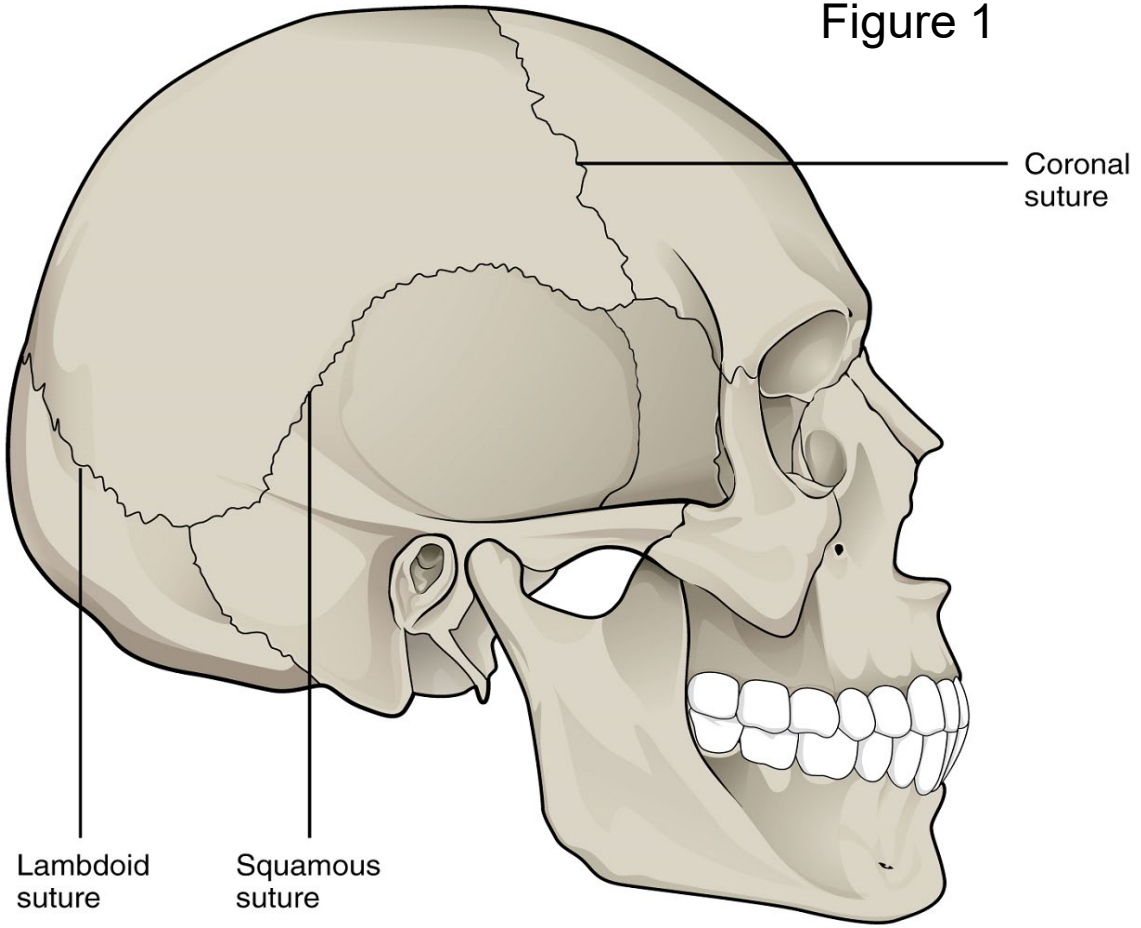
BIOLOGY 1103/1109
Human Anatomy and Physiology I

UNIT 13
Joints

Figure 1



Joints

Objectives

1. Explain what is meant by the terms synarthrotic, diarthrotic, and amphiarthrotic as descriptions of the functional classes of joints.

2. Describe the structures, classifications, functions, and locations of the various types of joints in the human body.

3. Describe the structure of a synovial joint and using the knee joint as an example, specify the functions of each component.

4. Describe the movements allowed by synovial joints and specify examples of each.

5. Describe the structures and movements allowed by each type of synovial joint and also specify an example of each in the human body.

Joints

In the skeletal system

What is a joint?	- An articulation surface between 2 bones, bone & cartilage or bone & teeth - Connective tissue
What are the main functions of a joint?	- Hold skeletal structures together - Allow for movement

Joint classification

based on their function

- **Synarthrotic** — Not movable
- **Amphiarthrotic** — Slightly movable
- **Diarthrotic** — Movable

based on their structure

- **Fibrous** — Dense fibrous connective tissue
  - Suture
  - Syndesmosis
  - Gomphosis
- **Cartilaginous** — Cartilage
  - Synchondrosis
  - Symphysis
- **Synovial** — Dense irregular & cartilage With a cavity
  - Gliding
  - Hinge
  - Pivot
  - Ellipsoidal
  - Saddle
  - Ball & socket

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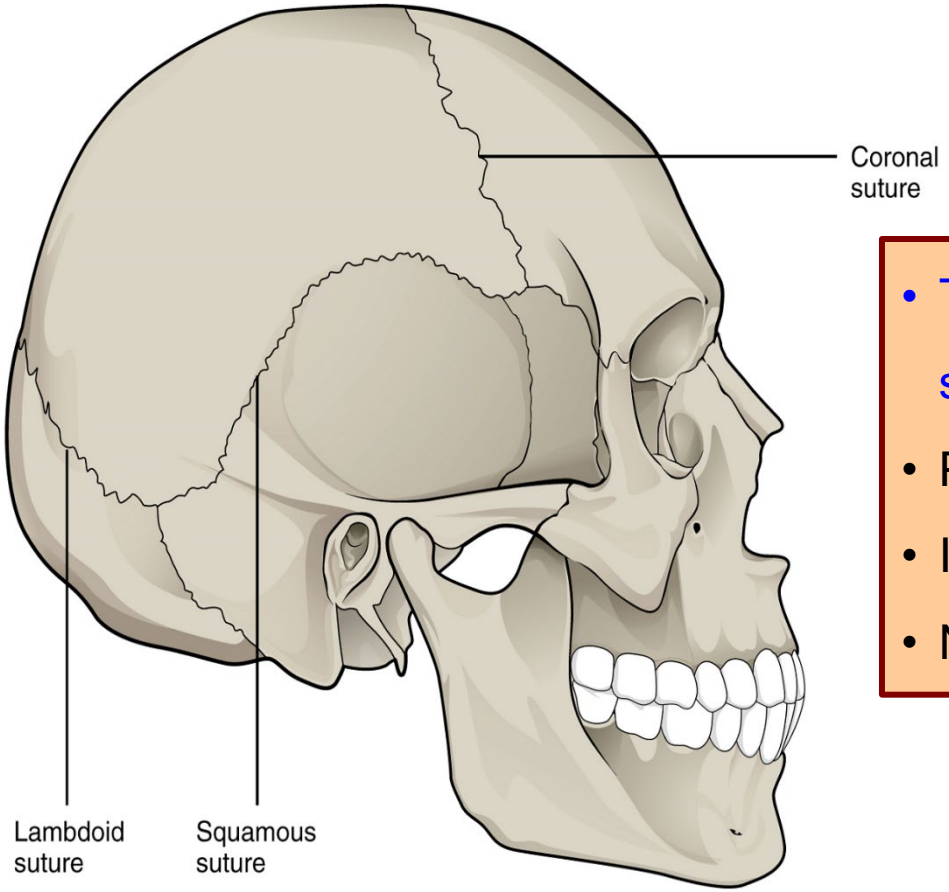
Fibrous joints

sutures



CT (Connective tissue)

- Thin layer of dense irregular CT uniting skull bones
- Present only in the skull
- Interlocking edges
- Not movable → Synarthrosis

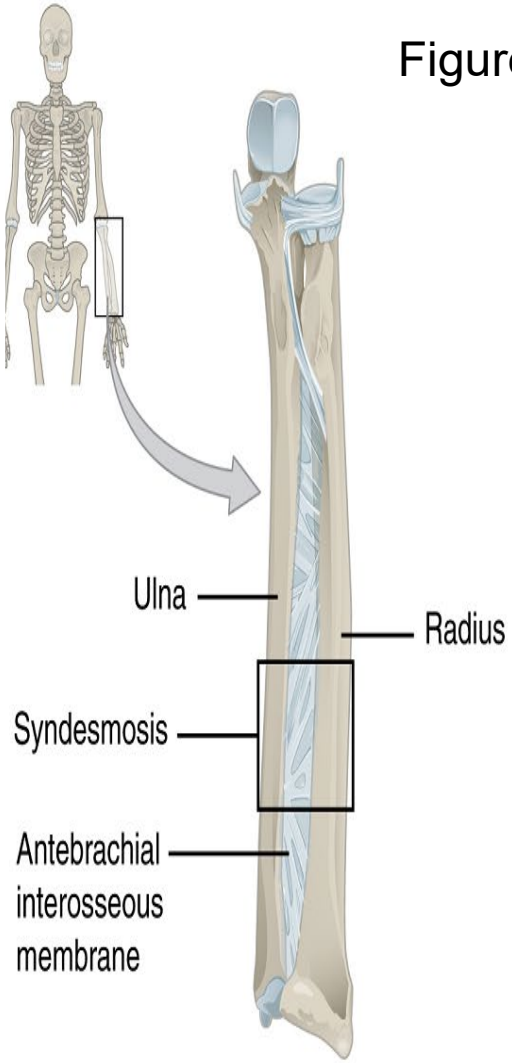
Figure 1

Fibrous joints

syndesmosis

- Bones connected by bundles of dense irregular CT (e.g. ligament)
- More distance between
- E.g. distal tibiofibular joint
- Slightly movable → amphiarthrosis

Figure 2b

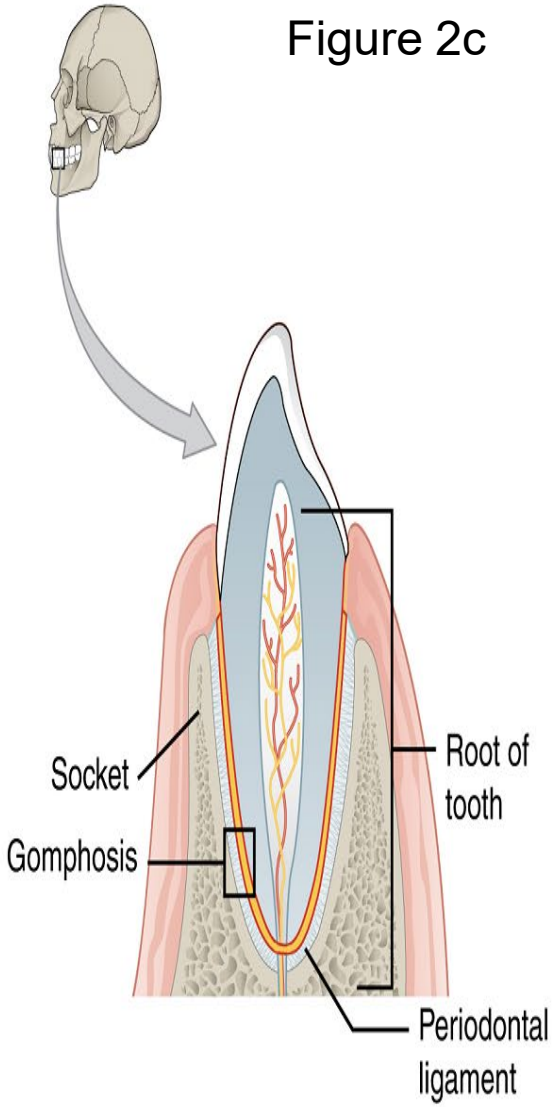


Fibrous joints

gomphosis

- Connecting fibrous tissue is a thin ligament
- Only example is teeth in sockets of maxillae and mandible.
- Ligament holds cone-shaped peg in bony alveolar socket
- Not movable → Synarthrosis

Figure 2c



Joint classification

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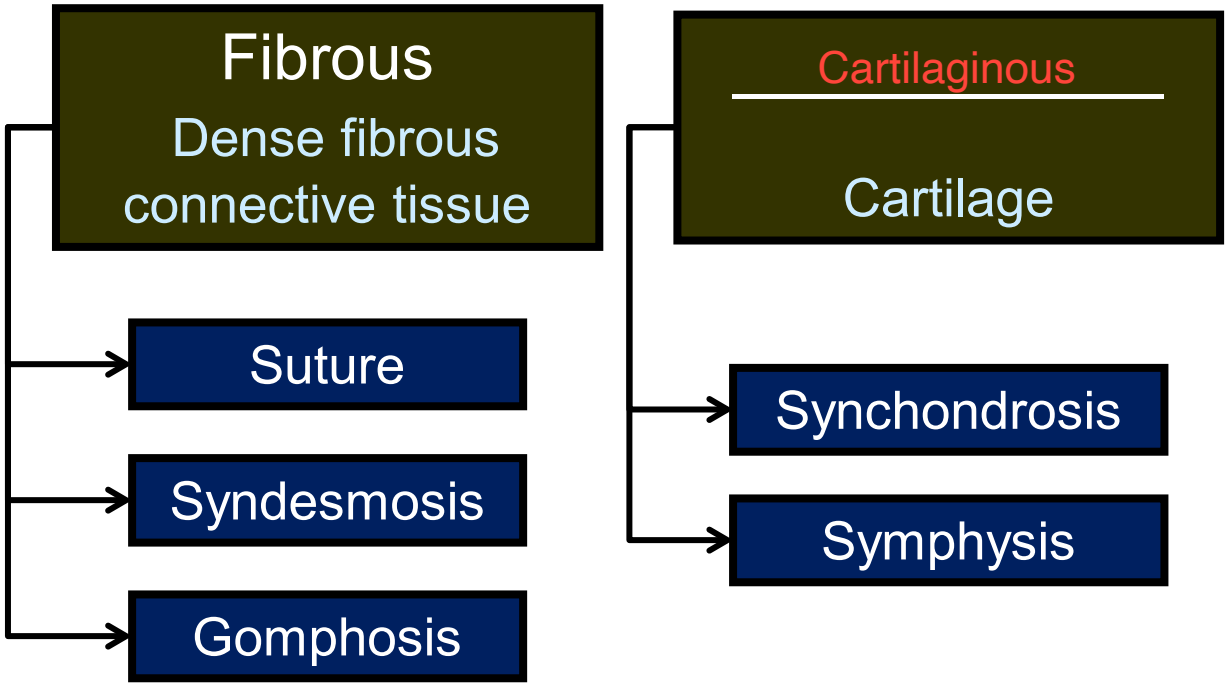
based on their structure



Cartilaginous joints

synchondrosis

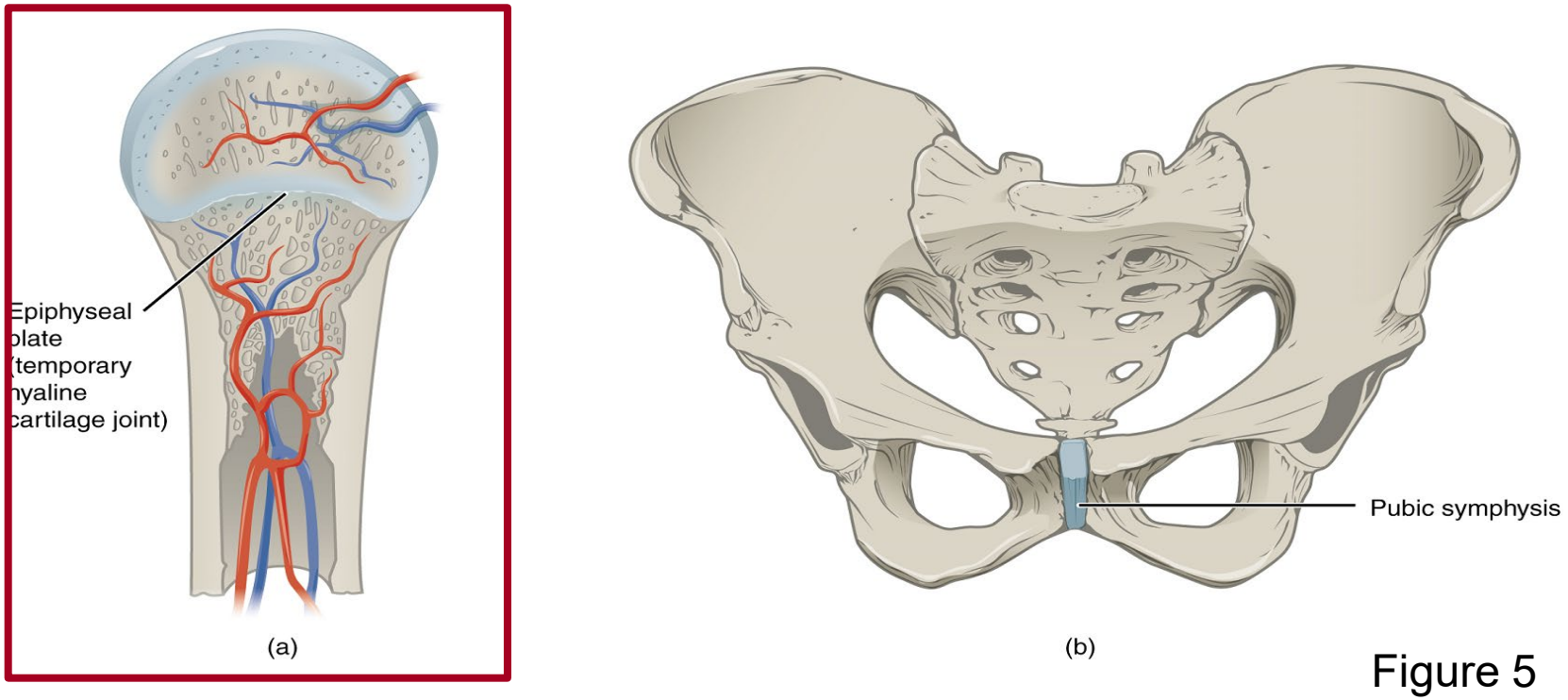


Figure 5

- Connecting tissue is hyaline cartilage
- Bone replaces cartilage after growth ceases.
- E.g. epiphyseal plate, sternum and first rib
- Not movable → Synarthrosis

