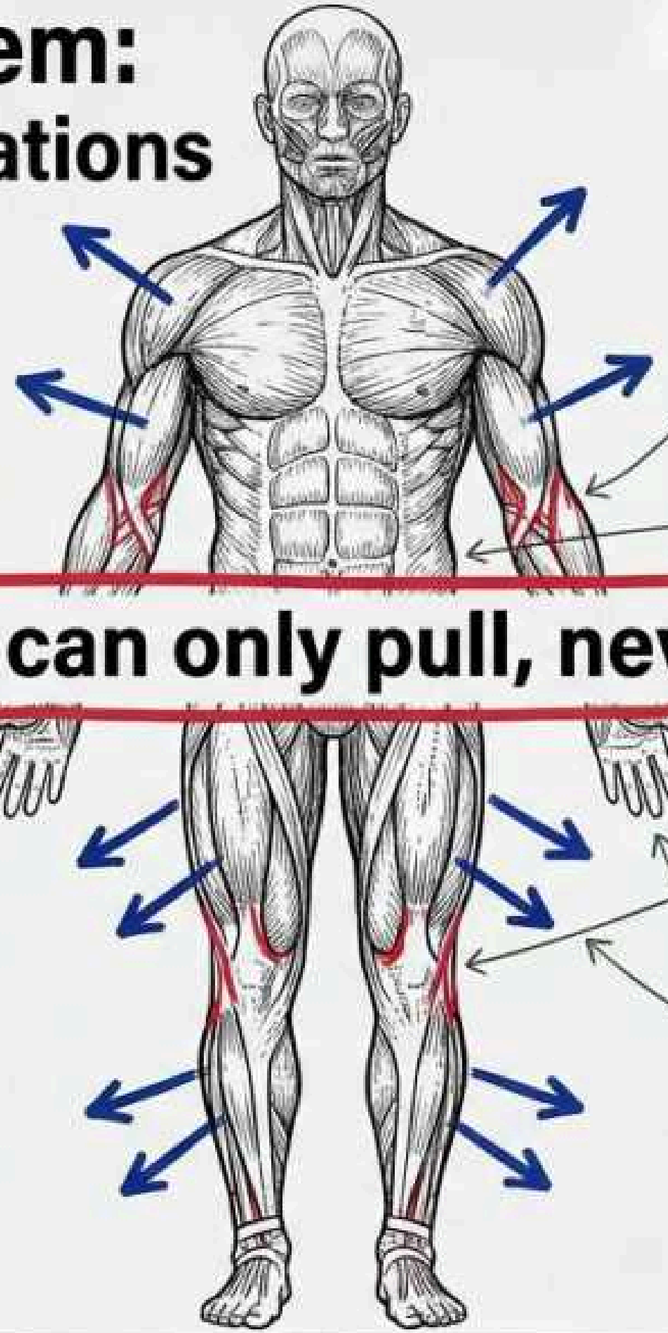
The Muscular System:
Mechanics and Foundations

¶ 3.1



1. Move the body
(pulling bones via tendons)

2. Maintain posture

3. Stabilize joints

4. Generate heat
(e.g., shivering)

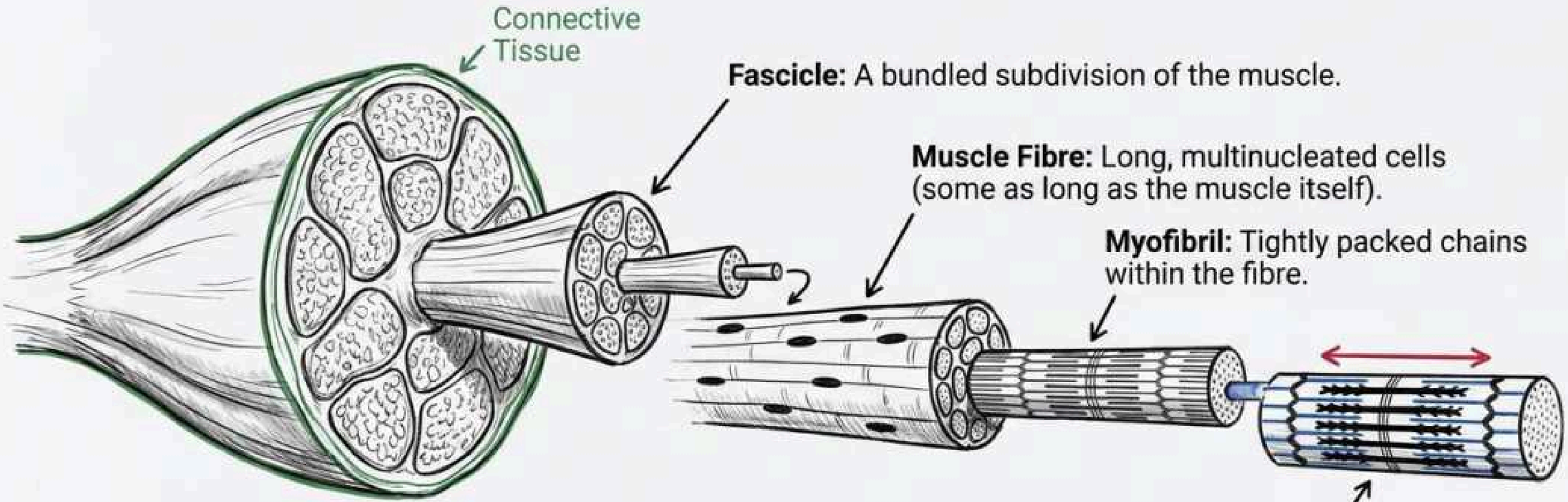
→ >600 skeletal muscles

→ ~40% of total body weight.

Muscles can only pull, never push.

