Physiotherapy Department

PT201: Biomechanics

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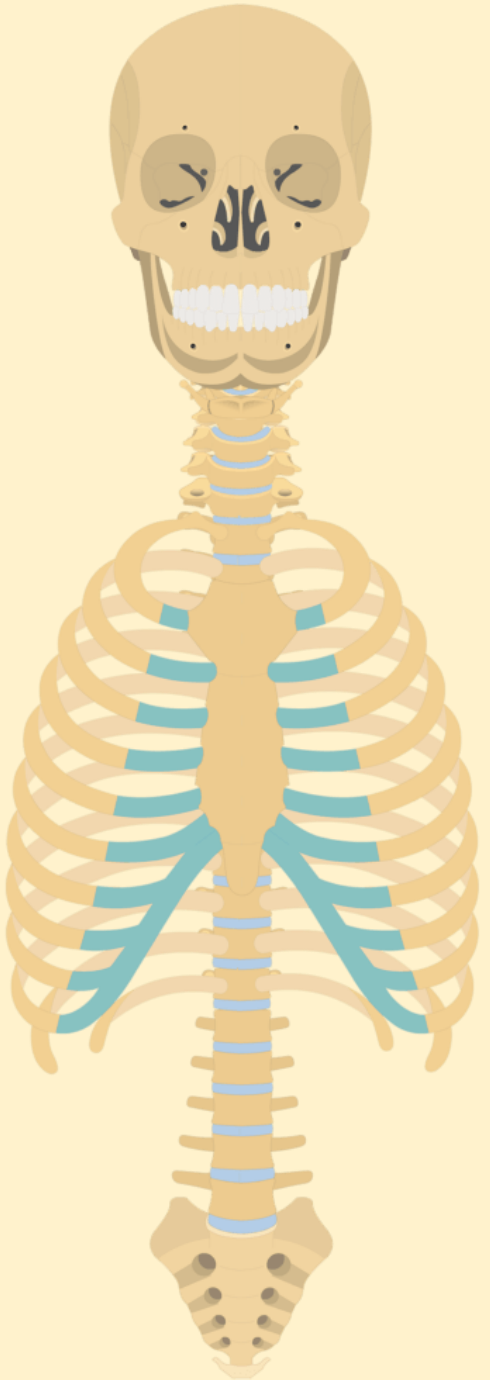
Tishk International University

Biomechanics of the Temporomandibular Joint and Spine



Lecture 5

Biomechanics of the Temporomandibular Joint (TMJ) and Structure of the Spinal Column

31-10-2023

Synopsis

- Overview of basic concepts
- Biomechanics of temporomandibular joint (TMJ)
- Structure and organization of the spine

Objectives

By the end of this lecture, students should understand and be able to describe the the following:

- Basic structure and biomechanics of temporomandibular joint (TMJ)
- Structure of the spinal column

Overview

- **Joint structure:** Anatomical composition
- **Kinematics:** Study of joint movement without regard to the force that produce the movement
- **Arthrokinematics:** Joint play or accessory joint motion (rotation/translation)
- **Osteokinematics:** Movement of the bones of a joint
- **Pathomechanics:** Abnormal body mechanics, the behavior of the locomotor system in injury and disease

Biomechanics of TMJ

- **Articulation:** Between mandibular condyloid process of mandible and mandibular fossa of temporal bone
- **Type**: Synovial, condylar, hinge, and gliding joint (ginglymoarthrodial)
- **Capsule:** Fibrous membrane that surrounds the joint and attaches to the articular surfaces
- **Articular disc:** Divides the joint into superior and inferior compartment (TMJ is atypical synovial joint, lined by fibrocartilage)

Biomechanics of TMJ

- **Synovial membrane:** Two synovial membrane covering the two joint cavities
- **Ligaments:** Three extracapsular ligaments, viz., stylomandibular, sphenomandibular, and lateral ligaments
- **Muscles acting on the joint:** Temporalis, masseter, pterygoid, digastric, hyoid, and platysma muscles
- **Osteokinematic and arthrokinematics:**
  - The upper joint is an amphiarthrodial gliding joint, and the lower joint is a hinge joint
  - TMJ as a whole allows motions in three planes around three axes

Biomechanics of TMJ

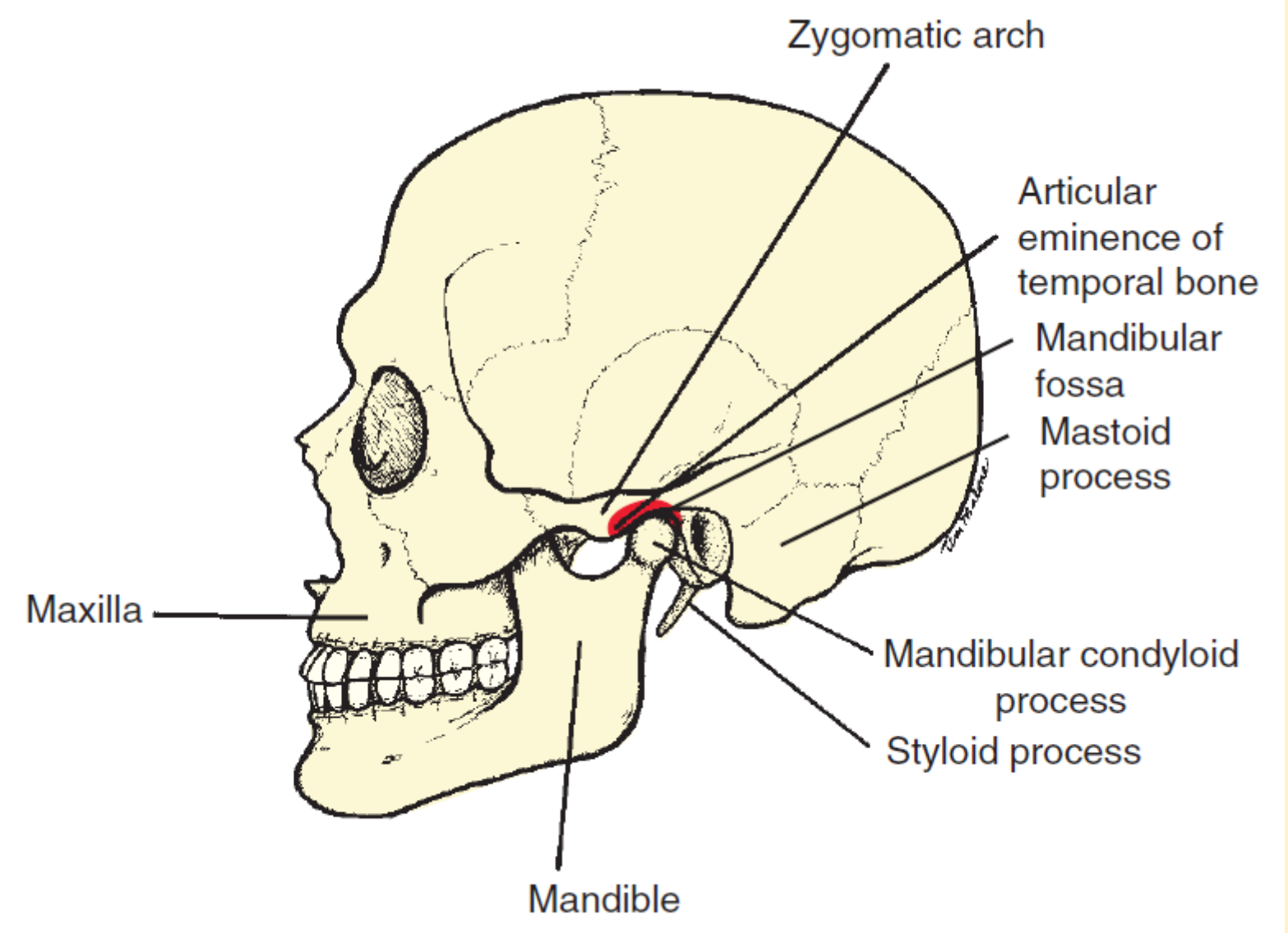
- **Osteokinematic and arthrokinematics:**
  - The upper joint is an amphiarthrodial gliding joint
  - The lower joint is a hinge joint
  - TMJ as a whole allows motions in three planes around three axes
  - Mandibular depression (mouth opening), mandibular elevation (mouth closing)

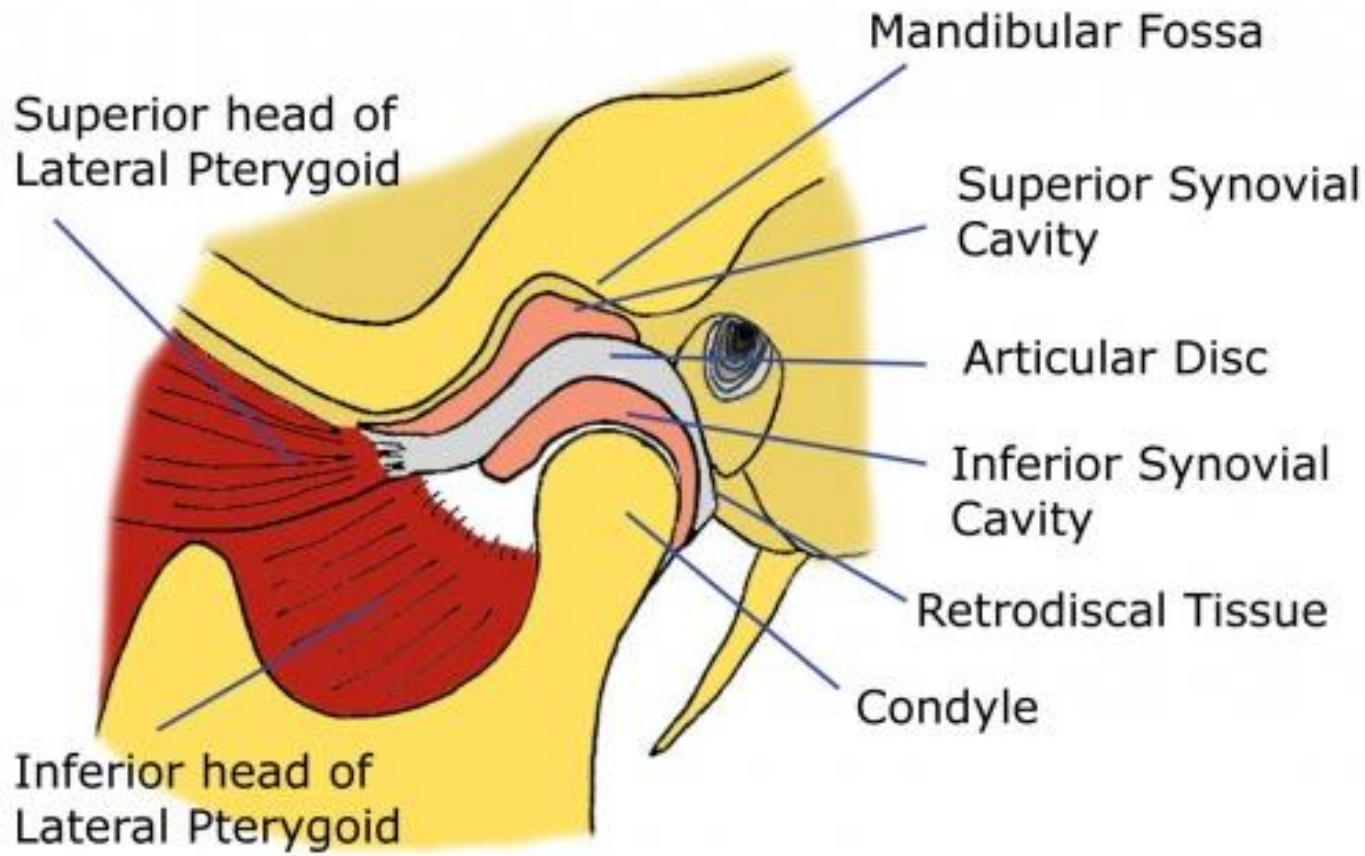
Biomechanics of TMJ

- Protrusion (anterior translation), and retrusion (posterior translation)
- Lateral excursion or laterotrusion (lateral deviation)

