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An Illustrated Glossary of Turtle Skull Nomenclature

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ABSTRACT

Herein is presented a glossary of turtle skull terms based on the terminology standardized by Parsons and Williams. The glossary includes literature references, discussion, and figures for most of the terms. The figures are primarily of *Chelydra serpentina*.

INTRODUCTION

Parsons and Williams (1961) have standardized the multitude of synonymous and inconsistently used anatomical terms available in the literature to describe turtle skulls. The purpose of this present glossary is to increase the usefulness and availability of Parsons and Williams's terminology by providing a guide to the identification of the structures involved. Although Parsons and Williams included a synonymy of terms from earlier literature (*ibid.*, pp. 99-105), it is nevertheless difficult and time consuming to acquire sufficient background information for each term and seek out its usage in regard to the description of turtle skulls. I hope that this glossary will simplify and stimulate more detailed work on turtle systematics and evolution by providing a ready reference for the descriptive terminology.

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The terms are restricted to features of the bony skull and are arranged alphabetically. Each term is followed by a short paragraph designed to aid in identification of the structure but not intended as a strict definition or as a complete description. The problems of homology of each structure within the Testudines and the Reptilia are not dealt with here. For the most part, the discussion of each term refers largely to *Chelydra*, and the types of variation met with in other turtles are not invariably stated.

Following the discussion section is a series of references that have been chosen to provide additional figures as well as an introduction to sources of identification and information. The references are mostly restricted to illustrations of recent turtles so that the association of soft tissues with each other and the skull may be determined by dissection. Each reference contains the original author's identification of the structure as printed in the original figure in quotes. If no quote is given, the original label is essentially the same as the term used herein.

Almost all the terms are illustrated in the figures. The choice of *Chelydra serpentina* for the illustrations is based on the following considerations: (1) skulls are easily obtainable commercially and present in most museums and universities; (2) skulls of adults are large enough so that most structures can be seen with the unaided eye; (3) some of the soft anatomy of the head is available in the literature (see below); and (4) detailed figures of the skull are not available in the literature. The identification of the structures in the figures of *Chelydra* serves two purposes: first, a visual identification is much easier to recognize quickly and may help prevent ambiguities in the discussion section; secondly, the availability of preserved specimens allows the checking of associated soft structures by dissection.

Although no single work is devoted specifically to the cranial anatomy of *Chelydra*, more information concerning particular areas can be obtained by consulting the following references: Nick (1912) for a series of transverse and sagittal sections plus a comparison of *Chelydra* and sea-turtles. Poglayen-Neuwall (1953) for a figure and description of the lower jaw nerves in *Chelydra*. Soliman (1964) for an extensive comparison of the cranial nerves of *Chelydra* and *Eretmochelys* including a very useful appendix of transverse sections identifying most of the cranial structures.

The literature on turtle skull morphology is widely scattered and little of it is comparative in nature. In addition to the above-mentioned works, some of the more useful references concerned with recent turtle cranial morphology should be mentioned: Siebenrock (1897)—the first and only attempt at an extensive comparison of turtle skulls in detail. The figures are very useful but inaccurate for some of the pleurodires. Ogushi (1911)—

the most intensive and well-illustrated description of the skull of one species (*Trionyx japonicus*). Bojanus (1819, reprinted 1970)—the only reasonably complete set of illustrations of the entire morphology of a turtle. The figures concerned with the skull contain information on bones, nerves, and blood vessels (cranial muscle information is limited). Kesteven (1910)—the only description of the skull of one turtle species (*Chelonia mydas*) in English. The figures, however, are not on a par with the other references cited herein.

Drs. Thomas Parsons and Donald Baird kindly read the glossary in an earlier form and made a number of useful suggestions. I should also like to thank Miss Jennifer Perrott and Mr. Chester Tarka of the Department of Vertebrate Paleontology for the drawings and photographs.

AMNH refers to specimens in the Department of Herpetology, the American Museum of Natural History.

ABBREVIATIONS

ang, angular	pal, palatine
art, articular	pf, prefrontal
bo, basioccipital	pm, premaxilla
bs, basisphenoid	po, postorbital
cor, coronoid	pr, prootic
den, dentary	pra, prearticular
epi, epipterygoid	pt, pterygoid
ex, exoccipital	qj, quadratojugal
fr, frontal	qu, quadrate
ju, jugal	so, supraoccipital
mx, maxilla	sq, squamosal
na, nasal	sur, surangular
op, opisthotic	vo, vomer
pa, parietal	

GLOSSARY

ADITUS CANALIS STAPEDIO-TEMPORALIS (figs. 6, 18, 21)—The posteroventral opening of the **CANALIS STAPEDIO-TEMPORALIS** into the roof of the **CAVUM ACUSTICO-JUGULARE**; in most cases formed by the quadrate and prootic. The **ARTERIA STAPEDIALIS** passes through it.

Siebenrock, 1897, figs. 16, 17 (unlabeled). Parsons and Williams, 1961, figs. 6, 7. Albrecht, 1967, figs. 1–3.

ANTRUM POSTOTICUM (figs. 3, 11)—Generally a cone-shaped cavity with apex pointing posteriorly and base opening anteriorly into the posterodorsal region of the **CAVUM TYMPANI** into which it grades gradually in most genera. The **INCISURA COLUMELLAE AURIS** in most cases marks the anteroventral limits of the **ANTRUM**. The **ANTRUM** is formed by the squamosal and quadrate.

Ogushi, 1911, fig. 24: "Sin. mast." Williams, 1954, fig. 4: "Sa."

APERTURA NARIUM EXTERNA (figs. 1, 3)—The external bony opening of the nares; formed by the prefrontals, maxillae, premaxillae and, in some groups, nasals. Kesteven, 1910, fig. 44 (unlabeled). Schumacher, 1954, fig. 1, pl. 4, fig. 2.

APERTURA NARIUM INTERNA (figs. 2, 4, 7)—The internal bony opening for the nares, in most cases on the palate. The bones involved vary somewhat. In most turtles (*Chelydra*, for example) the vomer, maxilla, and palatine bones outline the APERTURA. In most pelomedusids the vomer is lost, whereas in many chelonioids (particularly living cheloniids) the development of a secondary palate excludes the maxillae; the palatines and vomer are the principal elements. See also MEATUS CHOANAE.

Siebenrock, 1897, fig. 7: "ch." Ogushi, 1911, figs. 13, 17: "choan."

AREA ARTICULARIS MANDIBULARIS (figs. 14–16)—The area on the lower jaw that articulates with the CONDYLUS MANDIBULARIS of the quadrate; consists primarily of the articular bone.

Ogushi, 1911, figs. 32, 34: "cav. gl. med., cav. gl. lat." Schumacher, 1955a, fig. 8: "Facies articularis."

BASIS COLUMELLAE (fig. 9)—The medial, expanded end of the COLUMELLA AURIS, fits into the FENESTRA OVALIS. See COLUMELLA AURIS.

Ogushi, 1911, fig. 24, left end of the structure labeled "Col. aur."

BASIS TUBERCULI BASALIS (fig. 11)—An oval tubercle generally situated on the midline of the skull at the union of the basisphenoid and basioccipital. Most of the tubercle is generally on the latter bone. "Gives attachment to the bifid ligament of the medulla" (Kesteven, 1910, p. 376).

Kesteven, 1910, fig. 48: "48"; fig. 22: "3." Zangerl, 1953, pl. 9: "basis trabeculi basalis." Corrected in caption to read "basis tuberculi basalis."

CANALIS ALVEOLARIS INFERIOR (fig. 17)—A canal extending anteriorly for most of the length of the dentary, beginning at the FORAMEN ALVEOLARE INFERIUS. Soliman (1964, figs. 11–13) indicated that the RAMUS ALVEOLARIS INFERIOR (V_3), the RAMUS CUTANEUS EXTERNUS (V_3), and small blood vessels traverse the CANALIS.

Fuchs, 1931, pl. 2, fig. 6b.

CANALIS ALVEOLARIS SUPERIOR (figs. 11, 12)—This canal roughly parallels the lateral edge of the outer maxillary surface in the floor of the FOSSA ORBITALIS; has connections to the FORAMEN ALVEOLARE SUPERIUS and the CANALIS INFRA-ORBITALIS. "The superior alveolar artery goes through the foramen alveolare superius and into the canalis alveolaris superior" (Albrecht, 1967, p. 90).

Albrecht, 1967, figs. 1–3.

CANALIS CAROTICO-PHARYNGEALIS—A canal formed in the pterygoid bone, directed and opening ventrally, and communicating dorsally with the CANALIS CAROTICUS LATERALIS. Albrecht (1967, pp. 85, 86) reported it in *Chrysemys* and *Sternotherus*. The ARTERIA CAROTICO-PHARYNGEALIS is transmitted by this canal.

Albrecht, 1967, no figs.

CANALIS CAROTICUS INTERNUS (figs. 11, 12)—A pair of canals curving anteromedially, from the posterior region of the skull through the basicranium to an opening in the basisphenoid at the posterior end of the SELLA TURCICA; in most cases formed, at least in part, by the pterygoid and basisphenoid; contains the ARTERIA CAROTICA INTERNA.

Siebenrock, 1897, figs. 28–31, 36–39: "2–2." Kesteven, 1910, fig. 37: "12, 23."

Ogushi, 1911, figs. 22, 23: "C. car."; fig. 28: arrow "a." Albrecht, 1967, figs. 1–3.

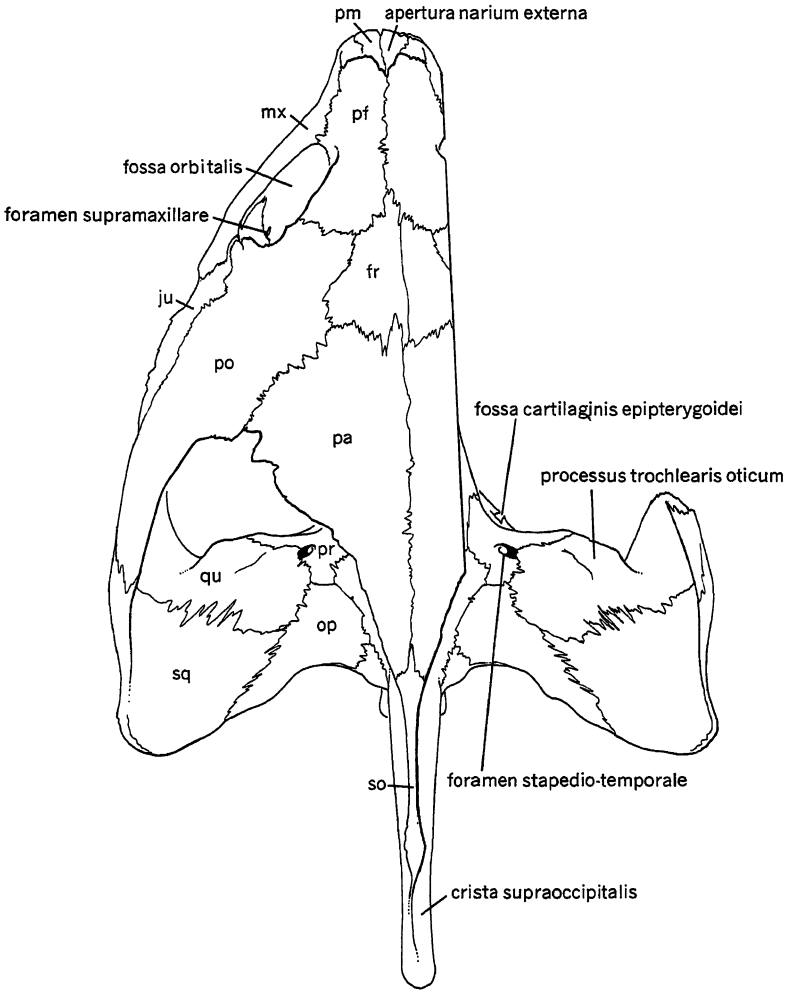


FIG. 1. *Chelydra serpentina*, AMNH 107385. Dorsal view of skull with most of right side removed to show otic chamber.

CANALIS CAROTICUS LATERALIS (figs. 12, 20)—“In *Chrysemys*, *Sternotherus*, and *Trionyx*, the canalis caroticus on each side of the skull gives off an anterior canal in the pterygoid bone which opens into the sulcus cavernosus directly lateral to the basisphenoid” (Albrecht, 1967, p. 84). The “anterior canal” is the CANALIS CAROTICUS LATERALIS and carries the ARTERIA PALATINA in the first two genera and the ARTERIA PSEUDOPALATINA in *Trionyx*. CANALIS CARTILAGINIS MECKELII—Any part of the SULCUS CARTILAGINIS MECKELII

that is roofed over by bone to form a canal.

Parsons and Williams, 1961, p. 84, no figs.

