stout, pointed epiotic process which rests upon the dorsal surface of the suprascapular process of the epiotic; and a short, stout and broad opisthotic process. The latter process is directed downward and forward, its flat surface lying in a somewhat transverse

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position, and, on one side of one of my three specimens, it almost entirely closed not only the posterior but also the lateral opening of the temporal fossa, leaving only small openings on either side of it. On the other side of that one specimen, and on both sides of the two other specimens, the opening lateral to the process was the larger of the two, the opening mesial to the process being practically closed in one of the two specimens. Mesial to the base of the opisthotic process there is, on the under surface of the bone, an articular facet, and directly posterior to the base of the process there is an articular eminence; the two surfaces giving articulation to the supraclavicular. The body of the bone is traversed by the main infraorbital canal and lodges one organ of that canal, innervated by a branch of the supratemporal branch of the nervus lineae lateralis. The bone is without spine.

The SUPRACLAVICULAR has, on the anterior corner of its dorsal edge, a facet which gives articulation to the articular eminence on the under surface of the suprascapular. From the mesial surface of this part of the bone a process arises, directed antero-mesially, and on its anterior end it has an articular eminence which articulates with the articular facet on the suprascapular. The dorsal edge of the bone is traversed by a short section of the main infraorbital latero-sensory canal and lodges one organ of that line. The posterior corner of the bone is prolonged into the stout supraclavicular spine.

The PARASPHENOID has, on either side, a tall and broad ascending process with two dorsal ends. These two dorsal ends are pointed and separated by a large V-shaped incisure in my small specimens, but bifid and separated by a shallow depression in the large specimen used for illustration. The posterior and shorter end, or point is directed toward, and nearly reaches the trigeminus foramen, and is in contact with and firmly bound to the proötic. The anterior and longer point is in contact with and firmly bound to the alisphenoid, and almost, if not quite reaches in certain specimens the ventral edge of the ventral flange of the frontal. These two ends, or points, belong respectively to posterior and anterior portions of the ascending process, and between the two portions the outer surface of the process is quite concave, its inner surface being correspondingly convex. Between the posterior portion of the process and the body of the parasphenoid there is a normal internal carotid foramen.

On the dorsal surface of the parasphenoid, between the bases of the ascending processes, there is a raised median portion on the dorsal surface of which there is a relatively large median pit, the point of the pit directed downward and backward. The pit gives insertion to the recti interni muscles. Immediately posterior to it there is a depressed region on the dorsal surface of the bone, and then a raised median rib, this rib lying between the ventral edges of the proötics of opposite sides and forming the median portion of the floor of the myodome.

The ALISPHENOID is bounded posteriorly by the sphenotic and proötic, with both of which bones it is in synchondrosis. Antero-dorsally it is overlapped externally by the ventral flange of the frontal, and ventrally it is in contact with the anterior portion of the ascending process of the parasphenoid. It has short but broad basisphenoid and parasphenoid legs, these two legs enclosing a V-shaped groove which begins at nothing, at the anterior end of the ventral edge of the bone, and deepens gradually toward its hind end. The external bounding plate of this V-shaped groove is the parasphenoid leg of the bone and is the part of the bone that is in contact with the ascending process of the parasphenoid. The internal bounding plate of the groove is the basisphenoid leg of the bone,

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and it projects ventro-mesially into the cranial cavity of the prepared skull and terminates with a free edge.

The hind edges of the two legs of the alisphenoid are in contact with the anterior edges of corresponding plates of bone on the ventral edge of the orbital portion of the proötic; and these two plates of this part of the proötic may for convenience be called the parasphenoid and basisphenoid legs of the orbital part of that bone. The basisphenoid leg corresponds to that part of the external surface of the proötic of Scorpaena that forms the mesial wall of the jugular groove on the orbital surface of the bone; the parasphenoid leg corresponding to the membrane that spans that groove and was referred to, when describing Scorpaena, as a membranous anterior extension of the lateral wall of the trigemino-facialis chamber. This membrane having ossified, in Cottus, as part of the proötic, the jugular groove of Scorpaena becomes, in Cottus, a canal which opens anteriorly into the cranial cavity, while posteriorly it opens by a foramen-like opening onto the external surface of the proötic. The anterior end of the canal is much larger than its posterior end, and the canal is continuous anteriorly with the V-shaped space between the two legs of the alisphenoid, the two spaces together forming a recess in the cranial cavity which may be called the internal jugular recess. The internal jugular vein and the truncus ciliaris profundi enter this recess at its anterior end, and, running posteriorly, issue through the foramen-like opening at its hind end. This latter foramen is accordingly an internal jugular foramen, but it is not the strict homologue of the foramen that I have described as the internal jugular foramen in one specimen of Scorpaena; for the foramen in Cottus is bounded by the proötic and the parasphenoid alone, while in Scorpaena it is bounded by the alisphenoid, the proötic and the parasphenoid. The foramina in the two fishes result, however, from the bridging of one and the same canal by a bridge of bone that is narrow in one fish and wide in the other.

On the internal surface of the alisphenoid of Cottus, there is, as in Scorpaena, a brace-like flange, which lies between the fore-brain and mid-brain recesses of the cranial cavity. In Cottus this flange is thin and tall and forms, with a corresponding flange on the ventral surface of the frontal, a somewhat important partition between the dorsal corners of the two recesses.

The alisphenoid is perforated, in its antero-ventral portion, by a foramen which varies considerably in position in my specimens. It transmits the lateralis nerve destined to innervate the 6th. or terminal organ of the supraorbital canal, the nerve always being accompanied by a blood vessel. Whether other than lateralis fibers form part of the nerve was not investigated. The nervus trochlearis passes across the free edge of the alisphenoid without perforating it.

The SPHENOTIC is normal in position and forms, as usual, the dorsal portion of the facet for the anterior articular head of the hyomandibular and the anterior portion of the dilatator fossa. The oticus canal enters the bone on its orbital surface, and traversing the bone opens into the bottom of the dilatator fossa. A flange on the cerebral surface of the bone forms part of the anterior bounding wall of the labyrinth recess. The dorsal surface of the bone is almost entirely covered by the frontal and pterotic, comes nowhere to the level of the dorsal surface of the skull, and gives support to a part only of the dorsal edge of the postfrontal.

The PROÖTIC differs in certain important respects from the bone in Scorpaena and Sebastes. One of these differences is the enclosing of the internal jugular groove, and has just above been described. The other relates to the trigemino-facialis chamber, and is described below. The bone is

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bounded as usual by the sphenotic, pterotic, exoccipital and basioccipital, and its ventral portion is overlapped externally by the parasphenoid. From the opisthotic it is separated by a considerable interval.

Immediately anterior to the base of the postorbital process, the proötic is perforated by two or three foramina, which transmit the profundus, trigeminus and facialis nerves; the profundus issuing alone through one of the foramina, where there are three, but issuing with the trigeminus where there are but two. The profundus foramen, when present, is a small canal which, running inward, either opens into the trigeminus foramen, or close to that foramen on the inner surface of the skull. The trigeminus foramen is the largest of the two or three and lies antero-dorsal to the facialis foramen, both foramina opening into a trigemino-facialis recess on the internal surface of the proötic, similar to the recess described in Scorpaena. This recess in Cottus is, however, relatively larger than in Scorpaena, and its floor as well as its roof is formed by a thin shelf-like flange of bone. The recess lodges, as in Scorpaena, the profundus ganglion and the ganglia formed on the communis and lateralis roots of the trigemino-facialis complex. The communis ganglion is a large, pear-shaped ganglion, and from it, two intracranial nerves arise. One of these nerves is the ramus palatinus facialis, which runs downward forward and mesially, perforates the horizontal ledge that forms the floor of the trigemino-facialis recess and then the prepituitary portion of the mesial process of the proötic, and so enters the myodome at its extreme dorso-lateral corner. The other nerve runs upward and backward, perforates the thin shelf of bone that forms the roof of the trigemino-facialis recess, and then continues upward and backward along the edge of the bony anterior wall of the labyrinth recess, until it reaches the roof of the cranial cavity. There it turns backward and mesially along the internal surfaces of the frontal and parieto-extrascapular, passes between those bones and the supraoccipital, and issues on the dorsal surface of the skull close to its hind edge and close to the median line. On one side of the one specimen examined, the thin roof of the trigemino-facialis recess was perforated by two foramina, the communis nerve just above described there doubtless arising from its ganglion by two strands. This nerve, in its general course, closely resembles the so-called lateralis accessorius of Gadus and Silurus, and, like the palatine, must consist largely, if not entirely of communis fibers.

In addition to these two intracranial nerves, two large nerve trunks and the smaller truncus ciliaris profundi arise from the complex and issue by the two or three foramina in the proötic. One of the two trunks is the root of the trigeminus accompanied by lateralis and communis fibers, and this root is closely accompanied by the truncus ciliaris profundi. The other trunk is the root of the facialis accompanied by lateralis and communis fibers. The truncus ciliaris profundi separates from the root of the trigeminus while still inside the cranial cavity and either issues through the trigeminus foramen, or through a separate and independent profundus foramen. It then enters the internal jugular canal through its posterior opening, and traversing that canal enters and traverses the anterior end of the myodome, and so issues in the orbit. The root of the trigeminus swells into a ganglion either as it traverses its foramen or wholly but immediately beyond that foramen, the trigeminus ganglion thus being largely or wholly extracranial in position. The facialis passes close to the hind end of this extracranial ganglion, and, as in Scorpaena, receives from its hind end a large communicating branch. Associated with the trigeminus ganglion and lying immediately ventral to it, there is, as in Scorpaena, a large sympathetic ganglion, but this ganglion here lies on the external surface of the proötic. The jugular vein and external carotid artery both come into the same rela-

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tions with these two ganglia that they do in Scorpaena, but they here both lie along the external surface of the proötic.

There is thus, in Cottus, no bony trigemino-facialis chamber, the outer wall of that chamber being represented by membrane only, as it is in the 44 mm and 55 mm specimens of Scorpaena. But singularly enough, the outer wall of the internal jugular canal, which canal is simply an anterior prolongation of the trigemino-facialis chamber, has been ossified in Cottus, while in Scorpaena it is almost wholly membranous. In the specimen of Cottus used for the figure, two little eminences on the outer surface of the proötic indicate a partial ossification of the outer wall of the trigemino-facialis chamber. In the other two of my three specimens these eminences did not exist, the bone there being simply slightly hollowed where the trigemino-facialis foramina perforated it.

The proötic of Cottus has a perfectly normal mesial process, connected, by intervening cartilage, with its fellow of the opposite side. The prepituitary portion of the process is short, not reaching the middle line. The pituitary opening is thus not closed anteriorly by bone, and so forms an apparent part of the large orbital opening of the brain case. The membrane that closes the latter opening is greatly thickened in the optic and basisphenoid regions, and there becomes a thick, tough, fibrous structure the lateral edges of which are attached to both edges of the internal jugular recess. The nervus oculomotorius pierces this membrane, on either side, near its lateral edge and enters the myodome, lying, in this part of its course, between the ascending process of the parasphenoid and the basisphenoid membrane, and hence morphologically between the two legs of the alisphenoid; its normal position. A median, encephalic artery, formed by the union of the internal carotids of opposite sides, pierces the membrane near the anterior edge of the membranous pituitary fossa, and enters the cranial cavity.

The MYODOME is well developed; and it would seem as if the skull of this fish must have been unknown to Cope when he placed the Cottidae among those fishes in which the canal is wanting. The hind end of the canal is continued a short distance in the basioccipital, but it does not open posteriorly on the outer surface of the skull.

The PTEROTIC presents no features differing especially from those of the bone in Scorpaena, excepting that it lodges two sense organs of the main infraorbital line, one innervated by the ramus oticus and the other by the supratemporal branch of the nervus lineae lateralis vagi; the preopercular canal joining the main infraorbital between these two organs. The bone accordingly contains a post-preopercular latero-sensory ossicle, this ossicle not being found in either Scorpaena or Sebastes.

The BASIOCCIPITAL is much less deeply and extensively grooved by the posterior portion of the myodome than in Scorpaena, and the cavum sinus imparis is simply a shallow depression. The bone forms part of the boundary of the foramen magnum, as in Scorpaena, and otherwise resembles the bone in that fish.

The EXOCCIPITAL is perforated by three foramina, as in Scorpaena, but the occipital foramen is very small and represents a part only of the foramen of Scorpaena; a deep incisure in the hind end of the exoccipital, immediately dorsal to the base of its condylar process, transmitting the larger part of the nerves that traverse the occipital foramen in Scorpaena. The bone, as in Scorpaena, has a mesial process, which rests on the dorsal surface of the basioccipital and roofs the hind end of the saccular groove.

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The EPIOTIC has on its posterior surface, an epiotic ridge, which projects postero-laterally to an unusual extent and nearly meets the opisthotic process of the suprascapular; thus nearly or even quite closing the posterior opening of the temporal fossa.

The SUPRAOCCIPITAL has dorsal and ventral limbs, the former of which is largely exposed, on the dorsal surface of the skull, between the frontals and parieto-extrascapulars. The hind edge of the dorsal limb projects backward, forming a short horizontal plate-like process which slightly overhangs the ventral limb and rests upon, and is fused with, the dorsal edge of the spina occipitalis.

2. INFRAORBITAL BONES.

The infraorbital bones are, as in Scorpaena, four in number; a lachrymal, two suborbitals, and a postorbital.

The lachrymal is concave on its outer and convex on its inner surface. It has a short anterior edge, the ventral half of which lies upon the lateral edge of the broad anterior end of the maxillary process of the palatine, and is very firmly bound to it by tissue. The dorso-anterior corner of the bone bears, on its dorsal edge, a large concave articular facet which articulates with the articular head on the ventral edge of the lateral process of the ectethmoid. The mesial edge of this facet is greatly thickened and forms a stout process projecting mesially, the outer end of which is deeply grooved. The ventro-anterior surface of this process is rounded, and fits against and is firmly bound to the bottom of a unshaped depression on the external surface of the palatine; some slight motion being possible between the two pieces. The groove on the outer edge of the process is presented posteriorly, is free, and simply gives attachment to tissues of the region. The bone lodges two sense organs of the main infraorbital line, instead of three as in Scorpaena, the third and fourth organs of the line here both lying in the first suborbital.

The first suborbital is a short and irregular bone, and lodges two sense organs, instead of a single one, as in Scorpaena.

The second suborbital is long and extends backward to the anterior edge of the preopercular, either touching, or almost touching that bone, and being bound to it by tissue. A broad, low and rounded ridge extends the full length of its outer surface. The main infraorbital canal traverses the anterior two-fifths of the bone in a nearly horizontal position and then turns abruptly upward to enter the postorbital bone, giving off at the bend a short tube directed ventro-posteriorly, this tube being double in the specimen used for illustration. The bone lodges two sense organs, one lying anterior and the other posterior (here dorsal) to this tube. The posterior three-fifths of the bone, and the ridge on its outer surface, are thus not developed in any apparent relation to any of the tubes of the latero-sensory canal.

The postorbital bone is bound to the dorsal edge of the second suborbital at about the anterior two-fifths of its length, and it and the postfrontal form a slightly curved line which is convex anteriorly and directed upward and backward to join the dorso-lateral edge of the skull at the sutural line between the frontal and pterotic. The two bones lie slightly posterior to the orbit, the hind edge of the orbit being formed by a stiff membrane that is attached to the anterior edges of the two bones. The postorbital lodges a single latero-sensory organ.

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3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The PREOPERCULAR is a stout bone with dorsal and ventral limbs lying at somewhat more than a right angle to each other. In their natural positions the dorsal limb is directed dorso-anteriorly and the ventral limb ventro-anteriorly. The dorsal portion of the dorsal limb rests against and is firmly bound by tissue to the grooved hind edge of the hyomandibular, its dorsal end not extending beyond the opercular process of that bone. The ventral portion of the ventral limb rests against and is firmly bound to the grooved postero-ventral surface of the posterior process of the quadrate. Between these two portions of the preopercular a large and thin web of bone extends across the angle between the two limbs and supports, on its internal surface near its ventral end, that part of the hyomandibulo-symplectic interspace of cartilage on which lies the articular facet for the interhyal. Dorsal to that facet, the web of bone is thickened to form a process-like portion, and the edge of this portion is bound by tissue to the hind edge of the ventral portion of the hyomandibular. At the dorsal end of the web there is an incisure, through which, between the preopercular and the hind edge of the hyomandibular, the ramus hyoideus facialis passes from the outer to the inner surface of the apparatus.

The large and well known preopercular spine of the fish extends posteriorly in the direction of the ventral limb of the bone, and almost as a posterior continuation of that limb. A second one of the three preopercular spines lies directly ventral to this large one, either parallel with it, or directed ventro-posteriorly at an angle to it. The third preopercular spine arises from the ventral edge of the ventral limb of the bone, close to its anterior end. The bone is traversed its full length by the preopercular latero-sensory canal and lodges five sense organs of that canal.

The HYOMANDIBULAR has anterior and posterior heads for articulation with the cranium, and a very stout head for articulation with the opercular. The shank of the bone is relatively broad and thin, and the longitudinal ridge on its outer surface is short, but stout. The bone is traversed by a facialis canal, which opens on the outer surface of the shank anterior to the longitudinal ridge, and also by a short branch canal which opens on the outer surface of the bone posterior to the ridge. A large web of bone fills the angle between the anterior articular head and the shank of the bone, and is in contact with and is firmly bound by tissue to the hind edge of the metapterygoid.

The SYMPLECTIC has a broad flat dorsal end, and from there tapers rapidly into a long rod-like ventral portion which lies in the symplectic groove on the inner surface of the quadrate. There is a canal along its anterior edge, between it and the anterior edge of the symplectic groove on the quadrate, which transmits the ramus mandibularis internus facialis.

The QUADRATE has a stout and long posterior process which is separated from the body of the bone by a shallow incisure. Anterior to the dorsal portion of the process, between it and the symplectic, there is a long oval opening which transmits the ramus mandibularis externus facialis and the arteria hyoidea. The posterior process of the quadrate is so long that it almost completely shuts the preopercular off from bounding participation in this opening. Along the anterior edge of the base of the process there is, on the inner surface of the body of the quadrate, a symplectic groove. From the inner surface of the anterior edge of the bone a stout ligament arises and running forward joins the tendon $A_2 A_3$-A_ω.

The METAPTERYGOID is large and flat, and without evident flanges on its hind edge. This edge of the bone is however in contact with the anterior edge of the flange on the anterior edge of

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the hyomandibular, this contact being a characteristic of the flanges of the metapterygoids of Scorpaena and Sebastes, and not of the bodies of those bones. The bone is perforated, in Cottus, in its dorso-posterior portion, by a foramen which transmits the external carotid artery from the external to the internal surface of the palato-quadrate apparatus. Immediately internal to the foramen, the carotid falls into the arteria hyoidea at a sharp bend in that artery, the arteria hyoidea there turning almost directly backward to enter the opercular hemibranch. The arteria hyoidea, ventral to this bend, lies at first along the internal surface of the metapterygoid, but comes to the outer surface of the apparatus through a large fenestra between the metapterygoid, hyomandibular and symplectic. It then crosses the external surface of the symplectic and passes to the internal surface of the apparatus through the opening between the symplectic and preopercular, the mandibular artery being here given off, as in Scorpaena. The relations of these two arteries to the metapterygoid would thus be the same as those in Scorpaena, if those parts of the hind edge of the bone of Cottus that lie dorsal and ventral to the foramen for the external carotid represented respectively the internal and external flanges on the hind edge of the bone of Scorpaena; and this is certainly the case, the ventral edge of the internal flange abutting against and fusing with the dorsal edge of the external flange, and the foramen for the carotid, in Cottus, representing the greatly reduced V-shaped space between the two flanges in Scorpaena. The relatively large fenestra that transmits the arteria hyoidea is then the homologue of the small opening that transmits that artery in Scorpaena.

The efferent pseudobranchial artery is as in Scorpaena.

The ECTOPTERYGOID and ENTOPTERYGOID are in normal position, the latter bone being relatively long.

The PALATINE has a short body and a long but low ventral flange, this flange being wholly without teeth and its hind end being prolonged posteriorly in a tapering point which lies against the ventral surface of the dorsal limb of the ectopterygoid. On the lateral surface of the body of the palatine, anterior to the base of the process-like posterior extension of its ventral flange, there is a deep U-shaped depression, the legs of the U being directed posteriorly. In the posteriorly directed hollow of this U, the process on the mesial edge of the articular head of the lachrymal is received, and is firmly bound to it by tissues, some slight motion between the parts being possible. The body of the palatine is in synchondrosis posteriorly with a well formed rod of cartilage which lies along the dorsal surface of the dorsal limb of the ectopterygoid and connects the body of the palatine with that portion of the palato-quadrate cartilage that lies between the quadrate and metapterygoid.

The maxillary process of the palatine is stout and its distal end is expanded into a broad flat portion which rests upon and is firmly bound to the dorsal surface of the maxillary. At the base of the process there is a small process directed dorso-mesially. This process is strongly bound by tissue to the lateral edge of the ethmoid cartilage, but does not have articular contact with that cartilage. In Scorpaenichthys this process is large, and articulates with a large articular surface on the lateral edge of the ethmoid cartilage. In Cottus, the lateral surface of the little process gives insertion to the rostro-palatine ligament. The vomero-palatine ligament is relatively long, arises from the hind edge of the raised, toothed portion of the vomer, and running postero-laterally is inserted on the internal surface of the body of the palatine.

The anterior and posterior ethmo-palatine articulations are thus both wanting in Cottus, the posterior articulation being replaced by the articular connection of the palatine with the lachrymal.

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In Hydrocyon also, both articulations are wanting, according to Sagemehl ('84 b, p. 95), and in the Cyprinidae, according to the same author ('91, p. 582), the posterior articulation is replaced by an articulation of the entopterygoid with the ectethmoid.

OPERCULAR BONES.

The opercular is so firmly bound by articular ligaments to the stout opercular articular head of the hyomandibular that it is capable of but little movement. From its articular head a stout raised portion runs posteriorly or postero-ventrally across the outer surface of the bone and terminates in the stout opercular spine; the point of that spine extending slightly beyond the point of the large preopercular spine and lying slightly dorsal to it.

The subopercular is an angular bone that embraces the ventral corner of the opercular. It bears a short, small spine at its ventral corner.

The interopercular is long and tapering. Its broad hind end is bound by tissue to the ventral portion of the anterior edge of the subopercular, but it is separated from that edge by a considerable interval, bridged by a connecting sheet of tissue. Its pointed anterior end is bound by ligament to the lateral surface of the hind end of the mandible.

MANDIBLE.

The mandible is long and rather slender, and has angular, articular and dentary elements that offer no special peculiarities. The dentary lodges three latero-sensory organs, and the articular one organ. The summit of the coronoid process of the articular is separated by a considerable interval from the hind end of the dorsal limb of the dentary, the intervening space being filled by a tough pad of fibrous tissue. In the mandibular labial fold there is a gristly core, as in Scorpaena, but it is smaller than in that fish.

4. MUSCLES.

The adductor mandibulae of Cottus resembles closely that of Scorpaena. The superficial division, A_1, of the muscle arises from the anterior portion of the external surface of the preopercular and runs almost directly forward, lying external to the levator arcus palatini and to the deeper division, $A_2 A_3$, of the adductor. It terminates anteriorly in a tendinous band which extends the full length of its anterior edge and is inserted dorsally on the maxillary, while ventrally it joins and becomes part of the tendon $A_2 A_3$. The deeper division of the muscle, $A_2 A_3$, is incompletely separated into superficial and deeper portions, the superficial portion, A_2, lying superficial and ventral to the levator arcus palatini and the deeper portion lying internal to that muscle. The two muscles have their origins, as in Scorpaena, from the anterior portion of the external surface of the preopercular, ventral to the muscle A_1, and from the external surface of the palato-quadrate apparatus. Running almost directly forward, certain fibers of the muscle pass directly into the mandible and are continuous with the fibers of A_ω, others are inserted on the ventral end of the tendinous band that edges the anterior end of the muscle A_1, while the larger portion have their insertion on a tendinous structure that forms on the inner surface of the muscle and runs forward and downward into the mandible. In the mandible this tendon separates into four portions, two of which give origin to the fibers of A_ω, the other two lying one external to the other and having their insertions on the internal surface of the articular near the hind end of Meckel's cartilage. From

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this tendon, A_2A_3-A_ω, a ligamentous band runs backward and is inserted on the internal surface of the quadrate.

The levator arcus palatini runs downward internal to A_1 and then internal to A_2, lying always external to A_3 and also always external to the palato-quadrate. The course of the muscle is thus in accord with the conclusion, already stated, that the dorsal portion of the hind edge of metapterygoid of Cottus represents the inner one of the two flanges on the hind edge of the metapterygoid of Scorpaena.

The dilatator operculi arises partly in the dilatator fossa, but mainly on the external surface of the dorsal end of the hyomandibular and on adjacent portions of the preopercular, and is inserted on the opercular as in Scorpaena.

The adductor hyomandibularis, and adductor and levator operculi are as in Scorpaena, but the latter muscle is represented by several separate bundles of muscle fibers all of which extend from the dorso-lateral edge of the skull to the dorsal edge of the opercular or subopercular; the posterior bundles being delicate bands lying in the membrane that closes the dorsal end of the opercular opening.

5. LATERO-SENSORY CANALS.

The main infraorbital canal of Cottus traverses the four infraorbital bones without interruption, and then enters and traverses the postfrontal, at the dorsal end of which it anastomoses with the penultimate tube of the supraorbital canal. It then turns sharply backward and traverses in succession the pterotic, lateral extrascapular, suprascapular and supraclavicular. The lachrymal lodges two sense organs of the line; the first suborbital bone lodges two regular organs and, in the one specimen examined, what was apparently a much smaller and additional organ between the two regular organs; the second suborbital bone lodges two organs; and the postorbital bone one organ: all of these organs being innervated by branches of the buccalis lateralis. The number of organs in this part of the line, excepting the small and apparently supplemental organ in the first suborbital, is thus exactly the same as in Scorpaena, but the third latero-sensory ossicle has, in Cottus, fused with the fourth ossicle and so forms part of the first suborbital bone instead of fusing with the first and second ossicles to form part of the lachrymal.

The postfrontal lodges one organ, innervated by a branch of the oticus lateralis; the pterotic two organs, one innervated by the oticus lateralis and the other by a branch of the supratemporalis lateralis vagi; the lateral extrascapular and suprascapular one organ each, innervated by branches of the supratemporalis lateralis vagi; and the supraclavicular one organ, innervated by the first branch of the lateralis vagi. This part of the line thus differs from that in Scorpaena only in that the pterotic lodges an organ innervated by the lateralis vagi; the dermal component of that bone thus being formed by the fusion of two latero-sensory ossicles.

The supratemporal commissure lodges two sense organs on either side, one lying in the lateral extrascapular and the other in the parieto-extrascapular, both innervated by branches of the supratemporalis lateralis vagi.

The supraorbital canal traverses the nasal and frontal bones, and anastomoses by its penultimate primary tube with that infraorbital tube that lies between the postfrontal and pterotic bones. The canal contains six sense organs, one lying in the nasal and five in the frontal, all innervated by branches of the ophthalmicus lateralis. A primary tube leaves the canal between each two adjoining

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organs, there thus being one more tube than in Scorpaena, that additional tube lying between the fourth and fifth organs of the line. The fourth tube of the line anastomoses, in the middle line of the head, with its fellow of the opposite side, thus forming a frontal commissure, as in Scorpaena.

The preoperculo-mandibular canal traverses the dentary, articular and preopercular bones, but did not anastomose, at its dorsal end, in the one specimen examined, with the main infraorbital canal: this specimen thus differing, in this, from the specimen examined in connection with one of my earlier works ('04). It contains nine sense organs, three lying in the dentary, one in the articular and five in the preopercular, all innervated by branches of the mandibularis externus facialis.

Most if not all of the primary tubes branch one to several times after they leave the bones to which they are related and enter the cutis, but no interanastomoses of these tubes were found.

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II. CRANIOMI.

I. Trigla hirundo.

1. SKULL.

Of the Triglidae I have selected Trigla hirundo for detailed descriptions, a short separate description being also given of Trigla lyra. The other members of the family examined are referred to only as they differ markedly from hirundo.

The dorsal surface of the skull of Trigla hirundo consists of two portions lying at slightly different levels. The higher portion forms by far the larger part of the dorsal surface of the skull, extending from the anterior ends of the nasals to the hind ends of the suprascapulars, and being covered, in the recent state, by a thin cutis only. The deeper portion is small, forms the dorsal surface of the anterior end of the snout, and is covered, in the recent state, by the rostral and the dermal and connective tissues that surround that cartilage.

The bones that form the larger, higher portion of the dorsal surface are all firmly bound together, and present an even surface everywhere similarly marked with little granulations arranged more or less distinctly in lines or ridges. At its anterior edge this part of the skull projects, eaves-like, above the hind edge of the deeper, anterior portion, this giving to this higher part of the prepared skull somewhat the appearance of a carapace, or, to use the expression employed by Gill in his descriptions of Dactylopterus, a „bony casque". This casque-like dorsal portion of the skull is somewhat rectangular in general outline, this being more marked in medium-sized than in large specimens. Its anterior and posterior edges are deeply concave, and there are deep, sometimes almost semi-circular incisures for the orbits. The mid-dorsal line is slightly convex, the amount and manner of the convexity varying with the size of the specimen. In medium-sized specimens the mid-dorsal line is nearly straight from its hind end to the middle of the orbits. Then it curves slightly downward to the anterior end of the orbits, where it again becomes nearly straight, and so continues to its anterior end. In the large specimen used for the drawings, the interorbital portion is, on the contrary, markedly flat and straight and is joined by slightly rounded angles to the straight anterior and posterior portions of the surface.

The mid-ventral line of the skull is concave, and has, as the mid-dorsal line has, posterior and anterior portions that are nearly straight and that are separated by an obtuse and rounded angle. The whole skull thus appears bent downward in its anterior half.

On the anterior portion of the dorsal edge of the orbit there are, in all my medium-sized specimens, two backwardly directed spines, but in my two large specimens there is but one spine, a

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large one, with one or two adjoining eminences rather than spines. Near the hind edge of the orbit there is, in medium-sized specimens, a short and somewhat blunt spine, which is not evident in the large specimens. The only other spines found on the head of the fish are two spines, or eminences, on the hind edge of the preopercular, and two spines on the opercular; only one of these latter spines showing on the outer surface of the fresh head.

Between the orbits, in medium-sized specimens, the dorsal surface of the skull is deeply concave transversely, while in large specimens it is much less so; and in all specimens there is here no longitudinal ridge, on either side, to mark, as in Scorpaena, the course of the supraorbital latero-sensory canal. The crown of the head is flat, the subquadrangular groove on the occiput, so characteristic of the Scorpaenidae, being slightly indicated in my medium-sized specimens by two little tuberculated and longitudinal ridges, one on either side, on the dorsal surface of the parieto-extrascapular bone. These ridges are not evident in the large specimens. The preorbital portion of the skull is relatively long, low and broad, the casque-like portion of its dorsal surface here being convex transversely and having straight lateral edges which converge but slightly forward; the casque being two-thirds or even three-fourths as wide at its deeply concave anterior end as it is at the anterior edges of the orbits.

The curved anterior ends of the lachrymals project forward and mesially, on either side, beyond the anterior end of the skull, and, with the concave anterior end of the casque, nearly enclose a subcircular space in which the rostral lies. The anterior edge of the lachrymal is, in all my specimens, serrate rather than being, as stated by Günther ('60), furnished with prominent spines.

The dorsal surface of the casque is formed by the nasals, mesethmoid, ectethmoids, frontals, postfrontals, pterotics, parieto-extrascapulars, lateral extrascapulars and suprascapulars, and also by a small portion of the sphenotic which comes to the level of the other bones and presents the same granulated appearance. The supraoccipital and epiotics are almost entirely, or even entirely covered by the overlying frontals, parieto-extrascapulars and suprascapulars.

The mesethmoid and ectethmoids come, as just above stated, to the level of the dorsal surface of the other bones that form the casque-like portion of the skull, and, having the same surface markings as those other bones, they form with them a uniform and continuous surface. They each contain the two somewhat different components, dermo-perichondrial and endosteal, referred to when describing these same bones in Scorpaena; but here, in Trigla, the dermal portion of the dermo-perichondrial component is much more important.

The MESETHMOID, as seen on the dorsal surface of the skull, is sometimes, as Günther ('60) says of the corresponding bone in Trigla gurnardus, a sexangular bone, once and a half as long as broad; but the two posterior corners of the bone thus described, are usually replaced, in medium-sized specimens, by a single point, the bone then being pentangular. The outer surface of the bone is marked by granulated ridges that all converge toward the central point of the bone, and in the substance of the bone, and converging toward this same point, there are tapering spaces. These spaces lie in the dermal portion of the bone, between the dense outer surface of this portion of the bone and the thin perichondrial layer, and the concave anterior edge of the bone is honeycombed by the openings of the spaces. This anterior edge of the dermal portion of the bone is grooved, the dense superficial layer of the bone projecting eaves-like above the deeper perichondrial layer. This latter layer extends anteriorly slightly beyond the dermal layer, and is there bounded, in the middle line,

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by the hind end of a narrow and low median ridge of cartilage which represents the relatively tall internasal ridge of Scorpaena. On either side of this ridge the mesethmoid is bounded by the hind edge of the corresponding ascending process of the vomer.

The mesethmoid is bounded, on either side, in its posterior half or two-thirds, by the ectethmoid, the hind end of the mesethmoid usually projecting beyond the bounding portions of the ectethmoids and there suturating with or being overlapped externally by the frontals. The anterior half or third of the bone gives support, on either side, to the nasal, the mesial half of the latter bone overlapping and lying upon a depressed lateral half of the dorsal surface of this part of the mesethmoid. The antero-lateral corner of the dorsal surface of the mesethmoid projects forward as a sharp process, and from this process and from the ventral surface of the overlying nasal, the ethmo-maxillary ligament has its origin. This little corner or process of the mesethmoid, together with the adjacent parts of the flat dorsal surface of the bone, thus replace functionally, in their relations to the nasal bone and the ethmo-maxillary ligament, the pronounced mesethmoid process of the Scorpaenidae.

The lateral edge of the mesethmoid, beneath the nasal, is grooved and forms the median wall and part of the floor of the shallow nasal pit. Posterior to the nasal, this same grooved edge of the mesethmoid forms the mesial wall of the olfactory canal through the antorbital process. Dorsal to this groove, between it and the thin dense external plate of the bone, there is another groove in the lateral edge of the bone, this groove lying between the suturating edges of the mesethmoid and ectethmoid. A canal is thus here formed between the two ethmoid bones, which, in large specimens, may become entirely enclosed in the mesethmoid alone, continuing posteriorly to the hind edge of that bone. It lodges that part of the supraorbital latero-sensory canal that lies between the frontal and nasal bones, but contains no sensory organ, the sensory canal thus here being secondarily and not primarily enclosed in the bone.

Under the central portion of the bone, primary ossification has begun, and, in large specimens, extends entirely through the cartilage of the snout. In the central portion of this part of the bone, in three specimens that were bisected, there was a large cavity filled with fatty tissue.

The ECTETHMOID has a convex dorsal surface, this convexity being so great in the posterior portion of the bone that a transverse section here has the shape of a quadrant of a circle. The external surface of the bone lies, as already stated, on a level with the corresponding surface of the other bones of the dorsal surface of the skull, and is marked by radiating and granulated ridges. The hind edge of the bone is thin and sharp, and projects posteriorly to form the anterior portion of the roof of the orbit. It bears the two or three preocular spines, the postero-mesial one of these spines being considerably longer than the others. The mesial edge of the bone suturates, in its posterior portion, with the frontal, and, in its anterior portion, with the mesethmoid and the hind end of the nasal. Along the mesial edge of the posterior portion of the bone, beneath the overlying frontal, there is a small canal which transmits the ramus ophthalmicus superficialis, this canal leading from the orbit into that larger canal, already described, that lies between the mesethmoid and ectethmoid and that lodges the supraorbital latero-sensory canal.

The ventral surface of the ectethmoid is large and inclines downward and mesially at an angle approximately of 30° with a horizontal plane. Along the lateral edge of this surface there is a stout and irregular longitudinal ridge which projects downward and but slightly laterally. The anterior half of this ridge has a somewhat rounded summit, and this part of the ridge gives articulation to

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the united lachrymal and palatine bones in a manner that will be described when describing those bones. It may however here be stated that the two articulating surfaces do not seem to come into close contact, being separated by a line of tough fibrous tissue which not only binds the bones strongly together but permits of a sort of swinging movement. The larger part of this articulation, such as it is, is with the lachrymal, the articulation with the palatine being limited to the extreme anterior end of the ridge, and the articulating surfaces there apparently coming into closer contact than elsewhere. The posterior half of the ridge is double, having mesial and lateral portions which diverge slightly. The mesial portion is a direct posterior prolongation of the anterior, articular portion of the entire ridge, but it is low and narrow, and curving ventro-mesially vanishes near the hind edge of the ventral surface of the bone. The other, lateral portion of the ridge is taller and more important than the mesial one, and running posteriorly and slightly laterally, soon becomes continuous with the posterior portion of the lateral edge of the bone. On the lateral surface of this portion of the ridge the dorsal edge of the second infraorbital bone slides as the hyomandibulo-palato-quadrate apparatus swings inward and outward.

The anterior end of the ventral surface of the ectethmoid projects forward beyond the rest of the bone as a thin flat process, of perichondrial appearance, which lies upon the ventral surface of that lateral portion of the ethmoid cartilage that forms the floor of the nasal pit; the lateral edge of the process of the ectethmoid projecting slightly lateral to the lateral edge of the overlying cartilage and so forming part of the floor of the nasal pit. The process extends forward onto the base of an anterior palatine process of the ethmoid cartilage, its anterior end there being overlapped externally (ventrally) by the small lateral process of the vomer.

The anterior palatine process of the ethmoid cartilage is a pronounced eminence on the lateral edge of the snout, bounded antero-mesially by the ascending process of the vomer, postero-mesially by the mesethmoid, and posteriorly by the process, just above described, of the ectethmoid. Ventrally it lies upon the dorsal surface of the body of the vomer, but projects laterally considerably beyond that bone. With the latero-ventral surface of the process the palatine articulates. The summit of the process always closely approaches, and is sometimes apparently in actual contact with, the ventral surface of the lateral edge of the nasal, near its anterior end; this relation of the process to the nasal varying considerably in different specimens. In most specimens a slight interval seems to separate the two structures.

The posterior, orbital surface of the ectethmoid lies at an angle to its ventral surface, the two surfaces being separated by a sharp ridge. This ridge, or angle, corresponds to the orbital rib of my descriptions of Scomber, and to a slight ridge which, in Scorpaena, extends dorso-laterally from the ventro-mesial corner of the orbital surface of the bone to the point of insertion of the posterior ethmo-palatine ligament. This latter ligament is, in Trigla, double, the two ligaments found partly fused in Scorpaena, here being wholly and quite widely separated. One of these ligaments is a flat band which has its origin on the ventro-lateral surface of the orbital ridge above referred to, and, running downward and forward, is inserted on the palatine cartilage in a manner to be later described. The other is a slender and delicate ligament which has its origin on the ventral surface of the ectethmoid and, running downward and forward, is also inserted on the palatine cartilage.

The orbital surface of the ectethmoid of Trigla thus corresponds to one half only of the same surface of the bones of Scorpaena and Scomber. The other half of this surface must then be looked for in what is apparently, in Trigla, the ventral surface of the bone, and it seems probable that it is

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represented in that part of that surface that lies between the two diverging, posterior portions of the articular ridge near its lateral edge. The ventro-lateral corner of the wing of the bone of Trigla, which forms a sharp spine-like corner, is certainly the homologue of the rounded angle in the lateral edge of the wing of Scorpaena, and the anterior end of the anterior, single portion of the articular ridge of Trigla must be the homologue of that process-like portion of the bone of Scorpaena that gives articulation to the palatine. The lachrymal articular process of the bone of Scorpaena must then be represented in some part of the articular ridge of Trigla that lies between its anterior and posterior ends.

The small orbital surface of the ectethmoid of Trigla is strongly concave, converging forward and inward to a large opening which leads into the hind end of a large median chamber in the antorbital cartilage, the chamber perforating the extreme ventro-anterior portion of the interorbital septum. This chamber is bounded laterally, on either side, by the primary portion of the corresponding ectethmoid, and its floor is perforated by a circular opening which is closed ventrally by the underlying parasphenoid. From the chamber, on either side, a canal leads forward into the nasal pit and transmits the olfactory nerve of its side, this canal lying between the mesethmoid and ectethmoid bones and becoming, in my large specimens, a large vacuity in those two bones, filled with loose fatty tissue. Anterior to this vacuity, there was, in the mesethmoid bone alone of the three specimens examined in this connection, a separate median vacuity, already referred to, which opened on the ventral surface of the bone. The oblique muscles of the eye extend into the median chamber and have their origins there, the chamber thus being an anterior eye-muscle canal. Immediately lateral to the opening that leads from the orbit into the anterior eye-muscle canal, there is, in the ectethmoid, a small canal which transmits an artery coming from the orbit. Considerably lateral to this canal there is another smaller canal, also in the ectethmoid, but no structure, either nervous, arterial or venous could be found traversing it.

The NASAL is a somewhat quadrilateral bone that forms the antero-lateral corner of the casque-like dorsal surface of the skull. The lateral portion of its hind end rests upon the dorsal surface of the ectethmoid. Its mesial half overlaps externally and is quite firmly bound to the lateral portion of the dorsal surface of the mesethmoid. Its anterior edge forms the lateral portion of the concave anterior edge of the casque of the skull. Its antero-lateral corner projects beyond the underlying corner of the mesethmoid and also beyond the anterior palatine articular eminence of the ethmoid cartilage, and is thickened by accretions to its ventral surface. This thickened portion rests partly upon the dorso-lateral surface of the base of the maxillary process of the palatine, and partly upon the external surface of a small flat process on the dorsal edge of the lachrymal. The lachrymal and palatine are here immoveably bound together, and the extent of the contact of one or the other with the nasal varies in different specimens. The nasal is strongly but somewhat loosely bound by dermal or fibrous tissues to both the palatine and lachrymal, and gives sliding articulation to them when the palato-quadrate and cheek-plate swing inward and outward; the sliding contact being mainly with the lachrymal. The ventral surface of this corner of the nasal closely approaches, and, as already stated, may even rest upon the summit of the anterior palatine process of the ethmoid cartilage, the palatine articulating with the latter process by an articular surface at the base of its maxillary process.

Between the summit of the anterior palatine process of the ethmoid cartilage and the projecting antero-lateral corner of the mesethmoid, the nasal roofs a large passage which leads from the rostral depression into the anterior end of the nasal pit. The nasal pit is a deep low fossa in the lateral edge

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of this part of the skull, lying between the nasal above, the mesethmoid and the cartilage of the snout mesially and below, the ectethmoid posteriorly and below, and the anterior palatine process of the ethmoid cartilage anteriorly. The pit is not large enough to lodge the entire nasal sac, a part of the sensory portion of the sac extending laterally, beyond the lateral edge of the skull, onto the dorsal surface of the palatine, and there lying between the palatine and lachrymal bones. A mesial diverticulum of the sac, corresponding to that in Scorpaena but somewhat differently disposed, runs forward and mesially through the passage that leads from the nasal pit into the rostral depression, and then turns mesially behind the rostral, between it and the anterior end of the mesethmoid, and abuts against but is apparently not continuous with its fellow of the opposite side.

The nasal bone is traversed by the supraorbital latero-sensory canal, and lodges one organ of that line, the anterior opening of the canal lying at the extreme antero-lateral corner of the bone. De Sède de Liéoux ('84, p. 111) says that the cephalic portion of the latero-sensory canals is absent „chez les Trigles", Trigla hirundo being the species particularly examined. This is far from being true, as will appear in the course of my descriptions.

The VOMER has ascending processes which are in contact, posteriorly, with the anterior end of the thin perichondrial layer of the mesethmoid. The ascending processes of opposite sides enclose between them, as in Scorpaena, the anterior portion of an internasal ridge of cartilage, the bone and cartilage here being, in medium-sized specimens, raised into a slight ridge, while in large specimens they become a prominent knob with a flat summit. The cartilaginous rostral slides backward and forward on this ridge or knob. The lateral corner of the ascending process of the vomer is slightly raised and embraces the anterior edge of the base of the anterior palatine process of the ethmoid cartilage; this raised or process-like portion of the vomer of Trigla corresponding strikingly, in position, to the septomaxillaries of Sagemehl's figures of the Cyprinidae. Antero-mesial to this little process there is a rounded eminence, prominent in large specimens, near the anterior edge of the dorsal surface of the bone. The lateral surface of this eminence, and the slight hollow between it and the palatine process, give articulation to the ventral edge of the ascending process of the maxillary, a pad of tough fibrous or semi-cartilaginous tissue lying between the two surfaces.

