

Ultrasound

- Basic Ultrasound
- Advanced Ultrasound

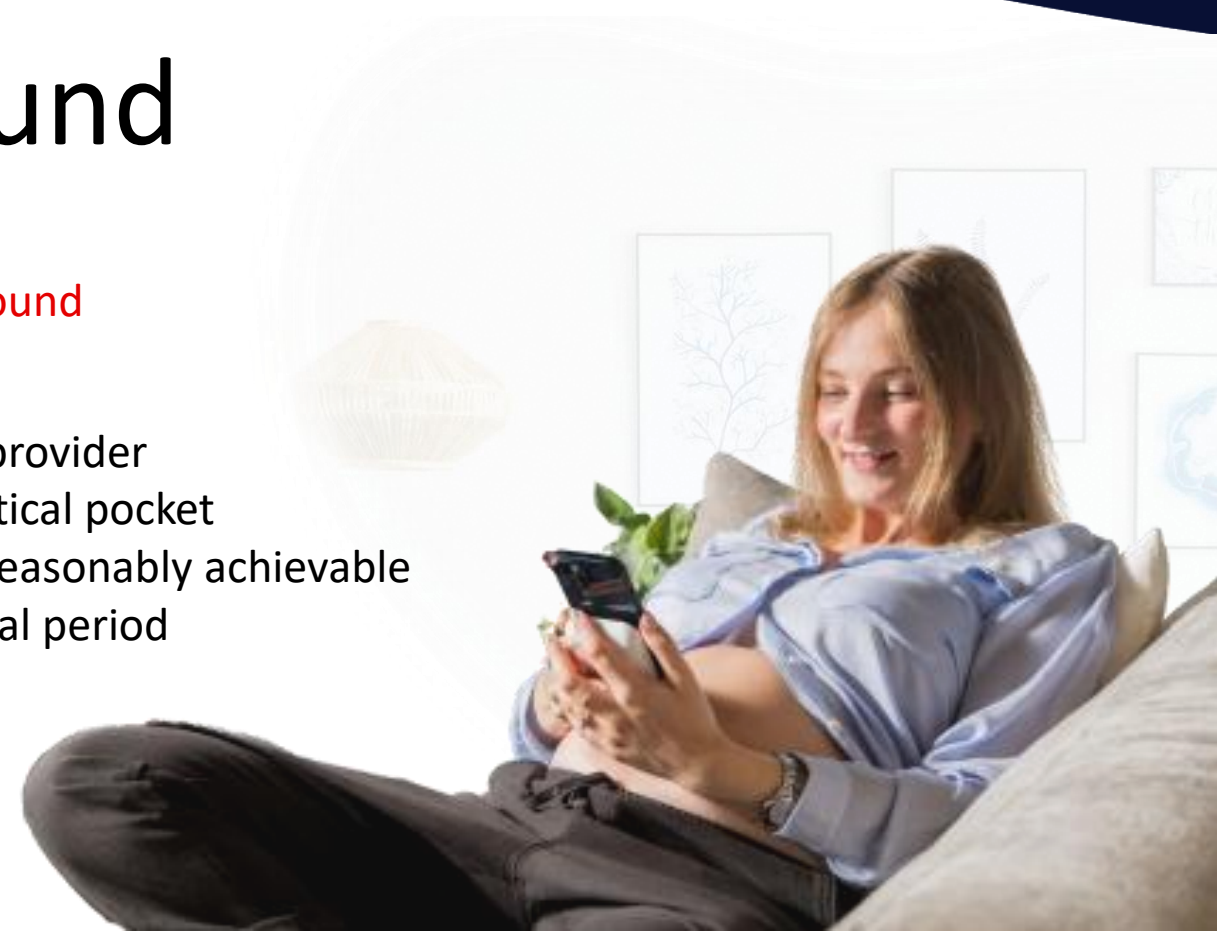
Acronyms

HCP – Health care provider

MVP - Maximal vertical pocket

ALARA - As low as reasonably achievable

LMP - Last menstrual period

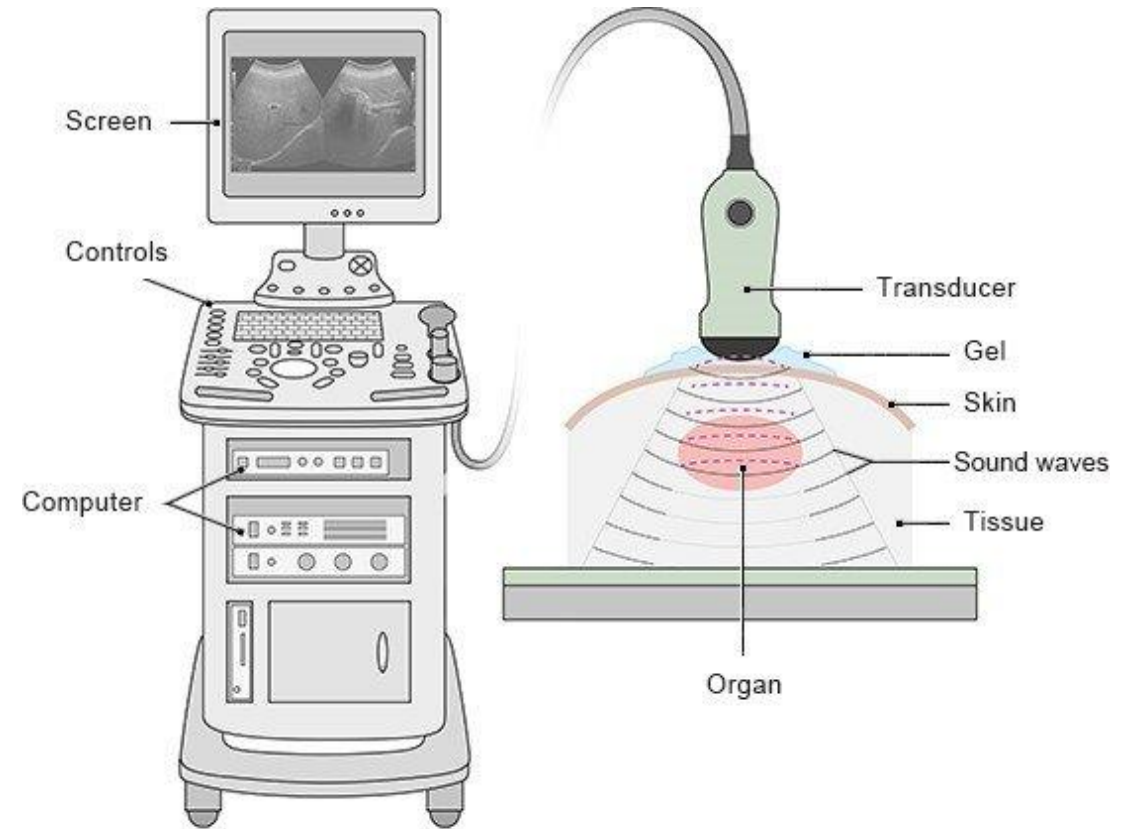


What is an ultrasound?

Ultrasound (also called sonography or ultrasonography) is a medical noninvasive imaging technique that uses high-frequency sound waves to create real-time pictures or video of structures inside the body.

Ultrasound imaging, also known as sonography.

