

# BONE AND CARTILAGE

REVIEW FOR NBME  
2004

## BONE and CARTILAGE

### Bone (osteo)

vascular  
mesodermal origin  
osteoclasts  
collagen type 1  
appositional growth  
-----  
compact, cancellous,  
woven

### Cartilage (chondro)

avascular - diffusion  
mesodermal origin  
-----  
collagen types 1,2  
appositional growth  
interstitial growth  
hyaline, elastic, fibro

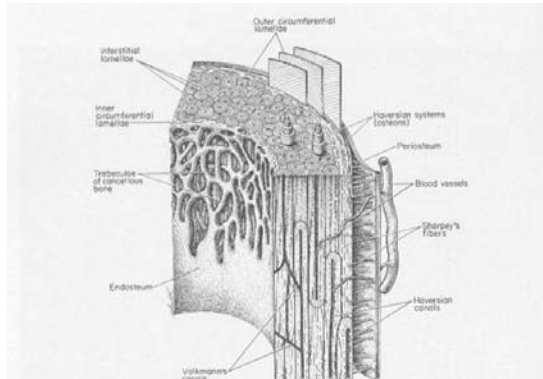
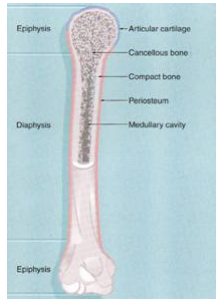
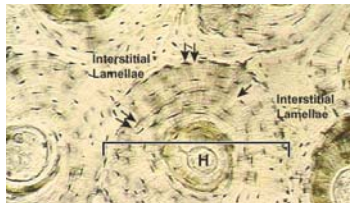
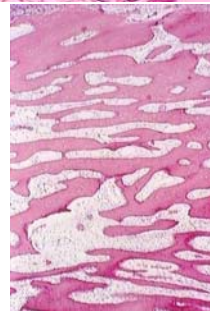
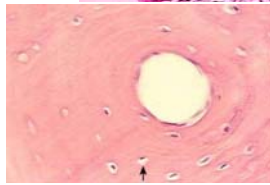
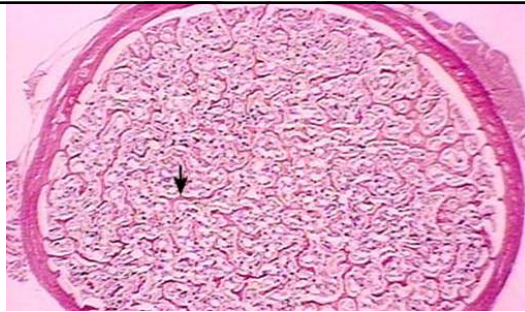


Figure 10-9 Diagram of a sector of the shaft of a long bone illustrating the disposition of the lamellae in the osteons or haversian systems, the interstitial lamellae, and the outer and inner circumferential lamellae. (After A. Benninghoff, Lehrbuch der Anatomie des Menschen. Berlin, Urban und Schwarzenberg, 1949.)