The ventral surface of the convex anterior edge of the vomer is slightly raised, and is furnished with an uninterrupted band of small villiform teeth. Immediately posterior to the lateral end of this band of teeth, there is a large depression which gives insertion to the very slightly developed vomero-palatine ligament. A slightly developed lateral process projects postero-laterally, extending beyond the anterior edge of the ventral plate of the ectethmoid and there lying upon the ventral surface of that plate.

In Trigla lineata the anterior end of the vomer is bent abruptly, though but slightly, downward; and although this is a natural formation, it has decidedly the appearance of having been produced by a blow on the end of the snout of the fish.

The PREMAXILLARY has a broad oral surface, covered its full length with small villiform teeth. At about the middle of the length of the bone, there is a thin flat postmaxillary process directed backward and slightly upward. This process forms the hind end of a pronounced longitudinal ridge on the internal surface of the bone, this ridge representing a thickened part of the bone, of membrane origin, which lies slightly dorsal to its tooth-bearing portion. This membrane component of the bone has a thin, flat and rounded hind (distal) end, which forms the postmaxillary process of the bone, and

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a thickened anterior (proximal) end which, in my large specimens, forms a marked eminence on the anterior end of the entire bone, the eminence being round in outline and having a flat summit. This flat surface is presented toward a similar surface on its fellow of the opposite side, and is bound to that fellow by a short strong ligament. The dorso-posterior corner of the eminence is in contact with the ventro-anterior corner of the rostral. The bone has ascending and articular processes, more or less fused to form a single large process which rises from the membrane component of the bone. The ascending process is shorter and stouter than in Scorpaena, being but little if any longer than the articular process. It lies upon and is firmly bound to the dorsal surface of the rostral, and between it and its fellow of the opposite side there is a deep V-shaped groove, as in Scorpaena. The articular process gives articulation to the maxillary in exactly the same manner that the corresponding process does in Scorpaena, and here, as there, a pad of semi-cartilaginous tissue lies between the articulating surfaces.

The MAXILLARY has an anterior, articular end, strictly comparable to that of Scorpaena, but the middle portion of the shelf-like ligamentary process of that fish is wanting here, as it is in Cottus. This is doubtless due to the fact that, in both Trigla and Cottus, the anterior end of the lachrymal has not the strong attachment to the maxillary that it has in Scorpaena, the lachrymal, in Trigla, projecting above and beyond the maxillary without coming into contact with it. The maxillary process of the palatine articulates with the dorsal surface of the maxillary, as in Scorpaena, the articulation taking place in a depression, which lies in the angle between the ascending process and the shank of the bone. The extreme proximal end of the bone lies along and is bound by tissue to the ventral surface of the rostral. The bone articulates by the dorso-posterior portion of its ascending process, and through the intermediation of a pad of fibrous or semi-cartilaginous tissue, with the lateral surface of the eminence, already described, on the dorsal surface of the ascending process of the vomer. On the internal surface of the bone, beginning opposite its ascending process and extending distally somewhat beyond it, there is a flat shelf-like ridge, the distal end of which is enlarged and gives insertion to a large tendon of the superficial division, A_1, of the adductor mandibulae muscle, that tendon having its insertion, in Scorpaena, in a slight depression in this same part of the maxillary. The maxillo-mandibular ligament has its insertion, together with a small tendon of the superficial division, A_1, of the adductor mandibulae, and also with a tendon of the deeper division, $A_2 A_3$, of that muscle, on a ridge-like eminence on the dorsal surface of the maxillary, this eminence thus replacing the distal end of the ligamentary process of Scorpaena. The ethmo-maxillary ligament is inserted on the base, or sometimes even near the summit of the ascending process.

The cartilaginous ROSTRAL is broader than in Scorpaena, and the median portion of its posterior half, alone, has sliding contact with the dorsal surface of the snout. This surface of contact is relatively wide and is usually slightly concave, but in some specimens it is flat or even slightly convex, conforming in this to the much flattened dorsal surface of the snout of the fish. The dorsal surface of the cartilage is conical, or pyramidal, sloping upward from all sides toward a central point. The ascending processes of the premaxillaries rest upon the anterior half only of this surface, the posterior portion being exposed. Immediately dorso-posterior to the ascending processes of the premaxillaries, on the central point of the cartilage, there is a mass of tough fibrous tissue from which, on either side, the rostro-palatine ligament has its origin. These ligaments do not form a continuous band crossing the middle line of the head, as in Scorpaena, and they are not, as in that fish, in contact

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with the premaxillary. Each ligament is inserted, as in Scorpaena, on the base of the maxillary process of the palatine. In one of four specimens examined, there was, in the middle line, between the two ligaments, a small disk of bone on which the ligaments had their origins; and it would seem as if this bone might be the rostral bone of Sagemehl's descriptions, a bone which that author considered as an ossification of the rostral cartilage.

The FRONTAL has a ventral flange, but it is but slightly developed. The anterior end of the bone overlaps externally the bounding edges of the mesethmoid and ectethmoid, those bones separating the frontal, by a considerable interval, from the hind end of the nasal. Mesially the frontal suturates, in the mid-dorsal line, with its fellow of the opposite side. Its hind edge is relatively straight, forms a right angle with its mesial edge, and, extending from the middle line of the head to the mesial edge of the pterotic, suturates its full length with the anterior edge of the parieto-extrascapular. The posterior portion of the short postorbital portion of the lateral edge of the bone suturates with the pterotic, its anterior portion touching a corner of the postfrontal and also abutting against a raised portion of the sphenotic that comes to the level of the dorsal surface of the skull and has surface markings similar to those of the dermal bones. This little raised portion of the sphenotic forms the dorso-lateral corner of the postorbital process of the skull, and between its hind edge and the lateral portion of the anterior edge of the pterotic there is a little notch which is occupied by the small postfrontal bone. The postero-mesial corner of the raised portion of the sphenotic arches toward and, in medium-sized specimens, touches, or almost touches, the anterior corner of the dermal portion of the pterotic, a circular passage being left between the two bones, which transmits that primary tube of the supraorbital latero-sensory canal that anastomoses with the main infraorbital canal as that canal passes from the postfrontal into the pterotic. The frontal is traversed by the supraorbital latero-sensory canal and lodges five sense organs of that line, the fourth and fifth organs of the line lying relatively close together, without intervening primary tube, as in Scorpaena.

The PARIETO-EXTRASCAPULAR is a flat bone, and is traversed, near its hind edge, by the supratemporal latero-sensory canal, that canal uniting with its fellow in the mid-dorsal line to form a complete cross-commissure. The bone suturates, in the mid-dorsal line, with its fellow of the opposite side, completely covering the supraoccipital excepting only a narrow hind edge of that bone, and, slightly anterior to that edge, a small, variable and irregular median portion of the dorsal limb of the bone. Anteriorly the bone suturates with the frontal. Laterally it suturates with the pterotic, lateral extrascapular and suprascapular, not appreciably overlapping, in most of my specimens, the epiotic process of the latter bone. On its dorsal surface, near the middle of the bone, there is, in my medium-sized specimens, a slightly raised and granulated ridge, longitudinal in position, which apparently corresponds to the ridge that forms the lateral boundary of the subquadrangular groove on the vertex of Scorpaena. The section of the supratemporal latero-sensory commissure that is enclosed in the bone lodges one sense organ of that canal.

The POSTFRONTAL is a small bone that lies in the angular interval between the pterotic and the raised, dermal-like portion of the sphenotic. Its mesial corner approaches closely, or even touches, between those two bones, the lateral edge of the frontal. It is traversed by the infraorbital latero-sensory canal and lodges one organ of that line, innervated by a branch of the oticus lateralis.

The LATERAL EXTRASCAPULAR is a small subcircular bone that lies in the space between the pterotic, parieto-extrascapular and suprascapular bones, with all of which bones it is firmly

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united. It forms part of the roof of the temporal fossa, and is traversed by the main infraorbital and supratemporal latero-sensory canals, lodging one organ of each of those lines.

The SUPRASCAPULAR is bounded anteriorly by, and firmly united with, the lateral extrascapular and the parieto-extrascapular, and forms part of the hind edge of the casque-like dorsal surface of the skull. It has opisthotic and epiotic processes which are attached, respectively, and in the usual manner, to processes of the opisthotic and epiotic bones. Immediately posterior to the base of the opisthotic process there is a large articular facet, the lateral edge of which is slightly differentiated as an articular eminence, this being more evident in small than in large specimens. The two surfaces give articulation to articular surfaces on the dorsal end of the supraclavicular. Immediately posterior to the articular eminence is the posterior opening of the section of latero-sensory canal enclosed in the bone, this section of canal lodging one sense organ of the main infraorbital line. The bone extends some distance beyond the opening of the canal and terminates in a stout point.

The SUPRACLAVICULAR has a small dorsal end, the anterior corner of which is entirely occupied by a large condylar eminence. Immediately postero-lateral to this eminence, there is a small flat or slightly concave articular surface. These two surfaces articulate with the two articular surfaces on the ventral surface of the suprascapular, the supraclavicular lying beneath the suprascapular and not extending back to the hind end of that bone. Immediately posterior to these articular surfaces the posterior half of the dorsal edge of the bone is traversed by the main latero-sensory canal, the section of canal lodging one sense organ of the line. The ventral end of the bone is slightly expanded, and has a large depression on its inner surface. The anterior and posterior edges of this depression, and also the thin ventral edge of the bone, rest upon and are firmly bound by tissues to the dorsal end of the clavicle, the supraclavicular fitting into a depression on the outer surface of the latter bone. This depression in the clavicle surrounds a deep notch in the edge of that bone, this notch corresponding to the notch shown in my figures of the clavicle of Scomber. The depressed region on the inner surface of the supraclavicular overlies this notch in the clavicle, and the occipito-supraclavicular ligament, passing through the notch, has its insertion in the depression on the supraclavicular. Nothing whatever in the arrangement of the parts is abnormal, as compared with Scorpaena, nor is the supraclavicular (postero-temporal) at all crowded out of its normal place and relation to the other bones, as stated by Gill ('88) and by Jordan and Evermann ('98). The bone is simply inclined backward more than in Scorpaena, its dorsal end is smaller, and the prolonged hind end of the suprascapular projects backward considerably beyond it.

The PARASPHENOID is large, with expanded anterior and posterior portions that are connected by a short but relatively wide intervening portion. The ventral surface of the anterior portion is deeply grooved to receive the vomer, the dorsal surface of this portion presenting a correspondingly wide, low and rounded, median longitudinal ridge. On the dorsal surface of the posterior portion of the bone there is a wide raised median portion, the deeply grooved lateral edge of which receives, on either side, the cartilaginous ventral edge of the proötic; the raised portion thus not only closing the hypophysial fenestra but also forming, on either side of that fenestra, a relatively considerable part of the floor of the myodome. The ascending process of the bone, on either side, is represented by a short, slender and sharply pointed dorsal extension of the thickened anterior edge of the expanded posterior portion of the bone, and so unimportant is it that the process seems, at first sight,

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to be wholly wanting. A deep and narrow incisure, which separates the process from the almost equally tall posterior portion of the bone, transmits the internal carotid artery. From this incisure a groove runs upward on the outer surface of the proötic, toward the facialis opening of the trigemino-facialis chamber, and lodges the internal carotid artery. Ventral to the internal carotid foramen this groove is continued on the outer surface of the parasphenoid, but there simply marks the posterior limit of the surface of insertion of the adductor arcus palatini. The infrapharyngobranchial of the first arch has its attachment to the skull anterior to the groove, in the immediate neighbourhood of the internal carotid foramen.

Between, or slightly anterior to the anterior edges of the ascending processes of the parasphenoid there is, in the middle line of the dorsal surface of the bone, a pronounced and sharply pointed process, directed dorso-posteriorly. The anterior edge of this process is grooved, is presented dorso-anteriorly, and lodges the ventral edge of the posterior portion of the cartilaginous interorbital septum and, dorso-posterior to that cartilage, and continuous with it, the ventral end of the pedicle of the basisphenoid. On the ventral surface of the bone, slightly anterior to this little process, there is, on either side, a slight process, or ledge directed laterally, which thus has approximately the position of the well developed process of Osteoglossum.

The ORBITS are roofed by the ectethmoids and frontals, and are separated from each other by an interorbital septum, the anterior portion of this septum being of cartilage, while its posterior portion is of membrane. The extreme anterior end of the septum is perforated by an opening which puts the orbits in communication with each other, this opening forming the median part of the anterior eye-muscle canal. The hind wall of the orbit is formed by the alisphenoid, basisphenoid, proötic and sphenotic, and is slightly reëntrant in its lateral portion, this being due to the projecting anterior edge of the lateral surface of the brain case. The ventral flange of the frontal being but slightly developed, the orbital opening of the brain case is, in consequence, large and somewhat rectangular in shape.

The MYODOME has proötic and basioccipital portions, the latter extending only about one half the length of the basioccipital, and opening posteriorly on the ventral surface of that bone by a small opening only. The orbital opening of the myodome is large and inclines strongly downward and forward, while the roof of the proötic portion, or body of the myodome inclines strongly downward and backward. This is due to a deepening of the orbits, posteriorly, and a correlated and marked tilting upward of the mesial processes of the proötics, this giving to the myodome the appearance of a large and deep recess at the hind end of the orbits.

There is no ORBITOSPHENOID.

The ALISPHENOID is bounded by the sphenotic, the frontal, and the prepituitary portion of the mesial process of the proötic, the basisphenoid not coming into bounding contact with it. The antero-mesial edge of the bone is slightly concave, and bounds the orbital opening of the brain case. This edge of the bone forms a continuous line with the anterior edge of the mesial process of the proötic, and the adjoining edges of the two bones are cut away to form a rounded incisure which transmits the nervus trochlearis. Dorsal to this incisure, in the anterior edge of the alisphenoid, there is another incisure, often closed to form a small foramen, which transmits the cerebral branch of the orbito-nasal vein. Near the center of the bone there is a larger foramen which transmits that branch of the ophthalmicus lateralis that supplies the small latero-sensory organ in the terminal

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tube of the supraorbital canal. This nerve, as in Scorpaena, perforates the alisphenoid, then runs upward along the inner wall of the skull, traverses the lateral fontanelle, and, perforating the frontal, reaches its organ. As in Scorpaena, the nerve is accompanied, as it traverses its foramen, by branches of the external carotid artery and the vessel x.

On the external surface of the bone, near its ventral edge, there is a short and slight ridge which is continued downward onto the external, ventro-anterior surface of the mesial process of the proötic. Toward this ridge a small process projects dorsally from that part of the proötic that forms the anterior edge of the lateral surface of the brain case, this process being of very variable length, and the process and the ridge above it being connected by fibrous tissues. That part of the ridge that lies on the alisphenoid represents a slight remnant of the parasphenoid leg of that bone, the part that lies on the proötic here replacing a part of that process of the parasphenoid that, in Cottus, comes into contact with the alisphenoid.

On the internal surface of the alisphenoid, at about its antero-dorsal quarter, there is a brace-like thickening of the bone, which is the greatly developed homologue of the small ridge described on the internal surface of the alisphenoid of Scorpaena. The flat dorsal surface of the brace is cartilaginous in places, reaches the level of the dorsal edge of the bone, and abuts against the ventral surface of the frontal; the hind edge of this surface of the brace almost reaching the anterior edge of the supraoccipital. The lateral edge of the dorsal surface of the brace forms the mesial boundary of the anterior half of the lateral cranial fontanelle, its mesial edge being in synchondrosis with a large, median postepiphysial interspace of cartilage which extends forward from the anterior edge of the supraoccipital. The anterior edge of this postepiphysial interspace of cartilage is slightly concave, and extends from the anterior edge of the alisphenoid of one side to that of the other side. From the antero-lateral corner of the cartilage, a band of cartilage runs postero-laterally along the dorsal edge of the plate-like body of the alisphenoid, the postero-lateral end of the band being continuous with a band of cartilage that runs backward along the mesial edges of the sphenotic and pterotic and forms the lateral boundary of the lateral cranial fontanelle. In Trigla gurnardus, a specimen of which was used for the figure showing a dorsal view of the chondrocranium, there was a deep bay in the anterior edge of the postepiphysial cartilage, much larger and deeper than that found in the specimens of Trigla hirundo that were examined.

The BASISPHENOID has a long pedicle which is directed downward and forward at an angle of from 30° to 45°, the two wings of the body of the bone being directed laterally and slightly upward. The bone does not come into bounding contact with the alisphenoid. Along the dorsal surface of the body of the bone, on either side, the optic nerve pierces the membrane that closes the orbital opening of the brain case and enters the orbit. Slightly dorsal to the optic nerve, the nervus olfactorius pierces the same membrane, and from there runs forward along the lateral surface of the interorbital septum, lying wholly free in the orbit. In the hind edge of the body of the bone, in my largest specimen, there is a median and imperfectly closed foramen which unquestionably transmits the median encephalic artery formed by the fusion of the internal carotid arteries of opposite sides of the head.

The LATERAL SURFACE OF THE BRAIN CASE is relatively flat and narrow, and its anterior edge has a pronounced reëntrant angle, at about the middle of its height. That part of this edge that lies ventral to the point of the angle inclines forward and downward and is formed by a thin plate of bone which, in its dorsal portion, projects forward considerably beyond the adjoining portion

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of the orbital surface of the brain case. The postero-ventral portion of the orbit is thus here bounded laterally by bone, this part of the orbit leading into and being continuous with the myodome.

The PROÖTIC forms the middle three-fifths of the anterior edge of the brain case, the dorsal fifth being formed by the sphenotic, and the ventral fifth by the short ascending process of the parasphenoid. At the middle of the entire edge there is a large foramen which perforates a thin plate-like portion of the edge and leads directly into a small recess which lies on the orbital surface of the proötic immediately dorso-lateral to the orbital opening of the myodome. This recess is the imperfectly enclosed trigemino-facialis chamber, and the large foramen that opens from it onto the lateral surface of the brain case is the facialis opening of that chamber. The lateral wall of the chamber is reduced to the slender column of bone that forms the anterior boundary of the facialis opening. Anterior to this column of bone there is, on the projecting plate-like edge of the proötic, a process of variable length and shape, already referred to, which projects upward toward the slight ridge on the orbital surface of the alisphenoid. This latter ridge, as already stated, represents the parasphenoid leg of the alisphenoid, the process of the proötic being a proötic outgrowth which has invaded the alisphenoid membrane, there replacing, in this fish, the parasphenoid outgrowth found in Cottus. Across the dorsal surface of this process of the proötic, or between it and the column that bounds the anterior edge of the facialis opening, this depending on the shape of the process, the truncus trigeminus has its exit from the chamber.

The mesial wall of the trigemino-facialis chamber is perforated by three or four foramina; two of them being large and the other one or two considerably smaller. Where there are four foramina, one of the large ones transmits the root of the trigeminus together with the buccalis lateralis, the other large one transmitting the motor root of the facialis together with the lateralis facialis and all of the communis fibers of the trigemino-facialis complex; the two small foramina transmitting, one, the ophthalmicus lateralis and the other the ciliaris profundi with the encephalic vein. Where there are but three foramina, the ophthalmicus lateralis issues with the trigeminus and buccalis lateralis through a partly separate portion of a single large foramen, the profundus and facialis always issuing through independent foramina. The palatinus facialis issues through the facialis foramen, then turns mesially along the floor of the trigemino-facialis chamber, and so enters the myodome. It is not here enclosed in a separate canal. Directly mesial to the profundus foramen, the prepituitary portion of the mesial process of the proötic is perforated by the oculomotorius, that nerve in 5 cm and 6 cm specimens of Lepidotrigla, separating into its superior and inferior divisions before reaching its foramen. The postpituitary portion of the mesial process is, in large specimens, either perforated or notched by a foramen that transmits the abducens, that nerve passing directly from the cranial cavity into the myodome.

In the ventral edge of the proötic, is the internal carotid incisure. Posterior to that incisure the ventral edge of the bone is capped its full length with cartilage and abuts against the parasphenoid in the deep groove along the lateral surface of the median longitudinal ridge on the dorsal surface of the bone.

On the internal surface of the proötic there is, as in Scorpaena, a trigemino-facialis recess, and this recess lodges, as in Scorpaena, the communis, lateralis and profundus ganglia.

On the lateral surface of the dorsal portion of the proötic there is a fossa, and immediately anterior to the fossa a brace-like process, the process and fossa giving insertion to the two internal

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and first four external levators of the branchial arches, as in Scorpaena. Between the thick dorsal end of this brace-like process and the adjoining portion of the sphenotic, there is a deep socket-like articular facet for the anterior articular head of the hyomandibular. Slightly posterior to this facet, on the lateral surface of the pterotic, is the oval and shallower facet for the posterior articular head of the hyomandibular. Immediately dorsal to the line between these two articular facets, there is a pit-like depression on the adjoining edges of the pterotic and sphenotic, the depression lying immediately beneath the postfrontal. It is the dilatator fossa, the dilatator operculi arising partly in this fossa and partly on the external surface of the dorsal end of the hyomandibular, as in Scorpaena. Immediately anterior to the dilatator fossa, and slightly dorsal to the anterior articular facet for the hyomandibular, on the slightly concave dorso-lateral corner of the sphenotic, the levator arcus palatini has its origin. A canal for the ramus oticus traverses the sphenotic, entering that bone on its orbital surface.

At about the middle of the lateral surface of the brain case, and near the hind edge of the proötic, there is a small foramen which transmits the root of the nervus glossopharyngeus. Dorsal to the line between this foramen and the vagus foramen there is a triangular subtemporal depression which, as in Scorpaena, gives origin to the adductor hyomandibularis and adductor operculi, and also, immediately posterior to the latter muscle, to the external levators of the fourth and fifth branchial arches. The levator operculi has its origin along the dorsal edge of the lateral surface of the skull, as in Scorpaena.

The PTEROTIC contains two latero-sensory organs innervated by the oticus lateralis, and one post-preopercular organ innervated by the supratemporal branch of the lineae lateralis vagi. The two organs innervated by the oticus were found in both of the two specimens examined, one being an adult Trigla and the other a small Lepidotrigla. These two organs lie relatively close together and there is no indication whatever of a primary tube between them. They accordingly quite probably represent the two independent otico-squamosal organs of Amia, here in process of concentration into a single organ, exactly as already set forth for the fourth and fifth supraorbital organs of this fish, of Sebastes and of Scorpaena. Otherwise the pterotic of Trigla offers no apparent difference from the bone in Scorpaena, excepting in that its posterior process is less extensive. The dorsal portion of the hind edge of the lateral surface of the brain case projects latero-posteriorly as a tall, thin ridge of bone, but this ridge is formed mainly by portions of the exoccipital and opisthotic, its dorsal edge only being formed by the posterior process of the pterotic.

The OPISTHOTIC forms an actual part of the bounding wall of the posterior semicircular canal, a part of that part of the pterotic region of the chondrocranium that, in Scorpaena, bounds this canal having been suppressed in Trigla, and a large opening, leading directly into the canal, being exposed when the opisthotic is removed. The opisthotic does not, however, seem to have anywhere acquired primary relations to the skull, the underlying cartilage apparently having simply been resorbed.

The EXOCCIPITAL is perforated by two foramina, one for the vagus and the other for the occipital nerves, these two foramina being separated by the base of the condylar process that gives articulation to the anterior articular process of the first vertebra. In Scorpaena both of these foramina lie antero-lateral to the base of the condylar process, separated by a slight ridge which is a ventral prolongation of the postero-lateral angle of the skull. Dorsal to the foramen for the occipital nerves

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there is, in Trigla, a slight projecting ledge, this being much more marked in my small specimens than in the large one used for the drawings. The hind edge of this ledge, in the small specimens, projects posteriorly as a sharp angle, and beneath this part of the ledge the dorsal surface of the condylar process of the exoccipital gives support to the lateral portion of the base of the first vertebral arch. The mesial and larger portion of the base of the arch rests upon a portion of the dorsal surface of the articular process of the independent centrum of the first vertebra, this surface of contact lying postero-mesial to and contiguous with the supporting surface on the exoccipital. The arch does not come into contact with the basioccipital.

The mesial process of the exoccipital, so well developed in Scorpaena, is but slightly developed in Trigla. It is directed ventro-mesially, at about 45°, its ventral end, which is widely separated from its fellow of the opposite side, resting upon a small process-like portion of the dorsal surface of the basioccipital, this part of the basioccipital forming the mesial wall of the hind end of the saccular groove.

The BASIOCCIPITAL is broad and relatively short. Its anterior end is deeply and widely excavated by the hind end of the myodome, a narrow, longitudinal, and slit-like opening leading from this groove onto the outer surface of the bone. That part of the basioccipital that forms the roof of the myodome is flat and inclines downward and backward almost at an angle of 45°, the wide and relatively shallow saccular groove of either side being, in consequence, pushed on to what appears as a lateral portion of the cerebral surface of the bone, and being also tilted upward at a considerable angle. The hind end of the saccular groove forms a recess in the basioccipital, and between the recesses of opposite sides there is, on the dorsal surface of the bone, a large median pit which is the cavum sinus imparis. Posterior to this pit, and at a considerably higher level, a short portion of the dorsal surface of the bone forms the floor of the foramen magnum. The hind end of the bone is irregular, the appearance being that of the ordinary vertebra-like hind end of this bone, with the dorso-lateral corners deeply cut away. This leaves a depressed surface on either side of the dorsal portion of the hind end of the bone, and this depression receives and gives support to the anterior articular process of the first vertebra. On the lateral surface of the hind end of the bone there is a flattened surface which gives origin to the occipito-supraclavicular ligament.

The centrum of the FIRST FREE VERTEBRA is an irregular disk of bone without attached dorsal arch. The posterior surface of the disk has the usual concave vertebral depression, while on its anterior surface there is simply a flat or slightly concave median portion. From the dorso-lateral portion of the centrum, on either side, a stout process projects antero-laterally, rests upon the basioccipital in the depressed region at the dorso-lateral corner of its hind end, and there articulates with the condylar process of the exoccipital. The bases of these two anterior articular processes of the first centrum are joined by a stout web of bone which forms a shelf projecting forward from the dorsal edge of the centrum, thus making the dorsal surface of the centrum much wider, antero-posteriorly, than its ventral surface. On either side of the dorsal surface of the centrum there is a depression which receives the ventral surface of an anterior process of the second vertebra, this latter process bearing and being fused with the base of the preforaminal portion of the arch of its vertebra. This process of the second vertebra, in small specimens, but not in the large one used for the figures, extends, in its lateral portion, almost to the anterior end of the corresponding process of the first vertebra, the free arch of this latter vertebra thus appearing, in lateral views, to rest almost

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entirely upon the condylar process of the exoccipital. This appearance is however deceptive, for, as stated when describing the exoccipital, the postero-mesial and larger portion of the base of the arch of the first vertebra rests upon the mesial portion of the dorsal surface of the anterior process of its own centrum. The dorsal arch of the first vertebra is represented by two bones, one on either side, which touch in the mid-dorsal line above the spinal cord but are not there ankylosed with each other. On the lateral surface of each half of the arch, there is a deep pit which gives insertion to the most anterior rib. Ventral to this pit, the base of the arch is perforated by a foramen which transmits the first spinal nerve. The base of the second arch is similarly pierced by a large foramen which transmits the second spinal nerve; and dorsal to this foramen there is, on the lateral surface of the arch, a large depression which gives insertion to the second rib. The two halves of this arch of the second vertebra meet and ankylose in the mid-dorsal line above the spinal canal, but, like the arch of the first vertebra, this arch does not extend dorsally beyond the point of ankylosis; these two arches being much shorter than the next following ones.

The POSTERIOR SURFACE OF THE SKULL of Trigla differs somewhat from that of Scorpaena. It slopes rapidly downward nearly to the level of the large foramen magnum, and then curves rather abruptly backward to form the nearly straight and horizontal dorsal edge of that foramen. Each half of the surface is separated into two portions by the nearly vertical epiotic ridge, and across the dorsal portion of the mesial one of these two portions there is a large and rounded transverse ridge. This ridge is formed entirely by the epiotic and supraoccipital, and apparently corresponds to what I have described, in Scorpaena, as the hind edge of the primary skull; this being more evident in Trigla gurnardus than in Trigla hirundo. Such being the case, the slightly depressed region, on either side, between the transverse ridge and the hind edge of the secondary skull would correspond to the supratemporal pocket of Scorpaena.

The TEMPORAL FOSSA is relatively small, as compared with Scorpaena. Its posterior opening is bounded mesially and laterally, respectively, by the epiotic ridge and the opisthotic process of the suprascapular, the latter process lying in a nearly vertical longitudinal plane, instead of, as in Scorpaena, in the inclined plane of the lateral surface of the skull. Because of this position of the opisthotic process of the suprascapular, there is a large opening leading into the fossa from the lateral surface of the skull. In the mesial wall of the fossa there is a large but low preëpiotic fossa, this fossa being simply a pocket-like diverticulum of the temporal fossa. The roof of the fossa is formed mainly by the suprascapular and lateral extrascapular, but partly also by projecting edges of the epiotic, pterotic and parieto-extrascapular.

The SUPRAOCCIPITAL has a large postero-ventral limb which forms a large median portion of the posterior surface of the skull. A small median ridge near the dorsal end of this limb of the bone represents the much reduced spina occipitalis. The dorsal limb of the bone is completely covered by the overlying parieto-extrascapulars excepting only a narrow hind edge and a small and variable portion of its dorsal surface which lies slightly anterior to that hind edge. The anterior edge of this limb of the bone bounds and is continuous with the hind edge of the post-epiphysial cartilage, its lateral edges bounding, on either side, the posterior portion of the lateral cranial fontanelle.

The EPIOTIC has a stout suprascapular process, this process and also the dorsal surface of the bone itself, being entirely covered, dorsally, by overlying portions of the suprascapular and parieto-extrascapular; the epiotic thus being wholly excluded from the dorsal surface of the skull.

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2. INFRAORBITAL BONES.

The infraorbital bones are all marked with granulated surface striae, and there were, in the two large specimens, but three of these bones. In all of the several smaller specimens there were four bones, the first and second bones of the series, found fused in the larger specimens, here being separate and distinct. Trigla hirundo thus differs in the number of its infraorbital bones from any of the combinations given by Günther in his descriptions of the fishes of the family, that author giving five of these bones in Trigla pini, two in Trigla gurnardus and six in Trigla lyra. But these numbers, given by Günther, may not be correct for all ages of the fishes mentioned, for in two specimens of T. gurnardus sent me by Dr. Allen, of Plymouth, England, there were five infraorbital bones instead of two as stated by Günther.

The anterior bone of the series, in the smaller specimens of Trigla hirundo, is the lachrymal, and is a large and somewhat triangular bone, the anterior end of which curves strongly mesially and so gives to the bone a concave internal and convex external surface. The curved anterior end of the bone is considerably thickened, but its ventro-anterior edge is simply coarsely serrated and not furnished with prominent spines, as Günther states in his descriptions of this fish. In this the fish resembles Günther's descriptions of Trigla gurnardus rather than T. hirundo, its colour and other characteristics however identifying it as the latter. The thickening of this anterior end of the lachrymal is apparently due to accretions to its inner surface, and this surface of this part of the bone is partly covered with surface striae or granulations. From the hind end of this thickened portion, two ridges run backward on the internal surface of the bone; one along the ventral edge of the bone, and the other near and parallel to its dorso-anterior edge; both ridges being prolonged beyond the body of the bone as relatively long and slender processes. The dorso-anterior edge of the bone, dorso-anterior to the second one of the two ridges just above mentioned, is thin, and its anterior and posterior thirds rest upon and are firmly bound to portions of the dorsal edge of the palatine. Between these two regions of contact with the palatine, the lachrymal is cut away by a long oval incisure which is bridged by the underlying palatine. An opening is thus left between the lachrymal and the palatine, this opening lying directly opposite the slit-like opening of the nasal pit and lodging the lateral half of the nasal sac. That part of this edge of the lachrymal that lies anterior to this nasal incisure rests upon the maxillary process of the palatine, and there has a flat, pointed, and more or less developed process which, as stated when describing the nasal, gives sliding articulation to the antero-lateral corner of that bone. That part of the edge of the lachrymal that lies posterior to the nasal incisure inclines mesially and rests upon those portions of the palatine bone and cartilage that form the posterior ethmoid process. On the external surface of this part of this edge of the lachrymal there is a small groove, parallel to the edge and extending posteriorly to the base of the slender and related dorso-posterior process of the bone. At its anterior end this groove is bounded mesially by a part of the palatine, and here, and throughout the larger part of its length, the groove is, in large specimens, filled with a line of tough fibrous tissue which binds the bone to the summit of the articular ridge on the ventral surface of the ectethmoid. There is thus articulation here between these two structures, but there are no regular articular surfaces. The articulation, such as it is, represents the combined ethmo-lachrymal and posterior ethmo-palatine articulations. Posterior to this articular portion, the dorso-posterior process of the lachrymal projects backward as a free and slender process which lies against and is closely attached to the larger one of the two ethmo-palatine ligaments already described. This

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ligament, running forward from its point of origin on the ectethmoid, has its insertion on the palatine cartilage, the process of the lachrymal thus being developed in supporting relation to it. The second ethmo-palatine ligament is, as already stated, a slender and delicate one that arises from the ventral surface of the ectethmoid. Running forward from there, parallel to but at a certain distance from the larger ligament, it also is inserted on the hind end of the palatine cartilage.

The lachrymal is traversed by the infraorbital latero-sensory canal and lodges three organs of that line.

The second infraorbital bone is a large and almost parallelogrammic bone. The striae on its outer surface radiate mainly from a point that lies near the ventral quarter of the bone directly superficial to the latero-sensory canal that traverses the bone, but partly also from a second point that lies slightly antero-ventral to the first one, and also directly superficial to a portion of the latero-sensory canal; these two points apparently representing the centers of ossification of two bones, here fused but found separate in a 63 mm specimen of Lepidotrigla examined in serial sections.[1])

In the hind edge of the bone, at about its ventral third, there is a more or less pronounced angular incisure. Dorsal to this incisure the hind edge of the bone abuts against the anterior edge of the preopercular, overlapping it but slightly at any place. Ventral to the incisure, the bone also abuts against the anterior edge of the preopercular, but it there also rests upon the lateral edge of the posterior process of the quadrate, the attachment to this latter bone being particularly strong, much stronger than to the preopercular. The point of the incisure lies in the line, anteriorly produced, of the dorsal and largest preopercular spine, and fits against a pointed portion of the anterior surface of the outer edge of the preopercular. From the point of the incisure, and extending backward across the outer surface of the preopercular to the base of its dorsal spine, there is a slight but distinctly evident tuberculated ridge, this ridge being also continued forward across the second infraorbital bone. Ventral to the ridge, both the preopercular and second infraorbital incline slightly downward and inward, the ridge thus separating two somewhat inclined surfaces. In my large specimens this ridge is but slightly indicated, while in the small ones it is quite pronounced.

The infraorbital latero-sensory canal enters the second infraorbital bone on its outer surface near the middle point of its dorsal edge, this point lying at the anterior edge of the orbit. Posterior to this point there is a depressed region on the outer surface of the dorsal edge of the bone, the depression lodging the ventral portions of the third and fourth infraorbital bones. From the point where the canal enters the outer surface of the second infraorbital bone it runs downward and forward in the line of the striae on the outer surface of the bone until it reaches the principal point from which those striae radiate. There it sends a long primary tube backward nearly to the hind edge of the bone, and itself turns gradually forward to leave the bone at its anterior end and enter the lachrymal. The primary tubes that arise from the canal as it traverses the bone all open on its outer surface ventral to the longitudinal striated ridge just above described. The bone lodges four organs of the infraorbital line.

The third and fourth infraorbital bones are relatively small. The third bone has the shape of an elongated rectangle, occupies the larger part of the depressed region along the dorsal edge of the second infraorbital bone, and forms the ventral edge of the orbit. The fourth bone is somewhat

[1]) Since the completion of the manuscript these two bones have also been found separate in a medium-sized specimen of Trigla hirundo.

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triangular, with curved edges. Its ventral edge fits onto the outer surface of the second infraorbital, its hind edge overlapping and resting upon the anterior edge of the preopercular, and extending nearly to its dorsal end. Its concave anterior edge forms the posterior boundary of the orbit. Its dorsal end does not quite reach the lateral edge of the postfrontal. These two bones are traversed by the main infraorbital canal, and each lodges one organ of that line.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The QUADRATE has the usual shape, with its ventral corner enlarged to form the articular head for the mandible. Its antero-ventral edge is bevelled, and fits into the grooved hind edge of the ventral limb of the ectopterygoid. Its ventro-posterior edge is greatly thickened, is prolonged dorso-posteriorly in a short sharp posterior process, and between this process and the body of the bone, on the internal surface of the element, there is a large symplectic groove. The ventro-posterior surface of the posterior process is grooved and fits against and is firmly bound to the anterior edge of the ventral end of the preopercular. The lateral surface of the process is raised in a large and tall ridge, the outer surface of which is roughened and gives support to, and is firmly bound to, the ventro-posterior corner of the second infraorbital bone. The dorso-posterior end of this raised portion fits into a small notch in the anterior edge of the preopercular. Between this raised portion of the process and the external surface of the body of the quadrate, there is a large depression which seems to have no special morphological significance.

The METAPTERYGOID has its dorso-anterior edge bent slightly inward, and has lateral and mesial flanges along its hind edge. The mesial flange is a small one excepting at its dorsal end where it is prolonged into a process which meets, or almost meets a flat process that projects antero-ventrally from the anterior edge of the thin web of bone that fills the space between the anterior articular arm of the hyomandibular and the shank of that bone, and is bound to that process by fibrous tissues. Ventral to this process-like portion, the hind edge of the mesial flange is connected by a wide sheet of membrane with the shank of the hyomandibular. The lateral flange projects postero-laterally at a slight angle to the body of the bone, and reaches, or overlaps slightly, and is attached to the outer surface of the ventral end of the shank of the hyomandibular. The ventral corner of this lateral flange approaches, or may even reach and rest upon the outer surface of the cartilaginous interspace between the hyomandibular and symplectic; and there is, in the corner of the flange, an incisure which, with the adjoining cartilage and the hyomandibular, forms a foramen which transmits the arteria hyoidea.

The ECTOPTERYGOID has the usual two limbs lying at an obtuse angle to each other, the dorso-anterior limb being a large plate the dorsal edge of which is grooved. This groove lodges the ventral edge of the anterior end of the entopterygoid, and also that part of the palatine bone and cartilage that forms the posterior ethmoid process of the apparatus, the lateral edge of the groove being a tall plate which lines the lateral surface of the palatine cartilage and may even project dorso-posteriorly slightly beyond the cartilage. The anterior edge of this part of the ectopterygoid is somewhat jagged, and suturates with the hind edge of the ventral flange of the palatine. The ventro-posterior limb of the bone is grooved on its posterior surface and fits against the antero-ventral edge of the quadrate.

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The ENTOPTERYGOID is small, and its ventral half lies closely against the inner surface of a part of the cartilage of the apparatus that lies between the metapterygoid and the ectopterygoid, along the dorsal edge of the quadrate. The dorsal half of the bone projects beyond the cartilage, is concave on its outer and convex on its inner surface, and lies against the under surface of and gives insertion to a portion of the adductor arcus palatini. The anterior end of the bone rests in the grooved dorsal edge of the dorsal limb of the ectopterygoid, its posterior end not quite reaching, in small specimens, the anterior end of the metapterygoid.

The PALATINE has a body, a maxillary process, and a stout and large ventral flange of dermal origin. The hind edge of the ventral flange is jagged and suturates with the anterior edge of the dorsal limb of the ectopterygoid. The hind end of the body of the bone is in synchondrosis with the cartilage of the posterior ethmoid process of the apparatus. The maxillary process of the bone curves slightly antero-mesially, is flattened on its dorso-lateral surface, and there rests against and is firmly bound to the internal surface of the dorso-anterior edge of the lachrymal. A small eminence at the base of the maxillary process gives insertion to the rostro-palatine ligament, and immediately posterior to this process there is an obliquely transverse facet which articulates with the anterior palatine process of the ethmoid cartilage. The vomero-palatine ligament is unimportant. The anterior end of the maxillary process of the bone is capped with cartilage and articulates with the dorsal surface of the maxillary, in the angle between the lateral surface of the ascending process and the shank of that bone. The posterior portion of the body of the palatine, and the cartilage that forms the posterior ethmoid process of the apparatus, are firmly bound to the lachrymal, in the manner already described. Between this posterior part of the palatine and the base of its maxillary process, the dorso-lateral surface of the body of the bone is slightly hollowed, this hollow lodging the lateral half of the nasal sac.

The palato-quadrate, as a whole, forms a plate which is slightly concave on its ectal surface, and the two anterior infraorbital bones together form a plate which is slightly concave on its ental surface. These two plates are firmly bound to each other by their anterior edges, while by their posterior edges they are firmly bound to the preopercular and hyomandibular. The two plates together thus form a flat, hollow, trapezoidal structure, open both dorso-mesially and ventro-laterally by large and relatively narrow openings. The space enclosed between the two plates is, in the recent state, almost completely filled by the adductor mandibulae muscle.

The HYOMANDIBULAR is cross-shaped, the arm of the cross lying obliquely to the shank. The summit of the longitudinal ridge on the outer surface of the shank projects forward, and so gives to the anterior surface of the bone a grooved appearance. The dorsal portion of this forwardly projecting ridge gives support, on its lateral surface, to the fourth bone of the infraorbital series. The shank of the bone is traversed by a facialis canal, the ventral opening of that canal lying anterior to the longitudinal ridge. From this canal a single branch canal arises, and running postero-ventrally opens on the outer surface of the bone, near the ventral end of the thin web of bone that fills the space between the opercular process and the ventral portion of the shank of the bone. It transmits a nerve destined to innervate the two dorsal ones of the latero-sensory organs in the preopercular, a single canal thus here replacing the two canals found in Scorpaena. A foramen leads directly from the main canal for the facialis onto the anterior surface of the bone, but it only transmits a blood vessel.

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The rod-like SYMPLECTIC lies in the symplectic groove on the internal surface of the quadrate. Between it, and the preopercular and the posterior process of the quadrate there is a large oval opening which transmits the mandibularis externus facialis and the arteria hyoidea. Anterior to the symplectic, between it and the quadrate, there is a small canal which transmits the mandibularis internus facialis.

The arteria hyoidea has a course exactly similar to that in the fishes already described.

The PREOPERCULAR has slightly indicated dorsal and ventral limbs, separated by a low and granulated ridge on the outer surface of the bone. This granulated ridge is much more apparent in small than in large specimens, and terminates posteriorly in a spine which, in small specimens, is sharply pointed. Immediately ventral to this spine there is, in these small specimens, a smaller spine. The dorsal limb of the bone is firmly bound to the hyomandibular, the ventral limb being similarly bound to the posterior process of the quadrate. The anterior edge of the bone gives support and is bound to the hind edge of the second bone of the infraorbital series. The bone is traversed its full length by the preopercular latero-sensory canal, and lodges six organs of the line, the second organ from the dorsal end of the bone being a double one in the one specimen examined.

The OPERCULAR has a large bluntly pointed process which rises from the dorsal edge of the bone immediately dorsal to the articular facet for the hyomandibular, and, projecting dorsally or dorso-anteriorly, nearly reaches the dorso-lateral edge of the skull in the suprascapular region. The inner surface of the process is slightly concave and gives insertion to the adductor operculi, that muscle having a large surface of origin in the subtemporal depression on the lateral surface of the skull, the surface of origin of this muscle lying immediately posterior to that of the adductor hyomandibularis. Immediately posterior to the base of the process, on the inner surface of the dorsal edge of the opercular, the levator operculi has its insertion; this muscle arising from the dorsal margin of the lateral surface of the pterotic in a line beginning immediately posterior to the latero-sensory tube that anastomoses with the dorsal end of the preopercular canal. The dilatator operculi arises partly in the dilatator fossa and partly on the external surface of the dorsal end of the hyomandibular, and is inserted on the anterior edge of the articular facet for the hyomandibular. On the hind edge of the opercular there are two stout spines, the dorsal one curving upward so that its point is directed almost dorsally.

