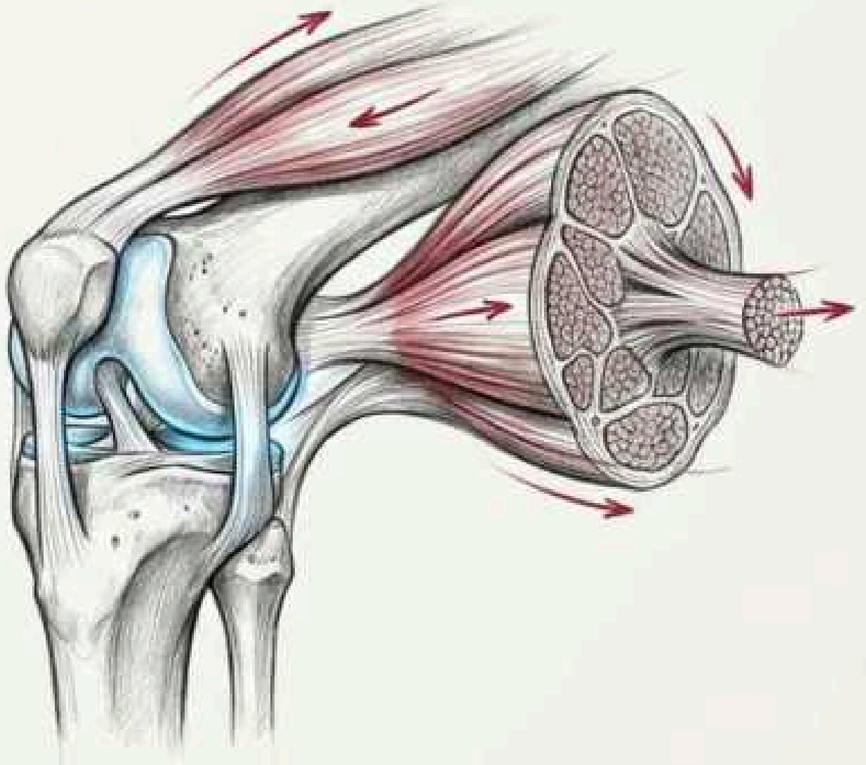
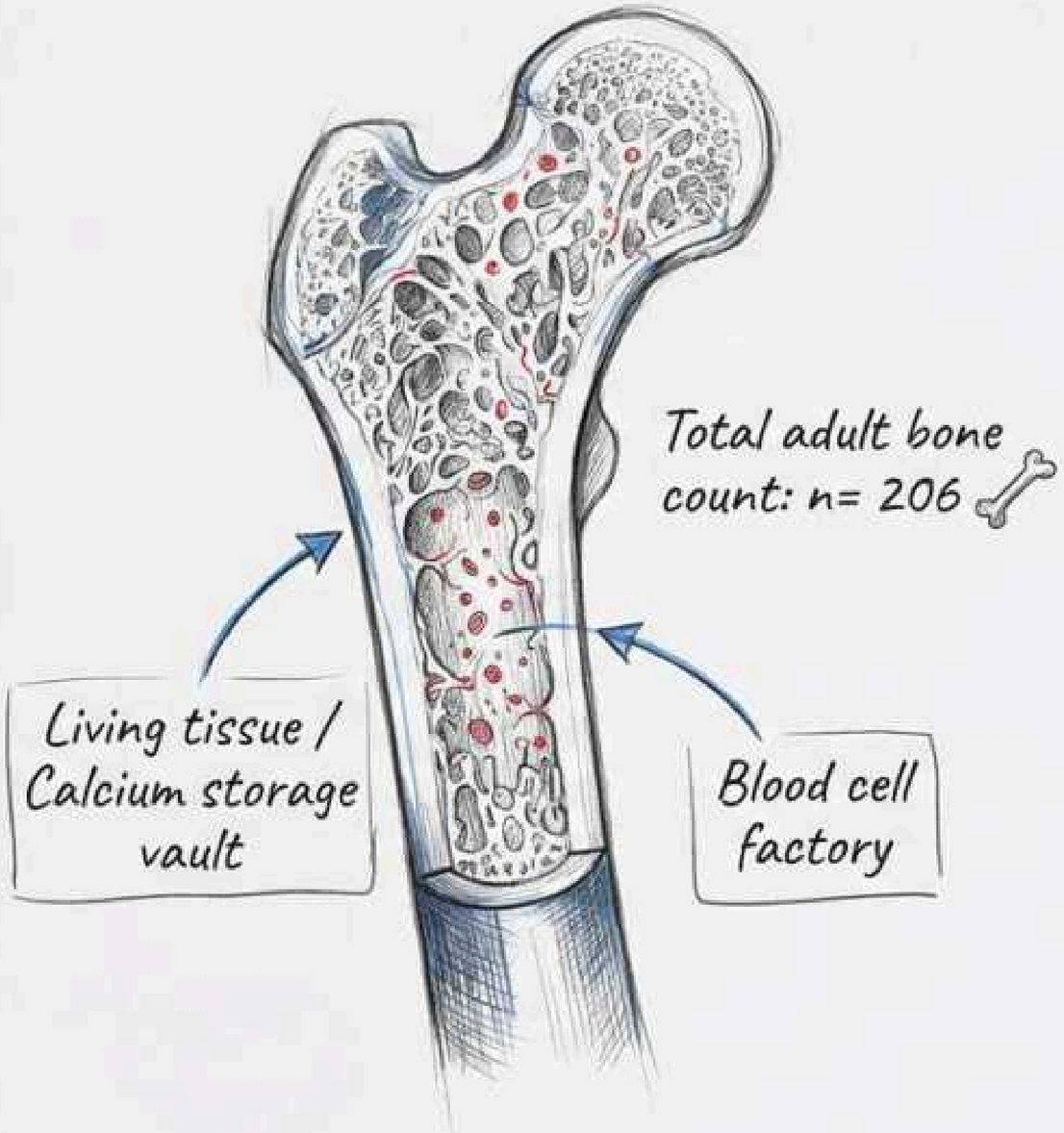
Lecture 1: Bone, Joints and Muscle

