

# Fracture and Bone Healing

## Objectives:

- Know the different types of fractures
- Be aware of the mechanism and stages of fracture healing process
- Know the factors affecting healing process and the possible complications of healing process
- Appreciate the importance of road traffic accidents as a major cause of disability in Saudi Arabia



- **Red : Important**
- **Green: doctors' notes**
- **Grey: extra**

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Please [check here](#) before viewing the file to know if there any changes or additions.

# Normal anatomy

- 1- parts of a long bone:

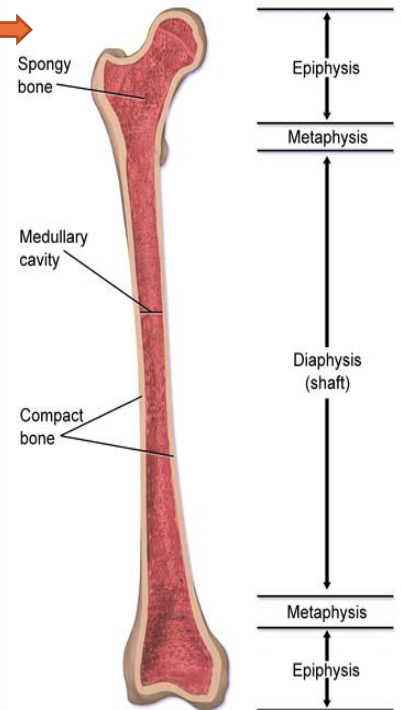
- **Epiphysis** (ends of bone, partially covered by articular cartilage).

- **Physis** (growth plate).

- **Metaphysis** (junction of diaphysis and epiphysis).

- **Diaphysis** (shaft).

Structure of a Long Bone



- We should know all of these parts when we diagnose the lytic lesion of the bone.

- Below the Epiphysis there is the Epiphyseal line (it's contain chondrocyte and progenitor cell which help in bone growth).

# Normal anatomy

- 2- Cross section:

we will see in the Cross section from outside to inside the:

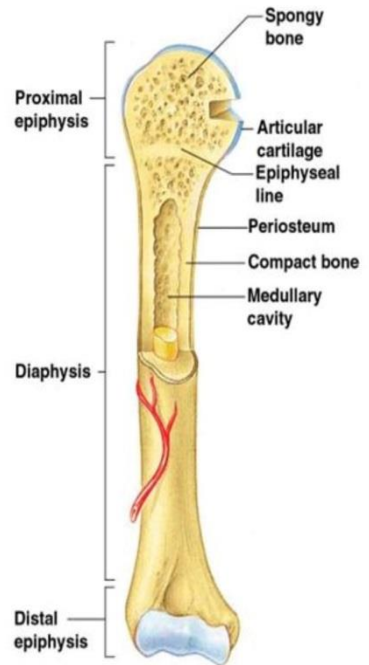
- **periosteum**

- **Cortex** composed of cortical bone (compact bone).

- **Epiphysis line:** found in adult bones.  
Thin line of bony tissue spanning the epiphysis

- **Epiphyseal plate:** cartilage in young bone between the diaphysis and the epiphysis for long bone lengthening.  
AKA: growth plate.

- **Medullary space** composed of cancellous (spongy bone) (NO lamellar bone here)



- **The Epiphyseal line** in the children is open because the bone is still growing, it's usually close after puberty.

- The upper part of bone is covered by **articular cartilage** (it is opening into the joint).

- There are some diseases which can effect only the **articular cartilage** ,the most important one is **Osteoarthritis** (التهاب المفاصل).

- The whole bone is covered by **periosteum**.

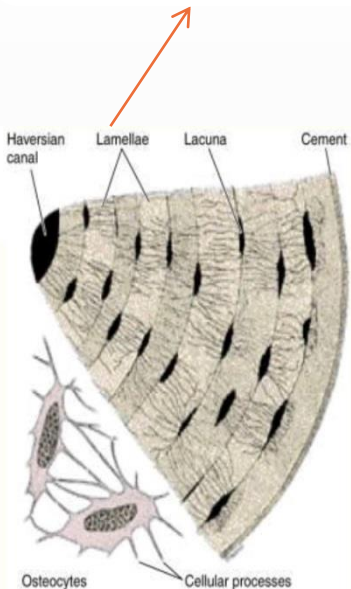
- what is the **periosteum**?

It is a membrane like structure cover the shaft of the bone, it contains progenitor cell and it is affected in the **fractures** and **Osteomyelitis** (التهاب العظام).

# Normal histology

- **Bone:** is composed of specialized collagen (**Osteoid\***) (ECM) synthesized by **Osteoblasts**, which is mineralized by the deposition of hydroxyapatite (Calcium – containing salts).

This is lamellar or cortical bone? Lamellar.  
Why? Because it's formed by lamellae.



**Bone type either:**

**Lamellar bone=cortical=compact:**  
Layered bone with concentric **parallel** lamellae.  
-found in adult skeleton.  
- Stronger than woven bone.

It is a hard part of the bone(cortex), it's varies in thickness according to the building body of a person and to the type of the bone.

**Woven bone=spongy=trabecular:**  
We see it in children.  
In this part of the bone there is a space filled by bone marrow.  
Bone marrow contain:  
1- Red marrow: hematopoietic stem cell.  
2 Yellow marrow: fat.

- Lamellar and woven Grossly they look the same, but under the microscope they are different.

## What's marrow?

A diagram of a long bone with marrow highlighted. To the right, a list of blood components is shown with corresponding icons: Red Blood Cells, Lymphocyte, Monocyte, Eosinophil, Basophil, Neutrophil, and Platelets.

Marrow and stem cell transplants are a lifesaving treatment option for more than 30,000 patients each year who are diagnosed with diseases such as leukemia, lymphoma and certain genetic disorders.

- **Osteoid\*:** is the unmineralized , organic portion of the bone matrix that forms prior to the maturation of bone tissue. Osteoblasts begin the process of forming bone tissue by secreting the Osteoid as several specific proteins.

