ANATOMY AND PHYSIOLOGY (C.I.)

HUMAN ANATOMY
(Mod. A)

THE SKELETON
THE AXIAL SKELETON – Sacrum and Coccyx
Sacrum and Coccyx
Dorsal Surface

Posterior view

Superior view

Lateral view
SACRUM AND COCCYX

SACRUM

Single bone resulting from the fusion of 5 segments, the original five sacral vertebrae → S1-S5

Fusion occurs around the age of 18-20

The bone shows a triangular morphology with:

- the **BASE** (i.e., the upper margin) on the most cranial portion of the bone

- **TWO LATERAL MARGINS/LATERAL SURFACES** that come closer as they go downwards and converge in the apex of the sacrum

- the **APEX**, the most caudal portion, is completed by the coccyx

The apex of the sacrum articulates with the coccyx forming the **SACROCOCCYGEAL JOINT** (amphiarthrodial joint)
BASE of the SACRUM - JOINTS

Anterior side

The BASE articulates superiorly with the 5th LUMBAR VERTEBRA. This kind of joint is similar to the joint between two vertebrae.

It occurs anteriorly at the level of the vertebral body of L5 which joints with the LUMBOSACRAL ARTICULAR SURFACE in the center of the base of the sacrum.

The superior margin of the lumbosacral articular surface is called the sacral promontory.
At the base of the sacrum, 2 bony processes are found: The **ARTICULAR PROCESSES OF THE SACRUM** where two articular facets are identifiable from the posterior view.

They correspond to the articular facets of the superior articular processes of the first sacral vertebra.

The superior articular processes of the sacrum join with the inferior articular processes of the L5 vertebra.
Lateral to the lumbosacral articular surface (anteriorly) and the articular processes (posteriorly), it is possible to identify the **WINGS OF THE SACRUM**

Bone surfaces that extend laterally, towards the right and the left
Observing the anterior and posterior side of the sacrum, there are other structures that can easily be identified.

On the **ANTERIOR SIDE** we recognize the **ANTERIOR SACRAL FORAMINA**, organized into 4 pairs.

They correspond in part to the vertebral foramina and are placed between adjacent vertebral segments. For example, the most cranial anterior sacral foramina are located between S1 and S2.

How are S1-S5 distinguished?

There are lines that are called the **TRANSVERSE RIDGES (LINES) OF THE SACRUM** recognizable between one vertebral segment and another.

These are the lines of vertebral fusion that remain visible as four transverse ridges.
The **POSTERIOR SIDE** shows a more irregular morphology.

On this side it is possible to identify

- **the POSTERIOR SACRAL FORAMINA**
- **RIDGES which are called CRESTS**

**A) the Median sacral crest**
A bumpy ridge which, thinking about the organization of the vertebrae, derives from the fusion of the spinous processes

Immediately laterally it is possible to identify

**B) the Intermediate sacral crest**
It results from the fusion of the articular processes

**C) the Lateral sacral crest**
It derives from the fusion of the transverse processes
POSTERIOR SIDE

Just as the vertebral canal in the vertebrae, in the sacrum we have the

SACRAL CANAL

a hollow space resulting from the juxtaposition of the vertebral foramina of the originary sacral vertebral segments
SACRAL CANAL

It runs through the entire sacrum and represents the lower completion of the vertebral canal

- It is open superiorly → Cranial opening of the sacral canal

- It is open inferiorly → Inferior opening of the sacral canal, also called SACRAL HIATUS
SACRAL CANAL
↓
SACRAL HIATUS

Delimited by two bony horns (the SACRAL HORNS)

At the level of the apex of the sacrum there is the articulation with the coccyx and therefore in part the sacral hiatus is also delimited by the coccygeal horns

*The sacral hiatus in the human body is actually closed by a connective membrane*

**COCCYX**
(or Tailbone)

- It derives from the fusion of four very small coccygeal vertebrae
- It articulates with the apex of the sacrum
- It is not weight bearing in the standing position, but may receive some body weight when sitting
The sacral canal is the continuation of the vertebral canal.

