PHYT 622 Clinical Gross Anatomy

Introduction

Overview of the course

- Staff
- Lectures; Days, Times, Locations
- Labs; Types, Days, Times, Locations
- Texts
- Cadavers – Assignments to dissection groups
- Exams; Format
- Schedule

Let's Get Started

Lecture One; Connective Tissue

- Supporting Tissues of the body; e.g., fascia, areolar, ligaments, joint capsules, tendons and the modified CT such as cartilage and bone
- In general
  - Does not form an organ or organ system, although it does form a significant portion of the skeletal system
  - The most widely distributed and fundamental tissue and is found everywhere

CT General (Continued)

- CT is essential to the structure and function of other tissues and organs
- Without it, organs would collapse and be shapeless and would lack vital protection
- Without CT, the body would be a quivering mass of protoplasm

CT General (Continued)

- Specific Functions
  - Binds structures together
  - Supports structures where rigidity is called for
  - Protects organs with sheaths or capsules, or, when necessary, bones or cartilage
  - Partitions parts of the body
  - Unites dissimilar tissue such as muscle + bone
  - Fills the empty spaces of the body
  - Provides the framework throughout the body through which vessels and nerves may proceed to their respective destinations

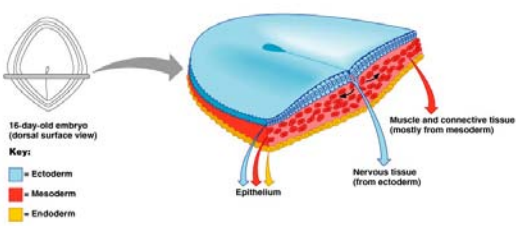
General (Continued)

- You will treat more CT injuries than any other soft tissue
- From fascia to tendons to ligaments to joint capsules
- Type, location, density etc. will dictate type of treatment

Origin of CT

- Develops in mesodermal germ layer along with muscle and bone
- Overview of three germ layers
  - Ectoderm
  - Mesoderm
  - Endoderm

Germ Layers



Mesoderm

- Comprised of primitive cells called mesenchyme
- In the embryo – is a mass of unspecialized cells
- Supports embryo much in the way it will support body in later life
- As embryo increases in size and shape changes, mesenchyme can not complete function – needs more support

Mesoderm (Continued)

- At this point, specialization of cells begins to occur. Cells are genetically programmed to develop into specific type of CT
- A mass of undifferentiated cells begins to develop into specific types of CT
- Some cells remain dormant, develop later when needed –remain programmed

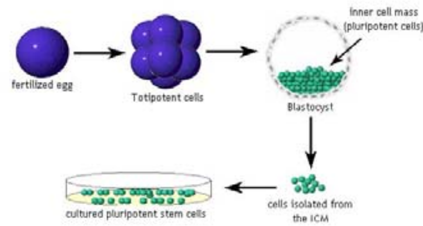
Stem Cells

http://www.time.com/time/2001/stemcells

Stem Cells

- Totipotent, Pluripotent, Multipotent
- Embryonic stem cells- properties
  - Pluripotent (NOT totipotent)
  - Give rise to three primary germ layers: ecto, endo and mesoderm
  - Can reconstitute into germ line (at least in mice)
  - Capable of self-renewal or commitment

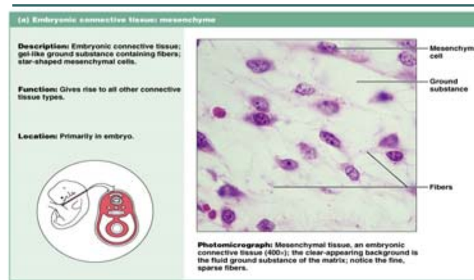
Embryonic Stem Cell Origin



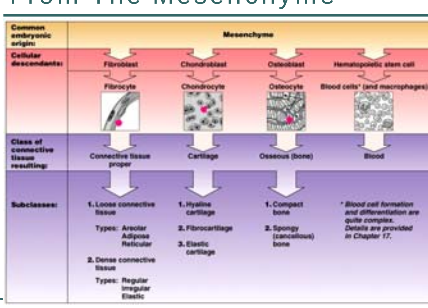
Components of CT

- All CT made up of same components, percentage or arrangement of components depends on function of CT
- Components are CT cells, fibers, and extracellular matrix (ECM)