CANALIS CAVERNOSUS (figs. 6, 18, 20, 21)—The canal that is continuous posteriorly with the **SULCUS CAVERNOSUS** (and is essentially the **SULCUS** closed over); runs on the floor of the **CAVUM CRANII** on either side of the basisphenoid postero-laterally beneath the **ADITUS CANALIS STAPEDIO-TEMPORALIS**, and into the **CAVUM ACUSTICO-JUGULARE**. The **CANALIS** and **SULCUS** contain the **VENA CAPITIS LATERALIS** and represent the cranioquadrate space of other vertebrates.

Siebenrock, 1897, figs. 16, 17: "s.c." Nick, 1912, fig. 11: "can. cav."

CANALIS CHORDA TYMPANI MANDIBULARIS (fig. 17)—The canal in the lower jaw that contains the chorda tympani branch of the facial (VII) nerve; formed in most cases by the articular and prearticular bones.

CANALIS CHORDA TYMPANI QUADRATI (fig. 18)—The canal in the quadrate bone between the **FORAMEN CHORDA TYMPANI SUPERIUS** and the **FORAMEN CHORDA TYMPANI INFERIUS**. The chorda tympani branch of the facial (VII) nerve exits from the skull via this canal.

Ogushi, 1911, fig. 20: line between asterisks.

CANALIS INFRAORBITALIS (fig. 12)—A canal beginning medially at the **FORAMEN SUPRAMAXILLARE** and extending anterolaterally to the **CANALIS ALVEOLARIS SUPERIOR**; contains the **ARTERIA SUPRAMAXILLARIS** in *Chrysemys*, *Sternotherus*, and *Trionyx* (Albrecht, 1967); is in most cases contained in the maxilla.

Albrecht, 1967, figs. 1-3.

CANALIS INTRAPALATINUS—A canal found in *Trionyx* (but not in *Sternotherus* or *Chrysemys*) that connects the **FORAMEN PALATINUM ACCESSORIUM** with the **FORAMEN PALATINUM POSTERIUS** and is formed by the palatine bone (Albrecht, 1967, p. 88); transmits a small branch of the **ARTERIA INFRAMAXILLARIS**.

Albrecht, 1967, no figs.

CANALIS NERVI ABDUCENTIS (fig. 11)—A paired canal in the lateral part of the **DORSUM SELLAE** in the basisphenoid. The abducent (VI) nerve traverses this canal.

Siebenrock, 1897, figs. 28-31: "1-----1." Ogushi, 1911, fig. 29: "C.VI." Zangerl, 1953, pl. 9: "can. n. abducentis."

CANALIS NERVI VIDIANI (fig. 12)—A canal that extends anteriorly along the side of the basicranium in the pterygoid and/or palatine bones; in most cases begins in the **FORAMEN PRO RAMO NERVI VIDIANI** and ends in the **FORAMEN PALATINUM POSTERIUS** in cryptodires. The palatine branch (vidian nerve) of the facial (VII) nerve and, in some cases, small arteries (Albrecht, 1967) traverse the **CANALIS**. Albrecht (*ibid.*) differentiated between an anterior and posterior part of the **CANALIS**. He (*ibid.*, p. 87) described the nerves and arteries in this area.

Siebenrock, 1897, figs. 28, 35, 36, 38, 39: "3-----3." Ogushi, 1911, figs. 16, 30: "*-----*." McDowell, 1964, upper part of fig. 3: arrow. Albrecht, 1967, figs. 1, 2.

CANALIS SEMICIRCULARIS ANTERIOR (fig. 11)—Strictly speaking the term **CANALIS SEMICIRCULARIS** should refer only to the membranous endolymphatic canals of the inner ear and not to the bony canals which contain them. The bony canals are variable in their enclosure of the membranous canals which tend to be rather consistent in vertebrates. However, it is common practice to use the term **CANALIS** as I do here for the bony canals; **CANALIS SEMICIRCULARIS ANTERIOR** extends from the **RECESSUS LABYRINTHICUS SUPRAOCCIPITALIS** to the **RE-**

- CESSUS LABYRINTHICUS PROOTICUS; formed by the supraoccipital and prootic.
 Siebenrock, 1897, figs. 10–15: “fo.s.” Kesteven, 1910, fig. 30: “2”; fig. 48: “44.”
 Ogushi, 1911, figs. 22, 24: “C. sem. a.”; figs. 23, 25: “semic. ant.”
- CANALIS SEMICIRCULARIS HORIZONTALIS (fig. 19)—Extends from the RECESSUS PROOTICUS to the RECESSUS OPISTHOTICUS; is in most cases formed by the prootic and opisthotic.
 Siebenrock, 1897, figs. 10–15: “fo.h.” Ogushi, 1911, fig. 26: “Can.s.l.”
- CANALIS SEMICIRCULARIS POSTERIOR (figs. 11, 19)—Extends from the RECESSUS SUPRAOCCIPITALIS to the RECESSUS OPISTHOTICUS; formed by the supraoccipital and opisthotic.
 Siebenrock, 1897, figs. 10–15: “fo. f.” Ogushi, 1911, fig. 25: “Semic. post.”; fig. 26: “Can. s. p.”
- CANALIS STAPEDIO-TEMPORALIS (figs. 6, 18)—The passage of the ARTERIA STAPEDIALIS from the ADITUS CANALIS STAPEDIO-TEMPORALIS in the CAVUM ACUSTICO-JUGULARE to the FOSSA TEMPORALIS SUPERIOR; formed between the quadrate and prootic.
 Siebenrock, 1897, figs. 16, 17: “s. c. e.” Albrecht, 1967, figs. 1–3.
- CARTILAGO TRANSILIENS—The sliding sesamoid cartilage at the site of contact between the external tendon (the main adductor aponeurosis or “Boden-aponeurosis”) and either the PROCESSUS TROCHLEARIS OTICUM (cryptodires) or the PROCESSUS TROCHLEARIS PTERYGOIDEI (pleurodires). This cartilage may ossify (Ray, 1959); is generally meniscus-shaped.
 Schumacher, 1954, figs. 7–9, 15, 16, 19, 20, pls. 8, 9; 1955a, figs. 1–3. Ray, 1959, figs. 1–3 (OS TRANSILIENS, the CARTILAGO TRANSILIENS ossified).
- CAVUM ACUSTICO-JUGULARE (fig. 21)—A large cavity in the posteroventral region of the skull approximately between the CAVUM TYMPANI and the CAVUM LABYRINTHICUM; contains the COLUMELLA AURIS, the ARTERIA STAPEDIALIS, the VENA CAPITIS LATERALIS, the glossopharyngeal (IX) nerve, the hyomandibular (posterior) branch of the facial (VII) nerve, and the VENA CEREBRALIS POSTERIOR. The PROCESSUS INTERFENESTRALIS tends to separate a small area including the RECESSUS SCALAE TYMPANI, which is posteromedial to the main part of the CAVUM. The posterior wall of the CAVUM ACUSTICO-JUGULARE is in most cases unossified and named the FENESTRA POSTOTICA. The CAVUM ACUSTICO-JUGULARE is generally bound anteriorly and laterally by the quadrate, medially by the prootic and opisthotic, ventrally by the pterygoid, and dorsally by the quadrate and opisthotic.
 Kesteven, 1910, fig. 43: “65.” Ogushi, 1911, fig. 19: “h. Ö.”; fig. 21: “Cav. intm.” Parsons and Williams, 1961, figs. 6, 7.
- CAVUM CRANII—The large central space occupying the area from the FOSSA NASALIS to the FORAMEN MAGNUM; is defined by bone, and an endocranial cast would be a replica of it. The brain and dura mater are the principal occupants of the CAVUM in life. Most of the median bones in the skull participate in the formation of the CAVUM CRANII.
 Siebenrock, 1897, figs. 1–9 (unlabeled, the large central space shown hemisected). Ogushi, 1911, fig. 16 (unlabeled, the large central space shown hemisected).
- CAVUM LABYRINTHICUM (figs. 9, 21)—The bony inner ear cavity, formed by the prootic anteriorly, the opisthotic posteriorly, and the supraoccipital dorsally.

In life, the bony capsule is usually completed by cartilage medially (the *HIATUS ACUSTICUS*) and ventrally. The *CAVUM* contains the membranous labyrinth of the inner ear.

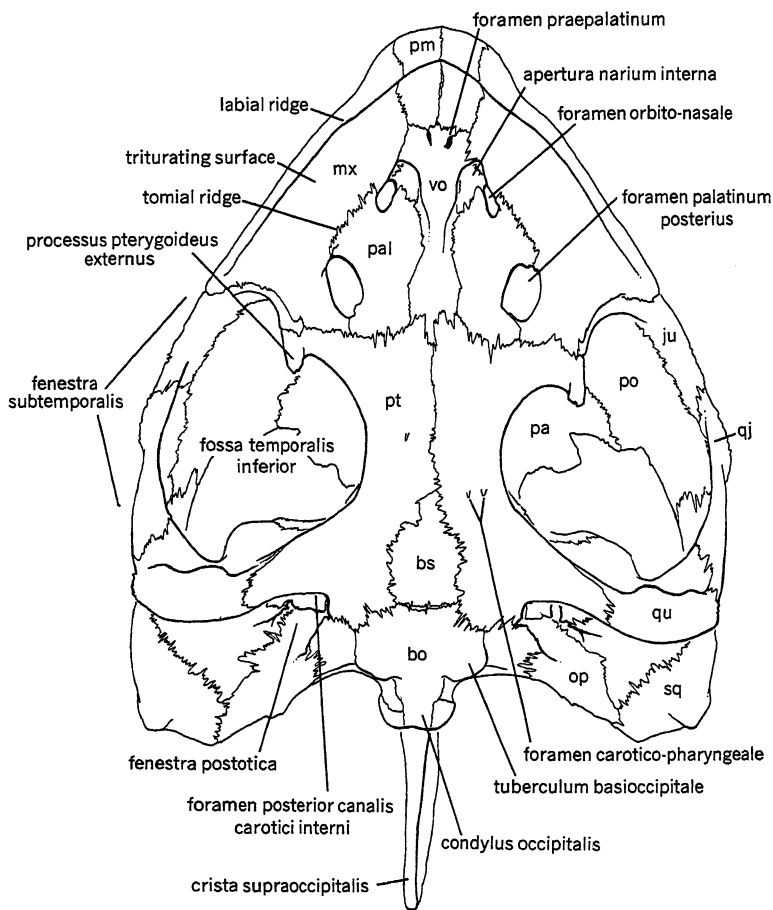


FIG. 2. *Chelydra serpentina*, AMNH 5305. Ventral view of skull.

Siebenrock, 1897, figs. 10–15 (unlabeled, figures show the *CAVUM* opened up). Ogushi, 1911, figs. 19, 22, 23 (unlabeled). Zangerl, 1953, plate 9: “vestibulum.” *CAVUM TYMPANI* (figs. 3, 4)—A large concavity, opening laterally, in the posterior region of the skull; houses the tympanic organ (middle ear) and distalmost portion of the *COLUMELLA AURIS*. The *INCISURA COLUMELLAE AURIS* lies in the center of the *CAVUM TYMPANI* and is in most cases the most medial portion of the *CAVUM*. Most of the *CAVUM* is formed by the quadrate with some contribution

from the squamosal. The ANTRUM POSTOTICUM is continuous with, and lies posterodorsal to, the CAVUM.

Siebenrock, 1897, figs. 18-27: "c. t." Ogushi, 1911, figs. 14, 19, 24: "cav. tymp." COLUMELLA AURIS (figs. 3, 4, 9)—The bony rod (stapes) extending from the FENESTRA OVALIS laterally across the CAVUM ACUSTICO-JUGULARE and through the INCISURA COLUMELLAE AURIS into the CAVUM TYMPANI. In most cases the lateral end is finished in cartilage, the extrastapes or extracolumella. This structure transmits sounds from the tympanic organ to the inner ear.

Ogushi, 1911, fig. 24: "Col. aur."

CONDYLUS MANDIBULARIS (figs. 3, 4, 18)—The distal end of the PROCESSUS ARTICULARIS of the quadrate that articulates with the AREA ARTICULARIS MANDIBULARIS of the lower jaw.

Siebenrock, 1897, figs. 16-25: "c. m."

CONDYLUS OCCIPITALIS (figs. 2-4, 7)—The posteriorly projecting end of the occiput that articulates with the axis-atlas complex.

Siebenrock, 1897, figs. 1-9: "c. oc." Ogushi, 1911, figs. 13-16, 23: "Pr. c. oc."

CRISTA DORSALIS BASIOCCIPITALIS (fig. 11)—The sagittal crest on the dorsal surface of the basioccipital just posterior to the BASIS TUBERCULI BASALIS.

Zangerl, 1953, pl. 9: "crista basioccipitalis." Wegner, 1959, pl. 6: "crista basioccipitalis."

