COURSE: ANIMAL FORM AND FUNCTION

Chapter: 1

PROTECTION, SUPPORT, AND MOVEMENT

Support and Movement

THE SKELETAL SYSTEM OF INVERTEBRATES

- ✓ Hydrostatic Skeletons
- ✓ Exoskeletons
- ✓ Endoskeletons
- ✓ Mineralized Tissues and the Invertebrates

➢ hydrostatic skeleton

The hydrostatic (Gr. hydro,water statikos, to stand) skeleton is a core of liquid (water or a body fluid such as blood) surrounded by a tension-resistant sheath of longitudinal and /or circular muscles.

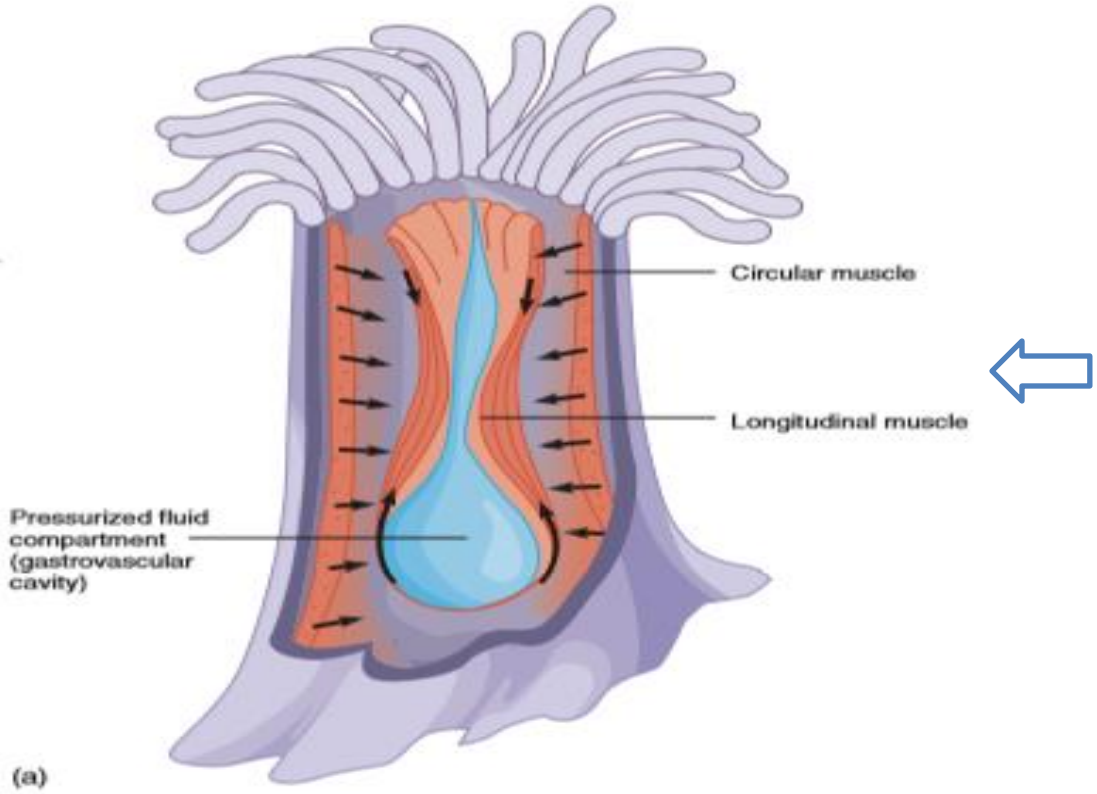
Contracting muscles push → hydrostatic skeleton → transmitted force → movement

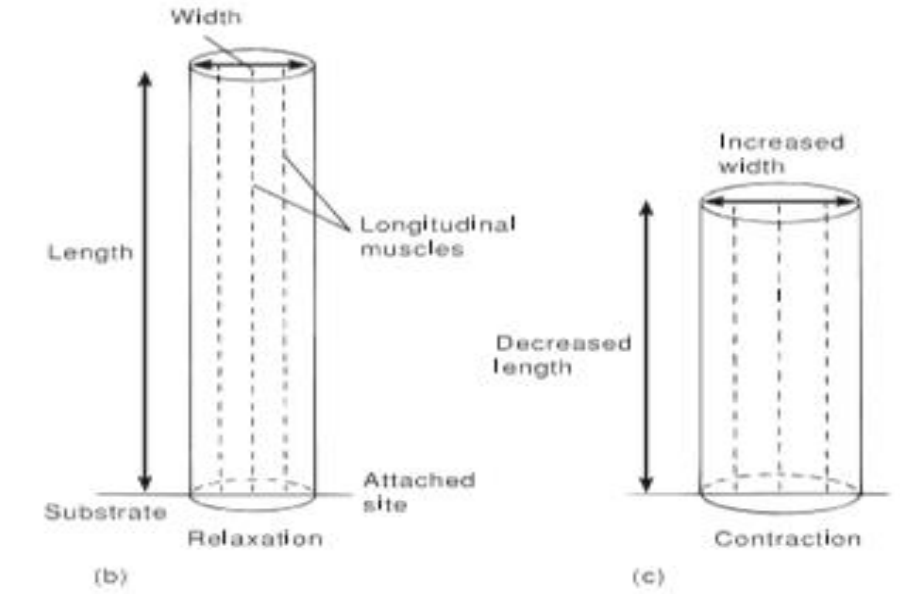
Examples:

sea anemone, earthworm (Lumbricus terrestris)

