Chapter 23

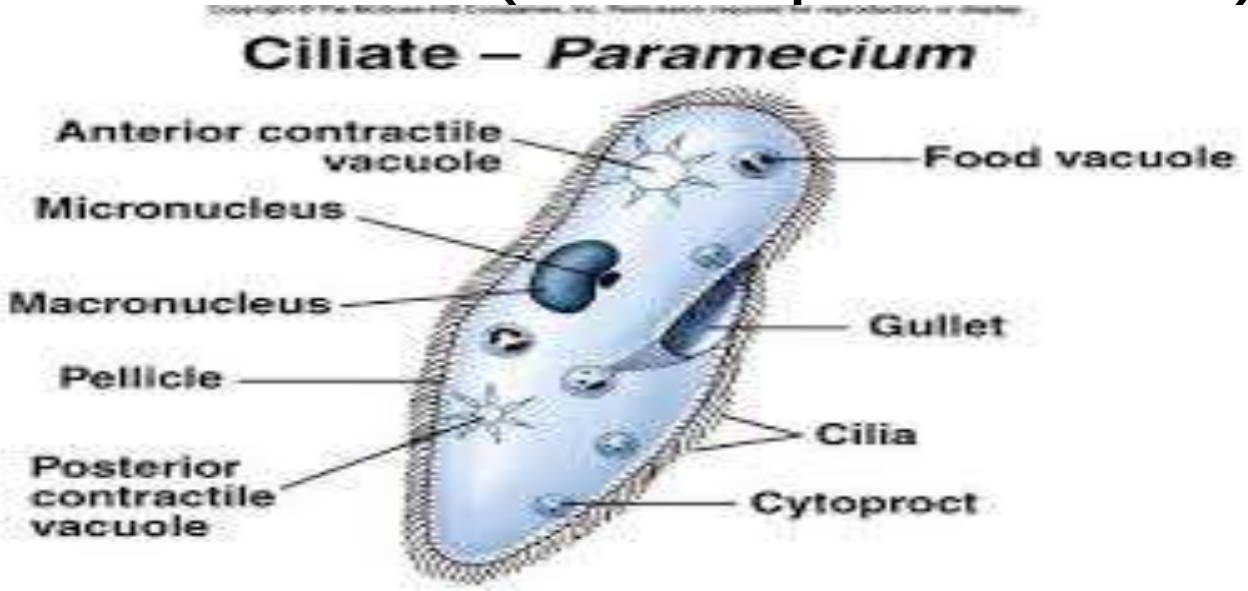
Protection, Support, and Movement

Protection: Integumentary System

Integument - is the external covering of an animal. It protects the animal from mechanical and chemical injury and invasion by microorganism.

THE INTEGUMENTARY SYSTEM OF INVERTEBRATES

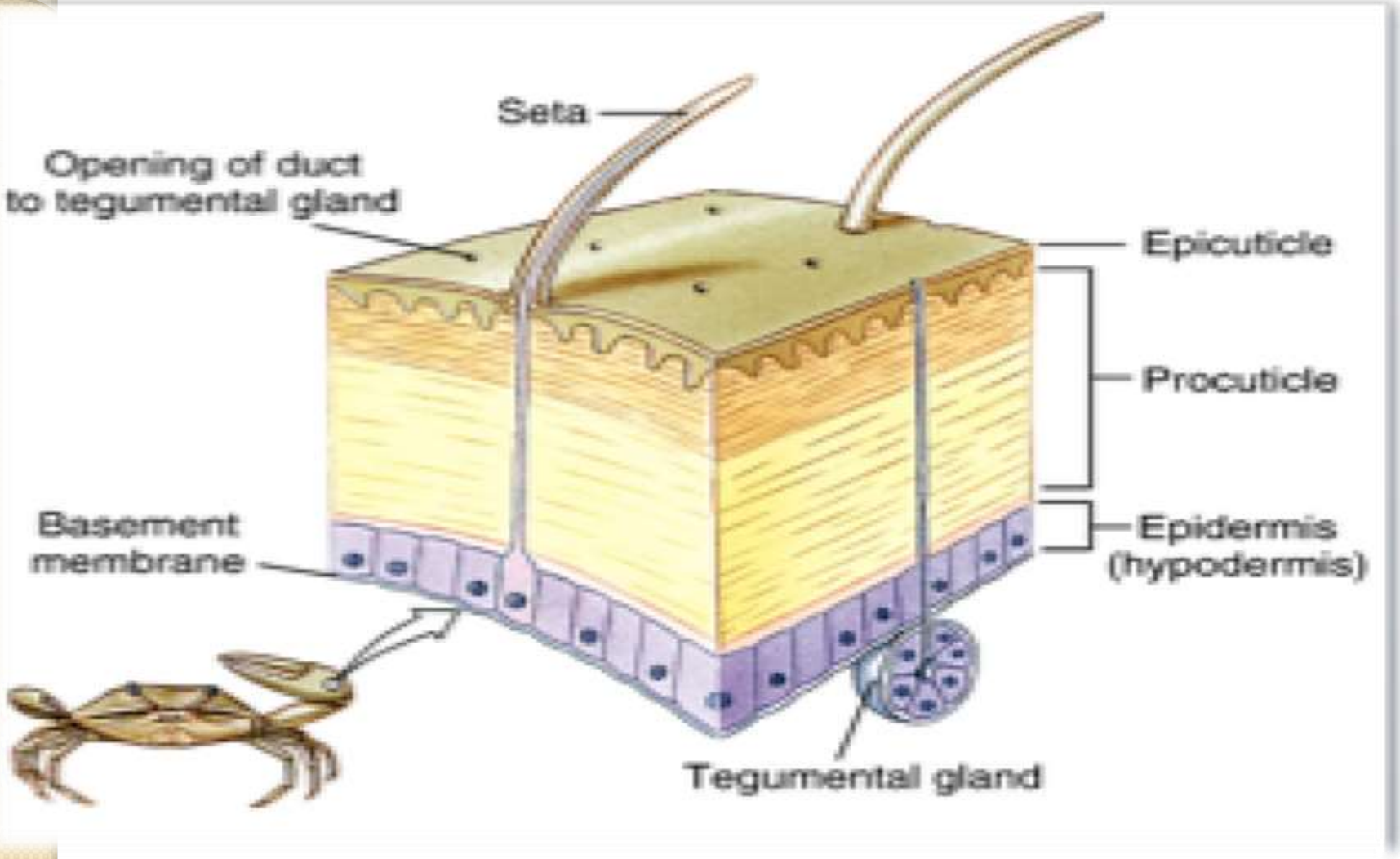
- **Single-celled protozoa**
  - Plasma membrane
- **Paramecium**
  - Pellicle (a thick protein coat)



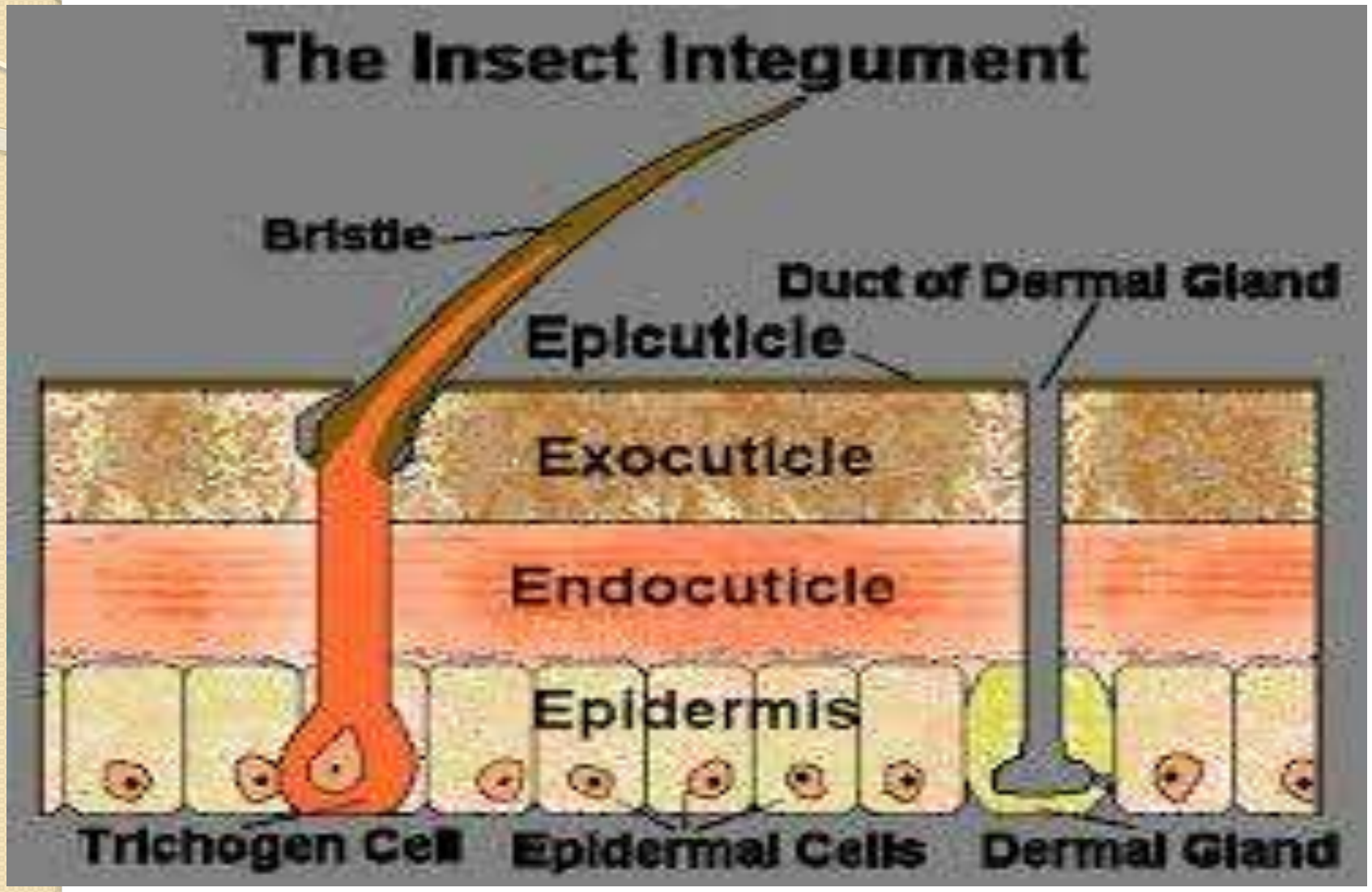
- **Multicellular invertebrates**
  - Epidermis (the outer layer)
- **Some invertebrates**
  - Cuticles (thin and elastic/,thick and rigid)
- **Cnidarian (corals)**
  - Mucus glands
- **Parasitic flukes and tapeworms**
  - Tegument
- **Nematodes and annelids**
  - Epidermis
- **Echinoderms**
  - thin, ciliated epidermis
- **Arthropods**
  - exoskeleton


