There are 3 types of muscle tissue

Skeletal, cardiac, and smooth muscle all share the commonality of being able to shorten, but are different in several other ways.

If you keep some prefixes in mind, it will help make learning about muscles easier for you:

- myo- and mys- mean “muscle”
- sarco- means “flesh”

For instance, a muscle cell’s ability to contract is due to two kinds of specialized myofilaments (the muscle cell’s equivalent of microfilaments).

There are 3 types of muscle tissue

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Skeletal</th>
<th>Cardiac</th>
<th>Smooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Body</td>
<td>Heart</td>
<td>Digestive tract</td>
</tr>
<tr>
<td>Type</td>
<td>Skeletal</td>
<td>Cardiac</td>
<td>Smooth</td>
</tr>
<tr>
<td>Number of Nuclei</td>
<td>Multinucleated</td>
<td>Mononucleated</td>
<td>Mononucleated</td>
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<tr>
<td>Connection</td>
<td>Direct</td>
<td>Indirect</td>
<td>Direct</td>
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<tr>
<td>Striations</td>
<td>Present</td>
<td>Absent</td>
<td>Present</td>
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<tr>
<td>Contractility</td>
<td>Strong</td>
<td>Moderate</td>
<td>Weak</td>
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</table>

Skeletal muscle cells are packaged into skeletal muscles

Cells are very large (up to 1 foot in length), and multinucleated. Characterized by being voluntary (the only voluntary muscle type), but some involuntary control as well. Has obvious striations (related to both structure and function). Has the ability to contract very forcefully, but tires easily.
Cardiac muscle is found only in the heart
Like skeletal muscle, cardiac muscle is **striated** in appearance
By most people it **cannot** be consciously controlled
Muscle cells are joined by **intercalated discs**
Muscle cells are also arranged in a spiral fashion
These two features allow muscle contractions to be closely regulated
Tends to contract at a fairly steady rate

Smooth muscle is found in our visceral organs
Smooth muscle is our only muscle tissue which is **non-striated**
It tends to be found mostly on the walls of **hollow visceral organs**
We have **no voluntary control** over smooth muscle
Often found in **longitudinal and circular layers**

Skeletal muscle has many functions

- **Producing movement** (all muscle does this, not just skeletal muscle)
- **Maintaining posture**—almost continuous function
- **Joint stabilization**
- **Generation of heat**—nearly 75% of the energy stored in ATP escapes as heat; our skeletal muscles is ~40% of our body mass, so it generates most of our heat
Skeletal muscle cells have specialized organelles

Beneath the sarcolemma, you can easily visualize the Dark and Light bands, as well as multiple nuclei. Organelles called Myofibrils take up most of the inside of the cell, and push the nuclei towards the sarcolemma.

Banding reveals a lot about how a muscle functions.

The myofibrils are divided into functional units called sarcomeres. Myofilaments within the sarcomeres produce the banding pattern. These myofilaments are myosin (thick) or actin (thin).
To contract, muscle cells must be stimulated

Because muscle cells can receive and respond to a stimulus, we consider them to be excitable (= responsive, irritable)
When they are stimulated, muscle cells shorten, or contract, thus they are contractile
Muscles can also be stretched…they are extensible
They also recoil and resume their original length after being stretched; they are elastic

To contract, muscle cells must be stimulated

In muscle cells, the stimulus to contract is caused by a nerve impulse
The impulse is delivered by a type of nerve cell called a motor neuron
Each motor neuron innervates multiple skeletal muscle cells

1 motor neuron + all of the muscle cells it innervates = 1 motor unit

Axons form neuromuscular junctions with muscle cells
Muscles have different degrees of shortening

An individual muscle cell will always react in the same way to a nervous stimulus (all-or-none principle)—this is a muscle twitch.

But muscles need to contract proportionately to the load being placed on them

This is called a **graded response**

Graded responses can be produced in 2 ways:

1. Changing the **frequency** of muscle stimulation
2. Changing the **number of muscle cells** being stimulated at once
Muscles have different degrees of shortening

Graded responses can be produced in 2 ways:

(1) Changing the frequency of muscle stimulation
(2) Changing the number of muscle cells being stimulated at once

Where does the energy for muscle contraction come from?

Types of contractions & muscle tone

Isotonic contractions: muscles build tension and shorten (iso = same; tonic = tension)

Isometric contractions: muscle builds tension, but no shortening occurs (iso = same; metric = length)

Muscle tone: continuous, partial contractions in your muscle; different motor units in your muscle are stimulated in a systematic way
Muscle disuse

= muscle atrophy

Specialized muscles for different jobs

Vertebrate striated muscle comes in a wide variety of types. Two basic forms are:

- ‘fast-twitch’ muscle (white muscle)
  - Specialized for burst activity:
    -- fast, all-or-nothing
    -- few mitochondria
    -- sparse blood supply
    -- fatigues quickly

- ‘slow-twitch aerobic’ muscle (red muscle)
  - Specialized for endurance activity:
    -- slow, graded contractions
    -- rich in mitochondria
    -- myoglobin (hence, red), large blood supply
    -- more resistant to fatigue

Aerobic conditioning

Muscles become more resistant to fatigue

Striated muscle is usually very responsive to conditioning
Resistance training

Increase in muscle cell size (increased # of muscle cell number and connective tissue).

Development of the muscular system

*In utero* muscles are laid down, and the nervous system controls it by 16 weeks of pregnancy.

At birth, baby’s fine motor control is not developed. Control is gained proximal --> distal.

In general, the muscular system is very resistant to infection (because of large blood supply) but it can malfunction…

Muscular dystrophy

Group of congenital muscle-destroying diseases.

Muscles enlarge due to increased fat and connective tissues; but muscle fibers atrophy.

*Duchenne's muscular dystrophy*: affects almost exclusively males from 2-6 years old.

Cause = sarcolemmal degeneration.

No cure.
### Myasthenia gravis

- Characterized by drooping eyelids, difficulty swallowing/talking, generalized weakness
- Shortage of ACh receptors at neuromuscular junction
- Sometimes blood contains antibodies to ACh receptors (autoimmune disease?)
- Death usually occurs as a result of the inability of the respiratory system to function