



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

DNS DEPARTMENT OF NEUROSCIENCE



ANATOMY AND PHYSIOLOGY (C.I.)

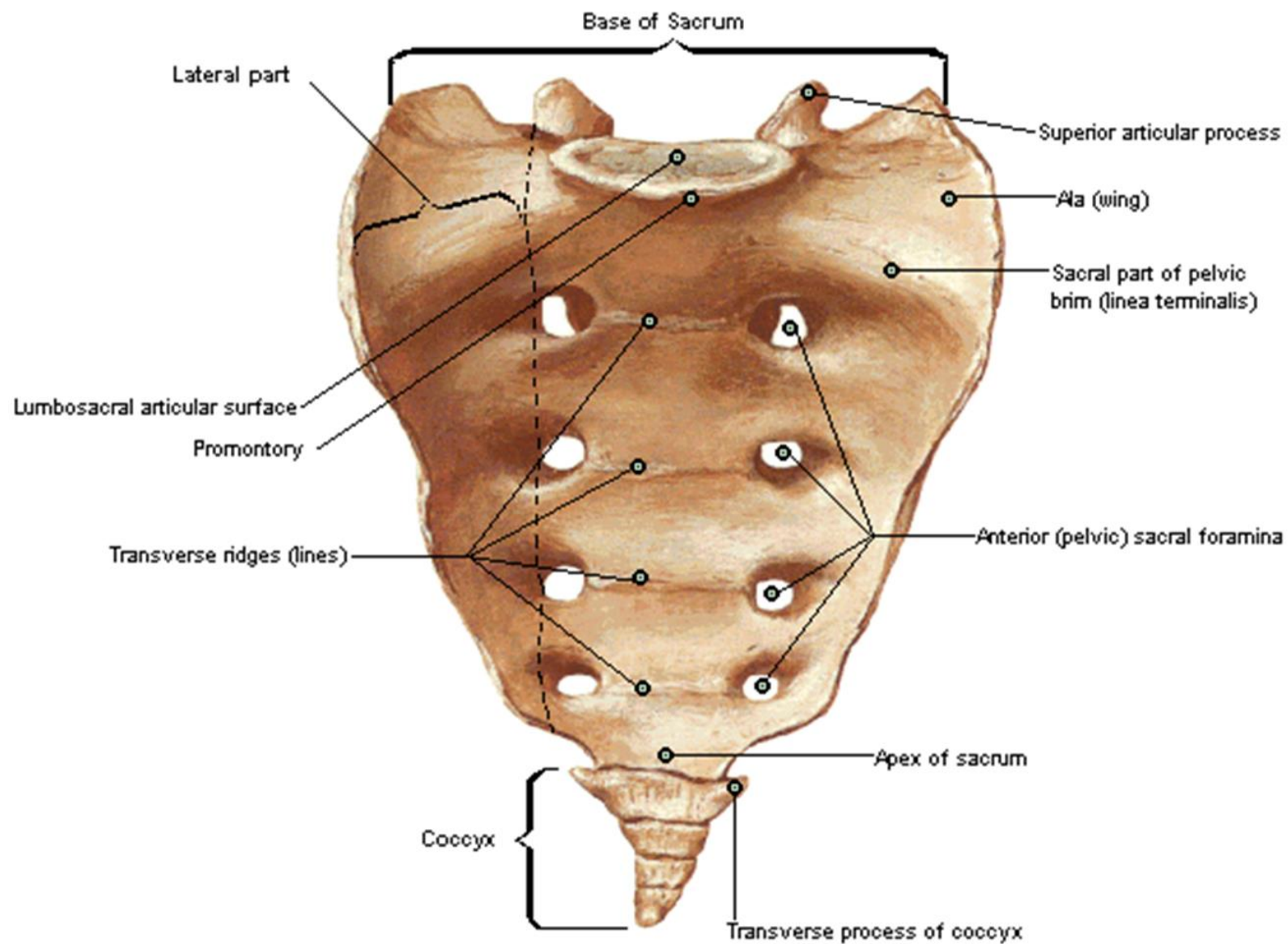
HUMAN ANATOMY
(Mod. A)

THE SKELETON

THE AXIAL SKELETON – Sacrum and Coccyx

Sacrum and Coccyx

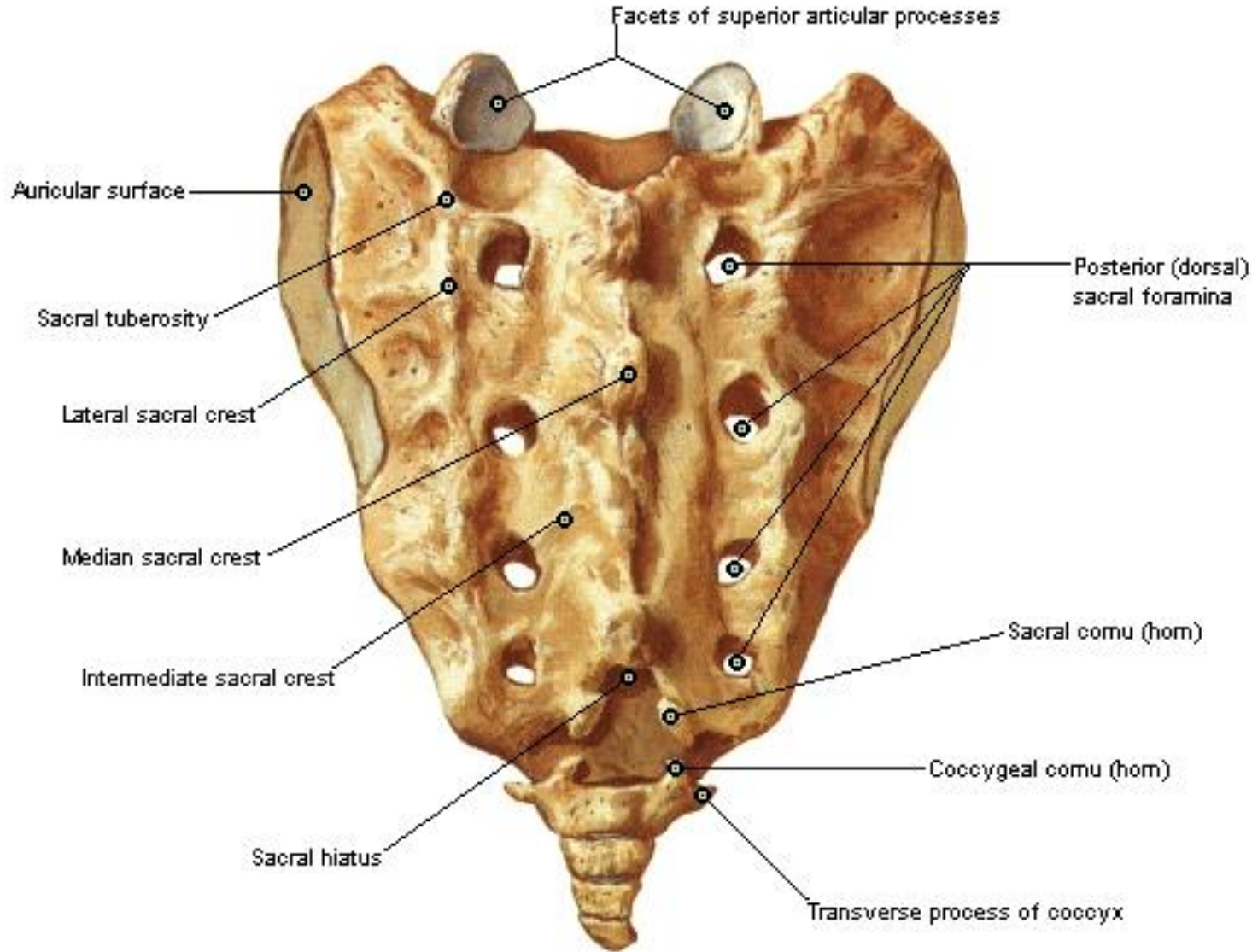
Pelvic Surface



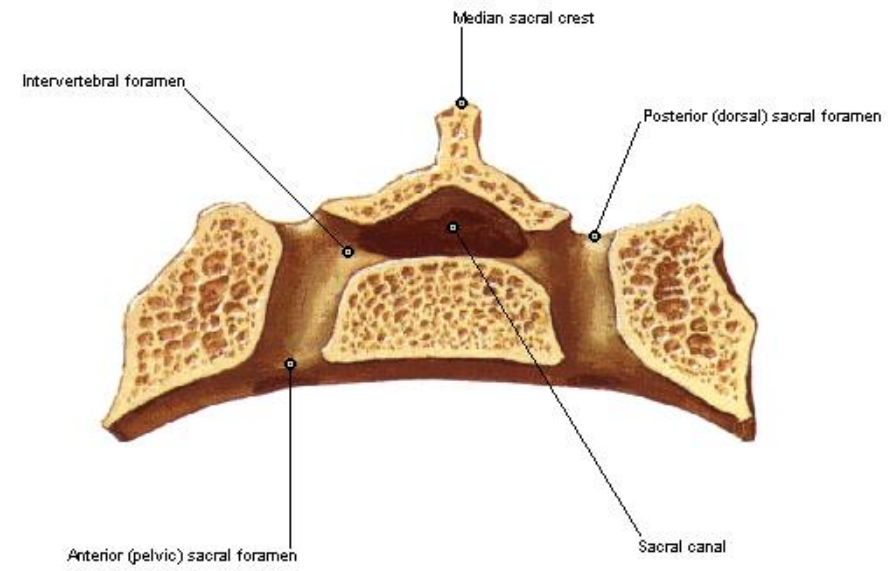
Anterior view

Sacrum and Coccyx

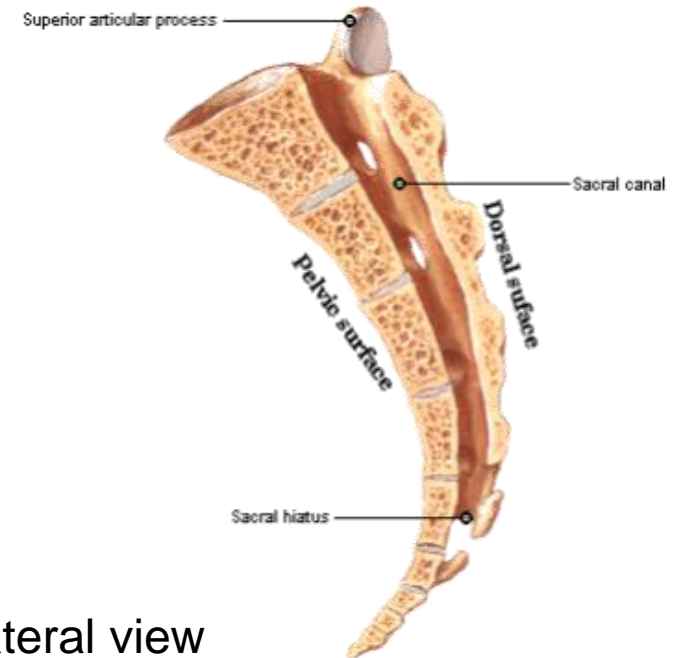
Dorsal Surface



Posterior view



Superior view

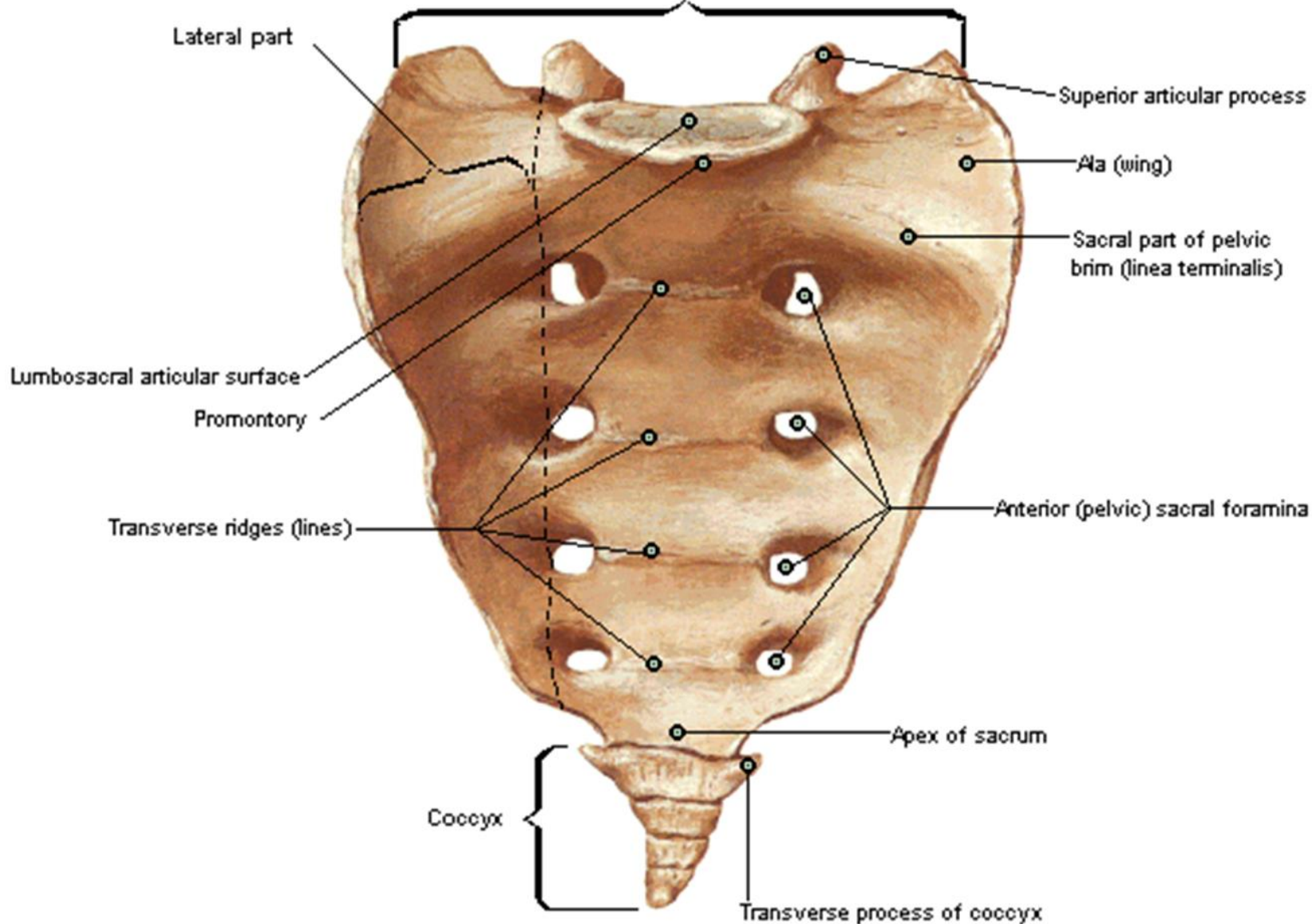


Lateral view

Sacrum and Coccyx

Pelvic Surface

Base of Sacrum



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

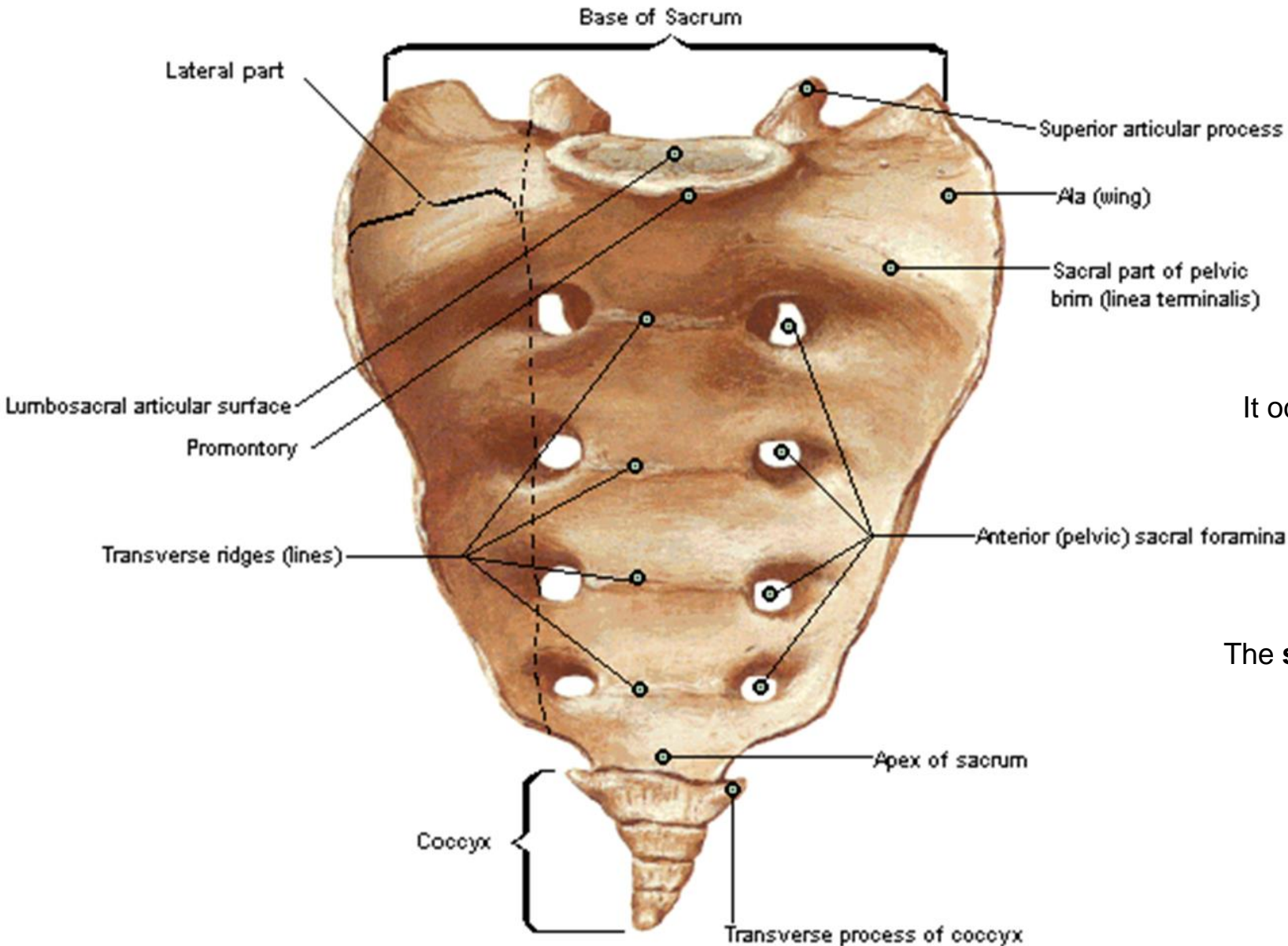
- the **APEX**, the most caudal portion, is completed by the coccyx



The apex of the sacrum articulates with the coccyx forming the SACROCOCCYGEAL JOINT (amphiarthrodial joint)