What manner of armor is this?!?
heh heh...
EXOSKELETON!

Integument of crustacean



Integument of vertebrates



THE INTEGUMENTARY SYSTEM OF VERTEBRATES

- Skin - is the vertebrate integument

  - largest organ

Skin has 2 main layers:

- **Dermis**

  – is the connective tissue meshwork of collagenous, reticular, and elastic fibers beneath the epidermis.

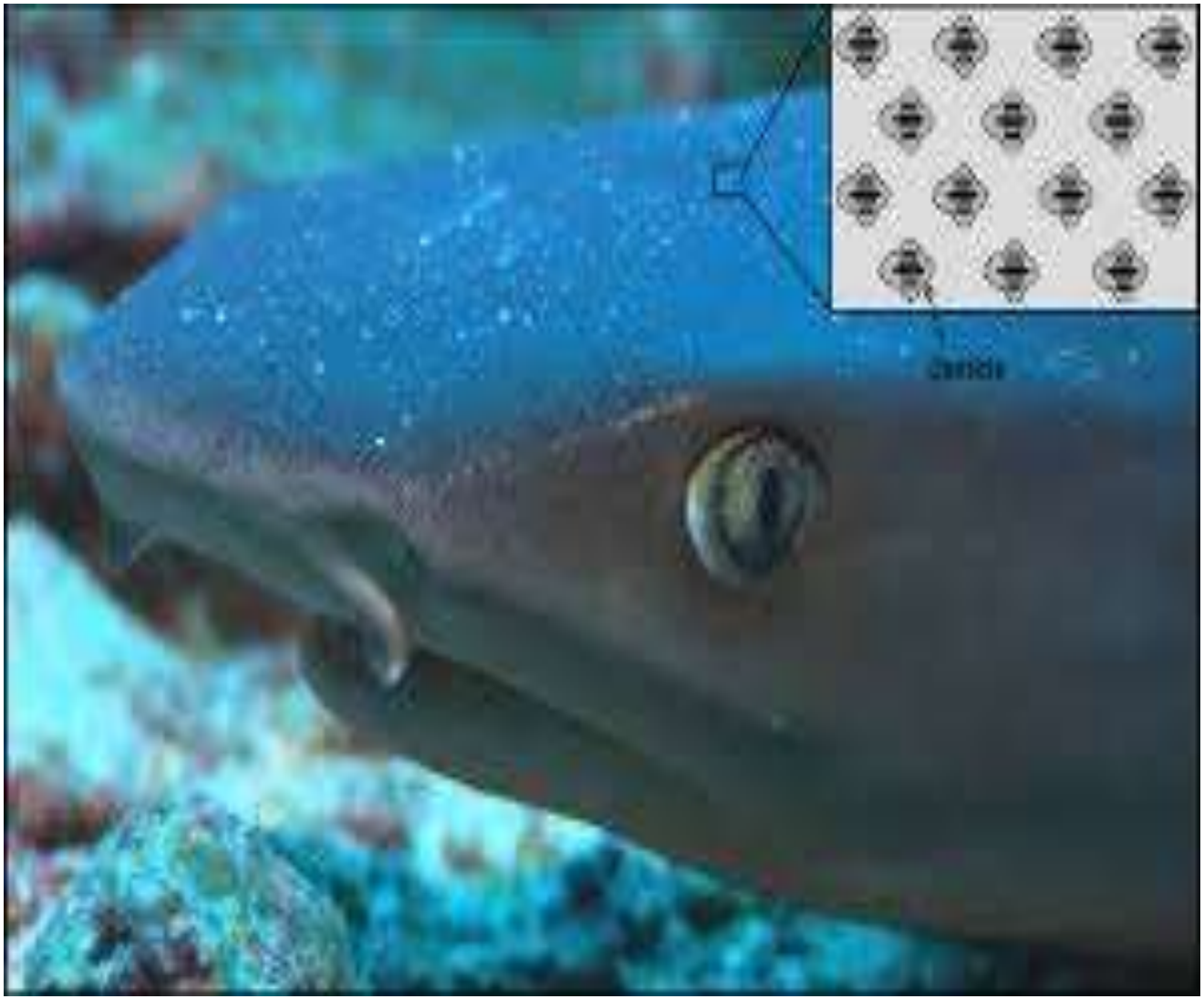
- **Hypodermis**

  – consisting tissue, adipose tissue, and nerve endings, separates the skin from deeper tissue.


Slime glands

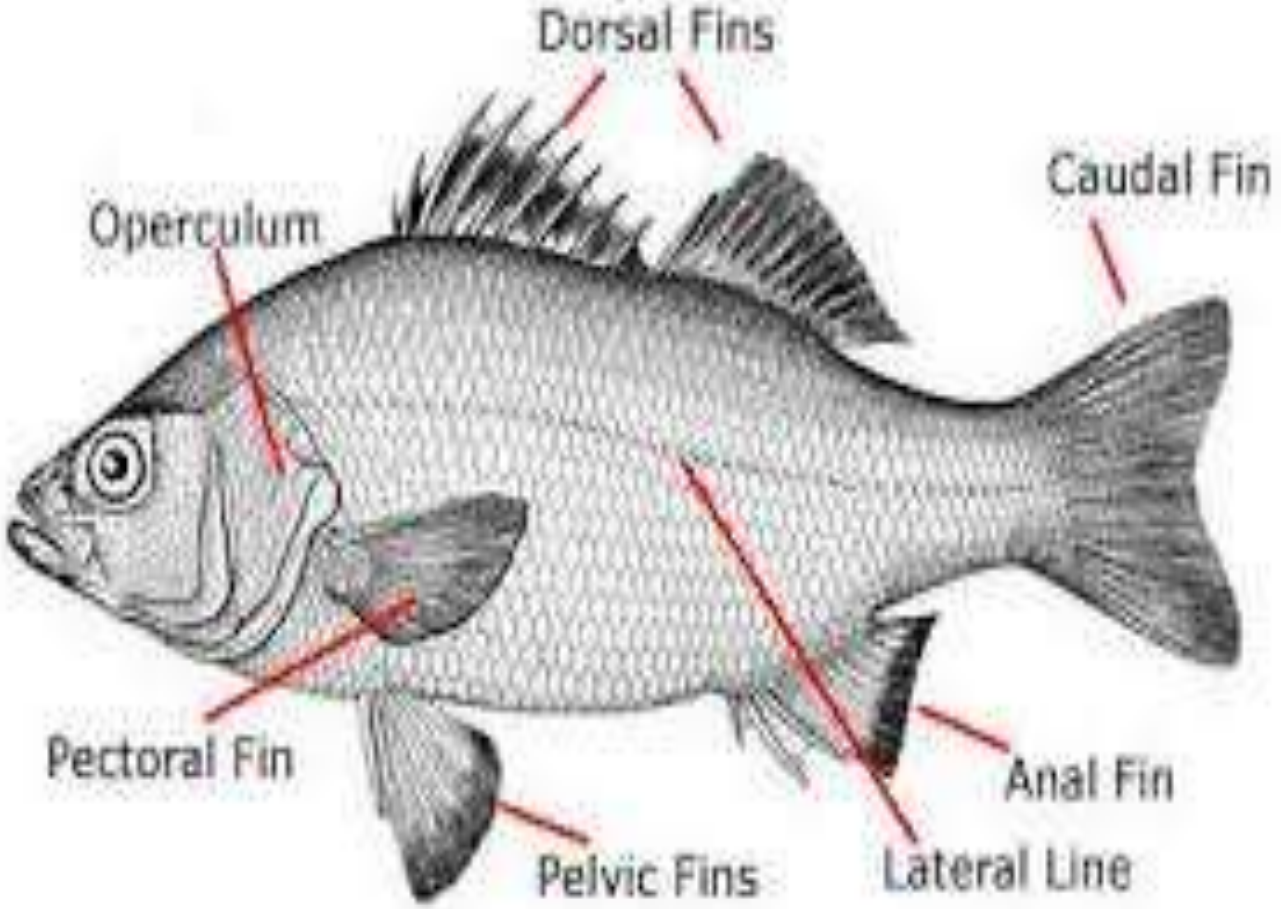
The Skin of Cartilaginous Fishes

- Multilayered and contains mucous and sensory cells.
- The dermis contains bone in the form of small placoid scales called **denticles**
- Cartilaginous fishes grow throughout life, the skin area also increases.
- New denticles are produced to maintain enough of these protective structures at the skin surface.


cells

The Skin of Bony Fishes

- Contains scales compose of dermal bone.
- Scales are not shed, they grow at the margins and over the lower surface.
- Permeable and function in gas exchange.
- The dermis is richly supplied with capillary beds to facilitate its use in respiration.
- The Epidermis also contains many mucous glands.
- Mucus production helps prevent bacterial and fungal infections and its reduces friction as fish swims.


