THE SKELETAL SYSTEM

COMPILED BY HOWIE BAUM

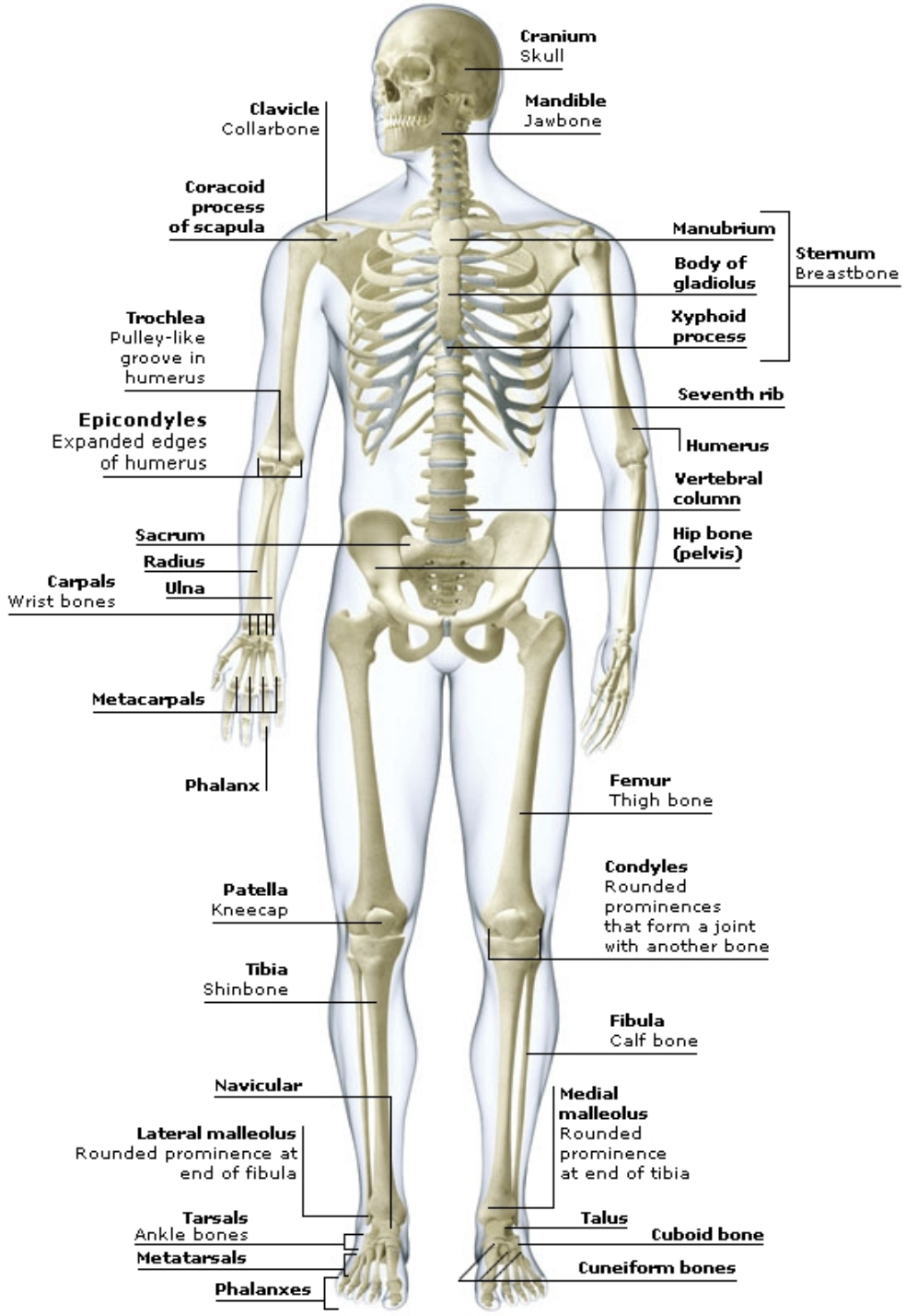
INTRODUCTION

With its highly engineered joints, the living skeleton is **intimately connected with the muscular system.**

It provides a framework of stiff levers and stable plates that permits a multitude of movements.

The skeleton also **integrates functionally with the cardiovascular system** – as **<u>every second, millions of fresh blood cells pour out of the bone marrow.</u>**

A healthy diet that provides enough minerals, especially calcium, along with regular moderate exercise, can reduce the risks of many bone and



INTERESTING FACTS ABOUT THE SKELETON

- The skeleton makes up almost one-fifth of a healthy body's weight.
- This flexible inner framework supports all other parts and tissues, which would collapse without skeletal reinforcement.
- It also protects certain organs, such as the delicate brain inside the skull.
- Bones are reservoirs of important minerals, especially calcium, and also make new cells for the blood.
- About one person in 20 has an extra rib.
- Bone is an active tissue, and even though it is about 22 per cent water, it has an extremely strong yet lightweight and flexible structure.
- A similar frame made of high-technology composite materials could not match the skeleton's weight, strength, and durability. It's as strong as steel but light as aluminum.
- It can repair itself if damaged and can remodel its bones to thicken and strengthen them in areas of extra stress, when persons do extreme sports.

The skeleton is the framework that provides structure to the rest of the body and facilitates movement.

When you look at the human skeleton the 206 bones and 32 teeth stand out.

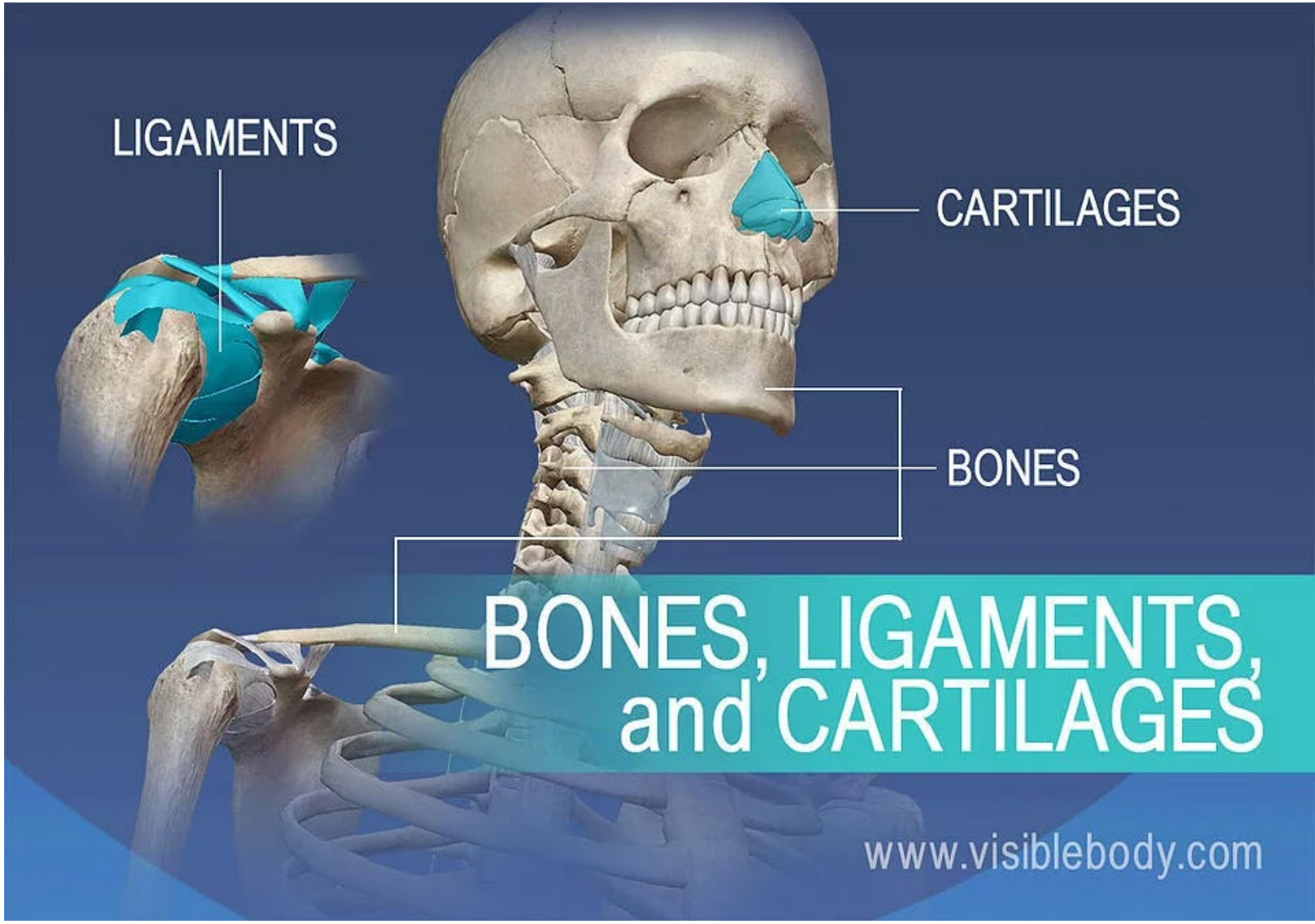
But look closer and you'll see even more structures.

The human skeleton also includes ligaments and cartilage.

Ligaments are bands of dense and fibrous connective tissue that are key to the function of joints.

Cartilage is more flexible than bone but stiffer than muscle.

Cartilage helps give structure to the larynx and nose. It is also found between the vertebrae and at the ends of bones like the femur.



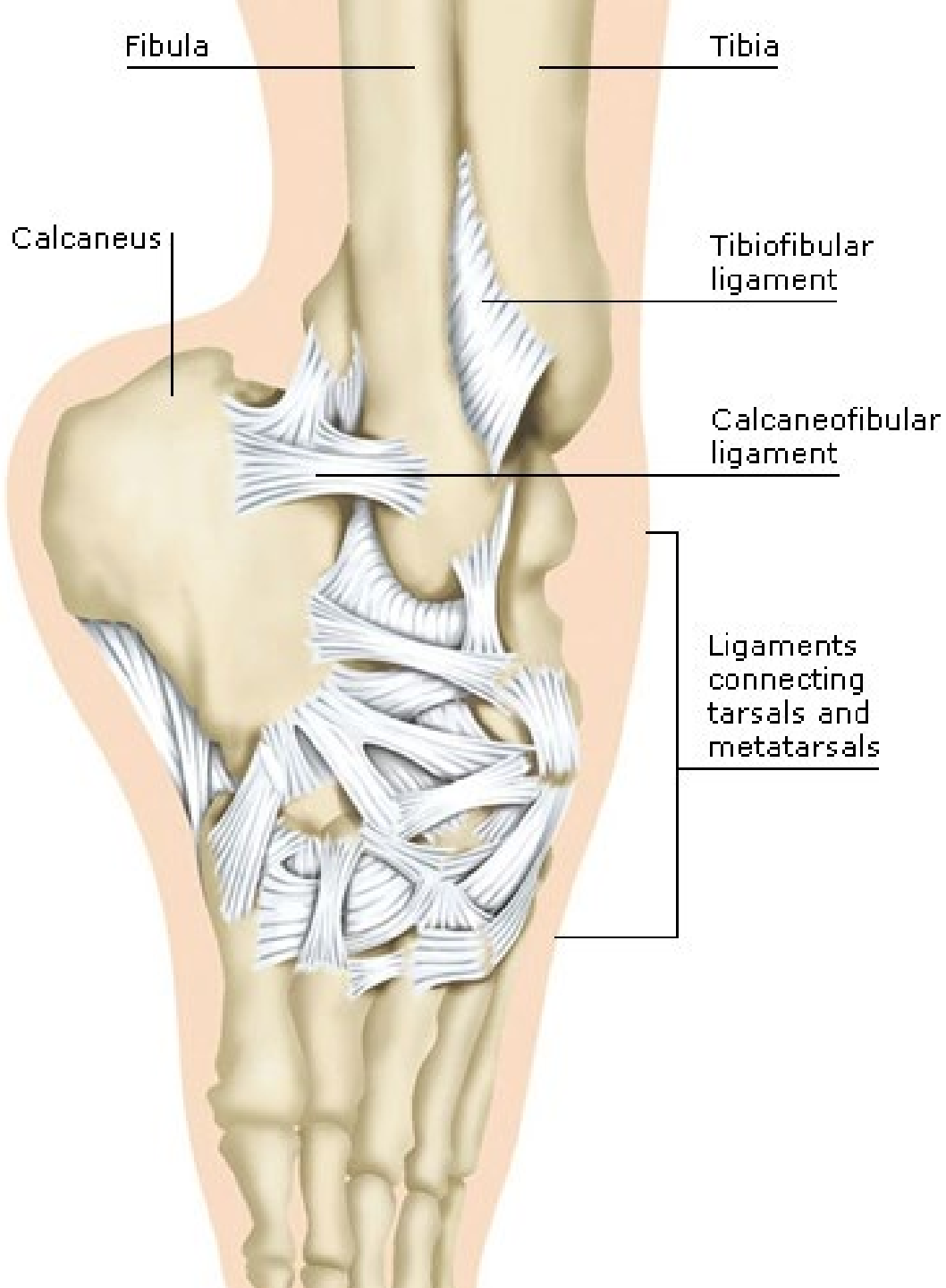
LIGAMENTS

Ligaments are strong bands or straps of fibrous tissue that provide support to bones and link bone ends together in and around joints.

They are made of collagen – a tough, elastic protein.

A large number of ligaments bind together the complex wrist and ankle joints

The foot ligaments store energy as they stretch when the foot is planted and then impart it again as they recoil and shorten to put a "spring in the step". This saves an enormous amount of energy when walking.



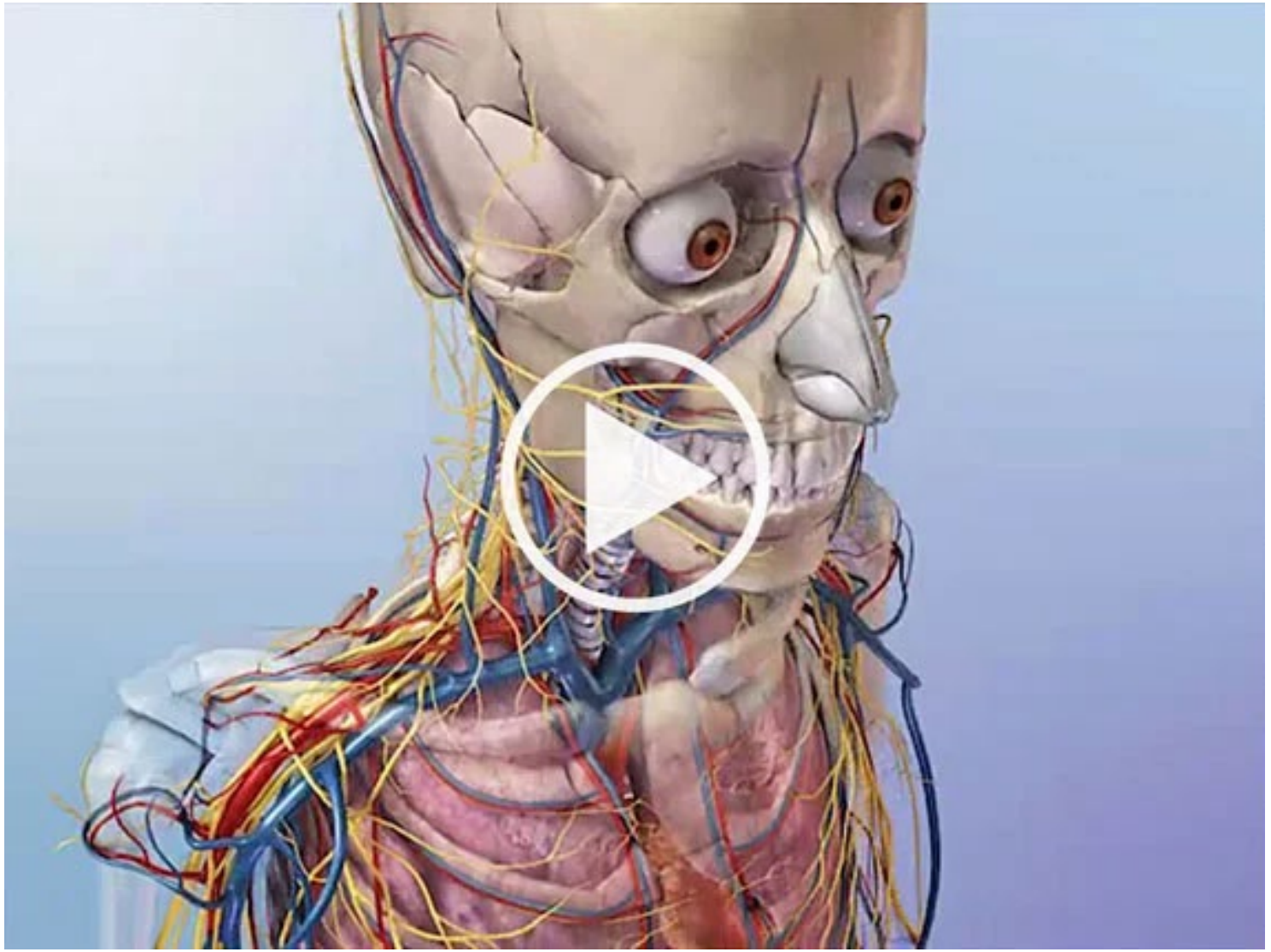
These bones provide structure and protection and facilitate motion.

- Bones are arranged to form structures.
- The skull protects the brain and gives shape to the face.
- The thoracic cage surrounds the heart and lungs.
- The vertebral column, commonly called the spine, is formed by over 30 small bones.
- Then there are the limbs (upper and lower) and the girdles that attach the four limbs to the vertebral column.

THE SKELETON PROTECTS VITAL ORGANS

The brain is surrounded by bones that form part of the skull.

The heart and lungs are located within the thoracic cavity, and the vertebral column provides structure and protection for the spinal cord.



INTERACTIONS BETWEEN THE SKELETON, MUSCLES, AND NERVES MOVE THE BODY

How does the skeleton move?

Muscles throughout the human body are attached to bones.

Nerves around a muscle can signal the muscle to move.

When the nervous system sends commands to skeletal muscles, the muscles contract.

That contraction produces movement at the joints between bones.

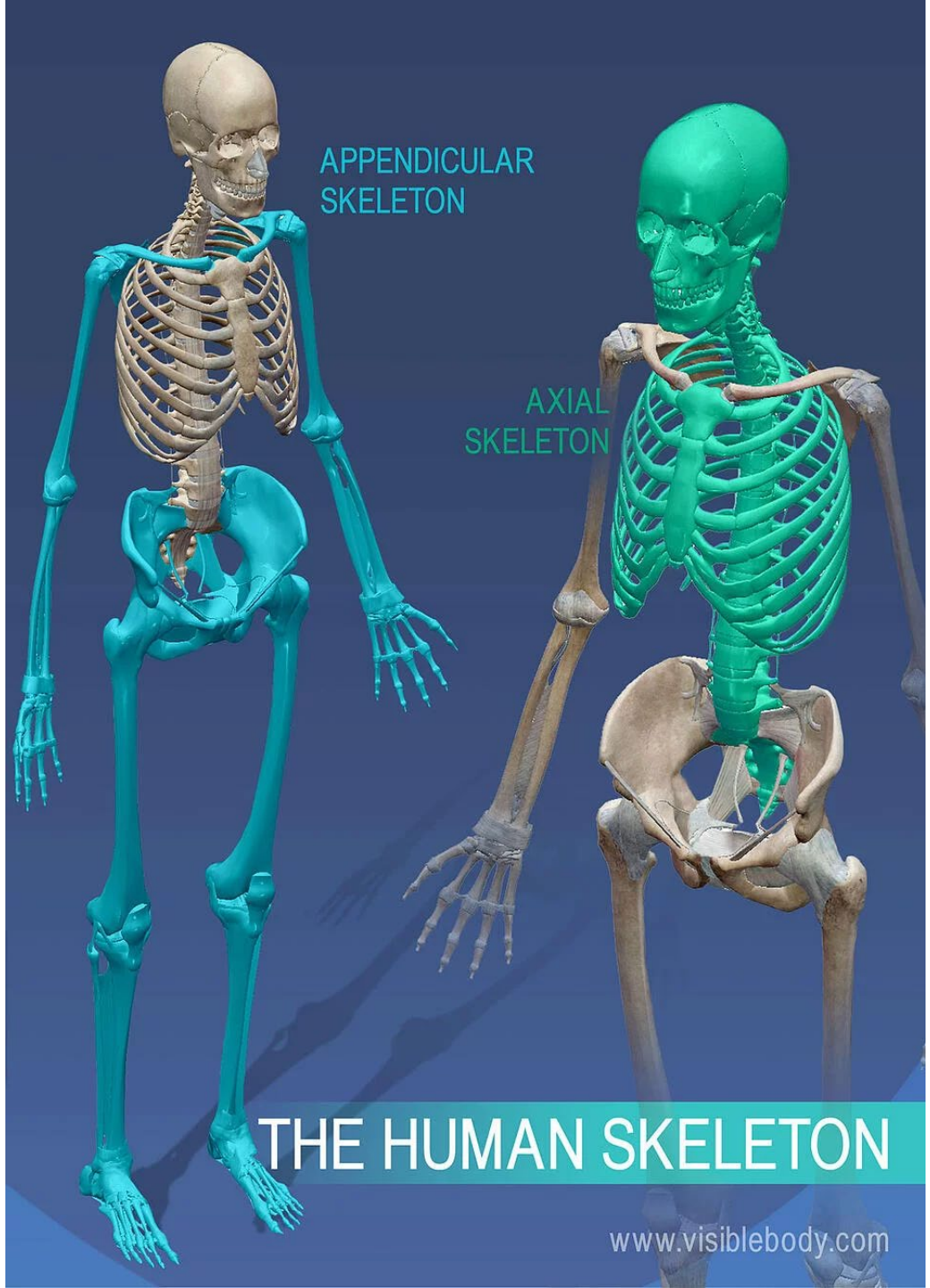
https://www.youtube.com/watch?v=59r9TG5IfU8&feature=emb_logo

BONES ARE GROUPED INTO THE AXIAL SKELETON AND THE APPENDICULAR SKELETON

Bones of the **appendicular skeleton** facilitate movement **- girdles and limbs**

Bones of the **axial skeleton** protect internal organs – **skull, vertebral column and thoracic cage**

Of the 206 bones, 80 are in the axial skeleton, with 64 in the upper appendicular and 62 in the lower appendicular skeleton.



BONES CAN BE CLASSIFIED INTO FIVE TYPES

Bones of the human skeletal system are categorized by their shape and function into five types.