Ultrasound enables healthcare providers to “see” details of soft tissues inside your body without making any incisions (cuts). And unlike X-rays, ultrasound doesn’t use radiation.



How ultrasound works:

Sound Wave Generation

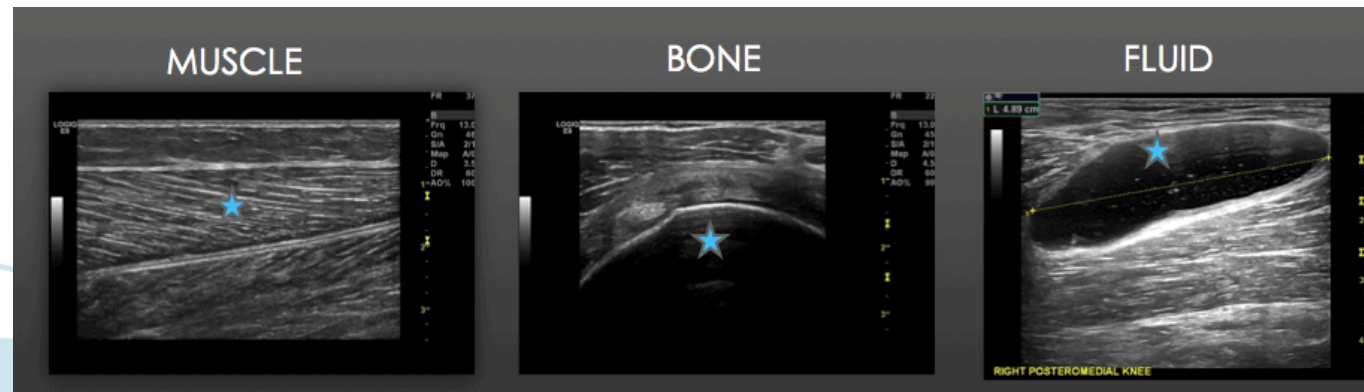
- An ultrasound machine has a device called a **transducer** that emits sound waves at frequencies typically above the range of human hearing (2–18 MHz).
- The transducer also receives the sound waves that bounce back.
 - Fluids (like blood or amniotic fluid) allow sound to pass through with minimal reflection.

