

كلية المستقبل الجامعة قسم الفيزياء الطبية  
المرحلة الثالثة

**ANATOMY**

**The Musculoskeletal System**

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# The Musculoskeletal System

## Key terms

<b>Term</b>	<b>Meaning</b>
Musculoskeletal system	The body system that provides support, stability, shape, and movement to the body
Joint	The point at which two (or more) bones meet.
Cartilage	Soft connective tissue found between joints
Ligaments	Connective tissue that attaches bone to bone at a joint
Tendons	Connective tissue that attaches muscle to bone
Voluntary muscle	Muscle that can be consciously controlled
Involuntary muscle	Muscle that is controlled by the autonomic nervous system (not consciously controlled)
Striated muscle	Muscle tissue that has a striped appearance due to its fiber composition

## The musculoskeletal system

In the **musculoskeletal system**, the muscular and skeletal systems work together to support and move the body.

The bones of the skeletal system serve to protect the body's organs, support the weight of the body, and give the body shape. The muscles of the muscular system attach to these bones, pulling on them to allow for movement of the body.

# The human skeleton

The human skeleton contains around 300 bones at birth, and by the time the person reaches adulthood this number has diminished to 206. As we age smaller bones join together to make bigger bones – they fuse. The bones give the body its shape. The main job of the skeleton is to provide support for the body. Without the skeleton the body would collapse into a pile. The skeleton is strong but light.

The skeleton also helps to protect the internal organs as well as the fragile body tissues. The skeleton protects the brain, eyes, heart, lungs and spinal cord. The cranium (the skull) offers protection to the brain and eyes, whilst the ribs protect the heart and lungs and the vertebrae (the spine, backbone) protect the spinal cord. Bones provide the structure for muscles to attach so that we are able to move. Tendons are tough inelastic bands that hold and attach muscle to bone. Red bone marrow makes blood cells and yellow marrow stores fat.

## Ossification

Ossification is the formation of bone by the activity of **osteoblasts** and **osteoclasts** and the addition of minerals and salts. Calcium compounds must be present for ossification to occur. Osteoblasts do not make these minerals, but take them from the blood and deposit them in bone. At birth, many of the bones have been at least partly ossified. Within the bone are blood vessels, nerves, collagen and living cells including:

- osteoclasts
- osteoblasts

**Osteoclasts** : Bone tissue is continually broken down and resorbed by multi nuclear cells called osteoclasts, derived from monocytes which originate within bone marrow. Osteoclasts have an important role to play in liberating minerals and other molecules stored within the bone matrix.

Bone tissue serves as an important source of essential minerals including calcium and phosphate.. Increased osteoclast activity leads to increased resorption of bone.

**Osteoblasts :** Osteoblasts are the cells responsible for building new bone tissue. These are derived from cells thought to be associated with blood vessels. When activation occurs they begin the production of the organic components of bone – osteoid this is predominantly made of collagen. Minerals begin to crystallise around the collagen scaffold forming the major inorganic constituent of bone which contains calcium phosphate.

As osteoblasts form, new bone tissue may become imbedded within the matrix differentiating into **osteocytes**.

The **interior of bone** is composed of bone marrow, surrounded by:

- **Cortical bone** (the hard outer shell of bone).
- **Trabecular bone** (the spongy looking centre).

