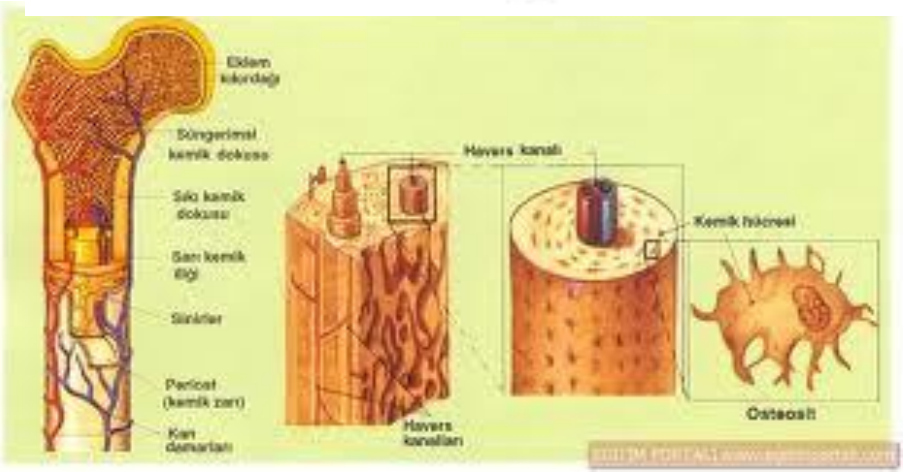
KEMİK DOKUSU



Kemik dokusunun Fonksiyonları

- Destekleme
- Koruma
- Hareket
- Mineral depolama (Ca, P)
- Kan yapımı
- Enerji depolama (kemiklerdeki sarı kemik iliği)

Hücrelerarası madde (matriks)

I. Organik maddeler

- I tip Kollagen iplikler(%95)
- Şekilsiz temel madde: proteoglikanlar (kondroitin-4-sülfat, kondroitin-6 sülfat, keratan sülfat), glikozaminoglikanlar (hiyaluron asidi) ve glikoproteinler(osteonektin)

II. İnorganik maddeler (temel mad. yarısı)

Kalsiyum fosfat (%85), Kalsiyum karbonat(%10), Kalsiyum fluorid,

Magnezyum fluorid, Magnezyum hidroksit, Magnezyum sülfat,

Ca ve P Hidroksi apatit kristalleri oluşturur.Bunların yüzeylerinde su ve diğer iyonlar ince bir tabaka halinde toplanırlar

Kemik dokusu

- **Primer kemik dokusu (Olgunlaşmamış kd)**
- İntrauterin hayatta şekillenen kemik dokusudur.
- Kollagen iplikler gelişigüzel seyrederek ağlar oluşturur.
- Temel madde henüz kireçleşmemiştir ve hücreden yana zengindir

- **Sekunder kemik dokusu (Olgunlaşmış kd)**
- Lamelli bir yapı gösterir.
- Kollagen iplikler kemik lamelleri içinde özel biçimde yerleşirler.
- Bir lamelde birbirine paralel seyreden kollagen iplikler (hidroksi apatit kristalleri bu ipliklerin üzerine oturur) komşu lameldekilere çapraz yönde ve spiraller yaparak dizilirler.

Sekunder kemik dokusu

1-Süngerimsi (spongiyöz) kemik

- Birbirleriyle anastomozlaşan kemik lamellerinden oluşur. Bunlara “trabekül” adı verilir.
- Trabeküllerdeki kemik lamelleri birbirlerine paralel seyirlidir.
- Trabeküllerin aralarında kemikiliği ile dolu düzensiz şekilli boşluklar vardır.
- Havers ve Volkman kanallarını içermez.
- Damarlar bulunmaz.
- Beslenmelerini kemik iliği içindeki kan damarlarından kanaliküller aracılığıyla alırlar.
- Kısa ve uzun kemiklerin metafiz ve epifizlerinin iç kısımları ile yassı kemiklerin iç yüzlerinde bulunur.

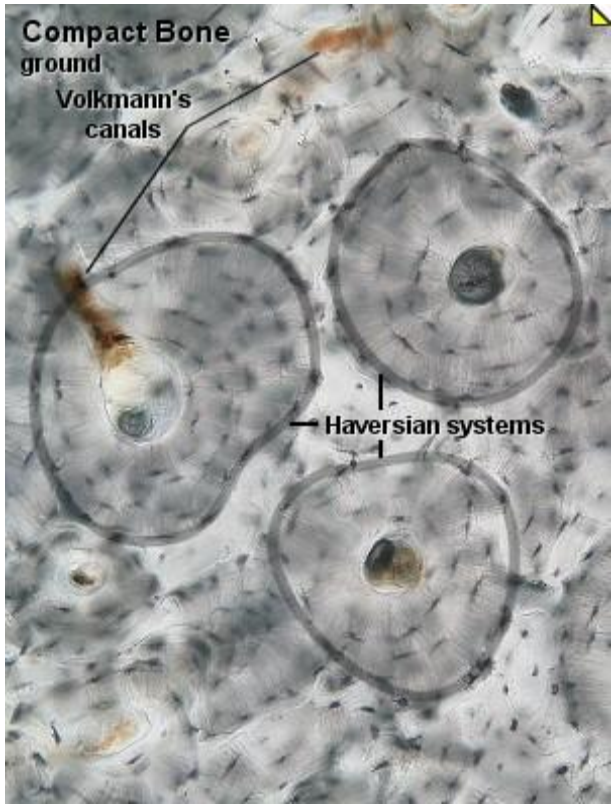
2-Kompakt kemik

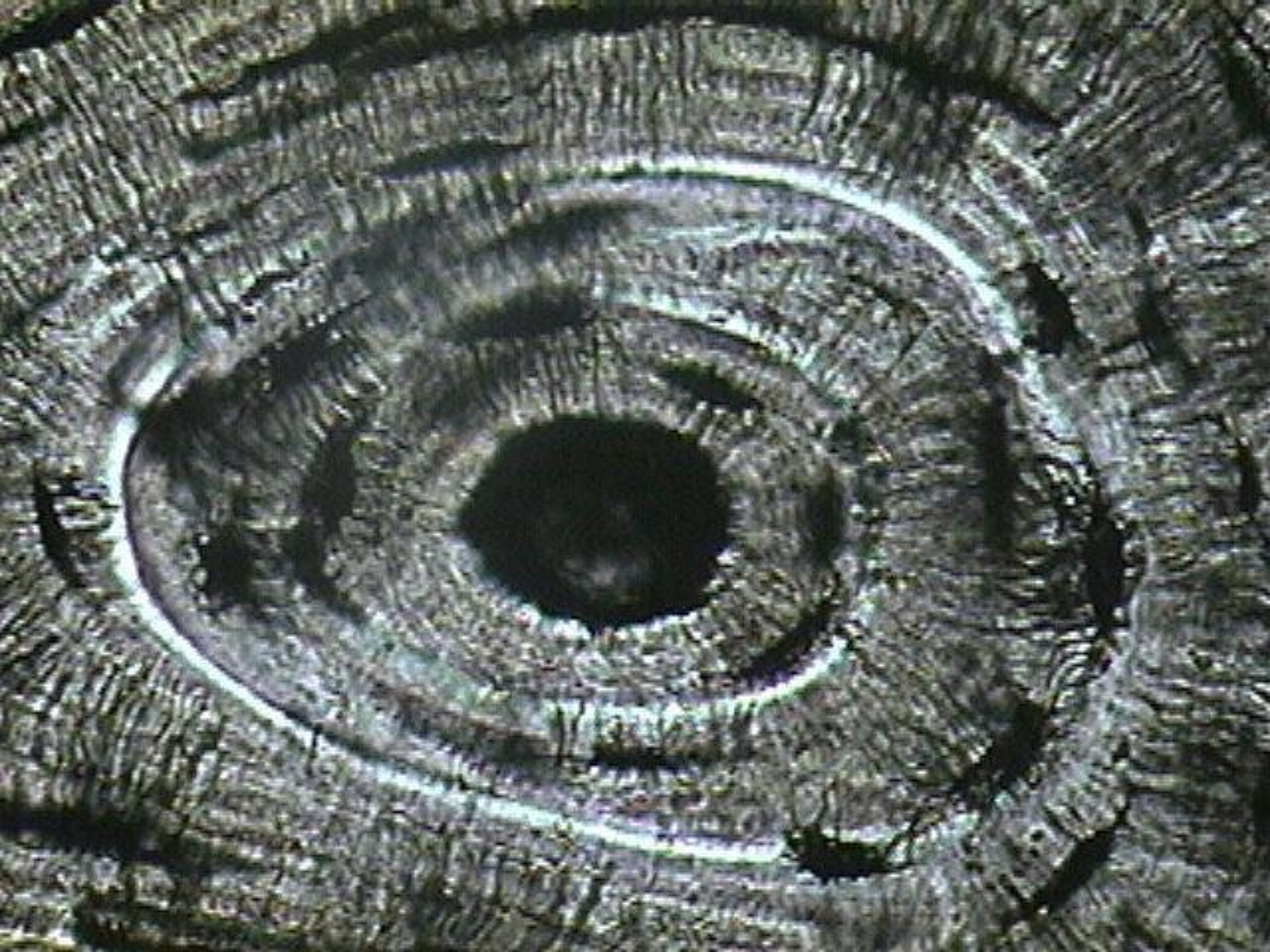
- Kemik lamelleri özel bir dizilime sahiptir.
- Spesiyal, ara(interstisyel)ve sirkumferensiyal lamelleri içerir
- Havers ve Volkman kanallarını içerir.
- Kemik dokusunun matriksi bu kanallar içinde bulunan damarlardan çıkan besin maddelerinin difüzyonu ile beslenirler. (Foramen nutritium: Kemik yüzeyindeki besleyici delikler, kan damarları buralardan doku içerisine girer)

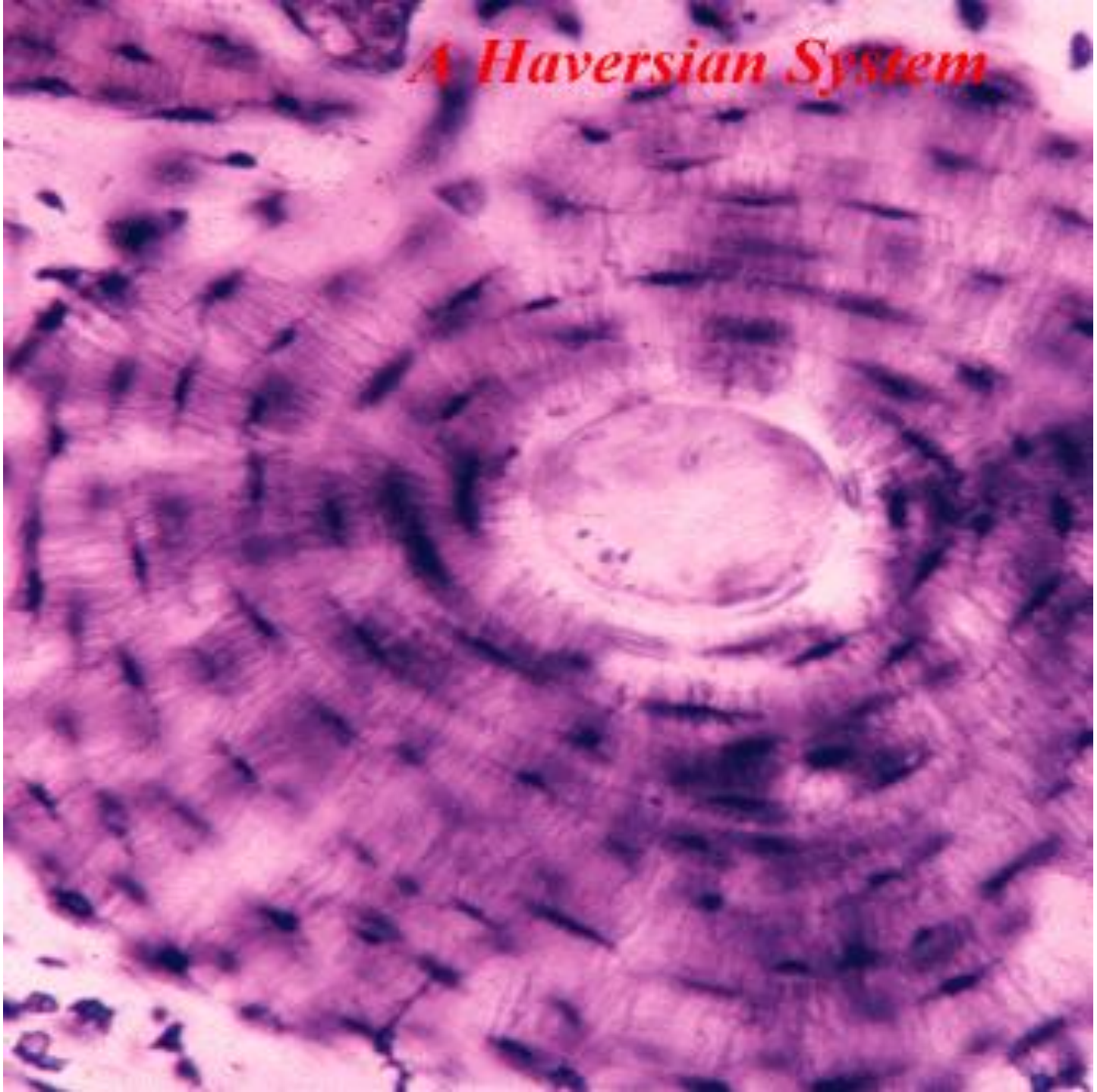
Havers Sistemi (Osteon)

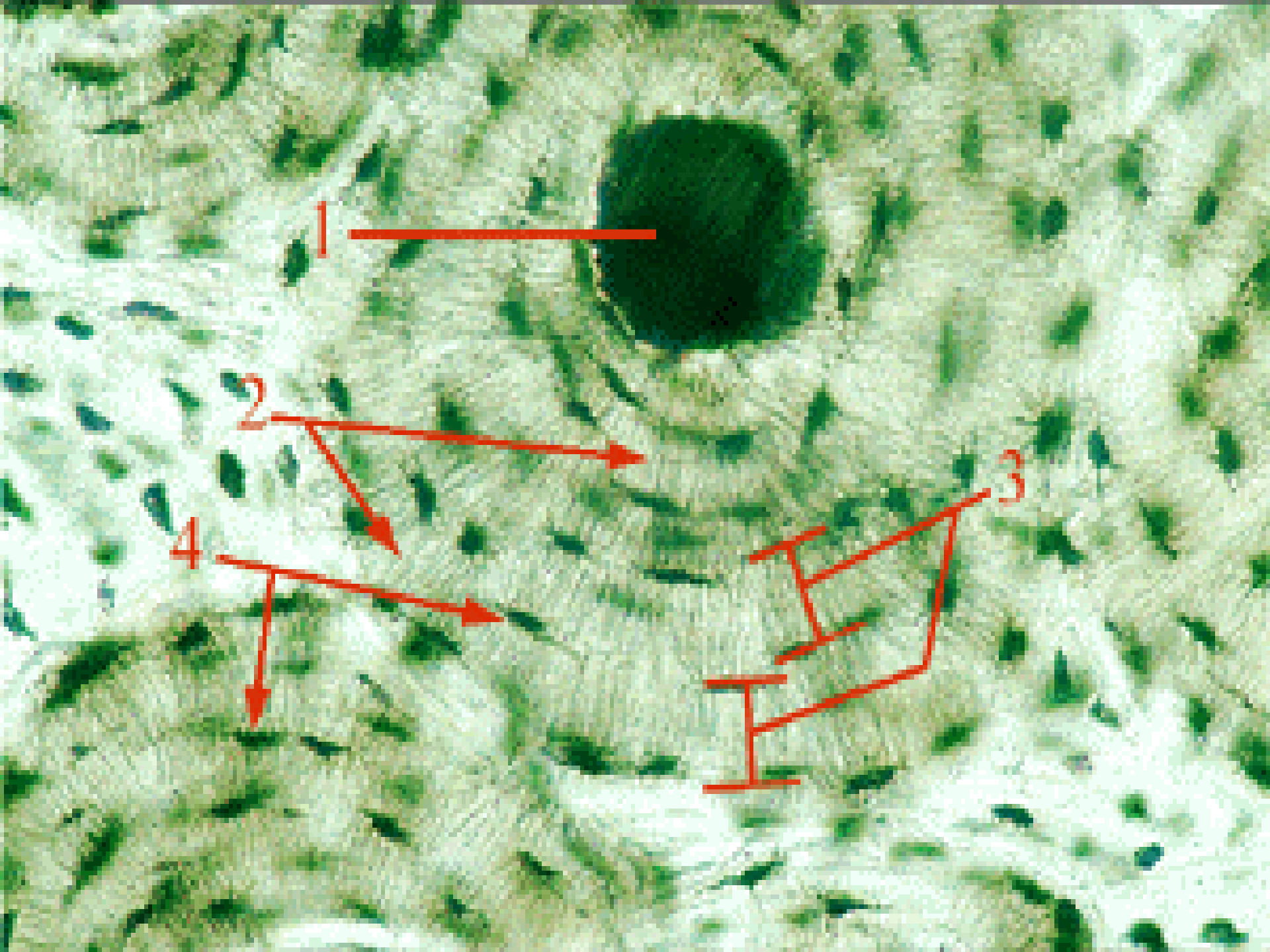
Kompakt kemikte bulunan lamellerin bir bölümü Havers kanalları etrafında iç içe yerleşmiştir. Bu tür lamellere **spesiyal lameller** denir.

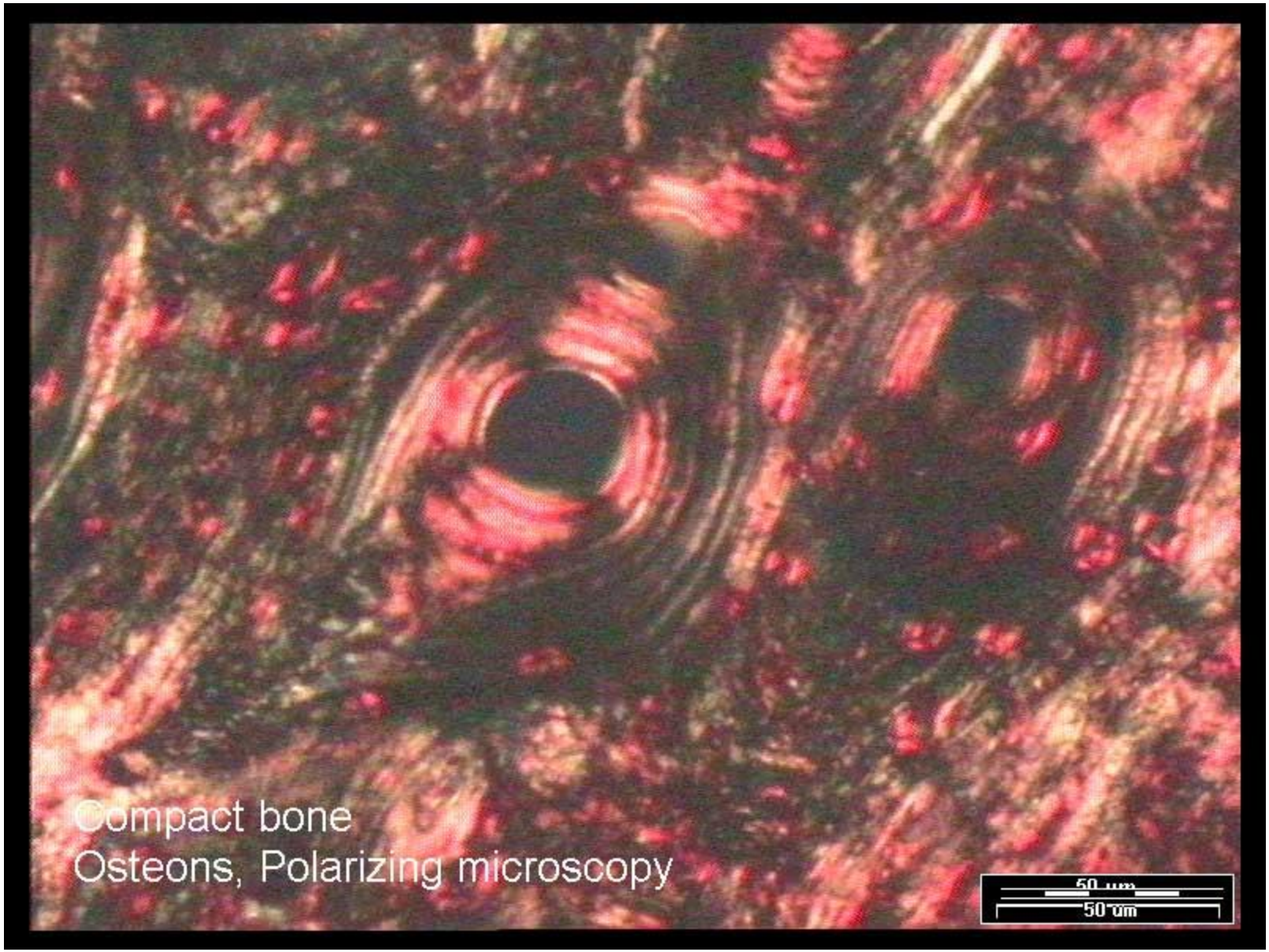
Ortadaki Havers kanalı ile bunu çevreleyen spesiyal lameller bir sistem kabul edilir ve **Havers Sistemi** ya da **Osteon** olarak isimlendirilirler.



