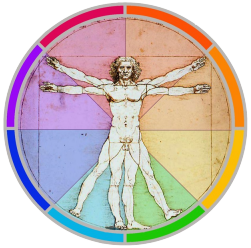
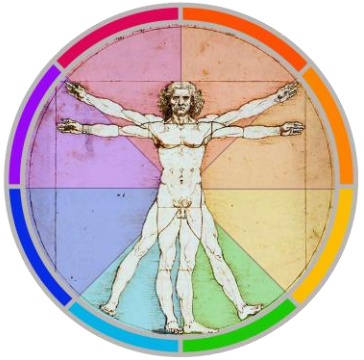
HUBS191 Lecture Material

This pre-lecture material is to help you prepare for the lecture and to assist your note-taking within the lecture, it is NOT a substitute for the lecture !



Please note that although every effort is made to ensure this pre-lecture material corresponds to the live-lecture there may be differences / additions.

Human Body Systems (HUBS) 191



Bone Tissue and its Microscopic Structure

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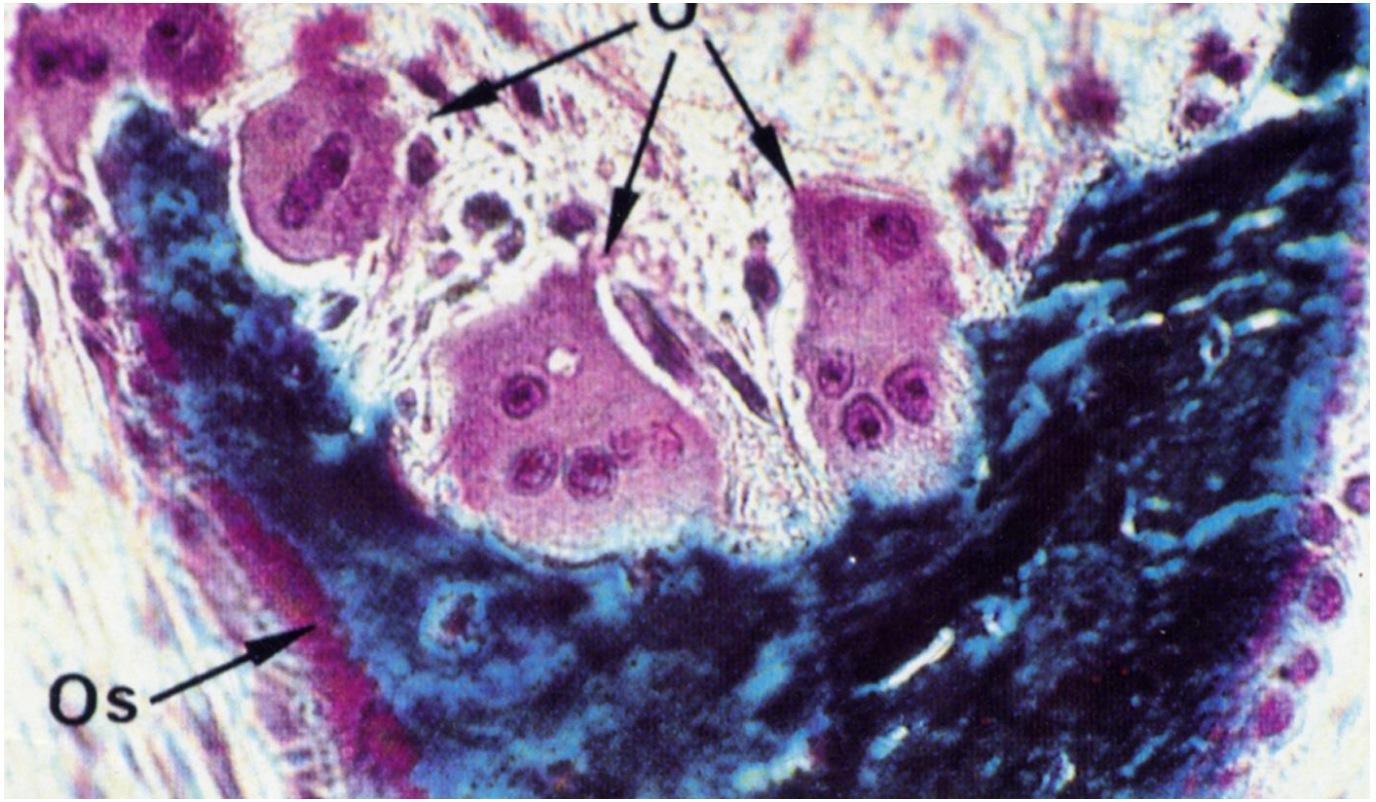
Objectives

- By the end of this lecture you should be able to:
- Describe the microscopic structure of bones
- Describe how bone maintains homeostasis
- Describe a bone pathology relating to lack of homeostasis (osteoporosis)

Bone is a living tissue!

- Bone has cells as well as a calcified extra-cellular matrix



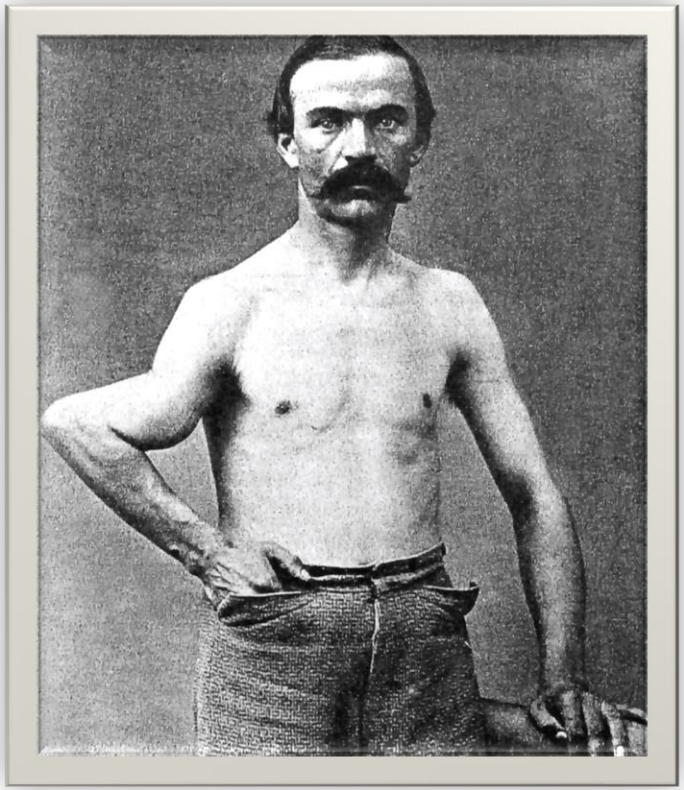
Wheater *et al*, Wheater's *Functional Histology*, 2006

Bone changes depending on how you use your body!

- Bone cells respond to external forces
- Bone remodels and can change shape through your life to reflect how you are using your skeleton!