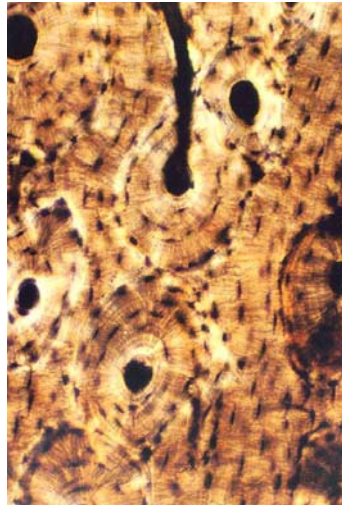
Bloom and Fawcett, 1975



HistoTime



HistoTime



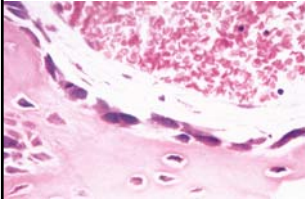
Dr. Gwen Childs

### THREE CELL TYPES IN BONE

**OSTEOBLAST**  
(mesenchyme)

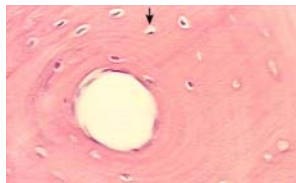


HistoTime

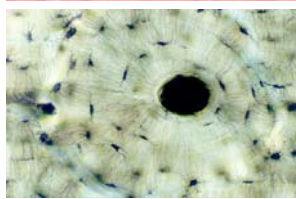


Young and Heath, 2000

**OSTEOCYTE**  
(mesenchyme)



HistoTime

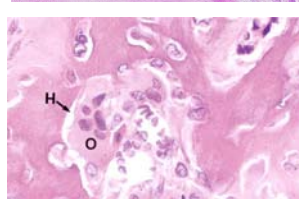


HistoTime

**OSTEOCLAST**  
(GM-CFU)



bone



Young and Heath, 2000

## OSTEOBLASTS

### ORIGIN:

*Mesenchymal* precursor cells  
Osteoprogenitor cells  
- periosteum  
- endosteum

### APPEARANCE:

Stellate shape (versus round chondroblasts)  
Basophilic = prominent RER

### FUNCTION:

Make and mineralize bone

-matrix proteins:

Type 1 collagen  
osteocalcin  
osteopontin  
osteonectin  
proteoglycans  
alkaline phosphatase

Use vitamin **C** when making **C**ollagen (s**C**urvy)  
Become osteocytes (*appositional growth*)  
Make factors that stimulate osteoclasts

## OSTEOCYTES

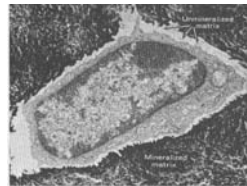
### ORIGIN

osteoblasts (mesenchymal origin)

### APPEARANCE

stellate (canaliculi, gap junctions)  
trapped in bone lacunae

periosteocytic space = osteocytic osteolysis  
small golgi and RER (unlike osteoblast)  
nondividing (unlike chondrocytes)



### FUNCTIONS

osteocytic osteolysis (plasma  $[Ca^{++}]$ )  
mechanotransduction (factors that recruit preosteoblasts)

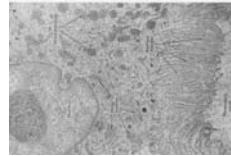
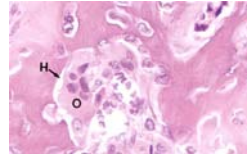
# OSTEOCLASTS

## ORIGIN

GM-CFU in bone marrow (think Monocyte / Macrophage)

## APPEARANCE

BIG, motile  
multinucleated  
acidophilic  
in Howship's lacuna (Not trapped)  
ruffled border  
'clear zone' (actin ring), seal  
integrins  
lysosomes



## FUNCTION

resorb bone  
mineral = hydroxyapatite ( $H^+$ )  
organic = collagen (lysosomal enz. TRAP, a marker)

# OSTEOCLAST ACTIVITY

## STIMULATORS

(-> increased serum calcium)

Parathyroid hormone (PTH)  
through osteoBLAST  
derived factors:  
OPGL and OSF

IL-1, IL-6, TNF, CSF-1  
-induces osteoclast  
production

## INHIBITORS

(-> decreased serum calcium)

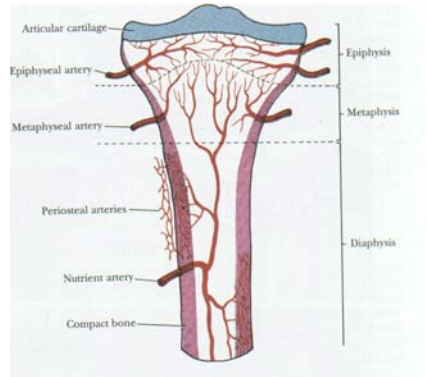
Calcitonin (calcium stays)  
from thyroid gland Clear  
cells

Osteoprotegrin, TGF, Interferon

Bisphosphonates (Fosamax)  
Tx for osteoporosis

## VASCULAR SYSTEM OF BONE

- **Blood supply 4 sources:**
  - Nutrient arteries
  - Periosteal system
  - Metaphyseal system
  - Epiphyseal system
- **Arterial supply of the cortex**
  - inside to out  
(*centrifugal*)
- **Venous flow**
  - Sinusoids -> cortical capillaries -> emissary venous system  
(*centripetal*)



