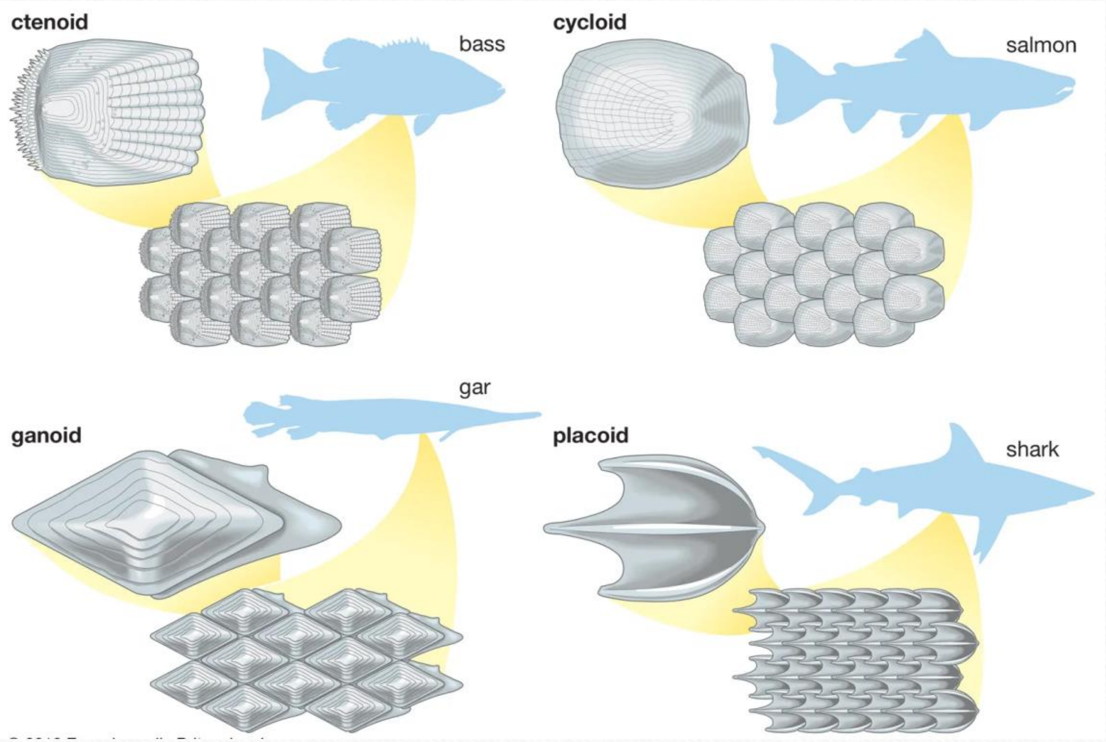
INTEGUMENT AND SKELETAL SYSTEMS OF ANIMALS

SEMESTER: I
UNIT: V



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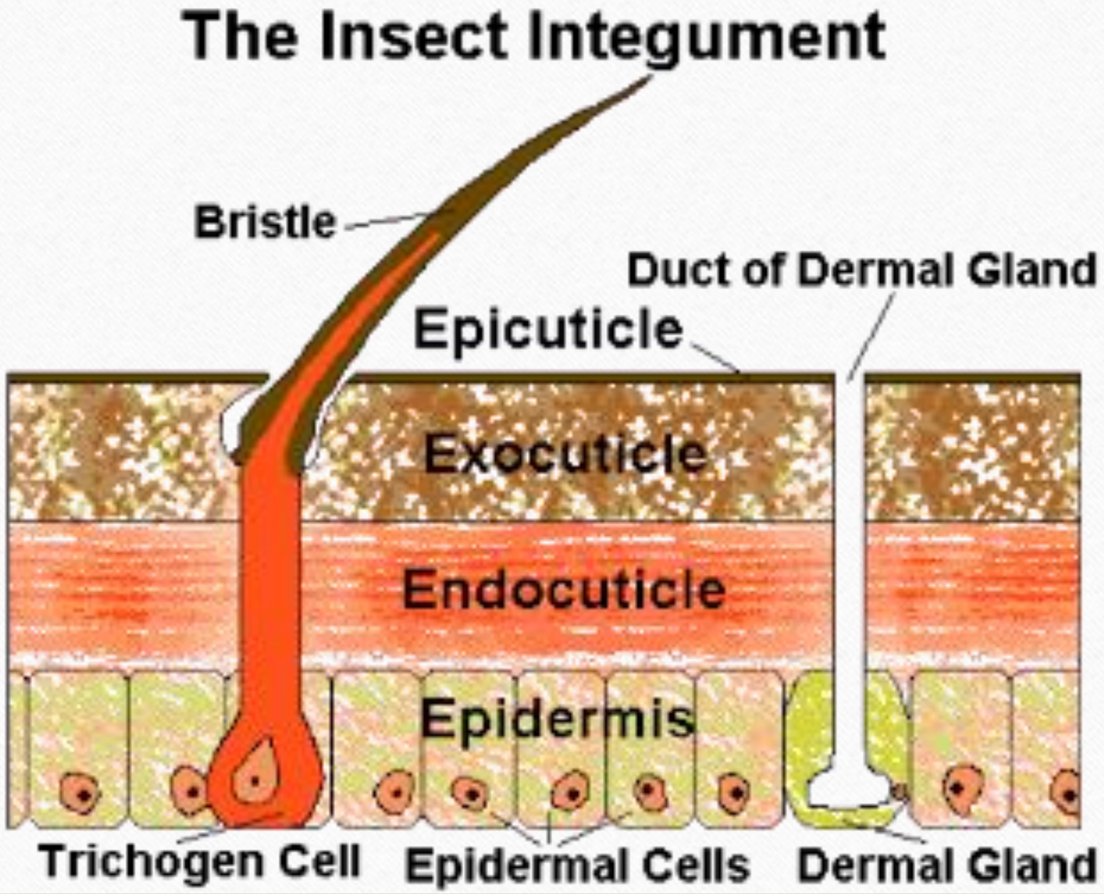
UNIT-V

INTEGUMENT AND SKELETAL SYSTEMS OF ANIMALS

General features of the Integument Dermis and Epidermis. Phylogeny-Specialization of the Integument-Skeletal System