CT Components



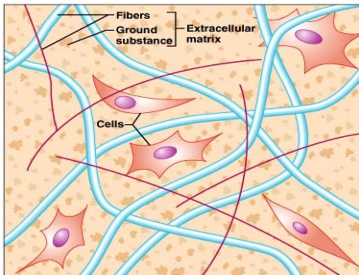
From The Mesenchyme



CT Cells

- Fibroblasts = fiber forming
  - Provide a structural framework for many tissues
  - Predominant cell in CT whose primary function is to maintain the structural integrity of CT
    - Secrete precursors of extracellular matrix (ECM) fibers evolve and give each type of CT its specific structure
- Also made up of cells found elsewhere in the body
  - adipocytes, WBC, melanocytes and macrophages

Cells and Fibers

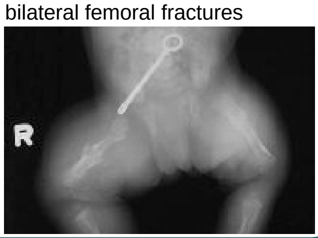


CT Fibers

- The outstanding characteristic of CT and are directly concerned with function-Collagen makes up 80% of CT
- Collagenous fibers – made from several types of collagen, Primarily Type I.
  - Found where strength and support is needed or where a firm union is required – e.g., ligaments have lots of collagen
  - Collagenoses, familial disease, is a disease characterized by the destruction of collagen

Osteogenesis Imperfecta

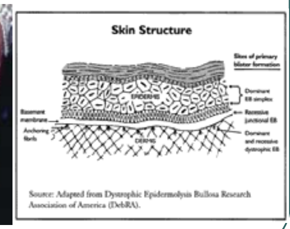
- Collagen I: fibrillar
- Newborn with bilateral femoral fractures



http://www.emedicine.com/PED/topic1674.htm

Epidermolysis Bullosa

- Collagen VII: Anchoring Fibrils



Types of Collagen

- Type I – Found in tendons, ligaments, bone and stratum fibrosum – 70-80% of dry weight
- Type II – Found in hyaline cartilage and annulus fibrosis
- Type III – Skin and stratum synovium
- Type XI – Articular cartilage

CT Fibers (Continued)

- Elastic fibers = made from protein elastin
- Not rigid and un-yielding, are elastic in nature
- Found where flexibility is needed
  - Blood vessels, lungs, skin, bladder
- Around vital organs – these change in size and volume – need support but not rigidity
- Can be found in ligaments where more flexibility is needed

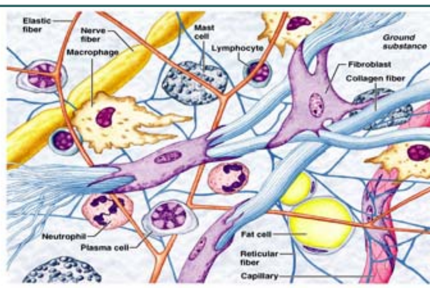
CT Fibers (Continued)

- Reticular fibers = made from protein reticulin
- Form a delicate network of supporting structures around individual cells or portions of some organs
- The fine mesh of CT around blood vessels and nerves would be a good example

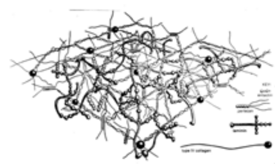
Extracellular Matrix

- Sometimes synonymous with:
  - Basement membrane (specialized ECM)
  - Ground substance (non-collagenous components)
- Made up of proteoglycans
  - Chondroitin sulfate, heparan sulfate, keratan sulfate
- Carbohydrates
  - Hyaluronic acid (non-proteoglycan) – a polysaccharide
- Various Collagens
- Up to 20% H_20
- Varies in consistency
- Some CT, like ligaments, cartilage and bone, requires a dense or firm matrix for strength

Matrix

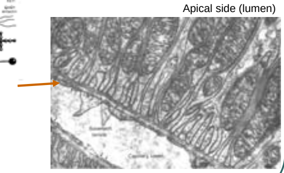


Basement Membrane



Section of kidney epithelium

Apical side (lumen)

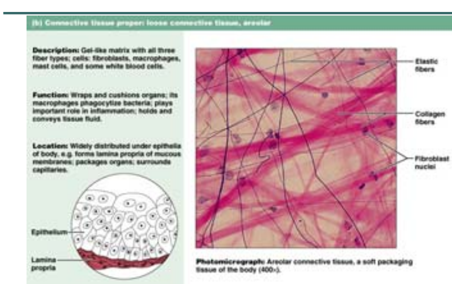


http://www.cytochemistry.net/microanatomy/epithelia/epith_lec.htm

Types of CT

- Two Broad categories – Loose and Dense
- Loose
  - Has all the components of CT but matrix is soft
  - Found where packing or anchoring material is necessary, not extreme strength
  - E.G., mesenchyme of embryo, loose areolar and adipose tissue

Loose CT, I.E., Areolar



Dense CT

- Three varieties: irregularly arranged, regularly arranged and elastic tissue
- Irregularly arranged
  - Stronger than loose CT, more collagen – I.E., fascia (subcutaneous tissue or superficial fascia, plantar fascia, etc.)
  - Also, capsules, perichondrium, periosteum

Regularly Arranged CT

- Ligaments, aponeuroses, tendons
- Ligaments
  - Essentially unite bone to bone – not that simple
  - Made up of closely packed Type I collagen fibers – arranged nearly in parallel manner to give tensile strength
  - Arrangement of Collagen Fibers
    - Less parallel in ligaments to allow these structures to sustain predominant tensile strength in one direction and smaller stresses in other directions
    - Nearly parallel in tendons to allow them to withstand high unidirectional loads

Ligaments (Continued)

- Ligaments are expansions of the synovial joint capsule (AKA fibrous joint capsule)
- Surround all freely moveable or synovial joints (AKA diarthrodial joints)
- Joint capsule can be thought of as an envelope that encapsulates the entire joint
- The space between joints is called the joint space or cavity

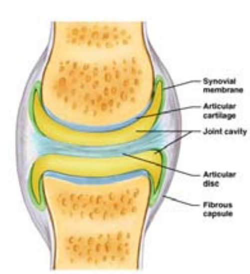
Ligaments (Continued)

- Two Layers of Joint capsule – stratum fibrosum and stratum synovium
- Stratum Fibrosum
  - Outer layer
  - Formed from tough, fibrous CT
  - Anchored to bone via Sharpey's fibers
  - Poor vascularization, rich in nerve supply – especially paint, temp, position sense (proprioception – joint position, speed of movement, etc.)
  - Relatively inelastic, main role is to restrict and guide

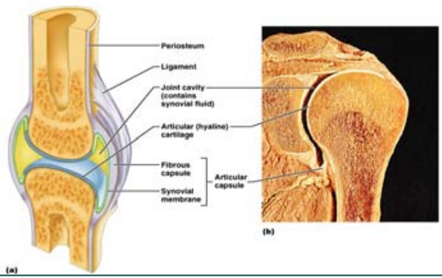
Ligaments (Continued)

- Stratum Synovium
  - Inner layer
  - Referred to as synovial membrane
  - Rich in blood supply, poorly innervated
  - Manufactures synovial fluid – aka hyaluronic acid – clear, pale yellow – does not clot – fairly sparse in most joints - hemarthrosis
  - Essential in nutrition of joint, especially cartilage
  - Lubricates joint – has a viscosity (viscosity decreases with as joint movement increase; increases as joint movement decreases) – also temperature dependent
  - synovitis

Joint Capsule



Joint Capsule Cont.



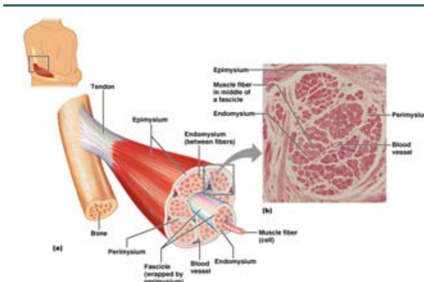
Ligaments (Continued)

- When, over the course of development or evolution, a joint requires more stability than the capsule itself can provide, it thickens in the appropriate locales and we refer top it as a ligament
- Many joints do not have named ligaments, simply have capsular support
- Most ligaments are extracapsular – outside the actual bony union
- Some are intracapsular – e.g., ACL – developmental are extracapsular
- plica

Tendons

- Functions
  - Attach muscle to bone
  - Transmit tensile loads from muscle to bone, thereby producing joint motion
  - Forces transmitted with relatively little loss of force

Tendons



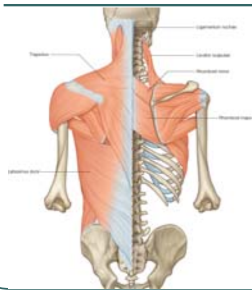
Tendons (Continued)

- Made up of highly arranged collagen
- Frequently surrounded by a sheath or capsule, much like a joint capsule, called the tenosynovium to lubricate and protect tendon
- Especially true if tendon moves a great deal, i.e. long finger flexors
- Also, some places where a tendon passes over a bony prominence, may see a fluid filled sac called a bursa, i.e. subacromial/subdeltoid in the shoulder

Aponeuroses

- A broad, flat tendonous sheath
- Serves as a large, usually origin, of a muscle – i.e. origin of latisimus dorsi
- Generally, this type of muscle has broad/large origin, relatively small insertion, therefore is powerful

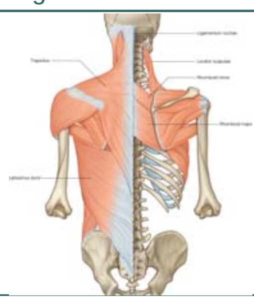
Aponeurosis



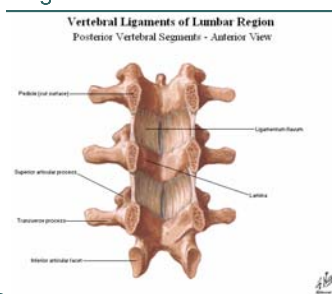
Elastic Tissue

- Yellow elastic ligaments – many elastic fibers
- Found where flexibility is required and where elastic effect (i.e. rebound) is needed
  - Ligamentum nuchae and liagmentum flavum
- Can store energy and assist muscular effort

Ligamentum Nuchae



Ligamentum Flavum



Common CT Injuries

- Inflammation
  - Tendonitis, faciitis, synovitis
- Associated injury reactions
  - Pain
  - Swelling
  - Decreased mobility
  - Adhesions
    - Adhesive capsulitis (frozen shoulder)

Modified CT

- Structures similar to connective tissue, difference is matrix will develop into more highly structured substance to provide more support and stability
  - Cartilage and bone

Modified CT (Continued)

- Cartilage
- Structurally different from CT in that the matrix is quite solid, consisting of chondrotin sulfate and glycoproteins
- Still has flexibility due to presence of CT fibers

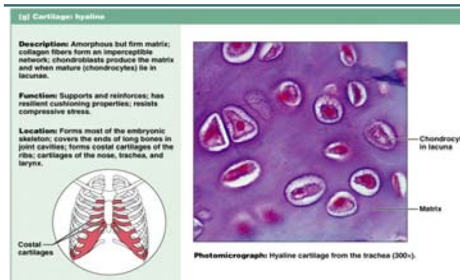
Cartilage (Continued)

- Develop from the mesenchyme
- Composition of matrix differs early
- Chondroblasts
  - Surrounded by fibers and secreted matrix
- As chondroblasts develop and matures, the matrix surrounding it stiffens

Cartilage (Continued)

- Chondroblasts become embedded in matrix and mature into chondrocytes (mature cartilage cells)
- The spaces within the matrix in which the cells lie are called lacunae
- The quality of the matrix is rubbery and resilient.
- Matrix is avascular

Matrix



Cartilage (Continued)

- The developing cartilage is surrounded by a thin fibrous layer of CT membrane that is vascular called the perichondrium
- Developing chondrocytes depend on diffusion of nutrients through the matrix from capillaries in the perichondrium or from synovial fluid in the joint cavity
- The reverse is true regarding waste removal

Cartilage (Continued)

- Initial growth of cartilage is called **interstitial** growth – chondrocytes divide within the matrix
- Later growth, as the matrix becomes harder and harder, is called **appositional** growth as it is impossible for cells to divide – growth can only occur on the borders of the matrix as though it is being added on to. The Perichondrium provides the fibroblasts for this
- Metabolism of cartilage is slow, repair difficult at best due to limited blood supply

Types of Cartilage

- Basically, three types; depending on the consistency of the matrix = hyaline, elastic and fibrocartilage
  - Hyaline (AKA Articular) cartilage
  - Found on the ends of all articulating bones in moveable joints, also the costal cartilages of 9 ribs, nasal cartilage and the walls of the respiratory passages
  - Also the cartilage used in the cartilage model of bone development (fetal cartilage)
  - Appears smooth and translucent
  - Surrounded by a thin layer of perichondrium ***except*** in the case of articular cartilage
  - The hyaline cartilage's only source of nutrition is from the synovial fluid in joint capsule

Purposes of Articular Cartilage

- Distribute joint loads over a wide area, thus decreasing the stresses sustained by the contracting joints
- To allow relative movement of opposing joint surfaces with minimal friction and wear
- Osteoarthritis AKA DJD vs. RA

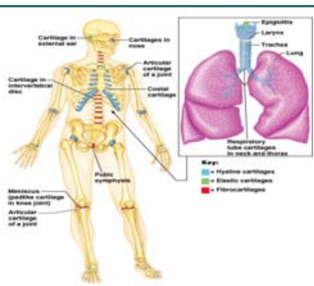
Types of Cartilage (Continued)

- Elastic
  - Has a yellow color dues to presence of elastic fibers
  - Found in epiglottis, larynx, external ear

Types of Cartilage (Continued)

- Fibrocartilage
  - Has a very tendonous character, lots of collagen in the matrix
  - Is tough, capable of withstanding compression
  - Found between semi-moveable joints such as the intervertebral disc and the pubic symphysis
  - Also, the type of cartilage seen in joints where more support or an increase in surface area is needed
    - menisci of the knee, glenoid labrum of the shoulder, sterno-clavicular joint

Types of Cartilage



Bone – the ultimate modification of CT

- Bone provides protection for the body, especially the brain, spinal cord, heart, lungs, and viscera
- Serves as the attachments for and, hence, the levers for skeletal muscle necessary for movement and locomotion
- Bone is also an ion reservoir – a storage center for for mineral salts
- Bone is a center for the production of RBC

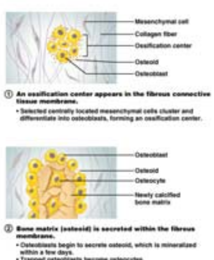
Bone (Continued)

- Characterized by both strength and flexibility
- Tensile strength of cast iron
  - Yet, it "gives"
- Relatively light weight
- Strength combined with light weight due to sound engineering principles:
  - Hollow tubular construction
  - Lamination
  - Reinforced matrix

Bone (Continued)

- Development of bone called ossification
- Generally begins about 6 weeks in embryonic life and continues throughout adulthood
- Two ways to develop bone, directly called **intramembranous** ossification or from a hyaline cartilage model called **endochondral** ossification
- Few bones develop via intramembranous
  - mandible, portions of skull, parts of clavicle

Intramembranous Ossification



Endochondral Ossification

- Mesenchymal condensation leads to development of a cartilage model
- Capillaries invade the perichondrium and transform it into periosteum
- Chondrocyte differentiation and hypertrophy then apoptotic death followed by mineralization of cartilage matrix
- Vascular invasion allow for migration of osteoblasts which deposit bone matrix
- Chondrogenesis at the ends of long bones establishes the formation of growth plates
- Secondary centers of ossification begin later in fetal life

Endochondral Ossification

Growth Plate Zones

- Growth plates serve as a continuous source cartilage conversion to bone, promoting linear growth

  1. Reserve Zone – randomly arranged, spherical chondrocytes

  2. Proliferative Zone – regularly arranged columnar discoid chondrocytes

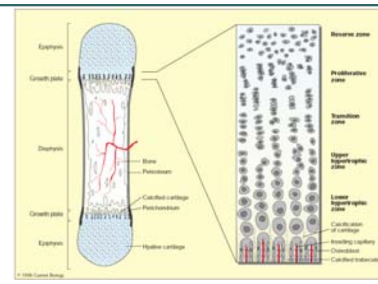
  3. Prehypertrophic Zone – growth ceases to be result of cell division (hyperplasia) and continues by increasing cell size (hypertrophy)
  - Once glycogen stores are depleted chondrocytes undergo apoptosis leaving behind longitudinal lacunae seperated by septae of cartilaginous matrix which becomes selectively calcified
  - Vascular invasion ensues as new blood vessels enter the lower hypertrophic zone

Endochondral Ossification: Growth Plate Zones (cont.)

