

The Muscular System

The Muscular System

The *muscular system* provides the mechanism for movement of the body, and for physical control over internal functions.

The systems involving smooth muscle and cardiac muscle are described in their relevant sections.

Muscle Tissue

Muscle tissue has the property of being able to contract when stimulated via the nervous system. Contraction occurs through a complex biochemical reaction, which requires 'food' and Oxygen.

There are three basic types of muscle tissue: smooth, cardiac, and striated.

Smooth Muscle Tissue

Smooth muscle is also known as 'visceral' or 'involuntary' muscle.

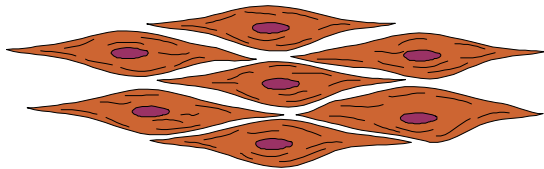
It provides control over internal organs and vessels, and is not under the control of the conscious will.

Smooth muscle cells each have one central nucleus, and have a 'double cone' shape.

The cells are formed into sheets of muscle, without additional fibrous tissue. [Figure 4 - 1]

Figure 4 - 1 smooth muscle tissue

The construction of smooth muscle tissue



Cardiac Muscle Tissue

Cardiac muscle is found only in the myocardium of the heart.

Cardiac muscle cells each have one nucleus, and one or more branches. The ends of the cells and branches link to give a contiguous sheet of muscle. [Figure 4 - 2]

Cardiac muscle has the special property that a stimulus of contraction may be passed from one cell to the next, without the need for external nerve connections.

Figure 4 - 2 cardiac muscle tissue

The construction of cardiac muscle tissue



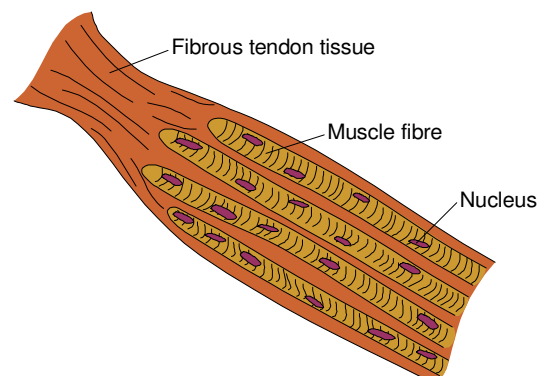
Striated Muscle Tissue

Striated muscle is also known as 'voluntary' or 'skeletal' muscle. It provides for the movement of the body and limbs, and is under the control of the conscious will.

Striated muscle cells are very long (up to 350mm) and thin (0.01 - 0.1mm). They have several nuclei found just under the outer membrane. The fibres have transverse stripes or striations (hence their name). [Figure 4 - 3]

Figure 4 - 3 striated muscle tissue

The construction of striated muscle tissue



A muscle is made up from a large bundle of parallel fibres enclosed in fibrous tissue. The overall muscle is then encased in further fibrous tissue.

Skeletal Muscular System

The skeletal muscles operate together with the bones of the skeleton to provide the power of bodily movement.

There are approximately 600 muscles in the skeletal muscular system. [Figure 4 - 4 and Figure 4 - 5] They are generally arranged in pairs, such that when one contracts, its partner is stretched. This allows movements to be reversed.

Muscle Attachments

All skeletal muscles are attached at their ends, most commonly to bones, but in some cases to the skin, and to other organs. The most common attachment is an extension of the outer fibrous sheath, formed into a cord, or *tendon*.

Tendons connecting to bones are attached through the periosteum into the actual bone tissue, providing a very strong linkage.

Classes of Muscle

Skeletal muscles are often classified according to the movements they perform. [Table 4 - 1]

Most muscular movements involve complex interactions between several muscles or groups of muscles. When interacting, muscles act in one of four ways:

Agonists. These muscles are prime movement producers.

Antagonists. These muscles oppose the movement of agonists, but only such as to provide for smooth movement.

Synergists. These muscles assist the movement of agonists by restricting the movement of intermediate joints.

Fixators or postural muscles. These muscles provide stability for agonists by fixing otherwise moveable joints.