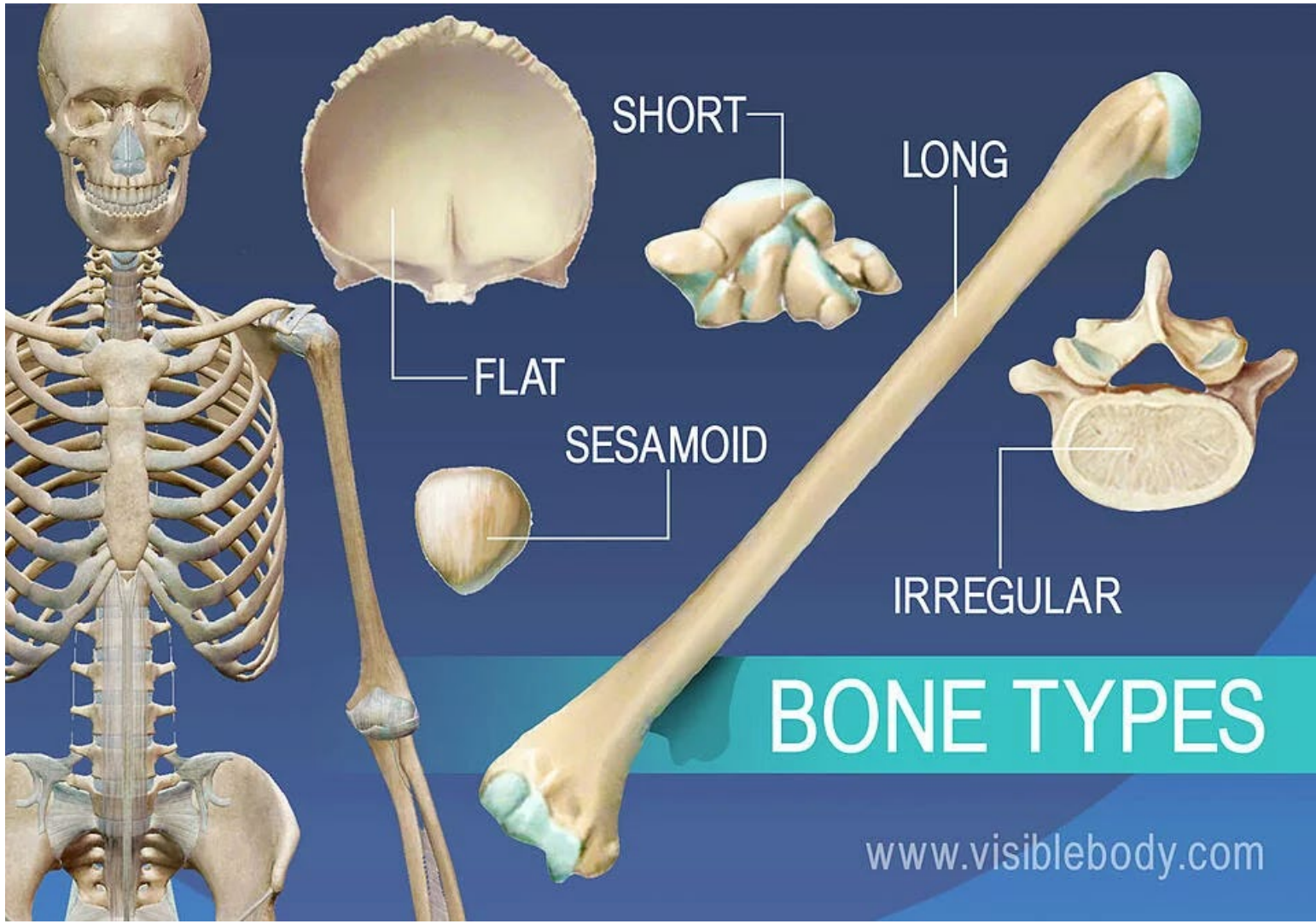
The femur is an example of a **long bone.**

The frontal bone is a **flat bone**.

The patella, also called the knee cap, is a **sesamoid bone.**

Carpals (in the hand) and tarsals (in the feet) are examples of **short bones.**

Vertebrae are classified as **Irregular shaped bones.**

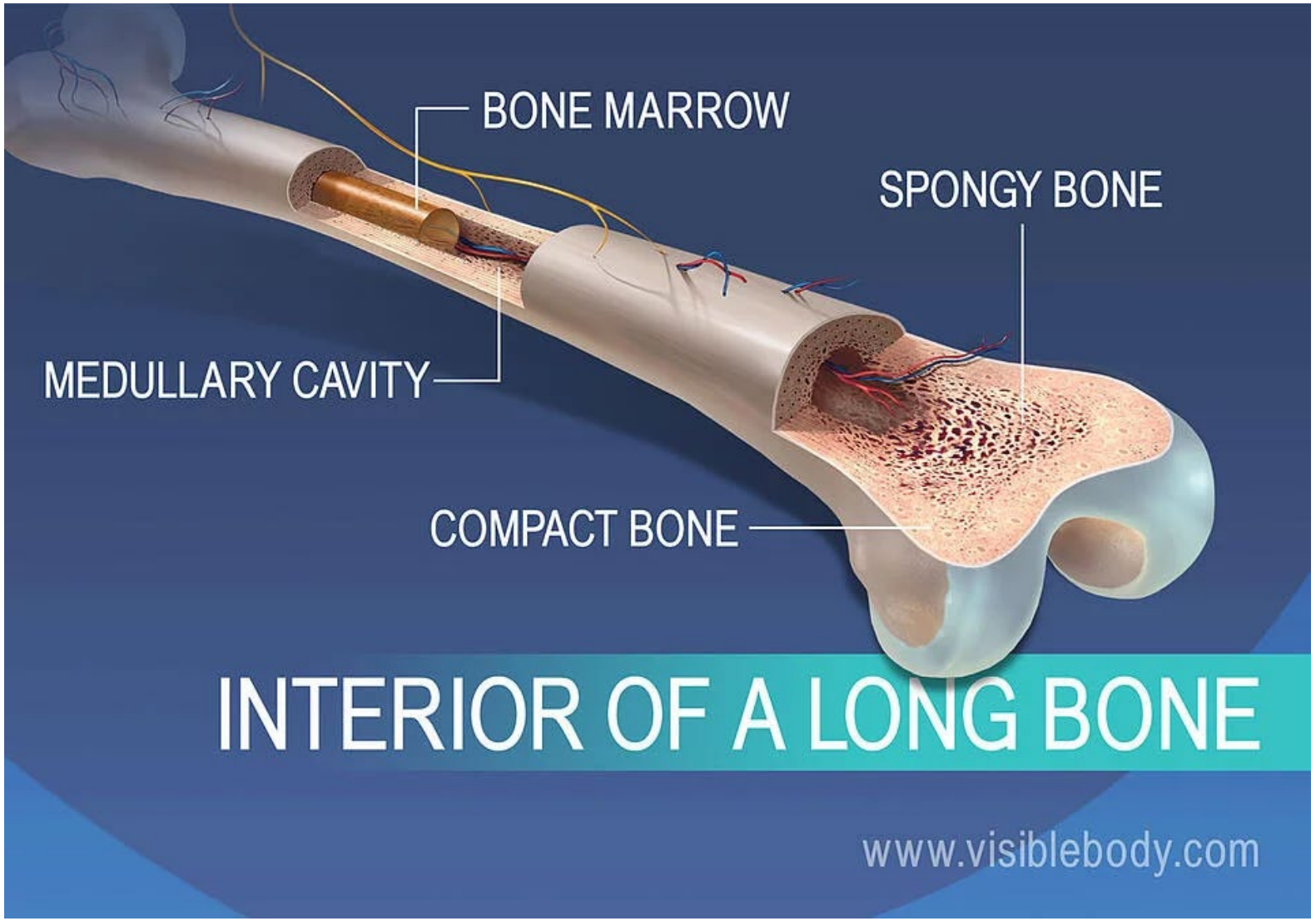


LONG BONES HAVE THREE MAIN PARTS TO THEM

The outside of a long bone consists of a layer of compact bone surrounding spongy bone.

Red bone marrow contains haemopoietic tissue, the chief function of which is to **produce all three main kinds of blood cell: red; white; and platelets.**

At birth, red marrow is present in all bones, but with increasing age, in the long bones it gradually becomes yellow marrow and loses its blood-making capacity.

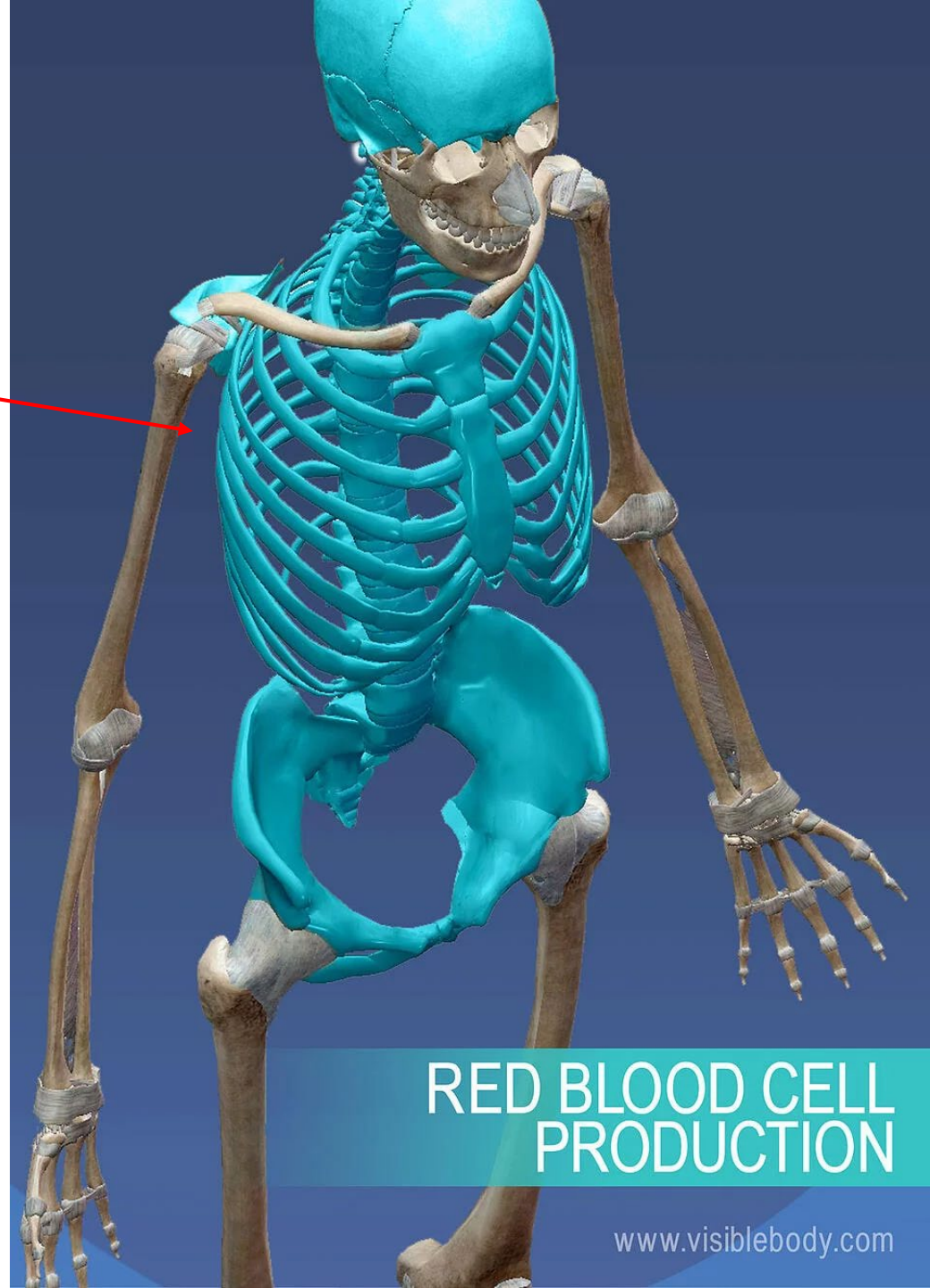


SOME BONES PRODUCE RED BLOOD CELLS

Red bone marrow is soft tissue located in networks of spongy bone tissue inside some bones. (shown in **blue** in the image)

In adults the red marrow in bones produce blood cells of the:

- **Cranium (skull)**
- **Vertebrae**
- **Scapulae (shoulder bones)**
- **Sternum (bone in the center of the chest)**
- **Ribs**
- **Pelvis**
- **The epiphyseal ends of the large long bones**



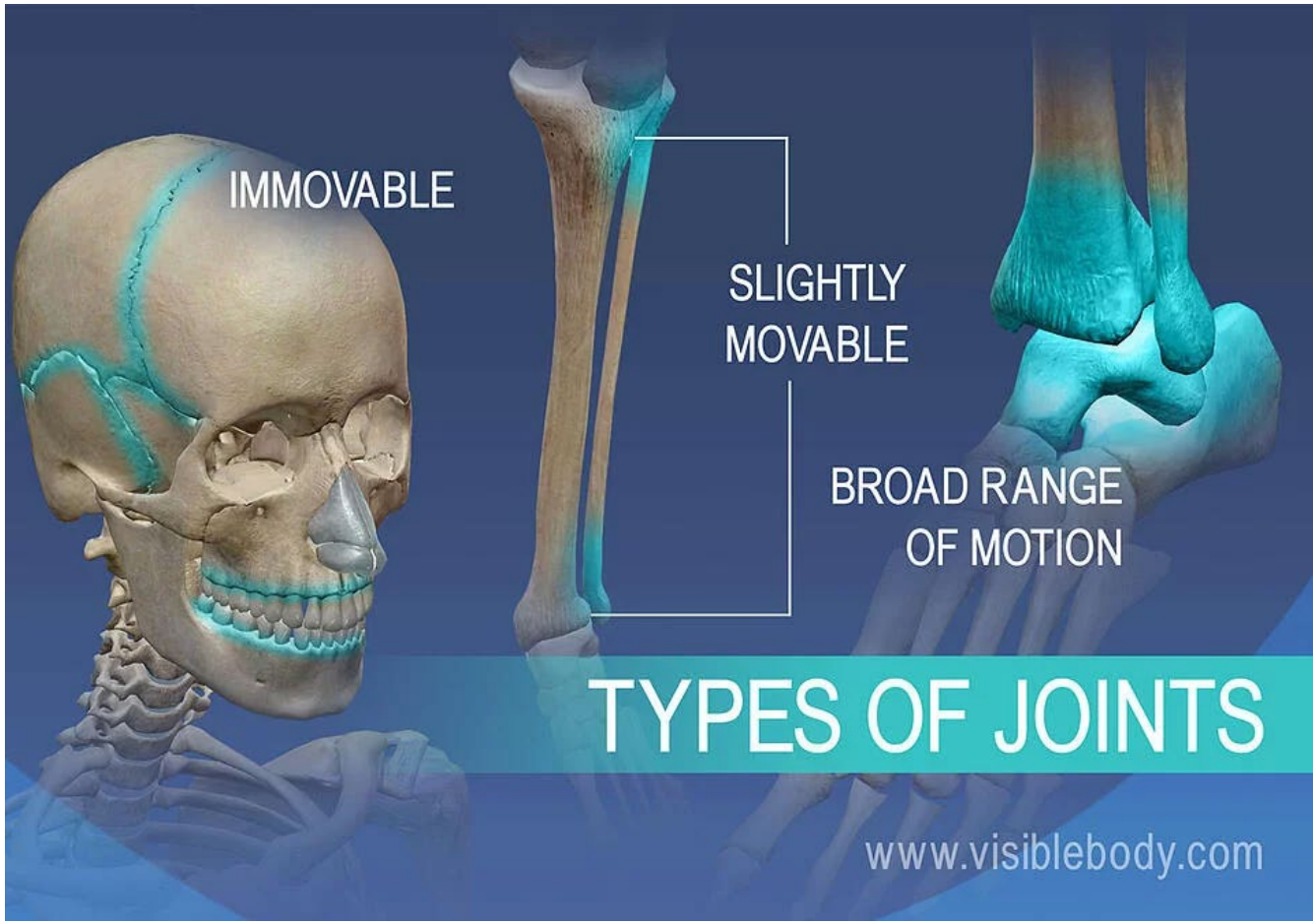
SOME JOINTS DON'T MOVE OR MOVE VERY LITTLE

One way to classify joints is by range of motion.

Immovable joints include:

- Sutures of the skull
- Articulations between teeth and the mandible
- The joint located between the first pair of ribs and the sternum.

Some joints have **slight movement**; an example is the distal joint between the tibia and fibula. Joints that **allow a lot of motion** (think of the shoulder, wrist, hip, and ankle) are located in the upper and lower limbs.



INFANTS HAVE MORE BONES THAN ADULTS

An infant skeleton has almost 100 more bones than the skeleton of an adult !

At first, it is all flexible but strong cartilage.

Bone formation begins at about three months gestation and continues after birth into adulthood.

An example of several bones that fuse over time into one bone is the sacrum.

At birth, the sacrum is five vertebrae with discs in between them.

The sacrum is fully fused into one bone usually by the fourth decade of life.

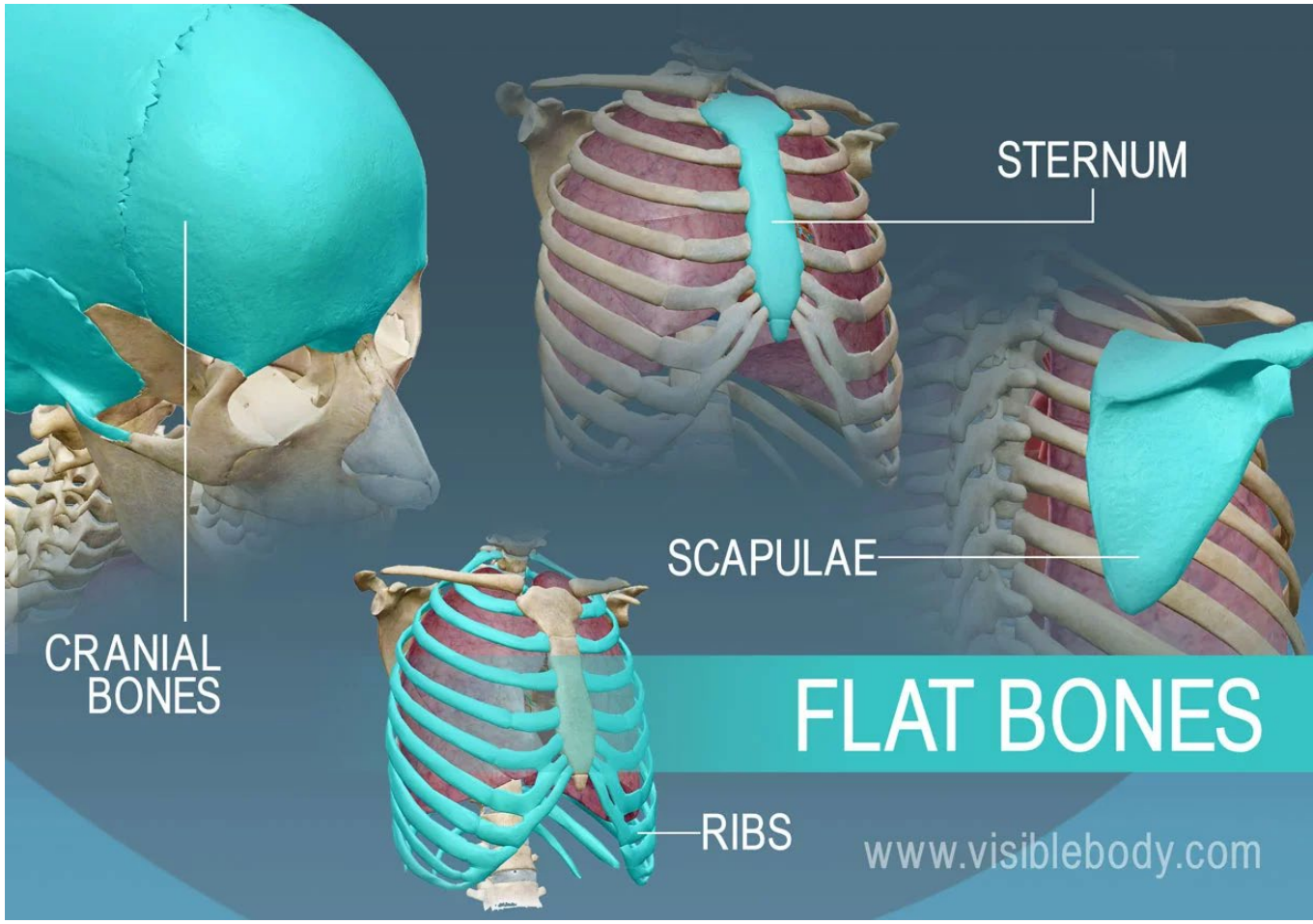
FLAT BONES PROTECT INTERNAL ORGANS

There are flat bones in

- the skull (occipital, parietal, frontal, nasal, lacrimal, and vomer),
- the thoracic cage (sternum and ribs)
- the pelvis (ilium, ischium, and pubis).

The function of flat bones is to protect internal organs such as the brain, heart, and pelvic organs.

Flat bones can provide protection, like a shield and can also provide large areas of attachment for muscles.



LONG BONES SUPPORT WEIGHT AND FACILITATE MOVEMENT

The long bones, longer than they are wide, include:

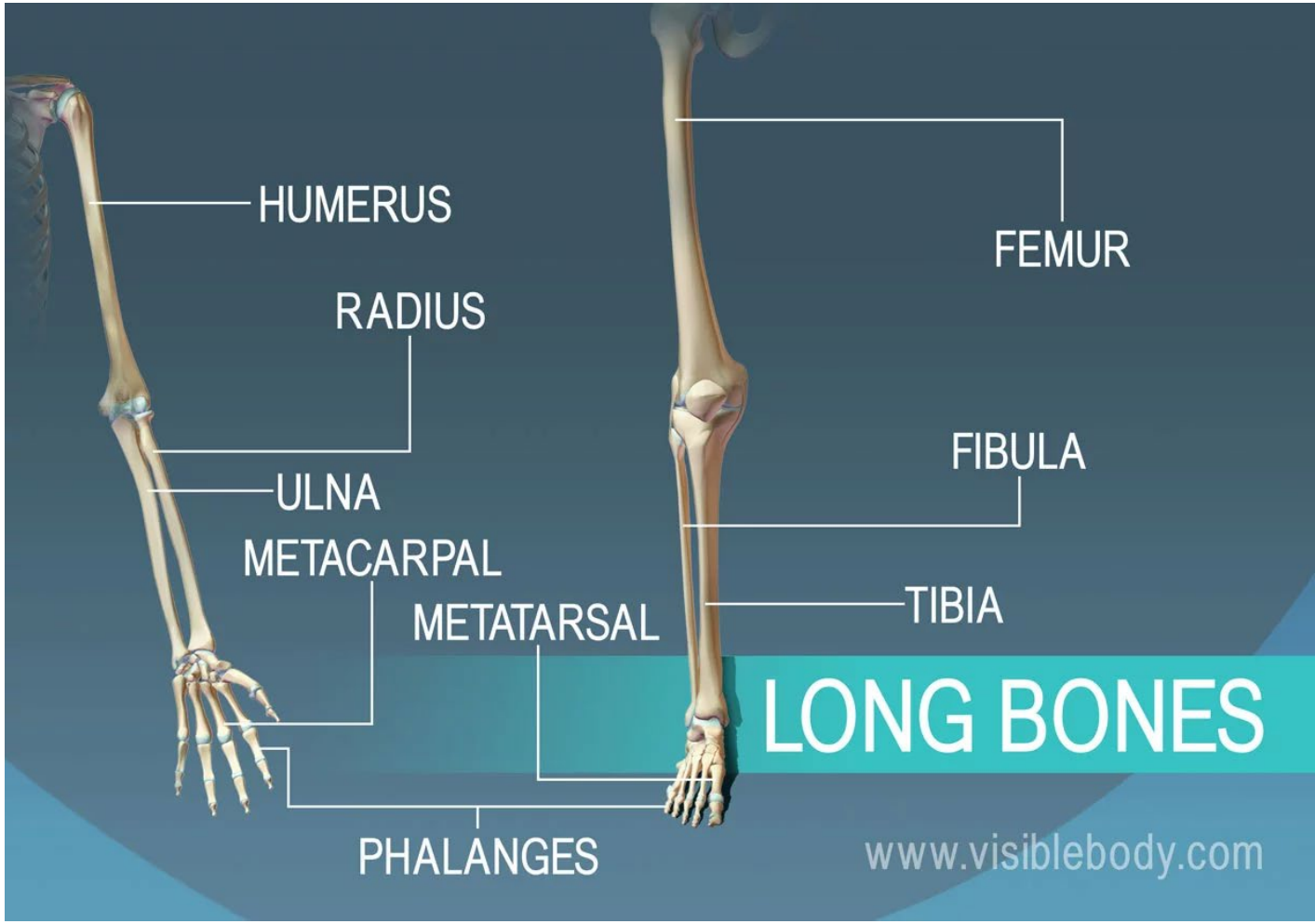
The femur (the longest bone in the body)

Relatively small bones in the fingers.