The Biomechanics of Human Movement



MED 533 B

¶ 1.1



MATERIAL SCIENCE EQUATION

Protein (Collagen) → Flexibility

\+ Mineral (CaPO4 Crystals) → Strength

= Total Resistance (Bending & Compression)

¶ 1.2

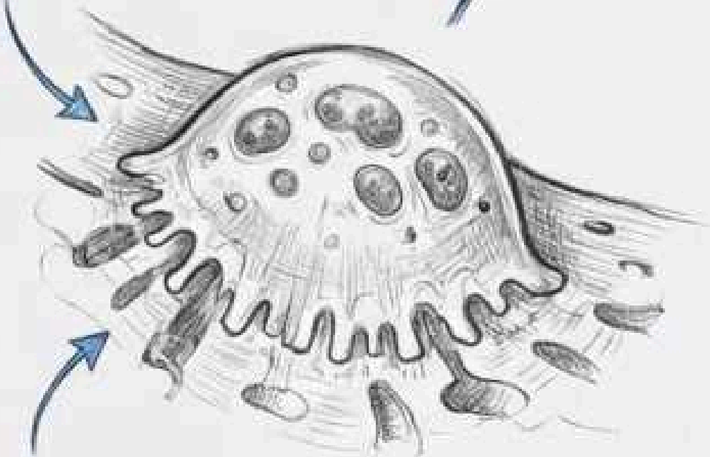


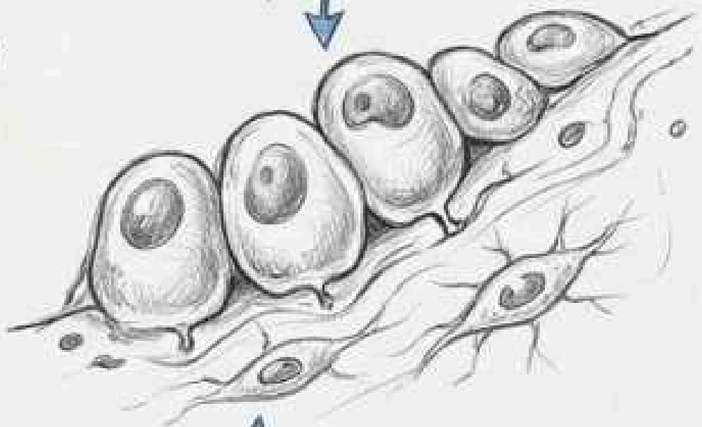
Weight-bearing exercise strengthens bone