Cartilaginous joints

symphysis

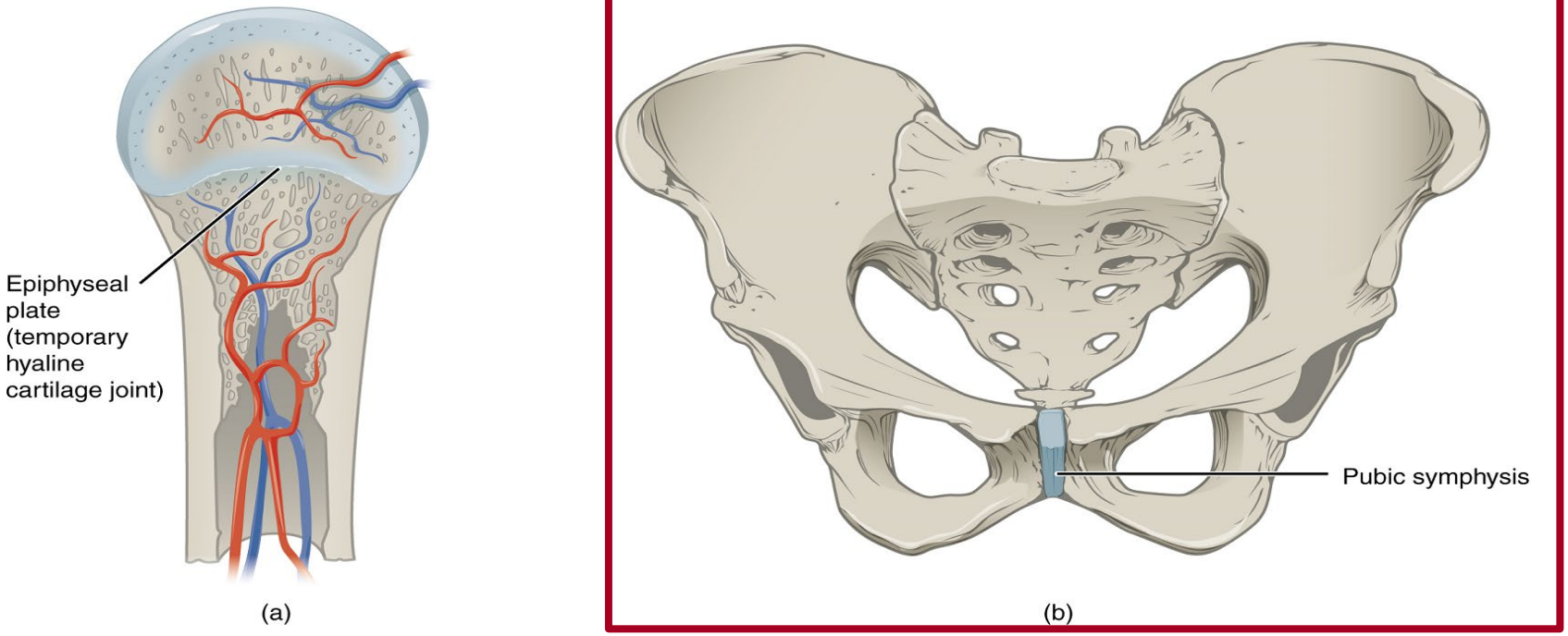


Figure 5

- Connecting tissue is a flat disc of fibrocartilage.
- All located close to the midline of the body.
- E.g. pubic symphysis, intervertebral joints
- Slightly movable → amphiarthrosis

Joint classification

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  - Gliding
  - Hinge
  - Pivot
  - Ellipsoidal
  - Saddle
  - Ball & socket

Synovial joints

Main characteristics

- Most common joint type
- Diarthrosis
- Main structures:
  - *Fluid-filled synovial cavity*
  - *Articular cartilage (layer of hyaline cartilage)*
  - *Joint capsule*
  - *Ligaments to reinforce joint*
  - *Rich network of blood vessels & nerve fibers*

General structure of a synovial joint

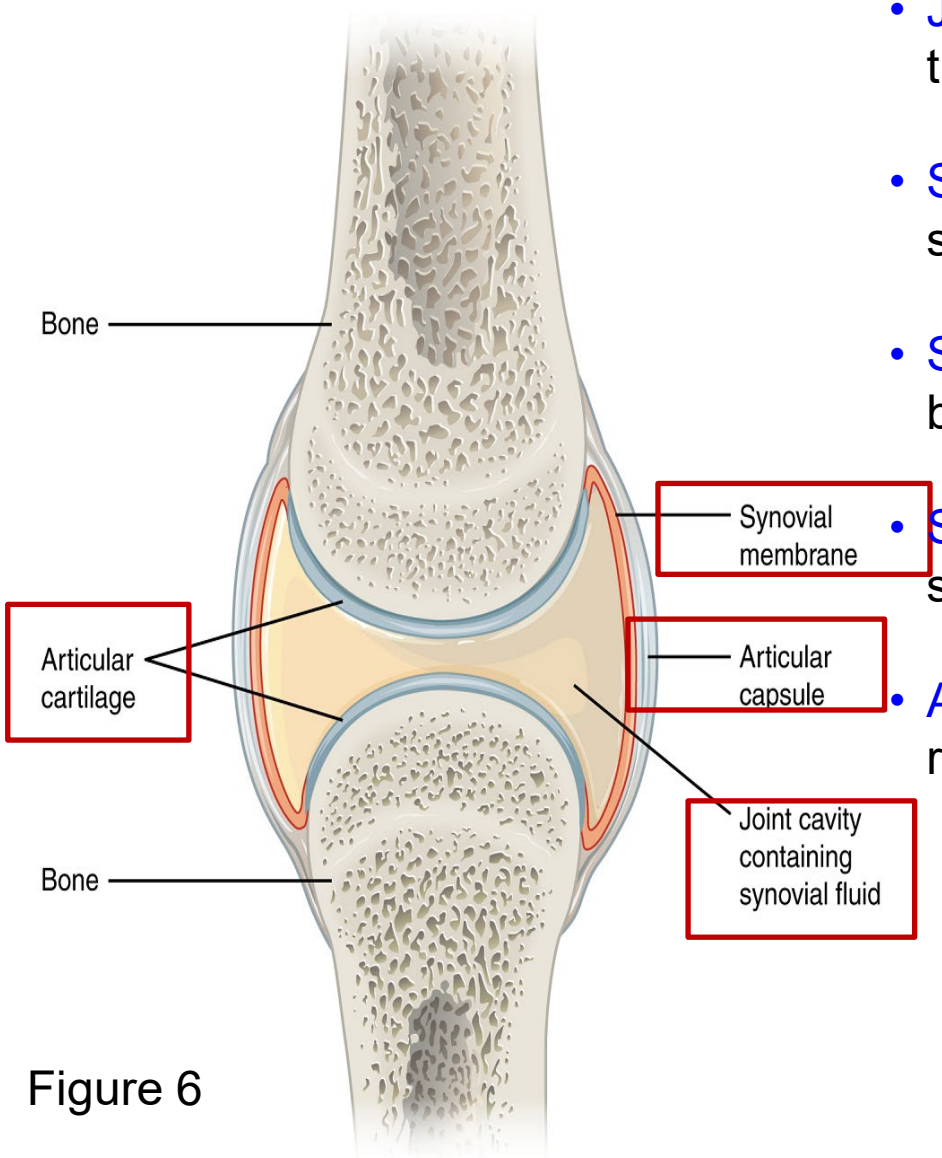


Figure 6

- Joint capsule: fibrous connective tissue that surrounds the joint
- Synovial membrane: lines the inner surface, secretes the synovial fluid
- Synovial cavity : space between the two bones which contains synovial fluid
- Synovial fluid: lubricates joint and act as a shock absorber
- Articular cartilage: at the end of the bones, reduced friction and absorbs shock

Structure of a synovial joint

knee joint

- Ligaments: band of fibers
- Meniscus: cartilage pads, act as spacers
- Bursa: fluid filled sacs that reduce friction

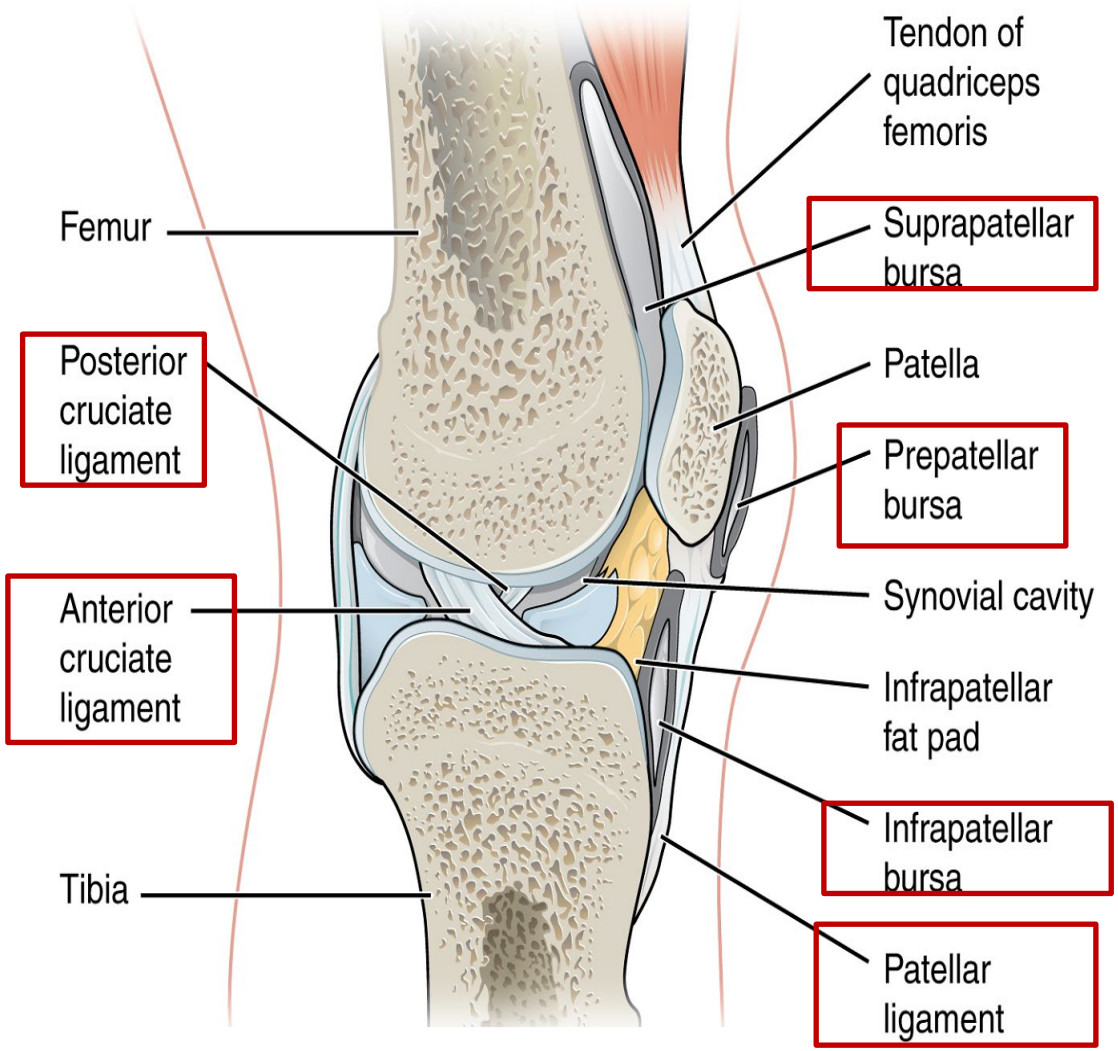


Figure 7

Components of the knee joint

summary of functions

Component	Function
Joint capsule	Forms the synovial cavity & holds bones together
Synovial mambrane	Secretes synovial fluid
Synovial cavity	Contains synovial fluid
Synovial fluid	Lubrication, cushioning, circulation of substances
Articular cartilage	Reduces friction, provides cushioning
Ligaments	Holds bones together
Meniscus	Allows articulating bones to fit together tighter
Bursa	Reduces friction, provides cushioning

Types of Movements at Synovial Joints

I. Gliding

II. Angular

III. Rotation

IV. Circumduction

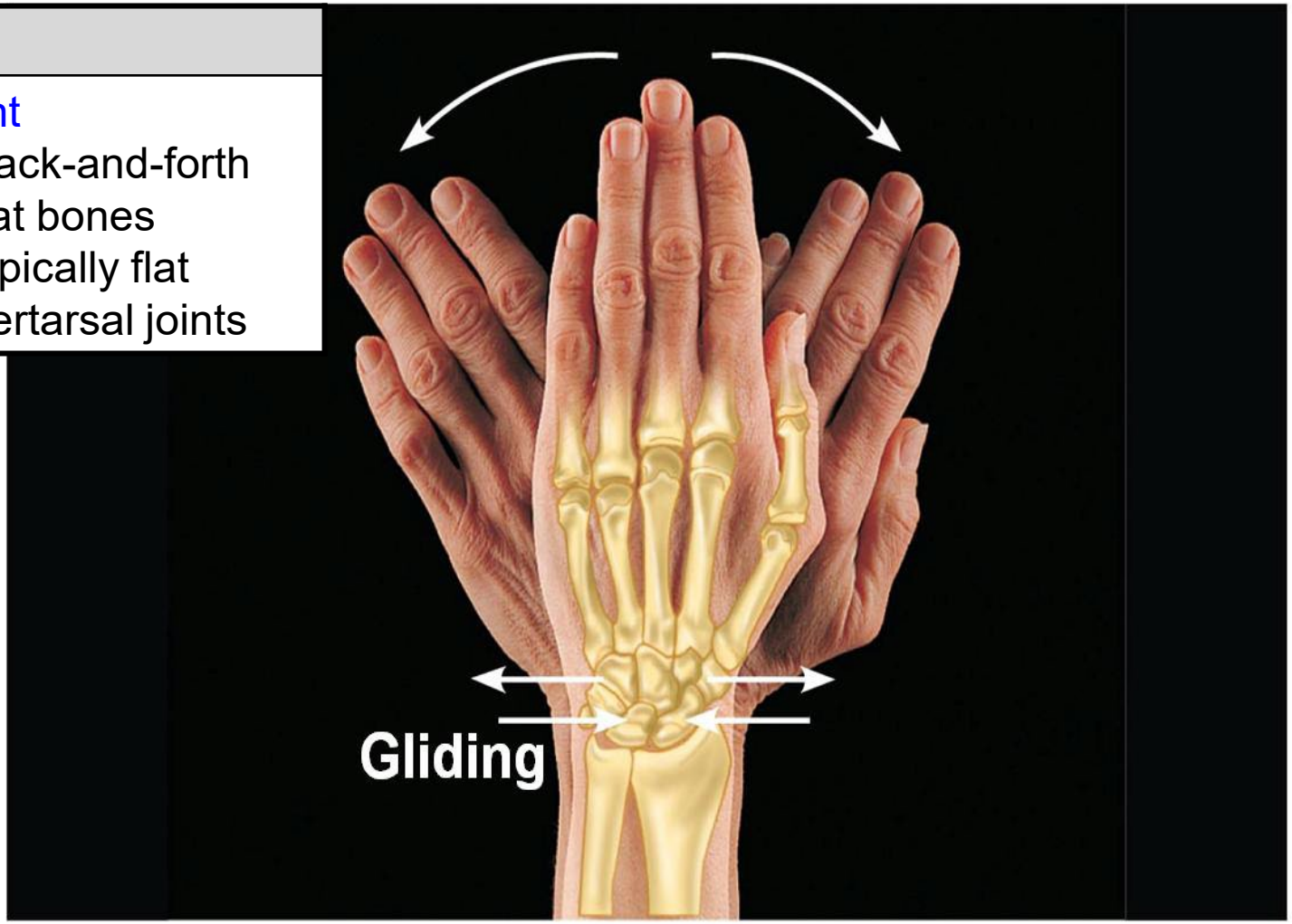
Movements at synovial joints

gliding movement

Marieb, Figure 8.5a

Description

- Linear movement
- Side-to-side & back-and-forth movements of flat bones
- Joint surfaces typically flat
- Intercarpal & intertarsal joints