Forms of hydrostatic skeleton:

- ✓ gastrovascular cavity of acoelomates
- ✓ rhynchocoel in nemertines
- ✓ pseudocoelom in aschelminths
- ✓ coelom in annelids
- ✓ hemocoel in molluscs





FIGURE

Hydrostatic Skeletons. *(a)* The hydrostatic skeleton of sea anemones *(Corynactis californic)* allows them to shorten or close when longitudinal muscles contract, or to lengthen or open when circular muscles contract. *(b,c)* How a hydrostatic skeleton changes an invertebrate's shape with only longitudinal muscles. Because the fluid volume is constant, a change (increase) in width must accompany a change (decrease) in length.

➢ Exoskeletons:

Rigid exoskeletons (Gr. exo, outside skeleton) also have locomotor functions because they provide sites for muscle attachment and counterforces for muscle movements. Exoskeletons also support and protect the body, but these are secondary functions.

Examples

- ✓ arthropods → epidermis of the body wall secretes a thick, hard cuticle
- ✓ crustaceans (e.g., crabs, lobsters, shrimp) → the exoskeleton contains calcium carbonate crystals

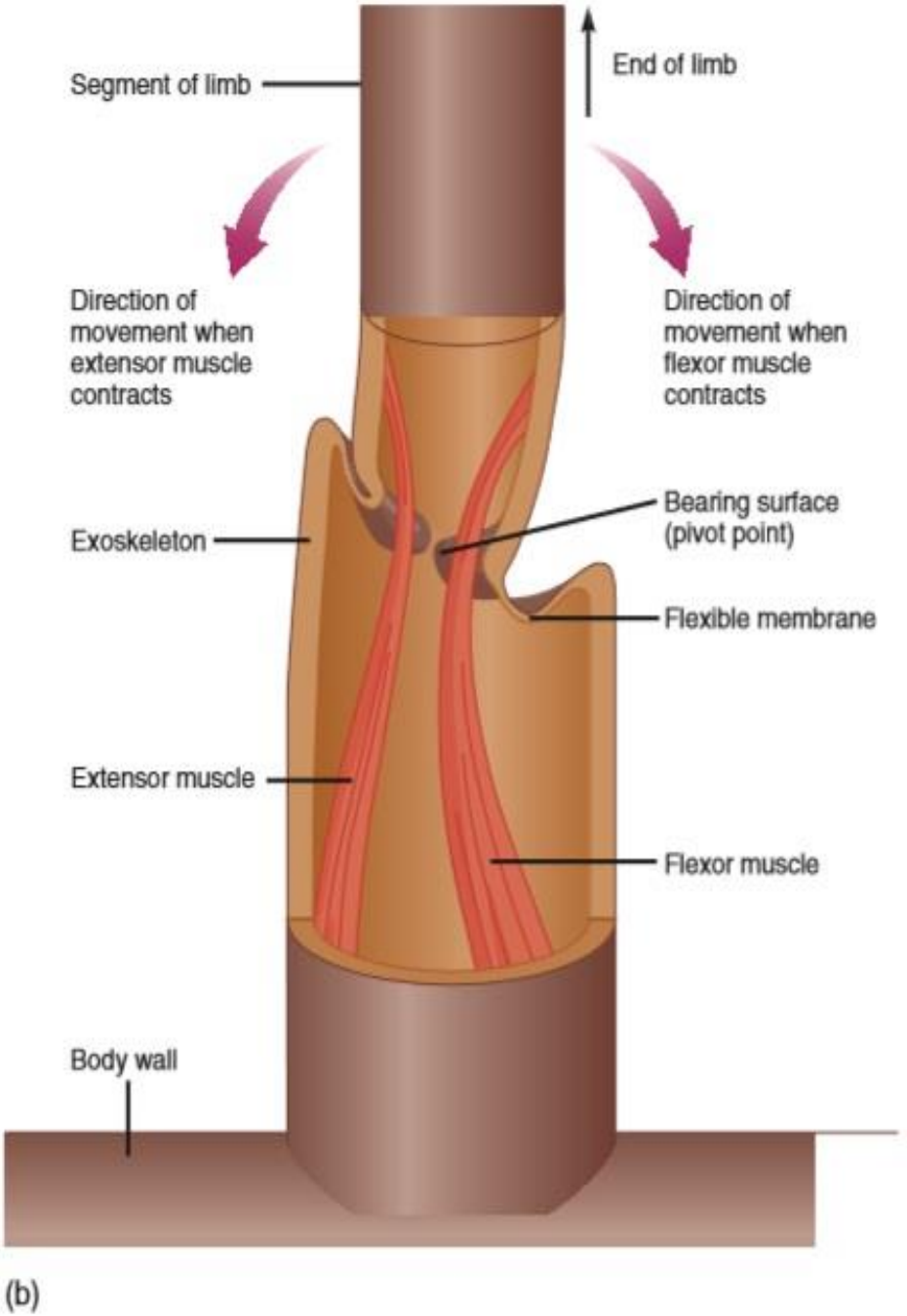
This important evolutionary adaptation contributed to arthropods' successful colonization of land. Exoskeletons, however, limit an animal's growth. Some animals shed the exoskeleton periodically, as arthropods do when they **molt.**

some arthropod joints ⇨ highly elastic protein called "animal rubber," or resilin