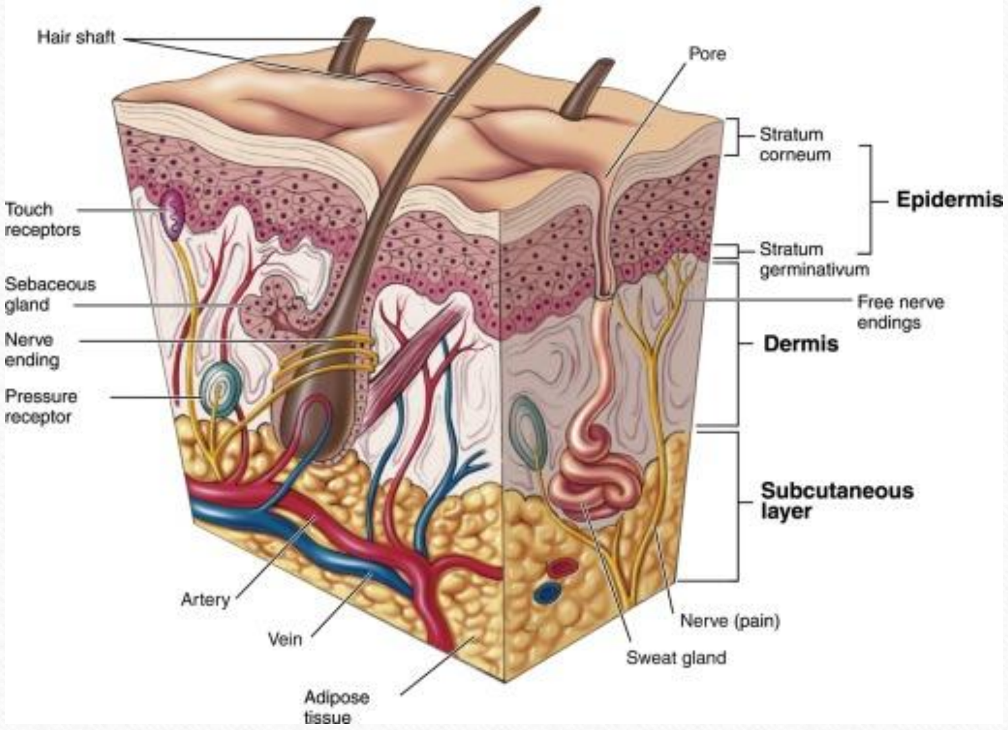


INTEGUMENT

- The integument is the protective outer covering of the body. Includes the skin and structures associated with the skin such as hair, setae, scales, feathers, and horns.

- Many invertebrates have a single-layered epidermis covering the body. Others have added a secreted noncellular cuticle over the epidermis. Additional protection

- Molluscs have a delicate epidermis. Protection is provided by the shell. Cephalopods have a more complex epidermis with a cuticle, simple epidermis, layer of connective tissue, & a layer of iridocytes.



- Arthropods have a complex integument that provides protection and skeletal support. Single layered epidermis (hypodermis) which secretes a complex cuticle. Procuticle – layers of chitin and protein. Epicuticle – moisture proofing barrier.
- The arthropod cuticle may remain tough, but flexible as in many small crustaceans and insect larvae, or it may become hardened. Decapod crustaceans have a cuticle stiffened by calcification (deposition of calcium carbonate in the procuticle. In insects, hardening occurs by sclerotization where protein molecules bond together producing the insoluble protein sclerotin.

FUNCTIONS OF INTEGUMENT

- Main Protection (first line of defense and protects from u.v radiations and dehydration)
- Others(evolutionary)
- Thermoregulation, Excretion.
- Conversion of sunlight into vitamin D.
- Reception of environmental stimuli, Locomotion and movement of nutrients and gases.

INTEGUMENT AND INVERTEBRATES

Single-celled Protozoans

Plasma membrane

- Large surface area relative to body volume.
- Gas exchange and removal of soluble wastes(diffusion)
- Facilitates uptake of dissolved nutrients from surrounding fluids.

Pellicle (L. pellicula, thin skin)

- Outside plasma membrane.
- Further environmental protection, semirigid structure, transmits force of cilia or flagella to entire body as it moves.
- Present in paramecium.

Multicellular Invertebrates

Plasma membrane

- Epidermis(gr. epi, upon and derm, skin)
- Single layer of columnar epithelial cells.
- Rests on basement membrane.
- Connective tissue fibres and cells lie beneath basement membrane.
- May possess cilia.
- Some may contains glandular cells.

Cnidarians (hydra) epidermis

- Only a few cell layers thick.
- Corals have mucous glands that secrete calcium carbonate shell.
- Cnidocytes, nematocysts, mesoglia, gastrodermis.

Nematodes(round worms) and Annelids(segmented worms)

- Contains one cell thick epidermis which secretes multilayered cuticle

Echinoderms

Thin usually ciliated epidermis and an underlying connective tissue dermis containing $CaCO_3$.

Molluscs

Molluscs have glandular epithelial envelope called mantle which secretes calcareous shell.

Porifera

Outer layer called pinacoderm made of cells called pinacocytes, inner layer (choanoderm), mesenchyme, spicules.

Cuticle(L. cuticula, skin)

Arthropods character.

Highly variable in structure. thin and elastic in rotifers. thick, rigid and support the body in (crustaceans, arachnids, insects.)

Non-cellular consists of chitin and proteins in rigid plates.