Dorsal Fins
Caudal Fin
Operculum
Pectoral Fin
Anal Fin
Pelvic Fins
Lateral Line

The Skin of Amphibians

- Consists of stratified epidermis and a dermis containing mucous and serous gland plus pigmentation cells.
- Amphibians are transitional between aquatic and terrestial vertebrates.
- Three problems associated with terrestial environments are : desiccation, the damaging effects of ultraviolet light, and physical abrasion.

- During amphibian evolution, keratin production increased in the outer layer of the skin cells.
- Keratin is a tough, impermeable protein that protects the skin in the physically abrasive rigorous terrestial environment.
- The mucus that mucous glands produce helps prevent desiccation, facilitates gas exchange when the skin is used as respiratory organ, and makes the body slimy which facilitates escape from predators.
- Within the dermis of some amphibians are poison glands that produce an unpleasant-tasting or toxic fluid that acts as a predator

The Skin of Reptiles

- Reflects their greater commitment to a terrestrial existence.
- The outer layer of epidermis (stratum corneum) is thick, lacks glands, and is modified into keratinized scales, scutes (thick scales)
- The thick, keratinized layer resists abrasion, inhibits dehydration, and protects like a suit of armor.
- During shedding or molting of the skin of many reptiles, the outer layer separates from newly formed epidermis.
- Diffusion of fluid between the layers aids this separation.

The Skin of Birds

- Shows typically reptilian features with no epidermal glands.
- The epidermis is usually thin and only two or three cell layers thick.
- The most prominent part of the epidermis are the feathers.
- Air spaces that are part of avian respiratory system extend into the dermis.
- Feather position is important in thermal regulation, flying, and behavior.

The Skin of Mammals

The notable features of mammalian skin are:

- Hair
- Epidermal glands
- Cornified epidermis
- Dermis

Keratinized cells make up the outer layer, called the stratum corneum.

The thickest potion of mammalian skin is composed of dermis which contains:

- Blood vessels
- Lymphatic vessels
- Nerve endings
- Hair follicles
- Small muscles
- glands

In humans

- The skin regulates body temperature by opening and closing sweat pores and perspiring or sweating.
- The skin screens out excessive harmful ultraviolet rays from the sun
- The skin also an important sense organ, containing sensory receptors for heat, cold, touch, pressure, and pain.
- The skin of humans and other mammals contains several types of glands.

- **Sudoriferous glands**

- are distributed over most of the human body surface.

- secrete sweat by a process called perspiration.

- **Perspiration -** helps to regulate body temperature and maintain homeostasis.

In some animals, certain sweat glands also produce ***pheromones.***

- **Pheromones -** chemical that animal secretes and that communicate with other members the same species to elicit certain behavioral responses.

- **Sebaceous (oil) glands**

- are simple glands connected to hair follicles in the dermis.

- they lubricate and protect by secreting ***sebum.***

- **Sebum –** is a permeability barrier, an emollient and protective agent against microorganisms

  - can also act as a pheromone.

- Mammalian skin color is either to pigment or to anatomical structures that absorbs of reflect the light.
- Some skin color is due to color of the blood in superficial blood vessels reflected through the epidermis.
- Other skin colors may camouflage the animal.
- In addition, color serve in social communication, helping members of the same species to identify each other, their sex, reproductive status, or social rank.

- **Hair** – is composed of keratin-filled cells that develop from the epidermis.
- An ***arrector pili muscle*** attaches to the connective tissue sheath of the a hair follicle surrounding the bulb of the hair root.
- **Nail –** like hair, are modifications of the epidermis.

- are flat, horny plates on the dorsal surface of the distal segments of the digits.

- **Horns**
- **Baleen plates**

MOVEMENT AND SUPPORT: SKELETAL SYSTEM

Four cells types contribute movement:

1. Amoeboid cells
2. Flagellated cells
3. Ciliate cells
4. Muscles cells

With respect to support, organism have three kinds of skeletons:

1. Fluid hydrostatic skeletons
2. Rigid exoskeletons
3. Rigid endoskeletons

Hydrostatic Skeletons

- is a core liquid surrounded by a tension resistant sheath of longitudinal and/or circular muscles.

- Contracting muscle push against a hydrostatic skeleton, and the transmitted force generates body movement.
- The hydrostatic skeleton of invertebrates is an excellent example of adaptation of major body functions to this simple but efficient principle of hydrodinamics – use of the internal pressure of body fluids.

Exoskeletons

- also have locomotion functions because they provide sites for muscle attachment and counterforces for muscle movements.

- also support and protect the body,

In arthropods, the epidermis of the body wall secretes a thick, hard cuticle that water proofs the body. The cuticle also protects and support the animal's soft internal organ.

In crustaceans, the exoskeleton contains calcium carbonate crystals that make it hard and inflexible – except at the joints.

Exoskeleton limit an animals growth.

Endoskeletons

- The endoskeletons of sponges consist of mineral spicules and fibers of spongin that keep the body from collapsing. Since adult sponges attach to the substrate, they have no need for muscle attached to the endoskeleton.
- The endoskeletons of echinoderms consist of small, calcareous plates called ossicles.

Endoskeleton

bones inside the human hand

Exoskeleton

the shell outside a snail

Hydrostatic skeleton

water pressure inside an earthworm

Mineralized Tissues and Invertebrates

- **Cartilage** – is the supportive tissue that makes up the major skeletal component of some gastropods, invertebrate chordates (amphioxus), jawless fishes such as hagfishes and lampreys, and sharks and rays.

- is lighter than bone, it gives these predatory fishes the speed and agility to catch prey. It also provides buoyancy without the need for a swim bladder.

The Skeletal System of Vertebrates

This endoskeleton consist of two main types of supportive tissue: cartilage and bone.

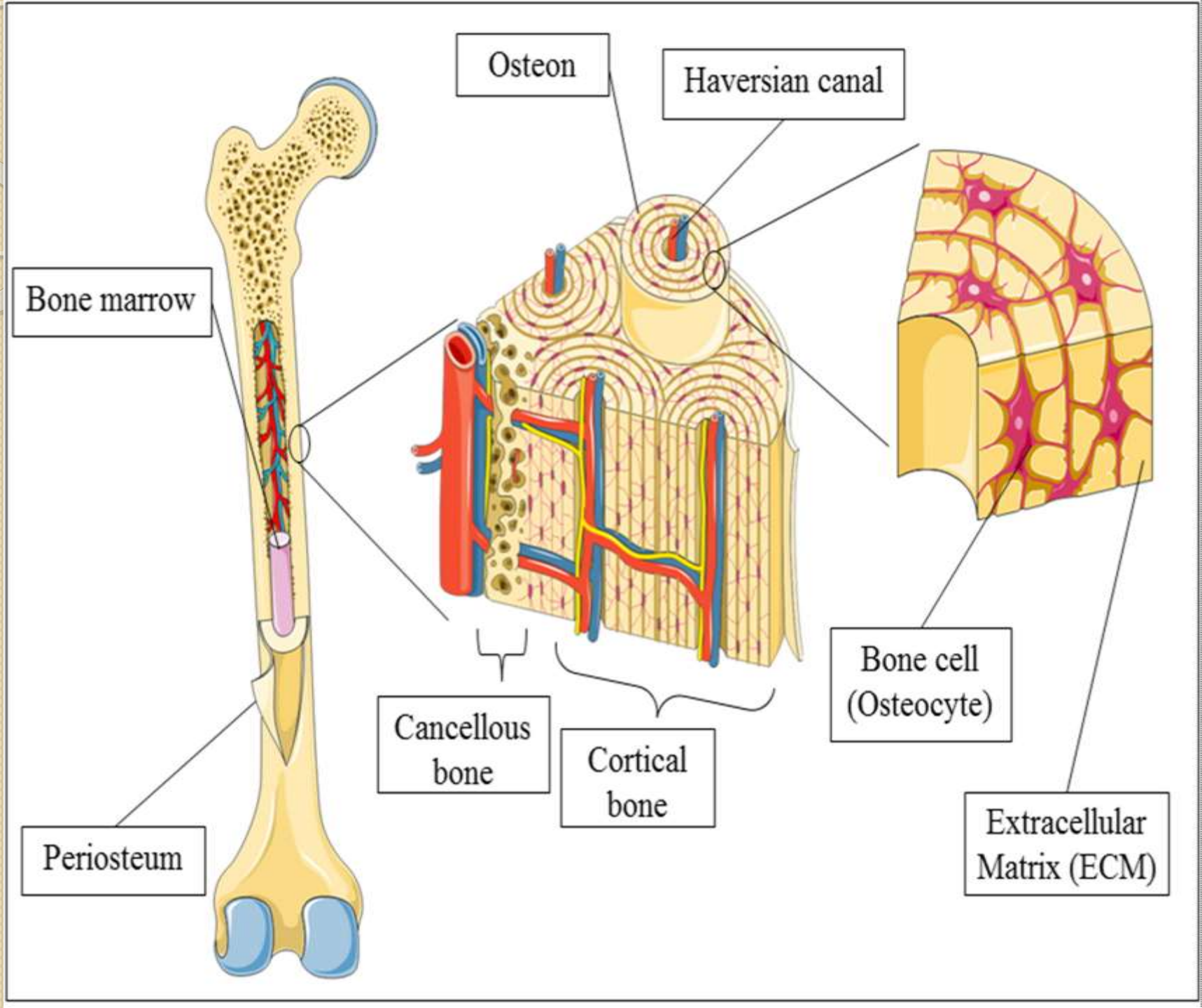
- **Cartilage –** provides site for muscle attachment, aids in movement at joints, provides support, and transmits the force of muscular contraction from one part to the body to another during movement,

  - it consist of cells, fibers, and cellular matrix.