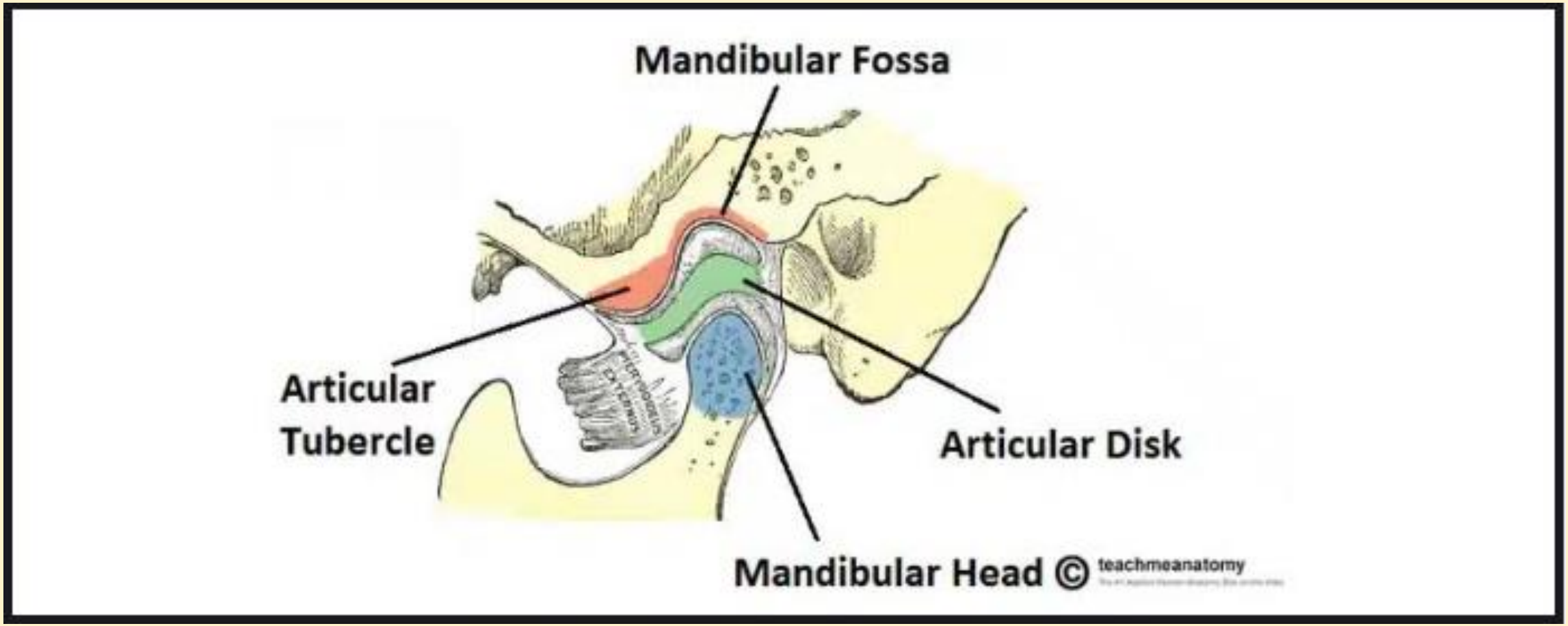
- **Resting position:** Mouth slightly open, the lips together and the teeth not in contact. All motions except mouth closing begin from the resting position of the joint