CRISTA PTERYGOIDEA (fig. 20)—A vertical plate rising from the main body of the pterygoid, and sutured to the parietal dorsally. Together with the PROCESSUS INFERIOR PARIETALIS it forms a lateral wall between the CAVUM CRANII and the FOSSA TEMPORALIS INFERIOR.

Siebenrock, 1897, figs. 32-36, 38, 39: "c. p." Ogushi, 1911, fig. 28: "cr. pt."

CRISTA SUPRAOCCIPITALIS (figs. 1-4, 6)—The sagittal crest of the supraoccipital in the posterodorsal part of the skull. The parietal may contribute to this crest in some cases. The ADDUCTOR MANDIBULAE EXTERNUS musculature attaches along the CRISTA. The CRISTA may develop a posteriorly projecting spine and/or horizontal plate in some genera.

Siebenrock, 1897, figs. 26, 27: "c. s." Kesteven, 1910, figs. 40, 41, 43, 49: "14."

Schumacher, 1954, figs. 5, 22, 23, 25, pls. 2, 3, 10, 13.

DORSUM SELLAE (figs. 7, 11)—A raised area in the center of the dorsal surface of the basisphenoid just posterior to the SELLA TURCICA. A PROCESSUS CLINOIDEUS extends anteriorly from each side.

Siebenrock, 1897, figs. 28, 29, 31: "d. e." Ogushi, 1911, fig. 29: "Dors."

FENESTRA OVALIS (figs. 6, 19, 21)—The lateral opening of the CAVUM LABYRINTHICUM into the CAVUM ACUSTICO-JUGULARE. The prootic forms the anterior border and the opisthotic the posterior border, whereas the ventral limits are formed by cartilage in life, but in the dried skull the FENESTRA is incomplete ventrally. In life, the BASIS COLUMELLAE fits into and fills the FENESTRA OVALIS and there is no free communication here between the CAVUM LABYRINTHICUM and the CAVUM ACUSTICO-JUGULARE.

Siebenrock, 1897, figs. 1, 2, 7: "f. v." Kesteven, 1910, figs. 49, 50: "33." Ogushi, 1911, figs. 16, 21, 22: "f. ov."

FENESTRA PERILYMPHATICA (figs. 9, 19, 21)—An opening between the CAVUM LABYRINTHICUM and the RECESSUS SCALAE TYMPANI of the CAVUM ACUSTICO-JUGULARE, formed mostly by the PROCESSUS INTERFENESTRALIS of the opisthotic; may be completely contained within the opisthotic or may have a ventromedial

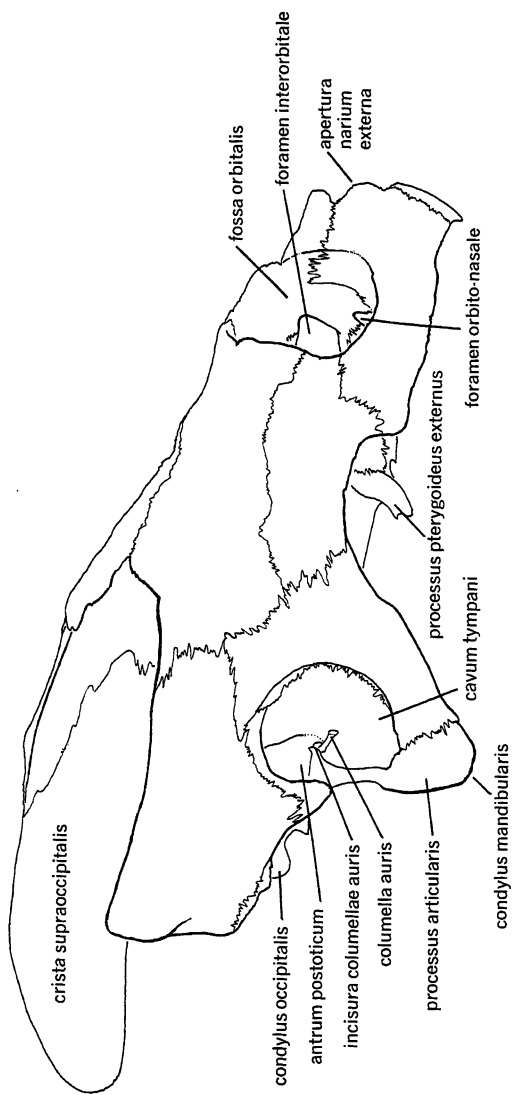


FIG. 3. *Chelydra serpentina*, AMNH 5305. Lateral view of skull.

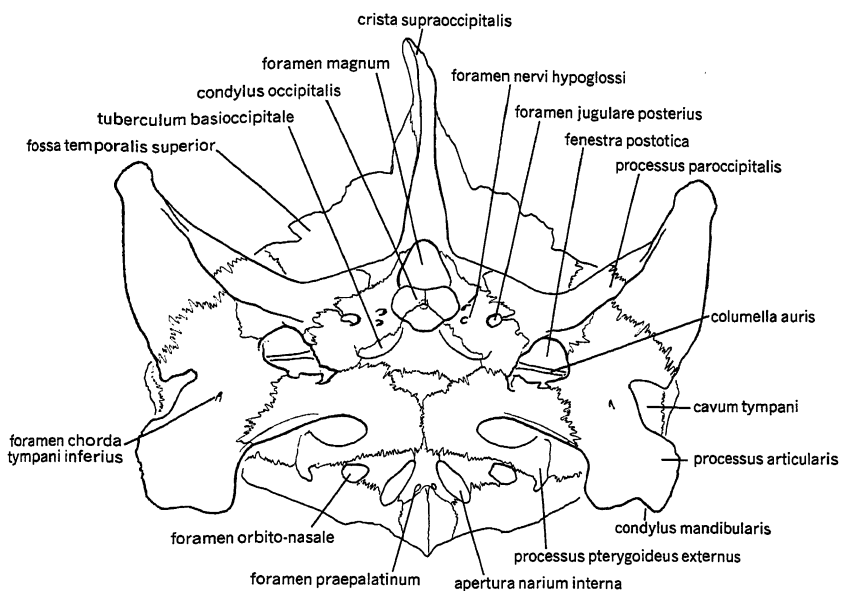


FIG. 4. *Chelydra serpentina*, AMNH 67015. Posterior and slightly ventral view of skull.

contribution from the basioccipital. Baird (1960, fig. 49) indicated that the periotic sac of the inner ear extends posteriorly through this opening.

Siebenrock, 1897, figs. 10–15: “f. co.” Ogushi, 1911, figs. 17, 23, 24, 26: “F. perl.” McDowell, 1964, fig. 2: “fp.”

FENESTRA POSTOTICA (figs. 2, 4, 9, 12, 20, 21)—The posterior opening of the **CAVUM ACUSTICO-JUGULARE**; may be continuous with the **INCISURA COLUMELLAE AURIS** or with the **FORAMEN JUGULARE POSTERIUS**; partially filled with cartilage in life; varies in morphology but in most cases the exoccipital, quadrate, pterygoid, opisthotic, and in some cases the basioccipital, border the opening. The following structures generally traverse the **FENESTRA POSTOTICA**: the **ARTERIA STAPEDIALIS**, the **VENA CAPITIS LATERALIS**, the **VENA CEREBRALIS POSTERIOR**, the vagus (X) nerve, and the hyomandibular branch of the facial (VII) nerve. In certain forms some or all of the **FENESTRA** may be ossified resulting in a series of smaller foramina.

Ogushi, 1911, fig. 17: “F. lac.” Nick, 1912, fig. 4: “fe. po.”

FENESTRA SUBTEMPORALIS (fig. 2)—The ventral opening of the **FOSSA TEMPORALIS INFERIOR**. The adductor jaw musculature, mandibular artery, and V_3 branch of the trigeminal nerve descend through this opening to the lower jaw. The quadrate, pterygoid, maxilla, jugal, and quadratojugal form the margins of the **FENESTRA SUBTEMPORALIS** in most cases.

Romer, 1956, p. 63, no figs.

FISSURA ETHMOIDALIS (fig. 7)—A fissure developed in the midline of the posterior wall of the **FOSSA NASALIS** above, and confluent with, the **SULCUS VOMERI** below;



FIG. 5. *Chelydra serpentina*, AMNH 9249. Lateral view of skull with a parasagittal section on the right side removed to show bony structures in CAVUM ACUSTICO-JUGULARE (lower left region).

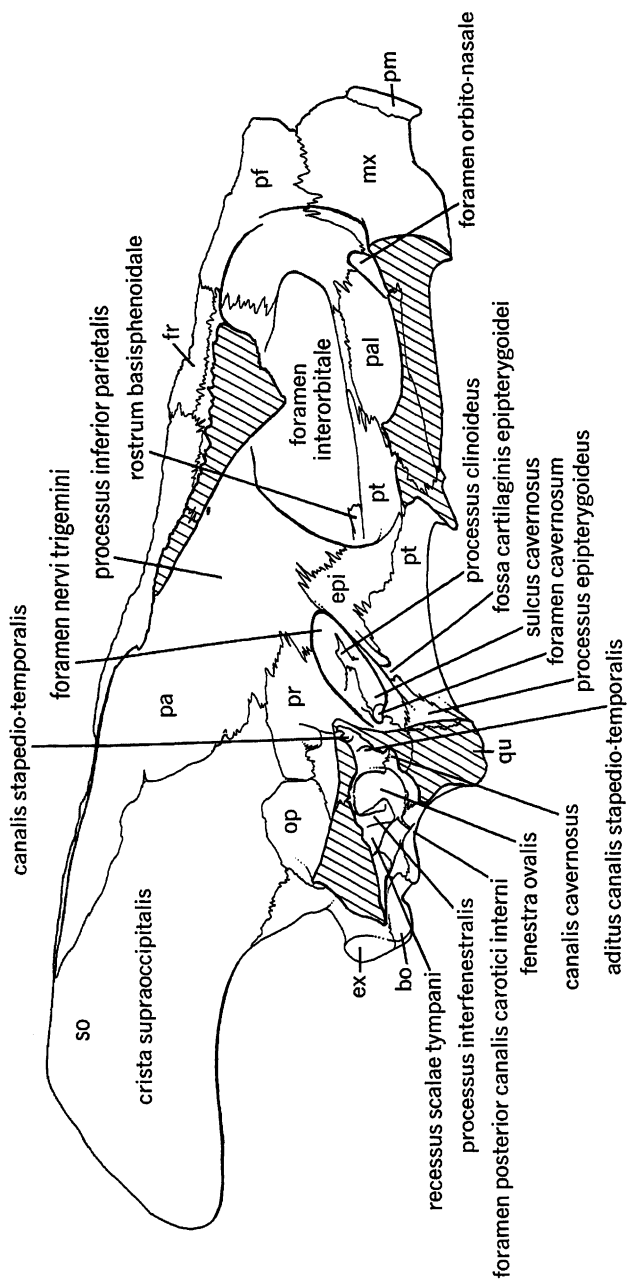


FIG. 6. *Chelydra serpentina*, AMNH 9249. Drawing of specimen illustrated in figure 5 with structures labeled. Hatching indicates cut surfaces.

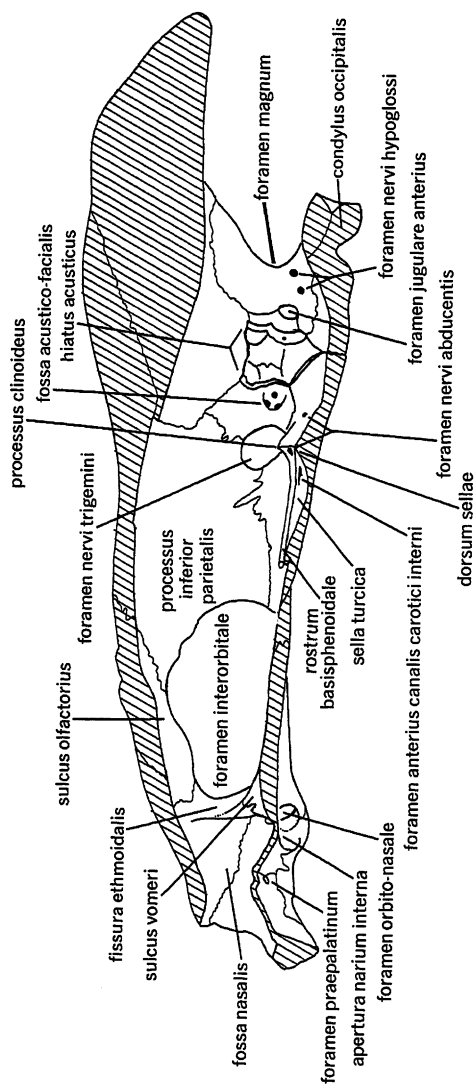


FIG. 7. *Chelydra serpentina*. Sagittal section of skull showing structures in CAVUM CRANII. Hatching indicates cut surfaces (after Siebenrock, 1897, fig. 3).

