LAB 6: THE HEAD SKELETON

Name: ____________________ SSN: _______________
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N.B. Preparation for next week’s lab (Shark Muscular System)

Preparation: Walker & Homberger - Chapter 4 (pp. 52-94).

Background

Perhaps nowhere is the relationship between ontogeny and phylogeny more clearly evident than in the vertebrate head skeleton. Its final form reflects both its own embryonic development and its long evolutionary history. In this lab, consider the fate of the three embryonic skull components (chondrocranium, splanchnocranium, dermatocranium) in the specimens you examine. What remains of each in the adult skull? How do different vertebrate groups differ in their expression of these components? Remember - we are mostly looking at adult material. These represent the result of evolutionary modification of homologous parts. Embryonic development, along with the fossil record, provides clues to the nature of these homologies.

Today’s Lab

The lab is organized into 7 sections although the seventh is strictly observational. The numbers below refer to the sections, each containing the appropriate material. The first 5 sections are straightforward identification. You are responsible only for the structures specifically identified in this handout and only structures appearing in bold will appear on the quiz. Additional sections illustrate a few evolutionary trends and patterns evident in the vertebrate head skeleton. Be able to identify the asked-for structures and understand the concepts illustrated by the skeletal material. The instructor(s) will assist. There is a lot of material to absorb and commit forever to memory, so work efficiently. A written description of each element will help in your learning and identification of the structures.

1) Head and Visceral Skeleton of the Dog Shark (Squalus acanthias), a Cartilaginous Fish

Work through pages 54-61 (omitting section (B) Sagittal Section of the Chondrocranium)) identifying as many of the structures labeled in bold as possible. For the quiz you will be responsible for the following structures:

- rostrum
- orbits
- occipital region
- foramen magnum
- cranial cavity
- occipital condyle
otic capsules
nasal capsules

visceral arches
  mandibular arch (I)
  palatoquadrat (I)
  hyoid arch (II)
    basihyal
    ceratothal
    hyomandibular
  branchial arches (III - VII)

? Using Figure W&H 4-4 as a guide, sketch a branchial arch in lateral view and label the following components:
  basibranchial
  hypobranchial
  ceratobranchial
  epibranchial
  pharyngobranchial

? What type of jaw suspension does Squalus posses? Anatomically, what does the term mean?

? Which of the cartilages bear teeth? Do the teeth differ morphologically from one another? What terms describes this condition?

? Are there more than one row of teeth in each arch? Why is this?

2) **Head Skeleton of Bowfin (Amia calva), a Bony Fish**

You will recall that the extant actinopterygians (ray-finned fish) are divided into two monophyletic sister groups: The primitive Chondrostei and the derived Neopterygii. Within the Neopterygii, the bowfins (Amiiformes) form the sister group to the most successful radiation of vertebrates known, the teleosts. Thus, the bowfin (Amia calva) is an excellent (and local) choice for studying the dermal component of the skull. Work through pages 61 and 62 using figure 4-6 and 4-7 to identify as many of the structures labeled in bold as possible. For the quiz you will be responsible for the following structures:

  dermal roof
  quadrate (I)
  articular (I) - ventral portion of jaw articulation; best seen internally
  hyomandibular (II)
  palatal series
  lower jaw series
  opercular series
  gular series

? Which of the above are endochondral rather than dermal bone ossifications? Hint: They are all three derived from the visceral arches.
Which bones of the skull bear a marginal (as opposed to medial) row of teeth? Do the teeth differ in shape? What terms describes this condition?

What type of jaw suspension does Amia possess? (See p. 58 and Figure 4-4).

Also displayed is the skeletal mount of an advanced teleost, the perch (Perca falvescenes). In which of the above areas does the perch appear to differ most from the Amia?

