

## Function of bone

**Supporting:** The system of bones and muscles support the body

The bones are attached to another bones through **ligaments**  
The muscles are attached to the bones through **tendons**



**Locomotion .2** Bone joints which permit the movement of one bone with respect to another. These hinges or articulations (are very important for walking as well as for many other motions of the body.)

**Protection: .3** protection of delicate body parts is an important function of some of the bones. The skull, which protects the brain and several of the most important sensory organs (eye and ears), is extremely strong container while the ribs form a protective cage for the heart and lungs.



**Storage of chemicals: .4** The bones act as chemical bank for storing elements for these chemicals as future use of the body, then the bones can withdraw needed, for example if the level of Ca fall too low in the blood, a calcium sensor to release more parathormone into the blood, causes the parathyroid glands and this in turn causes the bones to release the needed Ca.

**Nourishment.5** The teeth are specialized bones serve in providing nourishment for the body. Eg. Incisors, canines, molars

**6. Sound Transmission:** The three smallest bones in the body are the . -They act as **levers** which provide an *impedance* matching. They **تسمى Ossicles** form a system for converting sound vibration in the air into sound vibration in the **fluid** of the cochlea.



**7- Red blood cells generation:** The stem cells in the bone marrow **عظم** RBCs generate the

### Bone Composition:

The Bone is a living tissue which has blood supply as well as nerves with a special kind of cells distributed through the bone tissue; these cells are called **“Osteocytes”**

maintain the bone in a healthy condition. **هيمظعلا ليلخلا** The Osteocytes cells These cells make up about 2% of the volume of the bone, if these cells die (e.g. due to poor blood supply), the bone dies and it loses some of its strength. A **مماظعلا رخن** problem is caused by a condition called **aseptic necrosis** **سريس هيب** which the bone cells in the hip die due to the lack of blood.

Bones consist of two quite different materials plus water:

**Collagen:** it is the major organic part of the solid bone. It is quite flexible, it has **1** so that it can bend easily if it's compressed. **شلا هوف** a fair amount of tensile strength It forms about 40% of the weight of the solid bone and 60% of its volume.

**Bone Minerals:** it is the inorganic part of the solid bone. It is believed to be **2** made up of calcium hydroxyapatite  $[Ca_{10}(PO_4)_6(OH)_2]$ . It is very fragile and forms about 60% of the weight of the bone and 40% of its volume.

The bone minerals crystals are rod shaped with diameters of 20 to 70 Å. Because of the small size of the crystals, bone minerals have a very large surface area. Around each crystal is a layer of water containing in a solution many chemicals needed by the body. The large area exposed bone minerals permit the bone to interact rapidly with chemicals in the blood and other body fluids.

As described above bone is composed of small hard bone mineral crystals attached to a soft flexible collagen matrix. These components have vastly different mechanical properties. This combination provides a material that is strong as granite in compression and 25 times stronger than granite under tension.

The detailed chemical composition of the bone is given by the following table:

Element	% of the element in the bone
H	3.4
C	15.5
N	4
O	44
Mg	0.2
P	10.2
S	0.3
<b>Ca</b>	<b>22.2</b>
Miscellaneous	0.2

## Bone remodeling

change through the **بلاضوعي** Since the bone is a living tissue it undergoes life, a continuous process of destroying an old bone and building a new one is called **“bone remodeling”** **طب هداعا**

by specialized bone cells, they are: **في** Bone remodeling is performed

**Osteoclasts:** They are specialized cells which responsible for destroying the **1** bone.

**Osteoblasts:** They are specialized cells which responsible for building a new **2** bone

of a new skeleton about every seven years, **لقيم** We have the equivalent each day the osteoclasts destroy bone containing about (0.5 gm) of calcium, osteoblasts build a new bone by using about the same amount of calcium.

While the body is growing and young the osteoblasts do more than osteoclasts, but after the body is 35 to 40 years old the activity of osteoclasts is greater than that of osteoblasts, resulting in a gradual decrease in the bone mass that continuous until death. This decrease is apparently faster in women than in men and leads to serious problems of weak bones in older women. This . It is one of the bone diseases which is **ماظعلا هشائنه** condition called **Osteoporosis** produced by the reduction of the amount of Ca as a result:

-The **mass** of the bone **decrease**

-The **volume decrease**

-The **density of the bone = mass / volume = 1.9 kg/cm<sup>3</sup>** it s remain constant.