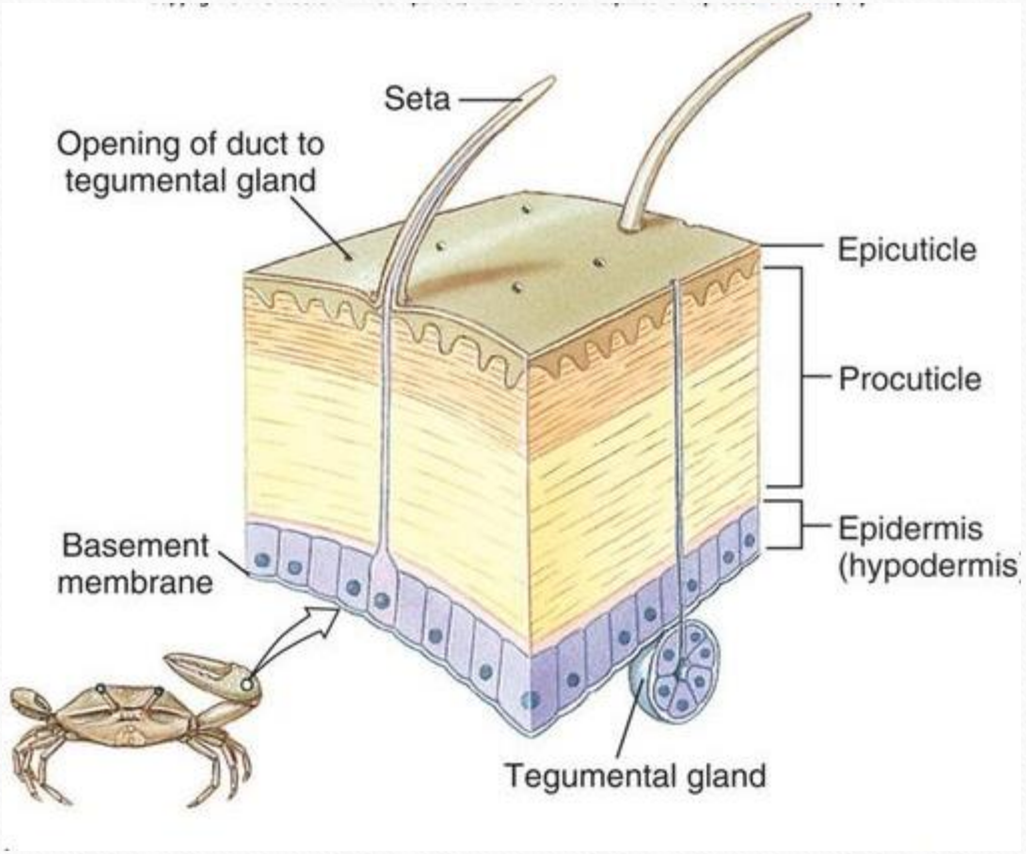
Disadvantage: difficulty in growing, ecdysis is done.

Tegument (L. tegumentum, to cover)

Complex syncytium (group of protoplasm, no cellularization, multinucleated)

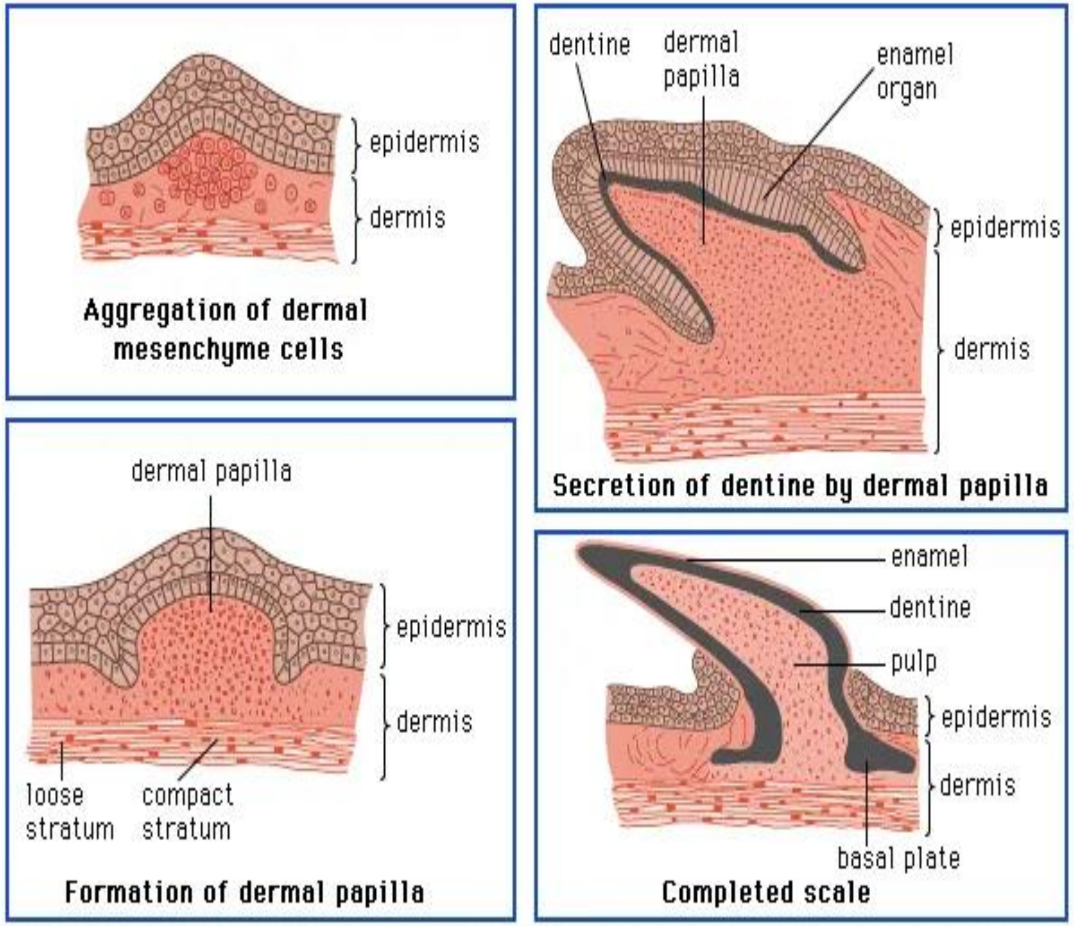
Outer covering of Parasitic flukes and tapeworms (Platyhelminthes).

Main functions are nutrient ingestion and protection against digestion by host enzymes.



Dermis and Epidermis

- ✓ The outermost layer of cells of the body of an animal.
- ✓ In invertebrates the epidermis is normally only one cell thick and is covered by an impermeable cuticle.
- ✓ In vertebrates the epidermis is the thinner of the two layers of skin (compare dermis).
- ✓ It consists of a basal layer of actively dividing cells (see Malpighian layer), covered by layers of cells that become impregnated with keratin (see keratinization).
- ✓ The outermost layers of epidermal cells (the stratum corneum) form a water-resistant protective layer.
- ✓ The epidermis may bear a variety of specialized structures (e.g. feathers, hairs).