Sound Wave interaction with tissues

When the sound waves travel through the body, they interact with different tissues, organs, and fluids. These waves are either absorbed, reflected, or refracted depending on the type of tissue they encounter:

- Soft tissues (like muscles) reflect sound moderately.
- Dense tissues (like bones) reflect sound strongly. Bones and air can not be penetrated – create strong echoes – They are hyperechoic
- Fluids (like blood or amniotic fluid) allow sound to pass through with minimal reflection. Sound waves tend to pass through fluids without reflecting – they do not produce echoes – Fluids are Anechoic. In an ultrasound fluid walls are smooth

Echogenicity – refers to the level of whiteness / brightness compared to echo set



Echoes & signal return

The sound waves that are reflected (called echoes) return to the transducer.

The time it takes for the echoes to return and their strength help the machine determine the location and characteristics of the tissue.

Image formation

The ultrasound machine processes the returning echoes and converts them into electrical signals.

These signals are then used to create a real-time image on the screen, showing the structure and movement of internal organs or blood flow.

ALARA stands for "**As Low As Reasonably Achievable**" and is a safety principle used primarily in fields involving radiation, such as medical imaging and nuclear industries. It emphasizes minimizing exposure to radiation while achieving the necessary diagnostic or operational goals.


Key Principles of ALARA

1. Time - Reduce the time spent near the radiation source to limit exposure.
2. Distance - Increase the distance between the individual and the radiation source, as radiation intensity decreases with distance.
3. Shielding - Use protective barriers like lead aprons, walls, or shields to absorb or block radiation.

Is ultrasound safe?

While ultrasound doesn't use ionizing radiation (like X-rays or CT scans), the ALARA principle is often applied to ensure the safety of patients and practitioners when ultrasound energy is used.

This includes:

- Using the **lowest possible power settings** to achieve adequate imaging.
 - Limiting exposure time to the shortest duration necessary.
 - Avoiding unnecessary or prolonged scanning, particularly during sensitive applications like fetal imaging.
- 

“MI” in the Pulsenmore ES device

The Mechanical Index (MI) and Thermal Index (TI) are key safety parameters used in obstetric ultrasound to minimize the risk of harm to the fetus during scanning. Both values are continuously displayed on the ultrasound machine during the examination, allowing clinicians to monitor and adjust the settings as necessary to ensure patient safety.

The MI is a measure of the likelihood that ultrasound-induced mechanical effects, such as cavitation (the formation of tiny gas bubbles), could occur in tissue.

Standard Care: In obstetric ultrasound, the MI is generally kept below 1.0 to minimize any potential risk. Lower MI values are preferred, especially during the first trimester, as the developing fetal tissues are more sensitive to mechanical effects.

Pulsenmore uses MI: 0.4

“TI” in the Pulsenmore ES device

Thermal Index (TI) definition: The TI estimates the potential for temperature rise in tissues due to ultrasound exposure, which could lead to thermal effects (heating).

Standard Care: The TI is typically kept below 0.7 during the first trimester and below 1.0 in the second and third trimesters. However, the safety threshold can vary depending on the duration of the scan and the specific tissue being scanned. Care is taken to avoid prolonged exposure, especially when the TI is close to or exceeds these values.

Pulsenmore uses TI: 0.03

Common uses of ultrasound:

1. Ultrasound guidance for procedures.
2. Diagnostic ultrasound
3. Pregnancy ultrasound (prenatal ultrasound)

What are 2D / 3D & 4D ultrasound?

1. Ultrasound guidance for procedures

Providers sometimes use ultrasound to perform certain procedures precisely.