Long bones are mostly located in the appendicular skeleton and include

The lower limbs

Bones in the upper limbs



SHORT BONES ARE CUBE-SHAPED

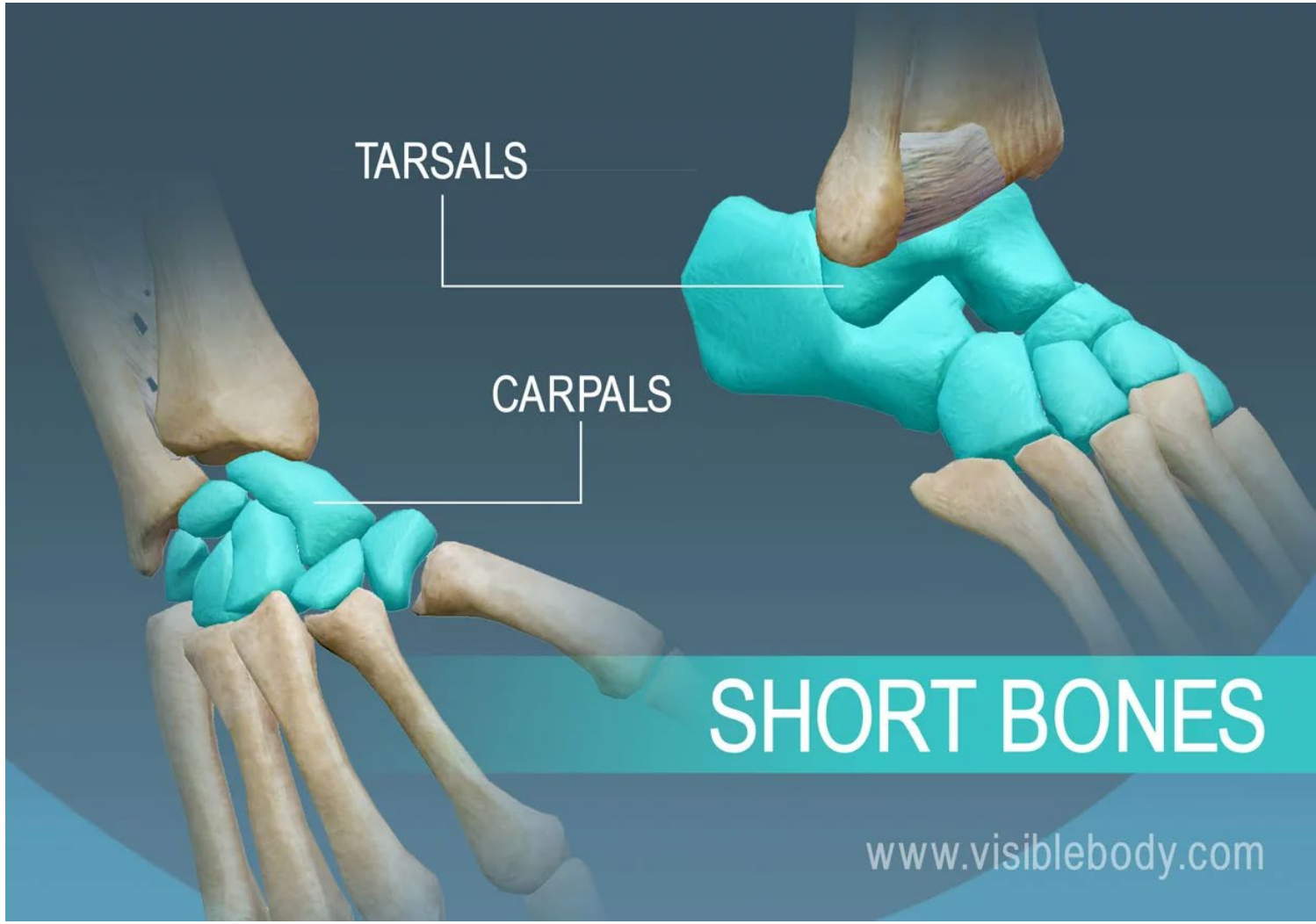
Short bones are about as long as they are wide.

Located in the wrist and ankle joints, short bones provide stability and some movement.

Examples of short bones are:

The carpals in the wrist

The tarsals in the ankles



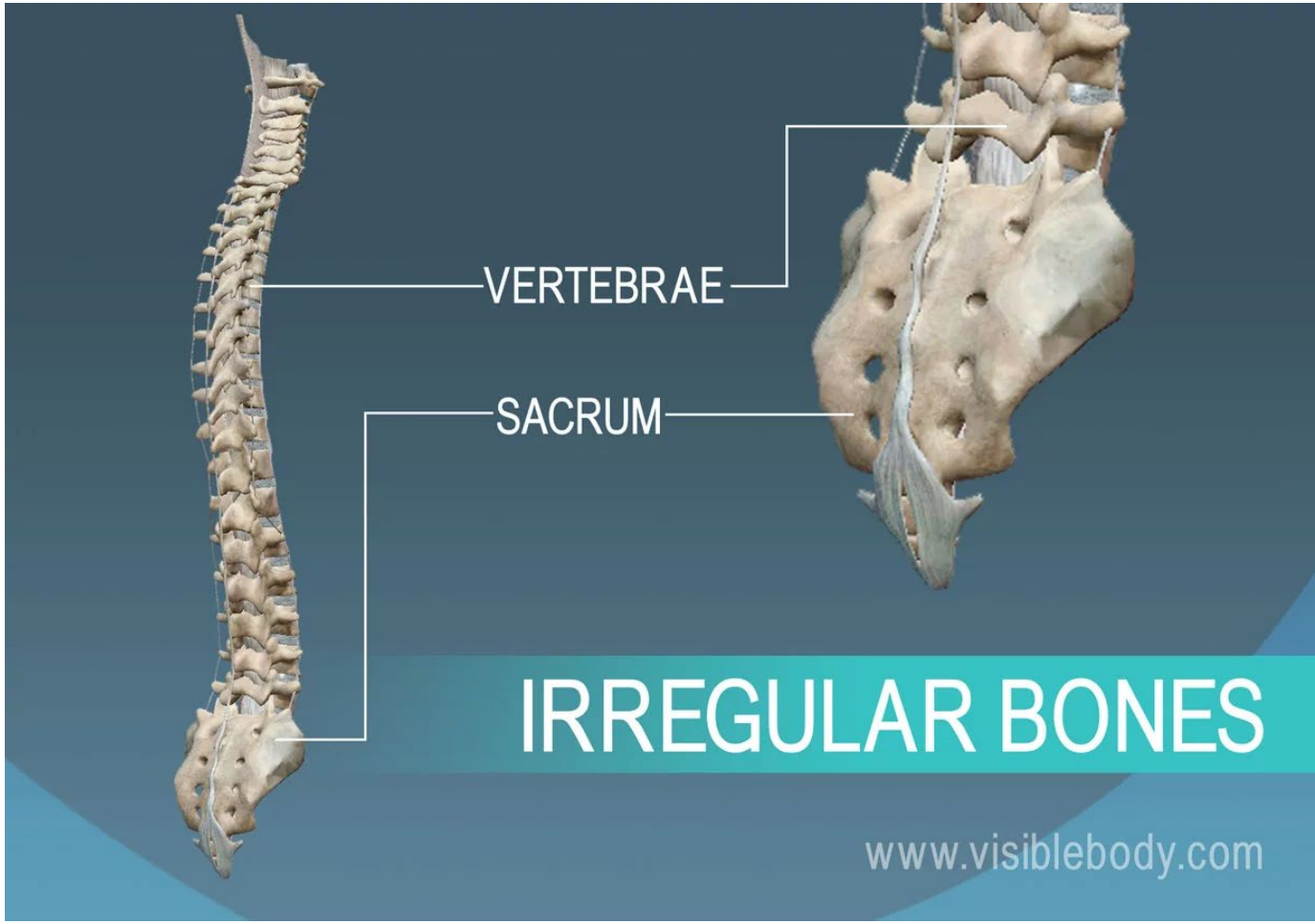
IRREGULAR BONES HAVE COMPLEX SHAPES

Irregular bones vary in shape and structure and therefore do not fit into any other category (flat, short, long, or sesamoid).

They often have a fairly complex shape, which helps protect internal organs.

For example, the vertebrae, irregular bones of the vertebral column, protect the spinal cord.

The irregular bones of the pelvis protect organs in the pelvic cavity.



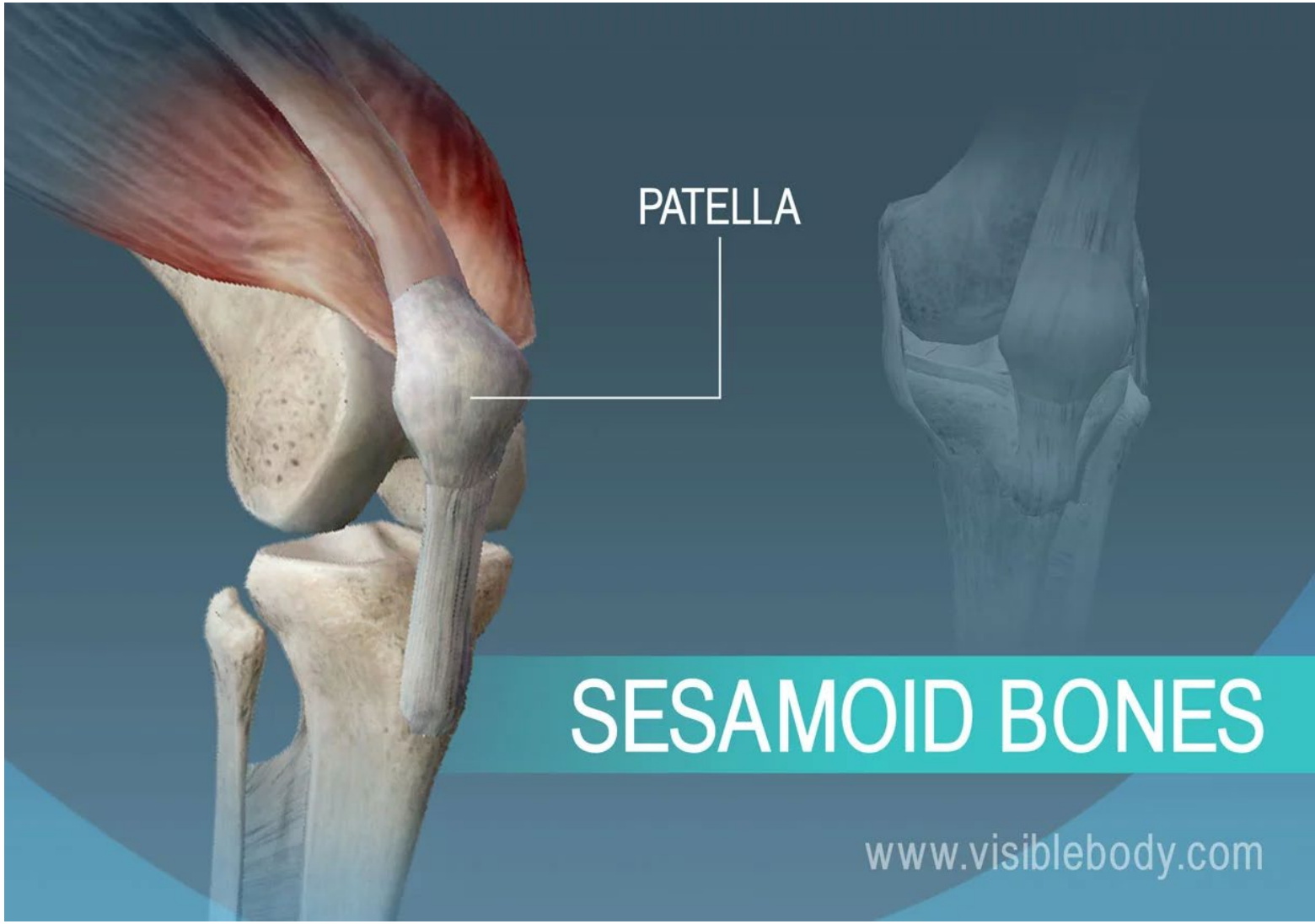
SESAMOID BONES REINFORCE TENDONS

Sesamoid bones are bones embedded in tendons.

These small, round bones are commonly found in the tendons of the hands, knees, and feet.

Sesamoid bones function to protect tendons from stress and wear.

The patella, commonly referred to as the kneecap, is an example of a sesamoid bone.



SKULL BONES PROTECT THE BRAIN AND FORM AN ENTRANCE TO THE BODY

The **skull** consists of the cranial bones and the facial skeleton.

The cranial bones compose the top and back of the skull and enclose the brain.

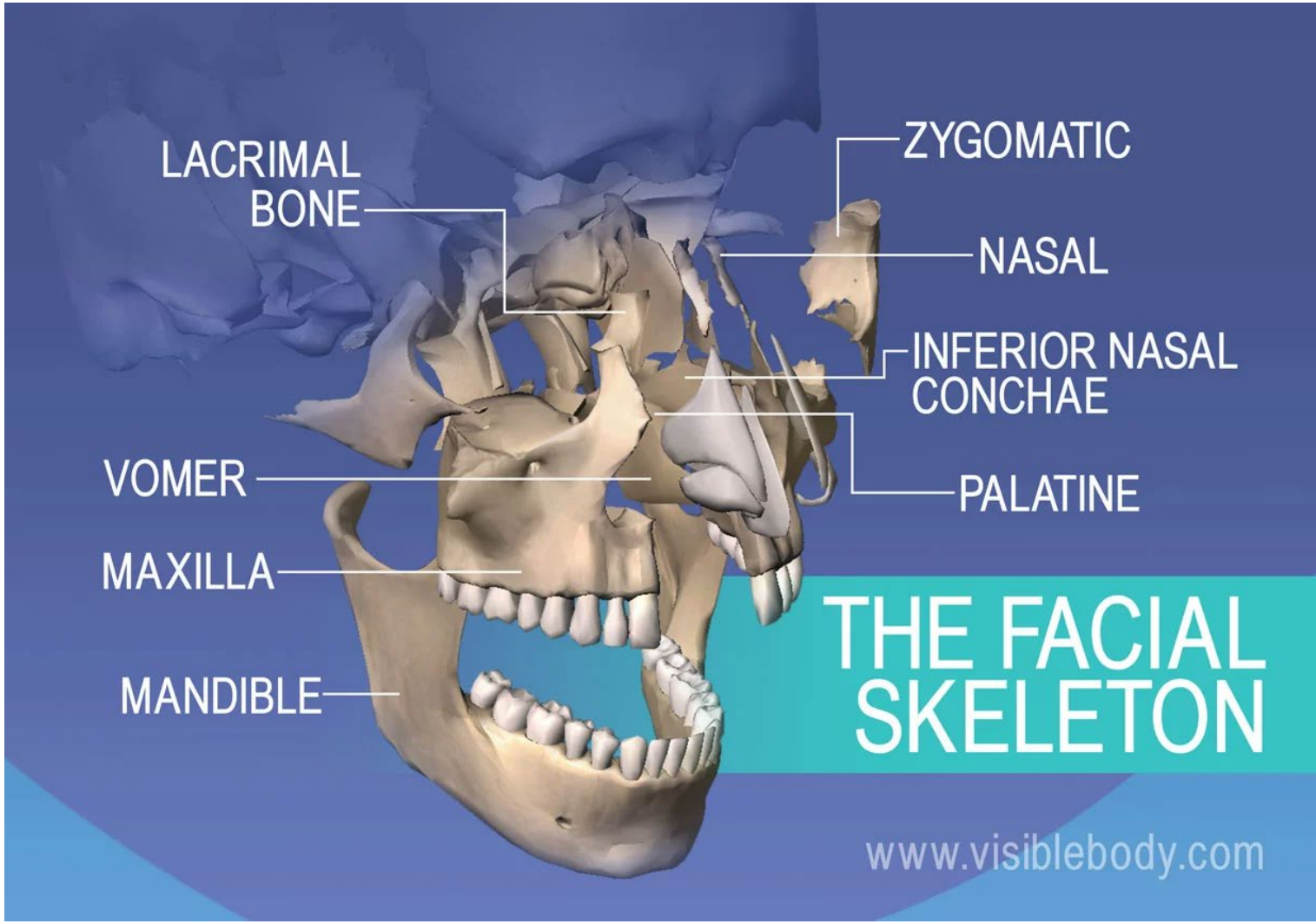
The facial skeleton, as its name suggests, makes up the face of the skull.

FACIAL SKELETON

The 14 bones of the facial skeleton form the entrances to the respiratory and digestive tracts.

It is made up of:

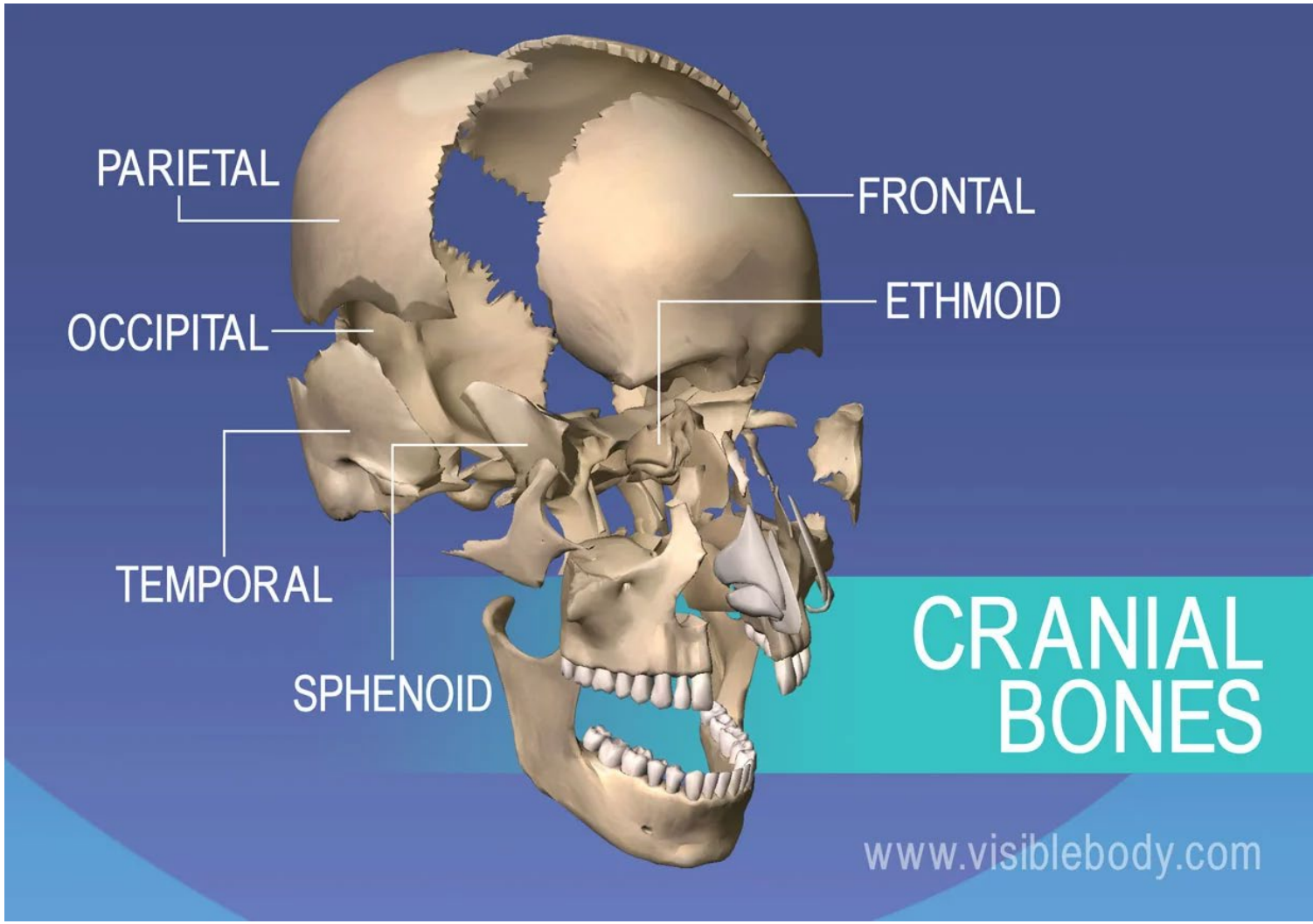
- The facial skeleton is formed by the mandible, maxillae (r,l), and the zygomatics (r,l),
- The bones that give shape to the nasal cavity



CRANIAL BONES

The eight cranial bones support and protect the brain:

- Occipital bone
- Parietal bone (r,l)
- Temporal bone (r,l)
- Frontal bone
- Ethmoid



SKULL SUTURES - In fetuses and newborn infants, cranial bones are connected by flexible fibrous sutures, including large regions of fibrous membranes called <u>fontanelles.</u>

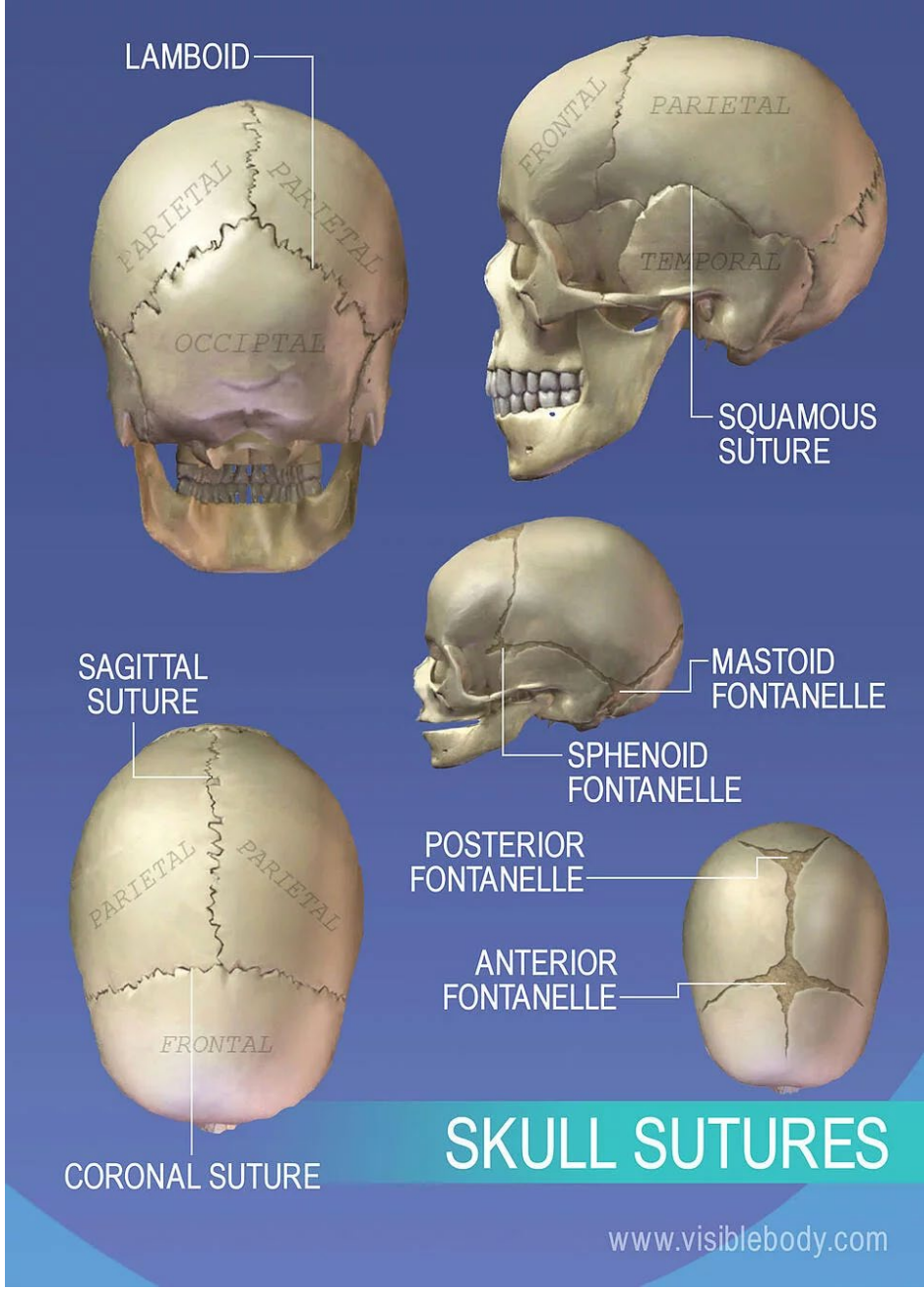
These regions allow the skull to enlarge to accommodate the growing brain.