⇩

releases the energy to produce movement ⇦ stores energy on compression

(a)



(b)

Exoskeletons. (a) A cicada nymph (Platypedia) leaves its old exoskele- ton as it molts. This exoskeleton provides external support for the body and attachment sites for muscles. (b) In an arthropod, muscles attach to the interior of the exoskeleton. In this articulation of an arthropod limb, the cuticle is hardened everywhere except at the joint, where the membrane is flexible. Notice that the extensor muscle is antagonistic to (works in an opposite direction than) the flexor muscle. (b) Source: After Russell-Hunter.

➢ Endoskeletons:

Like the term implies, other body tissues enclose endoskeletons (Gr. endo, within skeleton)

Examples

- ✓ the endoskeletons of **sponges** consist of mineral spicules and fibers of spongin that keep the body from collapsing.
- ✓ the endoskeletons of **echinoderms (sea stars, sea urchins)** consist of small, calcareous plates called ossicles
- ✓ The Skeletal System of **Vertebrates**

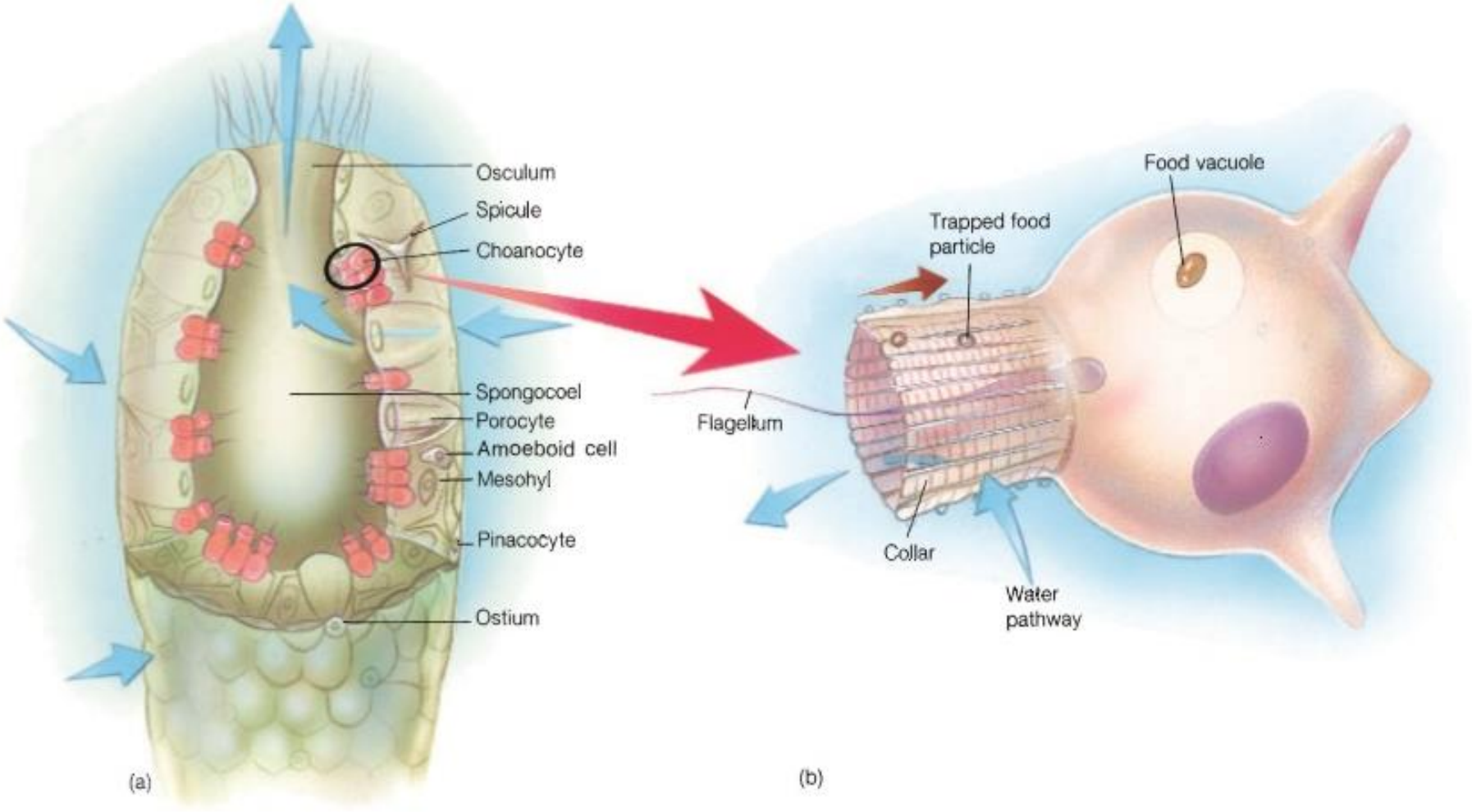


Figure: Morphology of a Simple Sponge. (a) In this example, pinacocytes form the outer body wall, and mesenchyme cells and spicules are in the mesohyl. Porocytes that extend through the body wall form ostia. (b) Choanocytes are cells with a flagellum surrounded by a collar of microvilli that traps food particles. Food moves toward the base of the cell, where it is incorporated into a food vacuole and passed to amoeboid mesenchyme cells, where digestion takes place. Blue arrows show water flow patterns. The brown arrow shows the direction of movement of trapped food particles.

