Biology 4B Laboratory
Muscles of Vertebrate: The Rat

Objectives:
- To be able to distinguish between the basic muscles of the rat
- Identify and learn the origin, insertion and action of selected vertebrate muscles
- Learn the embryological origin for selected vertebrate muscles

Introduction
This lab will examine the external features and muscular system of the domestic rat (Mammalia: Rattus rattus). Not every animal will be equally easy to dissect and some animals will require more time than others. You will have to work as a team in order to spread out the work load and make sure that you all have equal time to learn the material.

In the histology lab you learned to recognize smooth, cardiac, and skeletal (striated) muscle. In this lab we only look at skeletal muscles. Most muscles of the body are derived from mesoderm. The process of skeletal muscle fiber development occurs within myotomes (Fig. 1) in the embryonic trunk area, or from loosely organized masses of hypomeric mesoderm in the head and appendage areas. Embryonic formation of skeletal muscle tissue begins as specialized mesodermal cells, called myoblasts, which multiply rapidly. New cells continue to form as the myoblast cells fuse into syncytial myotubes. A syncytium is a multinucleated protoplasmic mass that forms by the secondary union of originally separate cells. Growth in length continues by addition of myoblasts to the syncytium. Thus, these voluntary muscle fibers are composed of long, unbranched cylinders.

Many muscles insert by means of fascia or by tendons (dense regular connective tissue) onto bone. The connection of bone to bone is also made of this type of connective tissue, but here it is called ligament.

We will be studying the muscles of the vertebrate skeleton. These muscles come from embryonic myotomes, which are segmented, in the embryonic body (Fig 1). The first three segments in the head region are located in front of the ear (pre-otic). The epimere mesoderm in these segments survives as the muscles of the eyes; the hypomere mesoderm does not develop. Each segment has split to form different eye muscle masses, which have then moved apart. These masses are traced by their innervation (the nerves going to them). We will look in detail at the eye muscles of the shark, but every vertebrate, including man has a similar pattern of eye muscles and innervation.

The hypomeric mesoderm in the head region does not contain a coelom and instead forms a solid sheet called the branchiomere. This branchiomeric muscle becomes the muscles of the jaw, hyoid arch, gills and spiracle of the dogfish. They are similar in Necturus, but in mammals, with the loss of gills, the more posterior muscles are lost or transformed into muscles of the larynx and the trapezius muscle of the shoulder.
The **axial** muscles of the body are from mesodermal somites and form the skeletal muscles of the trunk and tail. In the head region, **hypobranchial muscles** are formed from somites behind the gills that move (as embryonic mesenchyme) forward to the ventral region of the pharynx (between the gills).

**Appendicular** muscles are formed in the dogfish from muscle buds in the embryonic myomeres. These operate the pelvic and pectoral fins. In the dogfish the axial muscles do much of the locomotion. In *Necturus* the evolution of limbs makes the musculature more complex. In mammals, with more powerful limbs and increasing speed on land, appendicular muscles overlie many of the axial muscles.

As you already know, muscles work by contraction. As the muscle contracts, it draws various body parts together, creating an **action**. Muscles have points of connection to body parts. These are defined as **origins** (fixed or the most fixed part) and **insertions** (less fixed, or most movement). Muscles often work in pairs called **agonists** and **antagonists**. Muscle names are often based upon the action.

**Table One.** Some examples of Agonist/Antagonist muscle pairs and their actions

<table>
<thead>
<tr>
<th>Agonist/Antagonist Pair</th>
<th>General name</th>
<th>Name of action</th>
<th>Description of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abductor</td>
<td>abduction</td>
<td>move away from midline</td>
<td></td>
</tr>
<tr>
<td>Adductor</td>
<td>adduction</td>
<td>move toward midline</td>
<td></td>
</tr>
<tr>
<td>Flexor</td>
<td>flexion</td>
<td>reduce angle</td>
<td></td>
</tr>
<tr>
<td>Extensor</td>
<td>extension</td>
<td>increase angle</td>
<td></td>
</tr>
<tr>
<td>Protractor</td>
<td>protraction</td>
<td>move limb forward</td>
<td></td>
</tr>
<tr>
<td>Retractor</td>
<td>retraction</td>
<td>move limb backward</td>
<td></td>
</tr>
<tr>
<td>Elevator</td>
<td>elevate</td>
<td>raise the body part</td>
<td></td>
</tr>
<tr>
<td>Depressor</td>
<td>depress</td>
<td>lower the body part</td>
<td></td>
</tr>
</tbody>
</table>