- **Closed-pack position:** Teeth are tightly clenched

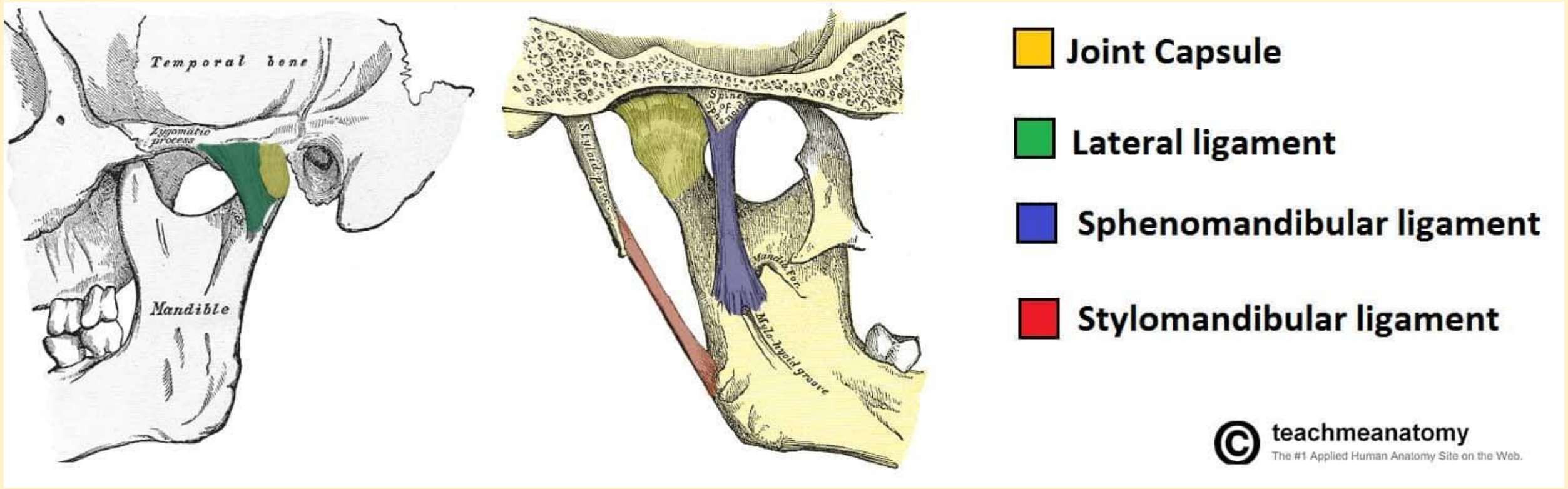


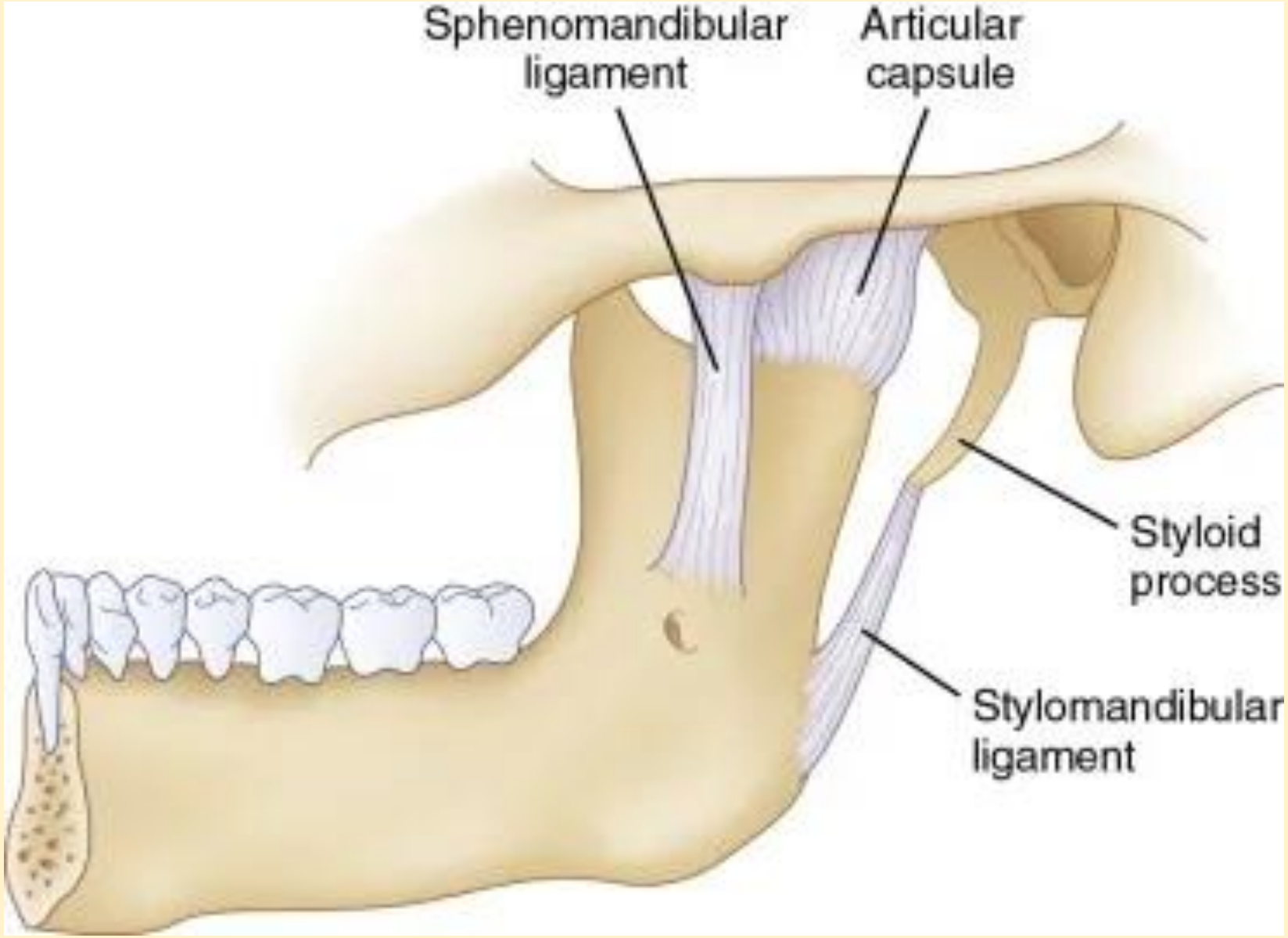


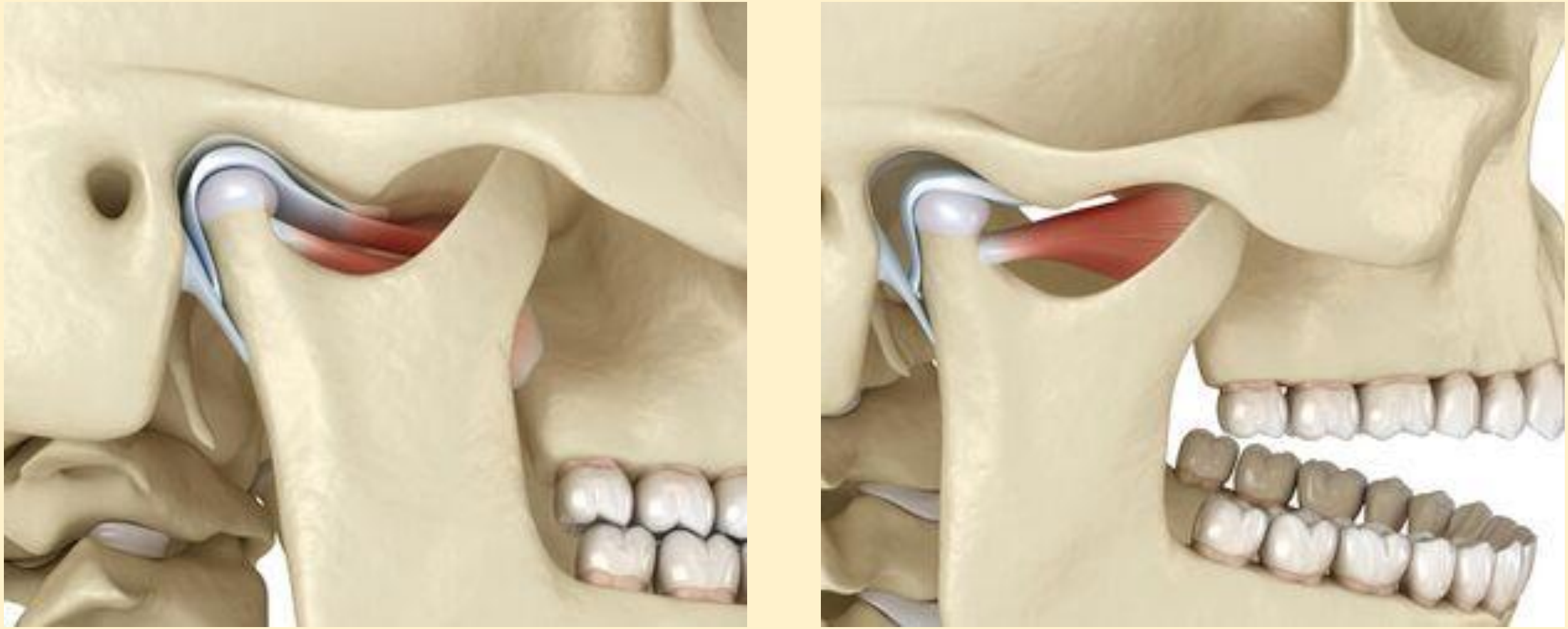
The Temporomandibular Joint



Biomechanics of TMJ







Temporomandibular joint closed and opened positions

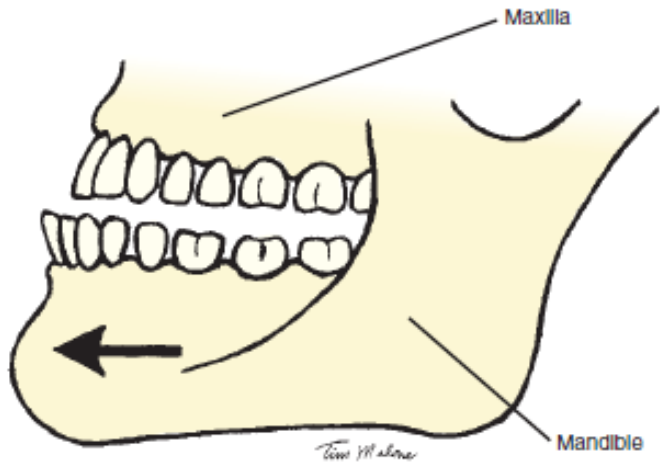


FIGURE 13.4 Protrusion is an anterior motion of the mandible in relation to the maxilla.

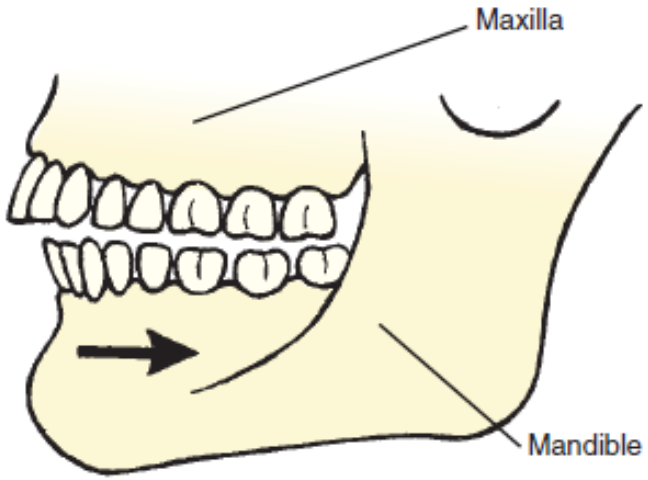


FIGURE 13.5 Retrusion is a posterior motion of the mandible in relation to the maxilla.

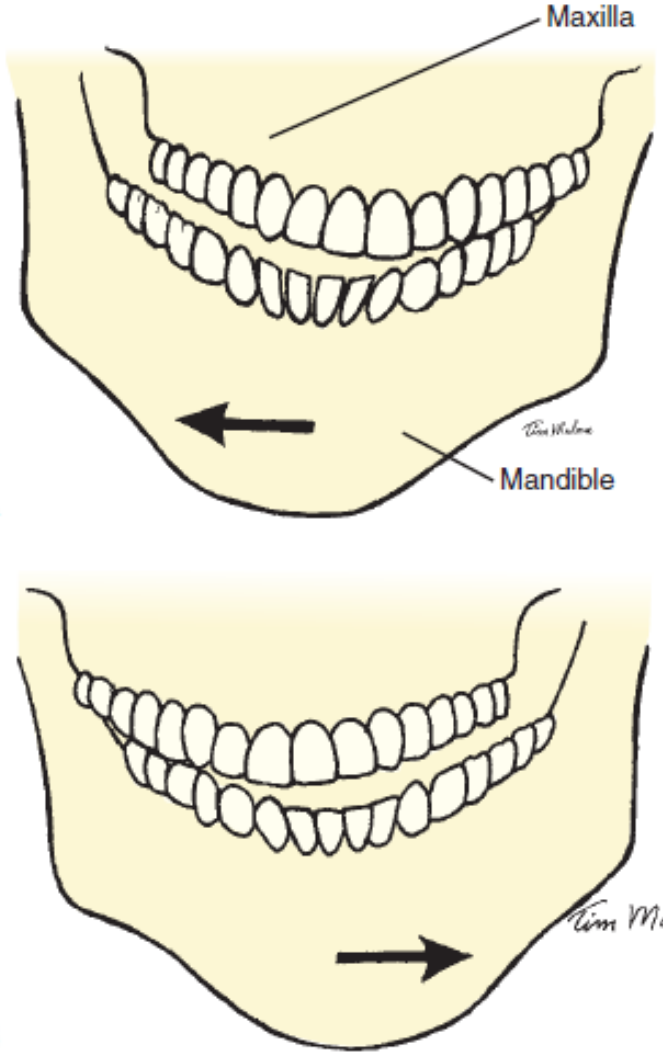
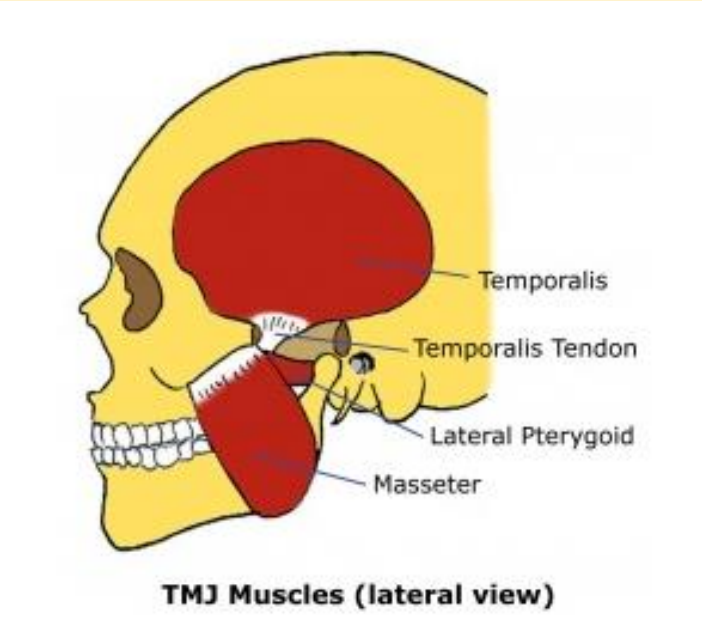


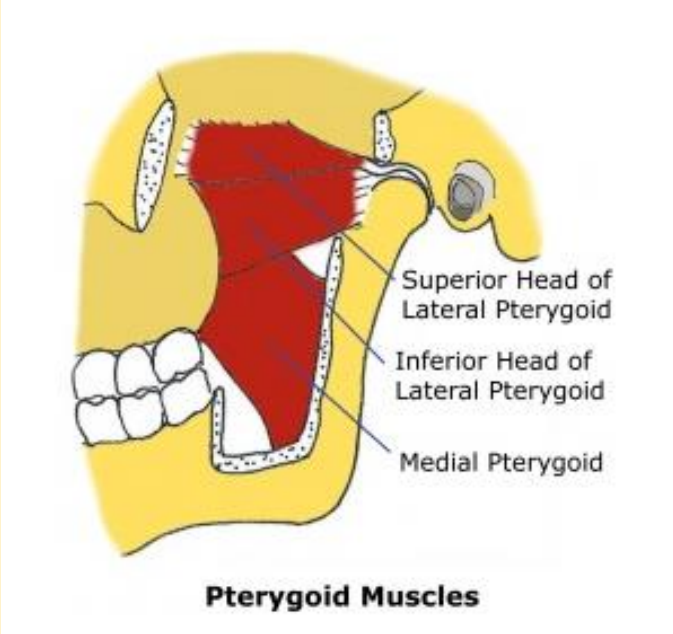
FIGURE 13.6 Lateral excursion is a lateral motion of the mandible to either side. (A) Right lateral excursion. (B) Left lateral excursion.