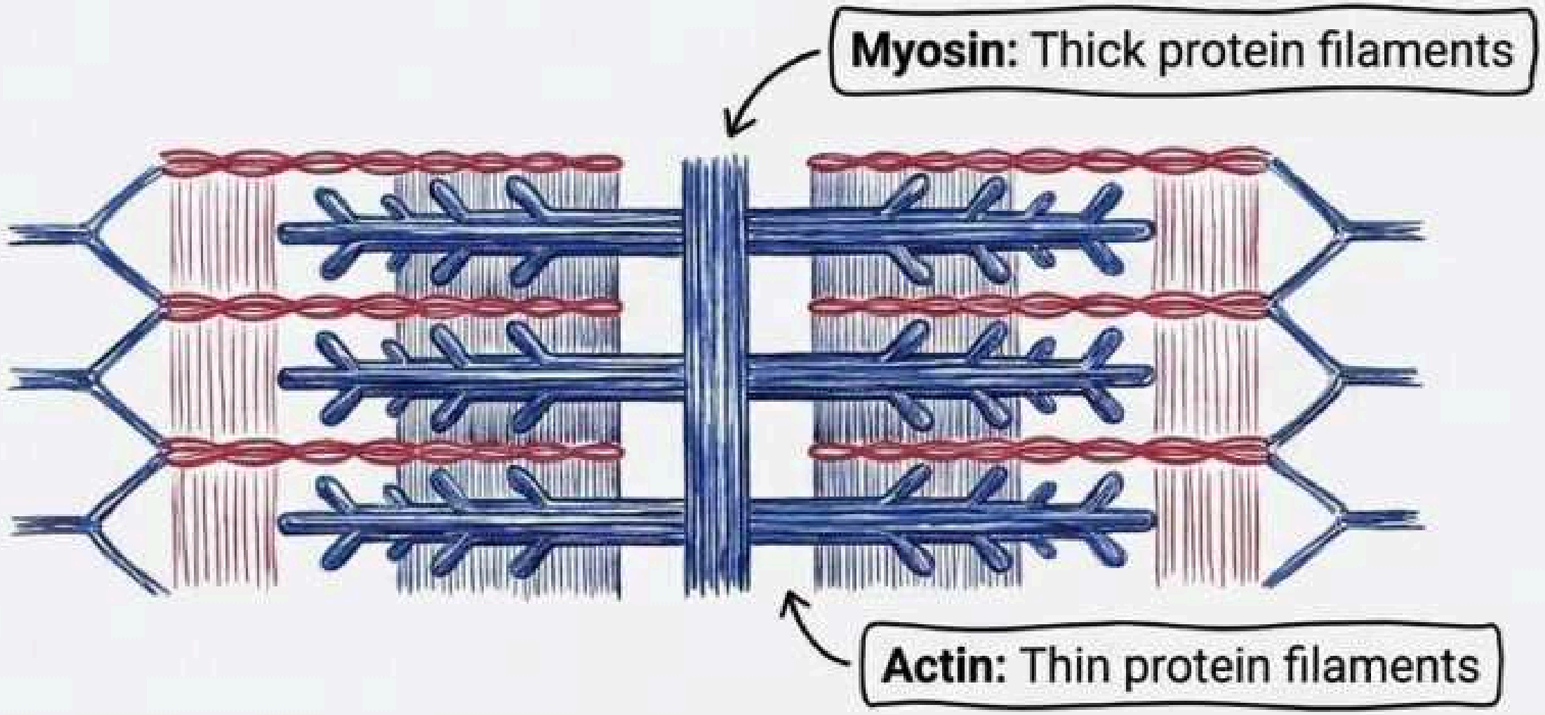
The Architecture of Contraction: A Nested Hierarchy

¶ 3.2



The Sarcomere: Striations and Sliding Filaments

¶ 3.3



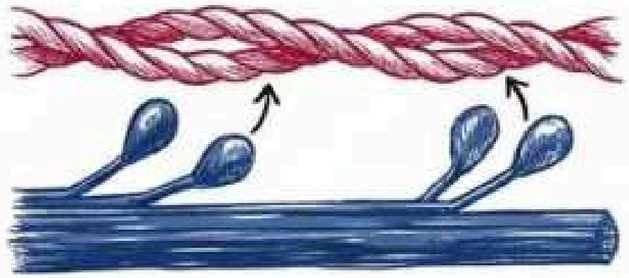
The Sliding Filament Theory

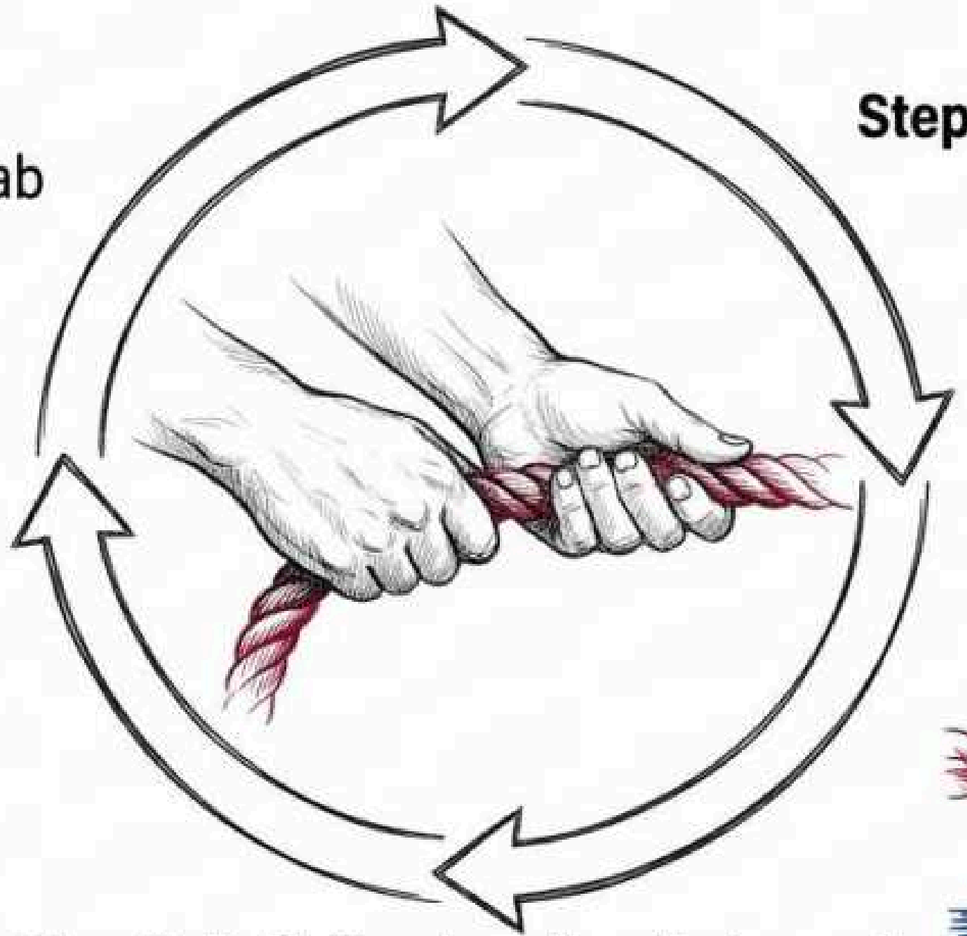
Proposed in 1954 by two unrelated scientists, Hugh Huxley and Andrew Huxley, explaining how this overlapping arrangement creates muscle contraction.