Bed rest or spaceflight weakens bone

Osteoclasts
→ Break down old bone / repair tiny cracks

Osteoblasts
→ Lay down new bone





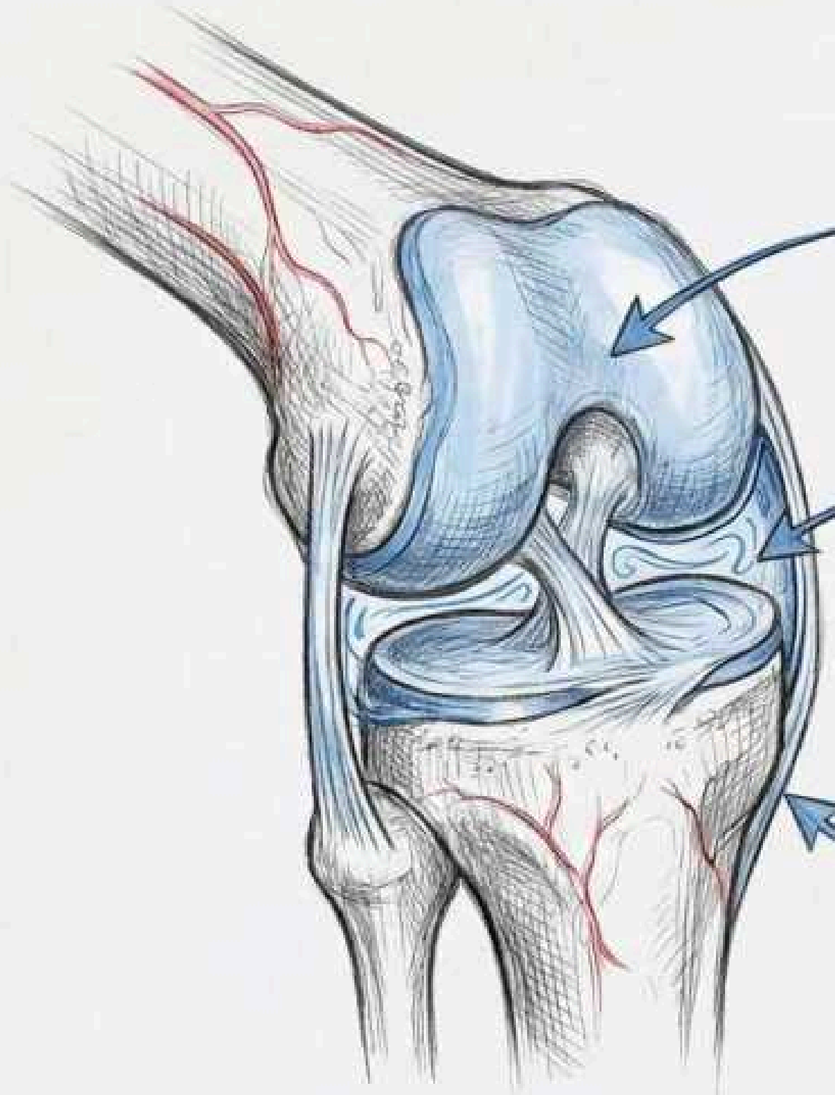
Mechanical Load is proportional to Bone Density

