

6.2.1

Fetal Development of Bone: Intramembranous and Endochondral Ossification

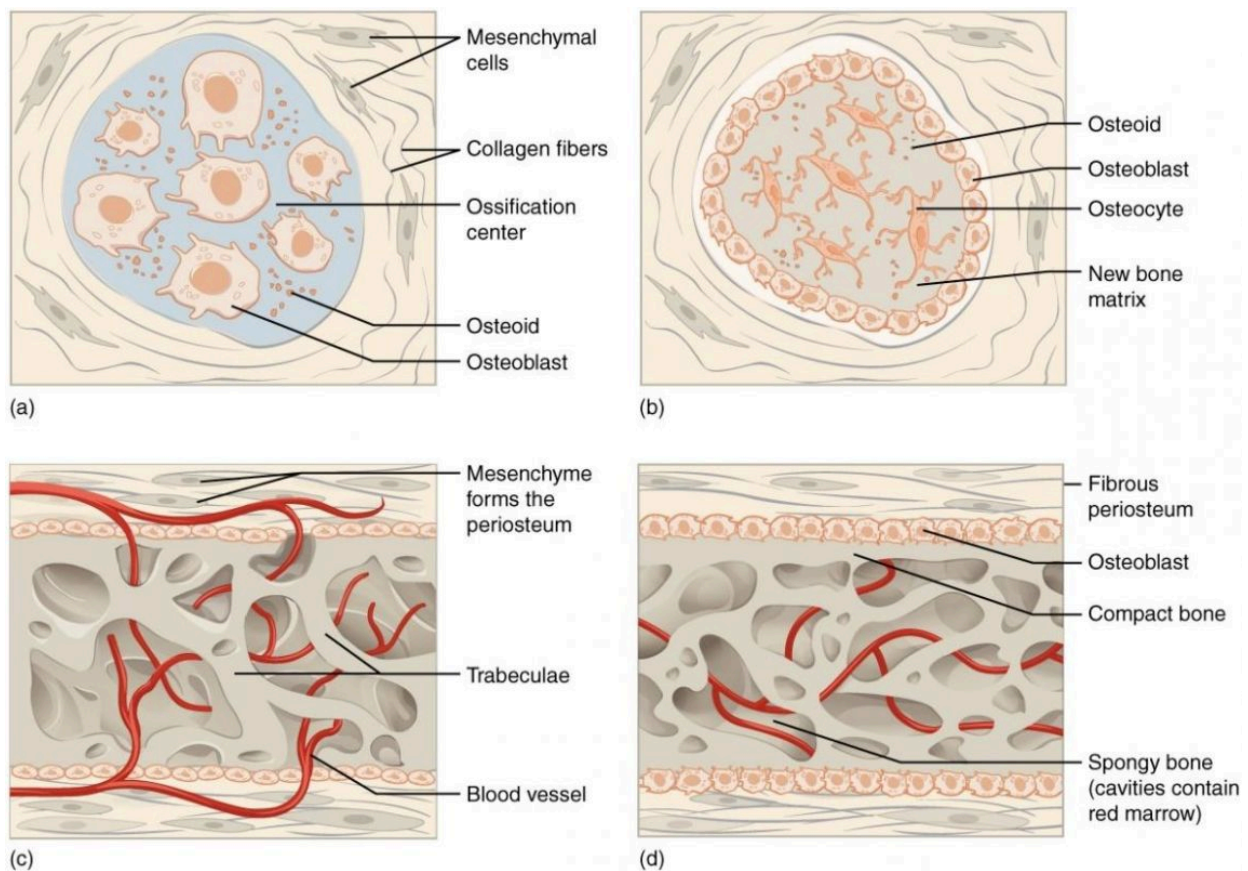
The formation of bone during fetal development occurs by two processes:

Endochondral ossification and **intramembranous ossification**. These names are derived from the tissue model upon which the bone forms. Endochondral ossification occurs on a model of hyaline cartilage while intramembranous ossification occurs on a model of fibrous connective tissue. These precursors to bone are typically formed by the 4th or 5th week of fetal development. Ossification typically starts around the 8th week and continues until well after birth. With both types of ossification, the first bone formed is woven bone, which is then remodeled to produce mature, lamellar bone. To see an image of the skeletal development of the fetus go to this link:

<http://slideplayer.com/slide/6950698/24/images/57/The+extent+of+intramembranous+and.jpg>

Intramembranous Ossification

Intramembranous ossification begins when osteoprogenitor cells differentiate into osteoblasts. This typically occurs in the deeper layers of the dermis. ([Link to an image of Intramembranous Ossification](#) or see below).