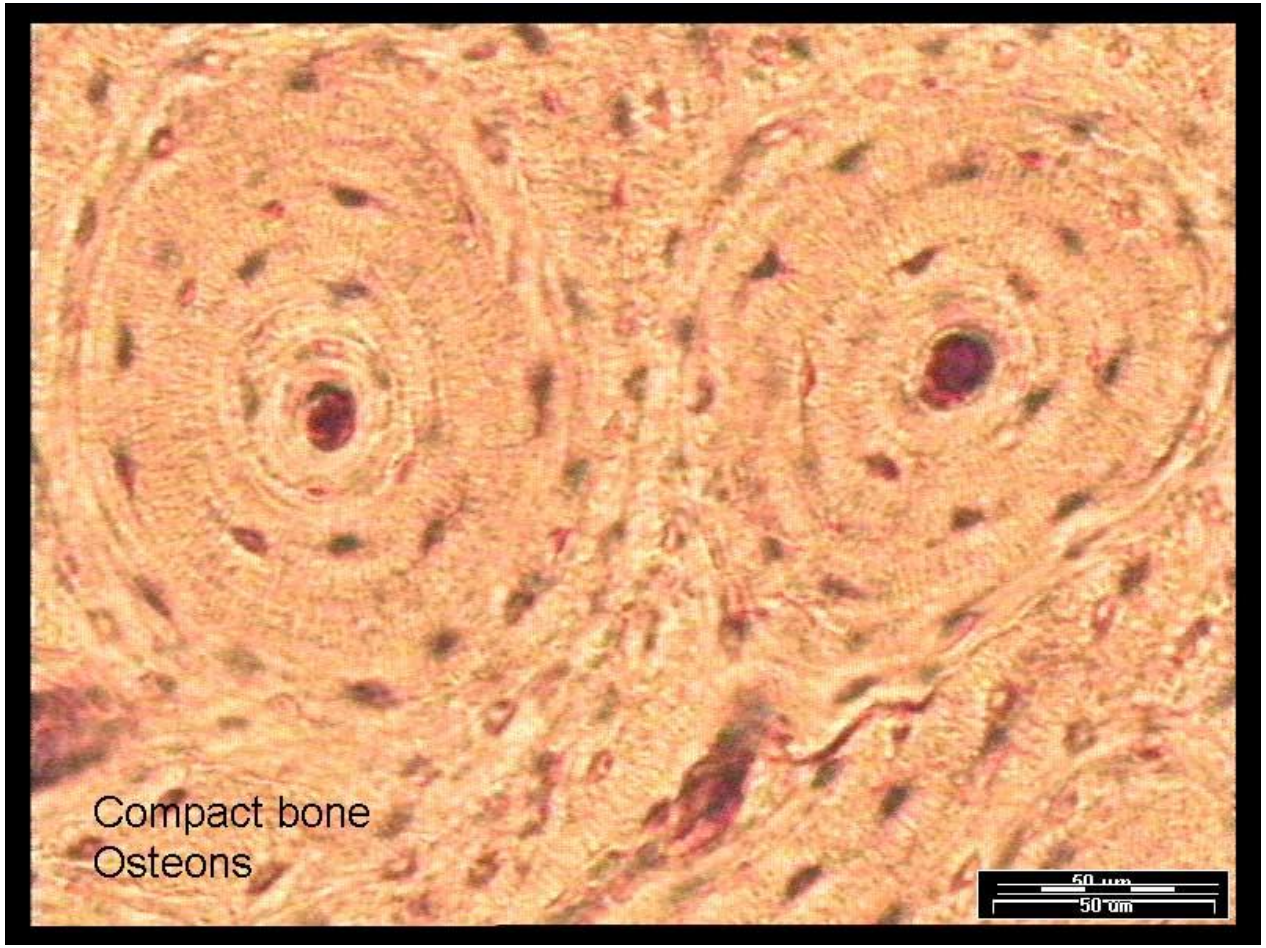


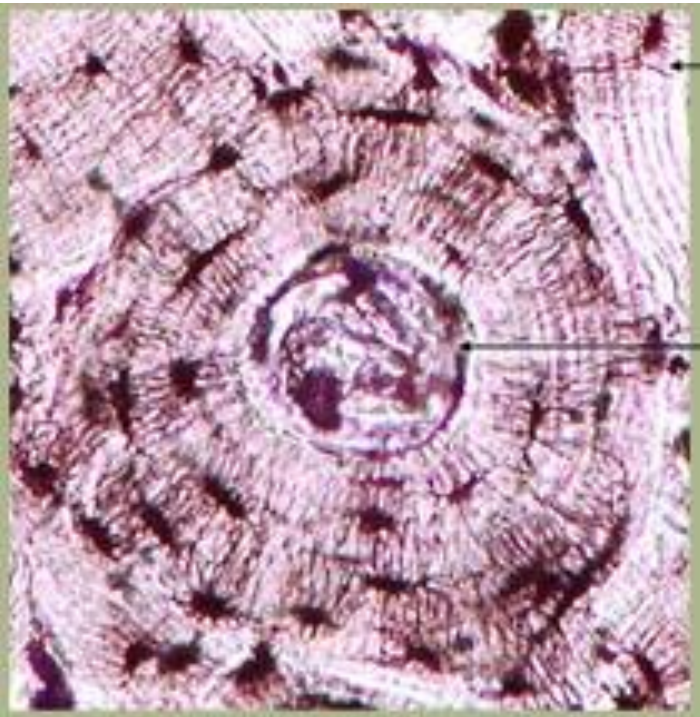

A Haversian System

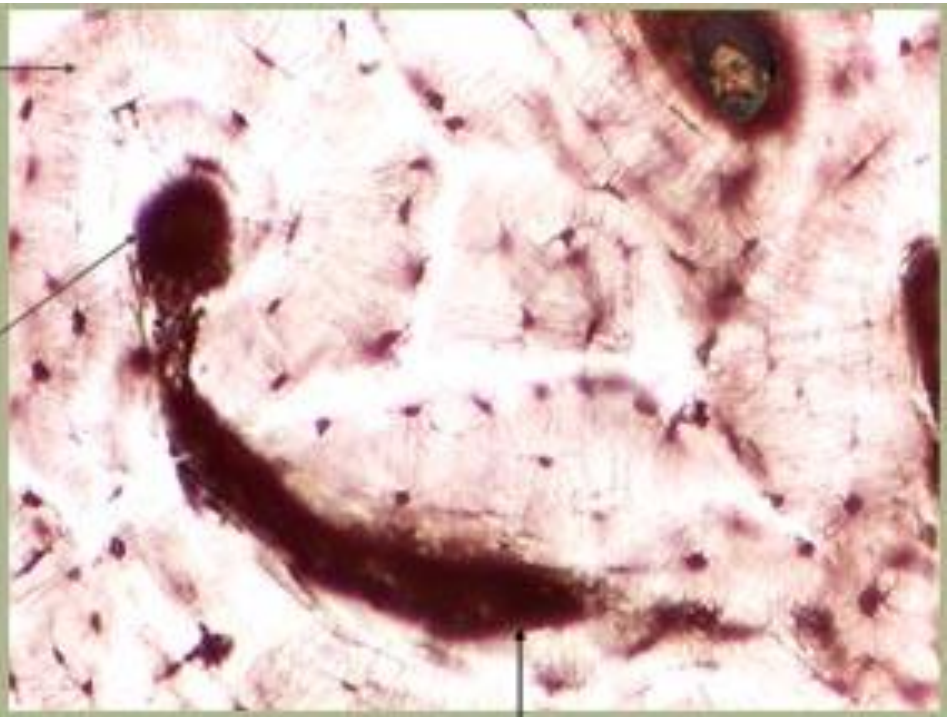

1
2
3
4

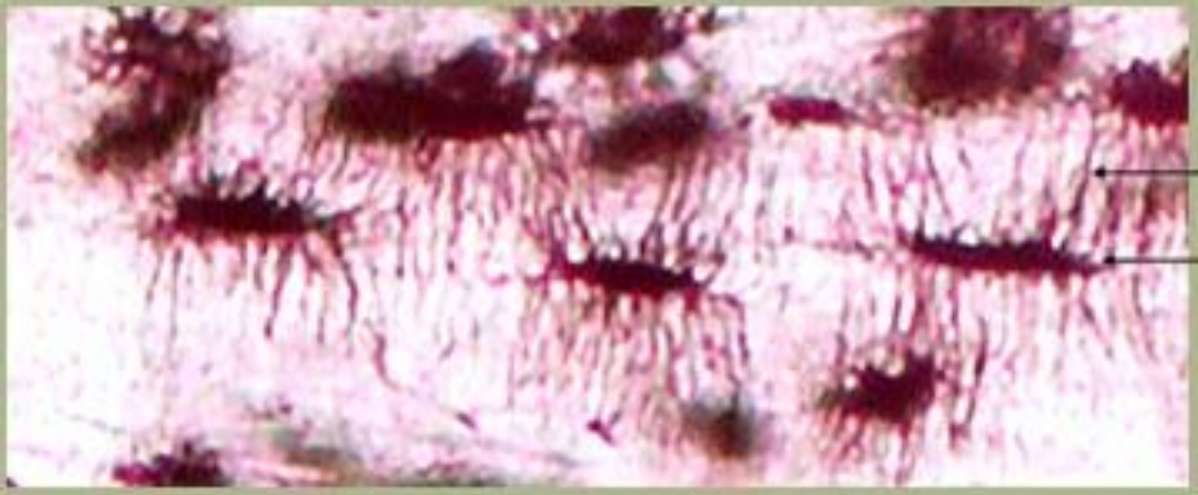

Compact bone
Osteons, Polarizing microscopy
50 um
50 um

Diğer lameller ise **ara (intersiyel)** lameller ve **sirkumferensiyal** lamellerdir.



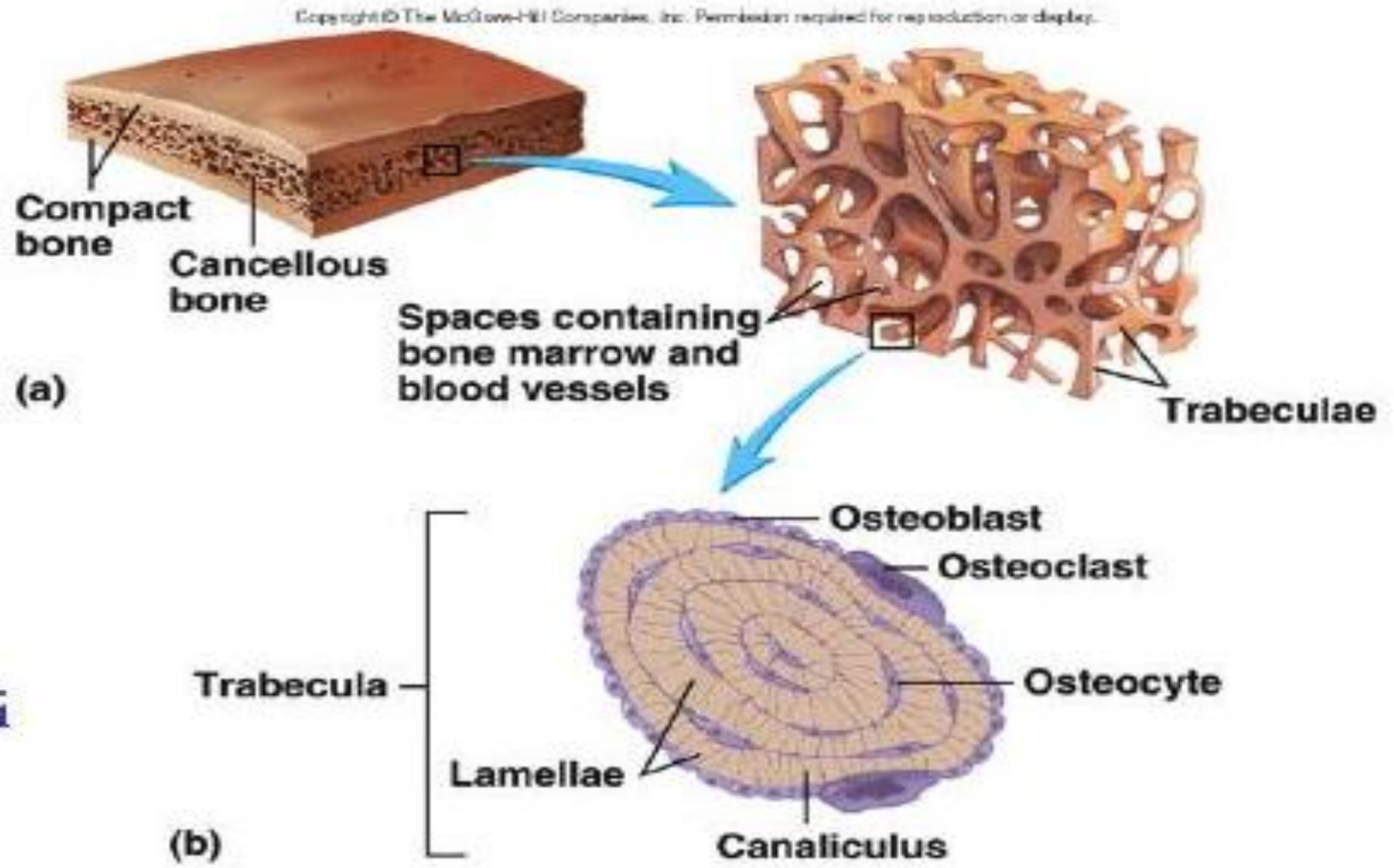


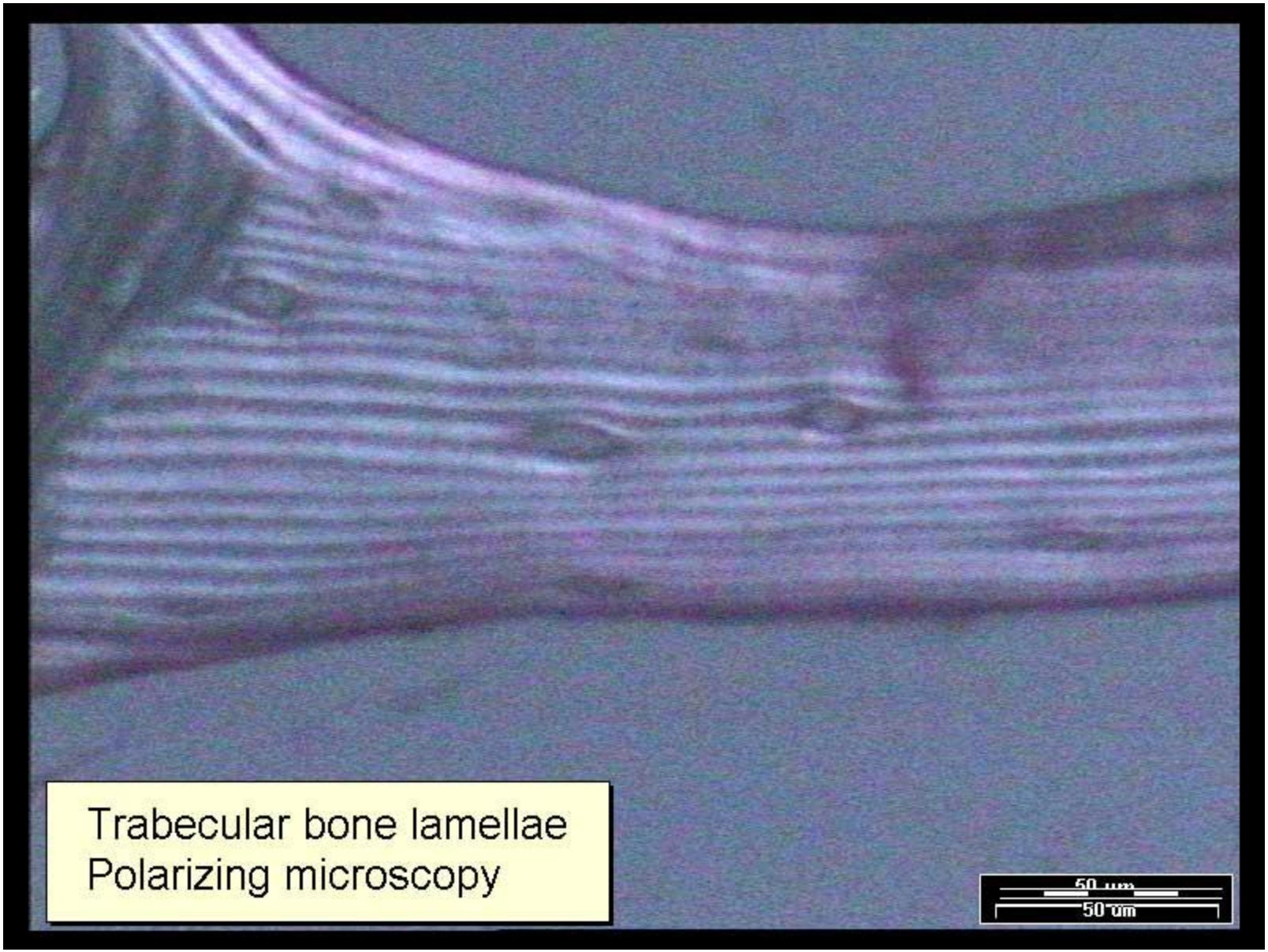




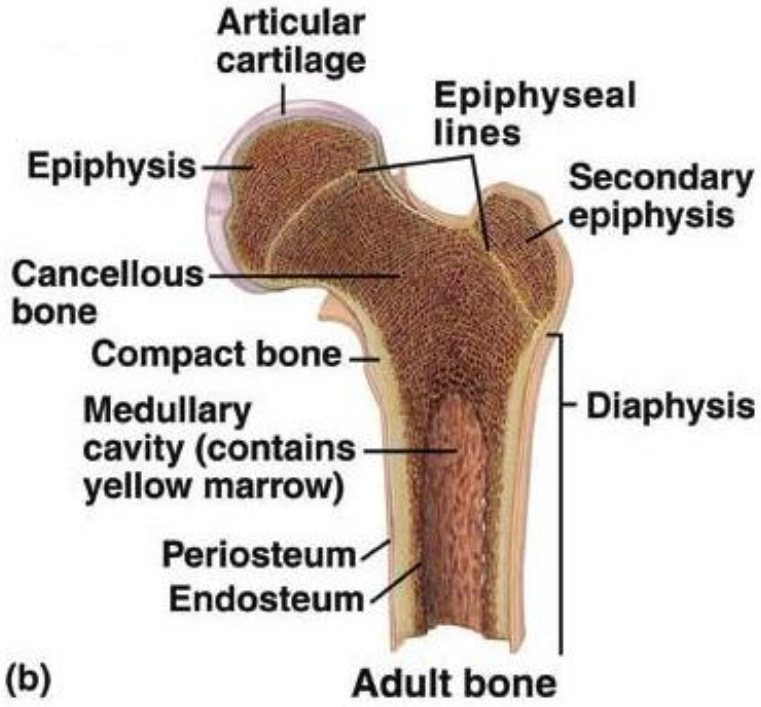
Slides 14 & 50 : Dry, Ground Bone

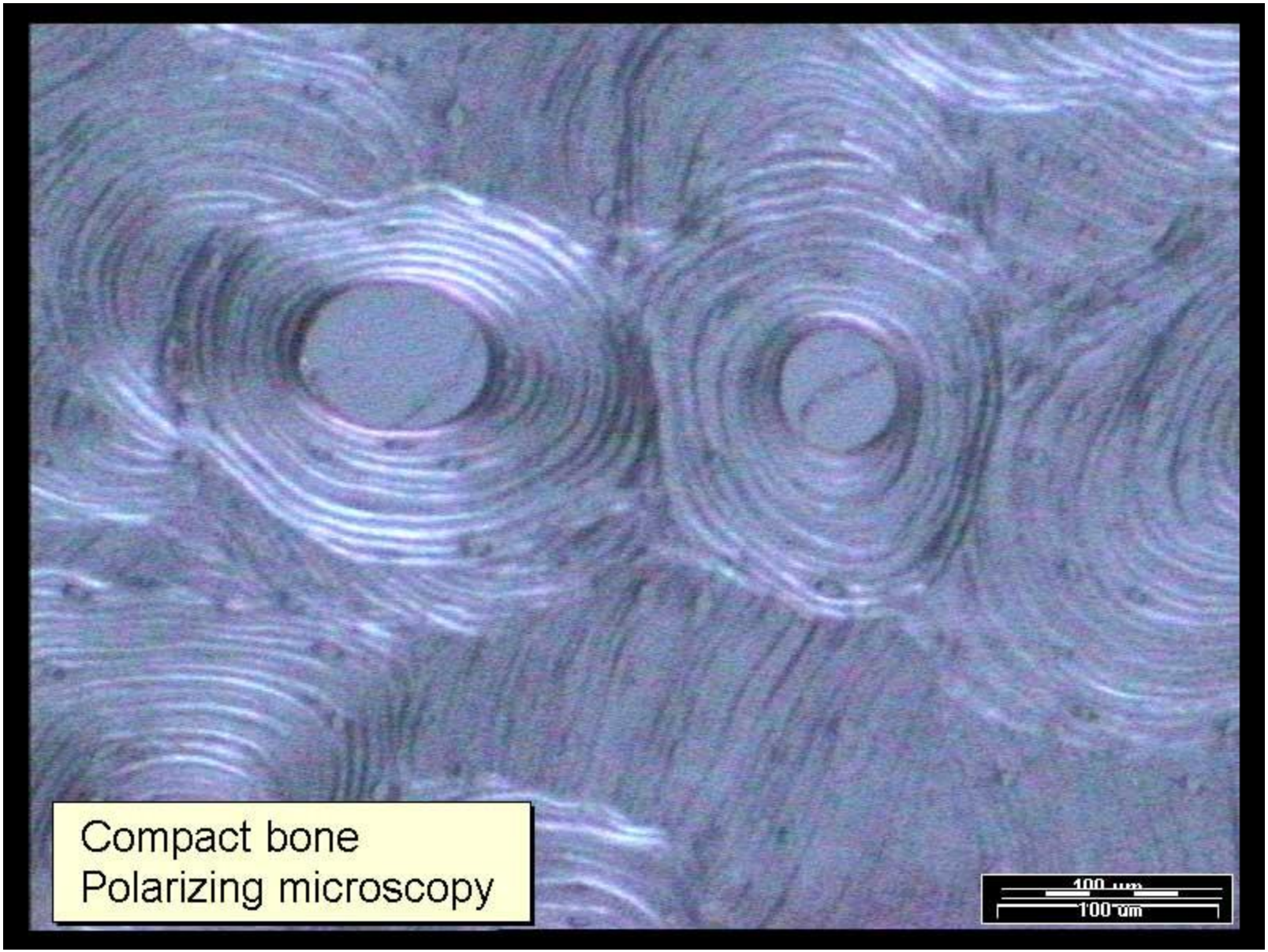
Spongiyöz kemik




Trabecular bone lamellae
Polarizing microscopy
50 um
50 um

Kompakt kemik




Compact bone
Polarizing microscopy
100 µm


Interstitial System
Lamellar bone
100 µm
100 µm

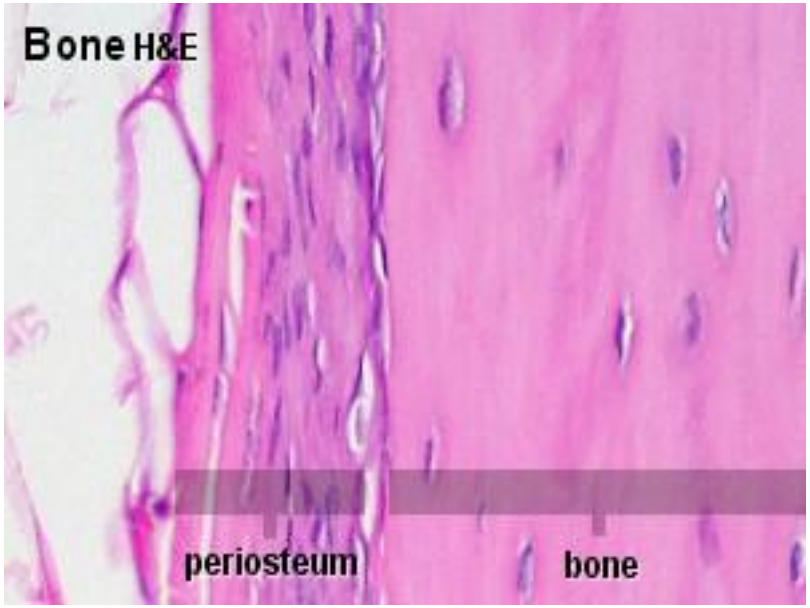
Kemik Hücreleri

Kemik dokularında dört tür hücre bulunur

- Osteoprogenitor (osteojenik hücreler)
- Osteoblast
- Osteosit
- Osteoklast

Osteoprogenitor (osteojenik) hücreler

-Kemik hücresi olma yönünde koşullanmış mezenkim hücreleri
-Mitozla **bölünüp çoğalırlar**, çoğalan hücrelerin bir bölümü osteoblastlara dönüşürler
-Sekunder kemiklerin zarlarında ve kanalları çevreleyen bağ dokuda inaktif olarak bulunurlar
-Gerekli durumlarda aktifleşip bölünerek osteoblastları meydana getirirler