~10% of the skeleton is replaced annually

Osteoclasts
→ Break down old bone / repair tiny cracks

Osteoblasts
→ Lay down new bone

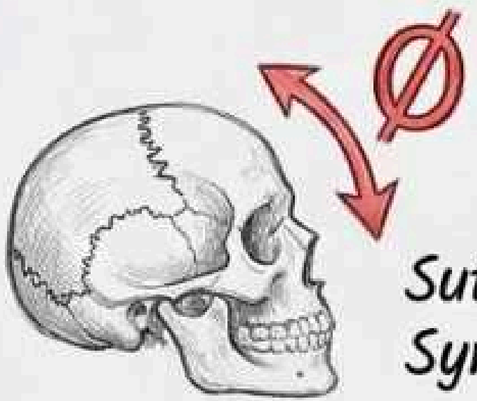
¶ 1.3



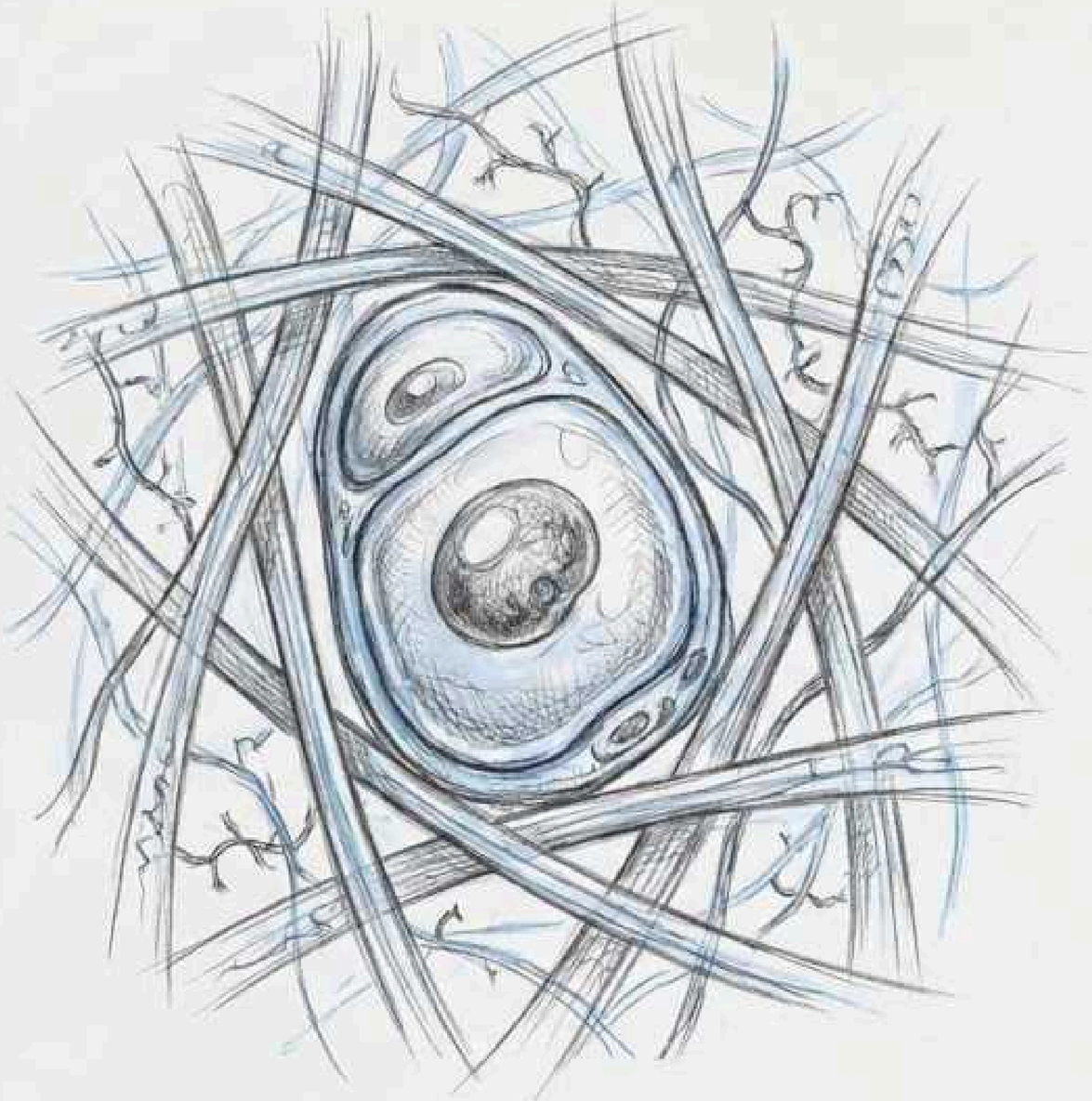
Articular Cartilage:
Smooth covering on bone ends.