The Sliding Filament Mechanism

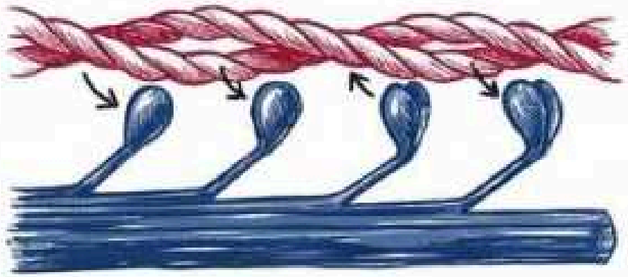
¶ 3.4

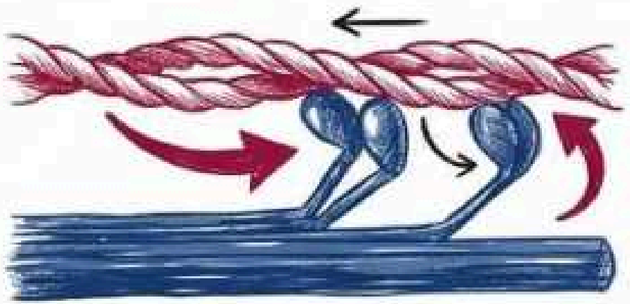
Step 3: Release & Repeat: Heads release and grab further down the line.





Step 1: Grab: Myosin heads attach to actin.





Step 2: Pull: Heads pull actin toward the center of the sarcomere.

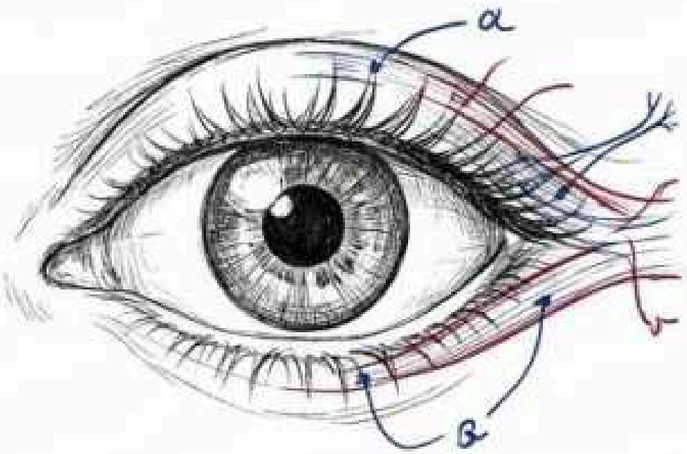
Key Insight: The filaments do not shorten; they slide past one another. The sarcomere shortens.

ATP = Energy Source | **Calcium** = The "On" Switch released inside the fibre

Motor Units: Neural Control and Precision

¶ 3.5

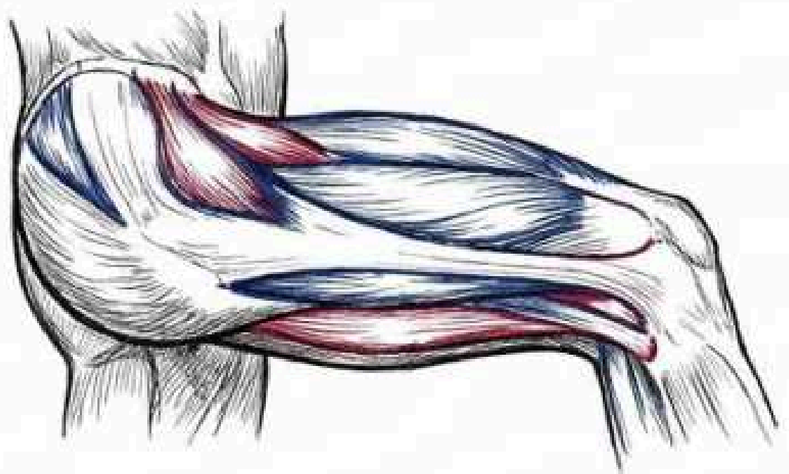
Motor Unit = 1 Motor Neuron + All the muscle fibres it controls.



Fine Control

1 neuron controls only a few fibres

Use case: Extremely precise, delicate movements.



Gross Control

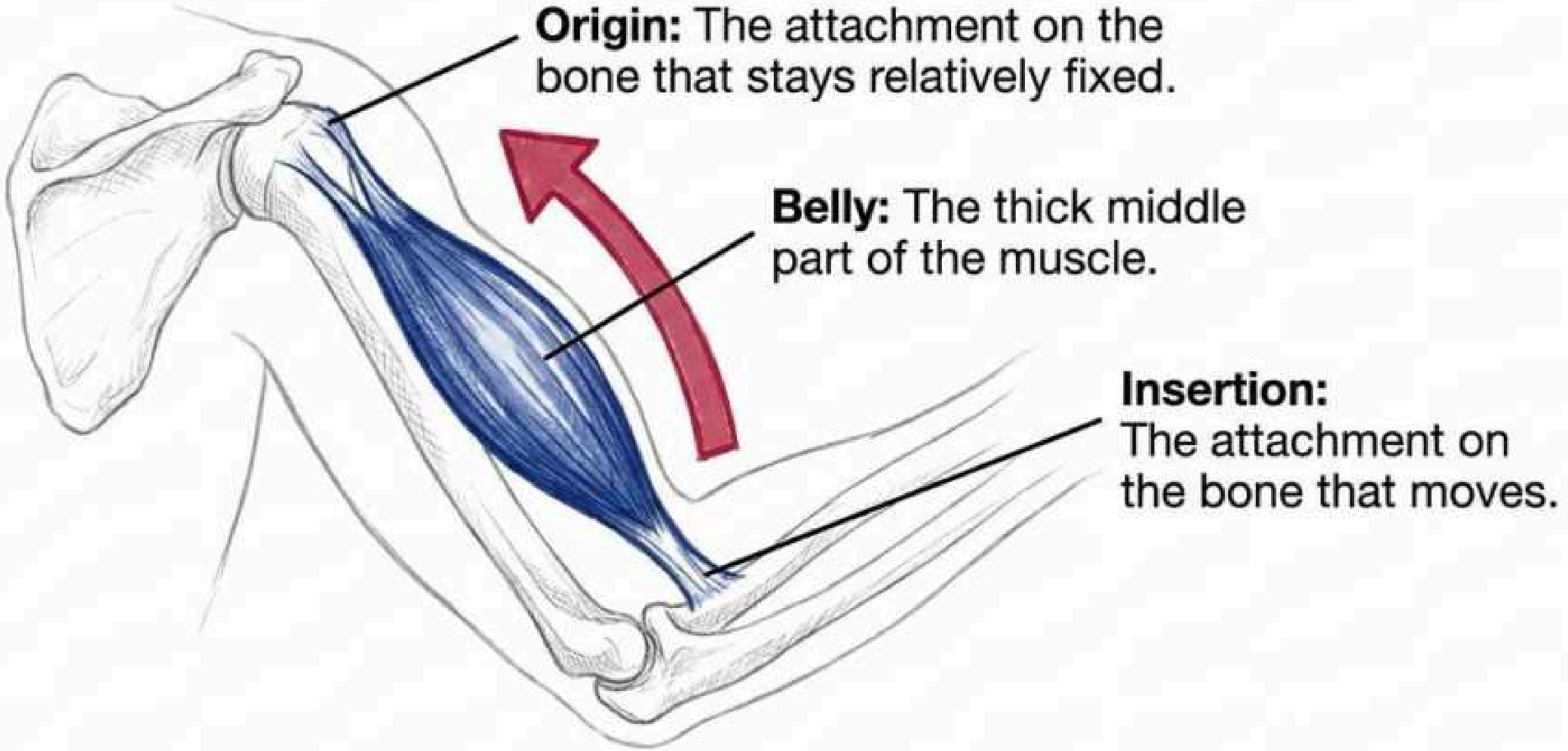
1 neuron controls **1,000+** fibres

Use case:
Massive force generation.