➢ Mineralized Tissues and the Invertebrates

over two-thirds of the living species of animals that contain mineralized tissues are invertebrates

✓ Collagen matrix

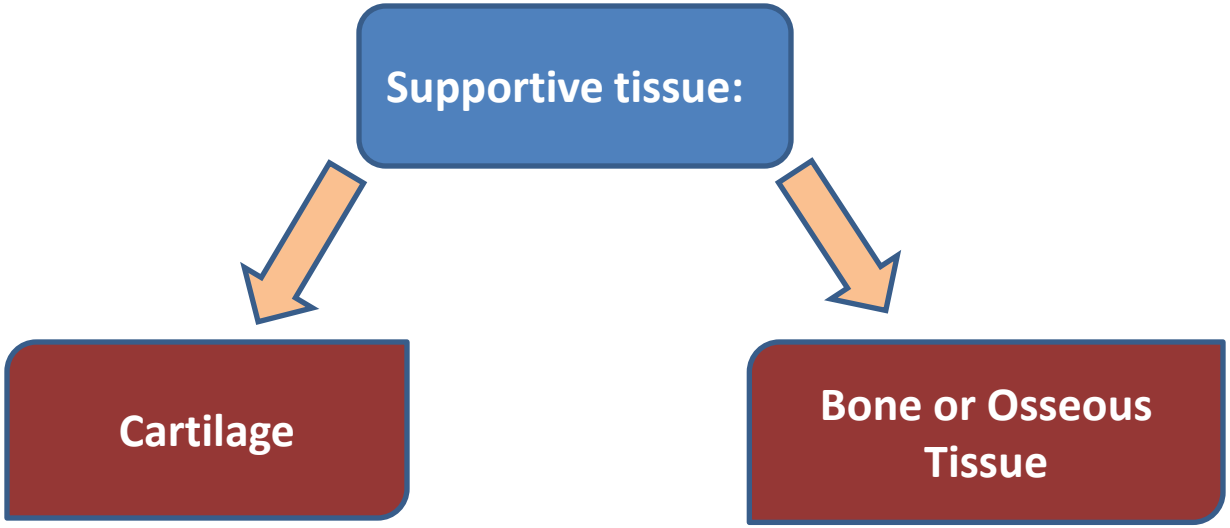
Most invertebrates have inorganic calcium carbonate crystals embedded in a collagen matrix.

✓ Cartilage

- supportive tissue
- lighter than bone
- gives speed and agility to catch prey
- provides buoyancy
- Examples: gastropods, invertebrate chordates (amphioxus), jawless fishes such as hagfishes and lampreys, and sharks and rays

THE SKELETAL SYSTEM OF VERTEBRATES

The vertebrate skeletal system is an endoskeleton enclosed by other body tissues. This endoskeleton consists of two main types of supportive tissue:



1) Cartilage:

- connective tissue
- provides a site for muscle attachment
- aids in movement at joints,
- pro- vides support
- consists of cells (chondrocytes), fibers, and a cellular matrix.

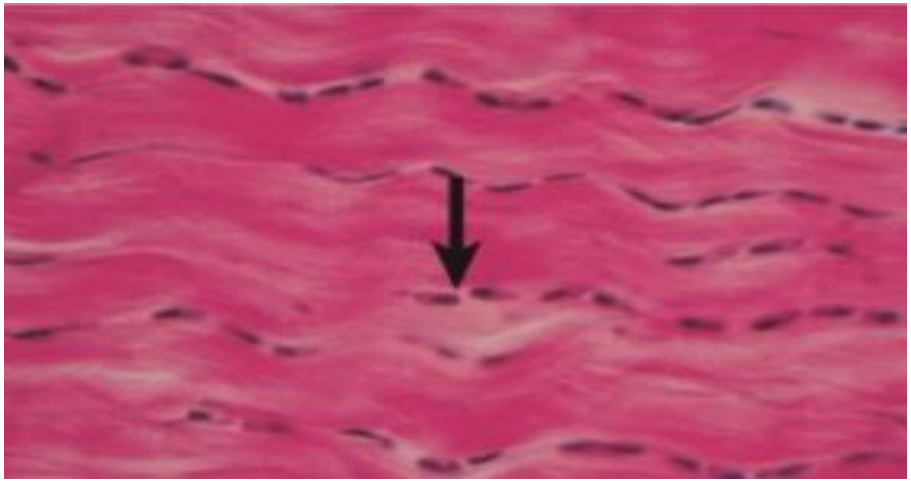


Fig: Fibrous connective tissue consists largely of tightly packed collagenous fibers. The arrow points to a fibroblast. Location: Dermis of the skin, submucosa of the digestive tract, and fibrous capsules of organs and joints. Function: Provides structural strength.