Bone or Osseous Tissue

- that provides a point of attachment for muscles and transmits the force of muscular contraction from one part of the body to another during movement.

- Bone tissue is more rigid than the other connective tissues because its homogeneous, organic ground substance also contains in organic salts.
- Bone cells are in minute chambers called lacunae which are arranged in concentric rings around osteonic canals (formerly called Haversian systems).


Osteon
Haversian canal
Bone marrow
Bone cell
(Osteocyte)
Cancellous
bone
Cortical
bone
Periosteum
Extracellular
Matrix (ECM)

The Skeleton of Fishes

- Both cartilaginous and bony endoskeletons first appeared in the vertebrates.
- 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.
- Most jawed fishes have an axial skeleton that includes a notochord, ribs, and cartilaginous or bony vertebrae.
- Muscle used in locomotion attach to the

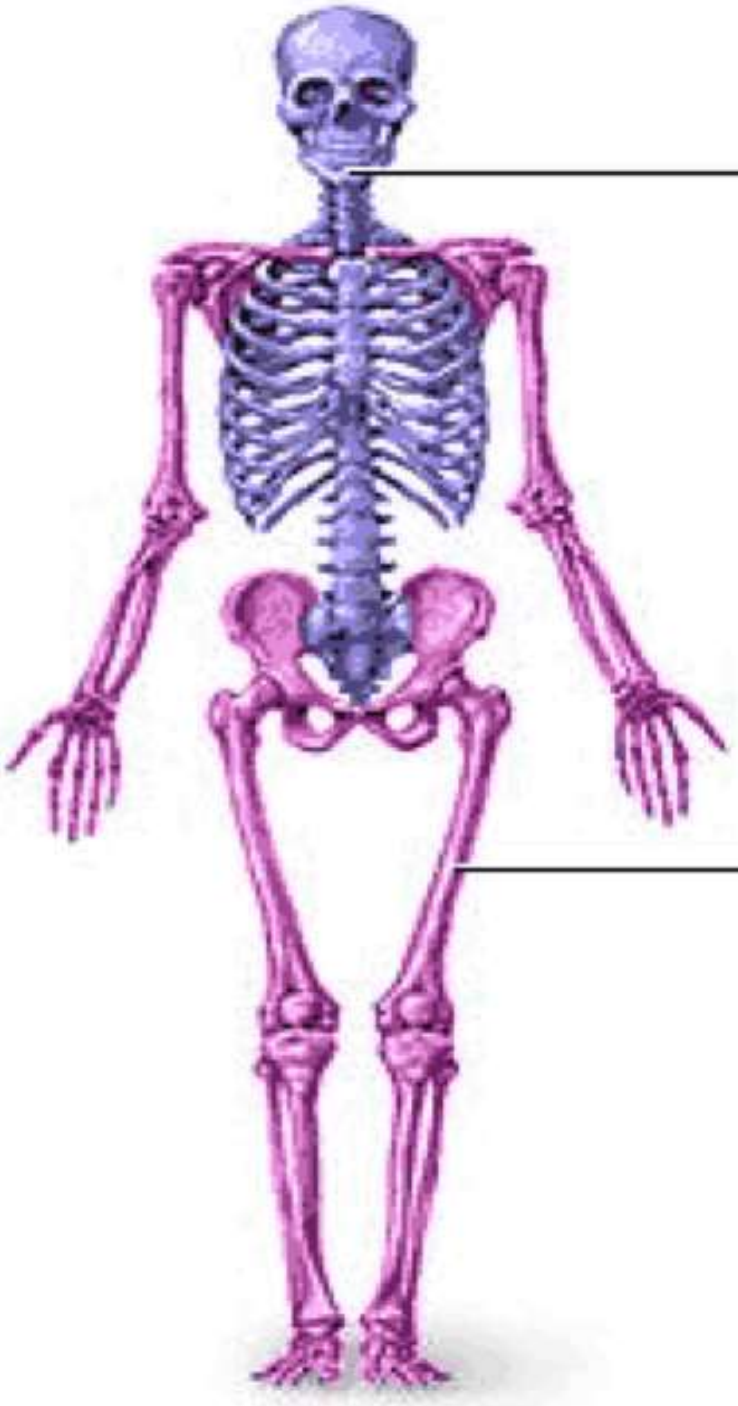
The Skeleton of Tetrapods

- Tetrapods must lift themselves to walk on land.
- The first amphibians needed support to replace the buoyancy of water.
- This added support resulted from the specializations of the intervertebral disk that articulate with adjoining vertebrae.
- The intervertebral disk help to hold the vertebral column together and also absorb shock and provide joint mobility.
- Bone replaced cartilage in the ribs, which became more rigid.
- Appendages became elongated for support on hard surface, and changes in the shoulder enabled the neck to move more freely.

The Human Endoskeleton

The human endoskeleton has two major parts:

- **Axial skeleton –** is made up of the skull, vertebral column, sternum, and ribs.
- **Appendicular skeleton –** is composed of the appendages, the pectoral girdle, and the pelvic girdle.



Axial skeleton (blue)

Appendicular skeleton (pink)

A.D.A.M.

MOVEMENT: NONMUSCULAR MOVEMENT AND MUSCULAR SYSTEM

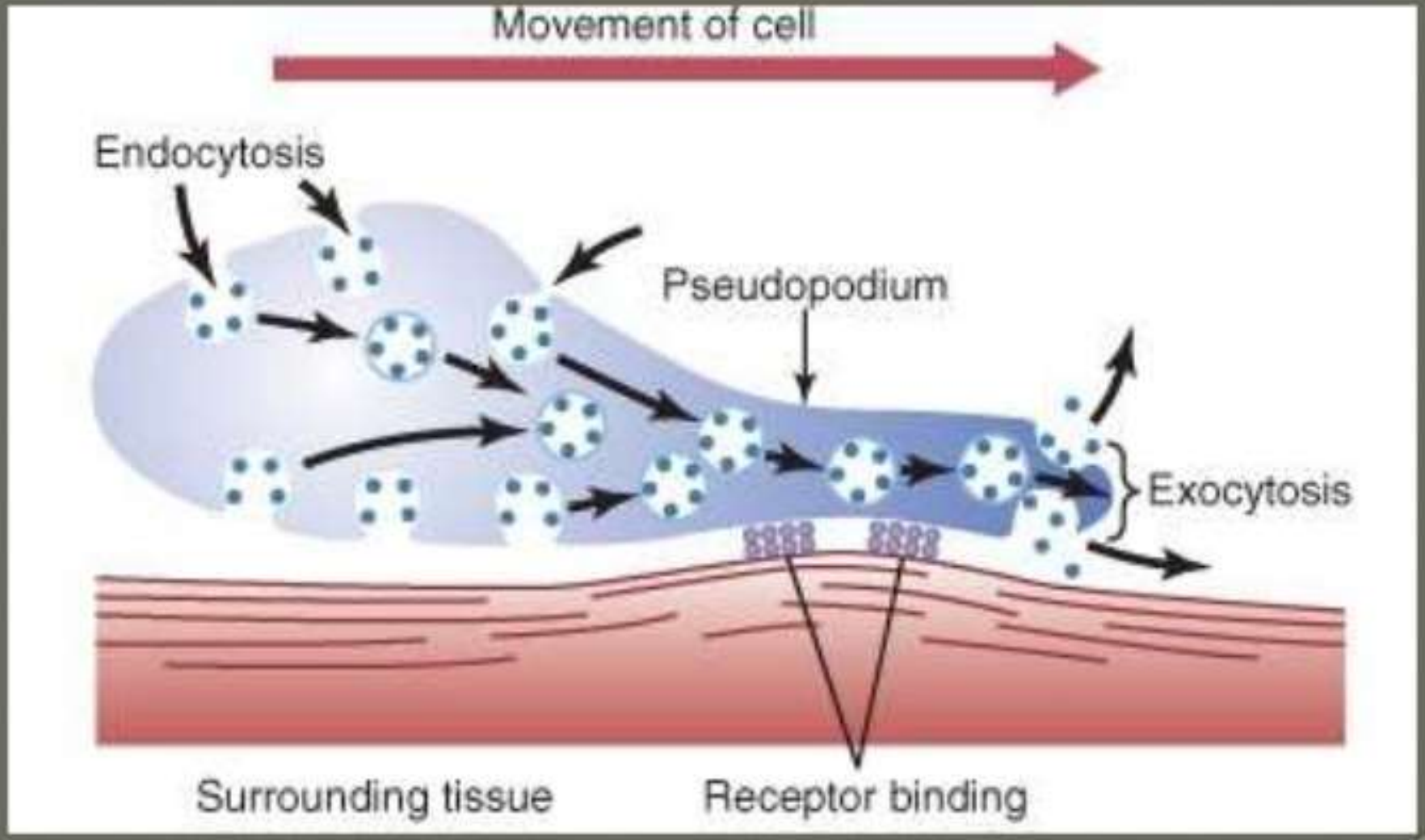
Nonmuscular Movement

- All cells have some capacity to move and changes shape due to their cytoskeleton.
- Protozoan protists move by means of specific nonmuscular (pseudopodia, flagella, or cilia) that involve the contractile proteins actin and myosin.
- Interactions between these proteins are also responsible for muscle contraction in animals.