The SUBOPERCULAR is a long, thin and delicate bone. In one of my large specimens the ventral half of this bone was wanting, and the dorsal half was almost completely ankylosed with the hind edge of the opercular.

The INTEROPERCULAR is bound by strong ligamentous tissue, at about the middle of its dorso-anterior edge, to the interhyal and ceratohyal. Its antero-ventral end is bound, by a short strong ligament, to the hind end of the mandible.

The MANDIBLE is relatively longer and more slender than that of Scorpaena. The hind edge of the dentary is V-shaped and receives, in the angle of the V, the long pointed anterior end of the articular, overlapping that bone externally. The dorsal arm of the V reaches the summit of the coronoid process of the articular, and is bound to its internal surface, slightly below the summit of the process. Between this arm of the dentary and the adjoining parts of the articular there is a relatively small and narrow space. The dorsal edge of the dentary is broad and is covered with small villiform teeth; and immediately ventral to this toothed surface there is a deep longitudinal groove

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which lodges, as in Scorpaena, a gristly tapering rod-like structure which forms the core of the mandibular labial fold of the fish. The pointed anterior limb of the articular is strongly convex externally and concave internally, and lodges, in its concave internal surface, the rod-like Meckel's cartilage. Posterior to the hind end of Meckel's cartilage the conformation of the rod is continued a short distance by a rounded ridge of bone. There is a short, stout, sharply-pointed coronoid process. The hind edge of the articular facet for the quadrate projects dorso-posteriorly as a stout process which has a sliding articulation on the ventro-posterior surface of the posterior process of the quadrate, as in Scorpaena. The angular is a small bit of bone that caps the hind end of the articular and gives insertion to the strong mandibulo-interopercular ligament. The articular and dentary are both traversed by the mandibular latero-sensory canal, and lodge, respectively, one and four organs of the line.

4. MUSCLES.

The adductor mandibulae muscle of Trigla has anterior and posterior divisions, instead of, as in Scorpaena, superficial and deeper ones. The anterior division forms the anterior third or quarter of the entire muscle and has its origin from a tendinous band that extends along its own dorsal edge and then backward along the dorsal edge of the posterior division of the muscle, to have its origin on the tendinous tissue that forms the anterior edge of the levator arcus palatini. This anterior division of the adductor has its insertion wholly on a tendinous fascia that forms on its internal surface and that terminates anteriorly in two tendons; a stout tendon inserted on the hind end of the ligamentary process of the maxillary, and a less important one inserted on the dorsal surface of the same bone.

The large posterior division of the adductor is partly separated into two portions by the ramus mandibularis trigemini, that nerve traversing the muscle from its inner surface and issuing on its outer surface close to its ventral edge. That part of the muscle that lies anterior to the nerve has its origin on the tendinous band that extends along the dorsal edge of the entire muscle, and that gives origin also to the anterior division of the muscle. It is inserted in part on the tissues that extend from the palato-quadrate apparatus to the maxillary, partly on a tendon that joins the tendon $A_2 A_3$, described below, and partly on a tendon that runs forward and has its insertion on the dorsal surface of the maxillary. This part of this division of the muscle, and the anterior division of the entire muscle, thus together correspond approximately to the superficial portion, A_1, of the muscle of Scorpaena. That part of the muscle of Trigla that lies posterior to the mandibularis trigeminus then corresponds to the muscle $A_2 A_3$ of Scorpaena, and, like that muscle, it arises from the hyomandibular, the preopercular and the outer surface of the palato-quadrate arch, and has its insertion on a tendon that may be called tendon $A_2 A_3$. This tendon is double, having anterior and posterior portions. The anterior portion separates into two parts one of which is continuous with a fascia that forms on the inner surface of A_{ω}, the other having its insertion on the internal surface of the articular ventral to the hind end of Meckel's cartilage. The posterior portion of the tendon $A_2 A_3$ runs downward along the hind edge of A_{ω} and has its insertion on the inner surface of the articular dorsal to the hind end of Meckel's cartilage. There is, in Trigla, no tendon running backward, as in Scorpaena, from the tendon $A_2 A_3$ to the inner surface of the quadrate.

The maxillo-mandibular ligament is as in Scorpaena.

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The levator arcus palatini is a strong muscle which arises from the small roughened surface on the dorso-lateral corner of the sphenotic. Running almost directly downward it spreads forward and backward, its deeper fibers being immediately inserted on the external surface of the dorso-anterior portion of the hyomandibular. The more superficial fibers of the muscle are inserted in part on the dorsal edge of the lateral flange on the hind edge of the metapterygoid, but in larger part they run downward between that flange and the mesial one and have their insertions on the latter flange, in the membrane that extends from that flange to the anterior edge of the hyomandibular, and also partly on adjoining portions of the hyomandibular.

The adductor arcus palatini is a broad sheet of muscle that has an origin and insertion similar to that of the muscle in Scorpaena. The surface of origin begins posteriorly on the external surface of the narrow bridge of bone that forms the external wall of the trigemino-facialis chamber, runs downward onto the ascending process of the parasphenoid and then, turning forward, extends along the ventro-lateral surface of the parasphenoid nearly to the anterior end of that bone. Running ventro-laterally the fibers of the muscle have their insertion in a long line that begins on the inner surface of the anterior edge of the dorsal portion of the hyomandibular and extends forward along the dorsal edge of the metapterygoid, and then onto the entopterygoid and the palatine cartilage and bone, the line of insertion passing along the dorso-mesial edge of the metapterygoid instead of crossing the internal surface of that bone, as it does in Scorpaena. The small entopterygoid lies upon the internal surface of the ventral edge of the muscle and gives insertion to certain of its fibers.

The adductor hyomandibularis, and the dilatator, adductor and levator operculi have already been sufficiently referred to when describing the opercular bones.

5. LATERO-SENSORY CANALS.

The latero-sensory canals of Trigla differ in no essential particular from those of Scorpaena. As in that fish, the primary tubes branch repeatedly after they leave the bones to which they are related and enter the overlying dermal tissues, large and complex dendritic systems being formed.

The lachrymal lodges three sense organs of the main infraorbital line, the large second infraorbital bone, four organs, and the third and fourth bones one organ each. This makes nine organs in all in this part of the line of Trigla, which is two more than is found in Scorpaena, and one more than is found in Cottus even when counting the small supplemental organ in the second infraorbital bone of that fish.

The postfrontal lodges one sense organ innervated by the oticus lateralis, and the pterotic two organs innervated by the same nerve. The two organs in the pterotic are without intervening primary tube, and are probably, as already explained, in process of condensation into a single organ. The pterotic also lodges a post-preopercular sense organ, innervated by a branch of the supratemporalis lateralis vagi, this organ not being found in Scorpaena but being found in Cottus.

The lateral extrascapular, suprascapular and supraclavicular each lodge one organ of the main line, the organs in the first two bones being innervated by branches of the supratemporalis lateralis vagi, and the organ in the supraclavicular by the next following and single branch of the nervus lineae lateralis vagi.

The supratemporal canal forms a cross-commissure with its fellow of the opposite side, and contains two organs, one lying in the lateral extrascapular and the other in the parieto-extrascapular, both innervated by branches of the supratemporalis lateralis vagi.

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The supraorbital canal contains six sense organs, one lying in the nasal and five in the frontal. As in Scorpaena, the fourth primary tube anastomoses in the middle line with its fellow of the opposite side to form a frontal commissure, the penultimate tube anastomoses with the main infraorbital canal between the frontal and pterotic bones, and the primary tube between the fourth and fifth organs of the line has been suppressed.

The preoperculo-mandibular canal anastomoses at its dorsal end with the main infraorbital canal between the pterotic organs that are innervated by the oticus lateralis and the supratemporalis lateralis vagi. It contains eleven sense organs, four lying in the dentary, one in the articular and six in the preopercular, as in Scorpaena, this being one more organ in the dentary and one more in the preopercular than is found in Cottus. The next to the most dorsal organ in the preopercular was nearly always a double organ.

II. Trigla lyra.

In Trigla lyra the granulations on the dorsal surface of the skull are considerably smaller than in T. hirundo, and the striae smaller and more numerous. This gives to the surface a sand-paper-like feel and appearance. The preorbital part of the skull is bent downward somewhat more than in T. hirundo and the skull is everywhere relatively taller than in that fish, excepting only in the anterior half of the snout, where it has the same relative height. On the posterior half of the dorsal surface of the snout there is a large, low, median swelling. The interorbital portion of the dorsal surface of the skull is but slightly concave, and there is, on either side, but one, short and stubby, preorbital spine. The postorbital portion of the dorsal surface of the skull is decidedly convex in transverse section, and slightly convex in median longitudinal section; and there is no slightest indication of a subquadrangular groove.

The rostral depression is relatively larger than in T. hirundo. The nasal rests definitely upon the summit of the anterior palatine process of the ethmoid cartilage, the rounded antero-ventral surface of the latter process articulating with a facet at the base of the maxillary process of the palatine. The anterior edge of this facet on the palatine is raised to form an eminence which gives insertion to the rostro-palatine ligament, and this eminence, lying in front of the palatine process of the ethmoid cartilage, fits in between the nasal above and the ascending process of the vomer below in such a manner that it seems to form part of the articular contact of the palatine with this part of the skull. The lateral edge of the nasal has a sliding articulation with the dorsal surface of the lachrymal, as in T. hirundo.

The ectethmoids suturate with each other in the middle line behind the mesethmoid, as Günther has stated. The orbital surface of the bone includes the orbital surface of the bone in T. hirundo and also that little surface that lies between the two posterior portions of the ridge along the lateral edge of the ventral surface of the bone in the same fish. This condition thus being intermediate between that in T. hirundo and that in Scorpaena.

The median anterior eye-muscle canal, in the antorbital cartilage, so well developed in T. hirundo, is here represented by what is little more than a perforation of the extreme anterior end of the interorbital septum. From there a canal for the olfactory nerve runs forward on either side, this canal being enlarged, as in T. hirundo, to form a deep and large recess in the hind end of the meseth-

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moid, the recesses of opposite sides being separated by a thin wall of bone. The mesethmoid extends entirely through the antorbital cartilage, and presents, on the ventral surface of that cartilage, a median circular surface which lies directly upon the parasphenoid; the vacuity found in this part of the bone of T. hirundo not here being present.

The parasphenoid has much the shape that it has in T. hirundo, but the ascending processes are well differentiated, and there is no median process in the interorbital region.

The basisphenoid has a short pedicle which descends only about one half the depth of the myodome, and there terminates with a free end. This free end gives attachment to the middle point of the anterior edge of a stout membrane which extends backward and downward in the middle line, and laterally and slightly downward on either side, and has its insertion on the floor and sides of the myodome. This membrane separates the myodome into two parts, a larger dorso-posterior portion and a smaller antero-ventral one. The dorsal portion lodges the rectus externus, the ventral portion lodging the rectus internus. This membrane, judging from the serial sections of the several fishes that I have examined, must be found in all teleosts, in a more or less developed condition. In Scomber I have already described it (Allis, '03, p. 92).

In other respects there are, in the cranium of T. lyra no important differences from that of T. hirundo.

The hyomandibulo-palato-quadrate apparatus differs somewhat in shape from that of T. hirundo, but in all important respects it closely resembles the apparatus of that fish. The lachrymal is somewhat differently shaped, and its anterior edge is furnished with a number of stout sharp spines. Two bones replace the large second infraorbital bone found in medium-sized specimens of T. hirundo, thus making five bones, in all, in the series.

According to Günther there are six bones in the series, but the specimens examined by him must have been young fish, for in all of my specimens, which are large ones, there are but five bones. The ridge that extends horizontally across the outer surface of the preopercular is much more pronounced than in T. hirundo, and extends forward to that point of the third infraorbital bone from which the striae of the bone all radiate. The dorsal end of the preopercular is prolonged upward and touches and is firmly bound to the outer surface of the hyomandibular, thus forming a closed oval passage through which that part of the dilatator operculi that has its origin in the dilatator fossa passes to reach its point of insertion on the opercular. The spine on the opercular, at about the middle of its hind edge, is much longer and stouter than in T. hirundo.

III. Peristedion cataphractum.

1. SKULL.

The orbital and postorbital portions, together, of the skull of Peristedion, occupy the posterior half only of the total length of the skull, and the posterior third only of the total length of the skeleton of the head. The anterior half of the skull is formed by the long, broad, flat and thin preorbital portion, or snout of the fish, which is straight and inclines slightly downward. The outer surfaces of all the bones are finely granulated, the granulations being arranged, in certain places, but not everywhere, in faintly indicated striae.

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The flat anterior ends of the lachrymals form the so-called preorbital processes. These processes are nearly as long as the snout of the fish, and their edges are finely serrated, each little tooth being the end of a vein on the thin edge of the process, this vein appearing both on the dorsal and ventral surfaces of the process as a slight and finely granulated ridge. At the base of the process two ridges begin. The dorsal one is much the stronger and extends backward, across the cheek bones, as a longitudinal, horizontally-projecting shelf, to the hind edge of the preopercular, where it terminates in a tall, thin, obtuse and finely serrated hind end. The anterior half of the ridge bears two groups of small point-like spines; a short anterior group, on the second bone of the infraorbital series, and a long posterior one, on the third bone of the series. Dorsal to the ridge the outer surface of the cuirass of the cheek inclines dorso-mesially, while, ventral to it, it inclines ventrally or ventro-mesially, the ridge making a prominent angle on the outer surface of the cuirass. The ventral ridge is much less important than the dorsal one, and lies near the ventral edge of the cheek bones. It, also, extends to the hind edge of the preopercular, but it is always interrupted, as, or just before, it reaches the anterior edge of that bone, and there usually breaks up into several slightly diverging ridges, all of which are finely serrated their full length.

On the anterior quarter line, approximately, of the dorsal surface of the snout, at about the middle of the length of the nasal bone, there is, on either side, either one stout vertical spine, or two or more smaller spines lying one directly behind the other. On the posterior quarter line of the snout, or even still nearer its base, there is, near the lateral edge of its dorsal surface, on the ectethmoid bone, a group of from one to three similar but smaller spines. Postero-lateral to these latter spines, there are, also on the ectethmoid, two or three short diverging lines of small tooth-like spines. The dorso-mesial one of these lines is continuous with the dorsal edge of the orbit, that edge being serrated. Slightly anterior to the transverse line of the ectethmoid spines, there is, on the dorsal surface of the mesethmoid, a single large median spine.

Starting from the group of ectethmoid spines, on either side, a ridge runs backward to the hind edge of the dorsal surface of the skull, traversing the ectethmoid, frontal and parieto-extrascapular bones. The ridges of opposite sides converge slightly, at first, in a gentle curve, and then run backward in slightly curved and slightly diverging lines to the hind end of the interorbital region, when they again converge slightly to the hind edge of the skull. As they pass between the orbits each ridge lies slightly mesial to the dorsal edge of the corresponding orbit. Each ridge bears a variable number of spines, the spines that lie on the ectethmoid part of the ridge being small and sharply pointed, while the others, on the frontal and parieto-extrascapular portions, are usually serratures that increase gradually in size toward the hind end of the ridge. The large posterior serrature lies on the parieto-extrascapular, extending the full length of that bone and ending almost directly dorsal to the summit of the epiotic. The next anterior serrature is slightly smaller than the posterior one, rises from the hind edge of the frontal, and extends across that part of the frontal that lies posterior to the frontal commissure of the latero-sensory canals. The next anterior serrature is still smaller, is sometimes double, and lies opposite and slightly posterior to the lateral end of the frontal commissure. Beneath the base of this last serrature the sixth tube of the supraorbital canal passes, on its way to join and anastomose with the main infraorbital canal at the edge of the frontal. The fifth tube of the supraorbital canal has been suppressed, as in Scorpaena, the seventh or terminal tube opening on the outer surface of the frontal slightly mesial to the point of this same serrature. This third serrature from the hind end of the line thus has the position, relative to the supraorbital

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canal, of the frontal spine of Scorpaena, but it does not lie at the hind end of the frontal, that position being held by the penultimate serrature of the line. Whether this latter serrature represents a part of the frontal spine or not, I can not determine, but it apparently does. The spine on the parieto-extrascapular must then be a parietal spine, and there is no nuchal spine. Starting from or slightly postero-lateral to the frontal spine, and running at first postero-laterally, and then posteriorly, near the lateral edge of the dorsal surface of the skull, there is another ridge, which corresponds in position to the lateral row of spines of Scorpaena. This ridge has a wavy or bluntly serrated edge and sometimes terminates, at the hind end of the suprascapular, in a small spine.

Emery ('85) has given a figure of the skull of the adult Peristedion in which the spines that I have just described are roughly shown, with the exception of the mesethmoid and ectethmoid spines, which are neither shown in the figure nor mentioned in the text. The spines are also shown by the same author in two figures of larvae of Peristedion of different ages, the skull of the youngest larva being said to so greatly resemble the skull of the adult Scorpaena that Emery calls that larva the scorpaenoid stage of the fish. At these two stages of Peristedion the spines are all very large, and a single spine on the nasal, and a single large spine on the frontal represent the several spines on those bones of the adult. A spine is also shown on the pterotic of the youngest larva, this spine being wholly wanting in the adult. Similarly, a spine is said by Emery to be found on the nasal of the young of Trigla hirundo, and to wholly disappear in the adult.

The dorsal surface of the skull of Peristedion, between the fronto-parietal serrated ridges, and posterior to the frontal commissure, is perfectly flat, lies in a horizontal position, and corresponds to the region of the subquadrangular groove on the vertex of Scorpaena. Lateral to the ridge that bounds this surface, on either side, the dorsal surface of the skull is a flat surface that slopes rapidly downward at an angle of approximately 30° to the vertical plane. Between the orbits the dorsal surface is concave. A low rounded ridge, on either side, here marks the course of the supraorbital latero-sensory canal, the two ridges converging forward, in nearly straight lines, toward the median spine on the mesethmoid. In the preorbital region the lateral edge of the dorsal surface of the skull lies, as it does in Trigla, in the level of the ventral surface of this part of the skull; and the line of this edge, prolonged posteriorly, falls, in Peristedion, nearly into the line of the lateral edge of the postorbital part of the dorsal surface of the skull.

The posterior surface of the skull resembles that of Trigla but is steeper, and hence shorter than it is in that fish. The hind edge of the secondary skull is sharp and finely serrated, and slightly ventral to this edge, and parallel with it, there is a slight but sharp ridge which projects posteriorly and forms a little shelf which gives support to the anterior edges of the anterior row of the bony plates of the body. The middle portion of the shelf is formed by the supraoccipital, its lateral portion, on either side, being formed by the parieto-extrascapular and suprascapular. Beneath the ridge, or shelf, there is a slight median vertical ridge which represents the spina occipitalis. This little shelf in Peristedion is apparently simply the ventral edge of the somewhat thickened hind end of the secondary skull of the fish. Ventral to it there is a low and rounded transverse ridge which represents what I have described in Scorpaena and Trigla as the hind edge of the primary skull. Between this ridge and the little shelf that represents the hind edge of the secondary skull, there is a shallow groove which, although it here lies definitely on the hind surface of the skull, evidently represents the supratemporal fossa.

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The ventro-posterior limb of the supraoccipital extends ventrally almost to the dorsal margin of the foramen magnum, being separated from that margin by a median bit of cartilage. This exposed bit of cartilage forms the hind end of a median band which separates the dorsal edges of the exoccipitals. The postero-lateral edge of the skull, the edge that separates its posterior and lateral surfaces, is thin, and projects ventro-laterally as a tall ridge. The ventral portion of this edge is formed by the exoccipital and lies in a nearly horizontal position; its dorsal portion, formed by the posterior process of the pterotic, lying in a nearly vertical position. Between these two portions there is a large rounded corner formed by the opisthotic. This gives to the posterior surface of the skull a flattened hexagonal appearance.

The temporal fossa is small and shallow, and on one side of one of the three specimens examined was almost obliterated by the encroaching growth of the bounding bones. The anterior portion of the fossa was especially affected by this contraction, but still remained as a small recess roofed by the small lateral extrascapular.

The dorsal surface of the skull is formed, as in Trigla, by the nasals, mesethmoid, ectethmoids, frontals, postfrontals, sphenotics, pterotics, parieto-extrascapulars, lateral extrascapulars and suprascapulars. All of these bones come to the level of the outer surface of the skull, the exposed portions of all of them being similarly marked by surface granulations. Slightly grooved lines mark most of their contours. Anterior to the nasals, and lying at a but slightly lower level, there is a small rostral depression. The floor of this depression is formed in part by a narrow, thin and smooth projecting plate of the deeper layers of either nasal, in part by the ascending processes of the vomer, and in part by a small intervening portion of the cartilage of the rostrum. The mesethmoid is entirely shut off, by the nasals, from bounding relations to the depression.

The MESETHMOID has an exposed dorsal surface that is usually somewhat lenticular in shape, and the stout, median, mesethmoid spine rises from it, slightly anterior to its middle point. Beneath the superficial, dermo-perichondrial portion of the bone there is a primary portion, of less extensive surface, which extends completely through the cartilage of the snout. In its deeper portion this primary component expands, and becomes a circular plate formed around a point that lies directly beneath the median mesethmoid spine. Between this circular basal plate of the bone and the dorsal dermo-perichondrial plate, there is, on the lateral and posterior edges of the bone, a deep groove; the grooves on the lateral surfaces of the bone being exposed laterally, but the one on the posterior surface lying within the cartilage of the skull. The lateral edge of the dermo-perichondrial component of the bone suturates with the mesial edge of the corresponding component of the ectethmoid, a canal, large anteriorly but small posteriorly, being left between the two bones; the canal lying partly between the primary components and partly between the deeper layers of the dermo-perichondrial components of the bones. The smaller, posterior portion of this canal transmits the supraorbital latero-sensory canal and the ramus ophthalmicus superficialis; the larger anterior portion transmitting that same canal and nerve, and also the nervus olfactorius. A varying number of openings, between the ethmoid bones, lead from the canal to the outer surface of the skull, but they are all closed externally by membrane. Anteriorly the mesethmoid suturates with the nasal bones, and posteriorly with the frontals. Ventrally, its primary portion lies directly upon the dorsal surface of the parasphenoid, the two bones being so firmly attached to each other that they would seem to be in process of ankylosis.

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The ECTETHMOID has dermo-perichondrial and primary portions, and resembles, in general shape, the corresponding bone in Trigla. Its posterior surface forms the anterior wall of the orbit. Posteriorly, its superficial component suturates with the frontal, while mesially it suturates with the mesethmoid and nasal, extending forward, along the lateral edge of the latter bone, almost and sometimes quite to the hind edge of a small oval nasal incisure in the lateral edge of the skull. This anterior end of the ectethmoid, when it reaches the nasal incisure, forms only a point in the hind wall of that incisure, and the bone has no other bounding relations to the nasal pit. The mesial edge of that part of the ectethmoid that bounds the nasal bone is grooved, and the lateral edge of the related portion of the nasal bone, that edge of the nasal bone here being grooved on its dorsal surface, fits into the groove on the ectethmoid; the nasal bone thus appearing, in dorsal views, to here underlie the ectethmoid, while in reality it overlies it. Between the dorsal edge of this portion of the ectethmoid and the dorsal surface of the body of the nasal, there is the long and wide groove above referred to, which groove, although it appears to lie between the two bones, lies largely on the dorsal surface of the nasal bone alone. This groove is roofed, in the recent state, by a thin and tightly stretched drum-head-like membrane, which is pierced by several small holes, the groove lodging he anteriorly-directed second supraorbital primary tube, and the several small holes being the pores by which that tube opens onto the outer surface. Similar drum-head-like membranes, perforated by several small holes, are found associated with nearly all of the primary latero-sensory tubes on the head of the fish, but none of them are so large as this second supraorbital one.

The ventro-lateral edge of the ectethmoid presents three regions, one of which forms the anterior half of the edge, and the other two its posterior half. The edge of the bone in the posterior one of these three regions is presented ventrally, in a line that extends posteriorly and slightly laterally, and forms the ventral edge of the lateral portion of the orbital surface of the bone. On the outer surface of this part of the bone there is a smooth surface which gives a sliding articulation to a corresponding surface on the inner surface of the dorsal edge of the third infraorbital bone. Immediately anterior to this posterior portion of the ventro-lateral edge of the bone, there is a short portion which is thickened and rounded to form an articular edge which articulates with a groove on the dorsal edge of what I shall later describe as the dermo-ectopterygoid. Directly mesial to this articular edge, a groove begins on the ventral surface of the ectethmoid and continues forward along the ventral surface of the lateral edge of the anterior half of the bone. The anterior portion of the lateral edge of the bone, lateral to the groove, is rounded. When the cheek bones swing inward the groove receives the dorsal edges of the palatine and dermo-ectopterygoid, and limits the swing of the bones. When the cheek bones swing outward the rounded lateral edge of the ectethmoid enters a groove on the dorsal edge of the lachrymal, between it and the palatine, and limits the swing of the bones in that direction.

A small olfactory canal perforates the antorbital cartilage, mesial to the ectethmoid, lying, in its posterior portion, in the specimens examined, wholly in that cartilage.

The VOMER caps the end of the thin flat and broad cartilage of the snout, and is wholly without teeth. It has a broad thin and delicate body, which lies partly on the ventral surface of the cartilage of the snout and partly on the ventral surface of the parasphenoid, and two short wide and somewhat stouter ascending processes which lie on the dorsal surface of the cartilage of the snout and come into contact, posteriorly, with the anterior edges of the ventral plates of the nasals.

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There is a broad rounded incisure between the two ascending processes, the incisure embracing the anterior end of a small median interspace of cartilage which lies between this incisure and a median incisure between the adjoining anterior edges of the ventral plates of the nasals. Directly anterior to the incisure in the vomer, there is a very small median eminence on the anterior edge of the bone, and midway between this eminence and the lateral edge of the bone there is a larger eminence, also on the anterior edge of the bone. Running dorso-laterally from this latter eminence there is a slight ridge which terminates in an eminence on the dorsal surface of the ascending process of the bone. Lateral to this ridge and eminence there is a broad and shallow groove which gives articulation, through the intermediation of a pad of tough fibrous tissue, to the postero-mesial surface of the ascending process of the maxillary. Lateral to this articular groove, the ascending process of the vomer bounds and supports the anterior palatine process of the ethmoid cartilage.

The ROSTRAL is pyramidal in shape, as in Trigla, and gives support, on its anterior surface, to the ascending processes of the premaxillaries. Its internal surface rests upon the little median interspace of cartilage on the dorsal surface of the snout, and also on the adjoining portions of the ascending processes of the vomer. This interspace of cartilage lies considerably anterior to the nasal pits, as it does in Trigla, instead of being internasal in position, as it is in Scorpaena.

Whether there is in Peristedion, as in Trigla, a diverticulum of the nasal sac of either side that extends into the rostral depression, was not investigated; but it would seem not, the space beneath the anterior end of the nasal seeming too small to permit it.

The PREMAXILLARY is a slender untoothed bone, with a large flat and thin postmaxillary process, and small ascending and articular processes. The proximal end of the shank of the bone is bent so as to project postero-ventrally and slightly mesially, and from the base of this bent portion the short ascending process arises; this process and the proximal end of the bone together forming a straight edge, and together looking like the flattened and broadened proximal end of the bone. This straight edge of the bone lies close to its fellow of the opposite side, the ascending process being directed dorso-anteriorly instead of dorso-posteriorly. From the dorso-anterior end of the process, or from the rostral immediately posterior to it, a ligament arises, and running ventro-postero-laterally is inserted on the maxillary at the base of the ascending process of that bone. This ligament is apparently the homologue of one half of the rostro-palatine ligament of Scorpaena and Trigla, the other half of the ligament arising on the maxillary, close to the point of insertion of this one, and extending from that bone to the palatine. The articular process of the premaxillary is small, is directed dorso-posteriorly, and articulates with a large but low articular eminence on the anterior surface of the proximal end of the maxillary.

The MAXILLARY has a slender shank, with its distal end abruptly expanded. On the anterior surface of the proximal end of the bone there is a large oval eminence which gives articulation to the premaxillary, the long axis of the eminence being directed dorso-distally across the anterior surface of the bone. From the dorsal edge of the bone, in the line of the axis of the articular eminence, the ascending process of the bone arises, the process lying transverse to the shank of the bone and being directed dorso-postero-laterally. The postero-ventral edge of the process is thickened, and has a sliding articulation with the dorsal surface of the ascending process of the vomer, in the groove already described, the articulating surfaces being separated by a pad of tough fibrous tissue. In the angle between the distal surface of the process and the shank of the bone, is the articular surface for

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the anterior end of the maxillary process of the palatine. This process of the palatine is, as in Trigla, closely bound to the dorso-mesial edge of the lachrymal, and from the adjoining edges of these two bones a strong ligament arises and has its attachment on the dorsal surface of the maxillary. This ligament, as already stated, apparently represents the distal half of the rostro-palatine ligament of Scorpaena. The ethmo-maxillary ligament is represented by a short ligament that extends from the ascending process of the maxillary to the ventral surface of the nasal, at the base of its process-like antero-lateral corner. There is no ligamentary process either on the external or internal surface of the bone, this doubtless being in causal relation to the slightly developed condition of the maxillo-mandibular ligament and of that tendon of the adductor mandibulae that has its insertion on the maxillary.

The NASAL is a flat quadrilateral bone, which rests, in large part, directly upon the dorsal surface of the thin flat anterior portion of the antorbital cartilage. In the anterior two-thirds of its length it suturates, in the middle line, with its fellow of the opposite side. Posteriorly it diverges slightly from the middle line, leaving a V-shaped space between itself and its fellow of the opposite side, this space receiving the pointed anterior end of the mesethmoid. The narrow hind end of the bone suturates with the mesethmoid, slightly overlapping that bone externally. Laterally, the posterior half of the bone suturates with the long anterior end of the ectethmoid, in the manner already described. The dorsal surface of this part of the bone is deeply grooved, near and parallel to its lateral edge, for the second primary tube of the supraorbital lateral canal, as also already described. A narrow wall of bone alone separates the extreme anterior end of this groove from the hind end of the nasal incisure. The antero-lateral corner of the bone is prolonged into a short stout horn-like process which rests upon the summit of the anterior palatine process of the ethmoid cartilage. On the lateral surface of the anterior end of this process there is the large opening of the anterior primary tube of the supraorbital latero-sensory canal, this tube opening on the outer surface by a single large pore. The bone is traversed by the supraorbital latero-sensory canal, and lodges one organ of the line.

The lateral half of the nasal is thickened, its full length, and this thickening would seem to be due to the fusion, with the usual dermal component of the bone, of a thin underlying plate of bone. This underlying plate lies directly upon the cartilage of the snout, and projects slightly beyond the overlying portion of the nasal, both anteriorly and laterally. The laterally projecting portion of the plate forms the floor of the nasal pit, while the anteriorly projecting portion overlaps externally the hind edge of the ascending process of the vomer. The antero-lateral corner of the plate lies directly beneath but is separated by a very narrow slit from the process-like antero-lateral corner of the dorsal, dermal portion of the bone, and here approaches and gives support to the base of the but slightly developed anterior palatine process of the ethmoid cartilage. This latter process forms, as in Trigla, the antero-lateral corner of the thin flat cartilage of the snout.

The ventral plate of the nasal of Peristedion thus occupies somewhat the position of the corresponding half of what I have described, in Trigla, as the perichondrial portion of the mesethmoid of that fish. It also occupies much the position of the plate that I have described, in Belone, as underlying the dermal component of the nasal of that fish. In Peristedion, as in Belone, it separates from the underlying cartilage, in slightly boiled specimens, without breakage of the cartilage, and hence would seem to be of membranous origin, but this was not carefully investigated. Two suppositions suggest themselves regarding it. The one, that there is a predisposition in the tissues of this region to the development of this plate, and that the plate attaches itself to the mesethmoid or nasal,

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according as the one bone or the other covers the region; and the other, that the anterior palatine process of the ethmoid needing support, a supporting plate is developed from the nearest bone available.

The FRONTAL has nearly straight mesial and hind edges, lying at a right angle to each other. It has a small ventral flange, resembling somewhat, but much smaller than that of Scomber. Posterior to this flange, on the ventral surface of the bone, there are two slight ridges, meeting at an angle, which form, as the similar but more developed ridges of Scomber do, the antero-mesial and antero-lateral boundaries of the anterior end of the lateral cranial fontanelle. The frontal suturates mesially with its fellow of the opposite side, posteriorly with the parieto-extrascapular, and laterally with the pterotic, the postfrontal, and a small corner of the sphenotic that comes to the level of the outer surface of the dermal bones. It is traversed by the supraorbital latero-sensory canal and lodges five organs of that canal, which are similarly disposed to those found in Scorpaena and Trigla; that is, the second, third and fourth organs of the line are in regular positions; the fourth and fifth organs lie close together without intervening primary tube; and the sixth organ is a small one lying in the small terminal tube of the line and innervated by a nerve that first issues in the orbit and then perforates the alisphenoid to enter the cranial cavity and perforate the frontal beneath the organ it innervates.

The POSTFRONTAL is a small bone that forms the roof of the small dilatator fossa, and is bounded mesially by the frontal, posteriorly by the pterotic, and anteriorly by the dorso-lateral corner of the sphenotic. It is traversed by the dorsal end of the postorbital portion of the main infra-orbital canal, and lodges one organ of that canal, innervated by the ramus oticus lateralis.

The PARIETO-EXTRASCAPULAR forms part of the hind edge of the secondary skull, and its hind edge is thickened and grooved, as already described. The bone suturates anteriorly with the frontal, and laterally with the pterotic, lateral extrascapular, and suprascapular, not overlapping dorsally the epiotic process of the latter bone. It lies directly upon the supraoccipital, the epiotic and the adjoining cartilaginous portions of the roof of the cranium, its lateral edge forming part of the roof of the temporal fossa. Its hind edge is traversed by the supratemporal commissure of the latero-sensory system and lodges one organ of that commissure.

The LATERAL EXTRASCAPULAR is a small subcircular bone lying between the fronto-parietal and lateral spinous ridges, wedged in between the pterotic, parieto-extrascapular and supra-scapular bones. It forms part of the roof of the temporal fossa, but does not come to the lateral edge of the skull, being shut off from that edge by relatively wide suturating portions of the pterotic and suprascapular. It is traversed by the lateral portion of the supratemporal latero-sensory commis-sure and lodges one organ of that commissure. It is not perforated by the main infraorbital canal, as in the other fishes described, the canal here simply passing along the lateral edge of the bone, partly enclosed in it, and there apparently being no organ of the main infraorbital line related to it. In this Peristedion resembles Dactylopterus, as will be later described.

The SUPRASCAPULAR forms the postero-lateral corner of the dorsal surface of the skull, and the larger part of the roof of the temporal fossa. It has a well developed opisthotic process, but no differentiated epiotic process, that part of the bone that represents that process being relatively short and appearing as an epiotic region rather than an epiotic process of the large body of the bone. On the ventral surface of this epiotic region of the bone there is a small ventral process, and this process and the adjoining portion of the mesial edge of the bone suturate with the hind end of the suprascapular process of the epiotic. The anterior edge of this part of the bone suturates with the

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lateral edge of the parieto-extrascapular, that bone not overlapping the suprascapular at all. The remainder of the anterior edge of the bone suturates with the lateral extrascapular and pterotic. The bone is traversed by the main infraorbital latero-sensory canal and lodges one organ of that canal. The canal leaves the bone by a large opening on its lateral edge, near its hind end, and immediately anterior to this opening, on the ventral surface of the bone, the wide stout opisthotic process arises. Immediately postero-mesial and also immediately postero-lateral, to the hind edge of the base of the opisthotic process, there are small articular facets. These two facets give articulation to two articular eminences on the dorsal edge of the supraclavicular, these eminences embracing the hind edge of the opisthotic process of the suprascapular. From the deep layers of the hind edge of the epiotic region of the bone there projects postero-mesially a thick plate of bone which gives support, on its dorsal surface, to the first one of the series of dorsal plates on the body of the fish.

The SUPRACLAVICULAR is a somewhat triangular bone, the external surface of which is slightly concave and partly covered with small granulations. On its short dorsal edge, which represents the base of the triangle, are the two little eminences, above referred to, which articulate with the suprascapular. Posterior to these eminences, the dorso-posterior corner of the bone is traversed by the main latero-sensory canal, and lodges one organ of that canal. The ventral end of the bone is pointed, instead of being expanded as in Trigla, but, as in that fish, it overlaps externally and is bound to the dorsal end of the clavicle; and, excepting that the bone is relatively smaller than in Trigla, there is nothing abnormal in its position or relations to the other bones.

The PARASPHENOID has the shape shown in the figures. The ascending process of either side rises at about the posterior quarter of the length of the bone, and is a thin triangular plate that lies transversely to the axis of the bone instead of parallel to that axis. The point of the triangle is directed upward and the base downward, and from this base of the triangle a thin flange of bone extends forward along the lateral surface of the bone. The mesial edge of the triangle is thickened somewhat, is directed dorso-latero-posteriorly and terminates in a sharp point; and this thickened part alone of the triangle would seem to be the homologue of the entire ascending process of the bone in the other fishes so far described, for it alone lies between the anterior edge of the posterior portion of the body of the bone and the hind end of its thickened interorbital portion. The triangular plate can accordingly be considered as a thin flange of bone that arises from the lateral surface of the ascending process proper; this flange projecting laterally and slightly posteriorly, and, at the ventral end of the process, being bent forward, in a rounded angle, and then continued forward as a flange that projects laterally and slightly ventrally from the ventral edge of the lateral surface of the interorbital portion of the bone.

On the dorsal surface of the interorbital portion of the parasphenoid, two thin laminae of bone arise, and converging posteriorly, unite, slightly anterior to the ascending processes of the bone, to form a median tooth-like process. The triangular space between the two laminae lodges, as in Trigla, the ventral end of the cartilage of the interorbital septum, the hind end of the process giving attachment to membrane that represents the leg of the basisphenoid; that bone being wanting in Peristedion. On the dorsal surface of the posterior portion of the parasphenoid there is a median longitudinal raised portion which is deeply grooved on its dorsal surface. This raised portion fills the hypophysial fenestra, the groove on its dorsal surface forming part of the floor of the myodome. The hypophysial fenestra extends backward slightly beyond the anterior edge of the basioccipital.

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There is no BASISPHENOID bone, as just above stated, nor is there an ORBITOSPHENOID.

The ALISPHENOID is bounded by the proötic ventrally, the frontal dorsally and the sphenotic postero-laterally. Its anterior edge forms the dorsal half of the large orbital opening of the brain case, this edge of the bone being, because of the flattening of the hind wall of the orbit, presented almost directly mesially. There is no indication of a parasphenoid leg to the bone. On the dorsal half of the inner surface of the bone there are two brace-like thickenings, the larger one of which underlies the antero-lateral corner of the postepiphysial interspace of cartilage, while the other forms the dorsal end of the anterior wall of the labyrinth recess. The mid-brain recess lies between the two braces. The anterior edge of the bone is either notched, or perforated by a small foramen which must transmit the anterior cerebral vein, though this vein was not traced in the dissections. Not far from the ventral edge of the bone a small opening leads into a canal which traverses the bone and transmits that branch of the ophthalmicus lateralis that innervates the terminal organ of the supra-orbital canal.

The SPHENOTIC is bounded by the alisphenoid, proötic and pterotic, and gives support, on its dorsal surface, to the frontal and postfrontal bones. Its dorso-lateral corner comes to the level of the dorsal surface of the secondary skull, and has surface markings similar to those on the adjacent dermal bones. Between it and the proötic there is a deep facet for the anterior articular head of the hyomandibular, while, posteriorly, between the sphenotic and the pterotic, there is a small dilatator fossa. The bone is traversed by a canal for the ramus oticus facialis, as in Scorpaena.

The DILATATOR OPERCULI, it may here be stated, is found in anterior and posterior portions which are separated from each other by the complete fusion of a suprapreopercular bone with the hyomandibular. The anterior portion arises in the dilatator fossa, is fibrous, with but few muscle fibers, and is inserted on the suprapreopercular and the adjoining portions of the hyomandibular. The posterior portion is muscular, arises from the posterior surface of the suprapreopercular and the adjoining portions of the hyomandibular, ventral to the opercular process of that bone, and has its insertion on the opercular. The fusion of the suprapreopercular with the hyomandibular thus cuts the originally continuous muscle into two portions.

The PROÖTIC is bounded by the alisphenoid, sphenotic, pterotic, exoccipital and basioccipital bones, its ventral edge being overlapped externally by the parasphenoid. The opisthotic does not come into bounding relations with it. The mesial process of the bone inclines strongly upward and corresponds to the postpituitary portion, only, of the processes of Trigla and Scorpaena. The lateral corner of the anterior edge of the process is perforated by the foramen for the nervus abducens. The anterior edge of the body of the bone is perforated, as in Trigla, by a large opening which is the facialis opening of the imperfectly enclosed trigemino-facialis chamber. This chamber forms a deep recess on the orbital surface of the proötic, and from it four foramina usually lead into the cranial cavity. Two of these foramina are large, one of them lying directly dorsal to the other and being separated from it by a delicate bar of bone. The other two foramina are small, one of them lying immediately dorsal to the dorsal one of the two large foramina, and the other one anterior to the line of separation between the two latter foramina. The dorsal one of the two large foramina transmits the nervus trigeminus and ramus buccalis lateralis, the ventral one transmitting the nervus facialis. The small foramen dorsal to the trigeminus foramen transmits the ramus ophthalmicus lateralis, this foramen being sometimes fused with the trigeminus foramen. The other small foramen transmits the ciliaris

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profundi and also the encephalic branch of the jugular vein. The antero-ventral edge of the trigemino-facialis chamber is either notched, or perforated by a foramen which transmits the palatinus facialis from the chamber into the myodome, this nerve here, as in Trigla, issuing from the cranial cavity through the facialis foramen and then running forward along the floor of the trigemino-facialis chamber. The edge of the orbital portion of the bone, dorsal to its mesial process, is notched to transmit the oculomotorius, and dorsal to this notch, near the ventral edge of the alisphenoid, there is a second but shallower notch for the nervus trochlearis.

The MYODOME has proötic and basioccipital portions, and, excepting in that the basisphenoid bone and the prepituitary portions of the mesial processes of the proötics are replaced by membrane, the canal is the exact equivalent of the canals of Trigla and Scorpaena. There being no basisphenoid bone, the myodome, in the prepared skull, opens into the hind end of the orbit by a wide median opening, bounded, on either side, by the ascending process of the parasphenoid. In the middle line of the floor of the opening there is the median tooth-like process of the parasphenoid. The hypophysial fenestra extends nearly the full length of the myodome, but is much narrower in the basioccipital region than in the proötic. The fenestra is completely closed by the underlying parasphenoid, the myodome not opening, posteriorly, on the ventral surface of the skull. The roof of the basioccipital portion of the canal is formed by a thin plate of bone, which separates this part of the myodome from the overlying cavum sinus imparis. The cavum sinus imparis extends posteriorly slightly further than the myodome, the pointed ends of both canals being directed toward the point of the conical vertebra-like depression on the hind end of the basioccipital.

The BASIOCCIPITAL is normal, but presents, in median-vertical section, a marked feature. The shallow conical vertebra-like depression in the hind end of the bone, in such sections, is lined by a superficial layer of dense bone differing markedly in appearance from the deeper portions of the bone. A thinner layer of similar bone lines the deeper conical depression, in the anterior end of the bone, that forms the hind end of the myodome. The ends of these two cones approach each other, and the dense bone lining them is continued, in the middle line of the bone, from one cone to the other. In Scomber I described ('03, p. 102) a similar but much less pronounced line, which, in that fish, connected the bottom of the cavum sinus imparis with the vertebra-like depression in the hind end of the basioccipital, and I said that this seemed to indicate that the cavum sinus imparis might be the remnant of the anterior conical depression of a vertebral body. In Peristedion it is not the cavum sinus imparis, but the hind end of the myodome, that has the appearance of being such a depression on the anterior surface of a vertebral element; and if it be such a depression, it would offer a rational explanation of the basioccipital extension of the myodome. That this extension of the myodome is due simply to the fact that the rectus externus, deriving great advantage from a slight additional posterior shifting of its point of origin, has extensively excavated the basioccipital, has never appealed to me. And if a simple posterior extension of its point of origin is of such considerable advantage to the rectus externus, why should it not also be of some advantage to the rectus internus, which muscle, in Scomber and in all of the mail-cheeked fishes that I have examined, never acquires this posterior extension? But, if there were a pre-existing depression in the anterior end of the basioccipital, its occupation and subsequent enlargement by one only of the two muscles would seem most natural. Similar reasoning, applied to the proötic, would account for the origin of the proötic part of the myodome, as will be further discussed in the section devoted to the myodome of fishes.