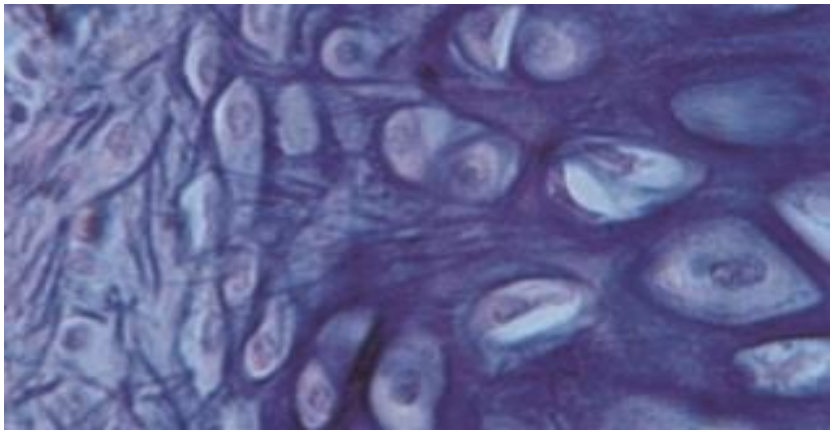


Fig: Elastic cartilage contains fine collagenous fibers and many elastic fibers in its intercellular material. Location: External ear, epiglottis. Function: Maintains a structure's shape while allowing great flexibility.

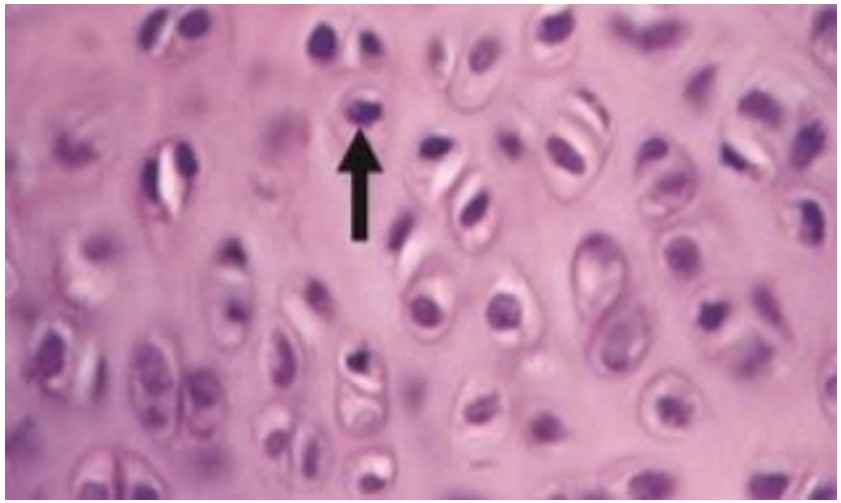
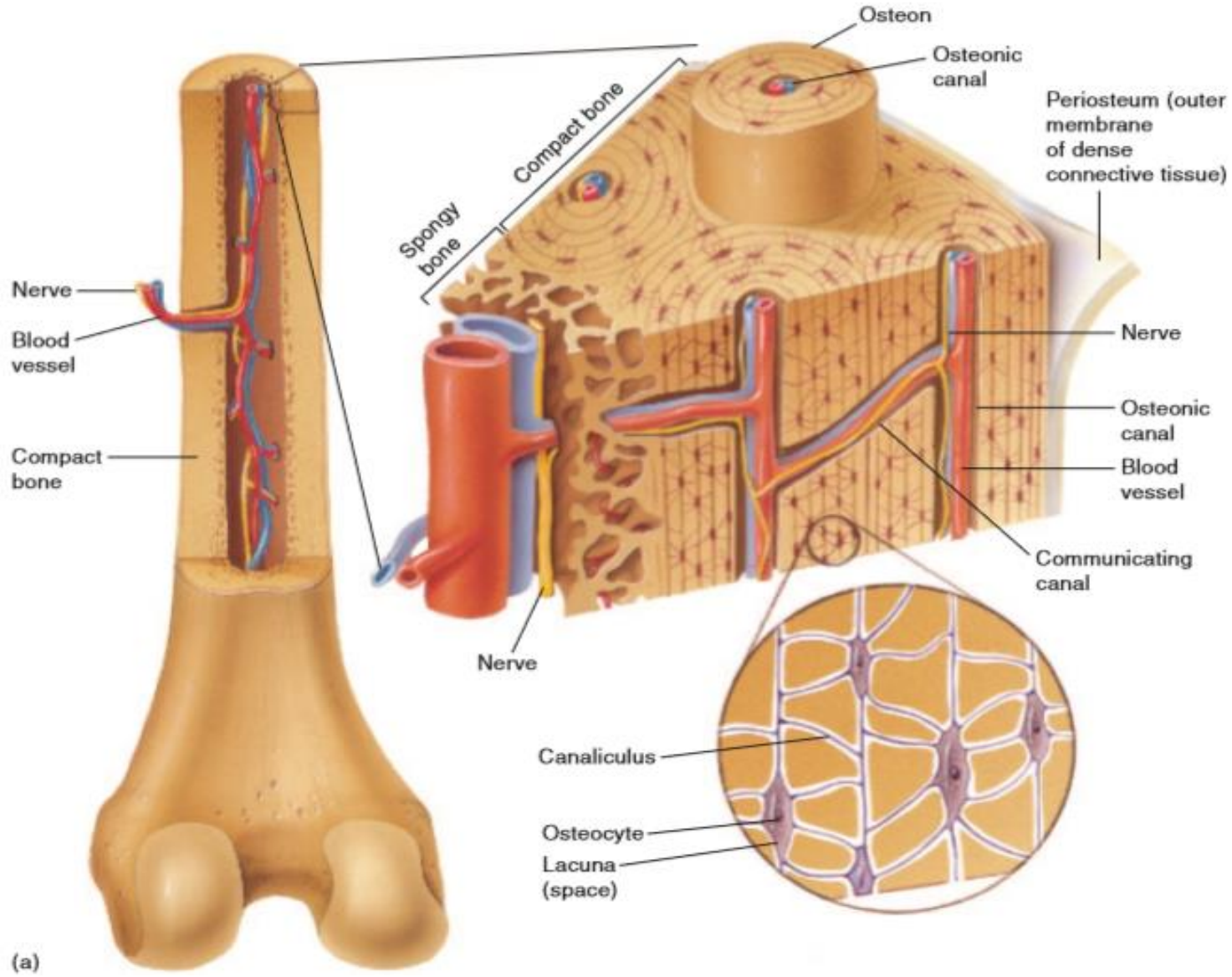