Synovium:
Thin inner membrane
→ Manufactures slippery, nourishing synovial fluid.

Capsule:
Encloses the joint system.



Sutures (Skull) = Barely move.
Synovial Joints (Knee, Hip, Fingers) = Primary movers.



¶ 1.4

Mechanical Feats

Friction coefficient: cartilage < ice

Load capacity: Sustains ≫ Body Weight for decades

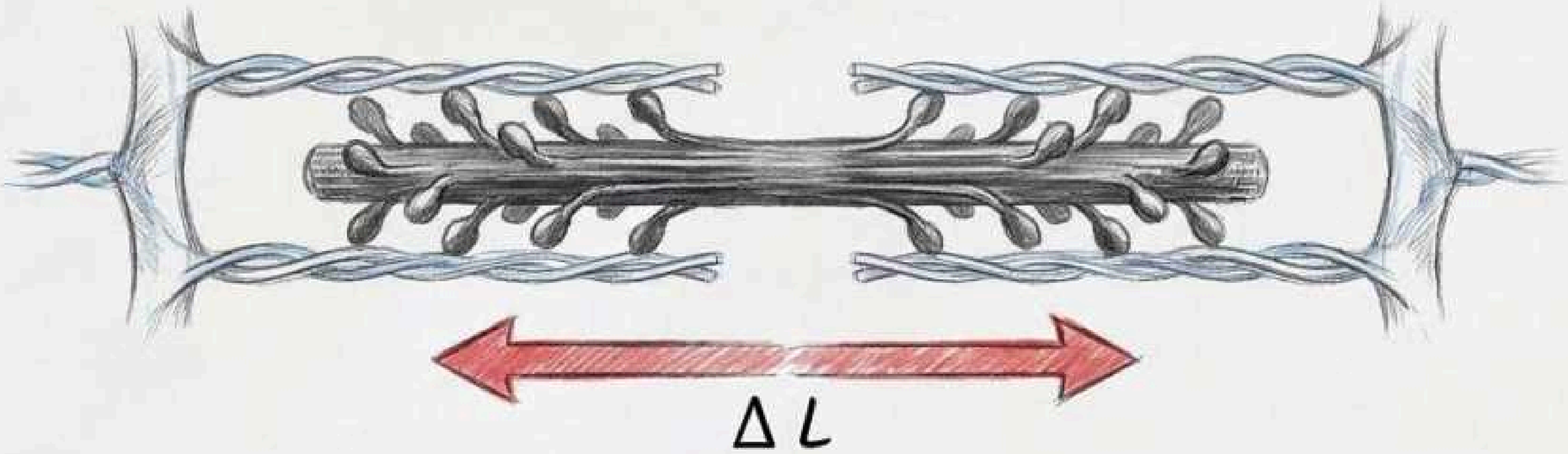
The Healing Paradox

0 Blood Supply + *0 Nerves* + *Low Chondrocyte Mitosis*