Amoeboid Movement

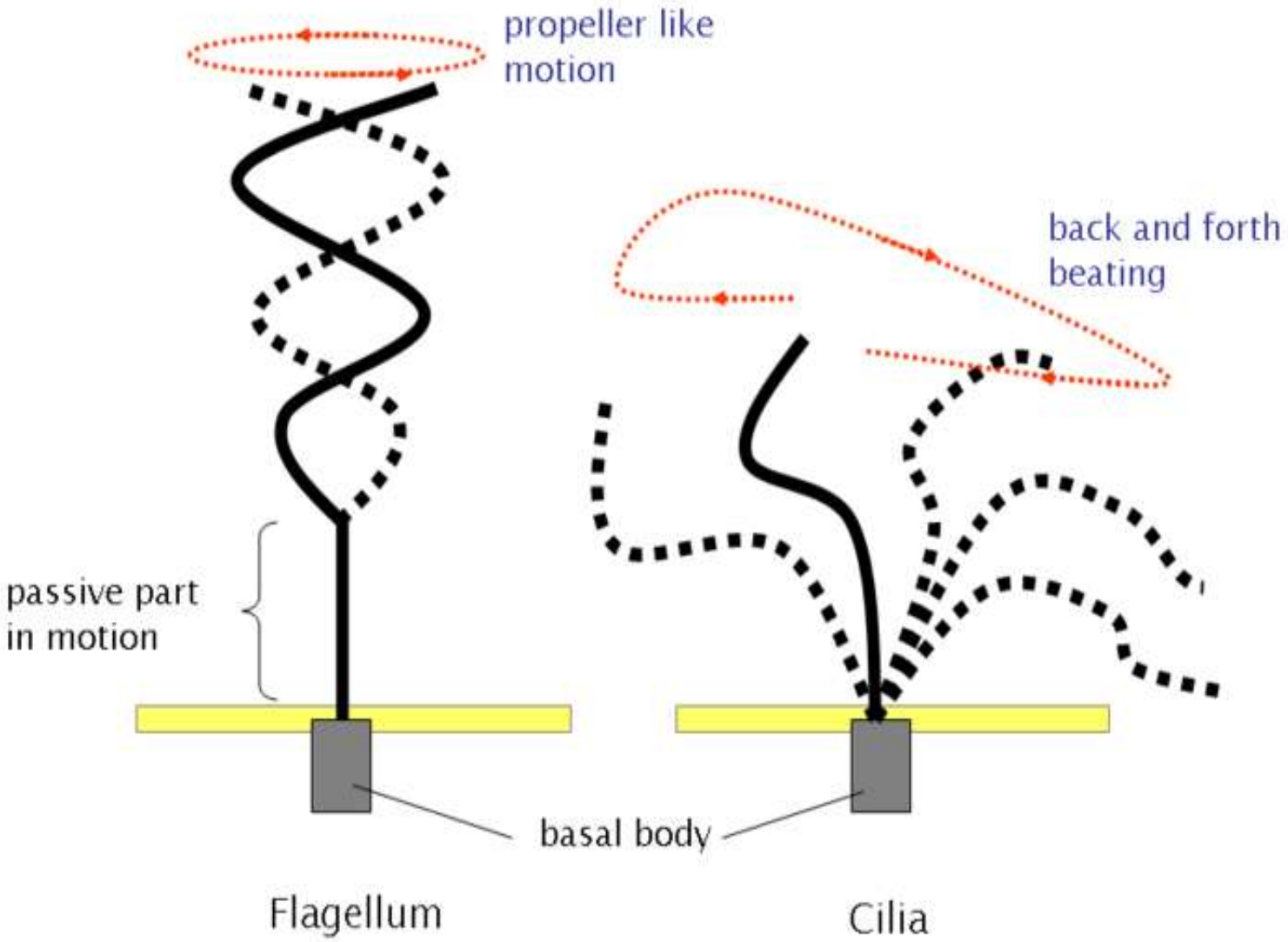
- The plasma membrane of an amoeba has adhesive properties since new **pseudopodia** attach to the substrate as they form.
- The plasma membrane also seems to slide over the underlying layer of cytoplasm when an amoeba moves.
- The plasma membrane may be “rolling” in a away that is (roughly) analogous to a bulldozer track rolling over its wheels.

Amoeboid movement



Ciliary and Flagellar Movement

- **Cilia –** are shorter and more numerous.
- **Flagella –** are long an generally occur singly or in pairs.
- Ciliary movements are coordinated.
- The epidermis of free-living flatworms and nemertines is abundantly ciliated.
- The smallest specimen lie at the upper end of the size range for efficient locomotion using cilia.
- Larger flatworms have retained ciliary creeping as the principal means of locomotion, and the largest animals move by ciliary creeping are the nemertines.



AN INTRODUCTION TO ANIMAL MUSCLE

Muscle tissue has three other important properties:

1. Excitability (or irritability)
2. Extensibility
3. Elasticity

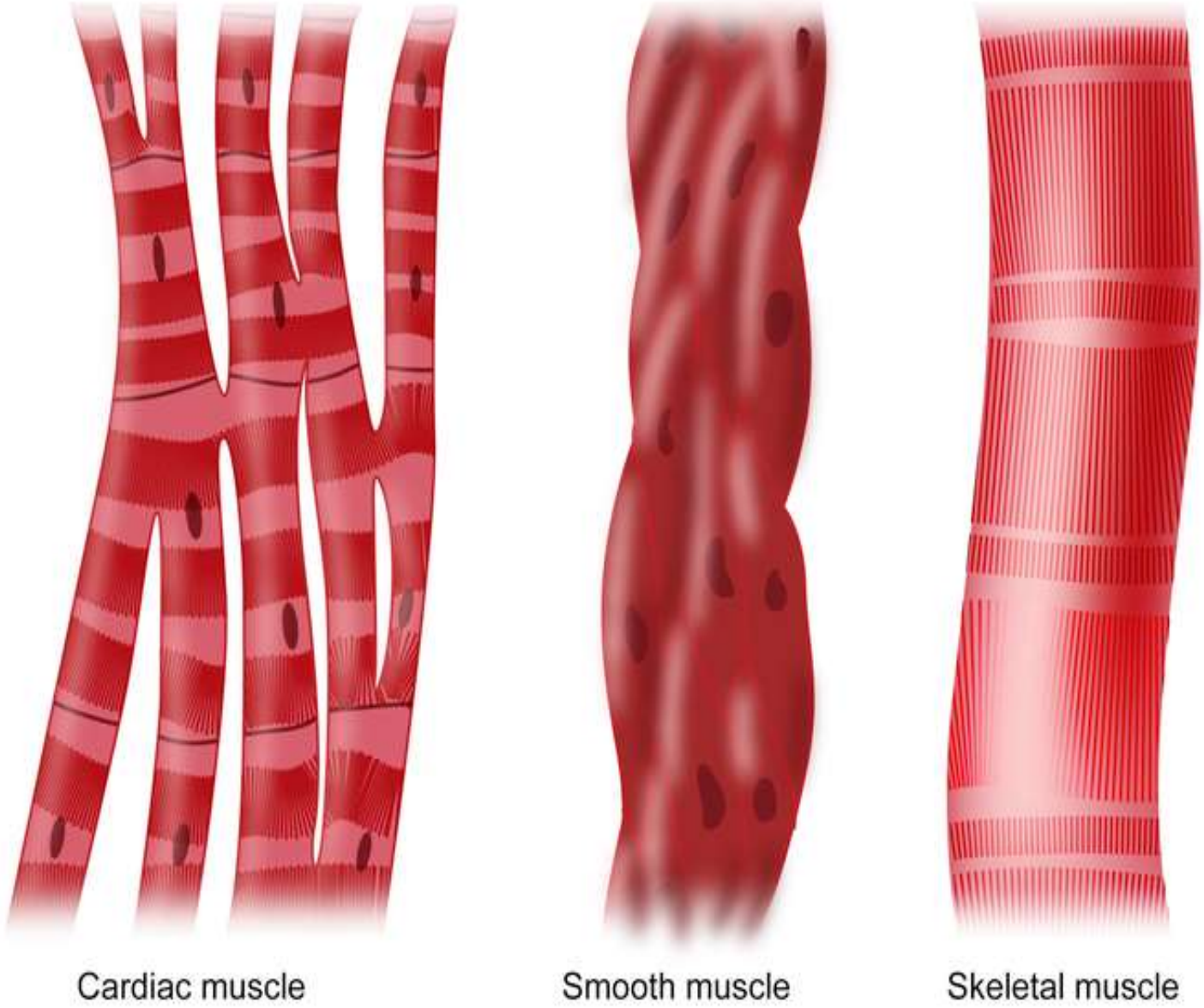
Animals may have one or more of the following types of muscle tissue: smooth, cardiac, and skeletal. The contractile cells of these tissue is called **muscle fibers.**

Smooth muscle – is called involuntary muscle because higher brain centers do not control its contractions.