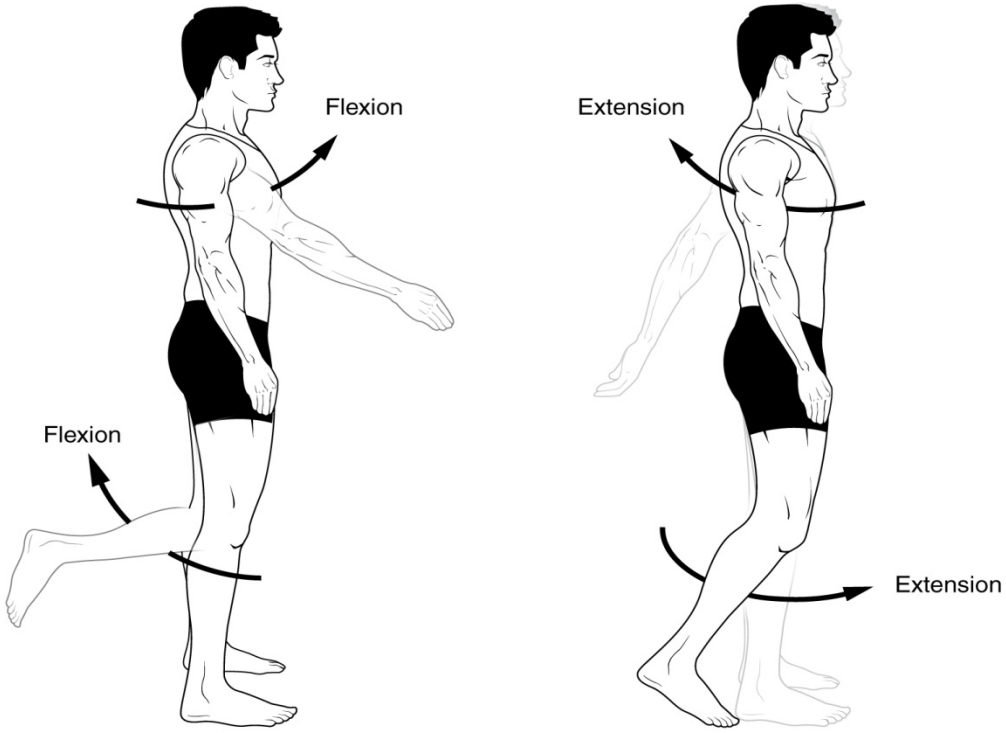


(a) Gliding movements at the wrist

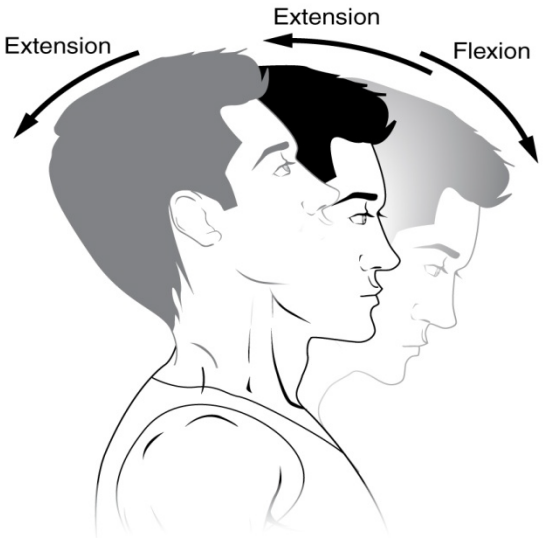
Movements at synovial joints

angular movement

Description
- Increase or decrease in angle between articulating bones - Several types



(a) and (b) Angular movements: flexion and extension at the shoulder and knees

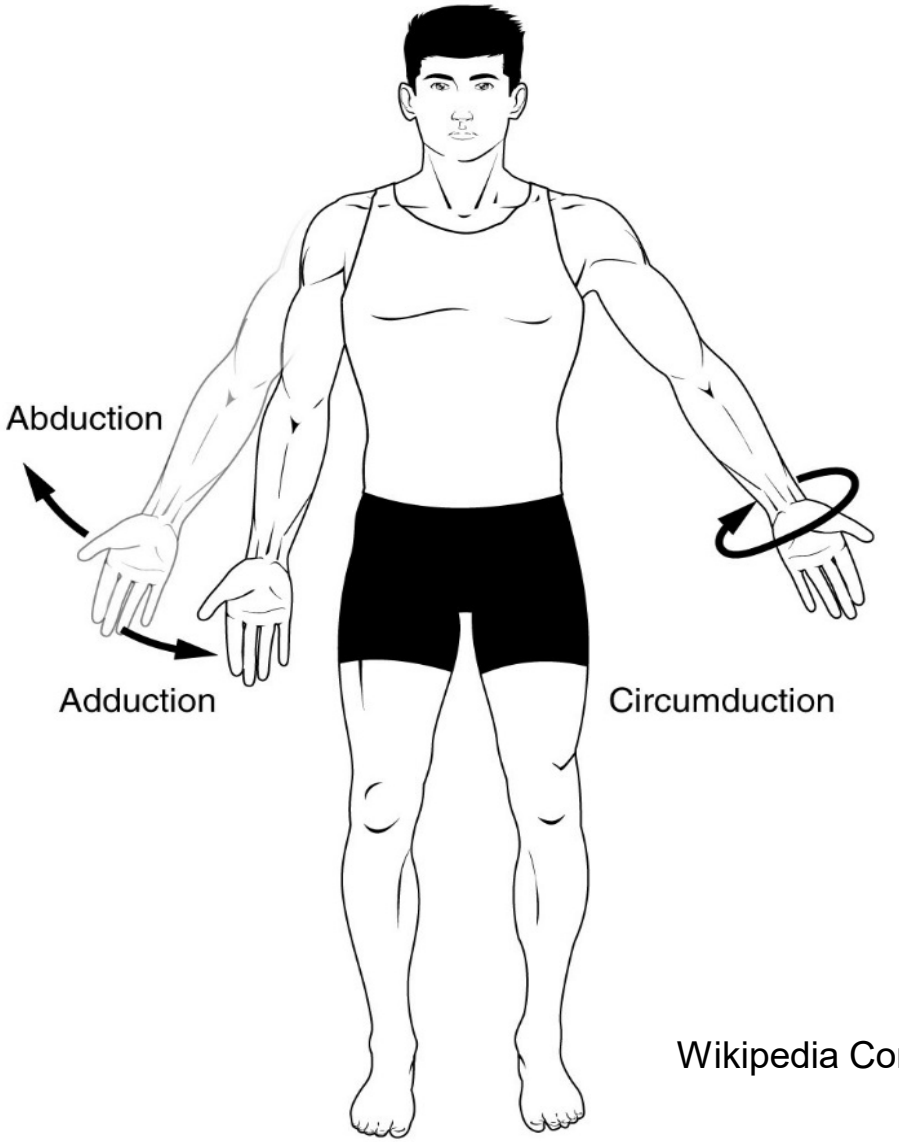


(c) Angular movements: flexion and extension of the neck

Wikipedia

angular movement: flexion, extension, hyperextension

angular movement: abduction, adduction and circumduction

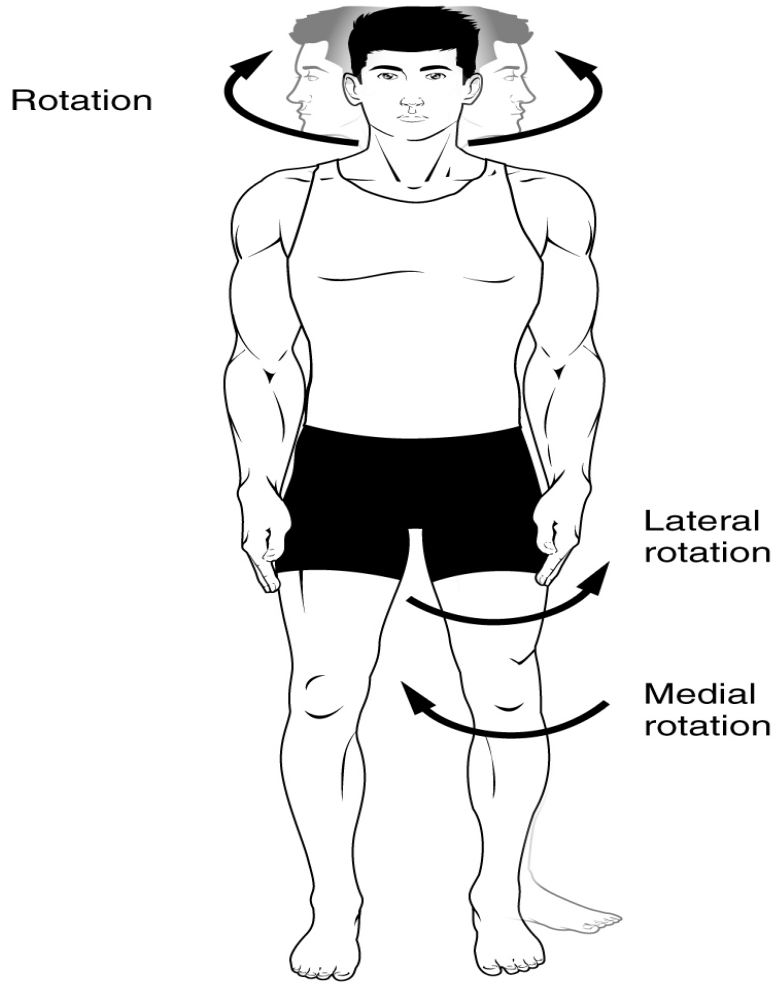


Wikipedia Commons

Movements at synovial joints

rotation movement

Description
- Bone moves around its longitudinal axis



f) Rotation of the head, neck, and lower limb

Wikipedia

Types of Movements at Synovial Joints

I. Gliding

Side-to-side and back-&-forth, no angle change.

II. Angular

Angle between bones changes.

III. Circumduction (a type of angular movement)

Distal end of bone “draws” a circle.

IV. Rotation

Bone “spins” around its axis.

Joint classification

based on their function

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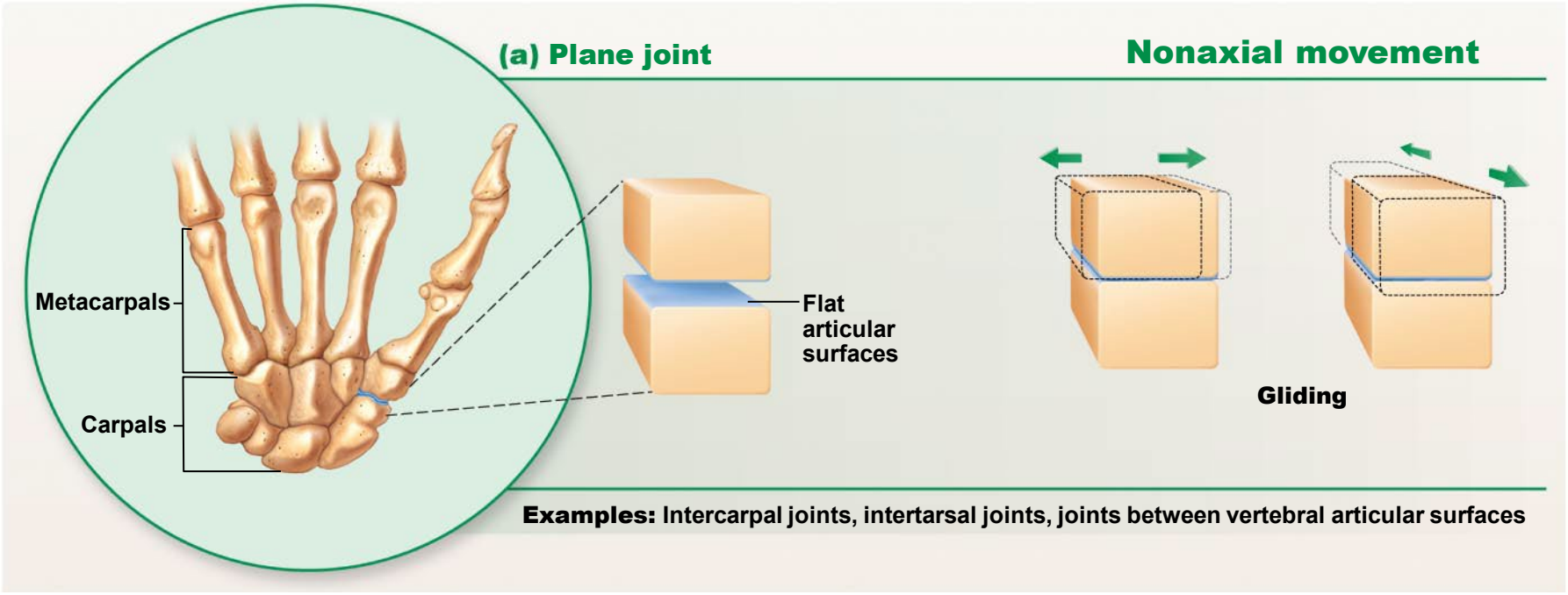
  - Saddle
  - Ball & socket

Types of synovial joints

gliding (planar) joint

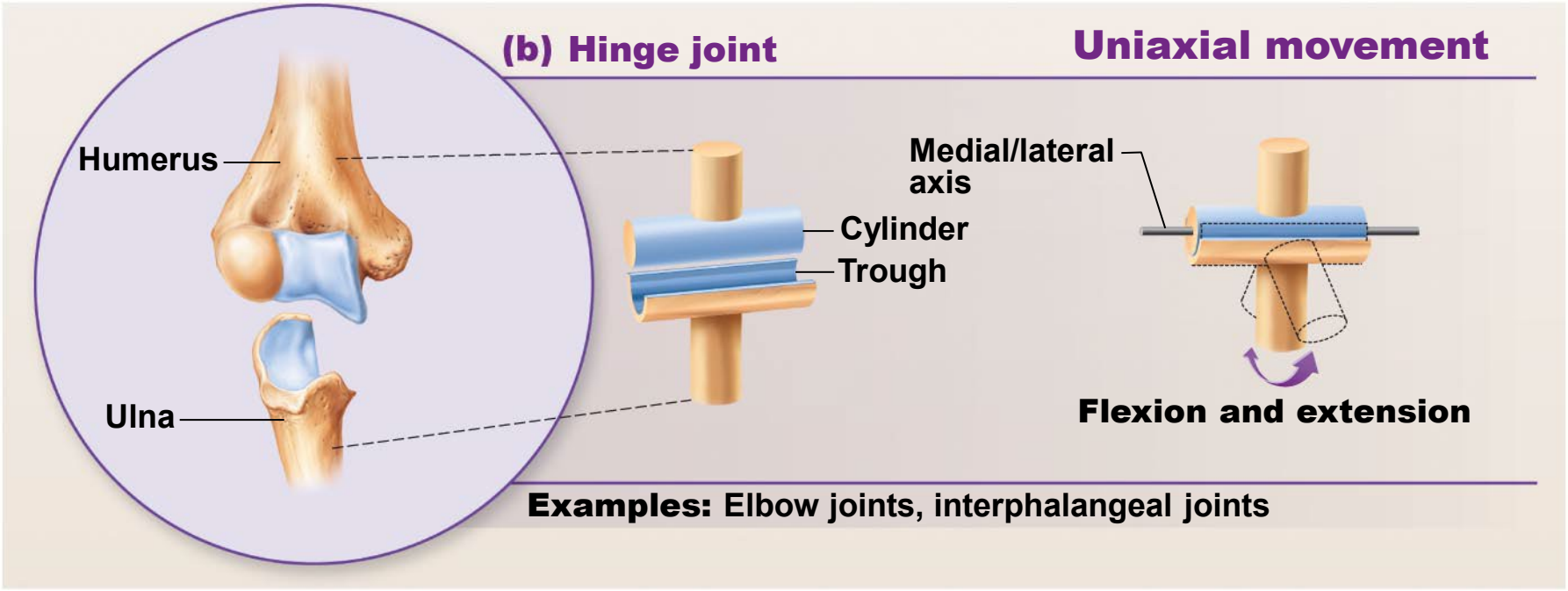


Marieb, Figure Focus 8.1a

- Flat or slightly curved articulating surfaces
- Back-and-Forth, Side-to-Side Movements
- Nonaxial or multiaxial

