Exercise 4
Muscle

Introduction

Muscle is another of the basic tissues. There are three types of muscle tissue in the body: skeletal muscle, cardiac muscle, and smooth muscle. All muscle tissues consist of elongated cells called fibers. Each muscle fiber cytoplasm contains numerous microfibrils which are made of two types of contractile protein filaments: actin and myosin.

Objectives

After completing this exercise you should be able to:

- **Identify** smooth and skeletal muscle in microscopic sections, both of isolated muscle and organs containing these tissues from different organisms.
- **Identify** the neuromuscular junction (motor end plate) and the muscle spindle as they are seen in the light microscope.
- **Identify** cardiac muscle in longitudinal and cross section in light microscopic preparations.
- **Identify** the Purkinje fibers of the heart.

Smooth muscle

Smooth muscle is found in many different locations and virtually all organs systems. It is present in large amounts in some organs of the reproductive tract, the uterus and the walls of the uterine tubes. Smooth muscle is also present in the wall of the epididymis in males. It forms the bulk of the wall of the digestive tract and is present to some degree in all blood vessels larger than capillaries.

Individual smooth muscle cells are “fusiform or spindle shaped”, that is, they are longer than they are wide, tapered at each end, and widest in the middle. They range in size from 0.02 to 0.5 µm wide by 4 to 7 µm long. The nucleus is central, elongated and located at the widest part of the cell. Since the nucleus length is much less than that of the cell itself, a sectioning plane that passes through the cell at right angles to its long axis usually misses the nucleus.

In the slides in which you have cross sections of smooth muscle you will notice two things: the profile of the cells is not of uniform size and very few show a nucleus. The reason for the lack of nucleus in a section plane has been discussed. The different sizes result from the tapering shape of the cells; if cut near the tip the profile will be very small, and if near the middle, much larger. In a longitudinal section, the cells lie neatly against each other, with the wide portions of one nested against the narrow parts of its neighbors.

Smooth muscle cells do not show a banding pattern like those of striated muscle. They do have internal actin and myosin filaments, but their contractile units are not in register.

List of slides – Smooth muscle

| SM-1 | Individual cells, teased |
| SM-2 | Intestine, c. s. and l. s. |
| SM-3 | Stomach (epithelium-mucous sheet) |
| SM-4 | Monkey, t. s. |
| SM-5 | Human, t. s. (name the tissue) |
| SM-6 | Urinary bladder, frog, w. m. |

REVIEW BOX SLIDES 5, 9, 19, 20, 36, 40, 46, 54, 60, 61
Skeletal Muscle

Skeletal muscles are voluntary because their contractions and relaxations are due to conscious control. In the cytoplasm of a skeletal muscle, the arrangement of actin and myosin filaments is very regular. As a result, these contractile filaments form distinct cross-striations, which are seen under the microscope as light I bands and dark A bands across each muscle fiber.

Skeletal myofibers are cylindrical in shape. The really amazing dimension is their length. Most of them are at least several centimeters long, and it is possible for individual myofibers in large anatomic muscles to be half a meter or more from end to end. The banding pattern of skeletal muscle is quite obvious in longitudinal sections. It is a dead giveaway for the nature of this tissue. In transverse (c. s.) sections the arrangement of cells in skeletal muscle is even more apparent. Each myofiber can be visualized as a separate unit. If a myofiber nucleus happens to be present in the plane of the section it is seen within the sarcolemma, right at the periphery of the cell.

Notice that there are two kinds of nuclei associated with the myofiber. The first type is that of the myofiber itself, which is clearly located within the fiber. Skeletal muscle cells are multinucleated and may have anywhere from ten to hundred of nuclei. The second type of nucleus is that of the satellite cell. These are small cells closely associated with myofibers. They rest in shallow depressions on the surface and represent a pool of undifferentiated muscle cells, which under very limited circumstances may begin to divide and produce new muscle fibers.

In transverse sections examine the relationship of the connective tissue to the muscle. Each myofiber is surrounded by a delicate CT covering: the endomysium. These collagenous fibers are in turn woven together to demarcate “bundles” of myofibers. The bundles are said to be joined together by the perimysium, which is the next higher level of CT. The muscle as a whole is covered with CT, which is of course continuous with the perimysium, and which represent the epimysium. The epimysium is attached to the end points at which the muscle originates or inserts on a bone. Thus, the CT provides something for the contracting muscle to “pull on” so that work can be done.

List of slides – Skeletal muscle

SK-1 Individual cells, teased
SK-2 Entire muscle, c. s. (note nerve bundle)
SK-3 Muscle, c. s. and l. s.
SK-4 Tongue, mammal
SK-5 Monkey, l. s., t. s.
SK-6 Monkey, c. s., t. s. (look for muscle spindle)
SK-7 Diaphragm, monkey, t. s.
SK-8 Human, l. s., t. s.
SK-9 Skeletal muscle, t. s.
SK-10 Red and white fibers
SK-11 Muscle-tendon junction
SK-12 Developing muscle
SK-13 Identify this tissue
SK-14 Trichinosis
SK-15 Fish
SK-16 Turtle
SK-17 Lobster

REVIEW BOX SLIDES 12, 16, 18, 20, 25, 30, 35, 52, 90, 91

Cardiac Muscle

Cardiac muscle fibers exhibit some of the features seen in skeletal muscle. In longitudinal sections the cross-striations in cardiac muscle closely resemble those seen in skeletal muscle; however, cardiac muscle fibers branch
without their diameters changing much. Also, unlike the multinucleated, elongated skeletal muscle fibers, each cardiac muscle fiber is shorter and contains a single centrally located nucleus. The central location of the nucleus is clearly visible when the muscle fibers are cut in a transverse section. Around these nuclei, are the clear zones of nonfibrillar perinuclear sarcoplasm. In transverse sections of the cardiac fibers, the perinuclear sarcoplasm appears as a clear space if the cut is not through the nucleus. Also visible in transverse sections are the myofibrils of individual cardiac muscle cells.

A distinguishing and characteristic features of cardiac muscle are the intercalated disks. These disks are dark-staining structures that are found at irregular intervals in the cardiac muscle; they represent the specialized junctional complexes between adjacent cardiac muscle fibers.

Numerous blood vessels are found in the connective tissue that surrounds the muscle fibers. Capillaries are abundant in the delicate endomysium between individual muscle fibers.

**List of slides – Cardiac muscle**

CM-1  Individual cells, teased  
CM-2  Cardiac muscle  
CM-3  Intercalated discs  
CM-4  Purkinje fibers  
CM-5  Monkey, t. s.  
CM-6  Human, t. s.  
CM-7  Cardiac muscle, t. s.  
CM-8  Entire heart, mammal  
CM-9  Myocardial infarct (note scar tissue)  
CM-10  Myasthenia gravis  
CM-11  Entire heart, bird  
CM-12  Review slide, 3 muscle types

**REVIEW BOX SLIDES 20, 53**