Muscles acting on TMJ

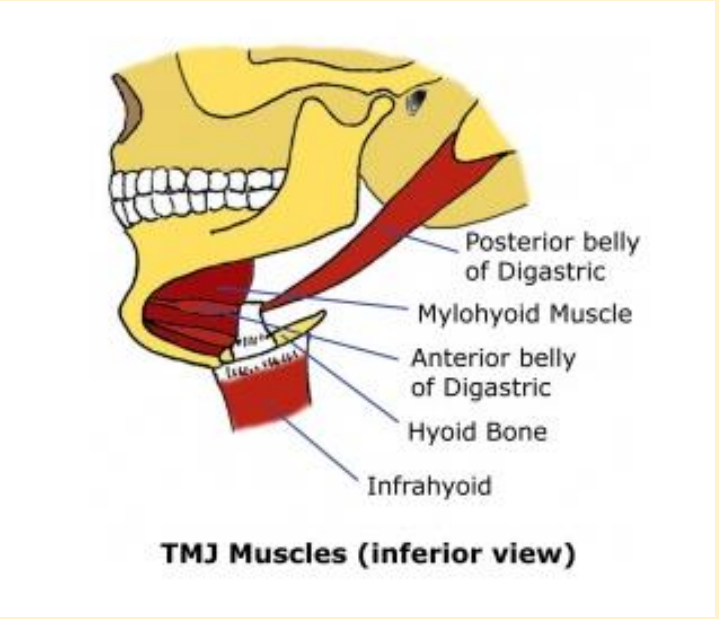
Muscles	Actions
Temporalis	Elevates mandible
Masseter	Elevates mandible
Lateral pterygoid	Protracts mandible, depresses chin, lateral deviation of mandible
Medial pterygoid	Works with masseter to elevate mandible, aids in protrusion,
Digastric Stylohyoid Mylohyoid Geniohyoid	Depresses the mandible against resistance when infrahyoid muscles stabilize or depress hyoid bone
Platysma	Depresses mandible against resistance



TMJ Muscles (lateral view)



Pterygoid Muscles



TMJ Muscles (inferior view)

ROM at TMJ

Depression of the mandible/opening of the mouth:	
Functional active motion	35–55 mm
Minimal opening for functional activity	25–35 mm
Elevation of the mandible/closing of the mouth The mandible returns from depression until the teeth of the mandible and maxilla come into contact	
Protrusion of the mandible	
Functional active motion	3–6 mm
Retrusion of the mandible	
Functional active motion	3–4 mm
Lateral deviation of the mandible	
Functional active motion	10–15 mm

Biomechanics of TMJ

Pathomechanics of the TMJ

- ***Inflammation*** due to trauma causing synovitis or discitis
- ***Internal derangement*** due to structural changes or damage such as disc displacement
- ***Arthritis*** owing to degeneration of the fibro-articular cartilage
- ***Hypermobility*** resulting in excessive anterior movement of the jaw and the articular disc

Biomechanics of TMJ

- ***Muscle spasm*** causing significant pain and range of motion limitation
- ***Cervical postural disorders*** such as forward head posture
- ***Temporal tendinopathy*** caused by excessive contraction of the temporalis muscle
- ***Dislocation (anterior/posterior)*** *via a blow to the side of the face, yawning, or taking a large bite*
- ***Fractures*** of the articular bones due to direct trauma

Key facts about the temporomandibular joint	
Articular surfaces	*Temporal bone:* Mandibular fossa and articular tubercle *Mandible:* Condylar process
Main components	Joint capsule Synovial membrane Articular disc (anterior/posterior bands, intermediate zone)
Ligaments	*Major:* Lateral temporomandibular ligament (thickened lateral portion of capsule, strengthens TMJ laterally) *Minor:* Stylomandibular ligament, sphenomandibular ligament
Cavities	*Superior* (discotemporal) cavity (translational movement) *Inferior* (discomandibular) cavity (rotational movement)
Rotational movements	***Elevation:*** Temporalis, masseter and medial pterygoid muscles ***Depression:*** Lateral pterygoid, digastric, geniohyoid and mylohyoid muscles
Translational movements	***Protrusion:*** Lateral pterygoid, medial pterygoid muscle, masseter ***Retraction:*** Posterior fibers of temporalis, deep part of masseter ***Lateral deviation*** (left or right): Posterior fibers of temporalis, digastric, mylohyoid and geniohyoid muscles (ipsilateral movement); lateral and medial pterygoid muscles (contralateral movement)

Structure of the Spine

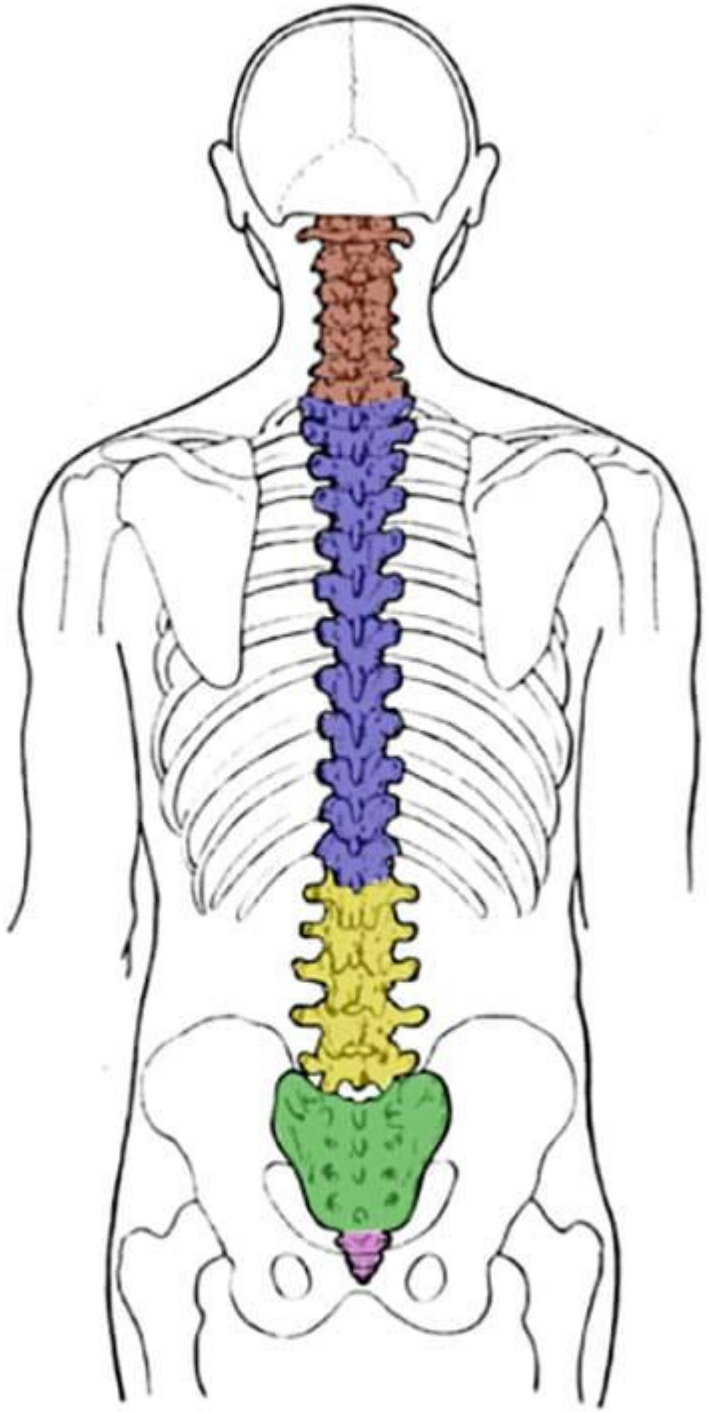
Organization of the spinal column

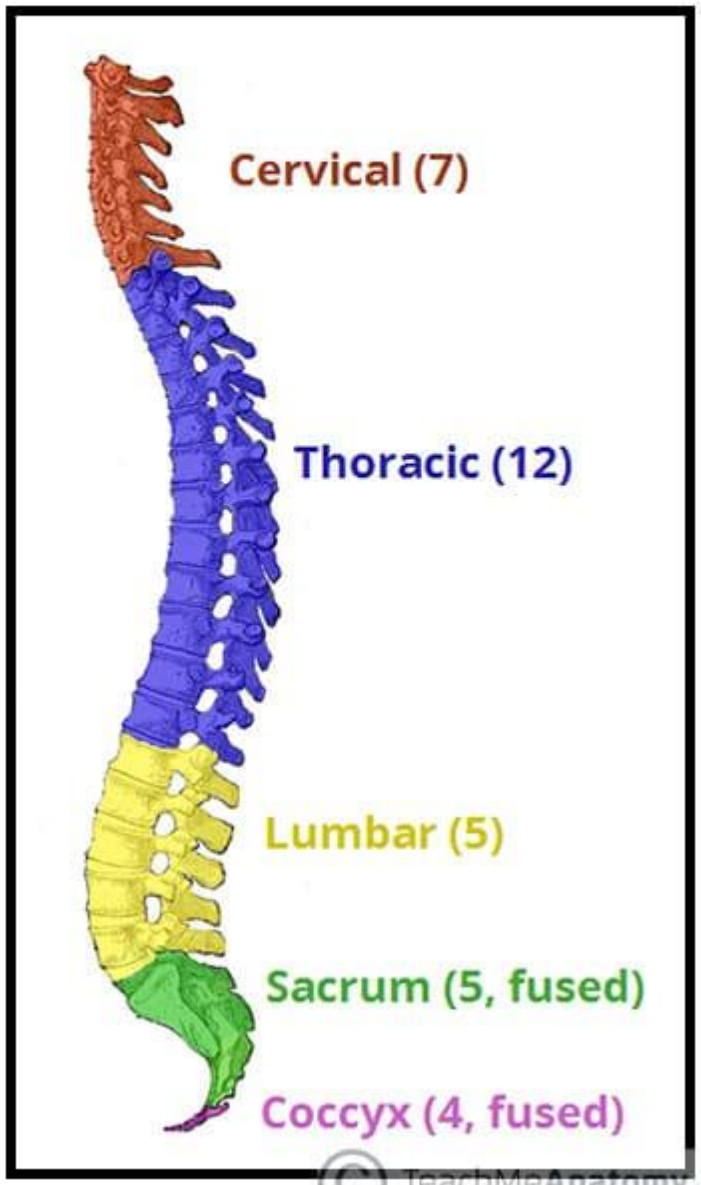
- Vertebral column composed of 33 vertebrae and 23 intervertebral discs
- Vertebral column is divided into five regions: cervical, thoracic, lumbar, sacral, and coccygeal
- Vertebrae adhere to a common basic structural design but show regional variations in size and configuration
- Vertebrae increase in size from the cervical to the lumbar regions and then decrease in size from the sacral to coccygeal regions