The brain grades total muscular force by recruiting more motor units as needed.

Bridging the Joint: Origins and Insertions

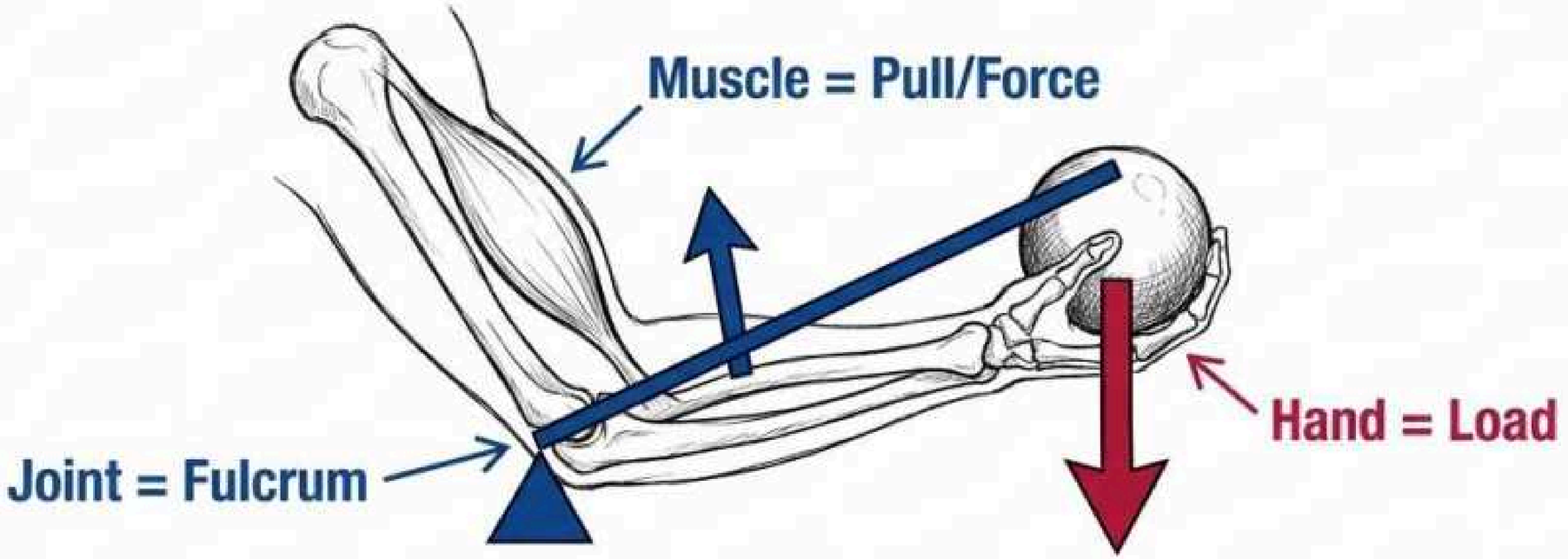
¶ 3.6



The Action: When the biceps contracts, the insertion point moves toward the origin point, bending the elbow. Most muscles cross at least one joint and attach to two different bones.

Muscular Physics: The Body as a Lever System

¶ 3.7



$$F_{muscle} \times d1 = F_{load} \times d2$$

Third-class levers place the muscle pull between the joint and the load.

Because the biceps inserts so close to the elbow (d1 is small), it must pull extremely hard.
The Trade-off: The body sacrifices raw force to gain speed and range of motion.

Muscle Teams: The Role Quadrant

¶ 3.8

The Prime Mover (Agonist)

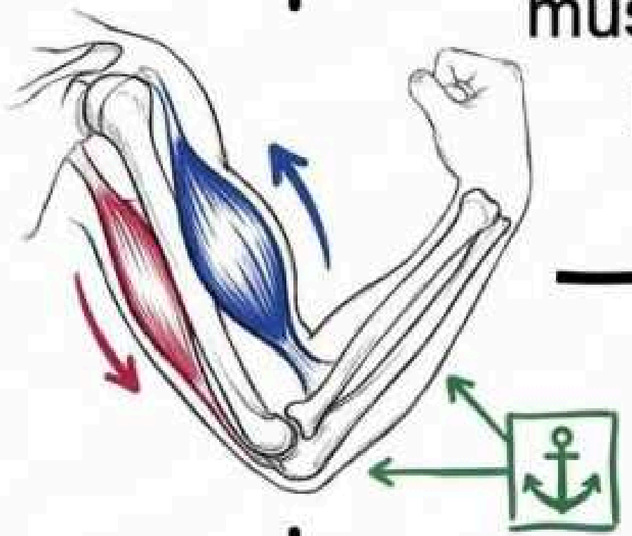
Does most of the work.

Example: Biceps during an elbow bend.

The Antagonist

Opposes the prime mover and must relax to allow movement.

Example: Triceps during an elbow bend.



The Synergist

Assists the prime mover in performing the action.

The Fixator

Steadies the origin point so the prime mover has a stable base.