Simple definition: it's the connective tissue of the bone when it becomes bone.

# Normal histology

## There are two main patterns of bone deposition

(bone cells also rebuild bone tissue by deposition minerals from the bloodstream).

In normal **lamellar bone** the Osteoid collagen is deposited in a mechanically strong, **parallel** stratified pattern.  
(نمط مرتب)

In **woven bone**, the Osteoblasts deposit Osteoid collagen in a **haphazard** (نمط غير مرتب) it's weaker than lamellar , less efficient and rapidly produce.  
يعني لما يحصل كسر اول شي يتكون في العظم هو  
Woven  
Easily fractured under stress.

- **Bone resorption:** is **resorption** of bone tissue, that is the process by which **Osteoclasts** breakdown the tissue in bones. During resorption, bone cells break down bone tissue and release Calcium and other minerals for use by other cells in the body.

**Note :** differentiate between resorption and reabsorption

## Bone cells

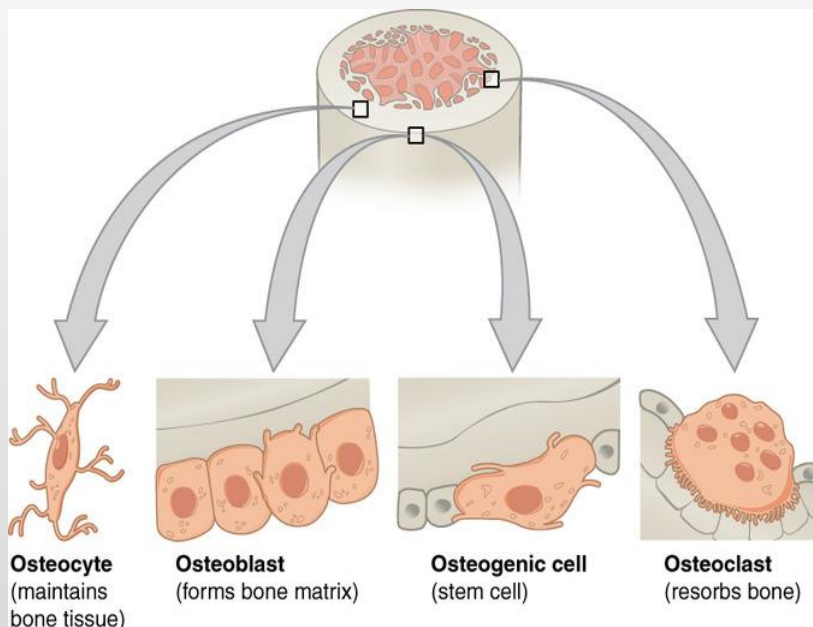
- **Osteoblasts:** arise from marrow mesenchymal cells (Mesenchymal stem cells, are multipotent stromal cells that can differentiate into a variety of cell types, including: osteoblasts (bone cells).

when active, are plump and present on bone surface. Eventually are encased within the collagen they produce. ( **secrete osteoid** )

- **Osteoclasts:** large **multinucleated** cells found attached to the bone surface at sites of active bone resorption.
- **Osteocytes:** set inside lacunae

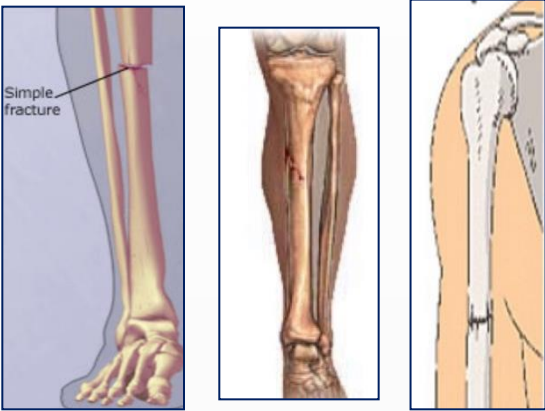
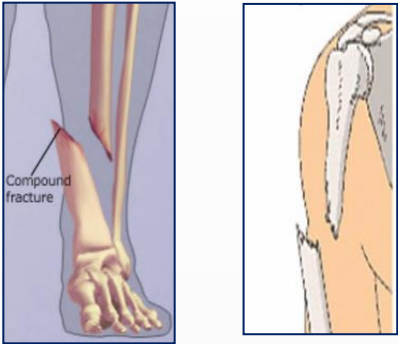
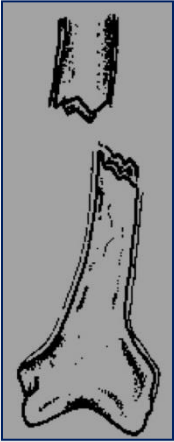

**NOTE: when we see osteocytes inside lacunae that means the tissue is viable and when we see empty lacunae that means the tissue is dead.**

Bone Cells		
Cell type	Function	Location
Osteogenic cells	Develop into osteoblasts	Deep layers of the periosteum and the marrow
Osteoblasts	Bone formation	Growing portions of bone, including periosteum and endosteum
Osteocytes	Maintain mineral concentration of matrix	Entrapped in matrix
Osteoclasts	Bone resorption	Bone surfaces and at sites of old, injured, or unneeded bone



**Definition of Fracture:** it is the medical term of a break in the continuity of the bone.

**The fracture can be:**

1-Closed (simple) fracture	2-Open ( <b>compound</b> ) fracture
<ul style="list-style-type: none"><li>• The fracture does NOT communicate with external environment</li><li>• there is no puncture or open wound in the skin</li></ul>  <p>The illustrations show three types of simple fractures. The first shows a forearm with a small red mark on the skin and a crack in the bone, labeled 'Simple fracture'. The second shows a leg with a similar mark and crack. The third shows a shoulder with a crack in the bone.</p>	<ul style="list-style-type: none"><li>• The fracture communicates with external environment</li><li>• Fracture extends to the skin</li><li>• open fracture has a risk of a <b>deep bone infection</b>.</li></ul>  <p>The illustrations show two types of compound fractures. The first shows a forearm with a large open wound on the skin and a crack in the bone, labeled 'Compound fracture'. The second shows a shoulder with a large open wound and a crack in the bone.</p>
3-Complete	4-Incomplete
 <p>The illustration shows a complete fracture of a bone, where the bone is broken into two separate pieces.</p>	 <p>The illustration shows an incomplete fracture of a bone, where the bone is broken but the pieces remain in contact.</p>

## Classification of fractures

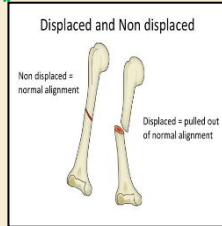
### Displaced fracture:

The bone has moved from its original place.