The sphenoidal, mastoid, and posterior fontanelles close after two months, while the anterior fontanelle may exist for up to two years.

As fontanelles close, sutures develop. Skull sutures are immobile joints where cranial bones are connected with dense fibrous tissue.

The four major cranial sutures are:

- **lambdoid suture** (between the occipital and parietal bones)
- **coronal suture** (between the frontal and parietal bones)
- **sagittal suture** (between the two parietal bones)
- **squamous sutures** (between the temporal and parietal bones)



https://www.youtube.com/watch?v=tM3OQR_7u4Q

The Hyoid Bone, Laryngeal Skeleton, and Bones of the Inner Ear Are Commonly Categorized with Skull Bones

BONES OF THE INNER EAR

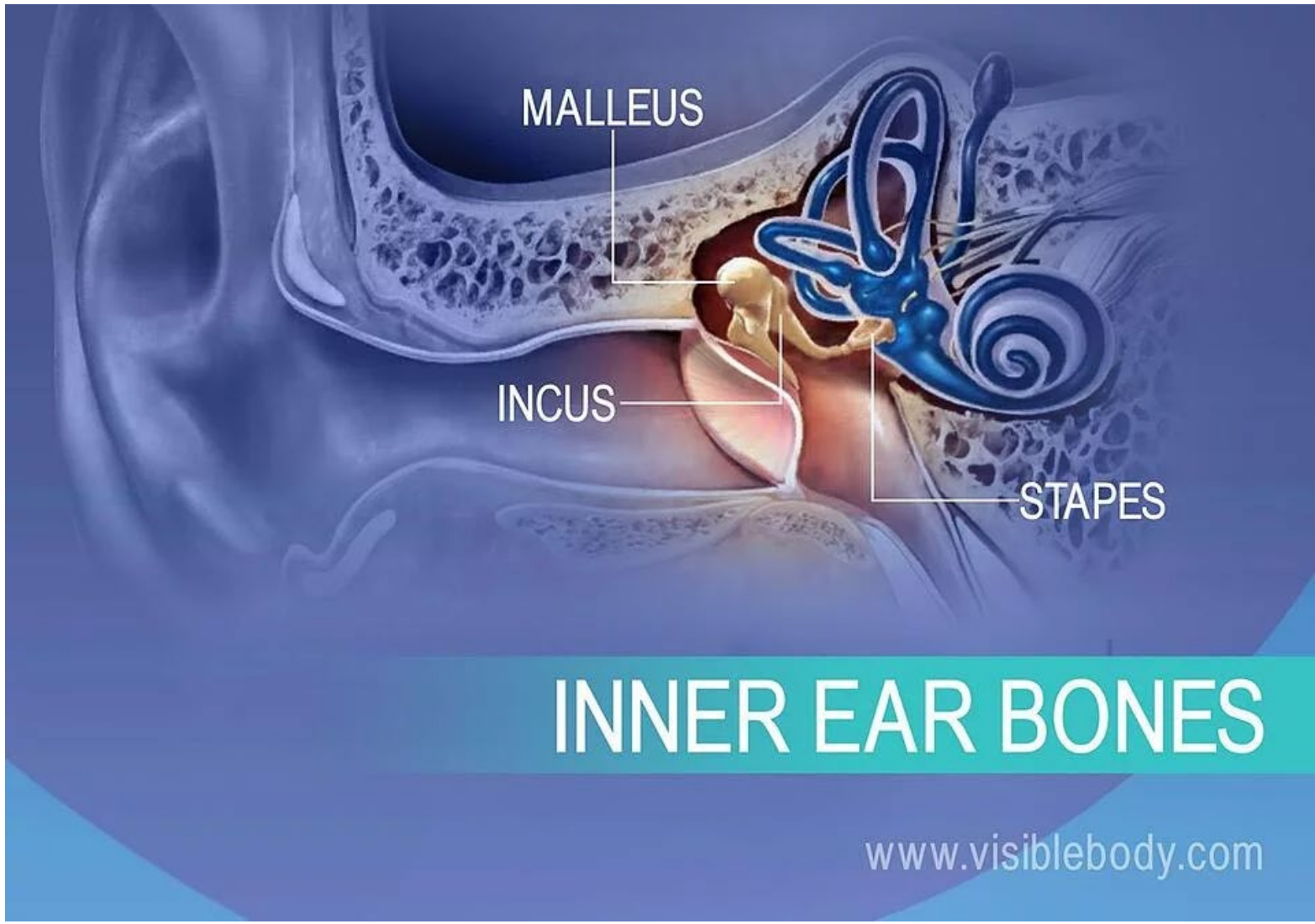
Inside the petrous part of the temporal bone are the three smallest bones of the body:

Malleus

Incus

Stapes (this is the smallest bone in the body !!)

These three bones articulate with each other and transfer vibrations from the tympanic membrane to the inner ear.



The laryngeal skeleton, also known as the larynx or voice box, is composed of nine cartilages.

It is located between the trachea and the root of the tongue.

The hyoid bone provides an anchor point.

The movements of the laryngeal skeleton both open and close the glottis and regulate the degree of tension of the vocal folds, which–when air is forced through them– produce vocal sounds.

THE BONES OF THE VERTEBRAL COLUMN: THE VERTEBRAE, SACRUM, AND COCCYX

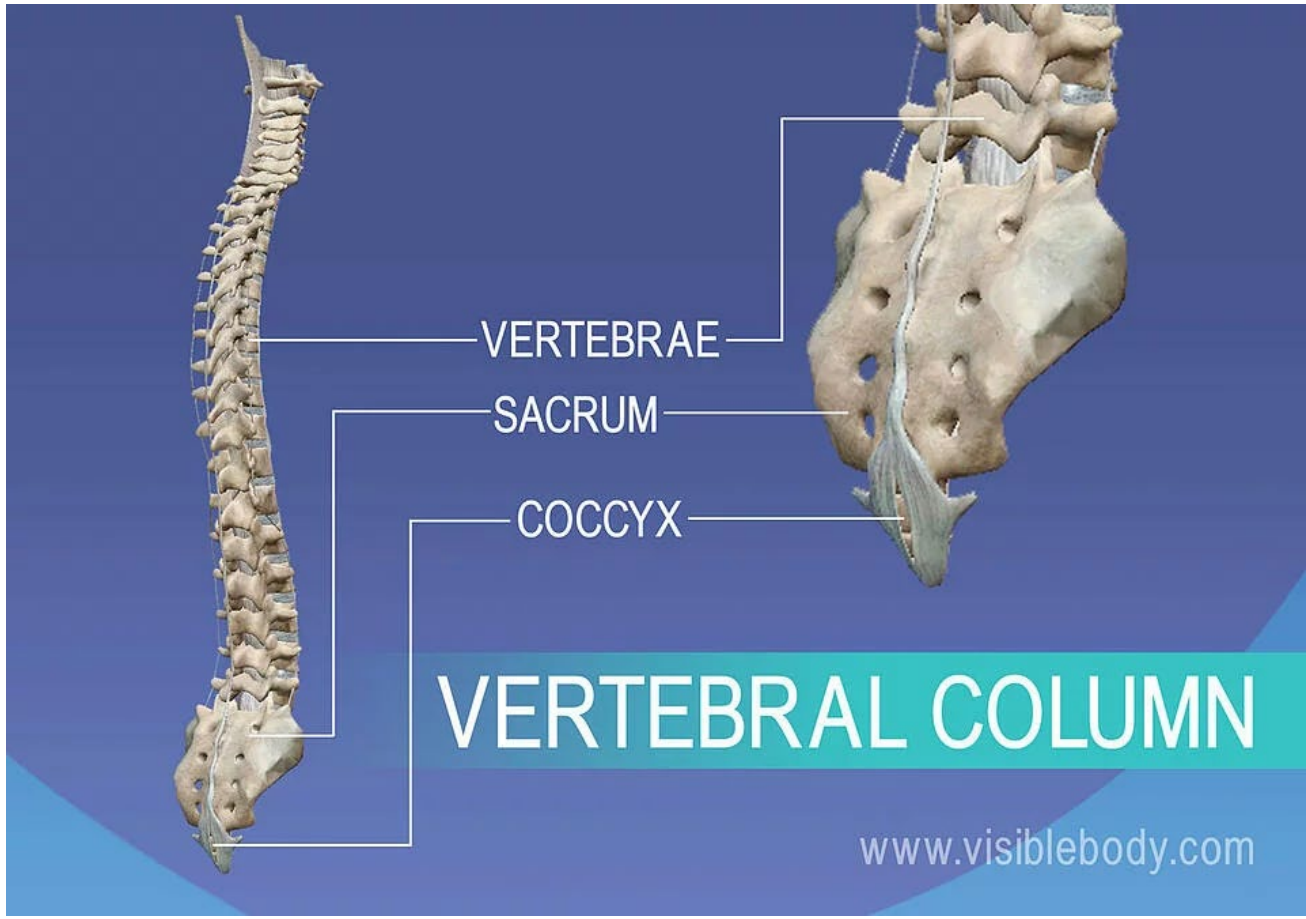
The vertebral column is a flexible column formed by a series of 24 vertebrae, plus the sacrum and coccyx.

Commonly referred to as the spine, the vertebral column extends from the base of the skull to the pelvis.

The spinal cord passes from the foramen magnum of the skull through the vertebral canal within the vertebral column.

The vertebral column is grouped into five regions:

- cervical spine (C01-C07),
- thoracic spine (T01- T-12
- lumbar spine (L01-L05)
- sacral spine
- coccygeal spine



The spine is also known as the spinal or vertebral column, or simply “the backbone”. This strong yet flexible central support holds the head and torso upright yet allows the neck and back to bend and twist.

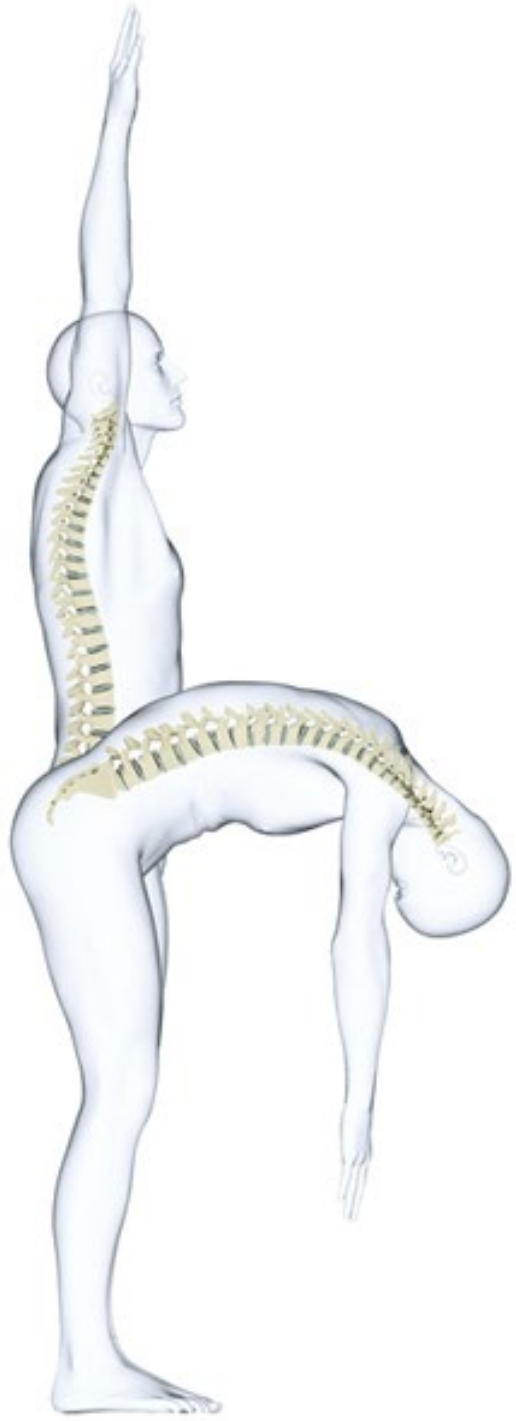
Spine function

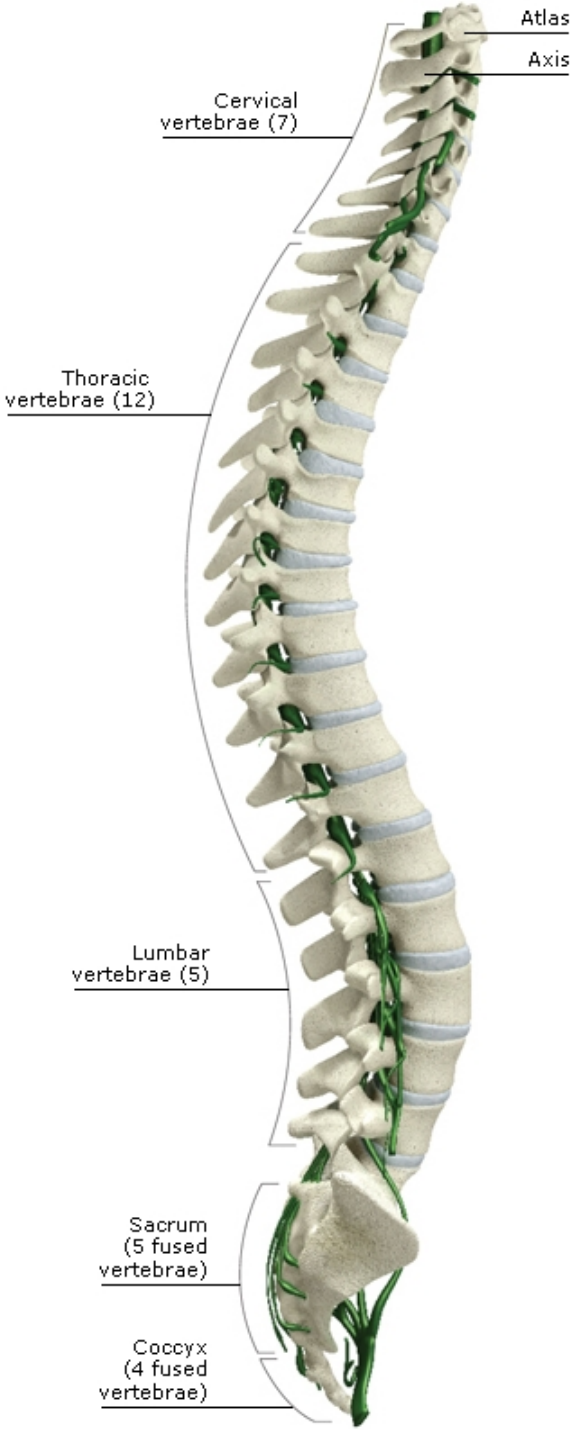
The spine consists of 33 ring-like bones called vertebrae.

With the S shape, it acts like a spring and can flex when we are young and jump off of something.

If it was straight up and down, it could break easily.

The bottom nine vertebrae are fused into two larger bones termed the sacrum and the coccyx, leaving 26 movable components within the spine.

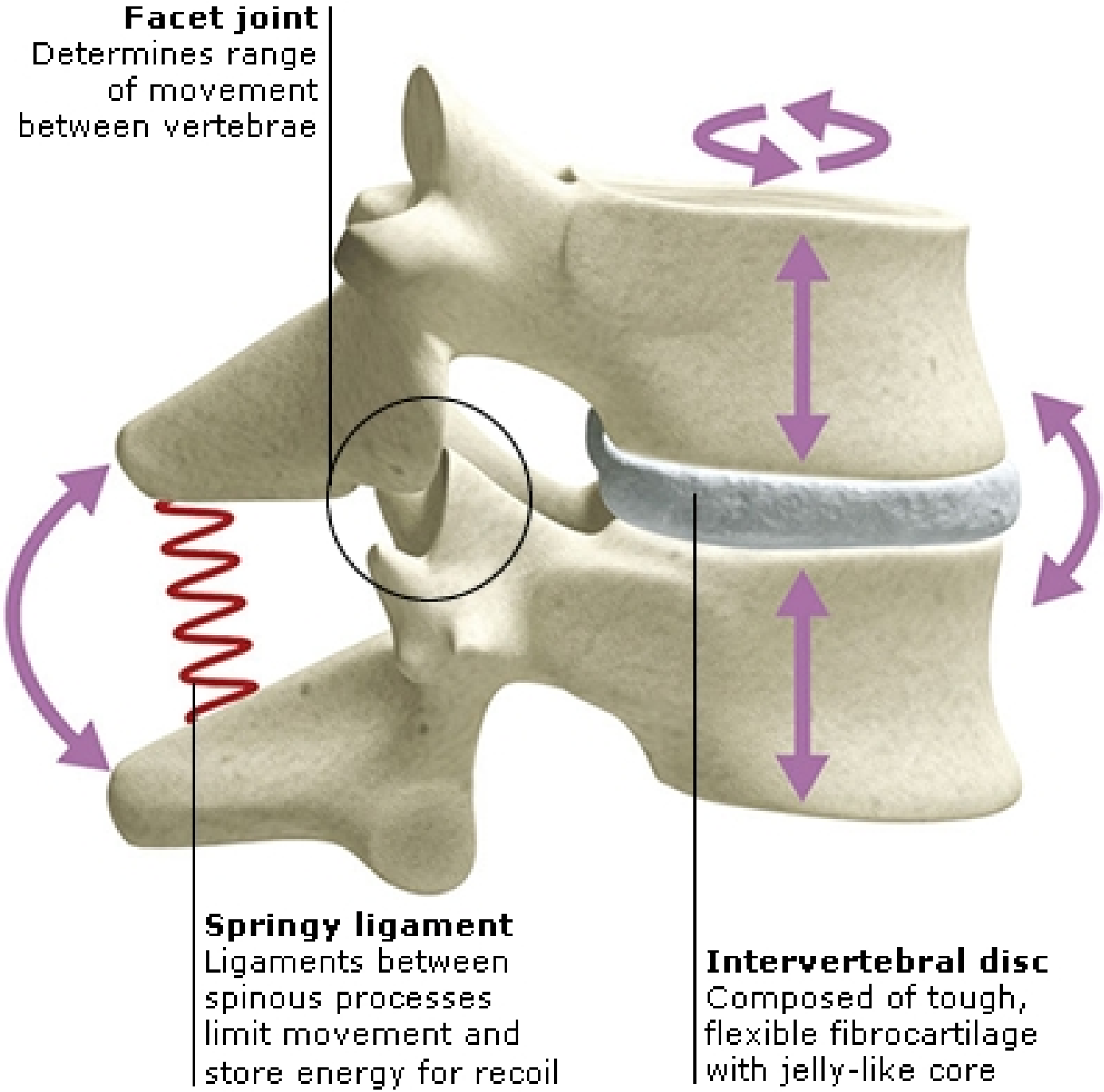




Spinal joints

Spinal joints do not have a wide range of movement, but they still allow the spine great flexibility, letting it arch backwards, twist, and curve forward.

Two facet joints help to prevent slippage and torsion.



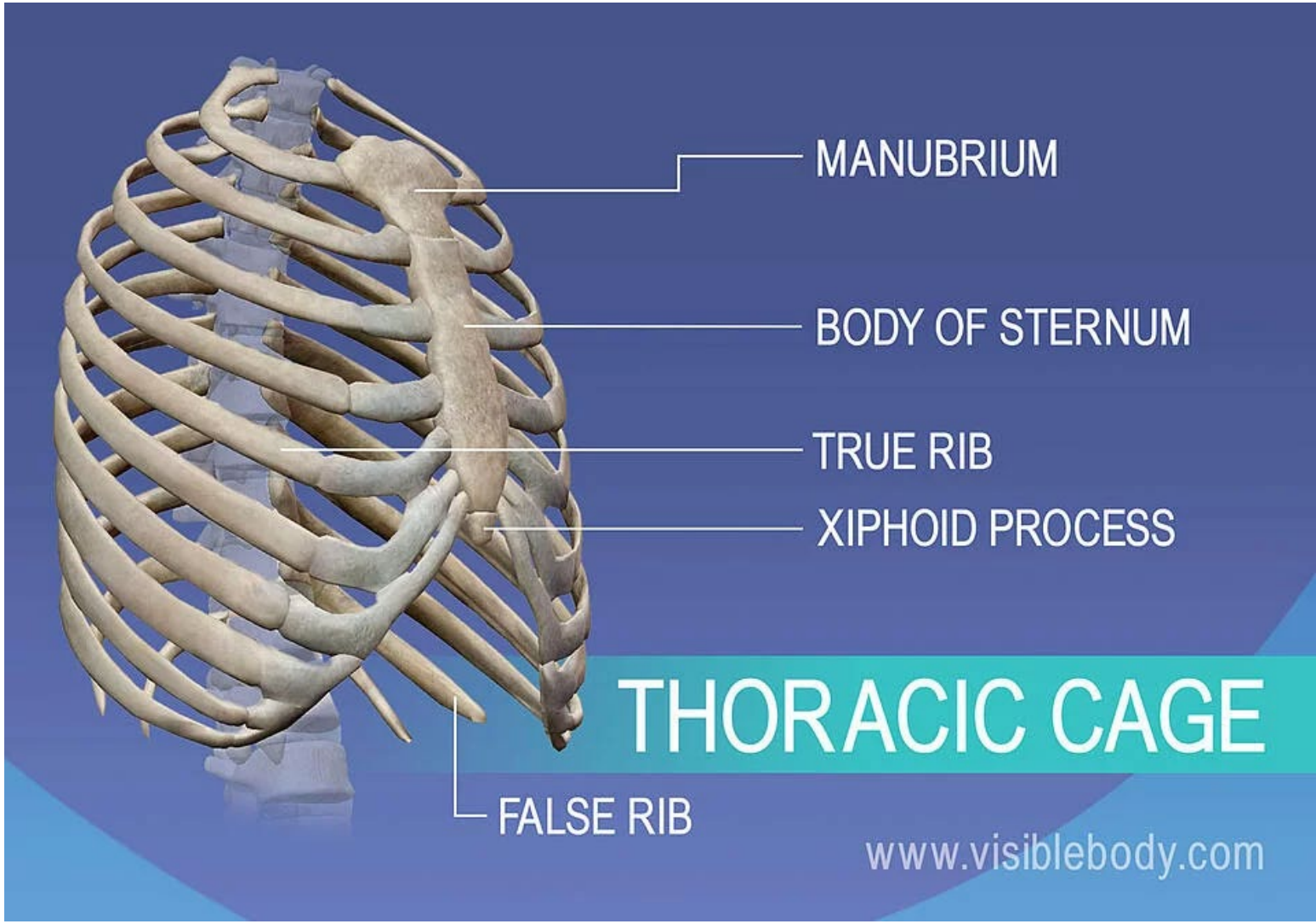
THE BONES OF THE THORACIC CAGE PROTECT INTERNAL ORGANS

The **thoracic cage**, formed by the ribs and sternum, protects internal organs and gives attachment to muscles involved in respiration and upper limb movement.