Differences among invertebrate groups

Protozoans

- The secreted coatings of protozoans exhibit all grades between soft forms (as in Amoeba) and forms with a cuticle that may be proteinaceous (as in Monocystis) or composed of cellulose (as in the plantlike flagellates).
- Other protozoans have definite shells, composed of protein incorporating various foreign bodies, such as siliceous plates or calcium carbonate (in most foraminiferans), or cellulose (in the resting stages of slime molds).
- The radiolarians have an internal lattice of silica that is laid down inside the cell—a kind of internal skeleton, or endoskeleton.

Sponges

- ✓ Sponges have a simple epithelium, known as the pinacoderm, which both covers the external surfaces and lines the internal waterways.
- ✓ Some sponges deposit needlelike spicules of calcium carbonate in the jelly (mesoglea) beneath this outer epithelium.

Cnidarians

- ✓ In the cnidarians the epidermis provides all the basic features of an integument. It may contain not only epithelial cells, some of which may be contractile, but also gland cells, pigment cells, stinging cells, and sensory cells with projecting hairs.
- ✓ The surface secretion may help in capturing food, adhering to substrates, cleaning away settling debris, or providing support and protection

Flukes and roundworms

- The parasitic flukes have a relatively thick integument, which bears many spines and sensory papillae, an apical membrane that is thrown into ridges and pits, and microvilli.
- The outer part of the integument contains secretory bodies, which are continuously released at the surface to renew the apical membrane.
- This appears to be a protective device for the parasite related to the immune reaction of the host. Roundworms have a thick, flexible cuticle, with three distinguishable zones, covered by an epicuticle.

Annelids

- Annelids have a thin, horny cuticle pierced by pores through which epidermal glands secrete mucus. In some marine annelids, glands are also present that secrete materials constituting a parchmentlike or calcareous tube within which the worm dwells. Earthworms and leeches secrete cocoons from a specialized epidermis in a region of the body known as the clitellum.

Arthropods

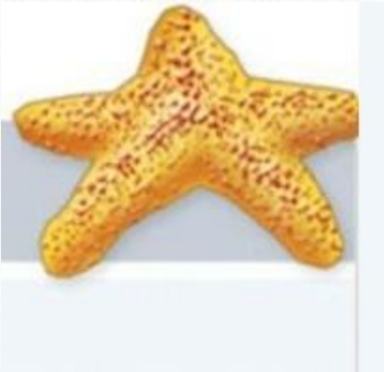
- The exoskeleton attains its most elaborate forms in the arthropods (for example, crustaceans and insects).
- The insect epidermis lies on a basement membrane and secretes a tough cuticle, the bulk of which is composed of fibres of a material known as chitin embedded in a matrix of protein.
- Peripheral to this is an epicuticle. Chitin is a high-molecular-weight polysaccharide containing amino groups.
- It is synthesized within the epidermis from sugars and amino sugars. In many crustaceans—crabs and lobsters, for example—much of the cuticle is rendered hard by the incorporation of calcareous substances such as aragonite or calcite.
- The cuticle of arthropods, pierced by ducts of dermal glands that pour out secretions over the surface, is a living structure; it can produce tactile bristles, pigment-bearing scales, claws, wings, and other structures.

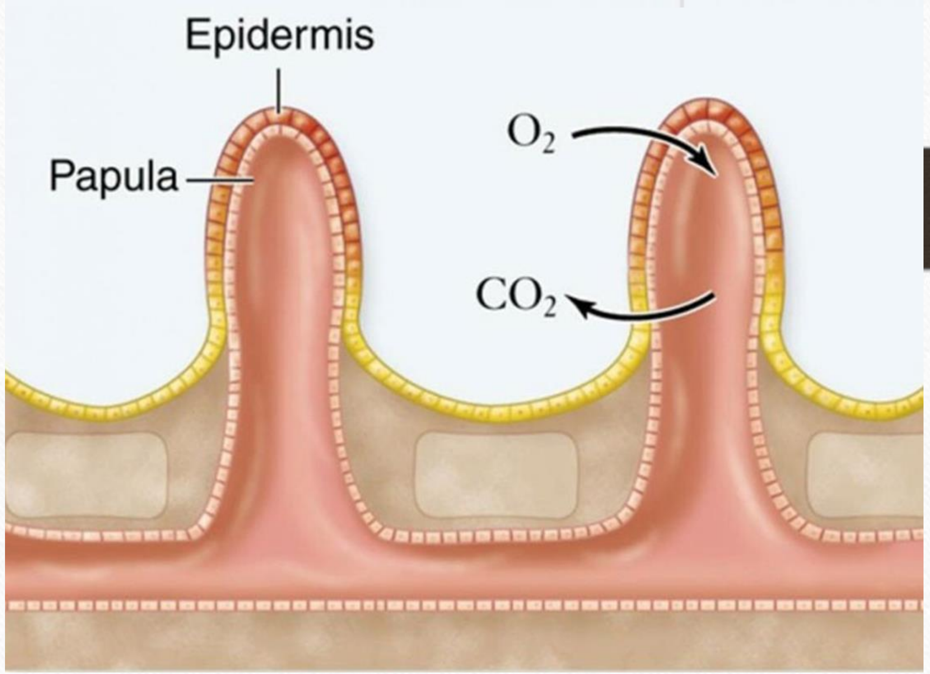
Mollusks

- The epidermis of mollusks is capable of a variety of functions.
- Ciliated epithelium is of particular importance for feeding in bivalves and for the gliding movement of snails.
- Abundant gland cells secrete mucus, which protects the animal from predators and from desiccation.
- Some cephalopods (squids, cuttlefish, octopuses) have luminous glands, although it is disputed whether the luminous material is produced by the epithelium itself or by bacteria.
- Cephalopods also have pigment cells that can be expanded by muscle contraction and can change colour very rapidly.
- The shell of mollusks is secreted by the epithelium of the mantle and consists of an outer layer of the horny substance conchiolin, an intermediate prismatic layer composed of calcite, and a smooth inner layer (the nacreous layer) also composed mainly of calcium carbonate.

Echinoderms

- The echinoderms are characterized by a calcareous exoskeleton, which may be a rigid armour, as in echinoids (sea urchins), or of a leathery consistency, as in holothurians (sea cucumbers).
- The epidermis lies outside of this skeleton.
- The apical plasma membrane is capable of taking up dissolved organic molecules from the surrounding seawater in amounts that are at least enough for the nourishment of the epidermal layer.
- Many sea urchins have projecting spines on which the epidermis is worn away to expose the calcareous material.