A common use of ultrasound is to guide needle placement to sample fluid or tissue from: tendons, joints, muscles, cysts or fluid collections, soft-tissue masses, organs (liver, kidney or prostate) and transplant organs (liver, kidney or pancreas).

Examples of other procedures that may require ultrasound guidance include embryo transfer for in vitro fertilization, nerve blocks, confirming the placement of an IUD (intrauterine device) after insertion and lesion localization procedures.

2. Diagnostic ultrasound

Providers use diagnostic ultrasounds to view internal parts of the body to see if something is wrong or not working properly.


They can help your provider learn more about what's causing a wide range of symptoms, such as unexplained pain, masses (lumps) or what may be causing an abnormal blood test.

- For most diagnostic ultrasound exams, the technician places the transducer (probe) on your skin. In some cases, they may need to place the probe inside your body, such as in your vagina or rectum.
- Examples of diagnostic ultrasounds include: abdominal, kidney (renal) breast doppler, vascular, pelvic transvaginal, thyroid and transrectal ultrasounds.

3. Pregnancy ultrasound

Healthcare providers often use ultrasound (often called prenatal or obstetric ultrasound) to monitor the mother and the fetus during pregnancy.

Providers use prenatal ultrasound to:

- Confirm pregnancy.
 - Check to see if there are multiple fetuses
 - Estimate the gestational age of the fetus.
 - Check the [fetal growth](#) and position.
 - See the fetal movement and [heart rate](#).
 - Check for congenital conditions ([birth defects](#)) in the fetal brain, spinal cord, [heart](#) or other parts of its body.
 - Check the amount of amniotic fluid.
- 

What is the difference between a 2 D, 3D and 4D ultrasounds?

For ultrasounds during pregnancy, the traditional ultrasound is a two-dimensional (2D) image of the fetus. 2D ultrasound produces outlines and flat-looking images, which allows your healthcare provider to see the fetus's internal organs and structures.



What is the difference between a 2 D, 3D and 4D ultrasounds?

Three-dimensional (3D) ultrasound allows the visualization of some facial features of the fetus and possibly other body parts such as fingers and toes.

Four-dimensional (4D) ultrasound is 3D ultrasound in motion.

Providers rarely use 3D or 4D fetal ultrasound imaging for medical purposes, though it can be useful in diagnosing a facial or skeletal issue. They do, however, use 3D ultrasound for other medical purposes, such as evaluating uterine polyps and fibroids.



What is the difference between a 2 D, 3D and 4D ultrasounds?

While ultrasound is generally considered to be safe with very low risks, the risks may increase with unnecessary prolonged exposure to ultrasound energy or when untrained users operate an ultrasound machine. (Please note ALARA requirements).

Because of this, the U.S. Food and Drug Administration (FDA) advises against getting a 3D ultrasound for non-medical reasons such as for “keepsake” moments or entertainment.



Advanced ultrasound

- B-mode and M-mode
- Parameters
- Anatomical Panes



B-mode Vs. M-mode

B-mode (Brightness Mode) and **M-mode (Motion Mode)** are two different types of ultrasound imaging modes used for specific diagnostic purposes. Here's how they differ:

B-mode (Brightness Mode)

Provides a 2D cross-sectional image of internal structures.

Displays varying levels of brightness based on the strength of the echoes. Stronger echoes appear brighter, while weaker echoes appear darker.

Usage:

- Commonly used for imaging organs, tissues, and structures like the liver, kidneys, heart, or fetus.
- Useful for assessing the size, shape, and position of structures.

Key Features:

- Static or real-time 2D imaging.
- Broad applications across various medical fields

M-mode (Motion Mode)

Captures a single line of ultrasound (from B-mode) over time to display motion.

Displays movement as a time-motion graph, with time on the x-axis and depth on the y-axis.

Usage:

- Primarily used for dynamic studies, especially in cardiology.
- Essential for analyzing heart valve motion, measuring heart chamber dimensions, and evaluating fetal heart rate.

Key Features:

- Provides high temporal resolution (accurate tracking of fast-moving structures).
- Focuses on one-dimensional motion over time rather than a 2D image.