The **sternum** consists of the manubrium, body of the sternum, and xiphoid process.

Ribs 1-7 are called true ribs because they articulate directly to the sternum

Ribs 8-12 are known as false ribs.



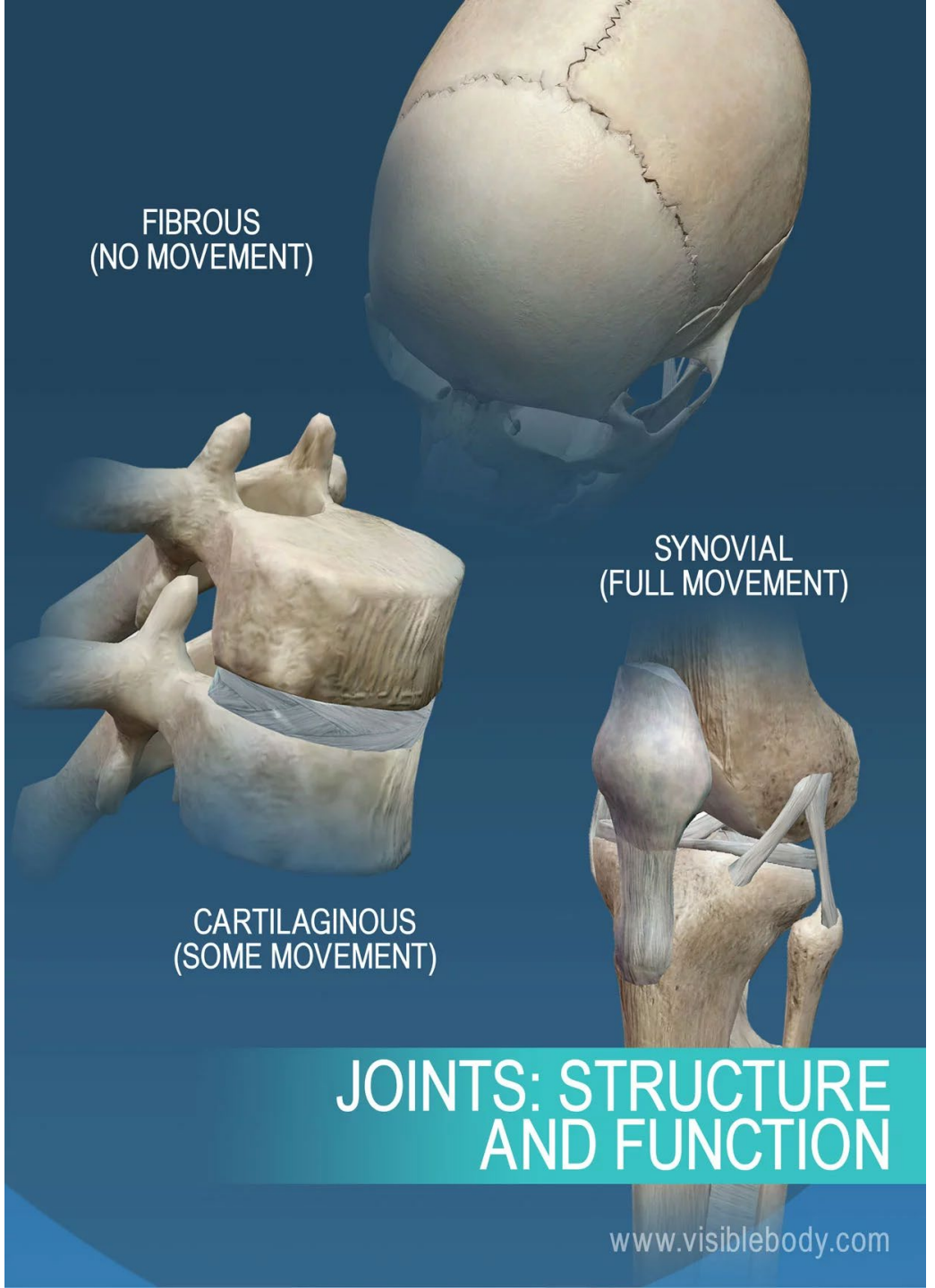
BONES COME TOGETHER: TYPES OF JOINTS IN THE HUMAN BODY

Joints hold the skeleton together and support movement. **There are two ways to categorize joints.** The **first** is by **joint function**, **also referred to as range of motion.**

The **second** way to categorize joints is by **the material that holds the bones of the joints together**; that is an organization of joints by structure.

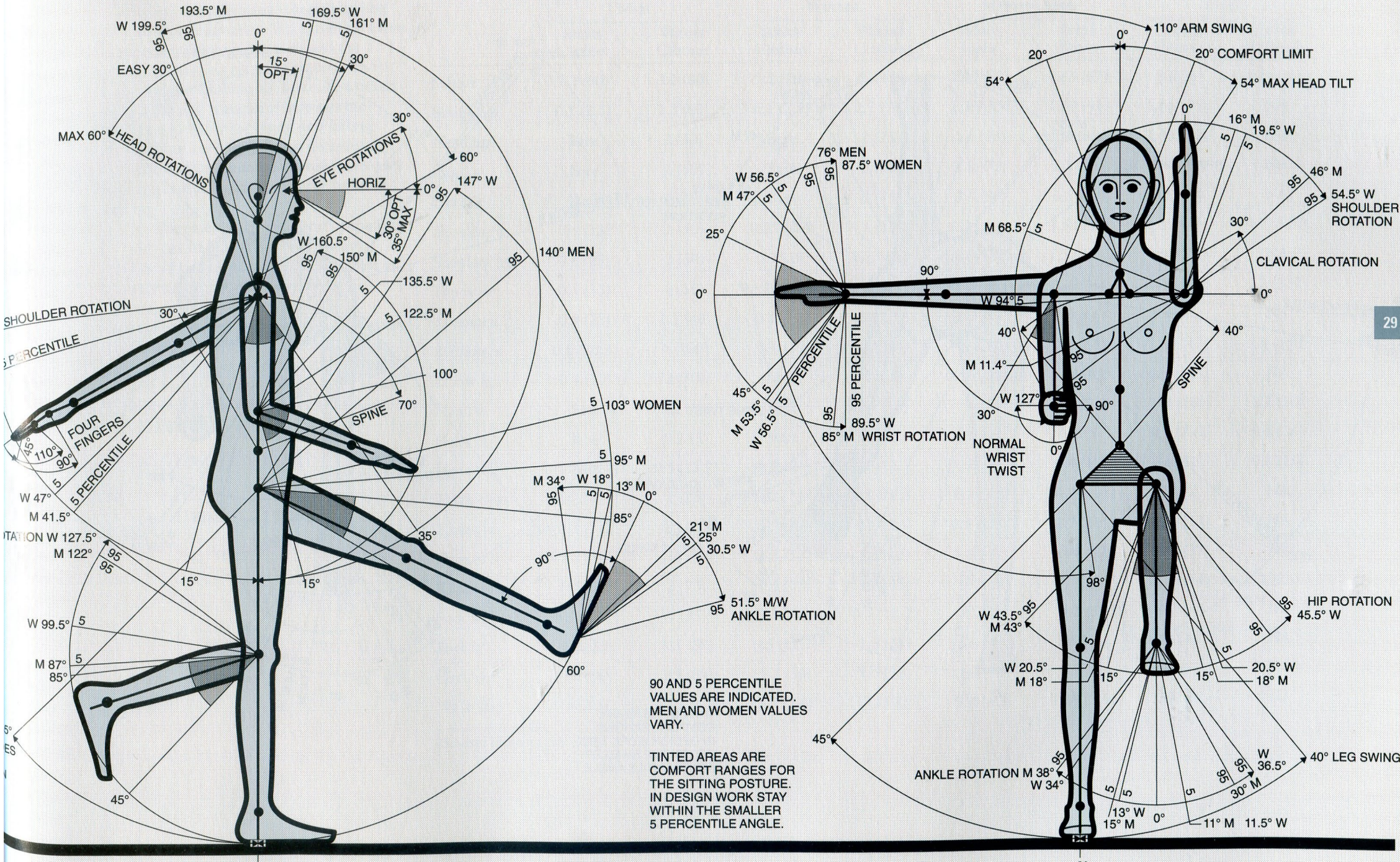
Joints in the human skeleton can be grouped by function (range of motion) and by structure (material).

Joint	**Range of Motion and Material**
Skull Sutures	Immovable fibrous joints
Knee	Full movement synovial capsule hinge joint
Vertebrae	Some movement - cartilaginous joint



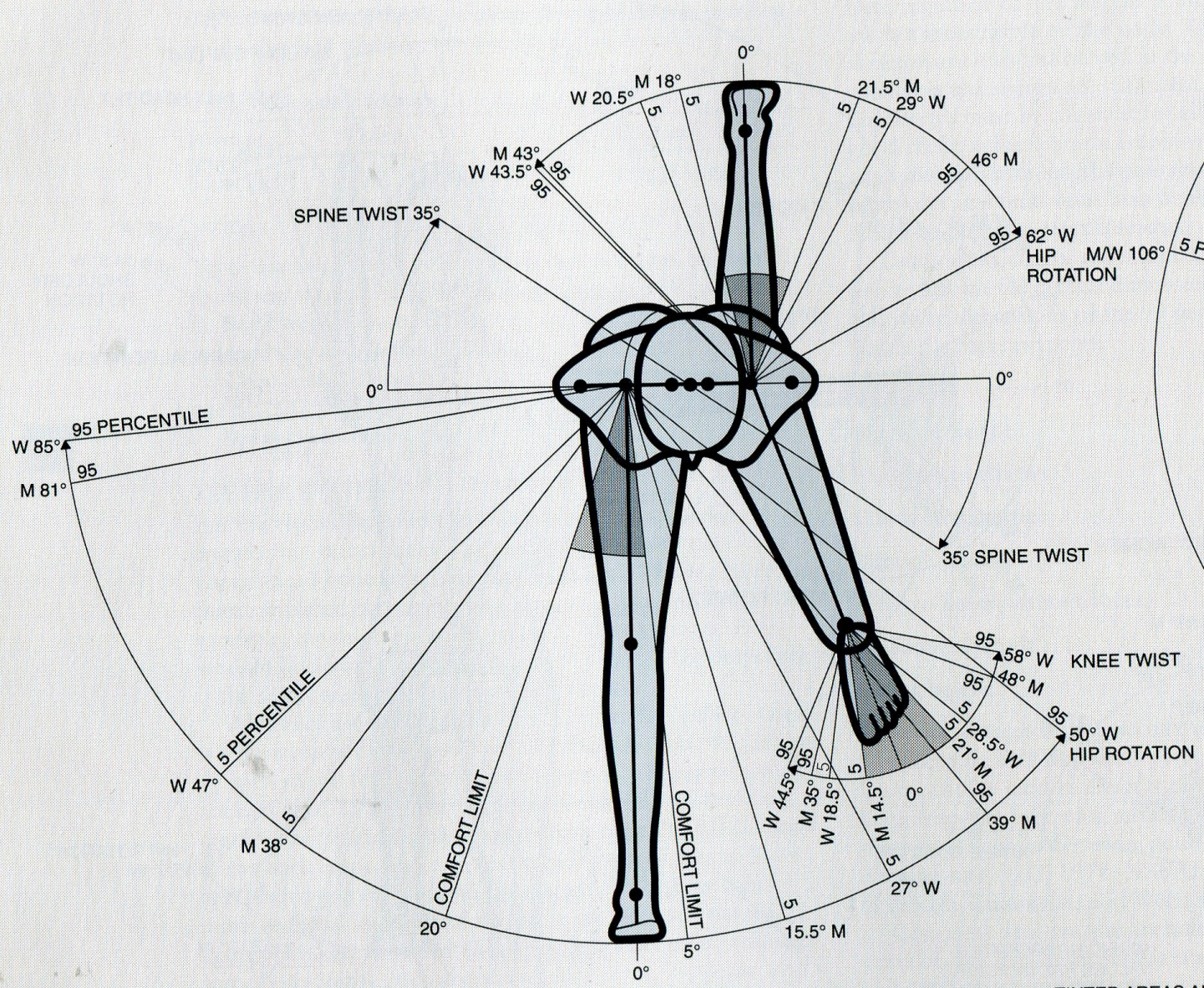
JOINTS CAN ALSO BE GROUPED BY THEIR FUNCTION INTO 3 RANGES OF MOTION

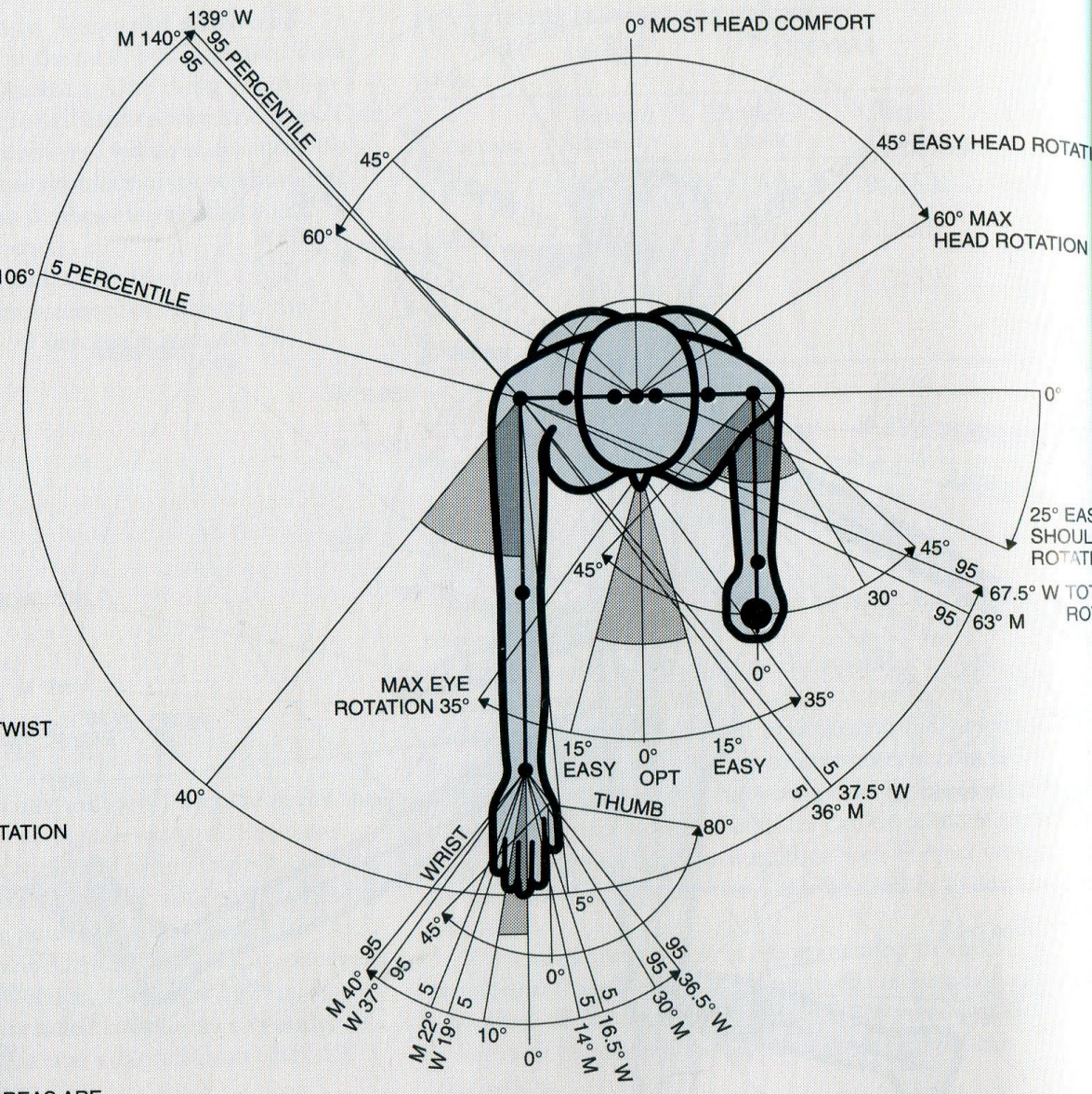
- Immovable joints
- Joints that allow a **slight movement**
- Joints allowing **full movement** include many bone articulations in the upper and lower limbs, such as the elbow, shoulder, and ankle.



90 AND 5 PERCENTILE VALUES ARE INDICATED. MEN AND WOMEN VALUES VARY.

TINTED AREAS ARE COMFORT RANGES FOR THE SITTING POSTURE. IN DESIGN WORK STAY WITHIN THE SMALLER 5 PERCENTILE ANGLE.





TINTED AREAS ARE
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JOINTS CAN BE GROUPED BY THEIR STRUCTURE INTO FIBROUS, CARTILAGINOUS, AND SYNOVIAL JOINTS

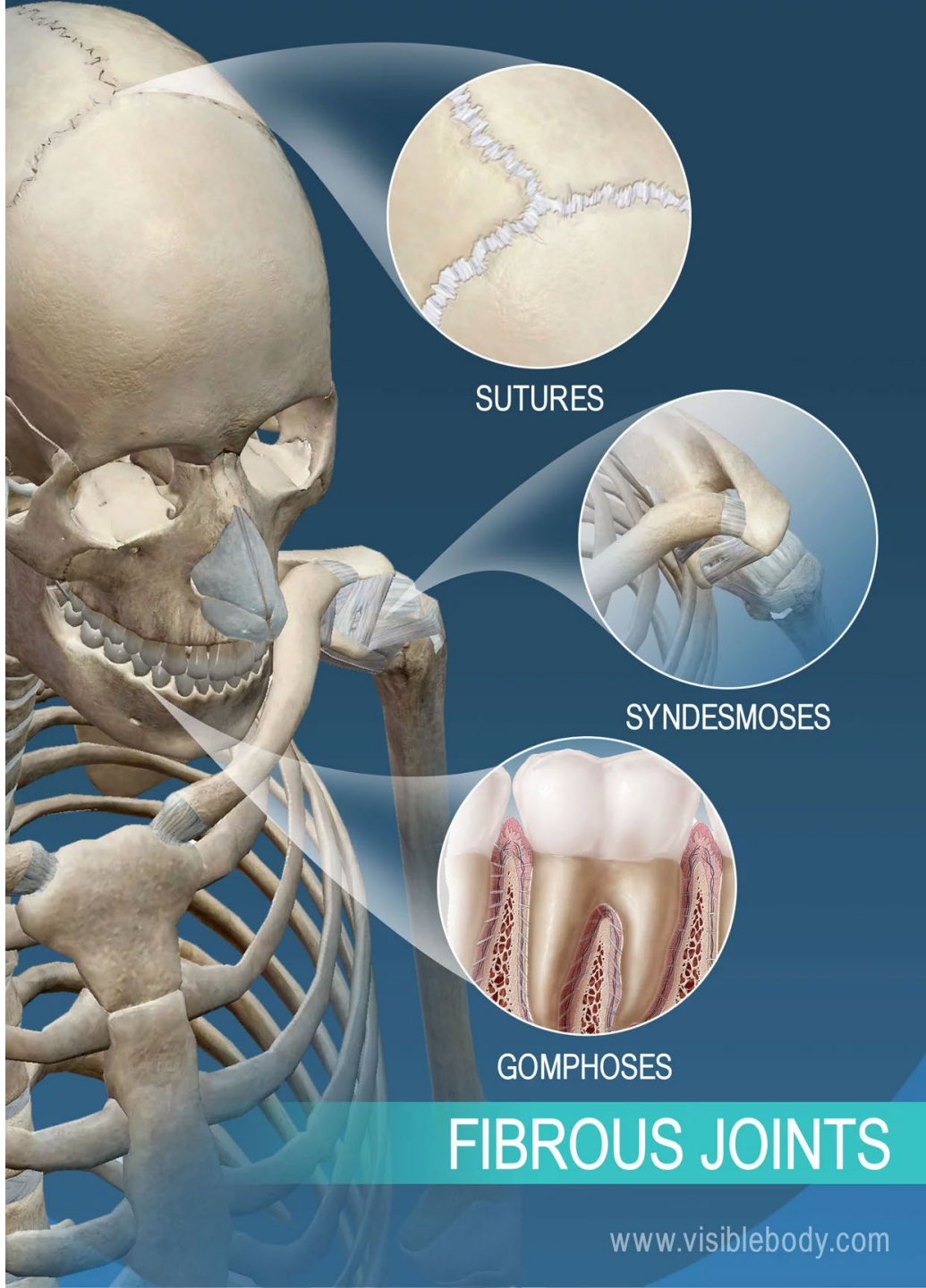
Fibrous Joints – Most of these have thick connective tissue between them which is why most are immovable.

There are three types of fibrous joints:

(1) **Sutures** are nonmoving joints that connect bones of the skull.

(2) **The fibrous articulations between the teeth and the mandible or maxilla**

(3) A **syndesmosis** is a joint in which a ligament connects two bones, allowing for a little movement



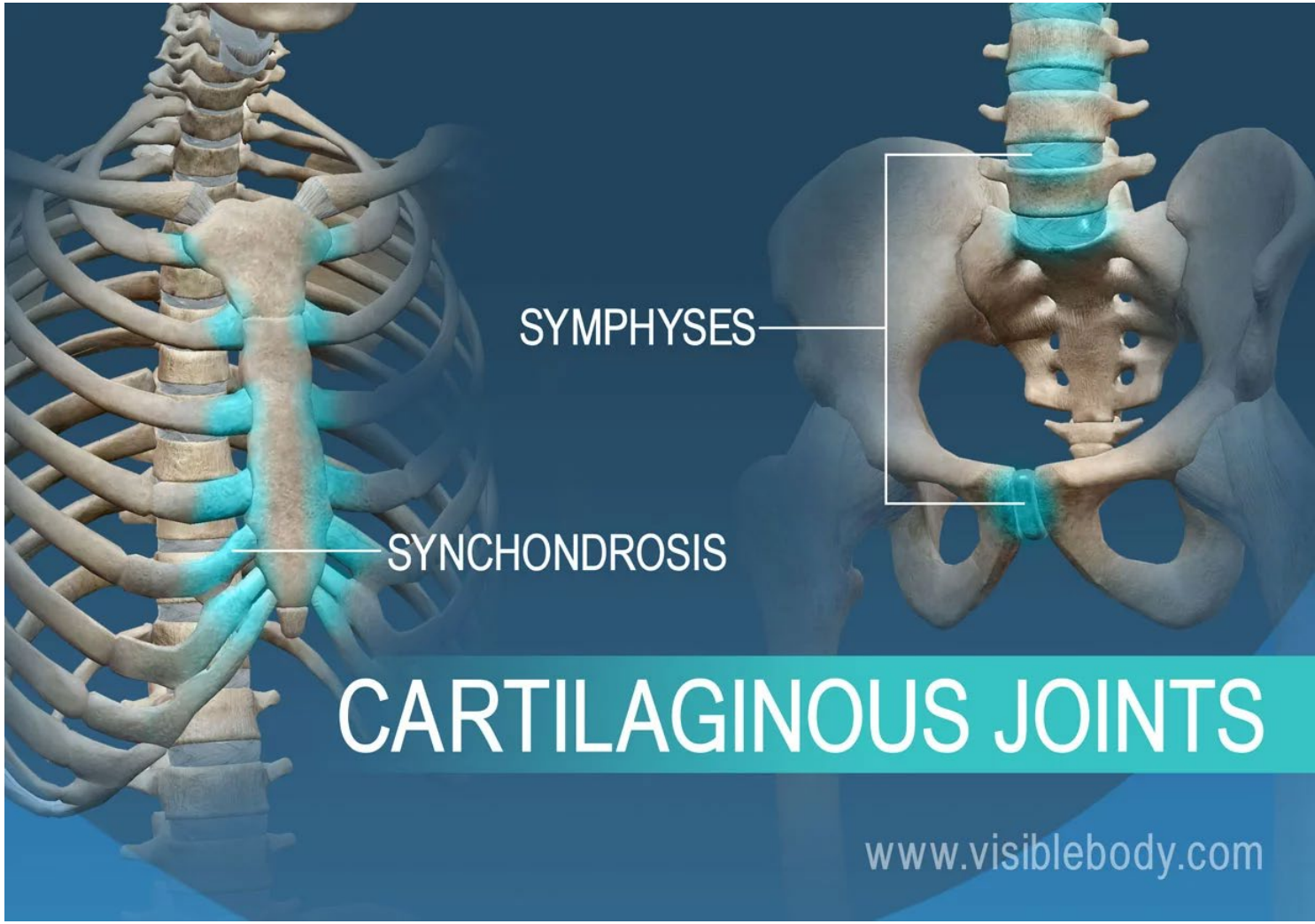
CARTILIGINOUS JOINTS.