- Single nucleus
- Spindle shaped
- Arranged in a parallel pattern to form sheets

Striated muscle fibers – with single nuclei are common in invertebrates, but they occur in adult vertebrates only in the heart, where they are called cardiac muscle.

Skeletal muscle – a striated muscle,


Cardiac muscle
Smooth muscle
Skeletal muscle

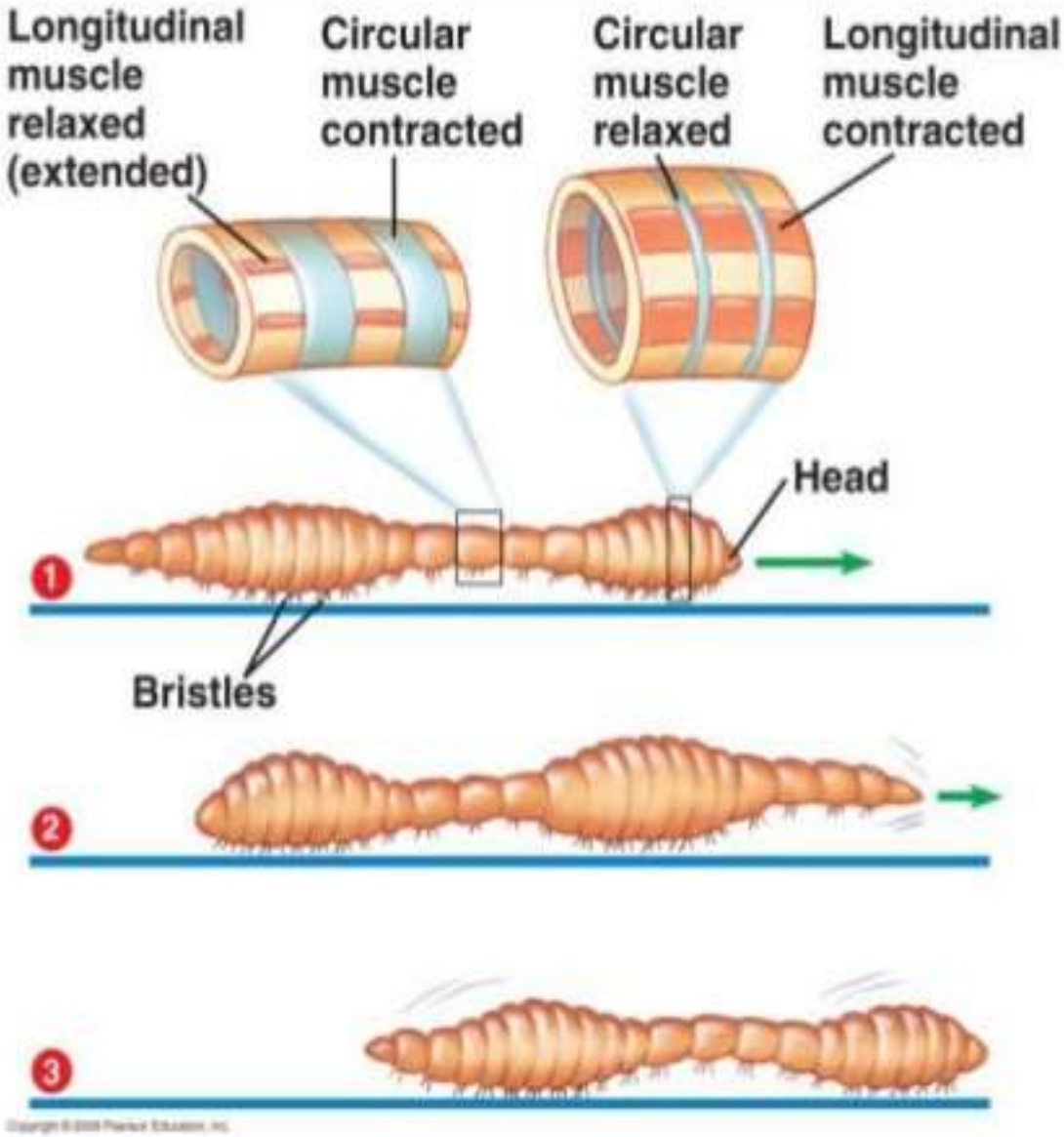
THE MUSCULAR SYSTEM OF INVERTEBRATES

A few functional differences among invertebrates muscle indicate some of the differences from the vertebrate skeletal muscle.

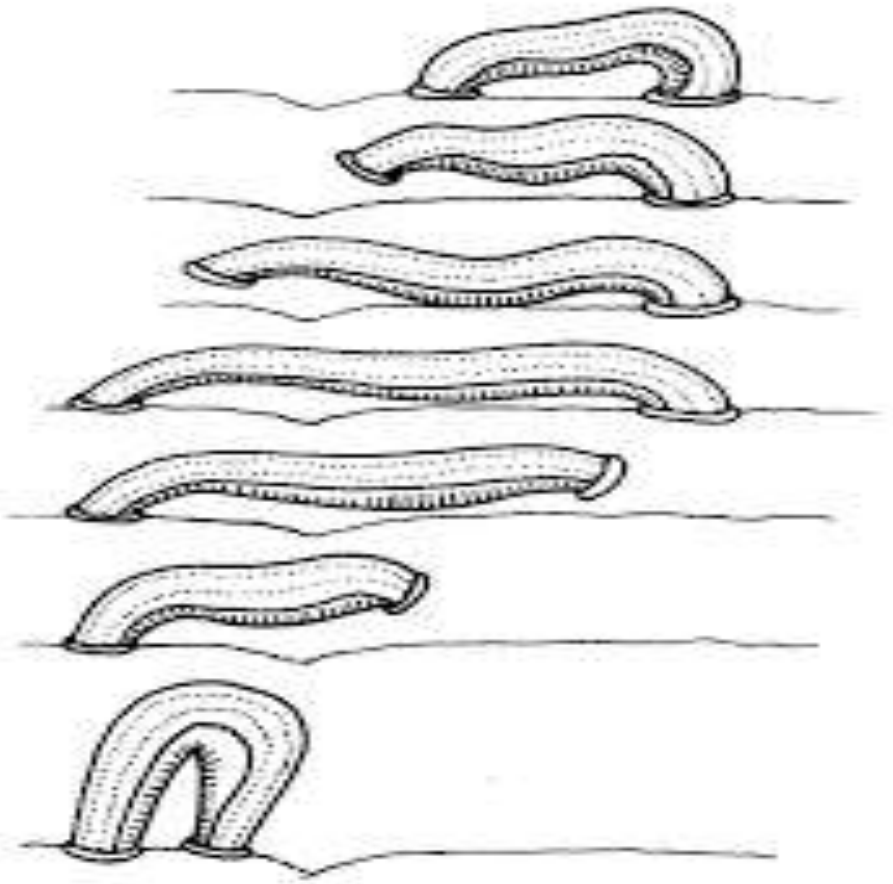
The Locomotion of Soft-Bodied Invertebrates

- **Pedal locomotion** – move by means of waves of activity in the muscular system that applied to the substrate.