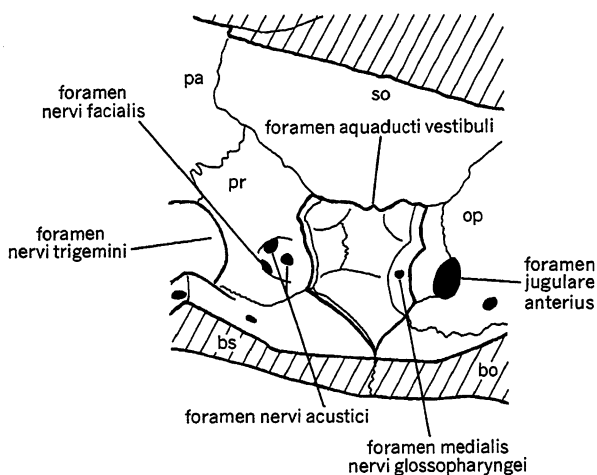


FIG. 8. *Chelydra serpentina*. Enlargement of area around HIATUS ACUSTICUS seen in figure 7 (after Siebenrock, 1897, and specimens).

transmits the olfactory (I) nerves dorsally; ventrally filled with cartilage to form a canal for the nerves in life.

Kesteven, 1910, figs. 44, 46: "58."

FORAMEN ALVEOLARE INFERIUS (figs. 16, 17)—The posterior opening into the CANALIS ALVEOLARIS INFERIOR in the dentary of the lower jaw; is in most cases in the posterior portion of the SULCUS CARTILAGINIS MECKELII on the medial (internal) face of the mandible.

Fuchs, 1931, pl. 2, figs. 5b, 6b. McDowell, 1964, fig. 3: "dc."

FORAMEN ALVEOLARE SUPERIUS (figs. 11, 12)—The medial opening of the CANALIS ALVEOLARIS SUPERIOR into the FOSSA NASALIS; contains the ARTERIA ALVEOLARIS SUPERIOR (Albrecht, 1967); is in most cases formed by the maxilla.

Siebenrock, 1897, figs. 1, 5: "f. a. s." Albrecht, 1967, figs. 1-3.

FORAMEN ANTERIOR CANALIS CAROTICI INTERNI (figs. 7, 11, 12)—Paired foramina in the dorsal surface of the basisphenoid in most cases opening at the posterior margin of the SELLA TURCICA. These foramina are the anterior openings of the CANALIS CAROTICI INTERNI. The medialmost branch of the ARTERIA CAROTICA INTERNUS enters into the CAVUM CRANII here.

Siebenrock, 1897, figs. 1-9: "f. c. i." Ogushi, 1911, figs. 16, 21: "C. car." Zangerl, 1953, pl. 9: "for. a. cerebialis." Albrecht, 1967, figs. 1-3.

FORAMEN ANTERIUS CHORDA TYMPANI (fig. 17)—The anterior opening of the CANALIS CHORDA TYMPANI MANDIBULARIS in the lower jaw; contains the chorda tympani branch of the facial (VII) nerve; opens into the FOSSA MECKELII in *Chelydra* and is formed by the articular and prearticular bones. In *Podocnemis*, however, it opens on the medial face of the prearticular (Fuchs, 1931, pl. 2, fig. 5b).

Fuchs, 1931, pl. 2, fig. 5b.

FORAMEN AQUADUCTI VESTIBULI (fig. 8)—A notch or foramen in the medioventral wall of the CAVUM LABYRINTHICUM in the supraoccipital bone; opens into the

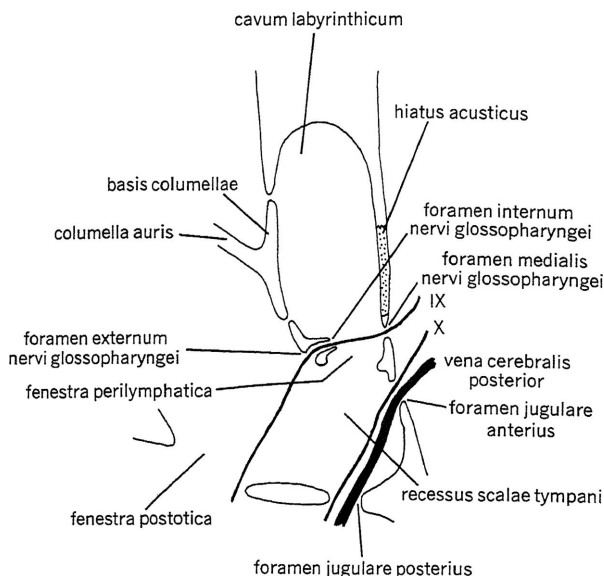


FIG. 9. *Chelydra serpentina*. Diagrammatic frontal section through left CAVUM LABYRINTHICUM and CAVUM ACUSTICO-JUGULARE. Cartilage is stippled [modified from Baird (1960, fig. 49)].

CAVUM CRANII and transmits the endolymphatic duct from the sacculus to the endolymphatic sac.

Siebenrock, 1897, figs. 10, 13-15: "a. v."

FORAMEN ARTERIAE ANTERIOVIDIANAE—A small opening on the dorsal surface of the pterygoid anterior to the anterior end of the CRISTA PTERYGOIDEA, posteromedial to the dorsal FORAMEN PALATINUM POSTERIUS in *Sternotherus* (Albrecht, 1967, p. 87); contains the anterior vidian artery in *Sternotherus*.

Albrecht, 1967, fig. 2.

FORAMEN ARTERIAE VIDIANAE—A series of "very small canals opening in the ventral surface of the palatine bone medial to the ventral foramen palatinum posterius . . ." (Albrecht, 1967, p. 87) in *Sternotherus*. A variable number of branches of the ARTERIA ANTERIOR VIDIANAE exit through these foramina to the roof of the mouth.

Albrecht, 1967, no figs.

FORAMEN CAROTICO-PHARYNGEALE (figs. 2, 12)—A ventral opening (or series of openings) in the pterygoid connecting with the CANALIS CAROTICUS LATERALIS. The ARTERIA CAROTICO-PHARYNGEALIS exits from the skull through this FORAMEN (Albrecht, 1967, p. 86).

McDowell, 1964, fig. 1: "fcp." Albrecht, 1967, no figs.

FORAMEN CAROTICUM LATERALE (figs. 11, 12, 20)—"In *Chrysemys*, *Sternotherus*, and *Trionyx*, the canalis caroticus internus on each side of the skull gives off an

anterior canal [the CANALIS CAROTICUS LATERALIS] in the pterygoid bone which opens into the sulcus cavernosus directly lateral to the basisphenoid" (Albrecht, 1967, p. 84). This opening is the FORAMEN CAROTICUM LATERALE, and in *Chrysemys* and *Sternotherus* (and most cryptodires) it carries the ARTERIA PALATINA, whereas in *Trionyx* the ARTERIA PSEUDOPALATINA passes through it.

Siebenrock, 1897, figs. 5, 8: "f. c. i'." Ogushi, 1911, fig. 23: "F. l. c. car." McDowell, 1961, figs. 1, 2: "APF." Albrecht, 1967, 1-3.

FORAMEN CAVERNOSUM (figs. 6, 20, 21)—The anterior opening of the CANALIS CAVERNOSUS into the CAVUM CRANII; is thus placed between the CANALIS CAVERNOSUS and the SULCUS CAVERNOSUS and traversed by the VENA CAPITIS LATERALIS; is in most cases formed by the pterygoid ventrally and the prootic dorsally. The posterior margin of the FORAMEN NERVI TRIGEMINI may also be the lateral margin of the FORAMEN CAVERNOSUM. Thus, the FORAMEN CAVERNOSUM is usually visible in anterolateral view through the FORAMEN NERVI TRIGEMINI. Kesteven, 1910, fig. 50: "67." Nick, 1912, fig. 9: "f. cav."

FORAMEN CHORDA TYMPANI INFERIUS (figs. 4, 18, 21)—The ventral and lateral opening of the CANALIS CHORDA TYMPANI QUADRATI; contains the chorda tympani branch of the facial (VII) nerve and usually occurs on the posterior face of the quadrate just below the INCISURA COLUMELLAE AURIS. Ogushi, 1911, figs. 15, 17, 18, 20: "F. ch. tym. i."

FORAMEN CHORDA TYMPANI SUPERIUS (fig. 18)—The dorsal and medial opening of the CANALIS CHORDA TYMPANI QUADRATI containing the chorda tympani branch of the facial (VII) nerve; is formed on the medial face of the quadrate near the INCISURA COLUMELLAE AURIS. Ogushi, 1911, figs. 18, 20: "F. ch. tym. i."

FORAMEN DENTOFACIALE MAJUS (figs. 15, 17)—An opening on the lateral surface of the lower jaw within the posterodorsal margin of the dentary; opens into a short canal (not named here) that extends anteroventromedially into the CANALIS ALVEOLARIS INFERIOR. I could not find a literature reference for the contents of this structure. Fuchs, 1931, pl. 2, figs. 5a, 6a.

FORAMEN EXTERNUM NERVI GLOSSOPHARYNGEI (figs. 9, 21)—The opening containing the glossopharyngeal (IX) nerve as it enters the CAVUM ACUSTICO-JUGULARE in the dorsal portion of the PROCESSUS INTERFENESTRALIS of the opisthotic. Ogushi, 1911, fig. 19: "F. p. IX." McDowell, 1964, fig. 2: "feg."

FORAMEN INTERMANDIBULARIS CAUDALIS (figs. 16, 17)—A small opening between the ventral region of the FOSSA MECKELII and the medial surface of the lower jaw. The RAMUS INTERMANDIBULARIS CAUDALIS of the mandibular (V_3) nerve passes through this structure. The FORAMEN is in most cases on the angular-prearticular suture but may not be completely surrounded by bone. Poglayen-Neuwall, 1953, fig. 10B, C, D: "R. int. c." McDowell, 1964, fig. 3: "mfp."

FORAMEN INTERMANDIBULARIS MEDIUS (fig. 16)—The large anterior opening of the FOSSA MECKELII on the medial surface of the lower jaw; is in most cases bounded posteriorly by the prearticular and anteriorly by the dentary. The RAMUS INTERMANDIBULARIS MEDIUS of the mandibular (V_3) nerve and in some cases (as in *Chelydra*) the meckelian cartilage are contained in the FORAMEN. Poglayen-Neuwall, 1953, fig. 10B, C, D: "R. int. m."

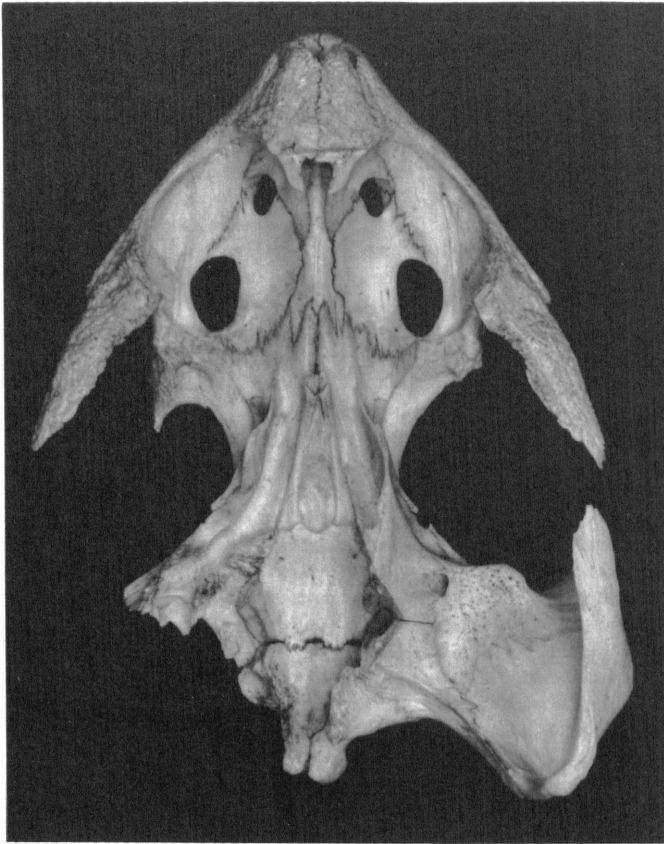


FIG. 10. *Chelydra serpentina*, AMNH 107386. Dorsal view of specimen with various bones removed to show features of basicranium.

FORAMEN INTERMANDIBULARIS ORALIS (figs. 16, 17)—A small opening or notch communicating between the anterior region of the **FOSSA MECKELII** and the medial surface of the lower jaw. The **RAMUS INTERMANDIBULARIS ORALIS** of the mandibular (V_3) nerve passes through this structure. The **FORAMEN** is formed by the prearticular and angular in *Chelydra* but may be present only as a notch or indentation in the angular or prearticular.