Osteoblastlar

- **Kemik yapan hücrelerdir**

-Kemik trabeküllerinin (süngerimsi kemik) ya da lamellerinin (kompakt kemik) yüzeylerinde tek sıra halinde dizilmişlerdir

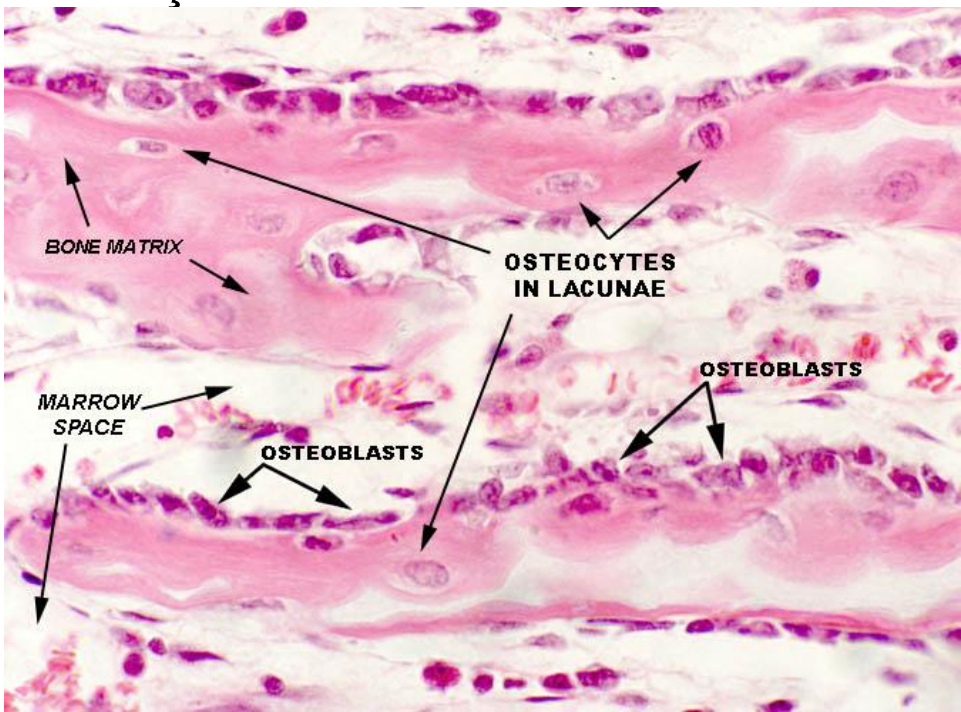
-Sitoplazmaları granüllü ret. ve Golgi aygıtlarından zengin (yüksek metabolik aktivite) ve çekirdekleri ökromatik

-Kemik matriksin organik bölümünü (kollagen ipl.,proteoglikan, glikoprotein ve glikozaminoglikan) salgılarlar. Henüz kireçleşmemiş bu tür temel maddeye **osteoid** denir

-Osteoblastlar, osteoid doku içinde gömülü kalırlar ve bu doku kireçleşince aktiviteleri azalır, şekilleri basıklaşır ve birer **osteosit** olurlar

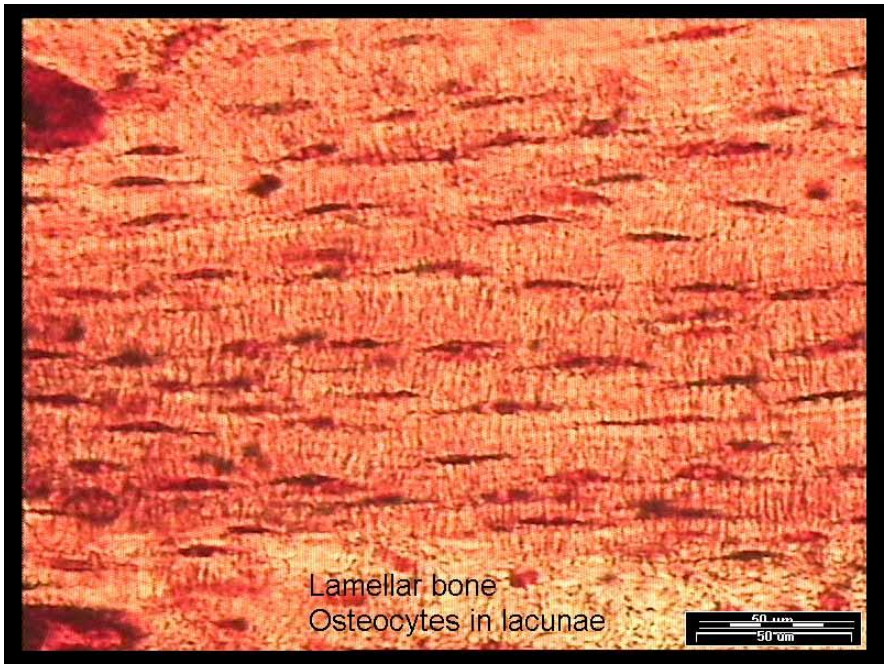
-Osteoprogenitör hücrelerden farkılaşırlar, **bölünme yetenekleri yoktur**

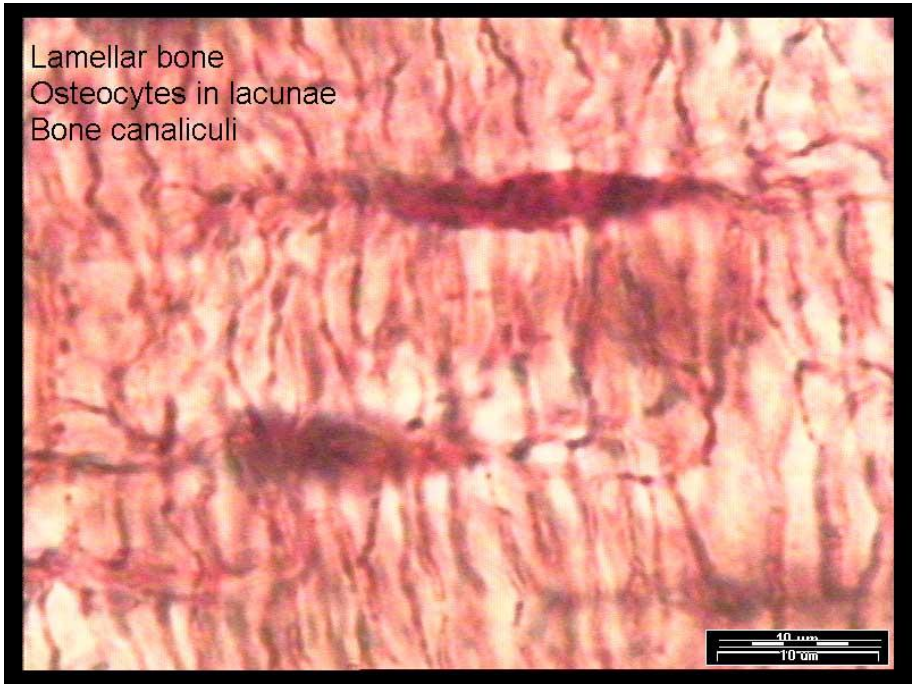
-Sitoplazmaları **alkali fosfataz**dan zengin (Ca depolanması, kemikleşmenin ölçüsü)

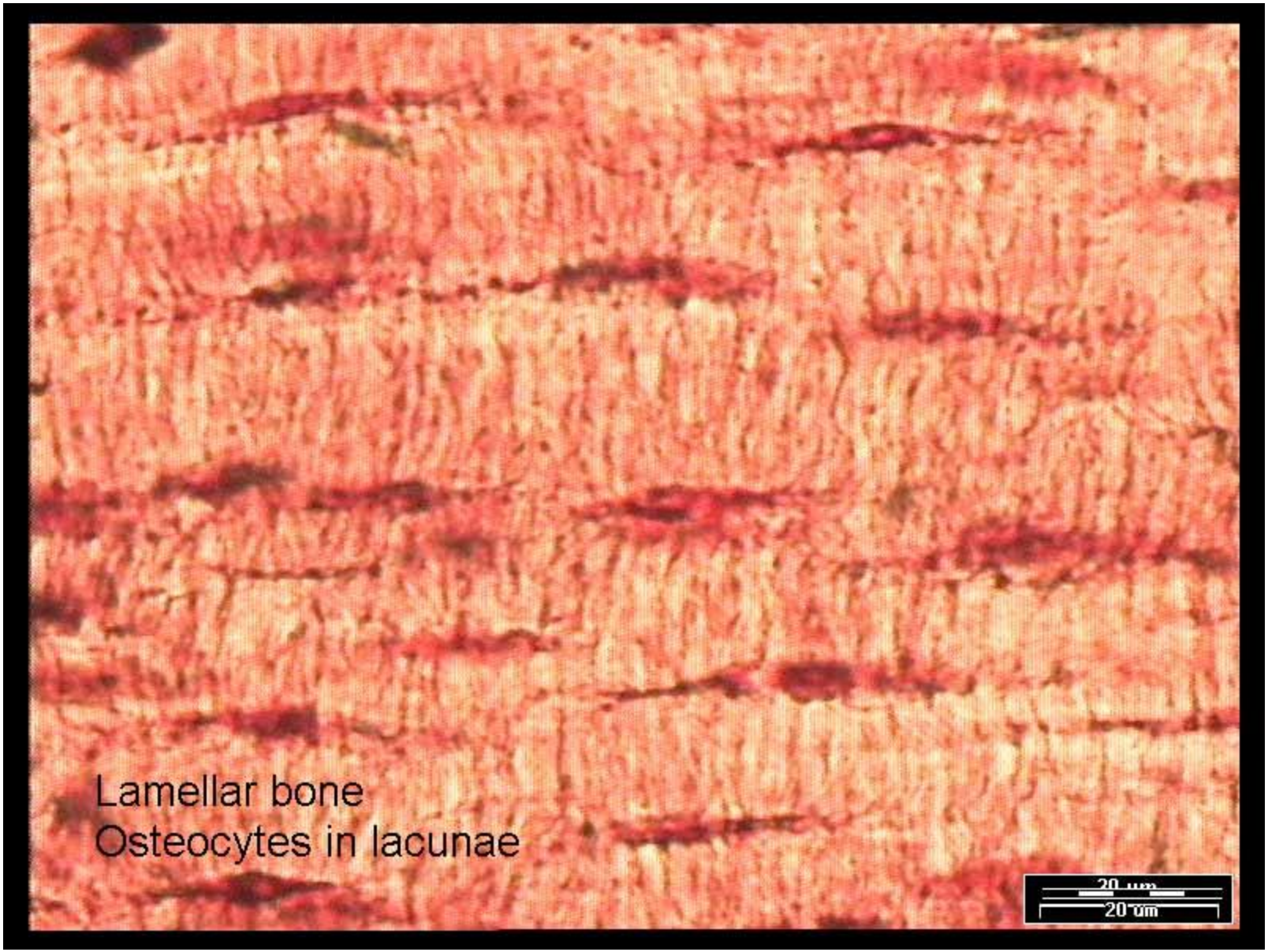


Osteositler

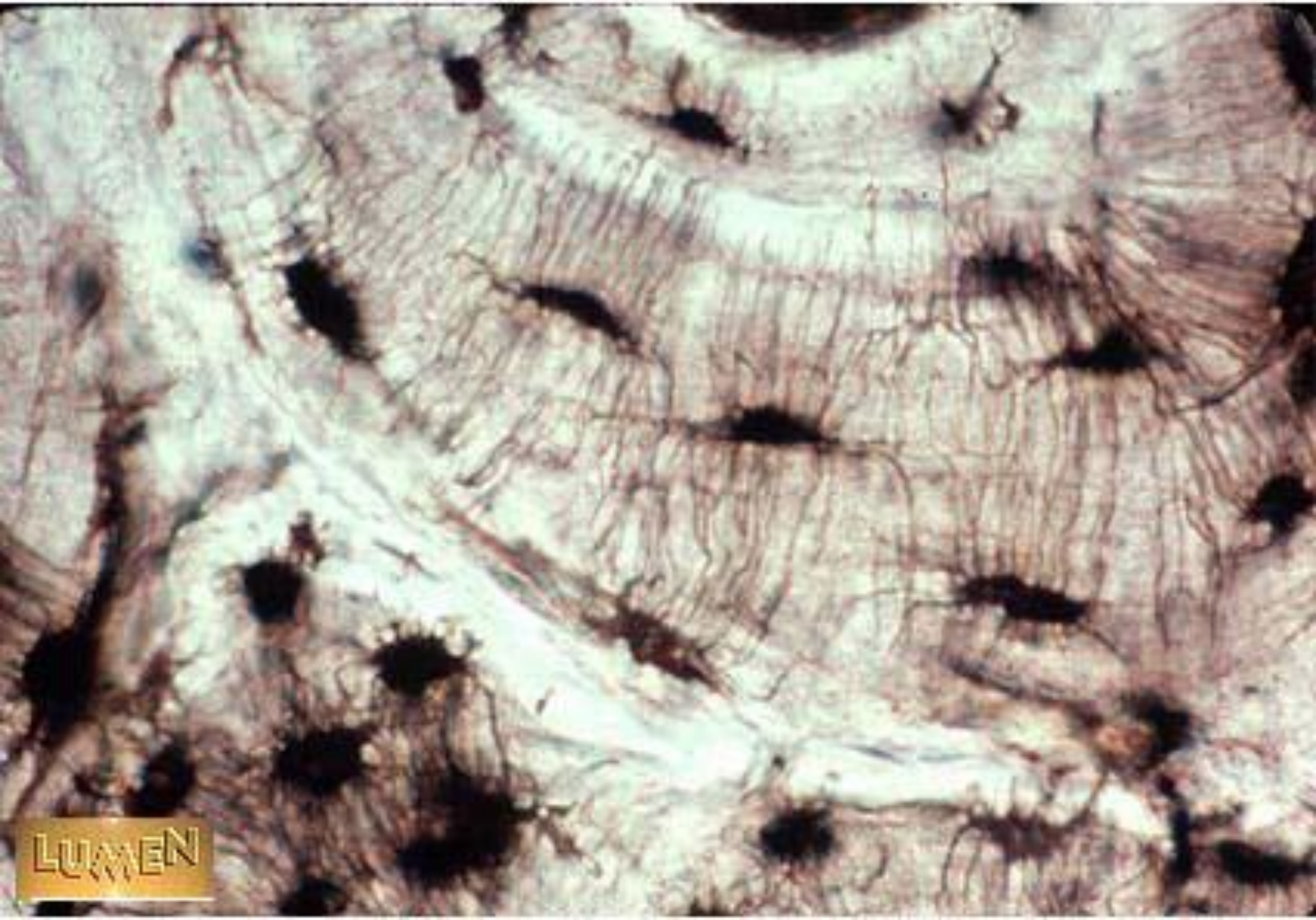
-Osteositler, kireçlenmiş kemik matriksi içinde kalan ve met. aktivitelerini azaltan osteoblastlardır
-Lakunlar içerisinde, uzun sitoplazmik uzantıları kanaliküllerin uçlarına kadar uzanır
-Kemik matriks kireçleşmiş olduğundan **madde transportu** osteositler üzerinden gerçekleşir, uzantılı olmalarının nedeni budur
-Kemik dokunun canlı kalabilmesi osteositlerin varlığı ile olanaklıdır
-Osteositler de osteoblastlar gibi **bölünme gücünü kaybetmiş** hücrelerdir






Lamellar bone
Osteocytes in lacunae
20 um
20 um

Histology Lab Part 9: Slide 42



Osteoklastlar

-Kemikleri **yıkıma uğratan** hücrelerdir

-Kırmızı kemik iliğindeki köken hücreler, osteoklastların salgıladığı maddeler tarafından uyarılır ve uyarılan hücreler birleşerek **(füzyon)** bir osteoklastı meydana getirir

-Kemiklerin yapımı sırasında osteoklastlar trabeküllerin yüzeyinde ya da kompakt kısımların iç yüzlerine yerleşip buraları eritirler, böylece kemikler genişleyip uzayabilme olanağına kavuşurlar (bir taraftan da yapım)

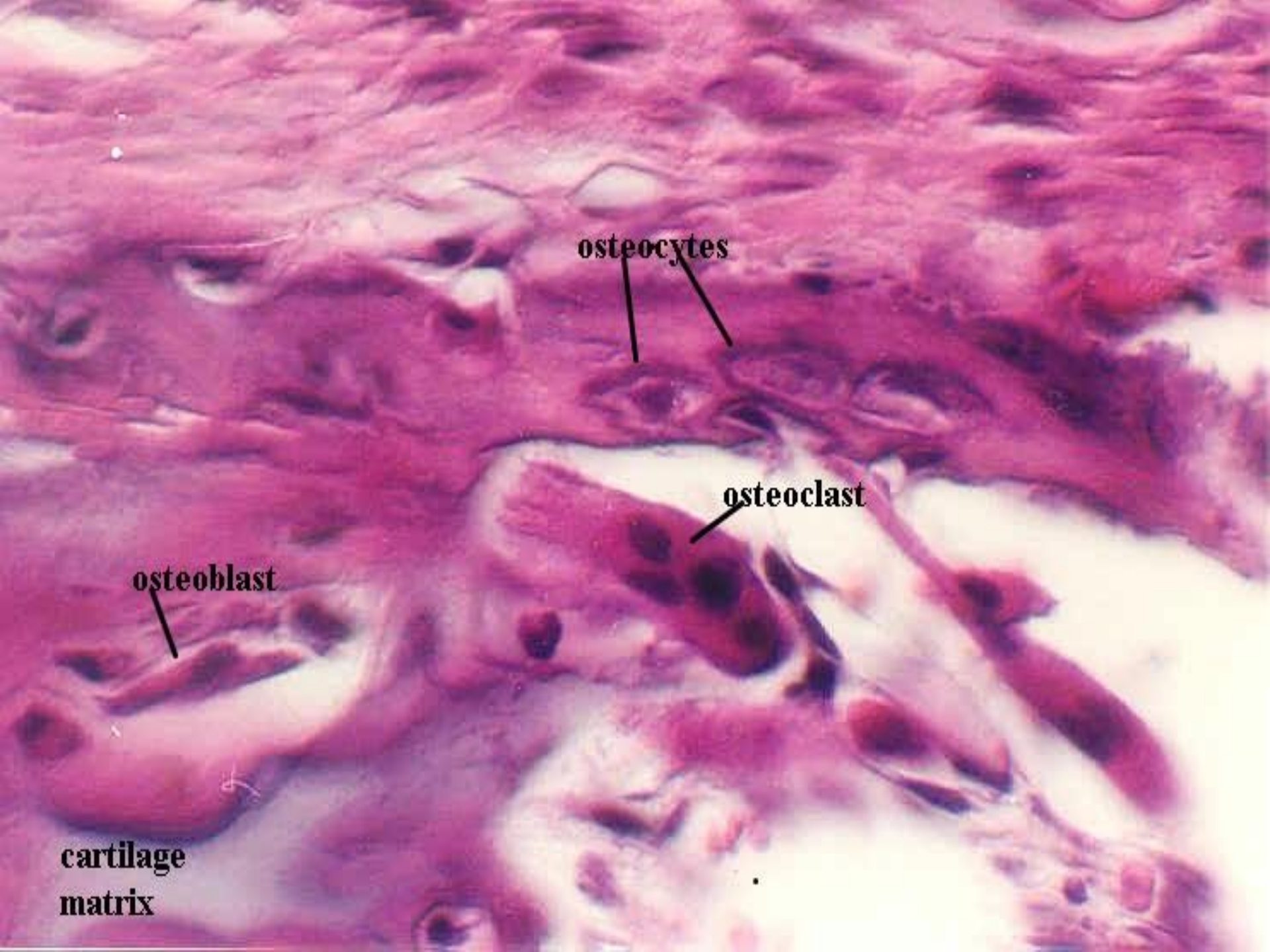
-Bu yıkım olaylarında açığa çıkan kalsiyum kana geçer, kan kalsiyum miktarını ayarlanır

