Lecture 7

The skeletal system I - Bone Development

Plan of the Lecture

1. Tissues and Organs of the Skeletal System
    a. Functions of the Skeleton
    b. Bones and Osseous Tissue
    c. General Features of Bones
2. Bone Development
    a. Intramembranous Ossification
    b. Endochondral Ossification
    c. Bone Growth and Remodeling
        i. Bone Elongation
        ii. Bone Widening and Thickening
        iii. Bone Remodeling

LEARNING OUTCOMES

1. name the tissues and organs that compose the skeletal system;
2. state several functions of the skeletal system;
3. distinguish between bone as a tissue and as an organ;
4. describe the general features of a long bone and a flat bone.
5. describe two mechanisms of bone formation; and
6. explain how mature bone continues to grow and remodel itself.

The skeleton plays at least six roles: 1. Support. Bones of the limbs and vertebral column support the body; the mandible and maxilla support the teeth; and some viscera are supported by nearby bones. 2. Protection. Bones enclose and protect the brain, spinal cord, heart, lungs, pelvic viscera, and bone marrow. 3. Movement. Limb movements, breathing, and other movements are produced by the action of muscles on the bones. 4. Electrolyte balance. The skeleton stores calcium and phosphate Ions and releases them into the tissue fluid and blood according to the body's physiological needs. 5. Acid–base balance. Bone tissue buffers the blood against excessive pH changes by absorbing or releasing alkaline phosphate and carbonate salts. 6. Blood formation. Red bone marrow is the major producer of blood cells, including cells of the immune system.

The general anatomy of a long bone. Much of it is composed of an outer shell of dense white osseous tissue called compact (dense) bone. The shell encloses a space called the medullary cavity or marrow cavity, which contains bone marrow. At the ends of the bone, the central space is occupied by a more loosely organized form of osseous tissue called spongy (cancellous) bone. A narrow zone of spongy bone also

occurs just inside the compact bone of the shaft and in the middle of most flat, irregular, and short bones. The skeleton is about three-quarters compact bone and one-quarter spongy bone in dry weight. Spongy bone is always enclosed by a shell of more durable compact bone.

The principal features of a long bone are its shaft, called the diaphysis, and an expanded head at each end called the epiphysis. The formation of bone is called ossification or osteogenesis. There are two methods of ossification—intramembranous and endochondral. Both begin with embryonic mesenchyme. Endochondral ossification is a process in which a bone develops from a preexisting model composed of hyaline cartilage. It begins around the sixth week of fetal development and continues into a person's 20s. Most bones of the body develop in this way, including the vertebrae, ribs, sternum, scapula, pelvic girdle, and bones of the limbs. In this lecture we will show the following steps in endochondral ossification. This lecture uses a metacarpal bone from the palmar region of the hand as an example because of its relative simplicity, having only one epiphyseal plate (growth center). Many other bones develop in more complex ways, having an epiphyseal plate at both ends or multiple plates at each end, but the basic process is the same.

The epiphyseal plate consists of typical hyaline cartilage in the middle, with a transitional zone on each side where cartilage is being replaced by bone. The transitional zone, facing the marrow cavity, is called the metaphysis. Thus, bone elongation is really a result of cartilage growth.

Cartilage growth from within, by the multiplication of chondrocytes and deposition of new matrix in the interior, is called interstitial growth. The most common form of dwarfism results from a failure of cartilage growth in the long bones. Bones also continually grow in diameter and thickness. This involves a process called appositional growth, the deposition of new tissue at the surface. Cartilages can enlarge by both interstitial and appositional growth. In bone, however, osteocytes embedded in calcified matrix have little room to spare for the deposition of more matrix internally. Bone is therefore limited to appositional growth. Wolff's law of bone states that the architecture of a bone is determined by the mechanical stresses placed upon it, and the bone thereby adapts to withstand those stresses.

Check yourself! The questions for self-control

1. Name at least five tissues found in a bone.
2. List three or more functions of the skeletal system other than supporting the body and protecting some of the internal organs.
3. Explain the difference between compact and spongy bone, and describe their spatial relationship to each other in a long bone and a flat bone. 4. State the anatomical terms for the shaft, head, growth zone, and fibrous covering of a

long bone.

5. Describe the stages of intramembranous ossification. Name a bone that is formed in this way.
6. Describe how a cartilage model is transformed into a long bone in endochondral ossification.
7. Describe the five zones of a metaphysis and the major distinctions between them.
8. How does Wolff's law explain some of the structural differences between the bones of a young child and the bones of a young adult?

Recommended readings:

1. Kenneth S Saladin - Anatomy & Physiology. The Unity of Form and Function (2016, McGraw-Hill Education)
2. Barbara Gylys - Medical Terminology Systems (2012, F.A. Davis Company)