Types of synovial joints

hinge joint

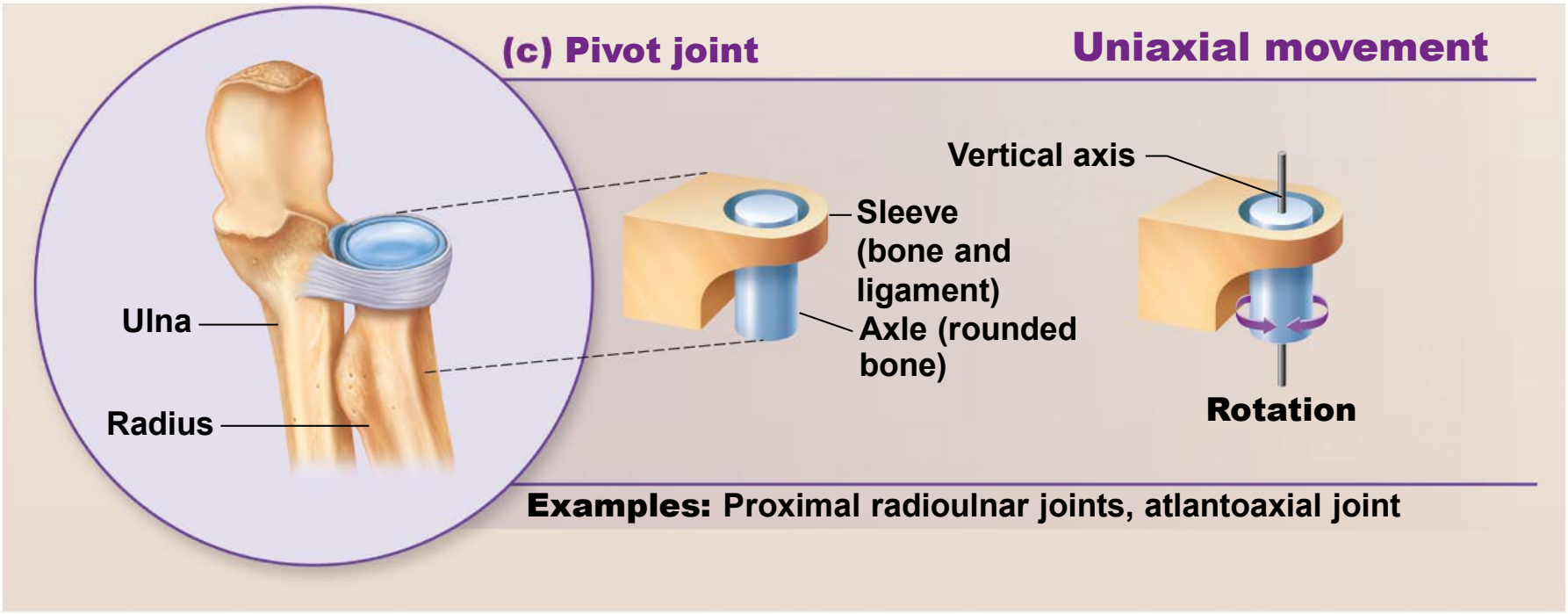


Marieb, Figure Focus 8.1b

- Convex surface fits inside concave surface
- Uniaxial
- Angular movements in 1 plane.

Types of synovial joints

pivot joint

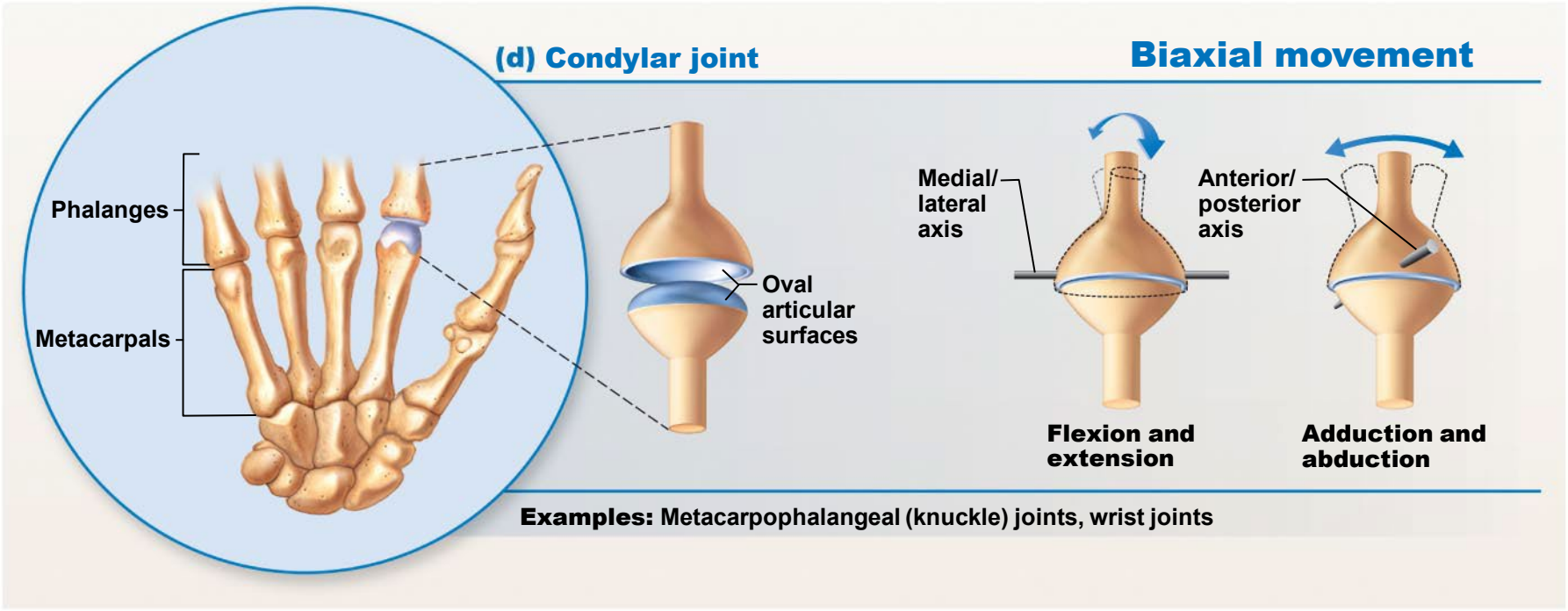


Marieb, Figure Focus 8.1c

- Rounded surface articulate with ring surface
- Uniaxial
- Rotational movement.

Types of synovial joints

ellipsoidal (condylar) joint

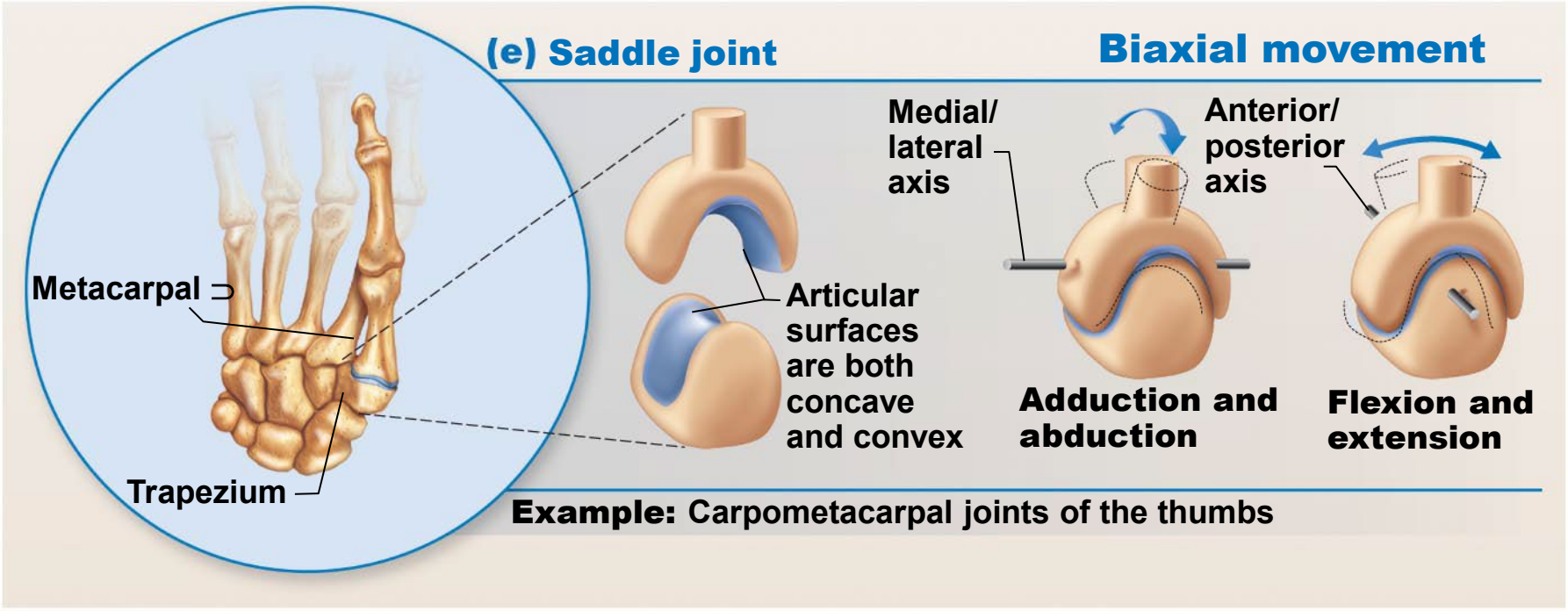


Marieb, Figure Focus 8.1d

- Oval-shaped projection fits into oval-shaped depression
- Biaxial
- Angular movement in 2 planes

Types of synovial joints

saddle joint

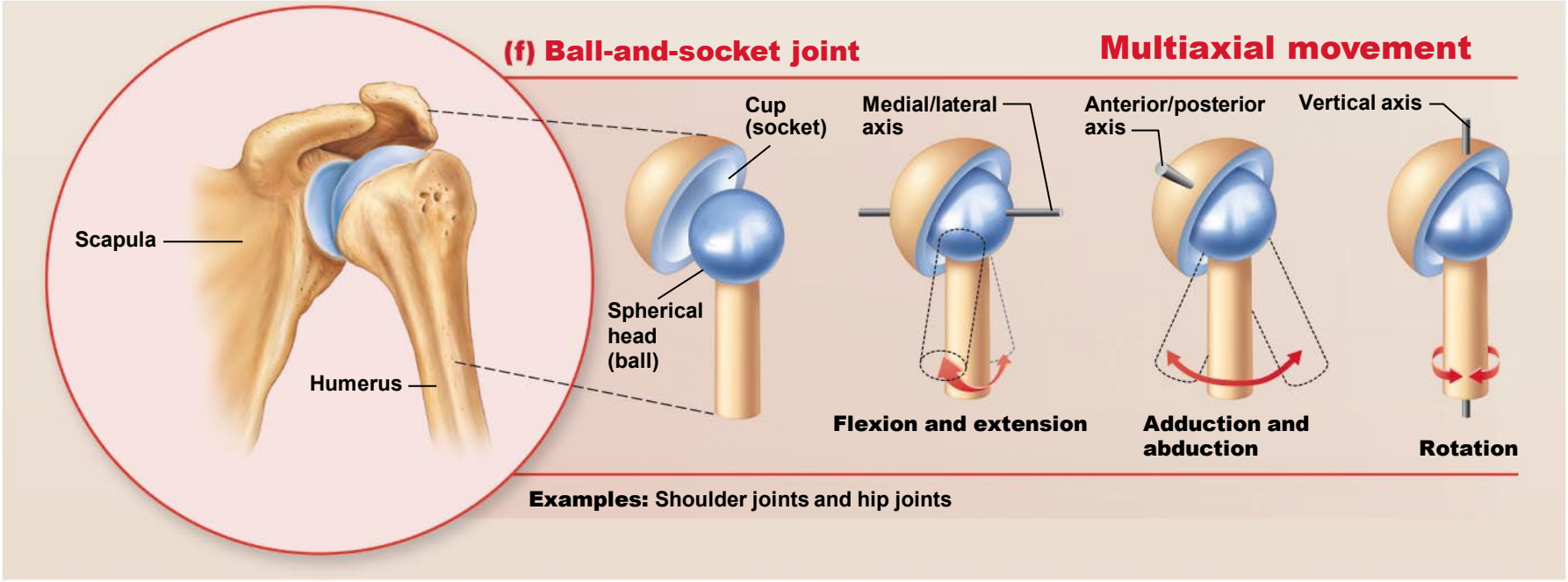


Marieb, Figure Focus 8.1e

- Saddle-shaped surface articulates with "legs" of another bone
- Biaxial
- Angular movement in 2 planes

Types of synovial joints

ball-and-socket joint



Marieb, Figure Focus 8.1f

- Ball-like surface articulates with a cup-like depression
- Multiaxial
- Angular movement in 2 planes and rotation

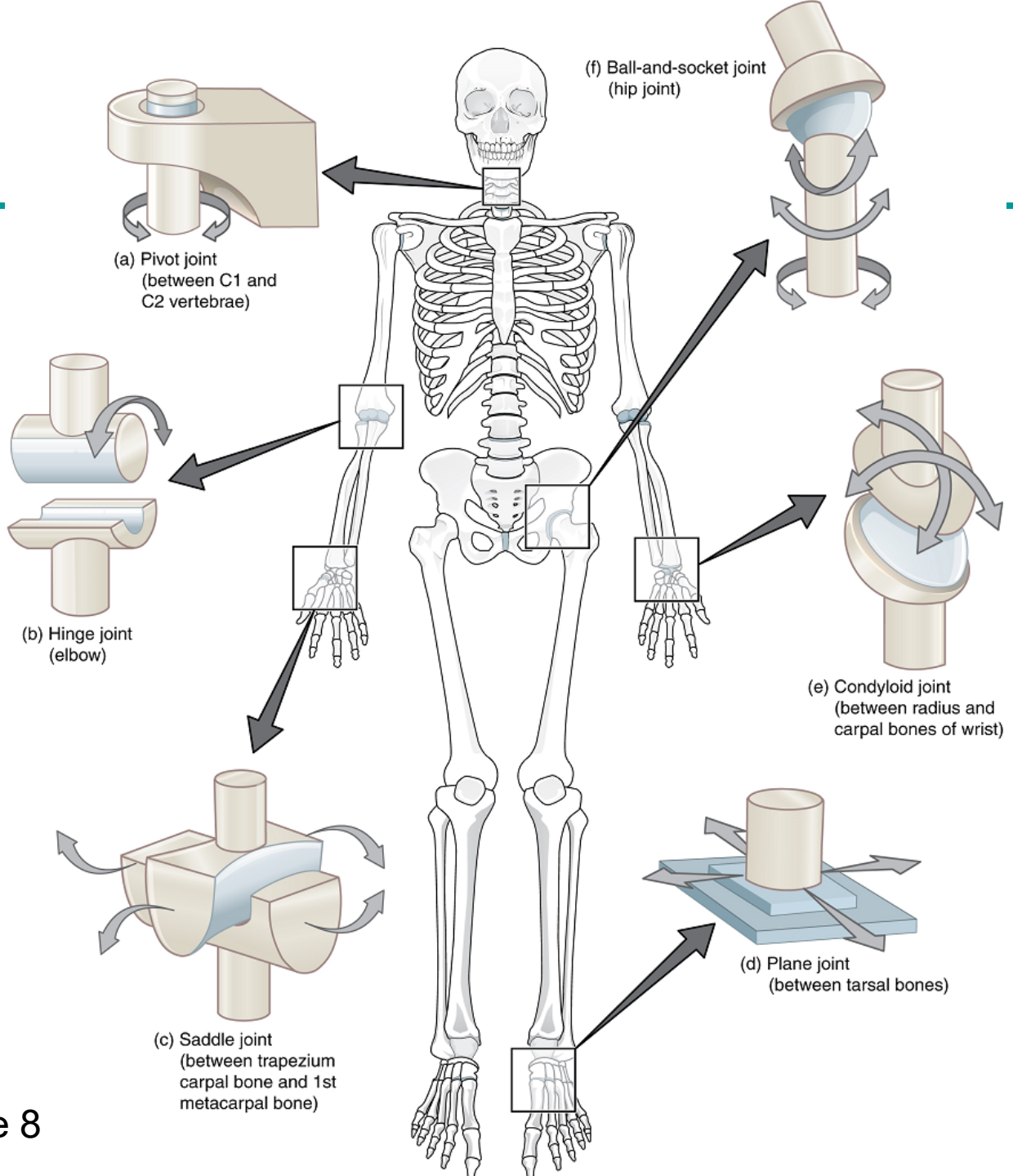

(f) Ball-and-socket joint
(hip joint)
(a) Pivot joint
(between C1 and
C2 vertebrae)
(b) Hinge joint
(elbow)
(e) Condyloid joint
(between radius and
carpal bones of wrist)
(c) Saddle joint
(between trapezium
carpal bone and 1st
metacarpal bone)
(d) Plane joint
(between tarsal bones)

Figure 8

Types of synovial joints

summary of movements

Type	Allowed Movement
Plane	Gliding
Hinge	Angular (flexion and extension)
Pivot	Rotation
Condyloid	Angular (flex., ext., abd., add. and circumduction)
Saddle	Angular (flex., ext., abd., add. and circumduction)
Ball-and-socket	Angular (flex., ext., abd., add. and circumduction), and rotation

Joints

Objectives

1. Explain what is meant by the terms synarthrotic, diarthrotic, and amphiarthrotic as descriptions of the functional classes of joints.

