2
SKELETAL HISTOLOGY AND THE FORMATION OF BONE

Histology, or microscopic anatomy, is a vital part of human anatomy especially if one is to understand pathological conditions and injuries as there is not a disease known that does not affect both the cells and tissues. This would include aspects of Connective tissues (as found in Tendons, Ligaments, bones, cartilage, and blood,) Nervous tissue (peripheral and central), Contractile tissues (striated skeletal and cardiac muscle and smooth muscle), and Epithelial/Endothelial tissue.

When it comes to organizing an organism, cells are the basic units of life which come together with matrix to form tissues. Tissues come together to form organs followed by organ systems and the entire organism. Many students get caught up early attempting to learn all tissues and the properties. I will use the model that function determines structure and attempt to simplify histology to present it later in a more complex clinical histology.

In essence, a tissue is a collection of cells held together by a matrix which can include almost anything. In tissues, cells work in concert to perform certain and specific functions. These functions are dependent on the structure of the tissue. As matrix can be just about anything, it will suffice to say that it is the non-cellular aspect of tissue.

There are four classes of tissues that are divided into more specific tissue types. The first is Epithelia/Endothelial tissue. The simplest way to look at the type of tissues is to look at how they are microscopically similar. We can begin with the relative amount of matrix within it. Looking at epithelial/ endothelial tissue. This tissue usually lines organs. It is found inside the lumen of body tubes, lining body cavities, the outer layer of skin, and the alveoli. If we look at the tissue itself, we see many cells with the matrix being found predominantly in the basement membrane, or the floor holding the cells together.

For the most part the major difference between epithelial and endothelial tissue is where in the body it is found. As the root endo means inside than the tissue lining blood vessels is endothelium. Epi means top so the tissue on top of your skin is epithelium. This tissue's characteristic is many cells with little matrix which is found on the bottom layer called the basement membrane. The cells in this tissue can be either simple (one cell layer thick) or stratified (many layers). Besides the layers, this tissue can have variations on cell shape. The three major types can be squamous or flat, cube shaped (cuboidal) or Columnar.

Connective tissues, the most numerous in the human body, are made up of more matrix than cells. This is seen in blood, tendons, ligaments, etc. These tissues connect the body and allow the support needed to maintain life. There is one tissue that is an exception to this rule which is adipose, or fat, tissue.

The next two tissues are classified by their functions. Contractile tissue is found in the musculoskeletal system, myocardium, and on skin, blood vessels, and intestines. These three types of are called; Striated skeletal muscle, striated cardiac muscle, and smooth muscle. The last classification is Nervous tissue which is the tissue that sends messages. This tissue can be found everywhere as there is a constant amount of information entering and leaving the body.

Those who have not studied the skeletal system think that bone is only a dry tissue, this is far from true. The skeletal system has many different tissues and even osseous tissue, that forms our bones, is dynamic. Before we get into all the parts, we will begin to look at the tissues.

Cartilage has many different functions in the formation of, adult, and support of the skeletal system. There are three types of Cartilage, each has a particular the function. Hyaline is the most abundant type. It has a smooth look to it and is formed by a cell called a Chondroblast (chondro for cartilage and blast for maker.) When the tissue is complete a cell, called a chondrocyte, (cyte for bag or in this case a cell) occupies a cavity called a lacuna. This type of cartilage provides support, elasticity, and resistance. It is the cartilage that is the precursor for the long bones of the skeletal system.