Bone can repair itself

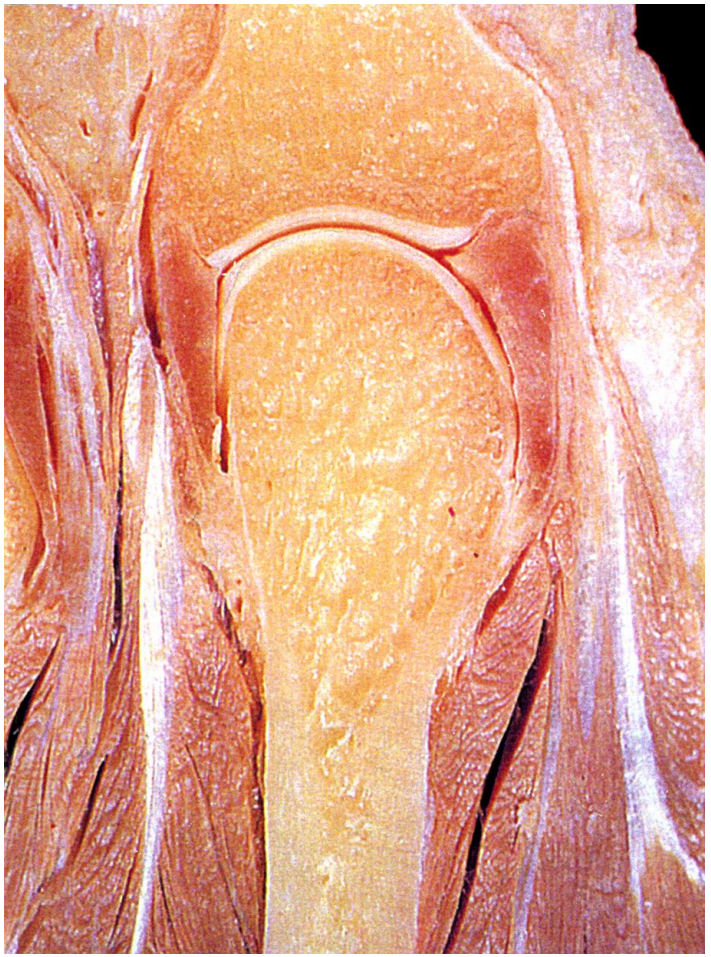
- Bone cells also respond to trauma to unite broken parts



Anatomy Resource Collection, University of Otago, 2020

Bone tissue composition

- Connective tissue
  - Supports other tissues/organs
  - Maintains form
- Bone has two extracellular components:
  - Organic
  - Inorganic



Anatomy Teaching Resources, University of Otago, 2018

Extracellular components – the organic bit

33% of bone ECM is organic

- **Collagen** (protein)
- Ground substance (proteoglycans)
- Function = **resists tension**

Saladin, *Anatomy & Physiology*, 3rd Edn, 2004

- This fibula with its collagen removed is brittle/breaks easily

Extracellular components – the inorganic bit

67% of bone ECM is inorganic

- Hydroxyapatite + other Ca minerals (**mineral salts**)

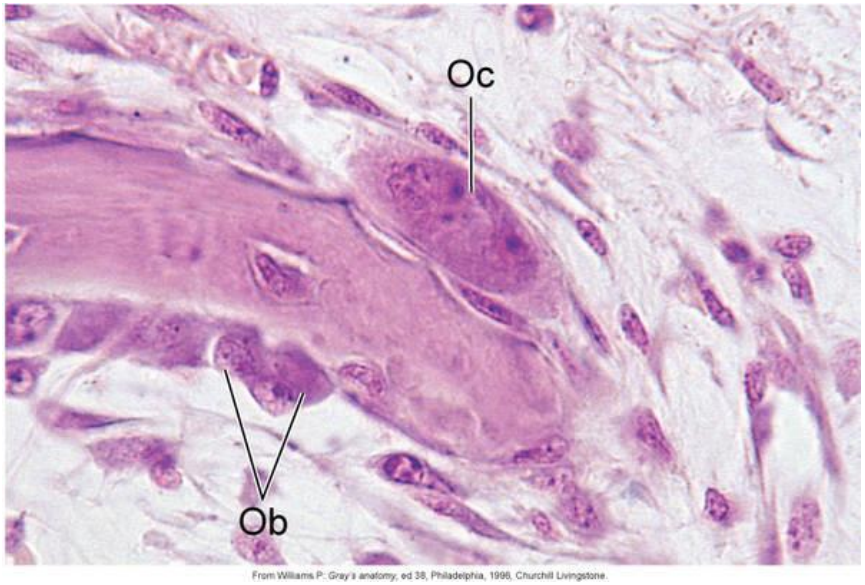
Mineral component makes bone hard & resistant to compression.

- This bone has had its inorganic components removed making it too flexible!

Martini *et al*, *Visual Anatomy & Physiology*, 3rd Edn, 2018, p.259

The cellular component of bone

- Makes up just 2% of bone by weight
- Four types of cells
  - Osteogenic cells
  - Osteoblasts
  - Osteocytes
    - Mature bone cells
  - Osteoclasts

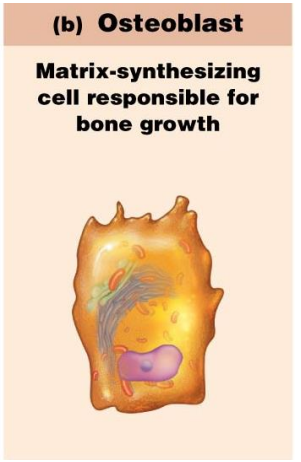


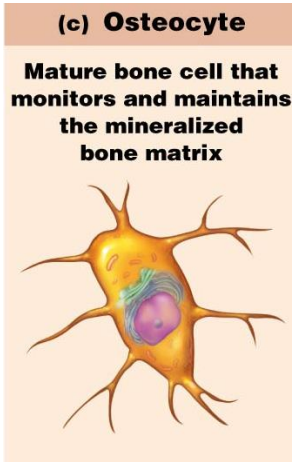
From Williams P: Gray's anatomy, ed 38, Philadelphia, 1996, Churchill Livingstone.

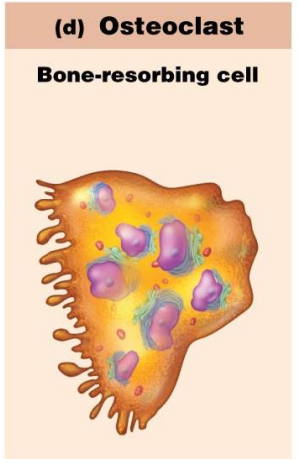
- Together these cells maintain bone homeostasis
  - Balance of bone destruction and formation that means amount of bone stays the same

What do bone cells do?