Sometimes this fracture could be compound fracture so we call it "displaced compound fracture "

**NOTE: displaced fracture** مو شرط يكون  
**Open fracture** (It might be closed or open ).

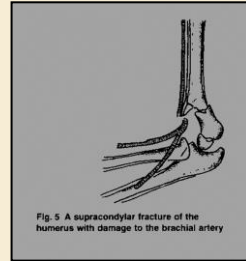
**Linear fracture** لو الكسر كان ثابت في مكانه  
يكون اسمه



### Complicated fracture:

Associated with damage of nerves, vessels or internal organs.

\*actually all fractures involve damage of small blood vessels. But complicated fracture involves damage of major vessels eg.brachial artery.



### Greenstick fracture :

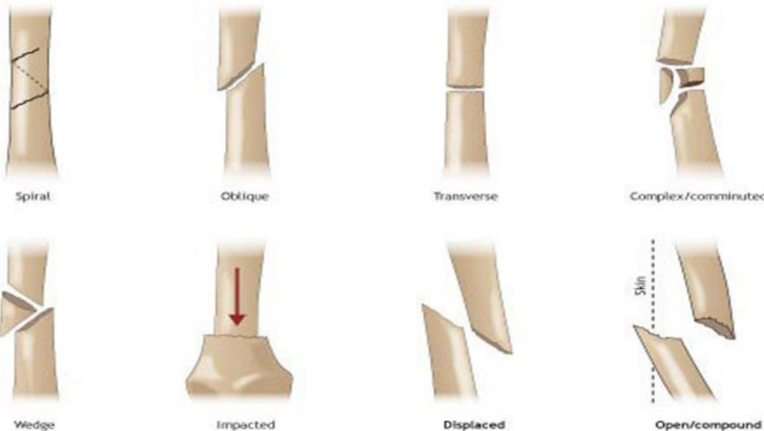
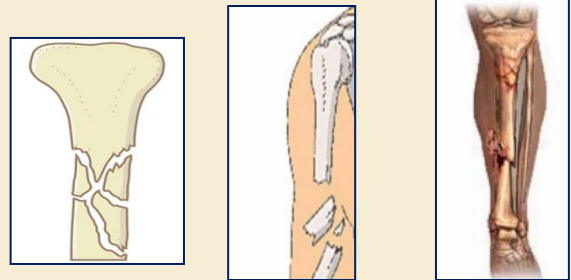
- A very common fracture which occurs only in children
- it's an **incomplete fracture** ,it's NOT very much displaced
- usually heals very well even without a splint(جبيرة)

Because it has osteoprogenitor cells



### Comminuted fracture (splintered fracture):

- There are **many fragments of the bones** thus it's very displaced.
- it is very difficult to treat.
- it is usually caused by a very severe shattering trauma.
- many times it is a compound fracture, but it can be closed also.



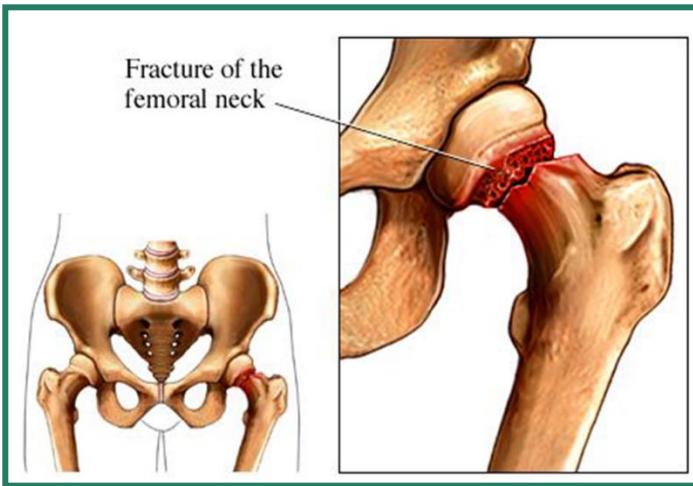
**NOTE :** Fracture can be:

- displaced and compound (**open**),
- Comminuted and compound .
- Linear and compound.



## Common sites of fractures:

### Fracture of the femoral neck



### Colles fracture

- It is a fracture of the distal end of radius .
- It is the most common fracture of the forearm.
- It results from a FOOSH (Fall Onto Outstretched Hand) with a pronated forearm in extension/dorsiflexion position (the position adopted when trying to break a forward fall).
- It causes dinner fork deformity. تصوير اليد منحنية. مثل شوكة الطعام
- 60% of the cases are coupled with fracture of ulnar styloid.
- Doctor must check for median and ulnar nerve involvement لأن قد يكون الكسر أثر على الأعصاب
- Urgent orthopedic referral
- Joint involvement requires emergent orthopedic referral.

# Causes of fractures

## 1-Traumatic fracture (Sever trauma)

Severe trauma  
e.g. MVA

- It's Trauma due  
to Motor Vehicle  
Accidents

- MVA it's the  
major cause of  
bone fracture

## 2- Pathological fracture

It occurs when there is a  
disease in the bone  
(underlying bone is  
abnormal) that means  
any **minor trauma**  
(minimal trauma) can  
cause fracture.