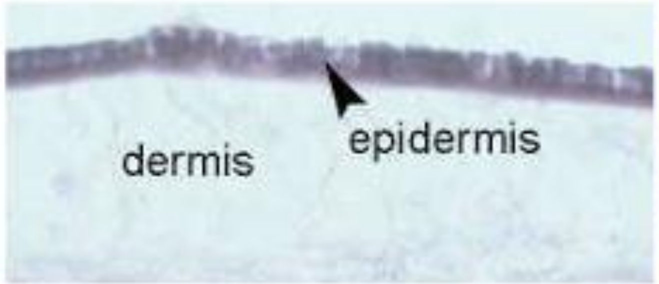
Phylogeny-Specialization of the Integument-Skeletal System

- ✓ The epidermis, derived from somatic ectoderm, is the exterior-most covering of the chordate body.
- ✓ It provides protection against the invasion of microorganisms, provides flexibility in motion, and seals in moisture.
- ✓ As will be seen, it also gives rise to a variety of differentiated structures such as feathers, hair, horns, claws, nails and glands.
- ✓ Amphioxus possesses the simplest possible form of epidermis - a single layer of columnar epithelium covered by a thin film of cuticle.
- ✓ All true vertebrates, however, have developed a multi-layered epithelium. Note the simple, multicellular, epithelium of the lamprey, which has no scales.
- ✓ Fishes and amphibians have a mucus layer for bacterial and mechanical protection and to prevent drying on land. Terrestrial vertebrates have replaced the cuticle with keratin.

Epidermal Derivatives of the Integument

Keratin Structures

- ✓ New epidermal cells are formed continuously in the lower layers of the epidermis. In terrestrial vertebrates, new epidermal cells push more superficial ones to the stratum corneum, the outer-most epithelial layer.
- ✓ In the process of self-destruction, these exterior epidermal cells accumulate protein products called keratin. Keratinized or cornified skin serves to prevent water escape and to protect against friction and direct mechanical stimulation (e.g. calluses in humans).
- ✓ The production of all of the following structures involves keratinization: .



Epidermal Scales

- ✓ A continuous layer of repetitious thickenings of the stratum corneum; you cannot dissect an individual epidermal scale out of the skin! These scales may be shed entirely (moulting) or in small flakes.

Claws and Talons

- ✓ Curved, laterally compressed keratinized projections from the tips of digits.

Hooves

- ✓ Enlarged keratinized plates found on the ends of ungulate digits.

Nails

- ✓ Keratinized epithelial cells are produced at the nail base and push the existing nail forward. They provide protection from mechanical injury and stabilize skin for better grasping. Found only in primates.

Horns

- ✓ A tough, cornified layer of the integument covers horns. Their core, however, is bone, which is of dermal origin. Horns are found in bovines (cattle, antelope, sheep, goats, bison, wildebeest). They are retained year-round and grow throughout the animal's lifetime.

Baleen

- ✓ Found in some whales, baleen is a series of keratinized plates that arise from oral epithelium. These sheets hang from the palate along its length and act as a sieve

Beaks :

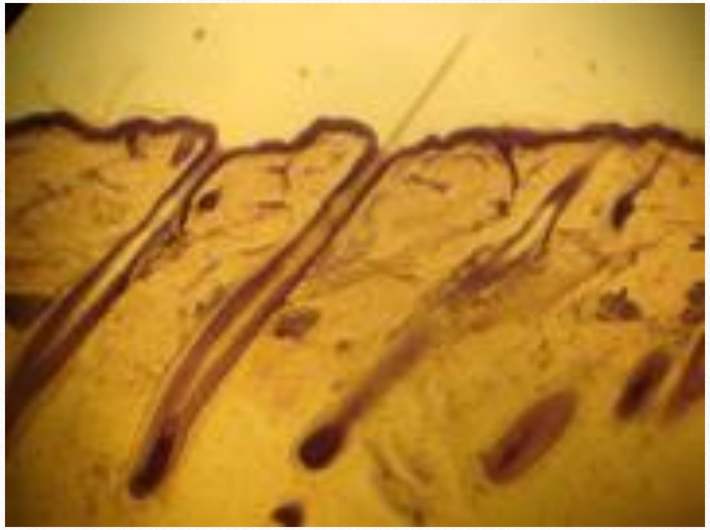
- ✓ Epidermal structures, jaws are covered by keratinized sheaths in birds and turtles.

Feathers

- Feathers are believed to have evolved from reptilian scales.
- Columns of epidermal cells project into the skin initially to form an invagination called the feather follicle.
- Later growth results in a projection out of the skin of a keratinized epidermal sheath with an inner feather shaft. These columns then separate and develop into barbs.
- Feather growth is initiated by dermal papillae, which die in the grown feather to form feather pulp. Examine the dried specimens.
- Note the quill (calamus), which attaches to the body and extends as a rachis.
- From the rachis project many veins with barbs and barbules to hold them together.

Hair

- Just as in feathers, there is an initial ingrowth of epidermal cells to form the hair follicle, followed by an outward growth of keratinized cells to form the hair shaft.
- Dermal papillae cells of the outer edge die and form the core substance of hair follicles. Note the similarities between hair and feathers both in development and in general anatomy.
- They both possess dermal papillae, shafts, an inner pulp and columns of specialized keratinized cells. Hair is characteristic of mammals.



THE DERMIS AND ITS DERIVATIVES

- ✓ The dermis is generally much thicker than the epidermis and lies more deeply.
- ✓ It is made of a fibrous mass of connective tissue (collagen) and is of mesodermal origin.
- ✓ It may directly produce dermal (membrane) bone.
- ✓ The dermis is important in defence against injury and in the maintenance of body heat.
- ✓ Deeper regions of the dermis often contain fatty deposits, smooth muscle, blood vessels and nerves.
- ✓ Chromatophore cells are sometimes epidermal, but usually dermal in origin.
- ✓ They secrete melanin, which can be passed to the stratum corneum of skin and to hair shafts to produce colour and block harmful sunlight.