Fig: Hyaline cartilage cells are located in lacunae (arrow) surrounded by intercellular material containing fine collagenous fibers. Location: Forms embryonic skeleton; covers ends of long bones; and forms cartilage of nose, trachea, and larynx. Function: Support and reinforcement.

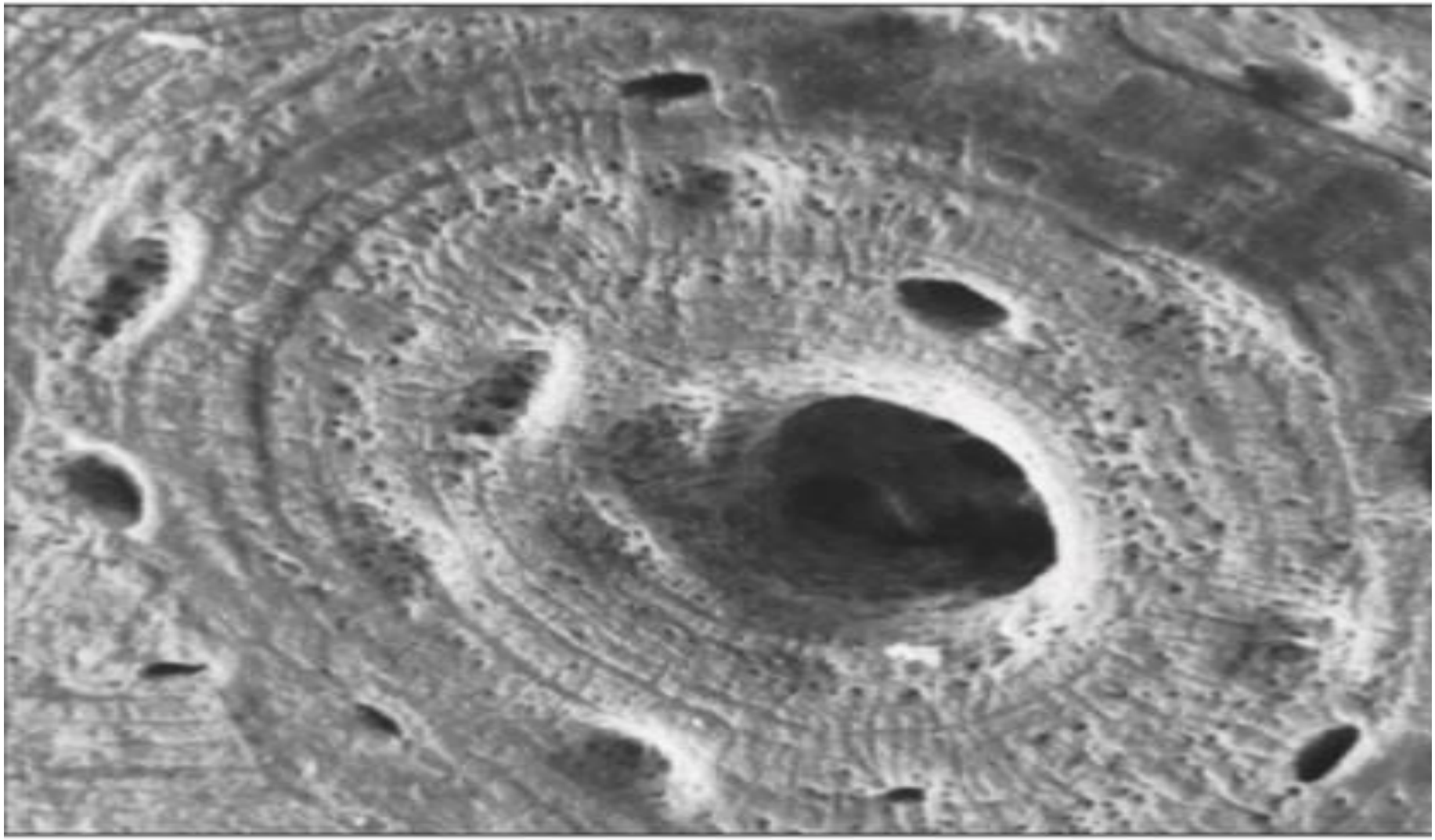
2) Bone or Osseous Tissue :