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The cavum sinus imparis extends, in Peristedion, but slightly beyond the middle of the length of the basioccipital, the bone posterior to it having a relatively broad, concave dorsal surface, the posterior portion of which forms the ventral boundary of the foramen magnum and the floor of the cranial cavity immediately anterior to that foramen. Lateral to the cavum sinus imparis the bone lodges a small portion of the short subcircular saccular groove.

The basioccipital is, as usual, bounded dorsally, on either side, by the exoccipital, and anteriorly by the proötic. Ventrally it is overlapped externally by the parasphenoid.

The EXOCCIPITAL is bounded by the basioccipital, proötic, pterotic, opisthotic, epiotic and supraoccipital, and it is perforated by separate foramina for the glossopharyngeus, vagus and occipital nerves. The vagus and occipital foramina have positions similar to those in Trigla, the vagus foramen, in all my specimens, being divided into two parts by a transverse bar of bone. The glossopharyngeus foramen lies directly anterior to the vagus foramen, at one half or two thirds the distance to the anterior edge of the bone. Immediately dorsal to the vagus and glossopharyngeus foramina there is a slight horizontal ridge along the outer surface of the bone; and dorsal to this ridge, nearly the entire lateral surface of the brain case is occupied by a large subtemporal depression which, as in the other fishes of the group, gives origin to the adductor hyomandibularis and adductor operculi muscles, and probably also to the fourth and fifth levators of the branchial arches; but the origins of the levator muscles of the branchial arches were not investigated. The fossa on the proötic, so well developed in Scorpaena, is apparently represented, in Peristedion, by a slight groove along the anterior edge of the subtemporal depression.

On the internal surface of the exoccipital there is a mesial process, but it has almost completely coalesced with the lateral wall of the bone, thus here giving to the bone a thick and distinctly double ventral edge which suturates with the basioccipital. At the anterior end of this thick ventral edge, the mesial process separates slightly from the side wall of the bone and so bounds a small dorso-posterior portion of the saccular groove.

The OPISTHOTIC forms part of the thin ventro-laterally projecting portion of the postero-lateral edge of the skull. It lies in a nearly transverse position, filling a large and somewhat square interval between the ventral edge of the posterior process of the pterotic and a right-angled incisure in that portion of the exoccipital that forms part of the postero-lateral edge of the skull. Because of its nearly transverse position, the bone forms part of the flat posterior surface of the skull. A process on its postero-mesial surface gives articulation to the opisthotic process of the suprascapular, suturating with it. The antero-mesial edge of the bone expands, Y-shaped, and overlaps externally the adjoining edges of the pterotic, exoccipital, and epiotic, covering also an interval of cartilage between those bones. The interval of cartilage forms part of the wall of that recess of the cranial cavity that lodges the hind end of the sinus posterior utriculi and the related ampulla posterior. and if the cartilage were to be suppressed the opisthotic would form part of the bounding wall of the recess.

The EPIOTIC is normal.

The PTEROTIC is bounded, in its deeper, primary portion, by the sphenotic, proötic. exoccipital and epiotic, the opisthotic overlapping, externally, the ventral edge of that part of the pterotic that encloses the posterior portion of the external semicircular canal. The dermal portion of the bone is bounded by the frontal, postfrontal, parieto-extrascapular, lateral extrascapular and

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suprascapular. The primary portion of the bone encloses, as usual, the outer portion of the horizontal semicircular canal. On the lateral surface of this part of the bone, near its dorsal edge, is the facet for the posterior articular head of the hyomandibular. Dorso-anterior to this facet, a small pit-like depression forms the posterior half of the dilatator fossa. The posterior process of the bone is relatively small, is directed ventro-laterally and but slightly posteriorly, and is in contact with the dorsal edge of the opisthotic. The dermal portion of the bone is traversed by the main infraorbital canal, the section of canal enclosed in the bone lodging one organ innervated by the oticus, and quite certainly, though this could not be positively determined, a second, post-preopercular organ innervated by the supratemporalis lateralis vagi. The primary tubes indicate the presence of two organs here, one tube arising from the canal at the anterior edge of the bone, another at the hind edge of the bone, and a third slightly anterior to the middle of the bone; this latter tube issuing from the bone on its lateral edge, immediately posterior to the facet for the posterior head of the hyomandibular, and anastomosing with the dorsal end of the preopercular canal. The post-preopercular organ must, if present, be a small one, for it could not be definitely recognized in any of the dissections, although a branch of the supratemporal branch of the vagus, which nerve contains lateralis fibers, was always found perforating the pterotic, and going to that part of the canal where the organ would be found, if present.

On the lateral edge of the pterotic, immediately posterior to the opening of the primary tube that anastomoses with the preopercular canal, there is a large, slightly convex surface, marked with striae. This surface lies on a slightly elevated portion of the bone, lies mainly on the primary portion of the bone, and gives a sliding articulation to the dorsal edges of the united suprapreopercular and hyomandibular.

The SUPRAOCCIPITAL has dorsal and ventral limbs, the dorsal limb being entirely covered by the frontals and parieto-extrascapulars, excepting only a small median portion of its hind edge. The anterior edge of this limb of the bone bounds the hind edge of the postepiphysial cartilage. The ventral limb of the bone has a prolonged median portion which extends nearly to the dorsal edge of the foramen magnum. This prolongation of the bone lies upon the external surface of the adjoining edges of the exoccipitals and on the narrow median band of cartilage that separates those bones, thus apparently being of ectosteal origin. In its dorsal portion the ventral limb of the bone expands and is in contact with the exoccipitals and epiotics. In the median line, near the dorsal end of the limb, there is a small vertical ridge which represents the slightly developed spina occipitalis.

2. INFRAORBITAL BONES.

The infraorbital bones are five in number, all of them traversed by the main infraorbital canal. The anterior bone, or lachrymal, lodges four sense organs of the line, the second bone one organ, the third bone two organs, and the fourth and fifth bones one organ each. The total number of organs enclosed in these bones is thus nine, that being the total number also in both Trigla hirundo and T. lyra. The latero-sensory ossicles are not however interfused in the same manner in either of these three fishes, as the following table will show. The young Trigla lyra, given in this table, is assumed to have six bones in the series, as Günther says it has, and the arrangement of the organs in this fish is hypothetical, as all of my fishes had but five bones.

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Bones	T. lyra (young)	T. lyra (old)	Peristedion	T. hirundo (young)	T. hirundo (old)
1st.	3 organs	4 organs	4 organs	3 organs	7 organs
2nd.	1 ,,			4 ,,	
3rd.	1 ,,	1 ,,	1 ,,		
4th.	2 ,,	2 ,,	2 ,,		
5th.	1 ,,	1 ,,	1 ,,	1 ,,	1 ,,
6th.	1 ,,	1 ,,	1 ,,	1 ,,	1 ,,

The lachrymal, in Peristedion, has a long, flat, spatula-shaped anterior portion, which forms the preorbital process of the skull, and an equally long, but slender and tapering process-like posterior portion. The spatula-shaped portion projects, its full length, beyond the anterior end of the cranium; and is marked with surface granulations on both its dorsal and ventral surfaces. It is traversed, in a somewhat peculiar manner, by the main infraorbital canal. This canal begins at a long groove on the dorsal surface of the spatula-shaped portion of the bone, the groove beginning at the hind end of that part of the bone, near its mesial edge, and from there running forward a short distance parallel to the mesial edge of the bone. The hind end of the groove lies immediately antero-mesial to the antero-lateral corner of the nasal bone, and hence immediately antero-mesial also to the first pore of the supraorbital canal. The groove is covered, in the recent state, by a drum-head-like membrane perforated by one or more small pores, and represents the first primary tube of the main infraorbital canal. From there the canal runs forward to the anterior end of the bone, where it curves latero-posteriorly and then runs backward to the hind end of the spatula-shaped portion of the bone. There it leaves the bone, lateral to its posterior, process-like portion, to enter the second bone of the infra-orbital series. On the ventral surface of the bone, three large oval openings lead into the canal, each closed by a perforated drum-head-like membrane, these openings representing the 2nd., 3rd. and 4th. primary tubes of the line. The 5th. tube of the line lies between the lachrymal and the 2nd. infraorbital bone, and it also opens on the ventral surface of the snout; the 6th. tube being the first one to open on the dorso-lateral surface of the skull. This opening of these first five tubes of the line, on the ventral surface of a portion of the snout of the fish, associated, as it is, with a mouth that also lies on the ventral surface of the snout and is supplied with barbels, strongly recalls the conditions found in Acipenser and Scaphyrhynchus.

The process-like posterior portion of the lachrymal lies along the dorso-mesial edge of the second infraorbital bone, over-lapping that bone internally. Its pointed posterior end passes beyond the second bone and there rests upon the external surface of the dorso-mesial edge of the dermo-ectopterygoid. The base of this posterior portion of the lachrymal is slightly grooved on its mesial edge and this groove is continued forward along the mesial and anterior edges of a flat depression, with a curved anterior edge, that lies on the ventral surface of the base of the anterior, spatula-shaped portion of the bone. The groove and depression lodge the flattened maxillary process of the palatine and a short adjoining portion of the slender body of that bone, the two bones being firmly bound together. Posterior to this groove, the lachrymal and palatine are, for a short distance, not in direct contact, a slit-like opening being left between them; this opening lying opposite the nasal pit and lodging the lateral portion of the nasal sac. Posterior to this nasal opening the two bones again come into contact, the rod-like hind end of the palatine lying in a narrow space between the lachrymal

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externally and the anterior end of the ectopterygoid internally; the three bones being firmly bound together. Posterior to the palatine, and in the same narrow space between the lachrymal and ectopterygoid, a narrow rod of cartilage continues backward and soon expands into a large flat piece of cartilage which lies against the inner surface of that part of the ectopterygoid that bears the dermo-ectopterygoid.

The second infraorbital bone is V-shaped, the hollow of the V embracing the bluntly pointed anterior end of the third bone of the series. The hind end of the dorsal limb of the V is rounded, and rests upon the external surface of the dermo-ectopterygoid. The hind end of the ventral limb is slightly grooved on its inner surface, and this groove receives the anterior end of a pointed anterior process of the quadrate, the two bones being strongly bound together but a slight sliding movement being permitted. The hind end of the second infraorbital, in some specimens, abuts against, while in others it does not quite reach, the anterior end of the ventral limb of the preopercular. The main infraorbital canal enters the bone at its anterior end, and leaves it at the point of the angle between its two limbs, one sense organ being found in the section of canal so enclosed. On the outer surface of the bone, near the middle of its length, there are two or three spines, these spines lying on the horizontal ridge already described, and that ridge marking the course of the latero-sensory canal in the bone.

The third infraorbital bone is large and somewhat parallelogrammic in shape. Its ventral end is in contact with the dorsal edge of the ventral limb of the second bone of the series, the ventral half of its anterior edge being in contact with the postero-ventral edge of the dorsal limb of the same bone. The dorsal half of its anterior edge rests upon the outer surface of the dermo-ectopterygoid, a small portion of the latter bone coming to the level of the outer surface of the infraorbital bones, being similarly marked with surface granulations, and appearing as a prolongation of the dorsal limb of the second infraorbital bone. The hind edge of the third infraorbital bone overlaps internally and rests against the anterior edge of the ventral half of the preopercular. The anterior portion of its dorsal edge is thickened, and bevelled on its inner surface, this bevelled surface having a sliding articulation on that free ventral edge of the ectethmoid that lies posterior to the posterior palatine articular surface of that bone. The posterior portion of the dorsal edge of the infraorbital bone lies internal to the fourth infraorbital, the latter bone lying in a large depressed region on the external surface of the third bone. The bone is traversed by the main infraorbital canal and lodges two sensory organs of the line.

The fourth infraorbital is a rhomboidal bone traversed by the main infraorbital canal, and lodging one organ of that line. It forms almost the entire ventral margin of the orbit, overlaps externally the third infraorbital, and is bounded both anteriorly and ventrally by that bone. Posteriorly, it overlaps externally and rests upon the outer surface of a flange of the hyomandibular, its hind edge abutting against the anterior edge of the preopercular, and its dorso-posterior corner being in contact with the fifth bone of the infraorbital series. On its outer surface there is a low, sharp and finely serrated longitudinal ridge, which lies superficial to, or slightly dorsal to the enclosed section of the latero-sensory canal.

The fifth infraorbital is a triangular bone that forms the hind margin of the orbit and transmits the main infraorbital canal from the fourth infraorbital to the postfrontal, lodging one organ of the line. Its hind edge rests upon the outer surface of the shank of the hyomandibular, and, in specimens that have been preserved in alcohol, is so firmly attached to that bone that it appears in process

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of ankylosis with it. Ventrally it is in contact with the fourth infraorbital. Posteriorly its ventral half abuts against the dorsal portion of the anterior edge of the preopercular, its dorsal portion abutting against the anterior edge of the suprapreopercular bone. The dorsal end of the fifth infraorbital does not quite reach the lateral end of the postfrontal.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The PREOPERCULAR is a large, stout and irregular bone. On its outer surface, slightly below its middle point, there is a thin and relatively tall ridge, already referred to. which crosses the bone horizontally, from one edge to the other, increasing gradually in height from in front backward; and that part of the bone that lies ventral to the ridge inclines ventro-mesially at a marked angle to the part that lies dorsal to it. The bone is traversed by the preopercular latero-sensory canal, that canal presenting two straight limbs, a dorsal and a ventral one, which unite at an angle that lies beneath the horizontal ridge on the outer surface of the bone. The canal lodges six sense organs.

On the inner surface of the preopercular, following the angular course of the latero-sensory canal, a flange arises from the bone, the dorsal portion of this flange projecting antero-mesially and the ventral portion projecting dorsally or dorso-mesially, the two portions of the flange lying at the same marked angle to each other that the two limbs of the latero-sensory canal do. In the angle between the two portions of the flange there is a concave surface which lodges the cartilaginous interspace between the hyomandibular and symplectic. Dorsal to this concave surface, in the angular space between the dorsal limb of the flange and the internal surface of the anterior edge of the bone, this angle being presented anteriorly, the ventral three-fifths of the hyomandibular is lodged. Against the lateral, or dorso-lateral surface of the anterior half of the ventral limb of the flange, the broad flat ventral surface of the posterior process of the quadrate rests; both the quadrate and the hyomandibular being firmly attached to the preopercular.

The HYOMANDIBULAR has, in alcoholic specimens, two dermal bones almost inseparably fused with its outer surface. The lines of separation between these dermal bones and the underlying hyomandibular can be everywhere traced, but the two bones could not be removed, without breakage, in any of the specimens examined, all of which had been preserved in alcohol and then slightly boiled. One of these two dermal bones is the fifth one of the infraorbital series, and the other the suprapreopercular. As already stated, the hind edge of the fifth infraorbital bone rests upon the lateral surface of a flange on the anterior edge of the hyomandibular. This flange arises from a stout longitudinal ridge on the lateral surface of the bone — this ridge being the homologue of the one already described in the other fishes of the group — and between the flange and the anterior edge of the body of the bone there is a V-shaped space, the hollow of the V directed anteriorly and forming the hind end of the flat space included, as in Trigla, between the cheek-bones, externally, and the palatoquadrate internally. In the hollow of this V, near its ventral end, and hence anterior to the longitudinal ridge on the lateral surface of the bone, the canal for the hyoideo-mandibularis facialis opens, having traversed the bone from its internal surface. The longitudinal ridge on the lateral surface of the bone inclines backward, its summit fitting into the V-shaped groove on the anterior edge of the dorsal limb of the preopercular. The fifth infraorbital was broken and picked off in the specimen used for the figures.

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The SUPRAPREOPERCULAR is in contact, by its ventral edge, with the dorsal end of the preopercular, and is partly traversed by, and in part forms a bounding wall of the dorsal end of the preopercular latero-sensory canal; but it lodges no organ of that canal. Its dorsal end lies immediately behind the posterior articular head of the hyomandibular, and this end of the suprapreopercular is firmly attached to a flange of bone that fills the obtuse angle between the posterior articular head of the hyomandibular and its opercular articular head, a circular passage being left between the two bones to transmit the dorsal end of the preopercular canal. The coinciding dorsal edges of the suprapreopercular, and the flange of the hyomandibular to which it is attached, form a broad surface which is slightly concave, is marked with transverse striae, and articulates with the lateral edge of the pterotic. The articulation is, accordingly, in part with a dermal bone, probably of latero-sensory origin, and in part with a portion of the hyomandibular that is apparently of membrane origin. This latter articulation, with a portion of the hyomandibular that is apparently of membrane origin, is found alone, but much more developed, in Dactylopterus. The intimate attachment of the suprapreopercular to the hyomandibular has not only completely blocked the passage for the dilatator operculi muscle, but has cut that muscle into anterior and posterior portions, as already described.

The anterior and posterior articular heads of the hyomandibular lie close together, on the dorsal end of the bone, separated by a narrow roughened surface that has the appearance of dermal bone. The opercular articular head is long and slender, and is connected, by a wide web of bone, with the ventral portion of the shank. The bone is traversed by the canal for the hyoideo-mandibularis facialis, a single small branch canal transmitting a nerve destined to innervate, as in the other fishes described, certain organs in the preopercular.

The SYMPLECTIC is a slender bone, with a flattened distal end which lies in the symplectic groove on the inner surface of the quadrate. Between this flattened distal portion and the proximal end of the bone, the symplectic arches slightly, leaving a long but narrow space between itself and the preopercular, this space transmitting the ramus mandibularis externus facialis and the arteria hyoidea. The mandibularis internus facialis passes anterior to the symplectic, between that bone and the hind edge of the quadrate, as in the other fishes of the group.

The hyomandibulo-symplectic interspace of cartilage lies in the little concave surface in the angle between the dorsal and ventral limbs of the flange on the inner surface of the preopercular, as already stated, but it occupies only the dorsal portion of the concavity. Ventral to it, the remainder of the concavity lodges the small interhyal, that element articulating with the cartilage in a little facet on its ventro-posterior surface. In the corner between the cartilage, the inner surface of the preopercular, and the ventro-posterior corner of the hyomandibular, there is a small opening which transmits the ramus hyoideus facialis.

The QUADRATE has a well developed posterior process, and on the lateral surface of the postero-ventral edge of this process there is a wide, flat flange. This flange projects dorso-laterally at an acute angle to the flat, plate-like body of the bone, and its anterior end is prolonged forward beyond the anterior edge of the body of the bone as a strong anterior process. The ventro-posterior surface of the body of the flange fits, in larger part, against the internal surface of the ventro-anterior end of the preopercular, in the angular groove between the body of the bone and the ventral limb of the flange on its internal surface; but a small anterior portion of this surface fits against the internal

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surface of the third bone of the infraorbital series. The anterior prolongation of the flange rests upon and is firmly bound to the internal surface of the ventral limb of the second infraorbital bone. The posterior process of the quadrate occupies the anterior half only of the ventral limb of the angular groove on the preopercular, and the articular head of the bone projects beyond the anterior end of the preopercular and is there exposed on the external surface of the apparatus in an angular notch in the ventro-anterior corner of the preopercular. On the internal surface of the quadrate, there is a shallow symplectic groove.

The METAPTERYGOID has a long and slender dorso-posterior process, the dorsal end of which closely approaches and is bound by tissue to a thin web of bone on the anterior edge of the hyomandibular; this process thus being the internal flange on the hind edge of the bone. At the base of the process there is a slightly developed external flange, the hind edges of both flanges being widely separated from the anterior edge of the hyomandibular. In the V-shaped space between the two flanges a portion of the levator arcus palatini has its insertion. The ventro-anterior edge of the bone is everywhere separated from the quadrate by a narrow line of cartilage, the posterior corner of this edge of the bone being in contact with the symplectic.

The ENTOPTERYGOID is a small, thin plate of bone which lies in the membrane that covers the ventral surface of the adductor arcus palatini muscle. Its ventral edge rests against the inner surface of the narrow band of cartilage that lies between the quadrate and metapterygoid, usually extending forward slightly beyond that cartilage onto the inner surface of the ectopterygoid. Its hind edge overlaps slightly the inner surface of the metapterygoid.

The ECTOPTERYGOID is a stout bone, with the usual dorsal and ventral limbs lying at an angle to each other. The two limbs of the bone form a thin plate, which is completely ankylosed, at the angle between the two limbs, with a plate of bone which is certainly of separate origin, and which has been already referred to as the dermo-ectopterygoid. The ventral limb of the bone has the usual position along the internal surface of the anterior edge of the quadrate, the dorsal limb lying along the ventral and outer surfaces of the hind end of the palatine, and also along the same surfaces of the palatine cartilage.

The DERMO-ECTOPTERYGOID lies on the external surface of the thin plate formed by the two limbs of the membrane-ectopterygoid, and extends from the angle between the two limbs of that bone forward along the dorsal limb. It projects dorsally beyond the membrane-ectopterygoid, along the lateral surface of the enlarged posterior portion of the palatine cartilage, and then beyond that cartilage, there forming an important angle in the apparatus. The ectal surface of the bone is presented dorso-laterally, and the posterior half of this surface lies against and is firmly bound to the inner surface of the antero-dorsal corner of the third infraorbital bone. A small anterior portion of the plate lies against but is much less firmly bound to the inner surface of the hind end of the dorsal limb of the second infraorbital bone. Between these two surfaces of contact with the infraorbital bones, the outer surface of the plate is granulated and comes to the level of and forms part of the outer surface of the bony cuirass of the cheek. The dorsal edge of the plate is presented dorso-mesially, and its thick posterior portion is grooved, the groove articulating with the articular ridge near the hind end of the lateral edge of the ectethmoid. Anterior to this groove the dorsal edge of the plate is thin, and lies against the lateral surface of the rod of palatine cartilage, the latter cartilage not coming into articular relations with the ectethmoid. On this thin portion of the dorsal edge of the

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bone, and also on the mesial edge of the grooved portion posterior to it, rests the slender pointed hind end of the posterior, process-like portion of the lachrymal. This end of the lachrymal is grooved on its dorso-external surface, and participates in the articulation with the ectethmoid, the articulation thus representing the lachrymo-ethmoid articulation of the other fishes described. The dermo-ectopterygoid, completely ankylosed with the ectopterygoid, thus fulfils the function of the posterior ethmoid process of the palatine of both Scorpaena and Trigla; but nevertheless the bone does not seem to be a palatine element, its relations to the ectopterygoid being much more intimate than those to the palatine.

The PALATINE is a slender rod of bone with an enlarged and flattened anterior end. The ventral surface of the hind end of the rod-like portion of the bone rests against the dorso-mesial surface of the dermo-ectopterygoid, as just above described. The lateral surface of this end of the palatine, or the lateral surface of the covering dermo-ectopterygoid, and the lateral surface also of the anterior portion of the palatine, rest against the internal surface of the posterior, process-like portion of the lachrymal, the slit-like opening between these two surfaces of contact lodging the lateral portion of the nasal sac. In the angle between the rod-like part of the bone and its enlarged anterior end, on the mesial surface of the bone, there is a concave articular surface, with a slight process at its anterior edge. This articular surface hooks around and articulates with the anterior edge of the little anterior palatine eminence of the ethmoid cartilage. Anterior to this articular surface, the anterior end of the palatine widens, its mesial edge being slightly concave and its anterior edge rounded and capped with cartilage. This part of the palatine forms its maxillary process, and fits in the depression and groove, already described, on the ventral surface of the base of the spatula-like anterior portion of the lachrymal. Between the curved mesial edge of this maxillary process of the bone and the lateral portion of the anterior edge of the vomer, a semi-oval space is enclosed, through which the ascending process of the maxillary projects from below upward; this process of the maxillary articulating by one surface with the vomer and by the other with the palatine, and being bound to both bones by connective tissue.

The OPERCULAR has the irregular shape shown in the figures. On the inner surface of the anterior edge of the bone there is a deep depression which receives the opercular articular process of the hyomandibular. Dorso-posterior to this depression there is a larger depression on the inner surface of a dorsal, process-like portion of the bone, this depression giving insertion to the adductor operculi. Dorsal to the surface of insertion of this latter muscle, in a narrow line along the dorsal edge of the bone, the levator operculi has its insertion. The dilatator operculi is inserted on the anterior edge of the bone, immediately lateral to the articular facet for the hyomandibular. On the outer surface of the bone there is a horizontal ridge which terminates posteriorly in a spine, this spine being double in one of my specimens. Dorsal to this spine there is, on the hind edge of the bone, a second spine.

The SUBOPERCULAR is a delicate bone that lies along the inner surface of the hind edge of the opercular, projecting dorsally beyond the dorsal edge of that bone.

The INTEROPERCULAR lies along the inner surface of the preopercular, considerably anterior to, and wholly detached from the opercular and subopercular. Its antero-ventral end is slender and rod-like, and almost reaches, and is bound by ligament to, the hind end of the mandible. Its dorso-posterior portion is flat and broad, and lies against and is firmly bound by ligament to the lateral

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surface of the proximal end of the ceratohyal, near the point where that bone articulates with the interhyal; the attachment apparently being to the interhyal as well as to the ceratohyal. From the dorso-posterior end of the interopercular a stout ligament arises, and running dorsally, parallel to and immediately posterior to the interhyal, is inserted on the inner surface of the preopercular.

The MANDIBLE is strongly curved at its anterior end, to meet, in the middle line, its fellow of the opposite side. Its middle point lies considerably posterior to the corresponding point of the upper jaw, and the dentary, like the maxillary, the premaxillary, and the vomer is wholly without teeth. The articular has a pointed anterior end which projects slightly beyond the hollow of the V between the dorsal and ventral limbs of the dentary, and there lies internal to that bone. Posterior to this point, the ventral edge of this portion of the articular slightly overlaps, externally, the dorsal edge of the ventral limb of the dentary. On the internal surface of the bone, posterior to the hind end of Meckel's cartilage, there is a slight eminence for the insertion of the tendon of a part of the adductor mandibulae muscle. The bone has a broad thin coronoid process. The angular is almost completely fused with the articular, a sutural line on the external surface of the bone alone indicating its presence. The dentary has a long and slender dorsal limb which does not reach, by a considerable interval, the dorsal end of the coronoid process. On the lateral surface of the dorsal edge of the dentary, slightly anterior to the middle of its length, there is a dorso-laterally projecting shelf of bone; and immediately beneath this shelf, on the external surface of the bone, there is the large anterior opening of a short canal which leads backward through the dentary into the ramus of the mandible. This canal transmits a large nerve which goes immediately to the large barbel of the fish, this barbel having its attachment on the outer surface of the dentary in a pit-like depression that lies immediately ventral to the anterior end of the projecting shelf of bone. On the projecting antero-lateral corner of this shelf of bone the mandibular labial fold has its origin. The barbel of Peristedion thus arises from the mandible in the place where the gristle-like core of the mandibular fold of Scorpaena arises, and, contiguous with it, the mandibular fold has its origin. Whether this means that the core of the mandibular fold of Scorpaena represents, or includes, the barbel of Peristedion, or not, I can not determine.

The dentary and articular are both traversed by the mandibular latero-sensory canal, the dentary lodging three sense organs of the line, and the articular one organ.

4. LATERO-SENSORY CANALS.

The main infraorbital canal has the course already described through the infraorbital bones, the lachrymal lodging four organs of the line, the second infraorbital bone one organ, the third bone two organs, and the fourth and fifth bones one organ each; making nine organs in all in this part of the line, that being the same number as in Trigla. The canal then traverses the postfrontal, in which bone there is a single organ innervated by a branch of the oticus lateralis, and then anastomes with the penultimate tube of the supraorbital canal. The canal then traverses the pterotic, in which bone there is a large pre-preopercular organ innervated by a branch of the oticus lateralis, and in all probability a second and much smaller post-preopercular organ innervated by a branch of the supratemporalis lateralis vagi. A branch of the latter nerve was found going to the canal in four different specimens, but the organ, if it exists, is so small that it could not be with certainty identified. The canal anastomoses with the dorsal end of the preopercular canal between these two organs.

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Having left the pterotic, the canal traverses a groove in the lateral edge of the lateral extrascapular, but no organ could be found related to that bone. The canal then traverses in succession the suprascapular and supraclavicular, in each of which bones there is a single organ.

The main infraorbital canal of Peristedion thus differs from that of Trigla in that the pterotic lodges but one organ innervated by the oticus lateralis, instead of two, without intervening primary tube; and in that there is no apparent organ related to the lateral extrascapular.

The supratemporal canal lodges, as in all the other fishes of the group, two organs, one lying in the lateral extrascapular and the other in the parieto-extrascapular.

The supraorbital canal agrees strictly with the canal in Scorpaena and Trigla, but between the nasal and frontal bones the canal is enclosed, for a relatively long distance, in the dermal portion of the mesethmoid bone; this section of canal lodging no sense organ. The nasal lodges a single sense organ, and the frontal five organs, the fourth and fifth organs of the line lying close together without intervening primary tube, as in Scorpaena and Trigla. The fourth primary tubes of opposite sides unite in the middle line to form a frontal commissure.

The preoperculo-mandibular canal contains ten organs, instead of eleven as in Trigla, three of these organs lying in the dentary, one in the articular and six in the preopercular. After leaving the dorsal end of the preopercular the canal traverses a short suprapreopercular bone, without related organ, to reach and anastomose with the main infraorbital canal between the two organs in the pterotic.

The primary tubes, in Peristedion, do not branch repeatedly after entering the dermal tissues, as they do in Scorpaena, Cottus and Trigla. Certain of the tubes, however, apparently undergo one or two subdivisions, and the mouths of all of them become enlarged and most of them are closed by drum-head-like membranes perforated by several small openings.

IV. Dactylopterus volitans.

1. SKULL.

Of this fish I have had five specimens, ranging from 13 cm to 41 cm in length, and a number of specimens ranging from 5 cm to 10 cm in length. A single one of these specimens, 35 cm in length, was the only one I had during the earlier periods of the investigation, the other large specimens being later obtained, one at a time. The study of the cranial bones presenting peculiar difficulties, all of these large specimens were successively sacrificed to it, the soft parts thus not being examined in any of the adults. When the small specimens were later obtained, several of them were sectioned, but, because of the character of the bones and other tissues, only one comparatively good series of sections was obtained. This series alone served for the study of the nerves.

Gill ('90, p. 245) says, of the skull of Dactylopterus, that „its upper surface is derived partly from a dermal ossification which is incongruous with the true bones". Just what this statement means is not clear, for the bones in this fish differ in no way, excepting in degree, from those in Trigla and Peristedion. As in these two latter fishes, all of the primary bones that come to the level of, and form part of the dorsal surface of the skull of Dactylopterus have an external surface exactly similar to that of the adjoining and purely dermal bones; and the sections of young Dactylopterus

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show, better even than those of the other fishes of the group, that this external portion of these primary bones is formed by osseous accretions that are apparently developed in exactly the same way as the corresponding portions of the purely dermal bones. A 13 cm specimen was treated with chlorine, in an early attempt to trace the sutures between the cranial bones, and in this preparation a superficial layer of bone could be stripped off from both the purely dermal and the primary bones, leaving, in the former case, a thin remaining plate of bone which may perhaps represent a separate, membrane component underlying a more important dermal or latero-sensory component. This membrane component would then be the part that persists in those higher animals in which the latero-sensory component has disappeared.

The skull of Dactylopterus is said by Cuvier & Valenciennes ('29, vol. 4, p. 131) to be depressed and widened in such a manner that it represents a subrectangular disk, the anterior edge of which is curved in an obtuse angle, and its posterior angles prolonged into long points. A very large median ethmoid and two prefrontals are said to form an anterior row of the bones that form the pavement-like dorsal surface of the skull. A second row is said to be formed by the large frontals, behind each of which bones there is a small postfrontal. A third row is formed by the median interparietal, the two parietals, and the two mastoids; and a fourth row by the two external occipitals and two suprascapulars. Between the third and fourth rows, on either side, two oval bones are said to be intercalated, these two bones together, on each side, representing the ,,rocher".

The prefrontals of this terminology are the ectethmoids of the nomenclature employed by me, the interparietal is the supraoccipital, and the mastoid is the pterotic. The term ,,rocher", as used by earlier authors, is said by Starks ('01) to be the synonym of the opisthotic of later authors; but it will be shown that the so-called ,,rocher" of Dactylopterus is the lateral extrascapular, and not the opisthotic of the fish, this latter bone being wholly absent. It will be further shown that the external occipital is a mesial extrascapular, and not an epiotic; and, what is much more important, it will be shown that the median ethmoid is not an ethmoid bone at all, but is a median bone formed by the fusion, in the middle line, of the two nasals.

Gill ('88) calls the median ethmoid of Cuvier and Valenciennes the prosethmoid, and says that it and the anteal (vomer) are ,,entirely disconnected, leaving a capacious rostral chamber opening backwards mesially into the interorbital region". Into this rostral chamber the well developed ascending pedicles of the intermaxillines (premaxillaries) are said to glide. And as Gill, in his descriptions of the Loricati, says that the ascending pedicles of the intermaxillines glide ,,over the front of the prosethmoid", the term prosethmoid, as used in his descriptions of Dactylopterus, is certainly intended by him to designate a bone that he considered as the strict homologue of the median, primary mesethmoid of current descriptions. No mention is made of a rostral either by Gill or by Cuvier and Valenciennes.

The floor of the rostral chamber, in my medium-sized specimens, inclines downward and forward at an angle of about 45°. In the 41 cm and 35 cm specimens this floor is somewhat less steep, while in the small specimens it is much steeper. In the middle line of the anterior half of the floor, there is a narrow strip of cartilage formed by a median rod-like projection from the anterior end of the antorbital cartilage. This rod-like process is the strict homologue of the prenasal process, or beak, of my descriptions of Amia and Scomber, but it is here a relatively long and narrow rod, curving downward and forward. It lies in a median groove on the dorsal surface of the vomer, and extends to the anterior edge of that bone, agreeing in this with the arrangement found in Scomber.

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On either side of this median rod of cartilage, the dorsal surface of the vomer forms the floor of the anterior half of the rostral chamber. Posterior to the vomer, the antorbital cartilage expands rapidly, on either side, and then again contracts to a narrow median column which is continuous dorsally with the ventral surface of the anterior end of a broad band of cartilage which forms the roof of the interorbital, olfactory prolongation of the cranial cavity. A diamond-shaped or nearly square surface of cartilage thus forms the median portion of the post-vomerine portion of the floor of the rostral chamber, this cartilage being bounded laterally, on either side, by the pedicle of the ectethmoid. There is thus no bone whatever at any point in the median line of the floor of the chamber.

The hind wall of the rostral chamber is formed by the median column of cartilage just above referred to, and, dorsal to that column, by the broad anterior end of the roofing band of interorbital cartilage. This anterior end of this latter cartilage projects forward slightly beyond the median column, slightly overhangs the hind end of the rostral chamber, and gives support, on its dorsal surface, to the hind end of the so-called median ethmoid. Immediately beneath this part of the median ethmoid there is, on either side, a slight eminence on the anterior edge of the cartilage, each eminence giving origin to a ligament which runs antero-ventrally and is inserted on the dorsal surface of the maxillary immediately lateral to its ascending process. This ligament is thus the homologue of the ethmo-maxillary ligament of the other fishes of the group, and the little eminence of cartilage from which it has its origin must accordingly be the mesethmoid process; but it is a process of the ethmoid cartilage only, there being no primary bone whatever in any immediate relation to it. On a slight median ridge in the cartilaginous floor of the chamber, the ventral surface of the rostral glides. There is accordingly, in this fish, no mesethmoid bone. That the median portion of the ethmoid cartilage should remain unossified, and that a median ethmoid bone, of primary origin, should nevertheless be found wholly external to that cartilage, dorsal to the rostral instead of ventral to it, and dorsal even to the mesethmoid processes of the ethmoid cartilage, is evidently impossible.

The roof of the rostral chamber is formed by the single median so-called ethmoid or proseth-moid. This bone suturates posteriorly with the frontals. Laterally, on either side, it suturates, in its posterior half, with the ectethmoid, while in its anterior half it forms the mesial boundary of an elongated nasal opening; which opening lies between this so-called ethmoid and the anterior portion of the ectethmoid, opens directly into the nasal pit and encloses the two nasal apertures. At the anterior end of the opening, the two bounding bones closely approach each other, but do not quite come into contact, a narrow space being left between them, closed antero-ventrally by the lachrymal.

Slightly antero-mesial to the nasal opening, there is, on the anterior edge of the so-called ethmoid, a short, broad, stout process which projects ventrally and antero-laterally. This process arises from the deeper layers only of the bone, the anterior edge of that superficial portion of the bone that bears the surface markings continuing, uninterruptedly, external to it. The internal surface of the process forms a large flat articular surface which gives a sliding articulation to the flattened anterior end of the maxillary process of the palatine. On its external surface the process gives support to the internal surface of the dorsal edge of the lachrymal, the two bones being strongly but somewhat loosely bound together by fibrous tissue, a slight sliding and oscillating motion, combined, of the lachrymal being permitted. The process thus corresponds, in its relations to the palatine and lachry-mal bones, to the process-like antero-lateral corner of the nasal bones of Trigla and Peristedion, excepting that here, in Dactylopterus, it is developed as a process-like prolongation of the ventral layers of the bone, and is interposed between the palatine and lachrymal instead of lying on the

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dorsal surfaces of those two bones. The process may accordingly be called the lachrymo-palatine process of the bone. From its postero-lateral edge, on the internal surface of the body of the bone, a tall sharp ridge begins, and running postero-mesially, nearly to the hind end of the bone, marks the boundary between the dorsal portions of the rostral chamber and the nasal pit; those two chambers being confluent beneath the ridge. Between the hind ends of the ridges of opposite sides there is, on the internal surface of the bone, a deep median pit which nearly perforates the bone and lodges the distal ends of the ascending processes of the premaxillaries. Immediately postero-lateral to the lachrymo-palatine process, close to the narrow space that leads into the nasal opening, the supra-orbital latero-sensory canal begins, and running at first dorso-mesially and then curving posteriorly, traverses the bone and issues at its hind edge, there entering the frontal. This median so-called ethmoid or prosethmoid bone of Dactylopterus is thus certainly a bone formed by the fusion, in the median line, of the two nasal bones of the fish.

The ROSTRAL is a narrow, flat and tall cartilage, which lies between the hind ends of the articular processes of the premaxillaries, and gives support, on its dorsal edge, to the ascending processes of those same bones. Its ventral edge has a slight median groove, and this groove slides upon a slight median ridge on the cartilaginous floor of the rostral chamber. The rostral is relatively small, as are also the maxillary and premaxillary bones; and all of these elements of the upper jaw of the fish are entirely concealed, in dorsal and lateral views, beneath the nasal and lachrymal bones.

The PREMAXILLARY has a long, flat and pointed ascending process, a relatively long, large and flat articular process, and a short and flat horizontal portion, or body. The short body of the bone ends in a broad blunt end, and its flat oral surface is garnished its full length, or very nearly so, with small villiform teeth. The ascending process arises by a broad base from the mesial (proximal) end of the body of the bone, and, in the medium-sized specimens, is directed dorsally and but slightly backward. It lies in a nearly longitudinal plane, inclining and but slightly ventro-mesially, the flat surfaces of the processes of opposite sides enclosing between them a deep and narrow groove. The long flat articular process also lies in a nearly longitudinal plane, inclined at a slight angle to the ascending process, the two processes projecting dorso-posteriorly nearly parallel to each other and separated by a narrow intervening space. From the distal surface of the base of the ascending process a rod of tough gristly tissue arises, and extending distally along the dorsal surface of the body of the bone, is attached, at its distal end, to the distal end of the maxillary. This rod of gristly tissue lies in the upper labial, or maxillary dermal fold, thus occupying a position that corresponds to that occupied by a considerable part of the body of the premaxillary in the other fishes of the group, the actual body of the premaxillary of Dactylopterus corresponding, not to the premaxillaries of the other mail-cheeked fishes, but, approximately, to the premaxillaries of those fishes in which the maxillary is said by Sagemehl to lie lateral (distal) to the premaxillary.

The MAXILLARY has a relatively large, right-angled ascending process, similar to that of Scorpaena, and a short broad ligamentary process which corresponds to the proximal half only of the process of Scorpaena. The distal end of the short and slender body of the bone is slightly expanded, gives attachment to the hind end of the upper labial rod of gristly tissue, and lies in a marked depression on the outer surface of the mandible. The bone articulates with the premaxillary and vomer in the same way that it does in Scorpaena, and it gives articulation, on the dorsal surface of its ligamentary process and the adjacent portions of its body and ascending process, to the anterior

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end of the maxillary process of the palatine. It does not give support, at any point, to the lachrymal; but a short, strong ligament extends from the summit of the ascending process of the bone to the dorsal edge of the lachrymal, this ligament having its attachment also in part on the lachrymo-palatine process of the nasal.

The LIGAMENTS associated with the upper jaw were not properly investigated, the smaller specimens not being suitable for this investigation, and the skeletons of the larger specimens having been prepared, as already stated, without special attention being given to any of the soft parts. The ethmo-maxillary ligament is well developed, even in the small adults, and has already been described. The rostro-palatine ligament is also well-developed and has the usual relations, but, because of the shortening and deepening of the snout, it lies in a nearly horizontal position, the position being the more nearly horizontal, the smaller the specimen. The tendon of that part of the adductor mandibulae muscle that has its insertion on the maxillary in the other fishes of the group, is here also well developed, and, the posterior portion of the ligamentary process of the maxillary not being developed, is inserted on the dorsal surface of the body of the bone near its proximal end. The naso-maxillary ligament is a short stout ligament that extends from the lachrymo-palatine process of the nasal to the outer end of the ascending process of the maxillary. The vomero-palatine and lachrymo-palatine ligaments are reduced, because of the articulating contact of the parts concerned, to tough fibrous or ligamentous tissues that hold the articulating surfaces together. No other definite ligaments were recognised in the dissections, but in the sections of the small specimens there is a well developed ligament that extends from the lateral surface of the rostral to the dorsal end of the ascending process of the maxillary; and another that extends from the ventral (here posterior) edge of the ascending process of the premaxillary to the proximal end of the maxillary, this ligament traversing the narrow space between the rostral and the articular process of the premaxillary.

The VOMER differs somewhat from the bone in the other fishes of the group, and it can be best understood by stating, at once, that this part of the skull of Dactylopterus has been so greatly flattened that the ascending processes of the vomer have apparently been pressed down upon and become completely fused with the underlying body and lateral processes of the bone; the antorbital cartilage being, so to speak, squeezed out from between the dorsal and ventral limbs of the bone. As a result of this, the vomer is a solid bone of the shape shown in the figures, with a convex ventral and a concave dorsal surface, the exposed portion of the latter surface being about two-thirds as long as the ventral surface of the bone, and representing the ascending processes of the bone. This part of the dorsal surface of the bone forms the floor of the anterior portion of the rostral chamber, is grooved in the middle line to receive the rod-like prenasal process of the antorbital cartilage, and, lateral to that groove, on either side, has a slightly raised and flattened surface which gives articulation to the ascending process of the corresponding maxillary. The middle portion of the hind edge of this part of the vomer abuts against the anterior edge of the antorbital cartilage, but whether it is in synchondrosis with that cartilage or not, could not be definitely determined. Apparently it is not, the vomer of Dactylopterus seeming to be a purely dermo-membrane bone, and not appreciably overlapping or having perichondrial relations to the dorsal surface of the adjacent cartilage. Lateral to the antorbital cartilage, on either side, the thin hind edge of this part of the vomer — here apparently formed by the fusion of the lateral and ascending processes — suturates with the pedicle of the corresponding ectethmoid, the hind end of the short body of the bone underlying the antorbital cartilage and suturating with the parasphenoid.