Joints that unite bones with cartilage are called cartilaginous joints.

There are two types of cartilaginous joints:

(1) A synchrondosis is an immovable cartilaginous joint. One example is the joint between the first pair of ribs and the sternum.

(2) A symphysis consists of a compressible fibro-cartilaginous pad that connects two bones, such as the hip bones and the vertebrae.



SYNOVIAL JOINTS

Synovial joints are characterized by the presence of a capsule between the two joined bones.

Bone surfaces at synovial joints are protected by a coating of articular cartilage. Synovial joints are often supported and reinforced by surrounding ligaments, which limit movement to prevent injury.

There are six types of synovial joints:

(1) Gliding joints

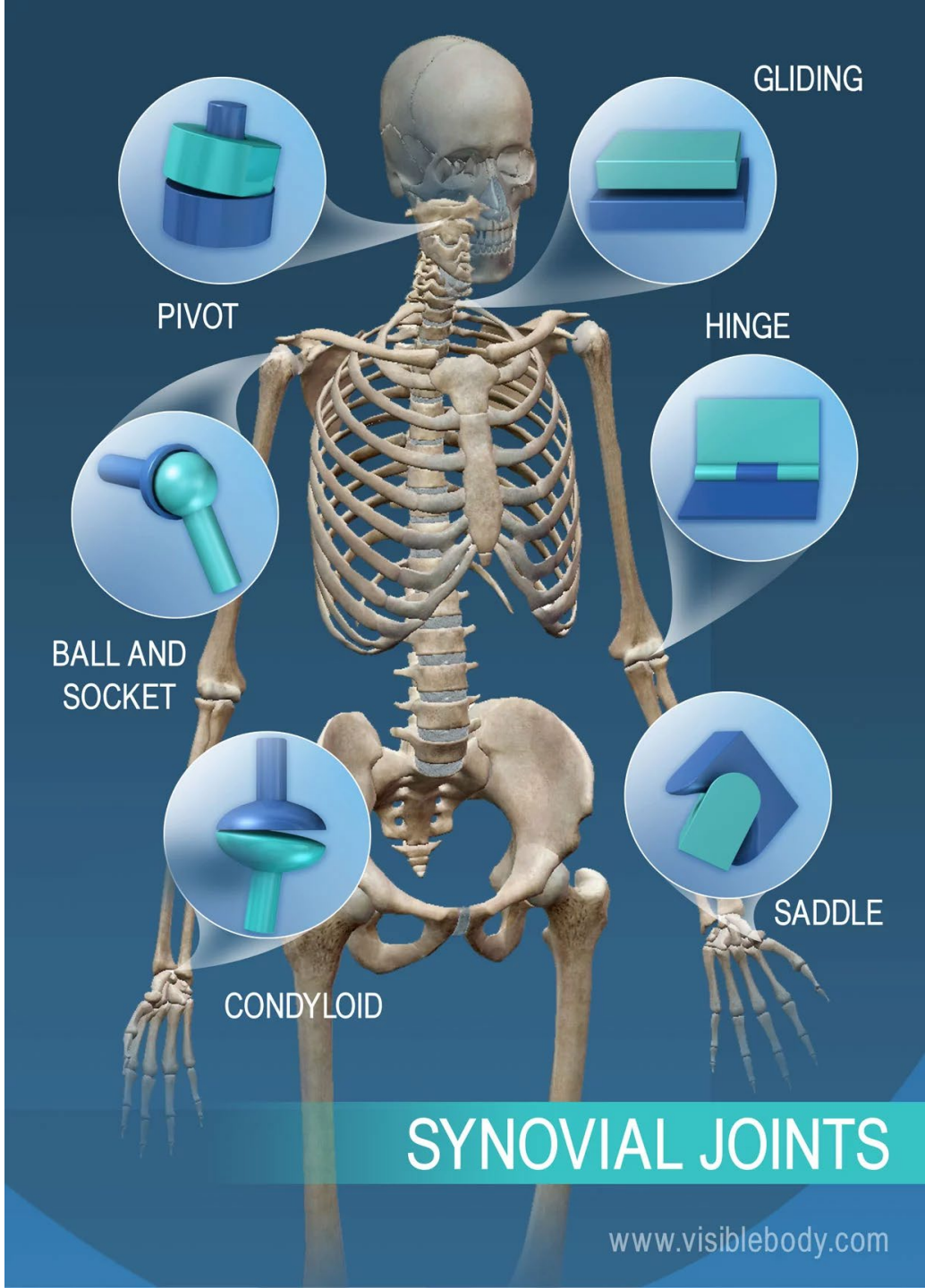
(2) Hinge joints

(3) A pivot *joint which provides rotation.*

(4) A condyloid joint allows for circular motion, flexion, and extension

(5) A saddle joint

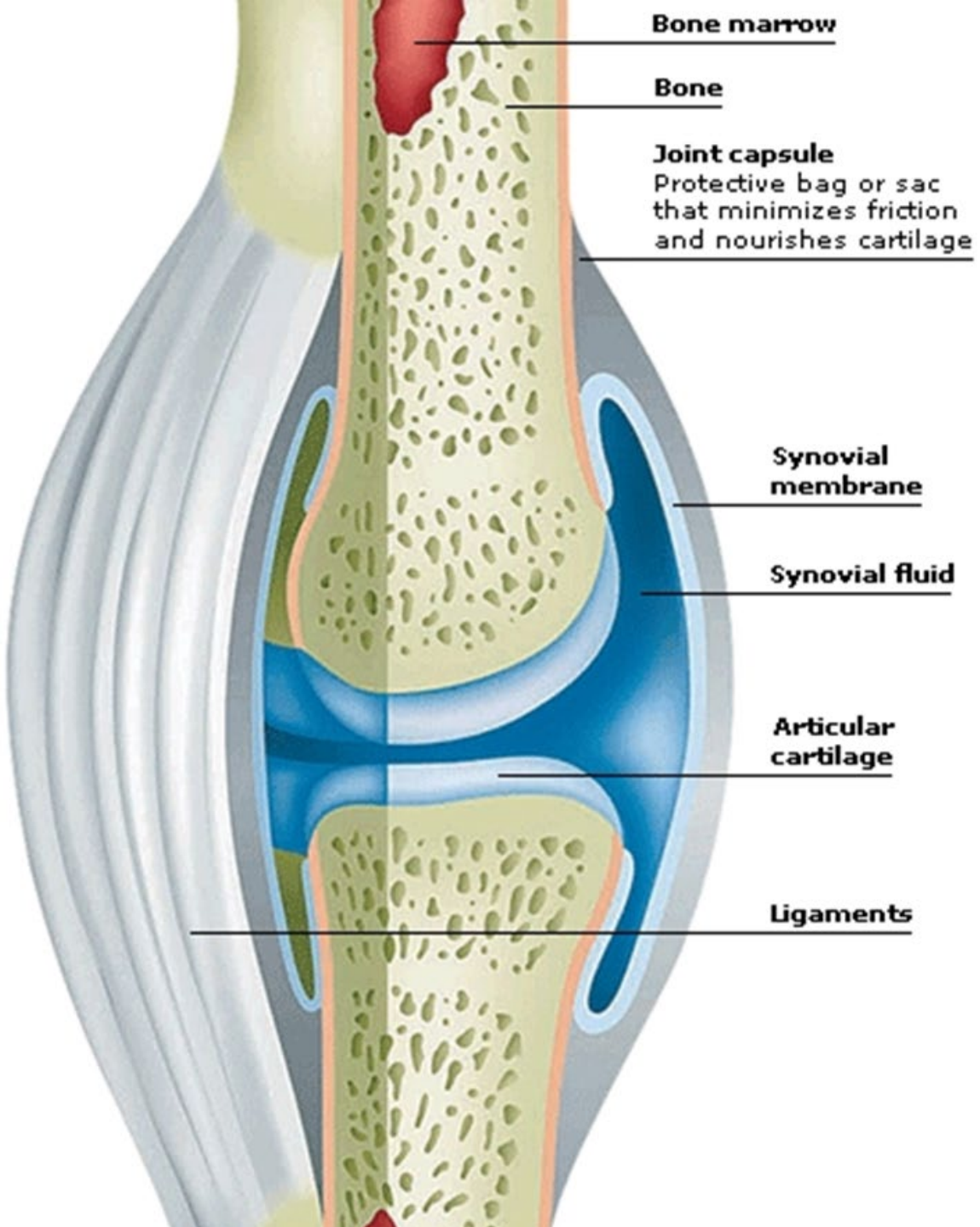
(6) The ball-and-socket joint such as in the hip and shoulder



Synovial joints are enclosed by a protective outer covering – **the joint capsule.**

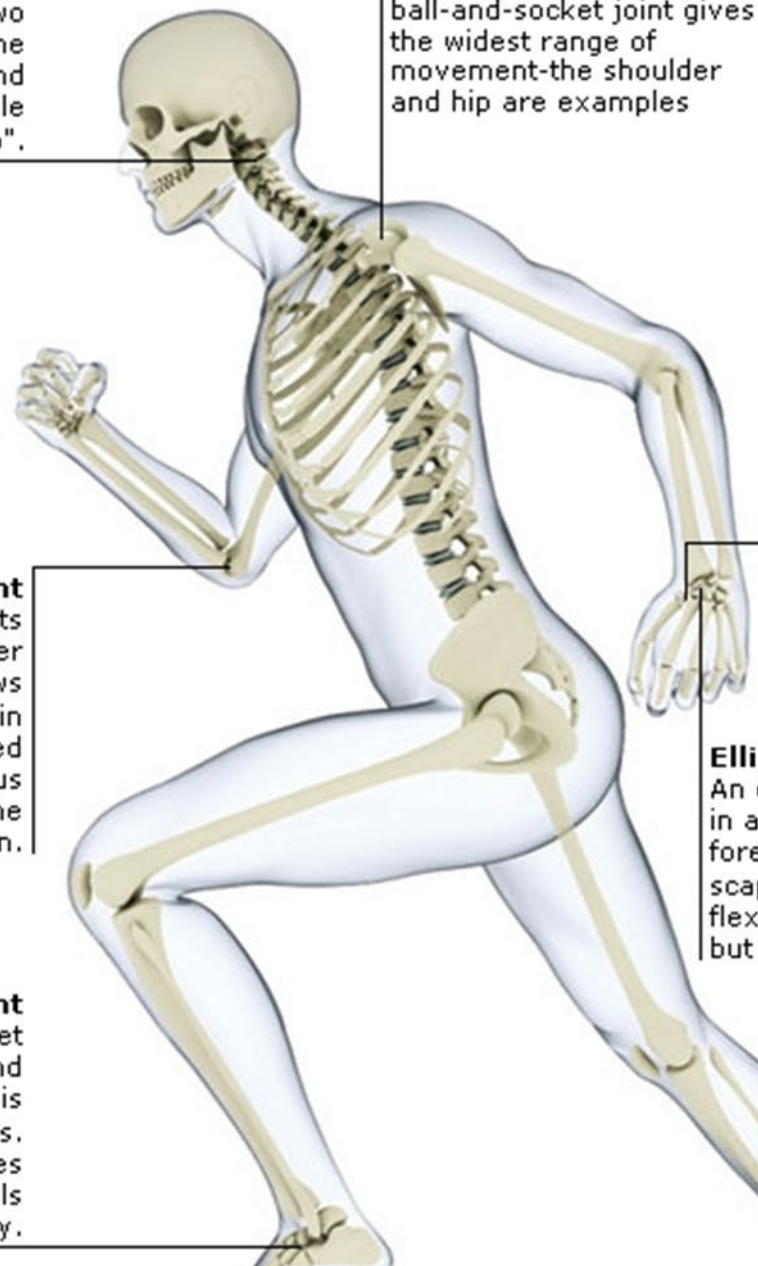
The capsule's inner lining, called the **synovial membrane**, produces slippery, oil-like synovial fluid that keeps the joint well lubricated so that the joint surfaces in contact slide with minimal friction and wear.

There are around 230 synovial joints in the body.



Pivot joint
A peg-like projection from one bone that turns in the ring-shaped socket of another bone, or conversely, the ring turns around the bony projection. The pivot joint between the top two neck (cervical) vertebrae enables the skull to rotate on the spinal axis,and move from side to side, for example when shaking the head to indicate "no".

Ball-and-socket joint
The ball-shaped head of one bone fits into the cup-like cavity of another. Of all joint structures, a ball-and-socket joint gives the widest range of movement-the shoulder and hip are examples



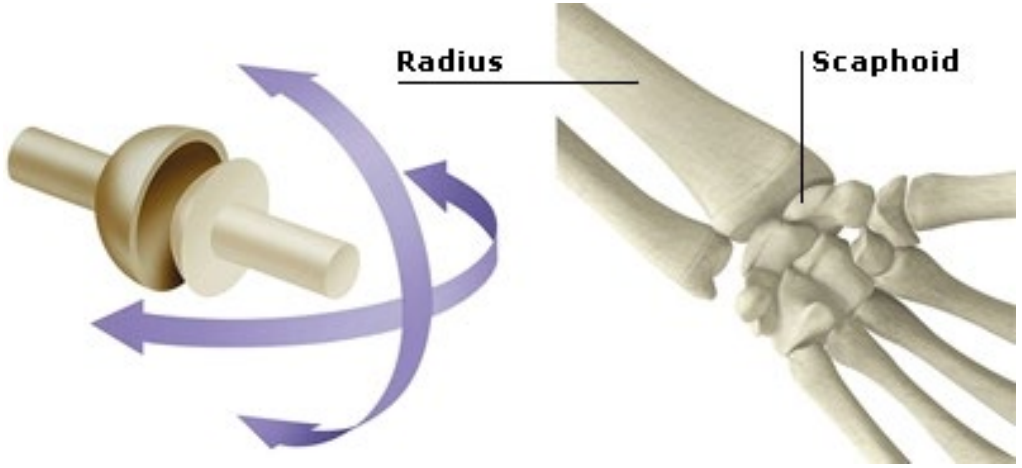
Saddle joint
Each bone's joint surface has both concave and convex areas, like a horse saddle, so the bones can slide back and forth and from side to side, but with limited rotation. The main saddle joint is the base of the thumb.

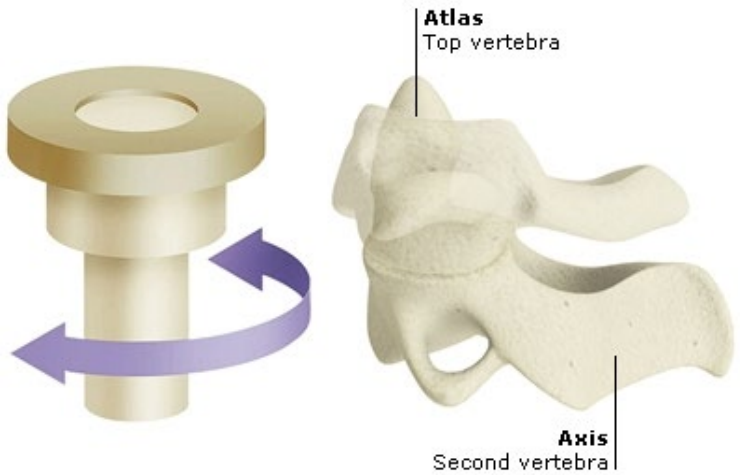
Hinge joint
The convex surface of one bone fits into the concave surface of another bone to form a hinge joint. This allows for to-and-fro movement mainly in one plane. The elbow is a modified hinge joint: the twisting of the radius and ulna in the forearm against the humerus permits limited rotation.

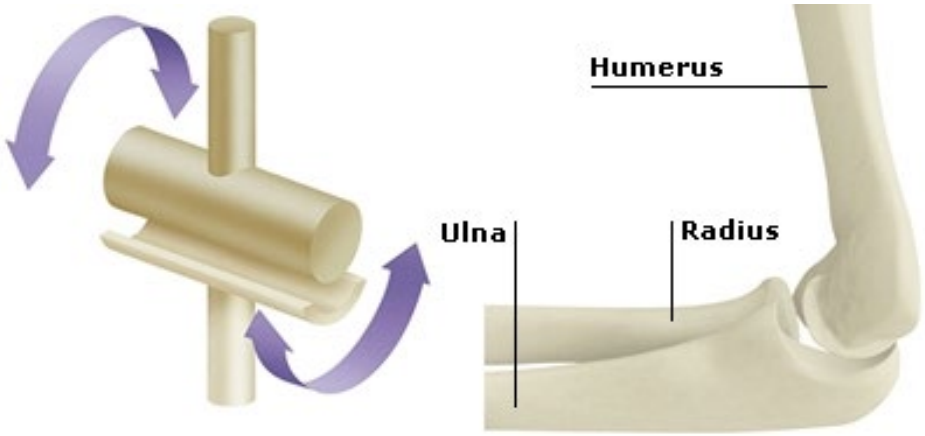
Ellipsoidal joint
An ovoid (egg-shaped) bone end nestles in an ellipsoidal cavity, such as where the forearm's radius bone meets the wrist's scaphoid bone. This type of joint can be flexed and moved from side to side, but rotation is limited.

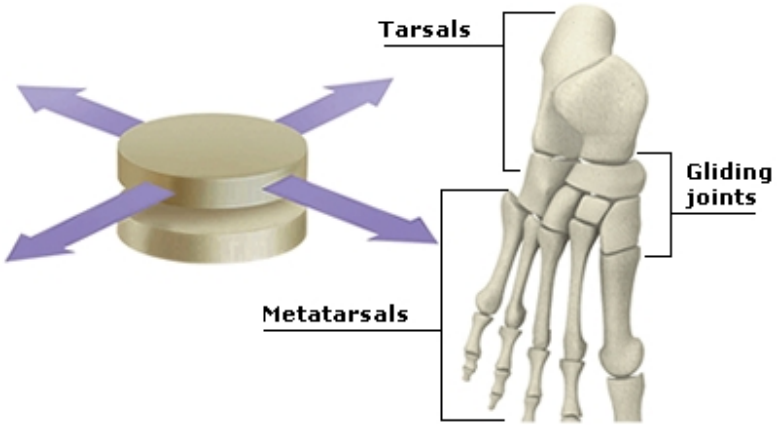
Gliding joint
The two surfaces of bones that meet in a gliding joint are almost flat and slide over each other. Movement is limited by strong encasing ligaments. Some joints between the tarsal bones of the ankle and between the carpals in the wrist move in this way.

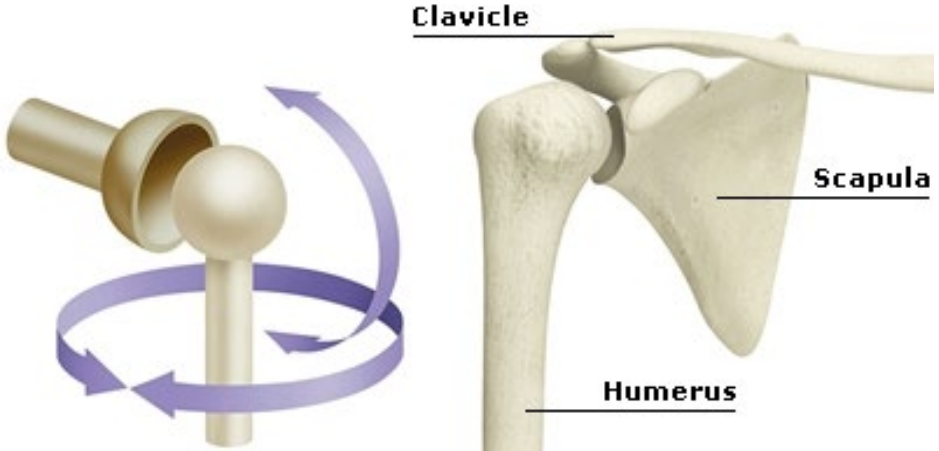
THE 6 BONE JOINTS

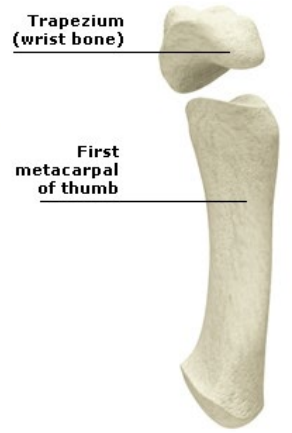












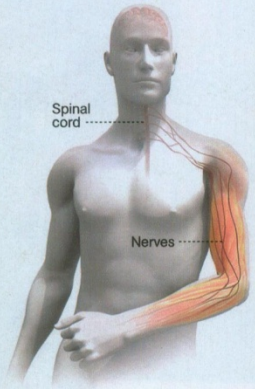
Closing In on a Lifelike Limb

THE ABILITIES OF TODAY'S PROTO 1 BIONIC ARM WILL TRIPLE IN THE NEXT PROTOTYPE.

HUMAN ARM

22+ MOVEMENTS

From the shoulder to a finger's last joint, an arm has at least 22 points of movement. Nerves carry the brain's instructions from the spinal cord to the muscles.



TRADITIONAL PROSTHESIS

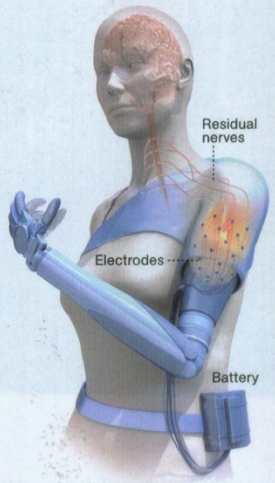
3 MOVEMENTS

Still the only device available to most amputees, the pincer-hand prosthesis relies on cables moved by pressing levers on a harness with the chin or other arm.

