MEDICAL EDUCATION RESOURCE

Introduction and Osteology

? Introduction to Abdomen

Definition

- The **abdomen** is the largest cavity in the body, located between the **thorax above** and the **pelvis below**.
- It houses most of the **digestive, urinary, and reproductive organs**.

Boundaries

- **Superiorly:** Diaphragm (separates it from thoracic cavity).
- **Inferiorly:** Continuous with the **pelvic cavity** at the pelvic brim.
- **Anteriorly and laterally:** Muscles of the abdominal wall.
- **Posteriorly:** Lumbar vertebrae, psoas major, quadratus lumborum, and fascia.

Divisions

1. **Abdominal cavity proper** – upper part, extending from diaphragm to pelvic brim.
2. **Pelvic cavity** – below the pelvic brim, contains pelvic viscera.
3. **Peritoneal cavity** – a potential space lined by peritoneum.

Planes and Regions

- The abdomen is divided into **nine regions** by two vertical and two horizontal planes:
    - **Vertical (midclavicular) planes**: Pass from midpoint of clavicle to midinguinal point.
    - **Horizontal planes**:
        - **Subcostal plane** (below 10th costal cartilage).
        - **Transtubercular plane** (through iliac tubercles).
- **Nine regions (R?L, top?bottom):**
    1. Right hypochondriac | Epigastric | Left hypochondriac
    2. Right lumbar | Umbilical | Left lumbar
    3. Right iliac | Hypogastric | Left iliac

Surface Landmarks

- **Xiphoid process:** Marks lower end of sternum, level of T9 vertebra.
- **Costal margin:** Inferior border of rib cage; overlies diaphragm and liver.
- **Umbilicus:** Level of intervertebral disc between L3–L4 in adults.
- **Pubic symphysis:** Marks lower midline of anterior abdominal wall.

? Osteology of Abdomen

Lumbar Vertebrae — General Features

- **Number:** 5 (L1–L5).
- **Distinctive features:**
  - **Body:** Large, kidney-shaped, wider transversely.
  - **Pedicles:** Strong, projecting backward.
  - **Laminae:** Short and broad, forming posterior wall of vertebral canal.
  - **Spinous process:** Thick, quadrilateral, directed horizontally backward.
  - **Transverse processes:** Long, slender (accessory processes present at base).
  - **Articular processes:**
    - *Superior facets* ? directed medially and backward.
    - *Inferior facets* ? directed laterally and forward.
  - **Mammillary processes:** Project from posterior surface of superior articular processes — give attachment to multifidus.
  - **Vertebral foramen:** Triangular and smaller than cervical but larger than thoracic.

Typical Lumbar Vertebrae (L1–L4)

- Large bodies with nearly horizontal spinous processes.

- **Accessory and mammillary processes** characteristic.

Fifth Lumbar Vertebra (L5) — Atypical

- **Body:** Deep anteriorly ? forms lumbosacral angle.
- **Transverse processes:** Thick and short.
- **Inferior articular facets:** Face forward; articulate with **sacral promontory**.

? Ossification of Lumbar Vertebrae

- **Primary centers:**
  - *1 for body* (centrum).
  - *1 for each neural arch* (two total).
  - Appear during **8th week of intrauterine life**.
- **Secondary centers (after puberty):**
  - 1 each for the **superior and inferior surfaces** of the body (ring epiphyses).
  - 1 for the **tip of each transverse process**.
  - 1 for the **tip of spinous process**.
  - These fuse by **25 years of age**.

?? Clinical Anatomy

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1. Lumbar Puncture

- Performed in **lower lumbar region (L3–L4 or L4–L5)**, below termination of spinal cord.
- Used to obtain **CSF** or administer **spinal anesthesia**.
- The **line joining iliac crests (Tuffier's line)** passes through the **L4 spine** — a key surface landmark.

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2. Lumbar Lordosis

- Forward curvature of lumbar spine; physiological in normal adults.
- **Excessive lordosis:** Common in pregnancy or obesity due to anterior shift of weight.
- **Flattened lordosis:** Occurs in muscle weakness or disc pathology.