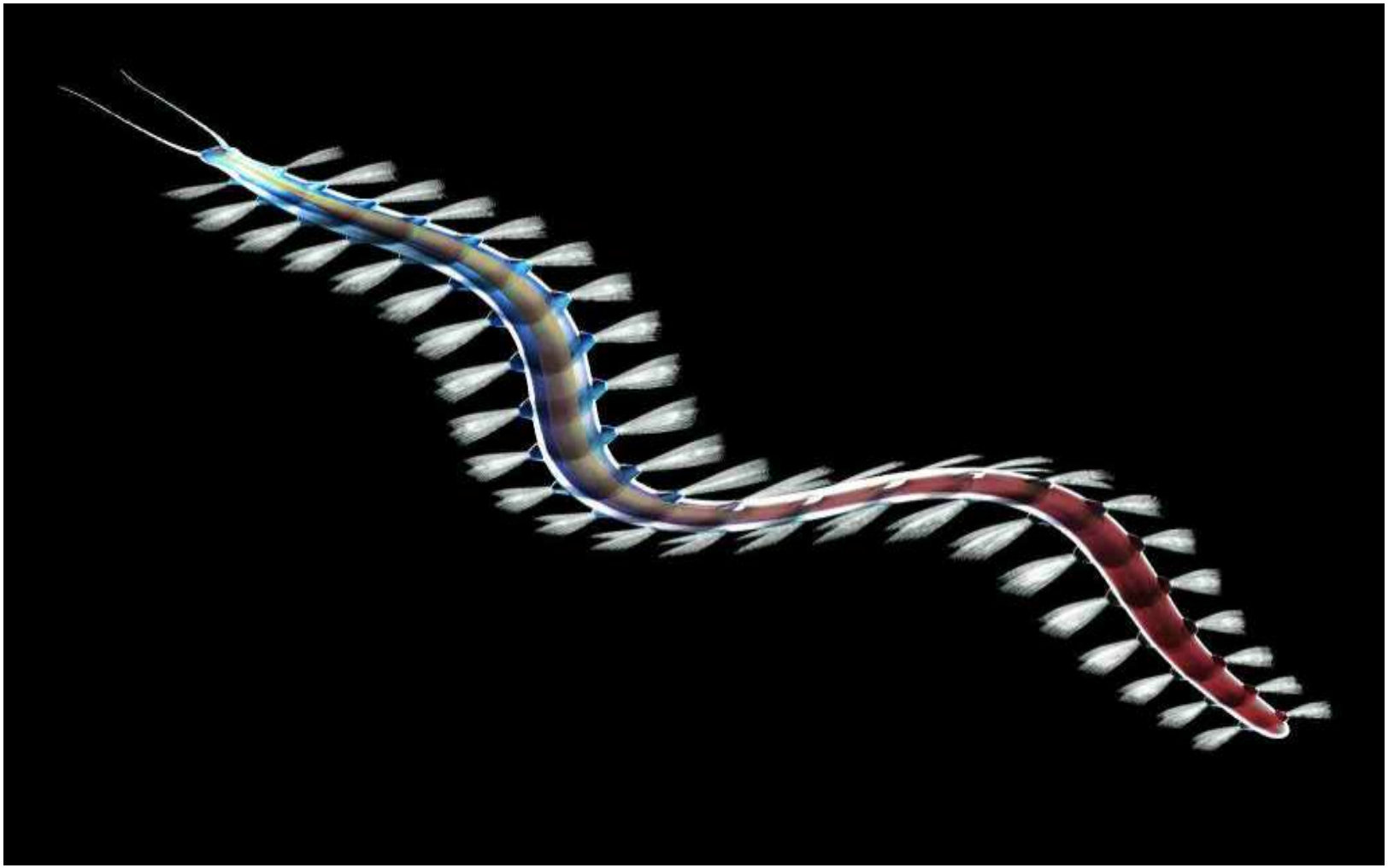
An earthworm uses its hydrostatic skeleton to crawl



- **Looping movement** – arching movements are equivalent to the contraction of longitudinal muscle.

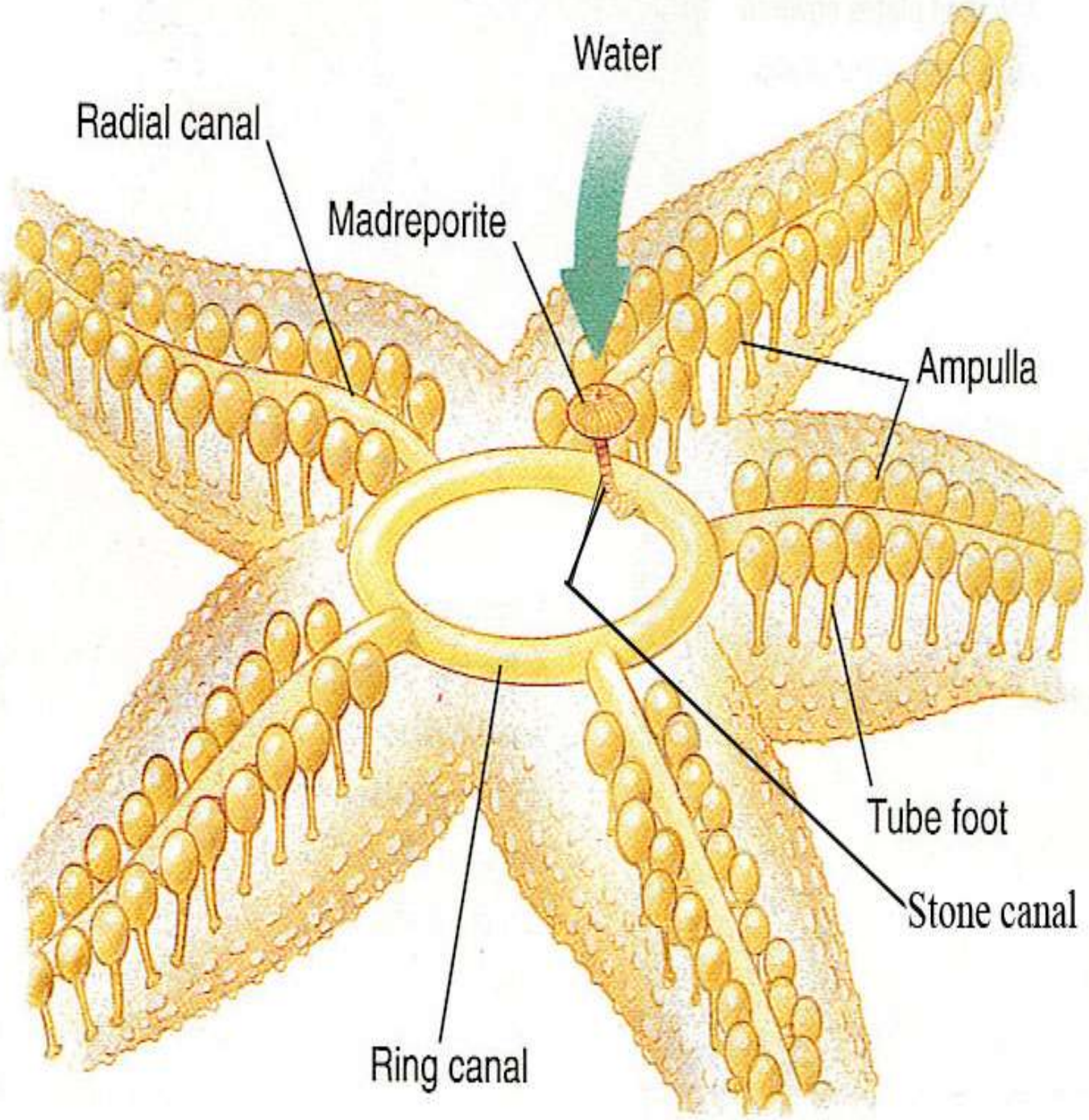


- Polychaete worms move by the alternate movement of multiple limbs (parapodia).



- The water vascular system of echinoderms provides a unique means of locomotion.
- Along each canal are reservoir ampullae and tube feet.

The starfish's water vascular system provides the water pressure that operates the animal's tube feet. From the madreporite, water moves into the ring canal, then into the rays through radial canals, and finally to the tube feet. The canals are like a network of water pipes attached to the tube feet. Water also exits the body through the madreporite.



Terrestrial Locomotion in Invertebrates: Walking

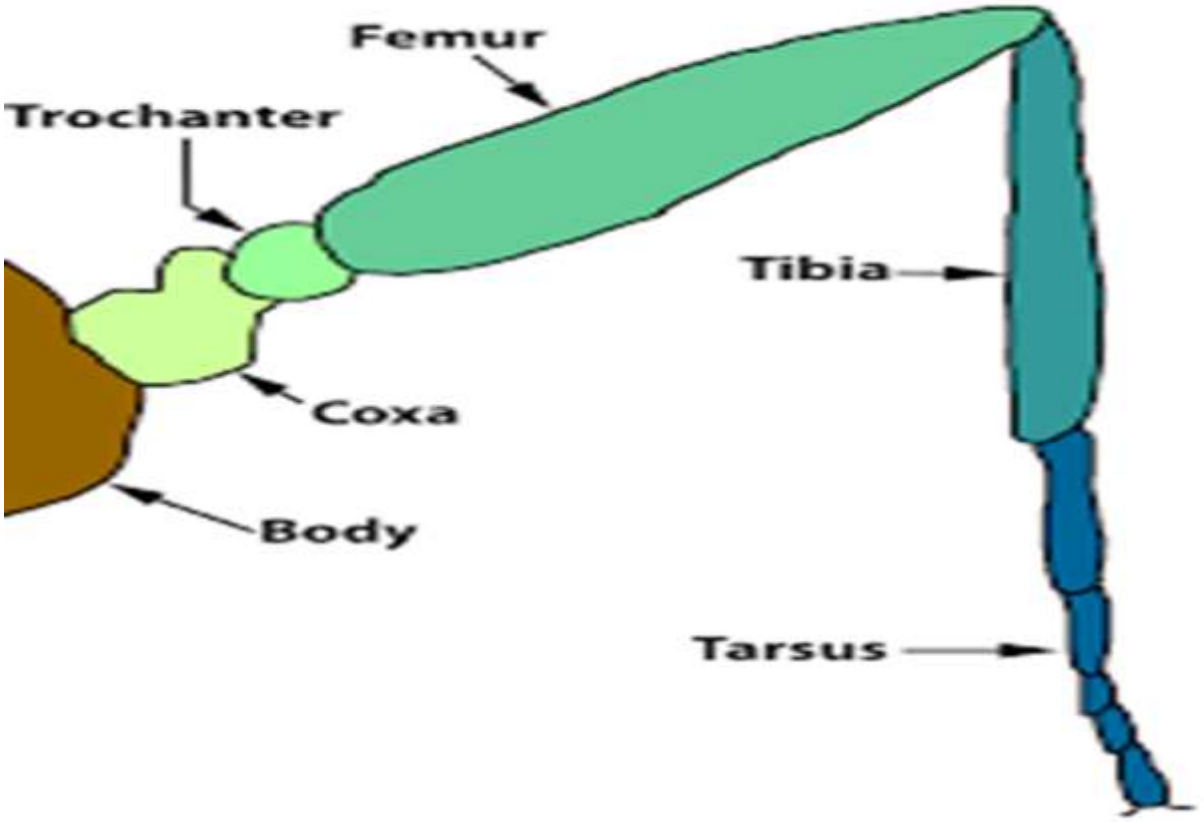
- They required structural support, and those that move quickly make use of rigid skeletal elements that interact with the ground.
- These The limbs are composed of a series of jointed elements that become progressively less massive toward the tip.
- Each joint articulated to allow movement in only one plane.
- The limb plane at the basal joint with the body can also rotate and this rotation is responsible for forward movement.