I. The Spiny Dogfish, *Squalus acanthias*

**a. External Anatomy**

First, look at the shape of this fish. Observe its adaptations for swimming. Feel the **placoid** scales; they point towards the caudal region of the fish. Identify the fins

- 2 dorsal (with spines),
- caudal (note shape of lobes)
- pectoral (1 pair)
- pelvic (1 pair)
- claspers (present or absent)

Follow the **lateral line** along the side of body. It is used for hearing/pressure sense. On the head find

- pair of lidless eyes
- pair of spiracles
- 5 pairs of gill slits
- pair of nares

On the surface of the head note the continuation of the lateral line into three principal lines: the supra orbital, the sub-orbital and the mandibular. Find the **ampullae of Lorenzini**, fluid filled pits that sense low-level electrical stimulus and sense depth. Examine the **cloaca**, a chamber between the pelvic fins and note the urinary papilla, and anus.
II. The Rat, *Rattus rattus*

a. External Anatomy and Skin Removal
Note the skin with hair and the mammary glands, characteristic of mammals. The head has a mouth with lips. The upper lip is split by a groove, the philtrum. The nose has nares and the eyes bear upper and lower eyelids and a reduced nictitating membrane. The external ears or pinna direct sound into the auditory canal. The whiskers or vibrissae are sensory. The trunk has an anterior thorax and posterior abdomen. The anus is at the base of the tail. The urinary and genital openings are separate in females, but in males they run as one duct to the tip of the penis. Males have a double pouch, the scrotum containing the testes. In the female, between the skin and muscles lies granular, mammary gland tissue in a band under the lines of nipples.

Cut through the skin of the rat from the pelvic region to the throat and the upper limbs on the left hand side. Remove the skin from the left side of the head. Skin the animal by inserting the handle of the scalpel or a blunt probe between the skin and the muscles. The muscles are connected to the skin by fascia.

b. Rat Musculature

*Mammal Branchiomeric Muscles (head and throat)*
In the mandibular arch, the temporalis muscles lie from behind the eye to the ear, occupying the temporal fossa of the skull. It elevates the mandible (lower jaw). Behind and below the eye is the large masseter muscle, which elevates the jaw and allows for complex chewing. Ventrally and medially lies the digastric muscle, which depresses the mandible.

In the hyoid arch, the most important muscle in mammals is the spincter coli, which is the posterior portion of the interhyoideus muscle. This muscle spreads onto the neck and becomes the platysma in mammals. It then spreads over the head and face to form the facial muscles of higher mammals.

The gills are now gone and the muscles of the gill arches have for the most part disappeared. Some muscles remain on the larynx and for swallowing. The cucullaris muscle has survived as the trapezius muscles of the pectoral girdle. The trapezius complex consists of three muscles, two of which originate on the spine and insert on the scapula to adduct and move it dorsally and forward. The third muscle inserts on the clavicle and protracts the humerus. The sternomastoid muscle is also derived from the cucullaris muscle and serves to turn or flex the head.

*Mammalian Axial Muscles (abdominal muscles)*
In mammals the hypobranchial muscles form the deep muscles of the throat and tongue.