- Osteogenic cells
  - Stem cells that produce osteoblasts
- Osteoblasts
  - MAKERS - Produce new bone matrix
- Osteocytes
  - MAINTAINERS - Recycle protein and minerals from matrix
- Osteoclasts
  - DESTROYERS - remove bone matrix

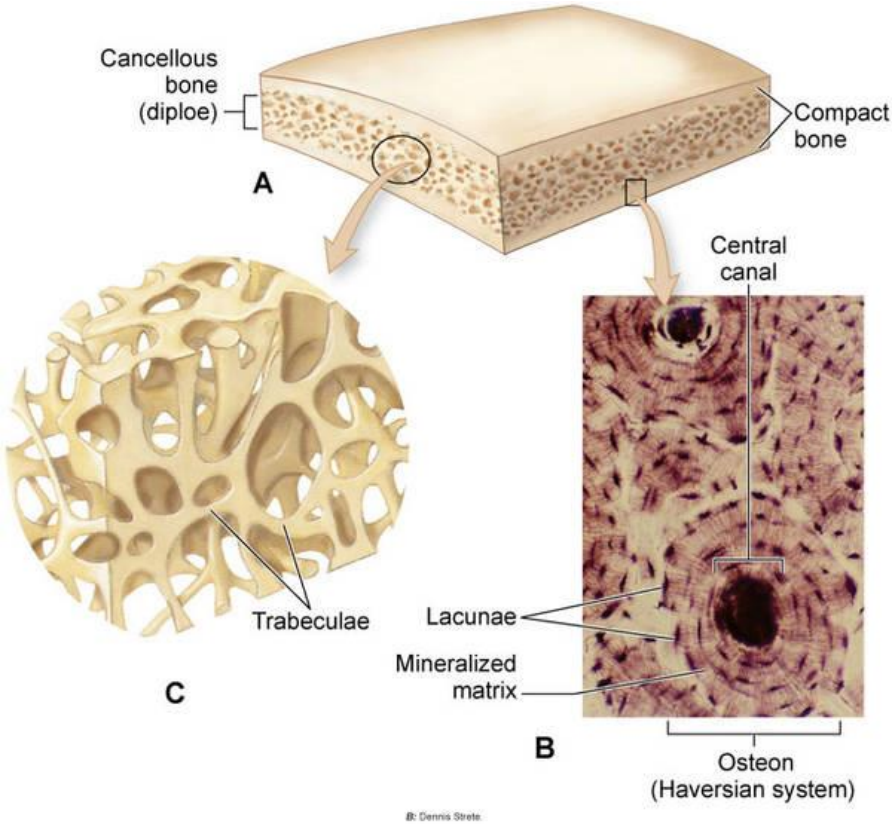






Gross structure of bones

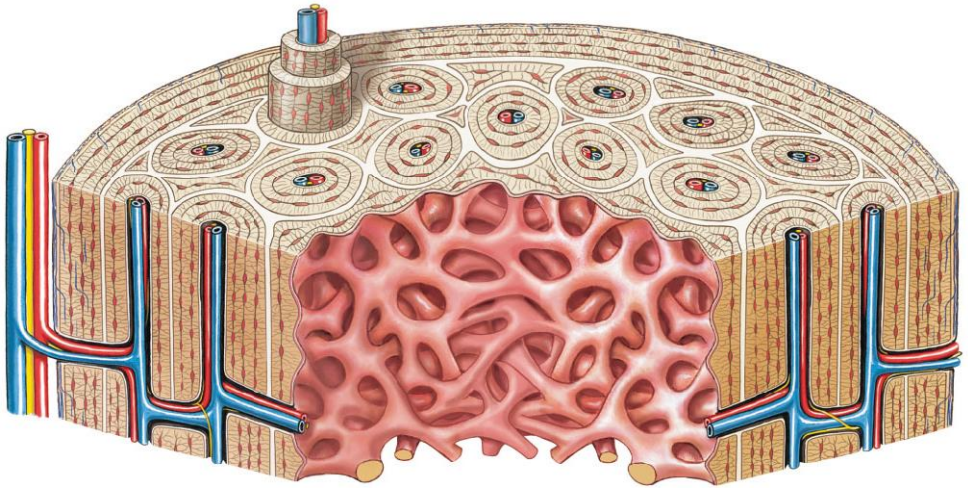
- *Reminder:* there are two types of bone tissue
  - Compact
  - Cancellous
- Made of the same things but structured differently
  - Osteon structure (compact)
  - Trabecular structure (cancellous)



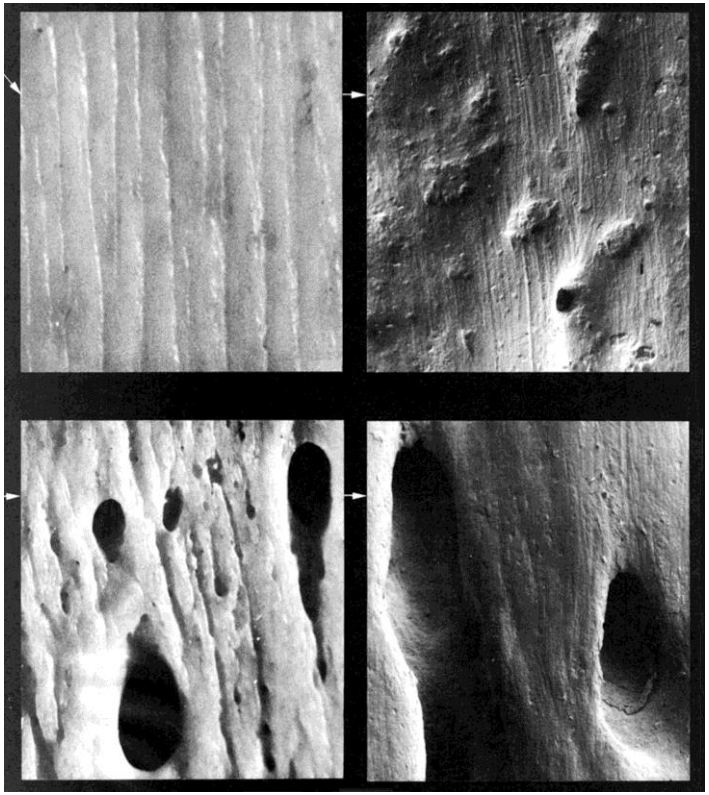
Patton & Thibodeau, *Anatomy & Physiology*, 7th Edn, 2010

Compact bone

- Macroscopically:
  - Outer surfaces seem dense and impenetrable (periosteum)
  - Foramina/holes for blood supply
- Microscopically:
  - Made up of circumferential lamellae and units called **osteons**



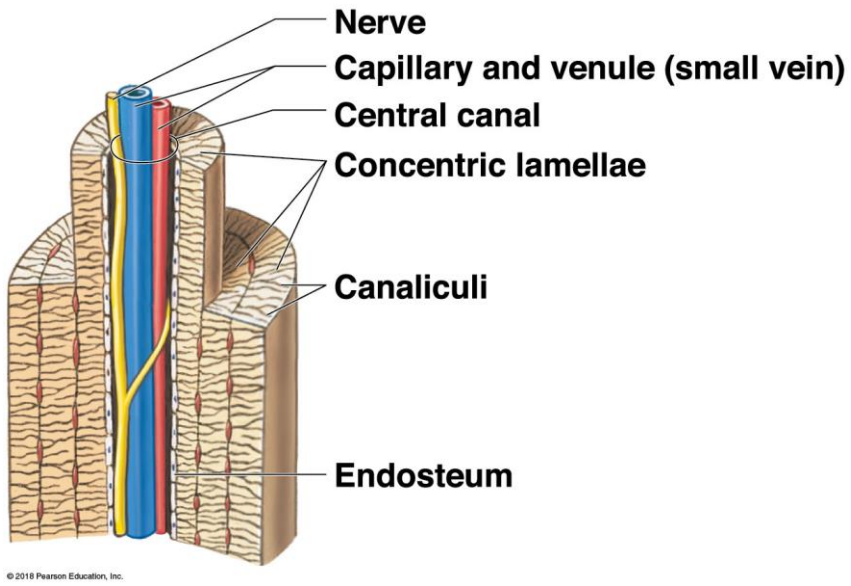
Martini *et al*, *Visual Anatomy & Physiology*, 3rd Edn, 2018, p.260