3) Head Skeleton of the Mudpuppy (Necturus maculosus), an Amphibian

Work through pages 68-73 omitting Section (B) [The Chondrocranium] to identify as many of the following structures as possible. The accompanying figure (necturus.tif) shows the skull of Necturus in lateral view and should help in your identification. For the quiz you will be responsible for the items which appear in bold:

- premaxilla
- frontals
- parietals
- opisthotic (endochondral)
- prootic (endochondral)
- squamosal
- quadrate (endochondral; arch 1)
- exoccipitals (endochondral)
- foramen magnum
- ethmoid plate (endochondral)
- vomer
- pterygoid
- parasphenoid
- stapes (arch 2)
- lower jaw
  - dentary
  - splenial
  - angular
  - mandibular cartilage

Hyoid apparatus (see Figure 4-12)

- hyoid arch (derived from visceral arch 2)
  - hypohyal
  - ceratohyal
- branchial arch 1 (derived from visceral arch 3)
  - basibranchial 1
  - ceratobranchial 1
  - epibranchial 1
  - branchial arch 2
  - basibranchial 2
  - ceratobranchial 2
  - epibranchial 2
  - branchial arch 3
epibranchial 3

? What respiratory structure do they branchial arches support in *Necturus*?

? Which bones of the skull bear teeth? Do the teeth differ in shape? What term describes this condition?

4) **Head Skeleton of a Turtle (sp?), a primitive Sauropsid (Reptile)**

The unidentified turtle skull we have is not a snapping turtle (*Chelydra* sp.) but clearly belongs to a closely related species so that the descriptions in W&H are applicable. Work through pages 73-79 noting we currently lack a hyoid apparatus (Section D) to identify as many of the following structures. For the quiz you will be responsible for the structures which appear in bold. **N.B.** Annoyingly, your text incorrectly refers to the various emarginations of the dermal roof as “fenestrae”. The more proper term *emargination* (L., *e + margo*, to deprive of its edge) should be used.

- nares
- choanae
- orbits
- posttemporal emarginations (“fenestrae”)
- subtemporal emarginations (“fenestrae”)
  - [infra orbital emarginations (“fenestrae”) - extremely reduced in this specimen]
- tympanic cavity
- foramen magnum
- occipital condyle
- dermatocranium
  - **premaxilla**
  - **maxilla**
  - zygomatic (jugal)
  - quadratojugal
  - prefrontals
  - **frontals**
  - **parietals**
  - postorbitals (how do they differ from *Chelydra*?)
  - **squamosal**
  - vomer
  - palatines
  - pterygoids
- chondrocranium
  - **supraoccipital**
  - **exoccipitals**
  - **basioccipital**
  - opisthotic
  - prootic
  - basisphenoid
- visceral cranium
  - **quadrate (arch I)**
    - [epipterygoid (arch I) - rudimentary]
  - **stapes (arch II)** - often these gracile bones fall out in preparation of the skull; however you should see its articulation with the fenestra ovalis of the prootic
- lower jaw (visceral and dermal cranium)
  - **articular (arch I)**
  - dentary
surangular
coronoid
prearticular
angular

What sort of temporal fenestrae do turtles have? In what traditional amniote group does this place them (Anapsids, Diapsids, Synapsids)?

What is unusual about the nares in turtles? Since the "agnathans" have a single midline nares, is this a primitive or derived trait? How would you test this with a cladogram?

What other major sauropsid group is edentate? Since turtles are the most primitive group of Sauropsids, does this mean that an edentate condition is ancestral for all Sauropsids? How would you test this with a cladogram?

5) **Head Skeleton of the racoon (Procyon lotor), a Mammal (derived Synapsid)**

Although the dissector uses the cat as its example, we have better material for the racoon. The skulls are similar enough in form so that you can use your dissector's illustration as a guide. Work through pages 83-94 to identify the structures listed below. For the quiz you will be responsible for the structures which appear in **bold**.

- **complete skull**
- dermatocranium
  - premaxilla (incisive)
  - maxilla
  - lachrymal
  - zygomatic
  - nasal
  - frontals
  - parietals
  - vomer
  - palatine
  - pterygoid processes and hamulus
- **dentary**
- chondrocranium
  - occipital (dermal and endochondral)
    - ethmoid (endochondral)
      - dorsal and middle nasal conchae
      - cribiform plate
      - perpendicular plate
    - sphenoid
      - basisphenoid (endochondral)
      - alisphenoid (endochondral; actually part of viscerocranium)
      - presphenoid (endochondral)
    - ventral nasal concha
  - **temporal**
    - squamous portion
    - petrosal portion (endochondral)
    - auditory bulla
      - tympanic portion (dermal; mammalian autoapomorphy)
visceral cranium
   malleus (endochondral; arch I)
   incus (endochondral; arch I)
   stapes (endochondral; arch II)

? What are the chondrocranial homologues of the petrous portion of the temporal bone of mammals in the turtle and mudpuppy?