2. Describe the structures, classifications, functions, and locations of the various types of joints in the human body.

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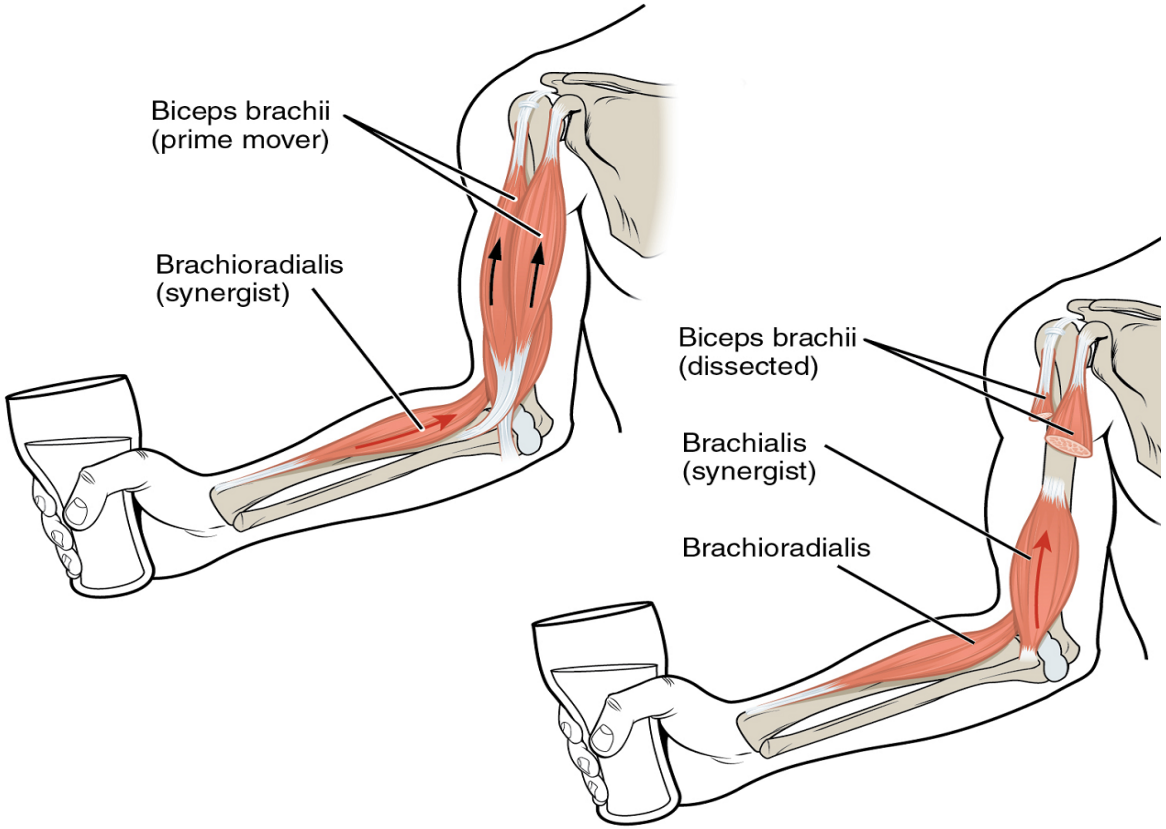
BIOLOGY 1103/1109
Human Anatomy and Physiology I

UNIT 14
Biomechanics



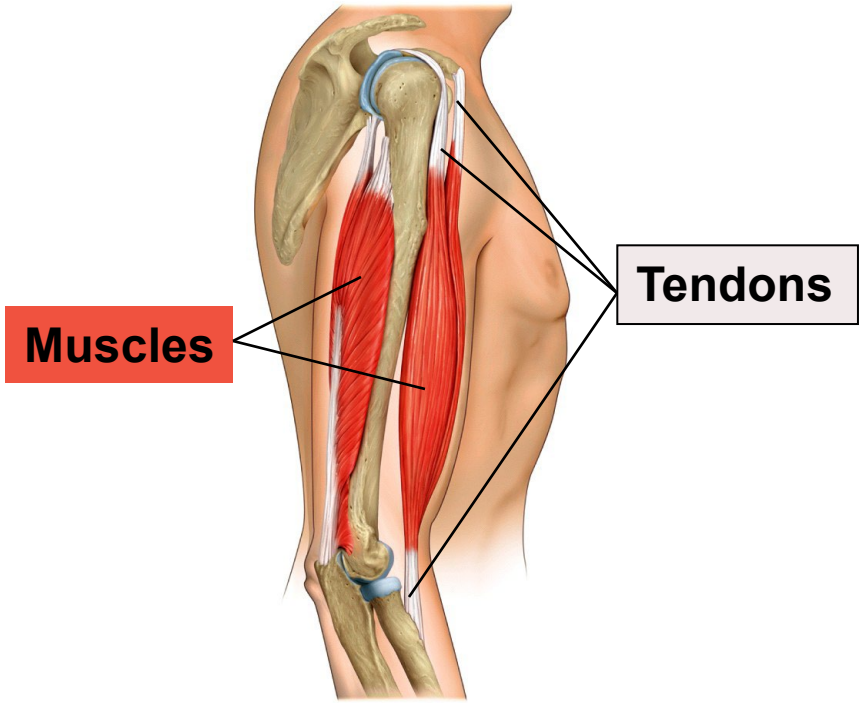
Biomechanics

Objectives

1. Describe how muscles attach to bones to produce movement.
2. Describe the principle of muscular antagonism in movement, using the forearm as an example.
3. Define the following terms: lever, fulcrum, resistance, effort.
4. Describe three types of levers and give an example of each type in the human body.
5. Explain the biomechanical principles and functioning of a lever system

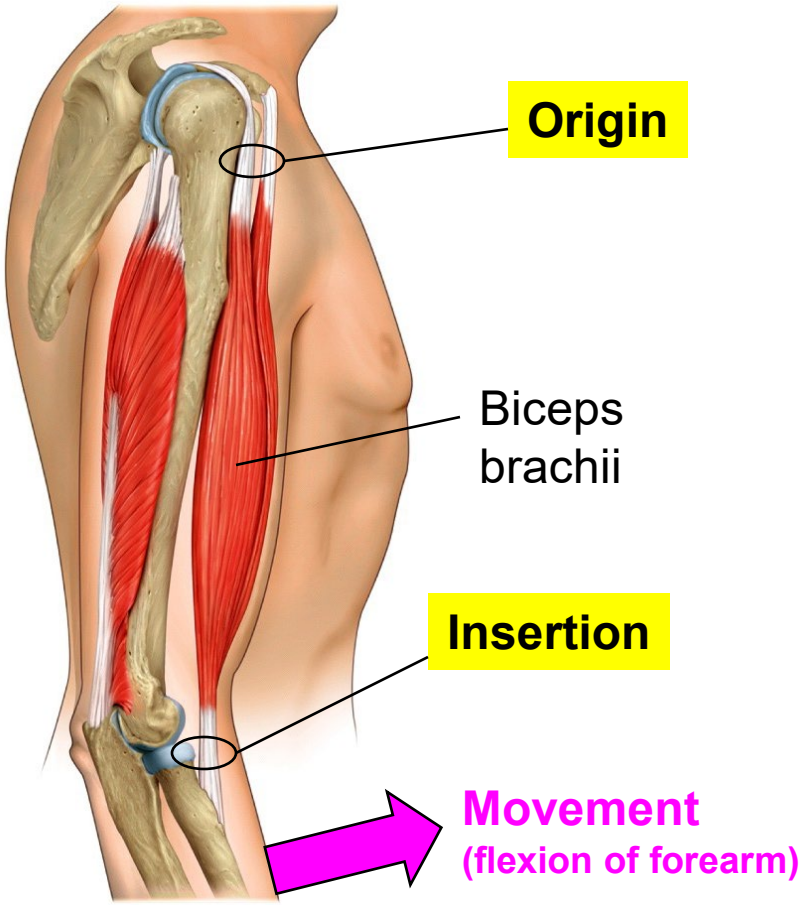
Muscles attach to bones via tendons

Tendons
- Dense CT - Connection between muscles & bones (sometimes between muscles) - Involved in movement - Muscles & tendons span joints



Movement via tendons

How to achieve movement?
- Muscle contracts & pulls bones together via tendons - One bone moves while another does not move
Muscle origin
Attachment on stationary (or less movable) bone
Muscle insertion
Attachment on movable bone



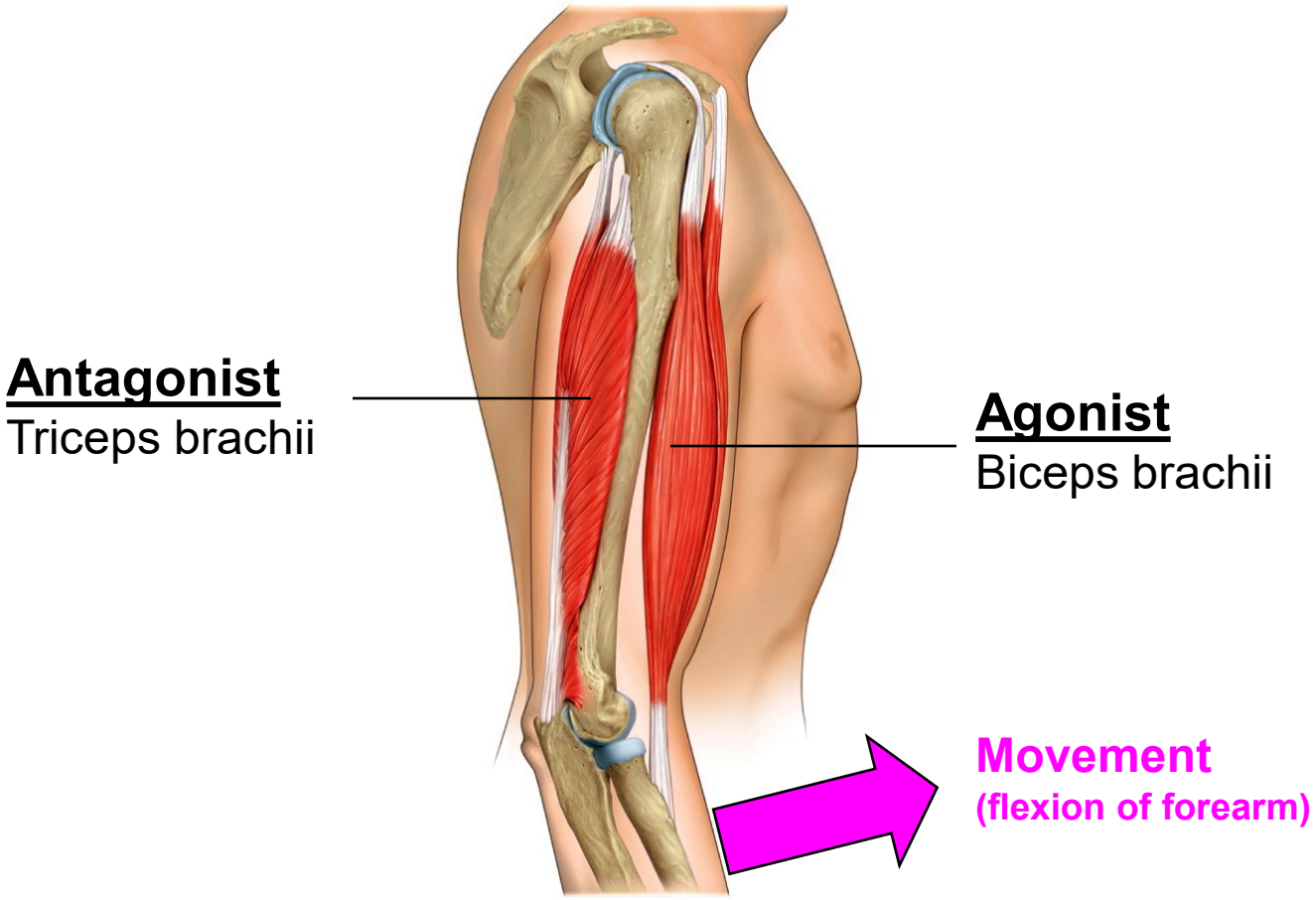
Muscular antagonism

Muscles often work as opposing pairs:

Agonist (prime mover)	Antagonist
- Muscle that provides the major force for producing a specific movement	- Muscle that opposes or reverses the movement - May also help regulate actions of prime movers

Muscular antagonism

example: flexion of forearm



Muscular antagonism

example: extension of forearm

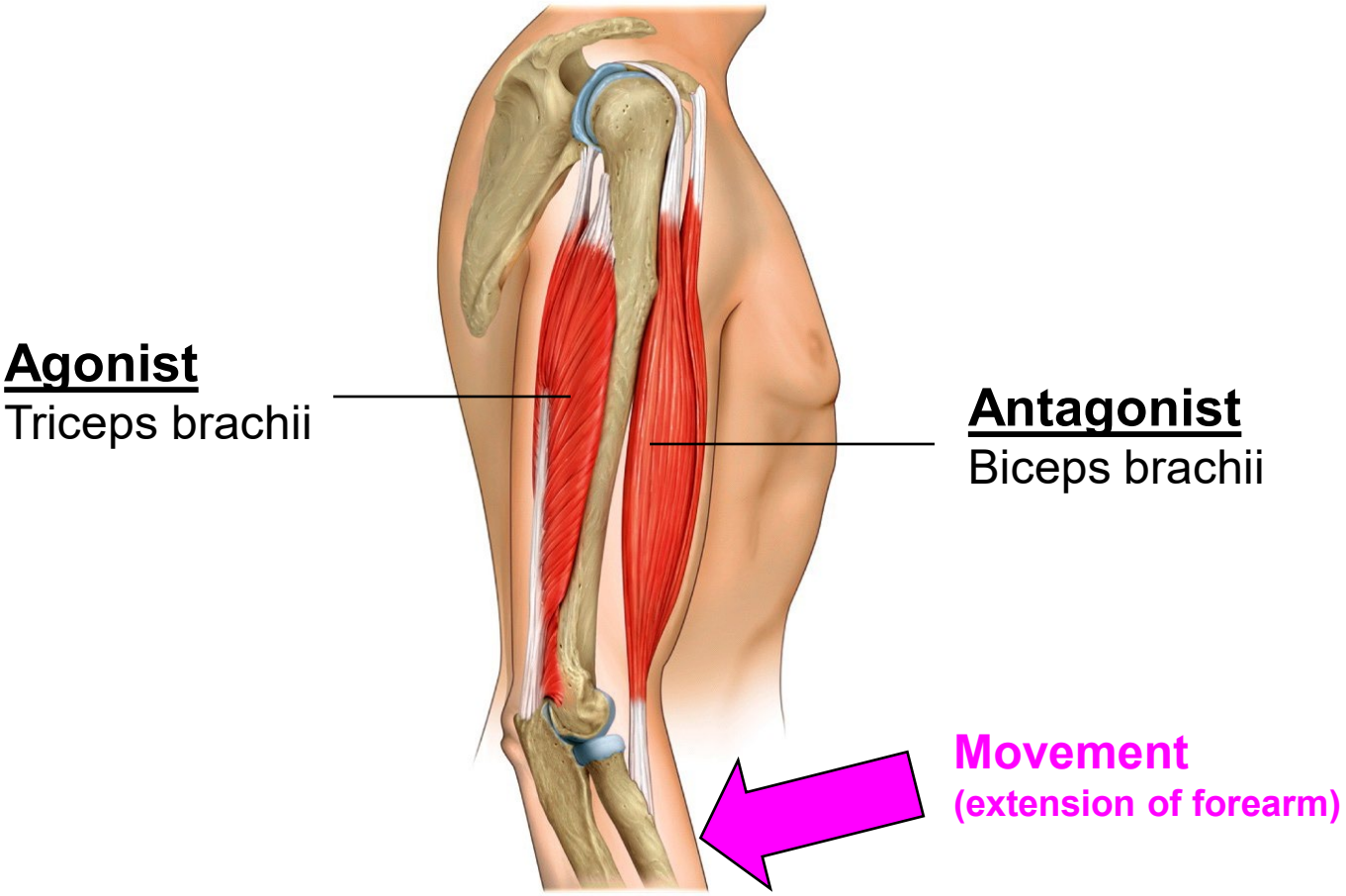
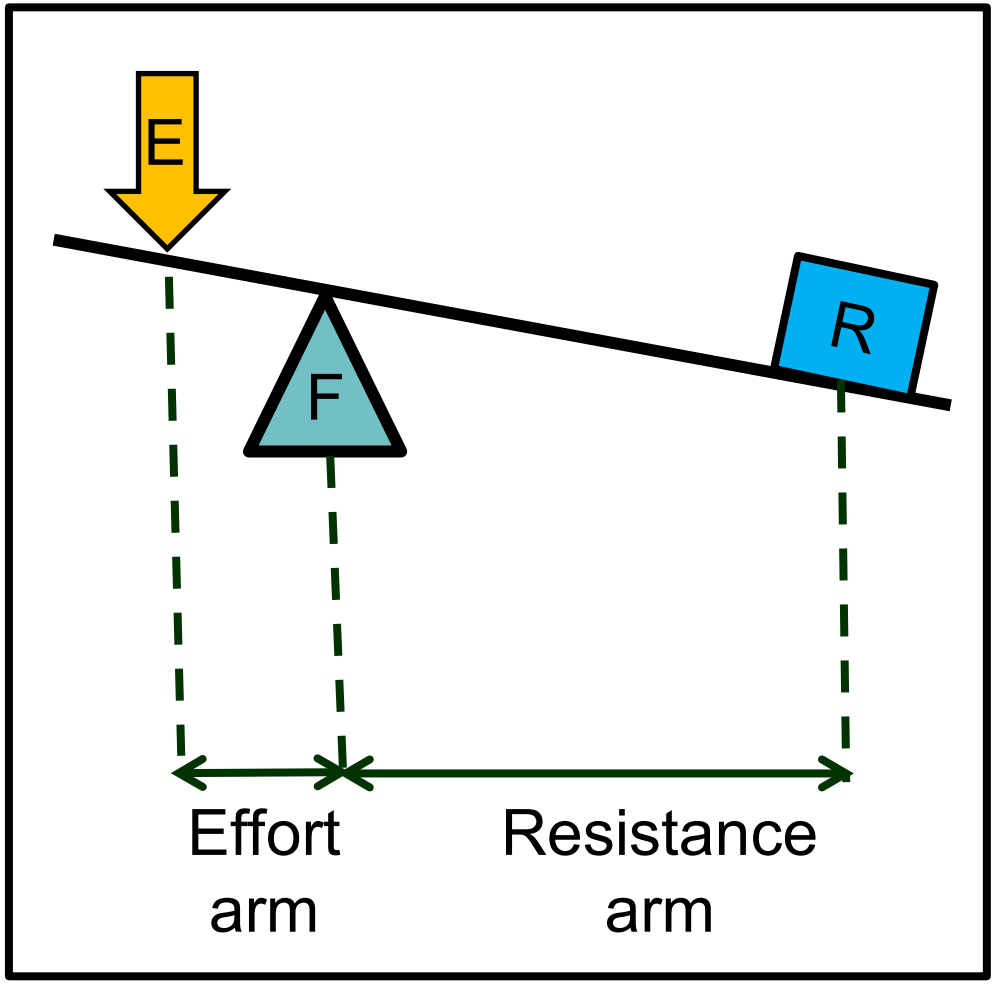