- Some causes :

Primary or Metastasis of  
malignant tumor, tumor  
to the bone, Bone cyst,  
Osteoporosis,  
Osteomalacia,  
Hyperparathyroidism\*\*,  
Paget's disease of bone,  
**Congenital bone  
disorders** e.g.  
osteogenesis imperfecta

## 3- Stress fracture

- A stress fracture is a  
slowly developing fracture  
that usually occur with  
increased physical activity  
especially with new  
repetitive mechanical  
loads on bone.

- It's usually occurs in the  
ankle.

- It's a linear fracture.

- Stress fractures are most  
common in the weight-  
bearing bones of the lower  
leg and foot.

Track and field **athletes**  
and **military** recruits who  
carry heavy packs over  
long distances are  
particularly susceptible

### Osteoporosis (metabolic):

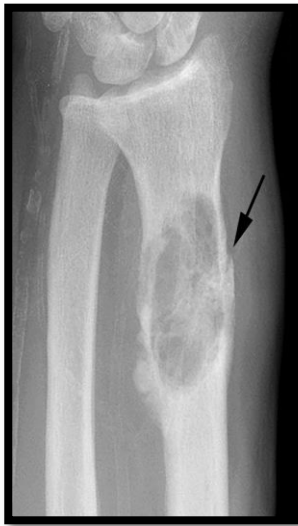
This man has kyphosis because the vertebra are compressed and he has many compression fractures, we can tell that this compression has led to some deformity of the vertebral column in a degree that the folds of the skin has increased (WHY? because the vertebra has become in a spongy form and became more compressed so the length of it has decreased resulting in excessive skin which will fold) and complaining of back pain he went to a lot of doctor with no use. we use pain relievers but we have to make sure that the patient understand that it is a chronic diseases which needs a long term treatment and we use substances that increase calcium in the bone and sometime physiotherapy and treat the fracture when they happen and a simple exercise.

it's a Small fractures for long  
time

\*\*parathyroid gland secrets  
hormone which help for  
migration of Ca from the  
bone to the circulation

If there is  
**Hyperparathyroidism** it will  
cause hypercalcemia and  
lytic bone lesion and this will  
cause fracture.

## Pathological fracture



## Stress fracture



### Osteogenesis imperfecta (congenital):

Osteogenesis imperfecta (OI) is a genetic disorder in which bones break easily. Sometimes the bones break for no known reason. OI can also cause weak muscles, brittle teeth, a curved spine, and hearing loss. OI is caused by one of several genes that aren't working properly. When these genes don't work, it affects how you make collagen, a protein that helps make bones.

\*child with this disease will have fracture even inside uterus

**What Is Osteogenesis Imperfecta?**  
The meaning of Osteogenesis Imperfecta or Brittle Bone Disease is imperfectly formed bone, which itself explains the meaning of this condition which is the bones in the body are inadequately formed.

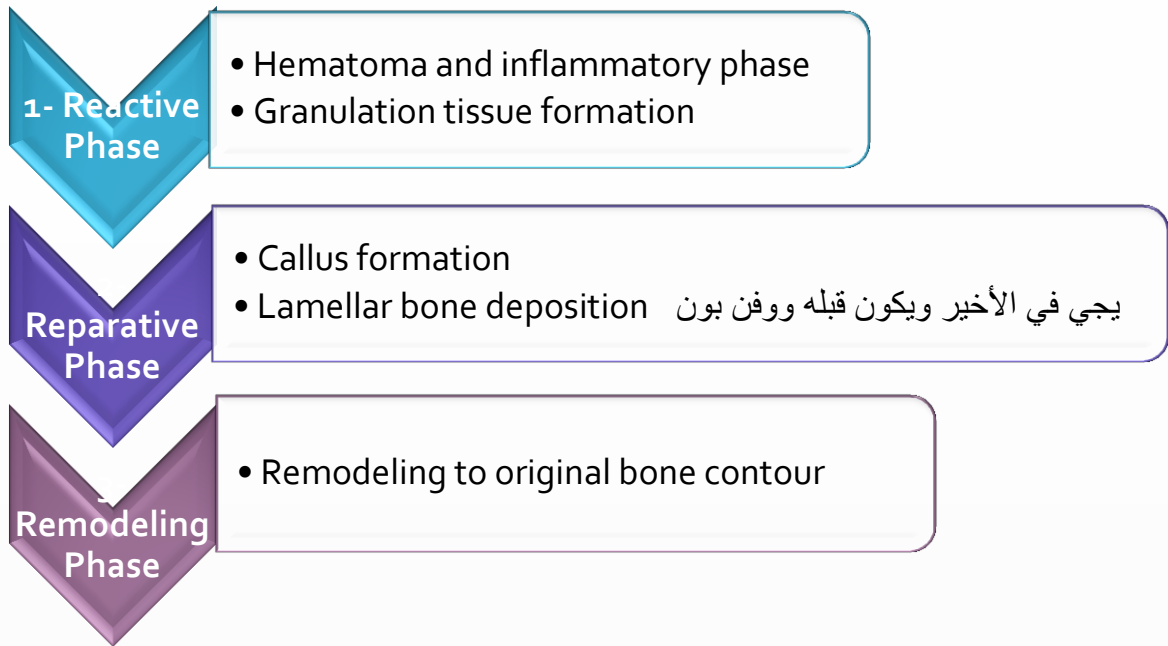
For More Information:  
Visit: [www.epainassist.com](http://www.epainassist.com)

An illustration of a young child with Osteogenesis Imperfecta. The child is wearing blue shorts and has several visible fractures on their arms and legs, represented by black lines. The child has a slightly distressed expression. The background is a light beige color.