Which of these actions a muscle performs will depend on the nature of the movement being carried out.

Table 4 - 1 muscle classifications

Main muscle classifications and the types of movement performed by them

Muscle class	Movement
Abductor	Movement away from the midline of the body or structure
Adductor	Movement towards the midline of the body or structure
Depressor	Lowering movement
Extensor	Bending to increase the angle between two bones
Flexor	Bending to reduce the angle between two bones
Elevator	Lifting movement
Protractor	Forward movement
Retractor	Backward movement
Rotator	Rotational movement around a longitudinal axis
Sphincter	Reduction of the size of a tube or orifice
Tensor	Increase in tension

Figure 4 - 4 skeletal muscles - anterior

Anterior view, showing main skeletal muscles

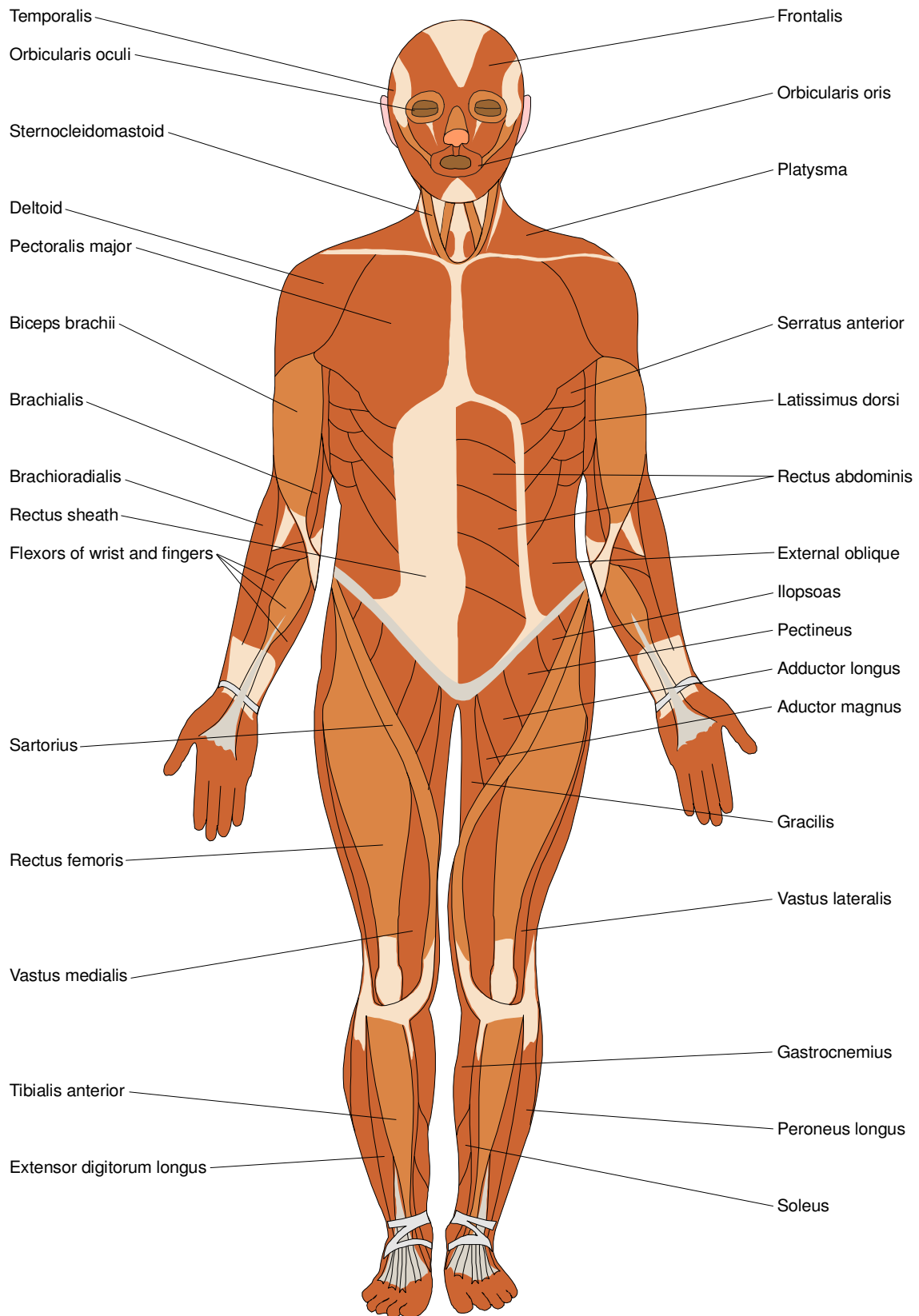
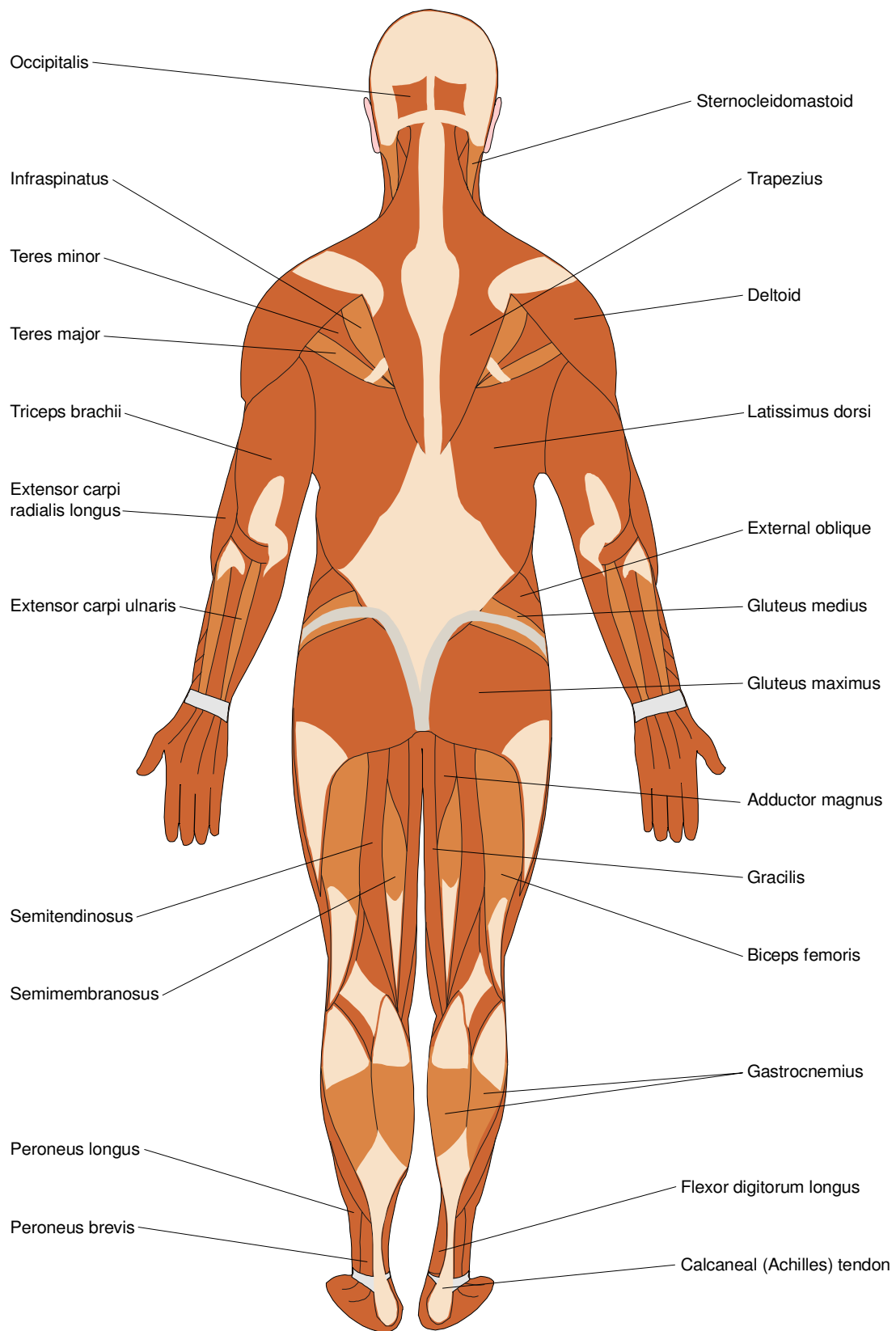


Figure 4 - 5 skeletal muscles - posterior

Posterior view, showing main skeletal muscles



Muscle Contractions

Muscle contraction is initiated by stimulation via motor nerve end plates.