? What are the visceral cranium homologues of the 3 ear ossicle of the mammals to the turtle and mudpuppy?

? What 4 endochondral bones and pair of dermal bones make up the mammalian occipital bone?

? Which bones of the skull bear teeth? What type of teeth are present?

bisected skull

   cranial cavity
      rostral, middle and caudal cranial fossae
   petrous portion of temporal bone
   sella turcica
      nasal (periorbital) sinuses
      sphenoidal
      frontal
   ethmoid
      cribriform plate
      perpendicular plate
   nasal conchae (turbinates)
      dorsal
      middle
      ventral

? What sensory apparatus lies within the petrous portion of the temporal? What does petrous mean (see Brown’s Composition of Scientific Words)?

? What endocrine gland rests within the sella turcica? What does sella turcica mean (see Brown’s Composition of Scientific Words)?

? With what physiological condition are turbinates associated? If a fossil dinosaur skull were found to have turbinates, what would you conclude?

? What does ethmoid mean (see Brown’s Composition of Scientific Words)? Does this description apply to raccoons? What about humans?

? Find the following foramina and then identify which canial nerve(s) passes through it: cribriform foramina
optical canal
orbital fissure
foramen rotundum
foramen ovale
internal acoustic meatus
stylomastoid foramen
jugular foramen
hypoglossal canal

? What roughly is the relationship between location of the above foramina along the rostral-caudal axis and the number of the cranial nerve which exits through it?

disarticulated skull

In front of you are the elements of a disarticulated raccoon skull. How many of these isolated elements can you identify? You may want to come back to this when you finish all the stations?

6) Amniote skull types

In front of you are the following skulls:
- loggerhead turtle (*Carretta caretta* tuatara (*Sphenodon sp.?*)
- green iguana (*Iguana iguana*)
- alligator (*Alligator mississippiensis*)
- raven skull (*Corvus corax*)
- opposum (*Didelphis virginianus*)

The major amniote groups are traditionally classified and named based upon openings associated with the jaw adductor musculature in the temporal and check regions of the dermocranium. Two types of openings exists: Emarginations and fenestrae. Emarginations (L. *e + margo*; to deprive of its edge) refer to the elimination of bone proceeding dorsally from the ventral margin of the cheek or rostrally from the caudal margin of the temporal roof, or both. Fenestrations (L. window) refer to openings between adjacent bones in the cheek or temporal roof, or both. Note that only fenestrae create apsides (G. *απσι*) or arches, one for each fenestra, and the major amniote groups take their names from the number of arches found in the dermocranium, e.g., anapsid, synapsids and diapsids. Using your new-found knowledge of temporal fenestration, answer the following questions:

? Which of these is an anapsid?

? Among the Saurians or Diapsids, which [hint: two] forms have retained the primitive diapsid condition (i.e., 2 temporal bars)?

? How has the iguana modified its skull from the original diapsid condition?

? How has the bird modified its skull from the original diapsid condition?
Which of these is a synapsid?

Which of these organisms has a kinetic skull (i.e., the upper jaw is mobile relative to the braincase)?

7) **Survey of craniate skulls - In Progress**

In front of you for your enjoyment are a wide array of tetrapod skulls.

Some points to consider:

- Compare the weight of the parrot skull to a comparable sized mammal; which is lighter and why?

- Note the variation in bone density within the bat skull, both in macroscopic view and in x-ray (jaws and inner ear dense, neurocranium transparent); why?

- Compare temporal fossa of various mammal groups, particularly carnivores vs ungulates. In which is the temporal fossa larger (indicating a larger temporalis muscle)? In which is the masseteric fossa larger (indicating a large masseter muscle)? Why is this so?

- How much of the aracari bill is bony? Why might this be (Hint: Between bone and bill (keratin), which is heavier)?

- Compare the three caviomorph rodents (the guinea pig, unknown caviomorph and the capybara). Aside from size, is there much variation in morphology (shape)?