## PERIOSTEUM

### Layers:

#### Inner (cells)

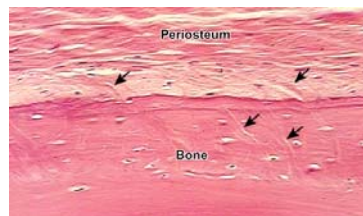
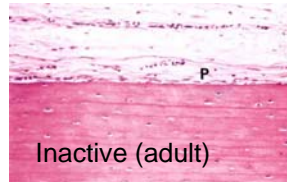
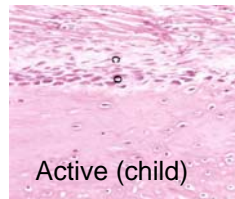
- Osteoprogenitor cells  
(bone repair)

#### Outer (fibers)

- Dense fibrous ct
- Meets joint capsule

### Modification:

- Sharpey's Fibers  
(Arrows)



## Distribution of The Various Types Of Cartilage

- **Hyaline Cartilage**
  - Most bones of the embryonic skeleton
  - Articular cartilage (synovial jt)
  - Epiphyseal Plate
  - Costal Cartilage
  - Xiphoid process
  - Nasal Cartilages
  - Most Laryngeal Cartilages
  - Tracheal Ring Cartilages
  - Cartilage plates in large and medium bronchi
- **Elastic Cartilage**
  - Pinna
  - External Auditory tube
  - Eustachian Tube
  - Epiglottis
  - Laryngeal Cartilages (2)
  - Cartilage plates in small bronchi
- **Fibrocartilage**
  - Symphyses
    - Intervertebral disks
    - Pubic symphysis
  - Menisci

## CARTILAGE

### ORIGIN

mesenchyme, chondrogenic cells (bone repair)

### CELLS

chondroblasts (RER, = basophilic, ROUND)  
chondrocytes (divide, unlike osteocytes!!!)

### GROWTH

Appositional and **INTERSTITIAL** growth  
(CHONDROCYTES DIVIDE so there is interstitial growth, unlike in bone!!!)

### FEATURES

- ✓ Perichondrium
  - NOT OVER ARTICULAR CARTILAGE and not over fibrocartilage
  - Cell layer (chondrogenic)
  - Fibrous layer
- ✓ Isogenous groups of chondrocytes (why?!)
- ✓ Matrix
  - Territorial (capsular, rich in GAG's = basophilic)
  - Interterritorial (less basophilic)
- ✓ Avascular (diffusion), can form "Joint mice"

WHAT IS APPOSITIONAL GROWTH?

WHAT IS INTERSTITIAL GROWTH?

### **Hyaline**

“Glassy” matrix (Greek, *hyalos*, means glassy)

- **Collagen type II**
- GAG's= chondroitin sulfate and heparan sulfate
- articular hyaline cartilage (no perichondrium)
- Isogenous groups (nests)
- Endochondral bone formation