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The head of the vomer is bent downward and thickened, as in the other fishes of the group, this thickened portion forming a broad transverse but untoothed surface which extends across the anterior end of the ventral surface of the bone. The lateral ends of this dental but untoothed ridge are concave or flattened, and give origin, on either side, to a very short but stout vomero-palatine ligament which has its insertion on the internal surface of the anterior end of the body of the palatine. Beginning immediately lateral to the dental ridge, at the anterior edge of the vomer, a slight ledge extends postero-laterally across the ventral surface of the bone to its hind edge, and that small part of the ventral surface of the bone that lies antero-lateral to this ledge lies at a slightly deeper level than the remainder of the surface. The anterior edge of this little surface of the bone is rounded, fits into a deep groove on the internal surface of the base of the maxillary process of the palatine, and gives articulation to that bone; the tall posterior wall of the groove on the palatine fitting against the little depressed surface on the vomer and the edge of this part of the groove abutting against the ledge on the vomer and so limiting the inward swing of the palato-quadrate apparatus. The rounded articular edge of the vomer is continuous with a similar edge on the pedicle of the ectethmoid, the latter bone apparently participating slightly in the articulation; this articulation thus certainly containing the anterior ethmo-palatine articulation of the other fishes of the group, and apparently representing that articulation alone. Posterior to the articular groove on the palatine, the dorsal edge of the latter bone abuts against the ventral surface of the pedicle of the ectethmoid and is bound to it by tough fibrous tissue, this contact apparently representing the posterior ethmo-palatine articulation, here practically suppressed.

The ECTETHMOID has a somewhat diamond-shaped and strongly convex external surface, the dorsal and lateral surfaces of the bone being inclined at more than a right angle to each other, and the lateral edge of the bone being, in consequence, directed ventro-mesio-posteriorly. The posterior edge of the bone is curved and slightly concave, is presented postero-laterally, and forms the anterior portion of the margin of the orbit. The mesial edge of the bone forms two sides of the diamond-shaped outline of the bone. The posterior one of these two sides is straight, is presented postero-mesially and suturates with the frontal; the anterior one suturating in its posterior half with the nasal, while its anterior half is occupied by a deep, oblong incisure which forms the ventro-antero-lateral boundary, and part of the dorso-postero-mesial boundary of the nasal opening. The bent-under lateral edge of the bone is slightly concave, the concavity arching over the lateral edge of a tall and flat articular eminence which begins at this edge of the ectethmoid and extends mesially and slightly posteriorly along the ventral surface of the bone. This eminence projects ventro-mesially and gives articulation to a facet on the dorsal edge of the lachrymal.

Beneath the curved external, and evidently purely dermal portion of the ectethmoid, the deeper portion of the bone extends into the cartilage of the antorbital process, forming a sort of pedicle to the external portion. The pedicle is directed ventro-mesially, and is partly in synchondrosis with the median remnant of the antorbital cartilage, and partly in sutural contact with the vomer and parasphenoid. The anterior surface of the pedicle is deeply hollowed to form part of the bounding wall of the nasal pit, its posterior surface being less deeply hollowed to form part of the anterior wall of the orbit. In the mesial edge of the pedicle there is an incisure which, with the adjoining cartilage, forms a foramen which transmits the olfactory nerve from the orbit to the nasal pit.

The ORBIT is deep and low, with curved but nearly transverse anterior and posterior walls, formed, as usual, by the concave posterior surface of the ectethmoid and the anterior surface of the

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brain case. The latter surface inclines slightly forward, but lies, as just above stated, in a nearly transverse position. It is formed, as usual, by the proötic, alisphenoid and sphenotic, but the latter bone is reduced and forms only the small dorso-lateral corner of the wall. The wide roof of the orbit is formed mainly by the frontal but partly also by the ectethmoid and sphenotic. Its floor is formed in part by the expanded base of the pedicle of the ectethmoid, in part by the wide parasphenoid, and in part also by the large orbital shelf of the second bone of the infraorbital series.

The interorbital wall is relatively thick. It is single in its ventral but double in its dorsal portion, this latter portion enclosing an anterior prolongation of the cranial cavity, which extends the full length of the interorbital region and lodges the olfactory nerves. The anterior half, approximately, of the wall is cartilaginous, and here the olfactory prolongation of the cranial cavity is roofed by a wide flat band of cartilage, already referred to when describing the rostral chamber. The posterior half of the wall is formed, in its ventral portion, by a median interorbital process of the parasphenoid, and in its dorsal portion by the alisphenoid of either side, the expanded dorsal edges of the latter bones not quite touching in the median line and so leaving a narrow longitudinal opening in the roof of this part of the olfactory extension of the cranial cavity. A ventral flange to the frontal, found more or less developed in all the other fishes of the group is here wholly wanting.

The cartilaginous portion of the interorbital wall is perforated, close to its antero-dorsal corner, by a large oval opening which leads from orbit to orbit and is closed, in the recent state, by membrane. This membrane is single in its ventral but double in its dorsal portion, the latter portion enclosing the anterior end of the olfactory prolongation of the cranial cavity, which prolongation extends to the hind surface of the short pillar of cartilage that forms the hind wall of the rostral chamber. The membrane is pierced, on either side, by the olfactory nerve, that nerve then traversing the extreme anterior end of the orbit to enter and traverse the opening that leads from the orbit into the nasal pit, that pit being, as already stated, confluent with the rostral chamber. From the single, ventral portion of the membrane, ventral to the olfactory nerves, the obliqui muscles have their origins.

The median interorbital process of the parasphenoid, above referred to, is a tall broad Y-shaped process, the spreading arms of which may be said to present three regions. In the anterior region each arm is formed by a thin plate of bone which overlaps externally the anterior edge of the corresponding alisphenoid, and, anterior to that bone, lies against the external surface of a part of the cartilage that encloses the interorbital extension of the cranial cavity. In the middle region, the dorsal edge of either arm is thickened and suturates with the ventral edge of the corresponding alisphenoid. In this region the dorsal surface of the process seems to form the floor of the interorbital extension of the cranial cavity, but there may here have been delicate lining plates of cartilage that were lost in dissection. The basal portions of the arms of the Y are connected, at the hind edge of this middle region, by a delicate transverse web of bone. In the posterior region, the arms of the Y are short and spread considerably, thus forming, on the dorsal edge of this part of the process, a basin-like depression in which the optic chiasma rests. The alisphenoid of either side arches above this optic depression of the process of the parasphenoid and, anterior to it, suturates, as already stated, with the corresponding dorsal edge of the olfactory portion of the process. The posterior corner of each arm of the Y is prolonged and terminates in a point directed toward, or even reaching the dorsal edge of the orbital surface of the proötic. A large fenestration of the interorbital wall is thus here formed which may be wholly enclosed by the bounding bones, those bones being the alisphenoids and proötics of either side and the median interorbital process of the parasphenoid. The

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fenestration, in the prepared skull, leads from orbit to orbit, traversing the interorbital portion of the cranial cavity. In the recent state, the fenestra of either side is closed by a membrane which is pierced by the optic nerve as it passes from the cranial cavity to the orbit. The two fenestrae are accordingly the optic fenestrae.

The interorbital process of the parasphenoid of Dactylopterus would seem to be the homologue of the median process of the same bone of Gymnarchus, as shown in Erdl's ('47) figures, which process is considered by that author as the lower portion of the ala magna, and by Ridewood ('04b, p. 198) as the basisphenoid. It seems also to be the equivalent of the basisphenoid of Ameiurus ('Mc Murrich, '84), fused, perhaps, with the orbitosphenoid of that fish. It is apparently the homologue of the median process of the parasphenoid of Peristedion, but enormously developed. That it contains an originally independent basisphenoid element, as its general relations would certainly indicate, seems improbable, for even in 5 cm specimens there is no slightest indication of two independent ossifications. In these latter specimens, the process is apparently wholly of membrane bone, but it is in part formed by two thin laminae of bone which enclose between them a part of the cartilage of the interorbital septum, much as the pedicle of the basisphenoid does in young specimens of Scorpaena.

Ventral to the optic fenestra, and, in most of my specimens, partly confluent with it, there is a second large perforation of the posterior portion of the interorbital wall, this perforation also leading from orbit to orbit but not traversing any portion of the cranial cavity. This perforation is bounded anteriorly by the hind edge of the interorbital process of the parasphenoid. Ventro-posteriorly it is bounded by a tall and thin ridge of bone which extends transversely across the dorsal surface of the parasphenoid between the small and pointed ascending processes of that bone. This ridge of bone projects dorso-posteriorly, suturates on either side with the anterior edge of the ventral portion of the proötic and slightly also with the ventral edge of the orbital portion of that bone, but between the two proötics presents a free dorsal edge. In the recent state, a membrane extends from this free portion of the edge of the ridge upward and forward to the concave hind edge of the spreading arms of the orbital portion of the interorbital process of the parasphenoid, the lateral edges of the membrane, postero-ventral to those arms, being attached, on either side, to the mesial edge of the nearly vertical orbital portion of the corresponding proötic. Against that part of this membrane that lies between the orbital portions of the proötics, or immediately postero-ventral to it, lies the pituitary body, the entire opening closed by the membrane, or at least that part of it that lies between the proötics, accordingly being the pituitary opening of the brain case. The whole opening may be referred to as that opening.

The ventral one of the two usually confluent perforations of the interorbital wall of Dactylopterus thus lies between a membrane that fills the pituitary opening of the brain case and a process of the parasphenoid the dorsal end of which fulfils the function of a basisphenoid, if it be not in part that bone. On the antero-dorsal portion of the osseous boundary of this ventral perforation of the interorbital wall, and partly also on the ventral surface of the membrane that closes the pituitary opening, a median vertical membrane has its attachment. Ventro-posteriorly this membrane becomes less strong, and separates into two parts which spread to either side and are doubtless attached to the parasphenoid, though this could not be satisfactorily determined in my material. The membrane is thus a median vertical one which closes, more or less completely, the ventral perforation. On the dorsal portion of this membrane, in 5 cm specimens, and directly opposite its fellow of the opposite

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side, the rectus externus muscle has its origin. Ventro-anterior to the rectus externus, and also wholly on the membrane, the rectus internus has its origin. The rectus inferior runs upward and backward lateral to the rectus internus, and has its origin in part on the posterior portion of the membrane that closes the optic fenestra and in part on the adjoining and bounding portions of the interorbital process of the parasphenoid. The rectus superior runs downward posterior to the rectus inferior, anterior to the rectus externus, and lateral to the rectus internus, and has its origin on the dorsal surface of the parasphenoid. The pituitary vein forms a transverse commissure across the dorsal surfaces on the recti interni, and, on either side, runs dorso-posteriorly to join the jugular vein as that vein enters the trigemino-facialis chamber. The internal carotid artery traverses a canal that lies wholly in the parasphenoid, traversing that bone from its ventral surface to issue on the dorsal surface in the region of the ventral perforation of the interorbital wall. There it gives off the orbito-nasal artery, and, joining its fellow of the opposite side, passes upward in the middle line, between the recti interni and immediately anterior to the transverse commissure of the pituitary veins, and, piercing the membranous floor of the cranial cavity, enters that cavity. Immediately anterior to the communicating branch to the internal carotid, the afferent pseudobranchial artery communicates with its fellow of the opposite side by a cross-commissural branch which traverses the ventral perforation of the interorbital wall.

The ventral perforation of the interorbital wall of Dactylopterus, and some indeterminate but adjoining portion of the hind end of the orbit, is thus a myodome strictly comparable to that of the other fishes of the group, but it is so short, antero-posteriorly, that it appears transverse instead of longitudinal in position. In Scorpaena the myodome extends almost to the hind end of the basioccipital. In Peristedion it has been considerably shortened, and extends, as it does in Amia, only to the hind edges of the proötics. In Dactylopterus, it has been still further shortened, and, as a result of this shortening, some portion of the proötic bridge has been tilted upward so that it lies in a nearly vertical transverse position and forms an apparent part of the hind wall of the orbit; the myodome being, so to speak, squeezed or shoved out of the brain case into the hind end of the orbit.

The PARASPHENOID is a broad flat bone the principal features of which have just above been described in describing the orbit. It suturates anteriorly with the vomer and ectethmoids, posteriorly with the basioccipital, and laterally, in its posterior portion, with the proötics. Dorsally it is in sutural contact, by its interorbital process, with the alisphenoids. Its ascending process, on either side, is a small pointed process which suturates with the ventral end of the sharp angle that separates the lateral and orbital surfaces of the proötic. On the dorsal surface of the bone, between these processes, there is a transverse ridge, already described, and posterior to this ridge the dorsal surface of the bone is flat and smooth, without the median longitudinal ridge usually here found on the bone. This seems to indicate, as will be more fully discussed below, that the transverse ridge represents the longitudinal ridge usually found in other fishes, but here greatly shortened. The ridge is tall and thin and inclines upward and backward, and on its posterior surface, in the median line, there is a large pit-like depression. The internal carotid foramina perforate the bone, instead of lying between it and the proötics.

The BASISPHENOID is either wanting or is indistinguishably fused with the interorbital process of the parasphenoid.

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The ALISPHENOID, as seen from the outside of the skull, is a sub-semicircular bone, the curved edge directed ventrally and deeply notched to form the superior border of the optic fenestra. Immediately anterior to this fenestra, the ventral edge of the bone suturates with the dorsal edge of the middle region of the interorbital process of the parasphenoid, while anterior to that region of sutural contact it is in synchondrosis with the cartilage of the interorbital wall. Posterior to the optic fenestra it suturates with the proötic, the hind corner of the bone being in synchondrosis with a small interspace of cartilage that lies between it and the proötic and sphenotic. On the internal surface of the bone there is, as in the other fishes of the group, a large brace-like process which separates the mid-brain and fore-bráin recesses of the cranial cavity. The dorsal edge of this process is greatly expanded, as is also the dorsal edge of the bone itself, the large flat surface thus formed giving support mainly to the frontal; but the hind corner of the brace-like process extends backward beneath the anterior edge of the supraoccipital and so gives support to that bone also.

The alisphenoid is perforated, in the adult, immediately posterior to the optic fenestra, by a small foramen which doubtless transmits the nervus trochlearis; that nerve traversing the optic fenestra, close against the alisphenoid, in 5 cm specimens. Near its dorsal edge the bone is traversed by a small canal which transmits a branch of the orbito-nasal vein, accompanied by a general cutaneous branch from the r. oticus trigemini. The bone is not traversed, as it is in the other fishes, by the lateralis branch that innervates the terminal organ of the supraorbital canal, that branch passing upward external to the alisphenoid and then perforating the frontal.

The SPHENOTIC is a small and irregular bone and is, in all my specimens, inseparably ankylosed with the postfrontal, which latter bone lies upon and occupies about one half of the dorsal surface of the sphenotic. The remainder of the dorsal surface of the sphenotic gives support mainly to the pterotic, a small corner only of the bone supporting the hind edge of the frontal. In the fusion of the sphenotic with the postfrontal, Dactylopterus resembles Polypterus, which latter fish is the only other one in which, as I have stated in a recent work ('04, p. 56), I know this fusion to be of regular occurrence. Ridewood, since the publication of that work, has said ('04a, p. 56) that the fusion of these two bones is also of almost constant occurrence in Amia, their separation in that fish, being an „occasional feature only". While this may be true of alcoholic or otherwise preserved specimens, it certainly is not of fresh material.

The sphenotic is in sutural contact with the proötic and pterotic but not with the alisphenoid, being separated from the latter bone by a small interspace of cartilage. On the lateral edge of the bone there is a stout process which gives articulation to one of four articular processes on the dorsal end of the hyomandibular, the particular process here concerned apparently being the regular anterior articular head of the hyomandibular, as will be later explained. Immediately dorsal to this articulating process there is, on the same edge of the sphenotic, a sharp process which gives support, on its lateral surface, to the small postorbital bone; probably also giving insertion to a part of the levator arcus palatini muscle, though this was not investigated.

Between the sphenotic and pterotic there is a large and deep dilatator fossa, roofed by the pterotic and sphenotic, the postfrontal apparently not coming into roofing relations with it. The anterior wall of the fossa is perforated by a large foramen which transmits the ramus oticus.

The PROÖTIC is a large bone with orbital and lateral portions, these two portions being separated from each other by a tall and ridge-like edge which, because of the flattened condition

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of the head, lies in a nearly horizontal position directed postero-laterally and but slightly upward. This ridge-like postorbital edge is perforated by a large opening which represents the trigemino-facialis chamber, and from this chamber five foramina lead into the cranial cavity. One of these foramina transmits the truncus ciliaris profundi accompanied by the encephalic branch of the jugular vein; a second one transmits the ramus ophthalmicus lateralis; a third the truncus trigeminus and related lateralis nerves, and a fourth the truncus facialis. The fifth foramen certainly transmits the nervus abducens, and probably that nerve alone, the palatinus facialis doubtless traversing the facialis foramen, but these nerves were not traced in the adult. In 5 cm specimens, they both traverse the ventral portion of the facialis foramen, enter the trigemino-facialis chamber, and traversing that chamber, issue through its trigeminus opening. The chamber is also traversed, as usual, by the jugular vein and the truncus sympatheticus.

Dorsal to the trigemino-facialis chamber, the tall postorbital edge of the proötic expands abruptly and bears, on this expanded portion, an elongated and curved articular surface the axis of which is directed dorso-posteriorly while the surface itself is directed laterally. This surface gives sliding articulation to a curved surface on the anterior one of the four articular heads of the hyomandibular. Slightly dorsal (here lateral) to this articular surface the bone is connected by synchondrosis with the sphenotic.

The orbital portion of the proötic is large, is transverse and nearly vertical in position, inclining upward and slightly forward, and arises from the internal surface of the lateral portion of the bone slightly posterior to its anterior edge. Near its dorsal edge it is perforated by the oculomotorius foramen. Its mesial edge does not reach the middle line, a small ventral portion of the edge suturating with the transverse ridge on the dorsal surface of the parasphenoid, while the dorsal portion of the edge is free and forms part of the boundary of the pituitary opening. The lateral portion of the bone has its ventro-mesial edge bevelled on its outer surface, and there suturates with the lateral edge of the parasphenoid. Internal to this line of sutural contact, and posterior to the orbital portion of the bone, the edge of the proötic is slightly grooved and this groove lodges the lateral edge of a broad band of cartilage which extends across the middle line to the corresponding edge of the proötic of the opposite side. The hind edge of the band is lodged in a groove on the anterior edge of the basioccipital, its anterior edge reaching to the posterior surface of the transverse ridge on the dorsal surface of the parasphenoid. This anterior edge of the cartilage seems not to be a free edge, but to rather abruptly but insensibly pass into a delicate membrane which is connected, anteriorly, with the stouter membrane that fills the pituitary opening of the brain case. Two suppositions are accordingly possible to explain the conditions here; either the postpituitary portion of the proötic bridge has been depressed and appressed upon the underlying ventral flanges of the proötics, as assumed by Gill ('91a, p. 379) in his descriptions of Hemitripterus, or the entire proötic bridge has been shortened and shoved forward nearly to the anterior edges of the ventral flanges of the proötics and there tilted upward to form, on either side, the orbital portion of the corresponding bone. The conditions found in Blennius, to be later described, indicate that the first of these two assumptions is probably the proper one, but they also indicate that the process has not been simply one of depression and appression of the proötic bridge, but also one of reduction of the ventral flanges of the proötics. These ventral flanges have, apparently, been so greatly reduced that they are practically suppressed, and the primary floor of the cranial cavity is here formed by the proötic bridge alone, that bridge lying directly upon the parasphenoid. The hypophysial fenestra is then represented, in its posterior

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portion in that long and wide space that lies between those surfaces of the proötics of either side that suturate with the lateral edges of the parasphenoid, while in its anterior portion it is represented in the space that lies between and anterior to the orbital portions of the proötics, this space opening onto the floor of the myodome and being filled by the transverse ridge on the dorsal surface of the parasphenoid. This latter ridge on the parasphenoid is accordingly the greatly shortened and widened homologue of the longitudinal ridge on the bone in the other fishes of the group. A result of this arrangement is that the pituitary opening of the brain case is partly filled, toward the orbit, by the transverse ridge on the parasphenoid, and that the hind end of the pituitary opening is confluent with the hypophysial fenestra at the hind end of that portion of the fenestra that opens onto the floor of the myodome.

The lateral surface of the proötic has dorsal and ventral regions separated by a pronounced but rounded angle which starts from the dorsal edge of the trigemino-facialis chamber and runs postero-mesially to the hind edge of the bone. The dorsal portion of the surface forms the anterior portion of a large subtemporal fossa, described below. On the internal surface of the bone, and parallel with this dorsal portion of its lateral surface, there is a tall flange of bone which projects from below upward and forms the anterior wall of the labyrinth recess. The dorsal edge of this flange is partly capped with cartilage and there gives support to the hind edge of the frontal and to the parietal, the hind edge of the flange projecting postero-mesially beneath the supraoccipital and there being continuous with a slight ridge on the internal surface of that bone. The deep tall space between the flange and the lateral wall of the bone is continued dorso-antero-laterally by a slight recess on the internal surface of the sphenotic, and the large recess thus formed between the two bones lodges not only the anterior semicircular canal and the anterior portion of the utriculus, but probably also the anterior end of the sacculus, for there is no differentiated saccular groove. The recess must also lodge an anterior portion of the external semicircular canal, for that canal leaves the recess near its dorso-antero-lateral corner to enter it own special canal in the pterotic. The exact relations could not be determined because of the want of sufficient material.

Anteriorly the proötic is bounded by, and is partly in synchondrosis and partly in sutural connection with the alisphenoid. Dorsally and posteriorly it is in similar relations with the sphenotic, pterotic, basioccipital and exoccipital. Ventrally it is overlapped externally by and is suturally connected with the parasphenoid.

The PTEROTIC has, more than in the other fishes of the group, the appearance of being formed of two separate and independent components secondarily fused with each other, for, although the two components have the same length, they are not exactly superimposed; the dermal component projecting forward beyond the primary component, and this latter component projecting posteriorly beyond the dermal one. This projecting portion of the primary component supports the anterior edge of the suprascapular.

The dermal component of the bone is bounded, as usual, by the frontal, postfrontal, parietal, lateral extrascapular (rocher) and suprascapular, and the lateral half of this part of the bone is bent abruptly downward, as are also corresponding portions of the postfrontal and suprascapular, a rounded longitudinal angle thus being formed, which extends across the three bones and terminates, at teh hind end of the suprascapular, in a strong spine. This component of the pterotic is thus an angular bone placed longitudinally along the lateral edge of the dorsal surface of the skull. It is traversed by the main infraorbital latero-sensory canal and lodges three sense organs of that line, two innervated

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by the oticus lateralis and one by the supratemporalis lateralis vagi. Near the middle of the bone, between the organs innervated by the oticus and supratemporalis lateralis vagi, the main infraorbital canal anastomoses with the dorsal end of the preopercular canal.

The primary component of the pterotic has a thickened anterior portion but is elsewhere a thin plate of bone which lines the ventral surface of the angular dermal component of the bone. It is traversed by the external semicircular canal, but otherwise has no bounding relations to the cranial cavity. This is due to the presence of a large and deep depression on the lateral surface of the brain case, this depression pinching the skull, so to speak, to such an extent that the primary component of the pterotic has been pressed upward against the under surface of its dermal component, has ceased to form part of the apparent lateral surface of the brain case, and simply lines the ventral and ventro-mesial surfaces of the overhanging roof of the depression. This depression includes both the proötic and subtemporal fossae of Scorpaena, and it has, in addition, a large posterior extension which lies posterior to the arch of the external semicircular canal and is not found in Scorpaena. The entire depression may, however, be called the subtemporal fossa, the fossae of opposite sides giving to the brain case, in ventral views, an hour-glass-shaped appearance. The adductores hyomandibularis and operculi have their origins in the fossa, arising mainly on a band of cartilage that separates the pterotic from the exoccipital. The levators of the first four branchial arches have their origins in the anterior portion of the fossa, anterior to the adductor hyomandibularis, while the fifth levator muscle has its origin ventro-mesial to the adductor operculi, between that muscle and the foramina for the vagus and glossopharyngeus. This fifth levator perforates, to reach its surface of origin, a mass of tissue that looks like degenerate glandular tissue and that must be the homologue of what I considered as the thymus in Amia ('97, p. 643). Whatever it may be, this tissue fills the entire fossa ventro-mesial and posterior to the adductores hyomandibularis and operculi, and the fossa would seem to be developed in some relation to it rather than as any consequence of the origins of the several muscles here.

On the anterior edge of the thickened anterior portion of the primary component of the pterotic there are two fossae, the larger, mesial one lying on the internal surface of the bone while the smaller, lateral one lies on its external surface. The mesial fossa lodges the anterior portion of the external semicircular canal, and is in communication with the dorso-antero-lateral end of the tall recess already described on the internal surface of the proötic and sphenotic; the posterior portion of the semicircular canal traversing the thin posterior portion of the auto-pterotic, and forming a prominent ridge on its external surface. The lateral one of the two fossae forms the posterior half of the dilatator fossa, the anterior half of that fossa lying in the sphenotic. Immediately posterior to the dilatator fossa, and so placed that it seems to form part of the mouth of that fossa, there is, on the external surface of the auto-pterotic, a large round articular fossa which gives articulation to the regular posterior articular head of the hyomandibular. The hind edge of this articular fossa is thickened and grooved to form an elongated, transversely placed and slightly convex articular surface, which gives a sliding articulation to the posterior one of the four articular heads of the hyomandibular. Immediately dorso-lateral to this articular surface is the perforation by which the preopercular latero-sensory canal joins the main infraorbital canal.

The auto-pterotic is bounded anteriorly by the sphenotic and proötic, and also by a small interspace of cartilage between the adjoining edges of those two bones. It is separated from the exoccipital by a band of cartilage, and beneath (dorsal to) this band it is in contact with the lateral

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edge of the epiotic. The hind end of the bone gives support, as already stated, to the anterior end of the suprascapular.

The pterotic of Dactylopterus thus has no exposed surface corresponding to the one that forms part of the lateral bounding wall of the temporal fossa in the other fishes of the group. That portion of the temporal fossa that is usually bounded by this bone is thus either wholly absent in Dactylopterus, or it has been reduced, by the compressive action that has given rise to the subtemporal fossa, to a narrow space that lies between the pterotic-exoccipital band of cartilage, just above referred to, and the overlying dermal bones on the dorsal surface of the skull. The band of cartilage is evidently the homologue of the cartilage that forms the bottom of the temporal fossa in the other fishes, and as this cartilage is certainly not in synchondrosis with the overlying dermal bones, a thin space must exist between them, in the place where the temporal fossa is usually found. A further possibility regarding a portion of the fossa will be referred to when describing the suprascapular.

The BASIOCCIPITAL is broad and thin, is slightly convex on its internal and slightly concave on its external surface, and the median longitudinal line on its ventral surface presents a slight reëntrant angle. On the hind end of the bone there is a deep median pit which extends forward to the line of the reëntrant angle and represents the vertebral depression on the hind end of the bone. Lateral to this pit, the wide flange-like portions of the bone give support, on their dorsal surfaces, to the ventral edges of the exoccipitals. Anteriorly the bone suturates with the proötics and parasphenoid. A very slight depression on either side of the internal surface of the bone forms the hind end of the saccular groove. Between these two depressions there is, in the anterior portion of the bone, a slight median depression, the significance of which could not be determined in my limited material. The anterior edge of the bone is grooved, and encloses the hind end of the thin median sheet of cartilage that connects the ventral edges of the proötics of opposite sides. The median portion of the hind edge of the dorsal surface of the bone forms the ventral boundary of the foramen magnum.

The EXOCCIPITAL has a concave lateral and a strongly reëntrant posterior surface. The latter surface has the two usual portions, one of which forms part of the hind wall of the cranial cavity while the other arches over the medulla, the two portions appearing, in the disarticulated bone as a stout, tall, V-shaped ridge arising from the dorso-mesial surface of a sub-oval bone. That part of the posterior portion of the bone that arches over the medulla has a thick dorso-mesial edge, which suturates in part with its fellow of the opposite side but mainly with the ventral edge of the spina occipitalis. The dorsal edge of that part of the bone that forms part of the hind wall of the cranial cavity suturates with the ventral edge of a strong ridge on the ventral surface of the epiotic, this ridge forming the posterior surface of the latter bone. Slightly antero-lateral to this ridge on the epiotic, a relatively large V-shaped portion of the ventral surface of that bone is in sutural contact with a corresponding surface on the dorso-mesial surface of the lateral plate of the exoccipital; this latter surface of contact extending downward from the dorsal edge of the exoccipital nearly to the central point of the bone. Between the portions of these two bones that have these two sutural connections — the lateral and posterior plates of the exoccipital, below, and the epiotic above — there is a tall and narrow space which must lodge the posterior portion of the external semicircular canal, the larger portion of the posterior canal, and possibly also the hind end of the utriculus; but want of material prevented my determining the exact relations. A broad, low and rounded ridge

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on the outer surface of the exoccipital marks the position of the dorso-lateral portion of this labyrinth space, and forms a continuation of the ridge on the pterotic that marks the course of the external semicircular canal in that bone.

The dorsal edge of the exoccipital reaches the ventral surface of the overhanging roof of the skull and is there separated by a relatively wide band of cartilage from the ventral edge of the pterotic, that edge of the latter bone here being presented mesially. This band of cartilage forms a nearly longitudinal line along the bottom (roof) of the subtemporal fossa, and lies against the ventral surfaces of the parietal and lateral extrascapular.

On the hind edge of the lateral plate of the exoccipital there are two flat stout processes separated by a deep and rounded incisure. The dorso-lateral process suturates with the pedicle of the suprascapular, the ventro-mesial one suturating with, instead of articulating with, a process on the anterior edge of the first vertebra. Antero-internal to the incisure between the bases of the two processes, a canal traverses the medullary plate of the bone, transmitting the occipital nerve or nerves. Ventrally the exoccipital suturates with the basioccipital, in the manner already explained. On the lateral surface of the bone there is a small foramen which doubtless transmits the nervus glossopharyngeus, and posterior to that foramen there is a large pit, in the bottom of which there are two to four foramina which open into the cranial cavity and doubtless transmit the nervus vagus alone; the actual relations of these nerves to the bone not being determined for the reasons already given.

The EPIOTIC is a small bone that seems at first sight to bear no resemblance whatever to the pyramidal bone of the other fishes of the group. The dorsal surface of the bone is flat and sub-oval in shape, and on the ventral surface of this thin dorsal plate there are two relatively tall and thin flanges. One of these flanges is straight and extends from about the middle of the mesial edge of bone, postero-laterally to its lateral edge, the ventral edge of the flange suturating with the posterior plate of the exoccipital. The postero-mesial surface of this flange is exposed externally, and forms a surface strictly comparable to the postero-mesial surface of the bone in the other fishes of the group. The second flange lies anterior to the first one and is strongly curved, the hollow of the curve directed forward and both ends of the flange reaching the antero-lateral edge of the bone and there vanishing. The space enclosed within the curve of this flange is roughened and suturates with the dorso-mesial surface of the lateral plate of the exoccipital, as already stated. This roughened surface of the epiotic thus corresponds to the ventral edge of that surface of the bone in the other fishes that forms part of the mesial wall of the temporal groove. The temporal-groove surface of the bone of Dactylopterus is accordingly wholly wanting, or at most is only represented in a part of the thin lateral edge of the bone, this edge being covered laterally and ventrally by the band of cartilage already described between the pterotic and exoccipital.

Between the two flanges on the ventral surface of the epiotic there is a space which forms the dorsal portion of that part of the labyrinth recess which, as just above explained, must lodge the posterior semicircular canal and the posterior portion of the external canal. The dorso-postero-lateral portion of this labyrinth space is bounded externally here ventrally by the band of cartilage between the pterotic and exoccipital; temporal and posterior surfaces of the epiotic not here uniting to form an angle which encloses the summit of the posterior canal, as in the other fishes. The large flat dorsal surface of the epiotic gives support to adjoining portions of the parietal, lateral extrascapular and mesial extrascapular, and its mesial edge is in sutural contact with the lateral edge

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of the supraoccipital. The thin plate that forms this part of the bone projects posteriorly beyond the flange that forms the posterior surface of the bone, the two plates forming part of the roof and part of the bottom (antero-lateral corner) of a large fossa on the posterior surface of the skull. The postero-lateral end of the flange that forms the posterior surface of the bone, and adjoining portions of the lateral edge of the bone, suturate respectively with the pedicle and body of the suprascapular.

The SUPRAOCCIPITAL, the interparietal of Cuvier and Valenciennes' descriptions, has the usual dorsal and ventral limbs, and a large spina occipitalis. The dorsal limb of the bone, with the exception of two small lateral processes on either side, comes everywhere to the outer level of the dorsal surface of the skull, and has surface markings exactly similar to those on the adjoining dermal bones; and this apparently dermal portion of this limb of the bone extends posteriorly slightly beyond the line of origin of the ventral limb, onto the dorsal surface of a dorsal plate-like portion of the spina occipitalis. This limb of the bone suturates anteriorly with the frontals, laterally with the parietals, and posteriorly with the mesial extrascapulars; its anterior edge resting, on either side, upon the hind end of the expanded dorsal surface of the brace-like ridge on the internal surface of the alisphenoid. On the ventral surface of the dorsal limb, beginning immediately anterior to the line of origin of the ventral limb, there is, on either side, a small ridge which, extending antero-laterally is continuous with that tall ridge on the internal surface of the proötic that forms the anterior wall of the labyrinth recess. The antero-lateral end of this ridge on the supraoccipital forms one of the two lateral processes on either side of the dorsal limb of the bone, the other process lying immediately posterior and parallel to it, giving support on its dorsal surface to the parietal, and being in synchondrosis, by its postero-lateral edge, with the antero-mesial edge of the epiotic.

The ventral limb of the supraoccipital is irregular, as shown in the figures, and has on either side a strongly concave dorsal and convex ventral surface. Along the median line of the limb a thin median vertical plate of bone arises supported on either side by a similar but slightly inclined plate, these three plates forming the vertical portion of the spina occipitalis. This vertical portion of the spina supports, on its dorsal edge, a flat broad thin plate which forms a direct posterior extension of the dorsal limb of the bone, and gives support, on either side of its dorsal surface, to the corresponding mesial extrascapular. The lateral edge of the anterior end of this flat portion of the spina, on either side, rests upon and is coalesced with the dorsal edge of the lateral portion of the ventral limb of the bone, a deep pocket thus being formed on either side of the posterior surface of the bone, this pocket forming the dorso-mesial corner of a large fossa on either side of the hind end of the skull. The posterior half of the ventral surface of the ventral limb of the bone rests, on either side, on the dorsal edge of the medullary plate of the corresponding exoccipital, either suturating or being in synchondrosis with that bone. Lateral to the exoccipital, the ventral limb of the supraoccipital is in similar contact with the mesial edge of the epiotic.

There is no separate OPISTHOTIC bone, nor is there any indication of the fusion of this bone with any of the other bones.

The primary bones, and their relations to the dorsal surface of the primary skull, now having been described, the dermal bones that overlie them and form the casque-like dorsal surface of the skull can be described.

The two NASALS have fused in the median line to form a single median bone, and have already been described.

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The FRONTAL is an eight-sided bone, each side being straight or slightly concave. One of these sides forms the middle portion of the dorsal margin of the orbit, another suturates with the frontal of the opposite side, the others suturating with the ectethmoid, nasal, supraoccipital, parietal, pterotic and postfrontal. The bone has no ventral flange. It rests upon the expanded dorsal edges of the body and brace-like internal process of the alisphenoid, on a small portion of the sphenotic, and on a small projecting shelf from the deeper layers of the anterior edge of the supraoccipital. It is traversed by the supraorbital latero-sensory canal and lodges five organs of the line, as will be later fully described.

The POSTFRONTAL is a small dermal bone that lies upon and is inseparably fused, in all of my adult specimens, with a lateral portion of the dorsal surface of the sphenotic. It suturates with the frontal and dermo-pterotic, and is traversed by the main infraorbital latero-sensory canal, lodging one organ of that canal, innervated by the oticus lateralis.

The PARIETAL is a sub-oval bone, bounded anteriorly by the frontal, laterally by the pterotic, posteriorly by the lateral and mesial extrascapulars, and mesially by the supraoccipital. It rests upon the dorsal surface of the epiotic, upon the dorsal edges of those flanges of the proötic and supraoccipital that form the antero-mesial wall of the labyrinth recess, and also upon a small shelf projecting mesially from what are apparently the deeper layers of the dermal portion of the pterotic.

The LATERAL EXTRASCAPULAR is a small oval bone traversed by the lateral portion of the supratemporal commissure of the latero-sensory canals, and lodging one organ of that canal. It is not traversed by the main infraorbital canal, but a groove on its lateral edge lodges a short section of that canal, apparently without related organ, as will be further explained when describing the canals. It is bounded antero-mesially by the parietal, antero-laterally by the pterotic, postero-laterally by the suprascapular, and postero-mesially by the mesial extrascapular. It has no bounding relations either to the subtemporal fossa or to the large fossa on the posterior surface of the skull, its ventral surface being entirely covered by the epiotic, pterotic and suprascapular, on which bones it rests.

The MESIAL EXTRASCAPULAR is a large subrectangular bone with straight and nearly parallel lateral and mesial edges. It is traversed by the mesial section of the supratemporal commissure and lodges one organ of that commissure. It suturates, in the middle line, with its fellow of the opposite side. Anteriorly, it is bounded by the supraoccipital and parietal, and laterally by the lateral extrascapular and suprascapular. Its mesial third, approximately, lies upon the broad flat dorsal surface of the spina occipitalis, its lateral third resting upon a shelf-like portion of the mesial edge of the suprascapular. Between those two bones it forms part of the roof of the large fossa on the corresponding side of the posterior surface of the skull.

The SUPRASCAPULAR is a large bone with a prolonged and pointed hind end. It is bounded anteriorly by the pterotic, antero-mesially by the lateral extrascapular, and mesially, along the anterior half only of its length, by the mesial extrascapular. The lateral half of the bone is bent downward at an angle to the mesial portion, as already stated, and along this angle there is a stout ridge which begins at the anterior quarter of the bone and extends backward to its pointed hind end. The bone is traversed by the main infraorbital latero-sensory canal and lodges one organ of that line, innervated by a branch of the supratemporalis lateralis vagi. This organ, in 5 cm specimens, is much

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larger than the other organs of the line, and may perhaps represent the two organs usually found one in this bone and the other in the supraclavicular in the other fishes of the group.

On the ventral surface of the bone there is a stout V-shaped flange, projecting ventro-antero-mesially. The line of origin of the anterior limb of the V begins at the rounded antero-mesial corner of the bone, and from there runs postero-laterally until it reaches the angle between the mesial and lateral portions of the bone. There it turns postero-mesially, nearly at a right angle, and so continues until it reaches the mesial edge of the bone at about its middle point. From this right-angled line of origin, the V-shaped flange projects ventro-antero-mesially, its two limbs and the overlying body of the bone enclosing a sub-pyramidal space which forms the lateral, recess-like corner of the large fossa on the hind end of the corresponding half of the skull. The angle of the V-shaped flange is thickened, and its ventral end suturates with the exoccipital, the dorsal portion of the mesial edge of the anterior limb of the flange suturating with the postero-lateral end of that flange on the internal surface of the epiotic that represents the posterior surface of that bone. At the dorso-mesial corner of the anterior surface of the anterior limb of the flange on the suprascapular, there is a small recess which lodges but is not in synchondrosis with the hind end of the band of cartilage that lies between the pterotic and exoccipital. The mesial edge of the suprascapular here closely approaches the lateral edge of the dorsal plate of the epiotic, but apparently does not touch that bone. The V-shaped flange of the suprascapular must accordingly certainly contain the opisthotic process of the bone, and it probably represents both that process and the epiotic process, joined by a web of bone which entirely closes the space usually occupied by the posterior opening of the temporal fossa. However this may be, a posterior opening of a temporal fossa is wholly wanting in this fish, and if any portion of the fossa exists it must open on the lateral surface of the skull and hence be represented in the posterior portion of the large subtemporal fossa. In certain specimens of Cottus octodecimospinosus, I have already shown that the posterior opening of the temporal fossa may be entirely closed by the invading growth of its bounding bones, the fossa then opening wholly on the lateral surface of the skull. In such a fish, if the subtemporal fossa were to be greatly deepened, as it is in Dactylopterus, it would inevitably absorb and incorporate in itself a posterior portion of the adjoining temporal fossa. But in that case the epiotic should form part of the bounding wall of the fossa, and I can not find that it does so in Dactylopterus: the epiotic here apparently being everywhere covered by the hind end of the pterotic-exoccipital band of cartilage which lies in the bottom (roof) of the fossa. The lateral edge of the epiotic, immediately anterior to the pedicle of the suprascapular, comes close to the lateral edge of the pterotic-exoccipital cartilage and may there perhaps be exposed, thus forming part of the bounding wall of the subtemporal fossa. Furthermore, the subtemporal fossa, as defined by Sagemehl, is said to be an excavation of the cranial wall within the arch of the external semi-circular canal, but, in Dactylopterus, the fossa has a large portion which lies posterior to that canal. This posterior extension may therefore represent the posterior portion of the temporal fossa of the fish, here incorporated in the subtemporal fossa by the unusual development of the latter.

On the ventral surface of the suprascapular, close against or even cutting into the lateral edge of the base of the posterior limb of the V-shaped pedicle, there is a deep circular pit, so deep that it shows, on the dorsal surface of the prepared skull, as a circular translucent spot in the bone. This pit gives origin to strong fibrous tissues which have their insertion on the dorsal end of the clavicle, that end of the clavicle not apparently entering the pit, in prepared specimens, but the pit being quite certainly developed in articular relation to it. At the anterior margin of the pit there is a slight

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depression which gives articulation to the dorsal end of a long, slender, gutter-shaped and tapering bone, which is applied to the antero-lateral surface of the dorsal end of the clavicle and is certainly the SUPRACLAVICULAR. This bone is not traversed by the main infraorbital canal, and its latero-sensory component must be represented either in a part of the unusually large suprascapular or in a small bone that lies along the postero-lateral edge of the suprascapular and is traversed by the main infraorbital canal after it leaves that bone.

On either side of the hind end of the skull there is a large and deep fossa, already several times referred to. This fossa occupies the entire posterior surface of either side of the skull, and has deep dorso-mesial and dorso-lateral corners, or recesses, and a shallow ventral one. It is bounded by the mesial extrascapular, suprascapular, supraoccipital, epiotic and exoccipital, and there is nothing comparable to it in any of the other fishes of the group. Want of material prevented a proper investigation of it, but it is largely, if not entirely filled by an anterior prolongation of the swim-bladder: the dorsal wall of this portion of the bladder lying close against the ventral surface of the dermal bones that form the roof of the fossa, and the lateral surface of the bladder having closely applied to it a band-like anterior prolongation of the trunk muscles.

2. INFRAORBITAL CHAIN OF BONES.

The infraorbital chain consists of four bones, all of which are traversed by the main infraorbital canal. In addition to these four bones, there is a small bone, the pontinal of Gill, which extends from the hind edge of the second bone of the series into a reëntrant angle on the anterior edge of the preopercular.

The first infraorbital bone, or lachrymal, has a thickened anterior end which curves mesially, and almost meets, in the middle line, its fellow of the opposite side. The dorsal edge of this part of the bone is slightly grooved and articulates moveably with the antero-ventral edge of the nasal, the dorsal edge of the lachrymal lying upon and being strongly but somewhat loosely bound to the outer surface of the lachrymo-palatine process of the nasal. Internal to the hind end of this grooved portion of the lachrymal, there is, on the internal surface of the bone, a short transverse ridge with a convex outer edge, and slightly posterior to this ridge there is a second but shorter ridge; these two ridges and the groove between them having a sliding articulation with the palatine on the dorso-lateral surface of its maxillary process, as will be later explained. Slightly ventro-posterior to these two articular ridges, a strong brace-like process arises from the internal surface of the lachrymal, projecting dorso-postero-mesially. The dorsal end of this process is large, lies in the level of the dorsal edge of the bone, and has on its dorsal surface a large oval facet which articulates with the lachrymal articular eminence of the ectethmoid. The hind edge of the articular facet suturates with the anterior edge of the orbital shelf of the second infraorbital bone, the hind edge of the lachrymal itself suturating with the second and third infraorbital bones; the second infraorbital lying ventral to the third one and having no bounding relations to the orbit. The bone is traversed by the main infraorbital latero-sensory canal and lodges three sense organs of that line.

The second infraorbital bone is an elongated one, bounded anteriorly by the first and dorsally by the third bone of the series. The main infraorbital canal enters it at its anterior edge, runs horizontally backward in it and then turns upward and forward at an acute angle, to leave the bone on its dorsal margin and enter the third bone of the series; this section of canal lodging two sense

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organs. The ventro-posterior corner of the bone is prolonged into a short process which has articular surfaces for articulation with the pontinal.

The pontinal is a small and somewhat elongated bone, which extends from the second infraorbital into a reëntrant angle on the anterior edge of the preopercular, articulating with and being firmly bound to each of these two bones. It does not lodge any part of the latero-sensory canal, and is accordingly either an independent dermal ossicle or a detached portion of the second infraorbital bone.

