Muscle

Muscle cells, called muscle fibers or myofibers, are responsible for all voluntary and involuntary movements of the body. There are two basic muscle types: striated muscle and smooth muscle. The defining characteristic of striated muscle is the presence of stripes, or striations that result from the regular organization of contractile proteins in the muscle cell (see Ross et al. Fig. 11.1). Both cardiac muscle and skeletal muscle are forms of striated muscle. Smooth muscle lacks these striations. Each muscle fiber is ensheathed by a basal lamina.

1. Smooth muscle:
   Stomach Slides 14, 17, 18;
   Intestine-Slides 19, 21, 22, 23, 25, 26
   Ross et al: Plate 22, Fig. 1-4; Plate 50, Fig. 1 Inset; Plate 52, Fig. 1; Plate 55, Fig. 1;
   Plate 59, Fig. 2; Plate 74 Fig. 1-2

Smooth muscle is primarily responsible for involuntary movements. It is found in the digestive tract, walls of arteries and veins, respiratory passageways, bladder, and the reproductive system. In many cases (digestive, circulatory and some reproductive), the contractions of smooth muscle travel in waves through an entire sheet (or bundle) of muscle cells. Smooth muscle fibers are mononucleated, long, and spindle shaped. Although individual cell boundaries are hard to see, the nucleus is centrally located in the cell. When you look at slides of intestine, notice that the smooth muscle is arranged in two layers with different orientations. The outermost layer (farthest from the lumen) runs longitudinally along the length of the intestine. The inner layer is circularly oriented and forms tight spiral around the epithelium and lumen of the intestine. Muscular arteries have a similar arrangement of smooth muscle, circular and longitudinal layers, though this arrangement is more difficult to see.

2. Skeletal muscle:
   Slides 8-10, 15
   Ross et al: Plate 18, Fig. 1-3; Plate 45, Fig. 1-2

Skeletal muscle fibers are long cylindrical cells that are formed by the fusion of myoblasts (muscle precursor cells), resulting in a large multinucleated cell. In mammals, muscle fiber nuclei are displaced to the side of the cell, and are flattened against the cell membrane by the bundles of contractile fibers (myofibrils) that occupy most of the cytoplasm. The cell membrane is called the sarcolemma and defines the boundaries of a single muscle cell. Just outside the sarcolemma of each muscle fiber is its basal lamina. Within the basal lamina are found satellite cells, the stem progenitor cells of skeletal muscle. A cluster of muscle fibers is enclosed by a connective tissue sheath called an endomysium. Clusters of muscle fibers are gathered into groups ensheathed by the perimysium. Finally, the entire muscle is surrounded by a sheath of dense connective tissue called the epimysium. Several structures can be found in these connective tissue sheaths including nerves, arteries, veins and capillaries. Golgi
tendon organs and muscle spindles are specialized structures for sensing muscle length; these may be observed in your sections (see Ross Figures 11.12). Skeletal muscles are attached to bone via tendons (dense connective tissue).

3. Cardiac Muscle:

Slides 81, 82
Ross et al: Plate 20, Fig 1-4; Plate 21, Fig 1-2

Cardiac muscle is a specialized type of striated muscle found only in the heart. Cardiac muscle fibers have one or two centrally-located nuclei. Unlike skeletal muscle fibers, cardiac muscle fibers branch. Cardiac muscle cells are joined together by intercalated disks forming a network of interconnected cells. The intercalated disks appear as dark stained bands at the juncture between cardiac muscle fibers. The intercalated disks contain gap junctions, which allow excitatory impulses to travel from muscle cell to muscle cell, desmosomes to bind the cells together, and fascia adherens (adhering junctions) to provide an anchor for the actin thin filaments of the muscle cell. Purkinje fibers, specialized cells for conducting the action potential in the heart, may also be observed.

Nerve:

Nervous tissue is composed of two basic cell types, neurons and glia. Neurons are excitable cells; they receive stimuli, transmit impulses, and integrate data. Glia (neuroglia) are the support cells of the nervous system. Glia provide nutrition, structural support, electrical insulation of axons, and regulate the ionic environment surrounding neurons. Glia can also act as macrophages, phagocytizing damaged and degenerating neurons.

Neurons are a diverse population of cells that share a common set of features although each characteristic may not be visible in every neuron. Neurons are typically composed of a large cell body (soma or perikaryon) and a number of long cytoplasmic processes. The cytoplasm of the cell body contains most organelles. Visible in the light microscope in the cell body are the neuronal nucleus (1 nucleus/cell) and rough endoplasmic reticulum and ribosomes, called Nissl substance. The neuronal nucleus is large and usually round with a prominent nucleolus. Nissl substance is basophilic resulting in a dark punctate staining of the cell body. Golgi stain is frequently used to visualize neurons in the brain; it randomly stains only a subset of neurons in their entirety.