ePainAssist.com

# Healing Of Fractures

Very important



## How does a fracture heal?

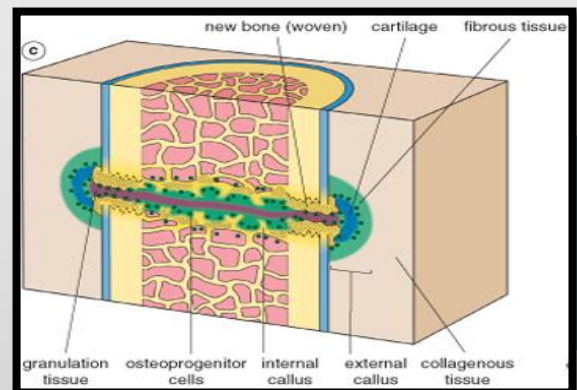
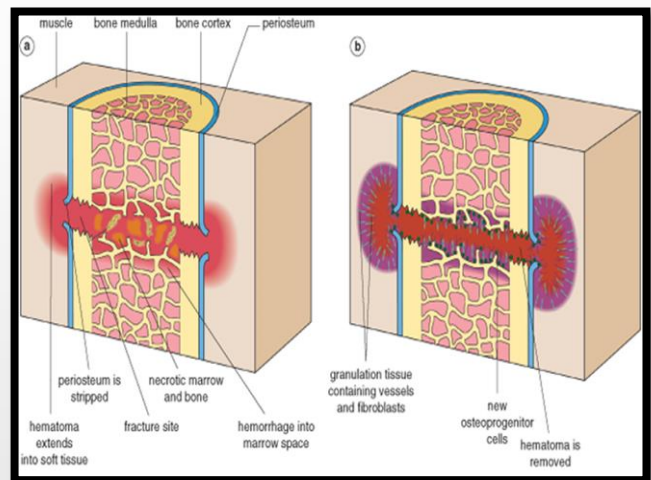
### 1- Reactive Phase

#### Stage 1: Inflammation

- Bleeding from the fractured bone and surrounding tissue causes the fractured area to swell due to inflammation induced by chemical mediator produced from macrophages and other inflammatory cells with granulation tissue formation.

This stage begins day one of fracture and lasts about 2 to 3 weeks.

- Degranulated platelets and migrating inflammatory cells release **PDGF**, **TGF- $\beta$** , **FGF**, and other factors which activate osteoprogenitor cells in the periosteum, medullary cavity, and surrounding soft tissues also stimulate osteoclastic and osteoblastic activity.



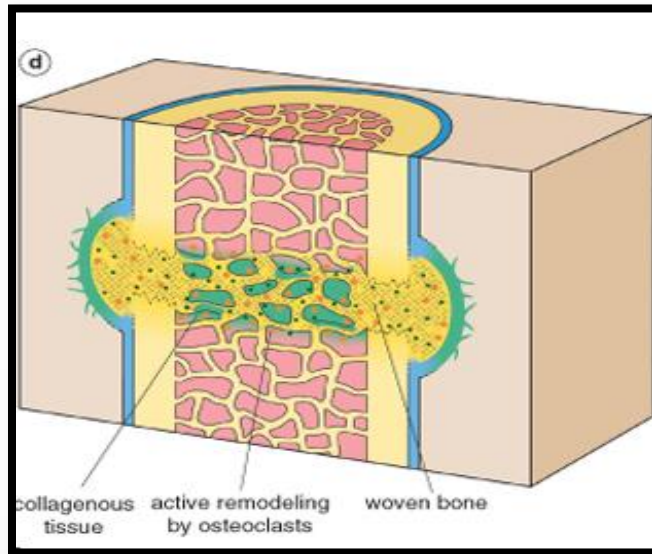
## 2- Reparative Phase

### ❖ Soft callus

by the end of the first week the hematoma is organizing, the adjacent tissue is being modulated for future matrix production, and the fractured ends of the bones are being remodeled. This fusiform and predominantly uncalcified tissue called soft tissue callus or procallus.

### ❖ Hard callus

Osteoblasts produce **woven bone**, resulting in a bony callus that stabilizes the fracture site.



For Treatment Fracture :

Immobilization promotes bone fracture healing e.g cast  
so there will be a good laying of bone during process of healing





# !!! For more understanding The Stages Of Healing Fracture

When there is a fracture, the shaft is discontinued (forming a gap in the bone). In addition, rupture of blood vessels around the bone and injury in soft tissue is usually present.

So the First step of healing is: **formation of hematoma** .

Second step: **organization of hematoma**. 3 days after fracture there is an organized hematoma (Hematoma with clotted blood and migration of fibroblast and inflammatory cells and proliferation of blood vessels [vascular granulation tissue]).

Third step : **Stimulation of osteoprogenitor cells**

Inflammatory cells release cytokines (Platelet drive growth factor and fibroblast growth factor, IL<sub>1</sub>, IL<sub>6</sub>, IFN) PDGF, FGF and TNF. These cytokines will stimulate , osteoprogenitor cells which are spindle cells which are capable of transforming into osteoblast. Within a week, the tissue will be called **Soft Tissue Callus**.

At the site of fracture, there are osteoblast and chondrocyte. Chondrocyte will go away and Osteoblasts start forming **osteoid** (connective tissue which is found in bone and it is a form of collagen I but it doesn't have calcium that means it is not ossified)

Finally, the **osteoid will get ossified** (mineralized) and there will be trabecular and cortical bone. The tissue now is called Bony Callus.

## Stages in the Healing of a Bone Fracture

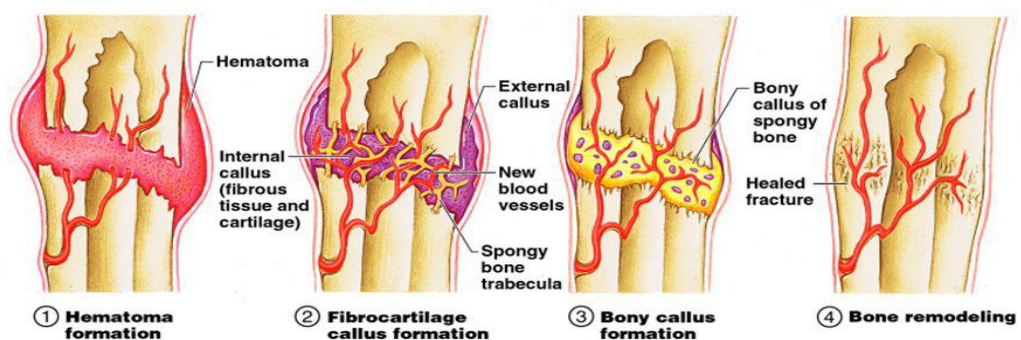


Figure 5.5

# 3-Bone Remodeling

"The final stage of fracture"