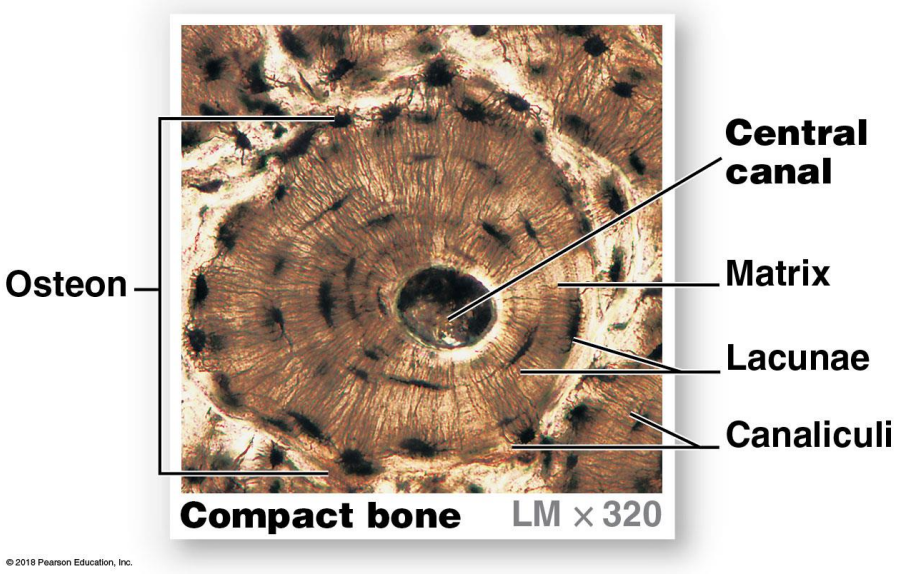


Surface of a femur (top = midshaft, bottom = distal). Anatomy Resource Collection, University of Otago, 2018

Osteons

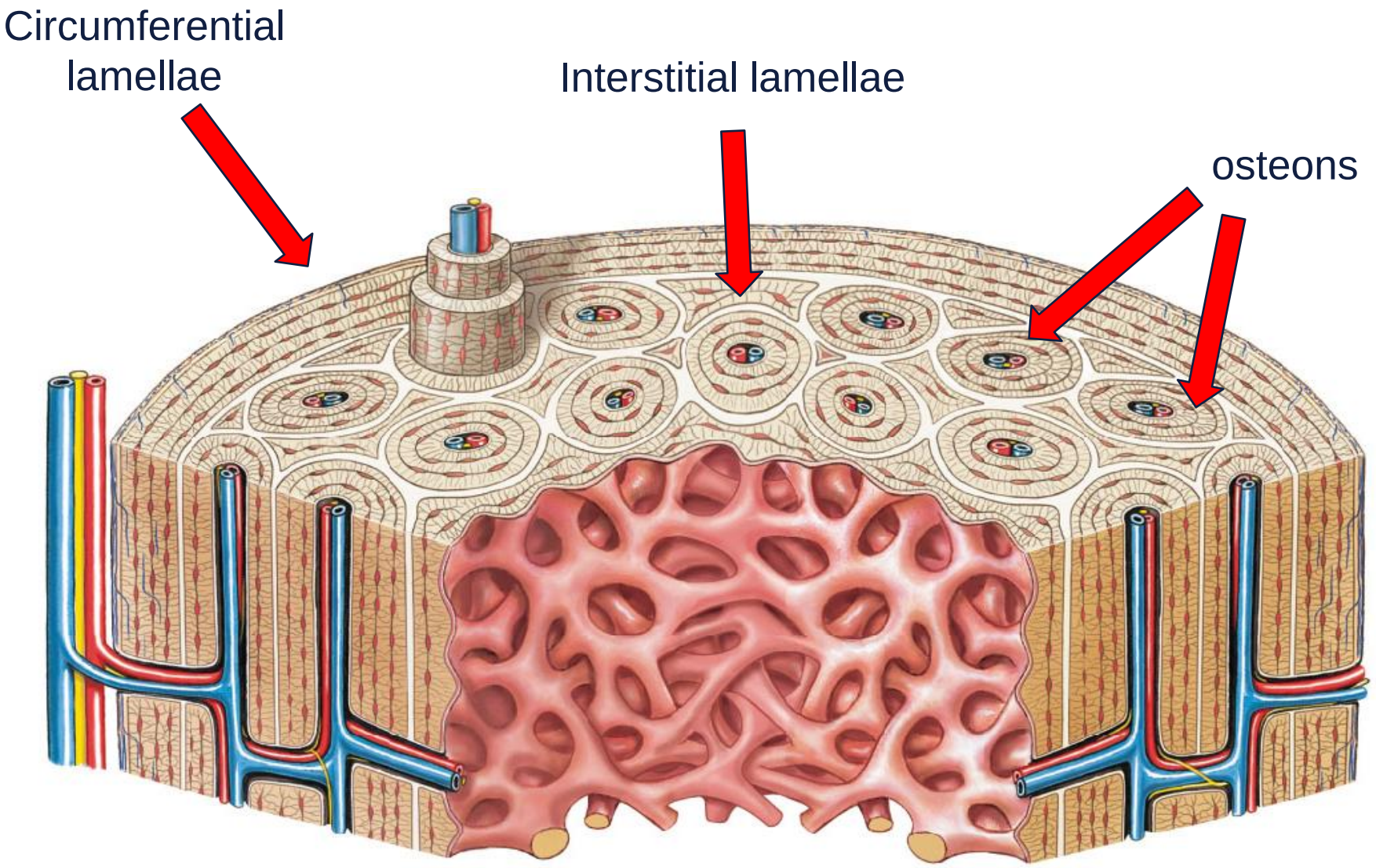
- **Osteon**= longitudinal (lengthwise) unit within compact bone.
  - provide a pathway for nutrients to get to cells in the ECM
- **Central canal** - contains blood vessel and nerves
- **Lamellae -** a series of cylinders formed of ECM around the central canal.
  - Form the shape of the osteon
  - Collagen fibres within lamellae resist forces
- **Lacunae**= 'lakes' for osteocytes
- **Canaliculi** = channels for nutrients to travel to osteocytes through the ECM