Sacrum and Coccyx

Pelvic Surface



BASE of the SACRUM - JOINTS

Anterior side



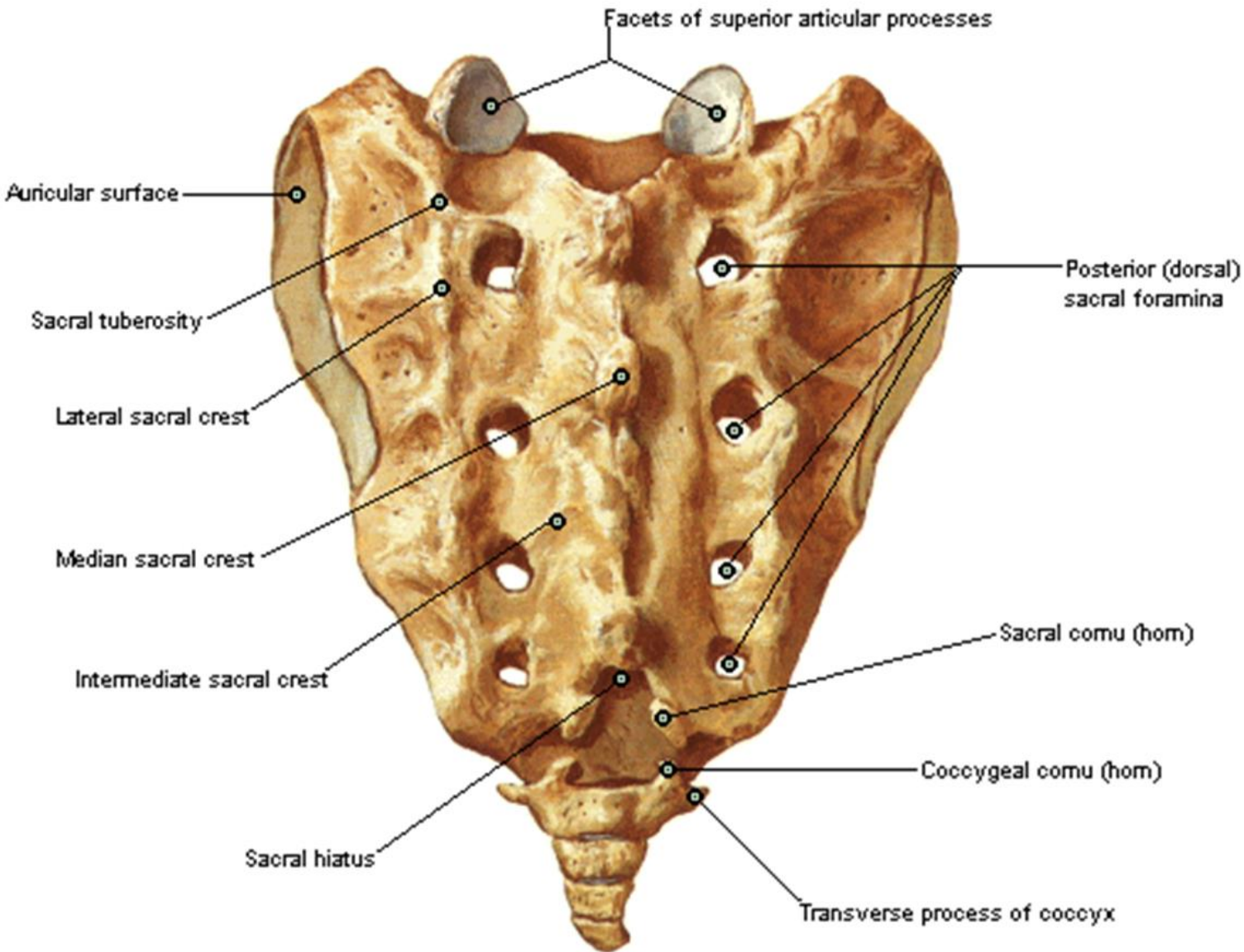
The **BASE** articulates superiorly with the **5th LUMBAR VERTEBRA**
This kind of joint is similar to the joint between two vertebrae

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**

Sacrum and Coccyx

Dorsal Surface



SACRUM AND COCCYX

BASE of the SACRUM - JOINTS

Posterior side



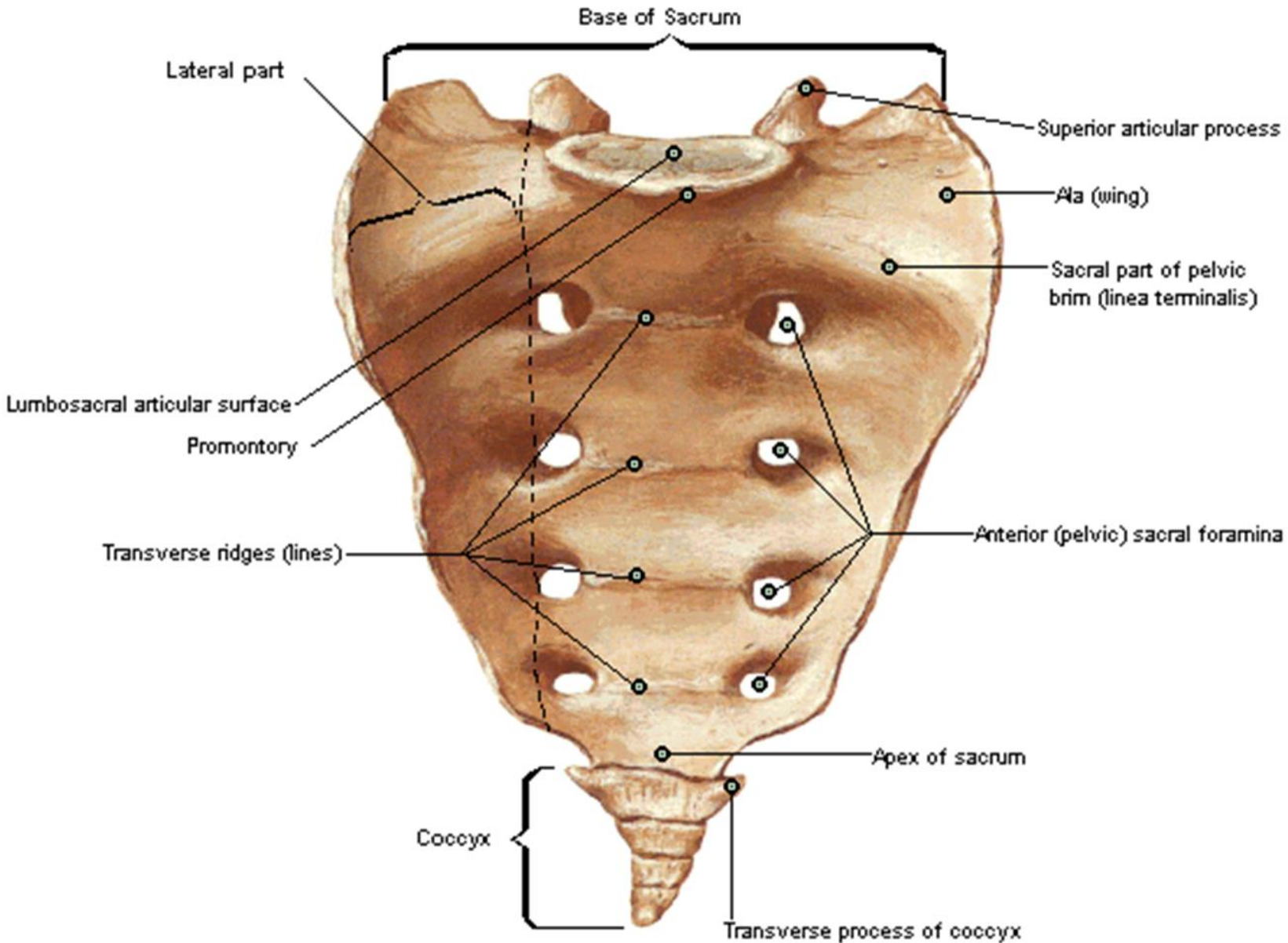
At the base of the sacrum, 2 bony processes are found:
The **ARTICULAR PROCESSES OF THE SACRUM**
where two articular facets are identifiable from the
posterior view

They correspond to the articular f. 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**

Sacrum and Coccyx

Pelvic Surface



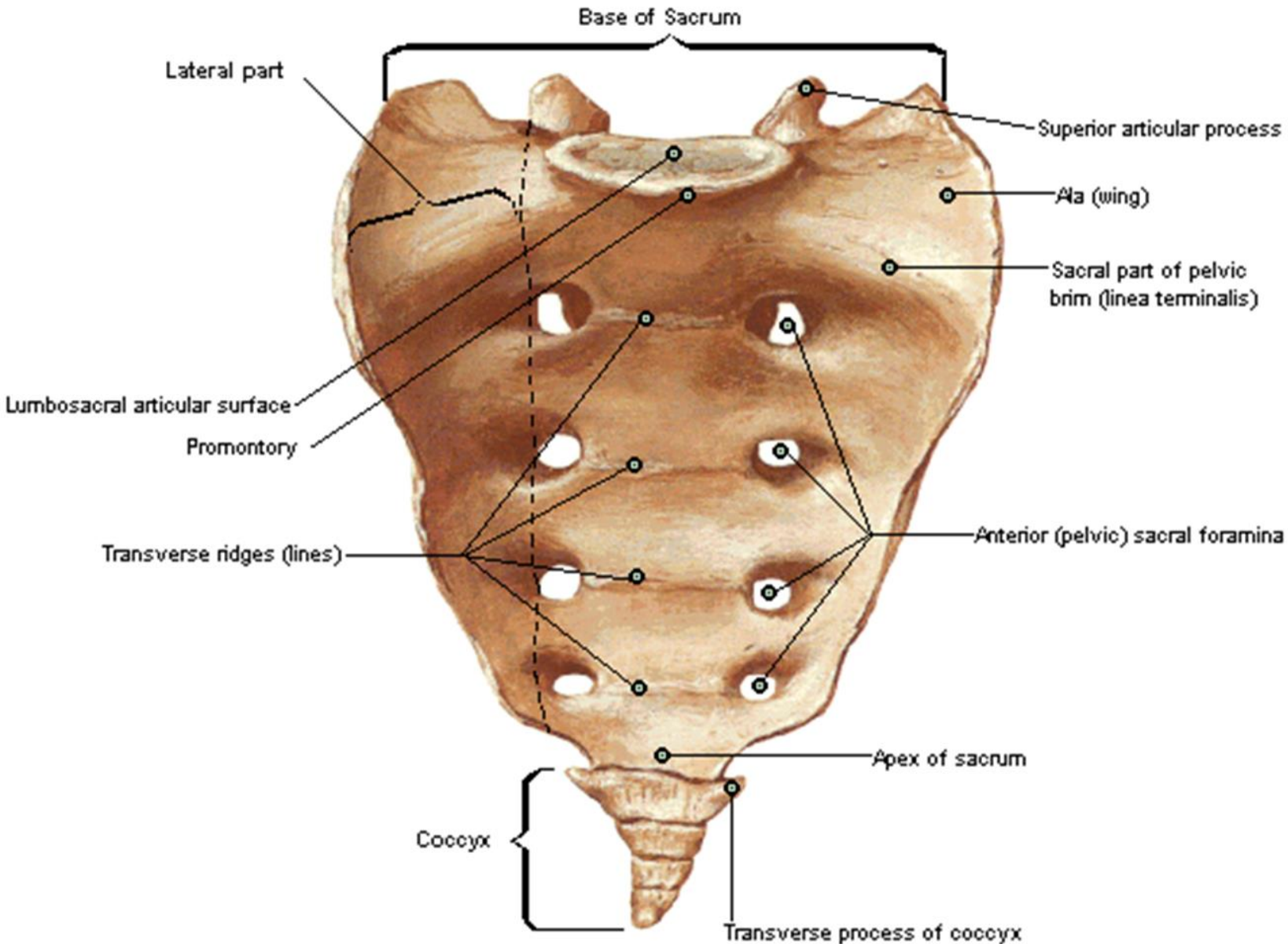
Lateral to the lumbosacral articular surface (anteriorly) and the articular processes (posteriorly), it is possible to identify

the **WINGS OF THE SACRUM**

↓
Bone surfaces that extend laterally, towards the right and the left

Sacrum and Coccyx

Pelvic Surface



SACRUM AND COCCYX

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

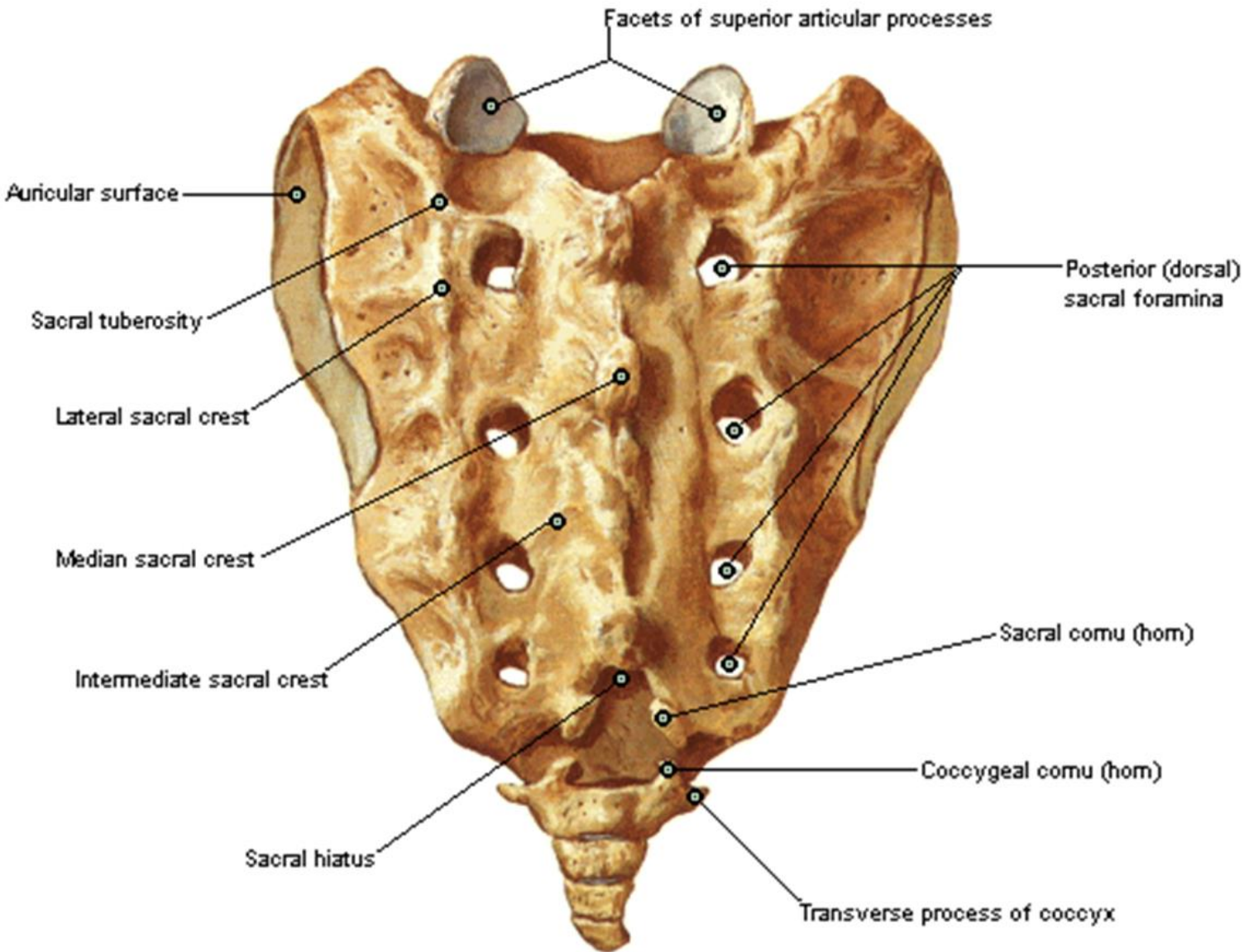
How are S1-S5 distinguished?

