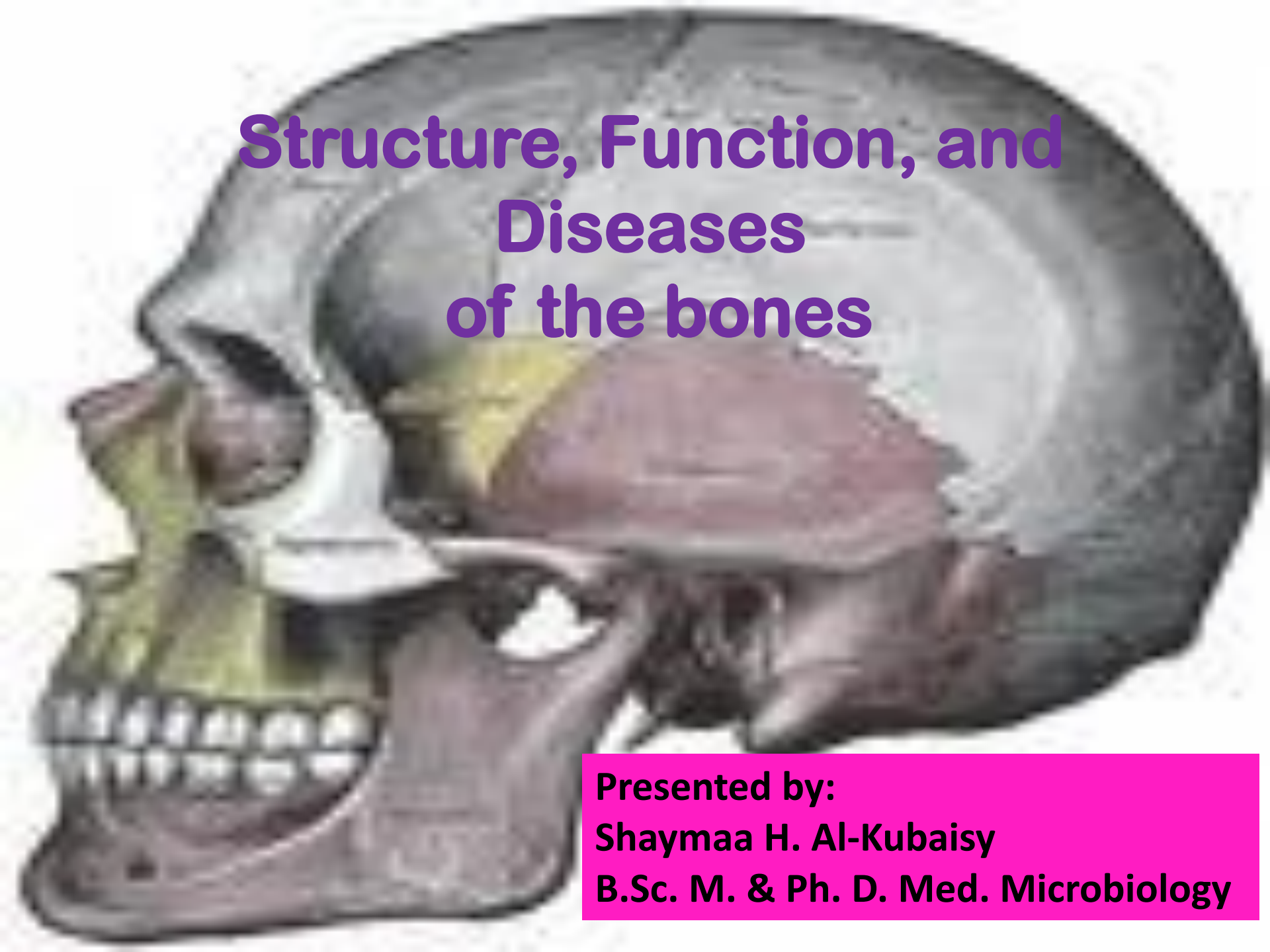


Structure, Function, and Diseases of the bones

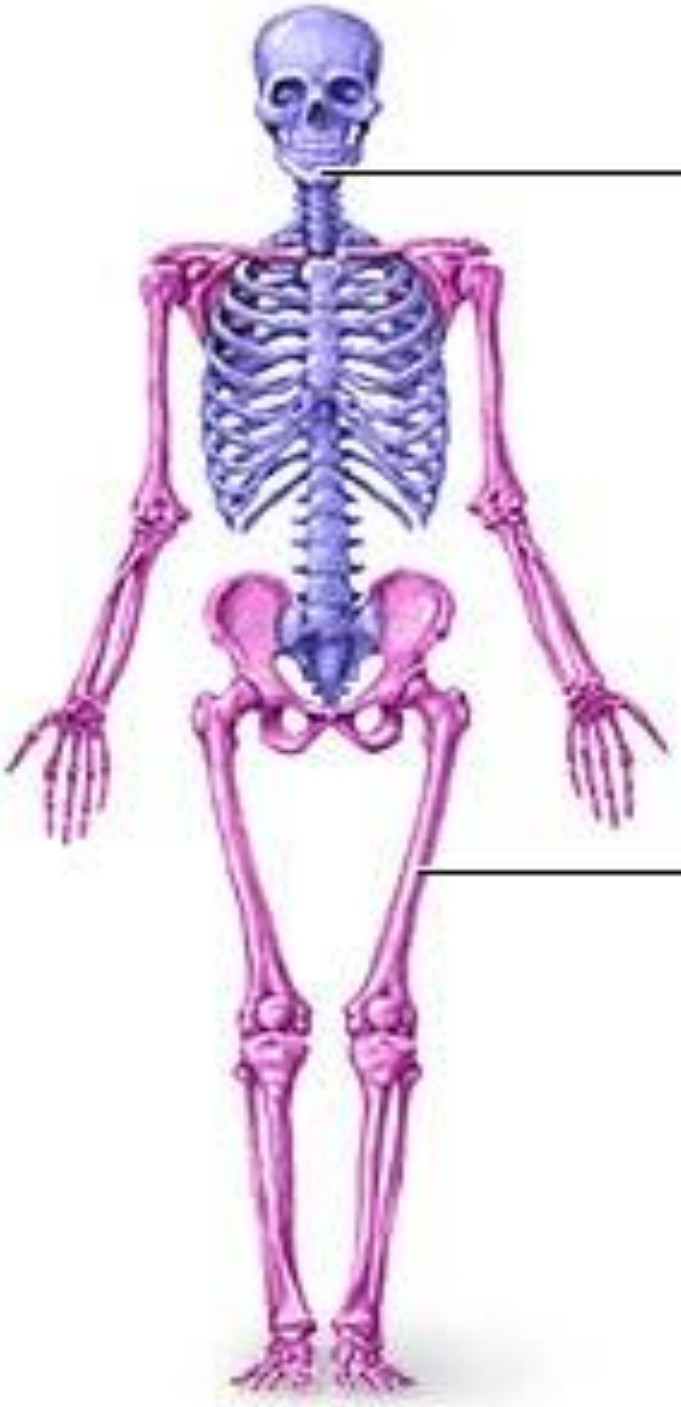
Presented by:
Shaymaa H. Al-Kubaisy
B.Sc. M. & Ph. D. Med. Microbiology

INTRODUCTION

- Bone is made up of several different tissues working together: bone, cartilage, dense connective tissue, epithelium, various blood forming tissues, adipose tissue, and nervous tissue.
- Each individual bone is an organ; the bones, along with their cartilages, make up the skeletal system.