Martini *et al*, *Visual Anatomy & Physiology*, 3rd Edn, 2018, p.260

Zooming out a bit…



Martini *et al*, *Visual Anatomy & Physiology*, 3rd Edn, 2018, p.260

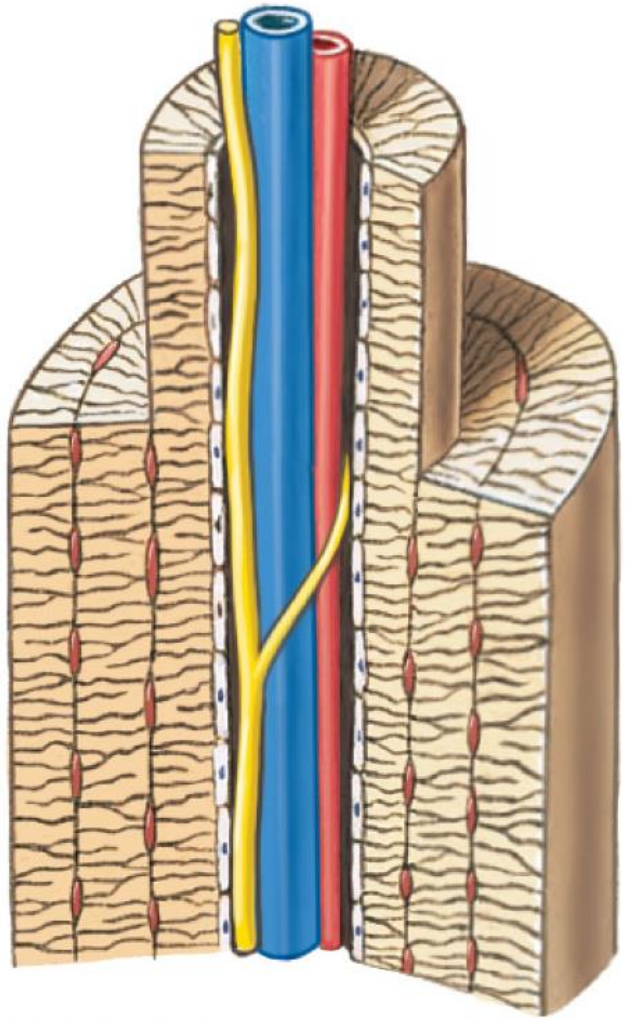
Osteon

Central canal

Lamellae

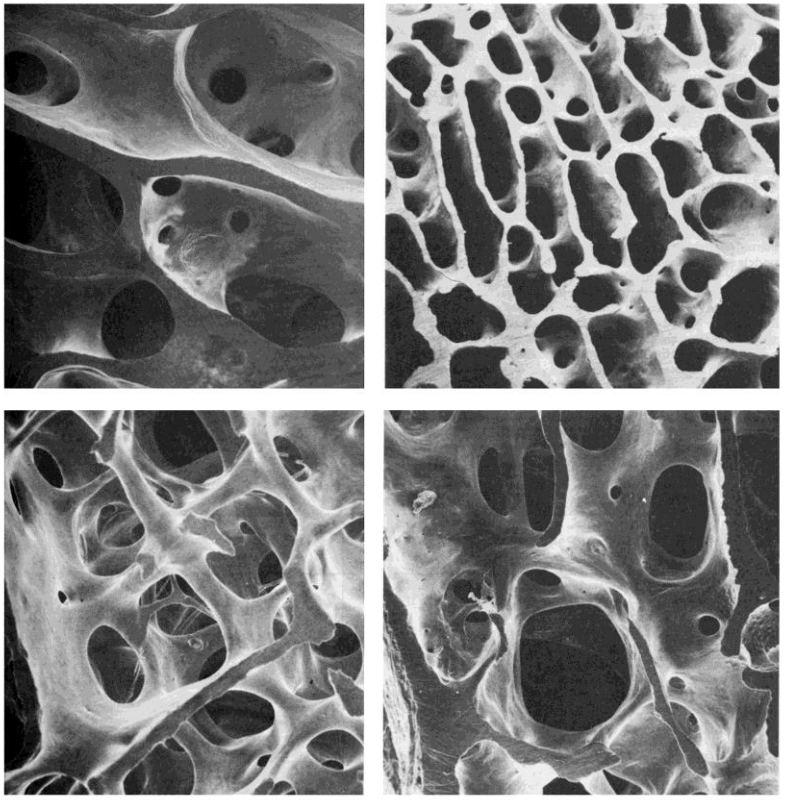
Lacunae

Canaliculi

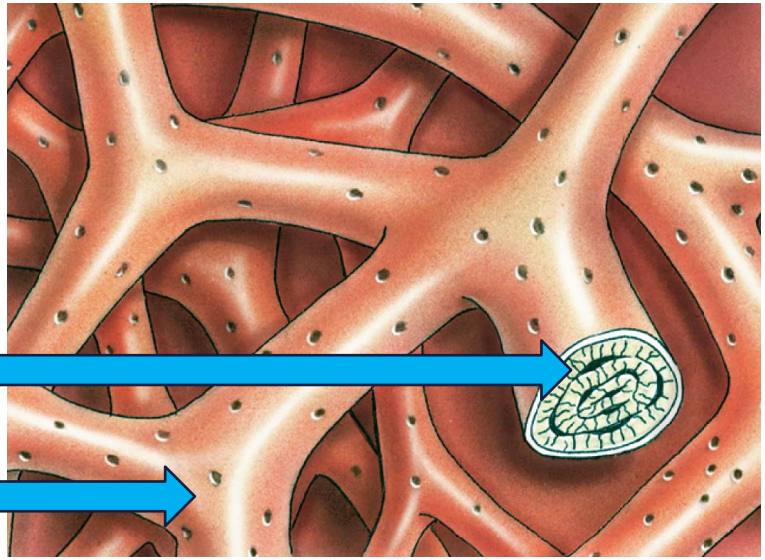


Cancellous bone

- Trabeculae
  - Struts of lamella bone
- Marrow fills the cavities between trabeculae
- Osteocytes housed in lacuna in between lamellae/on surface.



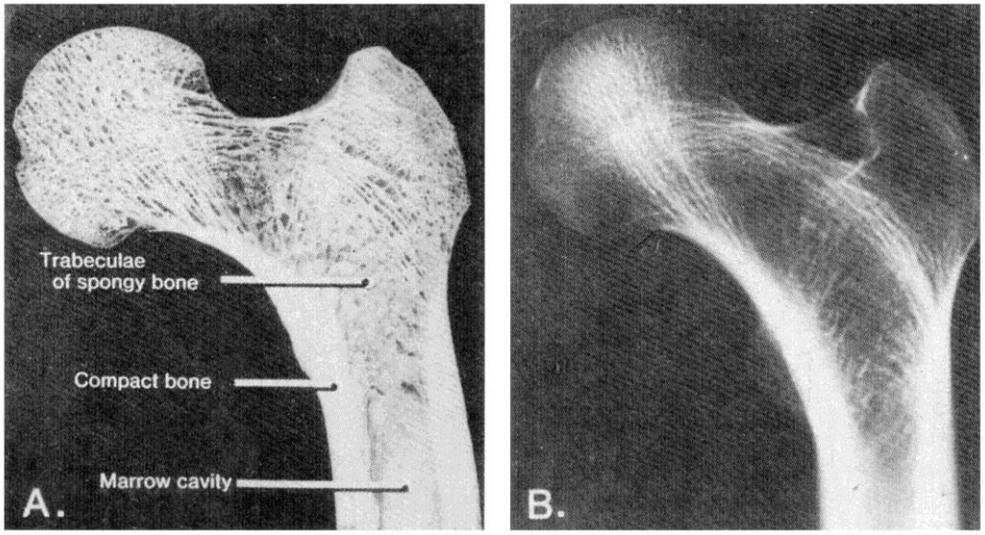
Anatomy Resource Collection, University of Otago, 2018



Martini *et al, Visual Anatomy & Physiology*, 3rd Edn, 2018, p.261

Why trabecular bone?