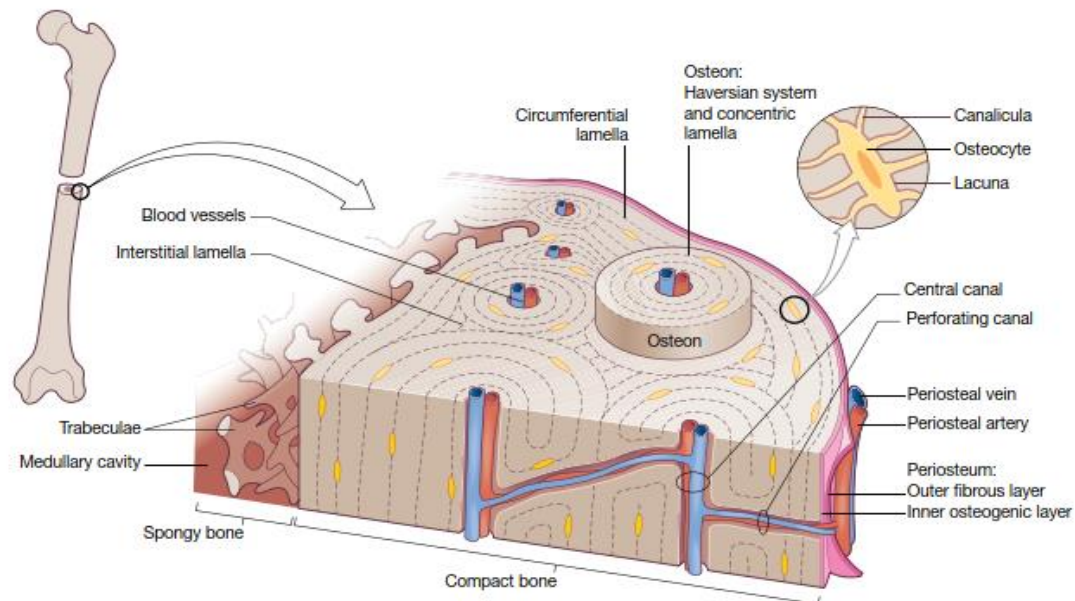
The amount of cortical or trabecular tissue is dependent upon the function of the bone. **The osteon** is the basic unit of structure of compact bone, comprising a Haversian canal and its concentrically arranged lamellae .

Osteocytes are distributed within the lamellae, forming a network that maintains the viability and structural integrity of bone.

The Haversian canal is located at the centre of the osteons, containing blood vessels and nerves; blood vessels facilitate the exchange between osteocytes and blood. The vascular network provides structural support,

nutrition and a waste removal system within this space.