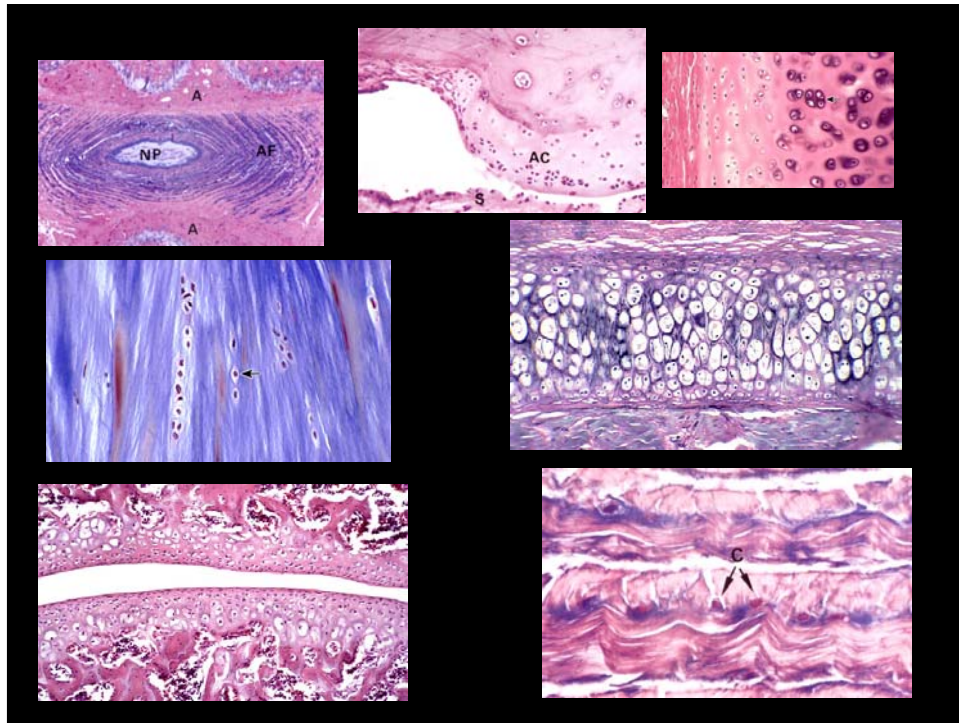
### **Elastic**

- Elastic fibers > **Collagen type II**
- GAG's= chondroitin sulfate and heparan sulfate
- Isogenous groups not as nest-like
- Chondrocytes more abundant than in hyaline
- special stain

### **Fibrocartilage (odd one)**

- **Collagen type I** (acidophilic) NUMEROUS fibers!!
- GAG's = chondroitin sulfate and dermatan sulfate)
- No perichondrium
- Few Chondrocytes compared to hyaline and elastic
- Isogenous groups in parallel ROWS (not nests)

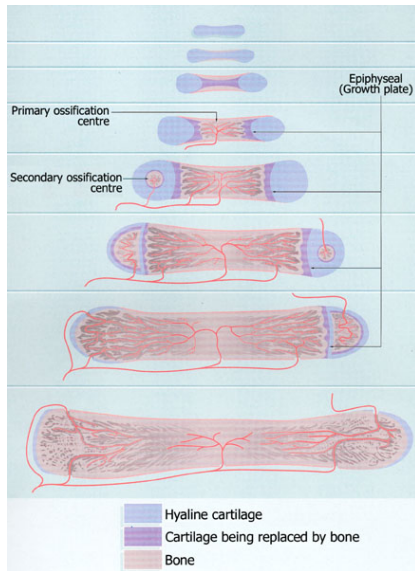




## SYNOVIAL MEMBRANE

- Not a true epithelium
- PRODUCES SYNOVIAL FLUID
- Not located over articular surface (ouch!)

## ENDOCHONDRAL OSSIFICATION

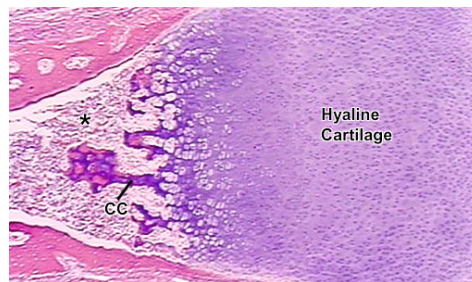
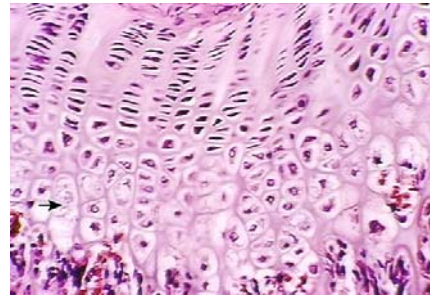
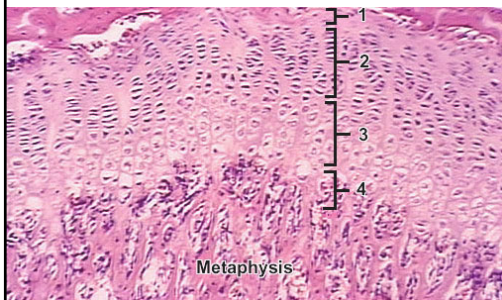


MODEL  
 PERICHONDRIUM (vasc.)  
 COLLAR (intramembranous ossif.)  
 DEATH  
 CALCIFICATION

1° CENTER OF OSSIF. (vess. progen.)  
 OSTEOID  
 MINERALIZATION  
 2° CENTER OF OSSIF. (epi., postpart)

FUSION (epi + dia)

## NAME THE ZONES



## MINERALIZATION OF OSTEOID (NOT JUST CALCIFICATION)

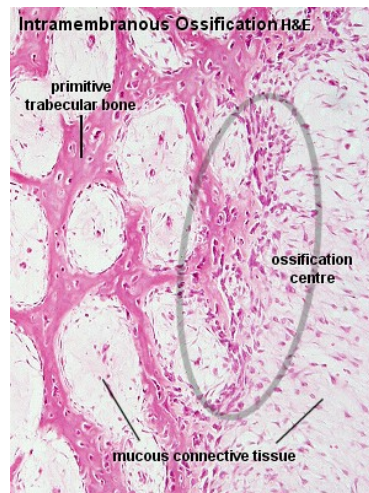
MINERALIZATION:  
OSTEOBLAST – MATRIX VESSICLES (HYDROXYAPATITE)