Begin about 8 to 12 weeks after the injury

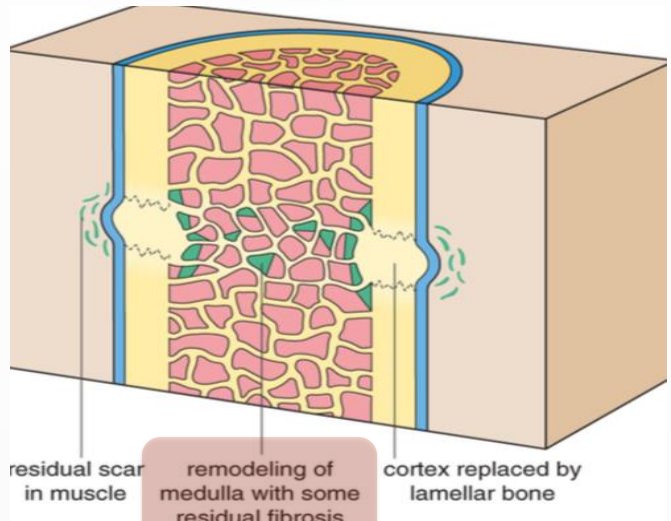
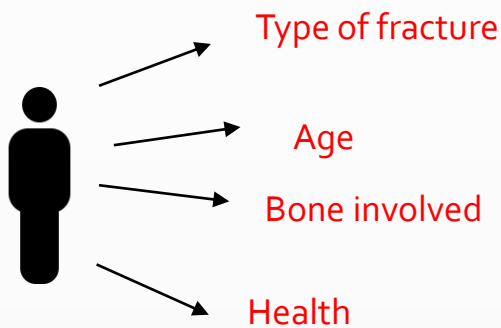
By osteoblast and osteoclast

the fracture site remodels itself. (correcting any deformities that may remain as a result of the injury.)

healing can last up to several years.

**NOTE: initial bone healing is by woven bone then lamellar bone.**

The rate of healing and remodeling vary tremendously for each person and depend on:



As we learned before, fibrosis is deposited in the site of injury during the healing process.

## Factors disrupting healing process:

- Displaced and comminuted (producing multiple bone splinters) fractures
- Infection
- Inadequate minerals and vitamins
- Inadequate immobilization

## Con. Factors disrupting healing process: (important)

### • Vascular insufficiency

This is particularly important in certain areas such as the scaphoid bone in the wrist and the neck of the femur, both of which can be associated with **avascular necrosis** \*\*of fracture fragments.

It happens in :

- the **head** of the femur

(fracture in neck of femur but Avascular necrosis in the head)

- Navicular bone.

The death of bone tissue due to a lack of blood supply. it can lead to tiny breaks in the bone and the bone's eventual collapse.

## There are Two types of necrosis :

- ❖ Sub-chondral ( under articular cartilage )

Causes more problems.

Can leads to secondary arthritis ( التهاب مفصلي )

- ❖ Intramedullary.

## Causes of Necrosis:

- 1- rupture of the arteriole which supply the area.
- 2- sickle cell anemia
- 3- arteriosclerosis
- 4- caisson disease

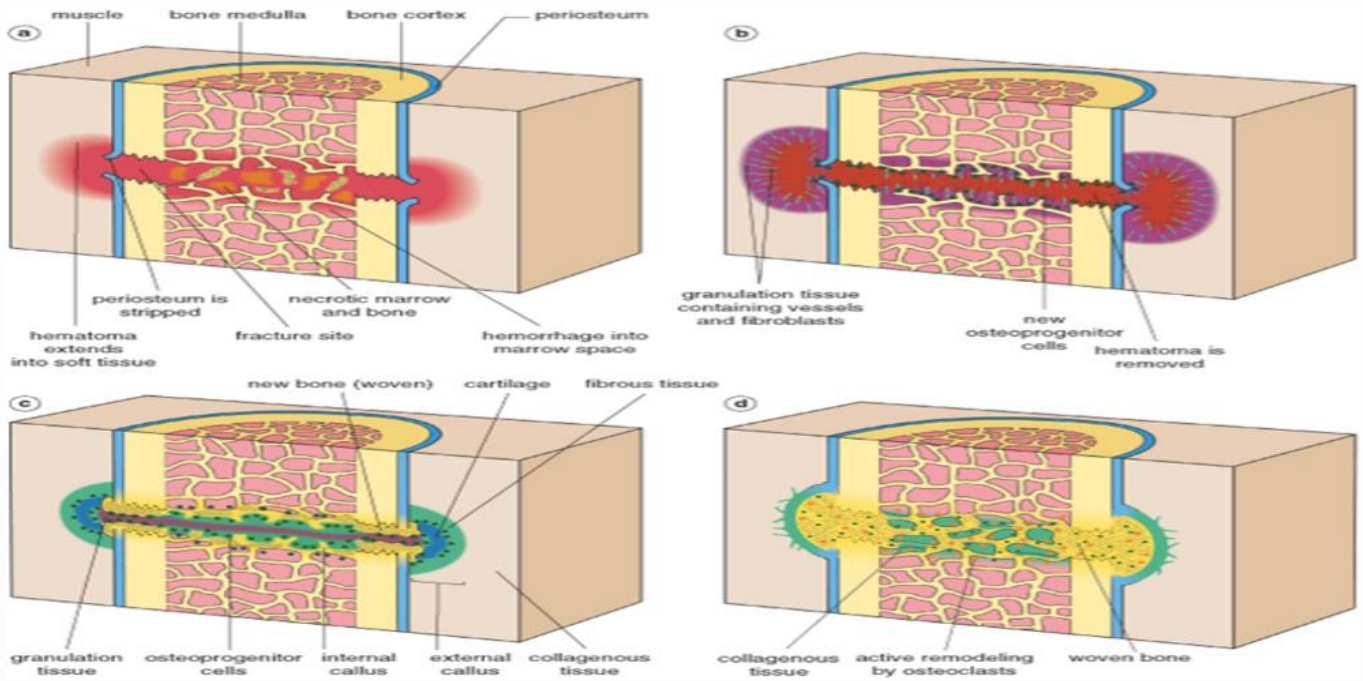
It is a rare disease , decompression sickness