Poglayen-Neuwall, 1953, fig. 10B, C, D: "R. int. or." McDowell, 1964, fig. 3: "mfa."

FORAMEN INTERNUM NERVI GLOSSOPHARYNGEI (figs. 9, 19)—The opening at the point of exit of the glossopharyngeal (IX) nerve from the **CAVUM LABYRINTHICUM** into a canal leading to the **FORAMEN EXTERNUM NERVI GLOSSOPHARYNGEI**. Both **FORAMINA** are in the opisthotic. The **FORAMEN INTERNUM** is absent when the glossopharyngeal passes to the outside without actually entering the **CAVUM**

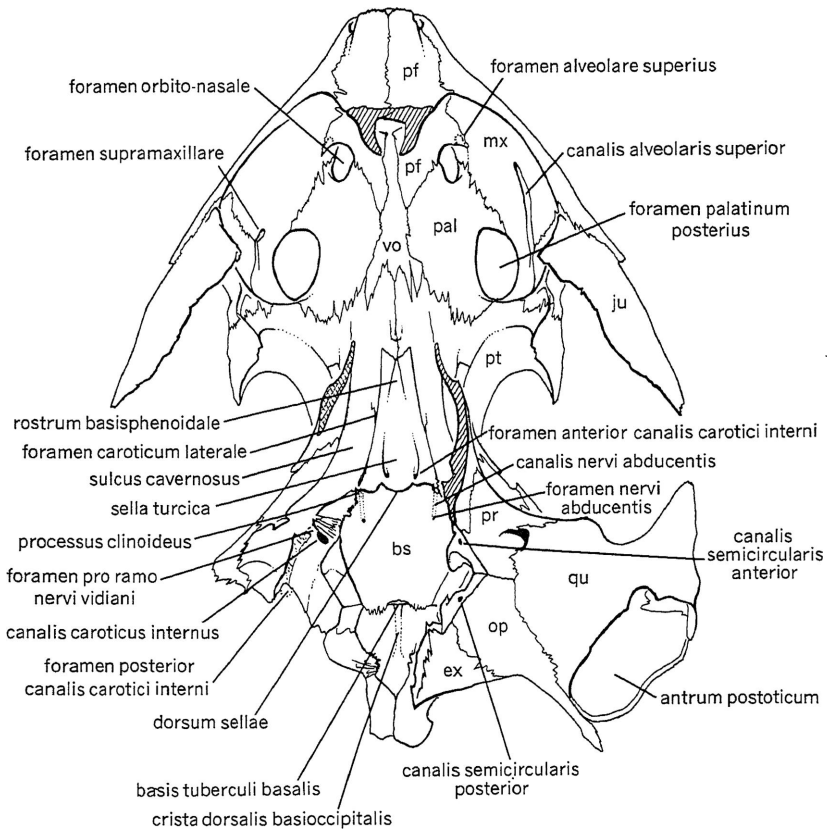


FIG. 11. *Chelydra serpentina*, AMNH 107386. Same specimen as figure 10 with structures labeled. Right squamosal is removed. Hatching indicates cut surfaces.

LABYRINTHICUM. Ogushi (1911, fig. 24, line between asterisks) showed the path of the glossopharyngeal (IX) nerve through the **CAVUM LABYRINTHICUM** in *Trionyx*.

Siebenrock, 1897, figs. 10, 13, 15: "IX." Ogushi, 1911, fig. 23: "F. a. IX."

FORAMEN INTERORBITALE (figs. 3, 6, 7)—The paired openings between the orbits filled in life with cartilage; traversed by the optic nerves (II), portions of the eye muscles and the oculomotor (III), trochlearis (IV), and a branch of the trigeminal (V) cranial nerves. Dorsally, the ridge defining the **SULCUS OLFACTORIUS** forms a border for the **FORAMEN INTERORBITALE**. The following bones may take part in the formation of the **FORAMEN INTERORBITALE**: prefrontal, frontal, parietal, epipterygoid, pterygoid, palatine, and vomer.

Ogushi, 1911, figs. 14, 16: "F. intorb." Wegner, 1959, fig. 4: "fenestra interseptalis."

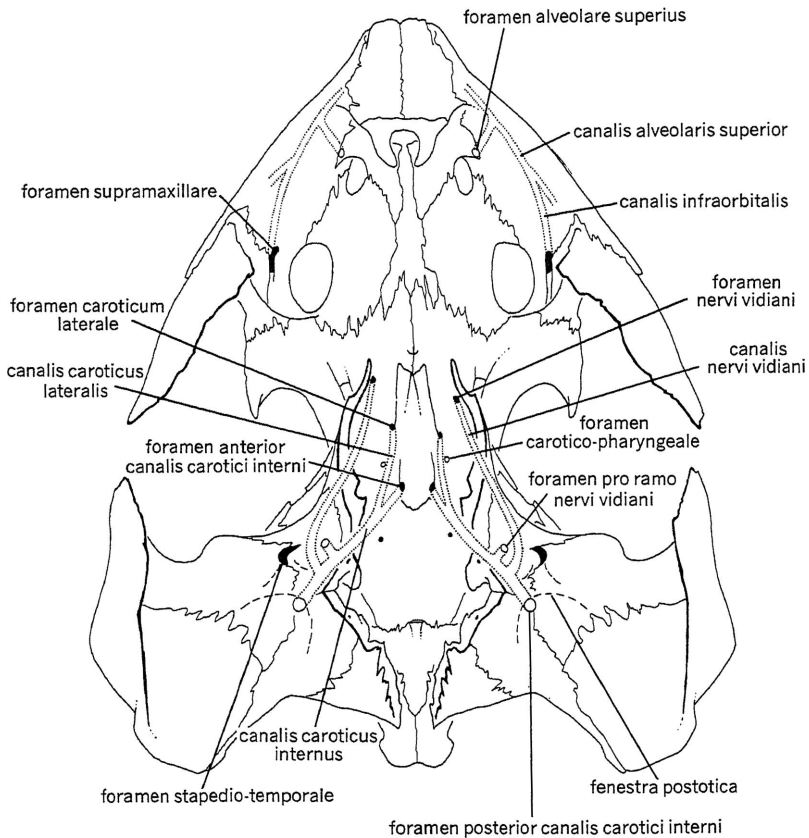


FIG. 12. *Chelydra serpentina*. Composite dorsal view of specimen showing internal canals (dotted). Foramina visible on dorsal surfaces shown solid; foramina hidden in dorsal view are open circles. Diameter of canals exaggerated for visibility.

FORAMEN JUGULARE ANTERIUS (figs. 7-9, 19)—The opening between the CAVUM CRANII and the RECESSUS SCALAE TYMPANI portion of the CAVUM ACUSTICO-JUGULARE through which pass the vagus (X) and accessory (XI) nerves and the VENA CEREBRALIS POSTERIOR (or VENA JUGULARIS of mammals). The FORAMEN is usually bounded anteriorly by the opisthotic and posteriorly by the exoccipital.

Siebenrock, 1897, figs. 1-9: "f. j. a." Ogushi, 1911, figs. 16, 19, 23: "F. jug. in."

FORAMEN JUGULARE POSTERIUS (figs. 4, 9)—An opening formed mostly by the exoccipital communicating between the RECESSUS SCALAE TYMPANI (a part of the CAVUM ACUSTICO-JUGULARE) and the outside of the skull; faces posteriorly and may be confluent with the FENESTRA POSTOTICA or completely absent; is traversed by the VENA CEREBRALIS POSTERIOR and in some cases by the vagus (X) and accessory (XI) nerves.

Siebenrock, 1897, figs. 18–21, 23–25: “f. j. p.” Ogushi, 1911, fig. 17: “F. jug. ex.” (the FORAMEN is incomplete laterally).

FORAMEN MAGNUM (figs. 4, 7, 19)—The large medial opening at the posterior end of the skull, opening posteriorly and placed just above the CONDYLUS OCCIPITALIS; transmits the spinal cord from the CAVUM CRANII to the outside of the skull. The following bones may be involved in the formation of the FORAMEN MAGNUM: supraoccipital, exoccipital, and basioccipital.

Ogushi, 1911, fig. 17: “F. oc.” Nick, 1912, fig. 4: “F. m.”

FORAMEN MEDIALIS NERVI GLOSSOPHARYNGEI (figs. 8, 9, 19)—The exit of the glossopharyngeal (IX) nerve from the CAVUM CRANII occurs either in cartilage (the HIATUS ACUSTICUS) or bone; when ossified, this structure is usually found in the opisthotic.

Siebenrock, 1897, figs. 1, 3, 5–9: “IX.” Ogushi, 1911, fig. 16: “F. a. IX.”

FORAMEN NERVI ABDUCENTIS (figs. 7, 11)—The anterior and posterior openings of the CANALIS NERVI ABDUCENTIS. The abducent (VI) nerve enters and exits via these FORAMINA in the basisphenoid.

Siebenrock, 1897, figs. 1–4, 6, 8, 9, 28–31: “VI.” Ogushi, 1911, fig. 16: “F. VI.”

FORAMEN NERVI ACUSTICI (fig. 8)—The FORAMINA, in most cases in the FOSSA ACUSTICO-FACIALIS, through which the branches of the acoustic (VIII) nerve exit from the CAVUM CRANII and enter the CAVUM LABYRINTHICUM. There are usually two FORAMINA and these are formed by the prootic bone.

Siebenrock, 1897, figs. 3, 6–14: “VIII, VIII α , VIII β , VIII γ .” Ogushi, 1911, figs. 16, 23, 27: “F. VIIIa pr., F. VIIIa acc.”

FORAMEN NERVI AURICULOTEMPORALIS (fig. 15)—An opening (may be more than one) in the posterior portion of the lateral surface of the lower jaw containing the auriculotemporalis nerve of Fuchs (1931) which appears to be the RAMUS CUTANEUS RECURRENS branch of the mandibular (V₃) nerve of Soliman (1964, fig. 15). The FORAMEN or FORAMINA are in most cases formed by the surangular bone.

Fuchs, 1931, pl. 2, fig. 5a. Poglayen-Neuwall, 1953, figs. 5b, 7b: “Ff. R. cut. rec.” Ogushi, 1911, fig. 14: “Os. buc. sup.” and “Os. buc. inf.”

FORAMEN NERVI FACIALIS (figs. 8, 21)—The opening, in most cases in the FOSSA ACUSTICO-FACIALIS in the prootic bone, through which the facial (VII) nerve exits from the CAVUM CRANII and enters the SULCUS CAVERNOSUS; may communicate with the FORAMEN PRO RAMO NERVI VIDIANI.

Siebenrock, 1897, figs. 3, 4, 6, 9, 10, 15: “VII.” Kesteven, 1910, fig. 49: “36.” Ogushi, 1911, fig. 16: “F. VII.” Parsons and Williams, 1961, fig. 8: “FNF.”

FORAMEN NERVI HYPOGLOSSI (figs. 4, 7, 19)—The openings by which branches of the hypoglossal (XII) nerve leave the CAVUM CRANII. The FORAMINA NERVI HYPOGLOSSI are in general formed by the exoccipital bone and in some cases by the basioccipital.

Siebenrock, 1897, figs. 1–9, 18–25: “XII.” Ogushi, 1911, fig. 18: “For. XII”; figs. 16, 17, 23: “Ff. n. XII.”

FORAMEN NERVI TRIGEMINI (figs. 6–8, 20, 21)—The opening between the CAVUM CRANII and FOSSA TEMPORALIS INFERIOR, in most cases bordered, at least in part, by the prootic posteriorly, the pterygoid ventrally, and the parietal dorsally. Two branches (V₂, V₃) of the trigeminal (V) nerve exit here along with the ARTERIA MANDIBULARIS in cryptodires (Soliman, 1964; Albrecht, 1967). Only the nerves exit in pleurodires.

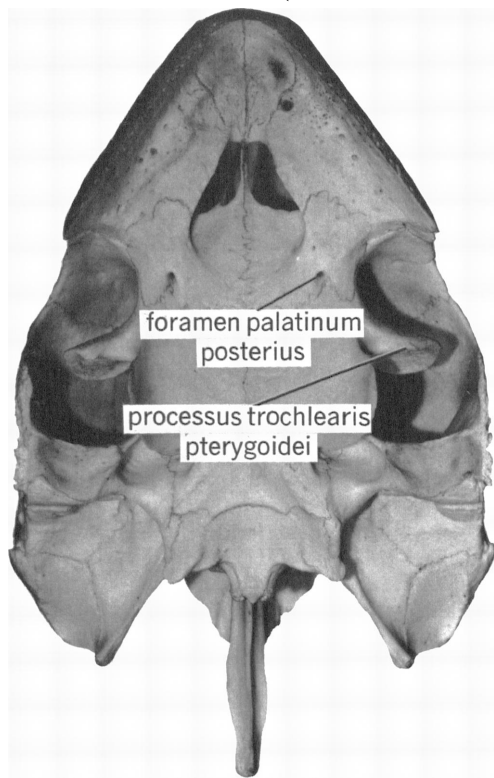


FIG. 13. *Podocnemis expansa*. Ventral view of skull.