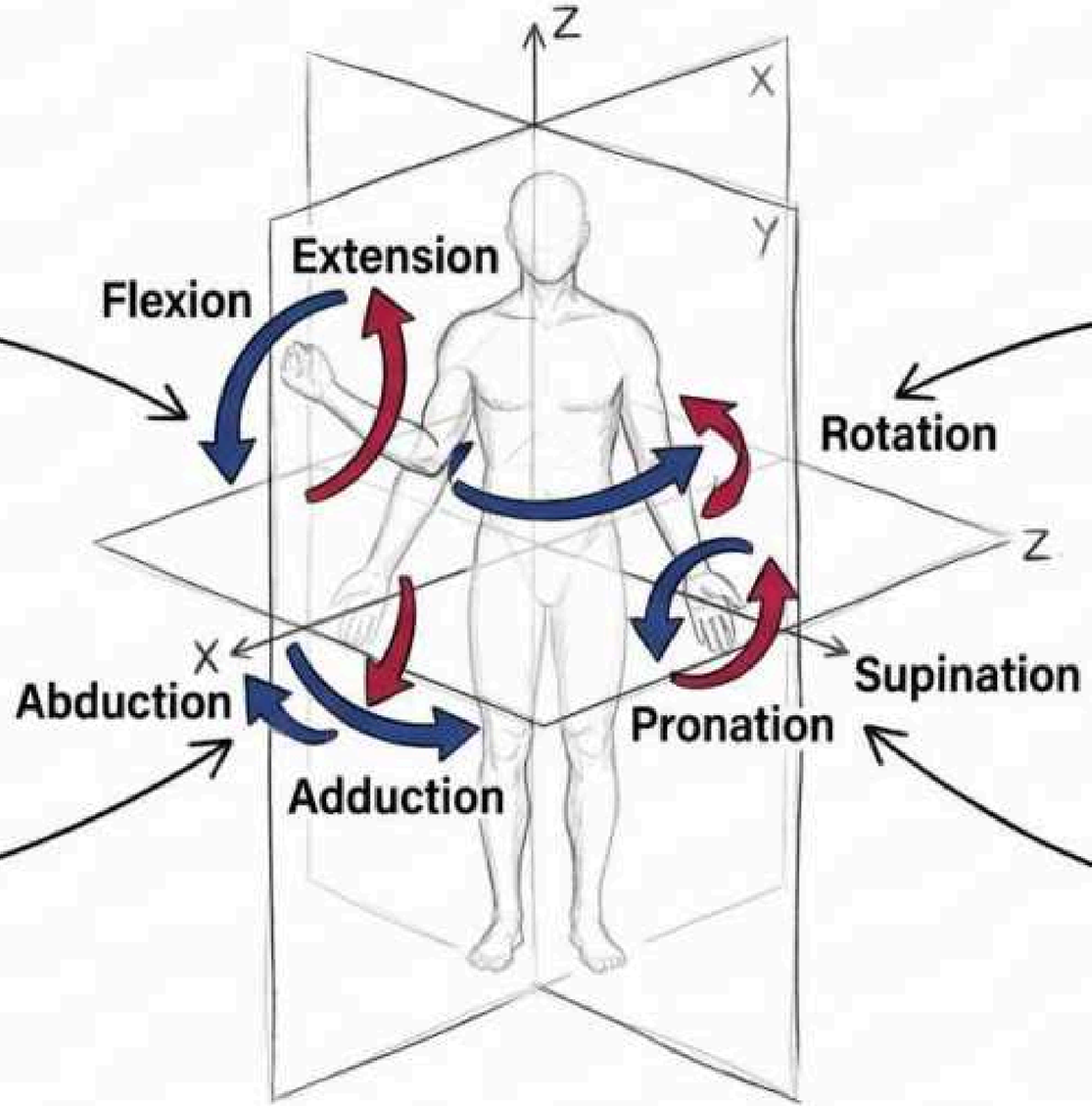
⚠ **Key Rule:** Reversing a movement (straightening the elbow) instantly reverses the roles (Triceps becomes agonist, Biceps becomes antagonist).

The Spatial Compass of Movement

¶ 3.9

Flexion
(decreases joint angle)
vs.
Extension
(increases joint angle).

Abduction
(moves limb away from midline)
vs.
Adduction
(brings limb back).

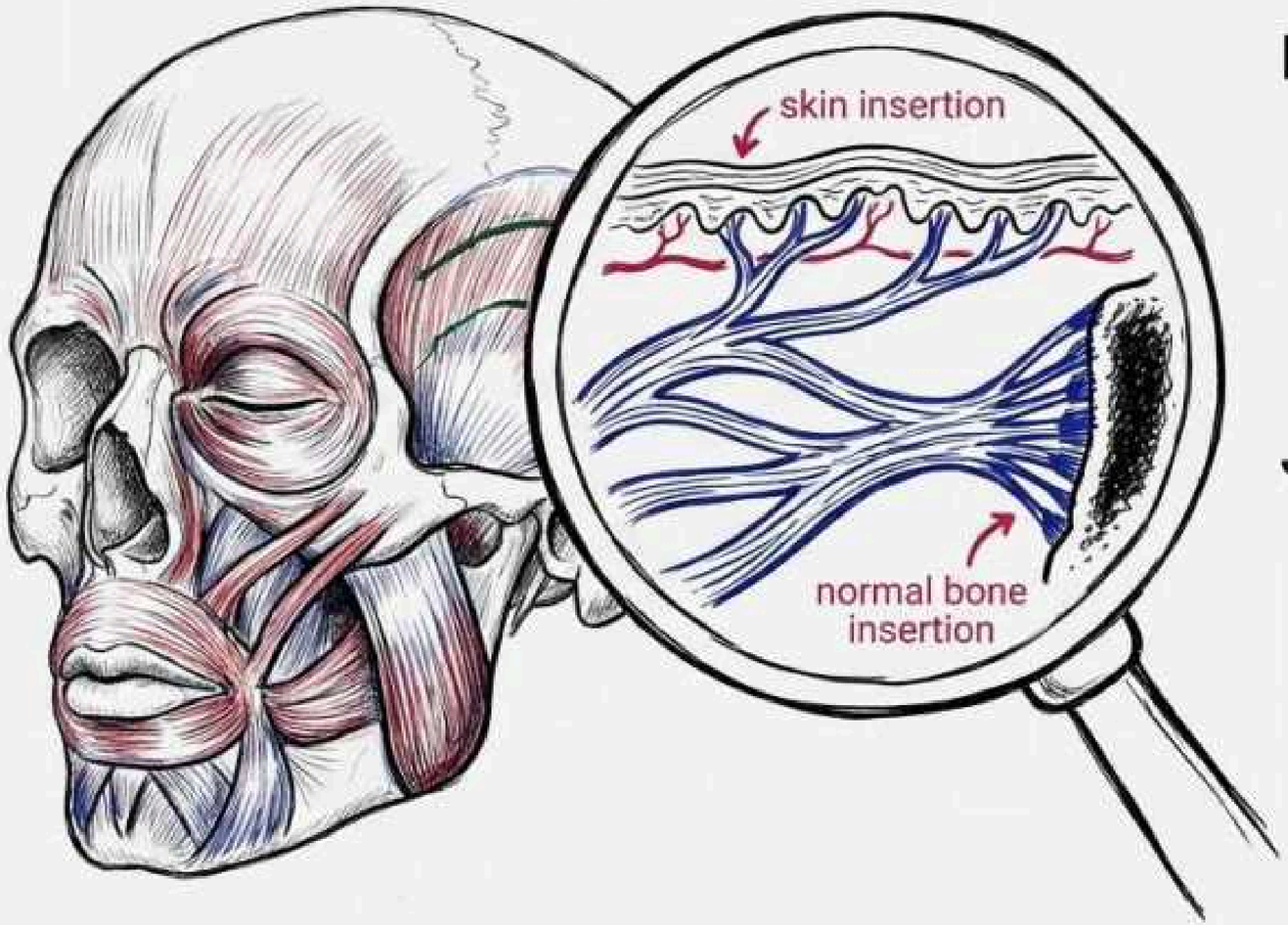


Rotation
(turning a bone around its own axis).

Pronation
(turns palm down)
vs.
Supination
(turns palm up).