## Bone Strength

If you cut the bones apart, you would find that it composed of two quite different types of bones:

**Compact bone:** This is found in the central shaft of the bone. صارتهم **Solid (compact)** 1

**Spongy (cancellous) bone:** This is made up of thin thread-like trabeculae (trabecular bone). It is predominantly found at the ends of the long bones. 2

Trabecular bone is considerably weaker than compact bone due to the reduced amount of bone in a given volume. Therefore the trabecular bone has two advantages over the compact bone:

Where the bone is subjected primarily to compressive forces, such as at the ends of the bones and the spine, trabecular bone gives the strength necessary with less material than the compact bone. •

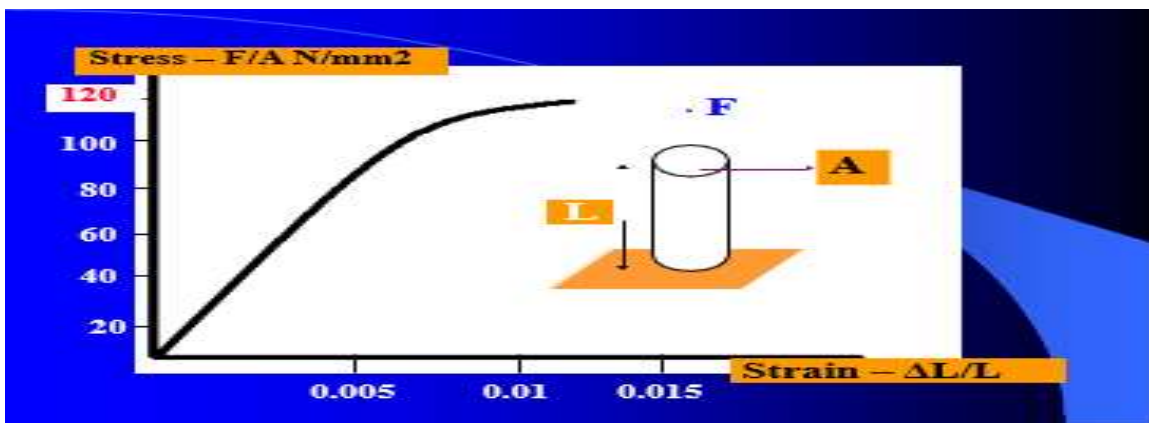
Because the trabecular is relatively flexible, it can absorb more energy when large forces are involved such as in walking, running and jumping. •

very well the **bending stress** يصلت Note: Trabecular bone cannot withstand that occurs mostly in the central portion of long bones.

**Hook law** All material change in length when placed under tension or compression

$$\text{Stress} = \text{strain} \rightarrow F/A \propto \Delta L/L \rightarrow F/A = Y \Delta L/L \quad Y = FL/\Delta LA$$

The strain ( $\Delta L/L$ ) increases linearly, at first indicating that it is proportional to the stress ( $F/A$ ), as the force increase the length increase more rapidly, and the bone breaks at a stress of about 120 N/mm<sup>2</sup>.



The ratio of stress to strain in the initial linear portion is the **Young's modulus**, that is:

$$Y = \frac{LF}{A\Delta L}$$

Where L= the length of the bone (mm)

F= the force exerting on the bone (N)

A= the cross section area of the bone (mm<sup>2</sup>)

The compressive طغاض breaking stress of the compact bone is 170 (N/mm<sup>2</sup>), while the tensile ش breaking stress اظغن is 120 (N/mm<sup>2</sup>), Young's modulus of the compact is about  $179 \times 10^2$  (N/mm<sup>2</sup>).