- ✓ specialized connective tissue
- ✓ provides a point of attachment for muscles
- ✓ transmits the force of muscular contraction from one part of the body to another during movement.
- ✓ sup- port the internal organs of many animals
- ✓ store reserve calcium and phosphate
- ✓ manufacture red blood cells and some white blood cells.
- ✓ Rigid
- ✓ In metabolic reactions releases the required amounts of calcium or phosphate stored within bones.

❖ Bone cells (osteocytes) are in minute chambers called lacunae (sing., lacuna), which are arranged in concentric rings around osteonic canals (formerly called Haversian systems). These cells communicate with nearby cells by means of cellular processes passing through small channels called canaliculi (sing., canaliculus)



Fig(a): Structural organization of a long bone (femur) of mammals. Compact bone is composed of osteons connected together. Spongy bone is latticelike rather than dense



(b)

Fig(b): Single osteon in compact bone

The Skeleton of Fishes:

- Since water has a buoyant effect on the fish body, the requirement for skeletal support is not as demanding in these vertebrates as it is in terrestrial vertebrates. Although most vertebrates have a well-defined vertebral column, the jawless vertebrates do not

- Most jawed fishes have an axial skeleton (a notochord, ribs, and cartilaginous or bony vertebrae).

Example:
lampreys only have isolated cartilaginous blocks along the notochord, and hagfishes do not even have these.