Tour of the Head: Expression and Mastication

¶ 3.10



Facial Expressions (Insert into skin):

- **Orbicularis oculi:** Closes the eye.
- **Orbicularis oris:** Purses the lips.
- **Zygomaticus:** Creates the smile.

Jaw Movers (Insert into bone):

- **Temporalis & Masseter:** Close the jaw.

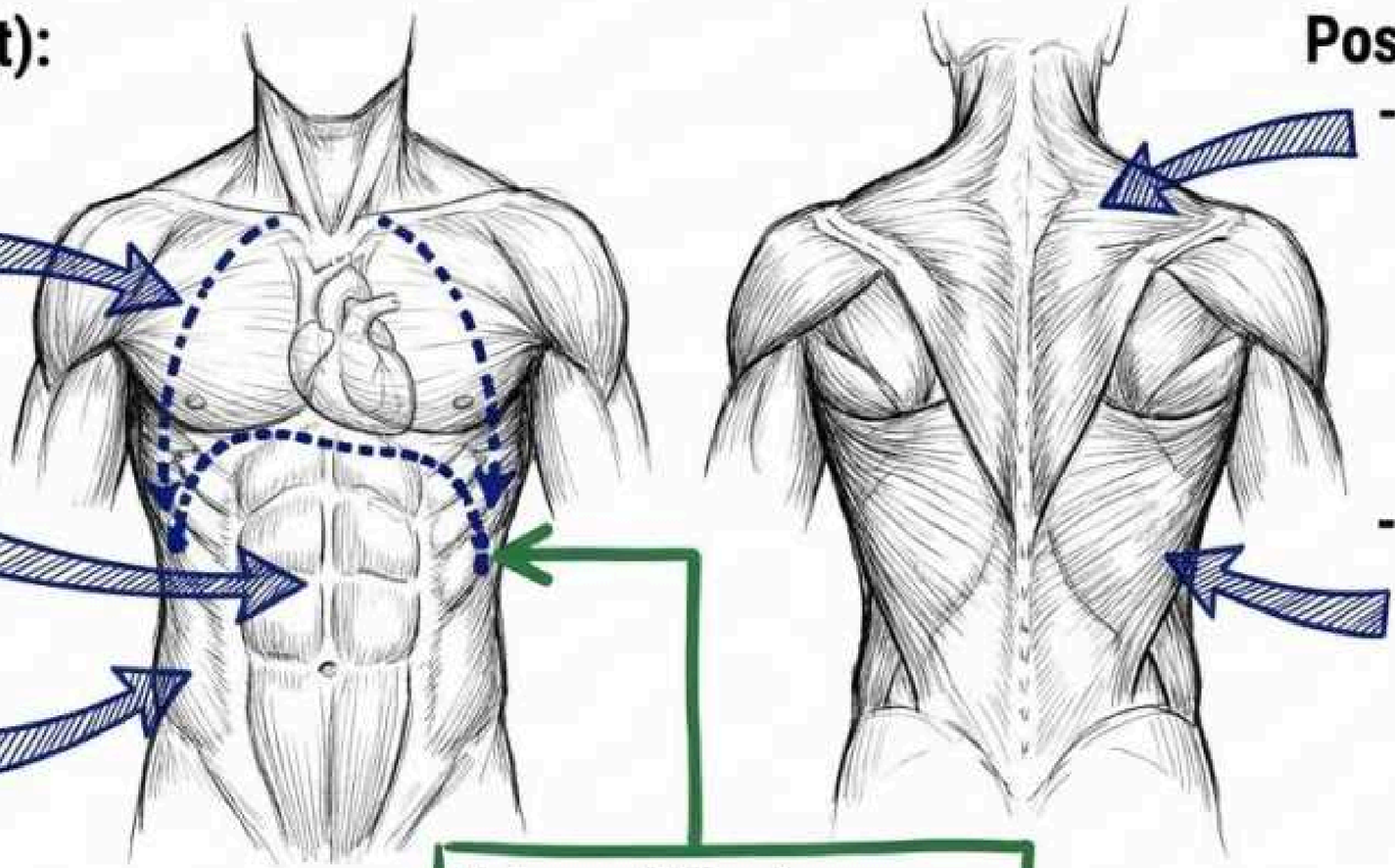
Fact Note: The Masseter is among the strongest muscles in the body relative to its size.

Tour of the Trunk: Core, Back, and Breath

¶ 3.11

Anterior Wall (Front):

- **Pectoralis major:** Chest; moves arm forward and across.
- **Rectus abdominis:** The "six-pack".
- **Obliques:** Flank the abdominal wall.



Posterior Wall (Back):

- **Trapezius:** Upper back; moves the shoulder blade.
- **Latissimus dorsi:** Broad lower back muscle; pulls arm down and back.

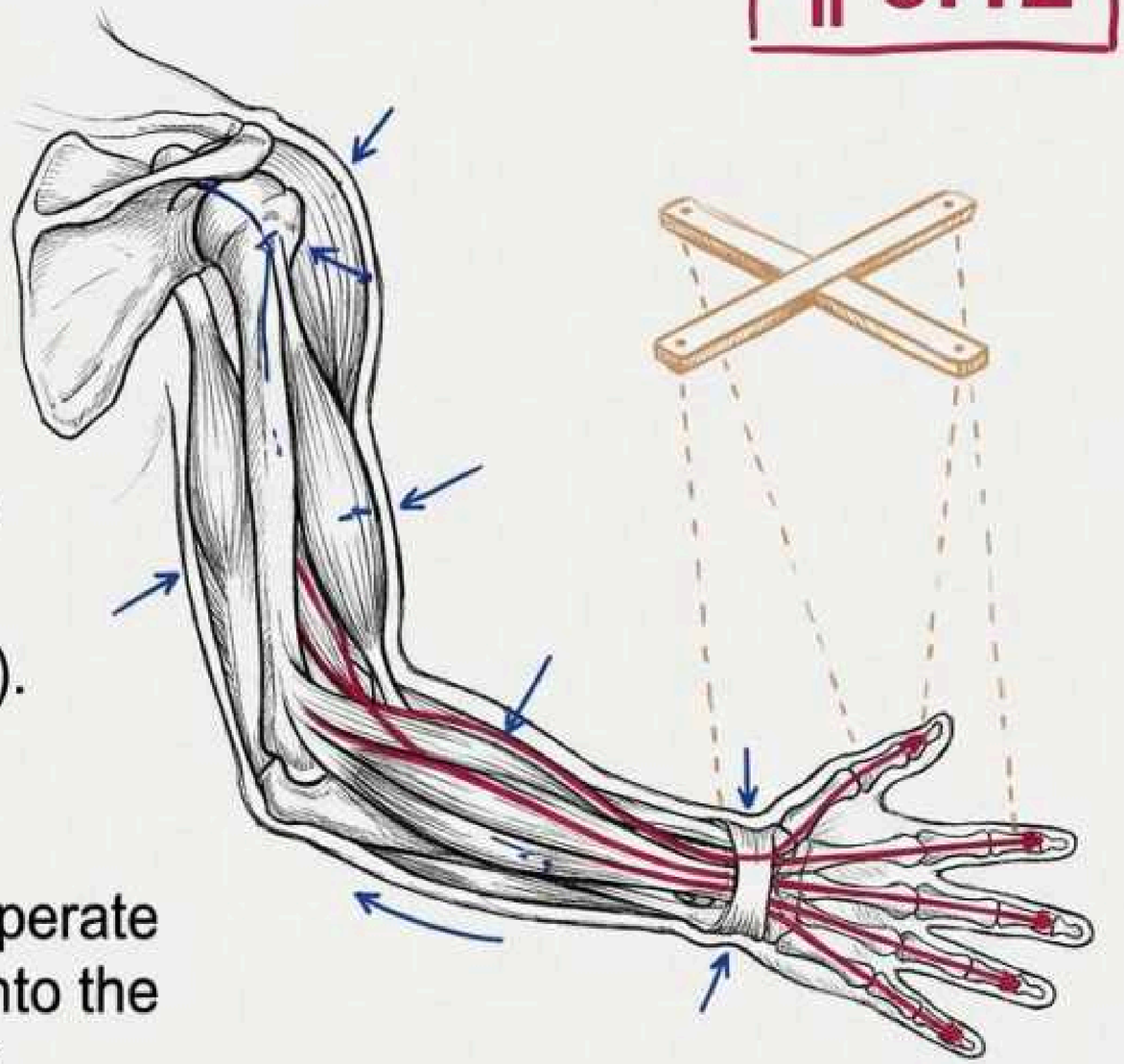
Internal Engine:
Diaphragm - The main muscle of breathing.