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

Sacrum and Coccyx

Dorsal Surface



SACRUM AND COCCYX

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

Sacrum and Coccyx

Dorsal Surface

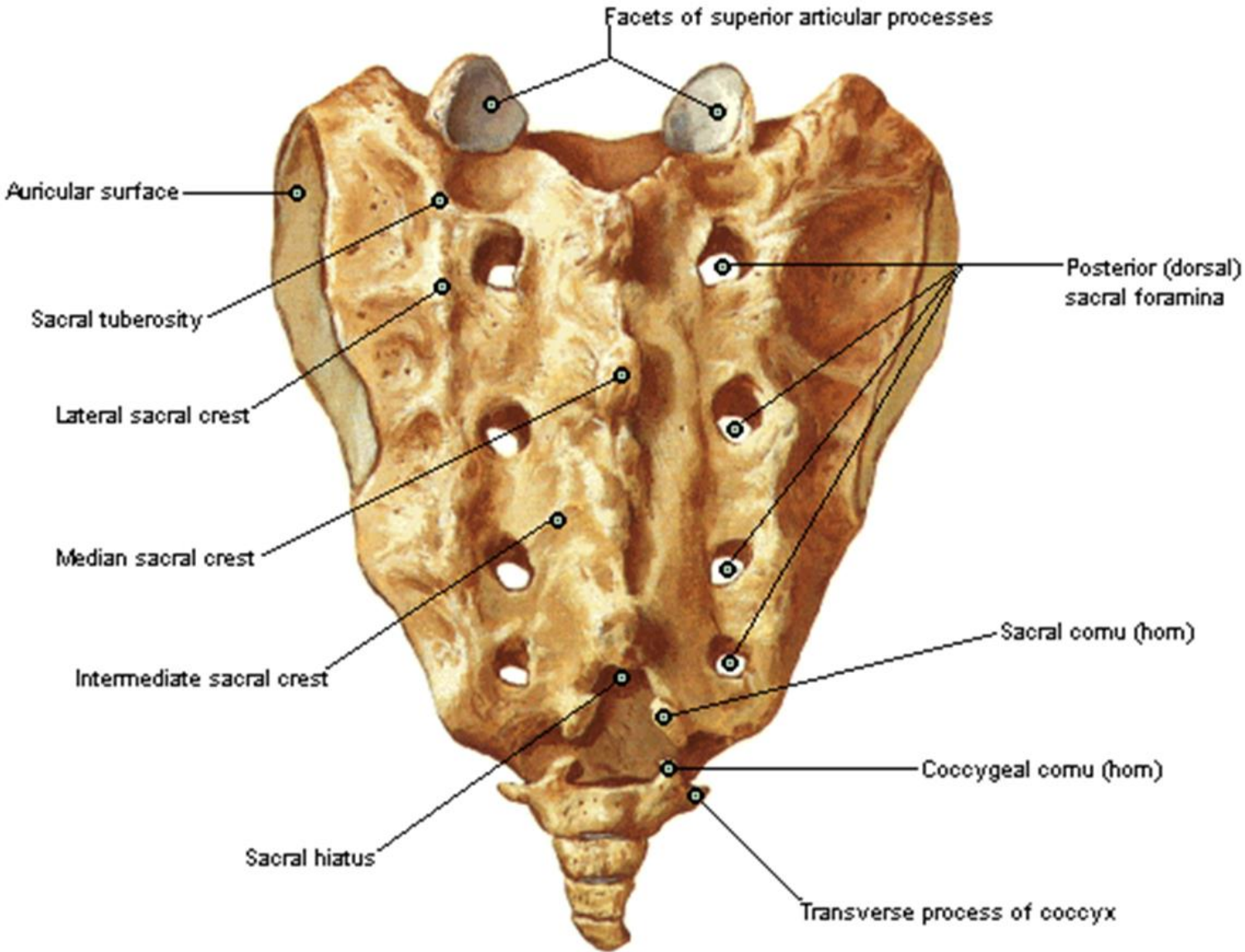
SACRUM AND COCCYX

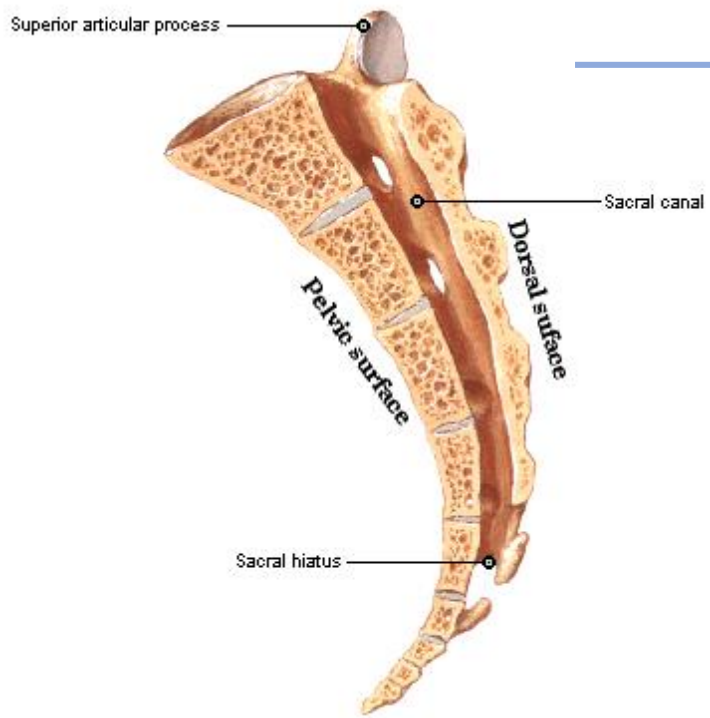
POSTERIOR SIDE

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



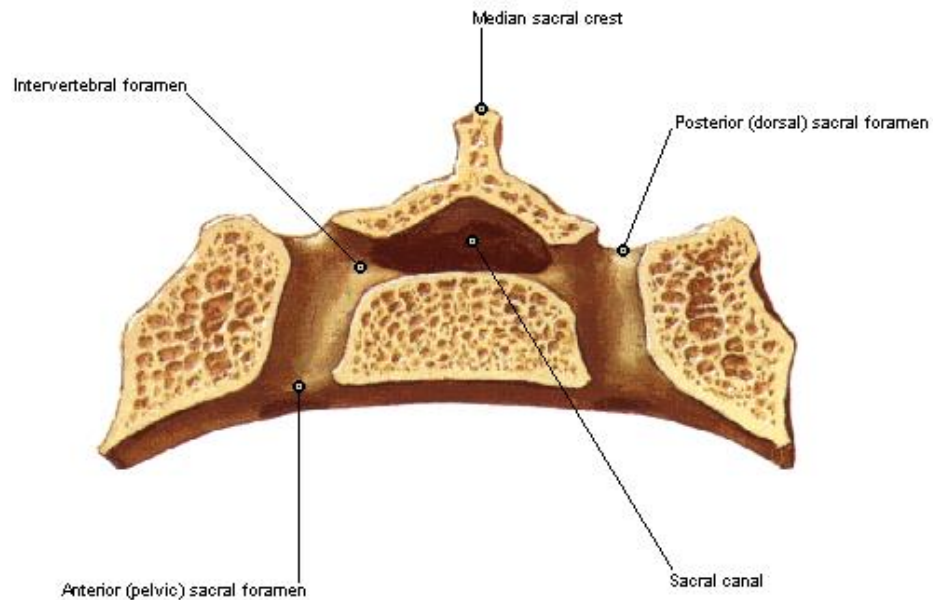


SACRAL CANAL

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

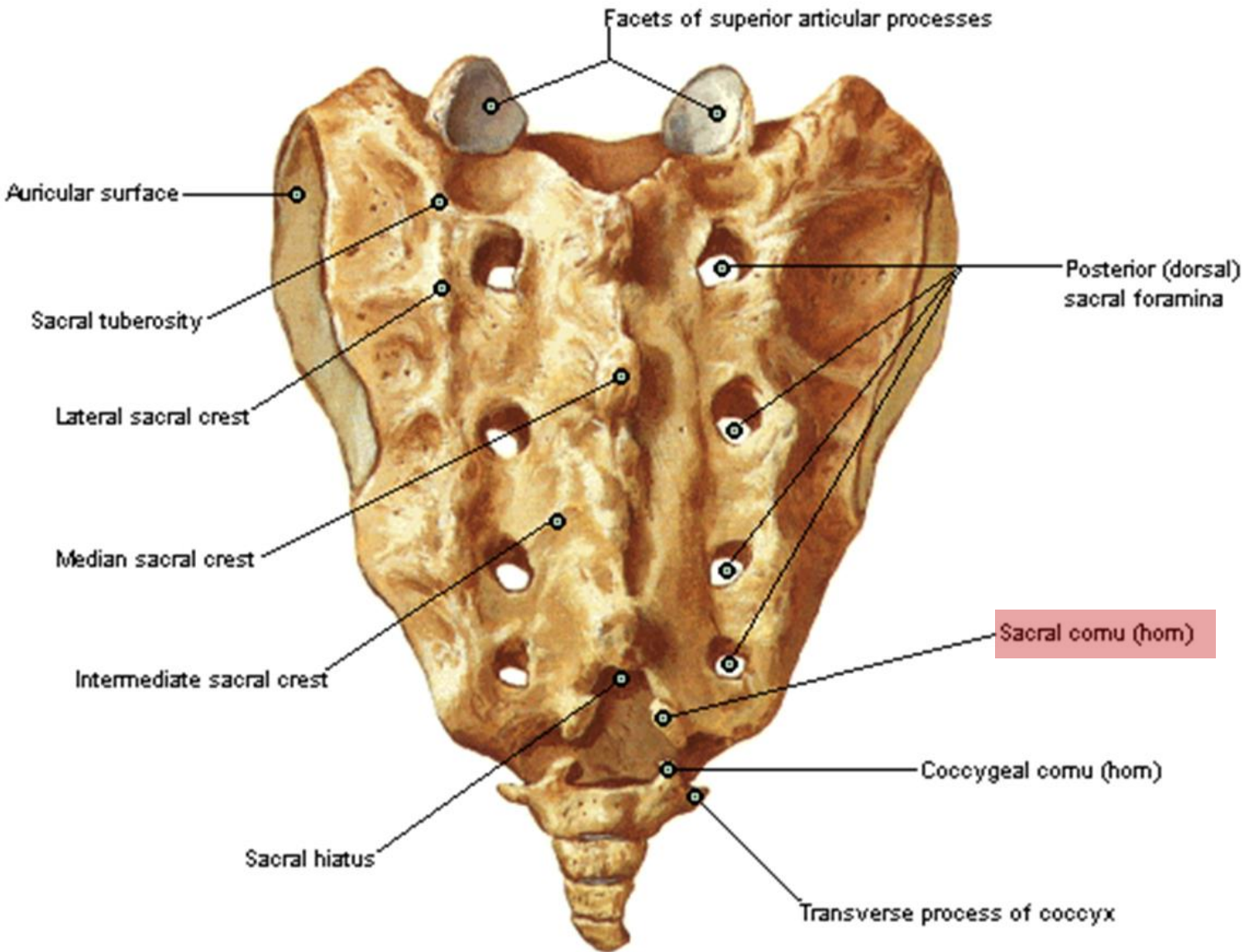
- It is open superiorly → Cranial opening of the sacral canal

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



Sacrum and Coccyx

Dorsal Surface



SACRUM AND COCCYX

SACRAL CANAL

↓
SACRAL HIATUS

Delimited by two bony horns (the **SACRAL HORNS**)

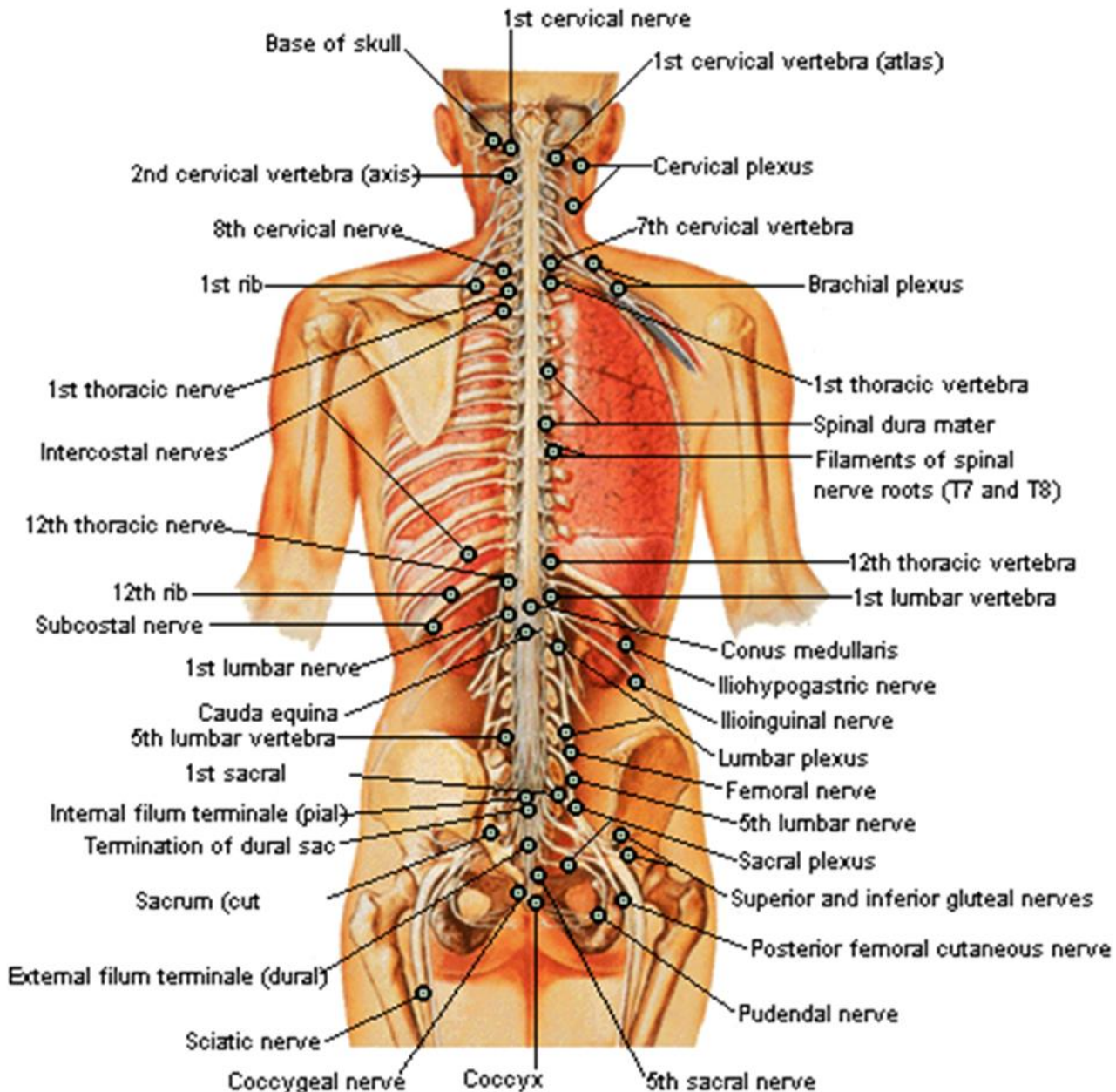
At the level of the apex of the sacrum there is the articulation with the coccyx and therefore in part the sacral hiatus is also delimited by the coccygeal horns

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

Spinal Cord in Situ



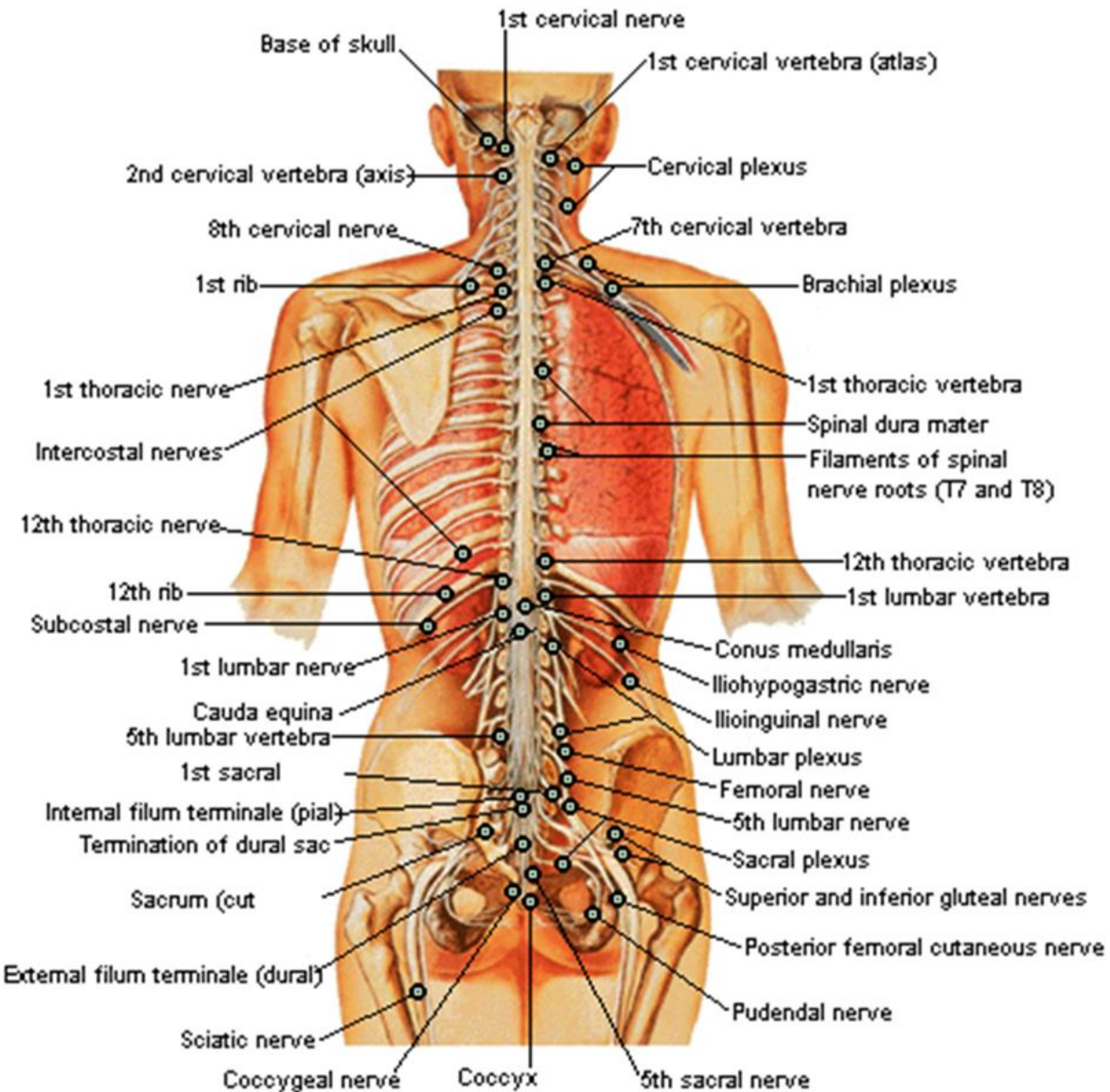
The sacral canal is the continuation of the vertebral canal

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

Spinal Cord in Situ



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

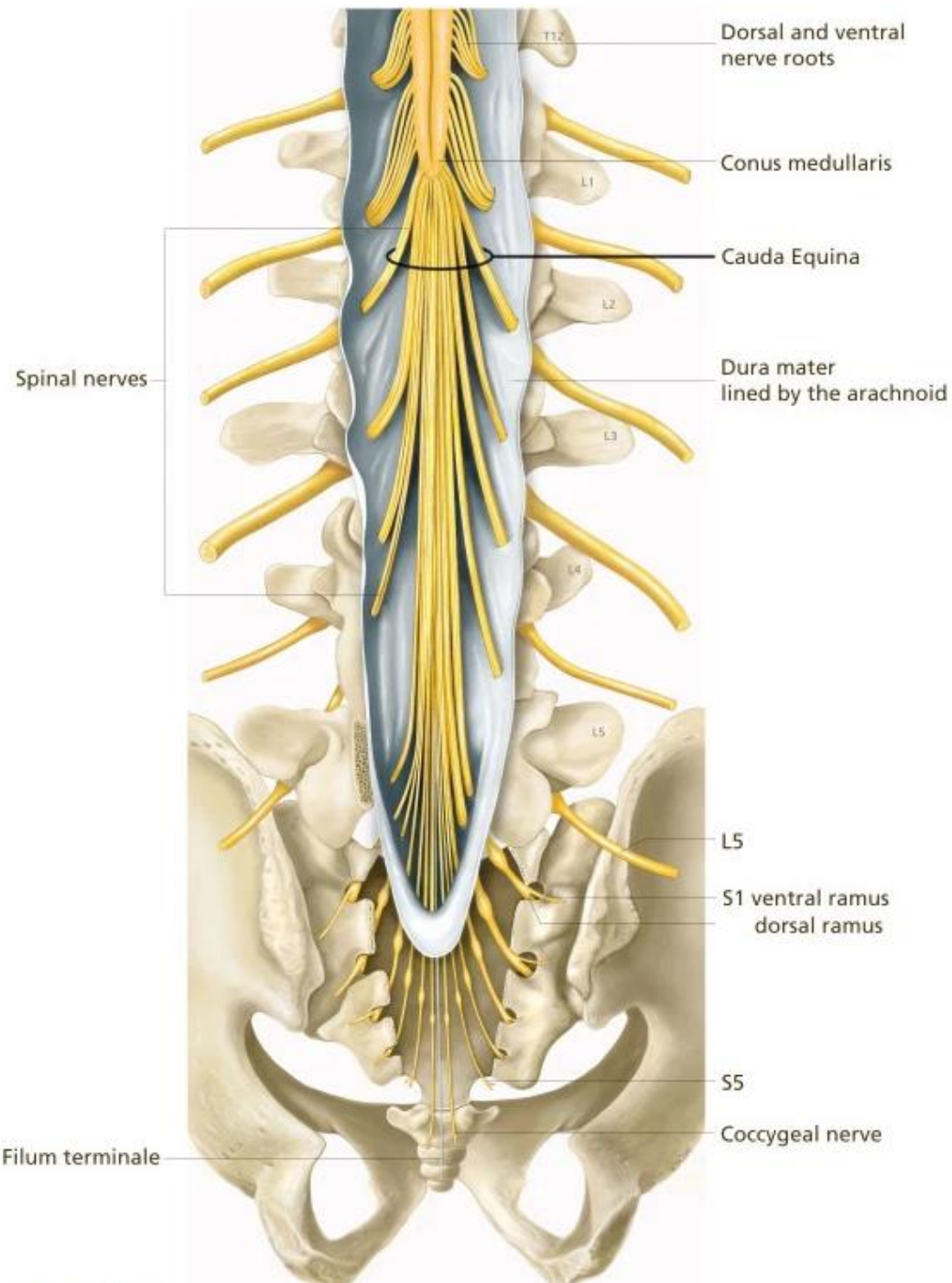
Followed by:

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

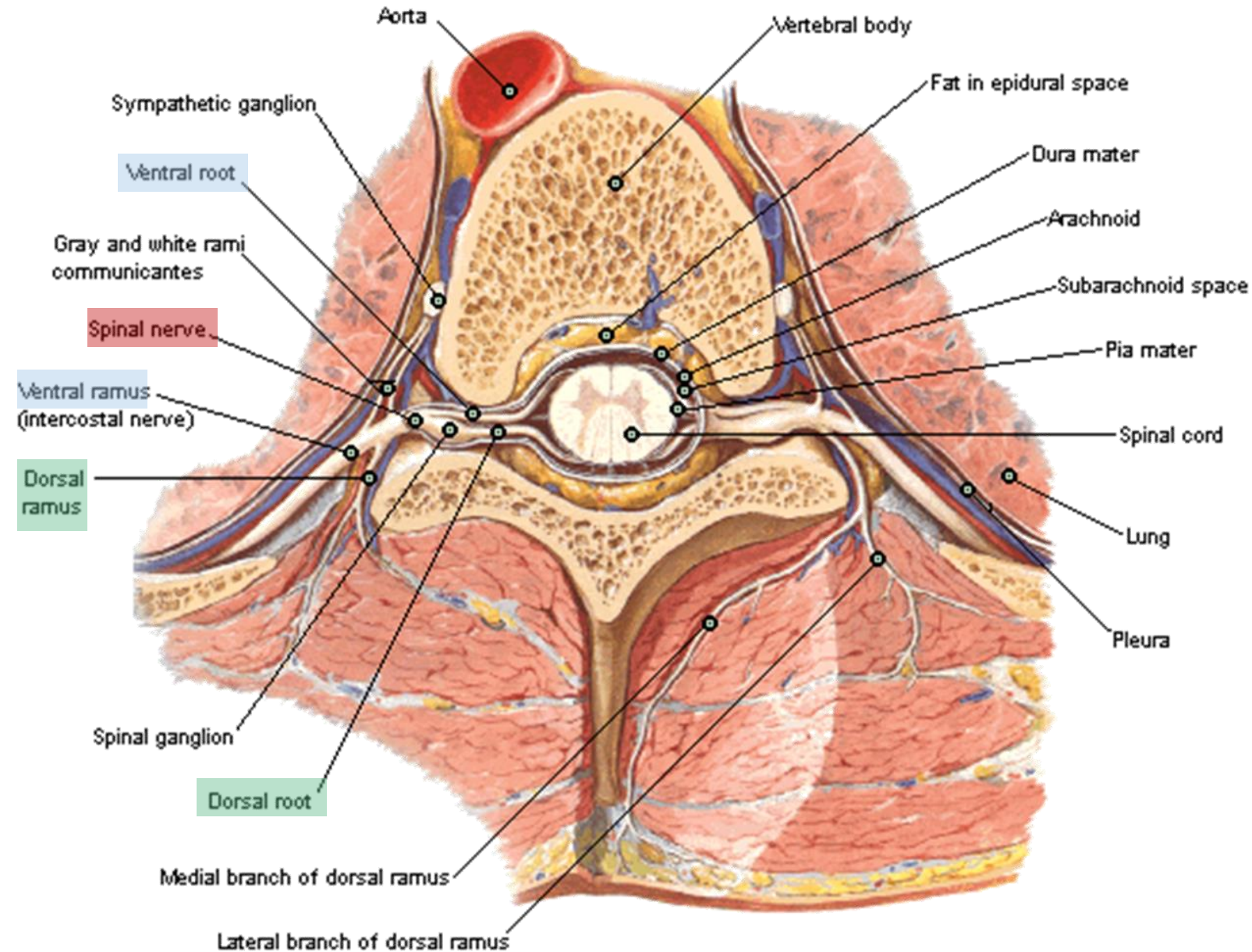
At the level of the sacrum we have anterior and posterior sacral foramina



TWO EXITS FOR EACH NERVE. WHY?