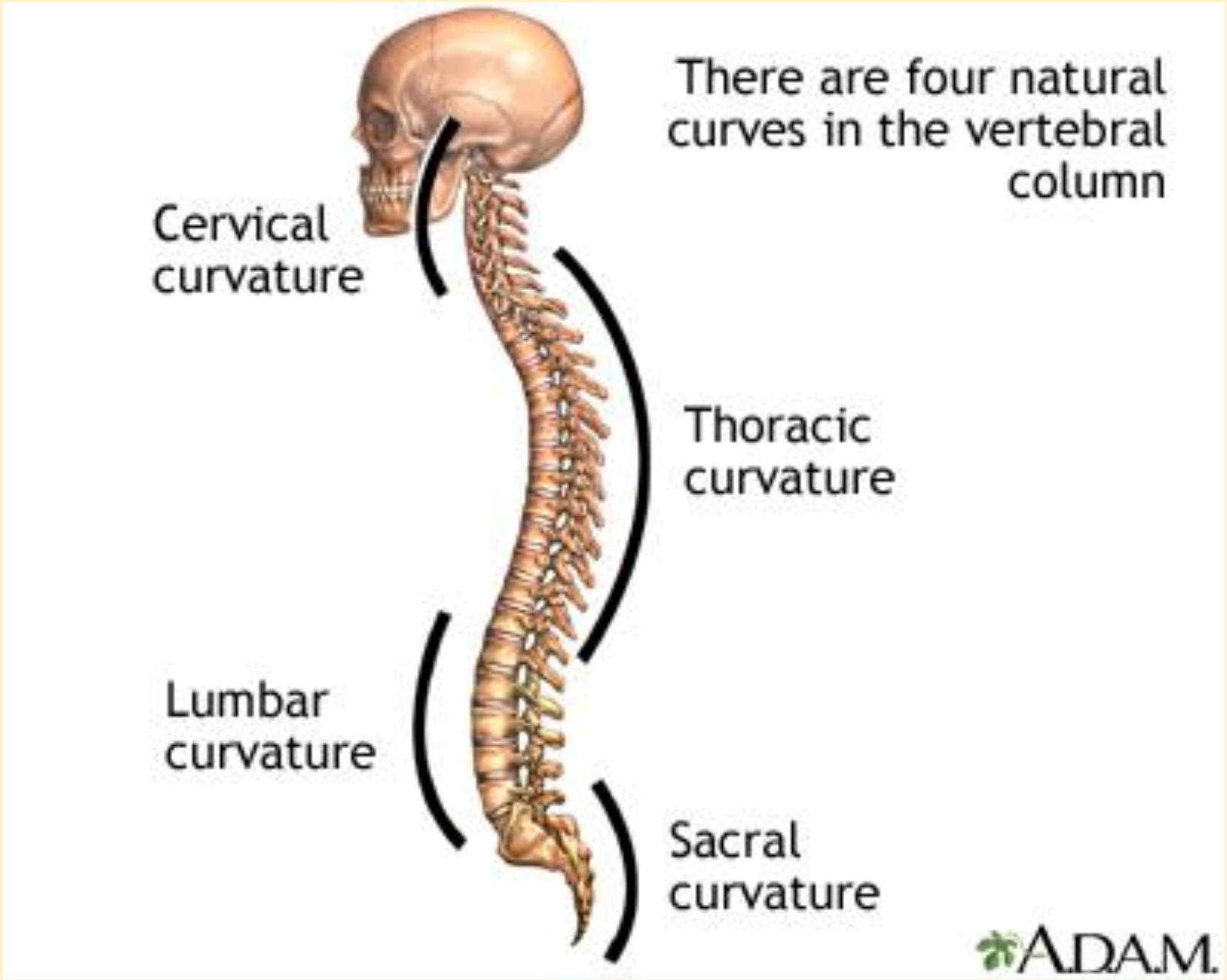
Structure of the Spine

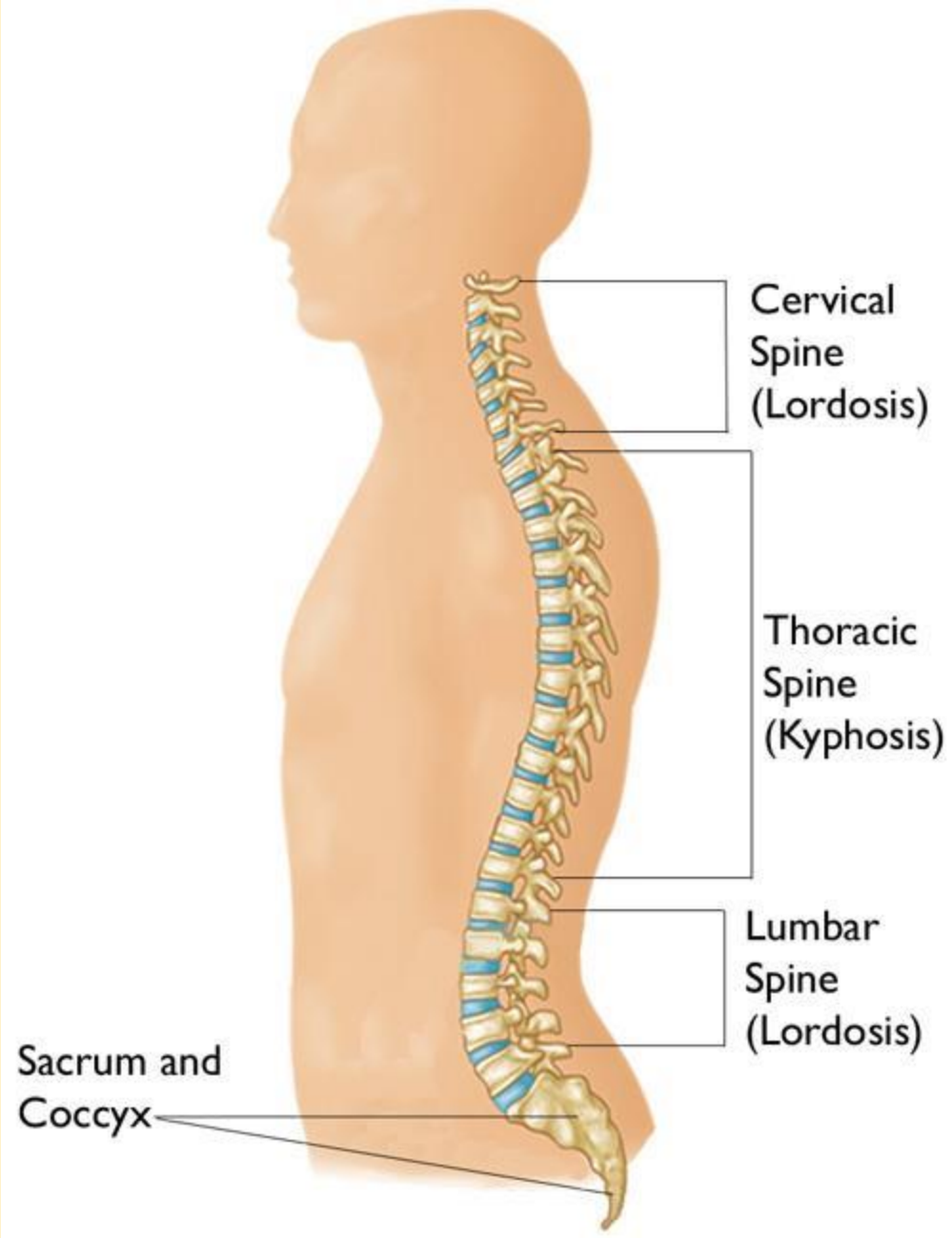
- Twenty-four of the vertebrae in the adult are distinct entities
  - Cervical-7
  - Thoracic-12
  - Lumbar-5
  - Sacrum-5 (fused)
  - Coccyx-4 (fused)

- Four distinct anteroposterior curves are evident:
  - 2 Posterior convexities (kyphosis) at thoracic and sacral regions (primary curves)
  - 2 Posterior concavity (lordosis) at cervical and lumbar regions (secondary curves)









Structure of the Spine

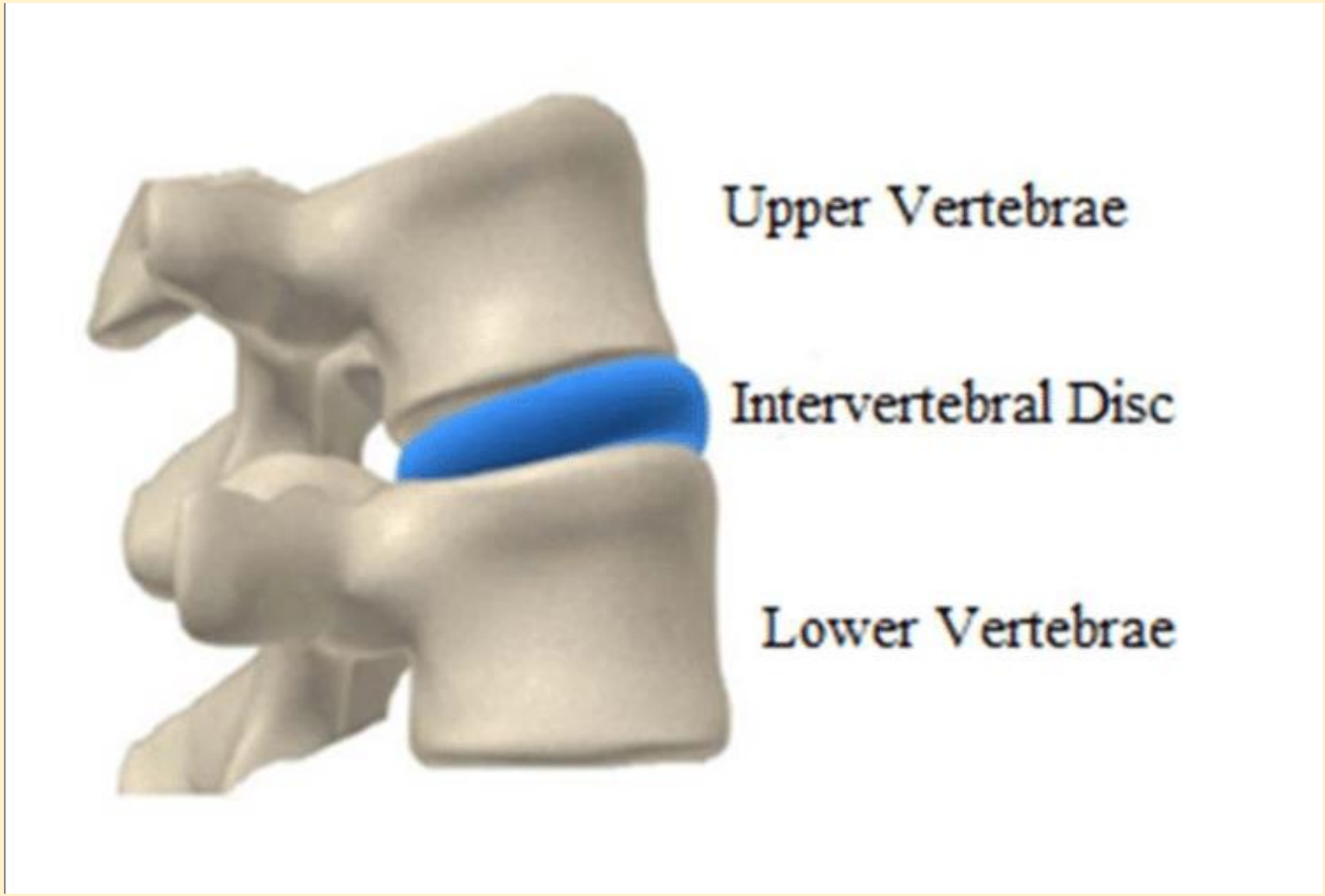
- Functional unit of the vertebral column is any two adjacent vertebrae, the intervening intervertebral disk, and all the soft tissues that secure them together

Structure of a typical vertebra

- Typical vertebra consists of two major parts:
  - Anterior, cylindrically shaped vertebral body
  - Posterior, irregularly shaped vertebral or neural arch