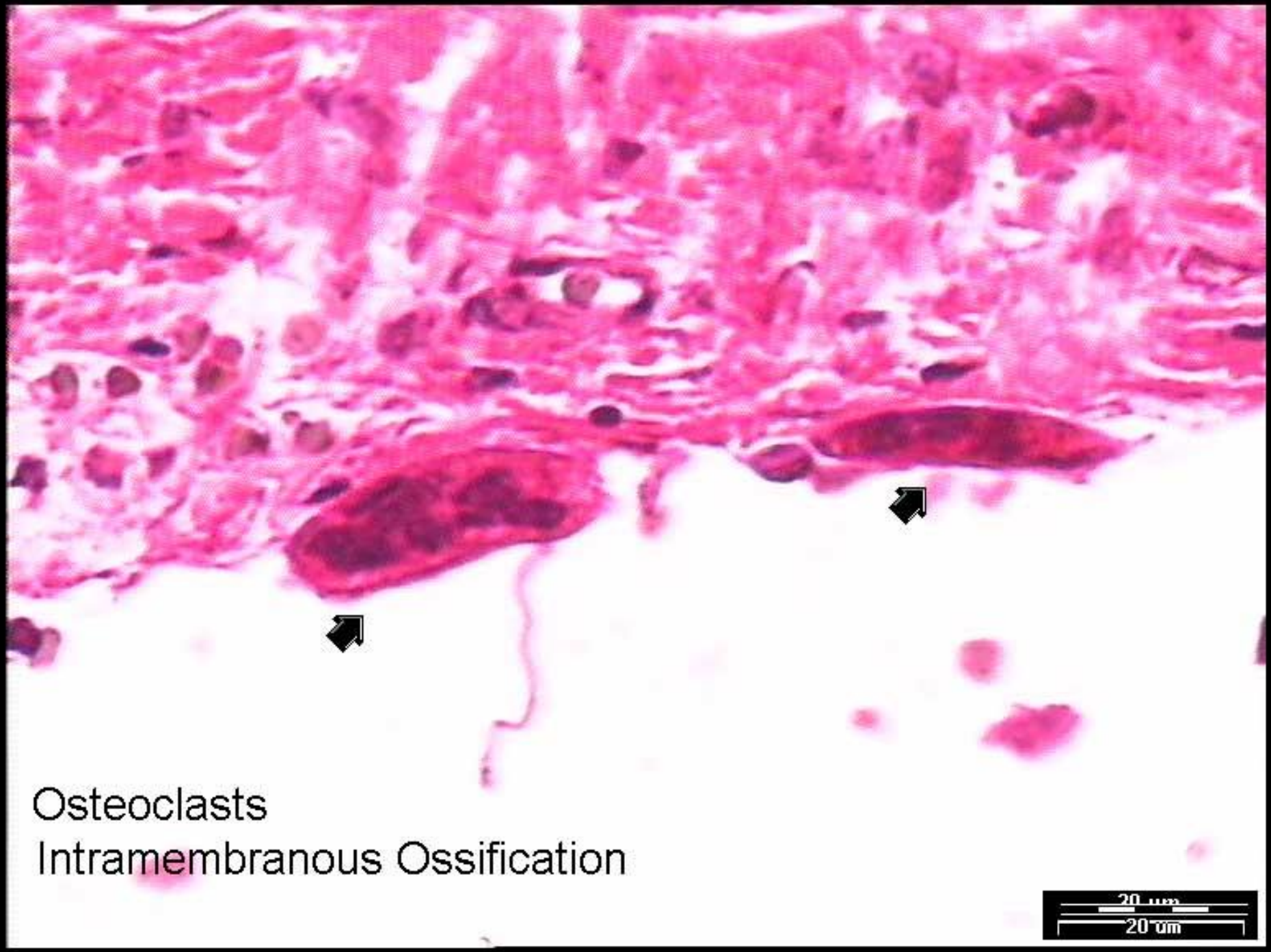
-Osteoklastlar çok iri hücrelerdir, elli kadar çekirdek içerirler

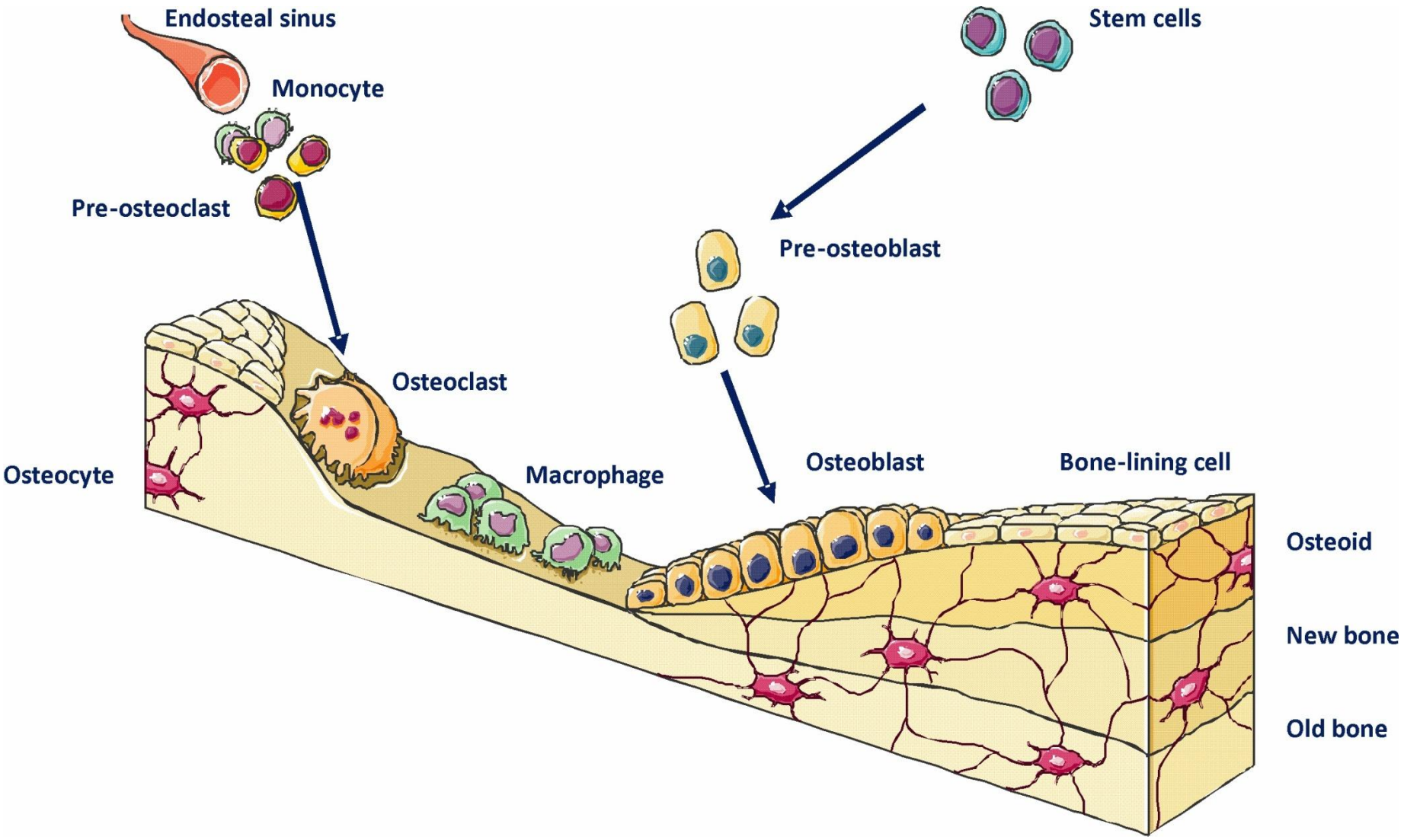
-Sitoplazmaları asidofiliktir ve **fazla miktarda lizozom içerirler.**Lizozomlarda lizozomal enzimler (asit fosfataz, kollagenaz, diğer proteazlar v.s.) bulunur

-Kemik yüzeyinde oturdukları yerler bu enzimler nedeniyle çukurlaşır (Howship lakunları)

-Paratiroid hormonu osteoklastları uyarır ve kana fazla kalsiyum geçer. Buna karşılık tiroid bezinden salgılanan kalsitonin hormonu matriks yapımını kamçılar ve kan kalsiyum miktarını düşürerek denge sağlar


osteocytes
osteoclast
osteoblast
cartilage
matrix


Osteoclasts
Intramembranous Ossification
20 um
20 um


Endosteal sinus
Monocyte
Pre-osteoclast
Stem cells
Pre-osteoblast
Osteoclast
Osteocyte
Macrophage
Osteoblast
Bone-lining cell
Osteoid
New bone
Old bone

KEMİK ZARLARI

Periosteum:

-Kemiklerin dış yüzünü örten zar

-Gelişme döneminde iki katlıdır, dış zar düzensiz sıkı bağ dokusu yapısında, iç kat ise hücreden zengindir (Periostal hücreler, osteoprogenitör hücreler)

-Kemik yapımı ve onarımı sırasında iç kat çok aktif

-Periosteum damarlardan zengindir, hem dokuyu hem zarı beslerler

-Olgun kemiklerde periosteum kemik dokusuna sıkı şekilde yapışmıştır **(Sharpey iplikleri;** kas, tendo ve lig. kemiklere bağlandıkları yerlerde bol **)**

- Eklem yüzleri dışında kemikler hertaraflarından periosteum ile çevrilmişlerdir

Endosteum

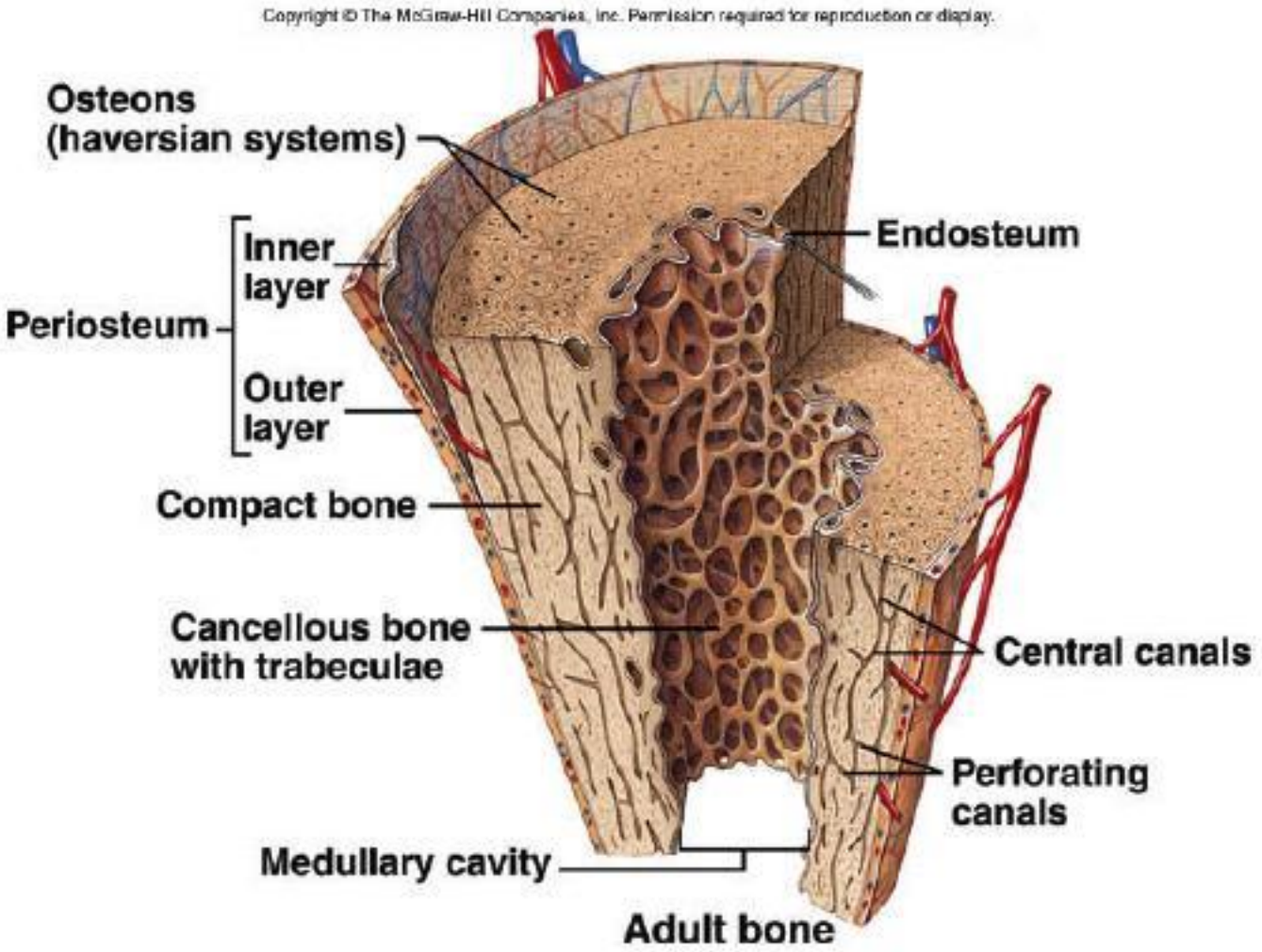
-Kompakt kemiklerin iç yüzleri ile süngerimsi kemikleri oluşturan trabeküller endosteum ile örtülüdür.

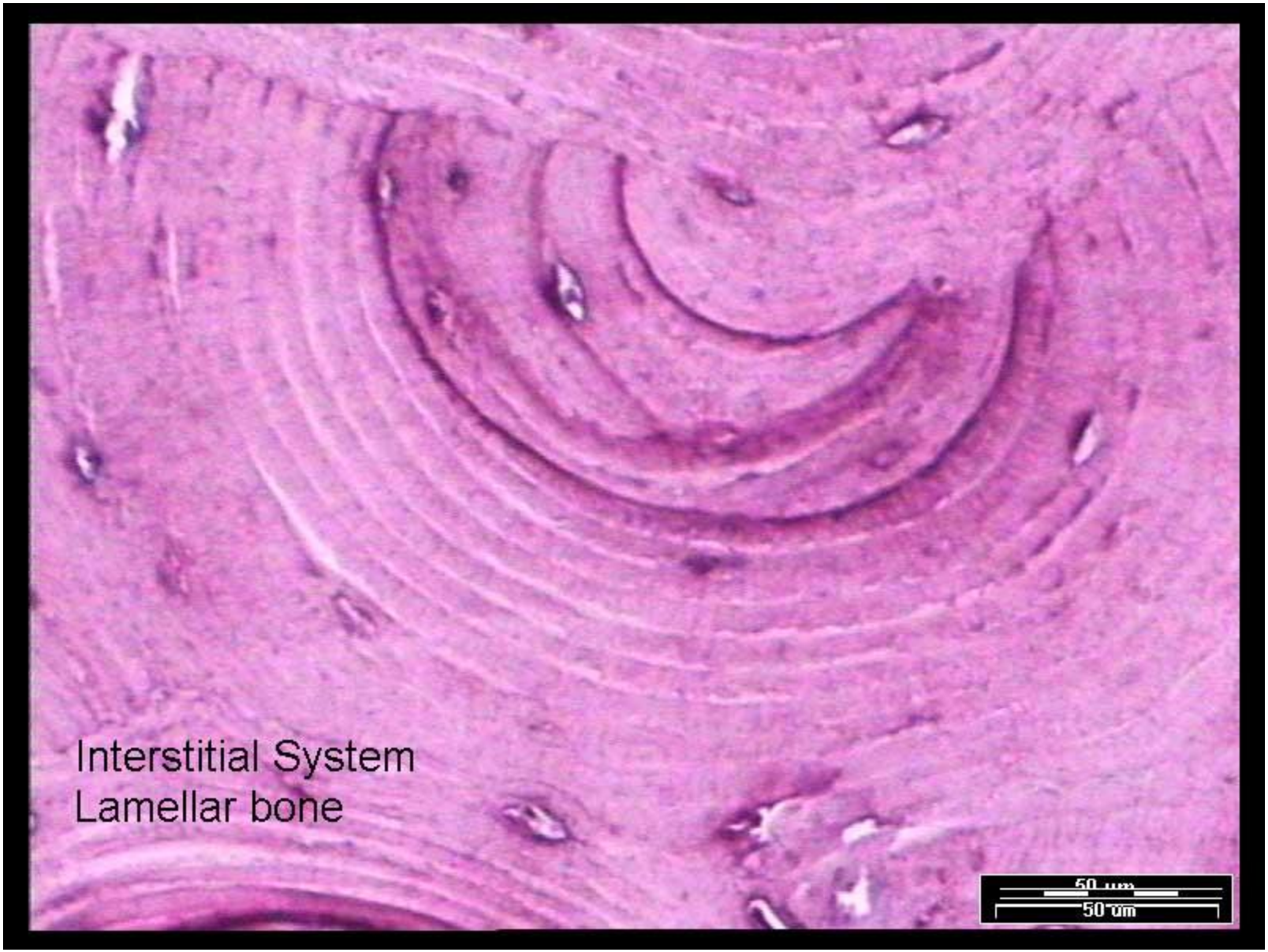
-Retiküler bağ dokusundan yapılmıştır

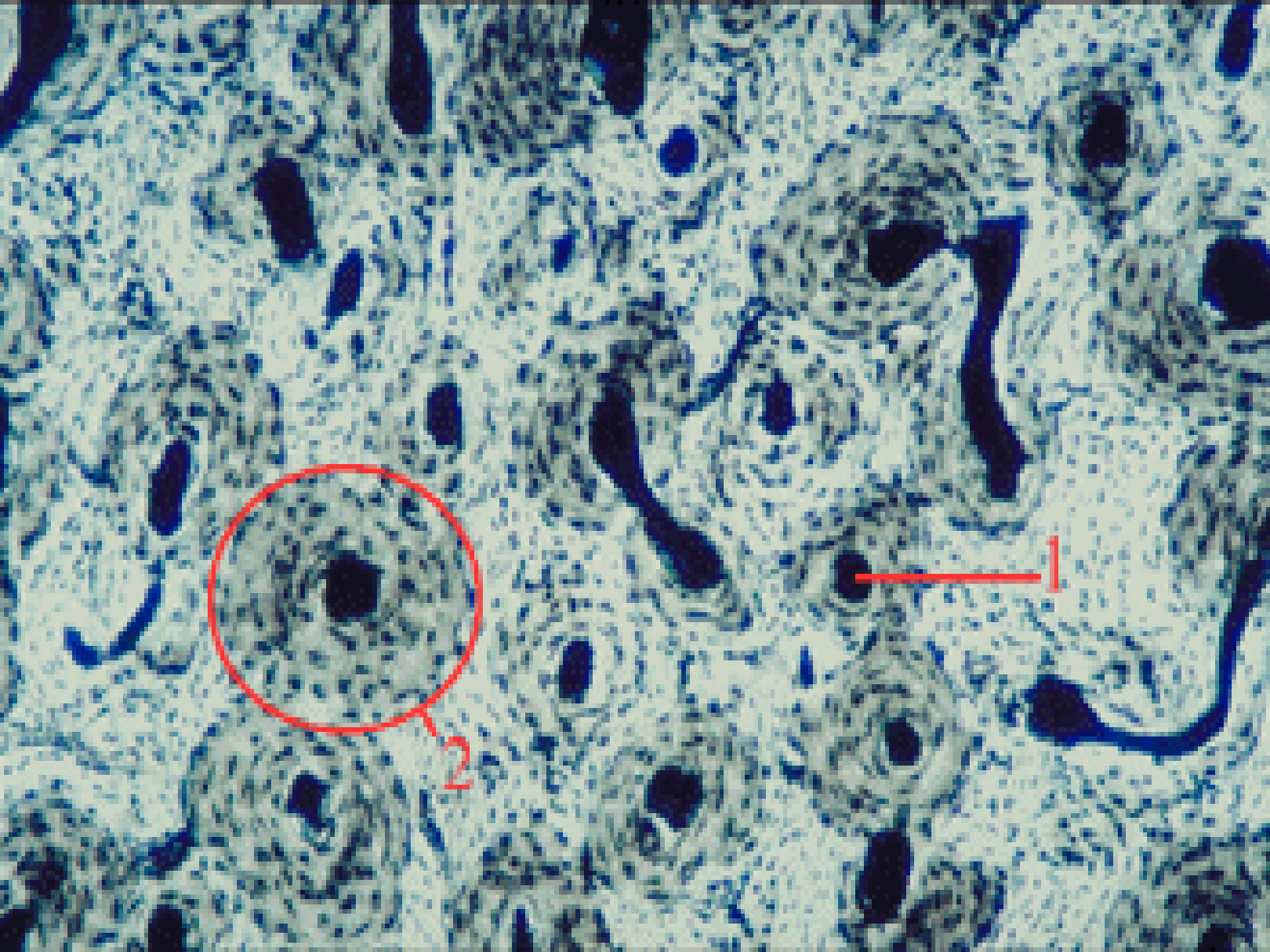
-Bunun kemik dokusuna dönük yarımında tek sıra halinde **osteoprogenitör (endostal)** hücreler bulunur.