The Skeletal System

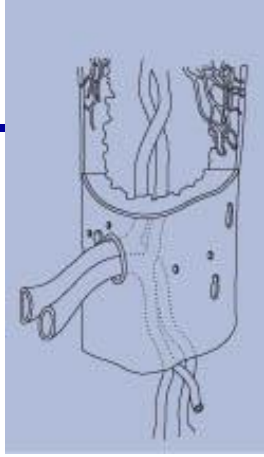
- Parts of the skeletal system
  - Bones (skeleton)
  - Joints
  - Cartilages
  - Ligaments (bone to bone)(tendon=bone to muscle)
- Divided into two divisions
  - **Axial skeleton-** skull, spinal column
  - **Appendicular skeleton** – limbs and girdle

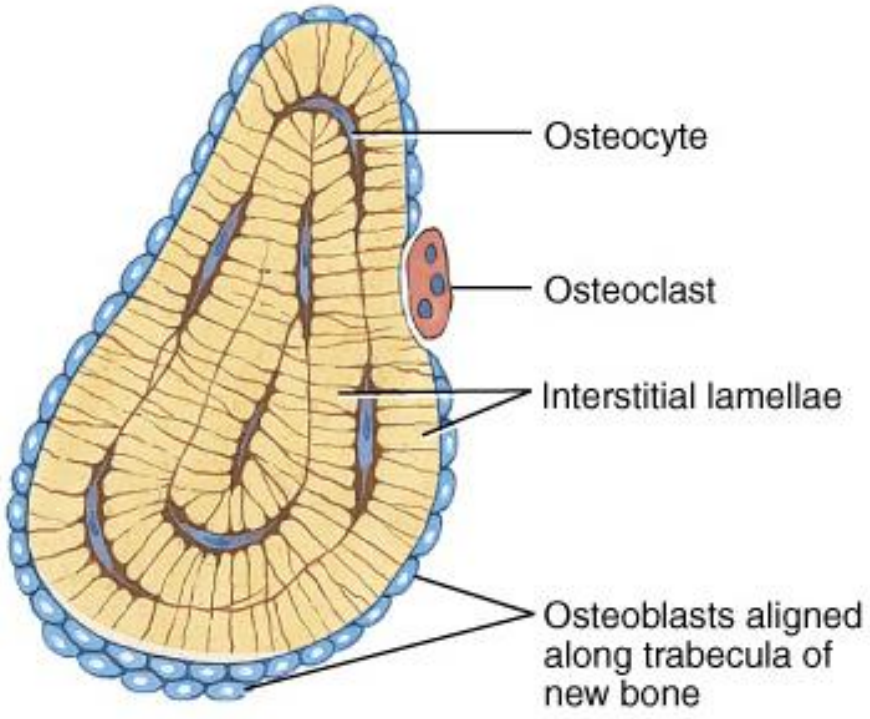


Axial skeleton (blue)

Appendicular skeleton (pink)

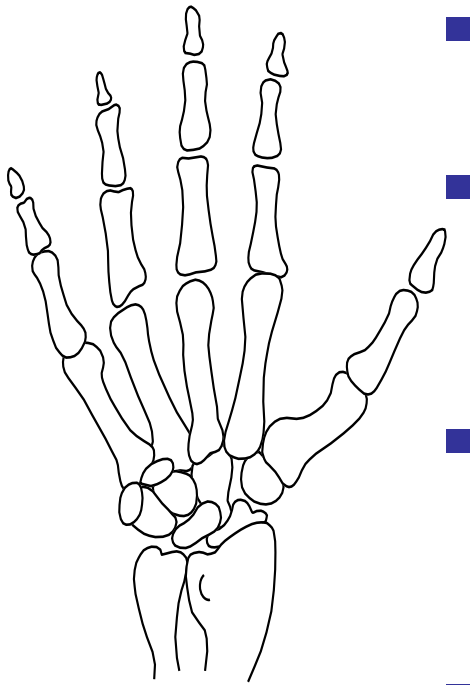
The Skeletal System: Bone Tissue





- Dynamic and ever-changing throughout life
- Skeleton composed of many different tissues
  - cartilage, bone tissue, epithelium, nerve, blood forming tissue, adipose, and dense connective tissue

Functions of Bone



- Supporting & protecting soft tissues
- Attachment site for muscles making movement possible
- Storage of the minerals, calcium & phosphate -- mineral homeostasis
- Blood cell production occurs in red bone marrow (hemopoiesis)
- Energy storage in yellow bone marrow

Importance of Ionic Calcium in the Body

- Calcium is necessary for:
  - Transmission of nerve impulses
  - Muscle contraction
  - Blood coagulation
  - Secretion by glands and nerve cells
  - Cell division

Bones of the Human Body

- The skeleton has **206** bones
- Two basic types of bone tissue
  - **Compact** bone
    - Homogeneous
  - **Spongy** bone
    - Small needle-like pieces of bone
    - Many open spaces