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3. Spondylolisthesis

- Forward slipping of one vertebra over another, usually **L5 over S1**.
- Due to congenital defect in pars interarticularis or trauma.
- Produces back pain and nerve compression symptoms.

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4. Lumbar Disc Herniation

- Protrusion of **nucleus pulposus** through annulus fibrosus compresses spinal nerves (usually L4–L5 or L5–S1).
- Causes **sciatica** — pain radiating down the back of thigh and leg.

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5. Lumbar Vertebral Fractures

- Common at **L1 or L2** from falls on buttocks or blows to head (compression type).
- May damage **cauda equina** or **spinal roots**, causing paralysis or sensory loss.

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6. Lumbosacral Angle and Backache

- Formed between long axis of lumbar spine and sacrum.
- Increased angle = more stress on intervertebral discs ? **low back pain**.

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7. Psoas Abscess

- Tuberculosis of lumbar vertebrae may track along **psoas sheath**, presenting as a **fluctuant swelling in groin or thigh**.

The Sacrum / Vertebra Magnum

- The **sacrum** is a **large, triangular bone** formed by fusion of **five sacral vertebrae**.
- Forms the **posterosuperior part of the pelvis**, articulating with hip bones at the **sacroiliac joints**.

- **Upper part** — broad and strong to support body weight; **lower part** — tapered and light.
- **Surfaces:**
  - **Pelvic surface:** Smooth and concave.
  - **Dorsal surface:** Irregular and convex.
  - **Lateral surfaces:** Irregular; partly articular (auricular surface) for hip bones.

Anatomical Position

- Pelvic surface faces **downwards and forwards**.
- Upper surface of **S1 body** slopes forward at **30° (sacral promontory)**.
- Upper end of **sacral canal** directed **upwards and slightly backward**.

Base

- Formed by **upper surface of first sacral vertebra**.
- Features:
  - **Body** articulates with **L5** at the **lumbosacral joint**; anterior projection forms **sacral promontory**.
  - **Vertebral foramen** ? leads into **sacral canal**, triangular.
  - **Superior articular processes** ? facets directed **backward and medially**.

Apex

- Small, oval surface articulating with **base of coccyx**.

Pelvic Surface

- Four transverse ridges mark fusion lines of vertebral bodies.
- **Anterior sacral foramina** (4 pairs) transmit **ventral rami of S1–S4** and **lateral sacral arteries**.

Dorsal Surface

- Median sacral crest — fused spines of vertebrae.
- Intermediate crest — fused articular processes.
- Lateral crest — fused transverse processes.
- **Posterior sacral foramina** transmit **dorsal rami of S1–S4**.

? Sacral Canal

- Continuation of **vertebral canal**, triangular in cross-section.
- Opens inferiorly as **sacral hiatus** (due to failure of laminae of S5 and S4 to meet).
- Transmits **cauda equina**, **filum terminale**, and **spinal meninges**.
- **At sacral hiatus:** exits **S5 nerves**, **coccygeal nerves**, and **filum terminale**.

? Relations of the Sacrum

- **Pelvic surface** related to:
  - Median sacral vessels, sympathetic trunks, peritoneum, and rectum.
- **Lateral surface** related to:
  - Sympathetic chain, lumbosacral trunk, iliolumbar artery, and obturator nerve (forming triangle of Marcille).
- **Dorsal surface**: attachment to erector spinae and multifidus muscles.

?? Attachments on the Sacrum

- **Anterior (pelvic) surface:**
  - *Piriformis* arises from anterior S2–S4.
- **Posterior surface:**
  - *Gluteus maximus* and *multifidus* attached.
- **Lateral border:**
  - Attachment for *sacroiliac*, *sacrotuberous*, and *sacrospinous ligaments*.
- **Ala (wing):** gives origin to *iliacus*.

? Sex Differences

- **Sacral Index** = (Breadth across base × 100) / (Length from promontory to apex).
  - Male ? **105** (long, narrow sacrum).
  - Female ? **115** (short, wide sacrum).
- **Body of S1**: broader than alae in males; equal in females.
- **Ventral concavity:** shallower and uniform in males; irregular and deeper in females.
- **Pelvic cavity:** larger in females for childbirth.