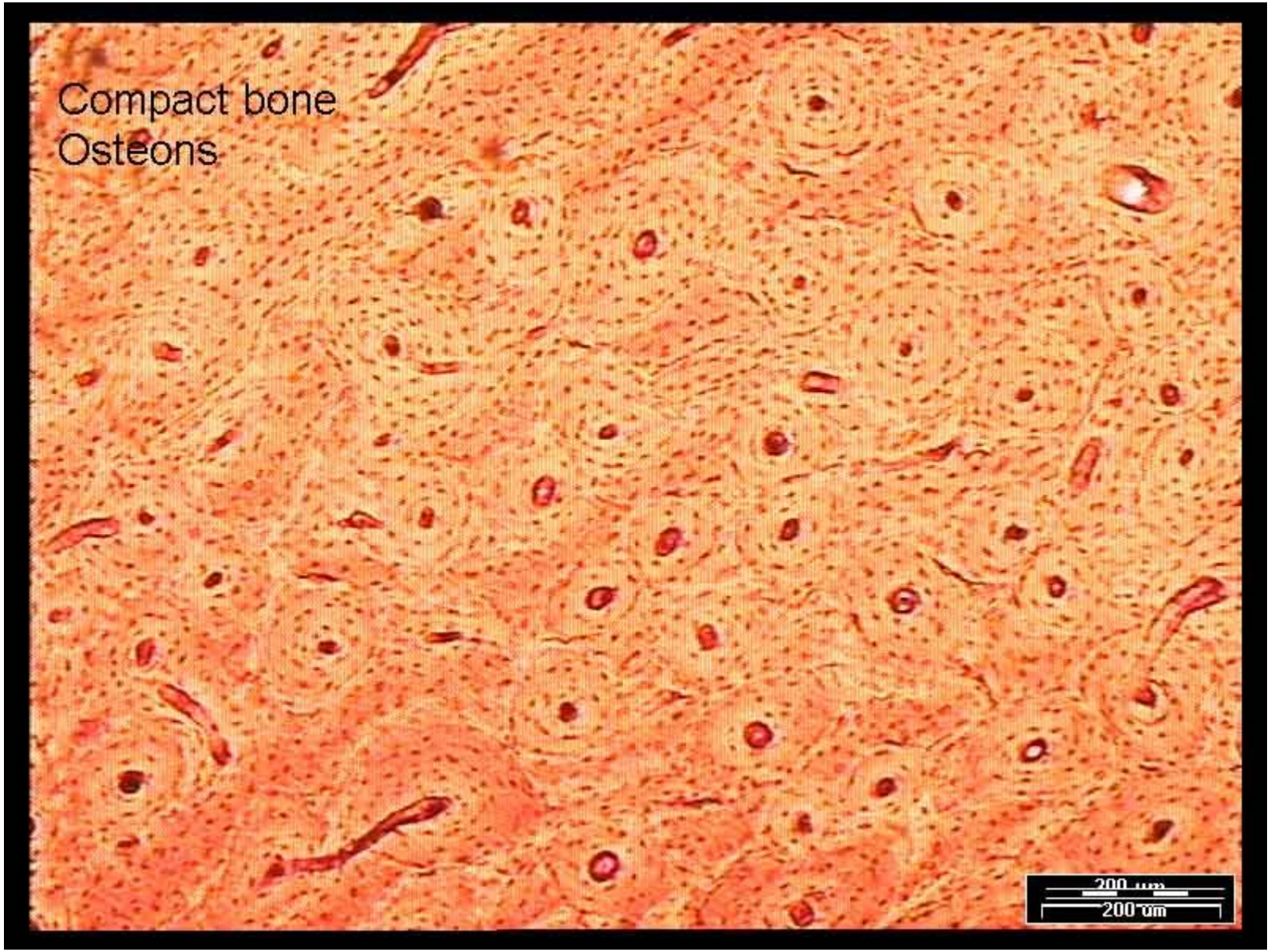
osteon (Haversian system)

The fundamental living unit of bone; consists of cells, layers of matrix and vessels.