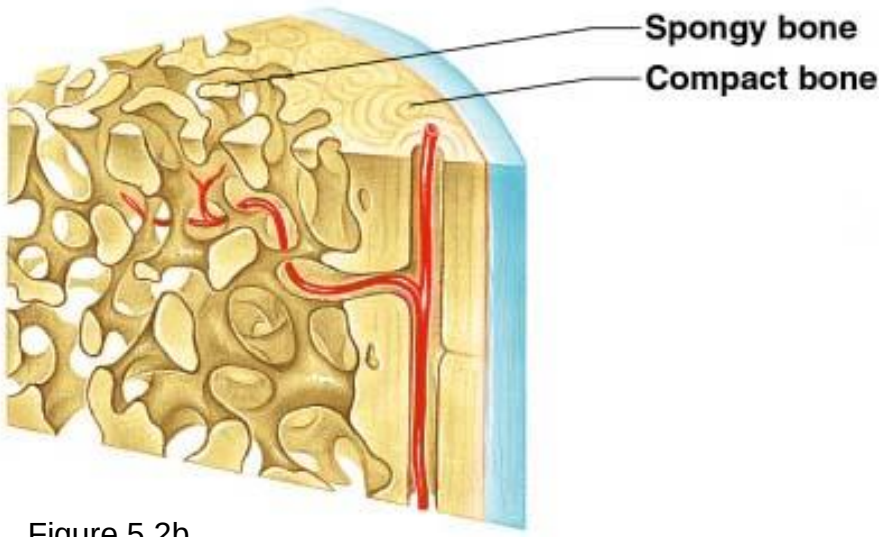


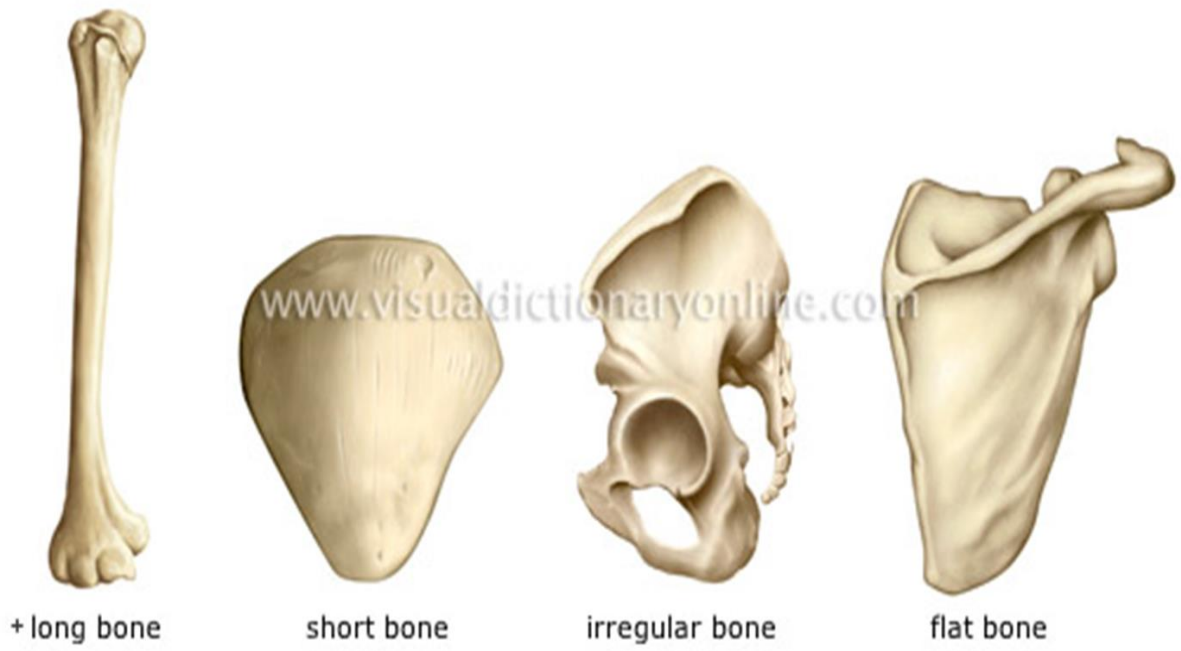
Figure 5.2b

Bones are classified by their shape:

1. **Long-** bones are longer than they are wide (arms, legs)
2. **Short-** usually square in shape, cube like (wrist, ankle)
3. **Flat-** flat , curved (skull, Sternum)
4. **Irregular-** odd shapes (vertebrae, pelvis)

What are the types of Bones?

- Long
- Short
- Flat
- Irregular



Long Bones

- Longer than they are wide
- Has a shaft and 2 ends
- Weight bearing bones (like steel beams)
- Provide the greatest structure and support