- Organisation of trabeculae resists force from multiple directions
- Directs force from body weight in single direction down shaft
- Spreads force distally



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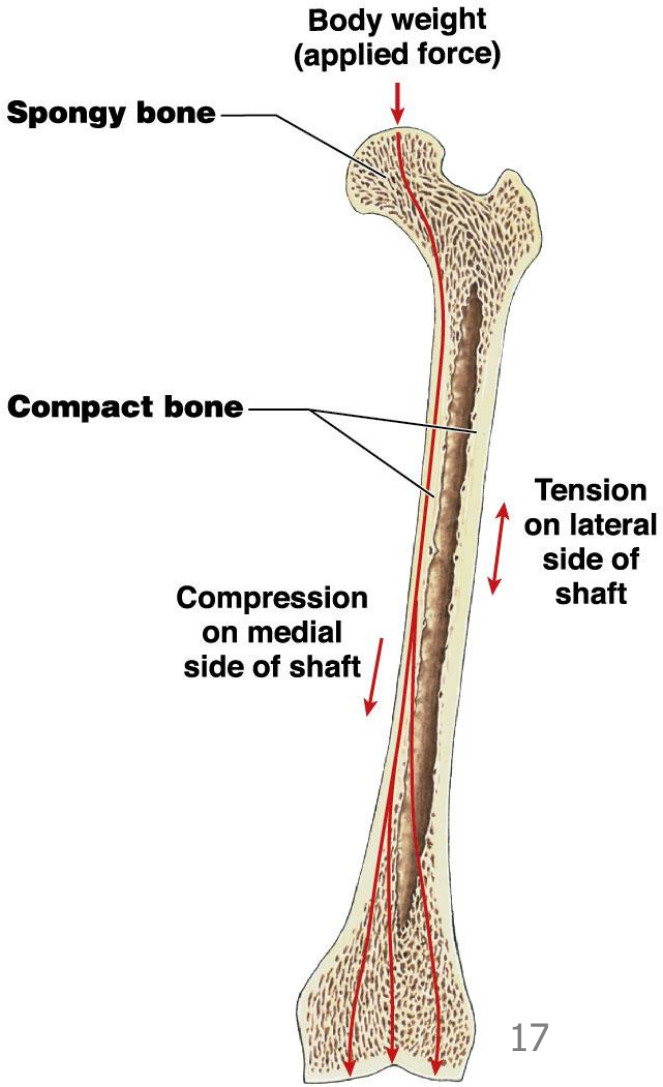
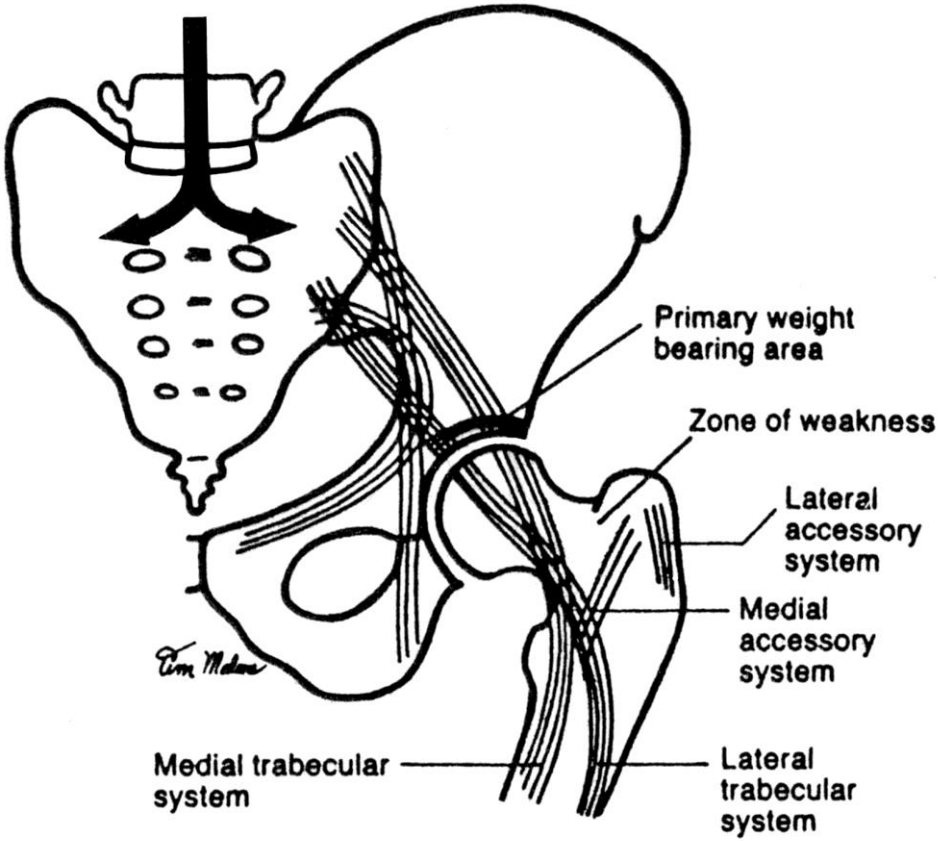


