

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

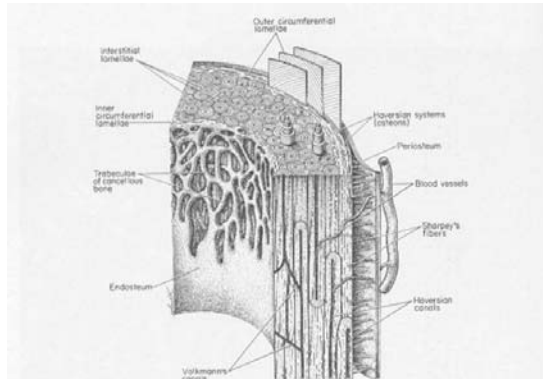
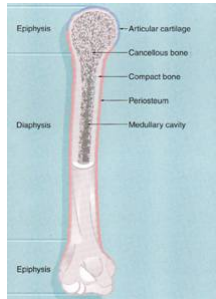
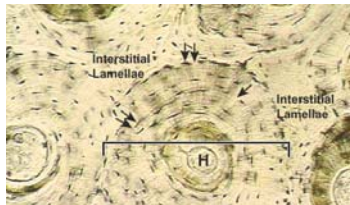
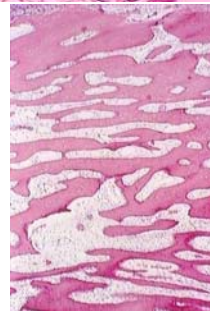
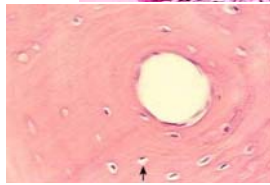
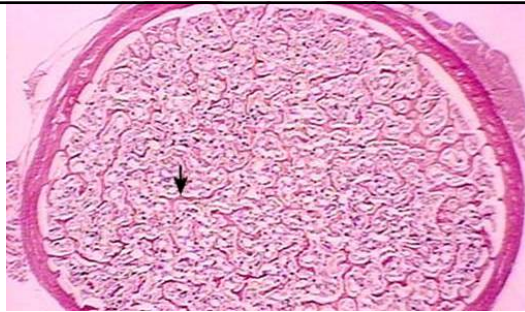


Figure 10-9 Diagram of a sector of the shaft of a long bone illustrating the disposition of the lamellae in the osteons or haversian systems, the interstitial lamellae, and the outer and inner circumferential lamellae. (After A. Benninghoff, Lehrbuch der Anatomie des Menschen. Berlin, Urban und Schwarzenberg,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

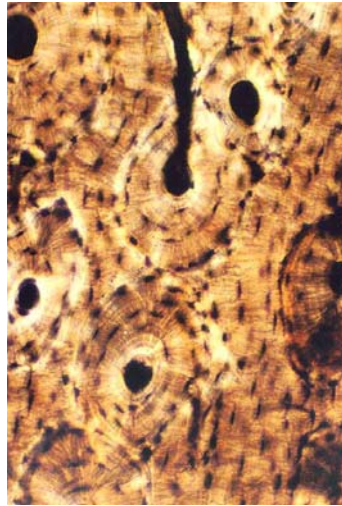
Bloom and Fawcett, 1975



HistoTime



HistoTime



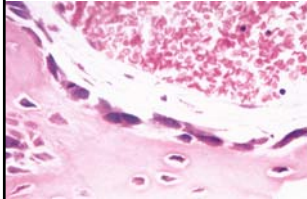
Dr. Gwen Childs

THREE CELL TYPES IN BONE

OSTEOBLAST
(mesenchyme)

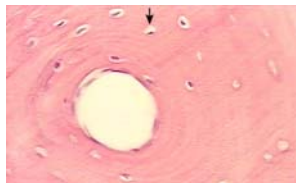


HistoTime

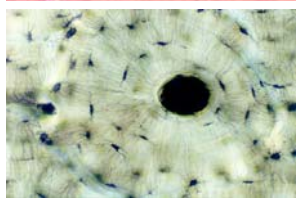


Young and Heath, 2000

OSTEOCYTE
(mesenchyme)