Table 11.1: Agonist and Antagonist Skeletal Muscle Pairs

Agonist	Antagonist	Movement
Biceps brachii: in the anterior compartment of the arm	Triceps brachii: in the posterior compartment of the arm	The biceps brachii flexes the forearm, whereas the triceps brachii extends it.
Hamstrings: group of three muscles in the posterior compartment of the thigh	Quadriceps femoris: group of four muscles in the anterior compartment of the thigh	The hamstrings flex the leg, whereas the quadriceps femoris extend it.
Flexor digitorum superficialis and flexor digitorum profundus: in the anterior compartment of the forearm	Extensor digitorum: in the posterior compartment of the forearm	The flexor digitorum superficialis and flexor digitorum profundus flex the fingers and the hand at the wrist, whereas the extensor digitorum extends the fingers and the hand at the wrist.

Lever systems in movement

components

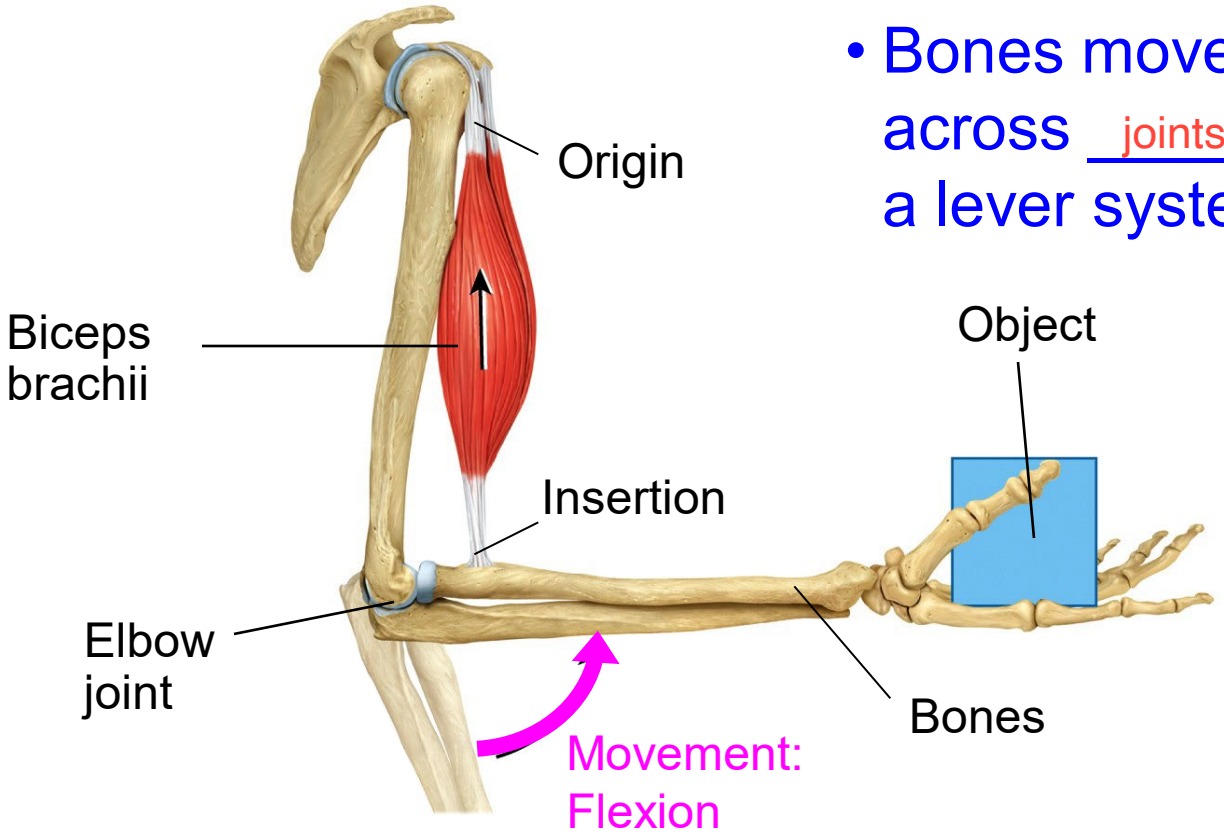


4 components:

1. Lever (bone)
2. Fulcrum = F (joints)
3. Resistance = R weigh
4. Effort = E (muscle)

Lever system

example: flexion of forearm

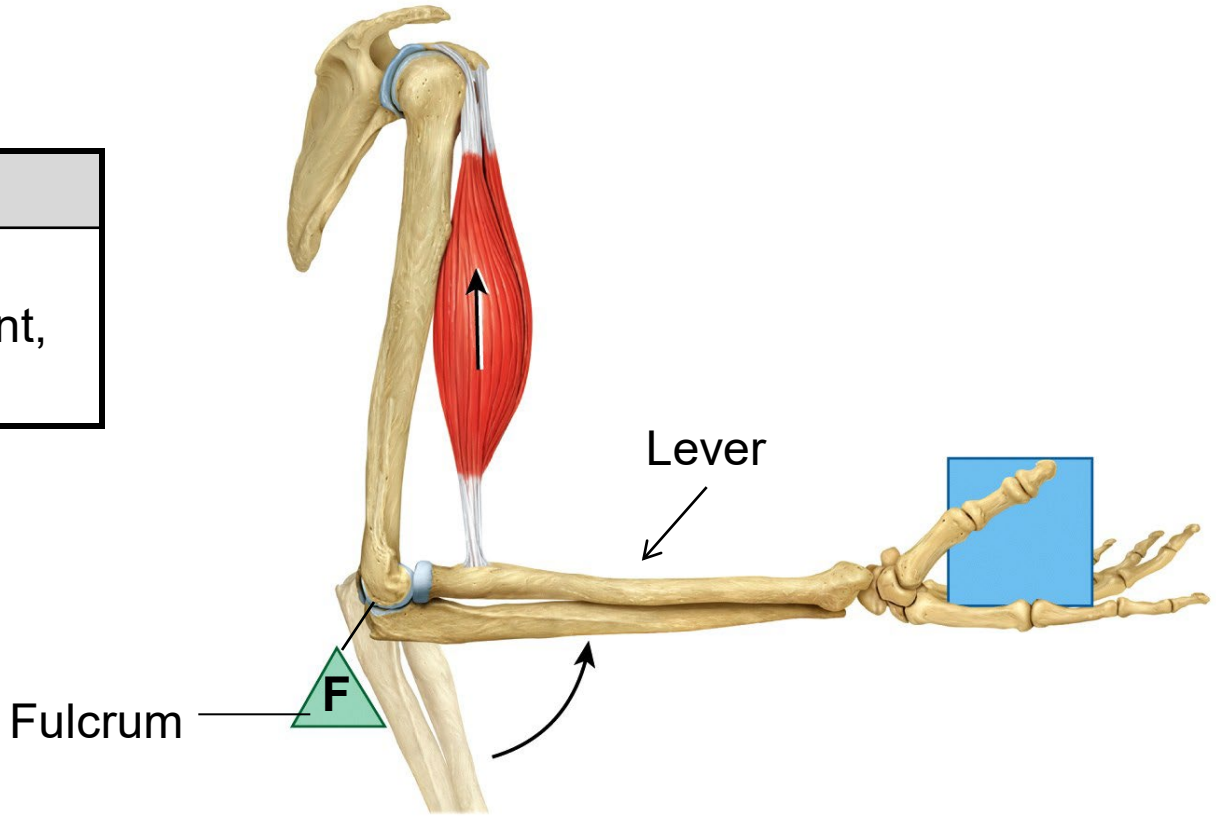


- Bones move across joints in a lever system

Lever system

example: flexion of forearm

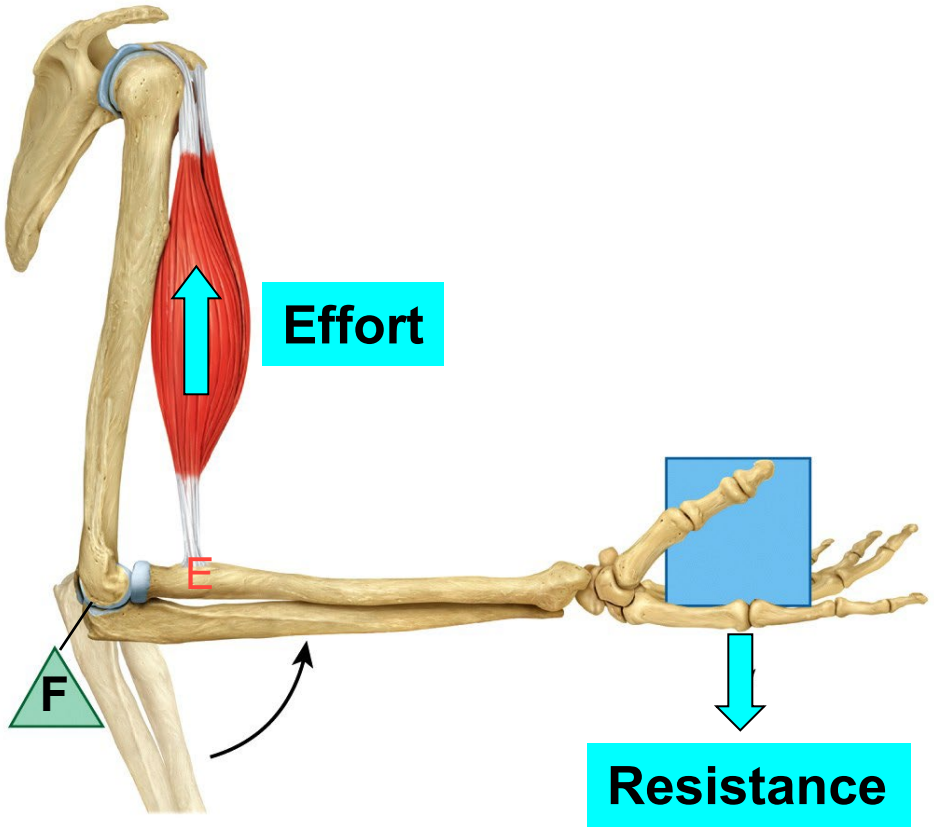
Lever (bones)
Rigid structure that can move around a fixed point, the Fulcrum **(F)** (joints)



Lever system

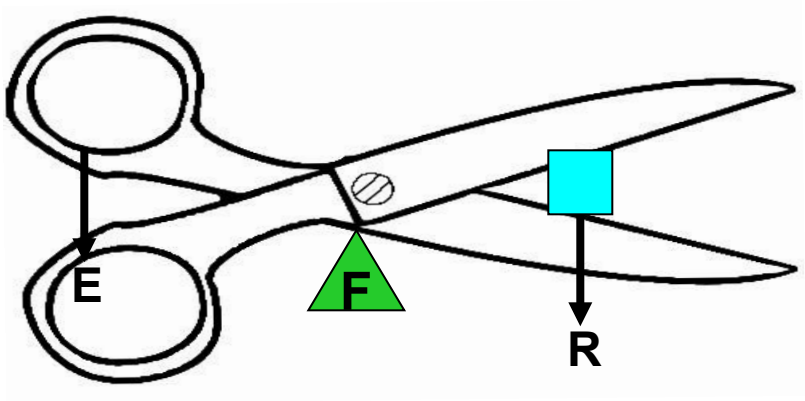
example: flexion of forearm

Opposing forces
1) Effort (E)
2) Resistance (R)



Mechanics of lever system

Lever system operates at a mechanical advantage

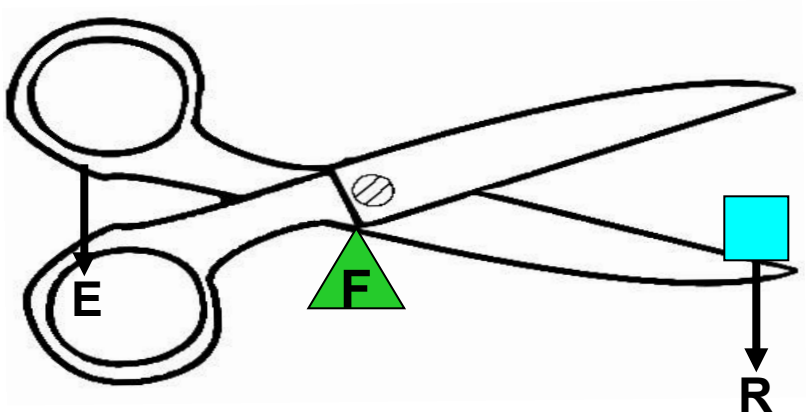


$d_2 > d_1$

"POWER LEVER"

Slower; more stable; small effort required

Lever system operates at a mechanical disadvantage



$d_2 < d_1$

" SPEED LEVER"

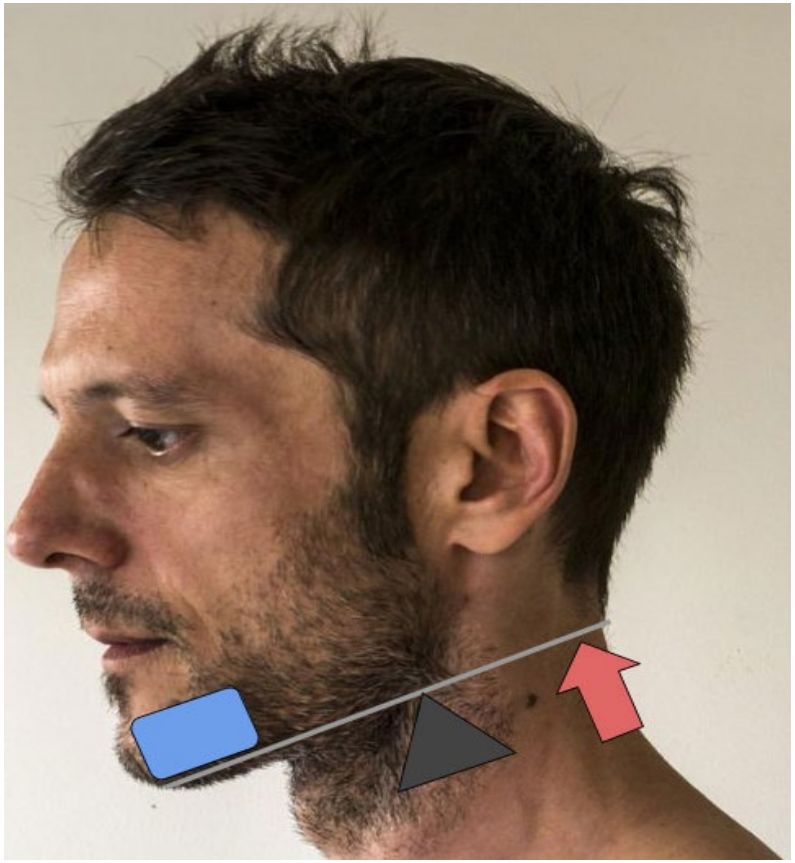
Greater speed & range of motion; large effort required