B-mode Vs. M-mode

Comparison Table

Feature	B-mode	M-mode
Image Type	2D static or real-time image	Time-motion graph
Purpose	Structural assessment	Motion and movement analysis
Applications	General imaging (organs, fetus, etc.)	Cardiology, fetal heart rate
Temporal Resolution	Moderate	High

In short, **B-mode** is best for viewing anatomical structures, while **M-mode** excels in tracking and analyzing motion over time.

Ultrasound parameters – Gain

Gain controls the overall brightness of the ultrasound image by amplifying the returning echoes. Increasing the gain makes the entire image brighter, while reducing it makes the image darker. It is used to ensure optimal brightness and contrast so that structures are clearly visible without introducing excessive noise.



Gain too low



Gain too high

If the middle band of the ultrasound is grainy the adjustment of the TGC parameters may help. (next page)

Ultrasound parameters – TGC

Time Gain Compensation (TGC) - TGC adjusts the brightness of the image at specific depths, compensating for the fact that echoes from deeper structures lose energy as they travel back. It helps to compensate for differences in returning ultrasound signals due to depth and tissue that absorbs some of the signal.

The TGC equalizes the amplification of the returning ultrasound echo signal so that the returning signal at different depths will be amplified similarly. The TGC controls the signal gain in several depth zones independently.

Ultrasound parameters - Depth

Depth adjusts how much of the body is displayed in the image by changing the penetration of sound waves. Depth determines the maximum depth visible in the image, and enables you to focus on the area of interest, whether shallow (e.g., skin or thyroid) or deep (e.g., liver or kidneys).

Increasing depth allows visualization of deeper structures, but reduces resolution and frame rate.
Decreasing depth provides better resolution for superficial structures.



Too much depth



Not enough depth

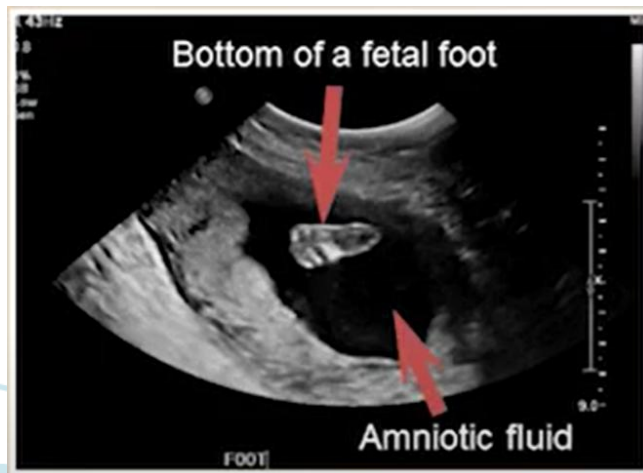
Ultrasound parameters - Zoom

Zoom magnifies a specific area of the image for closer inspection. It doesn't measure a parameter but enhances the visual resolution of a specific region. To closely examine small or detailed structures like blood vessels, valves, or fetal anatomy.

There are two types:

- **Read Zoom:** Magnifies the image after it's acquired, without increasing resolution.
- **Write Zoom:** Acquires the image at a higher resolution, improving clarity.

No zoom



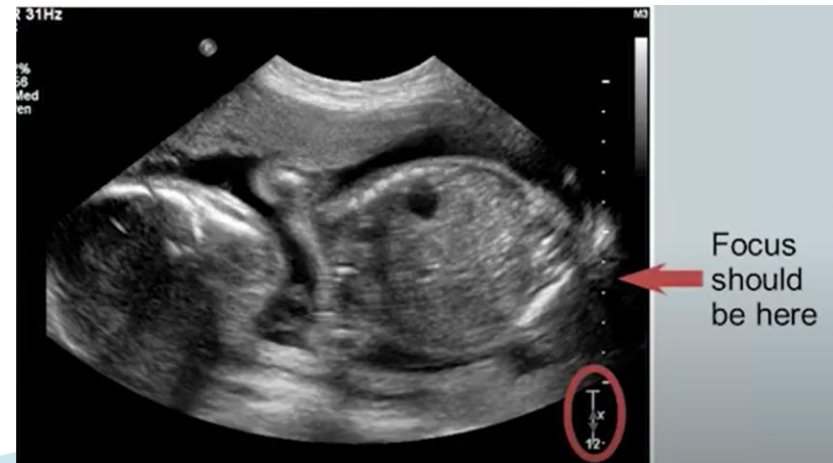
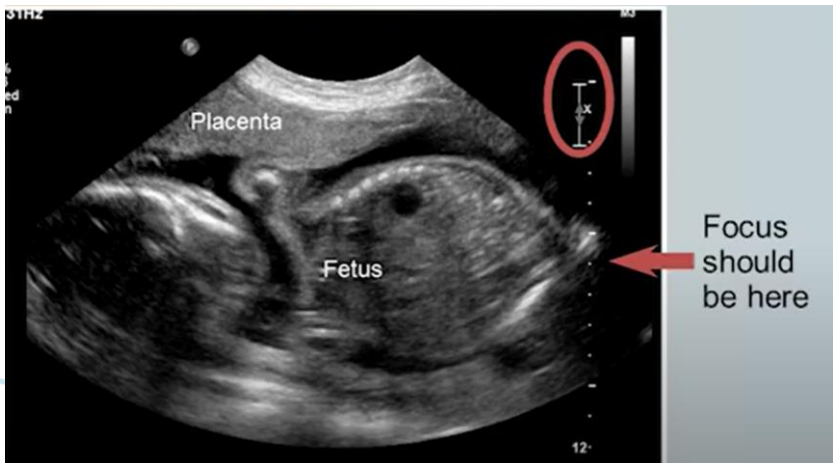
Can see individual bones and toes