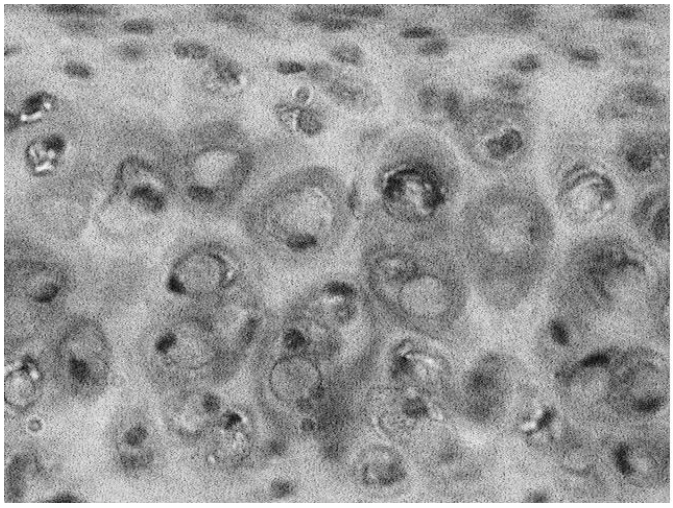
Next, we have elastic Cartilage which is made of bent strands of collagen and elastin which is found in epiglottis and external ear. It gives flexibility as will be needed in these areas. The last type of cartilage found in the human body is Fibrocartilage. Fibrocartilage is found in joint spaces that are under weighted stress. Looking at all cartilages, we see chondrocytes surrounded by matrix. This is because the Chondroblast in surrounding perichondrium start secreting the cartilage matrix and becomes trapped inside.

1. Where is each cartilage found in an adult human?
   a. Hyaline cartilage

   b. Elastic cartilage

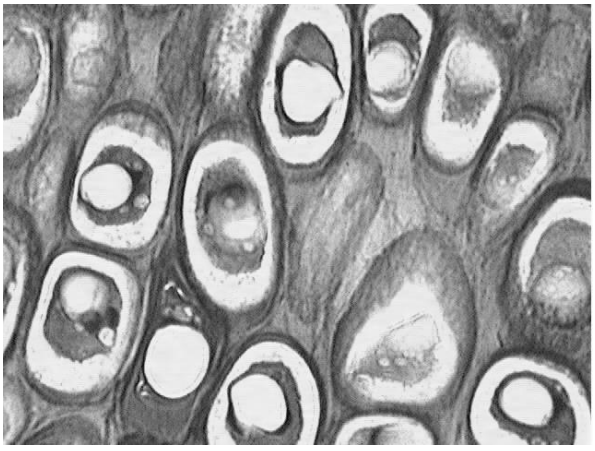
   c. Fibrocartilage

2. Copy what is seen on a slide of hyaline cartilage at highest magnification



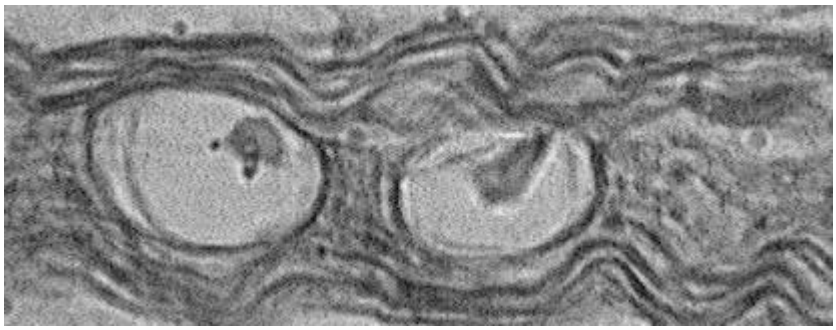
3. What are the properties of the tissue above?

4. Draw what is seen in a slide of elastic cartilage at highest magnification



5. What are the properties of elastic cartilage?

6. Copy what fibrocartilage at highest magnification



7. What are the properties of fibrocartilage properties?

8. Define chondro-

Intramembranous ossification:

Before talking about how osseous tissue looks, it helps to know how it was first made. The process of bone making is called Osteogenesis. It starts on week eight post-conception. It is important to remember that all cartilage and bone cells are form the mesoderm. Early during the third week when the primitive streak starts to form, some cells become a rod like structure called the notochord (making the embryo a chordate) this initiates neuroplate formation.

Late in week three, an invagination of ectoderm occurs being called the neural tube. This will become the brain and spinal cord. On about day twenty, some cells from the mesoderm begin to differentiate into what are called Somites. These will divide into three parts, the important one for bone development is the sclerotome (sclero means hard tome is layer) which will migrate and gather around the notochord and the neural tube.