The third infraorbital bone bears, along the internal surface of its orbital margin, a large thin projecting plate of bone which forms about one half of the floor and a corresponding part of the posterior wall of the orbit. The central portion of this orbital shelf is supported by a bracing web of bone which arises from the internal surface of this bone and is continued beyond it onto the internal surface of the second infraorbital bone, near its hind edge. From the internal surfaces of the adjoining edges of these two infraorbital bones, immediately anterior to the bracing web, a strong ligament arises, and running forward has its insertion on the ventral surface of the dorsal limb of the dentary. The anterior end of the orbital shelf projects forward beyond the anterior edge of the body of the bone, along the inner surface of the first infraorbital, and comes into sutural contact with, and is firmly bound to, the hind edge of the dorsal end of the brace-like articular process of the latter bone. The bone is traversed by the main infraorbital latero-sensory canal and lodges three organs of the line.

The fourth infraorbital is a small bone, postorbital in position, that is in contact ventrally with the third infraorbital and dorsally with the postfrontal. It transmits the latero-sensory canal from the former to the latter bone, lodging one organ of the line.

The first and third infraorbital bones are the preorbital and fourth suborbital, respectively, of Gill's descriptions; and these two bones and the second infraorbital, together, form the first suborbital of Cuvier and Valenciennes' descriptions. The second suborbital of Cuvier and Valenciennes is the third suborbital, or pontinal of Gill's descriptions, but this bone, not being traversed by the infraorbital canal, would seem not to properly be an independent element of the infraorbital series.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The bones that form the hyomandibulo-palato-quadrate apparatus are firmly united to form two pieces with a flexible joint between them. The posterior and much larger piece is formed by the preopercular, hyomandibular, symplectic, quadrate and metapterygoid; and the anterior piece by the palatine, the ectopterygoid and the entopterygoid. The flexible joint between the two pieces is nearly transverse to the axis of the body of the fish, and permits that extensive lateral motion of the hind end of the apparatus that easily places the large preopercular spine at an angle of more than 45° to the axis of the body.

The PREOPERCULAR has a horizontal limb, which terminates in the long and well known spine, and a vertical limb which extends antero-dorsally at an angle of about 75° to the horizontal limb. In the angle between the two limbs there is an articular facet, and immediately dorsal to this facet an articular eminence, both of which give articulation to corresponding surfaces on the hind end of the pontinal. The angle between the two limbs is spanned by a large web of bone which arises from the deeper layers of the preopercular; and, external to this web, on either limb of the bone, between the web and the outer surface of the thick, related limb, there is a large V-shaped

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groove. The bone is traversed its full length by the preopercular latero-sensory canal, and lodges six sensory organs.

The HYOMANDIBULAR is an irregular bone, roughly triangular in general outline, one of the angles of the triangle being directed dorsally and bearing the articular heads of the bone. Not far from the anterior edge of the triangle, and parallel with it, there is a slightly thickened portion, which represents the shank of the bone. The hind edge of the triangle is slightly convex, and bears on its external surface a tall ridge which projects laterally and slightly anteriorly. The posterior surface of this ridge is applied against, and firmly bound to the antero-mesially presented anterior surface of the dorsal limb of the preopercular, the dorsal end of the latter bone reaching to the lower edge of the opercular process of the hyomandibular. This tall ridge along the hind edge of the hyomandibular of Dactylopterus thus corresponds to the ridge that extends longitudinally along the external surface of the shank of the bone in the other fishes of the group; but here, in Dactylopterus, although the ridge begins on the external surface of the dorsal end of the slightly indicated shank, it extends postero-ventrally at an angle to the shank, and leaves, between itself and the shank, a wide intervening space which is spanned by a thin web of bone. The dorsal end of the ridge is thickened to form a large articular head, which articulates with the facet on the antero-lateral corner of the squamosal, and is accordingly the regular posterior articular head of the bone. Postero-mesial to this articular head there is a stout and bluntly pointed process, directed antero-dorsally in the line of the ridge on the external surface of the bone. The postero-lateral surface of this process is slightly concave, is grooved from its top to its base, and has a sliding articulation with the articular surface on the thickened posterior edge of the articular facet on the squamosal. From the anterior surface of the base of this articular process a strong process is directed antero-ventro-mesially. It expands at its distal end, and has a curved articular edge which is presented mesially and has a sliding articulation with the articular surface on the postorbital edge of the proötic immediately dorsal to the trigemino-facialis chamber. Fused with the lateral edge of the base of this process of the hyomandibular, there is a small process which arises from the anterior surface of the ridge on the external surface of the bone, immediately ventral to the regular posterior articular head. This small process is directed anteriorly and has on its dorsal surface a slightly concave articular surface which articulates with the articular eminence on the sphenotic. This small process accordingly represents the regular anterior articular head of the bone. Each of the two regular articular heads of the hyomandibular of Dactylopterus thus has a related, accessory articular head which has a sliding articulation with the cranium, this arrangement giving great solidity to the joint.

On the hind edge of the bone there is a short opercular process.

On the internal surface of the bone, immediately ventral to the bases of the two accessory articular processes, there is a slight transverse ridge of bone, and on the dorsal surface of this ridge is the internal opening of the facialis canal. This canal traverses the hyomandibular and opens on its external surface immediately posterior to the slightly thickened portion that represents the shank of the bone. Immediately ventral to the transverse ridge, on the internal surface of the bone, a large opening leads directly into the facialis canal, and this opening transmits the ramus hyoideus, this nerve thus never reaching the external surface of the hyomandibular. The remainder of the facialis canal transmits the ramus mandibularis lateralis certainly accompanied by communis fibers, and possibly also by certain general cutaneous fibers. The nerve so constituted is joined, as it reaches the outer surface of the bone, by a communicating general cutaneous bundle which arises from the

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trigeminus ganglion and issues through the trigeminus opening of the trigemino-facialis chamber, this being the second trigeminus bundle to join the facialis, the other bundle issuing through the facialis opening of the trigemino-facialis chamber, joining the nervus facialis internal to the hyomandibular, and going largely, if not entirely, to the ramus hyoideus. The ramus mandibularis, thus formed, after giving off certain branches, passes downward and inward through a large opening between the hind edge of the symplectic and the anterior edge of the web of bone that spans the angle between the two limbs of the preopercular, this opening being the regular foramen for the ramus mandibularis externus. Certain fibers other than lateralis ones form part of the nerve that passes through the foramen, but whether they are partly communis or wholly general cutaneous could not be determined in my material. It is, however, certain that, in this fish, no important bundle of communis fibers passes inward anterior to the symplectic, where the ramus mandibularis internus should normally pass, and, in my material, I could not there find an opening that I could certainly call a foramen and not an artifact. From the facialis canal, near its internal opening, a canal leads backward in the hyomandibular, as usual, opens on its external surface near its hind edge and immediately ventral to the opercular process, and transmits a nerve containing lateralis and general cutaneous fibers destined to innervate the dorsal two organs of the preopercular canal and tissues on the outer surface of the opercular.

The ramus hyoideus facialis thus never reaches the external surface of the hyomandibular, and it accordingly here has relations to that bone that might be taken to indicate that it was in process of cutting through the bone from its outer to its inner surface; but this is certainly not the case, the condition being in some way related to the development of that tall ridge on the external surface of the bone that gives support to the preopercular. This ridge lies, in certain fishes (Scorpaena, Trigla etc.), posterior to the external opening of the facialis canal through the hyomandibular, while in others (Scomber) it lies anterior to that opening. If, in one of these latter fishes, the ridge were to be pushed backward into the position, relative to the shank of the bone, that it has in Dactylopterus, it would probably pass over the ramus mandibularis, held in position by its lower foramen, but would push the ramus hyoideus downward and backward onto what would be morphologically a part of the posterior surface of the bone, though appearing as a part of its internal surface. An intermediate stage in such a process is shown in Gasterosteus, where, according to Swinnerton ('02, p. 544), ,,the hyomandibular nerve foramen occupies the same position as it did in the last stage, but externally at first sight it seems to have disappeared; in reality it has been carried to the ventral edge [of the hyomandibular] by overgrowth of bone".

The distal end of that slightly thickened portion of the hyomandibular that represents the shank of the bone is in synchondrosis with the usual interspace of cartilage, that cartilage being bounded anteriorly by the metapterygoid, antero-ventrally by the symplectic, and posteriorly by the web of bone that fills the angle between the two limbs of the preopercular. The interspace gives articulation, on its internal surface, to a relatively long and important interhyal. Immediately dorsal to this interspace of cartilage, the anterior edge of the hyomandibular is in contact with and firmly bound to the dorso-posterior corner of the metapterygoid, and between the two bones and the interspace of cartilage there is a relatively large foramen which transmits the arteria hyoidea.

The SYMPLECTIC is broad and flat, and lies in the line, prolonged, of the shank of the hyomandibular. Its ventral end overlaps the dorsal edge of the quadrate, and lies in a slight depression on the internal surface of that bone. The anterior edge of the bone is bounded externally by the

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cartilage of the palato-quadrate apparatus, while internally it overlaps that cartilage and is in contact with the hind edge of the metapterygoid. Its hind edge is in part in contact with the anterior edge of the web of bone that spans the angle between the two limbs of the preopercular, and in part is separated from that web of bone by a relatively large opening. This opening is spanned by membrane, and the membrane is pierced by the arteria hyoidea and the ramus mandibularis externus facialis, the lateralis fibers of that nerve being accompanied by general cutaneous ones and possibly also by communis fibers, as just above explained. No mandibularis internus foramen, between the symplectic and quadrate, could be found.

The METAPTERYGOID is a subcircular bone slightly concave on its internal surface. It is bounded anteriorly by the entopterygoid, with which it is flexibly connected by tissue; ventrally by the quadrate, from which it is separated by a narrow band of cartilage; and posteriorly by the symplectic and the interspace of cartilage between the latter bone and the hyomandibular. A small posterior process at the dorsal end of its hind edge is in contact with and bound by tissue to the anterior edge of the ventral end of the hyomandibular, and this process is pierced by a foramen which transmits the external carotid from the outer to the inner surface of the apparatus, the artery there falling into the arteria hyoidea. In the ventral edge of the process there is a notch, which, with the adjoining cartilage, forms a foramen which transmits the arteria hyoidea from the outer to the inner surface of the apparatus. The process on the metapterygoid thus represents, as the hind edge of the bone in Cottus does, the two flanges on the hind edge of the bone of Scorpaena.

The QUADRATE has a large posterior process, the thick and broad postero-ventral surface of which rests against the dorsal surface of the ventral limb of the preopercular, the point of the process passing into a pocket in that bone. The symplectic groove is simply a broad and shallow depression on the internal surface of the dorsal edge of the bone, immediately anterior to this process. Dorsally the bone is bounded by cartilage which separates it from the metapterygoid, and the anterior edge of the bone forms, with that of the metapterygoid, a continuous line which is slightly convex and lies in a nearly transverse position. The narrow band of cartilage that lies between the two bones is prolonged a short distance beyond their anterior edges, there lies in a depression on the external surface of the entopterygoid, and is exposed on the outer surface of the apparatus between the ecto- and ento-pterygoids. The anterior edge of the quadrate overlaps internally the hind edge of the ectopterygoid, but is itself overlapped internally by a short process at the ventral corner of the latter bone, this latter process being in articular contact with the dorsal surface of the mesial end of the articular head of the quadrate. The quadrate and ectopterygoid thus articulate in a measure with each other, and as their adjoining edges are strongly but flexibly bound together by tissue, and as the anterior edge of the metapterygoid is similarly bound to the hind edge of the entopterygoid, a flexible joint is here formed in the hyomandibulo-palato-quadrate apparatus. The anterior prolongation of the band of cartilage that lies between the quadrate and metapterygoid crosses the joint uninterruptedly, but being itself flexible does not interfere with the movements of the parts. In the Cyprinidae, according to Sagemehl ('91, p. 582), the palato-quadrate apparatus is also jointed, but in those fishes the joint is between the palatine and the ecto- and ento-pterygoids and hence not similar to the joint in Dactylopterus.

The ECTOPTERYGOID is a stout elongated bone directed antero-dorsally. Its dorso-anterior end suturates with the palatine, the two bones enclosing between them a palatine remnant

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of the palato-quadrate cartilage. The dorsal edge of the bone overlaps externally and suturates with the ventral edge of the entopterygoid, bounding, in its posterior portion, the short anterior prolongation of the palato-quadrate cartilage just above described. Its hind edge overlaps both externally and internally and articulates with the anterior edge of the quadrate, in the manner just above described. Near the ventro-posterior end of the free, ventral edge of the bone, there is a flat ridge-like process, the function of which was not evident in my preparations.

The ENTOPTERYGOID is a relatively large, thin, sub-oval bone, the anterior end of which overlaps internally the palatine, the ventral edge similarly overlapping the dorsal edge of the ectopterygoid. Its hind edge is flexibly bound to the anterior edge of the metapterygoid. In a slight depression on its outer surface, at its ventro-posterior corner, it lodges the short anterior prolongation of the palato-quadrate cartilage.

The PALATINE is a stout irregular bone, with a short body, a right-angled maxillary process, and a short ventral process the ventral edge of which is broadened and corrugated but bears no teeth. The hind end of the bone suturates with the ectopterygoid and entopterygoid, being overlapped externally by the former bone and internally by the latter. The three bones enclose between them a small palatine remnant of the palato-quadrate cartilage, this cartilage not being exposed on the outer surface of the apparatus. The maxillary process of the palatine is a stout process, the proximal portion of which is directed antero-dorso-laterally and the distal portion antero-ventro-mesially, the two parts lying nearly at a right angle to each other. The dorsal surface of the flat distal portion of the process lies against, and has a sliding articulation with the internal surface of the lachrymo-palatine process of the nasal bone, the ventral surface of the process giving articulation to, and being firmly bound by fibrous tissue to, the dorsal surface of the maxillary bone. Immediately posterior to the surface of contact with the nasal, the hind end of the flat dorsal surface of the maxillary process has a sliding articulation with the two little articular ridges on the internal surface of the dorsal edge of the lachrymal.

On the internal surface of the base of the maxillary process of the palatine, there is a V-shaped groove which has a wide dorsal end and from there tapers gradually downward to a point. This V-shaped groove articulates with the anterior edge of the lateral process of the vomer, and possibly also with adjacent portions of the corresponding edge of the pedicle of the ectethmoid, in the manner already described when describing those bones. Ventral to the groove there is, on the internal surface of the anterior end of the ventral process of the palatine, a concavity which gives insertion to the short vomero-palatine ligament and comes in contact with the lateral surface of the head of the vomer when the palato-quadrate apparatus swings inward. The dorsal edge of the body of the bone, and the dorsal edge of the entopterygoid immediately posterior to it, are both bound by strong tissue to the ventral surface of the pedicle of the ectopterygoid, touching that bone when the palato-quadrate apparatus swings inward.

The MANDIBLE contains dentary, articular and angular elements.

The dentary has the usual V-shaped hind end, the two limbs of the V being of about equal length. The ventral limb tapers gradually to a point, and its hind end lies in a deep groove along the internal surface of the articular. The dorsal limb of the bone is covered with small villiform teeth and ends in a flattened hind end which replaces functionally the dorsal end of a coronoid process, that process of the articular being wanting. On the external surface of the bone there is a deep groove

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which doubtless lodges the anterior end of a gristly mandibular core, but this was not investigated in the preparation of my material. On the ventral surface of the dorsal limb of the bone is inserted the strong ligament that has its origin on the internal surfaces of the second and third infraorbital bones. The bone is traversed by the mandibular latero-sensory canal and lodges but two sense organs of the line.

The articular is a stout bone with a pointed anterior end which fits into the V between the two limbs of the dentary, lying on the dorsal surface of the ventral limb of that bone. On the ventral half of its internal surface is a deep V-shaped groove which receives the hind end of the ventral limb of the dentary. Near the hind end of this groove a canal traverses the bone from its ventral to its dorsal surface, but what it transmits was not determined. The bone is without coronoid process, and nearly its entire hind end is occupied by the articular facet for the quadrate. The bone is traversed by the mandibular latero-sensory canal and lodges one organ of that line.

The angular is a small bone that fits against the ventral surface of the articular, there forming a low, longitudinal and rounded ridge. At about the middle of its length there is a low transverse ridge, the posterior surface of which gives insertion to a ligament that has its origin on a rod-like bone that must represent the interopercular. From the hind end of this little bone a ligament extends posteriorly and has its origin on the external surface of the dorsal ossification of the ceratohyal, near its dorso-posterior end; the bone thus being intercalated in the mandibulo-hyoidean ligament, as a part of that ligament, but seeming nevertheless to represent the interopercular.

The OPERCULAR is, as Gill has said, a flexible subtriangular bone, the external surface of which is covered with scales.

The SUBOPERCULAR is said by Gill to be „almost membranous, mostly concealed", and to lie internal to the ventral end of the opercular. I find it as a relatively stout and curved bone, the dorsal end of which lies internal to the ventral end of the opercular, while the ventral end curves forward and lies against the internal surface of the preopercular; this latter end of the bone being directed toward but widely separated from the hind end of the interopercular. In Figure 71, which alone shows these bones, the line separating the subopercular and opercular has been omitted.

The INTEROPERCULAR is apparently represented, as Gill has stated and as just above described by me, by a rod-like bone intercalated in the mandibulo-hyoidean ligament.

4. LATERO-SENSORY CANALS.

The main infraorbital canal begins at the dorsal edge of the lachrymal, directly antero-ventral to the anterior end of the large nasal opening between the nasal and ectethmoid bones, there lying directly opposite and close to the anterior opening of the supraorbital canal. It runs at first ventro-laterally, then turns sharply backward at a right angle, and so continues in a nearly horizontal position until it has traversed the lachrymal and the anterior two-thirds of the second infraorbital bone. There it turns sharply upward and forward, at an acute angle, and curving backward and upward borders the hind edge of the orbit, traversing the second, third, and fourth infraorbital bones. At the anterior end of the horizontal part of its course, it sends a short branching tubule forward in the lachrymal, and at the hind end of this part of its course, it sends a long branching tubule directly backward nearly to the postero-ventral corner of the second infraorbital bone. Numerous other tubules arise from the canal in this part of its course, some of them being simple tubes while

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others branch repeatedly, forming complicated dendritic systems. The tubules are scattered along the canal instead of being grouped together, and it is impossible from the tubules alone to determine the number of primary tubes. Furthermore, here, as in other parts of the latero-sensory system of this fish, the large dendritic systems arise from the canals in the bodies of the related bones, frequently near the middle point of the bone, and almost never in the sutural line between two bones; this being distinctly a characteristic of the canals in the chondrostean ganoids, here found in a teleostean fish. A full knowledge of the development of the system would accordingly be of considerable interest.

The main infraorbital canal, having left the dorsal one of the infraorbital bones, enters and traverses the postfrontal, at the dorsal end of which bone it turns sharply backward and enters the pterotic, anastomosing at the bend with what appears to be the terminal tube of the supraorbital canal. The main infraorbital then traverses in succession the pterotic and suprascapular, lying for a short distance, as it passes from one of these bones to the other, in a groove on the lateral edge of the lateral extrascapular. It then traverses a short tubular bone that lies along the lateral edge of the suprascapular and that apparently represents the latero-sensory component of the supraclavicular, as already set forth. As the canal traverses the pterotic it anastomoses with the dorsal end of the preopercular canal, and as it traverses the lateral edge of the lateral extrascapular, it gives off the supratemporal commissure.

In the main infraorbital canal there are three sense organs lodged in the lachrymal, two in the second infraorbital bone, three in the third infraorbital and one in the fourth infraorbital, all innervated by the ramus buccalis. In the postfrontal there is one organ innervated by the ramus oticus, and in the pterotic three organs, two innervated by the oticus and one by the supratemporalis lateralis vagi. In the section of canal that lies in the groove in the lateral extrascapular there is apparently no organ, but the organ usually found here may be represented in a part of the one organ found in this bone. This organ is unusually large, begins in the main canal, and from there extends postero-mesially in the supratemporal commissure, thus certainly belonging, in part at least, to that commissure. It is innervated by a single branch of the supratemporalis lateralis vagi. In the suprascapular there is one organ, innervated by the supratemporalis lateralis vagi.

The supratemporal canal begins at the lateral edge of the lateral extrascapular, opposite the sutural line between the pterotic and suprascapular, and running postero-mesially and then mesially traverses the lateral extrascapular and then the mesial extrascapular, anastomosing, at the mesial edge of the latter bone, with its fellow of the opposite side. Each of these two bones lodges a single sense organ innervated by a branch of the supratemporalis lateralis vagi.

The supraorbital canal begins at the lateral edge of the single median nasal bone, and from there runs upward and mesially, and then upward and backward in the nasal, curving around the anterior and then the mesial border of the large nasal opening of the skull. It then enters the anterior edge of the frontal and runs almost directly backward to the middle point of that bone. There it turns sharply laterally, and then curving laterally and backward reaches the postero-lateral edge of the frontal, where it anastomoses, by what is apparently its terminal tube, with the main infraorbital canal. In the full length of the canal there are, as in all the other fishes of the group, six sense organs, one in the nasal and five in the frontal, all innervated by the ophthalmicus lateralis; but in Dactylopterus the relations of the organs in the frontal to the frontal commissure are not as in those other fishes. Here, three organs lie anterior to the commissure and two posterior to it, the commissure

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accordingly being formed by what is, in its relations to the organs, the fifth instead of the fourth tube of the line. Furthermore, there is no primary tube between the first and second frontal organs, and it is apparently the terminal tube of the line, instead of the penultimate tube, that anastomoses with the main infraorbital canal.

The preoperculo-mandibular canal anastomoses by its dorsal end with the main infraorbital as that canal traverses the pterotic. The canal traverses, as usual, the preopercular, articular and dentary, the former bone lodging six sense organs, the articular lodging one organ, and the dentary two organs; all innervated by the mandibularis externus facialis.

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III. THE MYODOME.

Having found a myodome in Dactylopterus, in which fish it is said by Gill ('88) and other authors to be wholly wanting, I have been led to look up, as fully as the literature and material at my disposal would permit, all other teleosts in which this canal is also said to be absent. Before discussing these other teleosts it is, however, necessary to quite fully describe the related conditions in Lepidosteus; for a proper understanding of the conditions in that fish, already briefly described by Sagemehl, is most important in this connection.

Of Lepidosteus Sagemehl says ('84b, p. 86); ,,Bei Lepidosteus wird durch besondere Fortsätze der Petrosa ein nach vorn gegen die Schädelhöhle geöffneter Halbkanal gebildet, der dicht hinter der Hypophyse von einer Seite zur anderen verläuft und nach vorn, also gegen die Hypophyse hin, durch eine Membran vollständig abgeschlossen und zu einem allseitig gedeckten Querkanal verwandelt wird, welcher von lockerem Fettgewebe erfüllt ist. Lateral reicht dieser an der Basis cranii dicht hinter der Hypophyse verlaufende Kanal bis an den hinteren, unteren Winkel der Orbita, nach welcher hin er vollständig verschlossen erscheint. Abgesehen von dem letzteren Umstande besitzt dieser Raum genau dieselben Verhältnisse, wie der von Gegenbaur beschriebene Canalis transversus der Selachier; der Verschluß gegen die Orbitae ist wohl ein sekundärer. Auf der anderen Seite kann es eben so wenig einem Zweifel unterliegen, daß dieses der Augenmuskelkanal von Amia ist, wenn man die hier gegebene Beschreibung mit der Fig. 7 meiner Arbeit über Amia vergleicht, wo der unter dem horizontalen Fortsatz des Petrosum und vor demselben gelegene durch eine Fascie (die nicht abgebildet ist) zugedeckte Raum von dem Rectus externus eingenommen wird. Die von Gegenbaur vertretene Hypothese kann somit durch weitere Tatsachen gestützt werden."

In the adult Lepidosteus the brain case, in the region of the pituitary body, is somewhat more than twice as wide as it is tall. In a 19 mm embryo these two dimensions, in this same region, are nearly equal. There is thus, in this region, a flattening of the brain case as the fish develops, and this flattening process seems to particularly affect the ventral portion of the brain case. Because of it, the ascending processes of the parasphenoid of the adult are flat plates, projecting almost directly laterally from the body of the bone. Their lines of origin from the body of the bone incline backward and slightly upward, the two processes thus lying practically in the same plane, and that plane being a transverse one that inclines but slightly upward and backward to the axis of the parasphenoid. Each process is, in extent and position, the equivalent of the ascending process of Parker's ('82b) figures of young Lepidostei fused with the so-called alisphenoid bone of those same figures, Parker showing these latter bones as separate and independent ones in 2 and 4 inch larvae and describing them as such in the adult.

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In larvae 55 and 80 mm in length, I find, occupying the place of the alisphenoid bone of Parker's descriptions, a V-shaped process of the parasphenoid which embraces the mesial edge of an anterior plate-like process of the proötic cartilage. This process of the proötic cartilage occupies the place of, and certainly is the basipterygoid process of Parker's descriptions, but it has a short free mesial edge not shown by Parker. The anterior edge of the V-shaped process of the parasphenoid is closed by a rounded union of the plates that form its two limbs, and the limbs are here both short, extending laterally only about one third the width of the cartilage. This rounded anterior edge of the process, and the corresponding edge of the cartilage beyond it, together, give articulation to the metapterygoid. The point of the V of the V-shaped process is directed mesially toward the lateral edge of the parasphenoid, but it does not, in its anterior portion, quite reach that edge. Posteriorly it meets and fuses with the edge of the parasphenoid, thus becoming a part of the ascending process of that bone. The dorsal (internal) limb of the V there vanishes, while the ventral (external) limb becomes prolonged into that tall plate of the ascending process of the parasphenoid that lies against the external surface of the proötic cartilage. In 19 mm and 25 mm specimens, which I have also examined, the internal limb of the V-shaped process has not yet developed, the external limb alone being found. The V-shaped process of older specimens is thus, in these young larvae, simply a plate-like part of the ascending process of the parasphenoid which, projecting forward, forms the lateral boundary of a narrow space, or notch, between itself and the lateral edge of the body of the parasphenoid. Through this notch the efferent pseudobranchial artery runs upward, and then turns mesially between the body of the parasphenoid and the overlying cartilaginous basis cranii, to join and completely fuse with the internal carotid. Immediately posterior to the notch, the ventro-mesial edge of the base of the basipterygoid process of the proötic cartilage fuses with the ventral surface of the lateral edge of a short band-like portion of the cartilage of the region, this latter cartilage bounding the space in which the hypophysis lies. Posteriorly this band is continuous with the parachordal cartilage, while anteriorly the lateral end of its nearly straight anterior edge is continuous with the thickened ventral edge of the cartilage of the alisphenoid region; that thickened edge of the alisphenoid cartilage being continuous, anteriorly, with the hind end of a median portion of the trabecular cartilage. Whether the short band of cartilage is of trabecular origin, or not, I can not positively tell, but it would seem as if the trabecular cartilage could not extend posteriorly, on either side, beyond the hind end of the thickened ventral edge of the alisphenoid cartilage. This being the case, the short band of cartilage would represent the anterior end of the parachordal cartilage, and as such I consider it; the hypophysis then lying between the anterior ends of the parachordal cartilages. Parker shows this part of the chondrocranium of Lepidosteus somewhat different from what I find it, and he considers the cartilage of this region as of trabecular origin; but he also considers the basipterygoid process as of trabecular origin, and that cartilage, being a process of the proötic cartilage, must certainly be of post-trabecular origin.

The basipterygoid process of Lepidosteus, it may here be stated, has so closely the position and the relations to the nerves and blood vessels of the region that the basipterygoid process of Lacerta has (Gaupp, '00, p. 537), that it must be the homologue of that process. In Amia, it is apparently represented in the little cartilaginous process that is perforated by the efferent pseudobranchial artery (Allis, '97a), and that rises from the lateral edge of what is apparently the hind end of the fused trabeculae. In most teleosts the process seems wholly wanting.

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Parker's alisphenoid bone is thus, as I find it, even in 55 mm specimens, simply a part of the ascending process of the parasphenoid, and I am unable to explain how Parker could have found it, separate and independent, not only in a 2 inch (50 mm) but also in a 4 inch (100 mm) specimen. Parker furthermore states that his alisphenoid is an endosteal bone. In my 55 mm and 80 mm embryos the corresponding basipterygoid process of the parasphenoid is, in its anterior portion, surrounded by dense tissue the character and origin of which I am unable to determine, not being sufficiently versed in the subject; but it would seem to result, in part, from the breaking down of the superficial layers of the cartilage against which the bone lies. In the 19 mm and 25 mm specimens this dense tissue is already being developed, but at these ages the tissue lies almost entirely between the bone and the cartilage, and it may accordingly be wholly of perichondrial origin. Whatever its origin, this part of the parasphenoid certainly has relations to the underlying cartilage somewhat different from those of the other portions of the bone, and it would seem to be a typical case of a dermal bone in process of acquiring primary relations to an underlying cartilage. It is, however, to be noted that perichondrial bone has nowhere else appeared, in the earliest of the stages examined, and that when it does appear it is not imbedded in dense formative tissues, as the bone here in question is. In the adult this part of the ascending process of the parasphenoid certainly has much the appearance of perichondrial bone; but it runs insensibly into the posterior portion of the process, where both plates of the V-shaped portion of the bone are certainly of ectosteal origin, for they both extend beyond the dorso-lateral edge of the cartilage they enclose, and there overlap, superficially, portions of the inner and outer surfaces of the ventro-mesial edge of the proötic bone. But, whatever its origin, this part of the parasphenoid is certainly not the alisphenoid, for that bone is found elsewhere, in its proper place, as a wholly independent ossification.

In the adult, on the anterior edge of the basipterygoid portion of the ascending process of the parasphenoid, there is a tit-like process which projects toward and sometimes even abuts firmly against the lateral surface of the body of the parasphenoid slightly anterior to the base of its ascending process. This little process lies in a horizontal position, at right angles to the axis of the parasphenoid, and between it and the anterior edge of the basal portion of the ascending process there is a more or less completely closed opening which transmits the efferent pseudobranchial artery. The anterior edge of the tit-like process is straight and forms part of the articular surface for the metapterygoid, the remainder of that articular surface being formed by the straight anterior edge of the basipterygoid process and a corresponding edge of that part of the proötic cartilage that lies dorso-lateral to the process. This little tit-like process is thus a mesial growth of the anterior end of the V-shaped part of the bone of embryos, and it is to be remarked that, although it may abut firmly against the body of the parasphenoid, I have never found it fused with that bone. It is not shown in any of Parker's figures, but the general arrangement of the parts can be readily understood by reference to those figures.

Between the proötic bone and the hind edge of the external plate of the ascending process of the parasphenoid, there is an opening which leads into a short canal between the parasphenoid and the overlying cartilage of the basis cranii, the opening thus having exactly the position of the internal carotid foramen of Amia and teleosts, and unquestionably being the homologue of that foramen. In Lepidosteus, however, this foramen transmits the common carotid, which artery, immediately within the foramen, separates into its external and internal branches. The external carotid, turning upward, traverses a foramen that perforates the ventro-mesial edge of the proötic, but lies partly in that bone and partly in the cartilage that bounds it. The artery then runs upward

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and backward in a deep groove that lies on the orbital surface of the proötic and that leads into a large trigemino-facialis chamber. This groove, in Lepidosteus, transmits the ramus palatinus facialis as well as the external carotid artery, the nerve traversing the foramen in the proötic with the artery, and entering the carotid canal. This foramen in the proötic of Lepidosteus is accordingly the homologue of the palatinus and external carotid foramina of Amia, coalesced into a single opening. It has closely the position of the palatinus foramen of Amia, and neither it nor the carotid foramen are shown by Parker in any of his figures.

In sections of embryos, a delicate pharyngeal branch of the glossopharyngeus is found accompanying the common carotid artery, and although it could not be traced as far as the carotid foramen, it doubtless traverses that foramen, with the artery, as in Amia.

The internal carotid artery, having separated from the external carotid immediately beneath the palatinus foramen, runs forward in a canal between the cartilage of the basis cranii and the underlying parasphenoid, lying in a slight groove on the dorsal surface of the latter bone. It is accompanied, in this canal, by the ramus palatinus facialis and probably also by the delicate branch of the glossopharyngeus just above described. Having arrived near the anterior edge of the ascending process of the parasphenoid, and there lying anterior to the pituitary fossa, the internal carotid receives the efferent pseudobranchial artery. It then, in all my embryos, immediately separates into two parts. In the smaller embryos, these two parts both turn upward and traverse the intertrabecular space, while in the older embryos, they perforate the overlying cartilage and so enter the cranial cavity, one part traversing a large foramen and the other traversing a small and imperfectly enclosed branch canal which leads from that foramen. The larger one of these two branches gives off several intracranial branches and then leaves the cranial cavity with the nervus opticus. The smaller branch also issues with the opticus, but it gives off no perceptible branches during its intracranial course, and it may perhaps be reminiscent of the otherwise wholly wanting anterior continuation of the efferent pseudobranchial artery. Shortly before the anastomosis with the efferent pseudobranchial artery, the internal carotid gives off a small branch which runs forward, accompanying the palatinus facialis, in an anterior prolongation of the canal between the parasphenoid and the overlying cartilage of the base of the skull. This latter artery and the two carotids are all three briefly mentioned by Wright ('85) in his description of the arterial circulation in embryos of Lepidosteus, but their foramina and their courses relative to the cranium are not well or sufficiently given by him.

In the adult, the trabeculae of opposite sides have fused with each other in the middle line, and the internal carotids traverse foramina in the basis cranii, these foramina corresponding to the internal carotid canals of my descriptions of Amia ('97). Slightly anterior to these canals there is a shallow transverse groove across the dorsal surface of the fused trabeculae, this groove corresponding exactly, in position, to the canalis transversus of my descriptions of Amia, and being quite undoubtedly the homologue of that canal. The groove is, however, not the homologue of the canalis transversus of selachians, as I have pointed out in a later work ('01), and the selection of the name, in my descriptions of Amia, was unfortunate. The groove, in Lepidosteus, forms the anterior boundary of a slightly raised portion of the cartilage of the basis cranii, which extends backward to the anterior edge of the pituitary fossa and is the homologue of the much more pronounced transverse prepituitary bolster of Amia.

The pseudobranchial artery, in Amia, does not itself fuse with the internal carotid, a small communicating branch, only, which perforates a lateral projection of the basis cranii, uniting the

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two arteries. In Lepidosteus, it is the main efferent pseudobranchial artery, itself, that here unites with the internal carotid, traversing, to reach that artery, the imperfectly closed foramen in the anterior edge of the ascending process of the parasphenoid. This difference in this artery, in these two fishes, is doubtless due to the absence of a choroid gland in Lepidosteus; that orbital continuation of the artery that supplies that gland in Amia naturally being suppressed with the gland, in Lepidosteus, and the communicating branch of Amia becoming, in Lepidosteus, the direct anterior continuation of the main artery.

The palatinus facialis and external carotid of Lepidosteus run upward and backward, as already stated, in a groove that leads into a trigemino-facialis chamber in the proötic. This chamber has a very large trigeminus, and a smaller facialis opening, and its bony mesial wall is a direct posterior continuation of the bony wall that encloses the anterior part of the cranial cavity; Lepidosteus, in this, resembling Scomber and the mail-cheeked fishes, and differing markedly from Amia. The mesial wall of the chamber is perforated by a single large foramen for the roots of the trigemino-facialis nerves, two small processes representing the beginnings of a separation of the foramen into two or more parts. Slightly antero-ventral to this foramen the anterior edge of the proötic is perforated by another foramen, the anterior border of which is formed by a small flat bar of cartilage which, rising from the trabecular cartilage and extending upward to the ventral edge of the alisphenoid, separates the foramen from the ventral portion of the optic fenestra. This foramen transmits the pituitary vein, which vein arises beneath the hypophysis, in direct communication with its fellow of the opposite side, and from there runs dorso-antero-laterally to traverse its foramen and fall into the (internal ?) jugular slightly posterior to the point where that vein is joined by the orbito-nasal vein. The pituitary vein receives a small branch, on either side, from the cross-canal of Sagemehl's descriptions, these branches being traced in sections and not in the adult. The vein, in the adult, lies, in its intracranial course, beneath a mass of fatty tissue which covers the floor of the cranial cavity, and this fatty tissue in the cranial cavity of the skull of fishes is said by Sagemehl ('84a) to lie between inner and outer limiting membranes which are parts of the dura mater. Some part of this tissue, in Lepidosteus, is accordingly the homologue of the tough glistening membrane that, in Amia, forms not only the roof of the anterior portion of the myodome, but also the mesial wall of the trigemino-facialis chamber of that fish. The foramen that transmits the pituitary vein, in Lepidosteus, is thus quite certainly the equivalent of some part of the ventral portion of the orbital opening of the myodome of Amia.

Immediately dorsal to the foramen for the pituitary vein, between the adjoining edges of the proötic and alisphenoid, there is another foramen, which transmits the nervus oculomotorius and probably the radix profundi also, for although this latter nerve, in my 80 mm specimen, pierces the cartilaginous cranial wall close to but wholly separate from the oculomotorius, I do not find a separate foramen in the one adult skull that I have examined in this connection. Van Wijhe ('82) says that he found the profundus issuing by a separate and independent foramen. Somewhat dorsal to these two foramina, in the sections of my 80 mm specimen, the trochlearis pierces the cranial wall, and, slightly posterior to that nerve, the wall is perforated by a branch of the orbito-nasal vein. These two latter foramina are, one or both, represented, in my adult specimen, in a short canal that traverses the alisphenoid slightly dorsal to the oculomotorius foramen.

Stannius ('49, p. 19) says that, according to Müller, the oculomotorius, trochlearis and trigeminus of Lepidosteus all issue through a single large foramen in the „Keilbeinflügel"; a statement that is certainly not wholly correct.

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A short leg of the alisphenoid forms, in the adult, the anterior boundary of the oculomotorius foramen, the ventral end of the leg being continuous with the small flat bar of cartilage that lies between the ventral portion of the optic fenestra and the foramen for the pituitary vein; and as this bar of cartilage rises from the lateral edge of the basisphenoid region of the trabecular cartilage, the associated leg of the alisphenoid must be the basisphenoid leg of that bone. Of the parasphenoid leg of the alisphenoid I can find no trace, the alisphenoid of Lepidosteus thus being strictly of the usual teleostean type.

The recti muscles of the eye all have their origins from the skull immediately ventral and posterior to the optic fenestra, and hence in the immediate neighbourhood of the foramen for the pituitary vein. The rectus externus, in the 80 mm specimen, separates into two portions as it approaches the skull, and the tendon of one of these portions traverses the foramen with the vein, and, following it, has its origin beneath it; but whether its point of origin is on the cartilage of the basis cranii, on the parasphenoid, or in fibrous tissue of the region, I could not determine.

Although wholly unrelated to the present subject, it may here be stated that the rectus internus arises, in Lepidosteus, by a long and slender tendon which is closely applied to the antero-mesial surface of the rectus inferior, these two muscles thus arising as a single muscle and being, practically, not yet fully differentiated parts of a single muscle; this being in accord with my supposition (97a) that these two muscles of teleosts and bony ganoids arise by the splitting of the single rectus inferior of elasmobranchs. These two muscles, and the rectus superior and obliquus inferior, are innervated by the oculomotorius in the manner and order that they are in Amia, this confirming my interpretation ('97a, p. 520) of Van Wijhe's description of this fish. The abducens leaves the cranial cavity through the trigemino-facialis foramen, piercing the membrane that closes that foramen antero-ventral to and independent of the trigemino-facialis roots. It then runs antero-laterally, ventral to the jugular vein, between it and the external carotid, lying internal and antero-internal to the ventral edge of the trigemino-facialis ganglion, and reaches the rectus externus. It does not pass over the truncus trigeminus, as stated by Schneider ('81), but, as the rectus externus passes over that truncus, the abducens naturally also would, if it were sufficiently prolonged. The radix profundi, after its exit from the skull, enters an extra-cranial profundus ganglion which lies close against the side wall of the skull immediately dorso external to and in contact with the oculomotorius, and not below that nerve, as shown by Schneider. Two ventral or ventro-anterior prolongations of the ganglion terminate in small ganglionic swellings, which lie in contact with the inferior branch of the oculomotorius and are the ciliary ganglia. From the anterior end of the profundus ganglion a stout portio ophthalmici profundi arises. The trigemino-facialis ganglion lies, as in Amia, wholly outside the cavum cranii, a few scattered cells only being found in the roots of the nerves.

The cross-canal of Sagemehl's descriptions can now be considered. The enclosing walls of this canal form, in the fresh skull of the adult fish, a prominent transverse bolster on the floor of the cranial cavity, and this bolster must quite unquestionably have arisen by the depression of the anterior edge of the proötic bridge of a fish like Amia (Allis, '97a, Fig. 11) or Polypterus (Pollard, '92, Fig. 12) until it met and then fused with the floor of the cranial cavity on either side of the saccus vasculosus. The cross-canal of Lepidosteus is thus a strictly intramural space that lies beneath a proötic bridge of the primary type found in Amia, and that is related either primarily or secondarily to the saccus vasculosus. This space represents the posterior half only of the myodome of Amia, and it might have been developed either from the conditions found in that fish, which

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has a myodome, or from those found in Polypterus which has no myodome. In Lepidosteus the mesial processes of the proötics, which unite to form the proötic bridge, are said by Sagemehl to be connected, across the median line, by membrane, instead of by cartilage. To me this connecting tissue looks much more like cartilage or fibro-cartilage than like membrane, but this is unimportant, for even in Amia membrane is here first formed and later chondrifies. Sagemehl further says that this membrane entirely closes the canal toward the cranial cavity. This is an error, for I find the anterior wall of the canal always perforated by a median oval opening through which the apparently short saccus vasculosus projects. The cross-canal is filled, as Sagemehl states, with a mass of fatty tissue and this tissue is richly supplied with blood.

Immediately anterior to the cross-canal there is, in the floor of the cranial cavity, the pit-like and slightly oval pituitary fossa. The lateral and anterior walls of this fossa are of cartilage. The floor of the fossa is perforated by a nearly circular opening, the opening being closed ventrally by the parasphenoid. Posterior to this circular opening, and extending to or slightly beyond the anterior wall of the cross-canal, the floor of the pit is, in my medium-sized adults, formed of tough membrane only. Posterior to this membrane the floor of the cross-canal is of cartilage, and inclines gradually and slightly upward to the base of the ridge of cartilage that forms the posterior boundary of the cross-canal. The circular opening in the cranial floor is accordingly the hypophysial fenestra, the greatly reduced pituitary space, or pituitary fenestra of Parker's descriptions of embryos of Lepidosteus, and this fenestra of the adult Lepidosteus is the strict, but reduced homologue of the hypophysial fenestra of Amia. The fenestra of Lepidosteus is said by Parker to lie between the „roots“ of the trabeculae; but, as already stated, the laterally bounding cartilages seem to me to be the anterior ends of the parachordal cartilages. Parker's opinion was doubtless based; Ist., on the position of the hypophysis, in early embryos, between the hind ends of the trabeculae; and, 2nd. on the position of the posterior clinoid bridge of his descriptions, which bridge is said by him (l. c. p. 481) to run „straight across, joining the roots of the trabeculae together“. But, this posterior clinoid bridge simply represents an early stage in the development of the enclosing walls of Sagemehl's cross-canal, and hence joins regions of parachordal and not of trabecular origin. Furthermore, the position of the hypophysis in early embryos need not necessarily be the same as that in the adult. For, the intertrabecular and interparachordal fenestrae of early embryos being continuous, as shown by Parker, the well-known unequal longitudinal growth of the cartilage of the basis cranii and the overlying brain might easily pull the pituitary body backward, out of the hind end of the intertrabecular space into the interparachordal region. And this, in my opinion, has certainly taken place in Lepidosteus.

Sagemehl says that the lateral ends of the cross-canal closely approach the postero-ventral corner of the orbit. This is an error, for the cross-canal is everywhere widely separated from the orbit. He further says that the cross-canal exactly resembles the canalis transversus of selachians, excepting that it is closed toward the orbit. This also is not wholly correct, for as the canalis transversus of selachians is traversed (Allis, '01) by a venous sinus and not simply by a lymph sinus, as Sagemehl supposed, it must be represented, in part at least, in Lepidosteus, by the canal that transmits the pituitary vein. There are here, in fact, two spaces that would seem to be of separate and independent origin; one a median space that is either primarily or secondarily related to the saccus vasculosus, and the other a canal that leads from the orbit, on either side, and is traversed by the pituitary vein. The saccular space is roofed by the mesial processes of the proötics, and from it, or immediately in front

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of it, the canal for the pituitary vein leads on either side into the orbit, lying ventral and then lateral, or antero-lateral to the hypophysis.

