# Bone Histology

Gross Anatomy > Skeletal System > Skeletal System

**OVERVIEW** 

Here we will learn the histology of both compact bone and spongy bone. We include a review of general bone anatomy in the notes. We include two slides of compact bone, which will provide a frame of reference as we work through our first diagram:

• A high magnification slide of a single osteon (aka Haversian system), which is the basic until of compact bone.

• A lower magnification slide of multiple osteons and related structures.

**Diaphysis Cross-Section**
In the corner of the diagram, for orientational purposes, recreate the cross-section of bone through the diaphysis, so we can show that from outside to inside lies the:

• Periosteum (P)

• Compact Bone (C)

• Endosteum (E)

• Marrow cavity (M), which has spongy bone within it.

!periosteum endosteum marrow cavity bone collar We'll proceed from outside to inside. Note that this section is from the bone diaphysis — the bone epiphysis has articular cartilage instead of periosteum and is filled with spongy bone internally rather than a marrow cavity.

**COMPACT BONE: DIAGRAM**

**PERIOSTEUM**

**Periosteum**
Begin with the thick outer layer: the periosteum. Show that it comprises:

• An outer layer, which is made of thick collagenous fiber layer.

• An inner layer, call the cambium, which serves to nourish and activate the compact bone that lies internal to it.

**COMPACT BONE**

**Outer Circumferential Lamellae**
Internal to the inner periosteum, draw an outer circumferential lamellae layer (bone layer).

• The orientation of this lamella layer is distinct from the orientation of the lamella within the Haversian systems (shown next).

Here we delineate the distinct outer circumferential lamellae and some other key findings: inner circumferential lamellae, periosteum, marrow cavity, and one of the visible osteons. !Compact bone - periosteum, osteon, outer circumferential lamellae, inner circumferential lamellae

**Osteons (aka Haversian Systems)**

Now internal to the outer circumferential layer, draw an osteon (aka Haversian system). These columns comprises circular lamellae (bone layers) of compact bone. Show that the line formed between osteons is called a **cement line**. In the center of each osteon lies the **Haversian canal**. Show that the Haversian canal comprises a neurovascular bundle (artery, vein, and nerve) that is surrounded by endosteum. Then, indicate an **osteocyte** (a mature form of osteoblast (the bone-producing cells) within a **lacunae** in the bony matrix. The lacunae are cavities in the bone tissue. Each one can house a single osteocyte. The lacunae are interconnected via canaliculi. Show that spindly (spider-leg appearing) canaliculi stretch across the lamellae. The osteocytic cytoplasmic cell processes connect via these canaliculi for the transportation of nutrients and waste. They are oriented in perpendicular to the lamellae. On histological section, we identify these canaliculi as pervasive hair-like threads that stretch in perpendicular to the lamellae. Now draw additional osteons but leave their center open. Draw the Haversian canals in their centers. !Osteon

**Volkmann's (aka perforating) canals**

Show that in perpendicular to the Haversian canal's are Volkmann's (aka perforating) canals that connect these various osteons (Haversian systems). These canal systems form channels for the neurovasculature that interconnect the osteons.

**Interstitial System**

Show that an interstitial system of lamellae lie in between the osteons, which comprises remnants of partially resorbed osteons. These leftover bone fragments fill the space between neighboring osteons.

**Sharpey's Fibers**

Show that Sharpey's fibers are collagenous fibers that anchor the periosteum to the outer lamellae.

**Inner Circumferential Lamella**

Now, internal to the compact bone osteons, draw an inner circumferential lamellae (which in essence parallels the outer circumferential lamella layer.

**ENDOSTEUM**

**Endosteum**

Show that endosteum lies internal to the inner circumferential lamella layer. The endosteum comprises two core components:

• Flattened bone lining cells (as specific form of osteoprogenitor (aka osteogenic) cell) that lines the bone surface.

- These bone lining cells can activate and differentiate into **cuboidal osteoblasts** during times of bone formation.

- During times of bone resorption, bone lining cells produce signaling molecules (eg, RANKL) that promote the production of osteoclasts. Note that osteoclasts, themselves, are formed from the fusion of multiple monocyte/macrophage myeloid lineage precursor cells (hence, *osteoclasts are multinucleated*).