Spinal Nerve Origin

Section through Thoracic Vertebra



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

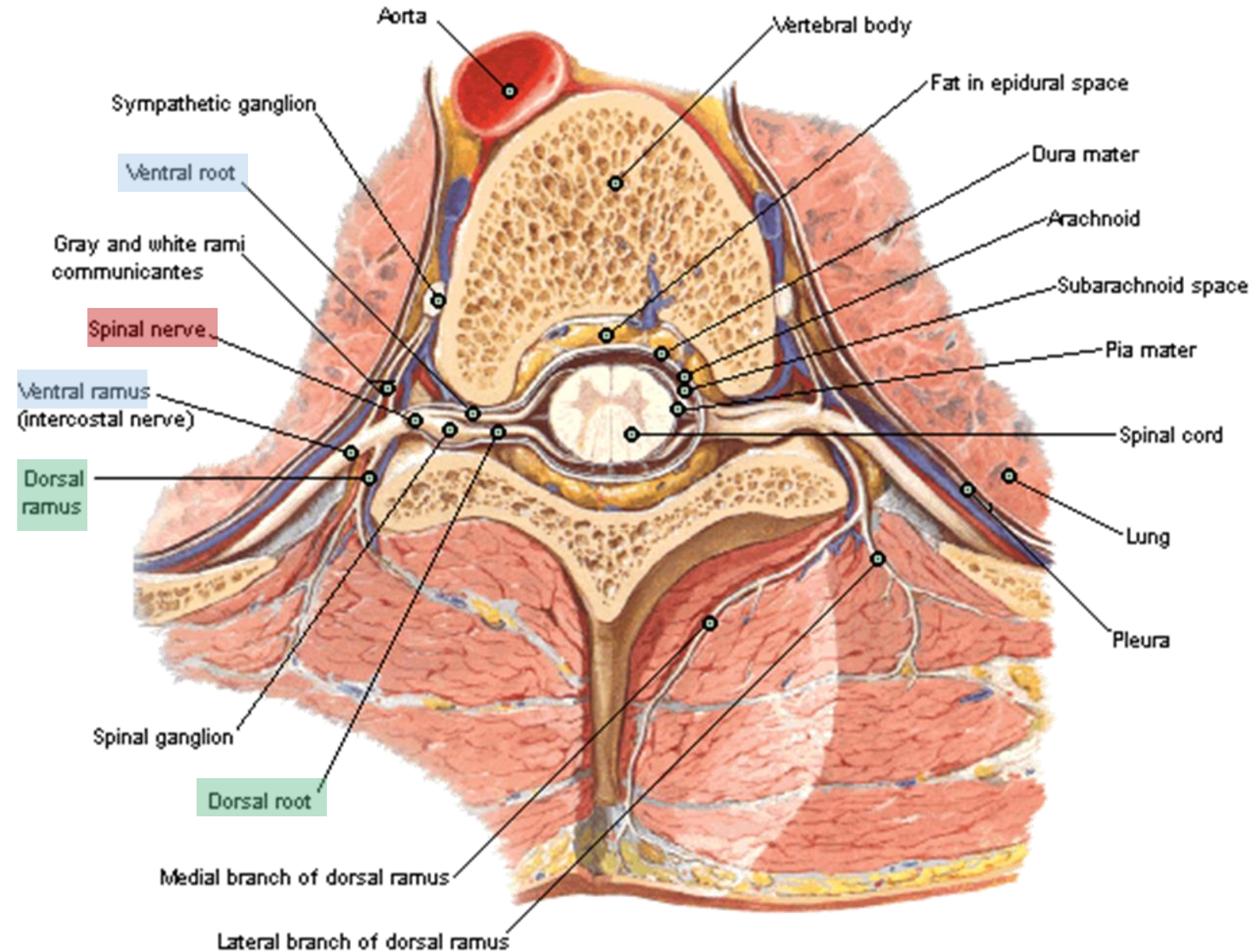
Then, once it exits the spinal canal, the spinal nerve divides into two branches:

- Anterior or ventral ramus (larger)
- Posterior or dorsal ramus (smaller)

Both present motor + sensory nerve fibers

Spinal Nerve Origin

Section through Thoracic Vertebra



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**

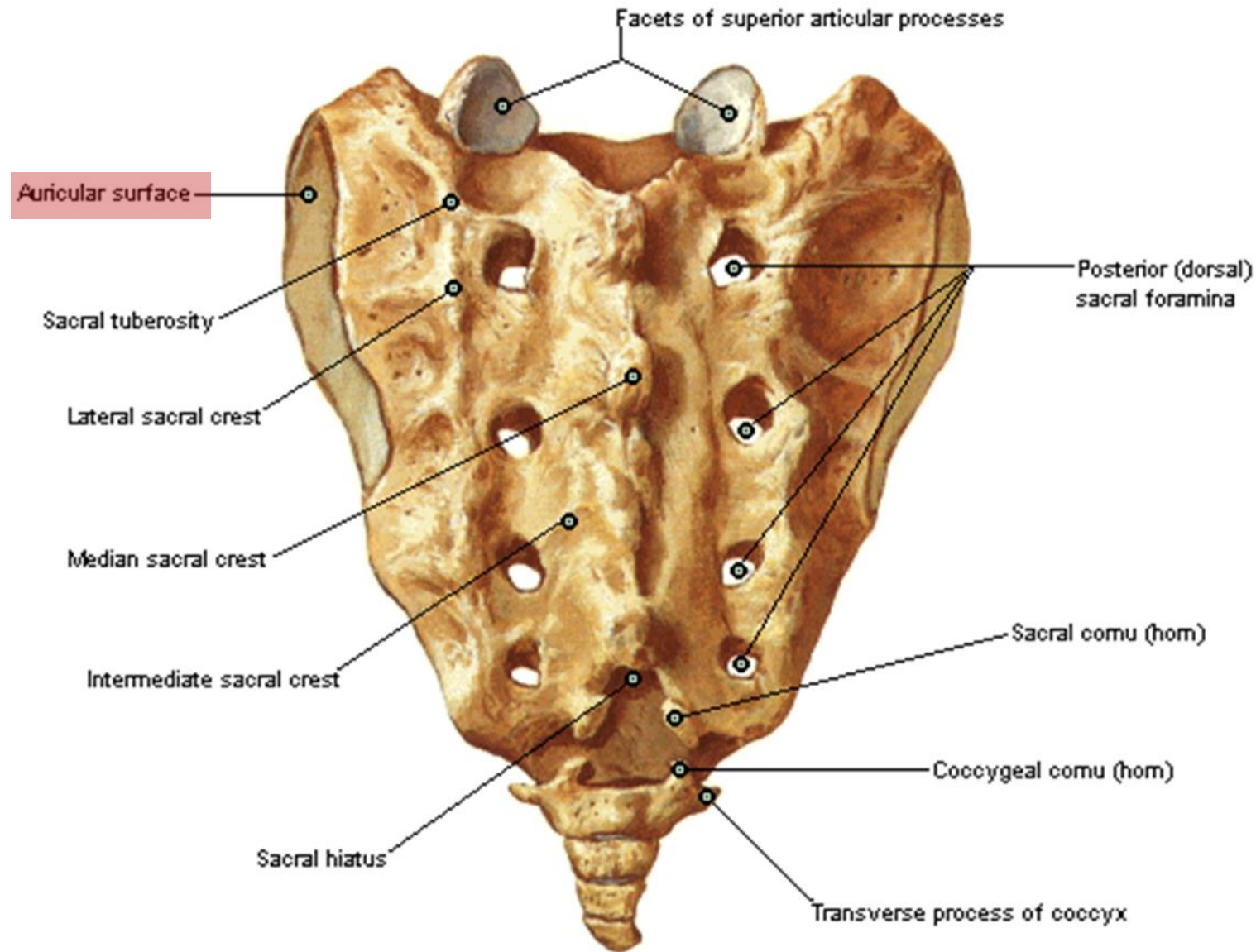


Ventral rami exit through → anterior sacral foramina

Dorsal rami exit through → posterior sacral foramina

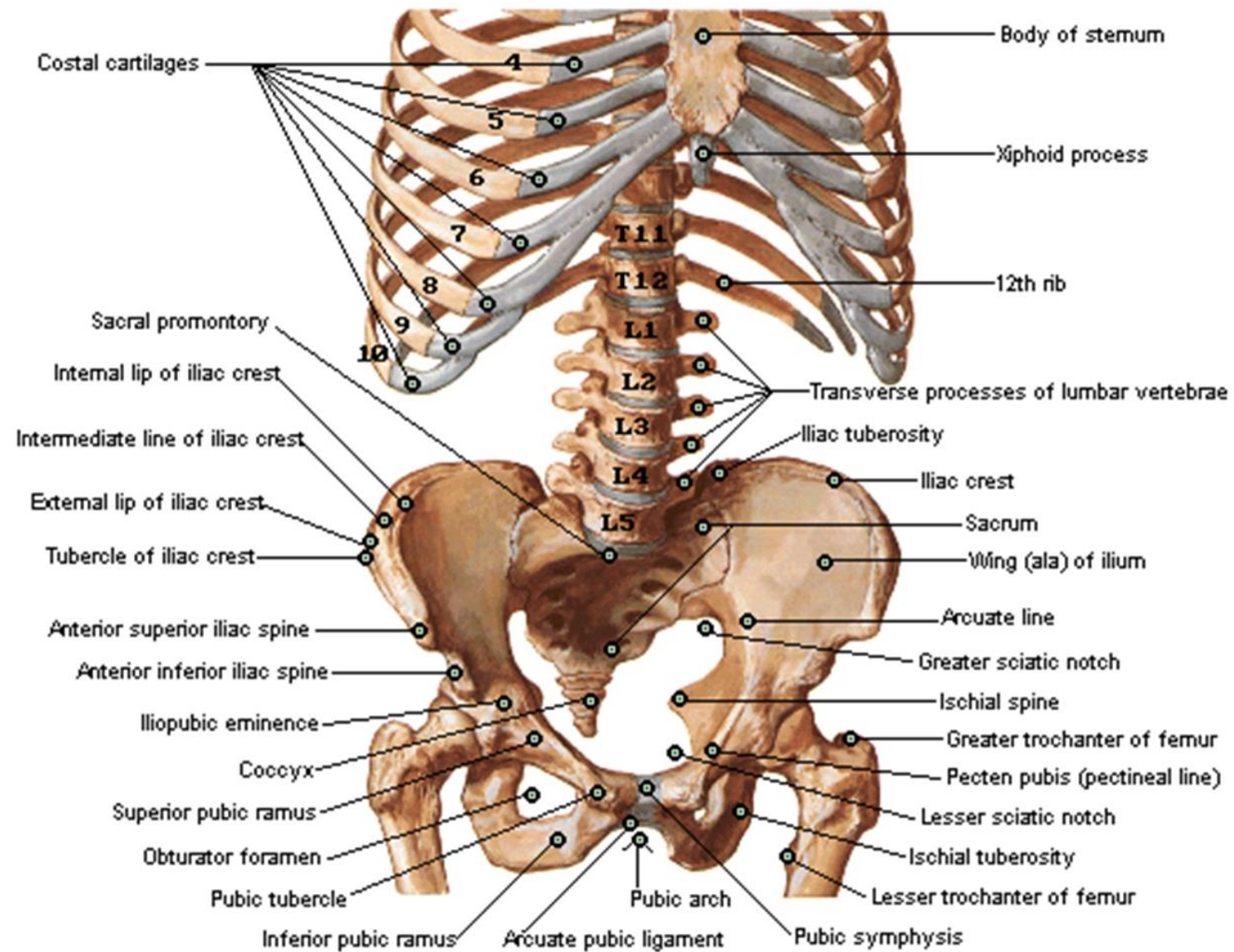
Sacrum and Coccyx

Dorsal Surface



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**



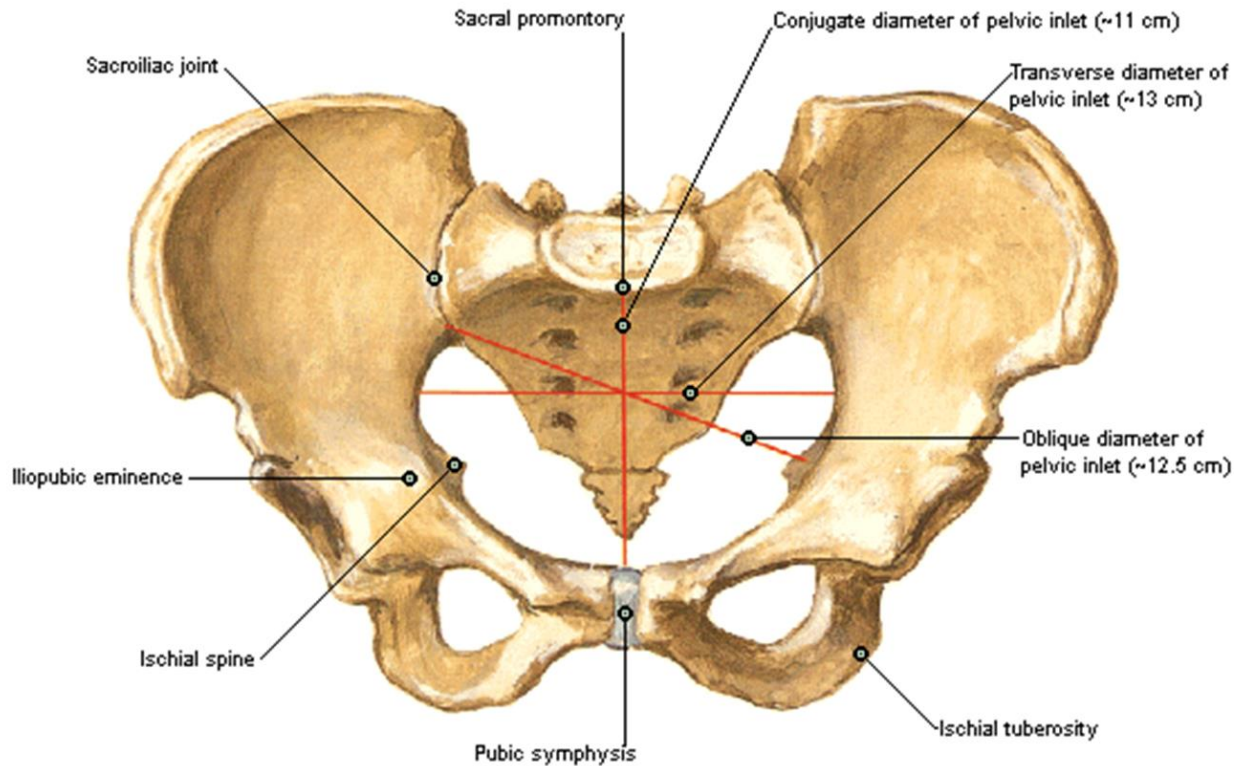
The **sacrum** articulates with **the two hip bones** to form the **PELVIS** (two hip bones + sacrum and coccyx).

PELVIS JOINTS

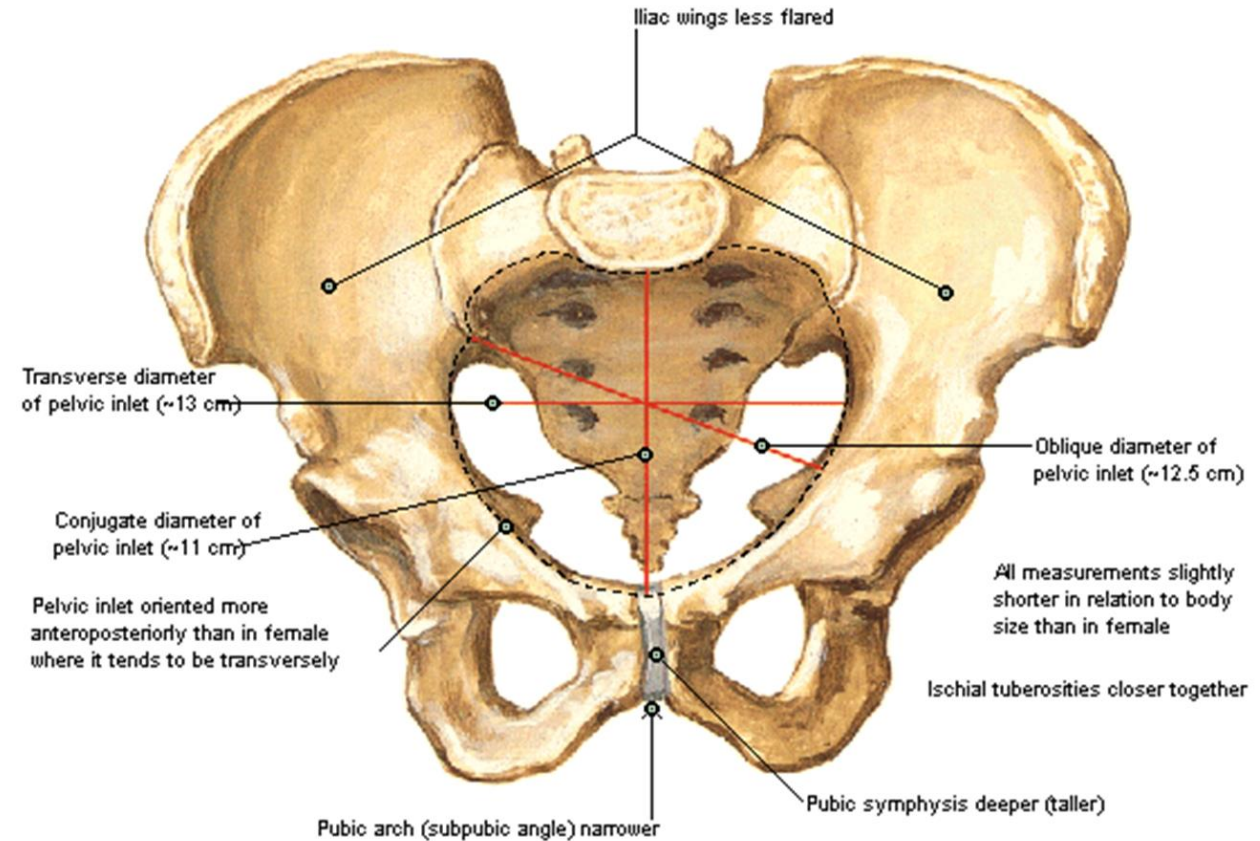
- POSTERIORLY: between the sacrum and the ilium portion of each hip bone (**sacroiliac joint**)
- ANTERIORLY: between the two hip bones (**pubic symphysis**)