The conditions in Lepidosteus thus all indicate that the myodome of Amia would arise if certain of the recti muscles of the former should force an entrance into the cranial cavity, and then into the saccular space, traversing, in this process, the foramen and then the canal for the pituitary vein. The recti muscles, as already stated, already have their origins in the immediate vicinity of the foramen for the vein, and one head of the rectus externus has, in my 80 mm specimen, already acquired a very considerably intracranial extension. If this head of this muscle were to continue its progress, at the same time increasing largely in size, it would, following the vein, make its way backward between the cartilaginous floor of the cranial cavity and the overlying membrane, would force that membrane and the overlying brain upward in the cranial cavity, and might finally reach and break down the anterior wall of the cross-canal; the myodome of Amia thus being produced. And this is, in principle, the manner in which Sagemehl suggests that the teleostean myodome did arise, although in the details of his explanation he is wrong. The conditions in Lepidosteus might however represent a stage in the abortion of the conditions that preceded and led to the establishment of a myodome, those pre-existing conditions being represented in Polypterus; and this seems to me the proper interpretation of the facts, as will be later discussed.

But, whatever the origin of the myodome, there are in Lepidosteus, as there are in Amia and Scorpaena, two floors in the pituitary region of the cranial cavity, the dorsal one of these two floors being membranous to a different extent in each of these three fishes. The lateral walls of this part of the skull are also double in each of these three fishes, one or the other of the two walls being also membranous to a different extent in each of the fishes. In the space between the two floors lies the myodome, either actual or potential, while in the space between the two lateral walls lies the trigemino-facialis chamber. In Dactylopterus the conditions are modified and obscured by the fact that the dorsal floor arises from or near the anterior edge of the ventral floor and is inclined at a marked angle to it.

According to Starks ('05), the ventral floor of the myodome of fishes ,,is the true cranial base", the dorsal floor being simply a septum of secondary development; and the conditions that I have described in Amia would seem to favor this interpretation, the dorsal wall of the myodome chondrifying, in that fish, much later than the ventral wall. But this condition is not invariable in fishes, as Handrick's ('01) descriptions of Argyropelecus show. In that fish the myodome is said to begin beneath the membranous pituitary fossa, and from there to extend backward immediately beneath the cartilaginous floor of the cranium until it reaches and ends against the ,,anterior outer wall" of the bulla that encloses the sacculi and lagenae. The side walls and floor of this myodome are not particularly described, but they are evidently formed by portions of the hard, modified, connective-tissue membrane that is said to largely cover the roof and side walls of the cartilaginous cranium, and the trigemino-facialis chamber of either side would seem to be in direct communication with the myodome, as it is in Amia. The trigeminus ganglion is said to be an extracranial one, and to lie in the upper corner of the myodome. The ciliary ganglion is also said to lie in the myodome, while the sympathetic ganglion is said to lie on the outside of the side wall of the myodome, and the communis and lateralis ganglia of the V—VII complex, which evidently form the large so-called facialis ganglion, to lie entirely within the cartilaginous cranium. The cartilaginous wall of the cranium is said to be perforated, on either side, by three separate foramina, one of which transmits the nervus oculo-

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motorius, a second the root of the trigeminus accompanied by a single trunk from which arise the ophthalmicus and buccalis lateralis, and a third the truncus facialis accompanied by the palatinus facialis and nervus abducens. The root of the trigeminus evidently includes the radix profundi, but whether the ganglion of that nerve is intracranial or extracranial is not evident. It is however plainly evident that the cartilaginous floor of the cranium, immediately posterior to the pituitary fossa, is a proötic bridge, and that the side wall of the cranium on either side of the pituitary region represents the inner wall of the trigemino-facialis chamber, the outer wall of that chamber, and also the ventral wall of the myodome, being wholly of membrane.

It is thus evident that no positive conclusion can be formed as to which one of the two floors of this part of the skull of fishes is the primary, and which the secondary one, until it is first known what parts of the membranes here concerned belong to the primordial membranous capsule of the brain and what parts, if any, are developed independently, internal to that capsule, as protective coverings to the brain. The myodome, as it actually exists, is however certainly a space in the dura mater, as that membrane is defined by Sagemehl in his descriptions of Amia, and as both its inner and its outer walls may in large part chondrify or ossify as parts of the cranial wall, the myodome is an intramural and not an intracranial space. This I have already stated in an earlier work ('97b, p. 10), there speaking of the myodome as an intracranial space, but qualifying this by saying that it is ,,a space that certainly lies morphologically in, and not internal to, the membranous bounding walls of the primordial skull".

In the labyrinth region also, both the ventral and the lateral walls of the skull of fishes are partly double, the sacculi of the membranous ear lying between the two ventral walls and the semicircular canals between the lateral walls. The inner one of these two walls is largely membranous in teleosts and the bony ganoids, but it may partly ossify as the mesial processes of the exoccipitals. In elasmobranchs the wall may be largely of cartilage.

In most prepared skulls these two walls of the skull of fishes are not apparent, for their membranous portions can only be preserved in careful preparations, and are almost always entirely removed. In serial sections of embryos, also, particularly of early embryos, the membranous portions of these walls are apt not to be recognized as such. Yet the fact that they both exist must always be carefully borne in mind, for it, alone, permits of a proper comparison of this region, not only of fishes with one another but of fishes with higher vertebrates.

In the chondrocranium of embryos of Lacerta agilis the hypophysis lies, according to Gaupp ('00, p. 470), in a hypophysial fenestra bounded laterally by the diverging hind ends of the trabeculae, and posteriorly by a transverse bar of parachordal cartilage, called by Gaupp the crista sellaris. This crista sellaris unites the anterior ends of the parachordal plates, and separates the interparachordal fontanelle from the intertrabecular fontanelle, or hypophysial fenestra; thus having approximately, if not exactly, the position of the posterior clinoid bridge of Parker's descriptions of Lepidosteus. The carotis cerebralis, on either side, traverses, in early stages, the postero-lateral corner of the hypophysial fenestra, but in later stages it becomes entirely enclosed in cartilage, in an independent carotid foramen. Slightly anterior to the hypophysial fenestra lies the subiculum infundibuli, a V-shaped cartilaginous plate that rises from the hind edge of the interorbital septum. Anteriorly, this plate of cartilage forms part of the hind border of the optic fenestra, while posteriorly it gives support to the anterior border of the lobus infundibularis. The V-shaped plate of cartilage thus has strikingly the position of the basisphenoid cartilage of Scorpaena, and this latter cartilage has been shown

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to be the homologue of the transverse prepituitary bolster of Amia. The lateral edge of the plate, in Lacerta, is connected, on either side, by the pila metoptica, with the taenia parietalis media, this latter structure being a horizontal bar of cartilage that forms part of the side wall of the cranial cavity. The pila metoptica forms part of the anterior boundary of the fenestra metoptica, which transmits the oculomotorius and trochlearis nerves; those nerves thus undoubtedly running forward lateral to the pila metoptica, into the orbit. The cartilaginous pila metoptica of Lacerta thus corresponds, in its relations to these two nerves, to the basisphenoid leg of the alisphenoid bone of Lepidosteus, and to the fibrous tissue that, in Amia, represent the same leg and forms the mesial boundary of the tall orbital opening of the myodome. In Amia, the relations of the two nerves to the basisphenoid leg of the alisphenoid are not positively indicated, that leg being represented by an undefined portion of a continuous membrane. In teleosts, the oculomotorius issues, in all the fishes I have examined, posterior to the sutural connection of the alisphenoid with the basisphenoid, and hence lies posterior to the basisphenoid leg of the alisphenoid. The trochlearis has however in teleosts the same indefinite relations to the basisphenoid leg of the alisphenoid that it has in Amia, for it issues along the ventral or ventro-anterior edge of the alisphenoid, but anterior to the sutural connection of that bone with the basisphenoid. It must accordingly either lie anterior to the basisphenoid leg of the bone, or perforate an unossified portion of that leg; probably the latter.

In Lacerta the hypophysis lies posterior to the subiculum infundibuli, between it and the crista sellaris. Lateral to the crista sellaris, the nervus abducens pierces the basal parachordal plate, near its anterior edge, and, running forward in the plate, opens on its very edge; the foramen not being shown in ventral views. From there the nerve must run forward dorsal to the trabeculae, as it does in the Frog (Gaupp, '93a) and Necturus (Platt, '97), and in this part of its course it must lie between the trabeculae and an overlying membrane of some kind, doubtless a somewhat differentiated layer of the dura mater. This membrane would certainly uuderlie the hypophysis and so represent a membranous floor of this part of the cranial cavity, but to what extent it is developed or differentiated, I can not determine from the literature at my disposal. Assume it to be well developed. It would extend between the subiculum infundibuli and the crista sellaris, forming a membranous fossa around the hypophysis, and leaving a space between itself and the underlying cartilage of the skull. This space must be traversed by the vein that is said by Gaupp ('93b, p. 571) to run forward from the hypophysis into the orbit, and which is the evident homologue of the pituitary vein of my descriptions of Amia, Lepidosteus and Scorpaena. The space must, furthermore, be traversed by the carotid artery, which artery having either traversed the hypophysial fenestra or a closely adjoining and independent foramen, is said by Gaupp (l. c. p. 571) to run forward close to the brain; thus doubtless passing dorsal to the subiculum infundibuli. These conditions in Lacerta are thus all too similar to those in the fishes referred to not to warrant the following conclusions: (1) that the cartilaginous floor of the cranial cavity of Lacerta is probably the homologue of the ventral floor of the myodome of fishes; (2) that there is, in the pituitary region of this skull, and dorsal to the cartilaginous floor, a space of uncertain dimensions which corresponds to a part, if not to the whole, of the myodome of fishes; (3) that the hypophysial fenestra of Lacerta is consequently the strict homologue of the hypophysial fenestra of Lepidosteus; and (4) that the subiculum infundibuli is the homologue of the basisphenoid cartilage of Scorpaena, and hence of the transverse prepituitary bolster of Amia.

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With the human skull I have already attempted, in an earlier work ('97b), to compare the condition found in Amia, and certain conclusions there arrived at can be repeated here with additional facts in their support.

In Man (Quain '92/'96), the Gasserian ganglion lies in the cavum Meckelii, that cavum being said to be a recess in the dura mater which occupies a depression on the upper surface of the petrous portion of the temporal bone. But this so-called recess must be a space in the dura mater and not a simple recess on its cerebral surface; for elsewhere in the same work the Gasserian ganglion is said to lie between the inner and outer layers of the dura, the inner one of these two layers being the primitive, single-layered dura, and the outer one being the endocranium, or internal periosteal membrane of the skull. The fusion of these two separate membranes of embryos is said to form the double-layered dura of the adult, the Gasserian ganglion being, in this process, enclosed between the two layers. The internal part of the cavum Meckelii is said to come into close relations with the posterior extremity of the cavernous sinus, that sinus also being a space between the two layers of the dura of the adult, and the sinuses of opposite sides being in communication by means of the intercavernous sinuses. Between the cavernous sinuses of opposite sides, in a median depression on the dorsal surface of the dura, lies the pituitary body. The cavernous sinuses each receive the ophthalmic vein anteriorly, these veins communicating with each other across the middle line by means of the intercavernous sinuses, and discharging their blood posteriorly into the petrosal sinuses. The intercommunicating veins are accordingly the homologues of the pituitary veins of my descriptions of fishes, and the cavernous sinuses, intercavernous sinuses, and Cava Meckelii are together the apparently strict homologues of the myodome of Amia; that myodome consisting, as I have already explained, of a ventral portion which is the homologue of the myodome of teleosts, and an upper lateral chamber, on either side, which is the homologue of the trigemino-facialis chamber of teleosts.

The outer wall of each cavernous sinus is traversed by the oculomotorius, trochlearis and abducens nerves, by the ophthalmic and superior maxillary branches of the trigeminus, and by the internal carotid artery. Having traversed the wall of the sinus, the oculomotorius, trochlearis, abducens and ophthalmicus trigemini all issue into the hind part of the orbit through the sphenoidal fissure, that fissure lying between the great and small wings of the sphenoid bones, the former of which is said to be formed by the alisphenoid bone and the latter by the orbitosphenoid. The fissure is also traversed by the ophthalmic vein as it passes from the orbit into the cavernous sinus. The sphenoidal fissure thus corresponds in every detail, excepting in that it transmits the ophthalmicus trigemini, to the orbital opening of the myodome of Amia. But the fissure lies, in man, between the alisphenoid and orbitosphenoid bones, instead of between the parasphenoid and basisphenoid legs of the alisphenoid. This however seems unimportant, for, as I have also pointed out ('97b), the so-called basisphenoid of Amia is probably simply a part of the orbitosphenoid, ossifying from a separate and independent center; the orbitosphenoid of Amia and Man invading a region that is ossified as part of the alisphenoid in teleosts. Regarding the ophthalmicus trigemini, which traverses the sphenoidal fissure in man, that nerve is the homologue of the ophthalmicus profundus of fishes, a nerve not found in Amia or teleosts, but as it arises from the profundus ganglion it would probably issue from the skull with the ciliaris profundi, which latter nerve traverses the orbital opening of the myodome.

The foramen rotundum and the foramen ovale both perforate, in man, the great wing of the sphenoid, and transmit respectively the superior and inferior maxillary branches of the trigeminus,

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the latter nerve being accompanied by certain meningeal vessels. The foramen rotundum is said by Thane (Quain, vol. II, pt. I) to have been separated off from the sphenoidal fissure by the growth of bone around the nerve, the foramen ovale being similarly cut off from the foramen lacerum. The foramen lacerum is an aperture between the apex of the petrous portion of the temporal bone and the body and great wing of the sphenoid, and would seem to correspond to the trigeminus foramen of Amia, though it may include some part also of the trigeminus opening of the trigemino-facialis chamber of teleosts. Comparison with fishes would thus indicate that the foramen ovale and the foramen rotundum must both be parts of the foramen lacerum, instead of being respectively parts of that foramen and of the sphenoidal fissure. The foramen spinosum of man, which perforates the great wing of the sphenoid and transmits the large middle meningeal vessels, must have its homologue in one or both of those perforations of the alisphenoid that, in teleosts, transmits branches of the external carotid artery and orbito-nasal vein.

The foramina related to the nervus facialis are not so readily homologized. The facialis foramen and the facialis opening of the trigemino-facialis chamber of teleosts must together represent parts of the Aqueduct of Fallopius of man, but apparently not the whole of it, for the lower part of the aqueduct is said by Thane to be included between the outer surface of the periotic and the tympanic plate, and until this latter plate is identified in fishes, the homologue of the stylo-mastoid foramen can not be determined. The hiatus Fallopii, which leads from the Aqueduct of Fallopius to the depression on the petrous that lodges the Gasserian ganglion, is evidently that part of the trigemino-facialis chamber that lies between the facialis and trigeminus foramina; the Vidian canal being what I have described as the palatine canal in Amia, a canal that lies between the parasphenoid (pterygoid of man, Gaupp, '05) and the cartilaginous basis cranii of that fish. In teleosts this canal is absent because of the suppression of the cartilage in this region. The internal jugular vein does not, in man, issue with the nervus facialis, issuing instead through the jugular foramen which transmits also the glossopharyngeus, vagus and spinal accessory nerves. The internal carotid canal, which, in man, traverses the petrous part of the temporal bone, seems not to be the exact homologue of the internal carotid foramen of fishes, this latter foramen lying between the proötic and parasphenoid instead of traversing the former bone. But as the artery then traverses the cavernous sinus in man and the myodome in fishes the canal of the one must be in large part the homologue of the foramen of the other.

Regarding the bones of the region, the posterior clinoid wall is represented in the mesial processes of the proötics of Amia, the anterior clinoid wall being represented either by the basisphenoid of teleosts, by the prepituitary part of the mesial processes of the proötics, or by those bones fused to form a single element. The spicula of bone that, in man, sometimes unite the anterior and posterior clinoid processes are then those parts of the mesial processes of the proötics of teleosts that lie lateral to the pituitary opening. The parasphenoid leg of the alisphenoid of teleosts is the great wing of the sphenoid bone of man, the basisphenoid leg of the bone of fishes apparently being suppressed by an invading growth of the orbitosphenoid which forms the small wing of the sphenoid of man. The basisphenoid of fishes, if it persists as a separate bone, is the presphenoid of man, but, as just above stated, that bone of man would seem to at least include the prepituitary parts of the mesial processes of the proötics of teleosts. The basisphenoid of man, if it is found in fishes, would seem to be represented in a part of the proötic, but it is perhaps possible that the median ossification in the dorsal surface of the proötic bridge of my one specimen of Gadus morrhua, described below, may be the homologue of that bone.

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Swinnerton, it should here be stated, has arrived, in a study of the development of Gasterosteus, at conclusions quite different from those just above proposed, in so far as regards the position of the myodome relative to the cranial walls in fishes, and the homologies of the hypophysial fenestra. According to him ('02, p. 527) those parts of the parachordals that, in embryos of Gasterosteus, bound laterally the interparachordal fossa, become depressed in late embryonic stages, so as to appear as mere downward processes of the proötics. These processes are said to be capped with cartilage, to each be continued posteriorly by a ridge on the ventral surface of the posterior portion of the related proötic, and, posterior to that bone, by a similar ridge on the ventral surface of the basioccipital. The two processes are said to enclose between themselves the anterior portion of the myodome, which portion is said to accordingly be an actual derivative of the cranial cavity; while the two ridges that form posterior continuations of the processes enclose a posterior portion of the myodome, which is said to be extracranial in position. These conclusions lead Swinnerton to the further conclusion (l. c., p. 528) that the so-called hypophysial fenestra of the skull of adult teleosts is related to the parachordals, alone, and hence can not be the homologue of the pituitary (hypophysial) fossa of embryos, which fossa is related to the hind ends of the trabeculae. The so-called hypophysial fenestra of the adult fish can not then be the homologue of the hypophysial (pituitary) fenestra of higher animals, and Swinnerton accordingly proposes for this fenestra of the adult teleost the name interparachordal fossa. The position, in the adult, of the pituitary fossa of embryos, Swinnerton does not give; the inference being that it has wholly disappeared in that suppression of the hind ends of the trabeculae that is said to take place in late embryonic stages.[1])

Those teleosts in which the myodome is said to be absent can now be considered. Vrolik ('73) says that it is absent in all the Gadidae, and also in Silurus, Lophius and the eel; Gill says ('91b, p. 363) that it is absent in the Cyclopteroidea, and also ('82) in Echeneis; Swinnerton ('02, p. 576) says that it is absent in Fistularia and Syngnathus; and Jordan and Evermann ('98) say that the basis cranii is simple in the Hemibranchii and Lophobranchii, which include Fistularia and Syngnathus; Cope (quoted by Gill, '88, p. 576) says that it is absent in all the fishes of the group Scyphobranchii, which group (Cope, '71) includes the Uranoscopidae, Gobiidae, Blenniidae, Gobiesocidae and Cottidae; Gierse ('04) says that it is wholly wanting in Cyclothone; and Starks ('05 a) says that it is absent in Caularchus, Callionymus and the Batrachididae, confirming also its absence in the Gobiesocidae. McMurrich ('84) says that it is rudimentary in Ameiurus; and Sagemehl ('91, p. 574) says that it has undergone retrogression in Cobitis, Misgurnus, Nemachilus and Acanthophthalmus. Boulenger ('04) says that the basis cranii is simple in the Mormyridae, Osteoglossidae, Pantodontidae, Phractolaemidae, Stomiatidae, Gonorhynchidae, Cromeriidae, Galaxiidae, Gobiiformes, Discocephali, Comephoriidae, Rhamphocottidae, and in all the five families of his suborder Pediculati. He further says that the basis cranii is double in the symmetrical forms of his division I of the suborder Acanthopterygii; which would seem to imply that it is simple in the asymmetrical forms of the same division, that is the Pleuronectidae. And the expression „basis cranii simple", while it is, strictly speaking, descriptive of a condition of the bony skull alone, is currently considered as equivalent to saying

[1]) Gaupp, in Bd. 3 of Hertwig's Handbuch der vergleichenden und experimentellen Entwickelungslehre der Wirbeltiere, a work that I have only seen since this manuscript was sent to press, describes practically similar conditions in Salmo, and arrives at practically similar conclusions regarding the homologies of the parts. This would seem to establish the fact that the basi-occipital portion of the myodome is extracranial in origin. Regarding the prootic portion of the myodome, Gaupp's descriptions would seem to confirm my contention that it is an intramural space and not an intracranial one.

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that there is no myodome. The list of fishes said, by one author or another, to be without a myodome is thus large, and I have attempted to control it as far as my material and the literature at my disposal will permit.

In Gadus aeglifinus, Brooks ('84) says that the proötic „unites below with its fellow of the opposite side, and below this with the parasphenoid, the three bones bounding a deep pit, which is open anteriorly, and gives origin to the recti muscles of the orbit". This fish would thus seem to possess a myodome, and as another one of the Gadidae, Gadus merlangus, is easily obtained here, I have examined it in this connection. In this fish there is, as in G. aeglifinus, a deep pit opening into the orbit and giving origin to certain of the recti muscles. The side walls of this pit are formed by the ventral portions of the proötics, those portions of those bones being capped with cartilage and not meeting in the middle line, a hypophysial fenestra, closed ventrally by the underlying parasphenoid, thus being left between them. The dorso-posterior wall, or roof of the pit is thick, and is formed by the proötic bridge, that bridge being formed by the mesial processes of the proötics united by a thick median interspace of cartilage. The cerebral surface of this roof slopes postero-ventrally and forms a convex and triangular-shaped surface between the anterior ends of the large saccular grooves. The wide anterior edge of the roof is bevelled, the bevelled surface sloping antero-ventrally. The transverse edge that lies between this sloping, bevelled surface and the posterior portion of the roof of the pit is continued dorsally, on either side, to form the anterior boundary of the labyrinth recess. The bevelled surface gives attachment to the ventro-posterior edge of a thick tough membrane that fills the large orbital opening of the brain case, a large pocket in this membrane, immediately anterior to the proötic bridge, lodging the pituitary body. In the anterior edge of the proötic there is, as in G. aeglifinus, a deep incisure for the exit of the trigemino-facialis nerves, and from this incisure a groove leads ventro-mesially into the anterior end of the myodomic pit. There is no closed foramen whatever in this part of the proötic bone, all of the nerves that pierce the bone in Scorpaena here passing across its anterior edge. There is also no internal carotid foramen between the proötic and parasphenoid, the internal carotid here passing inward across the anterior edge of the expanded, postorbital portion of the parasphenoid; that edge of the parasphenoid lying slightly anterior to the anterior edge of the ventral portion of the proötic. The anterior end of the large saccular groove is separated from the bottom of the trigemino-facialis incisure by only a thin layer of bone. There is no basisphenoid, but there is, as in Cottus, a considerable basisphenoid thickening of the membrane that closes the orbital opening of the brain case. Posterior to this thickened portion of that membrane and partly enclosed in it, in the region of the membranous pituitary fossa, is the transverse commissure of the pituitary veins. There is thus here a normal myodome, but it has been shortened both anteriorly and posteriorly. Posteriorly this shortening is due to a proötic constriction, while anteriorly it is due to the absence of the usual enclosing bones; for it is evident that the anterior portions of the bodies of the proötics of Scorpaena, and the entire ascending processes of the parasphenoid of that fish, are absent in Gadus.

In a prepared skull that I have of Gadus morrhua, the conditions are all similar to those just described for Gadus merlangus, excepting that there is a median ossicle on the cerebral surface of the cartilage of the proötic bridge, not found in G. merlangus. This ossicle is transverse in position and extends from proötic to proötic along the transverse edge that is continuous, on either side, with the anterior wall of the corresponding labyrinth recess. It is a stout ossicle, of perichondrial origin, and has never been described in any fish so far as I can find.

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One further condition of the Gadoid skull needs to be mentioned. The hypophysial fenestra is continued posteriorly, along the ventral surface of the interproötic cartilage, by a relatively deep groove which is prolonged posteriorly by two short recesses in the anterior end of the basioccipital, the two recesses being separated by a thin, vertical, median wall of bone. Laterally, on either side, this groove is in wide communication with a large and deep recess in the proötic. This recess extends antero-dorsally in the bone, lying immediately mesial to the saccular groove and tapering toward its dorso-anterior end, which end lies slightly postero-mesial to the trigemino-facialis incisure. The bone that forms the outer wall of the recess is thin, and seems to be of purely perichondrial origin. In the specimens of Gadus merlangus that were particularly examined in this connection, and which were all fresh specimens that had been slightly boiled, this recess was filled with loose and apparently fatty tissue: but in the skull that I have of Gadus morrhua, which had not been boiled, the recess lodged the spreading lateral portions of a membrane that covered the ventral surfaces of the proötics and the interproötic cartilage, lying between those structures and the underlying parasphenoid. The recess is certainly the homologue of the proötic vacuity found in the proötic of the 45 mm Scorpaena, as stated when describing that fish.

In Uranoscopus scaber the interorbital wall is thick, and is deeply and widely excavated, on its dorso-anterior edge, by the large rostral depression. The central portion of the floor of this depression is formed by the subcircular mesethmoid, the ventral surface of which bone rests directly upon the underlying parasphenoid and, perhaps, also on the vomer; but the existence of this latter contact was not established. The anterior portions of the side walls of the depression are formed by the deeply excavated ectethmoids, the posterior halves of the same walls, and the hind wall, being formed by a specially developed flange of the frontal of either side. No alisphenoid is evident as a separate bone, but it would seem to be represented in, or at least to be replaced by, what appears as an anterior process of the sphenotic. With a ventral process of this alisphenoid part of the sphenotic, and also with an adjoining portion of the anterior edge of the proötic, the ascending process of the parasphenoid is in contact. Posterior to this ventral process, the truncus maxillo-mandibularis trigemini, undoubtedly accompanied by the buccalis lateralis, issues through a perforation of the side wall of a well-developed trigemino-facialis chamber. The ramus ophthalmicus superficialis issues from the same chamber through a foramen that lies between the suturating edges of the parasphenoid and the ventral process of the alisphenoid portion of the sphenotic. This ventral process is, accordingly, a well developed parasphenoid leg of the alisphenoid process of the sphenotic.

Between the parasphenoid leg of the alisphenoid process and the body of that process, dorsally, the parasphenoid posteriorly and ventrally, and the rostral flange of the frontal and the cartilage covering the ventral part of that flange, anteriorly, there is a large subcircular opening. This opening gives exit to the olfactorius, opticus, oculomotorius and trochlearis nerves, and gives entrance to certain of the muscles of the eye, how many or which of them was not determined. The opening is accordingly, in function, an olfactorio-opticus fenestra and an orbital opening of the myodome combined. On the internal surface of the proötic, at a certain distance posterior to the hind edge of this opening, there is a low transverse and nearly vertical flange which suturates in the middle line with its fellow of the opposite side. That part of the cranial cavity of the prepared skull that lies anterior to this transverse vertical flange forms a recess in the cranial floor, but belongs properly to the orbit and not to the cranial cavity. The canal for the internal carotid passes inward between the proötic and the hind edge of the ascending process of the parasphenoid, and opens on the floor

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of the recess. The membranes closing this recess toward the cranial cavity were not investigated, but the recess is certainly a myodomic recess, similar to, and as well developed as, that recess in Gadus. Uranoscopus thus has a myodome of the kind found in Gadus. It furthermore has a proötic vacuity larger even than the vacuity in Gadus, and which, as in Gadus, extends posteriorly into the anterior end of the basioccipital.

In Blennius gattorugine the posterior portion of the ventral edge of the proötic is thick and grooved, the mesial edge of this groove representing the mesial process of the bone, and the other edge representing the ventral portion of the body of the bone. Anterior to the groove the actual ventral edge of the bone is formed by the mesial edge of its mesial process. This edge of the bone, as also both edges of the posterior, grooved portion, are widely separated from the corresponding portions of the bone of the opposite side, the space between the mesial processes being bridged by a membrane which underlies the hypoaria and pituitary body. Anteriorly, this membrane is attached to the hind edge of the basisphenoid, that bone being, in this fish, unusually wide in an antero-posterior direction. Beneath this membrane and the basisphenoid, between them and the underlying parasphenoid, there is a long and relatively large space which lodges certain of the eye muscles and is accordingly a well developed and perfectly normal myodome. The pituitary opening and the hypophysial fenestra are simply unusually large, and the pituitary opening lies much further posteriorly than in Scomber and Scorpaena.

In Lophius piscatorius there is, in the prepared skull, no myodome, as Vrolik has stated. In the fresh skull, however, there is a pocket between the bony floor of the skull and an overlying membrane, and in this pocket certain of the eye-muscles have their origin. The pocket is accordingly a myodome. The overlying membrane is thick and strong, and forms the hind wall of the orbit as well as the roof of the myodome. Laterally, on either side, it extends upward and forms, as in Amia, the mesial wall of the trigemino-facialis chamber. The membrane is thus similar to that in Amia, but it is even more extensive than in that fish, for it entirely replaces, in Lophius, the bony mesial processes of the proötics.

In both Syngnathus and Hippocampus, which I have examined in serial sections, there is a large myodome, roofed, in Syngnathus, entirely by membrane, while in Hippocampus the recti externi extend backward beyond the other muscles and pass beneath the cranial floor, between it and the parasphenoid.

In Gymnarchus, of the Mormyridae, a dilapidated skull of which I have, there is apparently no myodome, the conditions here being similar to those found in Ameiurus, which will be later described; but in two other members of the family, Mormyrops deliciosus and Petrocephalus bane, Ridewood ('04b) says there is a myodome.

In Osteoglossum Leichardti and Heterotis niloticus, of the Osteoglossidae, Ridewood ('05a) says there is a myodome; as there also is, according to the same author, in Pantodon Buchholzi and Phractolaemus Ansorgii.

In Galaxias of the Galaxiidae, Swinnerton ('03) says there is a myodome.

In Pleuronectes platessa, Cole & Johnston ('01, p. 13) say there is a myodome.

In Echeneis, of Boulanger's Discocephali, I find, ventro-antero-mesial to the trigemino-facialis chamber, a large aperture, which, in the prepared skull, leads directly into the cranial cavity, along its floor. The aperture is bounded dorso-mesially by a bone that must be the basisphenoid, although the sutures in this region can not be distinguished in my one specimen; and from the hind edge of this bone a strong membrane extends, in the recent state, backward and downward and is attached

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to the floor of the cranial cavity. Through the aperture and into the space roofed by this membrane, certain of the eye muscles extend, the space thus being a perfectly normal myodome.

Of the Cottidae, said by Cope to be without a myodome, I have described it in the present work, well developed, in Cottus octodecimospinosus; and Gill ('91b) gives as one of the characteristics of his family Cottoidea, „Myodome more or less developed".

Of the Rhamphocottidae, I have no specimens, but the Cottidae having a myodome, certainly well developed in some species, it must surely be also found in the closely related Rhamphocottidae.

In Gonorhynchus greyi, Ridewood ('05b) says there is a myodome.

Of the entire list of fishes said to be without a myodome, all of the individual species mentioned, excepting only Caularchus, Callionymus, Fistularia, Cyclothone, Silurus and the eel, are thus shown to have that canal; while of the several families in which the canal is said to be absent, some one or more members of each family, or of a closely related subfamily, are also shown to have it, excepting only the Cyclopteroidea, Cromeriidae, Gobiidae, Gobiesocidae, Stomiatidae, Batrachididae and Comephoridae. Of the Cyclopteroidea, Cromeriidae, Gobiesocidae, Stomiatidae, Batrachididae and Comephoridae, I have no specimens; neither have I of Caularchus, Callionymus, Fistularia or Cyclothone. These fishes must accordingly be left out of consideration. Of Fistularia, it may, however, be stated that Swinnerton shows a myodome in Gasterosteus, and that I find a well-developed myodome in Centriscus, both of which fishes belong with Fistularia to the Hemibranchii. Of the Siluridae, Muraenidae, and Gobiidae, I have specimens and they can now be considered.

In Conger conger of the Muraenidae, there is, at the hind end of the orbit, a small median transverse shelf of bone which projects forward slightly above the parasphenoid. The optic nerves leave the cranial cavity along the dorsal surface of this shelf, and beneath it, between it and the parasphenoid, the recti muscles have their origins. The bones of the skull are here all so firmly ankylosed in my specimens that I can not with certainty identify them, but the shelf of bone must certainly be either a basisphenoid, a proötic bridge similar to the bridge of Gadus, or a transverse ridge of the parasphenoid, as in Dactylopterus. And in either case the little space between the bone and the body of the parasphenoid would be a perfectly normal but very much reduced myodome. In a series of sections that I have of a young Conger, the recti muscles all seem to arise from a delicate median membrane, which lies partly beneath and partly anterior to the shelf of bone, each muscle arising directly opposite its fellow of the opposite side; no one of the muscles, apparently, having its origin either on the shelf or on the parasphenoid bone.

In a single small specimen of Gobius cruentatus that I have been able to obtain, the arrangement seems to be exactly similar to that in Dactylopterus. The proötic has a narrow orbital surface which lies at a slight angle to that part of the bone that lies immediately posterior to it and that forms the uniformly thin floor of this part of the cranial cavity. The narrow orbital surfaces of the bones of opposite sides are separated by a wide median interval, and the ventral part of this interval is filled by a transverse ridge on the dorsal surface of the parasphenoid. This ridge on the parasphenoid has the same antero-dorsal inclination as the orbital surfaces of the proötics, and forms the hind wall of a small pocket which lies at the hind end of the orbits, and recalls both the myodomic pocket of Gadus, and the myodome of Dactylopterus.

Of Silurus I can find no description that is of value in this connection. But McMurrich's ('84) descriptions of Ameiurus catus (nebulosus) are of value, and, as I have a few specimens of this fish, it can be described. Short reference must, however, first be made to Sagemehl's descriptions of

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the Cyprinidae. According to that author ('91, p. 574), a well developed myodome is found in most of these fishes. In Cobitis, Misgurnus, Nemachilus and Acanthophthalmus, all of which have small eyes, the myodome is said to have undergone retrogression. The weak muscles of the eye are said to all arise in the postero-ventral corner of the orbit, none of them entering the cranial cavity. The anterior edge of the proötic is said to be formed of two lamellae one lying above the other, the dorsal one ending with a free anterior edge, while the ventral one forms the floor of the cranial cavity. The slit-like space between the two lamellae, although it lies considerably posterior to the hind end of the orbit, is said to unquestionably represent a myodome that has undergone reduction. Reference to the figures of Cobitis fossilis (pl. 29, fig. 12) shows that the dorsal lamella must be a rudimentary mesial process of the proötic, and as such Sagemehl doubtless considered it, although he does not definitely describe it as such. Anterior to this process, there is said (l. c., p. 549) to be a wide rhomboidal hypophysial fenestra. The nervus abducens, in those Cyprinidae that are said to have no myodome, and of which Cobitis is one, is said not to perforate the mesial process of the proötic, but to apparently issue by the large optic fenestra. The condition of the myodome is thus here closely similar to that in Lepidosteus; that posterior portion of the canal that I have referred to as the saccular space, existing in a reduced condition, well within the brain case, widely separated from the orbit, and in no direct relation whatever to any of the eye-muscles. This condition is thus the reverse of that found in Dactylopterus, Gobius and Gadus, in which fishes this part of the myodome has been crowded out of the cranial cavity into the orbit.

Ameiurus can now be considered, and of this fish I have one skull, prepared some years ago and partly disarticulated, and a few small alcoholic specimens. Of Ameiurus, Mc Murrich says: ,,Below the proötics, where they meet in the middle line below, and between them and the anterior portion of the basioccipital above, and the parasphenoid below, is a small cavity. This is the almost aborted rudiment of the canal for the orbital muscles, which is largely developed in many fishes, but absent or rudimentary in Silurus, Ameiurus, Gadus, Lophius etc.“

This description of the conditions in Ameiurus is not very satisfactory, and it is not explained, either here or elsewhere in the descriptions, that this so-called rudimentary myodome is widely separated from the orbit and out of all relation to the eye-muscles. Yet such is the case. In the anterior three-fifths, approximately, of its length, the ventral edge of the proötic does not meet its fellow of the opposite side, a wide hypophysial fenestra, closed ventrally by the parasphenoid, being left between the two bones. Posterior to this fenestra, the ventral edges of the proötics meet in the middle line, and the two bones there form, on the floor of the cranial cavity, a prominent transverse bolster which has closely the position of the cross-canal of Lepidosteus; and it is certainly in this bolster that McMurrich found the small cavity that he considered as a rudimentary myodome. In two of my small specimens there was no indication whatever of such a cavity; the bolster there being completely filled with cartilage, but having, on its anterior surface, a slight median depression which doubtless lodged the saccus vasculosus. In one other specimen, there was a median cavity extending under, rather than into the bolster, while in a fourth specimen there was a smaller but similar cavity on one side only of the median line. The pituitary body lies immediately anterior to the bolster, directly above the hypophysial fenestra, and a vein that apparently drains the pituitary region begins here and runs directly forward along the floor of the cranial cavity, soon separating into two parts, one on either side. The venous cross-comissure of Lepidosteus thus here seems replaced by a median vein, this being a variation in detail but not in principle. The eye-muscles all have their

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origins ventral to and between the optic and trigemino-facialis foramina, on the outer surface of that median process of the parasphenoid that McMurrich considers as a basisphenoid completely ankylosed with the parasphenoid, but which Sagemehl ('91, p. 575) considers, in Silurus, as a simple process of the parasphenoid; none of the muscles entering the cranial cavity. It may furthermore here be stated that these muscles are said by Workman ('00) to be innervated as they are in Amia, and hence as I have shown them to also be in Lepidosteus (present work), and that Ameiurus is the only teleost in which this manner of innervation has, as yet, been described.

Ameiurus thus presents conditions similar to but even more extreme than those in Lepidosteus, the cross-canal of the latter fish here being a solid bolster, due, quite undoubtedly, to the invading growth of the surrounding cartilage. Yet, the condition in Ameiurus is said (McMurrich) to represent an aborted condition of the teleostean myodome, while that in Lepidosteus is said (Sagemehl) to represent a condition from which that myodome was developed! Wishing to determine which of these two directly opposed assumptions is the correct one, I have consulted the geological record, and, while that record certainly does not give a definite solution, it has suggested what seems to me such a solution; for it has led me to ascribe a totally different motive to the origin of the myodome than that proposed by Sagemehl, which, as is well known, is the simple seeking of a better point of origin by one or more of the muscles of the eyeball.

According to Zittel ('87—'90), whom I have selected because of the convenient tables given, representatives of the families Siluridae and Ginglymodi, in the latter of which the living Lepidostei are placed, are found in the Eocene formations, and no earlier; and in all the living representatives of these two families that have been examined in this connection, there is no functional myodome. Representatives of the family Halecomorphi, in which Amia, with a well developed myodome, is placed, are found considerably earlier, in the Jurassic deposits. Certain other families of the Lepidosteidae occur earlier than any of the Amiadae, the Stylodontidae being found in the Dyas (Permian) deposits; but, as two Jurassic representatives of this latter family, Lepidotus and Dapedius, are said by Woodward ('93) to have a ,,basicranial canal" — that is a myodome — it is evident that Lepidosteus can not descend from them, if its myodome represents a primary condition.

The earliest teleosts are said by Zittel to be the Hoplopleuridae and Clupeidae, both of which are said to be found in the Triassic, considerably earlier than the families Siluridae and Ginglymodi, and as early, even, as any representatives of the order Lepidosteidae excepting only the Stylodontidae. Of these two families of teleosts the Hoplopleuridae are extinct, while the Clupeidae are well represented by living species, several of which, Clupea, Elops, Albula and Megalops, are known to have a well-developed myodome. In Clupea harengus, which I have examined for this purpose, the proötic bridge is thick and has a bevelled anterior edge which slopes antero-ventrally, the whole bridge much resembling that of Gadus excepting that it lies in a horizontal instead of a strongly inclined position.

Several other families of teleosts existed at the beginning of the Cretaceous period, and hence earlier than the Ginglymodi and Siluridae. These families are the Saurocephalidae (extinct), Stratodontidae (extinct), Salmonidae and Scopelidae, all placed by Zittel in his order Physostomi; the Labridae and Chromidae of his order Pharyngognathi; and the Berycidae, Sparidae, Xiphiidae, Carangidae, Cataphracti, Gobiidae and Aulostomi of his order Acanthopteri. In living representatives of these several families, Parker shows a myodome in Salmo salar, of the Salmonidae; in Dactylopterus and Peristedion, of the living Cataphracti, I have described it in the present work: in Gobius of the Gobiidae, a myodome similar to that in Dactylopterus is found, as also already

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described in the present work: in Scopelus of the Scopelidae, Supino ('01/02) shows a large myodome, and I find one in Saurus griseus of the same family: in Crenilabrus pavo, of the Labridae, and in Trachurus trachurus, of the Carangidae, I find a myodome well and normally developed: in Hoplostethus, of the Berycidae, Supino ('04) shows a normal myodome, and Starks ('04, p. 602) gives, as one of the characteristics of the Berycoidea, „Myodome large in front, closed abruptly behind, or open to the exterior posteriorly only through a pore“: in Fistularia, of the Aulostomi, it is said by Swinnerton not to be developed, but, as already stated, this may be incorrect: in a Mediterranean Sargus, and in Chrysophrys aurata, both of the Sparidae, I find a well developed myodome; as I also do in a Mediterranean Xiphias of the Xiphiidae.

It is thus seen that a myodome is found in certain living representatives of nearly all of the earliest known families of teleosts; and that certain of these families, certain of the living representatives of which possess a myodome, are found in earlier geological periods than any of the families of the Teleostei the living representatives of which are known not to possess it. Certain of the Stylodontidae, the earliest known representatives of the Lepidosteidae, are also said to possess a myodome. The palaeontological record, as given by Zittel, thus certainly indicates that the conditions from which the myodome is developed are not to be looked for in either Lepidosteus or Silurus, but in fishes belonging to earlier deposits than those in which those teleosts and ganoids that possess a myodome are found; and the only fishes so found, living representatives of which are known, are, in Zittel's terminology, the Selachii, Dipnoi, Chondrostei, and Crossopterygii.

In the Selachii, Gegenbaur ('72) shows a thick interorbital wall, and a pituitary fossa (Sattelgrube) which lies between, or but little posterior to, the posterior portions of the orbits. The canalis transversus, which transmits the pituitary vein, lies in or beneath the bottom of this fossa (Hexanchus, Mustelus, Galeus), or but slightly posterior to it (Heptanchus, Scymnus). In Ceratodus (Bing & Burckhardt, '05, P. 523) a similar interorbital wall and pituitary fossa are found; and the same is true of Acipenser (Parker, '82a). In Polypterus there is a thick interorbital wall, and Pollard ('92) shows, in the cranial cavity of this fish, a cartilaginous shelf which, as already stated, closely resembles the proötic bridge of Amia. Bing & Burckhardt ('05, p. 571) show this bridge much more inclined than Pollard shows it, and they show, as Pollard does, what is probably the saccus vasculosus, projecting backward beneath the bridge. No mention is made, in either Ceratodus, Acipenser or Polypterus, of a canalis transversus or pituitary vein, but this vein must certainly exist in each of these fishes, and must lead into the orbit of either side, as it does in the Selachii and Teleostei. Imagine the orbits, in either one of these several fishes, to be enlarged and deepened. This would necessarily shorten the canal traversed by the pituitary vein, and would, if sufficiently continued, bring the pituitary fossa into the hind ends of the orbits, much as it is actually found in Dactylopterus and Gadus. Certain of the eye-muscles would then almost necessarily have their points of origin transferred to this pituitary pocket, and a myodome would be established.

This being accepted as the manner of origin of the myodome, do Lepidosteus and the Siluridae present a primary or a secondary condition? It is evident that they might be considered as presenting either one or the other, but it seems to me that both of them present a primary condition, for, as already stated, if the anterior edge of the proötic bridge of Polypterus were to be bent downward until it touched and coalesced, everywhere excepting in the middle line, with the underlying floor of the cranial cavity, it would give rise to a condition closely resembling that found in Lepidosteus: and if the cross-canal, thus produced, were to be invaded by the surrounding cartilage until only

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a slight pit was left on its anterior surface, it would give rise to the conditions found in Ameiurus. Under this assumption the condition of the myodomic region, as it exists, both in Lepidosteus and Ameiurus, would be primary and not derived secondarily from a pre-existing myodome. But this presupposes, if Ameiurus can be considered as typical of the Siluridae, either that the Weberian apparatus has been developed independently in the Siluridae and the other families of the Ostariophysi, or that the myodome has been developed, in those families of the Ostariophysi in which it is found, wholly independently of its development in other teleosts. For that a myodome could have been developed from the condition found in Ameiurus seems most improbable, Ameiurus quite certainly representing the end of a line in which the saccular portion of the myodomic region is aborting, whether it be primarily or secondarily.