- ***Examples:***
  - All limb bones
  - Except…. Kneecap, Wrist and Ankle bones

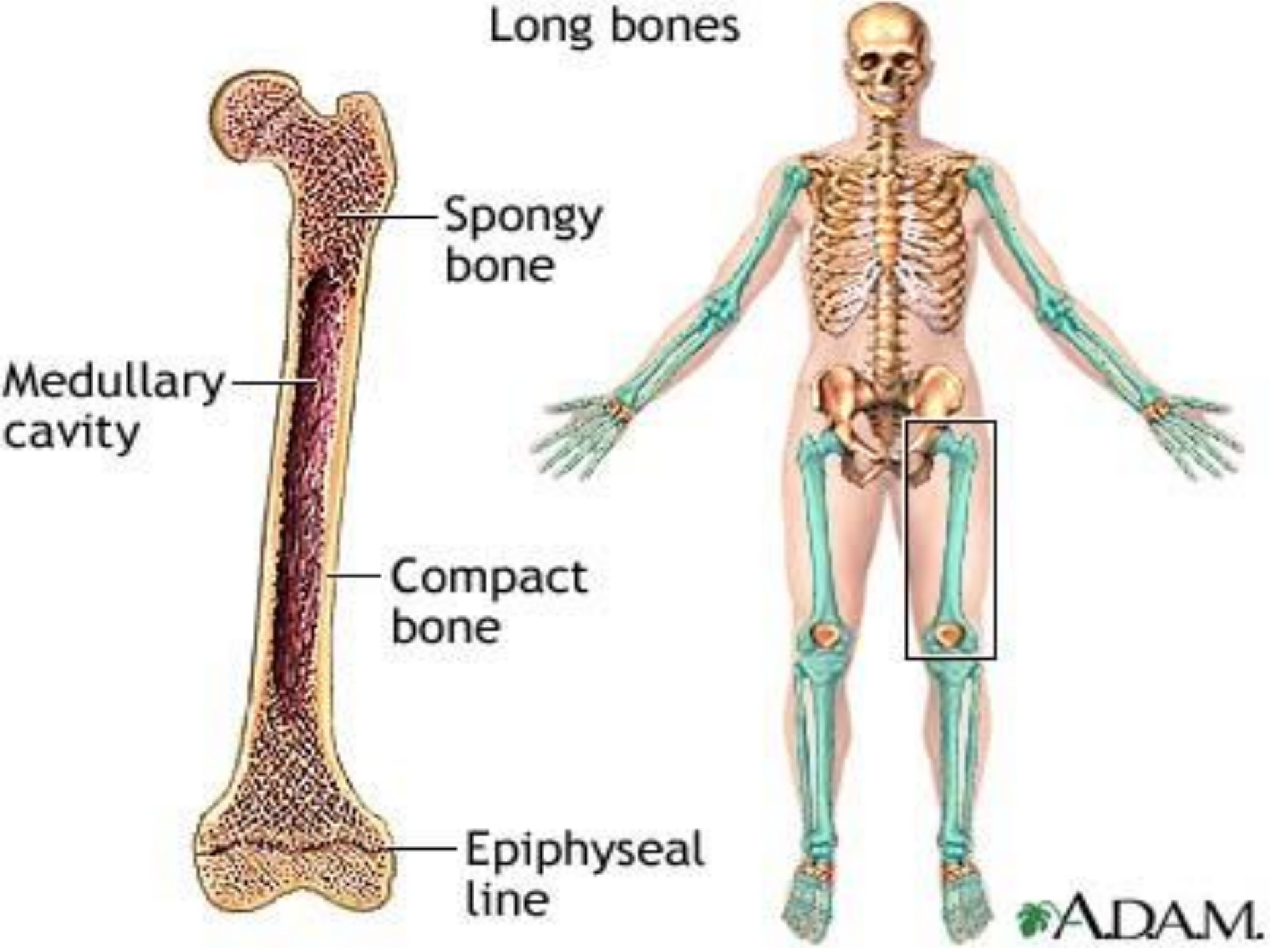
Structure of a Long Bone

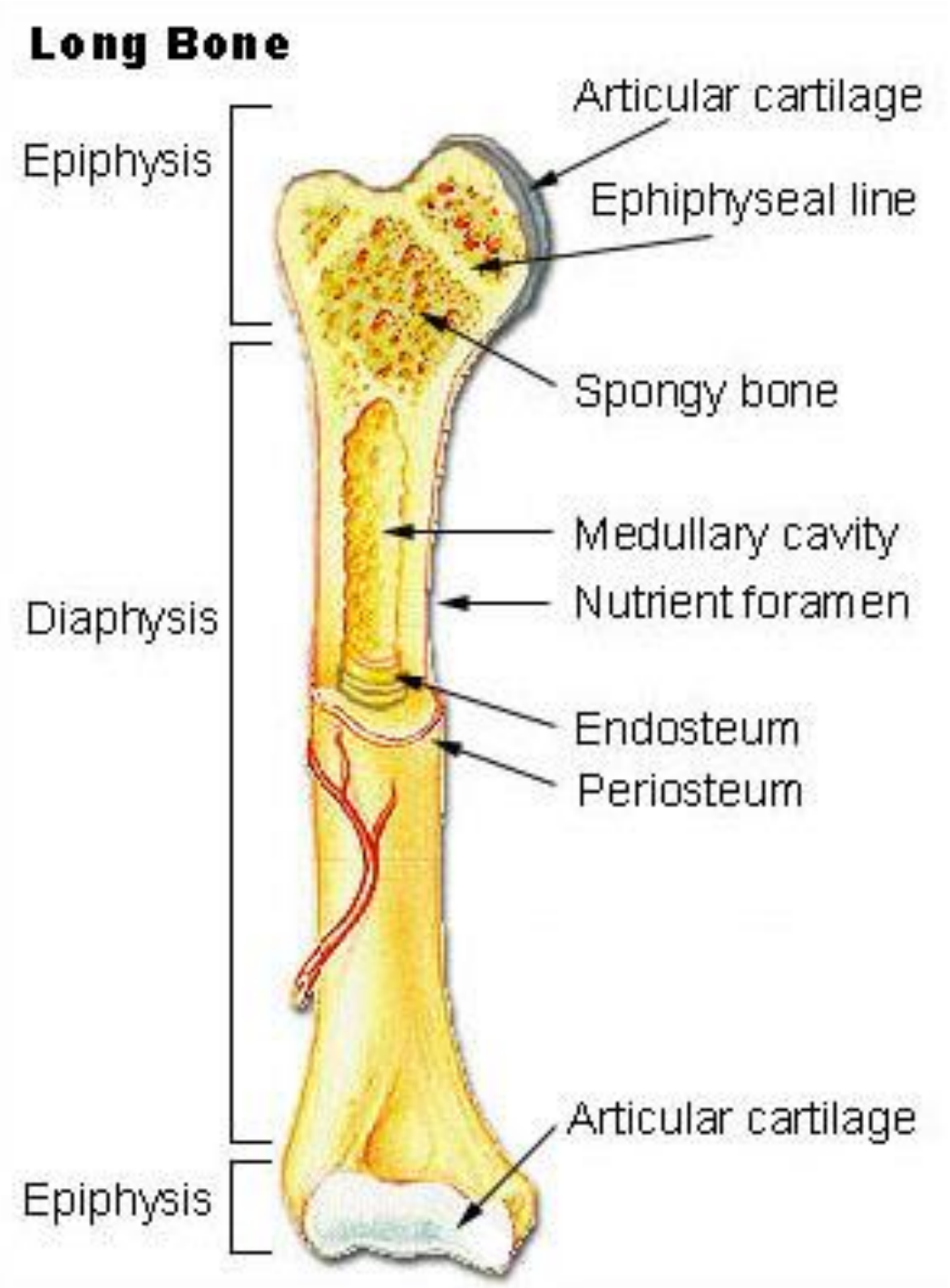
- ***Diaphysis:***
  - Center, main shaft
  - Long part of bone