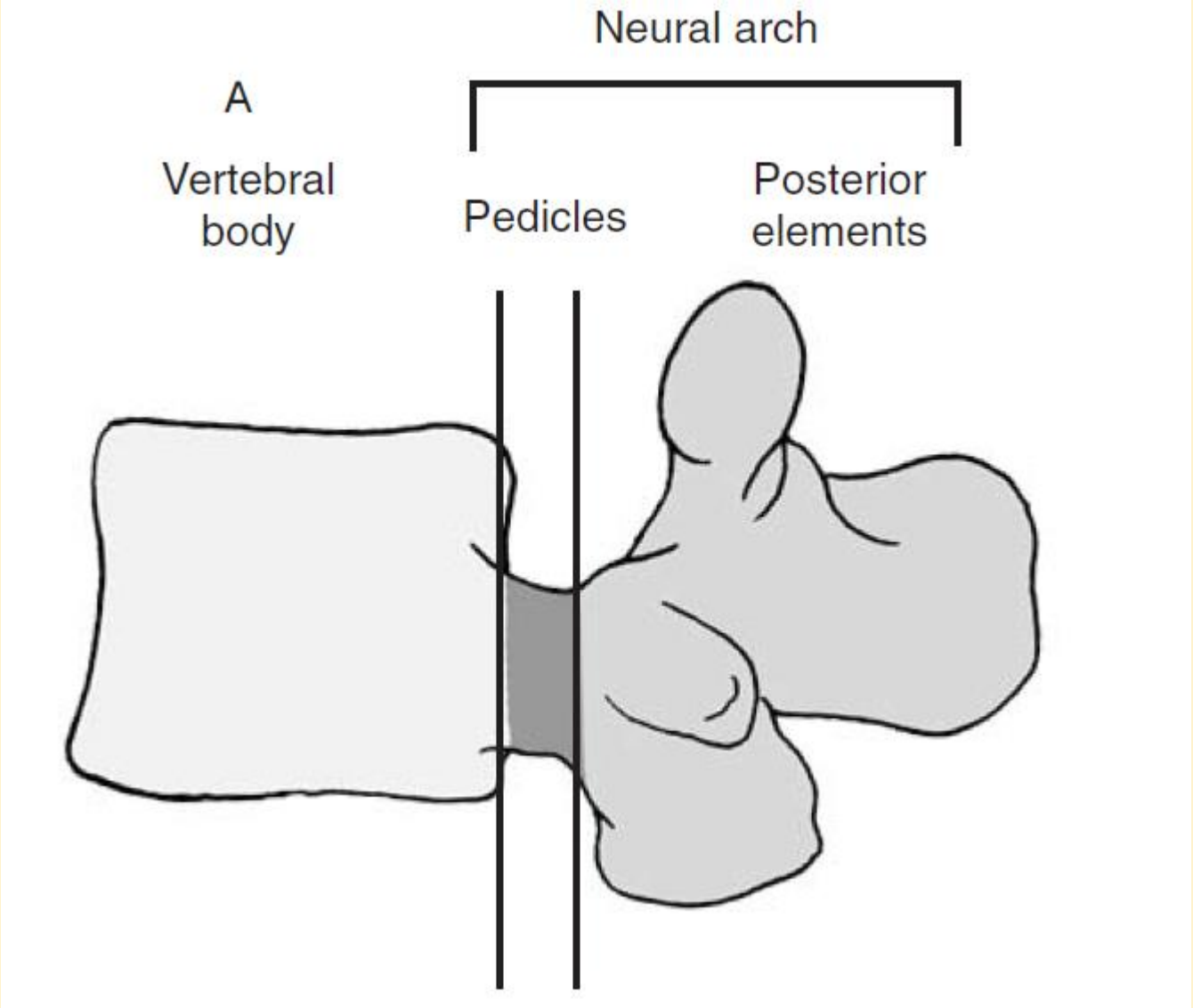
- Vertebral body has a blocklike shape with generally flat superior and inferior surfaces

- Vertebral body is designed to be the weight-bearing structure of the spinal column

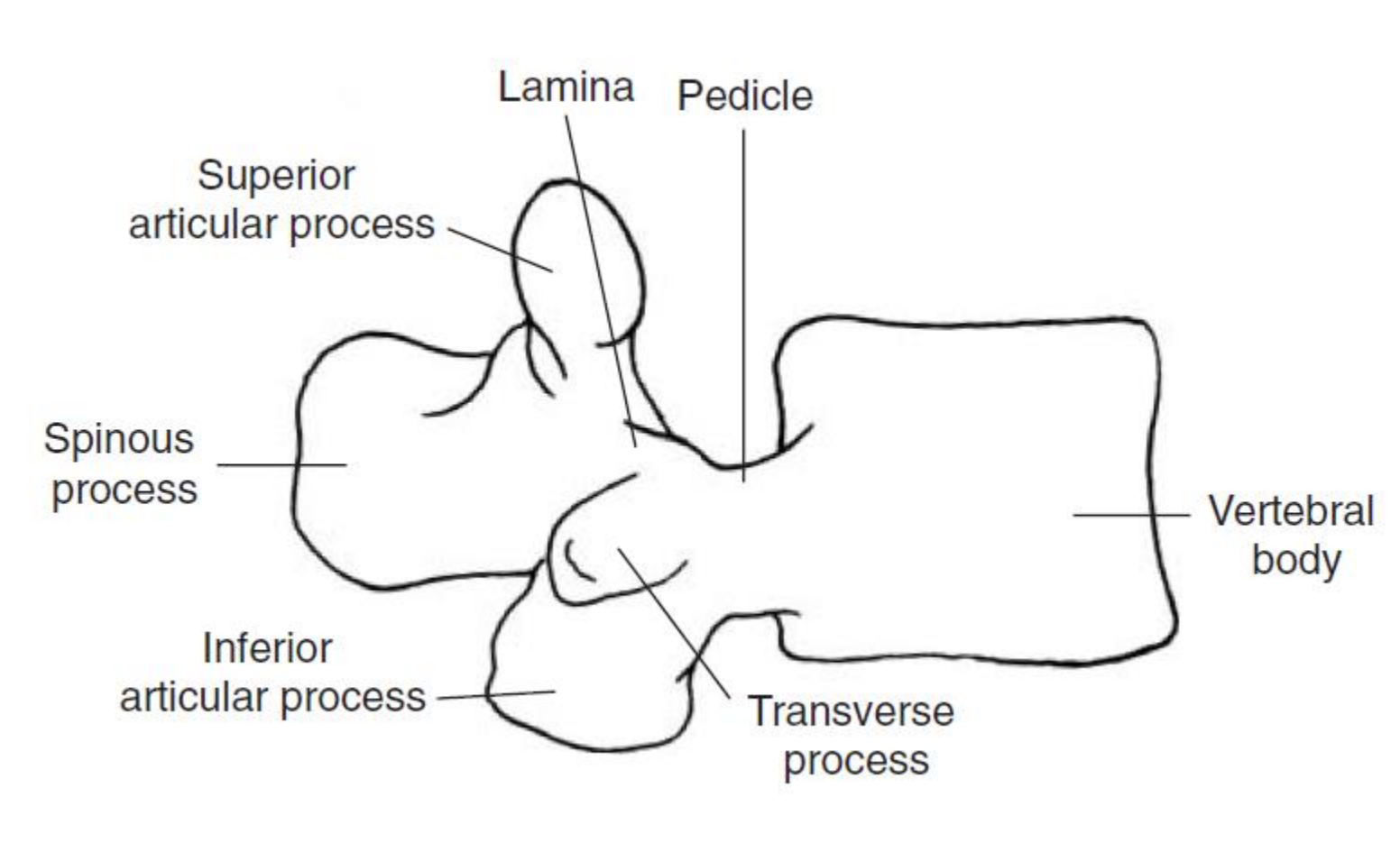


Structure of the Spine

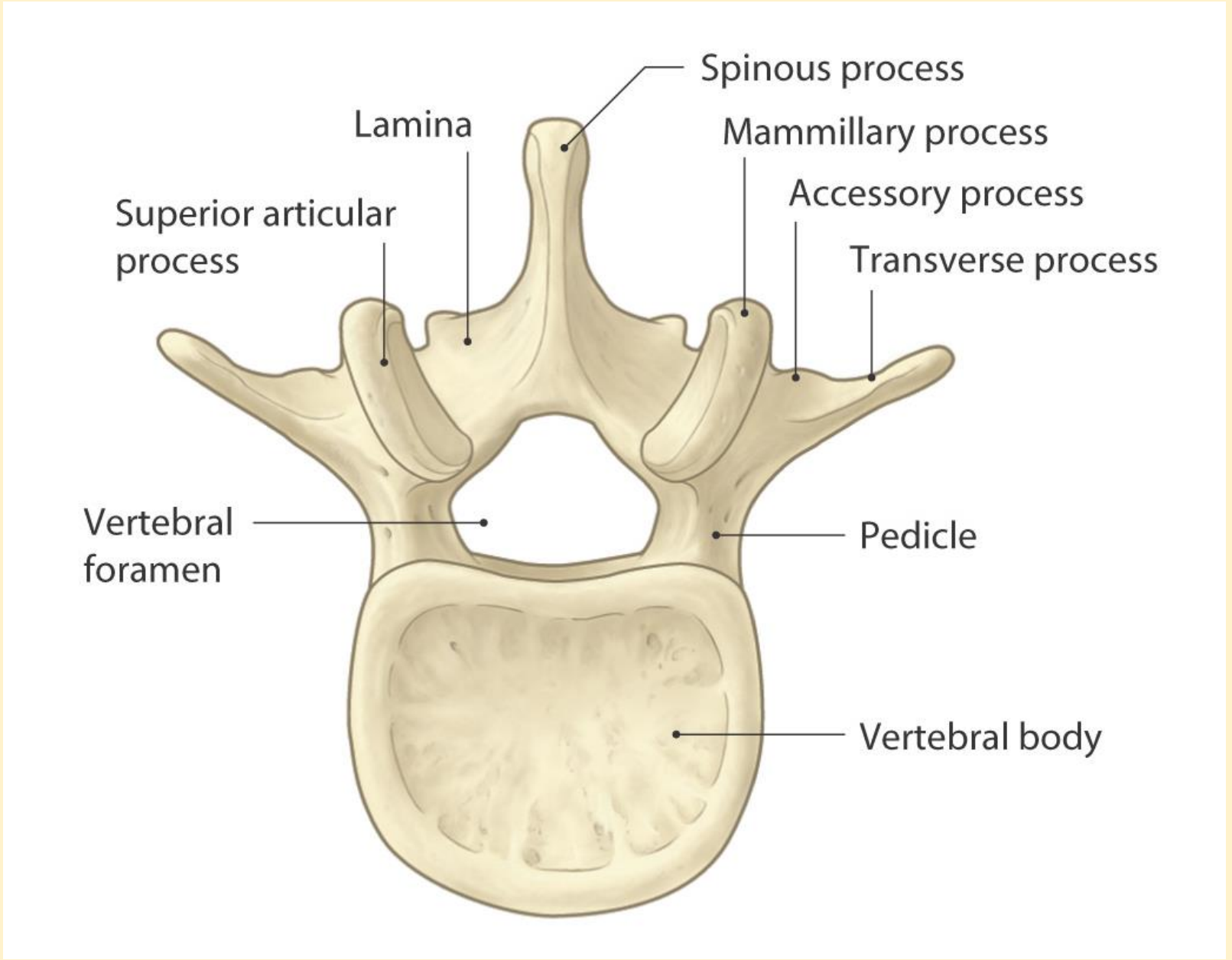
- Vertebral body is not a solid block of bone but a shell of cortical bone surrounding a cancellous cavity
- Vertebral neural arch can be further divided into:
  - Pedicles
  - Posterior elements (laminae, articular processes, the spinous process, and transverse processes)
- Neural arch function is to transmit tension and bending forces to the vertebral bodies
- Pars interarticularis is most developed in the lumbar spine, where the forces are the greatest in magnitude



