

Al-Mustaqbal University

College of Technology and Health Sciences

Medical physics Department



Medical Physics

First Semester

3rd stage

Lesson 1

Physics of skeleton

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Introduction

The medical specialists that are concerned with problems of bone are;

- **Dentist** (Deals with teeth and jaws)
- **Orthopedist** (Deals with orthopedic surgery)
- **Rheumatologists** (Specialize in problems of rheumatism)
- **Radiologists** (treat with x-ray images of bone structures).
- **Physicists and Engineers** (engineering type problems dealing with static and dynamic leading forces that occur during standing, walking, running, lifting, and forth).

Functions of Bones

1. **Support:** The body's muscle is attached to the bones through tendons and ligaments and the system of bones plus muscles support the body stand and move. Joints, connective tissue and muscles work together to make your body parts movable.
2. **Locomotion:** Bone joint permit movement of one bone with respect to another.
3. **Protection of various organs:** The skull, which protects the brain and several of the most important sensory organs (eyes and ears). The ribs form a protective cage for the heart and lungs.
4. **Storage of chemicals:** The bone acts as a chemical bank for storing elements for future use the body such as controlling of calcium in blood
5. **Nourishment:** The teeth are specialized bones that can cut food, tear it and grind it and thus serve in providing nourishment for the body.

6. **Sound transmission:** The smallest bones of the body are the ossicles in middle ear. These three small bones act as device converting sound vibrations in air to sound vibrations in the fluid in cochlea.

Bone Remodeling Cycle

Since bone is a living tissue it undergoes change throughout life. A continuous process of destroying old bones and building new bones, called **bone remodeling**, is performed by specialized bone cells. These cells maintain the bone in a healthy condition. If these cells die (e.g., due to a poor blood supply), the bone dies and it loses some of strength.

Osteoclasts destroy the bone, and **osteoblasts** build it. Young body is growing and the osteoblasts do more than the osteoclasts, but after the body is 35 to 40 years old the activity of the osteoclasts is greater than that of the osteoblasts. This faster in the women than in the men and leads to a serious problem of weak bones in older women. This condition called **osteoporosis** (decrease bone density). The bone remodeling cycle is shown in figure 1.1

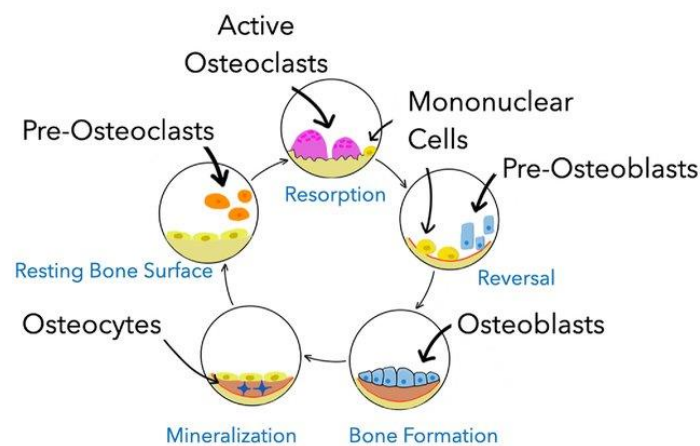


Figure 1.1. Bone remodeling cycle

Skeletal system parts

The skeletal system is a network of many different parts that work together to help you move. The main part of your skeletal system consists of your bones, hard structures that create your body's framework the skeleton. There are 206 bones in an adult human skeleton. Each bone has three main layers:

Periosteum: Tough membrane that covers and protects the outside of the bone.

Compact bone: Below the periosteum, compact bone is white, hard, and smooth. It provides structural support and protection.

Spongy bone: The core, inner layer of the bone is softer than compact bone. It has small holes called pores to store marrow.