In the vertebral canal the *spinal cord which extends only up to the L1-L2 passage*

FROM THE SPINAL CORD
SPINAL NERVES COME OUT IN PAIRS
The number of nerves mirrors the number of vertebrae with some exceptions

CERVICAL, THORACIC, LUMBAR VERTEBRAE
↓
CERVICAL, THORACIC, LUMBAR SPINAL NERVES
EXCEPTION:
In the cervical region there are 7 vertebrae BUT 8 pairs of cervical spinal nerves that emerge from the spinal cord

→ 8 pairs because:

The first pair of cervical spinal nerves emerges between the Atlas and the skull
The second pair emerges between the first and second cervical vertebrae and so on while...
...the eighth pair of spinal nerves emerge between C7 and T1

Going downwards:
- 12 pairs of thoracic spinal nerves emerge in progression from below T1 to below T12

Followed by:
5 pairs of lumbar spinal nerves
5 pairs of sacral spinal nerves
1 single pair of spinal nerves at the coccygeal level

8+12+5+5+1 = 31 PAIRS OF SPINAL NERVES
The lumbar spinal nerves emerge from the corresponding intervertebral foramina of lumbar vertebrae

*The sacral spinal nerves emerge from the sacral canal through the sacral foramina*

Each spinal nerve emerges from the cord through **nerve roots**

Since the spinal cord ends between L1-L2, the lumbar/sacral spinal nerves produce roots that descend to exit the intervertebral foramina/sacral foramina at the level of the corresponding vertebrae/sacral segments

**Example:**

*The L5 nerve have to exit between the 5th lumbar vertebra and the sacrum, going down beyond the end of the spinal cord; the same for the sacral nerves which will have to exit at the level of the sacral foramina*

This is why below L1-L2 we have the CAUDA EQUINA, formed by the roots of the lumbar/sacral spinal nerves that are descending to reach the corresponding exit foramen from the vertebral/sacral canal

At the level of the sacrum we have anterior and posterior sacral foramina

**TWO EXITS FOR EACH NERVE. WHY?**
The spinal nerve emerges from the spinal cord forming two nerve roots, one ANTERIOR or VENTRAL ROOT and one POSTERIOR or DORSAL ROOT, which then converge to form the spinal nerve.

- Anterior root → MOTOR NERVE ROOT
- Posterior root → SENSORY NERVE ROOT

Along the vertebral canal, the nerve exits through the intervertebral foramen, as a single nerve.

Then, once it exits the spinal canal, the spinal nerve divides into two branches:
- Anterior or ventral ramus (larger)
- Posterior or dorsal ramus (smaller)

Both present motor + sensory nerve fibers
In the sacral region, the division of the spinal nerve into two rami occurs inside the sacral canal (whereas it occurs outside the spinal canal for the cervical, thoracic and lumbar spinal nerves).

From the sacral canal the spinal nerve emerge not as the single nerve, but ALREADY DIVIDED INTO ITS VENTRAL AND DORSAL RAMI.

▼

Ventral rami exit through → anterior sacral foramina
Dorsal rami exit through → posterior sacral foramina
At the lateral sides of the sacrum TWO ARTICULAR SURFACES are present, called the AURICULAR SURFACES.

By means of these articular surfaces, the sacrum joins with the hip bone.
The **sacrum** articulates with the **two hip bones** to form the **PELVIS** (two hip bones + sacrum and coccyx).

**PELVIS JOINTS**
- **POSTERIORLY**: between the sacrum and the ilium portion of each hip bone (**sacroiliac joint**)
- **ANTERIORLY**: between the two hip bones (**pubic symphysis**)

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**SACRUM AND COCCYX**
THE FEMALE PELVIS AND THE MALE PELVIS HAVE A DIFFERENT MORPHOLOGY

The pelvis is one of the bony structures of the skeleton through which the sex of the individual can be distinguished in case of discovery of bone remains.
A central space is created from the articulation of the 3 bones of the pelvis

PELVIC CAVITY

- The broad, superior region, defined laterally by the upper hip bones, is called the **greater pelvis** (greater pelvic cavity).

  *This broad area is occupied by portions of the small and large intestines, and because it is more closely associated with the abdominal cavity, it is sometimes referred to as the false pelvis.*

- More inferiorly, the narrow, rounded space of the **lesser pelvis** (lesser pelvic cavity) contains the bladder and other pelvic organs, and thus is also known as the **true pelvis**.
LESSER PELVIC CAVITY:
it presents a superior margin = pelvic inlet or superior aperture of the pelvis or pelvic brim

The inferior limit of the lesser pelvic cavity is called the inferior aperture of the pelvis or pelvic outlet
The pelvic inlet shows a different morphology in the female than in the male.