The hypaxial muscles are three sheets (layers) joined ventrally at the linea alba. These formed by a muscle-to-muscle attachment of fascia called an aponeurosis. Cut out a rectangle of abdominal muscle about 1 cm x 1 cm, which includes the mid-line. Pull apart the layers of muscle from the lateral side towards the mid-line. On either side of the linea alba is a band of longitudinal muscle, the rectus abdominis, where the three muscle layers sit in a common sheath. The three muscle layers from the outside to the inside are: external oblique, internal oblique, and transversus abdominis. These muscles support the abdominal viscera in a muscular sling. Other, deeper hypaxial muscles will not be not seen. These are the intercostals and supracostals of the rib cage and the diaphragm, which acts as a suction pump in respiration. The muscles of the tail are continuations of the epaxial and hypaxial muscles bundles.
Mammalian Appendicular Muscles

Muscles of the pectoral girdle (shoulder, chest and front leg)

In the pectoral region, the pectoral abductor muscles of the dogfish now are represented by a number of forelimb muscles. Note the triangular *latissimus dorsi*, which originates from the neural spines of most of the thoracic vertebrae and inserts on the humerus, to pull the forelimb dorsally. Anteriorly it is overlain by the trapezius complex, which is branchiomerically in origin. From the scapula there are five deltoid muscles, which insert on the humerus to adduct and rotate it. Locate the spinodeltoid. The *triceps brachii* consists of three muscles originating on the scapula or humerus and inserting together on a process of the ulna, to extend the forearm.

The ventral pectoral adductor muscles of the dogfish have also become complex in mammals. The *biceps brachii* is located on the anterior of the forearm. They originate on a tendon inserting on the scapula and insert by a tendon on the tuberosity of the radius, to flex the forearm. Turn the animal on its back to see the large *pectoralis* muscles. There are several muscles in this group in mammals, some of which adduct or pull the forelimbs towards the midline, others retract the forelimb backwards. These muscles originate on the sternum and insert on different parts of the humerus. The most obvious of these muscles will be the anterior *pectoralis major (superficialis)* and the more posterior *pectoralis minor (profundus)*.

Muscles of the pelvic girdle (Hip and hind leg)

The pelvic abductor muscles of the dogfish have become specialized for locomotion in the mammal. In the thigh is found the large *sartorius* muscle, which runs from the ilium to the knee to adduct and rotate the femur and extend the lower leg. More posteriorly lay the thin, wide, *gluteus* muscles of the hip, originating on the last sacral and first caudal vertebrae and inserting on the femur to abduct the thigh.

The pelvic adductor muscles now occupy both surfaces of the hind limb. Anterior on the limb is the *tensor fascia latae*, a triangular muscle originating on the ilium and inserting on the knee by a *fascia lata*. It extends the lower leg. Posterior to it is the *caudofemoralis*, partly hidden by the *biceps femoralis*. It originates on the tail (caudal) vertebrae and inserts on the lower leg. The posterior thigh has the large, thick *biceps femoralis*, which runs from the ischium to the tibia and knee to abduct the thigh and flex the lower leg. The posterior-most muscle is the *semitendinosus*, which is stuck to the biceps femoralis and runs from the ischium to the tibia to flex the lower leg. Ventrally you will see the *gracilis* muscle which occupies the posterior half of the thigh. It runs from the pubic symphysis to the tibia and adducts and retracts the leg.

- Rat Muscle List
  - Mammal Branchiomeric Muscles (Head and throat)
    - Temporalis, masseter, digastric, platysma, facial muscles, trapezius (acromotrapezius/cleidotrapezius/spinotrapezius), sternomastoid, Sternohyoid
  - Mammalian Axial Muscles (abdominal muscles)
    - linea alba, rectus abdominis, external oblique, internal oblique, transversus abdominis
  - Mammalian Appendicular Muscles (shoulder, chest and front leg)
    - Muscles of the pectoral girdle
      - latissimus dorsi, spinodeltoid, triceps brachii, biceps brachii, brachialis, pectoralis major (superficialis), pectoralis minor (profundus), serratus ventralis, forearm flexors, forearm extenders
    - Muscles of the pelvic girdle (Hip and hind leg)
      - gluteus maximus (superficialis), tensor fascia latae, fascia lata, caudofemoralis
      - biceps femoralis, semitendinosus, gracilis, rectus femoris, vastus medialis, adductor magnus, gastrocnemius, soleus, tibialis anterior