مرض يحدث في الغطاسين ويسبب فقاعات النيتروجين في

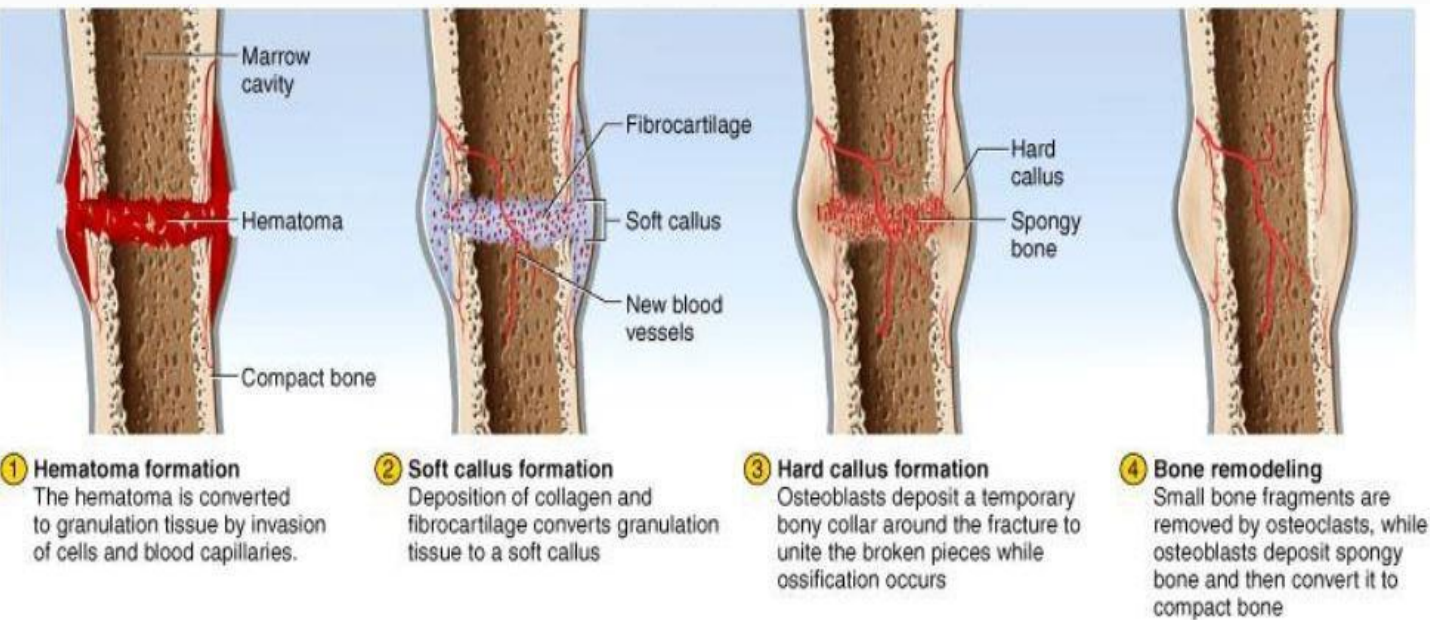
تسمى **air embolism**



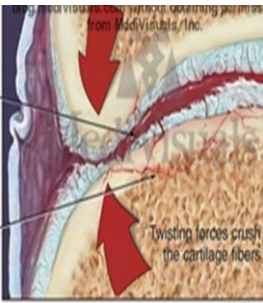
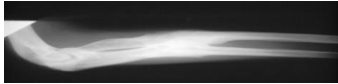
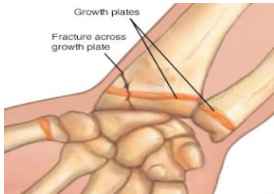
# Bone Remodeling: Summary



The picture below isn't in the doctor's slide but it explains the one above, which is included in the syllabus.



## Complication during bone healing:

Complication	Description
1-Compartment syndrome:	<p>Severe swelling after a fracture can cause increased pressure on the blood vessels that not enough blood can get to the muscles around the fracture.</p> <p>The decreased blood supply can cause the muscles around the fracture to die, which can lead to long-term disability.</p> <p><u>Compartment syndrome usually occurs only after a severe injury.</u></p>
2-Post-traumatic arthritis:	<p>Fractures that extend into the joints (intra-articular fractures) or fractures that cause the bones to meet at an abnormal angle in the joint can cause <b>premature arthritis</b> of a joint.</p> 
3-Malunion:	<p>A fracture that does not heal in a normal alignment.</p> 
4-Growth abnormalities:	<p>A fracture in the open physis, or growth plate, in a child, can cause many problems.</p> 
5-Delayed union:	<p>A fracture that takes longer to heal than expected is a delayed union.</p>
6-Infection:	<p>Open fractures can become infected</p>
7-Nonunion:	<p>A fracture that fails to heal in a reasonable amount of time is called a nonunion (pseudarthrosis)</p>
8-Neurovascular injury	

### Pathological Fracture

A person come to the emergency and can't move his leg , after doing an x-ray they find lytic bone lesion and fracture of the femur (abnormal bone). we should treat the fracture and take a biopsy of the bone. The biopsy shows a metastatic tumor from lung cancer.

- Most common tumor of bone is metastatic.