Tour of the Upper Limb: The Puppet String Mechanic

¶ 3.12

Shoulder & Upper Arm:

- **Deltoid**: Caps the shoulder, raises the arm.
- **Rotator Cuff**: Four small muscles that stabilize the shoulder joint.
- **Biceps brachii**: Bends elbow, turns palm up (supinates).
- **Triceps brachii**: Straightens elbow (extends).



The Forearm & Hand:

The Puppet Strings: Many forearm muscles operate the hand remotely via long tendons that run into the fingers, keeping the hand dexterous and light.

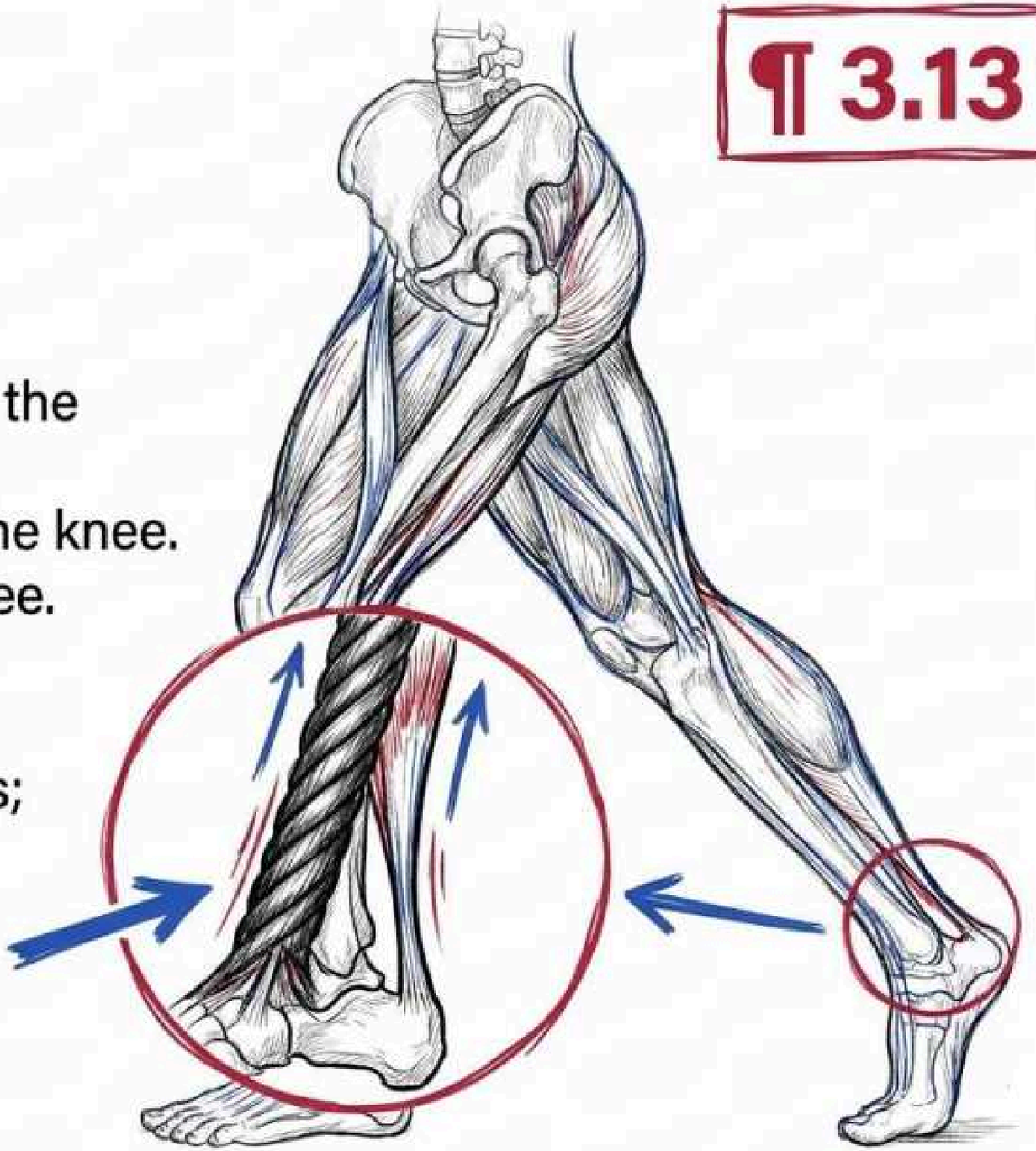
¶ 3.13

Heading:
Tour of the Lower Limb: Power and Propulsion

Hip & Thigh:
- **Gluteus maximus:** The largest muscle in the body; extends hip in climbing/standing.
- **Quadriceps:** Front of thigh; straightens the knee.
- **Hamstrings:** Back of thigh; bends the knee.

Lower Leg & Ankle:
- **Calf muscles:** Gastrocnemius and Soleus; point the foot.

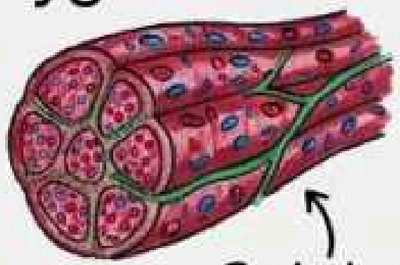
Achilles Tendon: Joins calf to heel; noted as the strongest tendon in the human body.