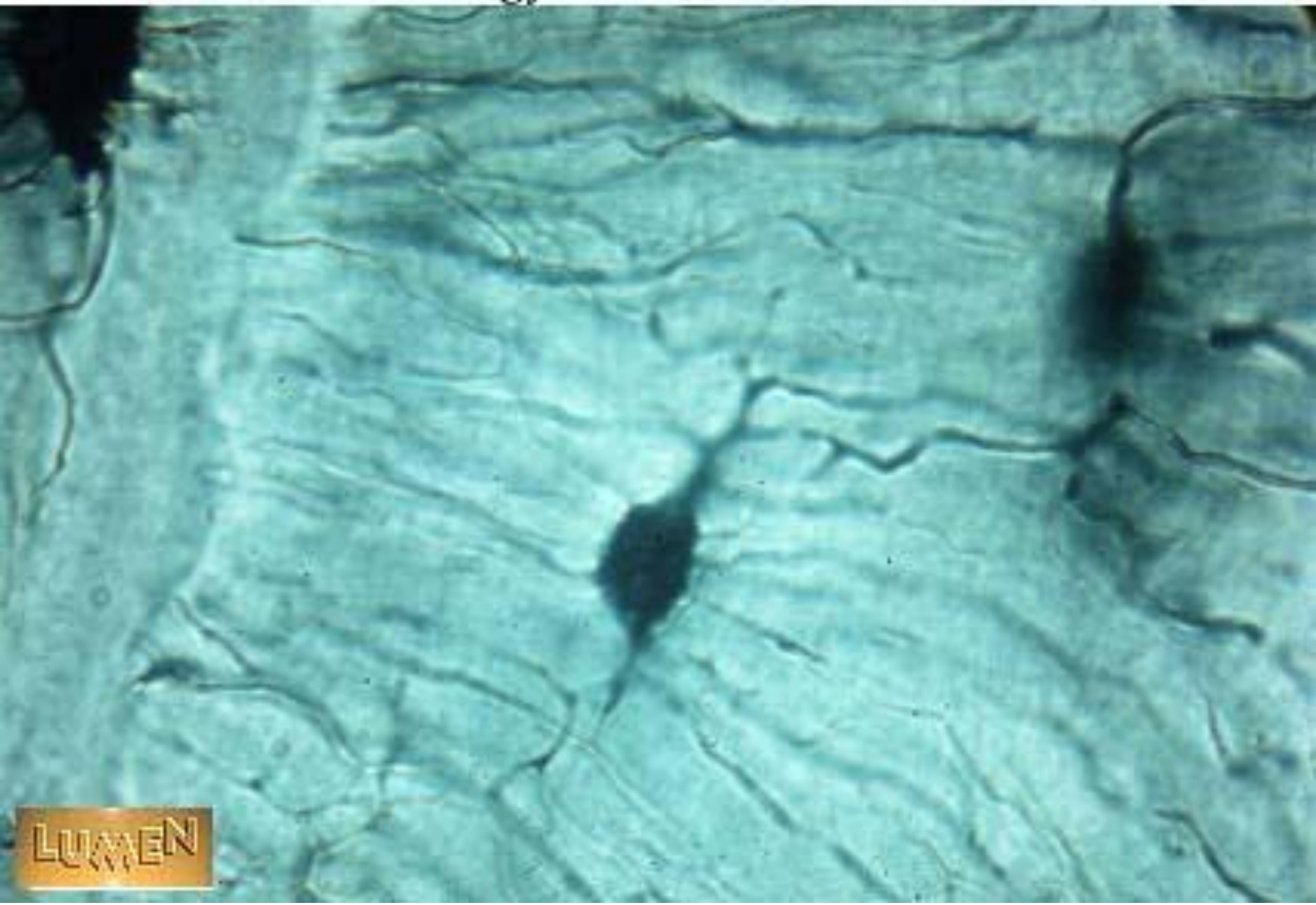


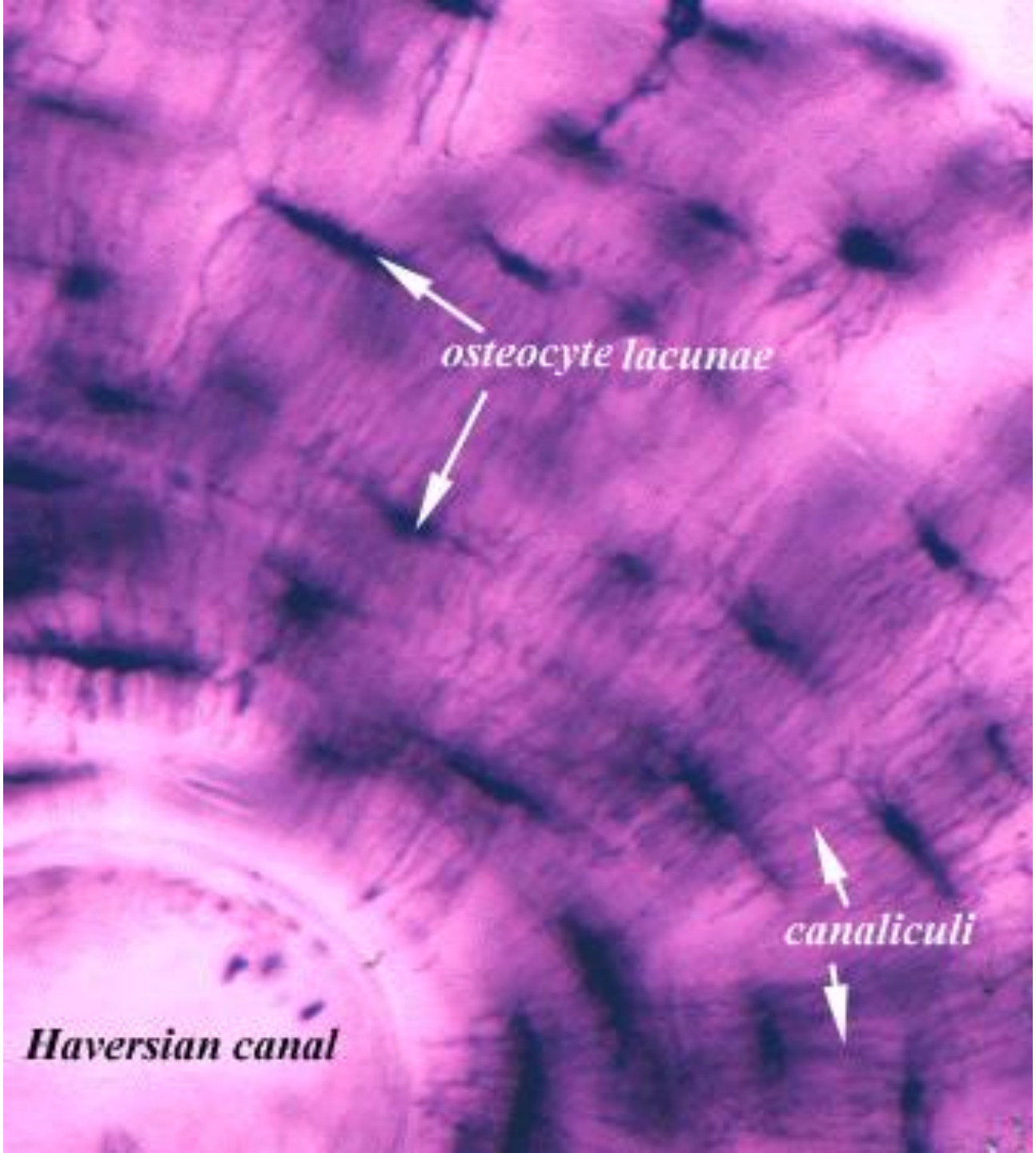

Interstitial System
Lamellar bone
50 um
50 um

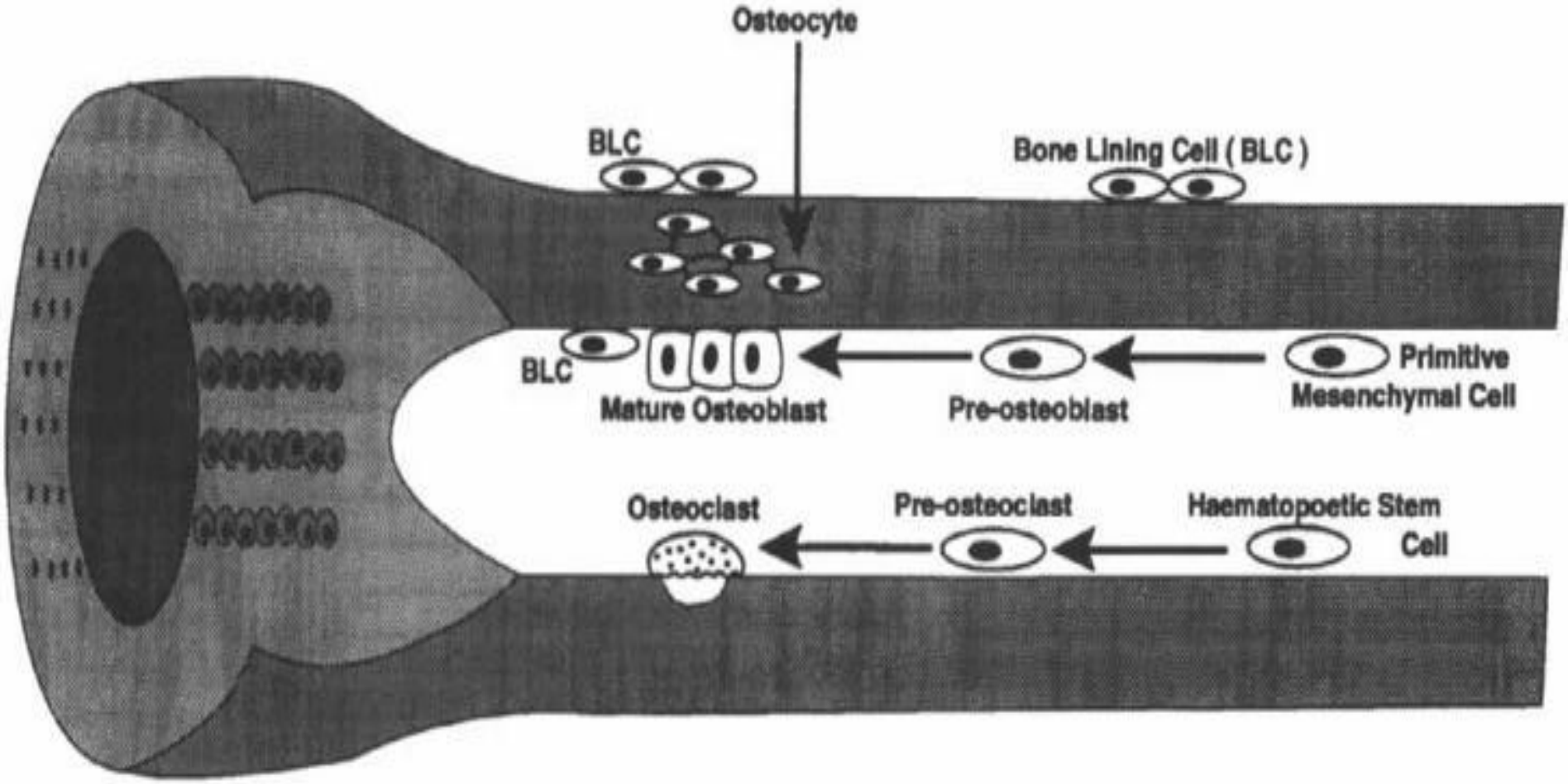

1
2

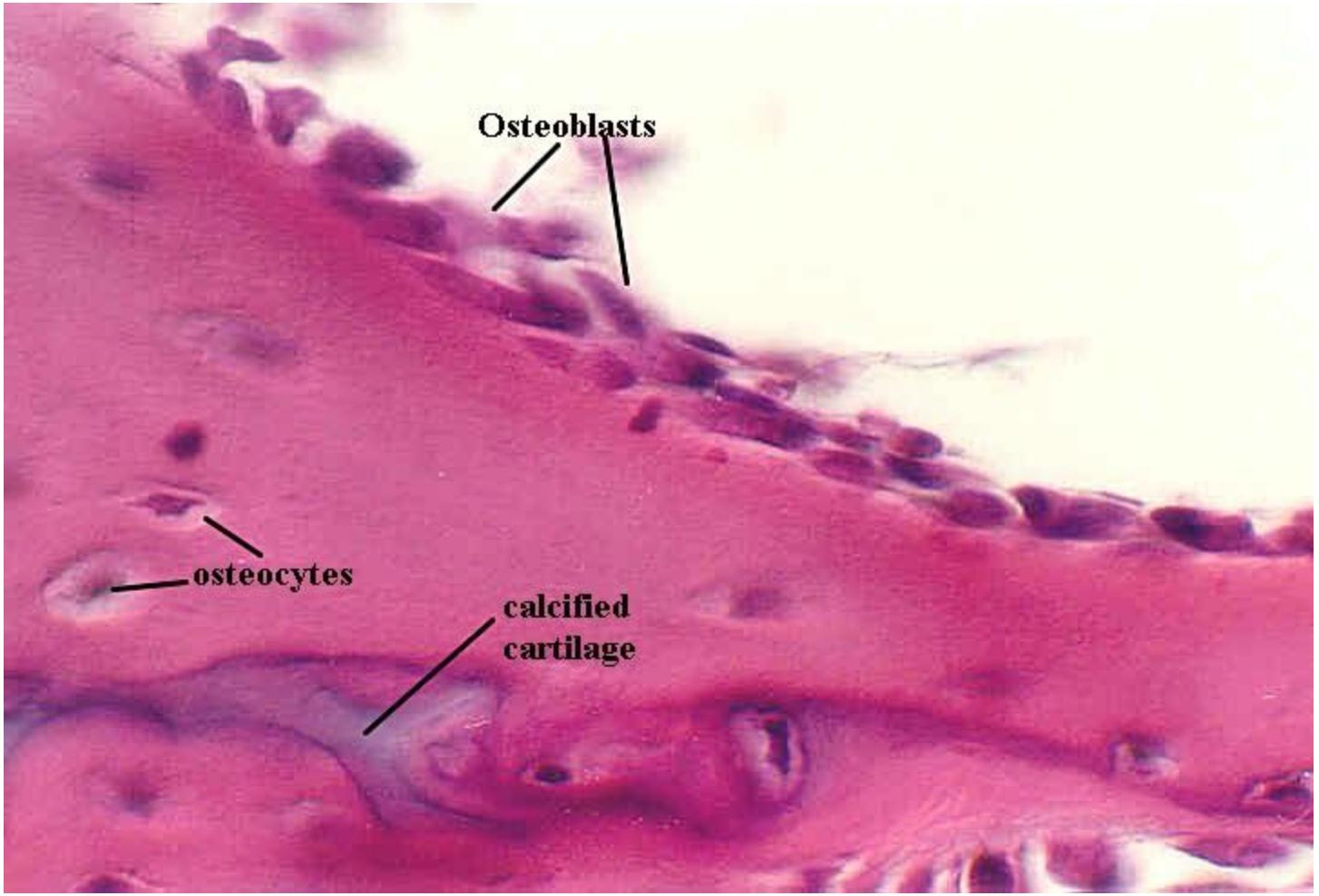

Compact bone
Osteons
200 µm
200 µm

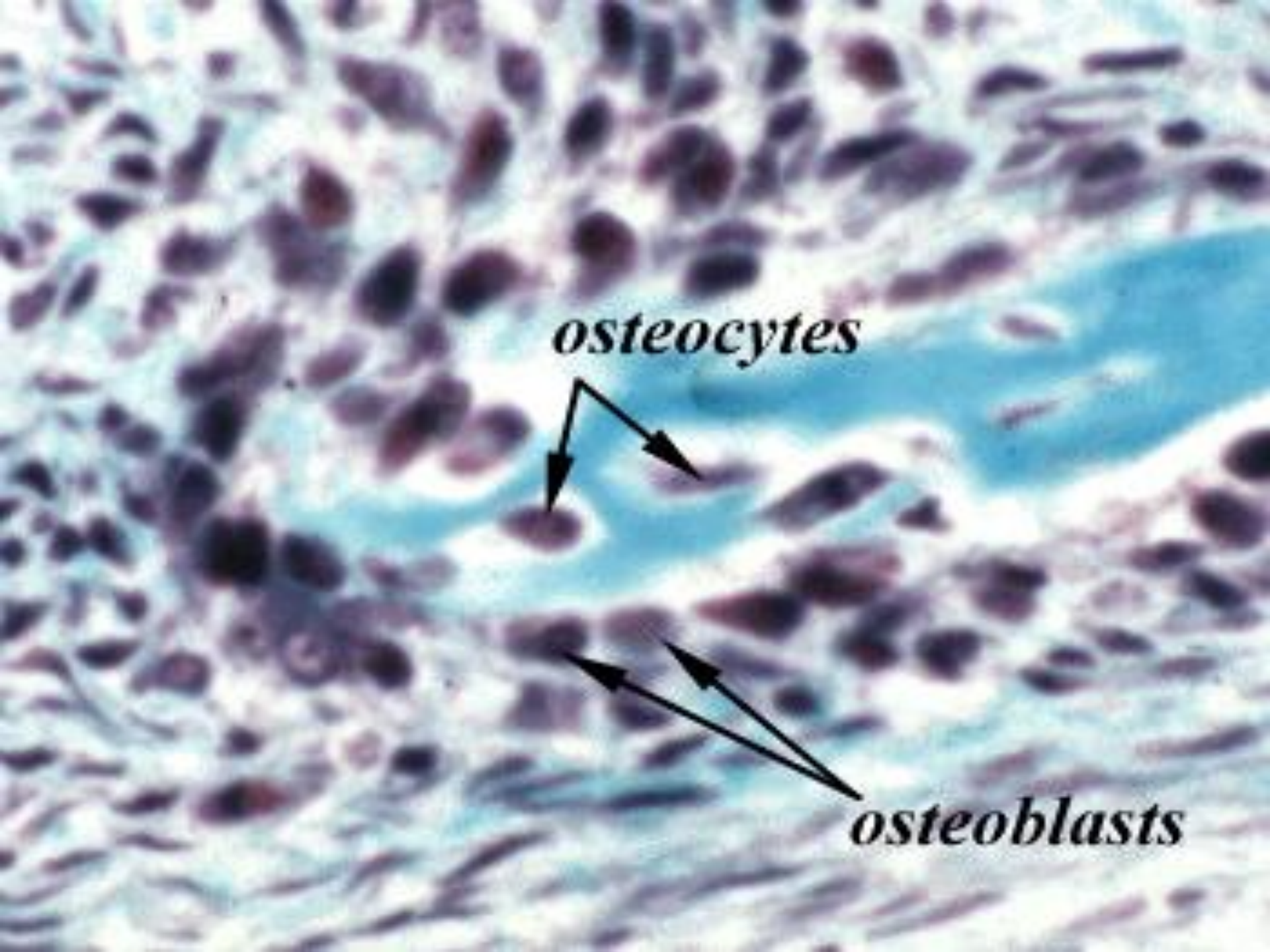
Histology Lab Part 9: Slide 43

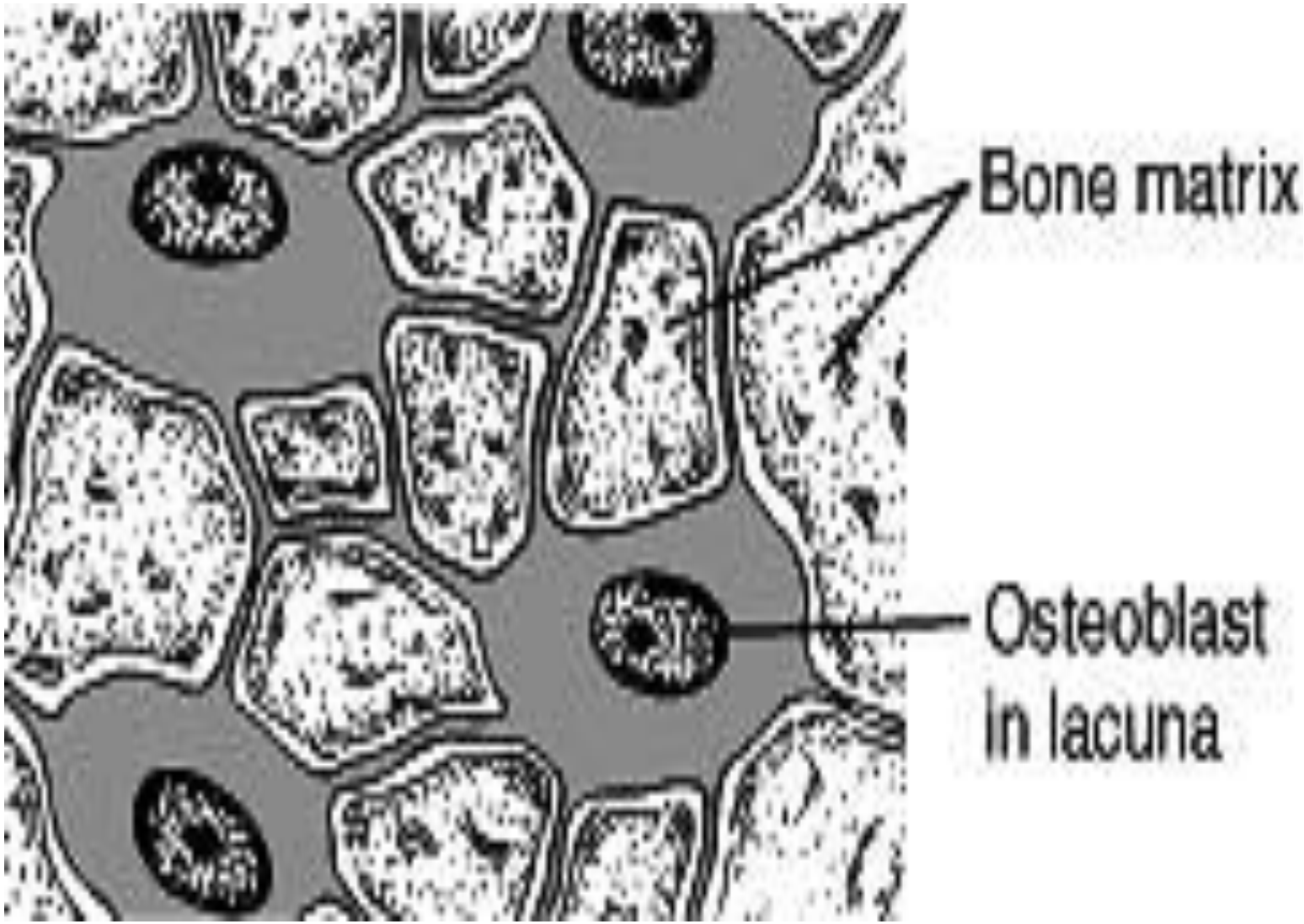


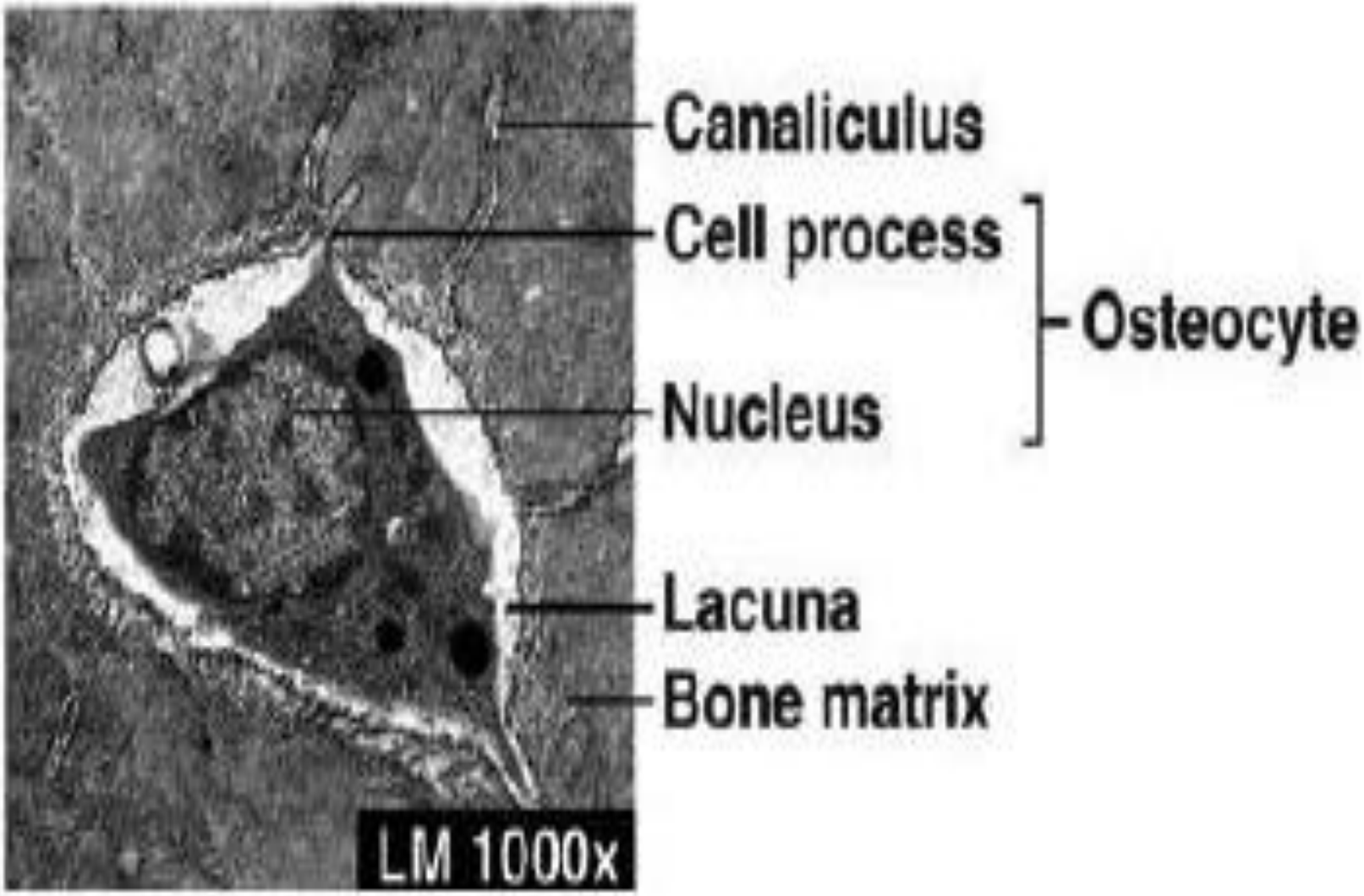

osteocyte lacunae
canaliculi
Haversian canal

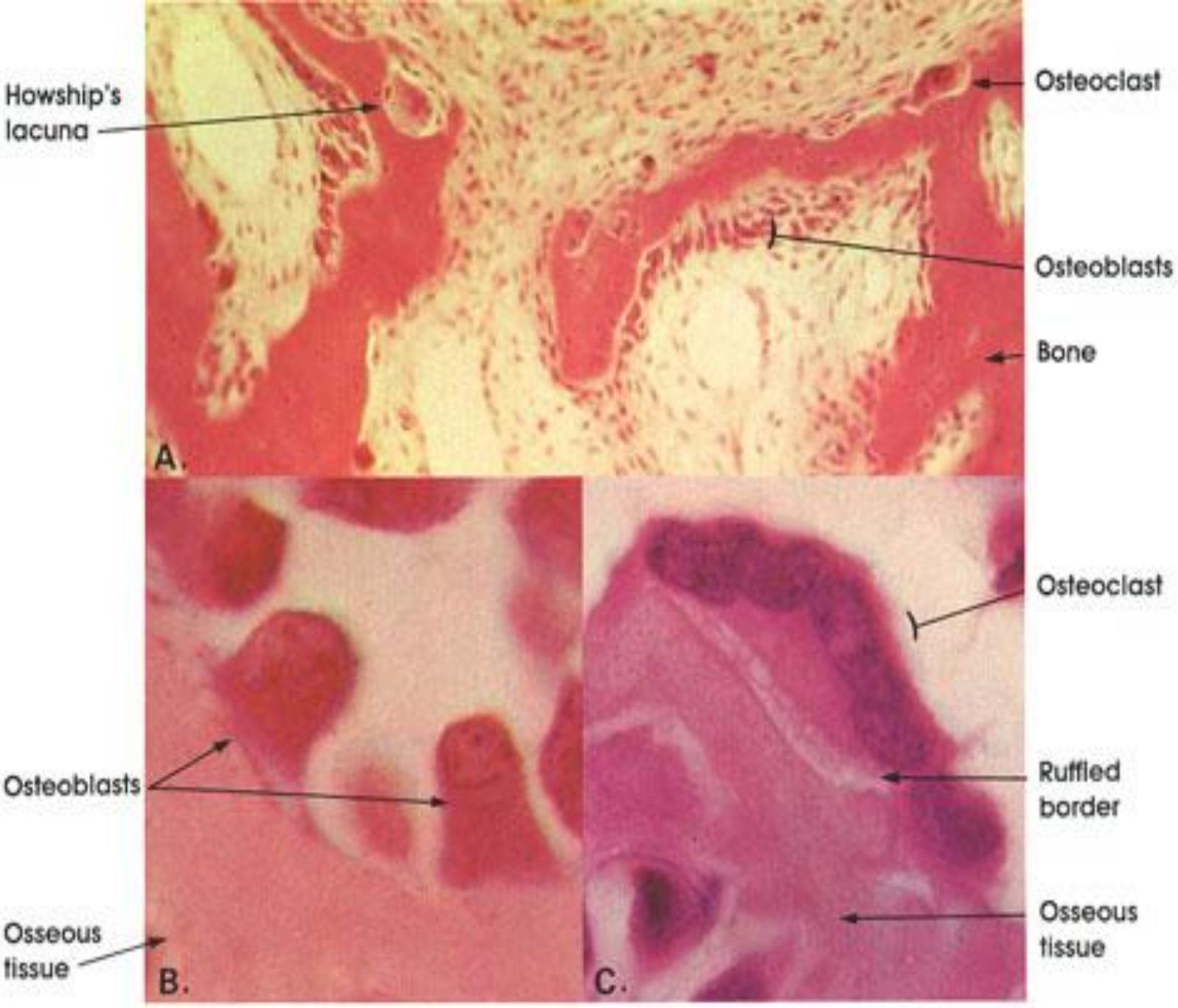

Osteocyte
BLC
Bone Lining Cell (BLC)
BLC
Mature Osteoblast
Pre-osteoblast
Primitive
Mesenchymal Cell
Osteoclast
Pre-osteoclast
Haematopoetic Stem
Cell

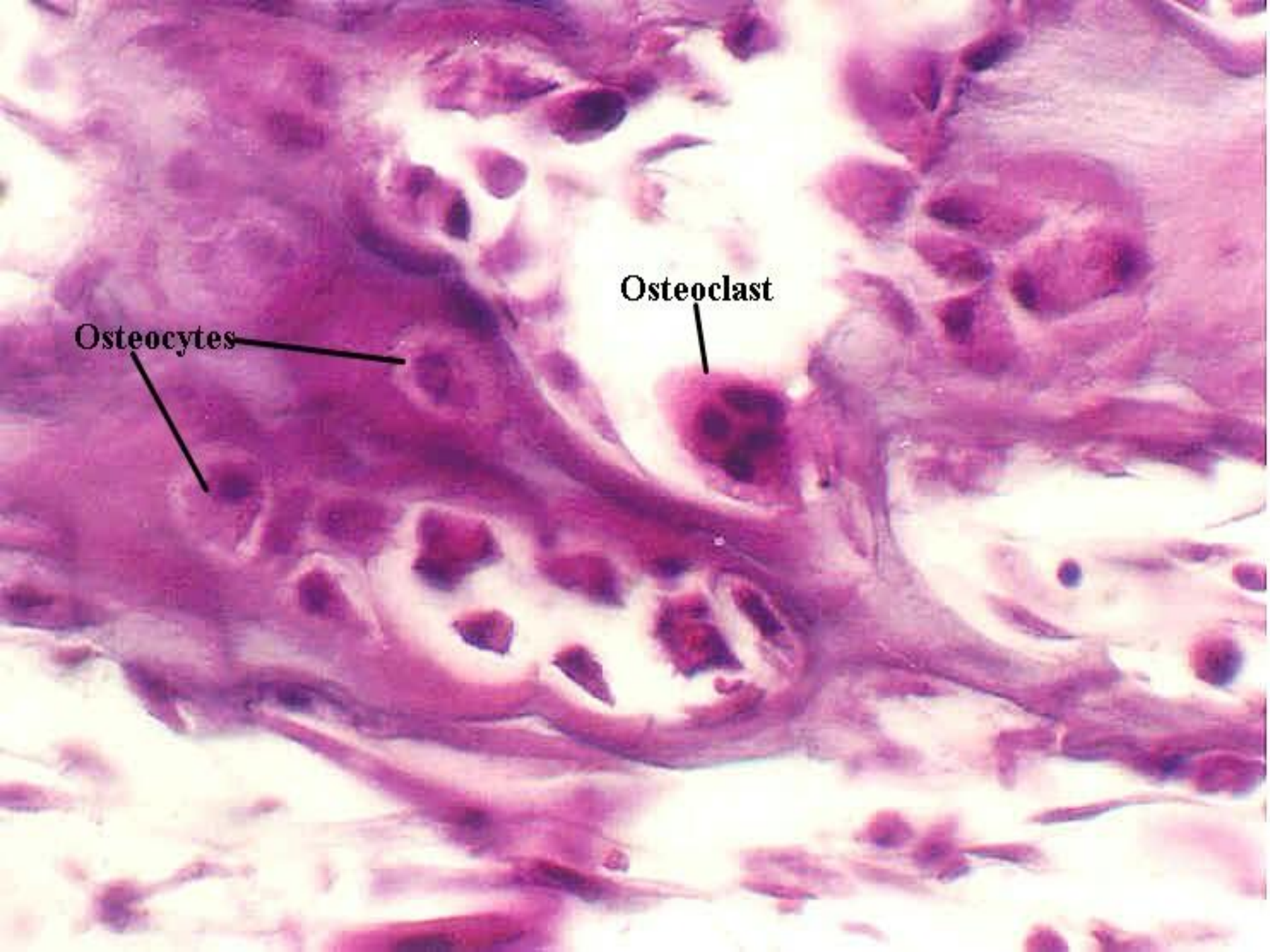

Osteoblasts
osteocytes
calcified
cartilage


osteocytes
osteoblasts


Bone matrix
Osteoblast
In lacuna


Canaliculus
Cell process
Osteocyte
Nucleus
Lacuna
Bone matrix
LM 1000x


Howship's lacuna
Osteoclast
Osteoblasts
Bone
A.
Osteoblasts
Osseous tissue
B.
Osteoclast
Ruffled border
Osseous tissue
C.
A
100 μm
B & C
10 μm


Osteoclast
Osteocytes


resorption
bay
osteoclast
bone

Physiology of ossification

ossification (osteogenesis)

Bone formation.

Starts in either cartilage or CT layers

Involves 2 cell types

Chondroblasts

Which from the cartilage model on which the bone structure is based.

osteoblasts

Which produce bone within the cartilage model.

Two types of ossification:

- Intramembranous
- Endochondral

intramembranous ossification

Takes place within a CT layer during fetal development

ossification center

Is initiated by a blood vessel which penetrates the middle of the CT layer.

The cells in the center transform into osteoblasts, which begin to form a collagenous matrix- non-calcified.

The matrix becomes calcified later forming trabeculae.

trabeculae fuse

Forming the mesh-like structure of spongy bone.

Apposition

The process of laying down bone on pervious deposits of bone; increase bone thickness.

There are layers of osteoblasts on either surface of the CT.

As these osteoblasts produce matrix on the surface of the CT model, the bone increases in thickness.

osteocytes

The osteoblasts become trapped in the growing matrix.

As the matrix becomes calcified these cells become osteocytes

endochondral ossification

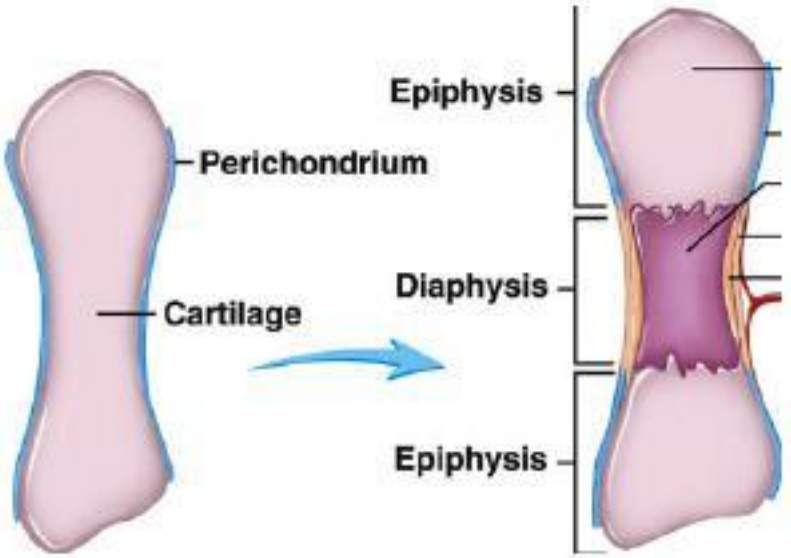
Endo= within; chrondral=cartilage

Bone formation within a cartilage model

Diaphysis **Within the shaft** of the bone

This is where ossification starts.

A blood vessel triggers changes in the surface of cartilage model



hyaline cartilage model

Is covered by a CT layer called the **perichondrium**

Def: "**near cartilage membrane**"

perichondrium to periosteum

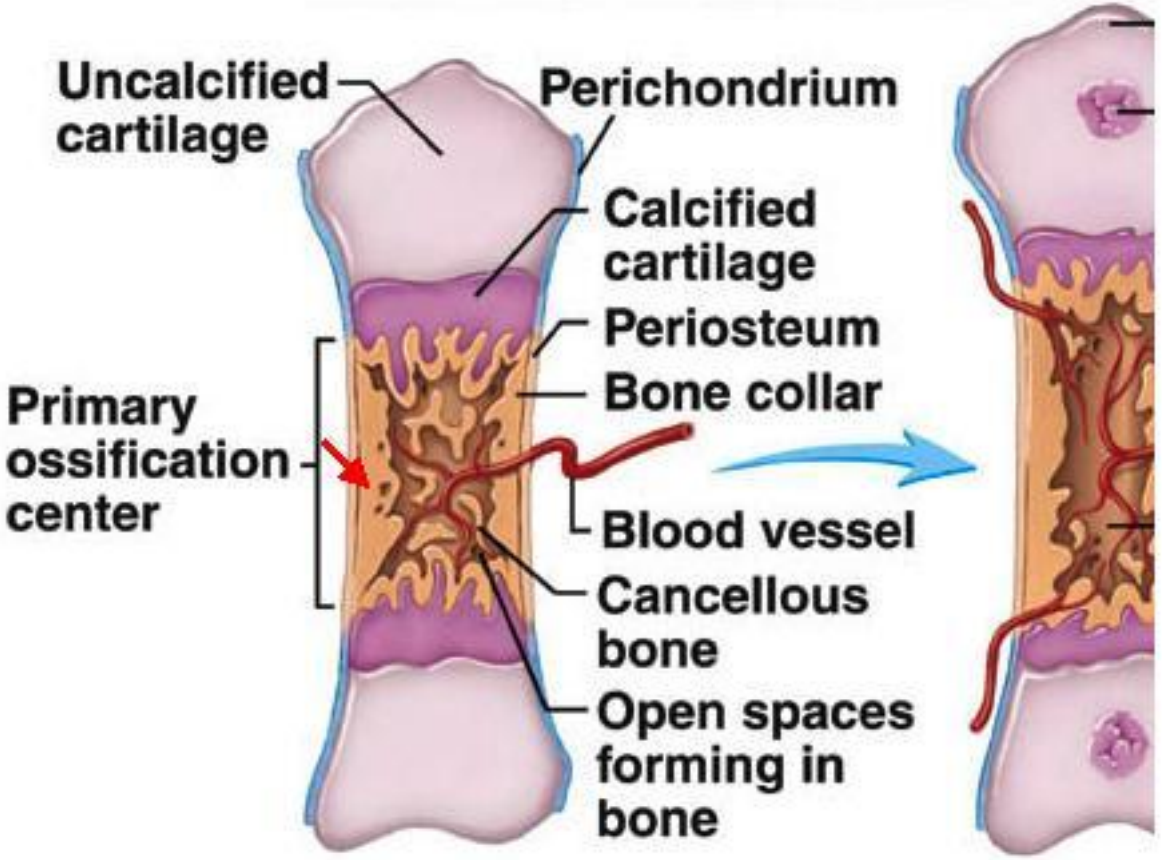
The blood vessels trigger a **conversion** of the perichondrium to a periosteum

This membrane begins to **secrete a bony material** which encircles the middle of the diaphysis.

This is called the ….

subperiosteal collar

A **ring of bone** around the diaphysis made by appositional growth.



1° ossification center

Is found in the **center of the diaphysis**

marrow cavity

Is formed as the **matrix is broken** down by osteoclasts.

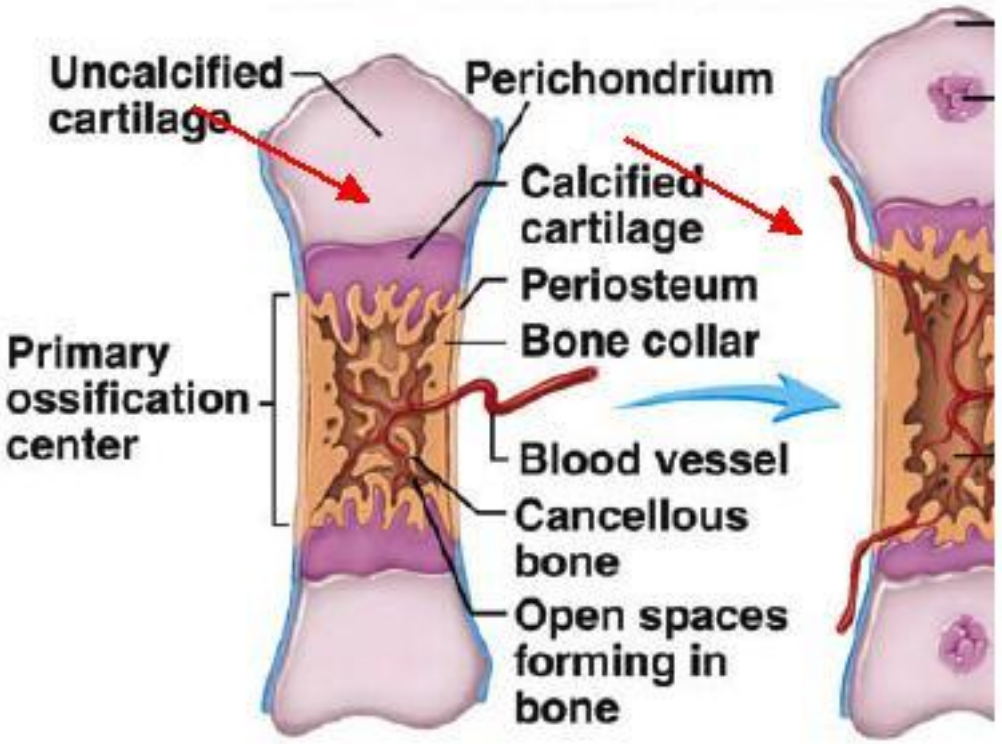
This will eventually fill with yellow marrow.

epiphysis

At **either end of the bone**. Is made of cartilage.

2° ossification center

Same sequence of events as the formation of the ossification center, but occurs within the epiphysis.



spongy bone

Is formed within the epiphysis, rather than a marrow cavity.

The spaces between the trabeculae are filled with **red marrow**.

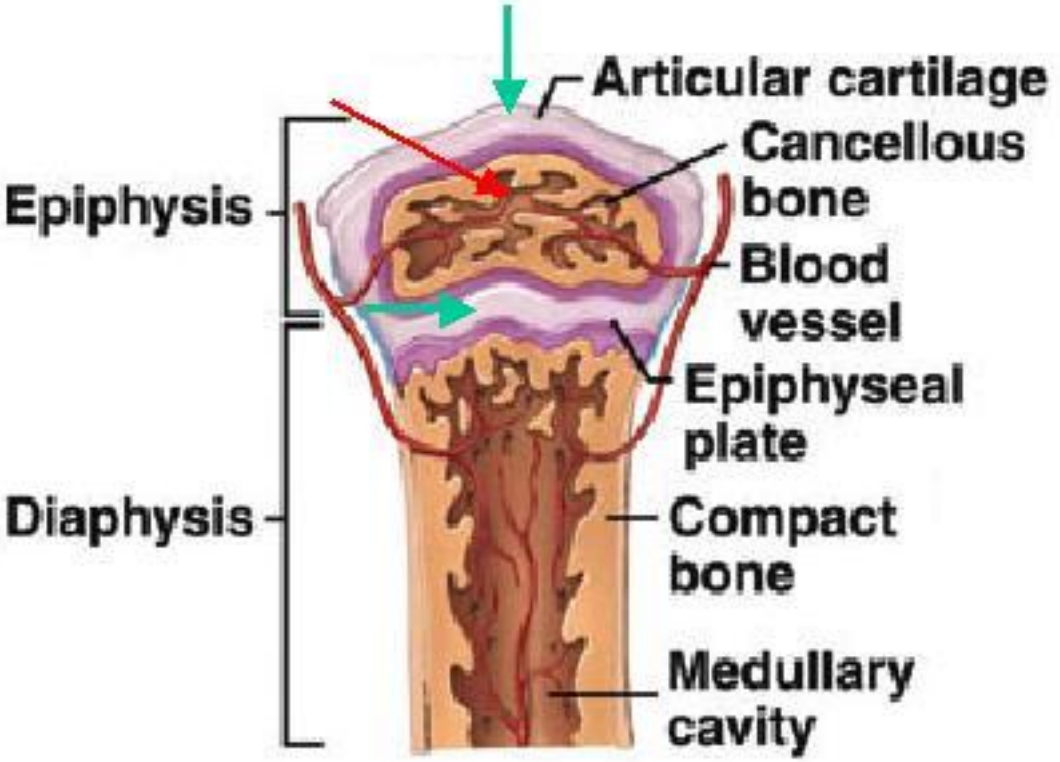
articular cartilage

Covers the distal and proximal **surface of the epiphysis**.

Forms part of the **joint**.

epiphyseal plate

A **plate of cartilage** found between the epiphysis (spongy bone) and the diaphysis.



4 zones of the epiphyseal plate

1. zone of reserve (resting) cartilage

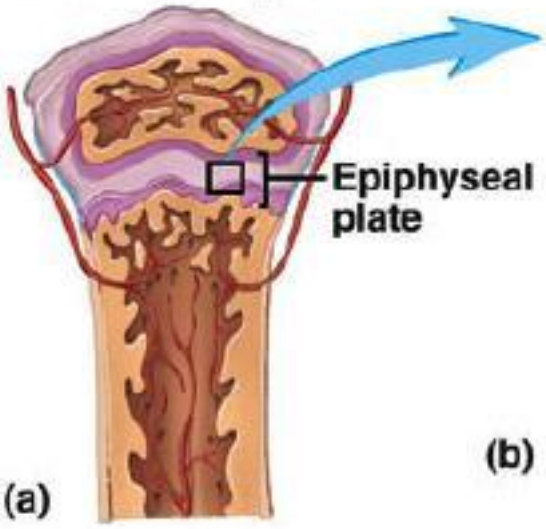
Next to the epiphysis; consists of hyaline cartilage

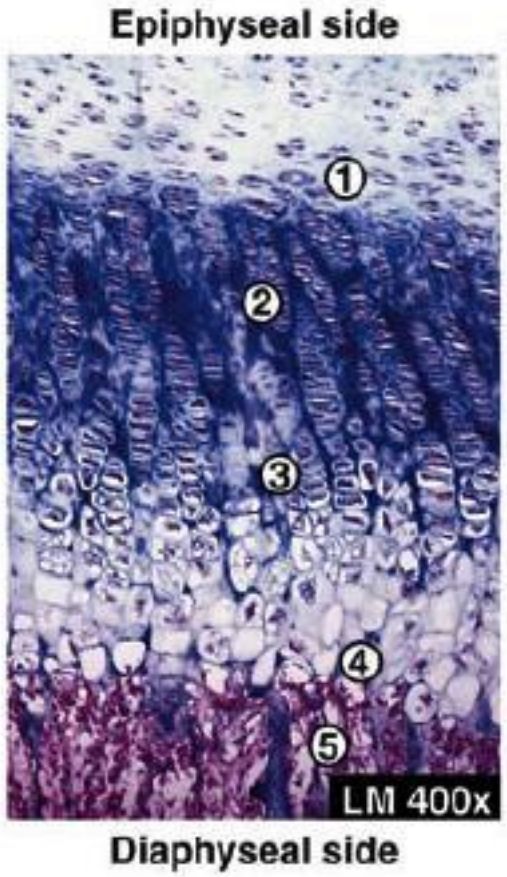
Anchor

Serves to anchor the plate to the epiphysis

Nutrients

Also provides nutrients and **cartilage cells** to the other zones

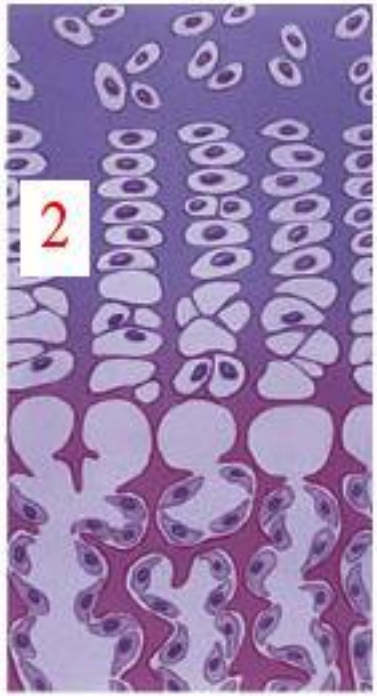


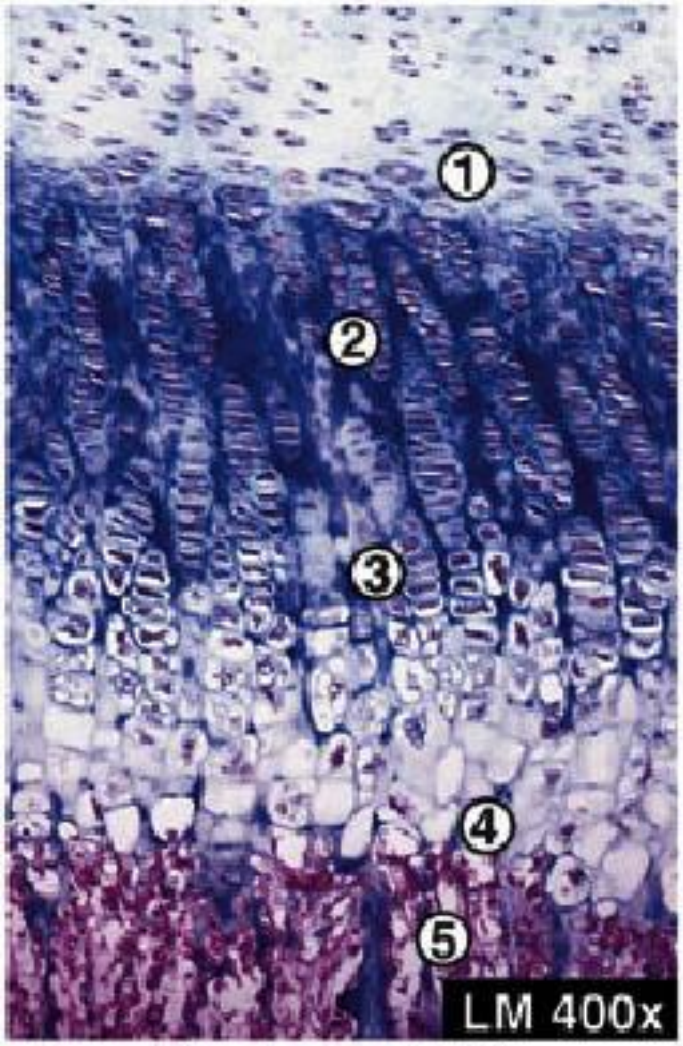


2. zone of proliferating cartilage

replacement

The cells supplied by the first zone **multiply** here.
The cartilage proliferates; this zone **increases in thickness**.
Plate growth occurs here.





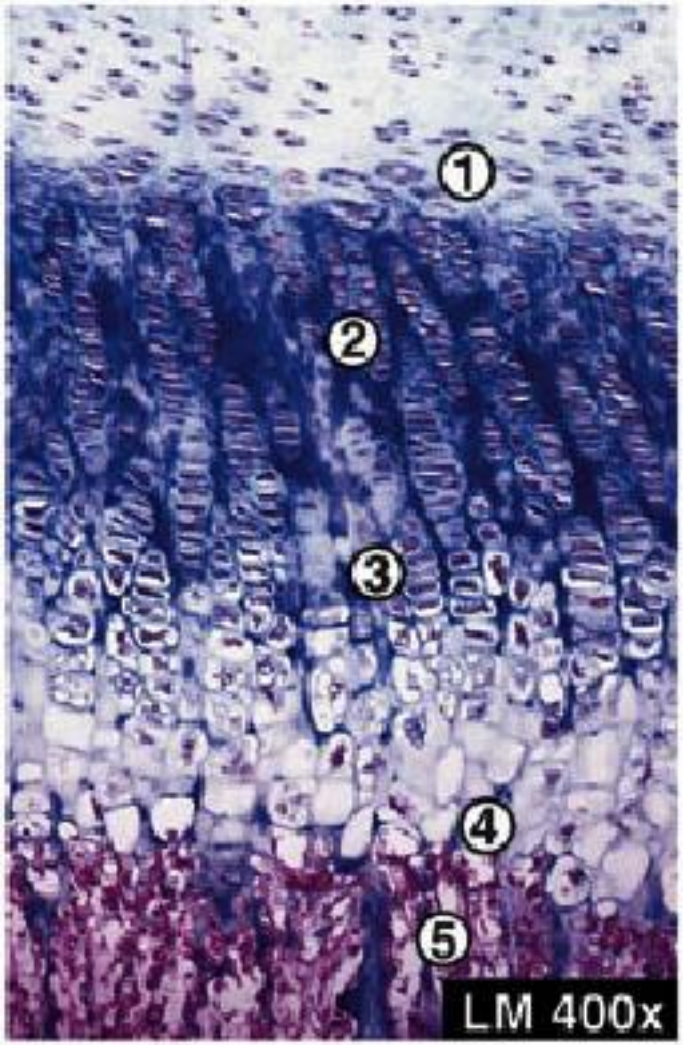
3. Zone of hypertrophy

maturation

The cells (still cartilage) **increase in size** and reach **maturity**.

Expansion

Growth continues here.



4. Zone of calcified matrix

As the cartilage cells in the previous zone mature, they convert the matrix into a **calcified matrix** (not bone)

Dead cells

The **chondrocytes die**

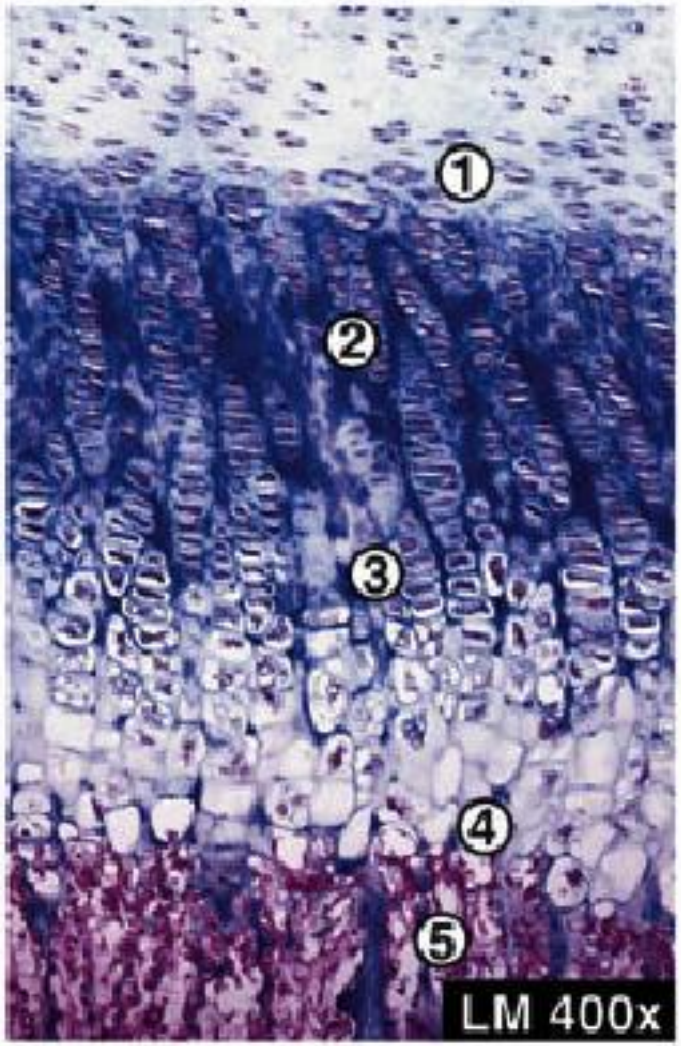
Calcified

The matrix starts eroding; breaks down and forms pockets and spaces, which merge to form the **marrow cavity (5)**

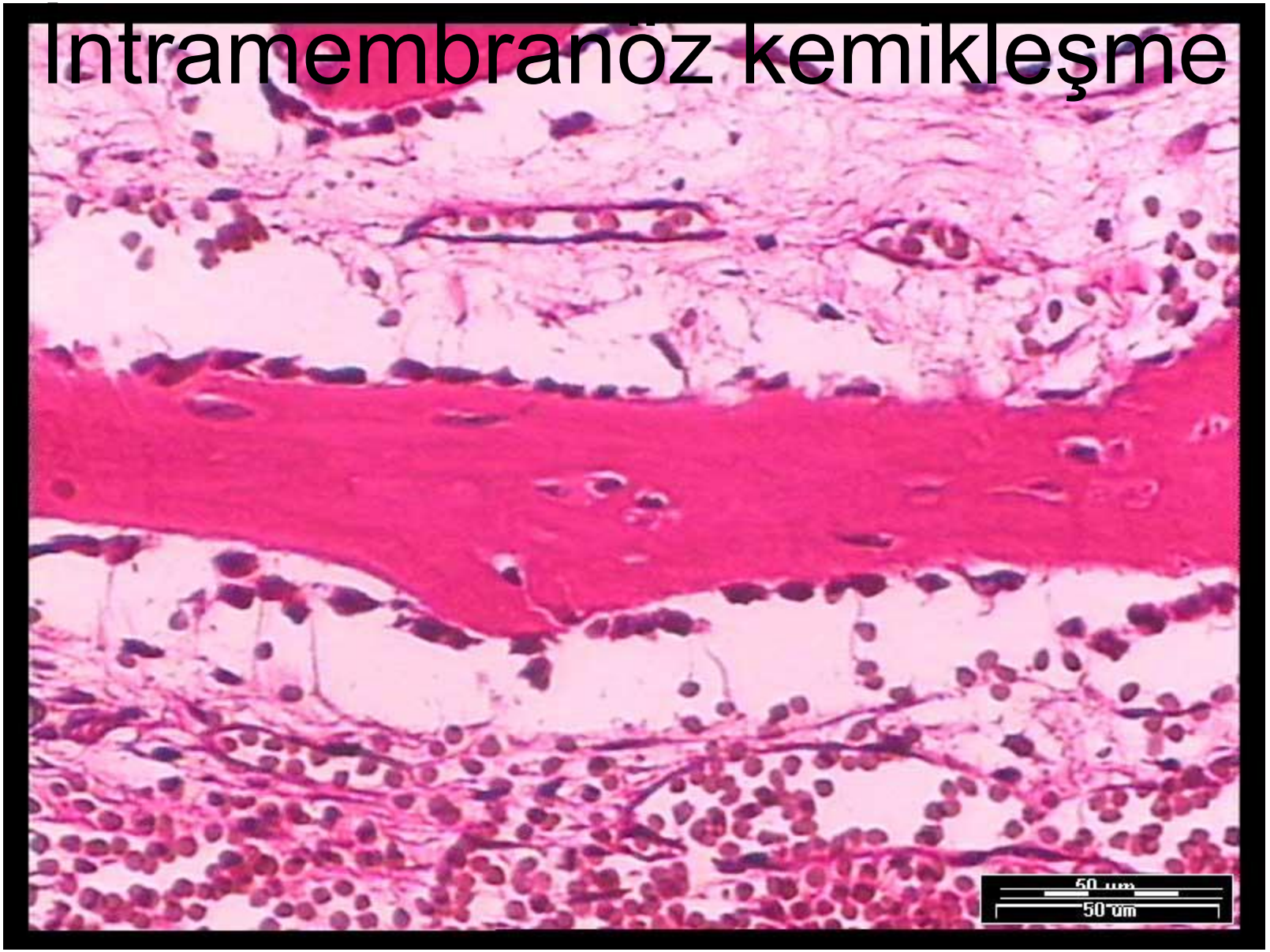
Osteoclasts

Cause the martix to erode.