Figure 45.3 Osteon, haversian canal

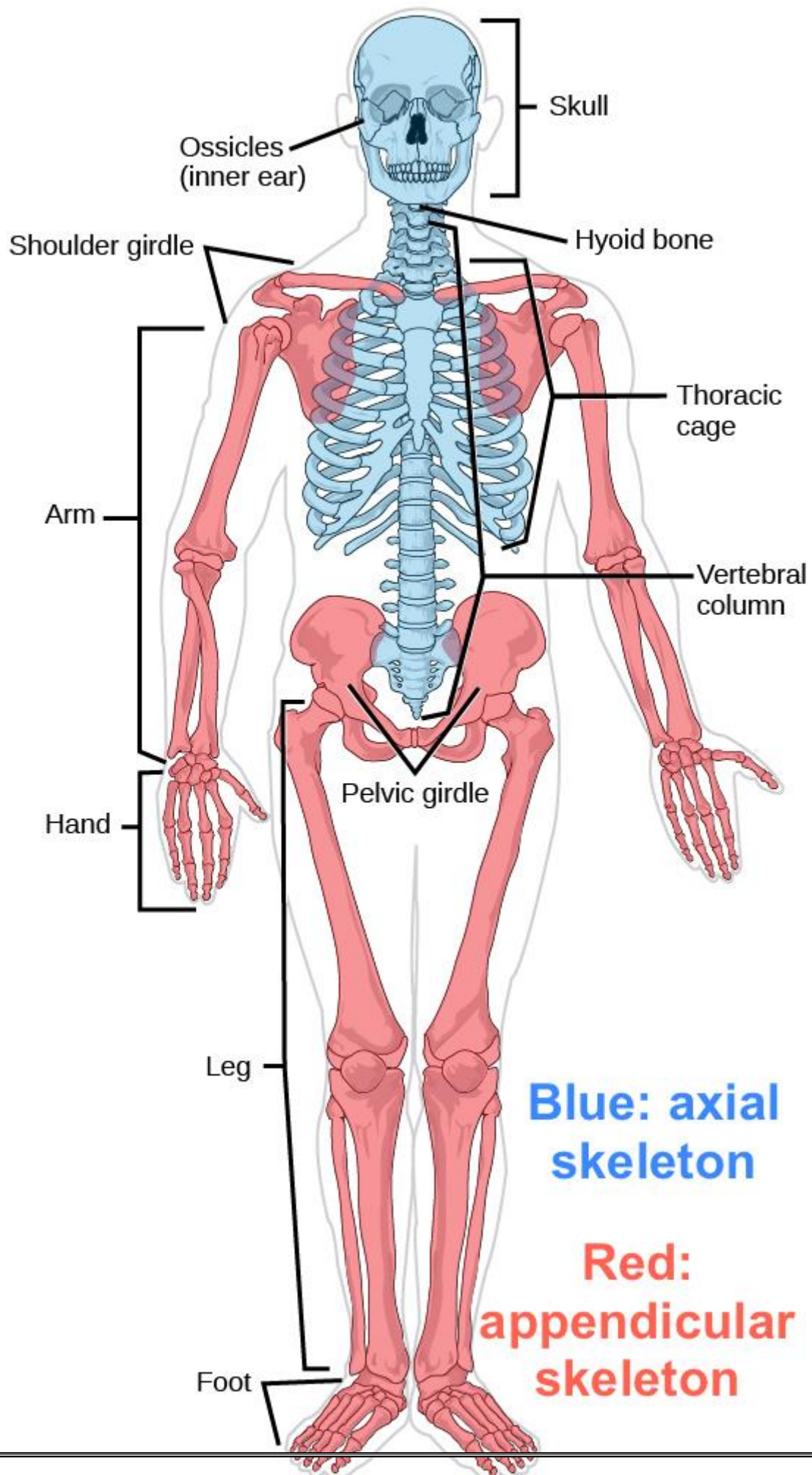


Trabecular bone is present in the interior of some bones and resists compression; within the structure there are osteocytes, playing an important part in sensing local changes in strain.

In the interior of bones is the bone marrow. Bone marrow is a site for haematopoiesis, the process by which the cellular components of blood are formed.

**The human skeleton** is divided into two parts: the axial skeleton and the appendicular skeleton. The **axial skeleton** consists of:

- the skull, which protects the brain and supports facial structure
- the vertebral column (spine), which surrounds and protects the spinal cord and support the head
- the thoracic (rib cage), which surrounds and protects the organs within the chest (including heart and lungs)



## Diagram labeling the axial and appendicular skeletons of the human body

The **appendicular skeleton** consists of:

- the pectoral girdle (shoulders):
- upper and lower limbs (arms and legs)
- the pelvic girdle (hip bones)

## Bone types

Bone types can be classified according to the shape and size of the bone. In terms of bone shape there are five main types of bone:

1 long bones

2 short bones

3 flat bones

4 irregular bones

5 sesamoid bones.

Bone tissue is classified as either **compact** bone or **spongy** bone and depends on how the bone matrix and cells are organised. Compact bone forms the outer layer of all bones and most of the structure of long bones; it provides few spaces and offers protection and support to the bones around which it is the outer layer as well as helping the long bones to bear the weight of the stress placed on them by body weight. Spongy bone (also called cancellous bone) has no osteons, instead spongy bone consists of an irregular lattice of thin columns of trabeculae. Spaces between the trabeculae of some spongy bones are filled with red bone marrow.

### Long bones

These bones are often curved to assist with strength; they are longer and wider than other bones and consist of a shaft and a variable number of extremities (endings). The femur, tibia, fibula, humerus, ulna and radius are examples of long bones.

### Short bones

Can be described as cube shaped and are approximately the same size length and width. Their primary function is to provide support and stability with little movement. Examples of short bones are the carpals and tarsals – the wrist and foot bones.

### **Flat bones**

Flat bones are strong, flat plates of bone whose key function is to provide protection to the body's vital organs as well as being a base for muscular attachment. A prime example of a flat bone is the scapula (shoulder blade). The sternum (breast bone), cranium (skull), os coxae (hip bone) pelvis and ribs are also classed as flat bones. The greatest number of red blood cells are formed in flat bones in adults.