= Poor Healing Potential

→ Increased Risk of Osteoarthritis

¶ 1.5



Step 1: Nerve Signal (Action Potential) → Surge in Intracellular Calcium

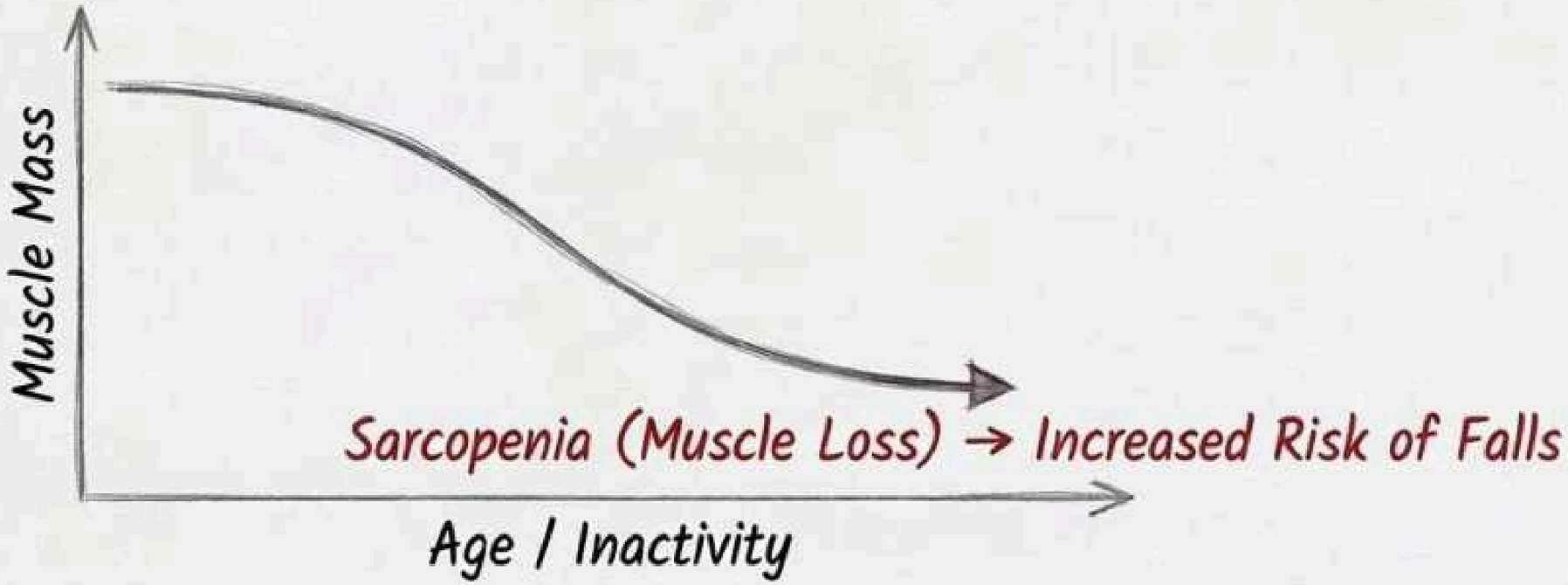
Step 2: Myosin binds Actin + Calcium

Step 3: Myosin pulls Actin → Filament Sliding & Muscle Shortening

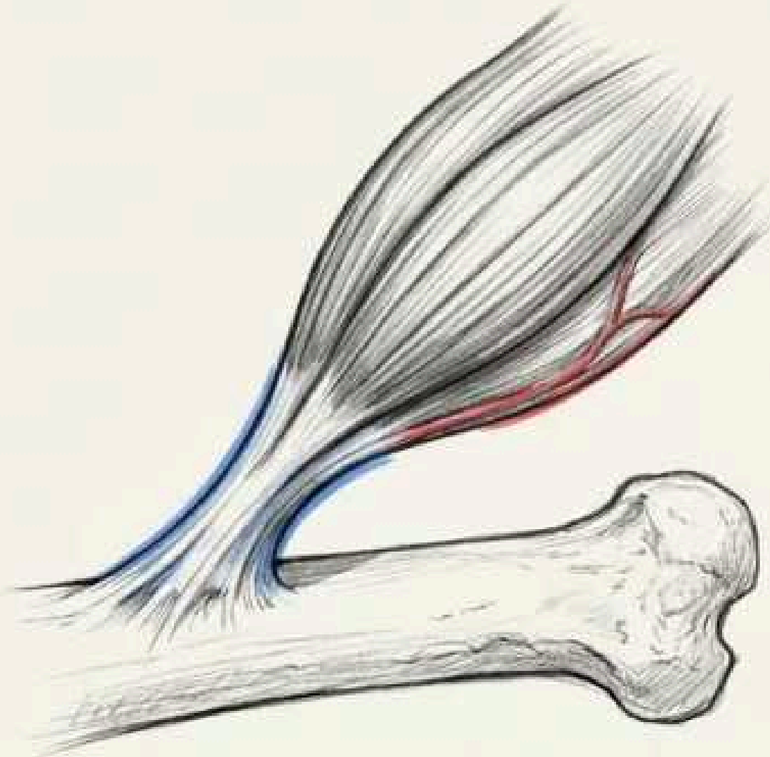
[Skeletal muscle = ~40% of total body weight.
Described in the 1950s as the sliding filament theory.]