THE PELVIS AND THE HIP BONE

Female Pelvis Measurements - Anterior View



Male Pelvis Measurements - Anterior View

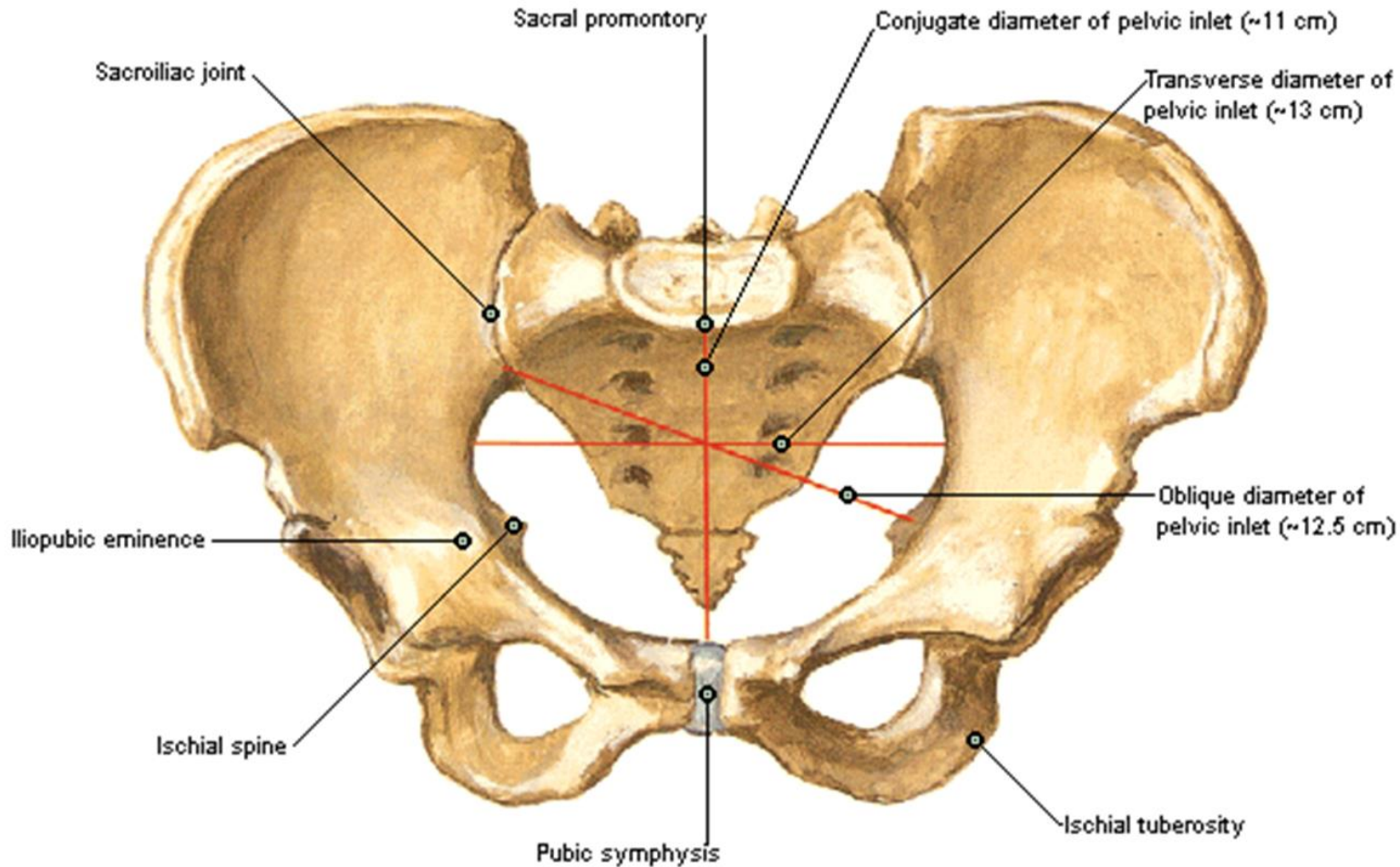


THE FEMALE PELVIS AND THE MALE PELVIS HAVE A DIFFERENT MORPHOLOGY

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

Female Pelvis

Measurements - Anterior View



A central space is created from the articulation of the 3 bones of the pelvis

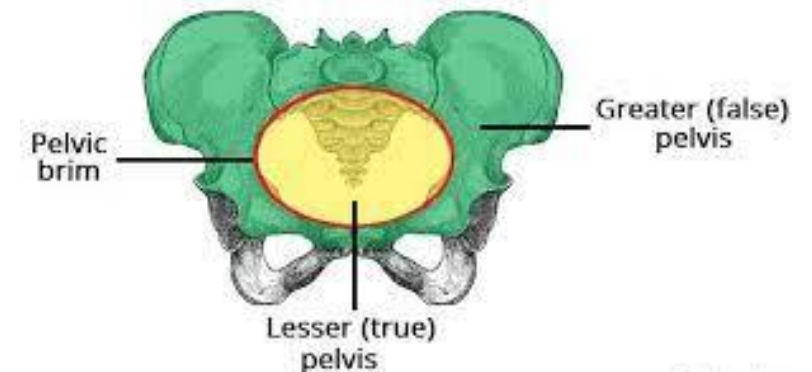


PELVIC CAVITY

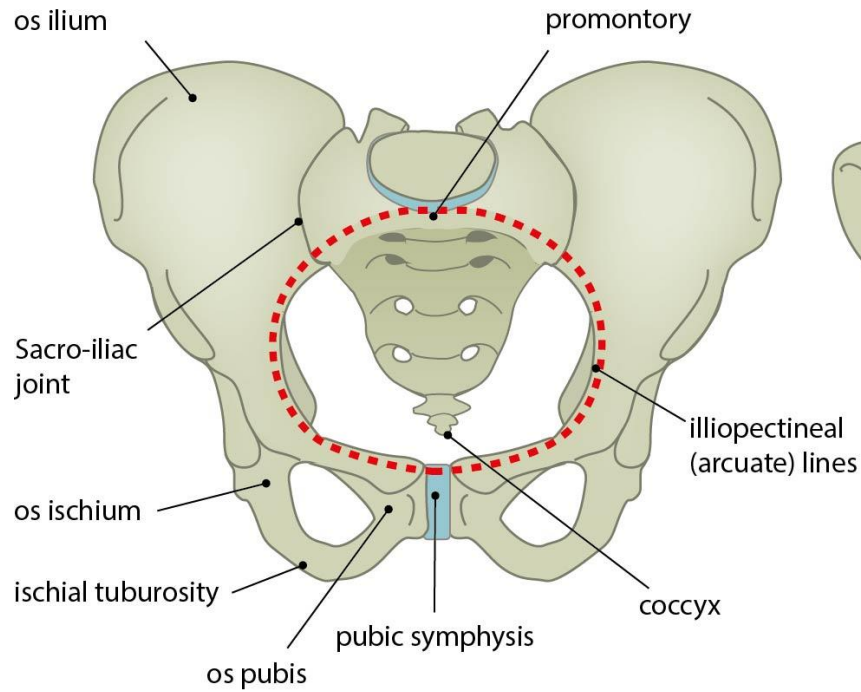
- The broad, superior region, defined laterally by the upper hip bones, is called the **greater pelvis** (greater pelvic cavity).

*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**.*

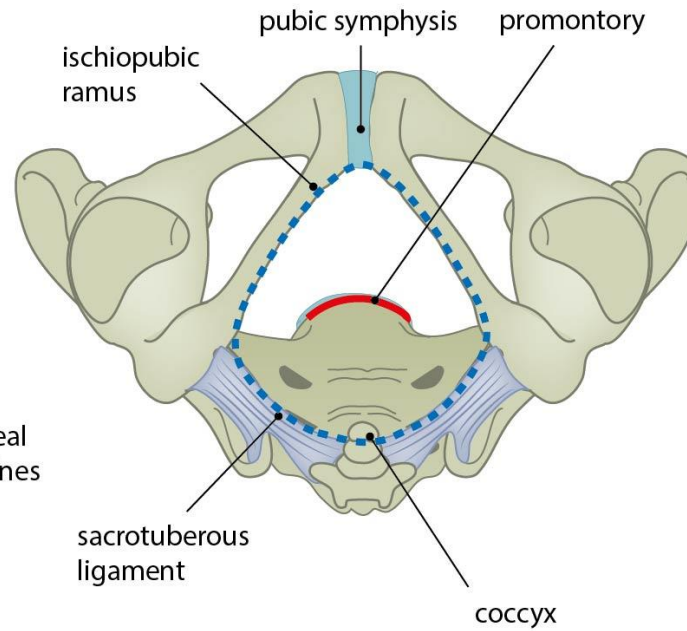
- More inferiorly, the narrow, rounded space of the **lesser pelvis** (lesser pelvic cavity) contains the bladder and other pelvic organs, and thus is also known as the **true pelvis**.



pelvic inlet



pelvic outlet

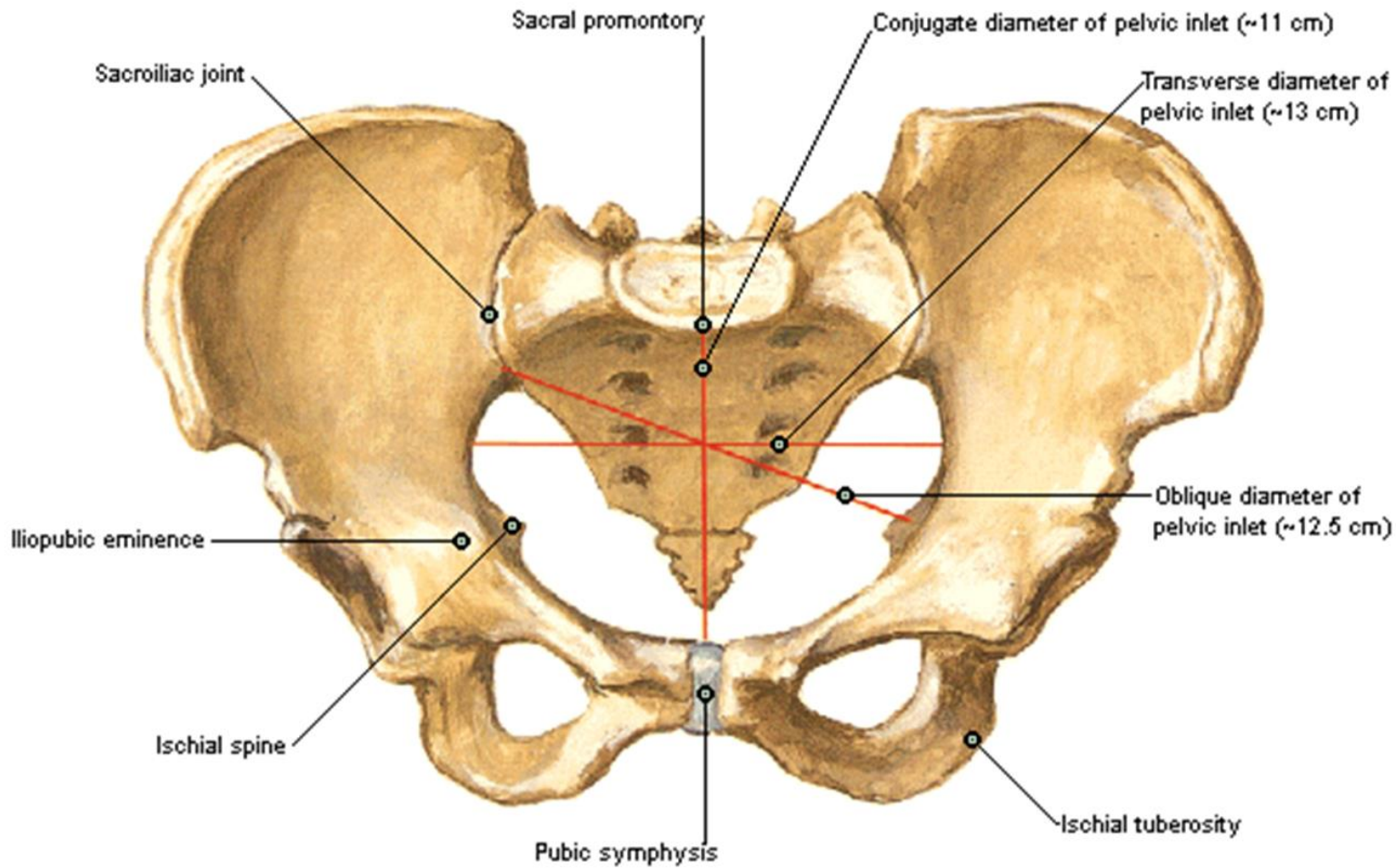


LESSER PELVIC CAVITY:
it presents a superior margin = **pelvic inlet or superior aperture of the pelvis or pelvic brim**

The inferior limit of the lesser pelvic cavity is called the **inferior aperture of the pelvis or pelvic outlet**

Female Pelvis

Measurements - Anterior View



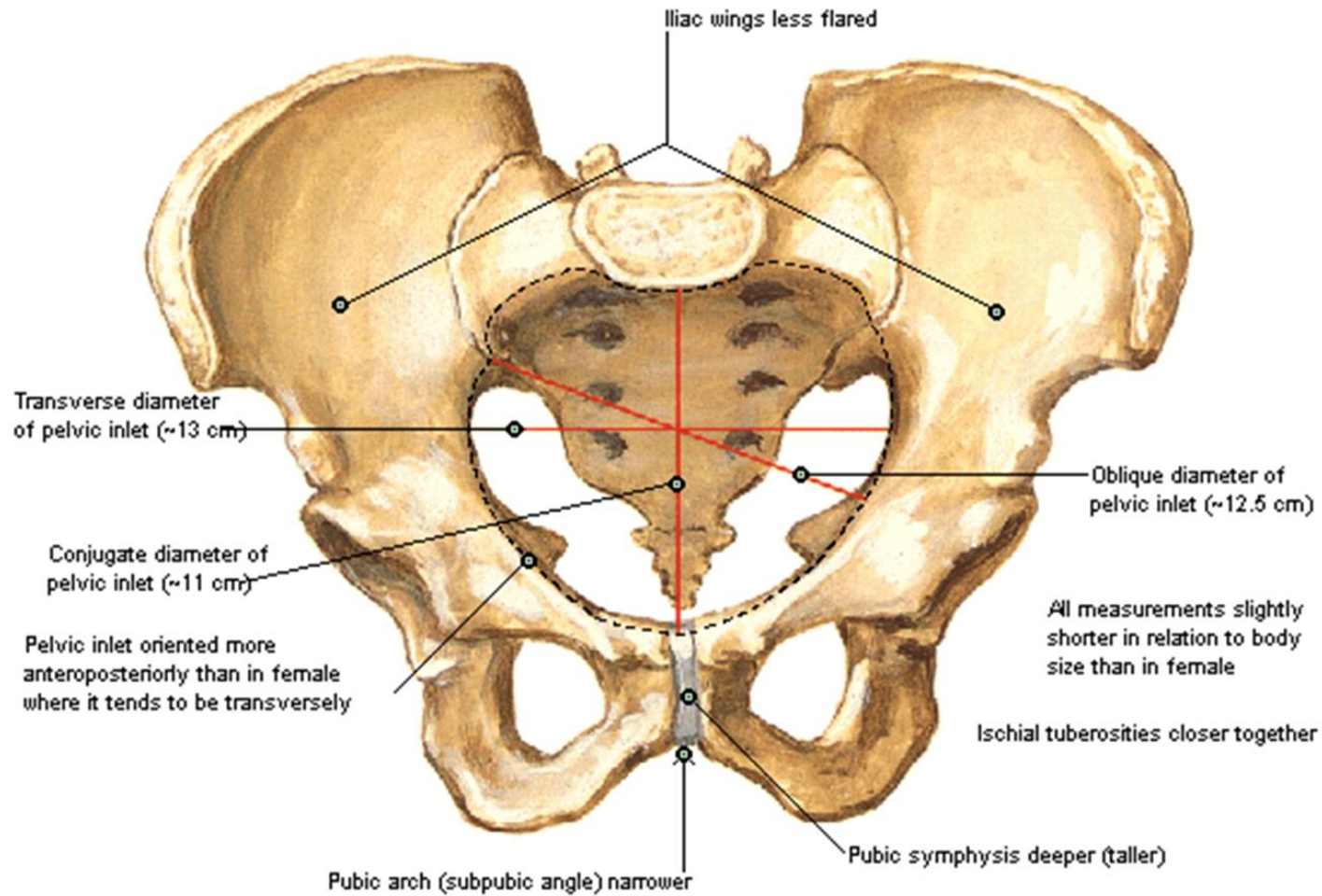
The **pelvic inlet** shows a different morphology in the female than in the male

In the **FEMALE**:

The pelvic inlet has a mainly **TRANSVERSE**, or **LATERAL-LATERAL**, extension

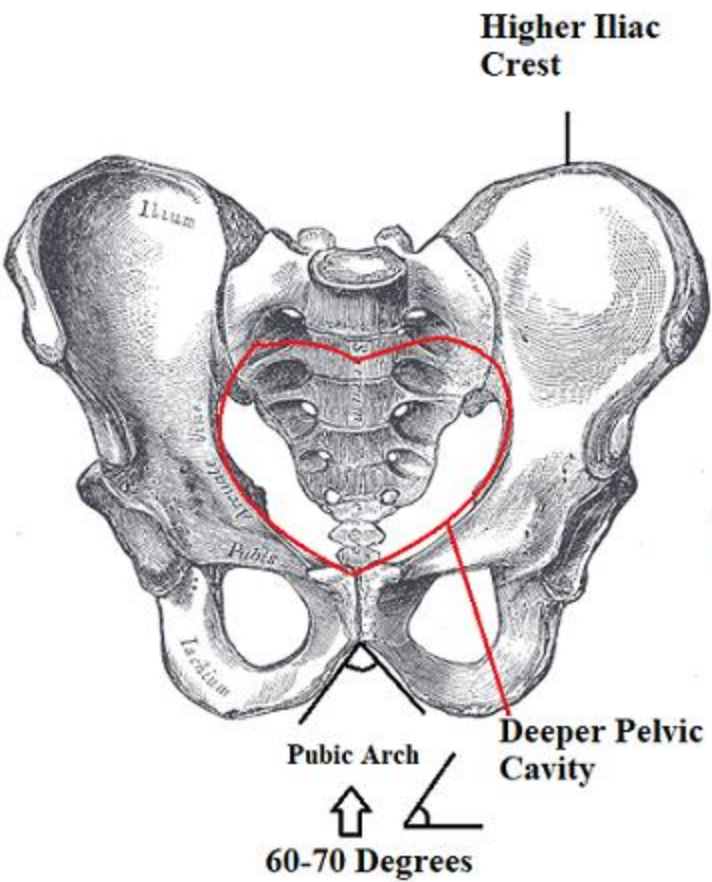
Male Pelvis

Measurements - Anterior View

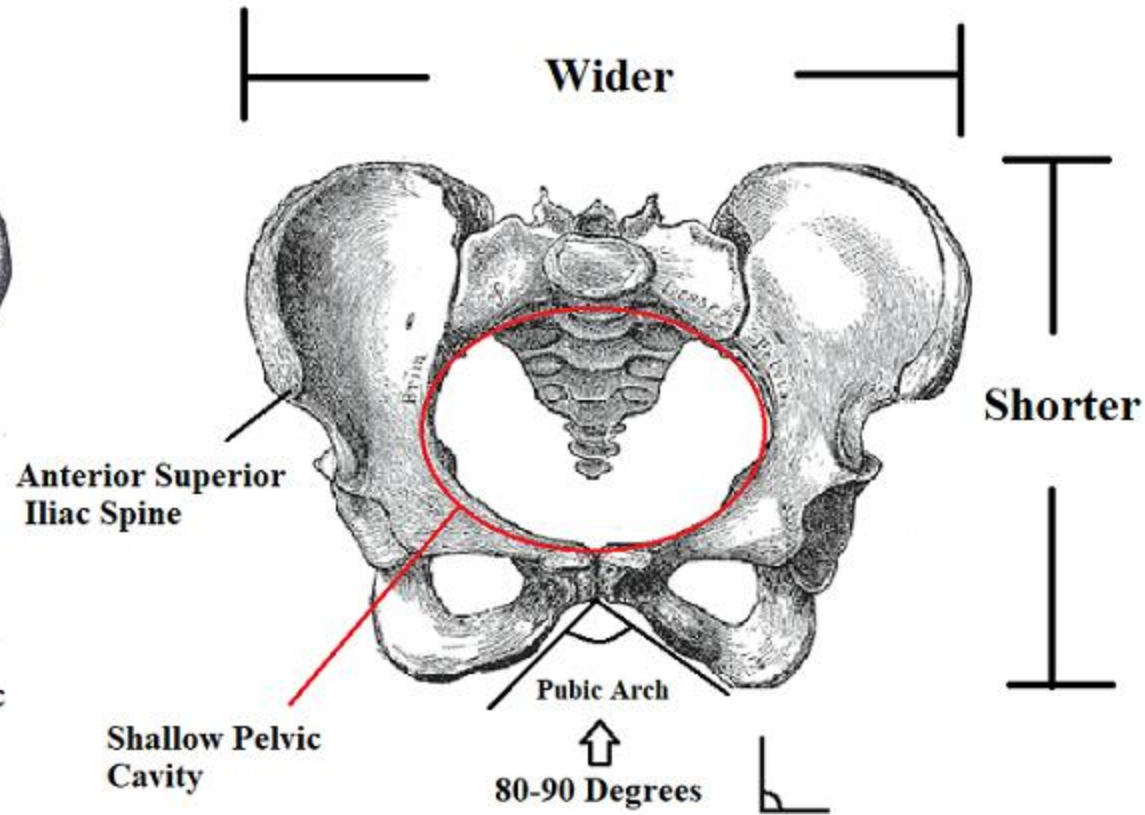


In the MALE:

The pelvis shows a heart-shaped brim or pelvic inlet
 ↓
 more extended anteriorly
 more narrow
 most prominent at the level of the sacral promontory



