TELEOST OSTEOLOGY and MYOLOGY

The fish's head is quite complex, with over 30 individual elements that can move. You could guess that this means there are many combinations of muscles and bones that interact to open and close the mouth. Throughout the evolution of fishes a great deal of variation among the jaws of fishes has been produced. You will there is a striking diversity is fish skulls in lab, but hopefully you will also see some underlying patterns.

The goals of this lab are to:

1. Learn the bones of a teleost skull using prepared perch skeletons, and handouts.
2. Observe evolutionary trends in changes in skull morphology by comparing the perch and bowfin skeletons.
3. Identify critical muscles and bones used in suction feeding
4. Learn the internal anatomy of a teleost. See lab manual.

OSTEOLOGY

- Jaws
  - Premaxilla
  - Maxilla
  - Dentary
  - Articular
- Suspensorium
  - Hyomandibular
  - Quadrate
  - Symplectic
  - Metapterygoid
- Operculum
  - Opercular
  - Subopercular
  - Preopercular
  - Interopercular
- Neurocranium
  - Frontal
  - Parietal
  - Supraoccipital
- Fins and fin supports
  - Scapula
  - Cleithrum series
  - Pectoral fin
  - Basipterygium
  - Pelvic fin
  - Fin rays vs. spines
  - Dorsal fin
  - Anal fin
  - Caudal fin
  - Hypurals
- Vertebrae
  - Neural spine
  - Centrum
  - Haemal spine
  - Rib
  - Epipleural
  - Precaudal vs. caudal vertebrae

TRENDS IN FISH SKULL EVOLUTION

Compare the skulls of a perch (a teleost fish) to a bowfin (the sister group to teleosts). Note the reduction of dermal bone and fused bones in the perch compared to the bowfin. Which bone in the upperjaw has teeth in each species? What is the primary bone in the upperjaw of the bowfin? In the perch?

In bowfin the premaxilla and the maxilla are separated by a hinge, which allows the maxialla to swing down and out during feeding. How might the mobile maxilla influence the size and shape of the bowfin's gape? How does the bowfin mouth differ from a more basal ray finned fish, like a Sturgeon, a Chondrostei (See lecture notes).

In the perch both the premaxilla and the maxilla are mobile. How does this influence the size and shape of the perch's gape? How might it influence feeding?

TELEOST SKULL DIVERSITY

Within the teleost there is an amazing diversity of feeding and skull morphology. Compare the skulls of some of the more derived forms of teleost available. Can you find some of the major jaw bones in each specimen? How do the size, shape and number of teeth vary among specimens? Can you guess what each fish eats?

MYOLOGY

Obtain a preserved perch. First massage the fish to loosen connections in the head. Really. Practice your ventriloquism, and make your perch say to your lab partner, "One intelligent morning, my hyomandibular turned into your stapes"…or something like that.

JAW MUSCLES. Working carefully so as to not cut any muscles, skin one side of the head from the preoperculum to the maxilla (the cheek region). Next skin the area anterior to the eye around the upper jaw, and then entire region posterior to the eye from neurocranium, across the operculum, to the pelvic fins.

The large muscles that form the cheek of the fish are the **adductor mandibulae (AM)**. As the name suggests, these muscles adduct the mandible (i.e. they close the lower jaw.) Starting with the mouth open, pull gently on the adductor mandibulae with forceps. Observe the jaw movements.

SUSPENSORIUM MUSCLES.

The suspensorium is the complex of bones that suspend the jaws from the neurocranium. One important phase in feeding is the expansion and contraction of the buccal cavity. The buccal cavity is expanded and contracted by lateral and medial movement of some of the components of the suspensorium. In particular, the **Levator arcus palatini (LAP)** located just posterior to the eye, originates on the neurocranium and inserts on the lateral edge of the suspensorium (mostly on the hyomandibular). It functions to expand the buccal cavity laterally.

OPERCULUM MUSCLES.

The operculum joins to the hyomandibular by a ball and socket joint. Find this joint on a skeleton. The operculum series are open and closed during respiration and feeding by several muscles. One muscle is the **Levator operculi (LO)**, which is a two-part muscle located caudally to the hyomandibular-opercular joint. This muscle rotates the operculum dorsally and caudally. This rotation of the operculum is translated to the rest of the opercular series, and then to the mandible via the **interopercular-mandibular ligament**. This ligament is located just under the mandibular-quadrate joint. The contraction of the LO, which rotates the operculum, which pulls the interopercular-mandibular ligament caudally, thus aids in depressing the mandible and opening the jaws. Try this on the prepared perch demos.

OTHER MUSCLES: Remove scales and skin from ventral side, anterior to the pelvic fins. Also remove the skin from one side of the fish in between the pelvic and pectoral fins.

The large muscle mass ventral to the pectoral fins is the **Sternohyoideus**. This muscle is important in rapid opening of the jaw, and expanding the buccal cavity. Using a forceps pull on the sternohyoideus and observe the movement of the lower jaw. What happens if the jaw starts out closed? What happens if it starts out open?

Remove skin along side of fish from the pectoral fins to the anterior edge of the dorsal fin. Observe the **myomeres** and **myosepta**. The myomeres are the zigzag muscle masses that form the bulk of the body musculature of a fish. The fine tissues separating the myomere are called myosepta. The dorsal sets of myomeres are called the **epaxial muscles**, and the ventral sets are called **hypaxial muscles**. While there is variation in individual myomeres, the epaxial muscles tend to originate on the vertebrae and insert on the bases of the dorsal fin rays. The hypaxial muscles generally lie below the vertebral column. These muscle masses work together to produce sinusoidal body waves that move the fish through water. The epaxial and hypaxial muscles also work in jaw opening.

HOW DOES A FISH OPEN AND CLOSE ITS MOUTH?

There are 4 phases in the opening and closing of a fish's mouth (see Figure 8.3 B, C on back).

1. First the fish must prepare. During the preparatory phase the volume of the buccal cavity is reduced. Basically the floor and the sides (i.e. the hyoid region and the suspensorium region) of the fish's mouth squeeze together.

2. Next the fish expands the volume of the buccal cavity, opens its jaws, and in some species also protrudes its upper jaw. During this phase water and prey are sucked into the fish's mouth. There are three musculoskeletal couplings that are involved in this expansion phase (see Figure A below and Figure 8.3 A on back):

I. The epaxial muscles lift the cranium and the roof of the mouth, expanding the buccal cavity.
II. The lower jaw is depressed. This occurs when the operculum is rotated via the LO and interopercular-mandibular ligament as explained above.
III. Additionally, the hypaxial muscles depress the lower jaw. Hypaxial and the sternohyoid muscles act on the bones of the floor of the mouth (the hyoids) and depress the lower jaw.

3. During the compression phase, the jaws are closed by the adductor mandibulae (see Fig. B below) Also the sides of the fishes mouth are squeezed in (the suspensorium is adducted), and the cranium returns to its original position. If the buccal cavity is being squeezed in, where does the water in the mouth go? During the compression phase, the operculum valve opens and the water in the buccal cavity flows over the gills, past the operculum and out of the fish. The protruded jaw returns to its original position also.

4. During the recovery phase, the muscles and bones return to their original positions. The length of this phase is longer when large prey are consumed.