Martini *et al, Visual Anatomy & Physiology*, 3rd Edn, 2018, p.256

Weight transmission upper – lower body

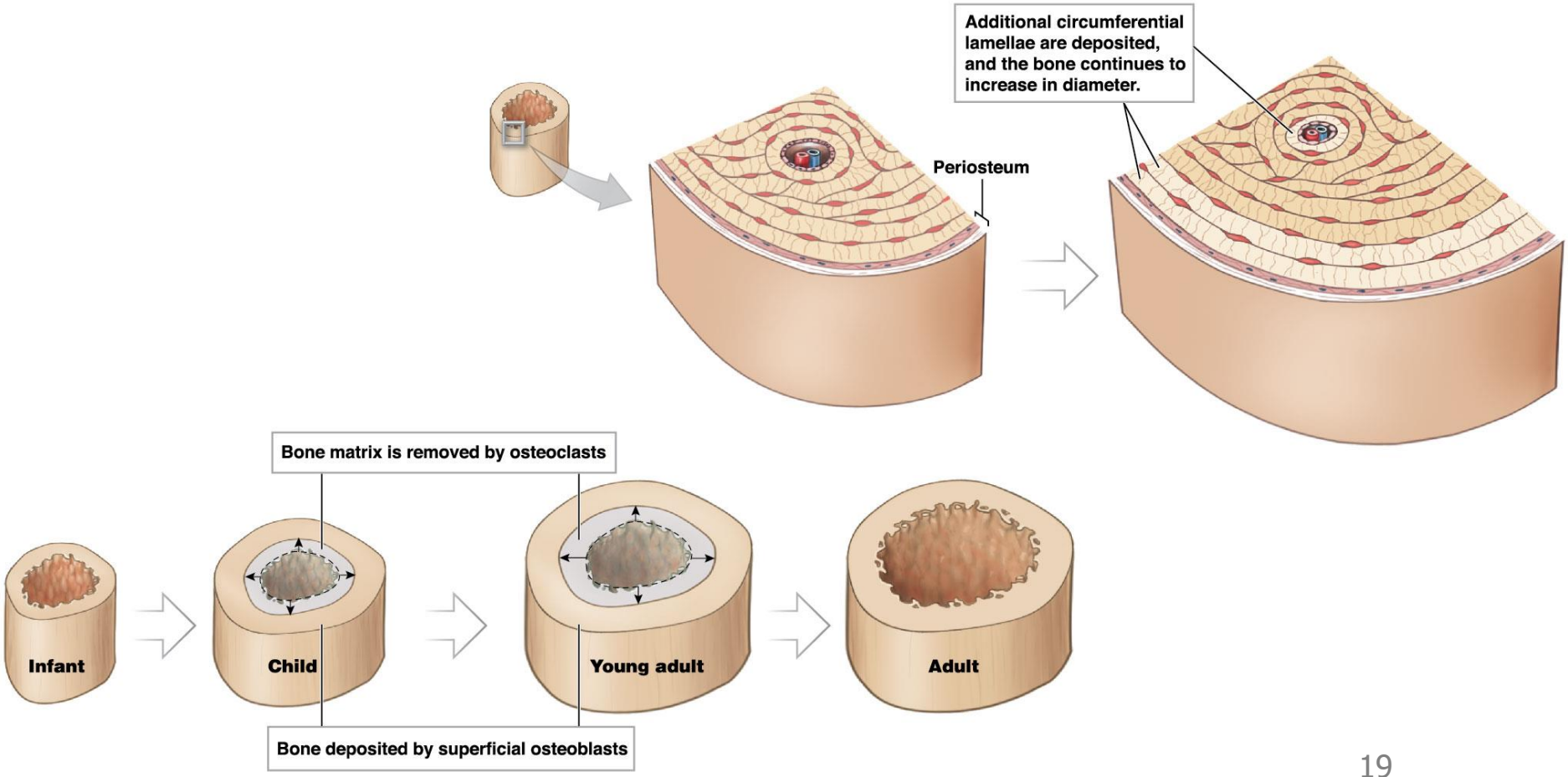
- Trabeculae channel weight around the ilia into femora



Palastanga *et al*, *Anatomy and Human Movement*, 1992

Bone Remodelling

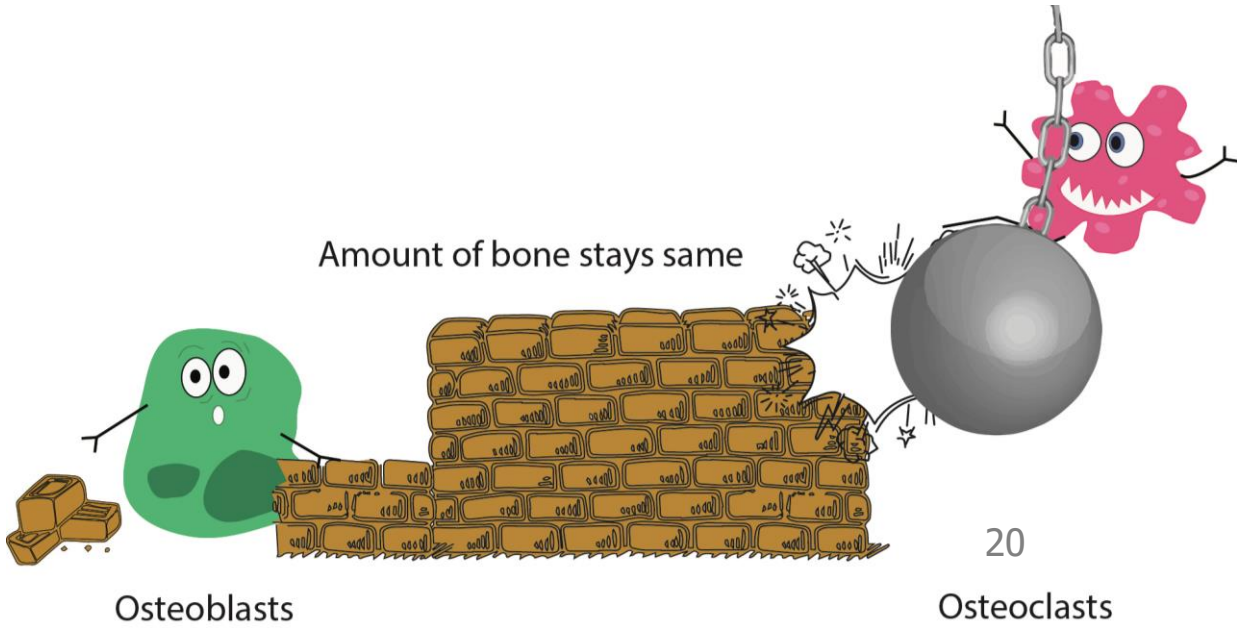
- Allows bones to grow - appositional growth
  - Osteoblasts add bone matrix in lamellae to bone surface
  - Osteoclasts remove bone from the medullary cavity.



Martini *et al*, *Visual Anatomy & Physiology*, 3rd Edn, 2018, p.262

Bone homeostasis

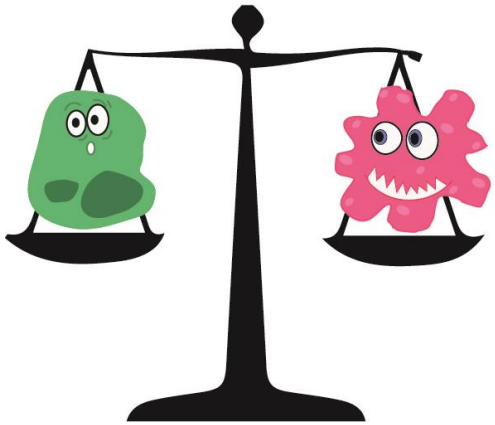
- Balance of OB and OC activity.
- Bone is constantly being formed/destroyed
  - Allows body to mobilise calcium, phosphate and other minerals from the bone matrix
- Process called REMODELLING
  - Allows bone to respond plastically
  - Shape change possible through life to resist strain etc.