Still another suggestion regarding the myodome is that its basioccipital extension may have been developed in relation to a vertebral depression on the anterior surface of that bone. In Trigla lyra, I have shown that, that depression in the anterior end of the basioccipital that lodges the posterior portion of the myodome is lined with a layer of dense bone that is similar to the bone that lines the vertebral depression in the hind end of the same bone, and that these two linings of dense bone are connected by a small median line of similar bone. This suggests, as I have already stated, that the myodomic depression on the anterior end of the basioccipital of this fish is, like the depression on its hind end, a vertebral depression, and if this be true of this fish, it must also be true of all other fishes in which the myodome has a basioccipital extension. In Gadus and Saurus the myodome has no basioccipital extension, but in both these fishes there is, nevertheless, a depression on the anterior end of the basioccipital, and this depression — although lodging no part of the myodome — would certainly seem to be the homologue of the myodomic depression of other fishes. This depression, in Gadus and Saurus, is continuous with a large vacuity in the hind edge of the prootic, and if the one is a vertebral depression on the anterior end of the basioccipital the suggestion is evident that the other might be a depression in some way related to a similar depression on the hind end of the proötic. The proötic vacuity both of Gadus and of Saurus is in communication, by the intermediation of the hypophysial fenestra, with the myodomic pocket on the anterior surface of the proötic. The supposition is thus evident that a myodomic pocket might have been first developed in relation to a vertebral depression on the anterior surface of the proötic region, and that this depression, pushing backward and gradually obliterating or absorbing a similar depression on the posterior surface of the same region, and then even occupying also a vertebral depression on the anterior end of the basioccipital, has given rise to all known forms of the myodome. But this necessarily attributes a vertebral origin to the basioccipital and proötic, for which, in the case of the proötic, there is no apparent warrant. Furthermore, according to Swinnerton's descriptions of the development of the basioccipital in Gasterosteus, even the depression in the anterior end of that bone can not be a vertebral one. For that author says ('02, p. 524) that, in that fish, a crest of membrane bone grows downward, in the middle line, from the ventral surface of the primary portion of the basioccipital, and that „within the substance of the fore part of this crest is a cavity which opens in front and receives the hinder end of the external rectus muscle; this is the homologue of the anterior conical excavation of the basioccipital of the Pike and many other teleosts“.

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Summary.

1. The mesethmoid processes of fishes are processes of the mesethmoid bone, or of the ethmoid cartilage, that give origin to the ethmo-maxillary ligament, and that support or give attachment to the hind end of the nasal of either side. In the Loricati they are prominent processes of the mesethmoid; in Trigla and Peristedion they are small processes of the same bone, wholly concealed beneath the nasals; while in Dactylopterus they are small processes of the ethmoid cartilage.

2. The dilatator, temporal and supratemporal fossae of fishes are grooves on the dorsal surface of the primary cranium, more or less completely roofed by dermal bones. Each of these grooves may have an anterior extension that lies upon the outer surface of the dermal bones of the roof of the skull, as in Scomber. In the mail-cheeked fishes, these anterior extensions are not found, but the areas occupied by them in Scomber are represented, on either side of the dorsal surface of the skull of the Loricati, by contiguous regions bounded by four more or less developed ridges that radiate approximately from the frontal spine. The ridge between the anterior extensions of the temporal and supratemporal fossae is in a measure continuous with the epiotic ridge on the posterior surface of the skull, and the posterior semicircular canal lies internal to this latter ridge. The ridge between the anterior extensions of the temporal and dilatator fossae is similarly continuous with the ridge that forms the boundary between the posterior and lateral surfaces of the skull, and the posterior leg of the external semicircular canal lies internal to a portion of this ridge. The ridge forming the anterior boundary of the anterior extension of the dilatator fossa is approximately continuous with the ridge that separates the hind wall of the orbit from the lateral surface of the brain case, and the summit of the anterior semicircular canal lies in a measure internal to it. The position of the frontal spine, from which these several ridges radiate, corresponds somewhat to that of the opening of the endolymphatic tube in selachians. The subtemporal fossa, on the lateral surface of the skull, lies between the external semicircular canal and the utriculus.

The temporal fossa may have an epiotic diverticulum, and it may also have, as in Amia, an anterior diverticulum. This latter diverticulum lies on the dorsal surface of the primary cranium, beneath the dermal bones of the roof of the skull, and in certain fishes (Elops, Albula) it becomes a large and important portion of the fossa. But this anterior diverticulum of the fossa is not to be confounded with the anterior extension just above referred to, the former lying ventral and the latter dorsal to the dermal bones.

The anterior extensions of the supratemporal grooves have coalesced in the Loricati to form the subquadrangular groove on the vertex.

3. The premaxillary of the mail-cheeked fishes has, on its anterior end, two processes, one of which is the ascending process properly so-called, and the other an articular process; but the two processes together are usually referred to as the ascending process of the bone.

The articular process is probably the earlier acquisition of the two, is apparently found in all osseous fishes, and it, alone, is sometimes miscalled the ascending process of the bone (Amia, Salmo).

The ascending process is formed by the fusion with the premaxillary of a supraethmoid bone, the latter bone being primarily developed in protective relation to a line of latero-sensory organs, and being so found, not only in certain ganoids (Amia, Polypterus) but also in Elops and probably

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in Belone, these two teleosts being the only ones in which it is known to occur. In Belone the bone is indistinguishably fused with the premaxillary, while in Elops it is found as an independent ossicle.

4. The maxillary of the mail-cheeked fishes has, on its anterior end, a process that may be called its ascending process. This process gives articulation to the articular process of the premaxillary, and itself articulates, by the intermediation of a pad of semi-cartilaginous tissue, with the dorsal surface of the ascending process of the vomer. This process of the maxillary is apparently found in all the Acanthopterygii and Anacanthini of Günther's classification, but it is not evident in all descriptions of the Physostomi. In those fishes in which it is found it varies greatly in its development, and may even be found as two instead of as a single process.

5. The vomer of fishes is primarily a bone, doubtless paired, that is developed in relation to tooth-bearing plates on the dorsal surface of the mouth cavity; and it was primarily limited to the roof of that cavity. In certain teleosts, however, this tooth-bearing plate has acquired a dorsal limb which may be said to consist of a head and two ascending processes, one on either side; and these ascending processes are quite certainly formed by the fusion, with the tooth-bearing plate, of the pre-ethmoid (septomaxillary, Amia) bone of either side. When the pre-ethmoids are found as independent ossifications the vomer is without ascending processes. The ascending process of either side gives articulation to the ascending process of the corresponding maxillary.

6. The septomaxillary of the Amphibia and the higher vertebrates is probably represented in fishes by the antorbital bone of Amia, that bone being developed in protective relation to the infranasal portion of the latero-sensory canals. This antorbital, latero-sensory bone is found in Polypterus and Elops, as well as in Amia, and is possibly also found in certain of the Siluridae (Pollard). In Polypterus it fuses with the premaxillary to form an infranasal process of that bone.

7. In Macrodon there is a bone, called by Sagemehl the accessory palatine, that is apparently developed in the maxillary breathing valve of the fish, and that is accordingly the homologue of the so-called vomer of Polypterus. It has never been recognised in any other teleost.

8. The palato-quadrate articulations with the ethmoid region of the skull differ considerably in different ones of the mail-cheeked fishes examined. In Scorpaena and Sebastes there are two of these articulations, one with an anterior palatine process of the ethmoid cartilage and the other with the ectethmoid; the lachrymal also articulating with the latter bone. In Cottus the articulation with the ectethmoid is suppressed, the palatine there being bound to the lachrymal and that bone alone articulating with the ectethmoid. In Trigla, this posterior articulation, with the ectethmoid, is much as in Cottus, while the anterior articulation, with the ethmoid cartilage, has been largely replaced by a swinging articulation (or attachment) of the lachrymal and palatine with the antero-lateral corner of the nasal bone. In Dactylopterus this latter articulation is still more pronounced.

9. The quadrate has, in most if not in all teleosts, a posterior process which forms the posterior boundary of the symplectic groove on the internal surface of the bone and has supporting relations with the preopercular. This process of the quadrate is not found, as a part of that bone, in the bony ganoids, but it is elsewhere represented both in Amia and Lepidosteus. In Amia it has fused with the symplectic to form a process of that bone that gives a supplementary articulation to the mandible; while in Lepidosteus it is the independent, so-called preoperculum of Parker's descriptions (interoperculum, Collinge), which, in that fish, has an independent articulation with the quadrate. In the Muraenidae, the process and the symplectic seem to both be indistinguishably fused with the body of the quadrate.

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The so-called quadrates of osseous fishes are thus not all equivalent structures. The articulations of the mandible with the suspensorial apparatus are also not all similar; Amia being the one known exception to the otherwise general rule, but Lepidosteus somewhat resembling it. A further development of the conditions found in Amia might transfer the mandibular articulation from the palato-quadrate to the hyomandibular.

10. On the hind edge of the metapterygoid, in all of the mail-cheeked fishes examined excepting Cottus and Dactylopterus, there are two flanges, apparently of membrane (exosteal) origin, one of which is lateral and the other mesial in position. Between these two flanges the external carotid artery runs downward to fall into the arteria hyoidea shortly before that artery joins the opercular hemibranch, and after it has passed from the external to the internal surface of the palato-quadrate apparatus. On the opposing surfaces of the two flanges the lavator arcus palatini muscle has the larger part of its surface of insertion.

In Cottus and Dactylopterus these two flanges, instead of being one lateral and the other mesial, are respectively one ventral and the other dorsal; both flanges lying in the plane of the body of the metapterygoid, with their adjoining edges fused but perforated by a foramen which transmits the external carotid and represents the V-shaped space between the flanges in the other fishes. In these two fishes the flanges appear to be of endosteal rather than of exosteal origin.

In Amia the lateral one of these two flanges is represented in the so-called metapterygoid process of the metapterygoid, the mesial flange being represented in that part of the body of the metapterygoid that lies posterior to the process. In Amia both these parts of the bone are quite evidently of endosteal origin.

11. In all of the mail-cheeked fishes examined there is a vessel, apparently an artery, that arises in connection with what seem to be either glomuses or rudimentary glandular structures related to the efferent arteries of the first three branchial arches. Certain evident connections of these glomuses with the lymphatic vessels were found, and occasional apparent connections with the arteries, but no indication whatever of a connection with the venous system. The vessel parallels the common carotid and its branches, and peripherally the walls of the branches of the vessel change abruptly in character, and there appear as lymphatic spaces. The fact that the external carotid branch of the vessel traverses the trigemino-facialis chamber in much the position of the hyo-opercularis artery of Amia, led me at first to homologize the vessel with that artery, but as there is much doubt of the correctness of this homologization I have described the vessel as the vessel x. In Dactylopterus one branch of the vessel seemed to enter the opercular hemibranch. In Polyodon the system is much more developed than in the mail-cheeked fishes, and I am investigating it in that fish. It would seem as if the glomuses from which the vessel arises might be serial homologues of certain of the nephritic structures, and possibly also homologues of the so-called thymus of Polypterus.

12. The external carotid, in all the fishes examined, traverses the trigemino-facialis chamber, gives off several branches, and then terminates in a branch which turns downward between two flanges on the hind edge of the metapterygoid and falls into the arteria hyoidea shortly before that artery enters the opercular hemibranch. This terminal portion of the external carotid corresponds closely in position to, and is probably the homologue of the secondary afferent pseudobranchial artery of my descriptions of Amia, and its connection with the arteria hyoidea, instead of with the pseudobranch, would give origin to the teleostean arrangement.

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13. The alisphenoid is perforated, in Scorpaena, Trigla and Lepidotrigla, by a foramen which transmits delicate branches of the external carotid artery and the vessel x, these branches being accompanied by a nerve which is composed of the lateralis fibers destined to innervate the terminal organ of the supraorbital canal and of certain other general cutaneous or communis fibers. In Dactylopterus, the nerve that traverses the foramen does not contain lateralis fibers; the nerve destined to supply the terminal organ of the supraorbital canal there having an extracranial course. The alisphenoid is also perforated, or notched, in Scorpaena, Trigla and Lepidotrigla by another foramen. which transmits the homologue of the anterior cerebral vein of my descriptions of Amia. These foramina, one or both, are found in the other mail-checked fishes also, but the arteries and veins that traverse them were not there traced.

14. The parietal is fused, in all the mail-cheeked fishes examined, with a mesial extrascapular latero-sensory element to form a single bone, which I have called the parieto-extrascapular. This same fusion of these two bones is also found in the Characinidae and Cyprinidae (Allis '04) and has been definitely established in no other fishes that I know of, excepting Chanos.

15. The side walls and floor of the skull of osseous fishes are more or less completely double in the sphenoid (orbito-temporal, Gaupp) and labyrinth regions; these walls being there represented in varying proportions by membrane, cartilage or bone. Between the two walls, in the sphenoid region, lies the myodome with its upper lateral or trigemino-facialis chambers, while between the two walls in the labyrinth region lie the membranous ears. The myodome and its trigemino-facialis chambers are thus all intramural spaces. The floor of the myodome proper is perforated by the hypophysial fenestra, while its roof is perforated by the pituitary opening. These two perforations of the cranial floor are doubtless strictly homologous in all vertebrates, but it must be determined, in each case, which one of the two perforations is in question. The myodome proper lodges a cross-commissure of the pituitary veins, and is the probable homologue of the cavernous and intercavernous sinuses of the human skull. The postpituitary portion of its roof apparently always chondrifies, and is the postclinoid wall. The prepituitary portion of its roof does not usually chondrify (Argyropelecus may be an exception), and it and the basisphenoid, one or both, represent the anterior clinoid wall. The orbital opening of the myodome, on either side, is the sphenoidal fissure.

The trigemino-facialis chamber of either side is, in the mail-cheeked fishes, and probably in most other teleosts, separated from the myodome by a partition of bone. It lodges the trigeminus and related sympathetic ganglia, and is the homologue of the cavum Meckelii of the human skull. Its outer wall is, in all the mail-cheeked fishes examined, excepting Cottus, represented by a narrow bridge of bone, this wall of the chamber here forming the outer surface of the skull. In Cottus this outer wall is entirely of membrane, the inner wall of the chamber thus here forming the outer surface of the prepared skull. The internal wall of the chamber forms part of the bounding walls of a recess on the internal surface of the skull, and this recess lodges the lateralis and communis portions of the V—VII ganglionic complex. In Amia these portions of the ganglionic complex lie in the upper lateral chamber of the myodome. There is accordingly question as to whether the inner wall of the chamber of teleosts corresponds exactly to the same wall in Amia. In any event, the recess that lodges, in teleosts, the lateralis and communis ganglia would seem to be the homologue of some part of the aqueduct of Fallopius.

The trigemino-facialis chamber is continued anteriorly by an intramural space that lodges the jugular vein and the truncus ciliaris profundi. The outer wall of this space is largely of membrane in

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all the mail-cheeked fishes examined, excepting Cottus, and there appears as a jugular groove on the outer surface of the prepared skull. In Cottus the outer wall of the space is of bone and the inner wall largely of membrane, the space there appearing as a recess on the inner surface of the prepared skull. The outer wall of the space, primarily of membrane, is invaded to a different extent, in different fishes, by the neighbouring bones, thus giving rise to greatly varying conditions.

16. The myodome of fishes is primarily a subpituitary space that is connected with the orbit of either side, or with the orbital region, by a canal that transmits the pituitary vein. Secondarily this subpituitary space acquires a wide communication with the orbits, the primal cause of this secondarily acquired communication apparently being a deepening of the hind ends of the orbits due to a marked enlargement of the eyeballs. Following this deepening of the orbits, certain of the eye-muscles of either side enter the pituitary canal and, enlarging that canal, finally wholly break down the wall that separates the orbits from the subpituitary space.

It seems possible that the subpituitary space may represent the conical depression on the anterior surface of the body of a vertebra, the later acquired, posterior, or basioccipital extension of the myodome then possibly being due to the assimilation of similar depressions in more posterior vertebrae.

17. The peripheral course of each of the cranial nerves is so constant that it would seem to be of greater value for the determination of the segmental position of the nerve than the apparent centers of origin of the fibers composing the nerve; it seeming more reasonable to postulate varying composition, and condensations of ganglia or of centers of origin, than variations in peripheral course. This being so, a nomenclature based on peripheral course seems much preferable to one based on the character of the component fibers of the nerve or on the apparent centers of origin of those fibers.

18. In all the Loricati examined, the ramus palatinus facialis either perforates the proötic bridge or adjoining portions of the side wall of the proötic, and so passes from the cranial cavity directly into the myodome. In all of the Craniomi examined this nerve first passes from the cranial cavity into the trigemino-facialis chamber and then traverses that chamber to issue by its trigeminus opening and so enter the myodome.

19. In all of the mail-cheeked fishes examined, excepting Dactylopterus, the nervus abducens, in passing from the cranial cavity to the muscle it innervates, either passes over the anterior edge of the postpituitary portion of the proötic bridge or perforates that bridge near its anterior edge. In Dactylopterus the nerve first passes from the cranial cavity into the trigemino-facialis chamber and then issues from that chamber through its trigeminus opening to reach the muscle it innervates. In Lepidosteus also the nerve has this latter course.

20. Cottus differs markedly, in many more or less important anatomical features, from the other Loricati, and Dactylopterus differs still more markedly from the other craniomi; and if craniological characteristics are of any especial value in phylogenetic determinations, it would seem as if these two fishes could not be closely related to the other fishes of the mail-cheeked group.

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Index to Fishes etc., referred to.

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Explanation of Figures.

Index letters.

Aap — Adductor arcus palatinus.
Ah — Adductor hyomandibularis.
ah.fr — Foramen for the arteria hyoidea.
ANG — Angular.
Ao — Adductor operculi.
ART — Articular.
art.h — Articular process of the hyomandibular, or corresponding process or facet on the skull.
art.mx. — Articular process of maxillary.
art.pmx — Articular process of premaxillary.
AS — Alisphenoid.
asc.mx. — Ascending process of maxillary.
asc.pmx — ascending process of premaxillary.
asc.v — Ascending process of vomer.
BO — Basioccipital.
BS — Basisphenoid.
cb — Ciliaris brevis.
cl — Ciliaris longus.
D — Dentary.
D.ECP — Dermo-ectopterygoid.
dgr — Dilatator groove.
Do — Dilatator operculi.
ec.fr — External carotid foramen.
ECP — Ectopterygoid.
ECT — Ectethmoid.
ENP — Entopterygoid.
EP — Epiotic (Exoccipitale, Sagemehl, Exoccipital, Allis).
ESC — Extrascapular.
EX — Exoccipital (occipitale laterale, Sagemehl).
fc — Facialis canal through the hyomandibular.
f.fr — Facialis foramen.
fo — Facialis opening of trigemino-facialis chamber.
FR — Frontal.
gc — Ciliary ganglion.
gcm — Communis ganglion.
ggle — Extracranial glossopharyngeal ganglion.
ggli — Intracranial glossopharyngeal ganglion.
gl — Nervus glossopharyngeus.
glfr — Glossopharyngeus foramen.
gp — Profundus ganglion.
gt — Trigeminus ganglion.
gsy — Sympathetic ganglion.
gv^e — Extracranial vagus ganglion.
gv^i — Intracranial vagus ganglion.
HMD — Hyomandibular.
ic.fr — Internal carotid foramen.
io^{1-11} — 1st. to 11th. Infraorbital latero-sensory organs.
ioc — Infraorbital latero-sensory canal.
IOP — Interopercular.
IOR^{1-4} — 1st. to 4th. Infraorbital bones.
LA — Lachrymal.
Labe I—V. — Levator arcus branchialis externus of first to fifth branchial arches.
$Labi^a$ — Levator arcus branchialis internus, anterior muscle.
$Labi^p$ — Levator arcus branchialis externus, posterior muscle.
Lap — Levator arcus palatinus.
Lo — Levator operculi.
mef.fr — Foramen for mandibularis externus facialis.
MET — Mesethmoid.
met.pr. — Mesethmoid process.
mif.fr — Foramen for mandibularis internus facialis.
MP — Metapterygoid.
MX — Maxillary.
mx.p — Maxillary process of Palatine.
NA — Nasal.
na — nasal aperture.
nf — nervus facialis.
nll — Nervus lineae lateralis.
o — Nervus opticus.

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oc.fr	Foramen for occipital nerves.
ol	Nervus olfactorius.
ol.fr	Olfactory foramen.
OP	Opercular.
opl	Ophthalmicus lateralis canal.
OPS	Opisthotic.
P	Palatine.
PA.ESC	Parieto-extrascapular.
pf	Palatinus facialis.
pmo^{1-11}	1st. to 11th. Preoperculo-mandibular latero-sensory organs.
PMX	Premaxillary.
PO	Pontinal.
POP	Preopercular.
POR	Postorbital.
pr.fr	Foramen for nervus profundus.
PRO	Proötic.
PS	Parasphenoid.
PSF	Postfrontal.
PT	Pterotic.
Q	Quadrate.
R	Rostral.
r.ctf	Ramus communicans from trigeminus to facialis.
r.int.inf	Branch of oculomotorius to rectus internus and rectus inferior.
rl	Radix longa.
r.oi	Branch of oculomotorius to obliquus inferior.
r.rs	Branch of oculomotorius to rectus superior.
SCL	Supraclavicular.
SO^{1-6}	1st. to 6th. Supraorbital latero-sensory organs.
SO	Supraoccipital.
soc	Supraorbital latero-sensory canal.
SOP	Subopercular.
SOR^1	1st. Suborbital.
SOR^2	2nd. Suborbital.
SPH	Sphenotic.
spoc	Spina occipitalis.
S.POP	Suprapreopercular.
SSC	Suprascapular.
stc	Supratemporal latero-sensory canal.
sto^{1-2}	1st. to 2nd. Supratemporal latero-sensory organs.
SY	Symplectic.
Tda	Transversus dorsalis anterior.
tfc	Trigemino-facialis chamber.
t.fr	Trigeminus foramen.
tgr	Temporal groove.
to	Trigeminus opening of trigemino-facialis chamber.
vfr	Vagus foramen.
VO	Vomer.

Explanation of Plates.

The figures used for illustration were to have been made from the specimens used for the descriptions, but as those specimens had been more or less injured by repeated handling, other specimens were specially prepared for the drawings. The figures will accordingly be found to differ from the descriptions in certain minor details.

Plate I. *Scorpaena scrofa.*

Fig. 1. Lateral view of the skeleton of the head x $1^1/_4$.
Fig. 2. Dorsal view of the same x $1^1/_4$.
Fig. 3. Dorsal view of the skull with the right nasal bone in place x $1^1/_2$.
Fig. 4. Ventral view of the same x $1^1/_2$.
Fig. 5. Lateral view of the skull x $1^1/_2$.
Fig. 6. Median view of a bisected skull x $1^1/_2$.

Plate II. *Scorpaena scrofa.*

Fig. 7. Dorsal view of the skull with the dermal bones removed, excepting the right postfrontal and suprascapular x $1^1/_2$.
Fig. 8. Posterior view of the same with right suprascapular in place x $1^1/_2$.
Fig. 9. Orbital view of the brain case x $1^1/_2$.
Fig. 10. Dorsal view of the vomer x $1^1/_2$.
Fig. 11. Lateral view of the left hyomandibulo-palato-quadrate apparatus x $1^1/_2$.

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Fig. 12. Median view of the right hyomandibulo-palato-quadrate apparatus with the preopercular attached x $1^1/_2$.
Fig. 13. Lateral view of the left maxillary x $1^1/_2$.
Fig. 14. Median view of the head of the right maxillary x $1^1/_2$.
Fig. 15. Lateral view of the brain case, showing the insertions of the muscles x $1^1/_2$.
Fig. 16. Lateral view of the left premaxillary x $1^1/_2$.
Fig. 17. Median view of the head of the right premaxillary x $1^1/_2$.
Fig. 18. Ventral view of the frontal x $1^1/_2$.
Fig. 19. Diagrammatic view of the latero-sensory canals x 1.

Plate III. Sebastes dactylopterus and Scorpaena scrofa.

Fig. 20. Dorsal view of the skull of Sebastes dactylopterus with both postfrontals and the left nasal, extrascapular, suprascapular and supraclavicular attached x 2.
Fig. 21. Lateral view of the same with postfrontal attached x 2.
Fig. 22. Ventral view of the same x 2.
Fig. 23. Posterior view of the same x 2.
Fig. 24. Lateral view of the left premaxillary x 2.
Fig. 25. Median view of the head of the right premaxillary x 2.
Fig. 26. Lateral view of the left maxillary x 2.
Fig. 27. Median view of the head of the right maxillary x 2.
Fig. 28. Ventral view of the brain of Scorpaena scrofa with the cranial and occipital nerves x 4.

Plate IV. Cottus octodecimospinosus.

Fig. 29. Lateral view of the skeleton of the head x 2.
Fig. 30. Dorsal view of the skull with left nasal, postfrontal, extrascapular, suprascapular and supraclavicular attached x 2.
Fig. 31. Ventral view of the skull x 2.
Fig. 32. Lateral view of the same x 2.
Fig. 33. Median view of a bisected skull x 2.
Fig. 34. Median view of the right hyomandibulo-palato-quadrate apparatus with preopercular attached x 2.
Fig. 35. Lateral view of the left hyomandibulo-palato-quadrate apparatus, without preopercular x 2.
Fig. 36. Median view of the right lachrymal bone x 2.
Fig. 37. Posterior view of the skull x 2.
Fig. 38. Diagrammatic view of the latero-sensory canals x $1^1/_2$.

Plate V. Trigla hirundo.

Fig. 39. Lateral view of the skeleton of the head x 1.
Fig. 40. Dorsal view of the same x 1.
Fig. 41. Lateral view of the occipital region of the skull and the first four vertebrae x 2.
Fig. 42. Posterior view of the skull x 1.
Fig. 43. Dorsal view of the same x 1.
Fig. 44. Ventral view of the same x 1.
Fig. 45. Lateral view of the same with supraclavicular attached x 1.
Fig. 46. Median view of a bisected skull x 1.
Fig. 47. Dorsal view of the skull of Trigla gurnardus with the dermal bones removed x $1^1/_2$.
Fig. 48. Lateral view of the left maxillary of Trigla hirundo x 1.
Fig. 49. Median view of the head of the right maxillary x 1.
Fig. 50. Lateral view of the left premaxillary x 1.
Fig. 51. Median view of the head of the right premaxillary x 1.
Fig. 52. Lateral view of the infraorbital bones of a specimen in which there were four of these bones x 1.
Fig. 53. Lateral view of the left hyomandibulo-palato-quadrate apparatus x 1.
Fig. 54. Median view of the right hyomandibulo-palato-quadrate apparatus with the preopercular attached x 1.

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Plate VI. Peristedion cataphractum.

Fig. 55. Dorsal view of the skeleton of the head x $1^1/_2$.
Fig. 56. Lateral view of the skeleton of the head x $1^1/_2$.
Fig. 57. Dorsal view of the skull x 2.
Fig. 58. Ventral view of the skull x 2.
Fig. 59. Lateral view of the skull x 2.
Fig. 60. Ventral view of the left lachrymal x 2.
Fig. 61. Lateral view of the left hyomandibulo-palato-quadrate apparatus x 2.
Fig. 62. Median view of the right hyomandibulo-palato-quadrate apparatus with the preopercular attached x 2.
Fig. 63. Dorsal view of the parasphenoid x 2.
Fig. 64. Lateral view of the same x 2.
Fig. 65. Dorsal view of the left premaxillary x 2.
Fig. 66. Dorsal view of the left maxillary x 2.
Fig. 67. Posterior view of the skull x 2.
Fig. 68. Diagrammatic view of the latero-sensory canals x $1^1/_2$.

Plate VII. Dactylopterus volitans.

Fig. 69. Dorsal view of the skeleton of the head, with the bones on the dorsal surface of the head filed down on the right side, so as to show the course of the latero-sensory canals x $1^1/_3$.
Fig. 70. Ventral view of the skull x $1^1/_3$.
Fig. 71. Lateral view of the skeleton of the head x $1^1/_3$.
Fig. 72. Ventral view of a part of the roof of the skull x $1^1/_3$.
Fig. 73. Posterior view of the skull with the hind ends of the extrascapulars, suprascapulars and supraoccipital cut off x 2.
Fig. 74. Orbital view of the brain case x 2.
Fig. 75. Dorsal view of the right epiotic x 2.
Fig. 76. Cerebral view of the left proötic x 2.
Fig. 77. Dorsal view of the alisphenoid x 2.
Fig. 78. Ventral view of the alisphenoid x 2.

Plate VIII. Dactylopterus volitans and Trigla hirundo.

Fig. 79. Dorsal view of the parasphenoid of Dactylopterus volitans x 2.
Fig. 80. Dorso-mesial view of the right sphenotic and postfrontal x 2.
Fig. 81. Dorsal view of the left premaxillary x 2.
Fig. 82. Dorsal view of the left maxillary x 2.
Fig. 83. Dorsal view of the basioccipital x 2.
Fig. 84. Dorsal view of the right exoccipital x 2.
Fig. 85. Lateral view of the left hyomandibulo-palato-quadrate apparatus with the preopercular attached x $1^1/_3$.
Fig. 86. Median view of the left palatine x 2.
Fig. 87. Median view of the right hyomandibular x 2.
Fig. 88. Diagrammatic view of the latero-sensory canals of Dactylopterus x $1^1/_3$.
Fig. 89. Diagrammatic view of the latero-sensory canals of Trigla hirundo x 1.

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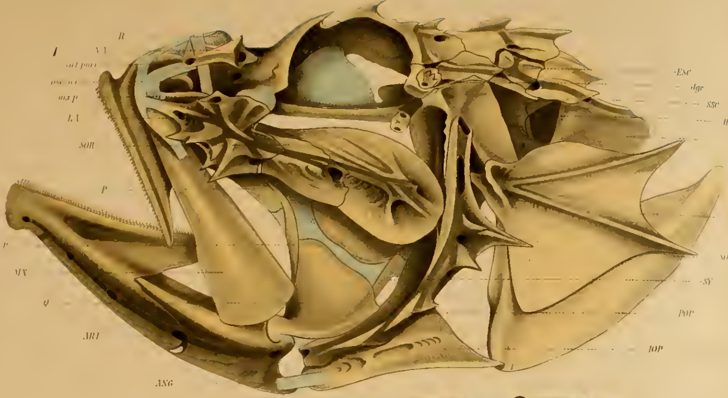

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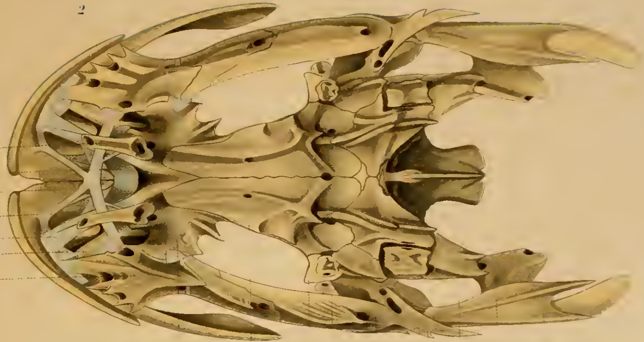

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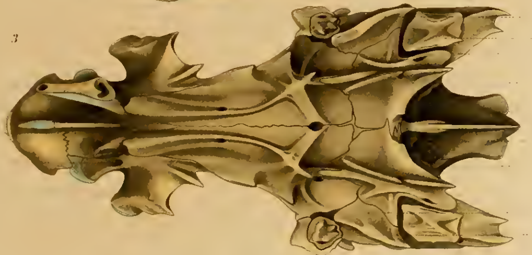

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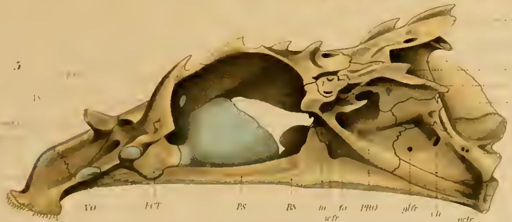

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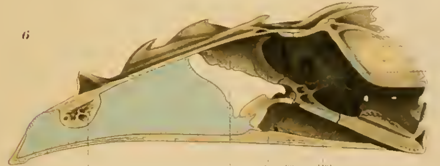

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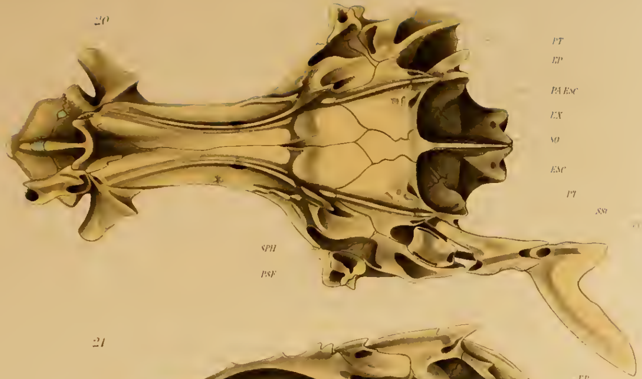

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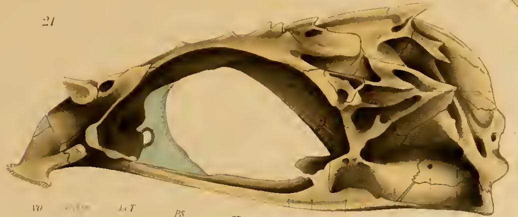

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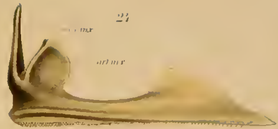

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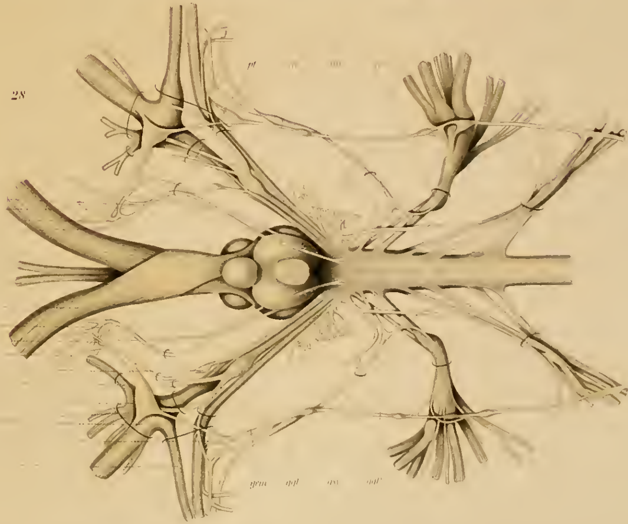

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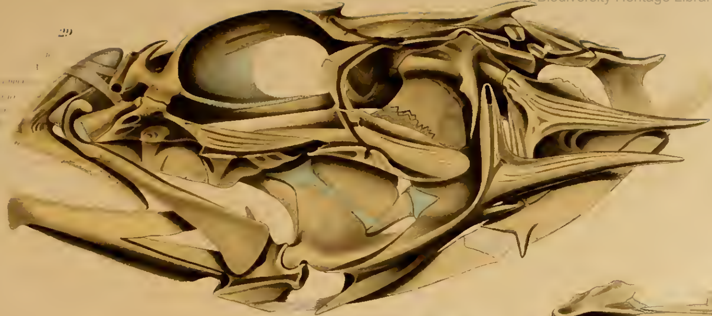

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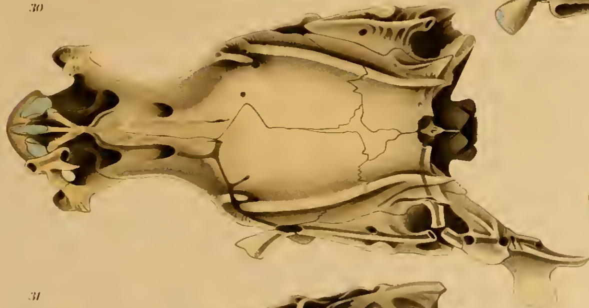

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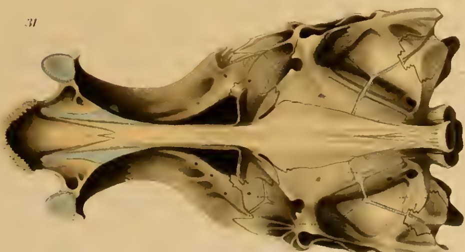

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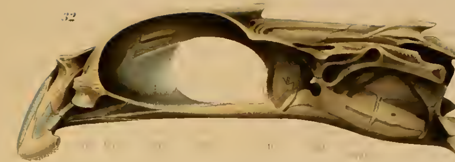

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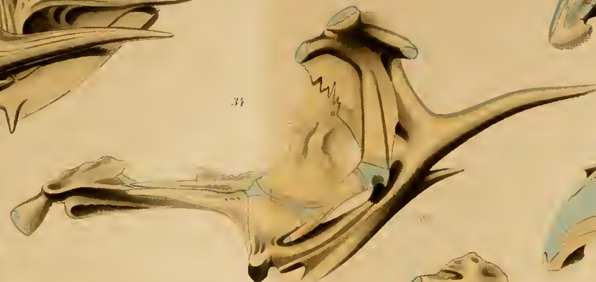

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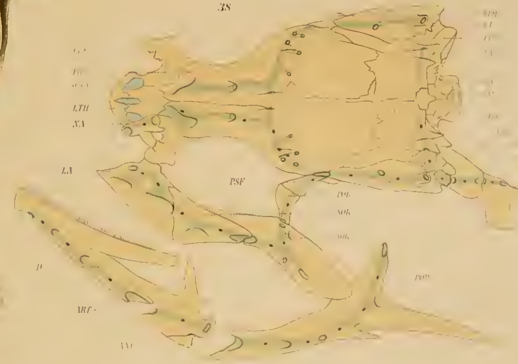

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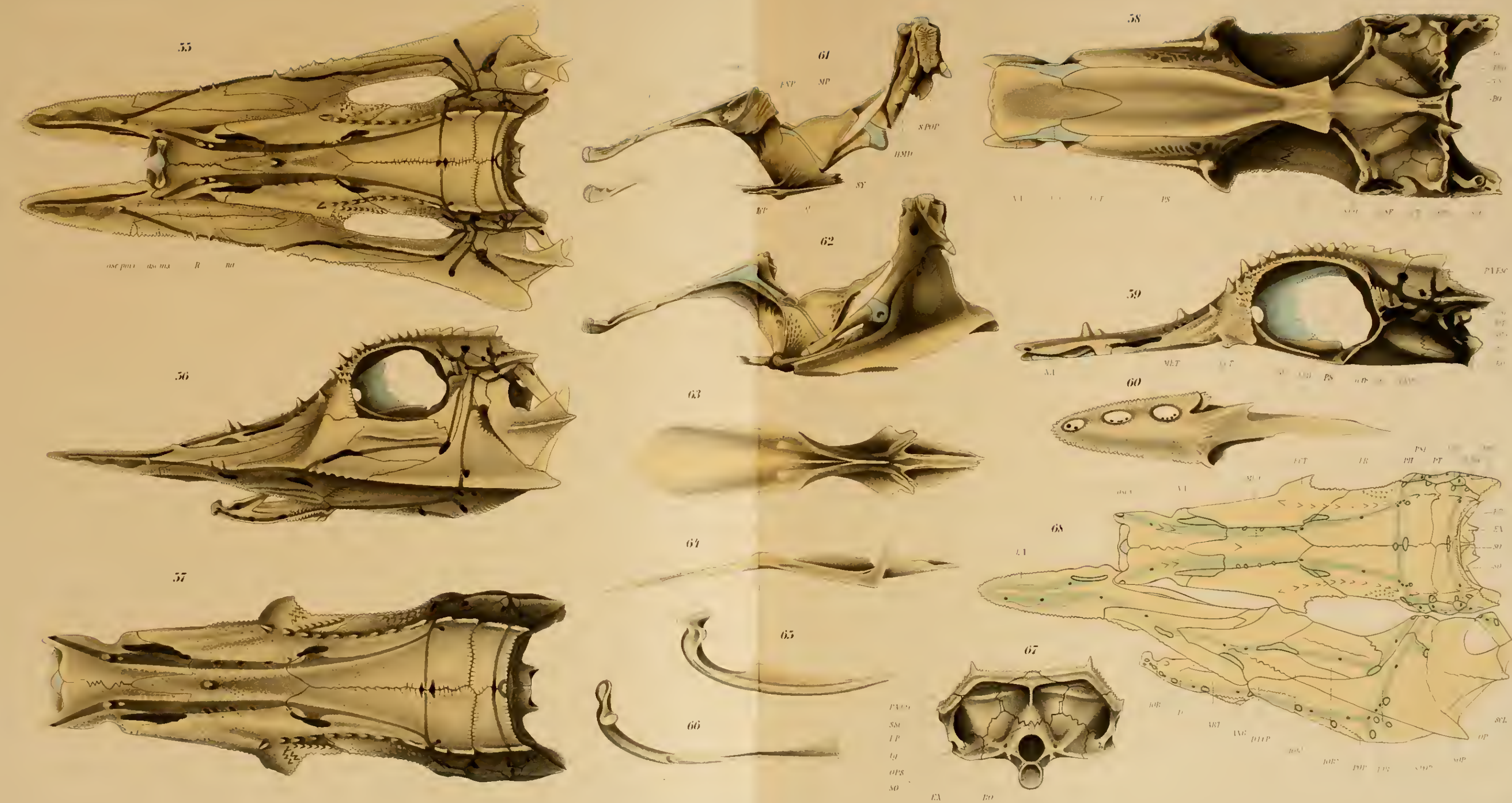

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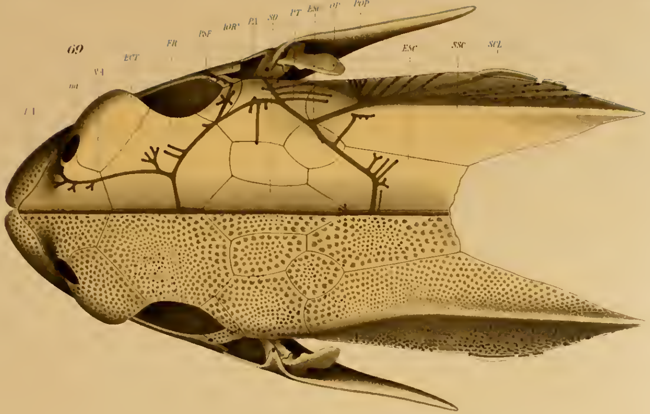

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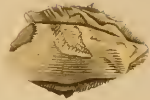

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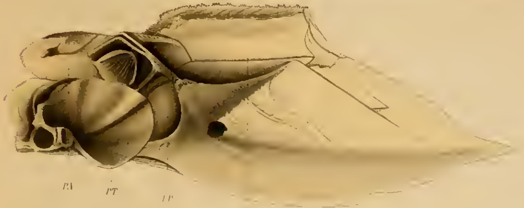

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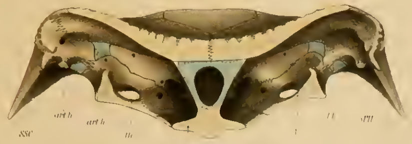

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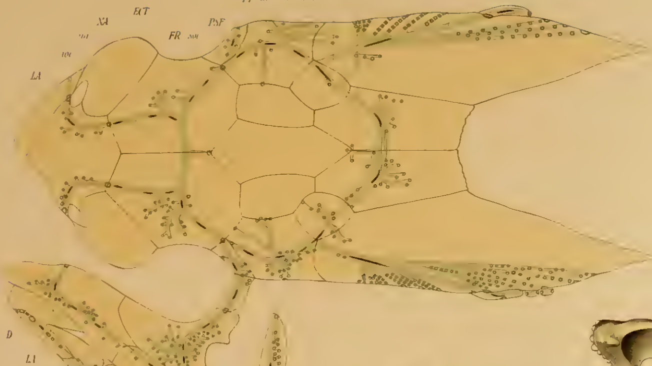


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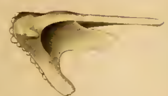

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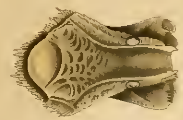

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