### **Example**

Leg has length 1 m with bone has cross section area 5 cm<sup>2</sup>, what amount of shorting when 1000 nt is supporting on leg body while  $Y = 2 \times 10^{10}$  nt/m<sup>2</sup>

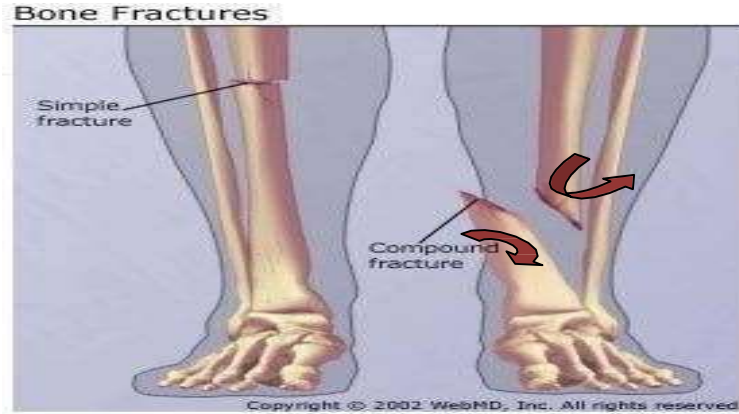
$$\Delta L = \frac{FL}{YA} = \frac{1000 \times 1}{2 \times 10^{10} \times 5 \times 10^{-4}} = \frac{1000}{1 \times 10^7} = 0.00001 \text{ m}$$

### **Bone Fracture:**

There are many types of fractures, but the main categories are:

**Simple Fracture:** It is also called a closed fracture, the bone breaks but there is no open wound جرح in the skin.

breaks through the **Compound Fracture**: It is also called an open fracture, the bone be visible through the skin back into the wound and not <sup>عجزني</sup>skin; it may then recede



## Physical factors affecting the degree of bone fracture

1-The amount of the exerting force during collision or falling

Force= The change in body momentum/ duration of impact

$$F=mg=Kg*m/sec^2 =Kg*m/sec * 1/sec=mv/t$$

, the greater the force. To reduce the force <sup>رئتك</sup>Therefore, the shorter the duration of impact of fracture, it is necessary to increase the impact time. In <sup>لامتعا</sup>the likelihood <sup>مكثرو</sup>and thereby , the impact time can be increased <sup>عقرا</sup>both falling down or jumping from elevation the change <sup>رئتنا</sup>significantly by simply rolling with the fall or jumping, thereby spreading of momentum of the body over longer time.

force (Tension, Compression, and Twisting). <sup>لئب</sup>The direction and the type of the exerting 2

children's fractures are The age, Broken bones are very common in childhood, though 3 generally less complicated than fractures in adults .

, are more likely to suffer fractures from <sup>شه</sup>Older people, whose bones are more brittle falls that would not affect younger people.



## Measurement of bone mineral in the body

Osteoporosis is the most common disease in elderly women and the most common feature of it is lower bone mineral mass, bone mineral mass decrease 1-2% per year, thus a precise technique was needed to show the changes.

The first tried is using an ordinary X-ray but it forced many problems

- X-ray beam has many different energies and the absorption of x-ray by calcium varies
- X-ray beam contain much scattered radiation when reach the film .  
with energy .

-The film is a poor detector for quantitative measurement .

Then ordinary x-ray can't detect the change in bone mineral until its lost 30-50% of density, at this time it was too late use preventive therapy

## Photon absorptiometry

A develop technique measured the bone density consist of

- Monoenergetic x-ray or gamma ray source .
- Narrow beam to minimize scatter radiation .
- Scintillation detector that detect all photons.
- The bone mineral mass (BM ) calculated electronically , it's use radioactive source gradually decay .

A single energy photon beam is passed through bone and soft tissue to a detector the amount of mineral in the path is then quantified

## The problems of photon absorptiometry are

- The radioactive source must be replaced after time .
- To measure the bone need uniform thickness of soft tissue ,therefor it can't measure hip and spine .



To solve the problems developed a new technique , it's called **Bone density scan (DXA )**.

### **Bone density scan (DXA )**

It's also called dual energy X-ray absorptiometry, DXA widely used for measuring bone mineral density (BMD ).

There are two types : central device and peripheral device.

Central DXA device measure bone density in the hip and spine .

Peripheral device measure bone density in wrest ,heel and finger.