Dermal Bone

- ✓ Once present in some extinct fish - Ostracoderms had a complete head shield, while Placoderms had a broken head shield and body armour.
- ✓ Now dermal bone is present in turtle dermal bone, antlers, and in the dermal armour of armadillo.
- ✓ In antlers the velvet is epidermal in origin and shapes and provides blood to the dermal bone. Once grown, the velvet is shed and only the bone remains.
- ✓ Antlers are found in deer, elk, moose and their relatives, often only in males. They are shed annually.
- ✓ In most modern vertebrates, dermal bone (membrane bone) is formed from embryonic mesenchyme by intramembranous ossification, and contributes to the skull and skeleton, rather than being manifested externally.
- ✓ An exception is teeth, which are partly derived from dermal bone.


ANTLER
DERMAL BONE

Fish Scales

Fish scales are also called dermal scales since they are derived mainly from the dermis.

1)Cosmoid Scales: Found in Placoderms (extinct) as plates, and also typical of the Lobe Finned Fishes or Sarcopterygii, (Choanichthyes). Extinct fish had scales of enamel, cosmine and bone with pulp cavities. Modern ones, like Coelocanth and the lung fish have calcified fibers so this type of scale is almost extinct.

2)Ganoid Scales: See bioplastic mounts, slides, the plates of sturgeon, called scutes, and the scales of the gar pike on display. Made of multi-layered enamel called ganoin over lamellar bone. Primitive (now extinct) species also had a cosmine layer and vascular bone with pulp, but these were lost in modern day examples.

3)Placoid Scales: See bioplastic mounts and dogfish slides. Made of enamel (epidermal) and the dermal derivatives, dentine and bone with a pulp core. They are typical of cartilaginous fishes. Placoid scales are responsible for the rough feeling of dogfish skin.

4) Teleost (bony fish) scales

These are thin scales of dermal bone. They have a thin covering of epidermal tissue over them. It is derived by reduction (loss) of parts of a ganoid scale. There are two types depending on their shape.

4a) Cycloid Scales: See bioplastic mounts and slides. A round ended scale.

4b) Ctenoid Scales: See bioplastic mounts and slides. A comb shaped end is characteristic of this scale type.

SKELETAL SYSTEM

- The skeleton of invertebrates, which may be either external or internal, is composed of a variety of hard nonbony substances.
- The more complex skeletal system of vertebrates is internal and is composed of several different types of tissues that are known collectively as connective tissues.
- This designation includes bone and the various fibrous substances that form the joints, connect bone to bone and bone to muscle, enclose muscle bundles, and attach the internal organs to the supporting structure.
- A skeletal system is necessary to support the body, protect internal organs, and allow for the movement of an organism.
- There are three different skeleton designs that fulfill these functions: hydrostatic skeleton, exoskeleton, and endoskeleton.

- ✓ Support of the body is achieved in many protozoans by a simple stiff, translucent, nonliving envelope called a pellicle.
- ✓ In nonmoving (sessile) coelenterates, such as coral, whose colonies attain great size, it is achieved by dead structures, both internal and external, which form supporting axes.
- ✓ The skeleton's protective function alone may be provided by structures situated on the body surface—e.g., the lateral sclerites of centipedes and the shell (carapace) of crabs.
- ✓ The skeleton facilitates movement in a variety of ways, depending on the nature of the animal.
- ✓ The bones of vertebrates and the exoskeletal and endoskeletal units of the cuticle of arthropods (e.g., insects, spiders, crabs) support opposing sets of muscles (i.e., extensors and flexors).
- ✓ In other animal groups the hydrostatic skeleton provides such support
- ✓ In a limited number of animals, the hard skeleton transmits vibrations that are sensed by the hearing mechanism.

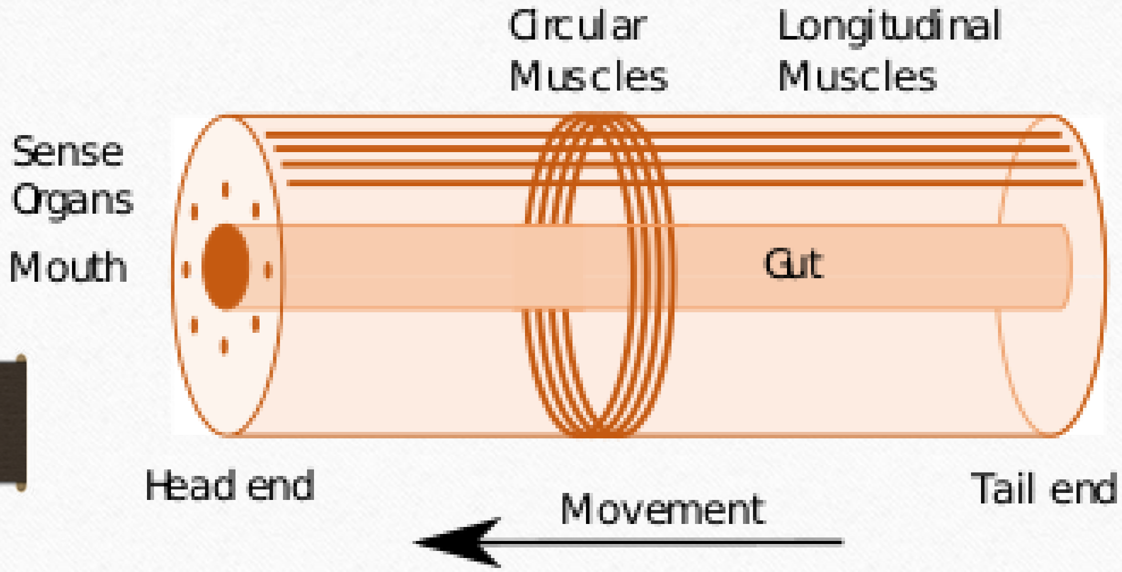
- ✓ In some forms—e.g., bony fishes and fast-swimming squids—it aids in the formation of buoyancy mechanisms that enable the animal to adjust its specific gravity for traveling at different depths in the sea.
- ✓ Skeletal fibres of similar chemical composition occur in unrelated animal groups; for example, coiled shells of roughly similar chemical composition are present in gastropods (e.g., snails), brachiopods (e.g., lamp shells), and cephalopods (e.g., chambered nautilus). The mechanical properties of different skeletal types vary considerably according to the needs of animals of particular size ranges or habits (e.g., aquatic, terrestrial).

Hydrostatic Skeleton

✓A hydrostatic skeleton is a skeleton formed by a fluid-filled compartment within the body, called the coelom.