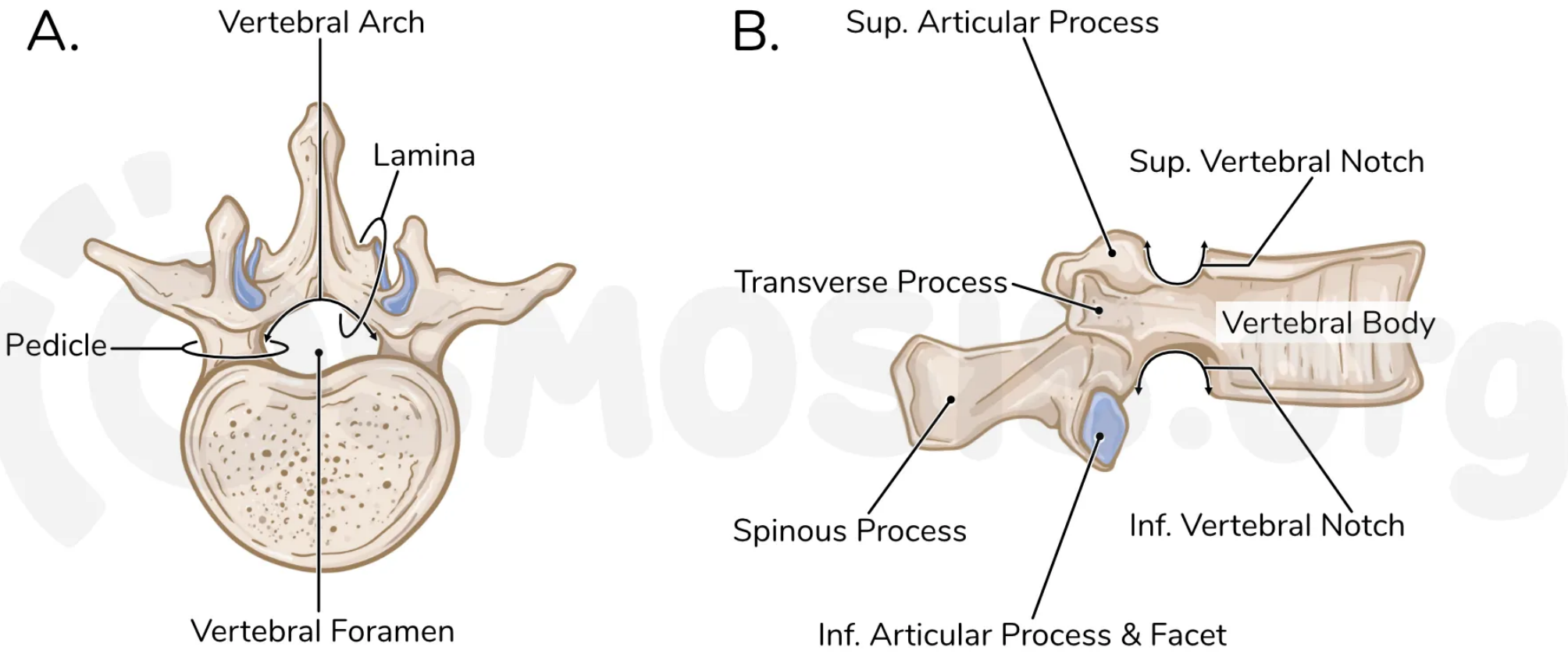
Typical vertebra

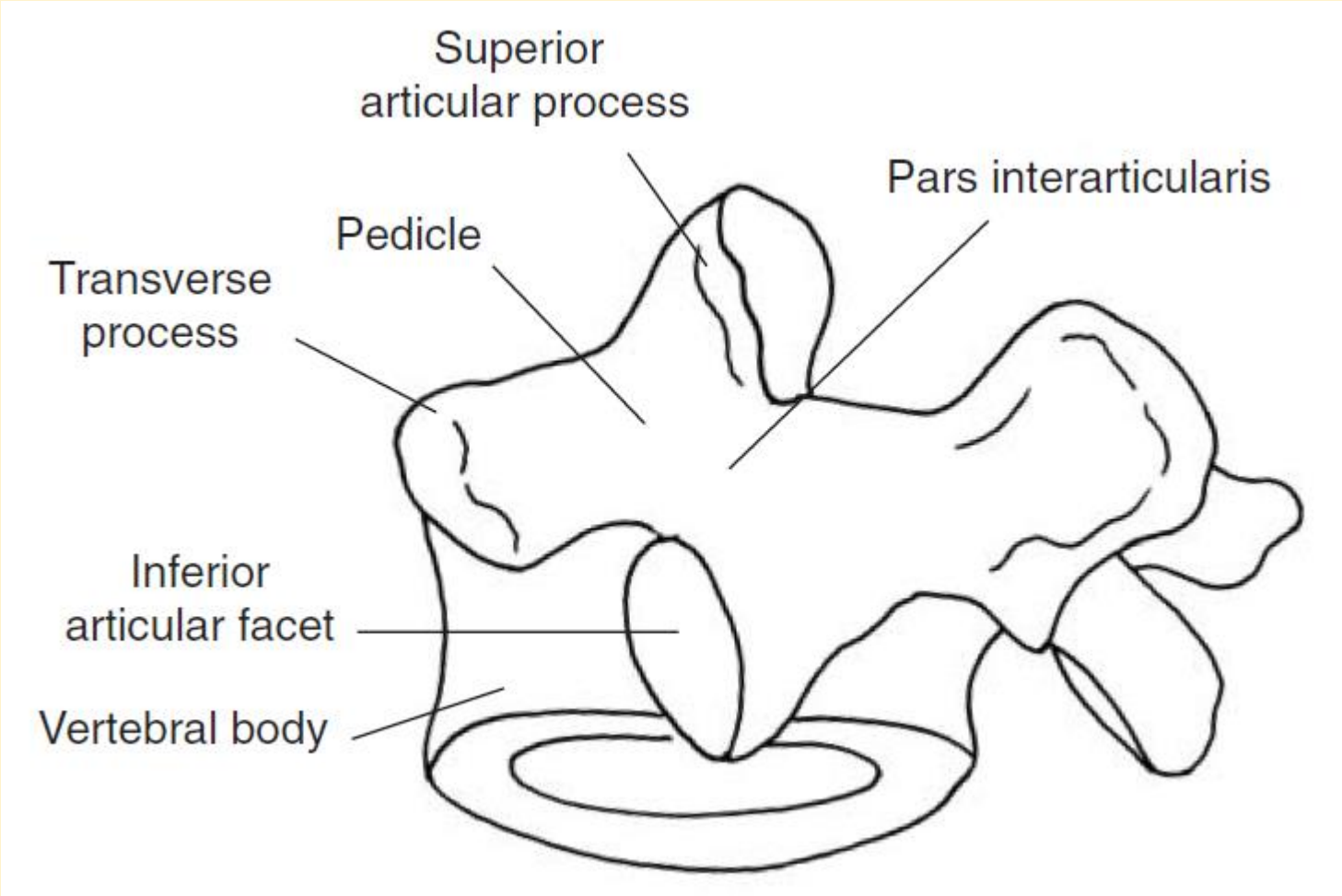


Posterior elements



Superior view of a typical vertebra





Pars interarticularis fracture results in spondylolisthesis

Table 4-1 Components of a Typical Vertebra

	Description	Function
Body	Block of trabecular bone covered by a layer of cortical bone	To resist compressive loads
Pedicle	Short, stout pillars with thick walls that connect the vertebral body to the posterior elements	To transmit the bending forces from the posterior elements to the vertebral body
Lamina	The vertical plate that constitutes the central portion of the arch posterior to the pedicles	To transmit the forces from the articular, transverse, and spinous processes to the pedicles
Transverse processes	Lateral projections of bone that originate from the laminae	Serve as muscle attachments and provide mechanical lever
Spinous process	Posterior projection of bone that originates from the central portion of the lamina, dividing it into two	Serves as muscle attachment and provides mechanical lever; may also serve as a bony block to motion
Vertebral foramen	Opening bordered by the posterior vertebral body and the neural arch	Combined with all segments, forms a passage and protection for the spinal cord

Structure of the Spine

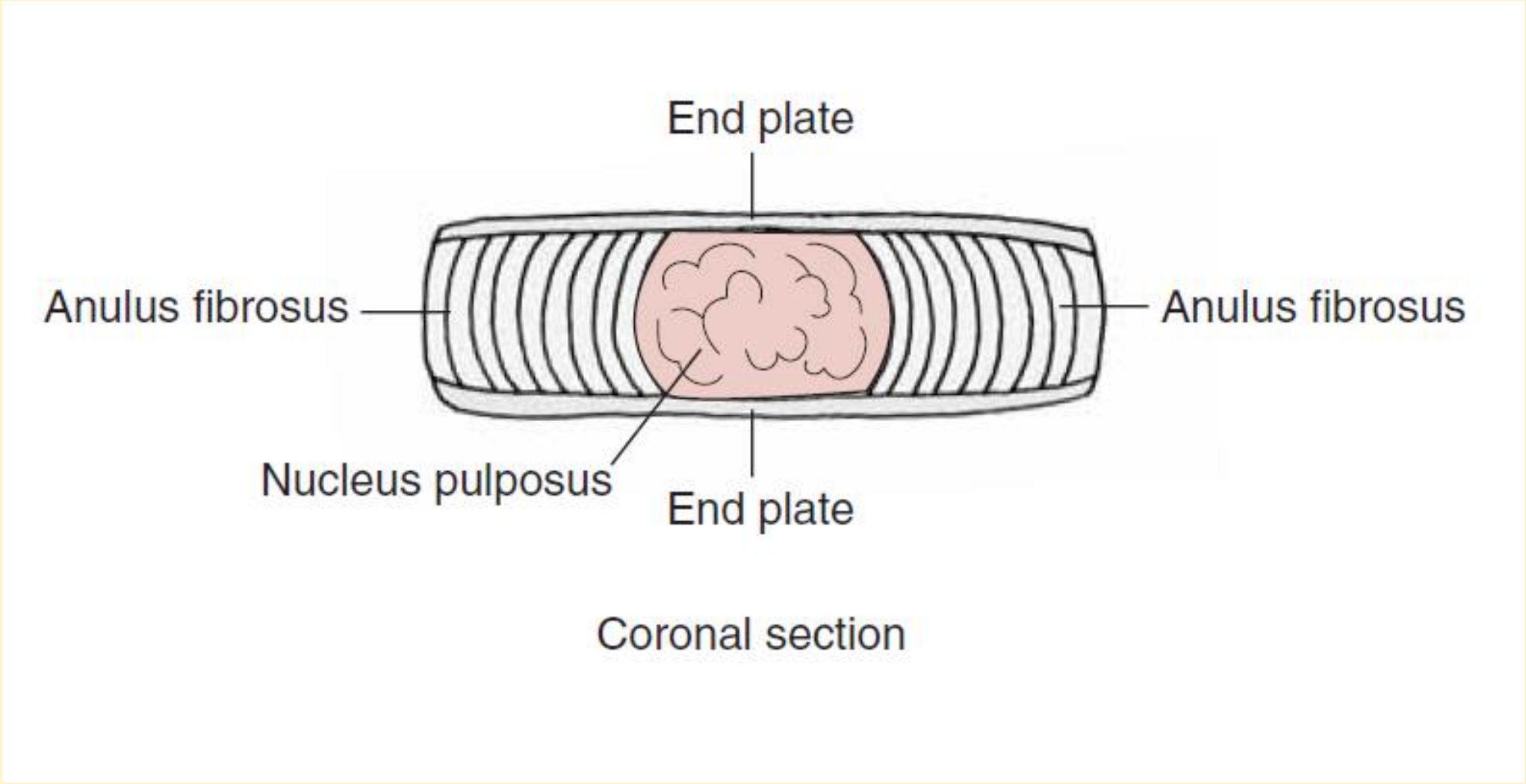
Structure of an intervertebral disk (IVD)

- IVD has two principle functions:
  - Separate two vertebral bodies, thereby increasing available motion
  - Transmit load from one vertebral body to the next