Lever systems in movement

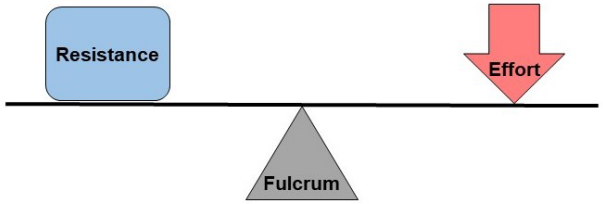
classes of levers

First Class Lever

R F E



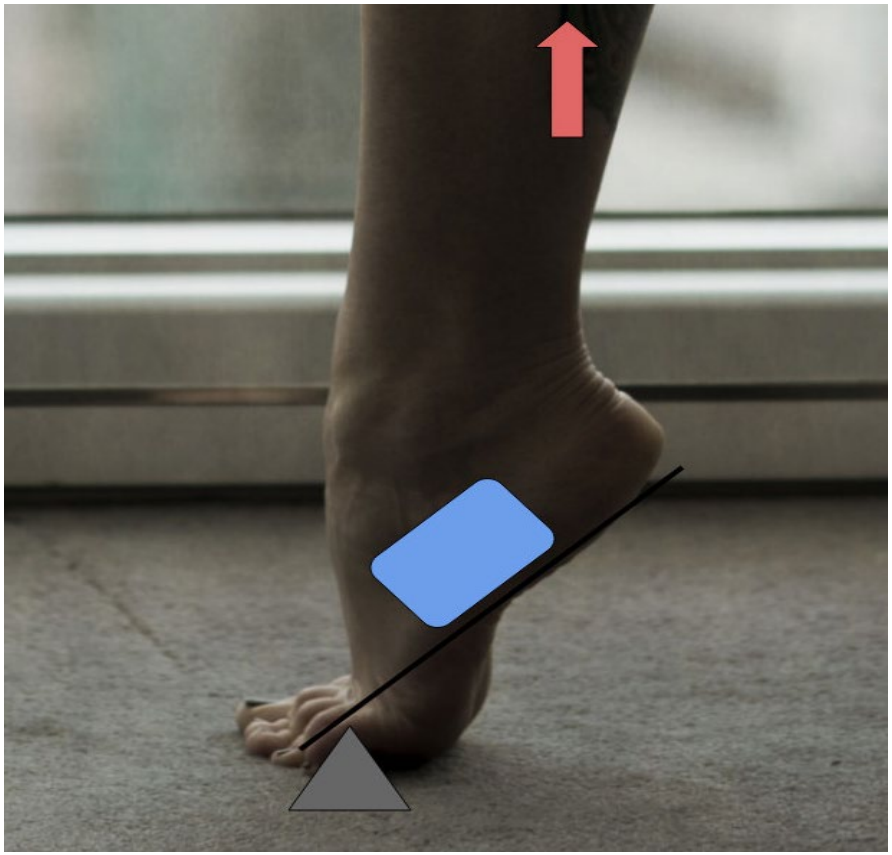
Main characteristics
- Fulcrum between Effort & Resistance - Operates at mechanical advantage or disadvantage - Uncommon in body



Figures 2 and 3

Lever systems in movement

classes of levers

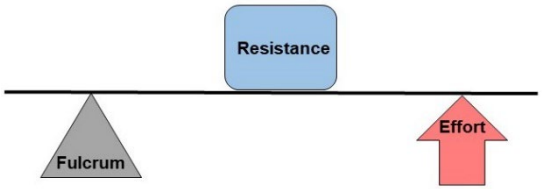


Second Class Lever

F R E

Main characteristics

- Resistance between Fulcrum & Effort
- Operates at mechanical advantage
- Uncommon in body

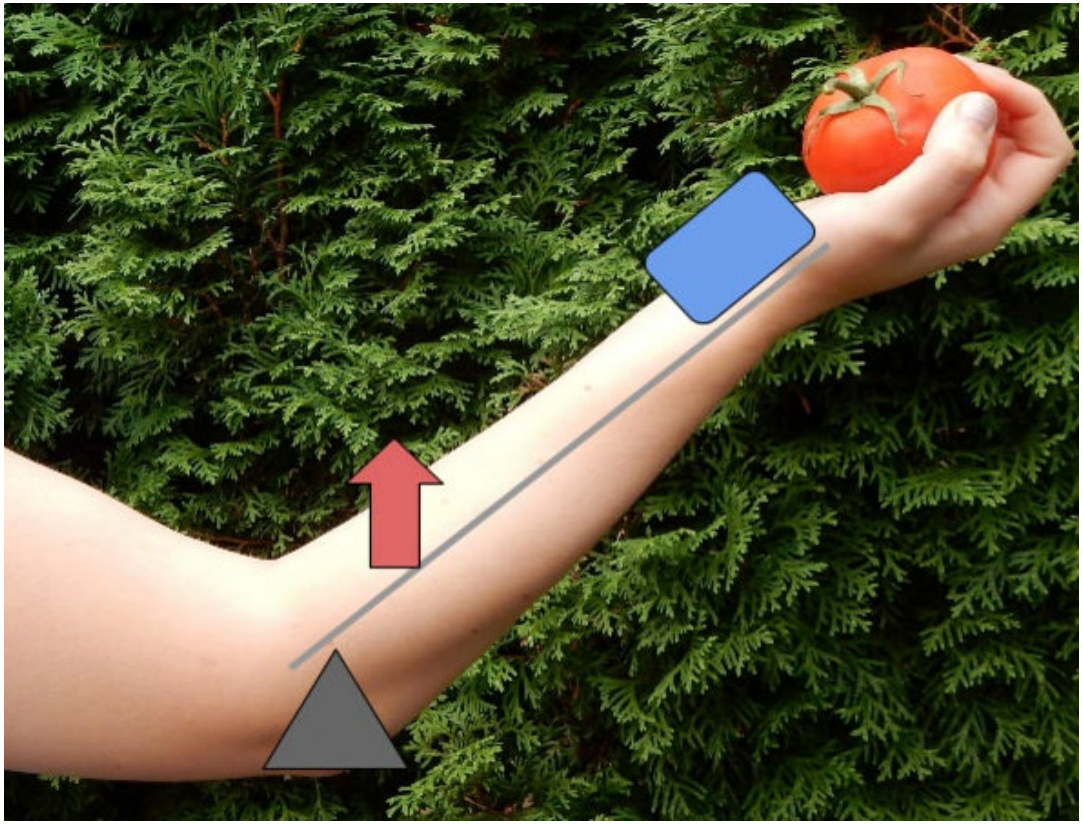


Figures 4 and 5

Lever systems in movement

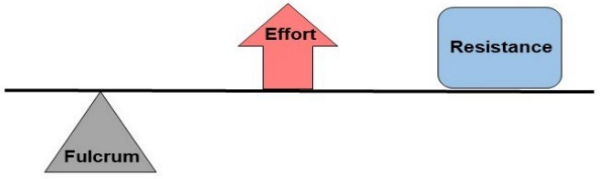
classes of levers

THIRD CLASS LEVER



F E R

Main characteristics
- Effort between Fulcrum & Resistance - Operates at mechanical disadvantage - Very common in body



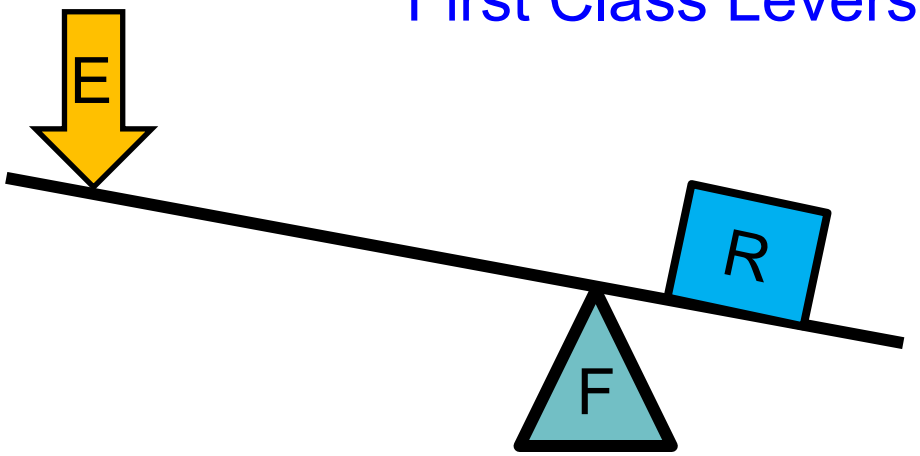
Figures 6 and 7

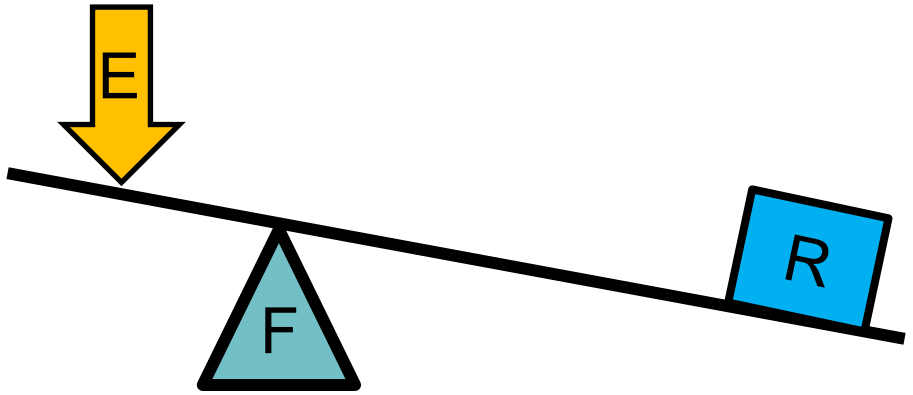
Power levers = move heavy resistance a short distance with little effort (1st and 2nd)
Speed levers = move light resistance a long distance with much effort (1st and 3rd)

Power Levers

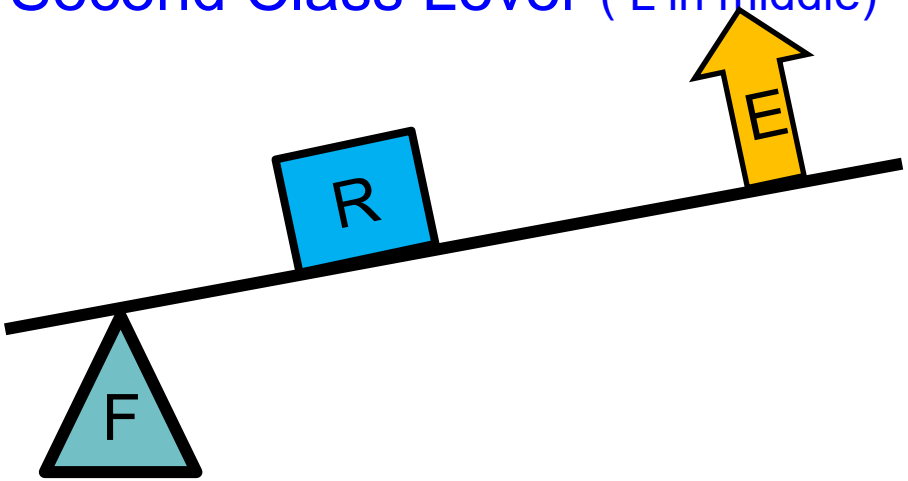
Speed Levers

First Class Levers (F in the middle)

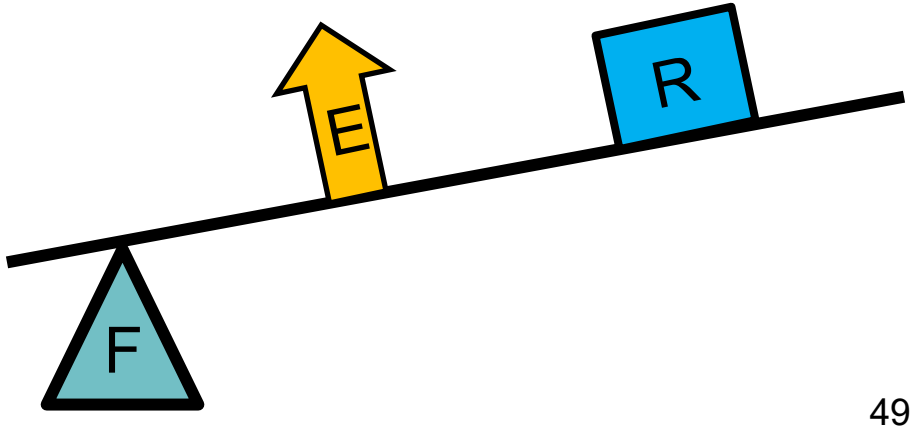




Second Class Lever (L in middle)



Third Class Lever (E in middle)



Lever systems in movement

classes of levers

First Class	Second Class	Third Class
E F R	F R E	F E R

based on their action

Power Levers

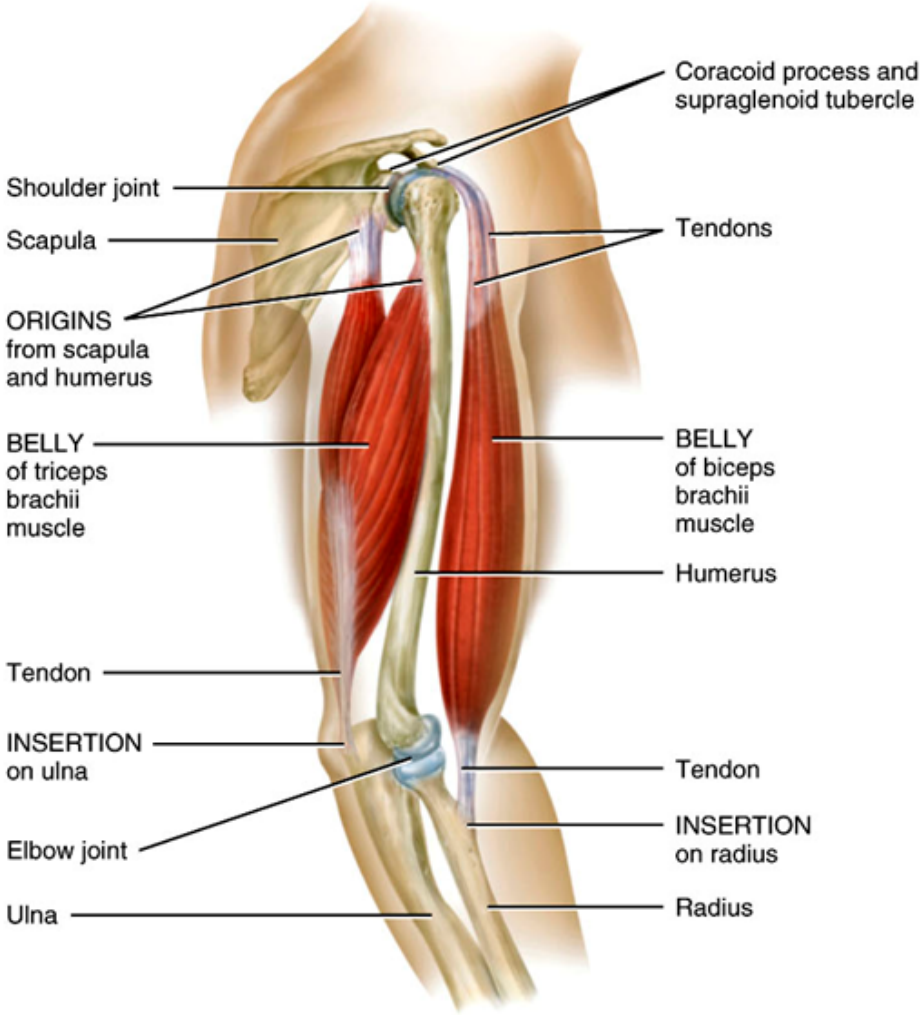
- Large resistance
- Short distance
- Small effort

Speed Levers

- Small resistance
- Long distance
- Large effort

Lever systems in movement

classes of levers

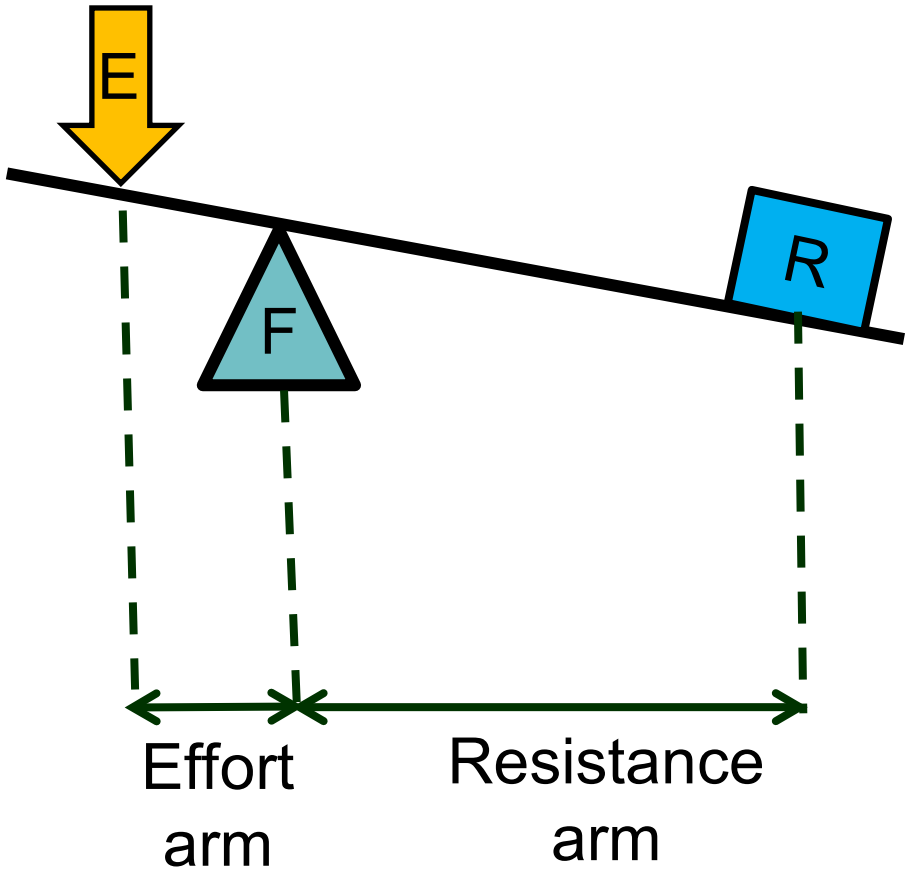


(a) Origin and insertion of a skeletal muscle

What class of lever system does triceps use for the extension of the forearm?