✓The organs of the coelom are supported by the aqueous fluid, which also resists external compression. This compartment is under hydrostatic pressure because of the fluid and supports the other organs of the organism.

- ✓This type of skeletal system is found in soft-bodied animals such as sea anemones, earthworms, Cnidaria, and other invertebrate
- ✓Movement in a hydrostatic skeleton is provided by muscles that surround the coelom.
- ✓The muscles in a hydrostatic skeleton contract to change the shape of the coelom; the pressure of the fluid in the coelom produces movement.
- ✓For example, earthworms move by waves of muscular contractions of the skeletal muscle of the body wall hydrostatic skeleton, called peristalsis, which alternately shorten and lengthen the body. Lengthening the body extends the anterior end of the organism.
- ✓Most organisms have a mechanism to fix themselves in the substrate. Shortening the muscles then draws the posterior portion of the body forward.
- ✓Although a hydrostatic skeleton is well-suited to invertebrate organisms such as earthworms and some aquatic organisms, it is not an efficient skeleton for terrestrial animals.


Circular
Muscles
Longitudinal
Muscles
Sense
Organs
Mouth
Gut
Head end
Tail end
Movement

Exoskeleton

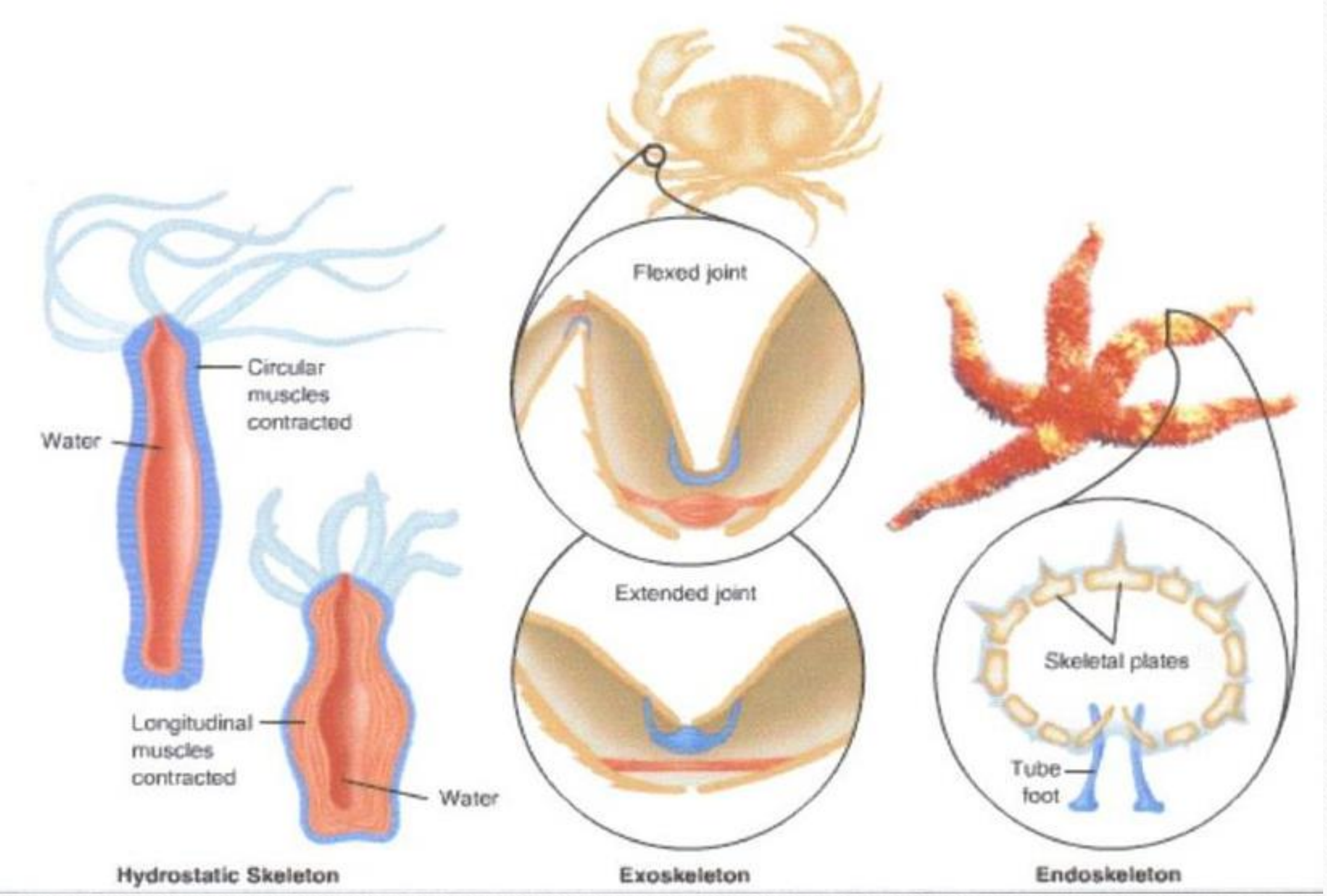
- An exoskeleton is an external skeleton that consists of a hard encasement on the surface of an organism. For example, the shells of crabs and insects are exoskeletons.
- This skeleton type provides defence against predators, supports the body, and allows for movement through the contraction of attached muscles.
- As with vertebrates, muscles must cross a joint inside the exoskeleton.
- Arthropods such as crabs and lobsters have exoskeletons that consist of 30–50 percent chitin, a polysaccharide derivative of glucose that is a strong but flexible material.
- Chitin is secreted by the epidermal cells. The exoskeleton is further strengthened by the addition of calcium carbonate in organisms such as the lobster.
- Because the exoskeleton is acellular, arthropods must periodically shed their exoskeletons because the exoskeleton does not grow as the organism grows.