Male Pelvis

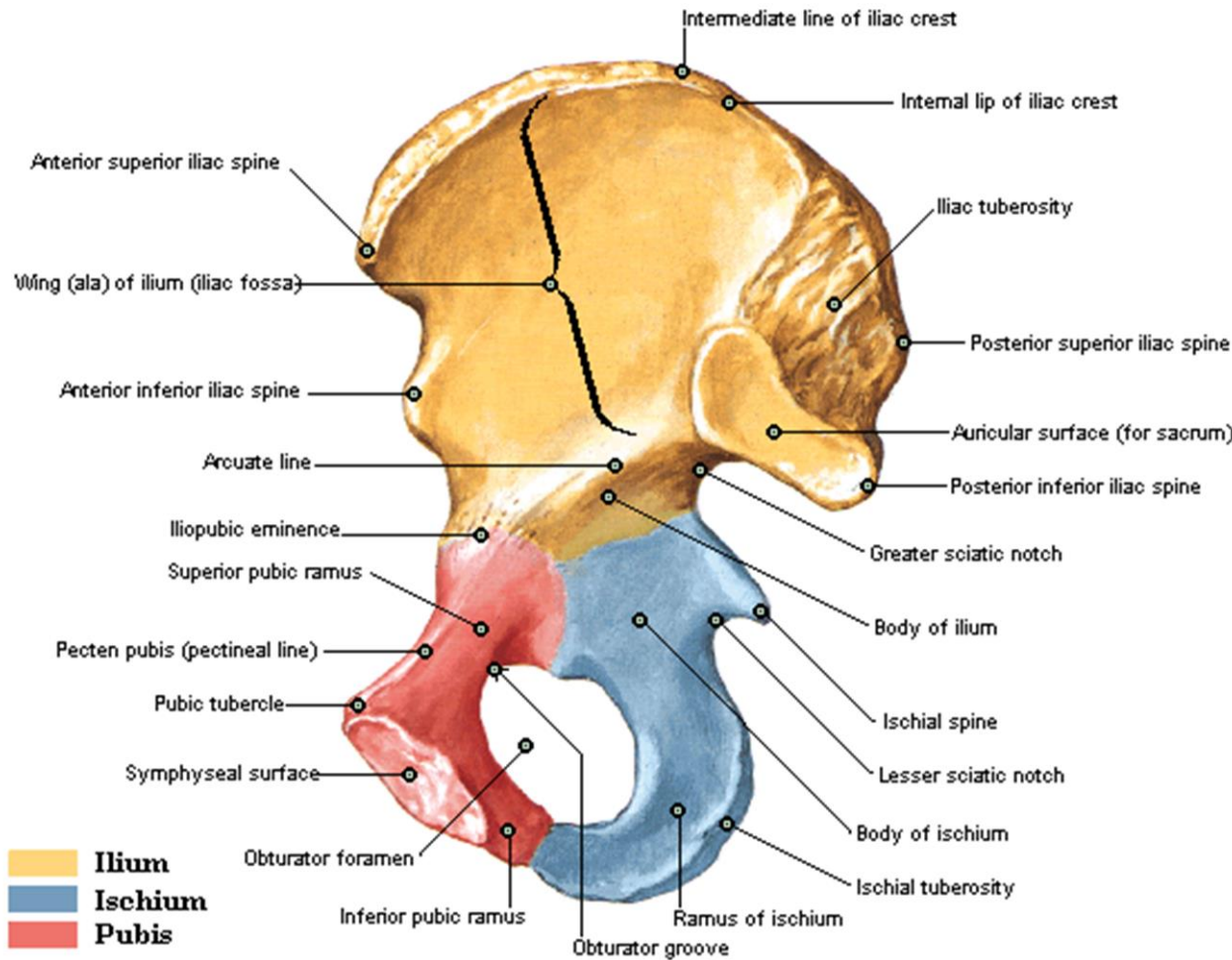


Female Pelvis

MALE versus FEMALE PELVIS

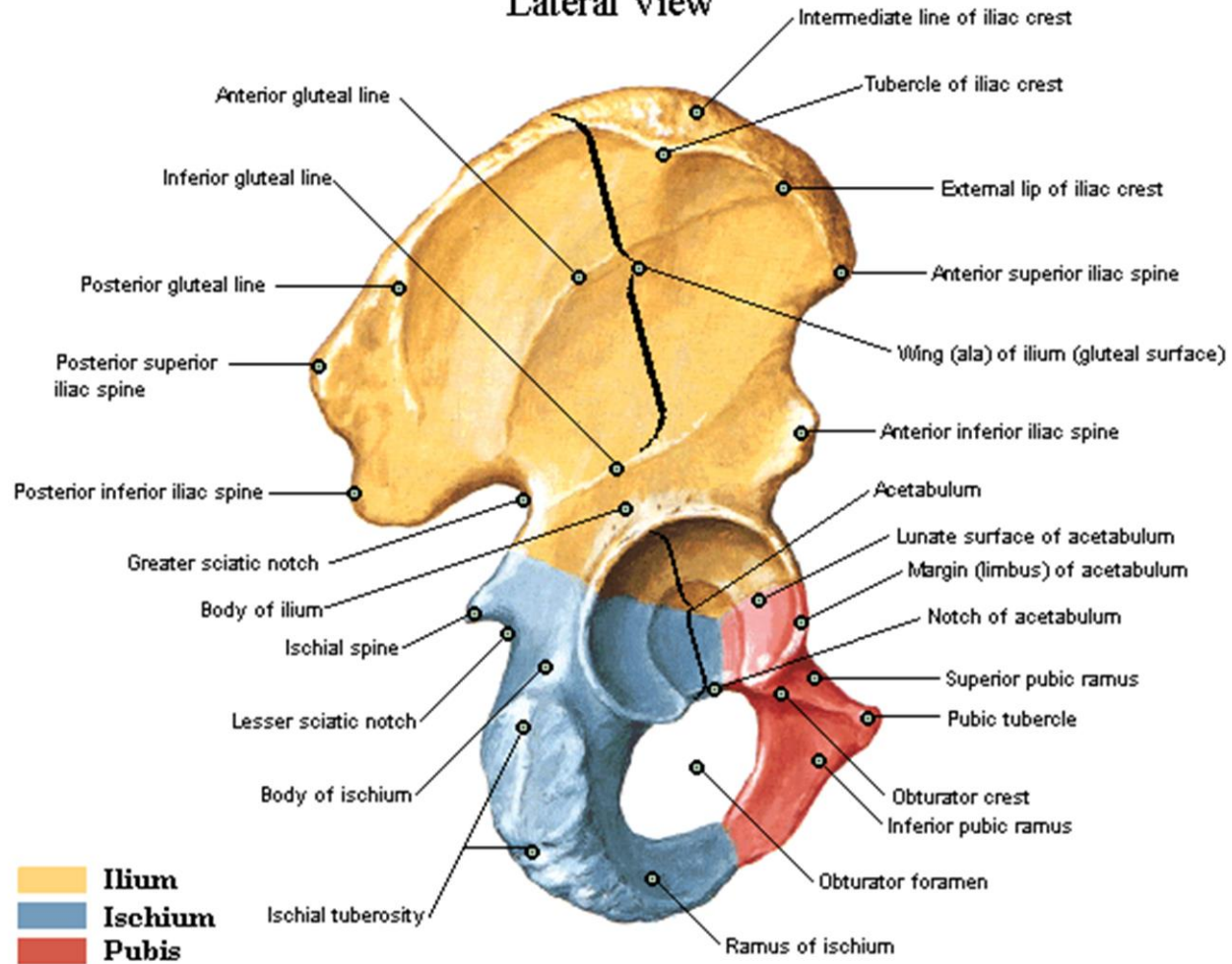
The female pelvis is adapted for childbirth:
 is wider
 has a larger subpubic angle (or pubic arch)
 Shows a rounder pelvic brim
 has a wider and more shallow lesser pelvic cavity
 than the male pelvis

**Coxal Bone
Medial View**



HIP BONE (or Coxal bone)

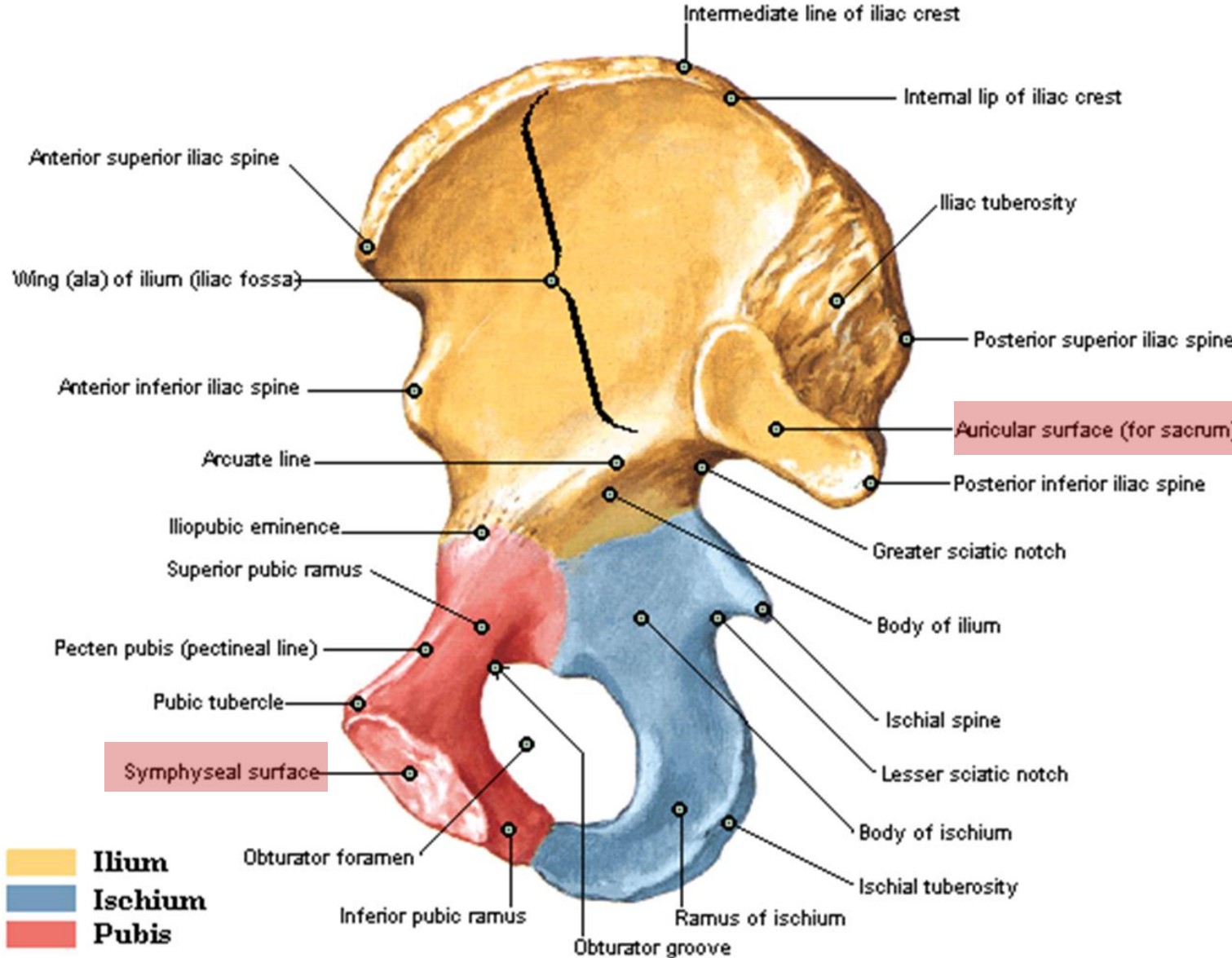
**Coxal Bone
Lateral View**



It consists of 3 portions:
ILIUM - ISCHIUM - PUBIS

Coxal Bone

Medial View



ARTICULAR SURFACES

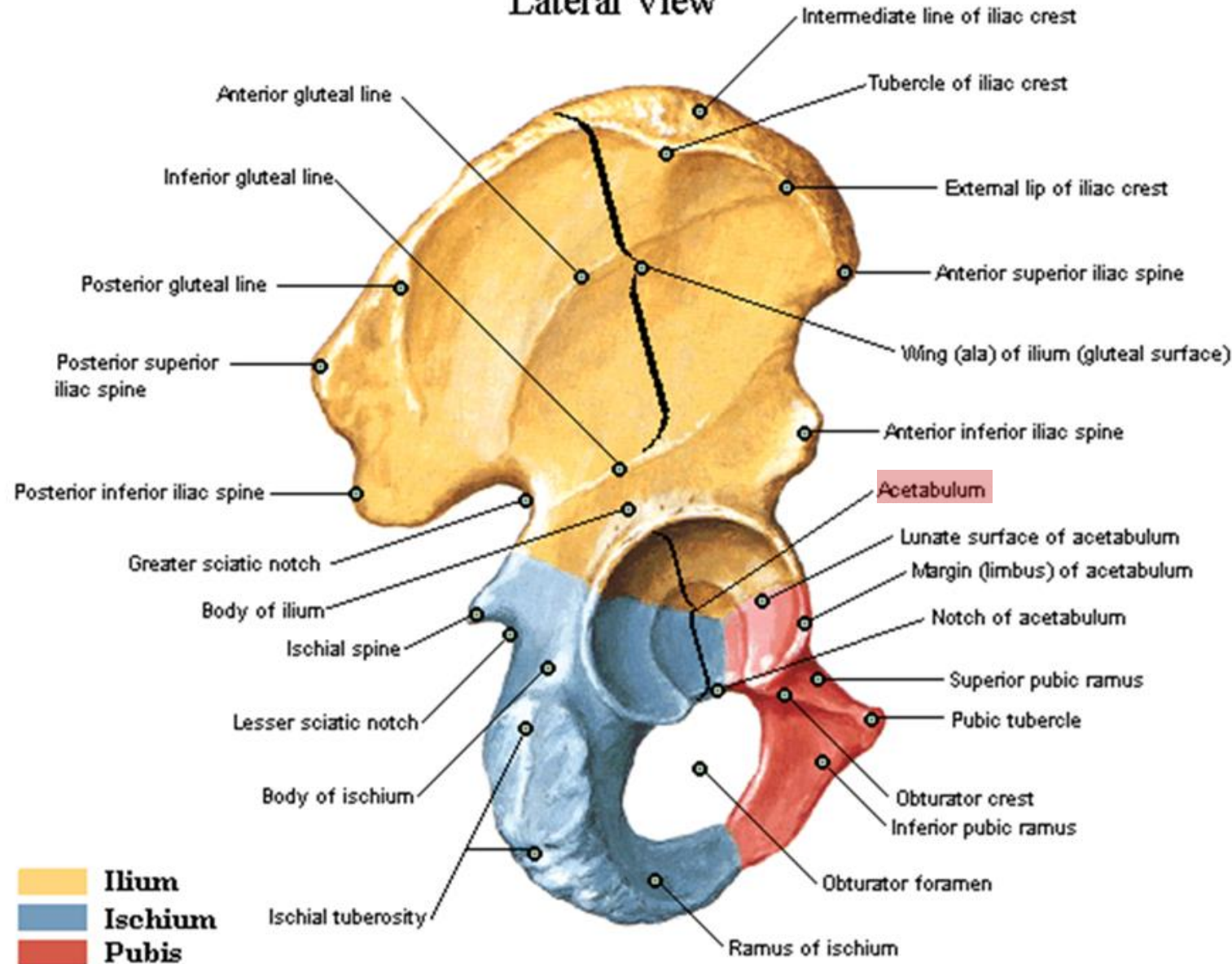
ON THE MEDIAL SIDE:

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)

**Coxal Bone
Lateral View**



ON THE LATERAL SIDE:

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



ACETABULUM

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

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

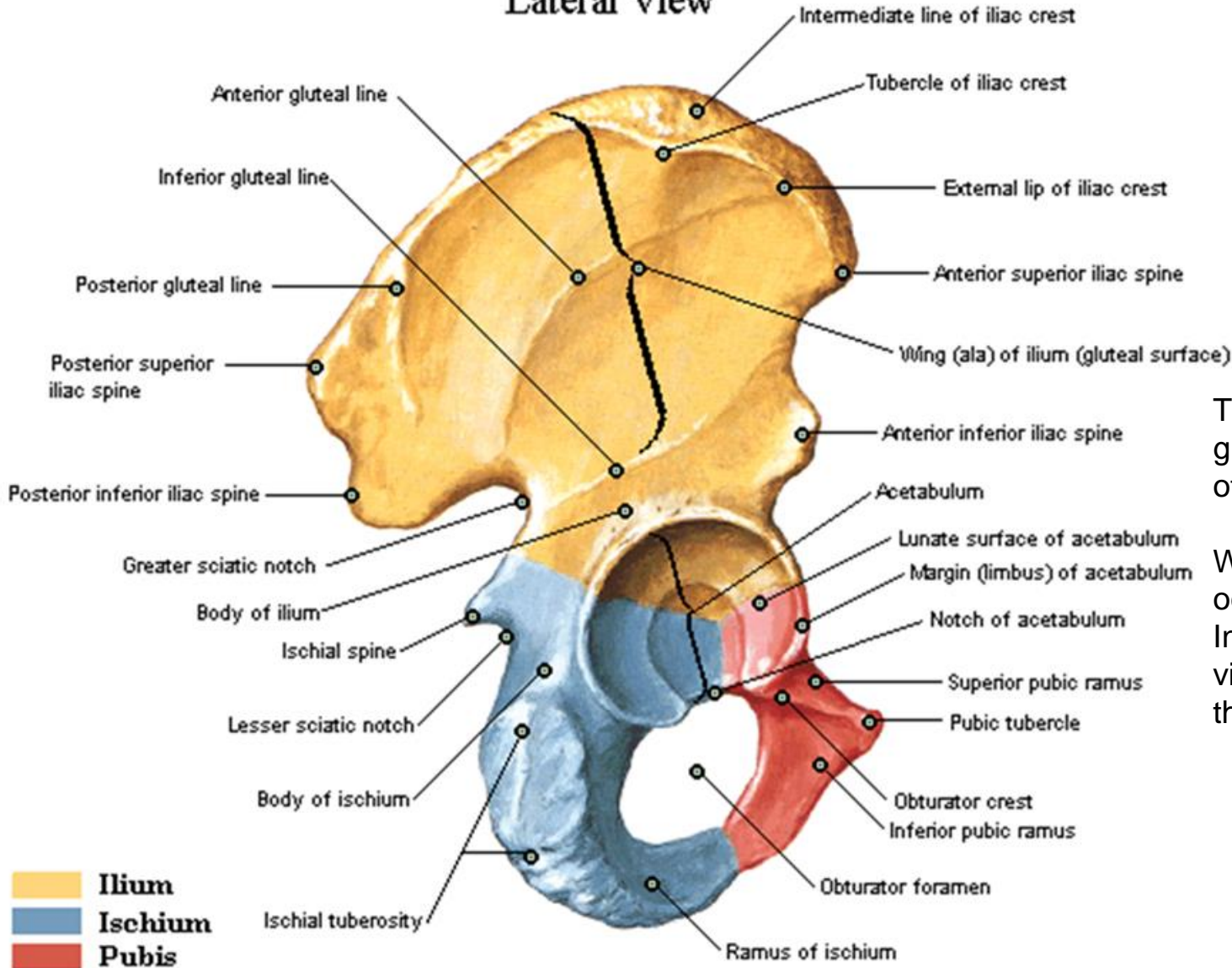
The surrounding articular surface is also **called lunate surface**

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

EACH HIP BONE PRESENTS 3 ARTICULAR SURFACES

Coxal Bone

Lateral View



The hip bone is made up of 3 different parts

ILIUM
ISCHIUM
PUBIS

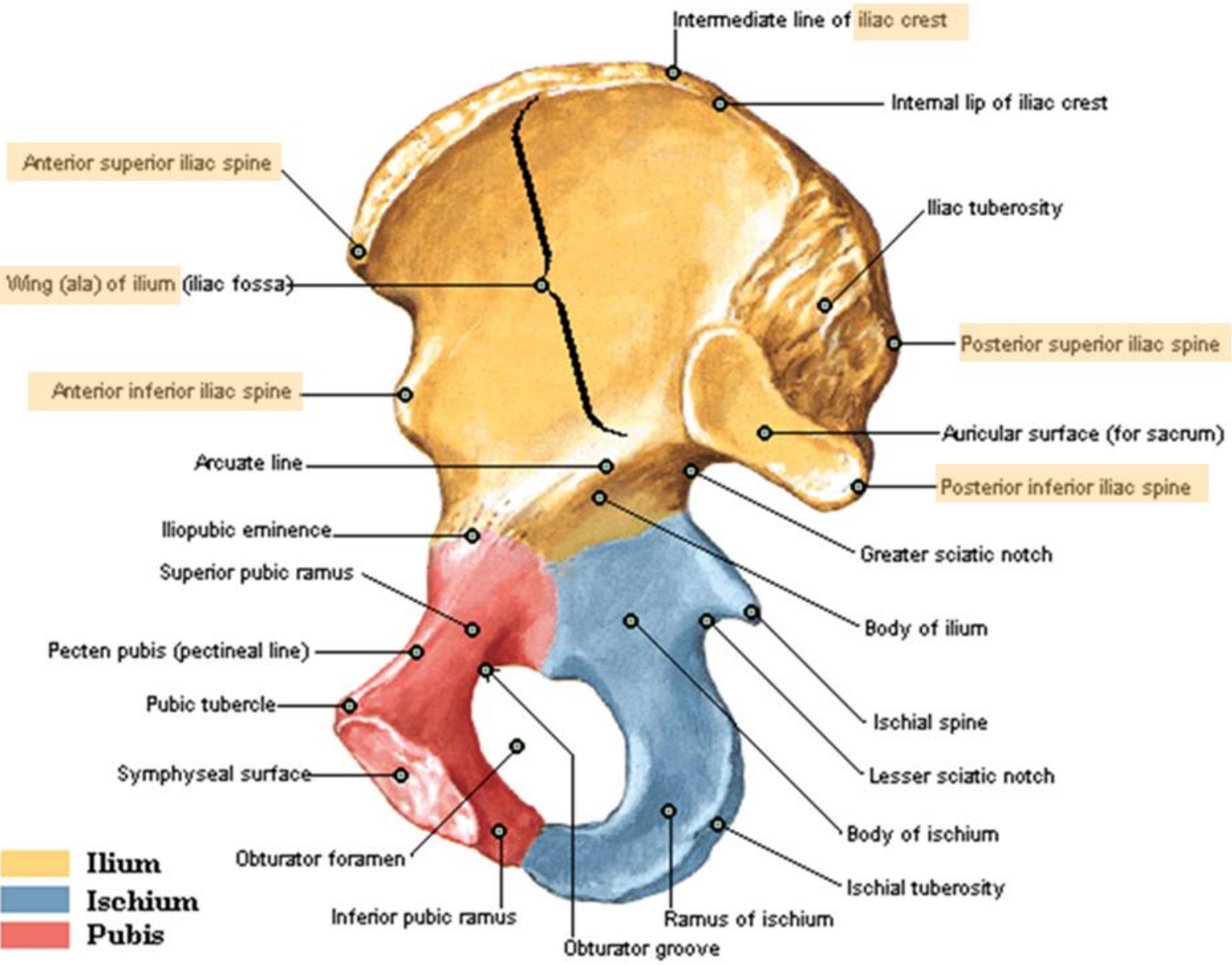
They fuse at the level of the acetabulum

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.