? Ossification of the Sacrum

- Develops from **five separate vertebrae**.
- **Primary centers (21 total):**
  - 5 for bodies, 10 for arches, 6 for costal bars (upper three vertebrae).
- **Secondary centers (14 total):**
  - 10 for body epiphyses, 2 for auricular surfaces, 2 for margins below auricular areas.
- **Timeline:**
  - Primary centers appear in **2nd–8th week of fetal life**.
  - Fuse between **2nd–8th years**.

- Secondary centers appear at **puberty** and fuse by **25 years**.

? Coccyx

- Small triangular bone formed by fusion of **four rudimentary coccygeal vertebrae**.
- Curves **downward and forward**, continuous with sacral curve.
- **First coccygeal piece:** largest, may remain separate.
  - Has **body**, **cornua (horns)**, and **rudimentary transverse processes**.
  - Cornua articulate with **sacral cornua** by intercornual ligaments.
- **Remaining segments:** small nodules decreasing in size inferiorly.

? Ossification of Coccyx

- **Four primary centers** — one for each segment.
- Appear between **1st and 20th years**; fuse by **20–30 years**.
- Fuses with sacrum late in life.
- Slight movement persists at **sacrococcygeal joint** until old age

? Bony Pelvis

- **Definition:**
  The **pelvis (Latin = basin)** is a ring of bones forming the lower part of the trunk between the vertebral column and the lower limbs.

- **Constituents:**

  1. **Two hip bones** (ossa coxae) — one on each side.
  2. **Sacrum** — posteriorly.
  3. **Coccyx** — posterior and inferior tip.

- **Joints forming the pelvis:**

  - **Sacroiliac joints** (between sacrum and ilium).
  - **Symphysis pubis** (between two pubic bones).
  - **Lumbosacral joint** (between L5 and sacrum).
  - **Sacrococcygeal joint** (between sacrum and coccyx).

- **Function:**

  - Supports the trunk and transmits body weight to lower limbs.
  - Protects pelvic viscera (urinary bladder, rectum, reproductive organs).
  - Provides attachment for pelvic and lower limb muscles.

?? Divisions of the Pelvis

1. **Greater (false) pelvis**
    - Above the pelvic brim.
    - Formed by the iliac fossae and lumbar vertebrae.
    - Supports abdominal contents.
2. **Lesser (true) pelvis**
    - Below the pelvic brim.
    - Formed by sacrum, coccyx, and lower ilium, ischium, and pubis.
    - Contains pelvic viscera.

? Pelvic Brim (Inlet)

- Formed by:
    - Posteriorly: **Sacral promontory and alae**.
    - Laterally: **Arcuate line of ilium and pectineal line of pubis.**
    - Anteriorly: **Pubic crest and symphysis pubis.**

?? Pelvic Cavity and Outlet

- **Pelvic cavity:** Funnel-shaped space between inlet and outlet.
- **Pelvic outlet:** Bounded by coccyx, ischial tuberosities, and pubic arch.

? Sex Differences in the Pelvis

FEATURE	MALE PELVIS	FEMALE PELVIS
General	Thick, heavy, narrow	Light, broad, shallow
Pelvic inlet	Heart-shaped	Oval or round
Pelvic outlet	Smaller	Larger
Subpubic angle	Acute (~70°)	Wide (~90–100°)
Ischial spines	Project medially	Everted laterally
Sacrum	Long, narrow, concave	Short, wide, less curved
Acetabulum	Large and faces laterally	Smaller, faces more anteriorly
Greater sciatic notch	Narrow and deep	Wide and shallow
Obturator foramen	Oval	Triangular
Pelvic cavity	Conical	Cylindrical
Pubic arch	Narrow	Wide, rounded

- **Functional note:**
  The female pelvis is **adapted for childbirth**, with a **larger inlet and outlet** and **wider pubic arch**.

? Anatomical Position of the Pelvis

- When the pelvis is in its **anatomical position**:
  - **ASIS (anterior superior iliac spine)** and **upper border of pubic symphysis** lie **in the same vertical plane**.
  - **Tip of coccyx** and **upper border of pubic symphysis** are **in the same horizontal plane**.
  - **Pelvic inlet** faces **forwards and upwards**; outlet faces **downwards and backwards**.
  - **Sacral promontory** forms the posterior boundary of pelvic brim.