**In the FEMALE:**
The pelvic inlet has a mainly TRANSVERSE, or LATERAL-LATERAL, extension.
In the MALE:

The pelvis shows a heart-shaped brim or pelvis inlet
more extended anteriorly
more narrow
most prominent at the level of the sacral promontory
The female pelvis is adapted for childbirth:
- is wider
- has a larger subpubic angle (or pubic arch)
- Shows a rounder pelvic brim
- has a wider and more shallow lesser pelvic cavity than the male pelvis

**Male Pelvis**
- Higher Iliac Crest
- Deeper Pelvic Cavity
- 60-70 Degrees

**Female Pelvis**
- Wider
- Shorter
- Anterior Superior Iliac Spine
- Shallow Pelvic Cavity
- 80-90 Degrees
HIP BONE (or Coxal bone)

It consists of 3 portions:
ILIUM - ISCHIUM - PUBIS
ARTICULAR SURFACES

ON THE MEDIAL SIDE:

1. Articular surface to join with the **sacrum (auricular surface)**

   Located on the **ILIUM PORTION**, so the joint between the sacrum and the hip bone is called the **sacroiliac joint**

2. Articular surface to form the pubis symphysis (anteriorly)
ON THE LATERAL SIDE:

3. Articular surface to join with the **head of femur**

↓

**ACETABOLUM**

It is a cup-shaped articular surface covered by articular cartilage.

It shows a central depression called **FOSSA** of the acetabulum.

The surrounding articular surface is also called **lunate surface**.

Finally we identify the prominent external **margin** of the acetabulum.

**EACH HIP BONE PRESENTS 3 ARTICULAR SURFACES**
The hip bone is made up of 3 different parts:

- **ILIUM**
- **ISCHIUM**
- **PUBIS**

They fuse at the level of the acetabulum.

The hip bone derives from multiple ossification nuclei that grow during embryo development, and are connected to each other by intermediate cartilage.

When the nuclei grow/fuse, reabsorption of the cartilage occurs.

In the last stages, the Y-PROFILE of reabsorbing cartilage is visible, defining the border line between the different parts of the bone.
ILIUM

It is the most cranial portion, mainly consisting of the **WING OF THE ILIUM** and then it ends with the **ILIAC CREST**

Going along the iliac crest, this ends forward with a prominence which is the **anterior-superior iliac spine**

Downwards, the **anterior-inferior iliac spine** is present

On the posterior side of the ilium it is possible to identify other spine structures: the **posterior-superior iliac spine** and the **posterior-inferior iliac spine**
On the posterior side of the ilium it is possible to identify other spine structures: the **posterior-superior iliac spine** and the **posterior-inferior iliac spine**.

The gluteal muscles attached to the lateral side of the ilium, creating ridges called **gluteal lines**.
ISCHIUM and PUBIS below the ilium

They extend from the acetabulum
The **ischium** extends → posteriorly
The **pubis** extends → anteriorly

They delimit the **OBTURATOR FORAMEN** (*)

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**Male Pelvis**

Measurements - Anterior View

- Transverse diameter of pelvic inlet (~13 cm)
- Conjugate diameter of pelvic inlet (~11 cm)
- Oblique diameter of pelvic inlet (~12.5 cm)
- Pelvic inlet oriented more anteposteriorly than in female
- Ramus of ischium
- Ischial tuberosity
The obturator foramen is not completely open but almost entirely closed by a connective membrane → OBTURATOR MEMBRANE.
ISCHIUM

It is the lower posterior portion of the hip bone.

The ischium consists of two main parts:

1. **Body of the ischium** - the portion that forms the posterior one-third of the acetabulum.
2. **Ramus of the ischium**

   It shows an inferior irregular prominence called the
   ▼
   **ISCHIAL TUBEROSITY** *(where you sit down)*

   It shows a sharp bony prominence which protrudes from the posterior margin called the
   ▼
   **ISCHIAL SPINE**
**PUBIS**

It is the lower anterior portion of the hip bone. The pubic bone is made up of a **superior ramus** and an **inferior ramus**. It joins anteriorly with the contralateral pubis forming the **pubic symphysis**.
The pelvic outlet (i.e., the inferior aperture of the lesser pelvis) is not only delimited by bone structures but is also completed by ligaments.
LIGAMENTS connect the sacrum and the hip bone:

- **SACROTUBEROUS LIGAMENT →** from the lateral margin of the sacrum to the ischial tuberosity

- **SACROSPINOUS LIGAMENT →** from the lateral margin of the sacrum to the ischial spine

These ligaments, together with the bony structures, delimit foramina such as:

- The **GREATER SCIATIC FORAMEN**
- The **LESSER SCIATIC FORAMEN**

Nerves pass through these structures; Greater ischial foramen → Sciatic nerve
The PELVIC OUTLET of the pelvic cavity is delimited by:

- Pubic symphysis (anteriorly)
- Ischial tuberosity
- Sacrotuberous ligament
- Sacrum
- Coccyx

The pelvic outlet is important in obstetrics → the exit route of the fetus.

In the last phase of pregnancy, the coccyx has a few more mobility with respect to the sacrum and the sacrococcygeal joint becomes looser to allow a certain posterior movement of the coccyx to allow childbirth.