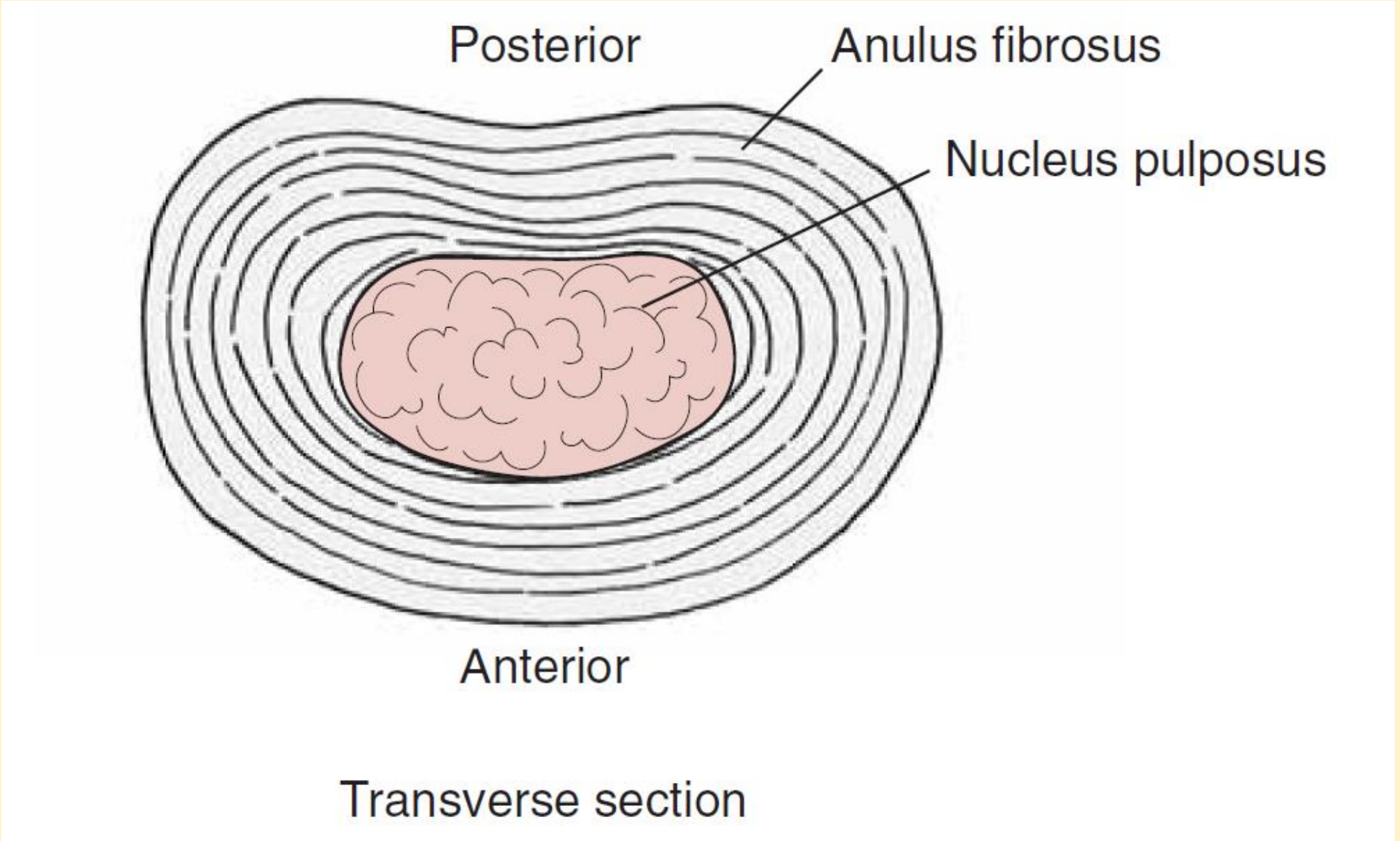
- IVD makes up about 20% to 33% of the length of the vertebral column

- IVD consists of three parts:
  - Nucleus pulposus
  - Anulus fibrosus
  - Vertebral end plate

- All three structures are composed of water, collagen, and proteoglycans



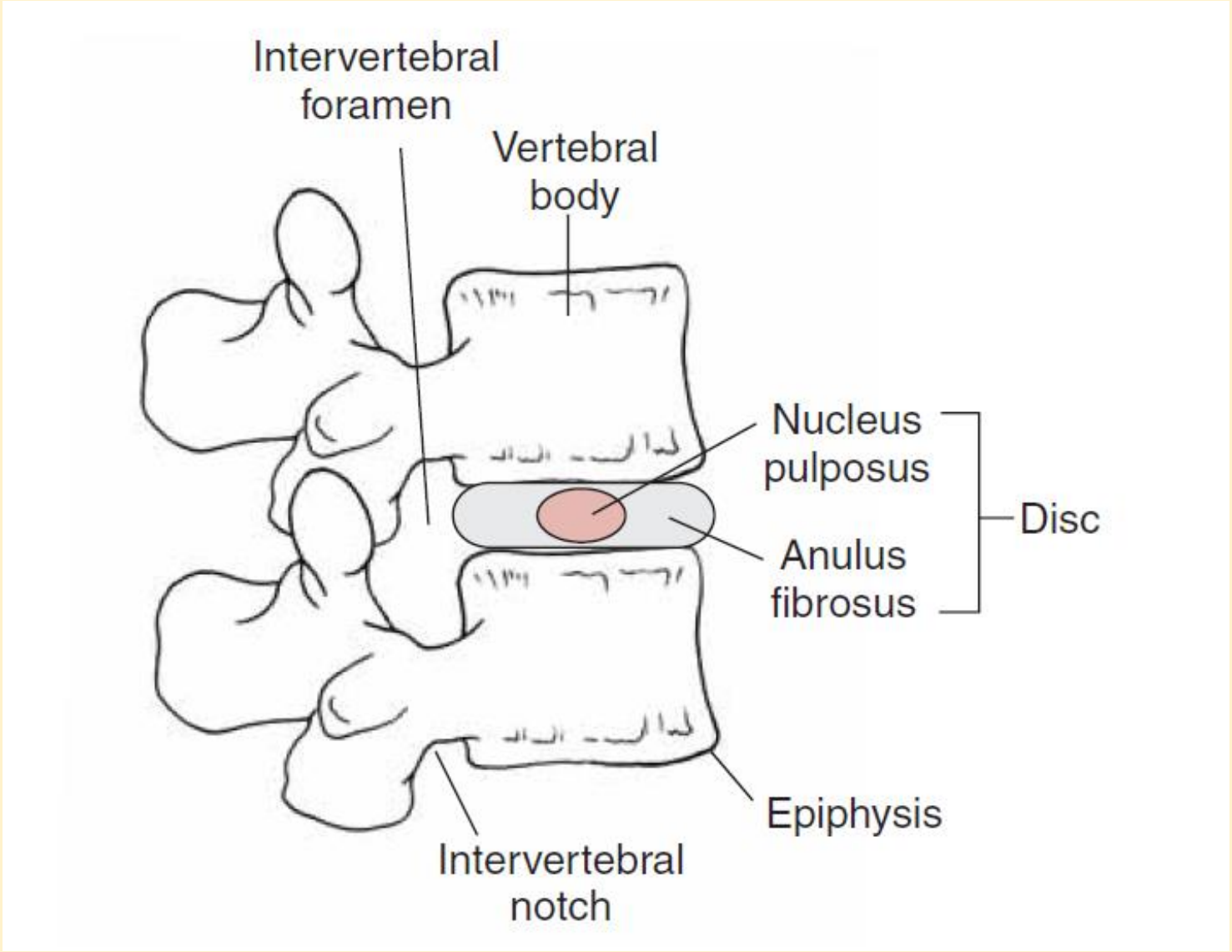
Structure of intervertebral disc



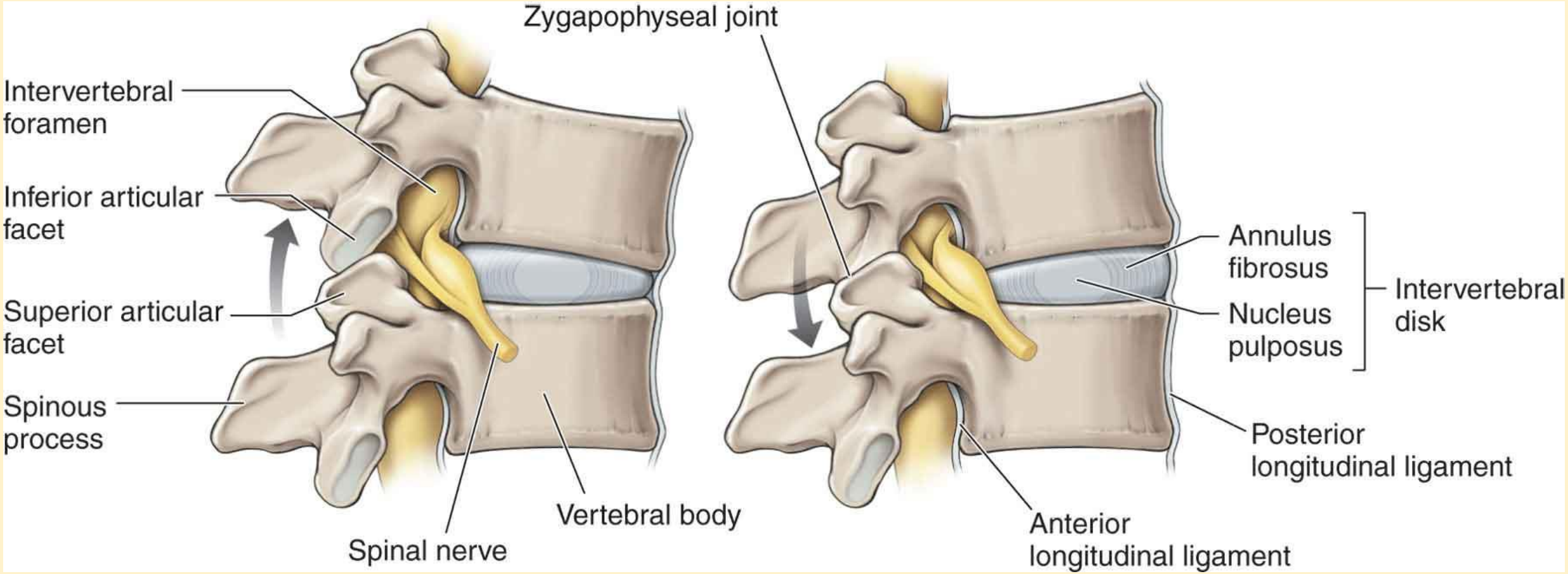
Structure of intervertebral disc

Structure of the Spine

- Nucleus pulposus
  - Gelatinous mass found in the center of the IVD
  - Made up of 70% to 90% water
  - Has both type I and type II collagen
- Anulus fibrosus
  - Fibrous outer ring of the IVD
  - Consists of 60% to 70% water
  - Has both type I and type II collagen
- Vertebral end plate
  - Cartilaginous layer covering the superior and inferior surfaces of the disk
  - Consists of layers of cartilage 0.6 to 1mm thick
  - Contains both hyaline cartilage and fibrocartilage



Spinal Unit



Spinal Unit and intervening IVD

Take-home message

- TMJ is one of the most active joints in the human body. Forces ranged as high as 15.7 kg during chewing and 13.0 kg during incisal biting
- TMJ is involve in vital functions of life including mastication, deglutition, speech, and respiration
- Spinal column serves as a shock absorber in the human body and provide protection to the central nervous system
- Spine keeps us upright and connects different parts of the skeleton to each other

Questions

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