? Intervertebral Joints

- **Type:** Secondary cartilaginous joints (amphiarthroses).
- **Components:** Between adjacent vertebral bodies.
- **Structure:**
  - **Intervertebral disc** between the bodies.

- **Thin layer of hyaline cartilage** covering each end-plate.

- **Movements:**
  - Permit slight movement (flexion, extension, lateral bending, rotation).
  - Range of motion greatest in the **cervical and lumbar regions**.

- **Reinforcing ligaments:**
  - **Anterior longitudinal ligament** (strong, limits hyperextension).
  - **Posterior longitudinal ligament** (narrow, limits flexion).

? Intervertebral Disc

- **Type:** Fibrocartilaginous pad between two vertebral bodies.

- **Composition:**
  1. **Annulus fibrosus:**
     - Outer concentric lamellae of fibrocartilage.
     - Resists torsion and provides strength.
  2. **Nucleus pulposus:**
     - Central gelatinous mass derived from the notochord.
     - Acts as a shock absorber and allows flexibility.

- **Function:**
  - Allows cushioning and slight motion between vertebrae.
  - Absorbs vertical shock and maintains spinal curvature.
- **Clinical relevance:**
  - **Prolapsed intervertebral disc (slipped disc):**
    - Nucleus pulposus herniates through annulus fibrosus, compressing spinal roots (commonly L4–L5 or L5–S1).
  - **Degenerative disc disease:** Leads to loss of disc height and back pain with aging.

> **? Mnemonics — Bony Pelvis & Intervertebral Joints**

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1. Contents of the Pelvic Cavity

Mnemonic: *"U R R"*

- **U** – Urinary bladder
- **R** – Rectum
- **R** – Reproductive organs (uterus in females, prostate and seminal vesicles in males)

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2. Features Forming the Pelvic Inlet

Mnemonic: *"PSA APP"*

- **P** – Promontory of sacrum
- **S** – Sacral ala
- **A** – Arcuate line of ilium
- **A** – Pectineal line of pubis
- **P** – Pubic crest and symphysis

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3. Differences Between Male and Female Pelvis

Mnemonic: *“WIDER FEMALE”*

- **W** – Wider subpubic angle
- **I** – Inlet more circular
- **D** – Deeper pelvic cavity (male: deeper; female: shallower)
- **E** – Everted ischial spines
- **R** – Round obturator foramen (female; male = oval)
- **F** – Flatter sacrum
- **E** – Enlarged outlet
- **M** – More space between iliac crests
- **A** – Arch broader
- **L** – Lighter bones

- **E** – Everything designed for childbirth

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4. Structures Passing Through Sacral Canal

Mnemonic: *“5 Cute Men”*

- **5** – Five pairs of sacral spinal nerves (S1–S5)
- **C** – Cauda equina
- **M** – Meninges (dura and arachnoid mater)

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5. Components of Intervertebral Disc

Mnemonic: *“A Noble Cushion”*

- **A** – Annulus fibrosus
- **N** – Nucleus pulposus
- **C** – Cartilaginous end plates

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6. Joints of the Pelvis

Mnemonic: *“SASS”*

- **S** – Sacroiliac joints
- **A** – Sacrococcygeal joint
- **S** – Symphysis pubis

- **S** – Lumbosacral joint

? Facts to Remember

- The **pelvis** is the **link between the vertebral column and lower limbs**.
- The **true pelvis** lies below the **pelvic brim** and contains **pelvic viscera**.
- The **false pelvis** is part of the abdominal cavity.
- The **pelvic inlet** faces forward and upward, while the **pelvic outlet** faces backward and downward.
- The **female pelvis** is **shorter, broader, and lighter**, adapted for childbirth.
- The **pelvic index (breadth/length × 100)** is higher in females (~115) than in males (~105).
- The **subpubic angle** is acute in males (70°) and obtuse in females (90–100°).
- The **intervertebral discs** make up about **one-fourth** of the total length of the vertebral column.
- The **nucleus pulposus** is a **remnant of the notochord**.
- **Spondylolisthesis** results from a defect in the **pars interarticularis** (usually L5).
- The **sacrum** is **concave anteriorly**, forming the **posterior wall of the pelvis**.
- The **lumbosacral angle** normally measures about **140°**; increased angle ? **lordosis**.