Siebenrock, 1897, figs. 1-9: "F. s."; figs. 32-36, 38, 39: "i. s." Ogushi, 1911, figs. 16, 23: "F. sph."; figs. 19, 28: "M. f. sph." Wegner, 1959, pls. 8, 9, figs. 4, 32, 33: "foramen interpilare." McDowell, 1961, figs. 1, 2: "TRA."

FORAMEN NERVI VIDIANI (figs. 12, 20 [2 places])—Any opening of the **CANALIS NERVI VIDIANI** into the **CAVUM CRANII**. The palatine branch of the facial (VII) nerve (see Soliman, 1964) and various small arteries (see Albrecht, 1967) in most cases traverse this **FORAMEN**. The **FORAMEN** (or **FORAMINA**) is usually formed by the pterygoid and/or palatine bones.

Siebenrock, 1897, figs. 1, 5, 6: "f. vi." Ogushi, 1911, fig. 16: "d." Albrecht, 1967, fig. 3.

FORAMEN ORBITO-NASALE (figs. 2-4, 6, 7, 11)—An opening between the **FOSSA NASALIS** and the **FOSSA ORBITALIS** generally situated in the posteroventrolateral region of the **FOSSA NASALIS**; transmits the posterior nasal artery from the **FOSSA ORBITALIS** to the **FOSSA NASALIS** (Albrecht, 1967). The prefrontal, palatine, and maxilla in most cases participate in the formation of the **FORAMEN ORBITO-NASALE**.

Kesteven, 1910, figs. 44-46: "64." Ogushi, 1911, figs. 13, 15, 16, 18: "F. orb. nas."

FORAMEN PALATINUM ACCESSORIUM—In *Trionyx*, the ventral opening (actually a variable number of small FORAMINA) of the CANALIS INTRAPALATINUS in the palatine bone (Albrecht, 1967, p. 88). A small branch of the inframaxillary artery goes through the CANALIS INTRAPALATINUS and exits through these FORAMINA to supply tissue on the roof of the mouth (Albrecht, 1967, p. 94). Albrecht, 1967, no figs.

FORAMEN PALATINUM POSTERIUS (figs. 2, 11, 13)—An opening between the palatal surface of the skull and the area just behind the FOSSA ORBITALIS (pleurodires) or at the posteriormost limits of the FOSSA ORBITALIS (cryptodires); transmits the inframaxillary artery from the skull to the palate (Albrecht, 1967). The maxilla, palatine, and pterygoid may participate in the formation of the FORAMEN PALATINUM POSTERIUS.

Siebenrock, 1897, figs. 2, 4, 5: "f. p. p." Albrecht, 1967, figs. 1-3.

FORAMEN POSTERIOR CANALIS CAROTICI INTERNI (figs. 2, 6, 11, 12, 20)—The most posterior opening of the CANALIS CAROTICUS INTERNUS. The ARTERIA CAROTICA INTERNA enters the CANALIS at this FORAMEN; in most cases contained within the pterygoid; in some forms the basisphenoid may enter the margin of the FORAMEN.

Kesteven, 1910, fig. 36: "16"; fig. 42: "13"; figs. 49, 50: "13." Ogushi, 1911, figs. 15, 17: "F. p. c. car." Wegner, 1959, figs. 8, 10: "foramen caroticum." Albrecht, 1967, figs. 1-3.

FORAMEN POSTERIUS CHORDA TYMPANI (figs. 14, 17)—The posterior opening of the CANALIS CHORDA TYMPANI MANDIBULARIS in the lower jaw; contains the chorda tympani branch of the facial (VII) nerve. The FORAMEN is formed by the articular and prearticular and occurs on the medial edge of the AREA ARTICULARIS MANDIBULARIS in *Chelydra*.

Fuchs, 1931, pl. 1, fig. 3: "Foramen chordae tympani"; pl. 2, fig. 5b. McDowell, 1964, fig. 3: "ct."

FORAMEN PRAEPALATINUM (figs. 2, 4, 7)—Paired FORAMINA in the anterior part of the palate that extend between the palate and FOSSA NASALIS; transmits the anterior nasal artery from the palate into the nasal tissue (Albrecht, 1967, p. 94; Seydel, 1896); is in most cases formed by the vomer and premaxilla.

Nick, 1912, fig. 17: "f. prp." Parsons and Williams, 1961, figs. 1, 2: "FPR."

FORAMEN PRO RAMO NERVI VIDIANI (figs. 11, 12, 20)—A short canal connecting the CANALIS CAROTICUS INTERNUS with the CANALIS CAVERNOSUS; transmits the vidian nerve (palatine branch of VII) and a small branch of the internal carotid artery (Albrecht, 1967). The CANALIS NERVI VIDIANI in most cases extends anteriorly from the FORAMEN PRO RAMO NERVI VIDIANI and contains branches of the vidian nerve and blood vessels (Albrecht, 1967, p. 87).

Siebenrock, 1897, figs. 35, 38: "f. vi." Ogushi, 1911, fig. 22: "C. r. com. pal. VII"; fig. 28: "*---*." Albrecht, 1967, figs. 1-3.

FORAMEN STAPEDIO-TEMPORALE (figs. 1, 12, 18)—The dorsal opening of the CANALIS STAPEDIO-TEMPORALIS into the FOSSA TEMPORALIS. The ARTERIA STAPEDIALIS passes through this structure. The prootic and quadrate form the FORAMEN STAPEDIO-TEMPORALE.

Siebenrock, 1897, fig. 27: "f. c. t." Kesteven, 1910, fig. 48: "42." Ogushi, 1911, figs. 13, 21: "C. art. temp. p." Albrecht, 1967, figs. 1-3.

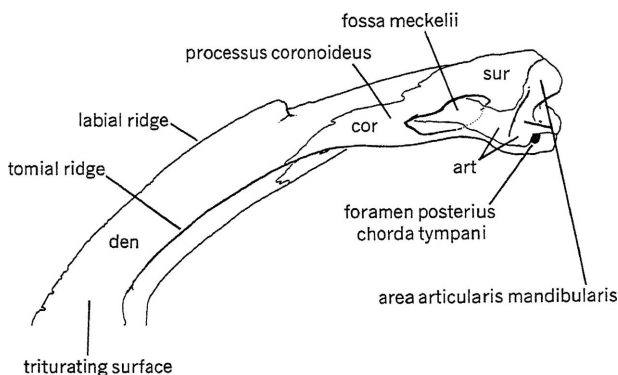


FIG. 14. *Chelydra serpentina*, AMNH 67015. Dorsal view of right lower jaw ramus.

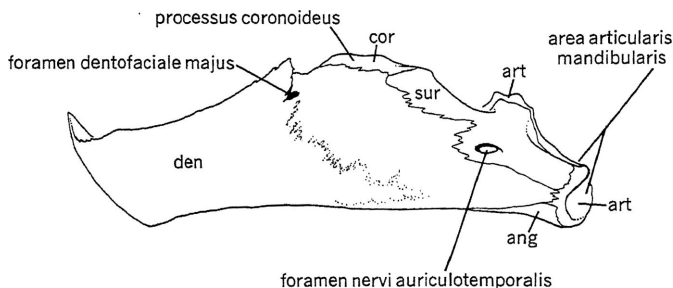


FIG. 15. *Chelydra serpentina*, AMNH 67015. Lateral view of left lower jaw ramus.

FORAMEN SUPRAMAXILLARE (figs. 1, 11, 12)—An opening in the maxilla in the floor of the FOSSA ORBITALIS; FORAMEN SUPRAMAXILLARE leads into the CANALIS INFRAORBITALIS and transmits the ARTERIA SUPRAMAXILLARIS (Albrecht, 1967). Ogushi, 1911, fig. 13: "S. orb. lat." Albrecht, 1967, figs. 1-3.

FORAMEN SUPRAORBITALE—An "extremely small arterial foramen . . . located on the prefrontal bone in the anterodorsal part of the orbit, dorsolateral from the dorsal edge of the fissura ethmoidalis" (Albrecht, 1967, p. 88); contains a branch of the ARTERIA SUPRAORBITALIS (*ibid.*). Albrecht, 1967, figs. 1-3.

FOSSA ACUSTICO-FACIALIS (fig. 7)—A depression in that part of the prootic that forms the lateral wall of the CAVUM CRANII. There are usually three FORAMINA in this FOSSA: the FORAMEN NERVI FACIALIS and two FORAMINA NERVI ACUSTICI. The FOSSA contains the GANGLION VESTIBULARE (Soliman, 1964). Siebenrock, 1897, figs. 1, 2, 5, 7, 8: "m. a."

FOSSA CARTILAGINIS EPIPTERYGOIDEI (figs. 1, 6)—The space between the postero-ventral process of the epipterygoid (or parietal if epipterygoid is absent) and the PROCESSUS EPIPTERYGOIDEUS of the quadrate which is occupied in life by a remnant of the palatoquadrate cartilage. The limits of the FOSSA are usually

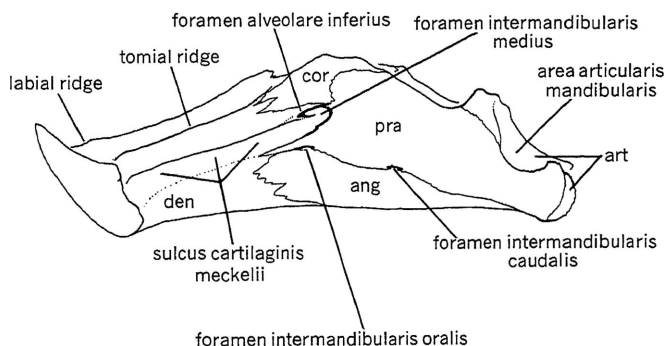


FIG. 16. *Chelydra serpentina*, AMNH 67015. Medial view of right lower jaw ramus.

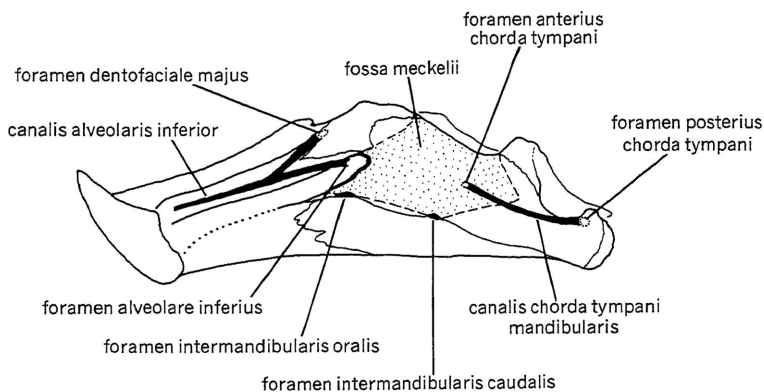


FIG. 17. *Chelydra serpentina*, AMNH 67015, with internal details from other specimens. Medial view of right lower jaw ramus showing internal structures. FOSSA MECKELII stippled, internal canals in black, hidden foramina open circles, visible foramina solid.

formed by the quadrate, pterygoid, and epipterygoid (or parietal).

Wegner, 1959, figs. 2-6, 8.

FOSSA MECKELII (figs. 14, 17)—In the lower jaw, a space behind the PROCESSUS CORONOIDEUS and anterior to the jaw articulation that is open dorsally and communicates anteriorly with the SULCUS CARTILAGINIS MECKELII. Schumacher (1954, 1955a, 1955b) reported muscle fibers of the *M. PSEUDOTEMPORALIS* and *M. ADDUCTOR MANDIBULAE POSTERIOR* in the FOSSA MECKELII.

Ogushi, 1911, fig. 34: "Os. sup. c. infm." Schumacher, 1955a, fig. 8: "Fossa primordialialis."

FOSSA NASALIS (fig. 7)—The large, median cavity at the very front of the skull, anterior and median to the FOSSA ORBITALIS. This cavity houses the nasal cap-

sules and cavities. The nasal (when present), prefrontal, maxilla, premaxilla, and vomer usually participate in the formation of this FOSSA.

Ogushi, 1911, fig. 16: "Cav. nas." Wegner, 1959, pl. 9.

FOSSA ORBITALIS (figs. 1, 3)—The bony socket for the eye, usually poorly defined and open to the FOSSA TEMPORALIS, CAVUM CRANII, and FOSSA NASALIS. The following bones usually form parts of the FOSSA ORBITALIS: prefrontal, maxilla, jugal, palatine, postorbital, and parietal.

Ogushi, 1911, fig. 16: "F. orb."