### **Irregular bones**

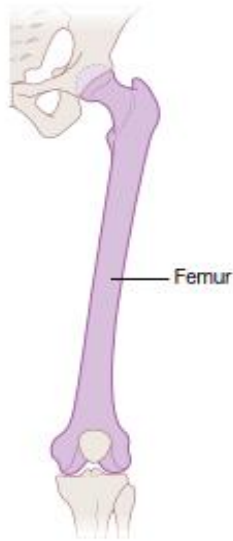
These bones do not fall into any other category, because of their non-uniform shape. Examples of these are the vertebrae, sacrum and mandible (lower jaw). They consist chiefly of cancellous bone, with a thin outer layer of compact bone.

### **Sesamoid bones**

These types of bones are mostly short or irregular bones, imbedded in a tendon. The patella (knee cap) is the most obvious example of this and sits within the patella or quadriceps tendon.



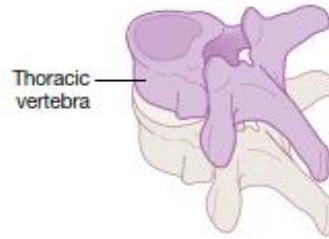
! **Compact bone (long bone):**  
found in the toes, legs, fingers  
and arms



**Figure 46.3 Short bone**



**Figure 46.5 Irregular bone**



**Figure 46.4 Flat bone**



**Figure 46.6 Sesamoid bone**



## Joint, cartilage, ligaments, and tendons

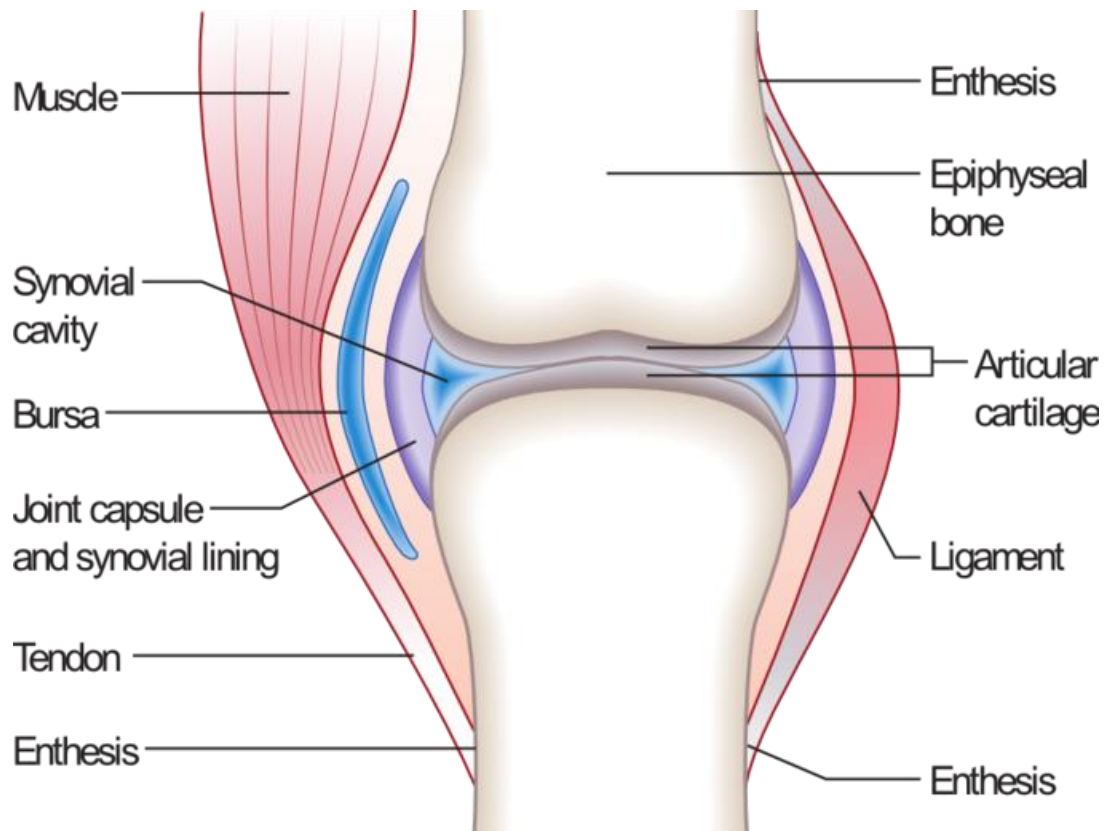


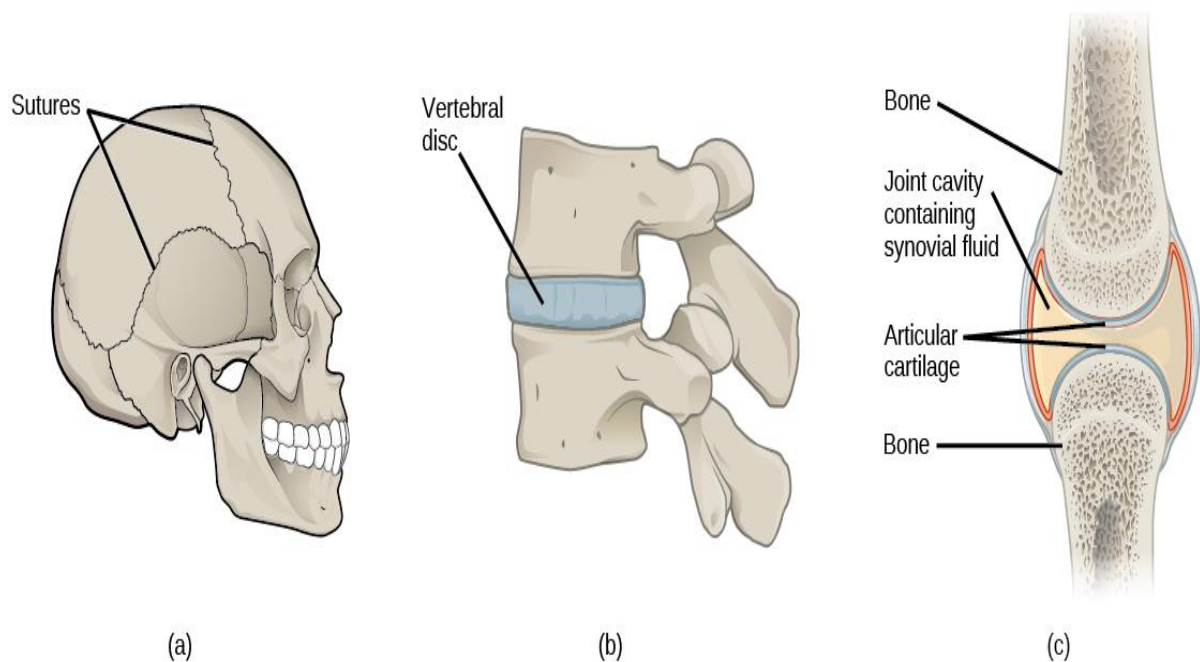
Diagram of a synovial joint, illustrating the various connective tissues (tendons, ligaments, cartilage)

The musculoskeletal system also contains connective structures and tissues that support the body and allow for its movement.

**Cartilage** acts as a shock absorber to reduce friction.

**Ligaments** help stabilize the joint, keeping it from moving outside of its intended range of motion.

**Tendons** connect the skeletal system to the muscular system by attaching muscle to bone. When muscle contracts, the tendon acts on the bone, causing movement.



Comparison of three types of joints: suture joints in the skull (fixed), cartilaginous vertebral discs (slightly movable), and a synovial joint (freely movable)

(a) Suture joint - fixed; (b) Vertebral discs - slightly movable; (c) Synovial joint - freely movable.

**Joints** : the point at which two or more bones connect, can be fixed, slightly movable, or freely movable.

## Muscles

The bones provide the framework for the body as well as providing leverage; however it is the muscles that pull the bones, muscles can only pull they cannot push, the bones cannot move body parts. The muscular system is made up over 600 muscles. Muscles contract and move the viscera and the blood vessels, cardiac muscle makes the heart beat. Energy is turned into loco- motion by the muscles, helping to drive the body. Without muscles we would not be able to do anything, each time we move, we blink the eyelids, we swallow our food, we inhale and exhale, we smile, muscle is involved. Muscle tissue generates heat as it contracts.