- The **pelvic cavity** in females is **cylindrical**, while in males it is **funnel-shaped**.
- The **pelvic outlet** in females is larger due to everted ischial spines and a wider pubic arch.
- The **intervertebral joints** are **secondary cartilaginous joints**, permitting limited movement but providing stability.

? Clinicoanatomical Problem

Case:
A patient complained of **chronic dull low backache**. One day, during **sudden bending**, he developed **radiating pain in the calf**.

Questions:

1. What is the reason for the low backache?
2. What triggered the radiating pain in the calf?

Answer:

- The low backache is likely due to a **slipped intervertebral disc** in the **lumbosacral region**.
- Initially, the slip is mild, producing dull pain.
- During sudden bending and straightening, the disc **herniated posterolaterally**, narrowing the **intervertebral foramen between L5 and S1**.
- This **compressed one of the roots of the sciatic nerve**, causing **shooting pain along the area of its cutaneous supply** — i.e., the posterior thigh and calf

? Frequently Asked Questions — Bony Pelvis and Intervertebral Joints

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1. Write an essay on the intervertebral disc. Add a note on prolapsed disc.

- The **intervertebral disc** is a **fibrocartilaginous joint** between vertebral bodies, composed of:
    - **Annulus fibrosus:** Outer concentric lamellae of fibrocartilage.
    - **Nucleus pulposus:** Central gelatinous core derived from the notochord.
- **Functions:** Acts as a shock absorber, maintains spinal curvature, and allows limited movement.
- **Prolapsed disc (slipped disc):** Posterolateral herniation of the nucleus pulposus compresses adjacent spinal roots (commonly L4–L5 or L5–S1), causing pain and neurological deficits (sciatica).

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2. Name five paired and unpaired processes of a lumbar vertebra.

- **Paired processes:**
    1. Superior articular processes
    2. Inferior articular processes
    3. Transverse processes
- **Unpaired process:**

- Spinous process
- Body (centrum) (though not a projection, it is the central unpaired part in morphology).

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3. List differences between male and female pelves.

- **Male pelvis:**
  - Heavy and narrow.
  - Heart-shaped inlet.
  - Acute subpubic angle (50–60°).
  - Sacrum long and narrow.
  - Ischial spines point medially.
- **Female pelvis:**
  - Light and shallow.
  - Oval or round inlet.
  - Wide subpubic angle (80–100°).
  - Sacrum short and wide.
  - Ischial spines everted laterally.

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4. Write the structures related to the pelvic surface of the sacrum.

- **Pelvic surface** is smooth and concave; related to:
    - **Median sacral vessels**
    - **Sympathetic trunks**
    - **Pelvic splanchnic nerves**
    - **Rectum**
    - **Peritoneum**

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5. Write the contents of the sacral canal.

- **Contents:**
    1. Cauda equina
    2. Filum terminale
    3. Dural sac and meninges (ending at S2)
    4. Ventral and dorsal roots of sacral and coccygeal nerves
    5. Internal vertebral venous plexus

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6. What are the contents of the abdominal cavity?

- **Contents:** Stomach, intestines, liver, gallbladder, pancreas, spleen, kidneys, ureters, and major vessels (aorta, IVC), plus part of the urinary bladder and reproductive organs.

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7. At which lumbar vertebra does the spinal cord end in an adult?

- In adults, the spinal cord **ends at the level of the lower border of L1 vertebra** (sometimes between L1–L2).
- In newborns, it extends to **L3**.

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8. How do you distinguish a lumbar vertebra from a thoracic vertebra?

- **Lumbar vertebra:**
  - Large kidney-shaped body.
  - Absence of costal facets.
  - Triangular vertebral foramen.
  - Quadrangular spinous process.
  - Mammillary and accessory processes present.
- **Thoracic vertebra:**
  - Heart-shaped body.
  - Costal facets for ribs.
  - Circular vertebral foramen.
  - Long, downward-pointing spinous process.