Coxal Bone Medial View



ILIUM

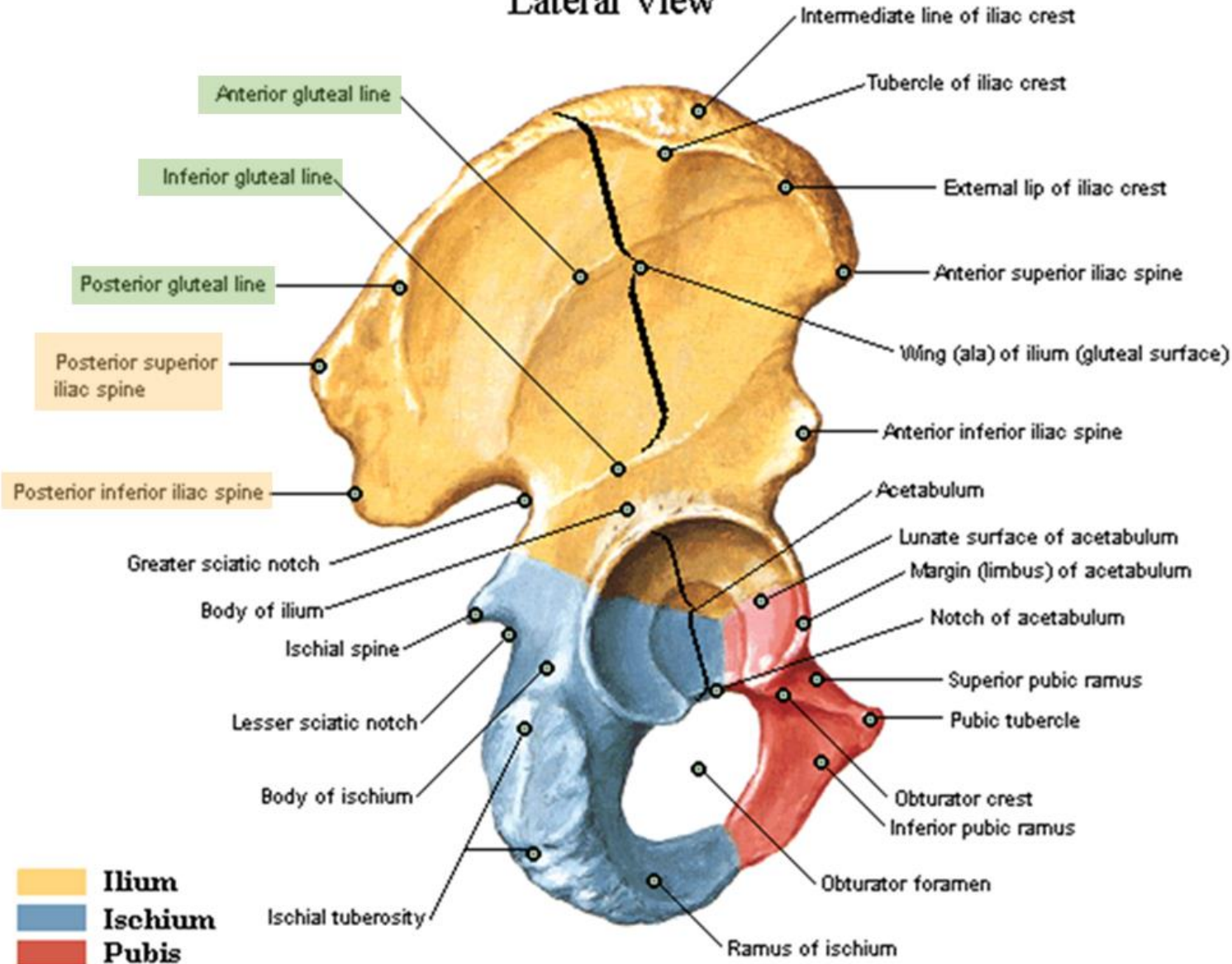
It is the most cranial portion, mainly consisting of the **WING OF THE ILIUM** and then it ends with the **ILIAC CREST**

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**
 the **posterior-inferior iliac spine**

Coxal Bone Lateral View



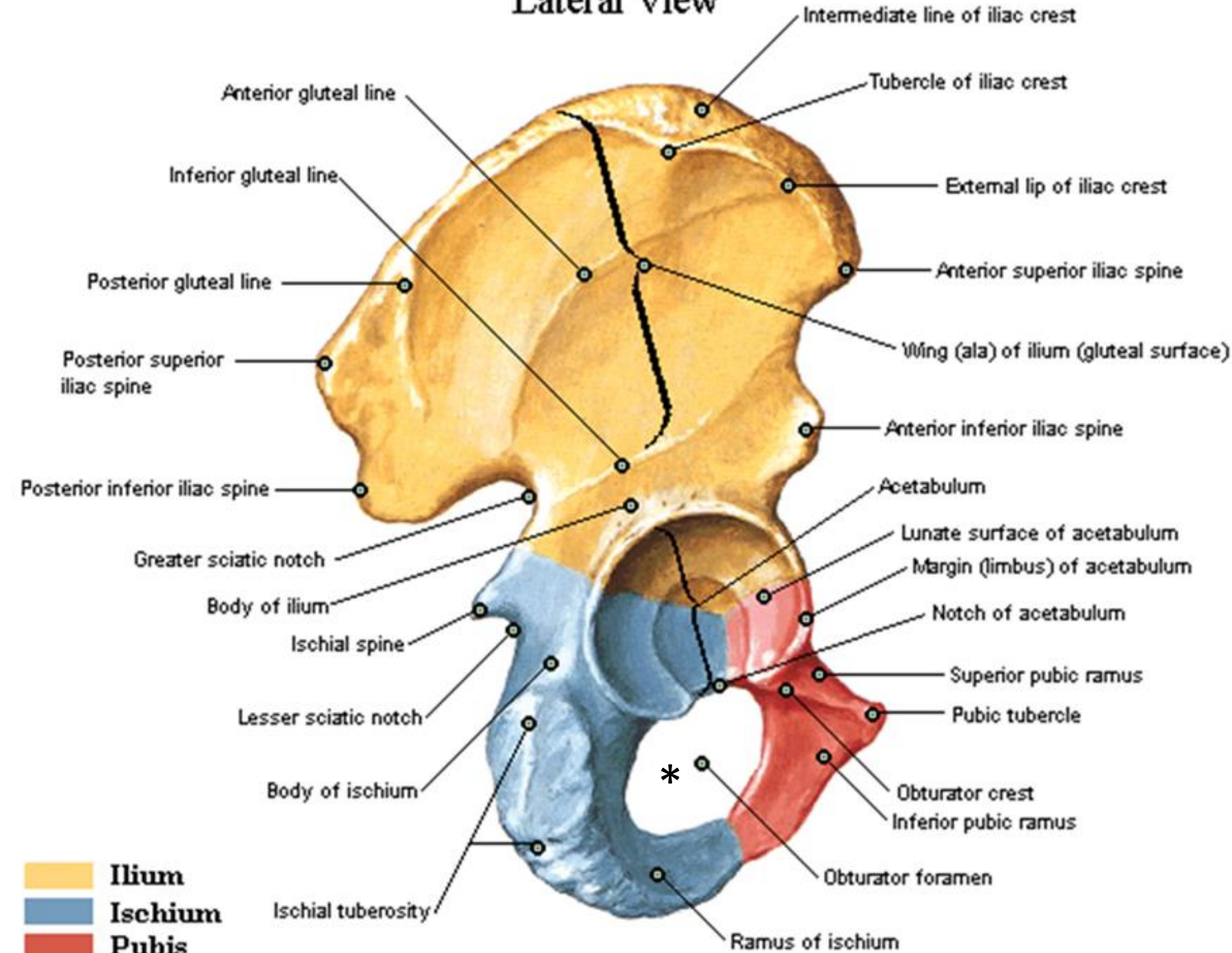
ILIUM

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

The gluteal muscles attached to the lateral side of the ilium, creating ridges called **GLUTEAL LINES**.

Coxal Bone

Lateral View



ISCHIUM and PUBIS

below the ilium

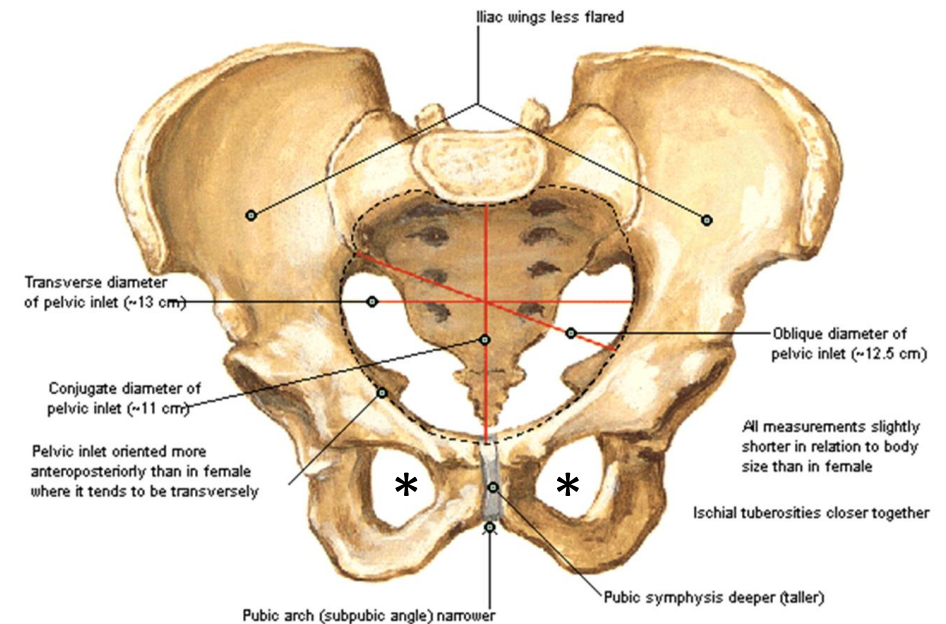
They extend from the acetabulum

The **ischium** extends → **posteriorly**

The **pubis** extends → **anteriorly**

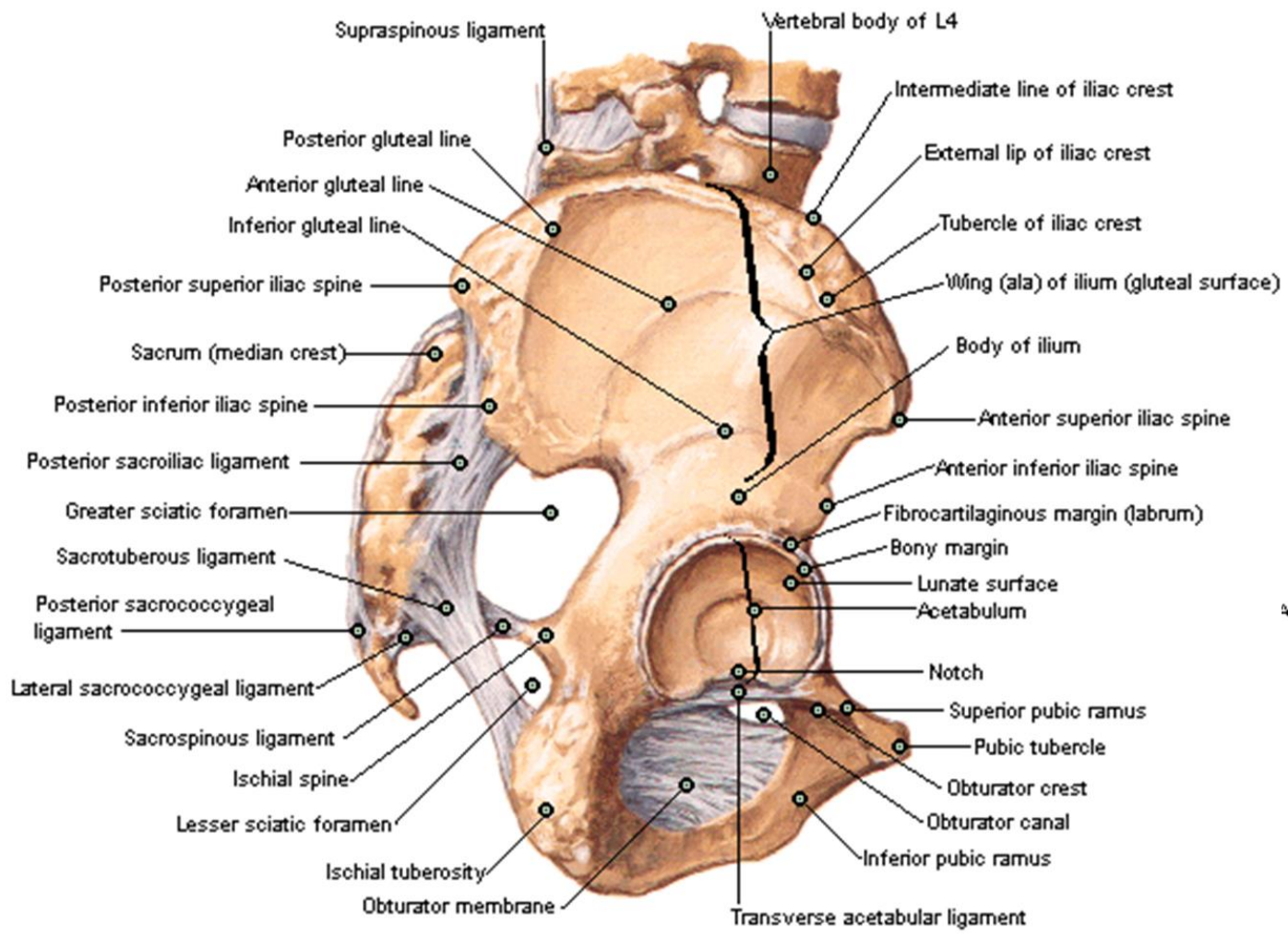
They delimit the **OBTURATOR FORAMEN** (*)

Male Pelvis Measurements - Anterior View



Bones and Ligaments of Pelvis

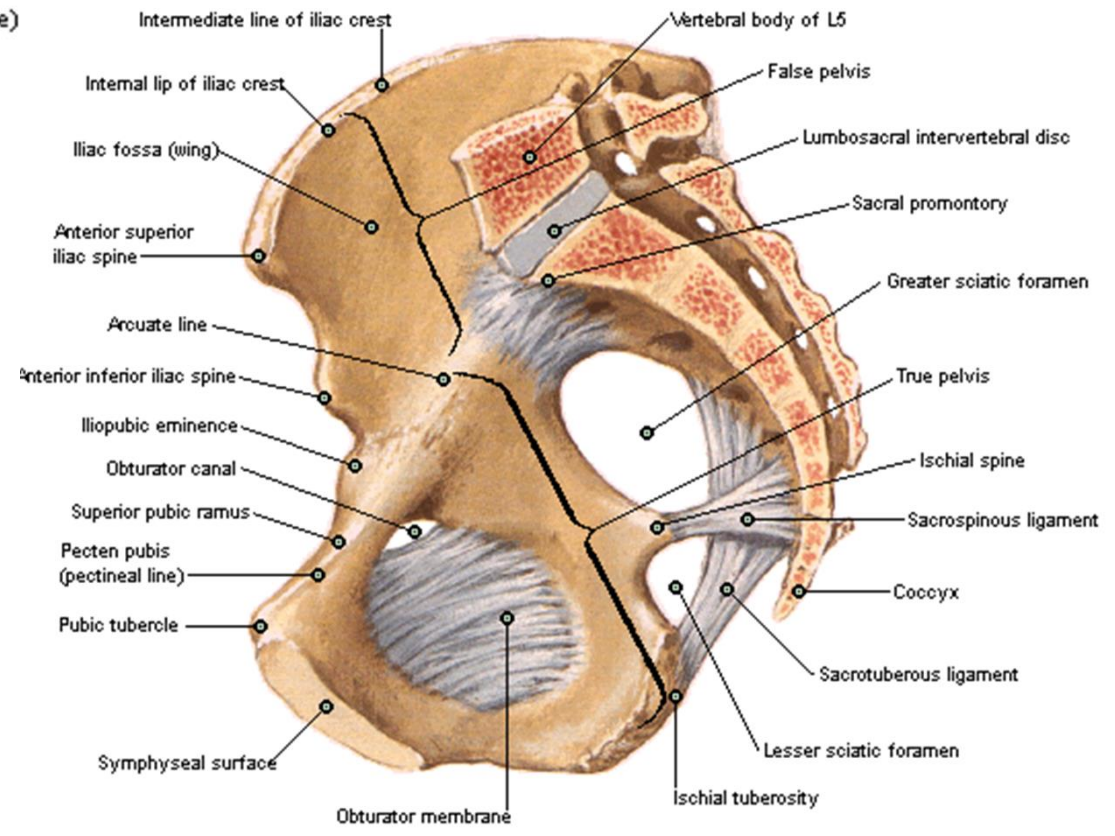
Lateral View



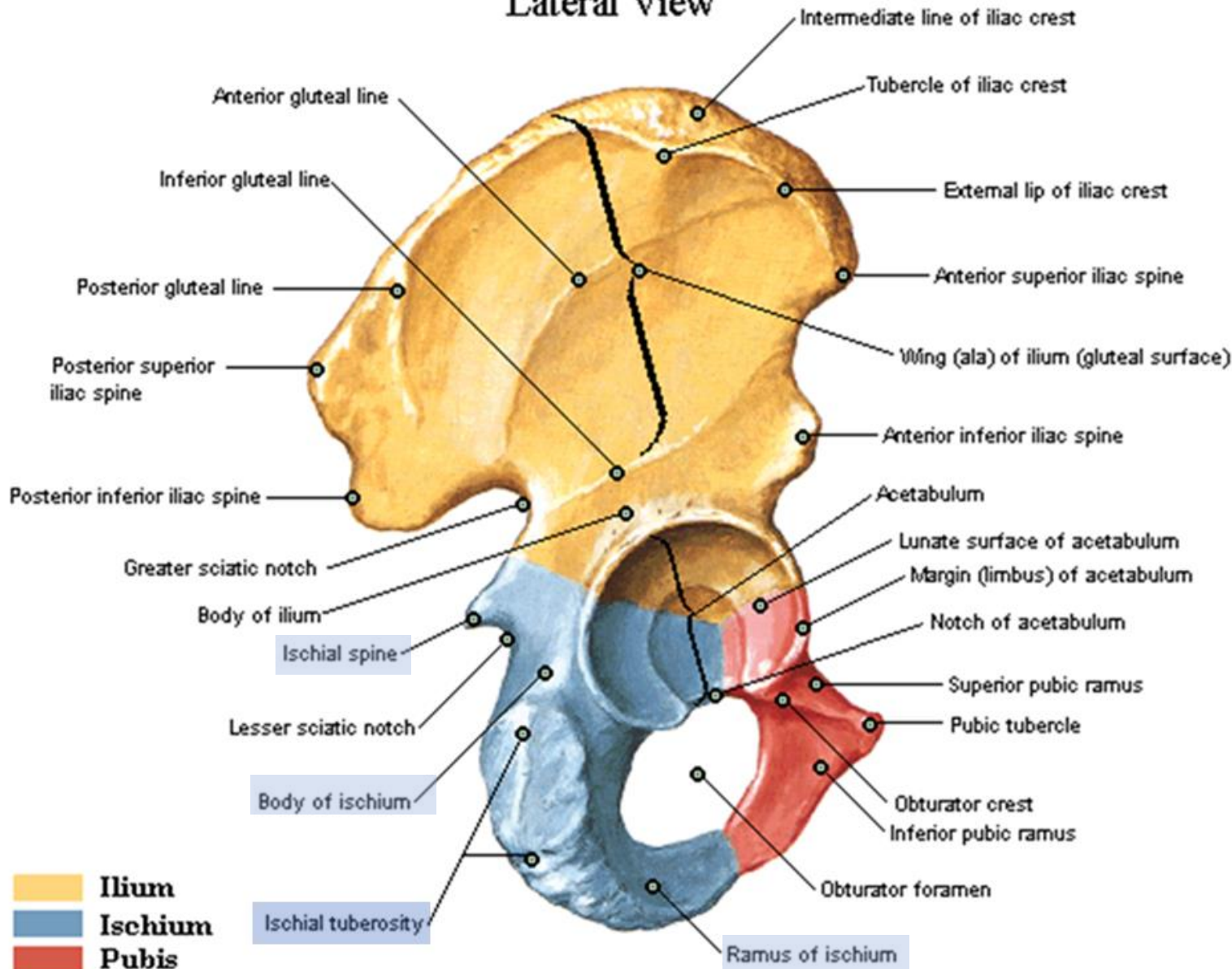
The obturator foramen is not completely open but almost entirely closed by a connective membrane → **OBTURATOR MEMBRANE**