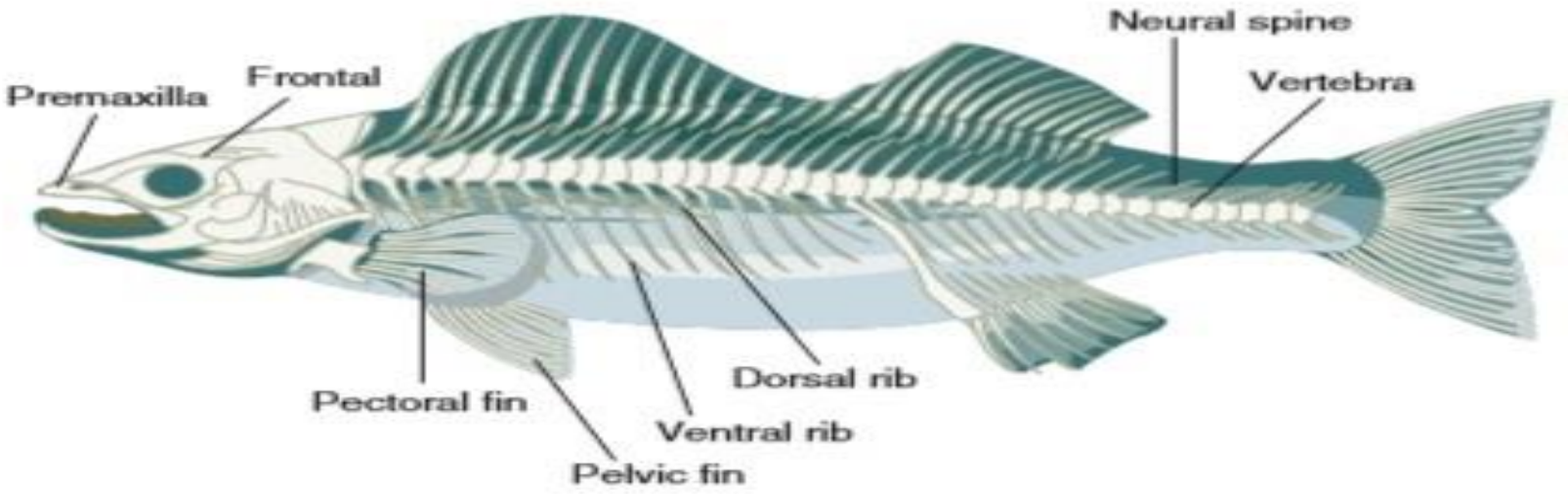
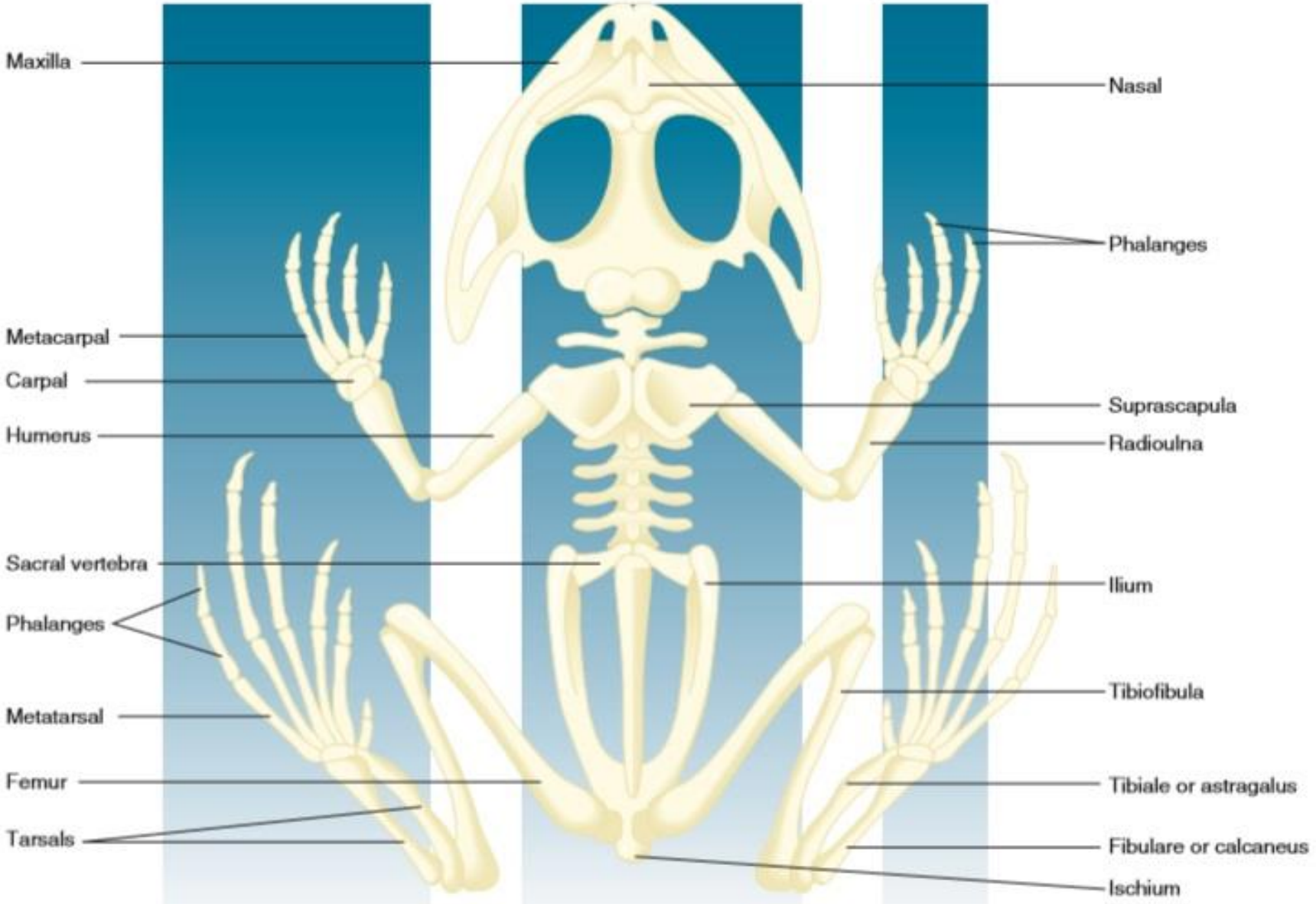


Figure: Fish Endoskeleton. Lateral view of the perch skeleton.

The Skeleton of Tetrapods

Tetrapods must lift themselves to walk on land. The first amphibians needed support to replace the buoyancy of water.

- During this evolution, the tetrapod endoskeleton became modified for support on land
- specialized intervertebral disks articulate with adjoining vertebrae
- intervertebral disks help hold the vertebral column together, and also absorb shock and provide joint mobility.
- Bone replaced cartilage in the ribs.
- various types of connective tissue that connect to the axial skeleton helped keep elevated portions from sagging
- Appendages became elongated for support on a hard surface
- changes in the shoulder enabled the neck to move more freely



Tetrapod Endoskeleton. Dorsal view of the frog skeleton

The Human Endoskeleton

The human endoskeleton has two major parts: