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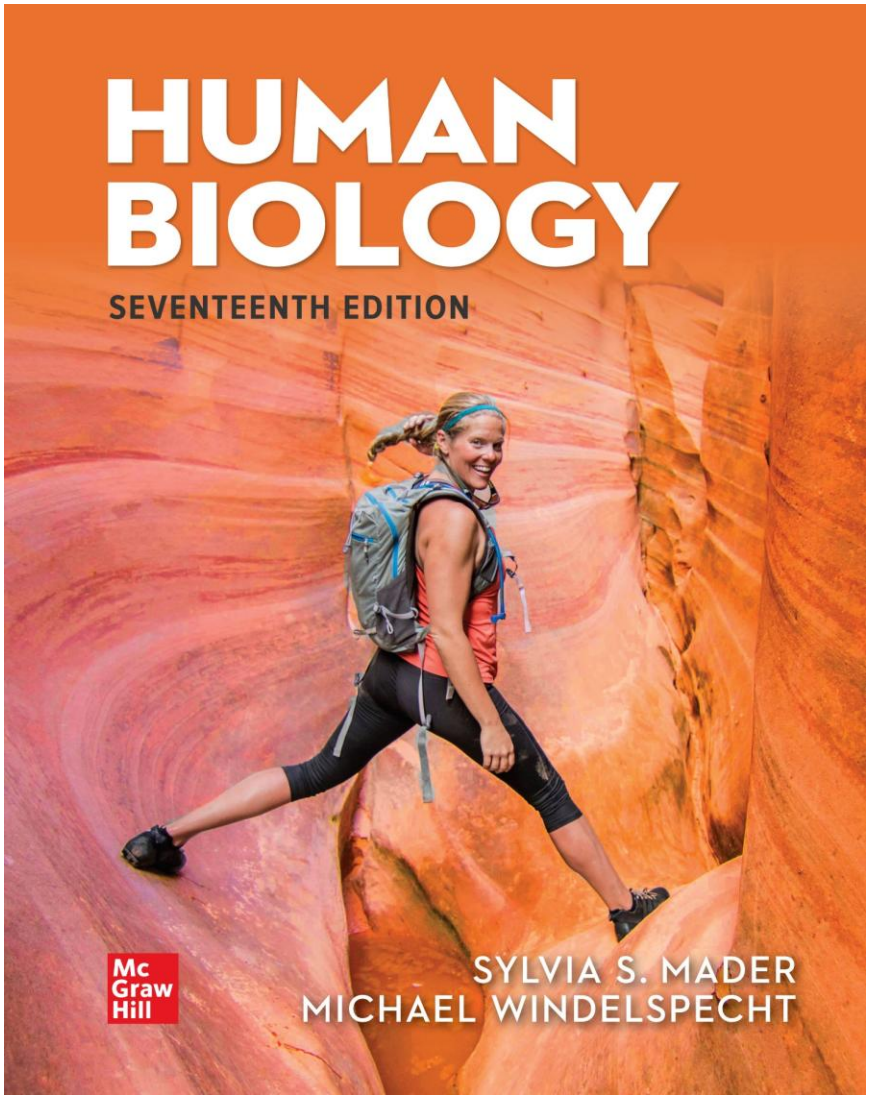

HUMAN BIOLOGY

Seventeenth Edition

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Michael Windelspecht

Chapter 12
Skeletal System

12.1 Overview of the Skeletal System 1

Learning Outcomes:

- State the functions of the skeletal system.
- Describe the structure of a long bone and list the types of tissues it contains.
- List the three types of cartilage found in the body and provide a function for each.

12.1 Overview of the Skeletal System 2

The **skeletal system**.

Provides attachment sites for the muscles, whose contraction makes the bones move.

Consists of two types of connective tissue:

- Bone.
- Cartilage.
  - Found at the **joints**, the point where two bones come together.
  - Found at **ligaments**, formed of fibrous connective tissue, join the bones.

Tendons connect muscle to bones.

Functions of the Skeleton

Functions of the skeleton:

Supports the body.

Working with the muscular system, **moves** the body.

Protection.

- Skull protects the brain, rib cage protects the heart and lungs, the vertebrae protect the spinal cord.

Produces blood cells.

Stores minerals (calcium and phosphate) **and fat**.

Anatomy of a Long Bone 1

Anatomy of a long bone.

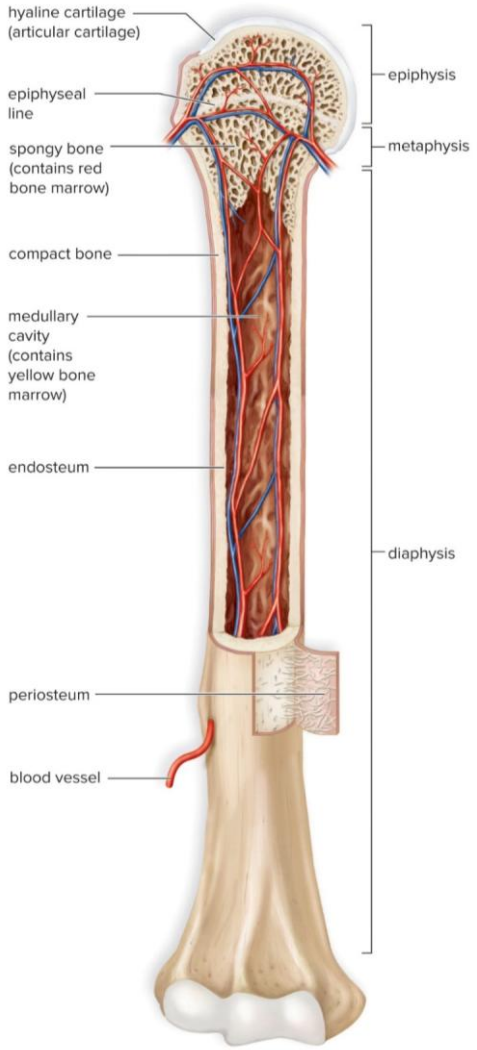
Diaphysis—shaft of the bone.

- **Medullary cavity**—inside the diaphysis; its walls are made of **compact bone.**
- The medullary cavity is lined with the **endosteum** and is filled with **yellow bone marrow**, which stores fat.

Epiphysis (*pl.*, epiphyses)—expanded end of a long bone.

- Composed of spongy bone that contains **red bone marrow**, where blood cells are made.

The Anatomy of a Long Bone (Figure 12.1)



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Anatomy of a Long Bone 2

Anatomy of a long bone, continued.

The epiphyses are coated with a thin layer of hyaline cartilage, which is also called **articular cartilage**, because it occurs at a **joint.**

Metaphysis—between the epiphysis and diaphysis.

- Contains the **epiphyseal plate**, a region of cartilage that allows for bone growth.

Periosteum—connective tissue covering all bones; continuous with ligaments and tendons.

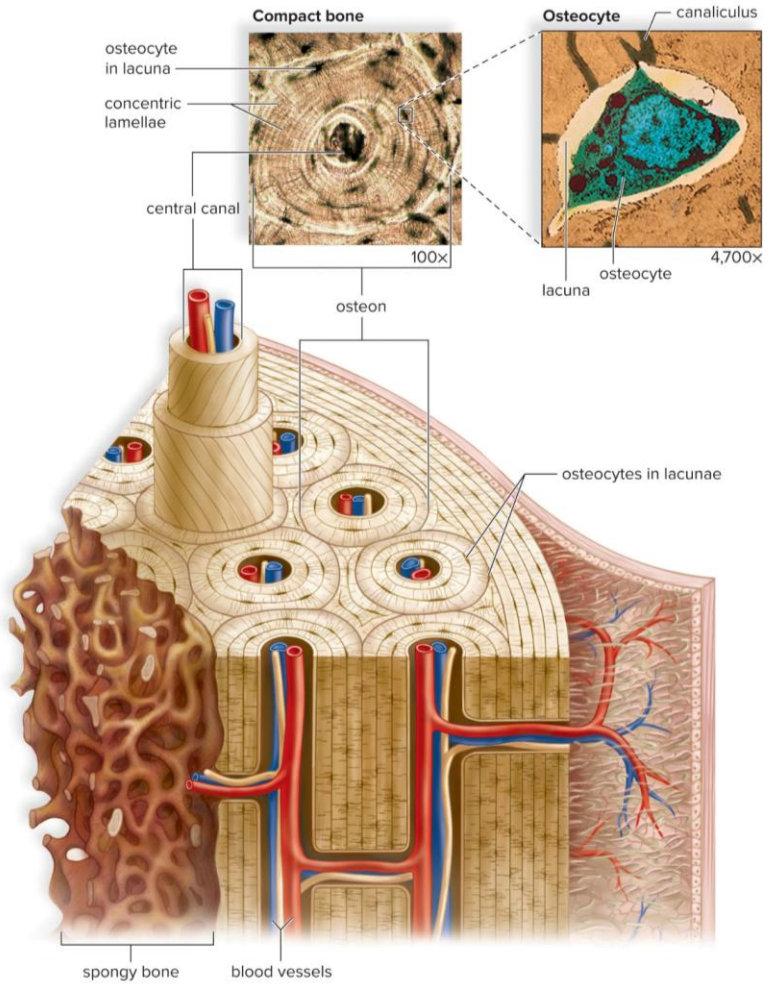
Anatomy of a Long Bone 3

Bone.

There are two types of bone tissue: **compact** and **spongy.**

- **Compact bone** is highly organized and composed of tubular units called **osteons.**
- **Osteocytes** are bone cells; they lie in **lacunae** (*sing.*, lacuna), tiny chambers arranged in concentric circles around a **central canal.**
- Matrix fills the space between the rows of lacunae.

Anatomy of Compact Bone (Figure 12.2)



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Anatomy of a Long Bone 5

Bone, concluded.

Spongy bone contains numerous thin plates called **trabeculae.**

- Although lighter than compact bone, spongy bone is still designed for strength.
- **Red bone marrow**—in the spaces of spongy bone.
  - Produces all types of blood cells.
- Osteocytes of spongy bone are irregularly placed within the trabeculae.

Anatomy of a Long Bone 7

Cartilage, continued.

Locations of cartilage.

- **Hyaline cartilage**: ends of long bones, nose, ends of ribs, larynx, and trachea.
- **Fibrocartilage**: disks between vertebrae and in the knee.
- **Elastic cartilage**: ear flaps and epiglottis.

Anatomy of a Long Bone 8

Fibrous connective tissue.

Made of rows of **fibroblasts** separated by bundles of collagenous fibers.

Makes up ligaments and tendons.

- Ligaments connect bones at joints.
- Tendons connect muscle to bone at a joint (also called an **articulation**).

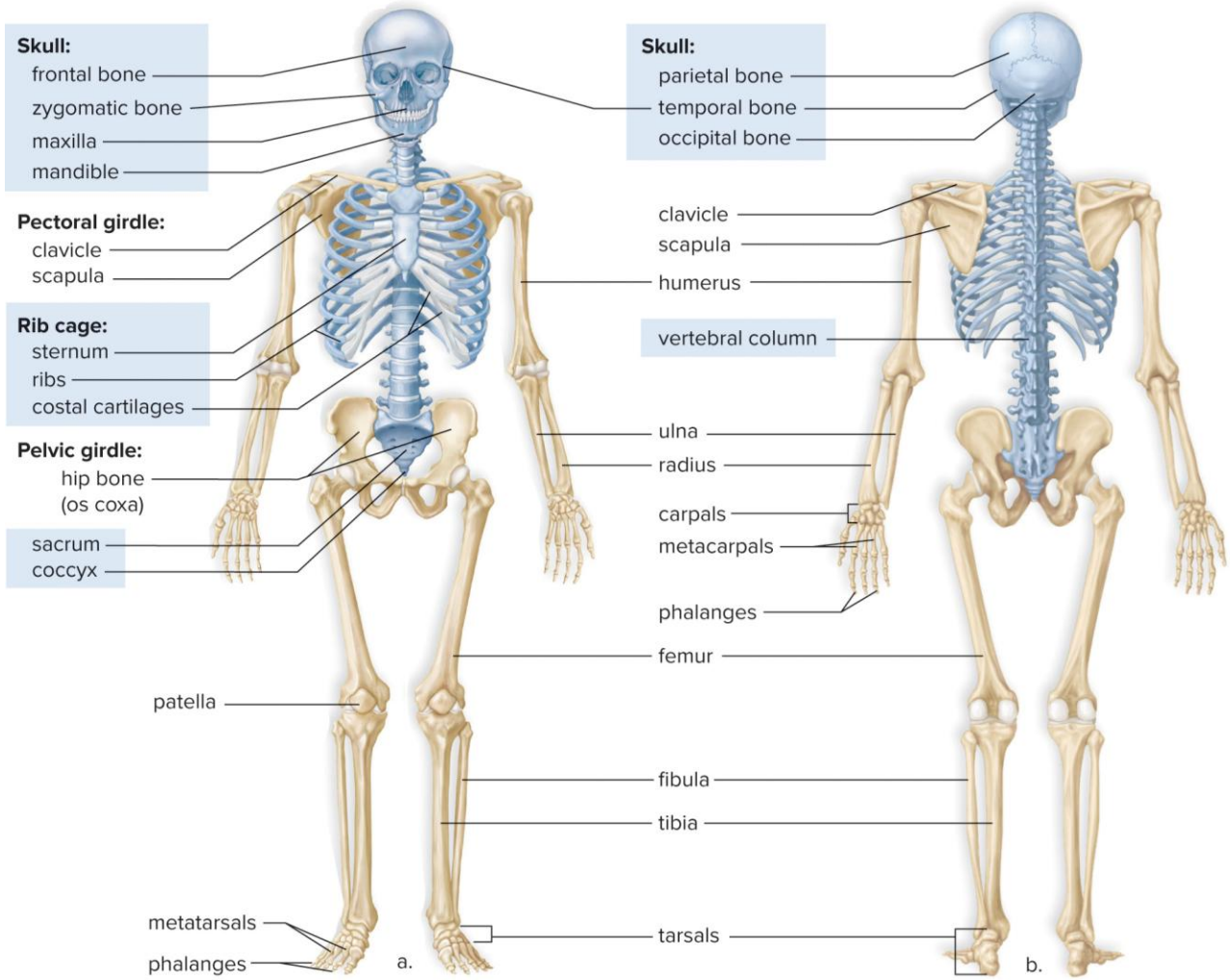
12.2 Bones of the Axial Skeleton 2

The 206 bones of the skeleton are classified as the axial or appendicular skeleton.

Axial skeleton—midline of the body.

- Consists of the skull, hyoid bone, vertebral column, and the rib cage.

The Axial and Appendicular Skeletons (Figure 12.3)



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The Skull 1

The **skull.**

- Formed by the cranium (braincase) and the facial bones.
- Some cranial bones contribute to the structure of the face.

The Skull 2

The cranium.

Contains and protects the brain.

In adults, made of eight bones.

In newborns, cranial bones are joined by membranous **fontanels.**

- Usually close by the age of 16 months.

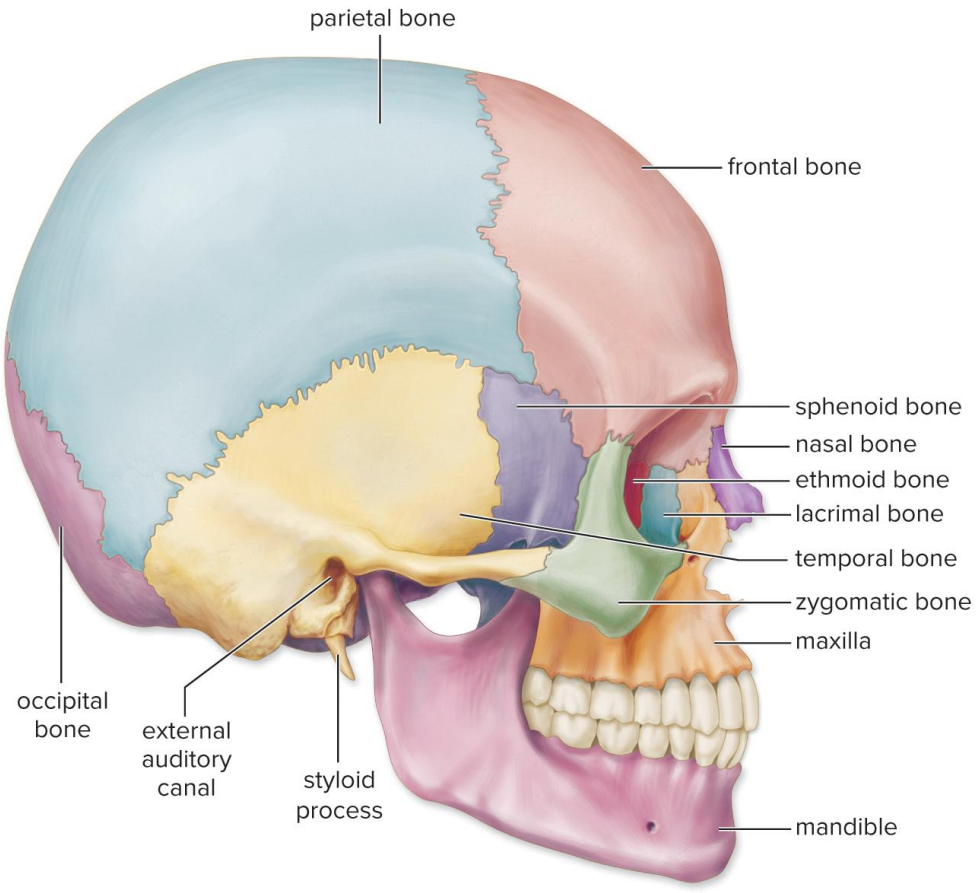
The Skull 3

The cranium, continued.

Bones: **frontal, parietal, occipital, temporal, sphenoid, ethmoid.**

- **Foramen magnum**—a hole in the occipital bone through which the spinal cord passes.
- **External auditory canal**—in each temporal bone; leads to the middle ear.
- The sphenoid completes the sides of the skull and contributes to forming the **orbits** (eye sockets).
- The ethmoid bone also helps form the orbits and the nasal septum.

The Bones of the Skull (Figure 12.4a) 1



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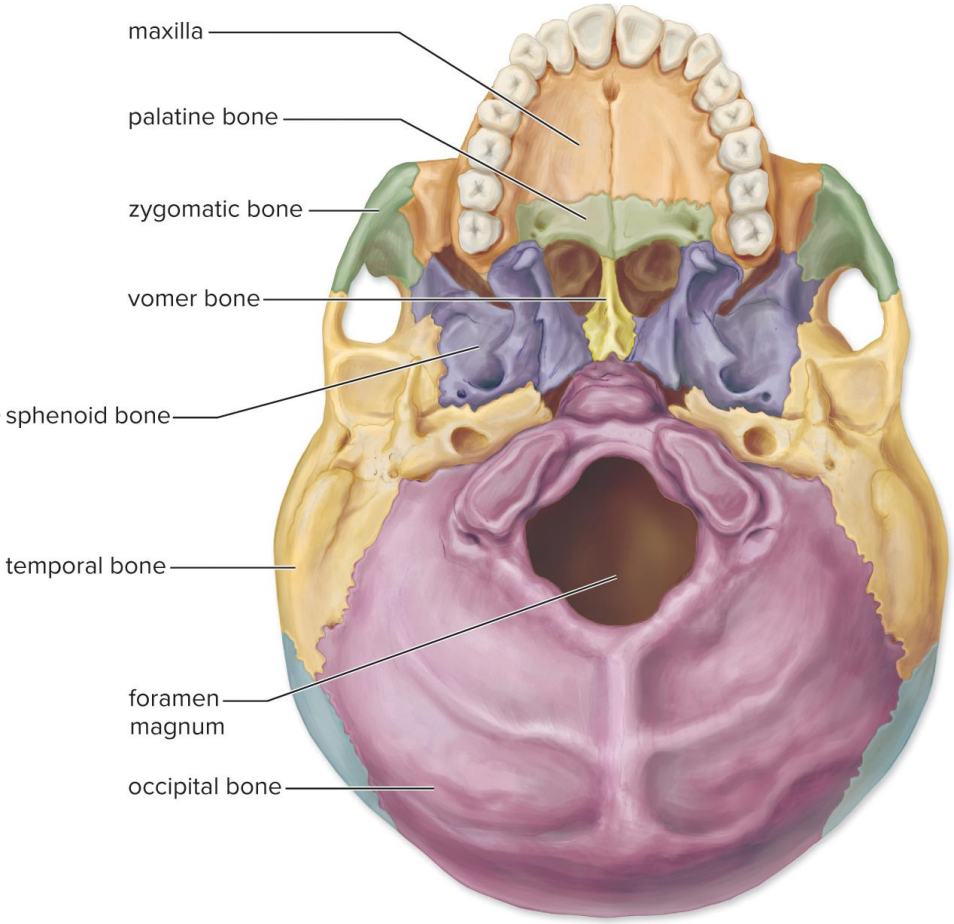
The Bones of the Skull (Figure 12.4b) 2



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The Skull 4

The cranium, concluded.

Sinuses—air spaces in some cranial bones.

- Lined with mucous membrane.
- Reduce the weight of the skull.
- Give a resonant sound to the voice.
- Are named according to the bones in which they are located: **frontal, sphenoid, ethmoid**, and **maxillary.**
- A smaller set of sinuses, called the **mastoid sinuses**, drain into the middle ear.
  - **Mastoiditis**—inflammation of these sinuses.

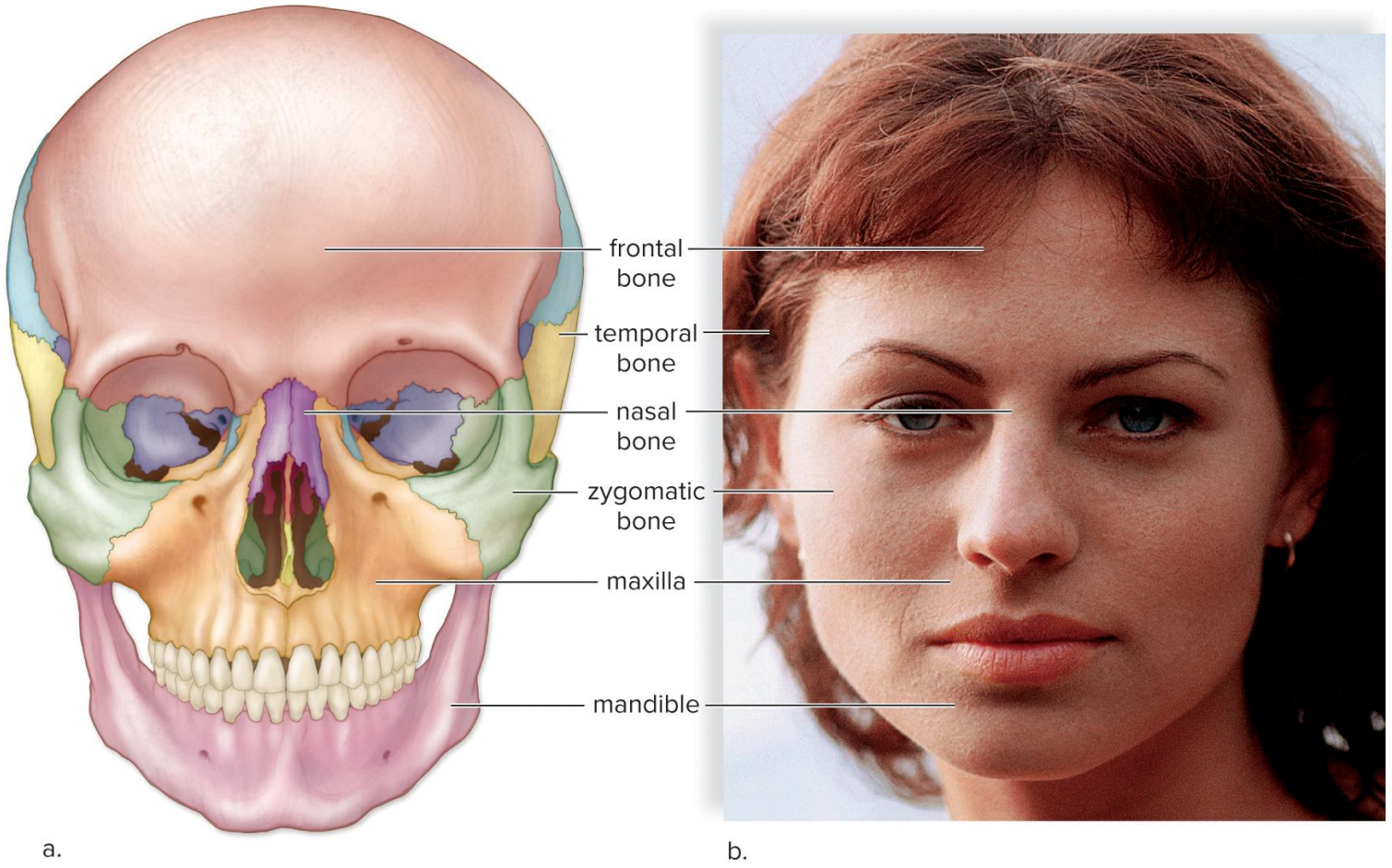
The Skull 5

The facial bones.

Mandible, **maxillae** (*sing.*, maxilla), **zygomatic** bones, and **nasal** bones.

- The mandible is the only movable bone in the skull.
- The maxillae form the upper jaw and a portion of the orbits.
- The hard palate and the floor of the nose are formed by the maxillae joined to the **palatine** bones.
- The zygomatic bones form the cheekbones.

The Bones of the Face and the Location of the Hyoid Bone (Figure 12.5a,b) 1



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(b): VCG/Corbis/Getty Images

The Skull 6

The facial bones, continued.

Mandible, **maxillae** (*sing.*, maxilla), **zygomatic** bones, and **nasal** bones, continued.

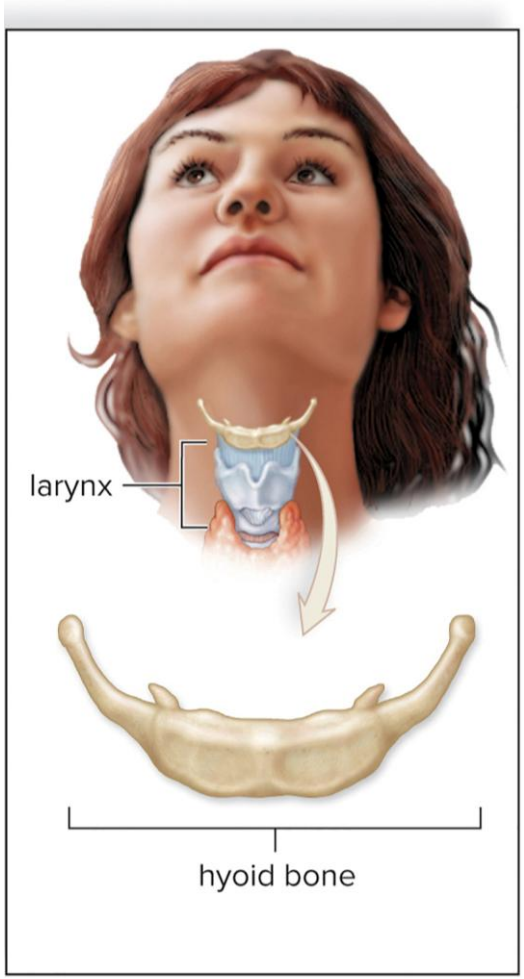
- The nasal bones form the bridge of the nose.
- Other bones (that is, **ethmoid** and **vomer**) are a part of the nasal septum, which divides the interior of the nose into two nasal cavities.
- The **lacrimal** bone contains the opening for the **nasolacrimal canal**, which drains tears from the eyes to the nose.

The Hyoid Bone

Hyoid bone.

- Not part of the skull, but is part of the axial skeleton.
- The only bone in the body that does not articulate with another bone.
- The hyoid bone anchors the tongue and serves as the site for the attachment of muscles associated with swallowing.
- In cases of suspicious death, a fractured hyoid is a strong indication of manual strangulation.

The Bones of the Face and the Location of the Hyoid Bone (Figure 12.5c) 2



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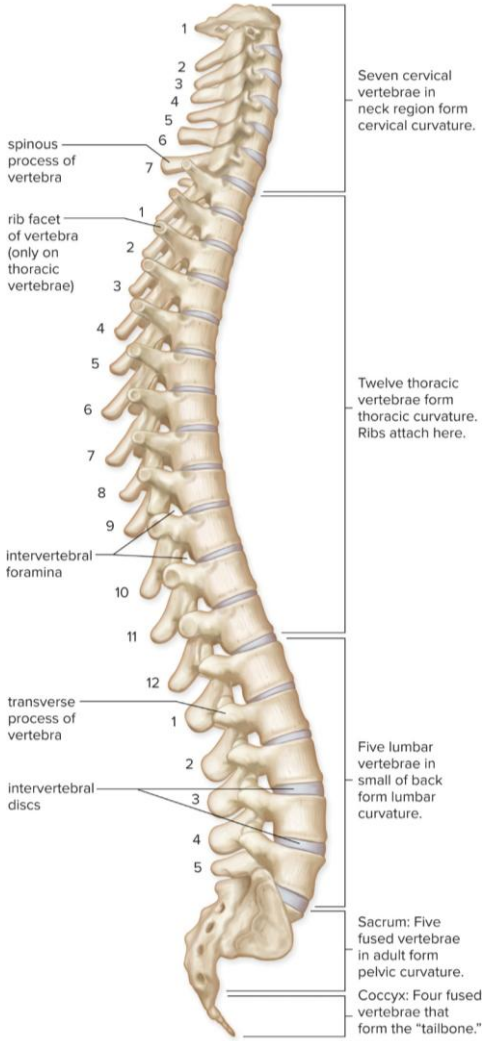
The Vertebral Column 1

Vertebral column—consists of 33 vertebrae.

- There are four curvatures that provide more strength for an upright posture than a straight column.
- **Scoliosis**—abnormal sideways curvature of the spine.
- **Kyphosis**—abnormal posterior curvature; “hunchback.”
- **Lordosis**—abnormal anterior curvature; “swayback.”

The Vertebral Column (Figure 12.6)



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The Vertebral Column 2

Vertebral column, continued.

Vertebral canal—in the center of the column; the spinal cord passes through.

Intervertebral foramina (*sing.*, foramen, "a hole") on each side of the column; **spinal nerves** travel through.

- Spinal nerves control skeletal muscle contraction, among other things.
- If the spinal cord and/or spinal nerves are injured, there can be paralysis or even death.

The Vertebral Column 3

Vertebral column, concluded.

- **Spinous processes** of the vertebrae—bony projections along the midline of the back.
- **Transverse processes** extend laterally.
- Both spinous and transverse processes serve as attachment sites for muscles.

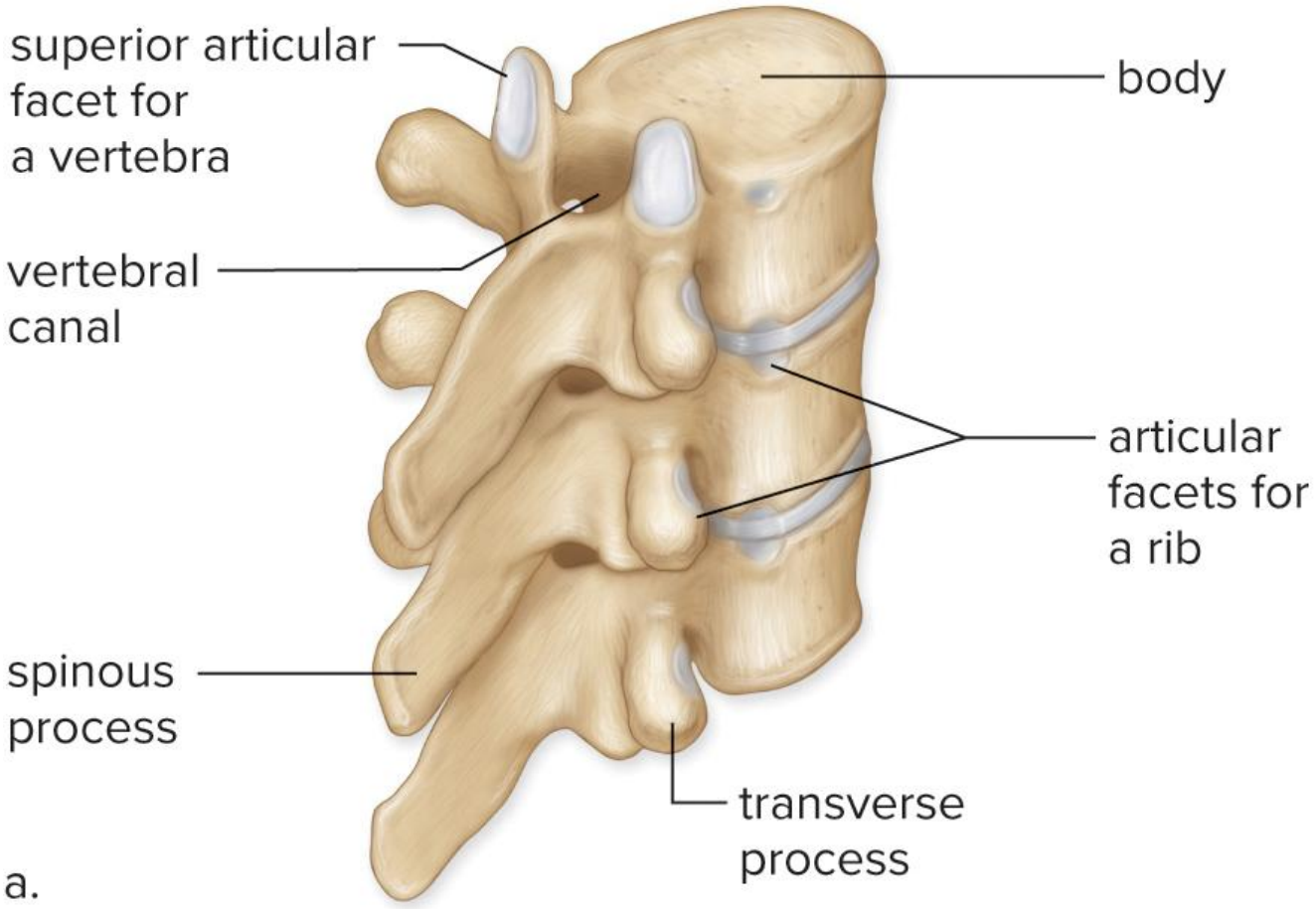
The Vertebral Column 4

Types of vertebrae.

Cervical vertebrae—in the neck.

- **Atlas**—first cervical vertebra; holds up the head.
  - Movement permits the “yes” motion of the head.
- **Axis**—second cervical vertebra.
  - Named because it rotates around the long axis of the body when we shake the head “no.”

The Thoracic Vertebrae, Ribs, and Sternum (Figure 12.7a) 1



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The Vertebral Column 5

Intervertebral disks.

- Composed of fibrocartilage.
- Prevent the vertebrae from grinding.
- Absorb shock caused by movements such as running, jumping, and even walking.
- Allows the vertebrae to move as we bend forward, backward, and from side to side.

The Vertebral Column 6

Intervertebral disks, continued.

Become weakened with age and can herniate and rupture.

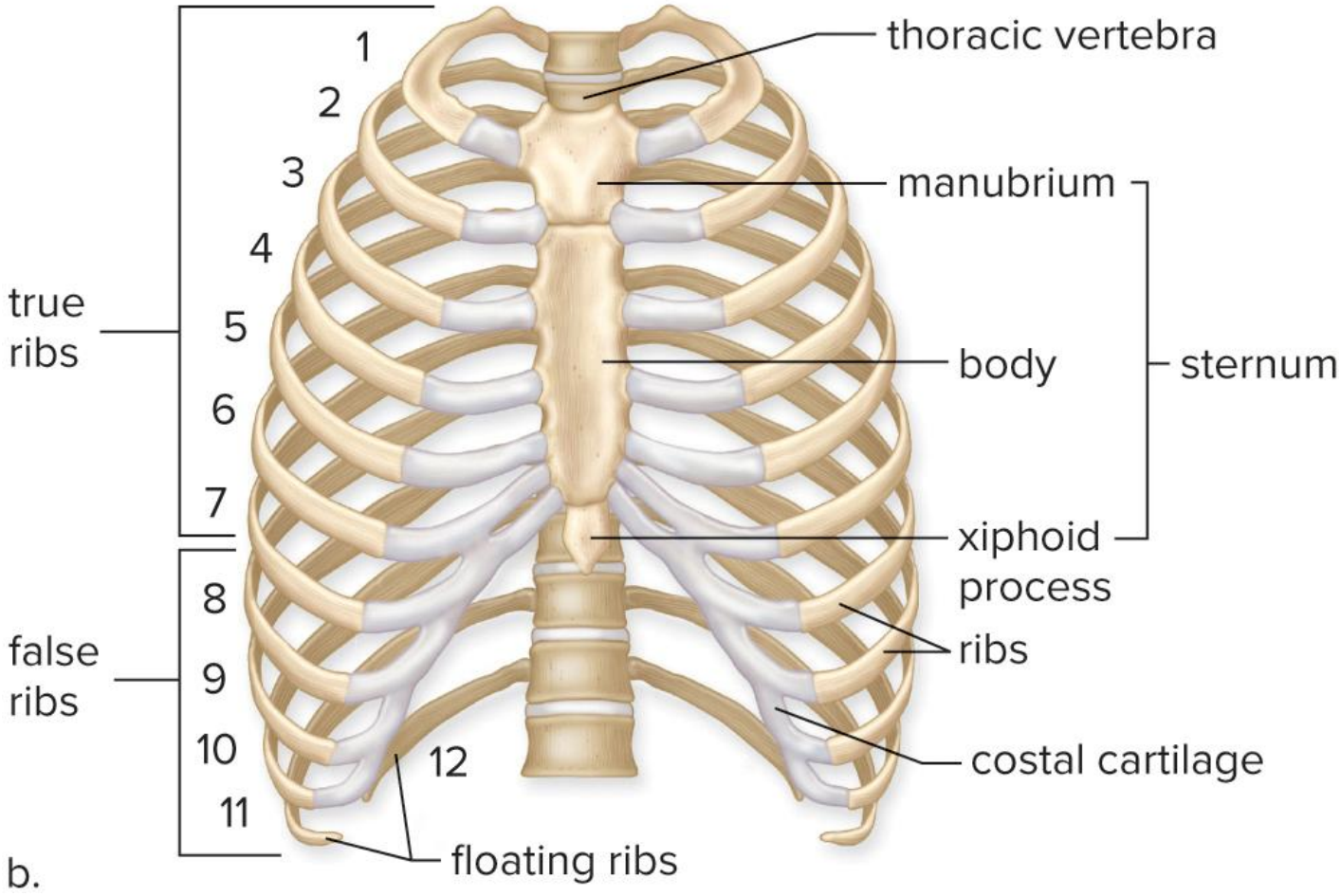
- Pain results if a disk presses against the spinal cord and/or spinal nerves.

The Rib Cage 1

Rib cage (thoracic cage)—composed of the thoracic vertebrae, the ribs and their associated cartilages, and the sternum.

- Part of the axial skeleton.
- Protects the heart and lungs.
- Swings outward and upward upon inspiration and then downward and inward upon expiration.

The Thoracic Vertebrae, Ribs, and Sternum (Figure 12.7b) 2



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The Rib Cage 2

The ribs.

- There are 12 pairs; all connect directly to the thoracic vertebrae in the back.
- Each rib articulates with the body and transverse process of its corresponding thoracic vertebra.
- Curve outward and then forward and downward.
- **True ribs**—ribs 1 to 7; connect directly to the sternum by means of a long strip of hyaline cartilage called **costal cartilage.**

The Rib Cage 3

The ribs, continued.

- **False ribs**—ribs 8 to 12; their costal cartilage does not connect directly to the sternum.
- **Floating ribs**—ribs 11 and 12; they have no connection with the sternum.

The Rib Cage 4

The sternum (breastbone).

Along with the ribs, it helps protect the heart and lungs.

Composed of three bones: **manubrium, body,** and **xiphoid process.**

- The manubrium articulates with the clavicles.
- The manubrium joins with the body of the sternum at an angle.

The Rib Cage 5

The sternum, continued.

- Counting the ribs is sometimes done to determine where the apex of the heart is located—usually between the fifth and sixth ribs.
- The xiphoid process serves as an attachment site for the diaphragm, which separates the thoracic cavity from the abdominal cavity.

Check Your Progress 12.2

- List the bones of the axial skeleton.
- Identify the bones of the cranium and face, and describe how they contribute to facial features.
- Describe the various types of vertebrae.

12.3 Bones of the Appendicular Skeleton 1

Learning Outcomes:

- Identify the bones of the pelvic and pectoral girdles.
- Identify the bones of the upper and lower limbs.

12.3 Bones of the Appendicular Skeleton 2

The **appendicular skeleton**.

- Consists of the bones within the pectoral and pelvic girdles and their attached limbs.
- A pectoral (shoulder) girdle and upper limb are specialized for flexibility.
- The pelvic (hip) girdle and lower limbs are specialized for strength.

The Pectoral Girdle and Upper Limb 1

Pectoral girdle (2)—consists of a **scapula** (shoulder blade) and a **clavicle** (collarbone).

- The clavicle extends across the top of the thorax; joins with the sternum and the **acromion process** of the scapula.
- The muscles of the arm and chest attach to the **coracoid process** of the scapula.
- The **glenoid cavity** of the scapula articulates with the head of the humerus, the upper arm bone.

The Pectoral Girdle and Upper Limb 2

Pectoral girdle, continued.

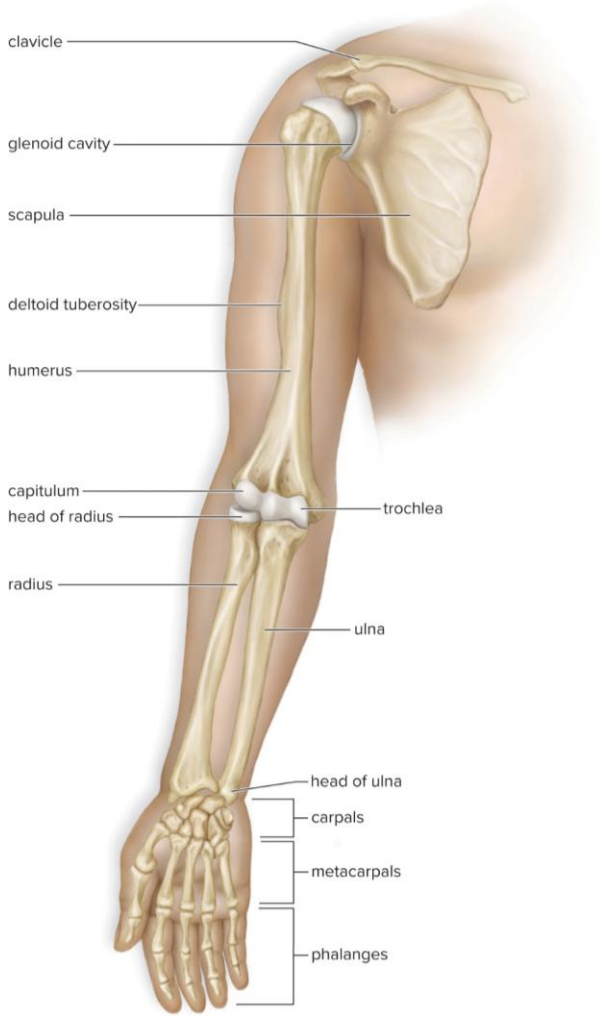
This joint is very mobile, but also unstable.

- It can dislocate.

Ligaments and tendons stabilize it.

- **Rotator cuff**—tendons that extend to the humerus from four small muscles originating on the scapula.
  - Vigorous circular movements of the arm can lead to rotator cuff injuries.

The Bones of the Pectoral Girdle and Upper Limb (Figure 12.8)



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The Pectoral Girdle and Upper Limb 3

Pectoral girdle.

- Scapula and clavicle.

Upper limb.

- Upper arm: humerus.
- Forearm: radius and ulna.
- Hand: carpals, metacarpals, and phalanges.

The Pectoral Girdle and Upper Limb 4

The upper limb.

The components of a pectoral girdle freely follow the movements of the upper limb.

The upper limb—**humerus** in the arm and the **radius** and **ulna** in the forearm.

- The humerus, the single long bone in the arm, has a smoothly rounded head that fits into the glenoid cavity of the scapula.
- The shaft of the humerus has a **tuberosity** (protuberance) where the deltoid, a shoulder muscle, attaches.

The Pectoral Girdle and Upper Limb 5

The upper limb, continued.

- The far end of the humerus has two protuberances, called the **capitulum** and the **trochlea**, which articulate respectively with the **radius** and **ulna** at the elbow.
- The bump at the back of the elbow is the **olecranon process** of the ulna.

The Pectoral Girdle and Upper Limb 6

The upper limb, concluded.

The hand.

Carpal bones—eight bones in the wrist.

Metacarpal bones—five bones in the palm.

- The metacarpal that leads to the thumb is opposable to the fingers.
  - An opposable thumb can touch each finger separately.
- The knuckles are the enlarged ends of the metacarpals.

Phalanges—the bones of the fingers and the thumb.

The Pelvic Girdle and Lower Limb 1

Pelvic girdle (hip girdle)—consists of two **coxal bones** (hip bones).

Pelvis—composed of the pelvic girdle, sacrum, and coccyx.

- Bears the weight of the body, protects the organs within the pelvic cavity, and is the place of attachment for the legs.

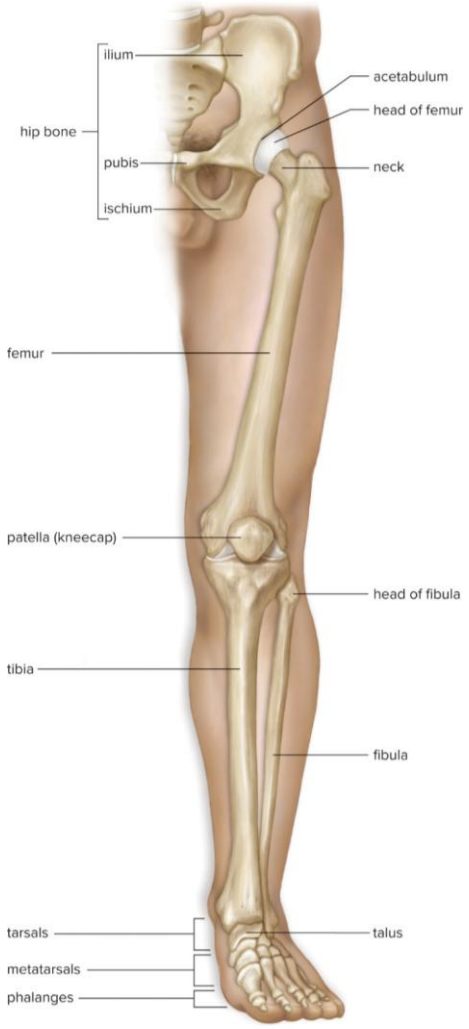
The Pelvic Girdle and Lower Limb 2

Pelvic girdle, continued.

Each **coxal bone** has three parts: the **ilium**, **ischium**, and **pubis**, which are fused in the adult.

- The hip socket, called the **acetabulum**—where these three bones meet.
- The ilium is the largest.
- We sit on the ischium, which has a posterior spine, called the **ischial spine**, for muscle attachment.
- The two pubic bones are joined by a fibrocartilaginous joint called the **pubic symphysis.**

The Bones of the Pelvis and Lower Limb (Figure 12.9)



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The Pelvic Girdle and Lower Limb 3

Pelvic girdle.

- Hip bones (os coxa).

Lower limb.

- Thigh: femur.
- Leg: tibia and fibula.
- Foot: tarsals, metatarsals, and phalanges.

The Pelvic Girdle and Lower Limb 4

Pelvic girdle, concluded.

The male pelvis is different from the female pelvis.

In the female, the iliac bones are more flared and the pelvic cavity is more shallow, but the outlet is wider.

- These adaptations facilitate the birthing process.

The Pelvic Girdle and Lower Limb 5

The lower limb—the **femur** in the thigh, the **tibia** and **fibula** in the lower leg.

Femur—longest, strongest bone in the body.

- The **head** of the femur articulates with the coxal bones at the acetabulum; the **neck** better positions the legs for walking.
- The femur has two large processes, the **greater** and **lesser trochanters**, which are places of attachment for thigh muscles, buttock muscles, and hip flexors.
- At its distal end, the femur has **medial** and **lateral condyles** that articulate with the **tibia.**

The Pelvic Girdle and Lower Limb 6

The lower limb, continued.

Patella (kneecap)—held in place by the quadriceps tendon, which continues as a ligament that attaches to the **tibial tuberosity.**

Medial malleolus—at the distal end of the tibia.

Fibula—the more slender bone in the leg.

- Has a **head** that articulates with the tibia and a distal **lateral malleolus** that forms the outer bulge of the ankle.

The Pelvic Girdle and Lower Limb 7

The lower limb, concluded.

The foot.

Tarsal bones—seven bones in the ankle.

- **Talus**—joins the tibia and fibula.
- **Calcaneus**—heel bone.
- The talus and calcaneus support the body weight.

Metatarsal bones—five bones in the instep.

Phalanges—the bones of the toes.

Check Your Progress 12.3

- List the bones of the pectoral girdle and the upper limb.
- List the bones of the pelvic girdle and the lower limb.
- Describe how you can tell the difference in gender from looking at the bones of the pelvic girdle.

12.4 Articulations 1

Learning Outcomes:

- List the three types of joints.
- Describe the structure and operation of a synovial joint.
- Summarize the types of movement made possible by a synovial joint.

12.4 Articulations 2

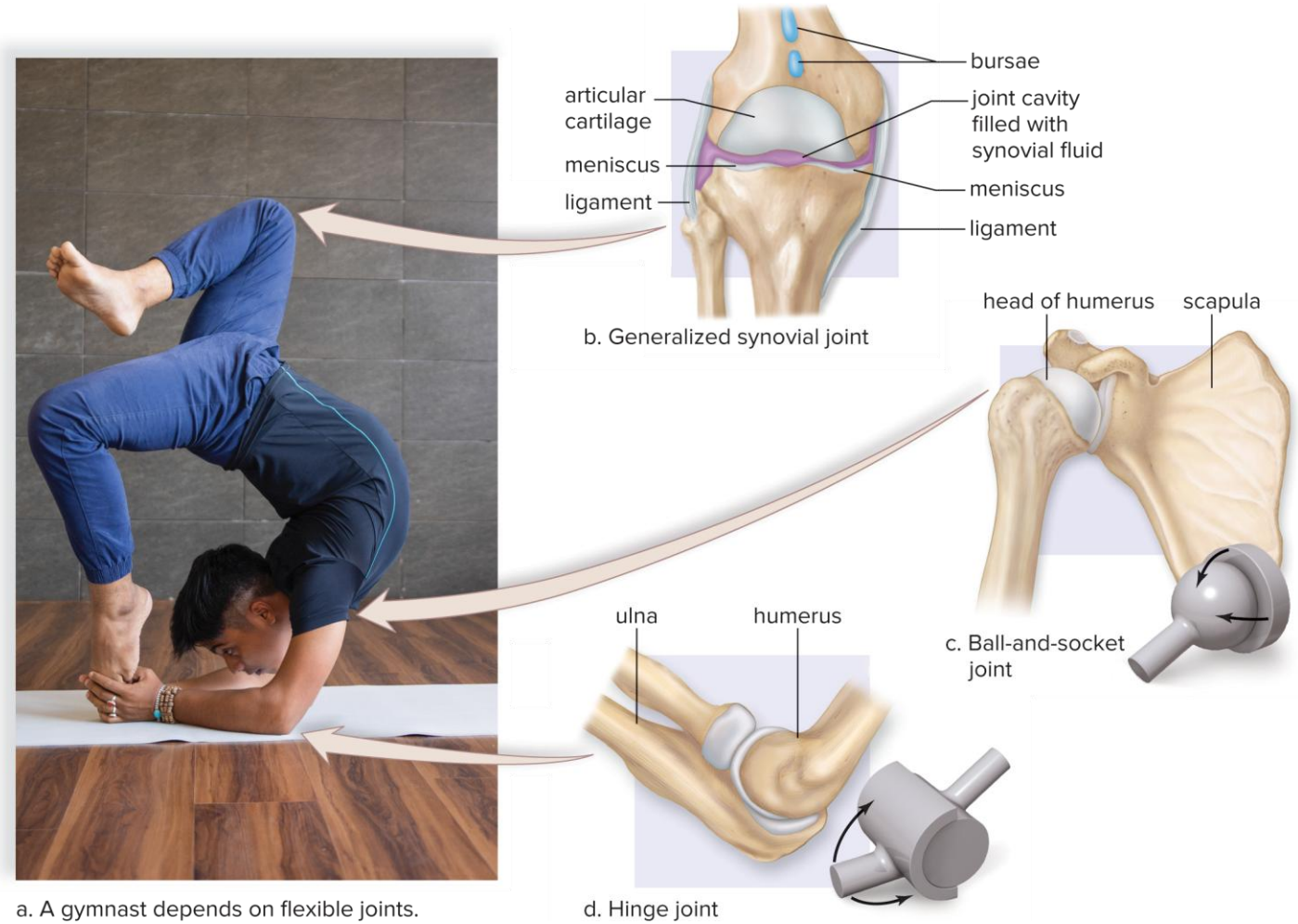
Articulations (joints).

Where bones come together.

Are classified as **fibrous, cartilaginous**, or **synovial.**

- Most fibrous joints are immovable.
  - That is, **sutures** between the cranial bones.
- Cartilaginous joints are connected by hyaline cartilage, (that is, costal cartilages) or fibrocartilage (that is, intervertebral disks).
  - Slightly movable.
- **Synovial joints** are freely movable.

The Structure of a Synovial Joint (Figure 12.10)



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12.4 Articulations 4

Types of synovial joints:

Ball-and-socket joints—allow movement in all planes, even rotational movement.

- That is, the hips and shoulders.

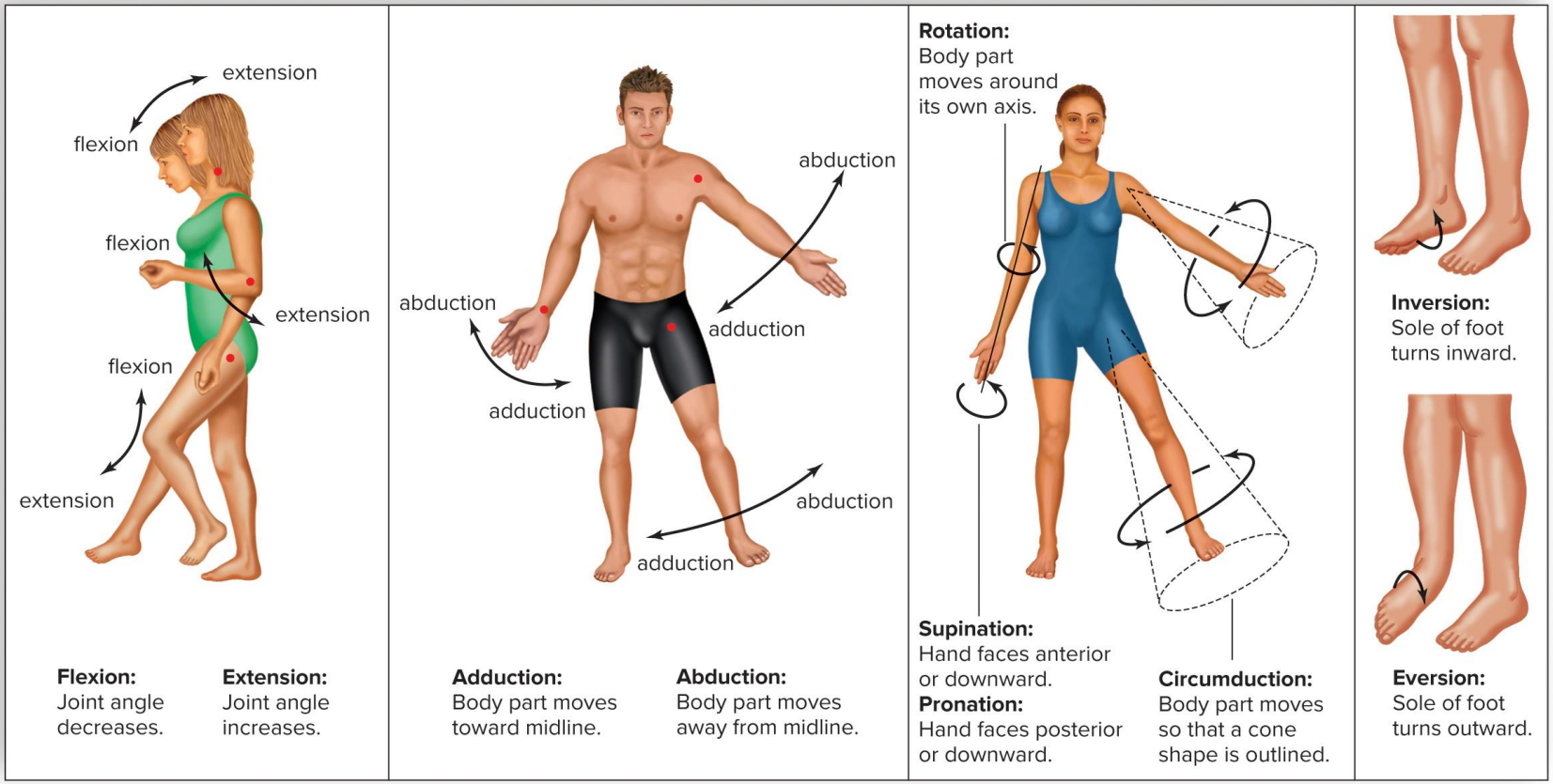
Hinge joints—permit movement in only one direction.

- That is, the elbow and knee.

Movements Permitted by Synovial Joints

- Intact skeletal muscles are attached to bones by tendons that span joints.
- When a muscle contracts, one bone moves in relation to another bone.

Synovial Joints Allow for a Variety of Movement (Figure 12.11)



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Check Your Progress 12.4

- List the three major types of joints.
- Describe the basic movements of cartilaginous and fibrous joints, and give an example of each in the body.
- Describe the different movements of synovial joints, and give an example of each in the body.

Bone Development and Growth 9

Hormones affect bone growth.

Vitamin D—formed in the skin when exposed to sunlight.

- Is converted to a hormone that is necessary for absorption of calcium from food.
- Low vitamin D levels in children causes **rickets.**
  - Bone deformities, including bowed long bones.

Bone Development and Growth 10

Hormones affect bone growth, continued.

Growth hormone (GH)—stimulates bone growth.

- Need concurrent action of thyroid hormone to stimulate metabolism.
- **Dwarfism**—too little GH in childhood.
- **Gigantism**—excess GH in childhood.
- **Acromegaly**—excess GH in adults.
  - Excessive growth of bones in the hands and face.

Sex hormones—increase growth during adolescence.

Bone Remodeling and Calcium Homeostasis 1

Bone remodeling—osteoclasts break bone down, osteoblasts build it up.

- Recycles 18% of bone each year.

Paget disease—new bone is generated at a faster-than-normal rate.

- Produces softer and weaker bones.
- Can cause bone pain, deformities, and fractures.

Bone Remodeling and Calcium Homeostasis 2

Calcium homeostasis.

- If blood calcium rises, some of the excess is deposited in bones.
- If blood calcium drops, calcium is removed from bones to bring it up to normal.

Bone Remodeling and Calcium Homeostasis 3

Calcium homeostasis, continued.

Parathyroid hormone (PTH).

- Stimulates osteoclasts to dissolve bone.
- Promotes calcium absorption in the small intestine and kidney, increasing blood calcium levels.

Vitamin D.

- Needed for the absorption of Ca^{2+} from the digestive tract.

Bone Remodeling and Calcium Homeostasis 4

Calcium homeostasis, concluded.

Calcitonin.

- Has opposite effects as PTH.

Estrogen.

- Increases the number of osteoblasts.
- The reduction of estrogen in older women can cause osteoporosis.

Bone Repair 2

Types of bone fractures:

- **Complete**—the bone is broken clear through.
- **Incomplete**—the bone is not separated into two parts.
- **Simple**—it does not pierce the skin.
- **Compound**—it does pierce the skin.
- **Impacted**—the broken ends are wedged into each other.
- **Spiral**—the break is ragged due to twisting of the bone.

Clinical Application 7.1 2

Types of Fractures

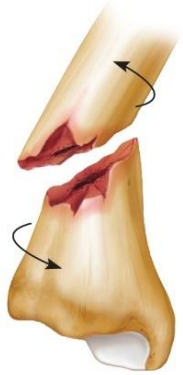
A *greenstick* fracture is incomplete, and the break occurs on the convex surface of the bend in the bone.

A *fissured* fracture is an incomplete longitudinal break.

A *comminuted* fracture is complete and fragments the bone.

A *transverse* fracture is complete, and the break occurs at a right angle to the axis of the bone.

An *oblique* fracture occurs at an angle other than a right angle to the axis of the bone.



A *spiral* fracture is caused by excessive twisting of a bone.

Blood Cells Are Produced in Bones

There are two types of marrow: **yellow** and **red.**

- Fat is stored in yellow bone marrow.
- Red bone marrow is the site of blood cell production.