HistoTime

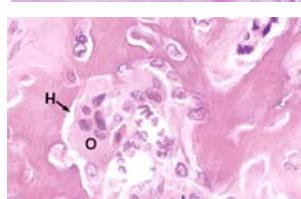


HistoTime

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)

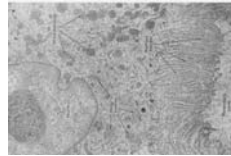
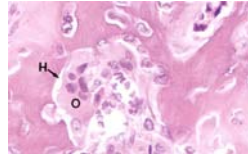
OSTEOCLASTS

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)

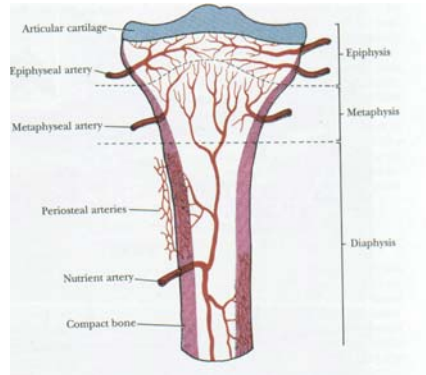
Calcitonin (calcium stays)
from thyroid gland Clear
cells

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)

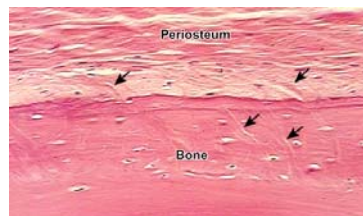
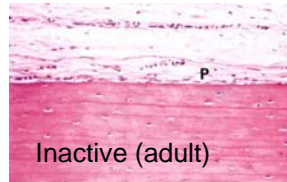
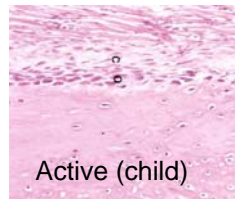
- Osteoprogenitor cells
(bone repair)

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)

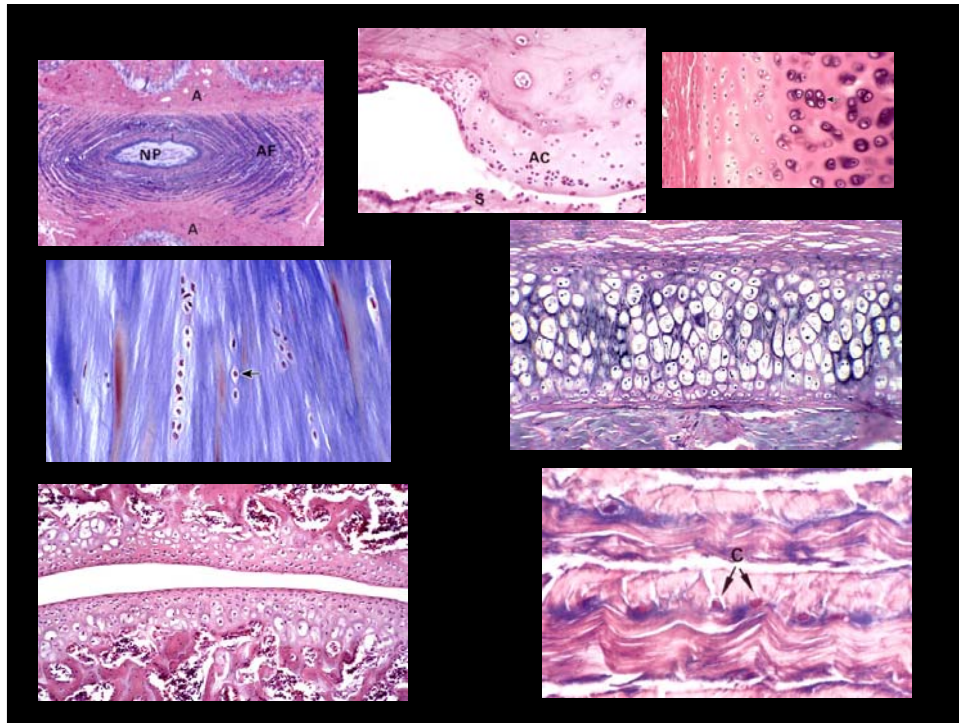
- **Collagen type II**
- GAG's= chondroitin sulfate and heparan sulfate
- articular hyaline cartilage (no perichondrium)
- Isogenous groups (nests)
- Endochondral bone formation