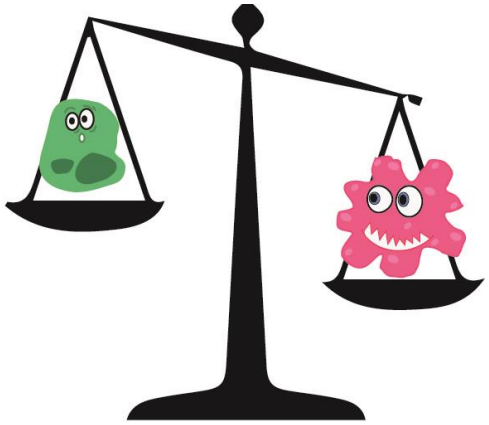
What happens if bone homeostasis isn't maintained?

- Body has requirements to maintain homeostasis
  - E.g. adequate calcium in diet, moderate exercise.

- Without these can get an imbalance in osteoblastic/ osteoclastic activity.



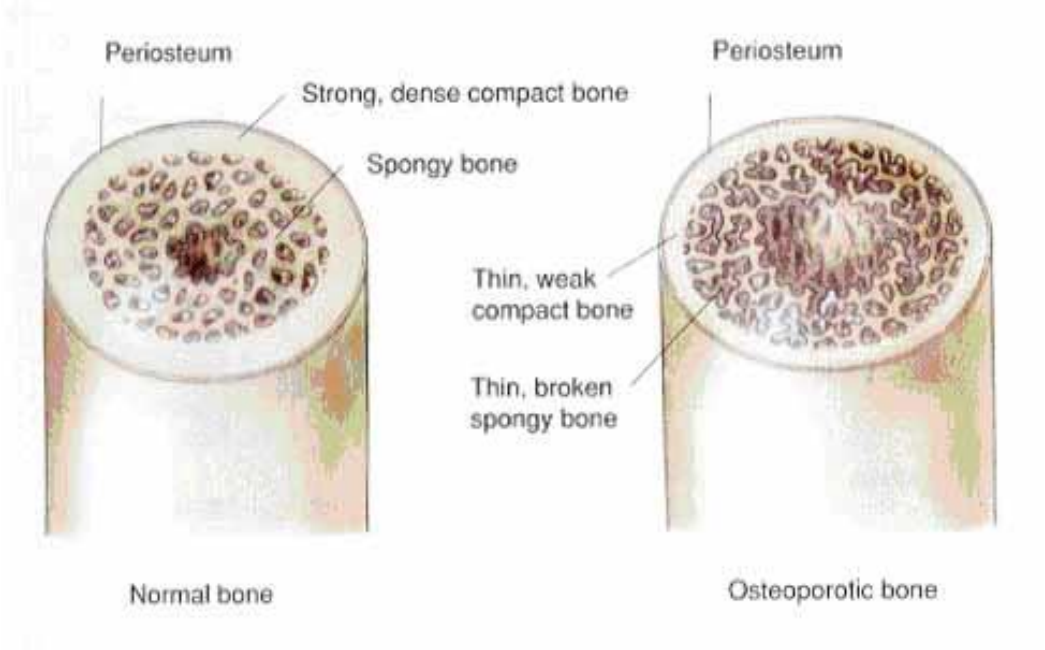
Homeostasis



Osteopenia

Imbalance in OB/OC activity

- Osteoporosis and osteopenia = OC > OB activity
- Osteoporosis = clinically significant version

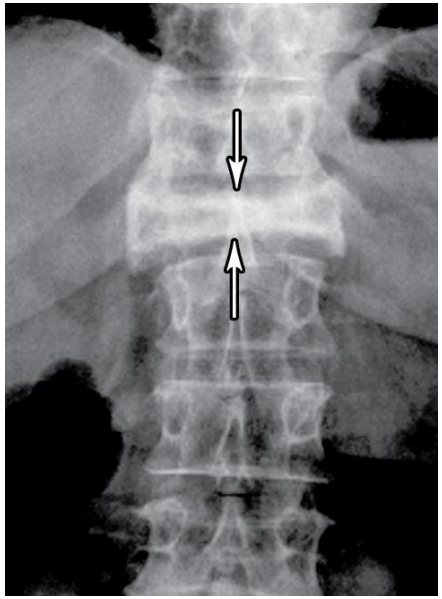


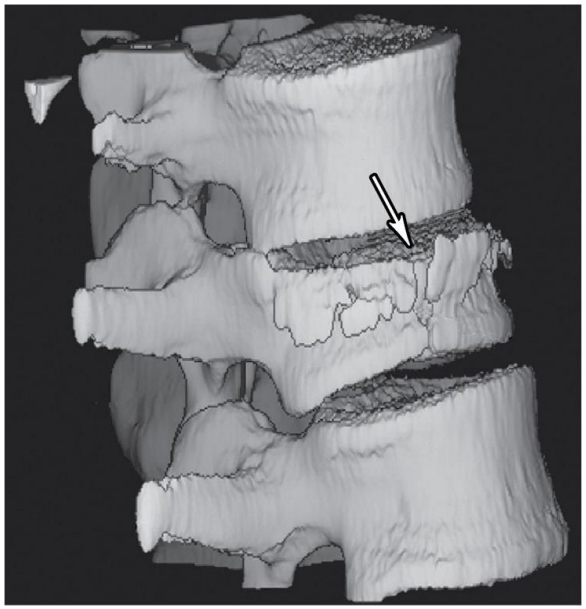
Osteoporosis

- Loss of cortical bone
- In cancellous bone trabeculae become thinner
- Compression fractures of vertebrae

(a) Normal bone

(b) Osteoporotic bone





Martini *et al*, *Visual Anatomy & Physiology*, 3rd Edn, 2018, p.343

Why do only some people get osteoporosis?

- Biological females more at risk
  - Loss of estrogen post-menopause
- Lifestyle factors
  - Lack of exercise
  - Nutritional factors
- Depends on your start point
  - Peak bone mass in your 20s
  - If this is already low then more likely to get osteoporotic

I need to revise this stuff…

Module 6.3 – 6.6 in Martini et al. 2018. *Visual Anatomy and Physiology*

Shout out (again) to this video that has a really nice explanation of osteon structure and bone cell types from 5:07-6:25 https://www.youtube.com/watch?v=rDGqkMHPDqE

Practice: Complete these sentences!

Compact bone is composed of units called _____

The _____ found in the centre of each osteon provide a pathway for blood vessels and nerves.

The cells in bone are called _____and sit within structures called _____.

What is the extracellular component of bone made of?

A. Osteoblasts, osteoclasts and osteocytes

B. Hydroxyapatite (mineral) and collagen (organic)

C. Osteons

D. Trabeculae

How do bones grow wider (appositionally)?

A. Osteocytes secrete bone and widen the osteons.

B. Osteoclasts hollow out bone from the medullary cavity

C. Osteoblasts add bone to the outer surface

D. A combination of B and C.

What is bone homeostasis?

A. When OB and OC activity are balanced and net bone mass stays the same

B. When osteocytes are functioning properly

C. When normal growth allows an increase in bone mass.

D. The process by which bones stay the same once they've finished growing.

HUBS191