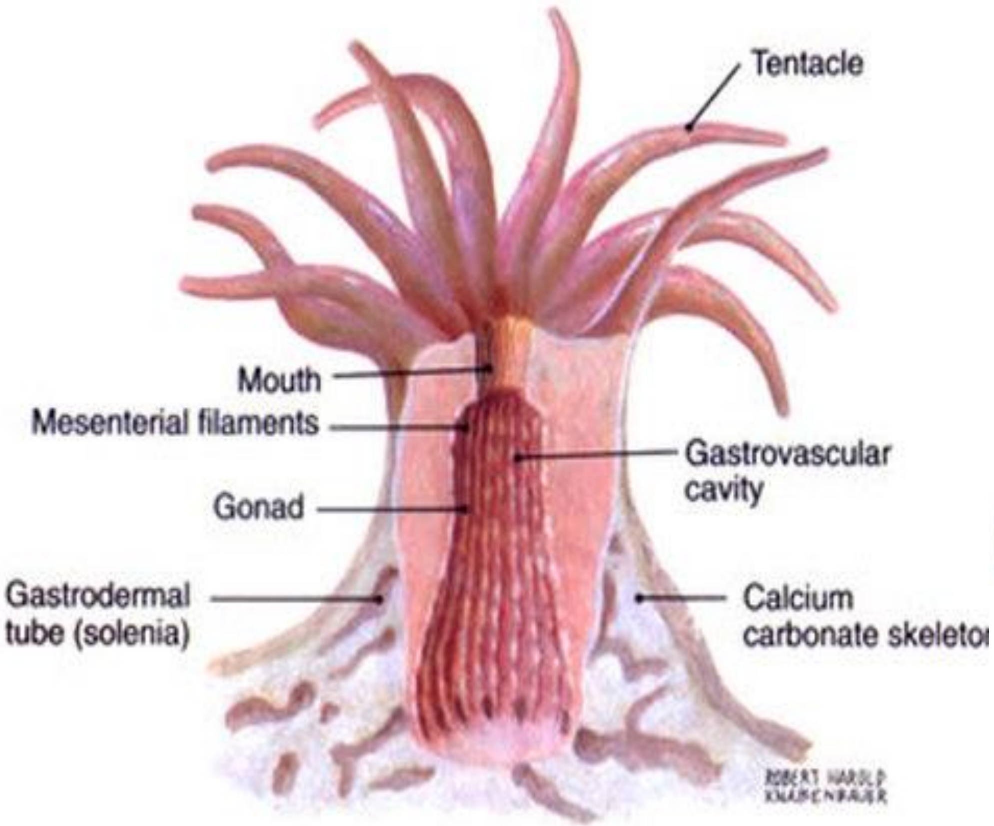

Endoskeleton

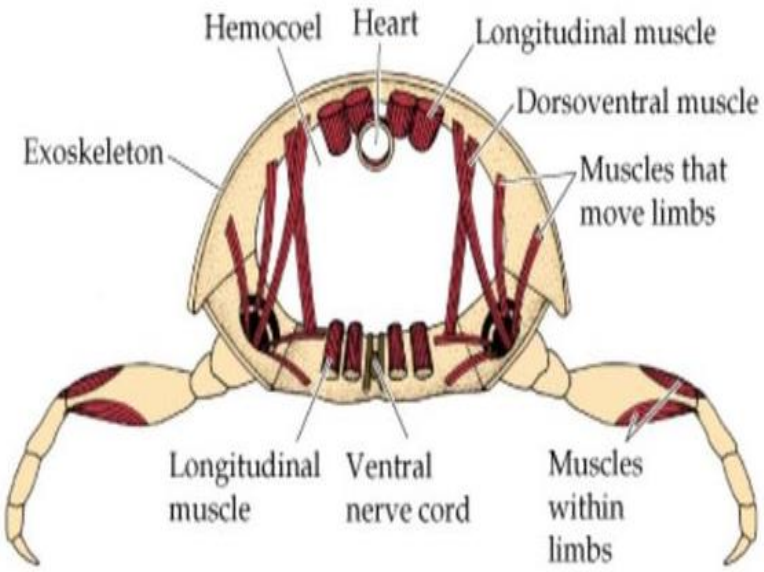
- ✓ An endoskeleton is a skeleton that consists of hard, mineralized structures located within the soft tissue of organisms.
- ✓ An example of a primitive endoskeletal structure is the spicules of sponges.
- ✓ The bones of vertebrates are composed of tissues, whereas sponges have no true tissues.
- ✓ Endoskeletons provide support for the body, protect internal organs, and allow for movement through contraction of muscles attached to the skeleton

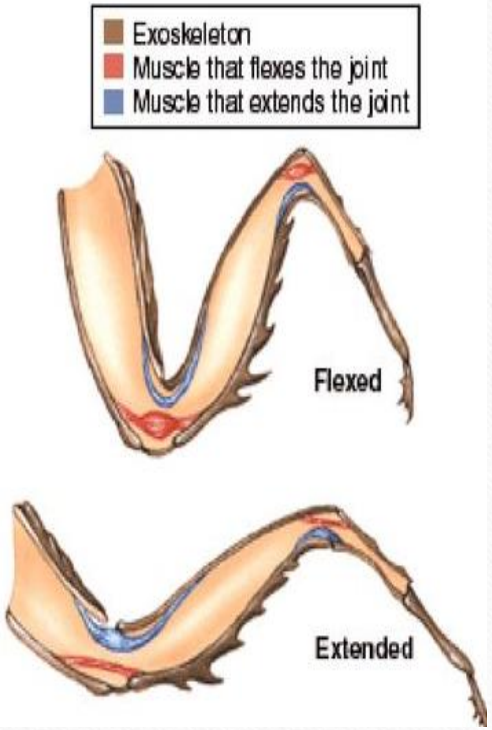
The human skeleton is an endoskeleton that consists of 206 bones in the adult. It has five main functions: providing support to the body, storing minerals and lipids, producing blood cells, protecting internal organs, and allowing for movement. The skeletal system in vertebrates is divided into the axial skeleton (which consists of the skull, vertebral column, and rib cage), and the appendicular skeleton (which consists of the shoulders, limb bones, the pectoral girdle, and the pelvic girdle)

Invertebrate Skeletal Systems




Tentacle
Mouth
Mesenterial filaments
Gastrovascular cavity
Gonad
Gastrodermal tube (solenia)
Calcium carbonate skeleto
ROBERT HAROLD KNABENBAUER


Hemocoel
Heart
Longitudinal muscle
Dorsoventral muscle
Exoskeleton
Muscles that move limbs
Longitudinal muscle
Ventral nerve cord
Muscles within limbs


Exoskeleton
Muscle that flexes the joint
Muscle that extends the joint
Flexed
Extended

Exoskeleton: seen mainly in invertebrates




Endoskeleton: seen in vertebrates, sea stars, sponges





Thank you