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)

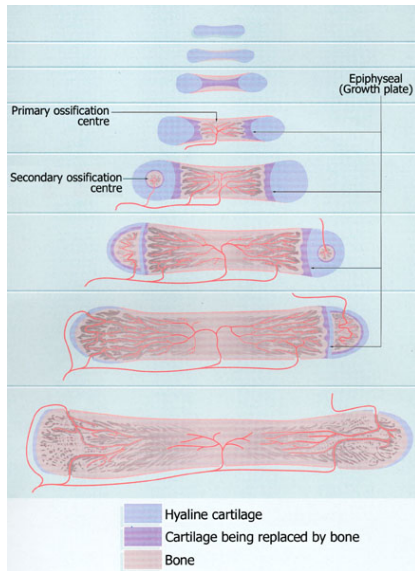
- **Collagen type I** (acidophilic) NUMEROUS fibers!!
- GAG's = chondroitin sulfate and dermatan sulfate)
- No perichondrium
- Few Chondrocytes compared to hyaline and elastic
- Isogenous groups in parallel ROWS (not nests)



SYNOVIAL MEMBRANE

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

ENDOCHONDRAL OSSIFICATION

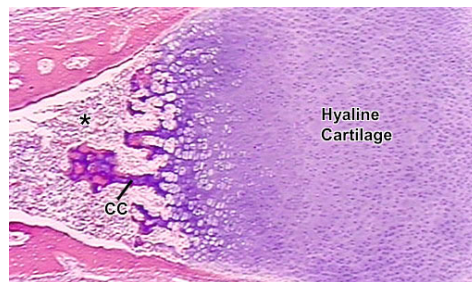
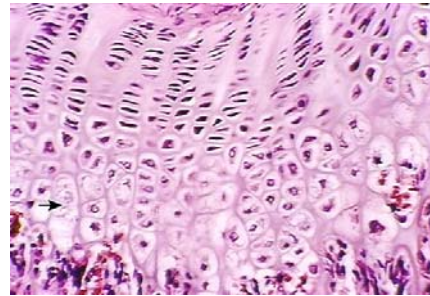
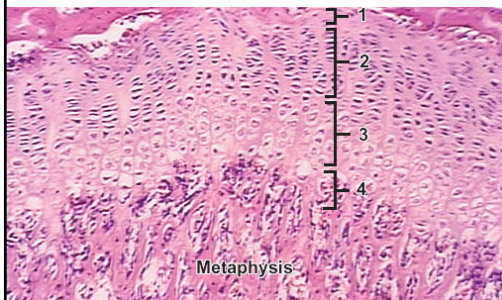


MODEL
 PERICHONDRIUM (vasc.)
 COLLAR (intramembranous ossif.)
 DEATH
 CALCIFICATION

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)

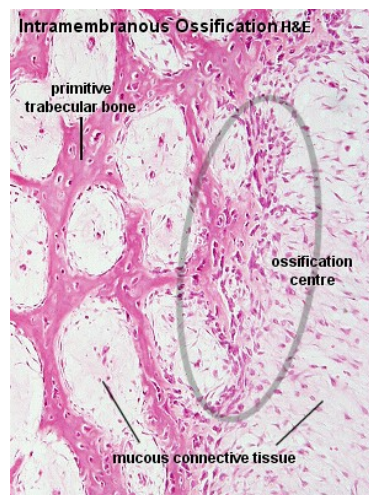
MINERALIZATION:
OSTEOBLAST – MATRIX VESSICLES (HYDROXYAPATITE)