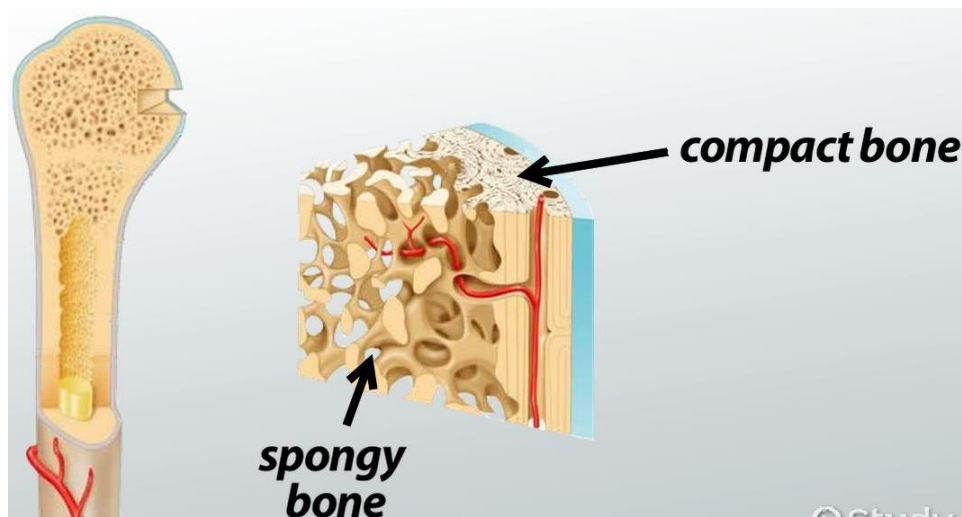


Figure 1.2. Compact and spongy bone

In general, there are two types of bone structure; **Compact** bone and **Trabecular** bone and table 1.1 below summarizes the differences between these two types;

Table 1.1. Compact and trabecular bone

	Compact bone	Trabecular bone
Occurrence	Forms the major parts of long bones such as arms and legs	Forms the major parts of short bones such as wrists and ankles
In Long Bones	Make up the shaft of long bones	Make up the ends of long bones.
The shape	Cylindrical shape	Cuboidal shape
Spaces between Lamellae	No spaces between lamellae	Has spaces between lamellae
Marrow Cavity	Has a marrow cavity	Does not have a marrow cavity
Bone Marrow	Contains yellow bone marrow	Contains red bone marrow
Amount Calcium	Contains a high amount of calcium	Contains a very low amount of calcium
Contribution	80% of the weight of the skeleton	20% of the weight of the skeleton
Porosity	Less porous	More porous
Function	Providing structural support to body	Acts as a buffer for compact bones

Other component of the skeletal system

- **Cartilage:** This smooth and flexible substance covers the tips of your bones where they meet. It enables bones to move without friction (rubbing against each other). When cartilage wears away, as in arthritis, it can be painful and cause movement problems.
- **Ligaments:** Bands of strong connective tissue called ligaments hold bones together.
- **Tendons:** Tendons are bands of tissue that connect the ends of a muscle to your bone.

- **Joints:** A joint is where two or more bones in the body come together. There are three different joint types. The types of joints are:
 - **Immovable joints:** *Immovable joints don't let the bones move at all, like the joints between your skull bones.*
 - **Partly movable joints:** *These joints allow limited movement. The joints in your rib cage are partly movable joints.*
 - **Movable joints:** *Movable joints allow a wide range of motion. Your elbow, shoulder, and knee are movable joints.*

What bones are made of

Bones are consisting of large percentage of **calcium**. Since calcium has a much heavier nucleus than most elements of the body, it absorbs x-rays much better than the surrounding soft tissue. ***This is the reason x-rays show bones so well.*** (Figure 1.3)

Bone consists of two quite different materials plus water collagen;

The major *organic fraction*, which is about 40% of the weight of solid bone and 60% of its volume, and *bone mineral* that so called inorganic component of bone, which is about 60% of the weight of the bone and 40% of its volume.

Either of these components may be removed from bone, and in each case the remainder, ***composed of only collagen or bone mineral***, will look like the original bone. The collagen remainder is quit flexible, it bends easily if it is compressed. When the collagen is removed from the bone, the bone mineral remainder is very brittle and can be crushed with fingers. Bone mineral is believed to be made up of mostly calcium hydroxyapatite $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$. The detailed chemical composition of compact bones is given by table 1.2;

Table 1.2. Chemical composition of compact bone

Element	Compact bone %
H	3.4
C	15.5
N	4
O	44
Mg	0.2
P	10.2
S	0.3
Ca	22.2
Miscellaneous	0.2



Figure 1.3. X-ray image of elbow

Exercises

- 1 The body's muscle is attached to the bones through;**
 - (a)Osteoclast and osteoblast
 - (b)Stress and strain
 - (c)Tendons and ligaments
 - (d)Cartilage
 - (e)Collagen
- 2is tough membrane that covers and protects the outside of the bone.**
 - (a)Periosteum
 - (b)Hydroxyapatite
 - (c)Joints
 - (d)Compact bone
 - (e)Spongy bone
- 3 joints allow a wide range of motion is called**
 - (a)Immovable joints
 - (b)Movable joints
 - (c)Partly movable joints
 - (d)Cartilage
 - (e)None of them
- 4 If collagen is removed from the bone, the bone will be ;**
 - (a)Stronger
 - (b)Very elastic
 - (c)Very brittle
 - (d)Flexible
 - (e)The same
- 5 Forms the major parts of short bones such as wrists and ankles.**
 - (a)Compact bone
 - (b)Joints
 - (c)Marrow
 - (d)Calcium
 - (e)Trabecular bone

Physics of skeleton is continued in the next lesson.....