Bones and Ligaments of Pelvis

Midsagittal Section



Coxal Bone Lateral View



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



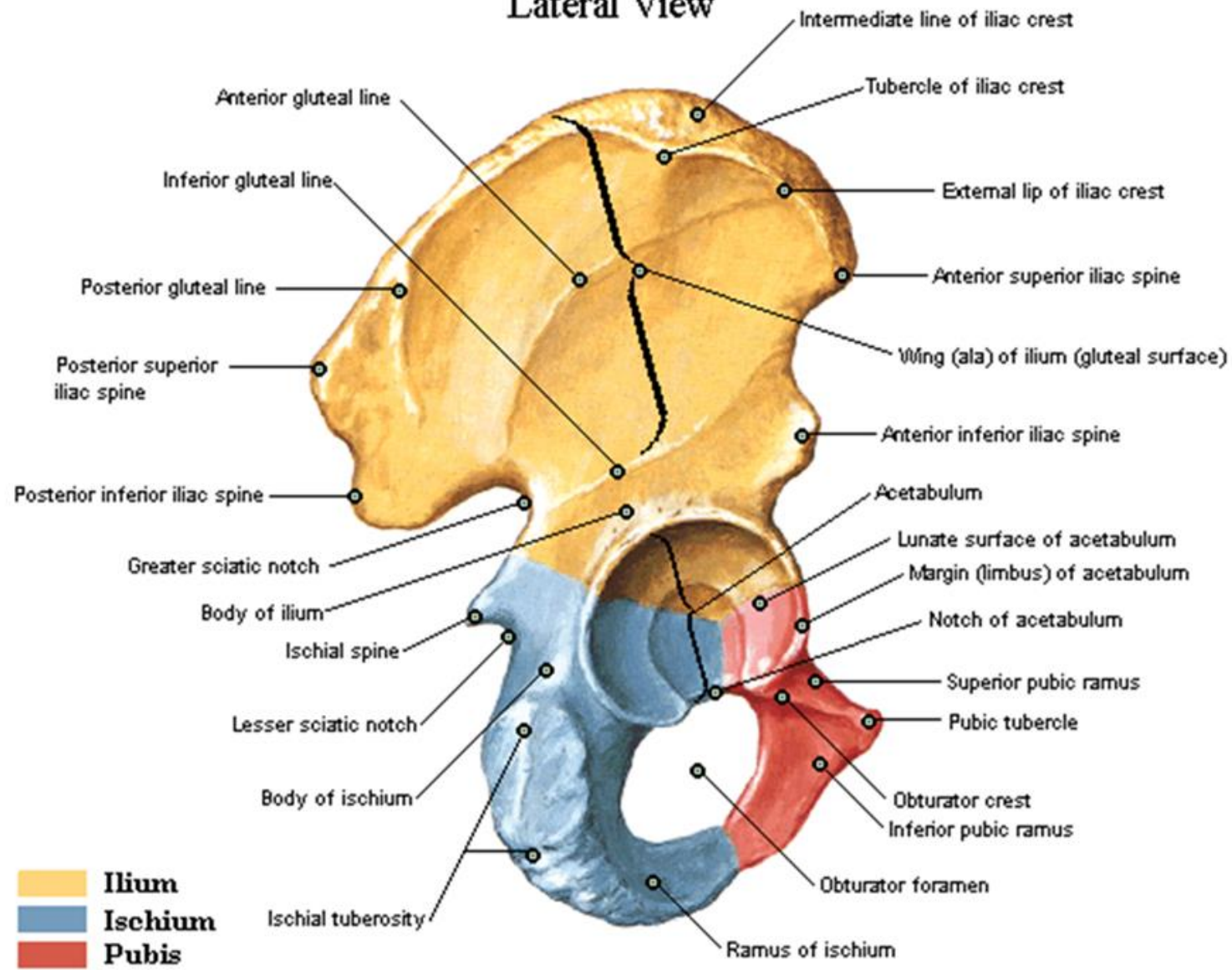
ISCHIAL TUBEROSITY (*where you sit down*)

It shows a sharp bony prominence which protrudes from the posterior margin called the



ISCHIAL SPINE

Coxal Bone Lateral View



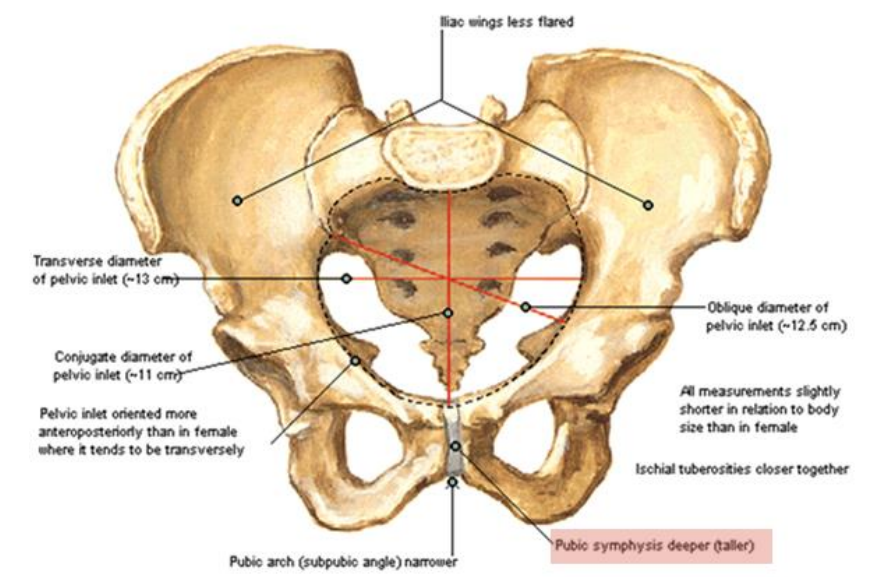
PUBIS

It is the lower anterior portion of the hip bone

The pubic bone is made up of a **superior ramus** and an **inferior ramus**

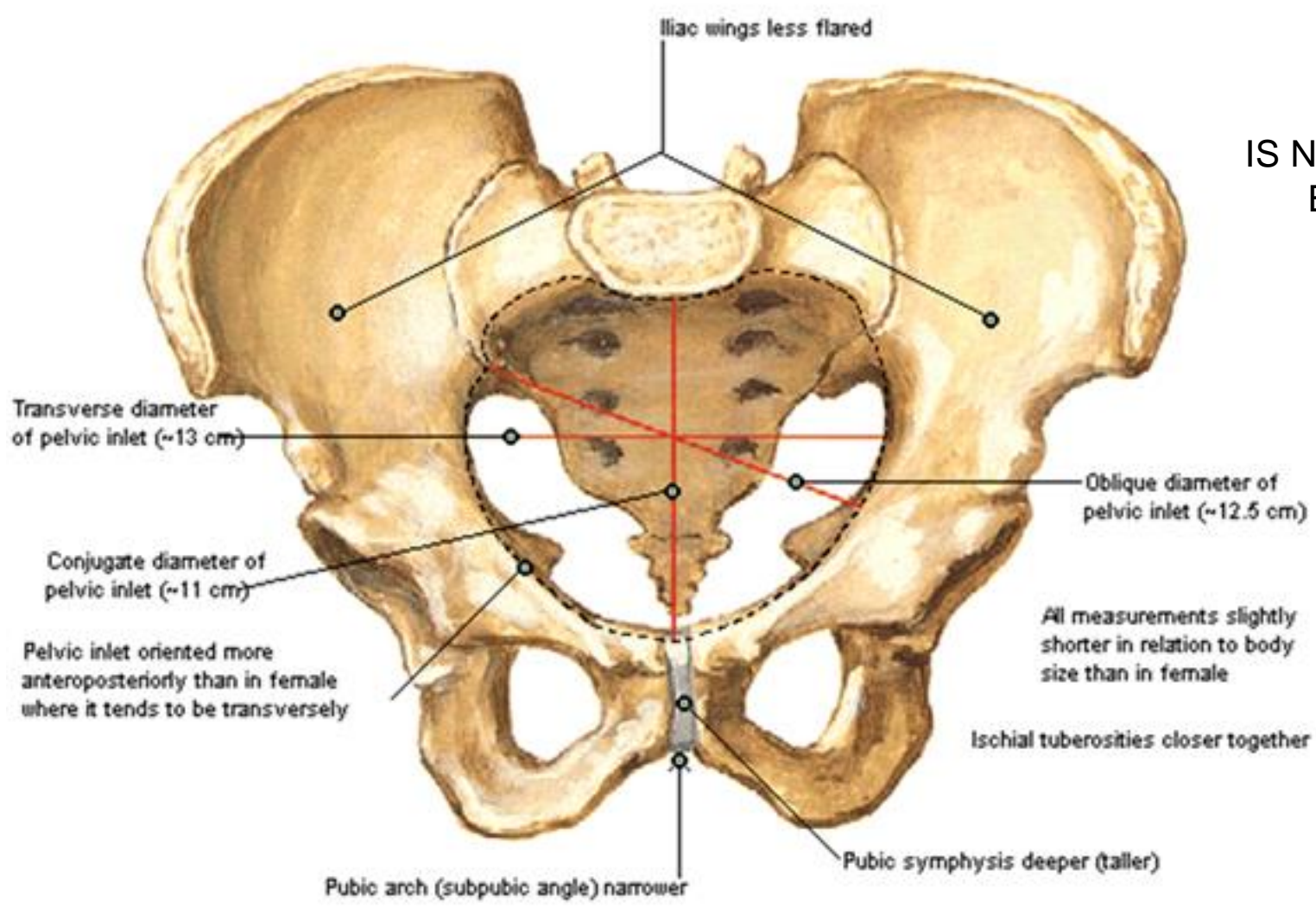
It joins anteriorly with the contralateral pubis forming the **pubic symphysis**

Male Pelvis Measurements - Anterior View



Male Pelvis

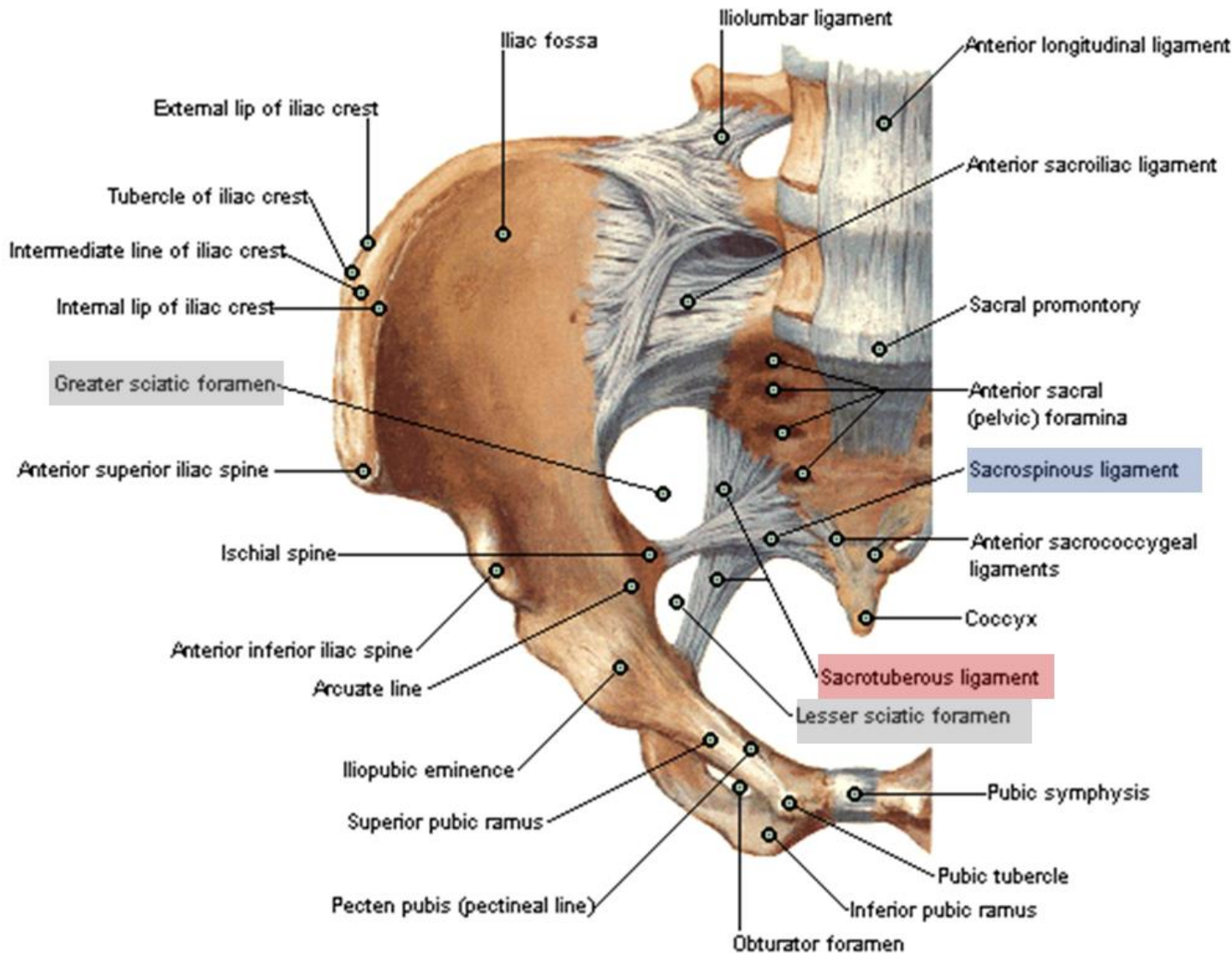
Measurements - Anterior View



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

Bones and Ligaments of Pelvis

Anterior View



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

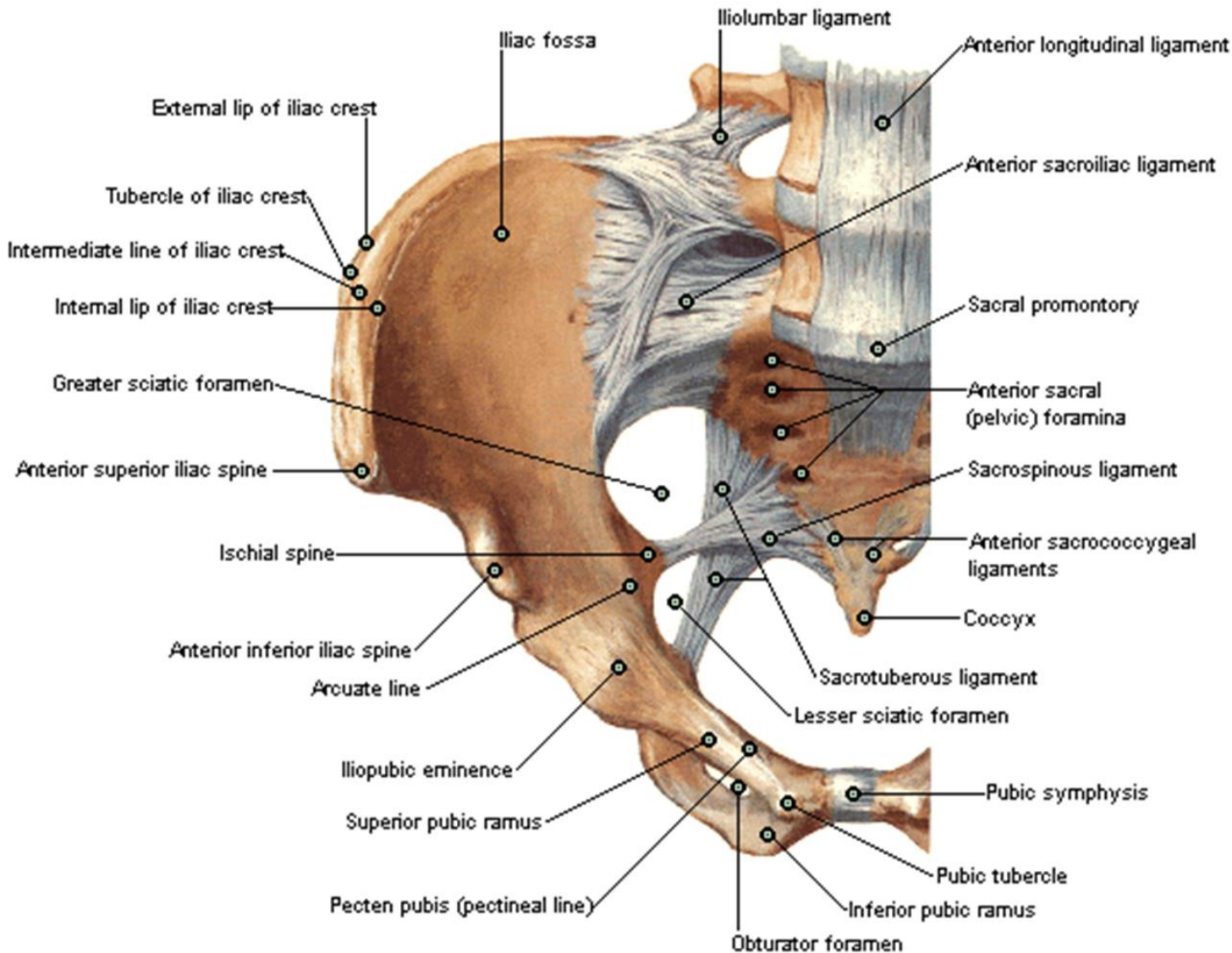
These ligaments, together with the bony structures, delimit foramina such as:

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

Nerves pass through these structures; Greater ischial foramen → Sciatic nerve

Bones and Ligaments of Pelvis

Anterior View



The **PELVIC OUTLET** of the pelvic cavity
Is delimited by:

- **Pubic symphysis (anteriorly)**
- **Ischial tuberosity**
- **Sacrospinous 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.