4. Hypertrophic Zone –

- Calcified cartilage is removed by chondroclasts that accompany the invasive angiogenic process
- The remaining longitudinal septae which now extend into the diaphysis, are used by osteoblasts from bone marrow to settle down and lay down ECM which then calcifies into woven bone
- With time osteoclasts resorb the woven bone and replace it with mature trabecular bone

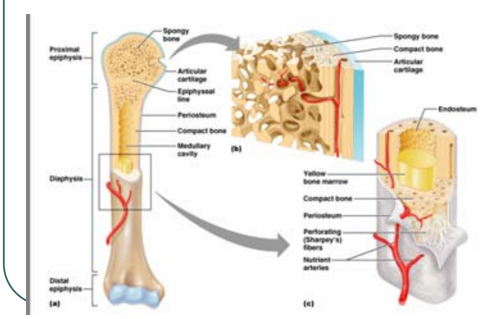
Endochondral Ossification



Bone (Continued)

- Growth after birth
- Secondary centers of ossification are formed
- Located at the ends of bones AKA the ephiphysis and can be called ephiphyseal plates or growth plates
- It is here bone grows as child grows
- Therefore, at birth, bone has replaced cartilage everywhere except 1) the articular ends of bones (Always cartilage) and the growth plates
- Around 17 or so, the EP becomes hardened or closed and growth stops called closing of the ephiphseal plate

Epiphyseal Plate



Anatomy

- Specialized Connective Tissue
- Cells, matrix and fibers
- Fibroblasts, fibrocytes, osteoblasts, osteocytes, and osteoclasts
  - Fibroblasts and fibrocytes from collagen

Anatomy Continued

- Osteoblasts lay down bone
  - What do we mean by "bone" in this case?
  - Osteoid - organic matrix secreted primarily by osteoblasts but also by osteocytes
- Osteoclasts are responsible for bone resorption
  - "Bone" here refers to mineralized matrix
  - How do osteoclasts resorb bone?
- Osteocytes are responsible for sensing mechanical load (makeup 90% of bone cells)

Bone

Image provided by Dr. Robert Weinstein, University of Arkansas (Endocrinology, 145:1980, 2004)

Matrix

- High content of *inorganic* material in the form of mineral salts
- Make the tissue hard and rigid
- Organic components give bone flexibility and resilience
- Mineral portion of bone consists primarily of calcium and phosphates
  - Hydroxyapetite

Matrix Continued

- Mineral accounts for 65-70% of dry weight and give bone its solid consistency
- Serves as a reservoir for essential minerals in the body, particularly calcium

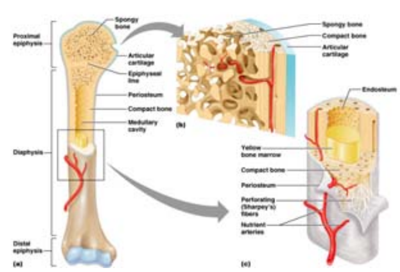
Matrix Continued

- Bone mineral is embedded in variously oriented collagen
- Collagen comprises 95% of the extracellular matrix and accounts for 25-30% of the dry weight of bone

Bone Structure

- All bone is surrounded by a dense fibrous membrane called the periosteum
- Permeated by blood vessels and nerves
- These pass into cortex via Volkmann's Canals connecting with the longitudinally running Haversian Canals and extend into spongy bone

Periosteum



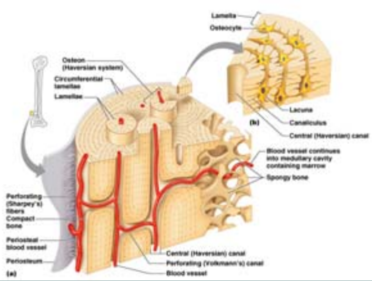
Bone Structure Continued

- The inner layer of periosteum is called osteogenic layer
- Contains osteoblasts responsible for generating new bone growth during growth and repair
- Covers the entire bone **EXCEPT** at joint surfaces where articular cartilage is found