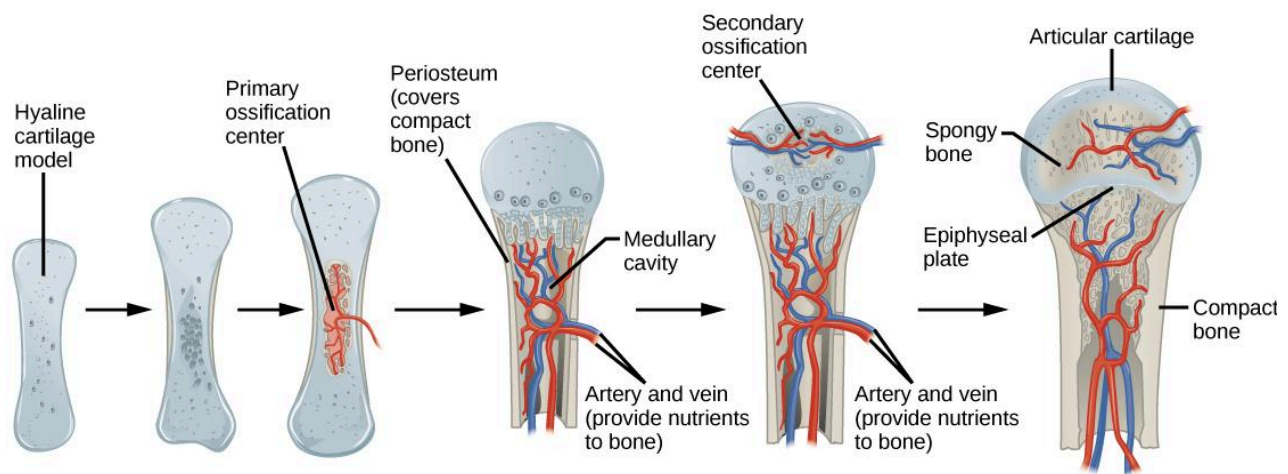


Intramembranous Ossification in four steps:(a) Mesenchymal (or osteochondral progenitor) cells group in clusters forming ossification centers in the connective tissue membrane and differentiate into osteoblasts.(b) Osteoid traps osteoblasts which become osteocytes.(c) Trabecular matrix and periosteum form (woven bone). (d) Compact bone develops under trabecular bone and blood vessels become red marrow. Author: OpenStax License: Creative Commons

Attribution 4.0 License. Link: https://opentextbc.ca/anatomyandphysiology/wp-content/uploads/sites/142/2016/03/611_Intramembraneous_Ossification.jpg

The process begins at one point in the membrane which is referred to as the **center of ossification**. The formation of the bone radiates out from these centers as thin trabeculae are produced which eventually develop into a solid mass of woven bone as more and more trabeculae are formed. As the bone grows, blood vessels invade the spaces between the trabeculae bringing cells which eventually develop into the bone marrow. In some bones more than one center of ossification will form and the two areas will grow together to produce the bone. Once the woven bone has been laid down osteoclasts begin the process of remodeling to form lamellar bone. The flat bones of the skull as well as the mandible and the clavicles are formed this way. The flat bones of the skull are not completely formed by birth leaving spaces or gaps between them. These areas that have not yet ossified are the fontanelles, or soft spots, seen on the baby's head. Also, the sutures have not developed yet so the bones are not tightly connected to each other. This allows for the baby's head to distort as it travels through the birth canal. It also allows for expansion of the baby's head as the brain grows. If the sutures fuse too early it can cause serious problems for the infant.

Endochondral Ossification



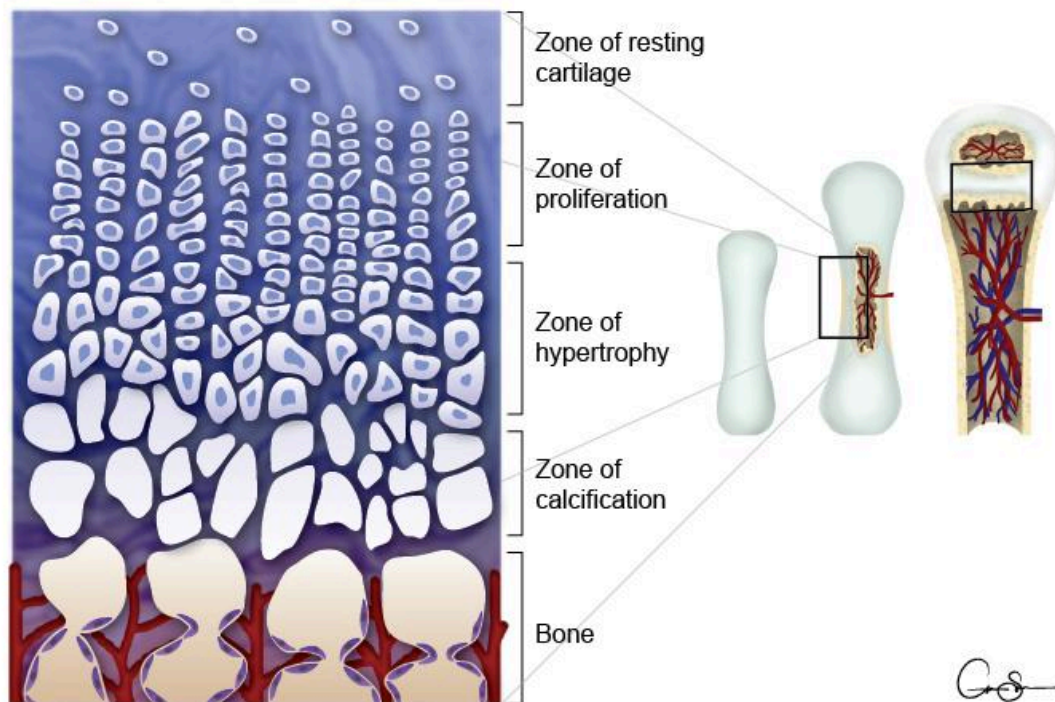
Endochondral Ossification. Title: Bone Structure; Author: OpenStax; Site:

<http://cnx.org/contents/FPtK1zmh@7.25:kwbeYj9S@4/Bone-Structure>; License: licensed under a Creative Commons Attribution 4.0 License.

Endochondral ossification involves the replacement of a hyaline cartilage model with bone tissue and is the primary method of formation of all of the other bones of the body. The process begins in the outermost edge of the cartilage model within the **perichondrium**. Newly converted osteoblasts (derived from osteoprogenitor cells) secrete osteoid, completely encasing the diaphysis and forming a structure called the **periosteal bone collar**. As the bone collar is forming, chondrocytes within the shaft begin to enlarge. They then begin to convert the cartilage matrix to calcified cartilage. Once the chondrocytes are encased in calcified cartilage they die, leaving a very porous material similar to Swiss cheese. Blood vessels, bringing with them precursor cells that differentiate into osteoblasts and osteoclasts, invade this porous matrix. This is occurring in the center of the diaphysis and is referred to as the **primary ossification center**. Within the ossification center osteoblasts arrange themselves on the calcified cartilage matrix and replace the calcified cartilage matrix with bone matrix, forming woven bone. The osteoclasts then go to work remodeling the woven bone into lamellar bone. In addition, they hollow out the center of the diaphysis forming the medullary canal. Above and below the primary ossification center the cartilage continues to grow, causing the bone model to elongate. As mentioned above, the primary ossification centers appear at about the 8th week of fetal development. Starting about one month before birth **secondary ossification centers** begin appearing in the epiphyses of the bones. The epiphyses will continue to ossify until all of the epiphyseal cartilage has been converted to bone with the exception of that on the articular surfaces of the bone and a band of cartilage between the epiphysis and the diaphysis. This band of cartilage is the **epiphyseal plate** or growth plate, which continues to grow via interstitial cartilage growth until we stop growing sometime after puberty.

The Zones of Endochondral Ossification

Endochondral Ossification (Long Bone Formation)



Endochondral Ossification. Image Created by BYU-Idaho student Cameron Sprouse Spring 2016

The image above summarizes how cartilage becomes bone. This happens at the ossification centers of the cartilage skeleton of fetal long bones. It also happens in the growth plates (shown in the square at the far right in the image above). Below is further description of the zones.

1. **Zone of resting cartilage:** Chondrocytes exist here but do not divide or grow.
2. **Zone of proliferation:** Chondrocytes are stimulated to divide in this region.
3. **Zone of hypertrophy:** Chondrocytes are stimulated to grow in size here. The chondrocytes become larger than any other area of the hyaline cartilage.
4. **Zone of calcification:** The large chondrocytes in the zone of hypertrophy are stimulated to lay down layers of calcium carbonate (a hard but molecularly different substance from hydroxyapatite). After this, the large chondrocytes die and leave the calcified lacunae.
5. **Bone:** Chondrocytes secrete substances that repel the attraction or growth of blood vessels into the cartilage tissue. With the death of the hypertrophied chondrocytes, blood vessels are not repelled but invade the calcified lacunae instead. The blood vessels bring osteoblasts that attach to the calcified walls and begin to develop hydroxyapatite. This is called woven bone now.
6. **Remodeling** occurs over time and new lamellar bone arises.

****Note:** As long as the zone of proliferation continues, new chondrocytes have to go somewhere and they push the other zones out which expands the length of the long bone. This is how our long bones grow.



This content is provided to you freely by BYU-I Books.

Access it online or download it at

https://books.byui.edu/bio_265_anatomy_phy_II/621_fetal_developmen.