  - Made of very thick compact bone surrounding a central marrow cavity

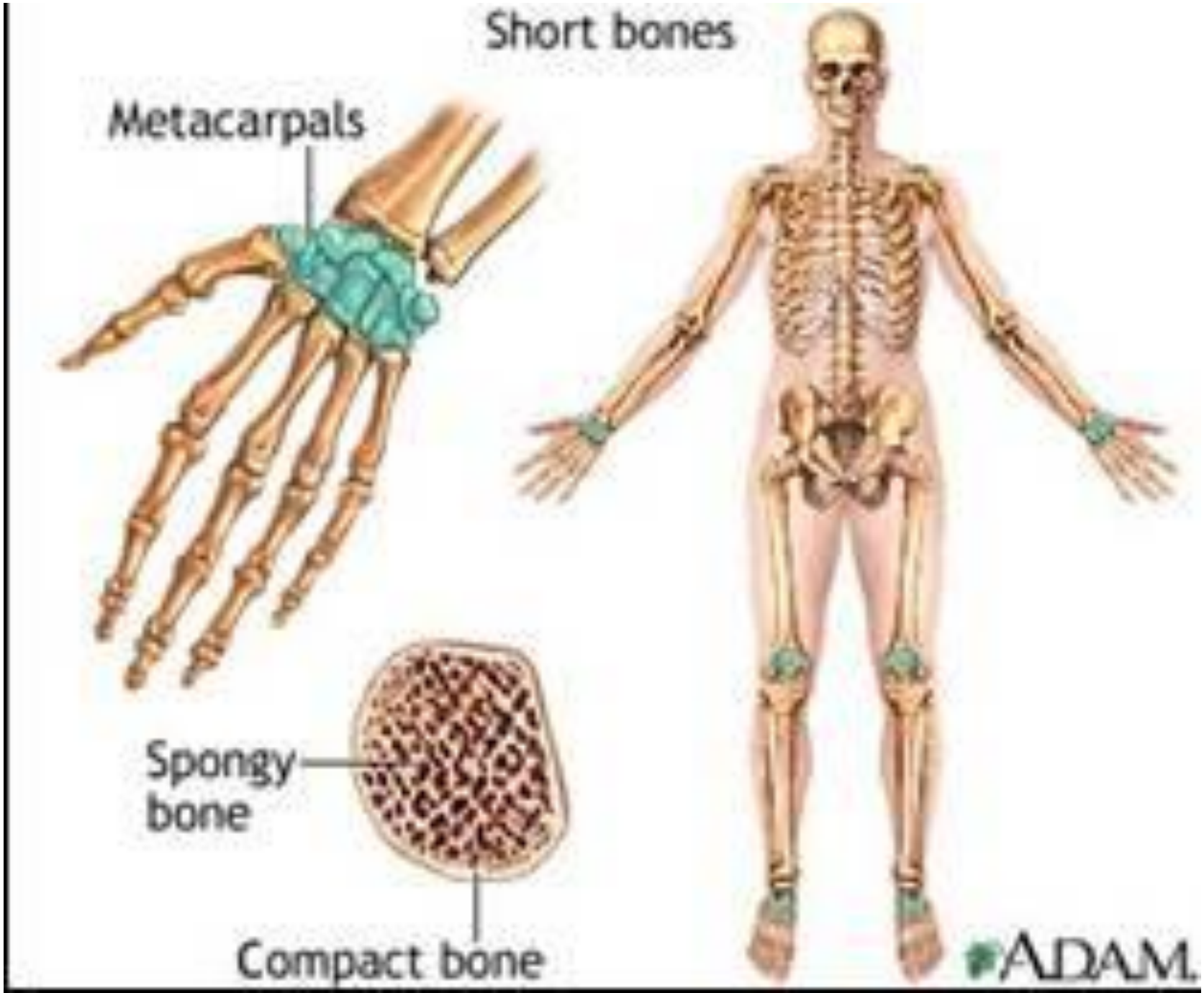
- ***Epiphysis:***
  - Ends of bone
  - Wider than diaphysis
  - Made of compact bone which surrounds spongy bone.
  - Joint surface of each epiphysis is covered with hyaline cartilage