¶ 1.6

Slow-Twitch Fibers	Fast-Twitch Fibers
• Function: Endurance, fatigue-resistant.	• Function: High force, quick fatigue.
• Adaptation: Endurance training → Increased Blood Supply Increased Mitochondria (energy).	• Adaptation: Resistance training → Increased Fiber Size Increased Strength.



¶ 1.7



Tendon = Muscle <-> Bone
(Transmits force)

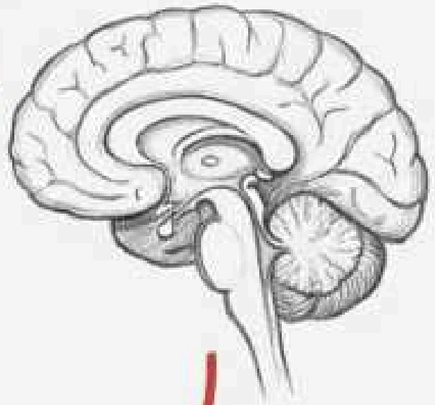


Ligament = Bone <-> Bone
(Stabilizes joints)

Composition: Both are densely packed collagen.
Clinical Math: Decreased Blood Supply = Takes months to recover from injury.

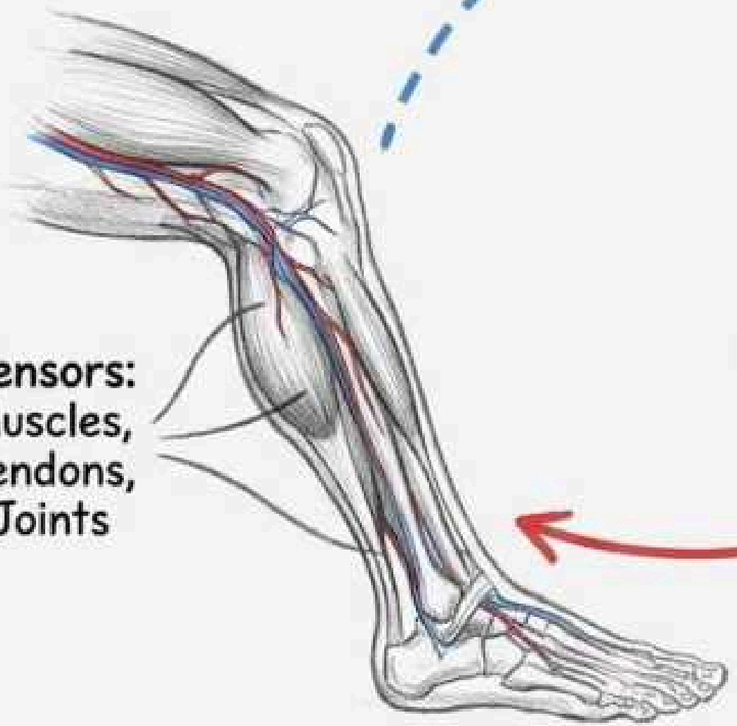
¶ 1.8

Processor
(Proprioception Awareness)



Afferent Signal:
Where is the body in space?