The exact biochemical process is complex (and still open to controversy), but is known to rely on an energy producing reaction involving calcium ions and the substance adenosine triphosphate.

Adenosine triphosphate is an unstable substance produced through the breakdown of glucose in the presence of Oxygen. Further adenosine triphosphate is derived from glycogen and the breakdown of fats and amino acids. A level of adenosine triphosphate and glycogen is stored in muscle tissue during times of rest.

All-or-none principle

Whenever a muscle fibre is stimulated to contract, it contracts to its maximum extent. The actual strength of a muscular movement is based on the number of individual fibres which are stimulated to contract simultaneously, rather than on an overall magnitude of contraction.

Types of muscular contraction

Muscle contractions are identified into five groups:

Twitch. This is a momentary contraction in response to a single nervous stimulus.

Isotonic contraction. This occurs when a muscle contracts by becoming shorter and thicker.
ie. when producing a steady movement.

Isometric contraction. This occurs when a muscle develops tension, but remains the same length.
ie. when restraining an external force.

Staircase phenomenon. (Sometimes referred to as *treppe*) This occurs when a rested muscle is given repeated stimuli; the contractions increase in strength until a steady tension is reached.

Tetanus. This occurs when repeated stimuli occur too fast for intermediate relaxation. At the limit, the muscle is in a complete state of contraction, with no relaxation between stimuli.

Muscle tone

Even when skeletal muscles are 'at rest', some fibres are partially contracted.

This contraction is known as *muscle tone*, and is caused by a continuous nervous stimulation via reflex paths.

Fatigue

There is a limit to the rate at which the circulation can supply Oxygen for the creation of adenosine triphosphate from glucose.

If adenosine triphosphate usage for muscular contractions exceeds this rate, incomplete breakdown of glucose leads to a build-up of lactic acid in muscle tissue.

This, plus a resultant deficit of adenosine triphosphate and an excess of carbon dioxide, leads to the sensation of fatigue. As fatigue develops, further muscular action becomes increasingly difficult and uncomfortable. In the extreme, it will become impossible.

Cramp

Cramp is the term associated with the painful sensation caused by either prolonged or sudden and extreme contraction of a muscle. The condition may be connected with electrolyte imbalance, and is often associated with fatigue, stress, and poor posture.

Muscular Dystrophy

The term *muscular dystrophy* refers to a group of inherited diseases where muscle fibres degenerate and are replaced by fatty tissue. Increasing weakness and loss of ability result.

The severity of the condition varies from slight weakness through to damage to the intercostal muscles or myocardium, with eventual fatal consequences.

Poliomyelitis

Although *poliomyelitis* is actually an infectious viral disease of the central nervous system, it is often attributed to the muscular system as it can lead to muscular stiffness, weakness, and eventual paralysis.

Strain

A *strain* occurs when there is excessive use or stretching of muscle tissue. This may damage the muscle fibres or tendons by tearing them and generally leads to pain and swelling.

In an extreme case, the tissue is completely torn apart, with extensive haemorrhage, swelling, pain, and loss of function.

Tendinitis

Tendinitis occurs when excessive use of a particular muscle leads to a painful inflammation of the associated tendon sheath. The condition may also be caused by bacterial infection or rheumatic disease.

Tension Headache

A *tension headache* is probably the most common form of headache. It occurs when muscular contractions in the back of the neck, caused by emotional stress, fatigue, or other factors, lead to pain. Muscular spasms may then constrict blood vessels - increasing the problem, which can be compounded by a build-up of toxic waste substances in the scalp.

Migraine

A *migraine* is a condition similar to the tension headache, but with much more severe symptoms.

Often a migraine is initiated by a trigger factor, and may occasionally be preceded by an 'aura', or warning symptoms.

Blood vessels supplying the brain constrict. At some point later, they dilate, causing an intense headache, and perhaps inducing other problems such as visual disturbances, dizziness, vertigo, and vomiting.