### Properties of muscle tissue :

There are four properties of muscle tissue:

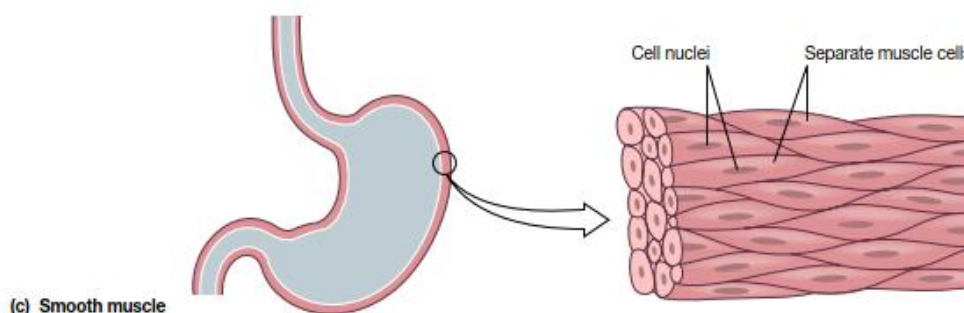
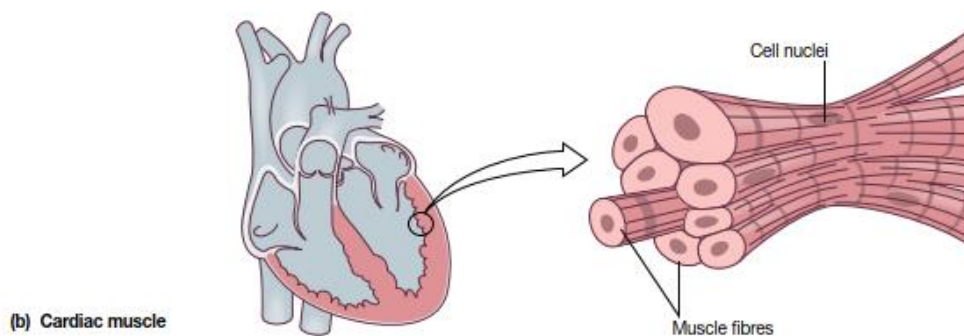
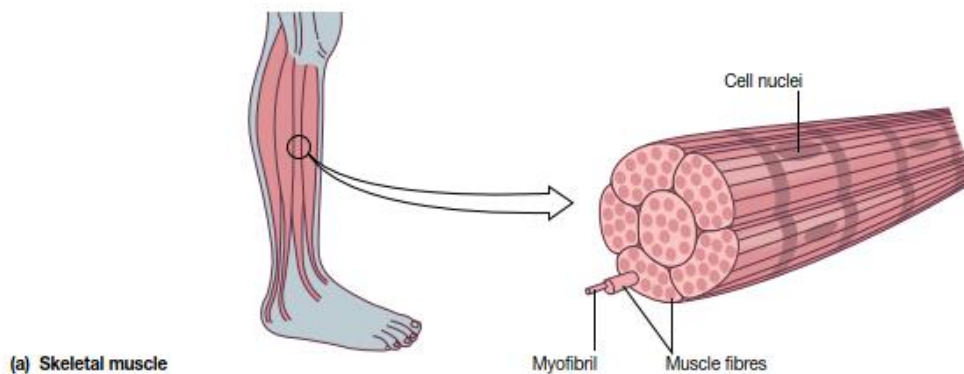
- 1 excitability (irritability) – the ability to receive and respond to stimuli via generation of an electrical pulse which results in contraction of the muscle cells;
- 2 contractility – ability to shorten;
- 3 extensibility – ability to be stretched or extended;
- 4 elasticity – ability of a muscle fibre to recoil and resume its resting length.

The body contains three types of muscle tissue: skeletal muscle, smooth muscle, and cardiac muscle.

**Skeletal muscle** is voluntary and striated. These are the muscles that attach to bones and control conscious movement.

**Smooth muscle** is involuntary and non-striated. It is found in the hollow organs of the body, such as the stomach, intestines, and around blood vessels.

**Cardiac muscle** is involuntary and striated. It is found only in the heart and is specialized to help pump blood throughout the body.



**Comparison of the three types of muscle - skeletal, smooth, and cardiac**