### **Central DXA consist of**

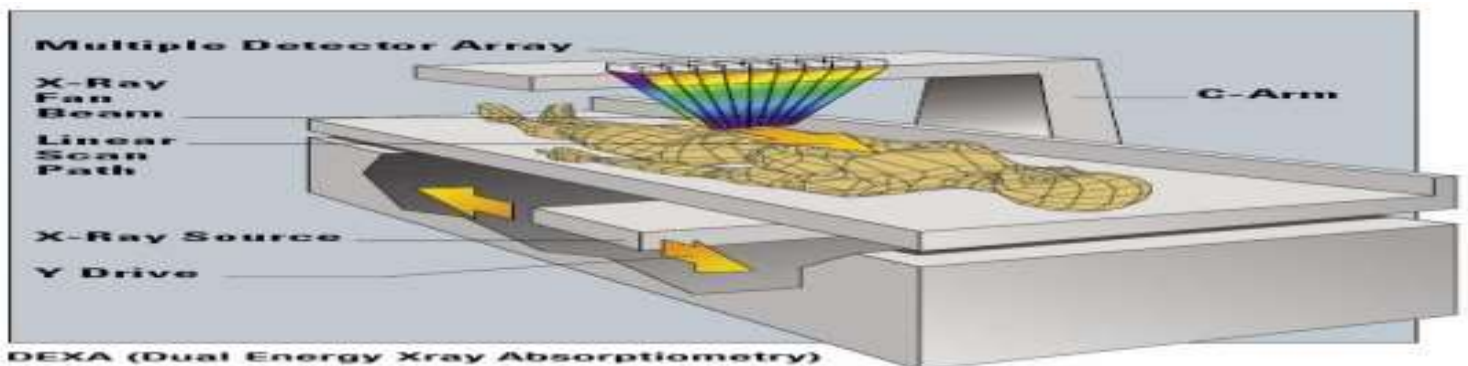
-Large flat table and an arm suspended overhead.

-X-ray source mounted under the flat table and x-ray detector mounted in suspended قلمع arm.

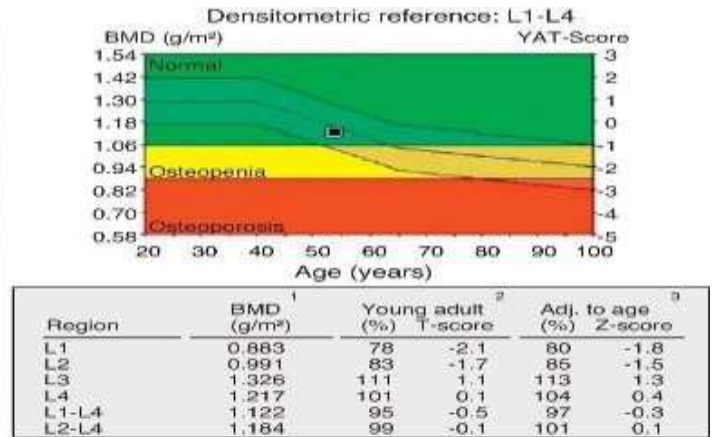
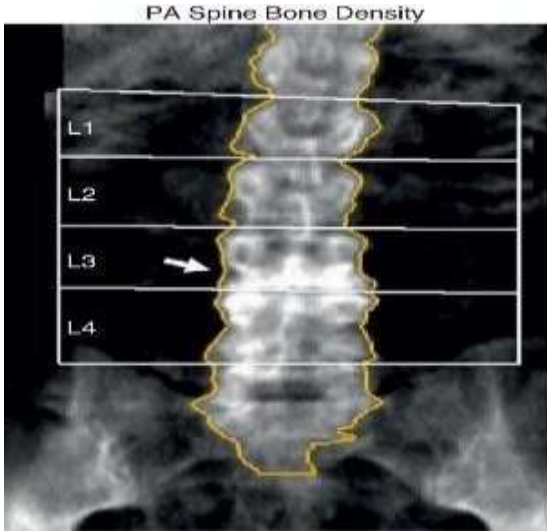
-special software for processing data, monitor to display the results.

### **The procedure of work**

The X-ray source sends a thin Invisible beam of low dose هعرج, with two distinct زيمتم energy peak through bones being examined, one peak is absorbed by soft tissue and the other by bone. The soft tissue amount can be subtracted احورطم from the total and what remains is patients bone mineral density. The DXA machines feature هزيم a special software that compute and display the bone density measurements on computer monitor.



How dose DXA report interpret :



*The T-score*

The “young normal” or T-score indicates how your BMD compares to that of a healthy 30 year-old. Peak bone density is reach by age 30.

T-score numbers interpreting as the following

- ||
- ||
- ||

Above (-1) considered normal.

