38.2D: Growth of Bone

Long bones lengthen at the epiphyseal plate with the addition of bone tissue and increase in width by a process called appositional growth.

Learning Objectives

• Describe the processes of post-fetal bone growth and bone thickening

Key Points

• The epiphyseal plate, the area of growth composed of four zones, is where cartilage is formed on the epiphyseal side while cartilage is ossified on the diaphyseal side, thereby lengthening the bone.

• Each of the four zones has a role in the proliferation, maturation, and calcification of bone cells that are added to the diaphysis.

• The longitudinal growth of long bones continues until early adulthood at which time the chondrocytes in the epiphyseal plate stop proliferating and the epiphyseal plate transforms into the epiphyseal line as bone replaces the cartilage.

• Bones can increase in diameter even after longitudinal growth has stopped.

• Appositional growth is the process by which old bone that lines the medullary cavity is reabsorbed and new bone tissue is grown beneath the periosteum, increasing bone diameter.

Key Terms

• metaphysis: the part of a long bone that grows during development
• **periosteum**: a membrane surrounding a bone
• **ossification**: the normal process by which bone is formed
• **chondrocyte**: a cell that makes up the tissue of cartilage
• **hypertrophy**: to increase in size
• **diaphysis**: the central shaft of any long bone
• **epiphysis**: the rounded end of any long bone
• **medullary**: pertaining to, consisting of, or resembling, marrow or medulla

## Growth of Bone

Long bones continue to lengthen (potentially throughout adolescence) through the addition of bone tissue at the epiphyseal plate. They also increase in width through appositional growth.

## Lengthening of Long Bones

The epiphyseal plate is the area of growth in a long bone. It is a layer of hyaline cartilage where ossification occurs in immature bones. On the epiphyseal side of the epiphyseal plate, cartilage is formed. On the diaphyseal side, cartilage is ossified, allowing the diaphysis to grow in length. The metaphysis is the wide portion of a long bone between the epiphysis and the narrow diaphysis. It is considered a part of the growth plate: the part of the bone that grows during childhood, which, as it grows, ossifies near the diaphysis and the epiphyses.

The epiphyseal plate is composed of four zones of cells and activity.

1. The reserve zone, the region closest to the epiphyseal end of the plate, contains small chondrocytes within the matrix. These chondrocytes do not participate in bone growth; instead, they secure the epiphyseal plate to the osseous tissue of the epiphysis.
2. The proliferative zone, the next layer toward the diaphysis, contains stacks of slightly-larger chondrocytes. It continually makes new chondrocytes via mitosis.
3. The zone of maturation and hypertrophy contains chondrocytes that are older and larger than those in the proliferative zone. The more mature cells are situated closer to the diaphyseal end of the plate. In this zone, lipids, glycogen, and alkaline phosphatase accumulate, causing the cartilaginous matrix to calcify. The longitudinal growth of bone is a result of cellular division in the proliferative zone along with the maturation of cells in the zone of maturation and hypertrophy.
4. The zone of calcified matrix, the zone closest to the diaphysis, contains chondrocytes that are dead because the matrix around them has calcified. Capillaries and osteoblasts from the diaphysis penetrate this zone. The osteoblasts secrete bone tissue on the remaining calcified cartilage. Thus, the zone of calcified matrix connects the epiphyseal plate to the diaphysis. A bone grows in length when osseous tissue is added to the diaphysis.

After the zone of calcified matrix, there is the zone of ossification, which is actually part of the metaphysis. Arteries from the metaphysis branch through the newly-formed trabeculae in this zone. The newly-deposited bone tissue at the top of the zone of ossification is called the primary spongiosa. The older bone at the bottom of the zone of ossification is called the secondary spongiosa.
Figure 1: **Longitudinal bone growth**: The epiphyseal plate is responsible for longitudinal bone growth. This illustration shows the zones bordering the epiphyseal plate of the epiphysis. The topmost layer of the epiphysis is the reserve zone. The second zone, the proliferative zone, is where chondrocytes are continually undergoing mitosis. The next zone is the zone of maturation and hypertrophy where lipids, glycogen, and alkaline phosphatase accumulate, causing the cartilaginous matrix to calcify. The following zone is the calcified matrix where the chondrocytes have hardened and die as the matrix around them has calcified. The bottom-most row is the zone of ossification which is part of the metaphysis. The newly-deposited bone tissue at the top of the zone of ossification is called the primary spongiosa, while the older bone is labeled the secondary spongiosa.

Bones continue to grow in length until early adulthood with the rate of growth controlled by hormones. When the chondrocytes in the epiphyseal plate cease their proliferation and bone replaces the cartilage, longitudinal growth stops. All that remains of the epiphyseal plate is the epiphyseal line.
Figure 1: From epiphyseal plate to epiphyseal line: As a bone matures, the epiphyseal plate progresses to an epiphyseal line. (a) Epiphyseal plates are visible in a growing bone. (b) Epiphyseal lines are the remnants of epiphyseal plates in a mature bone.

Thickening of Long Bones

While bones are increasing in length, they are also increasing in diameter; growth in diameter can continue even after longitudinal growth ceases. This is called appositional growth. Osteoclasts, cells that work to break down bone, resorb old bone that lines the medullary cavity. At the same time, osteoblasts via intramembranous ossification, produce new bone tissue beneath the periosteum. The erosion of old bone along the medullary cavity and the deposition of new bone beneath the periosteum not only increase the diameter of the diaphysis, but also increase the diameter of the medullary cavity. This process is called modeling.