The sclerotome will become a mesenchyme membrane made up of a special connective tissue, called Mesenchymal connective tissue, and surround the brain and spine and remain a mesenchymal membrane which will become the skull and vertebrae. In the areas that will become long bones, this membrane is invaded by chondrocytes that will lay down hyaline cartilage to form the first skeleton of the embryo.

On week eight, Osteogenesis begins in two ways. Intramembranous Ossification bone forms membrane bone (bones of the skull and clavicles). Cells of the mesenchymal membrane become osteoblast (Osteo= bone blast=maker). The cells begin to secrete organic bone matrix (mostly collagen) and form a structure called an osteoid, trapping themselves within it. Osteoids formed around embryonic blood vessels leading to the formation of a woven structure. Together this leads to a structure called an Osteon composed of a central canal holding a blood vessel and nerve. This protein matrix is fixed with inorganic calcium phosphates salts, called hydroxyapatite, which mineralize the bone matrix under the influence of osteoblast.

Endochondral ossification

Long bones of the arms and legs are made via Endochondral ossification. First, the mesenchymal membrane modifies and becomes perichondrium. The cells of the membrane differentiate into chondroblast. Once a cartilage bone model is made, bone begins to be formed within the model. In stage one, the perichondrium surrounding the cartilage model becomes periosteum and osteoblast form a bone collar around the middle of the cartilage shaft (called the diaphysis).

On Stage two, the chondrocytes within the diaphysis enlarge and the surrounding cartilage matrix calcifies cutting the living cell from nutrients killing it. This only affects the cartilage in the diaphysis, the other chondrocytes continue to grow making the skeleton longer at the ends of the bone called the epiphysis. As stage two ends a cavity develops within the diaphysis, this area is invaded by an artery and vein that will feed the osteocytes and the stem cells that will from the bone marrow. Along with this, osteoclast (osteo=bone clast= breaker), form. These will erode the calcified cartilage and osteoblast, which secret bone matrix, enter the cavity. Together these items make up the periosteal bud. Osteoblasts begin to make bone as described pervious getting trapped within the osteoid making an osteon. Cartilage continues to elongate at the epiphysis. The area closest to bone will calcify and be invaded the periosteal bud.

After birth the center area of the epiphyses calcifies and degenerates then a periosteal bud enters and starts a

secondary ossification center. After the second ossification center grows there are only two places that cartilage is found on bone, the epiphyseal plates, between both ossification center, and on the articulation surfaces. As child grows the epiphyseal plate continues to grow until adulthood when the cartilage mitotic activity is exhausted and bone formation catches the plate.

The last way that bone can grow is through appositional growth. Appositional bone growth occurs so to widen bones or for the grow and development of short bones. Osteoblast in the periosteum secret bone.

Bone remodeling and repair of fractures.

Bone is a dynamic organ constantly being built up and torn down. Bone deposition is under the effect of osteoblasts (Back to bone) which take Calcium (Ca) and integrate it to the matrix. Bone reabsorption is under accomplished by osteoclast. Osteoclasts secrete hydrochloric acid (HCl) onto bone causing it to dissolve the minerals. In concert, this can help maintain normal Calcium ion levels in blood.

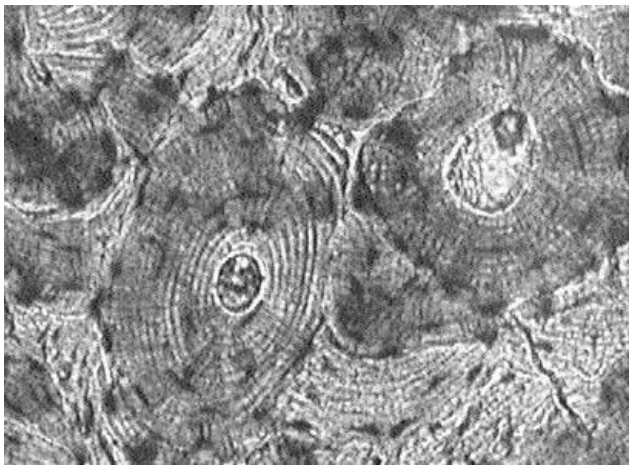
Fractures are breaks in bone and as bone breaks, so does the artery inside. This leads to pooling of blood within a cavity held in place by the periosteum which is called a hematoma. Fibroblast (fiber makers) and clotting factors come in and clot the blood. Next, Chondrocytes are sent to the tissue and secrete a fibrocartilage matrix leading to the formation of a soft callus.