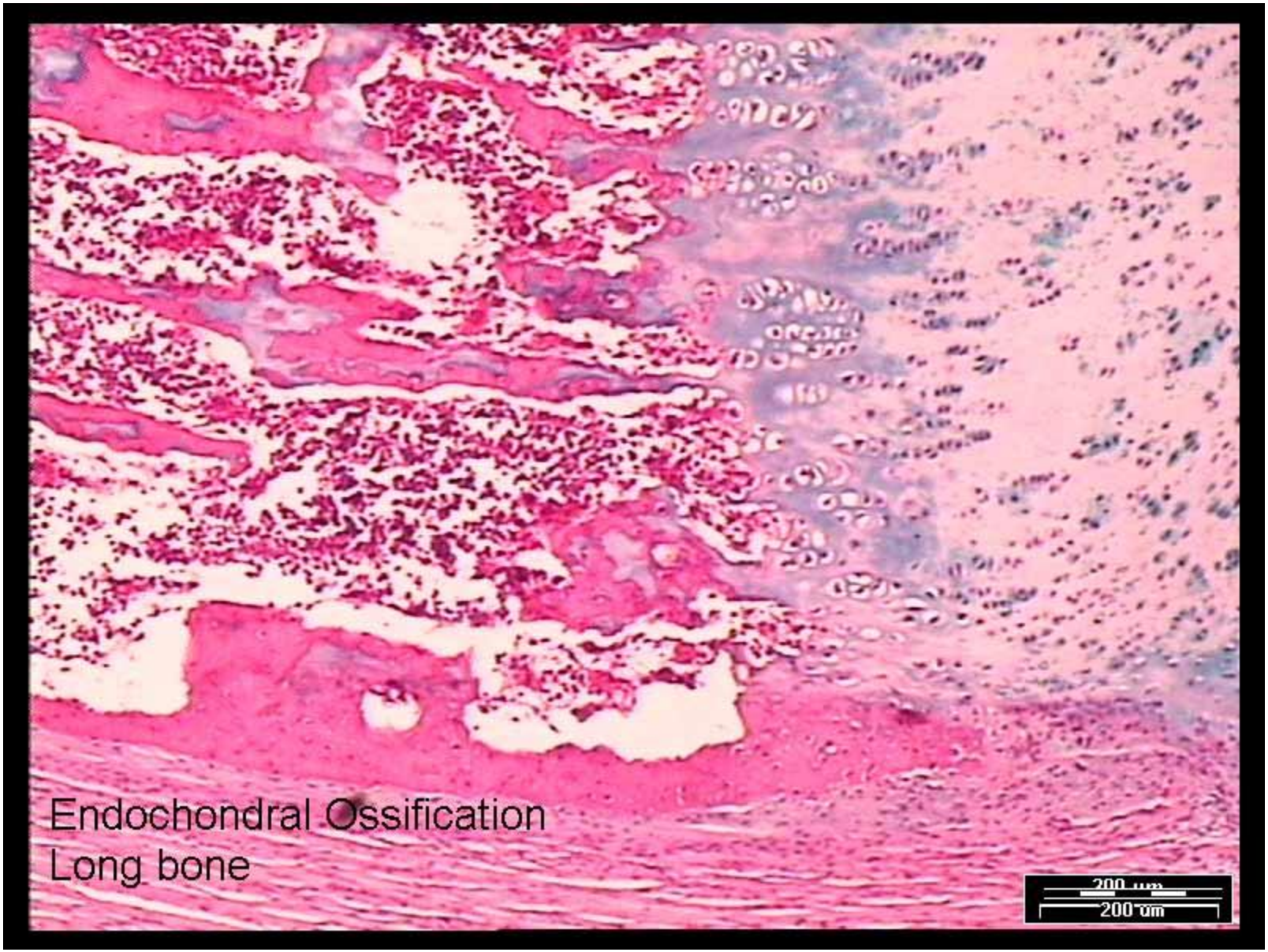
The cavity fills with **yellow marrow**

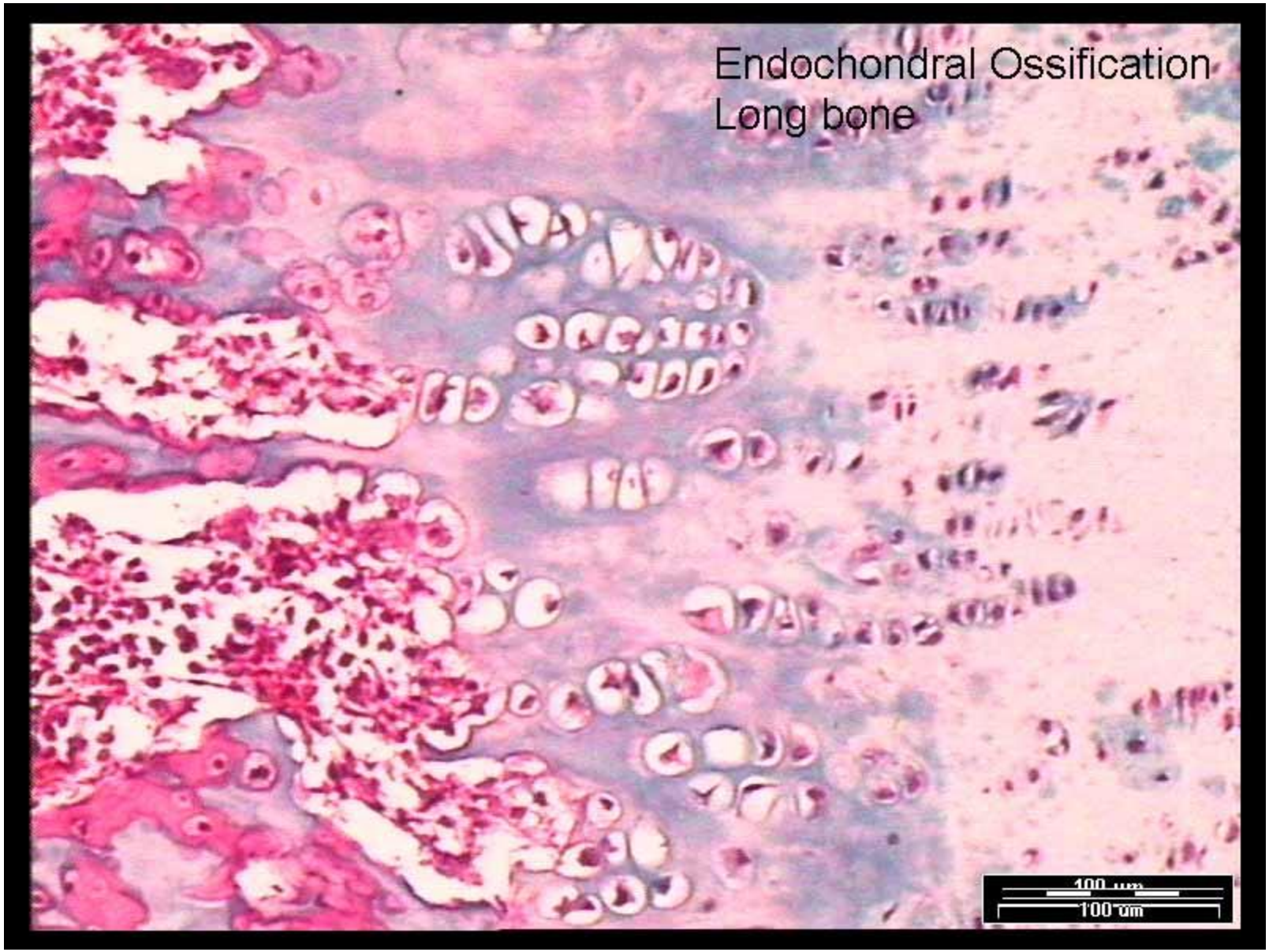


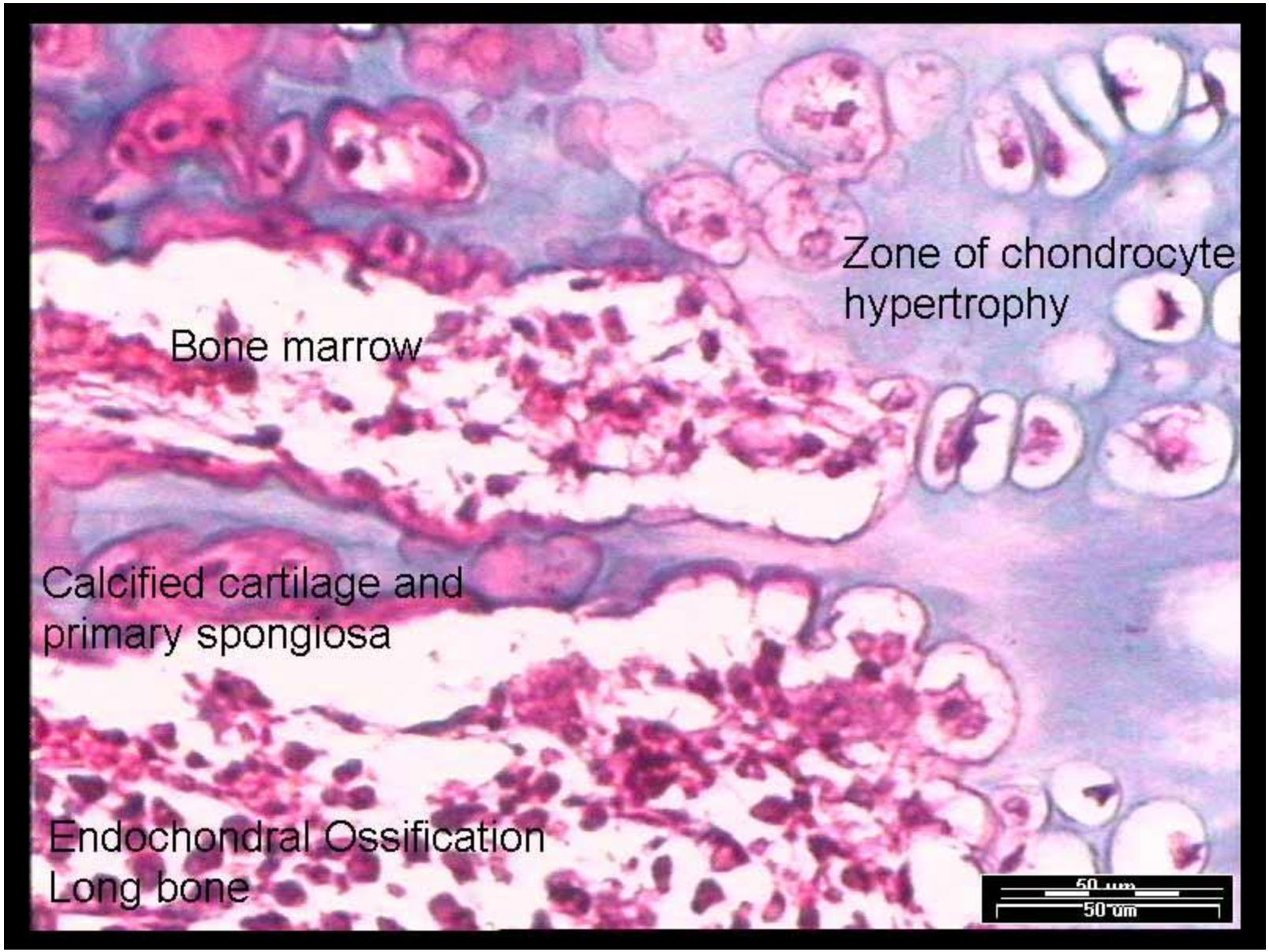
Intramembranöz kemikleşme

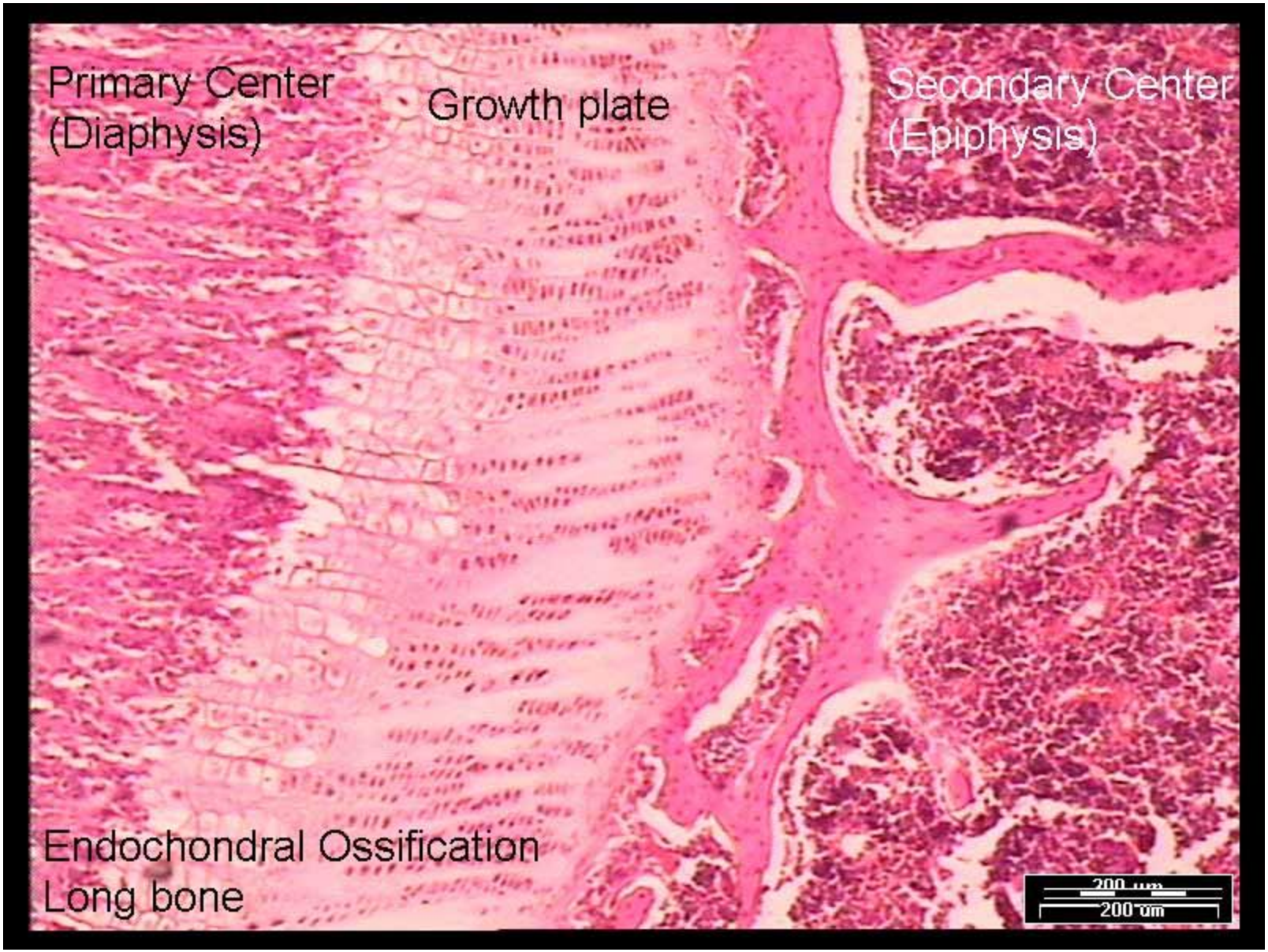



Intramembranous Ossification
Calvarium, embryo
200 um
200 um

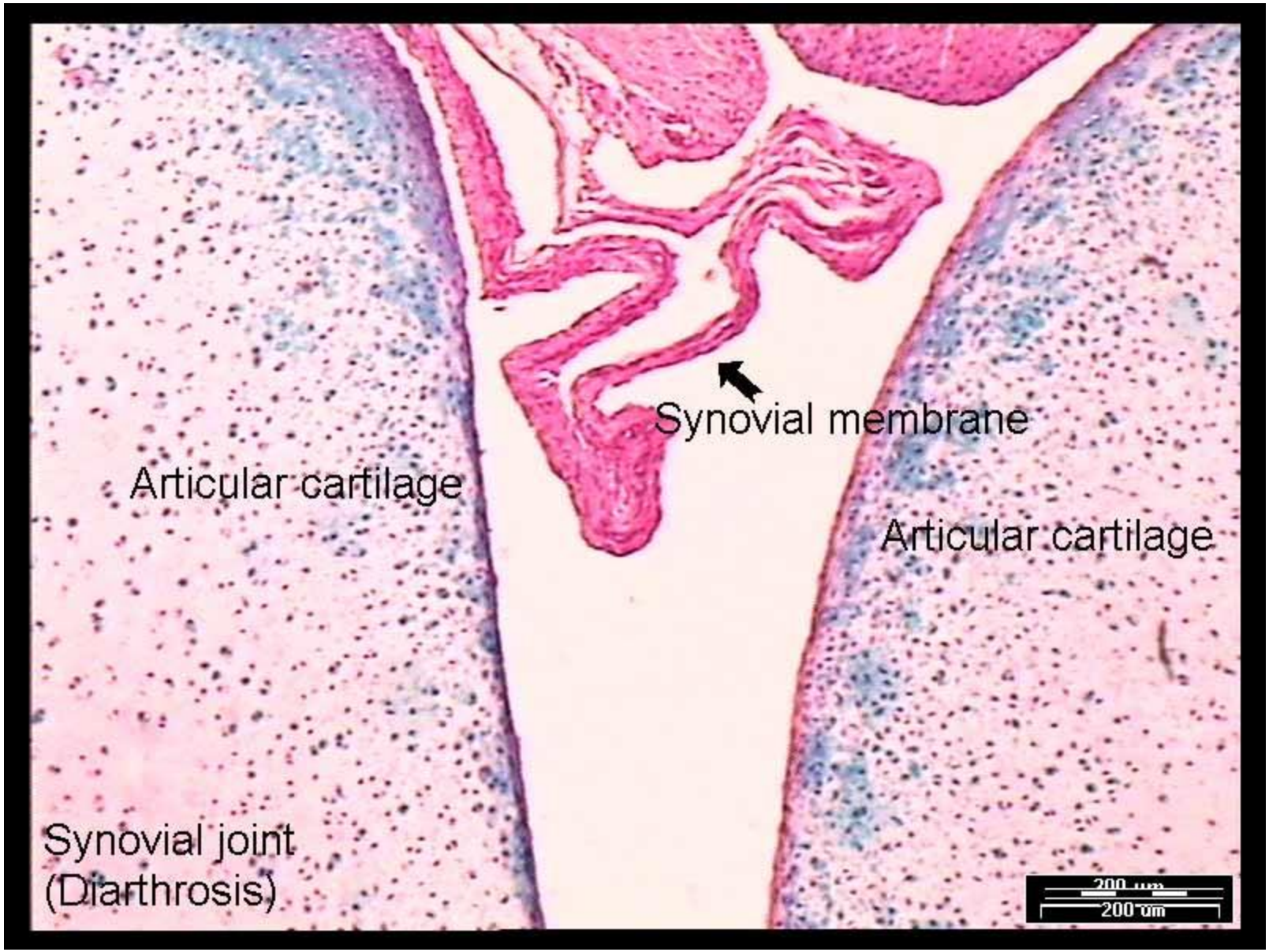

Endochondral Ossification
Long bone
200 um
200 um

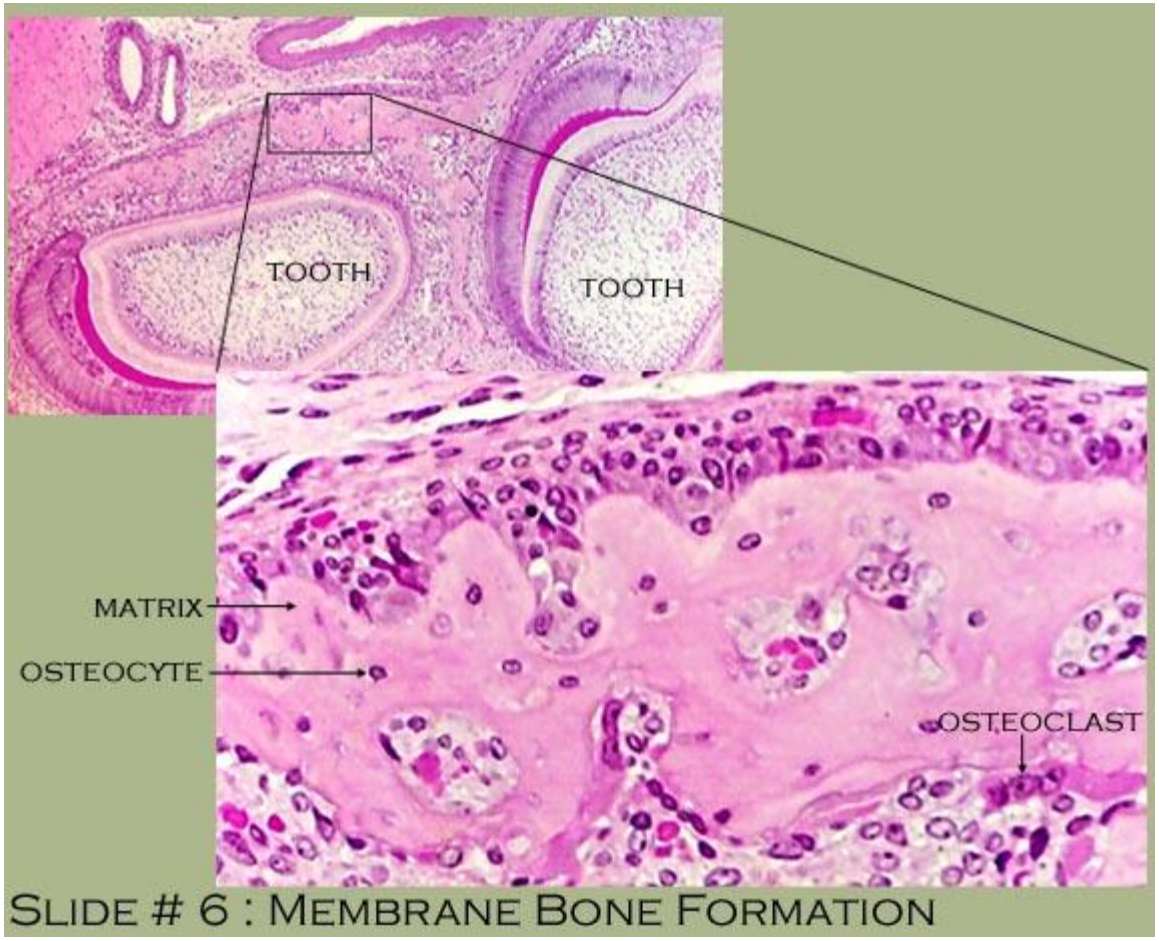

Endochondral Ossification
Long bone
100 um


Zone of chondrocyte hypertrophy
Bone marrow
Calcified cartilage and primary spongiosa
Endochondral Ossification Long bone
50 um
50 um


Primary Center
(Diaphysis)
Growth plate
Secondary Center
(Epiphysis)
Endochondral Ossification
Long bone
200 µm
200 µm


Growth Plate
Endochondral Ossification
100 um
100 um


Synovial membrane
Articular cartilage
Articular cartilage
Synovial joint
(Diarthrosis)
200 µm
200 um



SLIDE # 6 : MEMBRANE BONE FORMATION

KAYNAK LİSTESİ

1. Veteriner Özel Histoloji (Ed. Aytekin Özer, 2008)
2. Temel Histoloji (Ed. Aytekin Özer, 2011)
3. Genel Histoloji (Mahmut Sağlam, R.Nuri Aştı, Aytekin Özer 2001)
4. Özel Histoloji (Attila Tanyolaç 1999)
5. Histoloji (Ercan Artan 1988)
6. Textbook of Histology (Leeson Leeson Paparo 1981)
7. Basic Histology (L.C. Jungueira, J.Carneiro 1983)
8. Textbook of Veterinary Histology (Dellman Brown 1983)
9. Basic Histology (Douglas F. Paulsen 1989)
10. Moleculer Biology of the Cell (Bruce Alberts, Denis Brg, Julian Lewis, Martin Reff, Keith Roberts, James D. Welson 1989)
11. Histology and Cell Biology (Kurt E. Johnson 1990
12. Wheater's Interactive Histology (CD-ROM) (Wheater, P. R.1995)
13. A Brief Atlas of Histology (Thomas leeson, C. Roland Leeson 1979)
14. Oral Histology: Development, Structure and Function (Ten Kate, Arnold Richard 1980)
15. Bloom and Fawcett a Textbook of Histology (Fawcett, Don W 1986)