Types of Bone

- Compact (cortical) and Spongy (cancellous)
- Cortical bone forms the outer shell or cortex of bone and has a dense structure
- Has few spaces – found in the diaphysis – provides protection, support and strength
- Filled with concentric like circles known as the Haversian system
  - Consists of Haversian canals that run longitudinally through bone
  - And Volkmann's canals that penetrate bone
  - Through these, nerves and vessels enter bone via the Nutrient Foramen

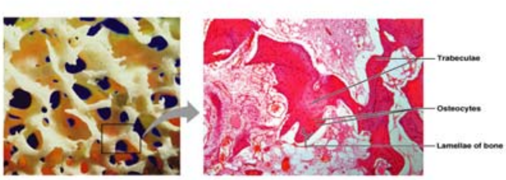
Compact Bone



Types of Bone Continued

- Spongy bone within the shell is composed of thin plates or trabeculae, in a loose mesh structure
- The spaces between trabeculae are filled with red marrow and are arranged in concentric lamellae
- Typically found in epiphysis
- Gives bone resiliency and light weight

Spongy Bone



Bone Remodeling

- Bone turnover occurs at a rate of 10% each year
  - We have a new skeleton every 10 years
- Delicate balance between osteoblast and osteoclast activity
- Occurs normally through life as bone responds to external forces

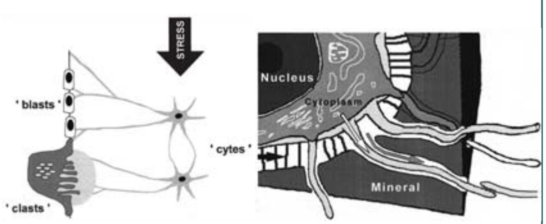
Remodeling Continued

- Wolff's Law
- The normal pull of tendons and the weight of the body during activities
  - formation of apophyses
- Internal influences such as disease and aging affect remodeling

Remodeling Continued

- External forces cause osteoblast activity to increase and bone mass increases
- Without these forces, osteoclast activity predominates and bone mass decreases – bone is sensitive to disuse
- If osteoclasts break down or absorb bone faster than osteoblasts can remodel, osteoporosis will result
  - Bones decrease in density and weaken
- Osteoid is deposited by osteoblasts
  - About ten days to mineralize
  - Matrix is collagen based

Mechanical Load



Remodeling Continued

- Weight lifters will develop thickenings at the insertion of very active muscles – bones more dense where stresses are the greatest
- Professional tennis players can have up to a 35% increase in cortical thickness in dominant arm than the off arm

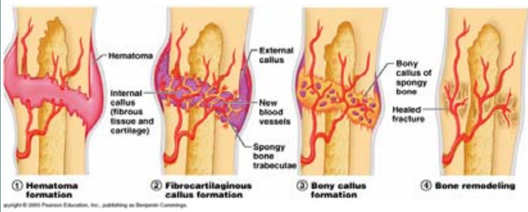
Physical Activity

- Bones need mechanical stress to grow and strengthen
- Must experience daily stimulus to maintain health
- Lack of activity
  - Decreased bone density following decrease in activity
  - Astronauts experience significant loss in short periods of time due to reduced activity as a result of low or no gravity
  - Changes include less rigidity, more bending displacement, decrease in bone length and cortical cross section, and a slowing in bone formation

Fractures

- In general, for any loading there will be three principal stress planes
  - Tension
  - Compression
  - Shear
- The plane that first exceeds the strength of the bone in that mode will allow for fracture initiation
- Cortical bone generally fails in tension or shear

Fracture Healing



Fracture Classification Long Bones

- Direct Injury mechanisms:
  - Tapping force – small force acting on small area
    - Nightstick fracture of the ulna
  - Crushing force – high force acting on large area
    - crush fx with comminution and severe soft tissue injury
  - Penetrating force – high force acting on a small area
    - open fx with minimal to moderate soft tissue damage
  - Penetrating-Explosive force – high force (high loading rate) acting on small area
    - Open fx with severe soft tissue disruption

Fracture Classification Continued

- Indirect Injury Mechanism
  - Transverse Fx – tensile force – patellar fx
  - Oblique Fx – axial compressive force – distal femur
  - Spiral Fx – torsional force – tibia
  - Transverse Fx with small butterfly – bending force – humerus
  - Transverse oblique Fx with large butterfly – axial compression and bending - tibia

Types of Bone

- Long
- Short
- Irregular
- Flat
- Sesamoid

Types of Bones