Lever systems in movement

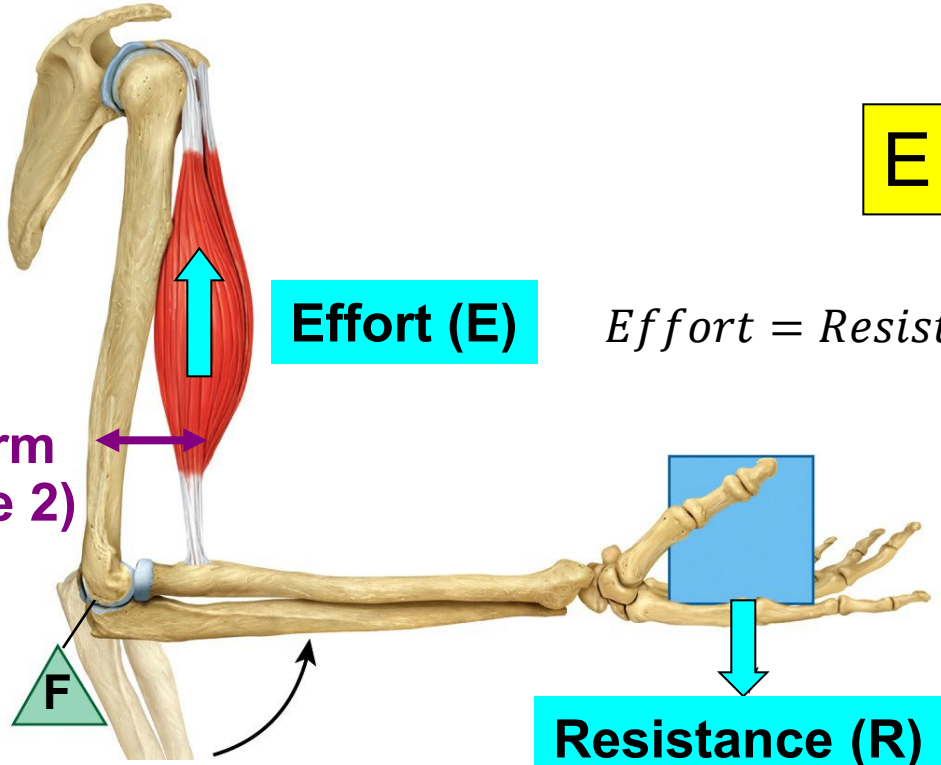
components



- The insertion of a muscle relative to the joint and the resistance will determine the mechanics of the lever
- There is a trade off between force required and distance/speed of movement

Resistance x Resistance arm = Effort x Effort arm

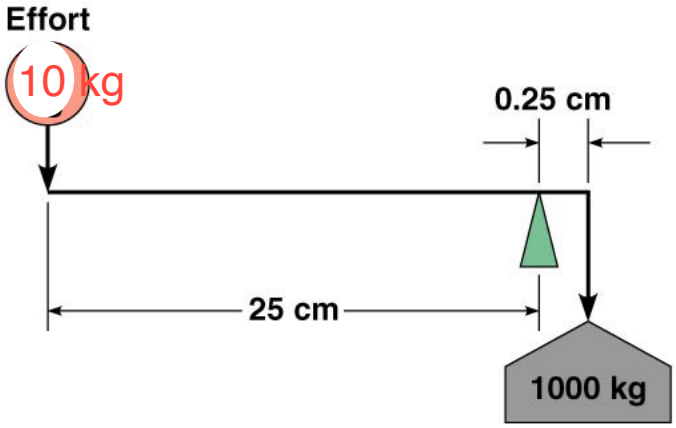
MECHANICS OF LEVER SYSTEM



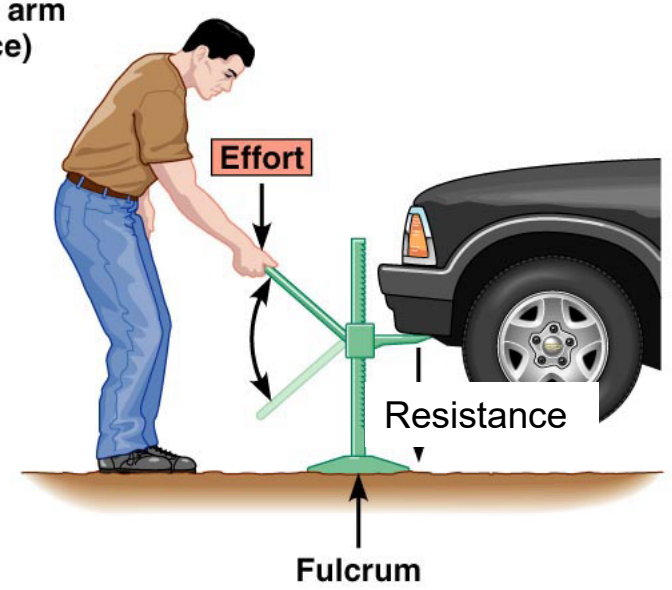
E x EA = R x RA

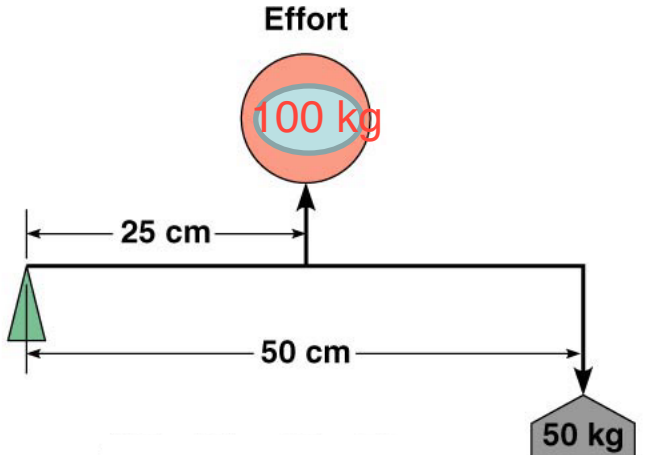
$$Effort = Resistance\ x\ \frac{Resistance\ arm}{Effort\ arm}$$

Effort × length of effort arm = load × length of load arm
(force × distance) = (resistance × distance)



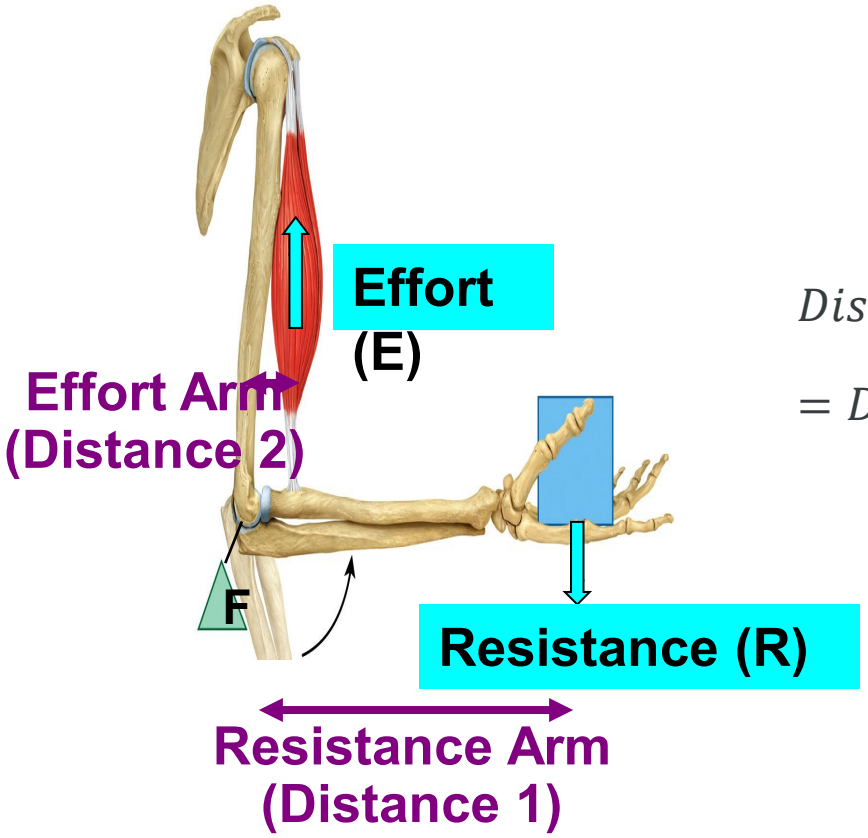
(a)





(b)

MECHANICS OF LEVER SYSTEM



E x EA = R x RA

$$Distance\ moved\ by\ resistance = Distance\ moved\ by\ effort\ x\ \frac{Resistance\ arm}{Effort\ arm}$$

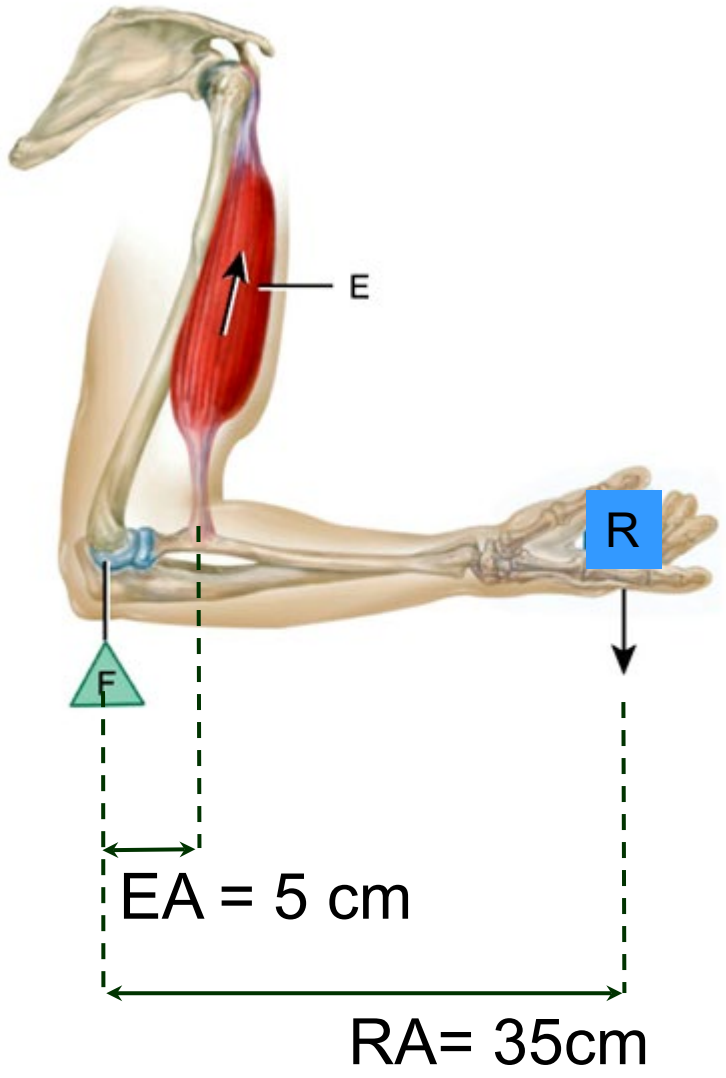
$$Speed\ of\ resistance = Speed\ of\ effort\ x\ \frac{Resistance\ arm}{Effort\ arm}$$

Lever systems in movement

1. When the biceps contracts 1 cm, the arm moves 7 cm.

2. When the biceps contracts at 1 cm/s, the arm will move at 7 cm/s.

3. To lift a load of 10 Kg, the biceps exerts a force of 70 Kg.



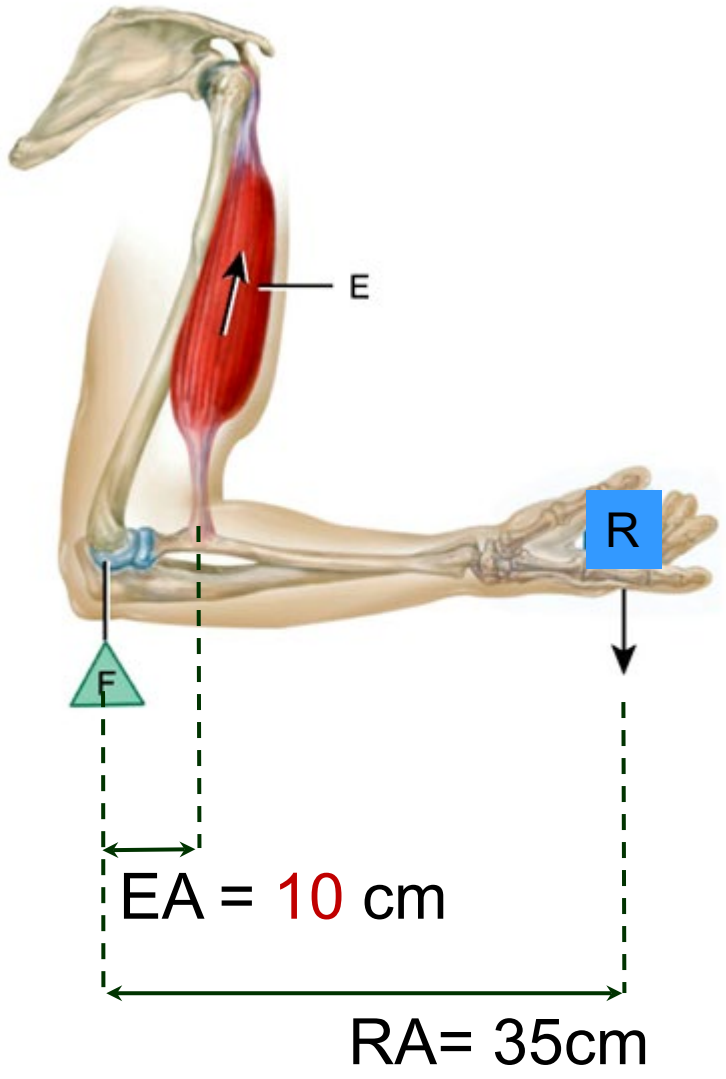
Lever systems in movement

mechanical advantage

1. When the biceps contracts 1 cm, the arm moves 3.5 cm.

2. When the biceps contracts at 1 cm/s, the arm will move at 3.5 cm/s.

3. To lift a load of 10 Kg, the biceps exerts a force of 35 Kg.



Advantages and disadvantages of biceps insertion being near the elbow joint

ADVANTAGES:

1. Greater speed of movement.
2. Greater range of movement.

DISADVANTAGE:

1. Large effort (force) required to lift an object.

Biomechanics

Objectives

1. Describe how muscles attach to bones to produce movement.
2. Describe the principle of muscular antagonism in movement, using the forearm as an example.
3. Define the following terms: lever, fulcrum, resistance, effort.
4. Describe three types of levers and give an example of each type in the human body.
5. Explain the biomechanical principles and functioning of a lever system