- ***Epiphyseal Line:***
  - Remnant of Epiphyseal Plate
  - Found in adult bones
  - Shows amount of cartilage growth during adolescence

- ***Membranes:***
  - Periosteum = Around the outside
    - Richly supplied with nerve fibers, lymphatic vessels and blood vessels
    - Provides anchoring points for tendons and ligaments
  - Endosteum = Around the inside
    - Surrounds the spongy bone


Long bones
Spongy bone
Medullary cavity
Compact bone
Epiphyseal line
A.D.A.M.


Long Bone
Articular cartilage
Epiphysis
Ephiphyseal line
Spongy bone
Medullary cavity
Diaphysis
Nutrient foramen
Endosteum
Periosteum
Articular cartilage
Epiphysis


Short bones
Metacarpals
Spongy bone
Compact bone
A.D.A.M.

Classification of Bones on the Basis of Shape

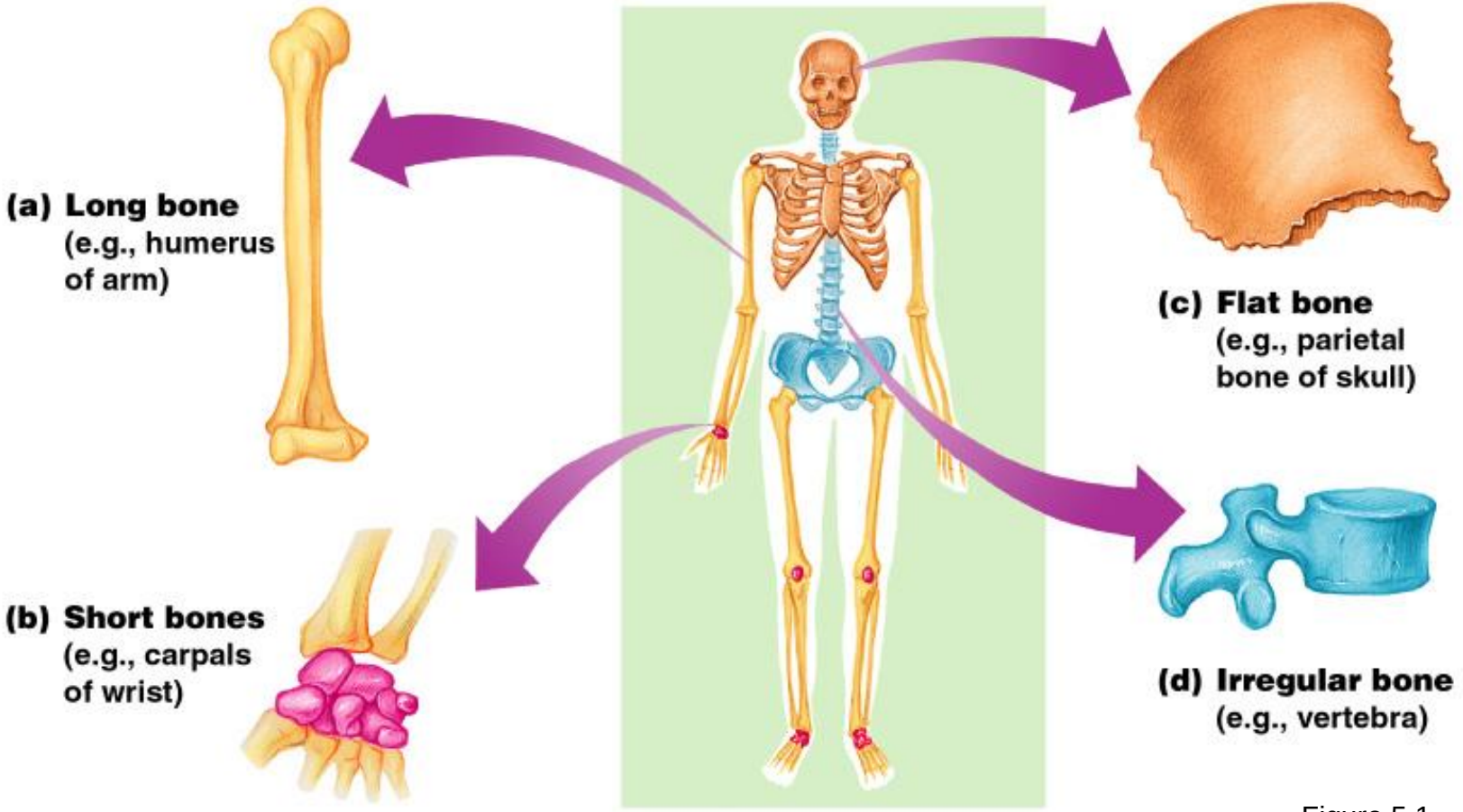
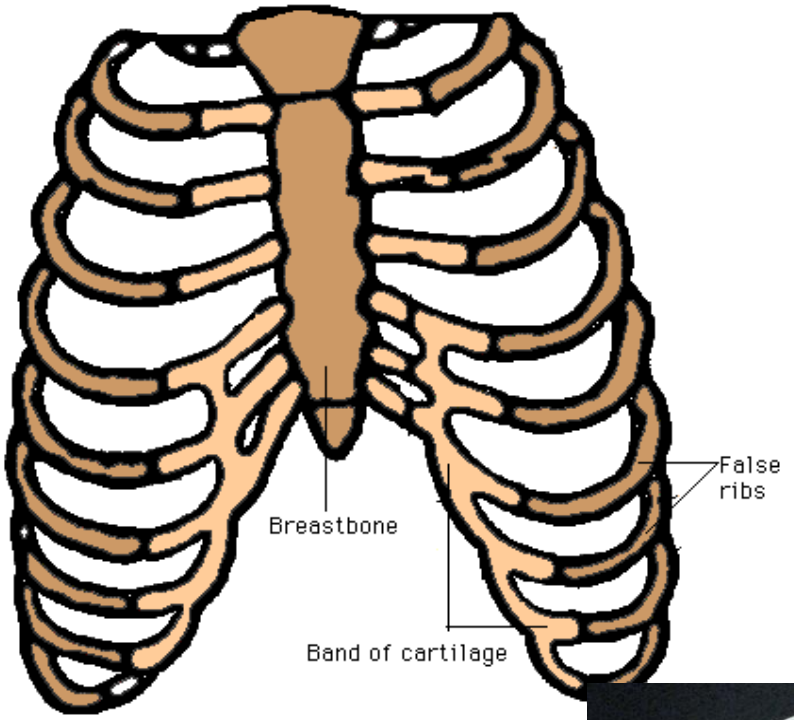
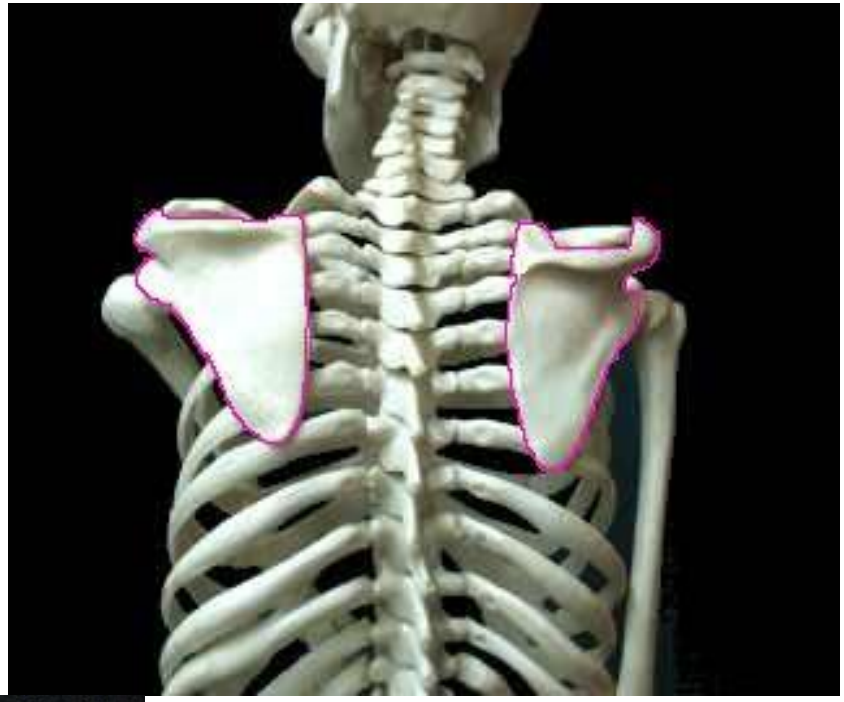
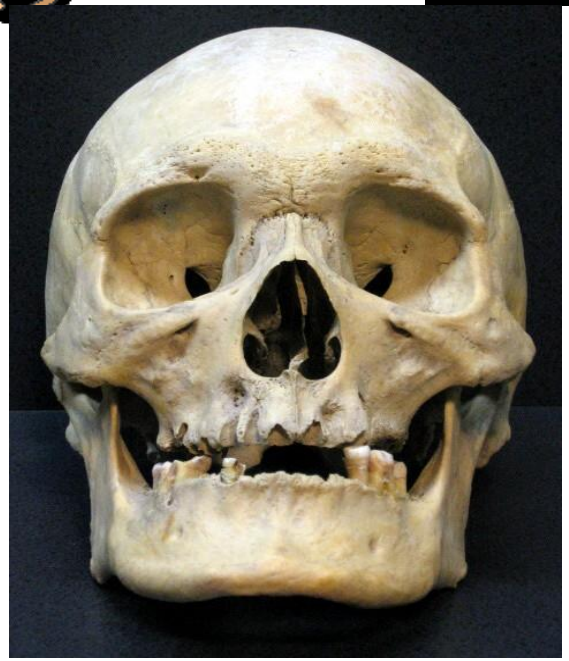