• Type-III collagenous fibers (reticular fibers), which serve as a supporting layer.

## COMPACT BONE: HISTOLOGICAL SLIDES

**OSTEON (HAVERSIAN SYSTEM)**

Let's work through this slide from inside to outside.

• Indicate the **Haversian canal** (HC): the central canal that encompasses the neurovascular bundle.

• Then, a **lamella**(Lm): a ring of compact bone.

• Next, indicate **canaliculi** (C): the thread-like canals that carry osteocyte cytoplasmic processes across the lamellae.

• Finally, a **lacuna** (Lc), a cavity in the bone that houses a single osteocyte.

**COMPACT BONE: MULTIPLE OSTEONS**

This slide is lower-magnification, which allows us to see a larger swath of compact bone.

• Encircle an **osteon (aka Haversian system)**: the basic cylindrical unit of compact bone.

• Show that we can see a Volkmann's canal connecting two different osteons: the neurovascular channel that connects the Haversian canal of adjacent osteons. We can see that the canal runs in perpendicular to the osteon.

• Show a small section of an **interstitial system**. The interstitial system is a remnant (leftover piece) from a partially resorbed osteon.

• Indicate the **cement line** between osteons.

**SPONGY BONE: HISTOLOGICAL SLIDE**

Now, let's focus on spongy bone. !Spongy bone trabeculae with osteoblasts and osteoid and osteocytes We will use a histological slide from bone marrow to draw out key details of spongy bone, here. Note that spongy bone is found both in a mass of tissue at the epiphyses internal to the compact bone and also as a spicule meshwork within the bone marrow cavity. Here let's start with the histological slide and then we will draw-out a section of spongy bone at very high resolution because a lot of what we need to learn about spongy bone will only make sense if expand the tissue and think about it at a cellular level.

**Trabeculae**

Encircle a section of a trabecula. Trabecula (which means "small beam") are the spindles of bone lamellae. Spongy bone is a porous network of trabeculae arranged along stress lines with parallel sheets of lamellae that lack the cylindrical organization of osteons. In the bone anatomy tutorial we drew trabeculae with red blood cells interspersed as would be found in the end of the long bones (the epiphyses). Here, we see trabeculae within bone marrow, as would be found in the bone shaft (the diaphysis).

**Bone Marrow**

Encircle a swath of bone marrow, which comprises red marrow and yellow marrow. Red marrow (aka hematopoietic marrow) is primarily constituted with hematopoietic stem cells (cells that can differentiate into red blood cells, white blood cells, and platelets). Yellow marrow is constituted with adipose cells (aka fat cells). Bone marrow also contains some other cell types but they are much lesser focus. These include:

• Mesenchymal stem cells (aka stromal cells), which can differentiate into NON-hematopoietic cells: osteoblasts (bone-forming cells), adipocytes (fat-forming cells), and chondrocytes (cartilage-forming cells).

• Differentiated hematopoietic stem cells: red blood cells, white blood cells, and platelets.

**Endosteum**

Show that endosteum covers the trabeculae, as mentioned it contains bone-lining cells (here, lining the trabeculae), which can activate and differentiate into osteoblasts or signal the production of osteoclasts.

**SPONGY MARROW CELLULAR COMPONENTS**

Let's focus on a section of a trabecula where we can enrich our understanding of the relationship between the endosteum and the trabeculae and where we can appreciate the lamellar organization of spongy bone. First, outline a wedge of the trabecula. Then show that the endosteum in this section is a row of activated bone lining cells: osteoblasts. Show that the osteoblasts secrete **osteoid**, which is unmineralized bone — it is the new bone that hasn't hardened yet.

Show that the lamellae form in parallel sheets. Remember, they do not form the concentric rings found in the osteons in compact bone. Then, add-in osteocytes within their lacunae. Finally, within the bone marrow, include fat cells. And hematopoietic stem cells.

• We can imagine how bone marrow transplantation, is essentially hematopoietic stem cell transplantation.

- It's used in the treatment of a variety of hematologic (blood-based) cancers (eg, leukemia) and disorders (eg, in children with sickle cell anemia).

**HISTOLOGIC IMAGE SOURCES**

• Compact Bone

• Bone Marrow with Spongy Bone