CALCIFICATION:  
CHONDROCYTES DIE

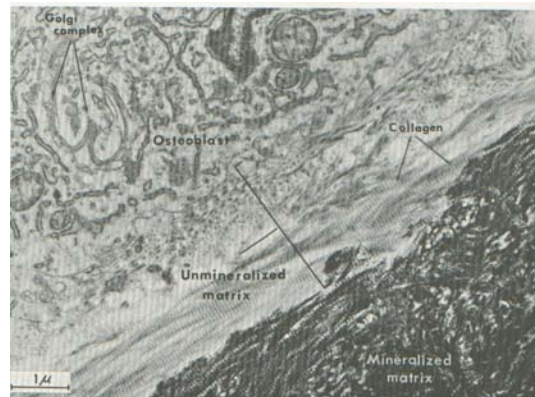
(Both require Vitamin D or Rickets in child, osteomalacia in adult)

## Intramembranous Ossification

- Mesenchyme
- Osteoprogenitor cells
- Osteoblasts
- Osteoid
- Woven Bone
- Remodeling
  - Compact
  - Cancellous

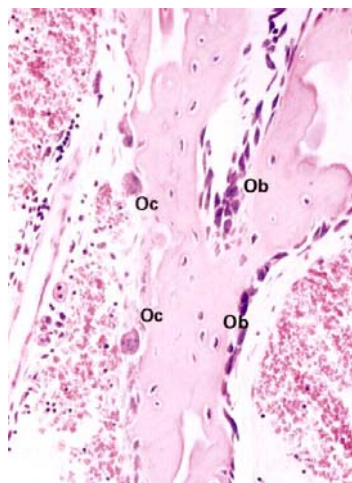


What is wrong with this picture?

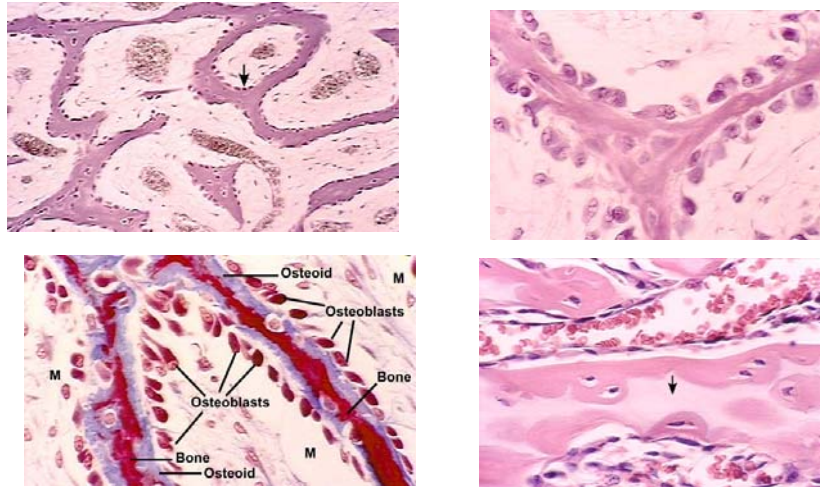


MINERALIZATION FRONT

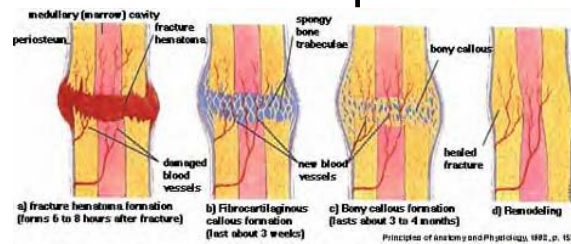
What is happening here?



# What's going on?



## Bone Repair



- A person breaks a bone
- What is broken besides bone?
- The clot organizes = granulation tissue
- low O<sub>2</sub>
- Going backwards in time...
  - **Endochondral** ossification  
where vessels broken  
(Fibrocartilage callus)
  - **Intramembranous** ossification  
where vessels intact
- Fibrous (Woven) bone produced first  
(after 4 - 6 weeks, remove cast)
- Remodeled according to Wolff's law  
(for up to 2 years)