PROTO 1

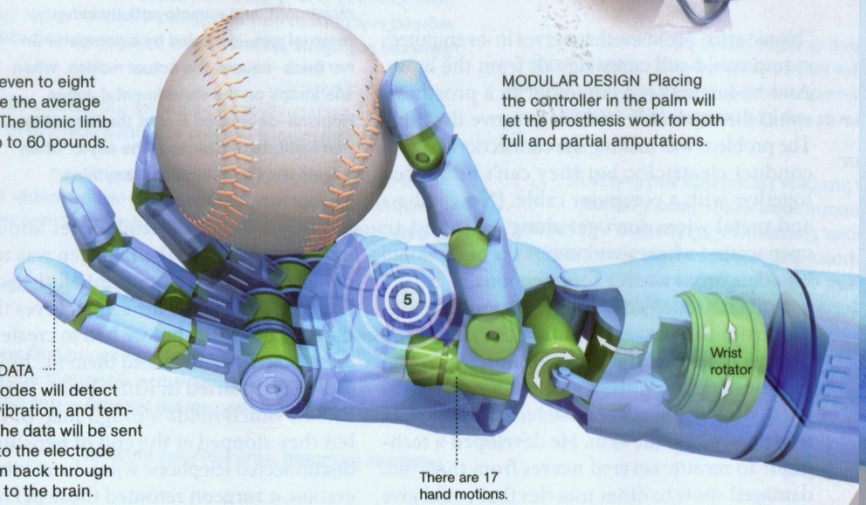
7 MOVEMENTS

Nerves that once reached the lower arm are rerouted into other muscles. Electrodes placed on those muscles capture the brain's commands and relay them by wires in the prosthesis.



WEIGHT Seven to eight pounds, like the average adult arm. The bionic limb can curl up to 60 pounds.

MODULAR DESIGN Placing the controller in the palm will let the prosthesis work for both full and partial amputations.



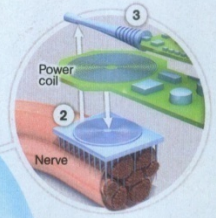
SENSORY DATA
Fingertip nodes will detect pressure, vibration, and temperature. The data will be sent wirelessly to the electrode arrays, then back through the nerves to the brain.

There are 17 hand motions.

MODULAR PROSTHETIC LIMB

UP TO 22 MOVEMENTS

Nerves running from the spinal cord (1) will send the brain's commands to electrode arrays implanted in the residual nerves (2). A computer chip on each array sends data wirelessly to a receiver on the skin (3). The receiver wires the data to another chip (4) that decodes the command and wires it to the limb controller in the palm (5), which sets the motors in motion.



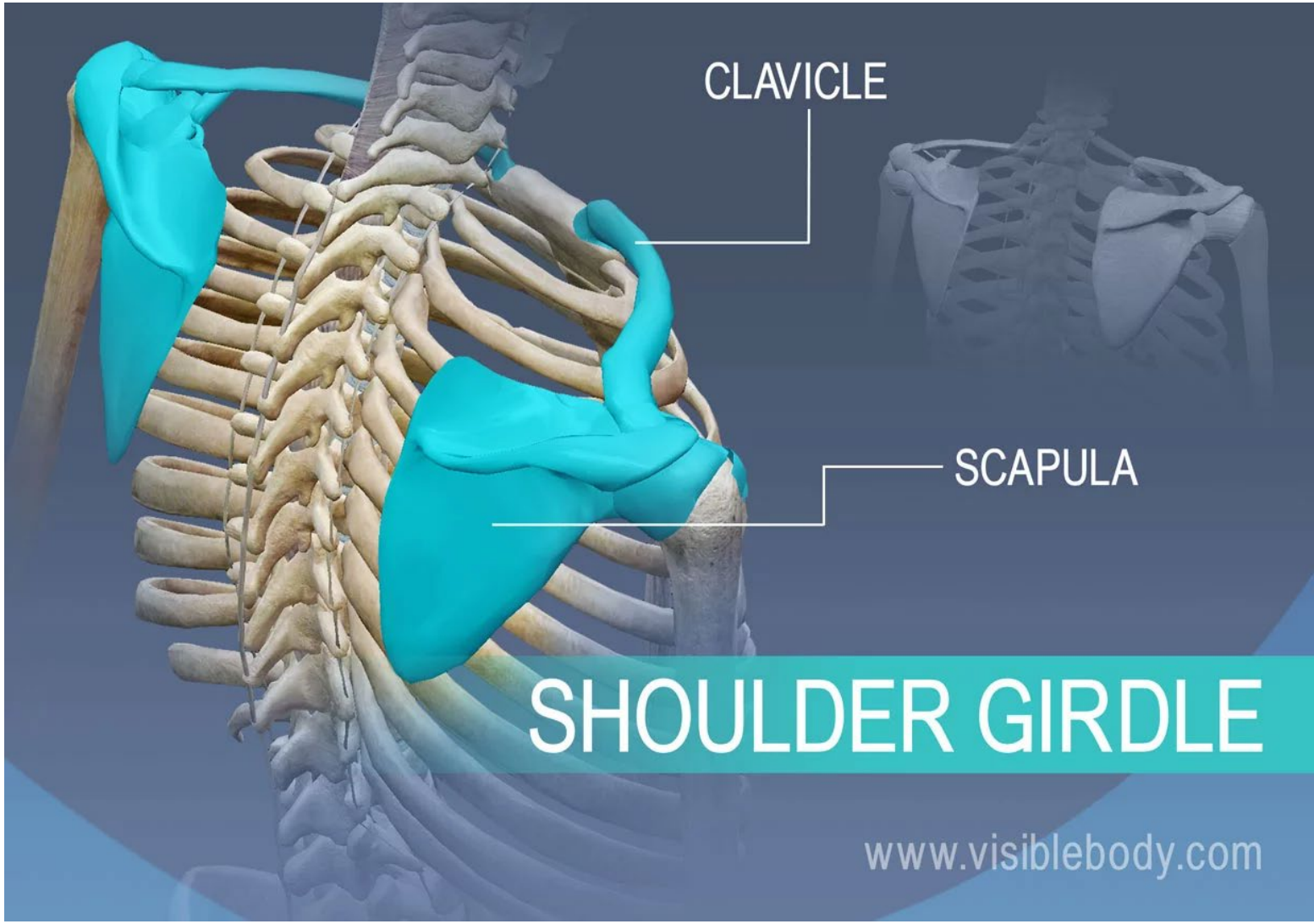
For amputees with severely damaged residual nerves, electrode arrays could be implanted in the brain. The brain's commands would be received by sensors in a cap and sent by wire to the arm.

THE BONES OF THE SHOULDER GIRDLE

The pectoral or shoulder girdle consists of the scapulae and clavicles.

The shoulder girdle connects the bones of the upper limbs to the axial skeleton.

These bones also provide attachment for muscles that move the shoulders and upper limbs.

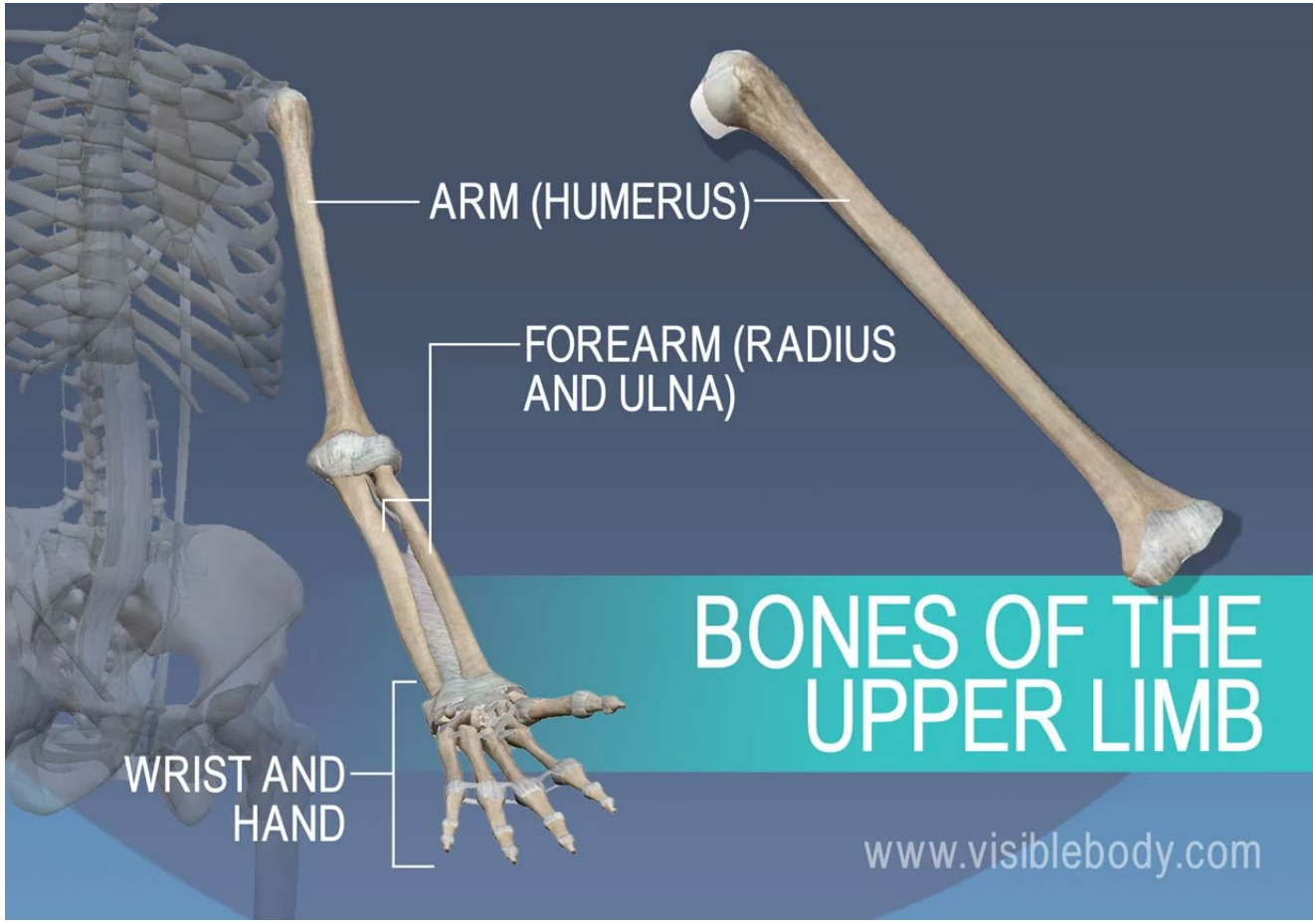


BONES OF THE UPPER LIMBS

The upper limbs include the bones of the arm (humerus), forearm (radius and ulna), wrist, and hand.

The only bone of the arm is the humerus, which articulates with the forearm bones–the radius and ulna–at the elbow joint.

The ulna is the larger of the two forearm bones.

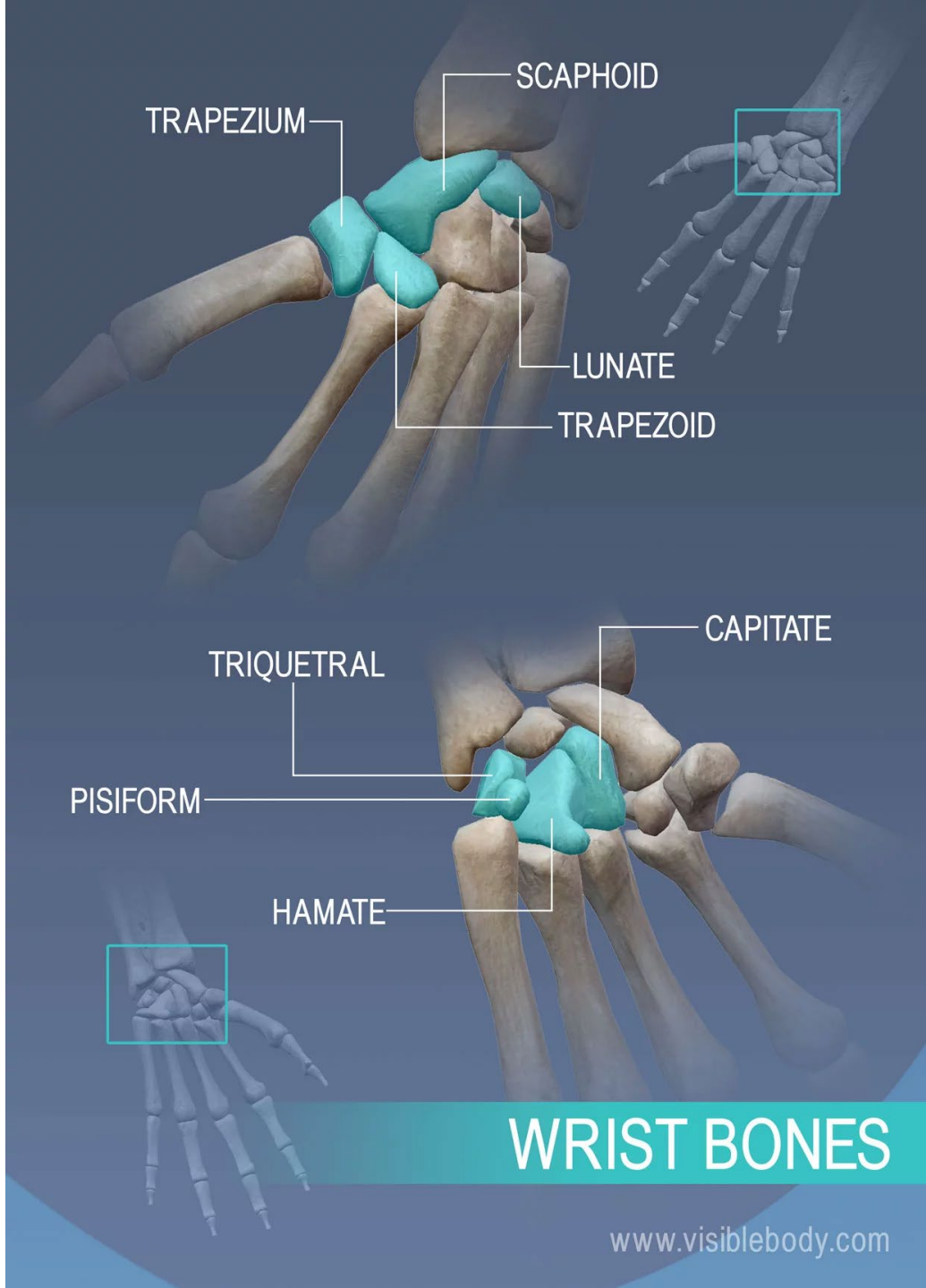


WRIST BONES.

The wrist, or carpus, consists of eight carpal bones.

One mnemonic to remember the carpal bones is the sentence: Some Lovers Try Positions That They Can't Handle.

The eight carpal bones of the wrist are the Scaphoid, Lunate, Triquetral, Pisiform, Trapezoid, Trapezium, Capitate, and Hamate.



HAND BONES.

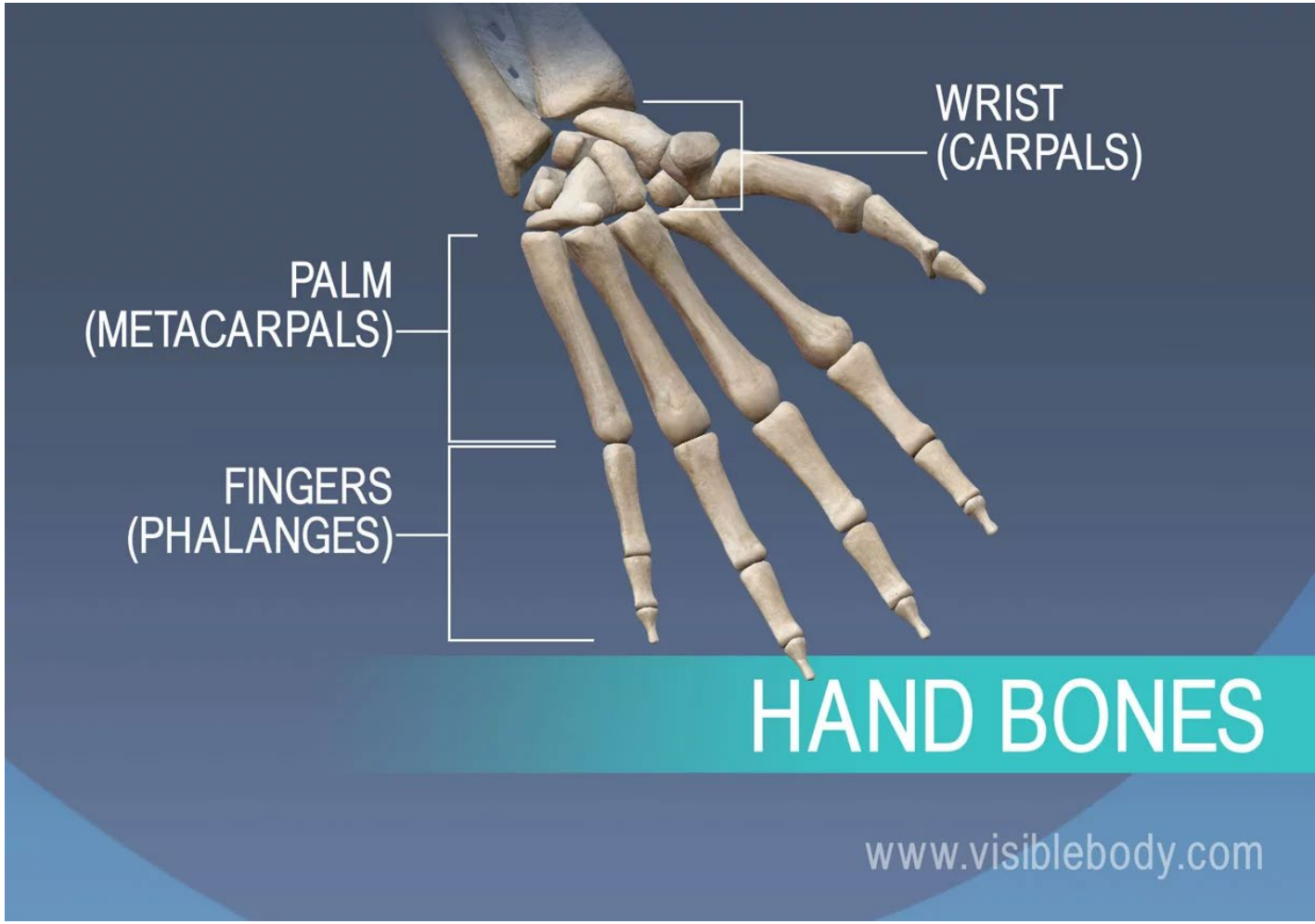
The hand includes:

- 8 bones in the wrist
- 5 bones that form the palm
- 14 bones that form the fingers and thumb.

The wrist bones are called carpals.

The bones that form the palm of the hand are called metacarpals.

The phalanges are the bones of the fingers.



THE BONES OF THE PELVIS

The **pelvic girdle** is a ring of bones attached to the vertebral column that connects the bones of the lower limbs to the axial skeleton.

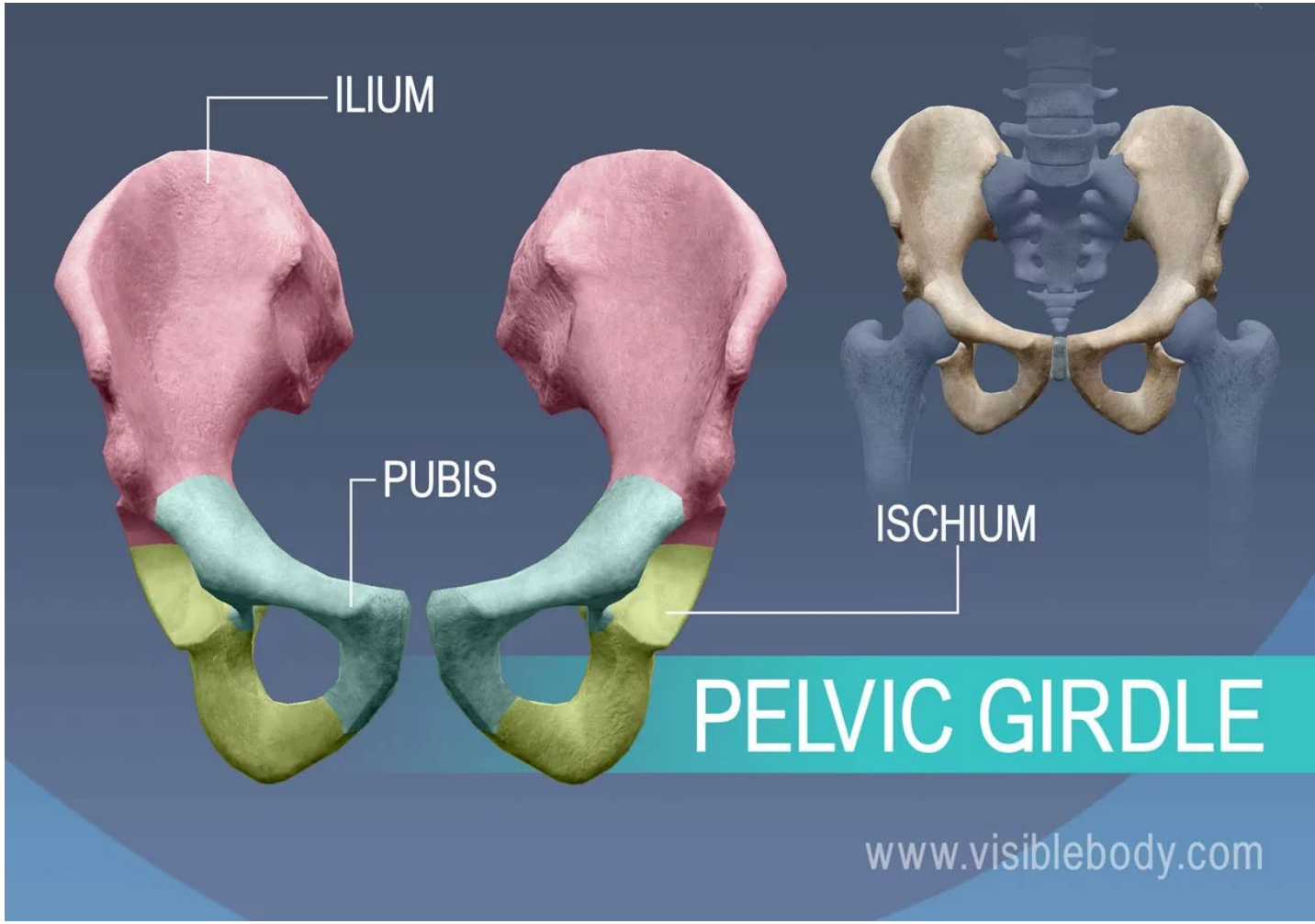
The pelvic girdle consists of the right and left hip bones.