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9. What is sacralization of the 5th lumbar vertebra?

- **Definition:** Fusion of **L5** vertebra with the **sacrum** either partially or completely.
- **Clinical importance:** Decreases lumbar mobility; may cause **backache** or **nerve compression** symptoms.

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10. What is spondylolisthesis?

- **Definition:** Forward slipping of **L5 over the sacrum** due to defect or fracture of the **pars interarticularis**.
- **Clinical features:** Low back pain, restricted movement, and nerve compression (sciatica).

? Multiple Choice Questions — Bony Pelvis and Intervertebral Joints

1. **The true pelvis is located:**
   A. Above pelvic brim B. Below pelvic brim C. Between ilium and sacrum D. At level of pubic arch
   ? **Answer:** B

2. **The pelvic inlet is formed posteriorly by:**
   A. Sacral ala B. Sacral promontory C. Arcuate line D. Pubic crest
   ? **Answer:** B

3. **The pelvic outlet is bounded posteriorly by:**
   A. Coccyx B. Sacrum C. Ischial tuberosity D. Pubic arch
   ? **Answer:** A

4. **The subpubic angle in males is approximately:**
   A. 30° B. 50°–60° C. 70°–80° D. 90°–100°

? **Answer:**

5. **The subpubic angle in females is approximately:**
   A. 50° B. 70° C. 80°–100° D. 40°
   ? **Answer:** C

6. **The true conjugate (anteroposterior diameter of inlet) extends from:**
   A. Sacral promontory to upper border of symphysis pubis B. Sacral promontory to lower border of symphysis pubis
   C. S1 to pubic crest D. Ischial spine to pubic tubercle
   ? **Answer:** A

7. **The pelvic cavity in females is generally:**
   A. Deep and conical B. Shallow and cylindrical C. Flat and narrow D. Triangular
   ? **Answer:** B

8. **The lumbosacral angle in normal adults is about:**
   A. 120° B. 130° C. 140° D. 150°
   ? **Answer:** C

9. **The intervertebral joints are classified as:**
   A. Primary cartilaginous B. Secondary cartilaginous C. Plane synovial D. Fibrous
   ? **Answer:** B

10. **The nucleus pulposus is derived from:**
    A. Mesoderm B. Notochord C. Ectoderm D. Sclerotome
    ? **Answer:** B

11. **The annulus fibrosus is composed of:**
    A. Elastic fibres B. Fibrocartilage C. Hyaline cartilage D. Ligamentous fibres
    ? **Answer:** B

12. **Prolapse of lumbar disc most commonly occurs at:**
    A. L2–L3 B. L3–L4 C. L4–L5 or L5–S1 D. S1–S2

? **Answer:**

13. **The sacral canal contains:**
    A. Spinal cord B. Cauda equina and filum terminale C. Lumbosacral trunk D. Femoral nerve
    ? **Answer:** B

14. **The pelvic index (breadth × 100 / length) is higher in:**
    A. Males B. Females C. Children D. Elderly
    ? **Answer:** B

15. **Which type of pelvis is best suited for childbirth?**
    A. Android B. Anthropoid C. Gynaecoid D. Platypelloid
    ? **Answer:** C

16. **Spondylolisthesis most commonly occurs at:**
    A. L4–L5 B. L5–S1 C. T12–L1 D. S1–S2
    ? **Answer:** B

17. **The joint between bodies of vertebrae is strengthened anteriorly by:**
    A. Anterior longitudinal ligament B. Posterior longitudinal ligament C. Ligamentum flavum D. Supraspinous ligament
    ? **Answer:** A

18. **Which of the following is a secondary cartilaginous joint?**
    A. Sacroiliac joint B. Symphysis pubis C. Zygapophyseal joint D. Costotransverse joint
    ? **Answer:** B

19. **The vertebral column curvature that develops first in the embryo is:**
    A. Cervical B. Thoracic C. Lumbar D. Sacral
    ? **Answer:** B

20. **The ligament connecting the tips of spinous processes is:**
    A. Supraspinous ligament B. Interspinous ligament C. Ligamentum flavum D. Posterior

longitudinal ligament

? **Answer:** A