Figure 5.1


False ribs
Breastbone
Band of cartilage





Bone Structure

- **Unique based on location + bone type.**

- **Compact Bone (Outer Layer):**
  - Dense
  - Smooth and Solid to naked eye

- **Spongy Bone (Inner Layer):**
  - Hole-y (like a honeycomb)
  - Made of small needle-like, flat pieces called “trabeculae”
  - Open spaces between trabeculae are filled with red or yellow bone marrow

Chemical Composition of Bone

- **Contains organic & inorganic components**

- ***Organic:***
  - Cells (osteoblasts, osteocytes, osteoclasts)
  - Osteoid
    - Made of glycoproteins and collagen fibers
    - Secreted by osteoblasts
    - “filler matrix” around cells
  - Contribute to flexibility and tensile strength

- ***Inorganic:***
  - Mineral Salts (calcium phosphates)
  - Contribute to hardness of bone (allowing for compression resistance)

Types of Bone Cells

- **Osteocytes**
  - Mature bone cells
- **Osteoblasts**
  - Bone-forming cells
- **Osteoclasts**
  - Bone-destroying cells
  - Break down bone matrix for remodeling and release of calcium
- ***Bone remodeling is a process by both osteoblasts and osteoclasts***

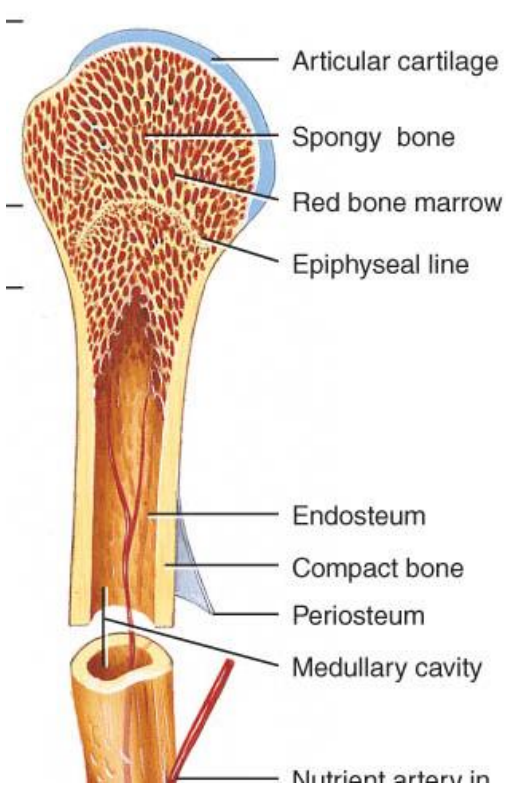
Matrix of Bone

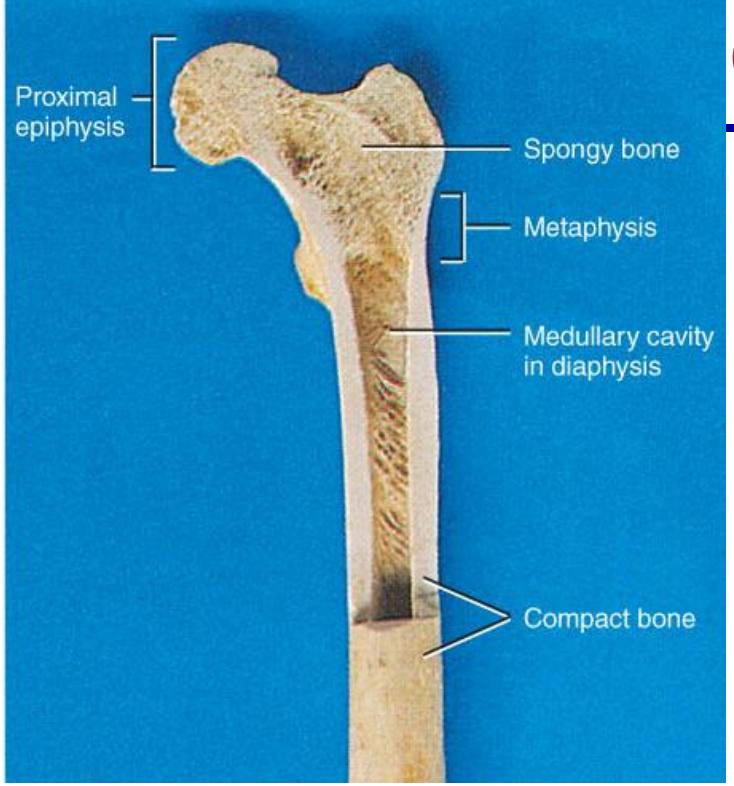
- Inorganic mineral salts provide bone's hardness
  - hydroxyapatite (calcium phosphate) & calcium carbonate
- Organic collagen fibers provide bone's flexibility
  - their tensile strength resists being stretched or torn
  - remove minerals with acid & rubbery structure results
- Bone is not completely solid since it has small spaces for vessels and red bone marrow
  - spongy bone has many such spaces
  - compact bone has very few such spaces

Compact Bone

- *Compact bone* is arranged in units called *osteons* or *Haversian systems* .
- Osteons contain blood vessels, lymphatic vessels, nerves, and osteocytes along with the calcified matrix.
- Osteons are aligned in the same direction along lines of stress. These lines can slowly change as the stresses on the bone changes.

Compact or Dense Bone

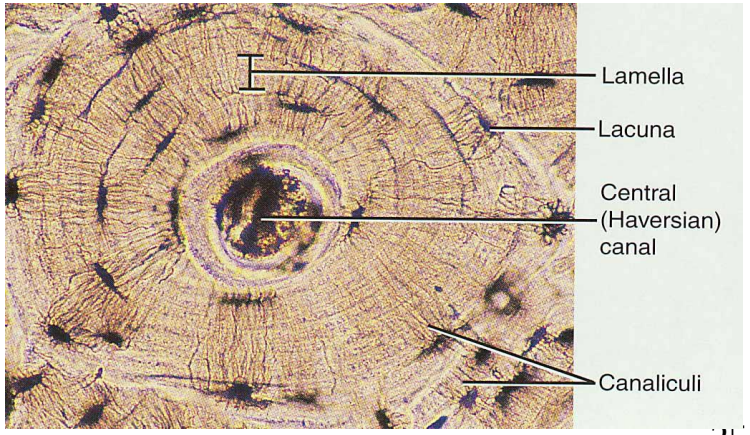


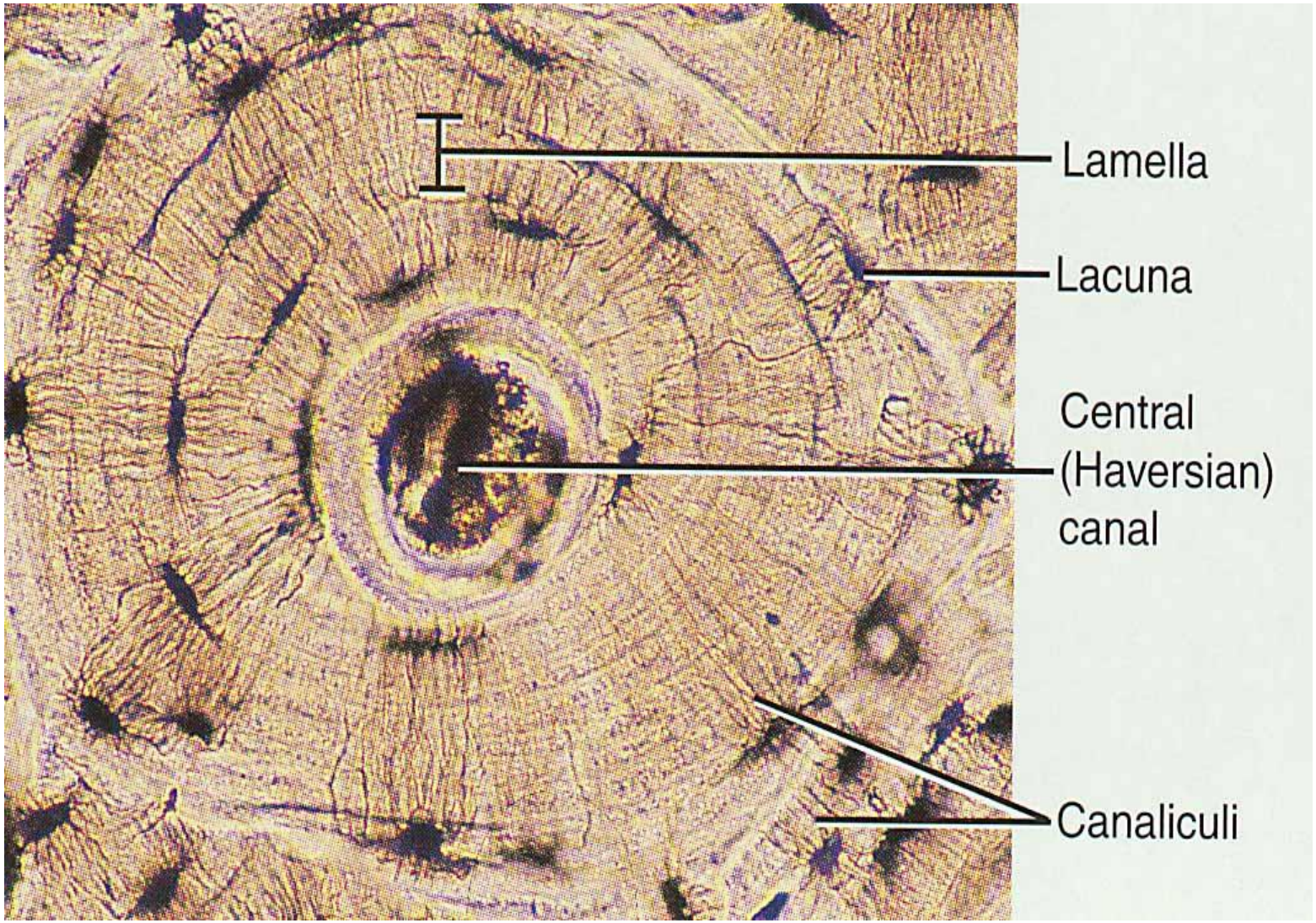


- Looks like solid hard layer of bone
- Makes up the shaft of long bones and the external layer of all bones
- Resists stresses produced by weight and movement