Each hip bone is a large, flattened, and irregularly shaped fusion of three bones:

Ilium

Ischium

Pubis



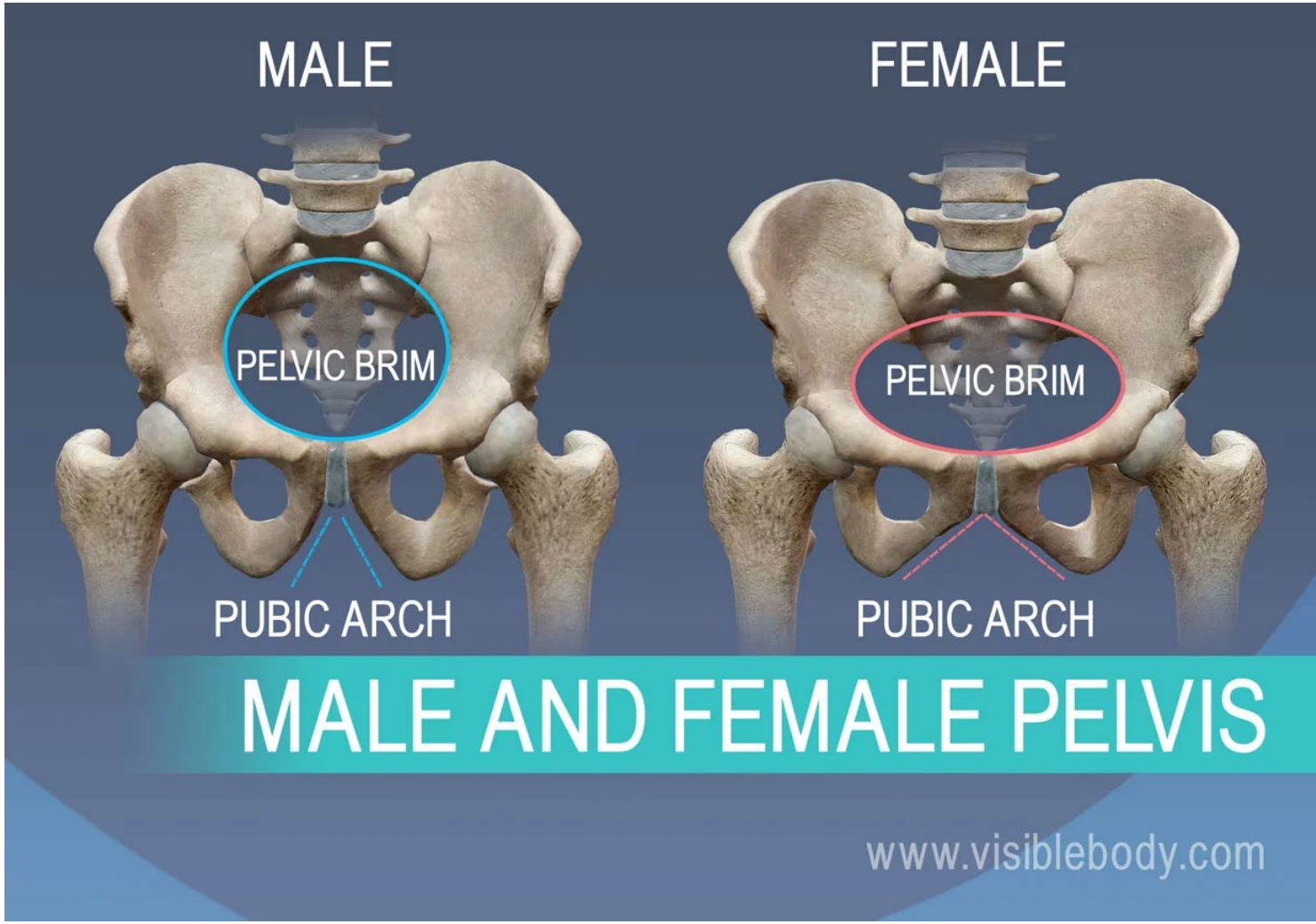
FEMALE AND MALE PELVIS.

The female and male pelvises differ in several ways due to childbearing adaptations in the female.

The female pelvic brim is larger and wider than the male's.

The angle of the pubic arch is greater in the female pelvis (over 90 degrees) than in the male pelvis (less than 90 degrees).

The male pelvis is deeper and has a narrower pelvic outlet than the female's.



THE BONES OF THE LOWER LIMBS

The **lower limbs** include the bones of the thigh, leg, and foot.

The femur is the only bone of the thigh. It is the biggest bone in the body !!

It articulates with the two bones of the leg–the larger tibia (commonly known as the shin) and smaller fibula.

The thigh and leg bones articulate at the knee joint that is protected and enhanced by the patella bone that supports the quadriceps tendon.

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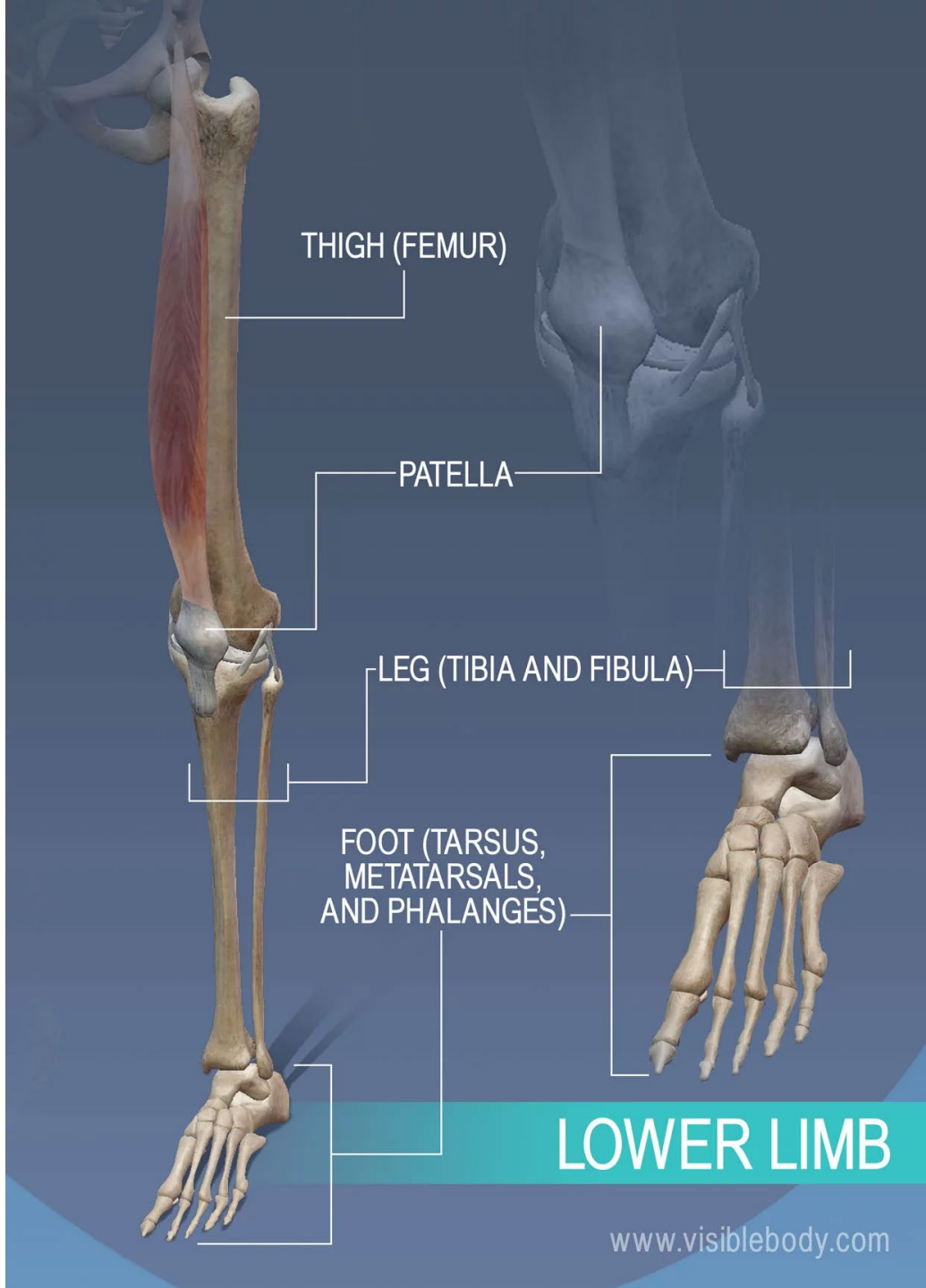


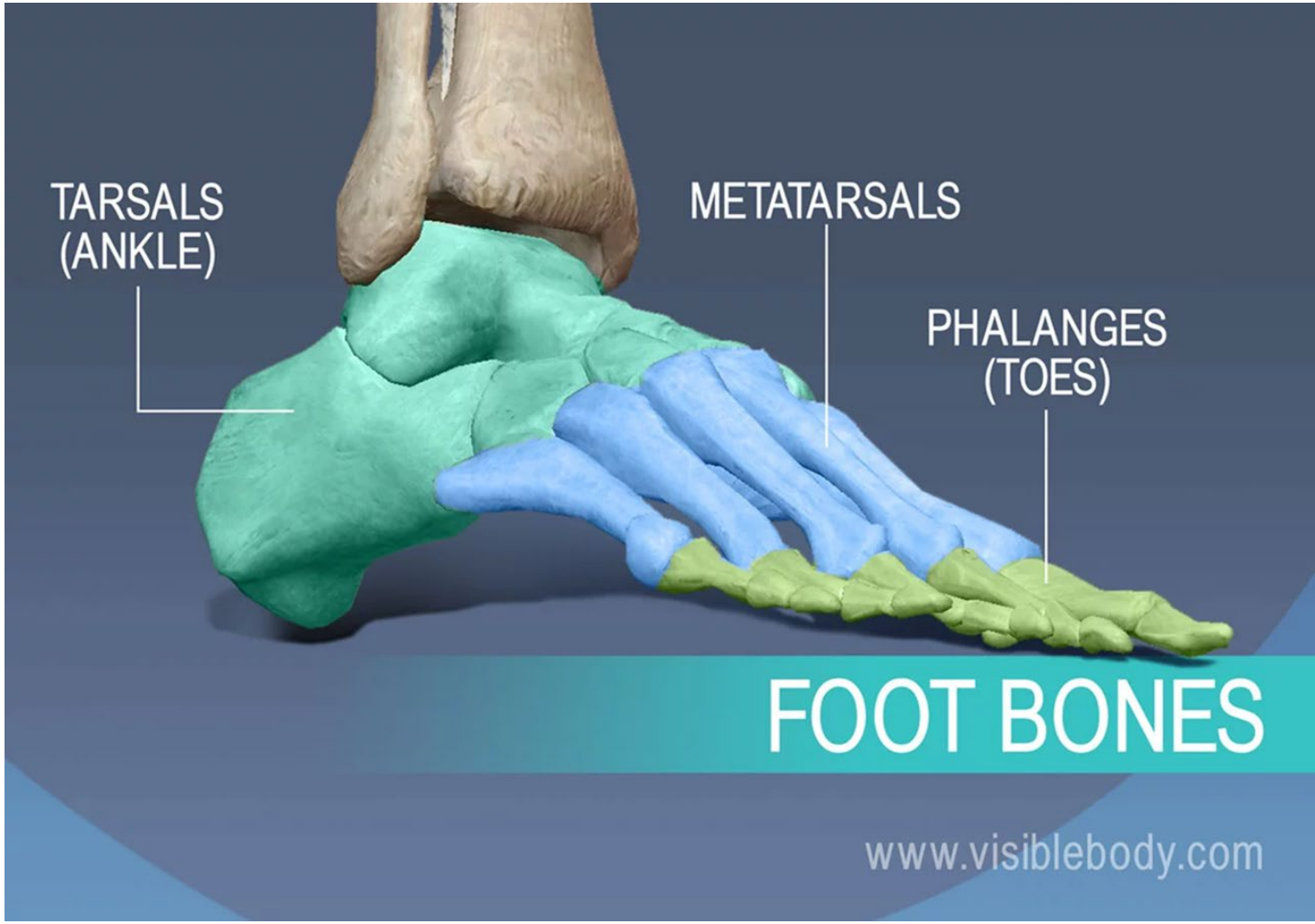
FOOT BONES.

The bones of the foot consist of:

- tarsal bones of the ankle
- phalanges that form the toes,
- metatarsals that give the foot its arch.

As in the hand, the foot has:

- five metatarsals
- five proximal phalanges
- five distal phalanges
- only four middle phalanges (as the foot's "big toe" has only two phalanges).



WALKING PRESSURE

With each step, the main weight of the body moves from the rear to the front of the foot.

The heel region bears initial pressure as the foot is put down.

The force passes along the arch, which flattens slightly, then recoils to transfer the energy and pressure to the ball of the foot, and finally to the big toe for the push-off.

ANKLE BONES.

The ankle, or tarsus, consists of 7 tarsal bones:

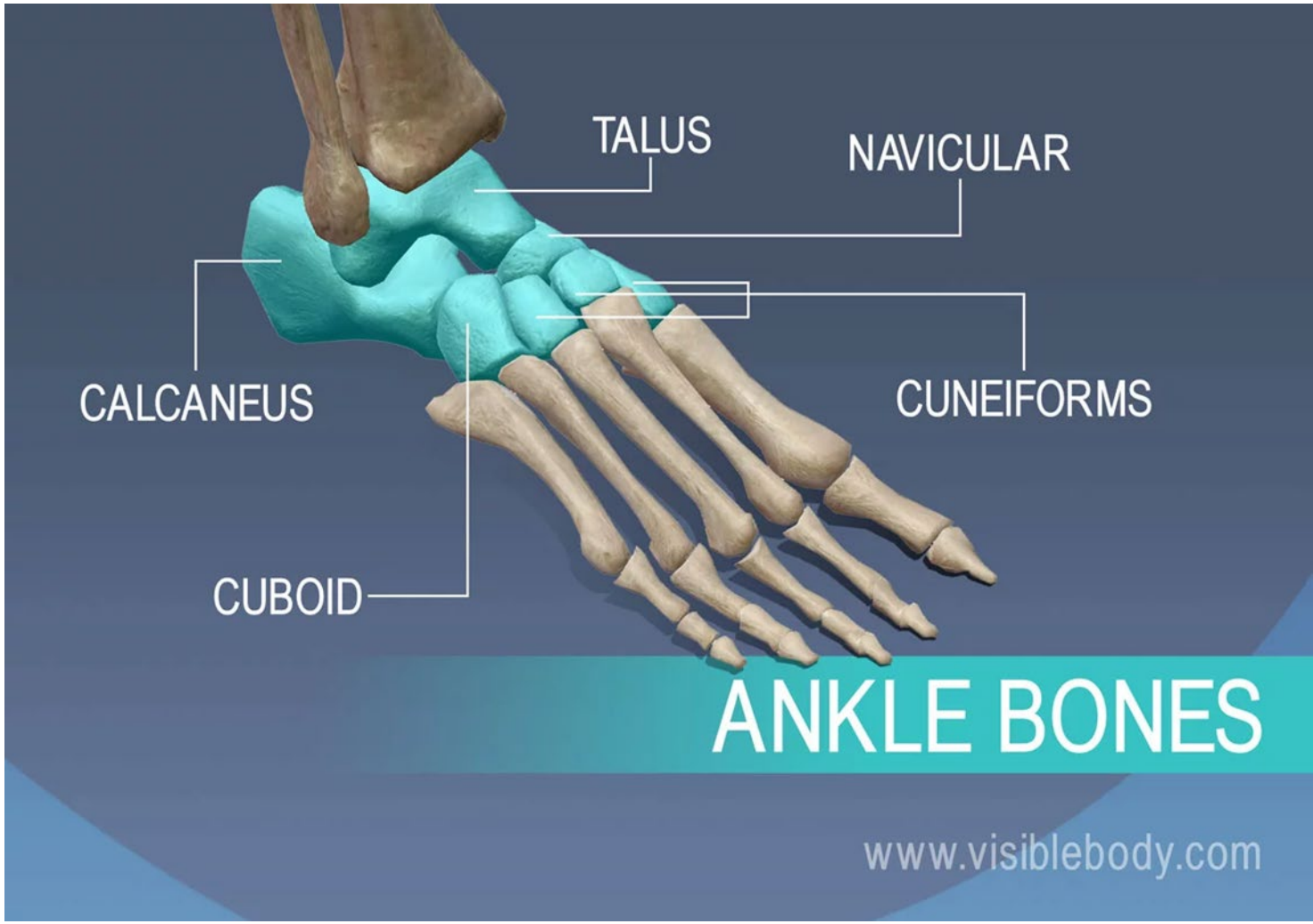
Calcaneus

Talus

Cuboid

Navicular

3 Cuneiforms



GAMES WITH SHEEP OR GOAT ANKLE BONES

The astragalus or talus bone, the ankle bone, usually taken from goats or sheep.

They have been used in games of chance and skill since at least 3500 BCE.

When tossed in the air, they will land with one of four sides face up, sometimes referred to as Camel, Goat, Horse and Sheep (see photo).

Because of the irregularities of each bone, the probabilities of landing on any side are not equal as they are for dice. Games evolved with these differences in mind.

Dice were originally made from these bones, colloquially known as "knucklebones" which lead to the nickname "bones" for dice.

The photo below is of one astragulus bone taken from a sheep, with it's 4 sides and their names shown.

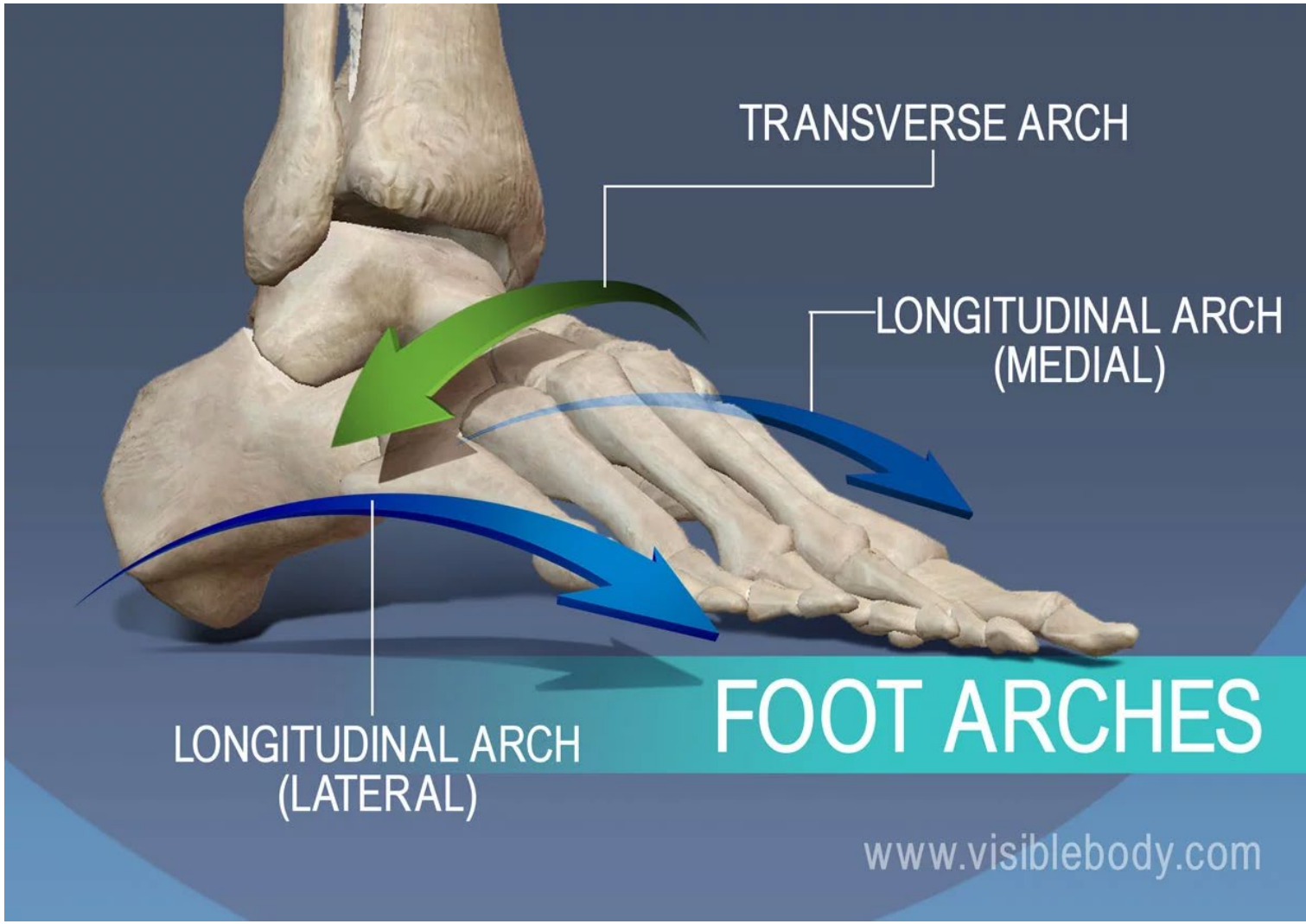
FOOT ARCHES

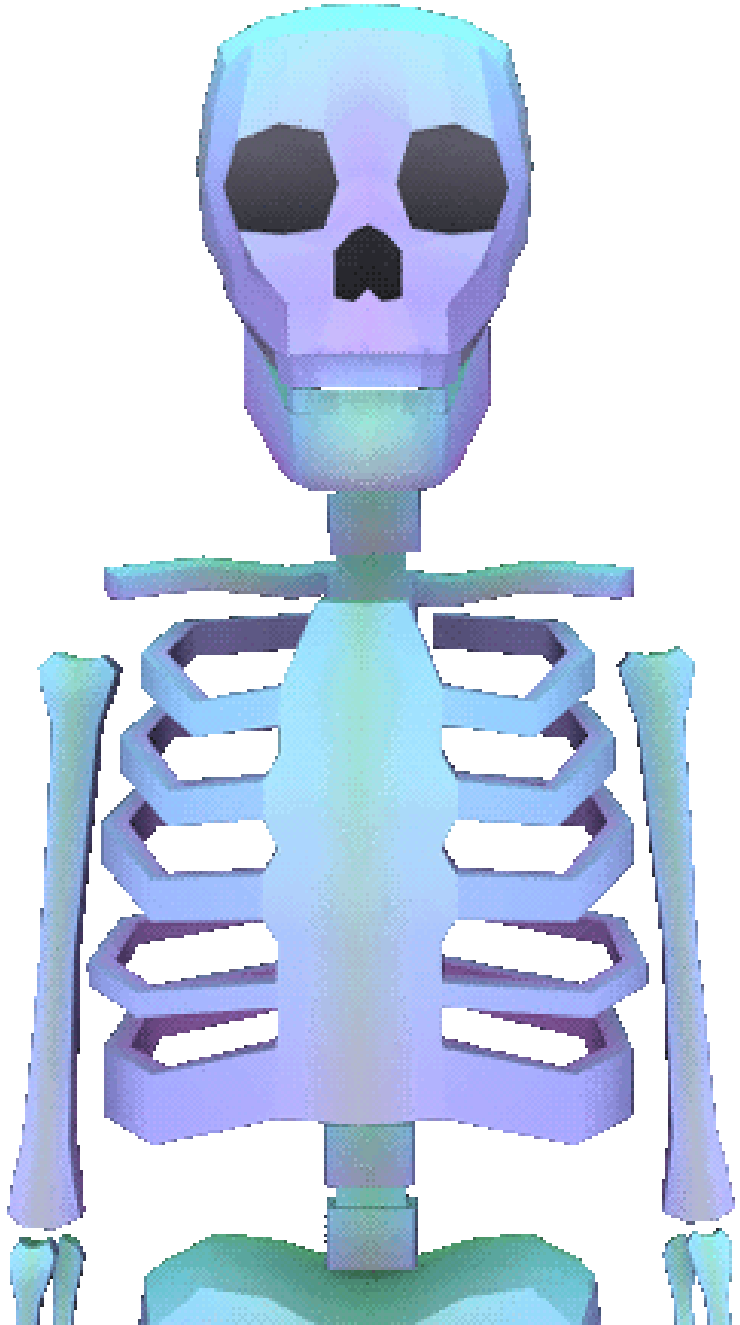
The arches of the foot are formed by the interlocking bones and ligaments of the foot.

They serve as shock-aborbing structures that support body weight and distribute stress evenly during walking.

The longitudinal arch of the foot runs from the calcaneus to the heads of the metatarsals and has medial and lateral parts.

The transverse arch of the foot runs across the cuneiforms and the base of the metatarsal bones.





THANK YOU !!