FOSSA TEMPORALIS INFERIOR (fig. 2)—The space below the level of the otic chamber and anterior to it and continuous with the FOSSA TEMPORALIS SUPERIOR; contains the M. ADDUCTOR MANDIBULAE INTERNUS, part of the M. ADDUCTOR MANDIBULAE EXTERNUS, and the M. PTERYGOIDEUS. Parietal, postorbital, jugal, maxilla, quadratojugal, pterygoid, epipterygoid (when present), prootic, and quadrate in most cases are involved in forming the FOSSA TEMPORALIS INFERIOR. Ogushi, 1911, figs. 13, 15, 19: "F. int. temp."

FOSSA TEMPORALIS SUPERIOR (fig. 4)—The space above and behind the otic chamber and below the temporal roof (if present); contains the main mass of the M. ADDUCTOR MANDIBULAE EXTERNUS. The following bones usually form the boundaries of the FOSSA TEMPORALIS SUPERIOR: supraoccipital, parietal, prootic, opisthotic, quadrate, squamosal, postorbital, and exoccipital.

Ogushi, 1911, figs. 13, 14: "Fos. m. temp." Nick, 1912, fig. 12: "fo. te." Schumacher, 1955a, fig. 5.

HIATUS ACUSTICUS (figs. 7, 9)—The large, irregular opening between the CAVUM CRANII and the CAVUM LABYRINTHICUM; in life is occupied by a cartilaginous wall; in some forms may be ossified. The following bones in most cases form the margins of the HIATUS ACUSTICUS: supraoccipital, prootic, basisphenoid, basioccipital, and opisthotic. Siebenrock (1897, figs. 1–9) illustrated variable conditions of ossification of the bones surrounding the HIATUS ACUSTICUS.

Kesteven, 1910, fig. 49: "56." Ogushi, 1911, fig. 23: "X."

INCISURA COLUMELLAE AURIS (figs. 3, 18)—The groove or canal within the quadrate which contains the COLUMELLA AURIS. In some turtles the INCISURA also contains the eustachian tube.

Siebenrock, 1897, figs. 16, 18, 19: "i. cl."; figs. 17, 27: "f. cl." Ogushi, 1911, figs. 14, 19: "F. ov. sec."

MEATUS CHOANAE—A tunnel or tube connecting the FOSSA NASALIS and the APERTURA NARIUM INTERNA, not developed in most turtles.

Kesteven, 1910, fig. 44: "63." Wegner, 1959, fig. 20: "Canalis choanalis."

PROCESSUS ARTICULARIS (figs. 3, 4, 18)—The ventral process of the quadrate that bears the actual articulation with the lower jaw, the CONDYLUS MANDIBULARIS. Schumacher, 1954, pl. 10, fig. 1: "Proc. articularis quadrate"; 1955a, figs. 2, 5, 7: "Proc. art. oss. quadrati." Wegner, 1959, figs. 7, 12: "Proc. articularis quadrati."

PROCESSUS CLINOIDEUS (figs. 6, 7, 11)—Paired anterolateral spines on the basisphenoid, generally on either side of the DORSUM SELLAE. The CANALIS NERVI ABDUCENTIS in most turtles penetrates the base of the PROCESSUS.

Siebenrock, 1897, figs. 29–31: "p. cl." Zangerl, 1953, pl. 9.

PROCESSUS CORONOIDEUS (figs. 14, 15)—A dorsally directed process of the lower jaw generally developed on the coronoid bone; is found between the triturating surface and the FOSSA MECKELII. Fibers of the M. ADDUCTOR MANDIBULAE EX-

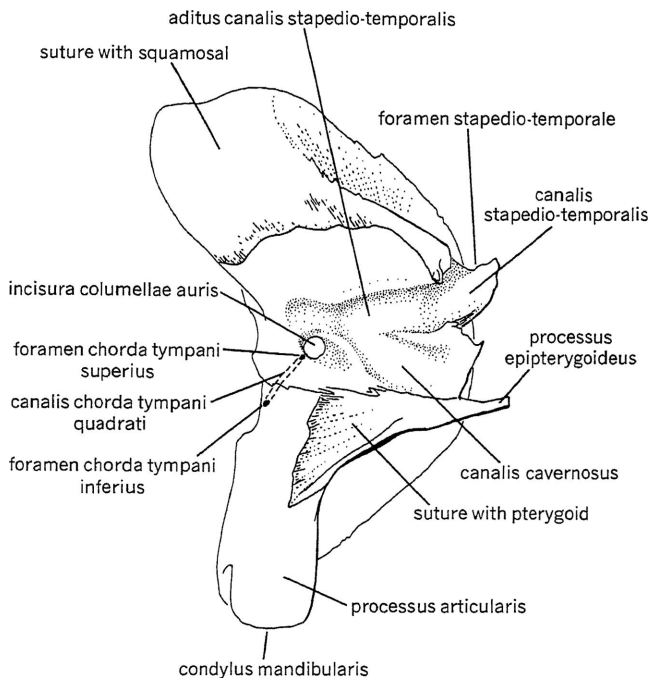


FIG. 18. *Chelydra serpentina*, AMNH 107386. Medial view of left quadrate.

TERNUS attach on the PROCESSUS along with the main external adductor tendon (Schumacher, 1954, 1955a, 1955b).

Ogushi, 1911, figs. 32, 34: "Pr. coron." Schumacher, 1954, pls. 1-13; 1955a, figs. 8, 9.

PROCESSUS EPIPTERYGOIDEUS (figs. 6, 18, 21)—An anterior extension of the quadrate, generally found below the FORAMEN NERVI TRIGEMINI in the FOSSA SUBTEMPORALIS; process generally extends toward the epipterygoid or a ventral extension of the parietal if the epipterygoid is absent.

Siebenrock, 1897, figs. 16, 17: "p. e." Kesteven, 1910, figs. 31, 32, 34, 35: "6." Wegner, 1959, fig. 3: "Proc. pterygoideus os. quadrati"; fig. 33: "Proc. vaginalis quadrati."

PROCESSUS INFERIOR PARIETALIS (figs. 6, 7)—The ventral process of the parietal that forms a lateral wall for the CAVUM CRANII; the PROCESSUS generally has an extensive ventral contact with the CRISTA PTERYGOIDEA and forms part of the lateral wall between the CAVUM CRANII and the FOSSA TEMPORALIS.

Kesteven, 1910, figs. 15, 16: "2." Wegner, 1959, figs. 3, 5: "Pila pterygoidea"; figs. 33, 35: "Pila prootica+Pila pterygoidea+Pila palatina"; fig. 37: "Pila pterygoidea+Pila prootica."

PROCESSUS INTERFENESTRALIS (figs. 6, 19, 21)—A ventral process of the opisthotic extending into the CAVUM ACUSTICO-JUGULARE and separating the CAVUM into

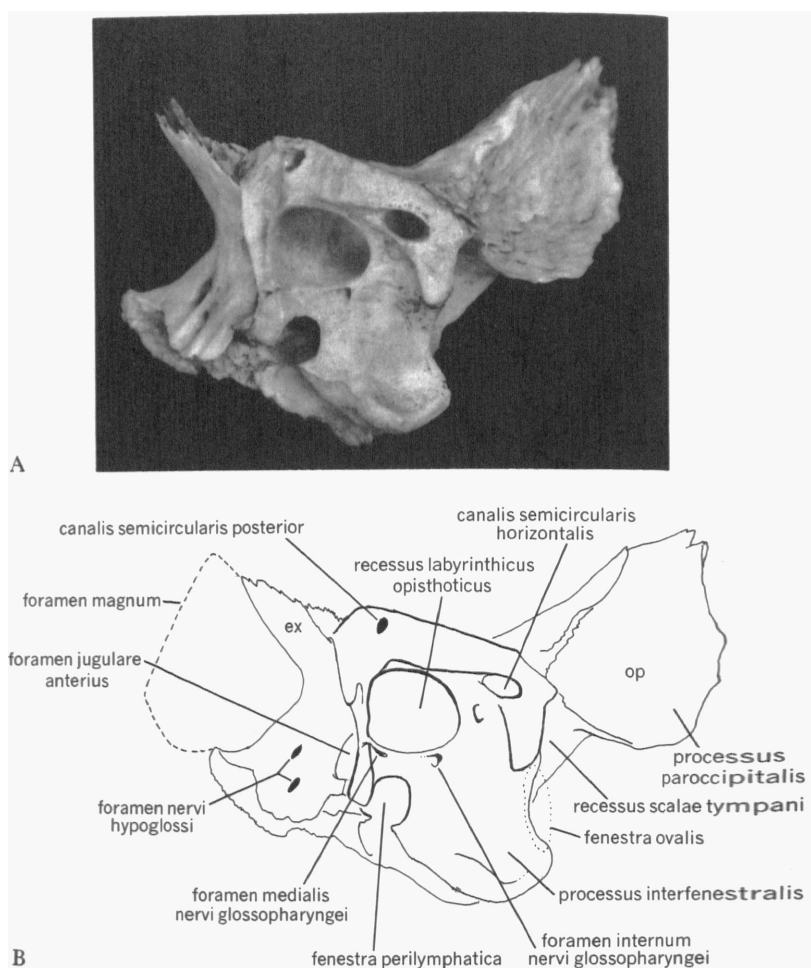


FIG. 19. *Chelydra serpentina*, AMNH 107386. Posterior and slightly medial view of left opisthotic and exoccipital exposing posterior half of CAVUM LABYRINTHICUM. A. Photograph of elements. B. Labeled diagram.

two parts, lateral and posterior, the latter being the RECESSUS SCALAE TYMPANI. The FORAMEN INTERNUM Nervi GLOSSOPHARYNGEI and FORAMEN EXTERNUM Nervi GLOSSOPHARYNGEI generally penetrate the dorsal portion of the process. The anterior surface of the PROCESSUS walls the CAVUM LABYRINTHICUM. Siebenrock, 1897, figs. 13–15: “v.” Kesteven, 1910, figs. 28, 29: “10”; fig. 50: “35.” McDowell, 1964, figs. 1, 2: “pi.” PROCESSUS PAROCCIPITALIS (figs. 4, 19, 21)—The posterolateral process of the

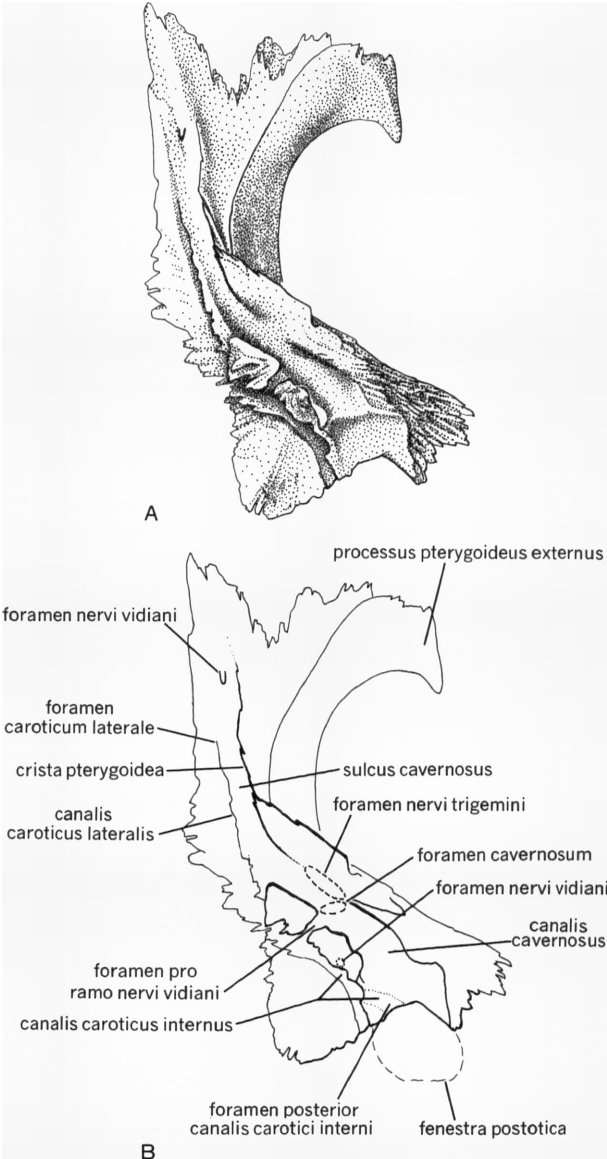


FIG. 20. *Chelydra serpentina*, AMNH 107388. Dorsal view of right pterygoid. A. Stippled drawing. B. Labeled diagram.