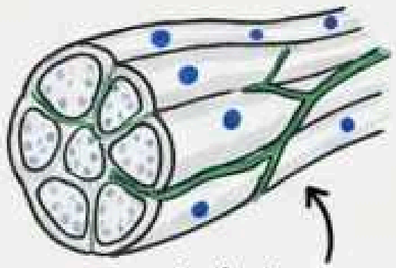
Skeletal Fibre Types: Endurance vs. Power

¶ 3.14

Slow-Twitch Fibres (The Marathoner)	Fast-Twitch Fibres (The Sprinter)
• **Speed & Fatigue:** Contracts slowly, • **Speed & Fatigue:** Contracts slowly, highly resistant to fatigue. • **Metabolism:** Uses oxygen efficiently. • **Anatomy:** Rich in mitochondria and myoglobin (appears Red).	• **Fastd & Fatigue:** Contracts quickly. • **Speed & Fatigue:** Contracts quickly and powerfully, tires very fast. • **Anatomy:** Lower myoglobin (appears White).



Red, dense network

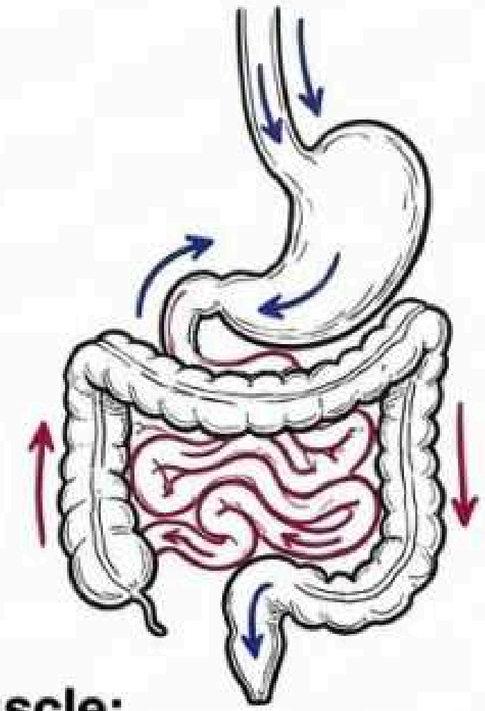


White, sparse network

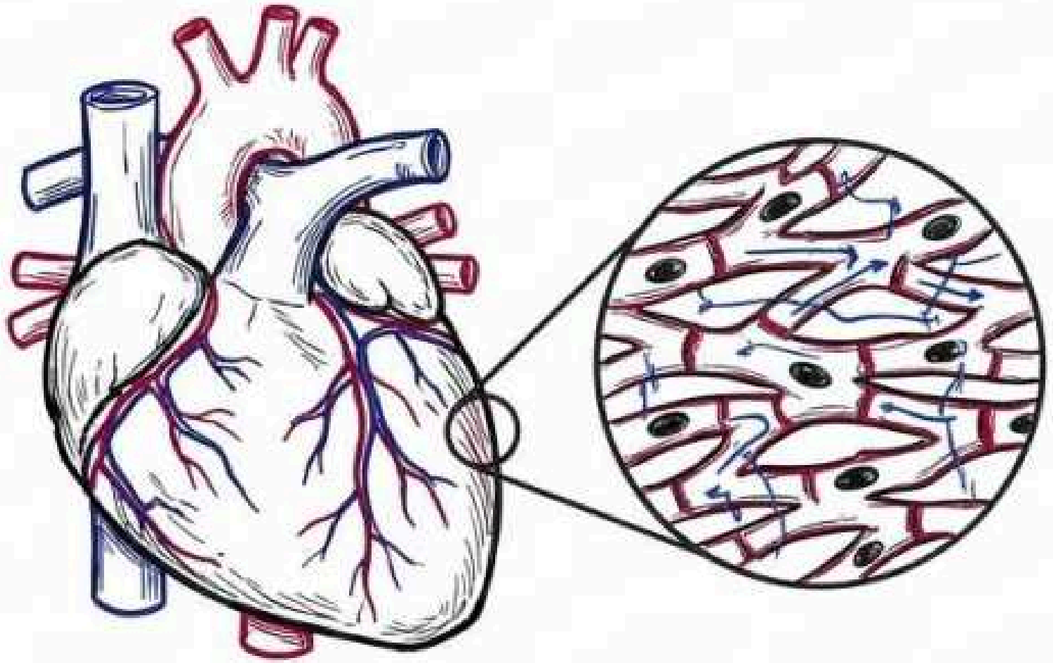
Note: While genetics dictate baseline ratios, physical training can alter fibre properties to some degree.

Autonomous Tissues: Smooth and Cardiac Muscle

¶ 3.15



Smooth Muscle:
- **Location**: Walls of hollow organs (gut, blood vessels, bladder).
- **Structure**: No neat rows of sarcomeres = lacks stripes/striations.
- **Action**: Slow, sustains contraction for long periods with little energy. Pushes food in waves (peristalsis), controls vessel diameter.

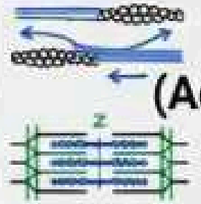


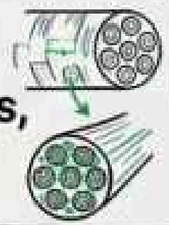
Cardiac Muscle:
- **Location**: The Heart.
- **Structure**: Cells are branched and structurally bound together.
- **Action**: Joined by intercalated discs that rapidly pass signals, ensuring the entire organ beats as a single coordinated unit.

System Synthesis: From Sarcomere to Skeleton

¶ 3.16

Micro: Proteins Slide
(Actin/Myosin inside Sarcomeres, Myofibrils, Fibres, Fascicles)





are commanded by...

Control: Nerves Fire & Physics Pulls
(Motor Units grade force -> Muscles act as Levers -> Agonist/Antagonist Pairs)

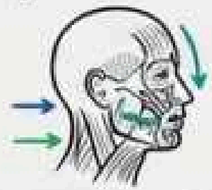


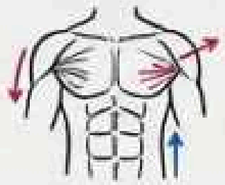




to animate the...

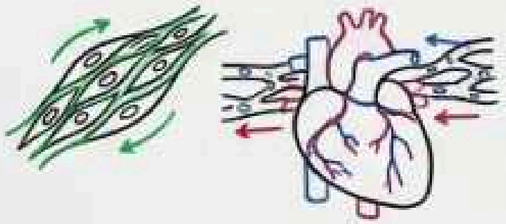
Macro: The Gross Machine
(Major muscles of the Head, Trunk, and Limbs)







Tissue Exceptions:
Smooth (Hollow Organs) & Cardiac (Heart).



Next Lecture:
The Heart and Lungs.