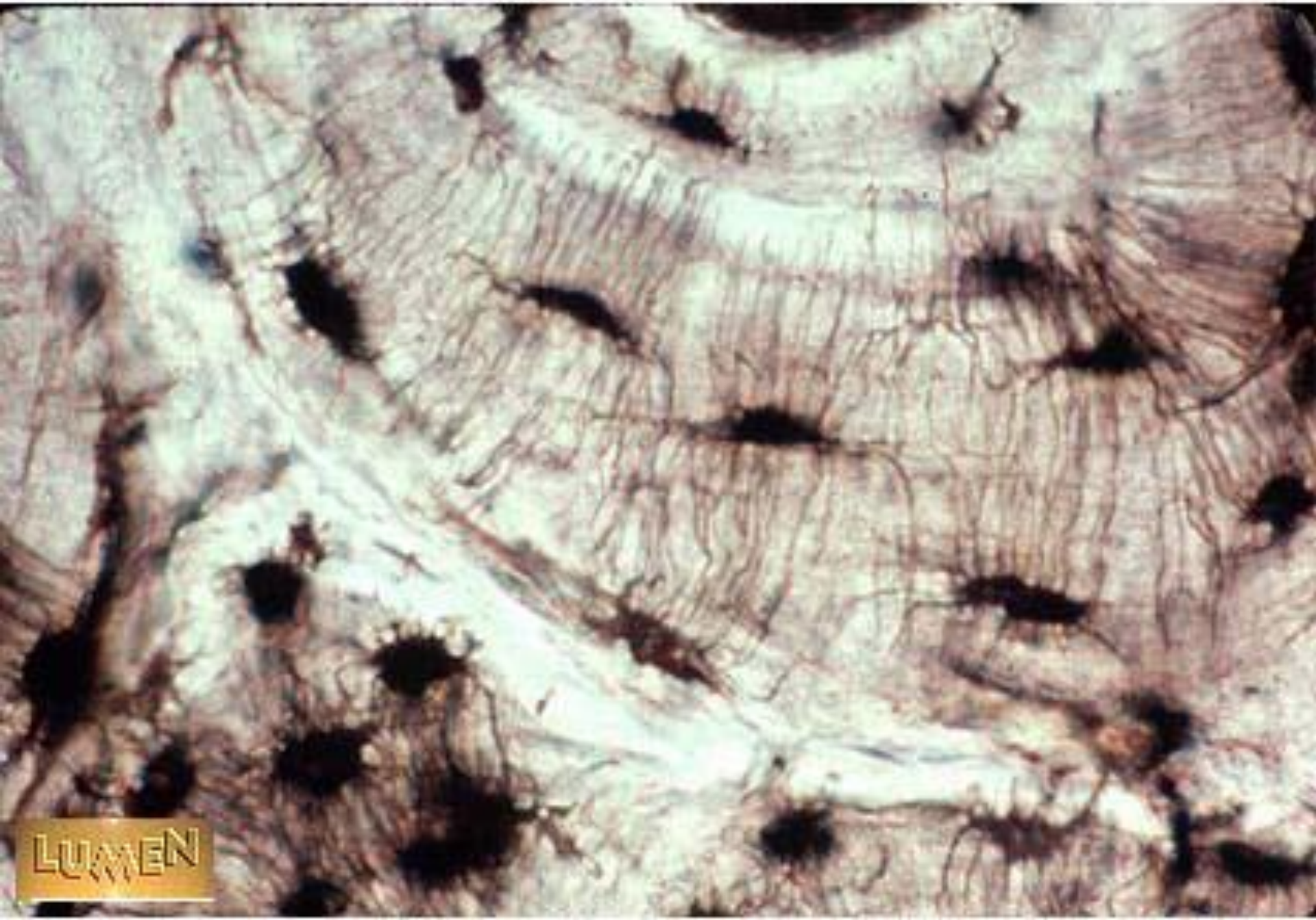
Histology of Compact Bone

- Osteon is concentric rings (lamellae) of calcified matrix surrounding a vertically oriented blood vessel
- Osteocytes are found in spaces called lacunae
- Osteocytes communicate through canaliculi filled with extracellular fluid that connect one cell to the next cell
- Interstitial lamellae represent older osteons that have been partially removed during tissue remodeling





Histology Lab Part 9: Slide 42



Spongy Bone

- Spongy (cancellous) bone does not contain osteons. It consists of trabeculae surrounding many red marrow filled spaces.
- It forms most of the structure of short, flat, and irregular bones, and the epiphyses of long bones.
- Spongy bone tissue is light and supports and protects the red bone marrow.

BONE FORMATION

- All embryonic connective tissue begins as mesenchyme.
- Bone formation is termed *osteogenesis* or *ossification* and begins when **mesenchymal** cells provide the template for subsequent ossification.
- Two types of ossification occur.
  - *Intramembranous ossification* is the formation of bone directly from or within fibrous connective tissue membranes.
  - *Endochondrial ossification* is the formation of bone from hyaline cartilage models.

Changes in the Human Skeleton

- In **embryos**, the skeleton is primarily hyaline ***cartilage***
- During development, much of this cartilage is replaced by bone
- Cartilage remains in isolated areas
  - Bridge of the nose
  - Parts of ribs
  - Joints

Factors Affecting Bone Growth

- Nutrition
  - adequate levels of minerals and vitamins
    - calcium and phosphorus for bone growth
    - vitamin C for collagen formation
    - vitamins K and B12 for protein synthesis
- Sufficient levels of specific hormones
  - during childhood need **insulinlike growth factor**
    - promotes cell division at epiphyseal plate
    - need hGH (growth), thyroid (T3 &T4) and insulin
  - sex steroids at puberty
  - At puberty the sex hormones, estrogen and testosterone, stimulate sudden growth and modifications of the skeleton to create the male and female forms.

Factors that affect Bone Growth

- EXERCISE: Within limits, bone has the ability to alter its strength in response to mechanical stress by increasing deposition of mineral salts and production of collagen fibers.
  - Removal of mechanical stress leads to weakening of bone through demineralization (loss of bone minerals) and collagen reduction.
    - reduced activity while in a cast
    - astronauts in weightless environment
    - bedridden person
  - Weight-bearing activities, such as walking or moderate weightlifting, help build and retain bone mass.

AGING AND BONE TISSUE

- By age 25, nearly all bones are completely ossified
- A single gene that codes for vitamin D docking determines both the tendency to accumulate bone mass early in life, and the risk for osteoporosis later in life

AGING AND BONE TISSUE

- In old age, bone resorption predominates
- Of two principal effects of aging on bone, the first is the loss of calcium and other minerals from bone matrix (demineralization), which may result in osteoporosis.
  - very rapid in women 40-45 as estrogens levels decrease
  - in males, begins after age 60
- The second principal effect of aging on the skeletal system is a decreased rate of protein synthesis
  - decrease in collagen production which gives bone its tensile strength
  - decrease in growth hormone
  - bone becomes brittle & susceptible to fracture