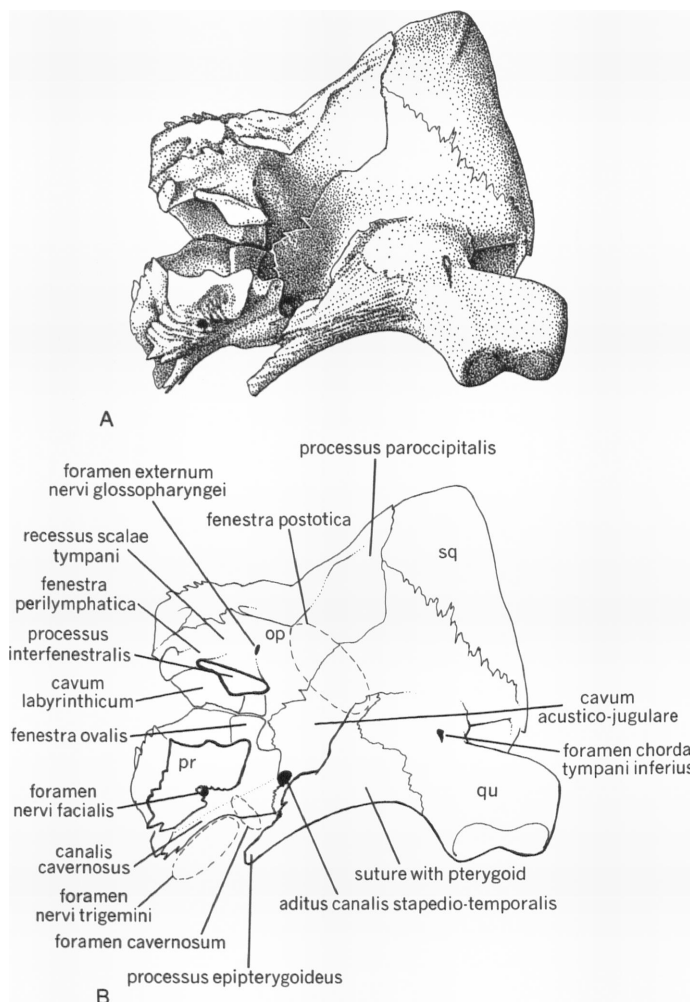


FIG. 21. *Chelydra serpentina*, AMNH 107388. Ventral view of right otic chamber (consisting of quadrate, squamosal, opisthotic, and prootic) with ventral elements removed to expose the CAVUM ACUSTICO-JUGULARE and the CAVUM LABYRINTHICUM. Posterior is toward top of page, lateral to the right. A. Stippled drawing. B. Labeled diagram.

opisthotic that contacts the quadrate and squamosal laterally.

Siebenrock, 1897, figs. 18–25: the process of the opisthotic labeled “pa. o.”

Ogushi, 1911, fig. 26: “Pr. coch.” + “Pr. lat.”

PROCESSUS PTERYGOIDEUS EXTERNUS (figs. 2–4, 20)—The lateral process of the

pterygoid in cryptodires that extends around the anteromedial edge of the FOSSA TEMPORALIS INFERIOR and may extend into the FOSSA. The lateral edge is generally produced into a vertical plate that acts as a guide for the lower jaw during adduction of the lower jaw.

Siebenrock, 1897, figs. 33–36, 38, 39: “p. e. p.” McDowell, 1964, figs. 3, 4: “lpp.”

PROCESSUS TROCHLEARIS OTICUM (fig. 1)—The extension or area on the otic chamber developed for an articular facet with the CARTILAGO TRANSILIENS; it is generally borne mostly by the quadrate with a smaller contribution from the prootic, and found only in cryptodires.

Ogushi, 1911, figs. 13, 20–22: “Troch.” Schumacher, 1954, fig. 23, pls. 7, 10:

“Proc. trochlearis”; 1955a, fig. 6; 1955b, pls. 4, 6, 7: “Proc. trochlearis.”

Wegner, 1959, figs. 4, 31–33: “Processus trochlearis.”

PROCESSUS TROCHLEARIS PTERYGOIDEI (fig. 13)—A lateral extension of the pterygoid into the FOSSA TEMPORALIS INFERIOR which supports the CARTILAGO TRANSILIENS; the PROCESSUS is generally convex outward or forward and is found only in pleurodires.

Schumacher, 1954, fig. 25, pls. 5, 6, 9, 11, 13; 1955a, figs. 1, 2; 1955b, pl. 3.

RECESSUS LABYRINTHICUS OPISTHOTICUS (fig. 19)—A hemispherical cavity off the CAVUM LABYRINTHICUM in the opisthotic that houses the posterior ampulla and the union of the posterior and horizontal semicircular canals.

Siebenrock, 1897, figs. 10–15: “a. f.” Kesteven, 1910, fig. 29: “6.” Ogushi, 1911, fig. 23, 24, 26: “rec. p.”

RECESSUS LABYRINTHICUS PROOTICUS—A hemispherical cavity off the CAVUM LABYRINTHICUM in the prootic that houses the ampullae of the anterior and horizontal semicircular canals.

Siebenrock, 1897, figs. 10–15: “a. s.” Kesteven, 1910, fig. 30: “1.” Ogushi, 1911, fig. 22: “Atr. amp. a.”; fig. 27: head of lefthand arrow.

RECESSUS LABYRINTHICUS SUPRAOCCIPITALIS—A variously shaped cavity off the CAVUM LABYRINTHICUM in the supraoccipital that houses the union of the anterior and posterior semicircular canals.

Siebenrock, 1897, figs. 10–15 (unlabeled). Kesteven, 1910, fig. 26: “7.” Ogushi, 1911, fig. 25: “Rec. s.”

RECESSUS SCALAE TYMPANI (figs. 6, 9, 19, 21)—That portion of the CAVUM ACUSTICO-JUGULARE lying roughly posterior to the PROCESSUS INTERFENESTRALIS of the opisthotic. The vagus (X) nerve and the VENA CEREBRALIS POSTERIOR traverse the posterior part of the chamber. Most of the RECESSUS is filled by the periotic sac (Baird, 1960).

McDowell, 1964, fig. 2: “rst.”

ROSTRUM BASISPHENOIDALE (figs. 6, 7, 11)—The anterior elongation of the basisphenoid anterior to the SELLA TURCICA.

Siebenrock, 1897, figs. 28–31: “p. t. i.” Zangerl, 1953, pl. 9. Wegner, 1959, figs. 3, 5: “Spina basisphenoidea”; fig. 4: “Spina os. sphenoidalis.”

SELLA TURCICA (figs. 7, 11)—The pit or depression in the anterior part of the dorsal surface of the basisphenoid that houses the pituitary.

Ogushi, 1911, fig. 29: “Sel. t.” Zangerl, 1953, pl. 9: “fossa hypophyseos.”

SULCUS CARTILAGINIS MECKELII (fig. 16)—A medially concave groove on the inside of the dentary bone of the lower jaw extending anteriorly from the FOSSA MECKELII.

Ogushi, 1911, fig. 32: “S. infirm.”

SULCUS CAVERNOSUS (figs. 6, 11, 20)—A long trough lying on the floor of the **CAVUM CRANII** medial to the **CRISTA PTERYGOIDEA** on the pterygoid and lateral to the **ROSTRUM BASISPHENOIDALE**; begins at the anterior opening of the **CANALIS CAVERNOSUS** and continues anteromedially. The **VENA CAPITIS LATERALIS** travels along the **SULCUS**.

Siebenrock, 1897, figs. 32–39: "S. C." Ogushi, 1911, figs. 28, 30: "S. cav."

SULCUS OLFACTORIUS (fig. 7)—A ventrally open median trough extending from the **CAVUM CRANII** into the **FOSSA NASALIS**; carries the olfactory (I) nerve to the nasal capsule.

Kesteven, 1910, fig. 14: "2."

SULCUS VOMERI (fig. 7)—A dorsally open, median groove extending posteriorly from the **FOSSA NASALIS** and formed by the vomer; supports the cartilaginous **SEPTUM NASALIS** (Soliman, 1964, figs. 12, 23).

Kesteven, 1910, figs. 11, 12: "5." Ogushi, 1911, fig. 30: "S. vom."

TUBERCULUM BASIOCCIPITALE (figs. 2, 4)—Paired posterolateral processes formed on the ventral surface of the basioccipital.

Kesteven, 1910, figs. 42, 43, 50: "12." Ogushi, 1911, figs. 14, 15, 17: "Pr. p. B."

REFERENCES CITED

ALBRECHT, W.

1967. The cranial arteries and cranial arterial foramina of the turtle genera *Chrysemys*, *Sternotherus*, and *Trionyx*: a comparative study with analysis of possible evolutionary implications. *Tulane Studies Zool.*, vol. 14, pp. 81–99.

BAIRD, I. L.

1960. A survey of the periotic labyrinth in some representative recent reptiles. *Kansas Univ. Sci. Bull.*, vol. 41, pp. 891–981.

BOJANUS, L. H.

- 1819 [reprinted 1970]. *Anatome Testudinis Europaeae*. Soc. Study Amphibians Reptiles, Facsimile Reprints Herpetol., no. 26, pp. i–vi+179 pp.

FUCHS, H.

1931. Über den Unterkiefer und die Unterkiefernnerven (Ramus tertius nervi trigemini et Chorda tympani) der Arrauschildkröte (*Podocnemis expansa*). Nebst Bemerkungen zur Kiefergelenksfrage. *Zeitschr. Anat. Entwickl.*, vol. 94, pp. 206–274.

KESTEVEN, H. L.

1910. The anatomy of the head of the green turtle *Chelone midas*, Latr., Part I. The skull. *Jour. Proc. Roy. Soc. New South Wales*, vol. 44, pp. 368–400.

MCDOWELL, S. B.

1961. On the major arterial canals in the ear region of testudinoid turtles and the classification of the Testudinoidea. *Bull. Mus. Comp. Zool.*, vol. 125, no. 2, pp. 23–39.

1964. Partition of the genus *Clemmys* and related problems in the taxonomy of the aquatic Testudinidae. *Proc. Zool. Soc. London*, vol. 143, pp. 239–279.

NICK, L.

1912. Das Kopfskelet von *Dermochelys coriacea* L. *Zool. Jahrb., Abt. Anat.*, vol. 33, pp. 1–238.

OGUSHI, K.

1911. Anatomische Studien an der japanischen dreikralligen Lippenschild-

- kröte (*Trionyx japonicus*). Part I. Mitt. Morph. Jahrb., vol. 43, pp. 1-106.
- PARSONS, T. S., AND E. E. WILLIAMS
1961. Two Jurassic turtle skulls: a morphological study. Bull. Mus. Comp. Zool., vol. 125, pp. 43-107.
- POGLAYEN-NEUWALL, I.
1953. Untersuchungen der Kiefermuskulatur und deren Innervation bei Schildkröten. Acta Zool., vol. 34, pp. 241-292.
- RAY, C. E.
1959. A sesamoid bone in the jaw musculature of *Gopherus polyphemus* (Reptilia: Testudinidae). Anat. Anz., vol. 107, pp. 85-91.
- ROMER, A. S.
1956. Osteology of the reptiles. Chicago, Univ. Chicago Press, xxi+772 pp.
- SCHUMACHER, G. H.
1954. Beiträge zur Kiefermuskulatur der Schildkröten, Pt. I. Mitt. Wiss. Zeitschr. Univ. Greifswald, Jahrgang 3, Math.-Naturwiss., pp. 149-210.
1955a. Beiträge zur Kiefermuskulatur der Schildkröten, Pt. II. *Ibid.*, Jahrgang 4, Math.-Naturwiss., pp. 501-518.
1955b. Beiträge zur Kiefermuskulatur der Schildkröten, Pt. III. *Ibid.*, Jahrgang 4, Math.-Naturwiss., pp. 559-587.
- SEYDEL, O.
1896. Über die Nasenhöhle und das Jacobson'sche Organ der Land- und Sumpfschildkröten. Festschr. 70 Geburtstage Gegenbaur, vol. 2, pp. 385-486.
- SIEBENROCK, F.
1897. Das Kopfskelet der Schildkröten. Sitzber. K. Akad. Wiss. (Wien), Math.-Naturwiss. Kl., vol. 106, pt. 1, pp. 245-328.
- SOLIMAN, M. A.
1964. Die Kopfnerven der Schildkröten. Zeitschr. Wiss. Zool., vol. 169, pp. 216-312.
- WEGNER, R. N.
1959. Der Schädelbau der Lederschildkröte *Dermochelys coriacea* Linne (1766). Abhandl. Deutschen Akad. Wiss. Berlin, Kl. Chem., Geol., Biol., no. 4, pp. 3-80.
- WILLIAMS, E. E.
1954. A key and description of the genus *Podocnemis* (*sensu* Boulanger) (Testudines, Pelomedusidae). Bull. Mus. Comp. Zool., vol. 111, pp. 279-295.
- ZANGERL, R.
1953. The vertebrate fauna of the Selma Formation of Alabama. Part 3. The turtles of the family Protostegidae. Part 4. The turtles of the family Toxochelyidae. Fieldiana: Geol. Mem., vol. 3, nos. 3, 4, pp. 61-277.