Section 23: Articular Cartilage
Structure and Function
Articular cartilage covers the joint surfaces:
- Bottom of the femur
- Top of the tibia
- Back-side of the patella
Articular Cartilage: Primary Functions

- Transmits applied loads across mobile surfaces
- Lines the ends of bones
- Surfaces roll or slide during motion
  - Hyaline cartilage is fluid-filled wear-resistant surface
  - It reduces friction coefficient to 0.0025.
Cartilage Types

• Distinguished by composition, microstructure, and mechanical properties
• Hyaline cartilage
  – Glassy-smooth and bluish-white
  – e.g. articular cartilage, and growth plate
• Elastic cartilage
  – Yellowish and opaque, more flexible than hyaline
  – e.g. epiglottis, external auditory canal
• Fibrocartilage
  – e.g. annulus fibrosus, meniscus
Understanding cartilage tissue mechanics requires knowledge of:

- Mechanical properties of normal cartilage
- Relationship between biochemical and structural factors in cartilage and its material properties
- How changes in composition and structure (with arthritis) affect mechanical properties of cartilage

From: Iatridis
Structural Considerations

• Before we consider tissue mechanics, we must understand certain concepts of structural mechanics

• Cartilage tissue will be overloaded because of excessive loading through
  – High contact stresses
  – Excessive frictional forces

From: Iatridis
Diarthrodial (articulating) joints

- Enclosed in strong fibrous capsule
- Inner surfaces of joint capsules are lined with synovium
  - Secretes synovial fluid – a lubricant
  - Provides nutrition
- Articular cartilage at the ends of bone on articulating surfaces

From: Iatridis
Structure diarthrodial joints

• Enclosed in fibrous capsule
• Lined with synovium (secretes fluid / provides nutrients)
• Articular cartilage lines each end of articulating bone
• Joint cavity formed from synovium and articular cartilage
Composition

• Fluid phase: water and electrolytes
• Solid phase: chondrocytes (cells), collagen fibers (type I and II), proteoglycans & other glycoproteins
  – Collagen: key structure within connective tissue, hair-like, helical molecule
  – Proteoglycan: protein with 1 or more glycosaminoglycan (GAG) chains attached by covalent bonds

From: Grimm and Atkinson
Articular Cartilage: Composition

Components are arranged in a way that is maximally adapted for biomechanical functions.

- Chondrocytes (~1%)
- Collagen (15%) (Type II in articular cartilage)
- Proteoglycans (15%)
- Water (70%)
Collagen (15%)

Creates a framework that houses the other components of cartilage

- Majority is Type II collagen
- Provides cartilage with its tensile strength

Look at Ligament & Tendon notes for structure of collagen fibers

STZ  Middle zone  Deep zone

Fig. 8. Schematic representation of collagen fibrils; stiff and strong in tension but weak in compression.
Collagen

Alpha chains are the building blocks.

What is the mechanical role of collagen?
The mechanical role of collagen is to support tension in the extracellular matrix.
Articular cartilage structure

• Collagen
  – Dense at surface, parallel to surface
  – Fine fibers at surface, larger below
  – Middle zone random
  – Calcified cartilage
  – Perpendicular, thick fibers at calcified cartilage
Extracellular matrix structure

Zones
- Superficial tangential (10-20%)
- Middle (40-60%)
- Deep (30%)

Articular surface
Tide mark
Subchondral bone
Calcified cartilage
Cancellous bone

Images:
- Superficial tangential zone
- Middle zone
- Deep zone

From: Iatridis