Once the soft callus is formed, osteoblasts are sent in to convert the cartilage into bone. Once the soft callus becomes bone, it is called a hard callus. The hard callus is usually large than the surrounding bone so the hard callus must be reshaped to restore function. The removal of bone is done via Osteoclast.

As you are aware different organs are made from different tissues. In lecture you have gone over the tissues that are found in bone, most of which are connective tissues. This is a histology lab in that you will have to draw out most of what you see in microscope.

9. Define the following:
   a. Osteo-
   b. Cyte-
   c. Blast-
   d. Clast-
   e. Intra-
   f. Endo-
   g. Peri-
   h. Sclero-
   i. Tome-

10. Copy the image of ground bone, label the central canal, Canaliculi, lacuna, and osteocyte.



11. What is the name of the tissue of question 11?

12. Which of the families of tissues does it fall into?

13. What cells form this tissue above?

14. What cells break it down?

15. What type of bone needs cartilage to form?

16. What the type of Ossification which needs cartilage called?

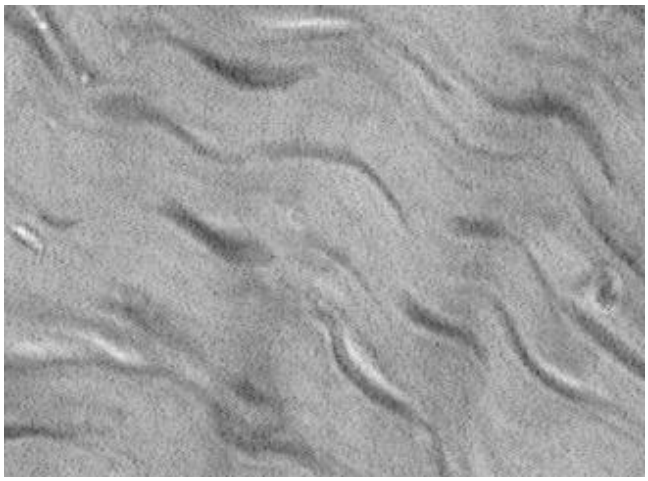
17. Where is cartilage found in a pre-pubescent person?

18. Where is cartilage found in adults?

Connecting bone to bone are ligaments and connecting muscle to bone are tendons which are usually composed of dense regular connective tissue. This tissue is formed by cells called fibroblast (fibro=fibers blast=maker) which secrete collagen and some elastic fibers. Unlike bone, dense regular connective tissue is mostly composed of cells within a matrix which lack a blood supply. This means that while the tissue is extremely durable, if it is damaged it may continue to cause problems though out life. After staining, the nucleus of the fibrocytes (fibroblast stuck in the tissue) becomes visible as a dark elongated structure within a collection of collagen fibers.

A specialized connective tissue that can sometimes be found in the ligaments of looser joints is the dense irregular connective tissue. This tissue is like the dense regular connective tissue but for the nuclei maintaining their round shape and an irregular arrangement of the collagen fibers. It is important to note that dense irregular connective tissue can also be found in the second layer of skin called the dermis, around bones as a membrane called the periosteum, and around cartilage called the perichondrium. As can be noticed Peri- will mean around.

19. Copy the image of what is seen in Dense regular connective tissue at highest magnification, Label the cells that make this tissue. Draw in the collagen fibers.



20. Name two places in the skeletal system where the tissue above is found can be found.

21. What fibers make this tissue?

22. Look at a slide of dense irregular connective tissue and draw it next to the picture provided. Note the difference in appearance compared to the Dense Regular connective tissue then draw and label what you see in dense irregular connective tissue.