Efferent Signal:
Motor control & joint stabilization

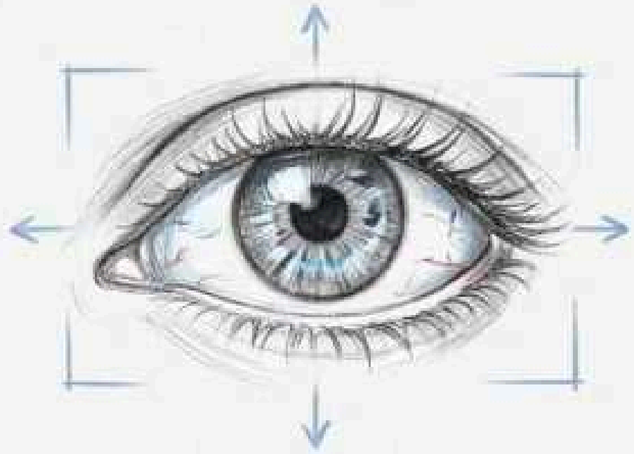


Sensors:
Muscles, Tendons, Joints

Nerve damage or joint injury breaks the loop -> Unsteadiness & further injury.

Action: Rehabilitation must include balance training.

¶ 1.9



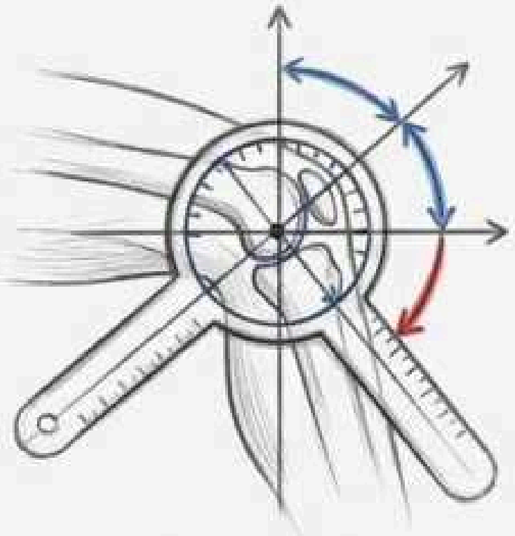
Look

Assess for swelling, redness, and deformity.



Feel

Palpate for warmth, tenderness, and fluid.

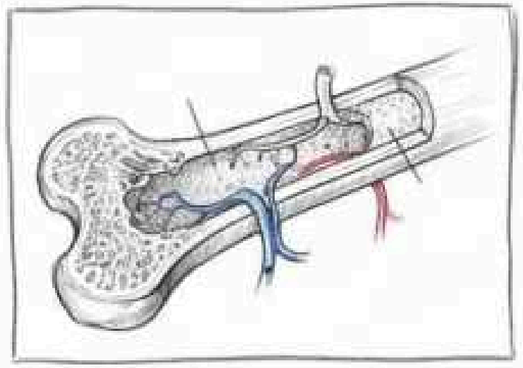


Move

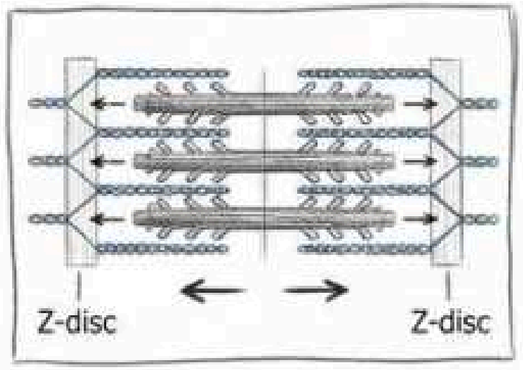
Assess active and passive range of motion, and joint stability.

Diagnostic Baseline: Always compare with the contralateral (other) side.

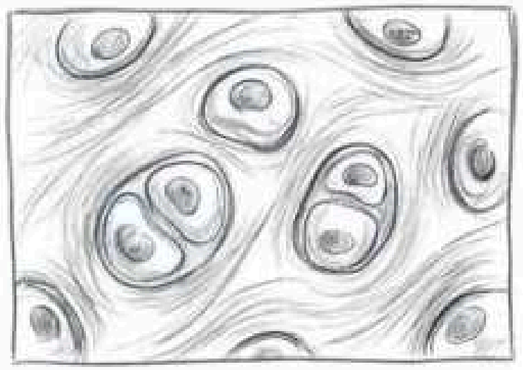
¶ 1.10



Living &
Adaptive



Shortens by
sliding filaments



Poor healing
capacity

Conclusion

Up Next: Osteoarthritis
The commonest joint disease.