Ultrasound parameters - Focus

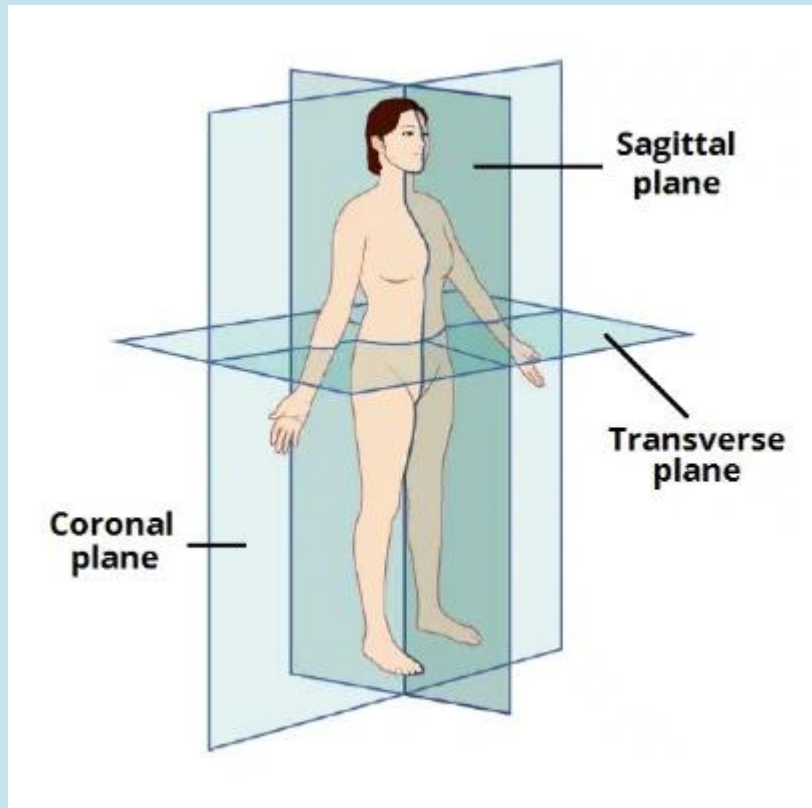
Focus optimizes the ultrasound beam at a specific depth to improve image clarity and resolution.

It indicates the area of greatest lateral resolution (sharpness). By adjusting the focal point, the device concentrates the sound waves to create a sharper image at the selected depth.

To ensure that the area of interest (e.g., a tumor or fetal organ) appears as sharp and detailed as possible.



Anatomical planes



Sagittal Plane

The sagittal plane is a vertical plane which passes through the body **longitudinally**. It divides the body into a left section and a right section. A specific sagittal plane is the **median sagittal plane** – which passes down the midline of the body, separating it into equal halves.

Coronal Plane

The coronal plane is a vertical plane which also passes through the body longitudinally – but **perpendicular** (at a right angle) to the sagittal plane. It divides the body into a front (anterior) section and back (posterior) section.

Transverse Plane

The transverse plane is a **horizontal** plane. It is perpendicular to both the sagittal and coronal planes, and parallel to the ground. It divides the body into an upper (superior) section and a lower (inferior) section.