Between (-1 and -2.5) its osteopenia.

Below (-2.5) indicates osteoporosis.

**DXA device is most used in :**

| Diagnosis of osteoporosis, which involves a gradual loss of calcium, as well as structural changes causing bones to become thinner, more fragile and more likely to break.

Tracking the effect of treatment of osteoporosis and other conditions  
cause bone loss.

|| risk of developing fractures. Assess an individual's

## Bone Scan

-Bone in a bone tumor is being destroyed somewhat like a brick house  
being torn down at a time.

-When radioactive fluorine ( $F^{18}$ ) is injected into a patient, it will be  
distributed through the bones of his body.

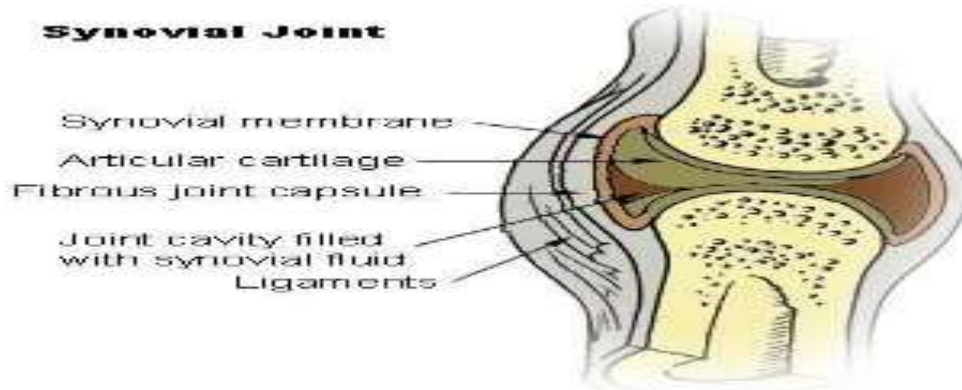
-When the radioactive fluorine atoms come in contact with the partially  
destroyed bones, they find many places that they can fit in more so than  
in normal bone. -The increased radiation from the tumor area signals the  
possibility of a bone tumor.



## Bone Joints

Joints are placed in the body where two bones come together; the joints make  
most of the body movement possible. In this type of joint, the ends of the  
opposing bones are covered with hyaline cartilage, and they are separated by a space called the joint cavity. The  
joint capsule, also called an articular capsule, components of the joints are enclosed in a dense fibrous  
called an articular capsule. The outer layer of the capsule consists of the  
ligaments that hold the bones together. The inner layer is the synovial  
synovial fluid into the joint cavity for lubrication. that secretes membrane

Because all of these joints have a synovial membrane, they are sometimes called synovial joints.



**The types of bone joints are:**

1. **Ball and socket** (رجم) which allows circular motion. (Hip and shoulder) فاك
2. **Hinging joints** (ابليا) which allow back and forth movement. (Knee and elbow) تقوم
3. **Pivot** (روح) joints which allows back and forth turning motion. (Vertebrae of neck) هبقر
4. **Gliding joints** (اوتلا) which allow sliding and twisting movement. (Bones of wrist and ankle) غسر
5. **Fixed joints** which don't allow movement. (Bones of the skull)

### Bone Joints Lubrication Mechanism

Each bone ended with porous **هيماسم** and not very smooth cartilage lubricated with the **Synovial fluid**.

The roughness of the cartilage plays useful role in joint lubrication trapping some of the synovial fluid and because of its porous nature, other lubricating material is squeezed into the joints. **لخدت**

Pressure causes lubricating threads to squeeze out of the cartilage into the joints, one end of the each lubricating thread remains in the cartilage, and as the pressure is reduced the threads pull back into their holes

of the synovial fluid reduces. Under a large shear stress the viscosity •  
The coefficient of friction of the healthy joints was found to be 0.01 i.e: when •  
100 N of force exert on a joint, only 1N of force is needed to move it, it is the  
least friction in the nature.

### Joints Diseases

There are two major diseases affect the joints:-

of the synovial -جنتلاب هدايز **Rheumatoid arthritis:** It results from the overproduction

fluid in the joints and commonly causes swollen joints

- **Osteoarthritis:** it is the disease of the joint itself. Its occur when cartilage or  
and swelling. cushion between joint breaks down leading to pain, stiffness