### Closed Fracture

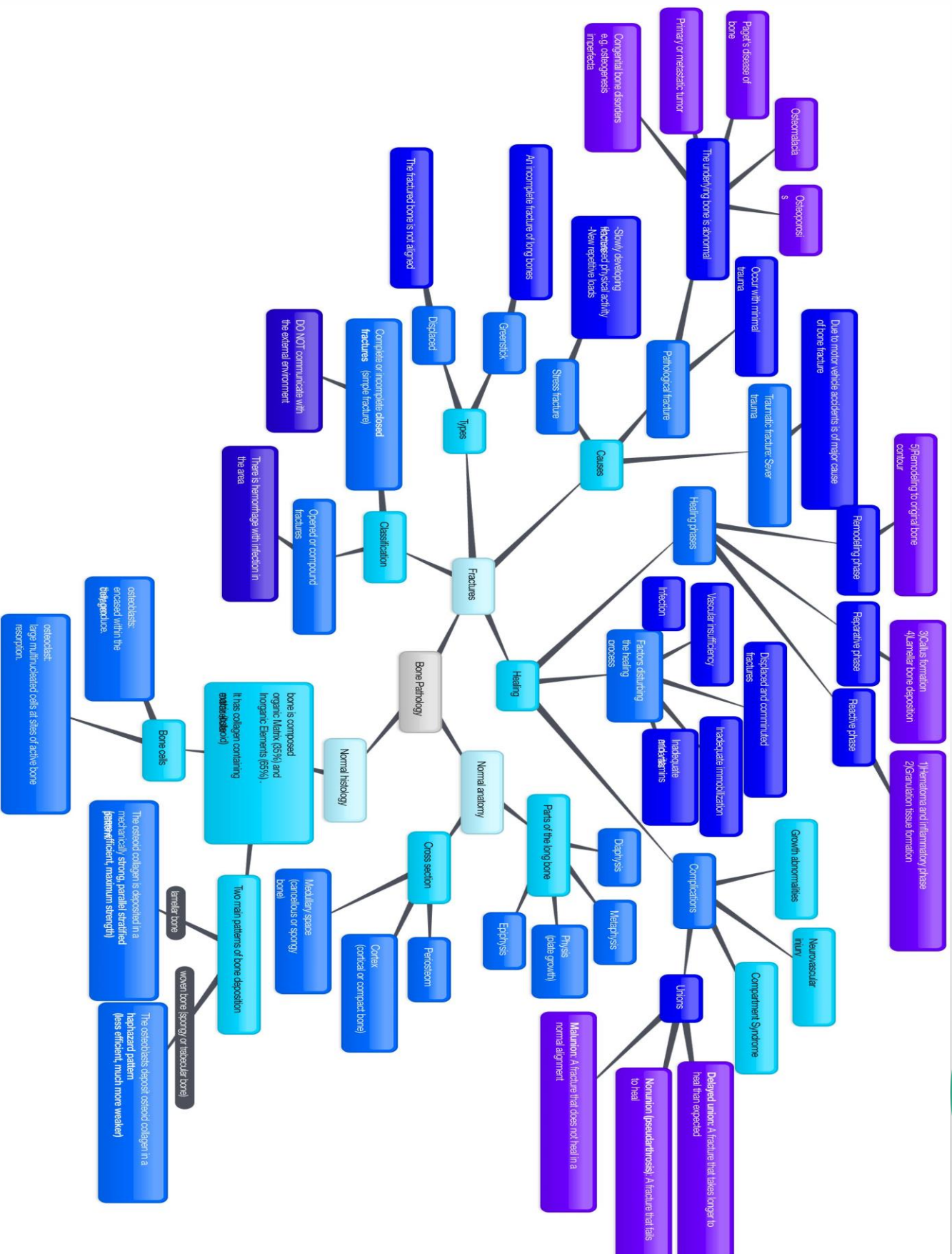
A women with a fractured ankle : we could see extreme swelling / hemorrhagic area and hematoma formation ورم دموي which is an accumulation of blood within the soft tissue and loss of function (can't move). **Diagnosis:** This is a closed fracture because there is no bleeding or open wound. Further examination: So we do x-ray to determine which bone is fractured.

### Osteomalacia

A 71 years old patient with constant diarrhea after tests you'll find he has iron deficiency, anaemia and calcium, phosphorus levels are decreased sometimes alkaline phosphatase level are increased. This patient has malabsorption (chronic diarrhea) caused by a gastrointestinal disease and this induced osteomalacia.

- If he was a child it would be called Rickets.

# Summary



# MCQ

A child patient presented to the hospital with a fracture in his tibia, the manifestations are:

Superficial bone.  
Open skin.

1-What type of fracture is this?

- A. Comminuted fracture
- B. Compound fracture.
- C. Green stick fracture.
- D. Transverse fracture.

A 27 yrs old male came to the emergency complaining from a pain in his upper arm and he can't move it properly. After taking history the doctor found out that he started feeling this pain after a heavy exercise. X-Ray done to the patient and we found a fracture in his humerus.

2- What type of fracture does he have?

- A. Stress fracture.
- B. Pathologic fracture.
- C. Osteoporosis.
- D. Open fracture.

3-Cytokines PDGF, FGF stimulates which of the following?

- A. Osteoclast.
- B. Osteoblast.
- C. Osteoid.
- D. Osteoprogenitor.

4- In case of inappropriate healing of the fracture the patient develop a situation known as:

- A. Colles fracture.
- B. Pseudo arthrosis.
- C. Osteomalacia.
- D. Pseudo fracture.

5-What are the cells involved in bone remodeling?

- A. Osteoblast.
- B. Osteoclast.
- C. Both a,b
- D. None of the above.



# Good Luck

## Team leaders:

Ashwaq Almajed – Fahad Alzahrani

## Team members

### Girls:

Samar Alqahtanii  
Fatimah Altassan  
Doaa Walid  
Lama Altamimi  
Reema Alshayie

### Boys

Abdulaziz alqahtanii  
Essam Alshahrani

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Contact us on:

Pathology436@gmail.com

Twitter: @Pathology436