CALCIFICATION:
CHONDROCYTES DIE

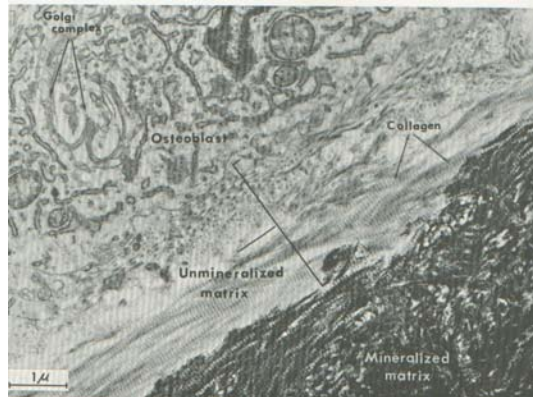
(Both require Vitamin D or Rickets in child, osteomalacia in adult)

Intramembranous Ossification

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

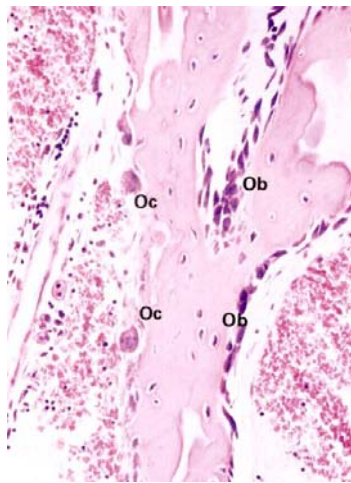


What is wrong with this picture?

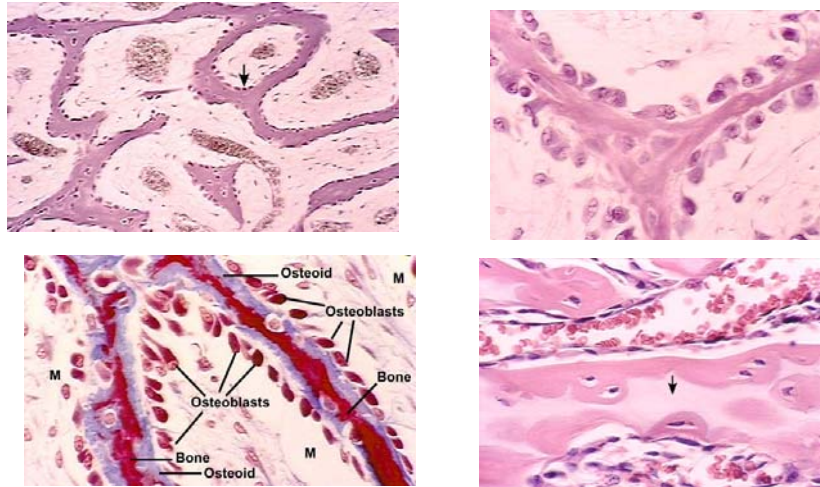


MINERALIZATION FRONT

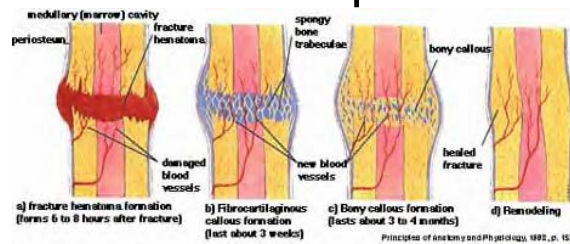
What is happening here?



What's going on?



Bone Repair



- A person breaks a bone
- What is broken besides bone?
- The clot organizes = granulation tissue
- low O_2
- 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)