There are two types of neuronal processes, axons and dendrites. Dendrites receive information from other neurons at synapses and transmit it to the cell body. They often branch and their number/neuron ranges from none to a few hundred. Typically, a neuron has a single axon that may branch. The axon originates at the axon hillock and conducts impulses away from the cell body. At its terminal, an axon forms synapses on target cells such as neurons, muscle fibers or glandular cells. Axons are often covered with a lipid coating called myelin that speeds the conduction of the action potential. Myelin is produced by glia: Schwann cells in the peripheral nervous system (PNS) and oligodendrocytes in the central nervous system (CNS). It is often difficult to tell the difference between dendrites and axons with the light microscope.

Anatomically, the nervous system is divided up into the central nervous system (CNS), composed of the brain and spinal cord, and the peripheral nervous system (PNS). The CNS is further divided into white matter and gray matter. Gray matter is composed of neuronal cell bodies, while white matter contains axons. Glia are present in both gray and white matter. In the CNS, the cell bodies of a group of like neurons are called a nucleus while a similar aggregation of cell bodies in the PNS is called a ganglion.
4. Peripheral Nerves:
Slides 19-22, 100
Ross et al: Plate 24 Fig. 1-4

Peripheral nerves consist of bundles (fascicles) of axons surrounded by a connective tissue sheath (epineurium). Most nerves are mixed; they contain axons of both sensory and motor neurons. Each individual axon is surrounded by a thin layer of loose connective tissue, the endoneurium. In addition, each fascicle of axons is surrounded by a perineurium. Most of the axons in slide 100 are myelinated. In cross section, these fibers look like tiny doughnuts. The doughnut hole corresponds to the actual axon, while the doughnut, the empty space, corresponds to the myelin sheath which was removed during the staining process. In longitudinal sections of axons or whole mounts of axons (intact cells), the unmyelinated node between myelinated segments called the node of Ranvier may be detected.

5. Spinal Cord:
Slides 98, 99
Ross et al: Plate 27 Fig. 1-3

The spinal cord is divided into a central "H" shaped region of gray matter, and the surrounding white matter layer (Ross et al, Fig. 12-26). The gray matter is arranged into two dorsal and two ventral horns. Each dorsal horn receives input from sensory neurons in a dorsal root ganglion. If your section is through the upper (cervical) spinal cord, two small lateral horns may also be present. Motor neurons in the ventral horn transmit impulses to skeletal muscles. These neurons have large triangular or star-shaped cell bodies and are easy to see. Locate and be able to identify: the ventral fissure, dorsal root ganglia, dorsal and ventral horns, and ventral horn motor neurons.

6. Cerebrum (cerebral cortex):
Slides 94, 96
Ross et al: Plate 25 Fig. 1-6

The brain is organized like an inside-out spinal cord. White matter inside is surrounded by a multilayered cerebral cortex of gray matter. Pyramidal cells, the most prominent neurons in the cerebral cortex, are triangle shaped with a single large apical dendrite.

7. Cerebellum:
Slide 97
Ross et al: Plate 26 Fig. 1-4

The cerebellum also is composed of an inner white matter and an outer gray matter. The gray matter, the cerebellar cortex, has an outer layer, the molecular layer, with relatively few cell bodies. The inner layer, the granular layer, has abundant cell bodies, evident by the presence of nuclei. Interposed between the molecular and granular layer is a single layer of extremely large flask-shaped cells called Purkinje cells.
8. Sensory Receptors:
Demonstration Slides
Ross et al: Plate 42 Fig. 1-4, p. 454, 455: Figs. 15.12 and 15.13

There are many types of sensory receptors that mediate the sensation of heat, odor, sound, light, pain and touch. Here we concentrate on two types of touch sensory receptors found in the skin. **Pacinian Corpuscles** are touch receptors found in the deep layers of the skin that are sensitive to pressure and vibration. The corpuscles are composed of concentric layers of flattened Schwann cells with a single nerve fiber in the center. When sectioned, the flattened layers of cells look like an onion. **Meissner's Corpuscles** are much smaller than Pacinian corpuscles and are found beneath the skin epithelium of the fingertips, soles of the feet, and lips. Meissner's corpuscles respond to light touch. They are tapered cylinders perpendicular to the skin surface composed of flattened lamellae of Schwann cells and 1-2 axons.

*In addition to these structures, you should be able to identify and define the following items as they relate to muscle or nervous tissue. Some of these are challenging to identify and can viewed in the demonstration slides.*

**Muscle:**
- Motor Endplate or Neuromuscular Junction
- Muscle Spindle
- Purkinje Fibers of the heart

**Nervous Tissue:**
- Nissl bodies or substance
- Purkinje Cell of Cerebellum
- Pyramidal cell of Cerebral Cortex
- Node of Ranvier
- Dorsal Root Ganglion