Terrestrial Locomotion in Invertebrates: Flight

- The physical properties of an arthropods cuticle are such that true flight evolved for pterygote insects some 100 million years ago.
- The basic mechanism for flight has been modified.
- Present day insects exhibit a wide range of structural adaptations and mechanism for flight.

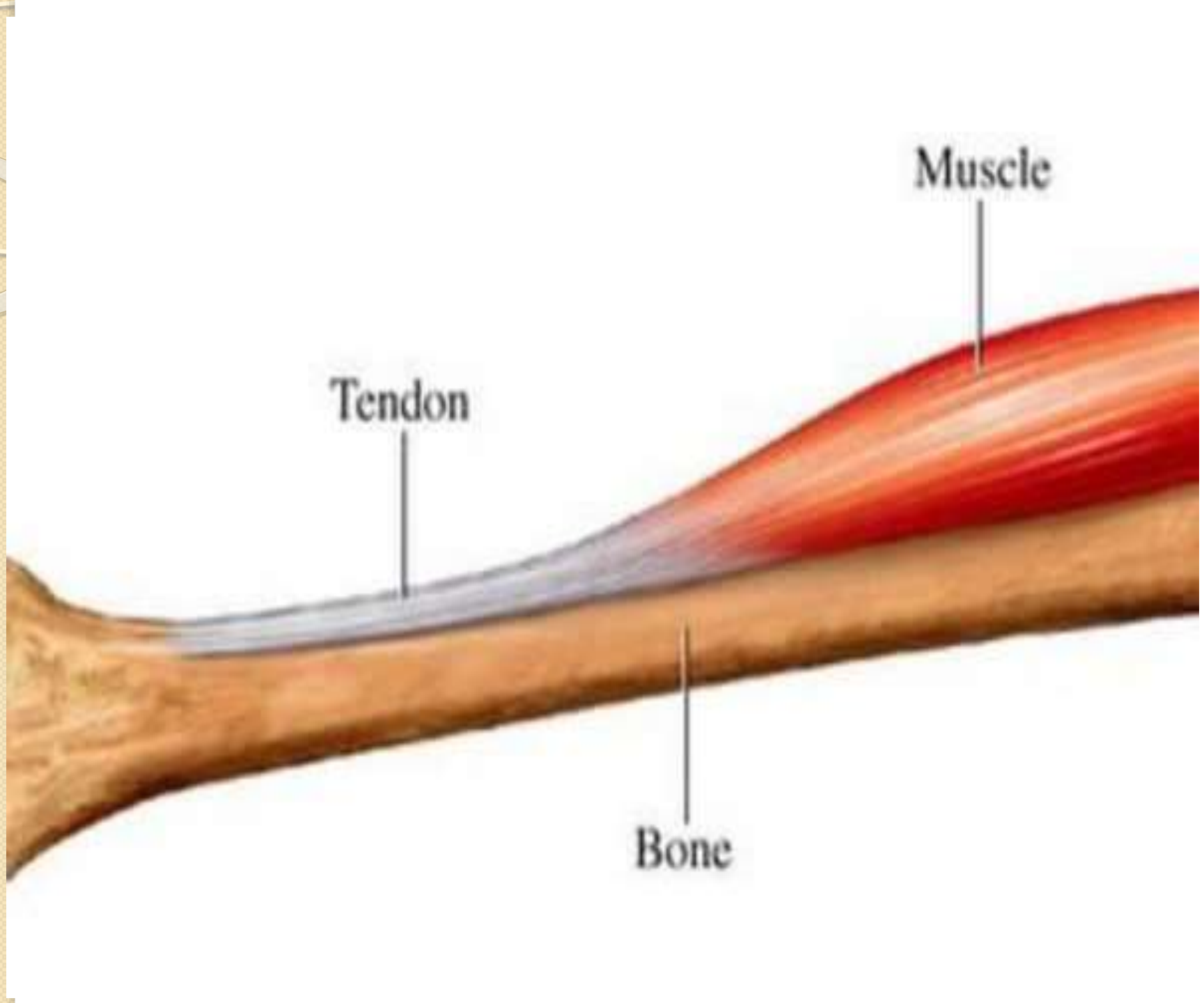
Terrestrial Locomotion in Invertebrates: Jumping

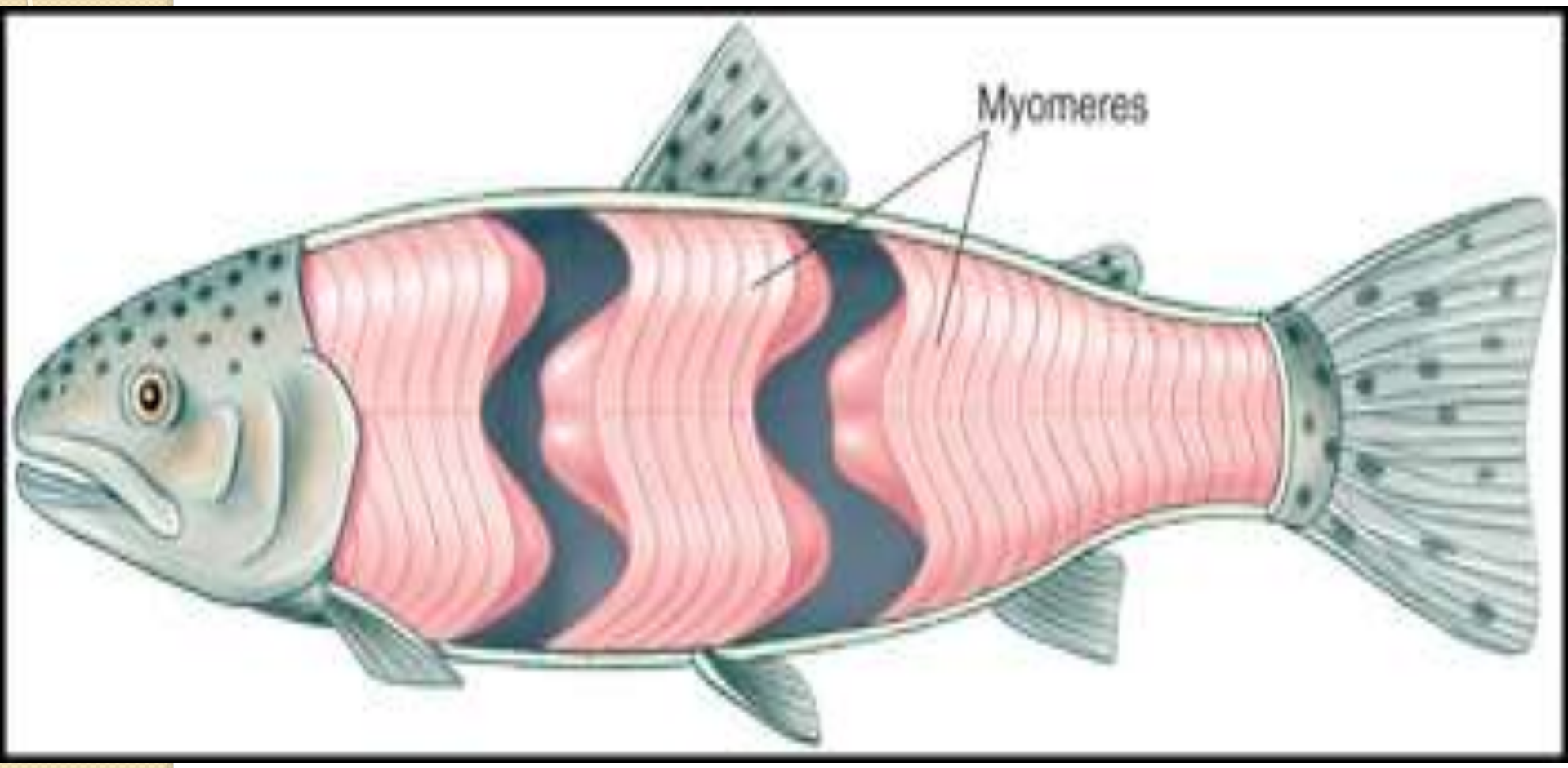
Long legs increase the mechanical advantage of the leg extensor muscle.



MUSCULAR SYSTEM OF VERTEBRATES

- **Tendons** – which are tough, fibrous, bands or cords, attach skeletal muscle to the skeleton.
- **Myomeres segments** – cause the lateral undulations of the trunk and tail that produce fish locomotion.


Muscle
Tendon
Bone

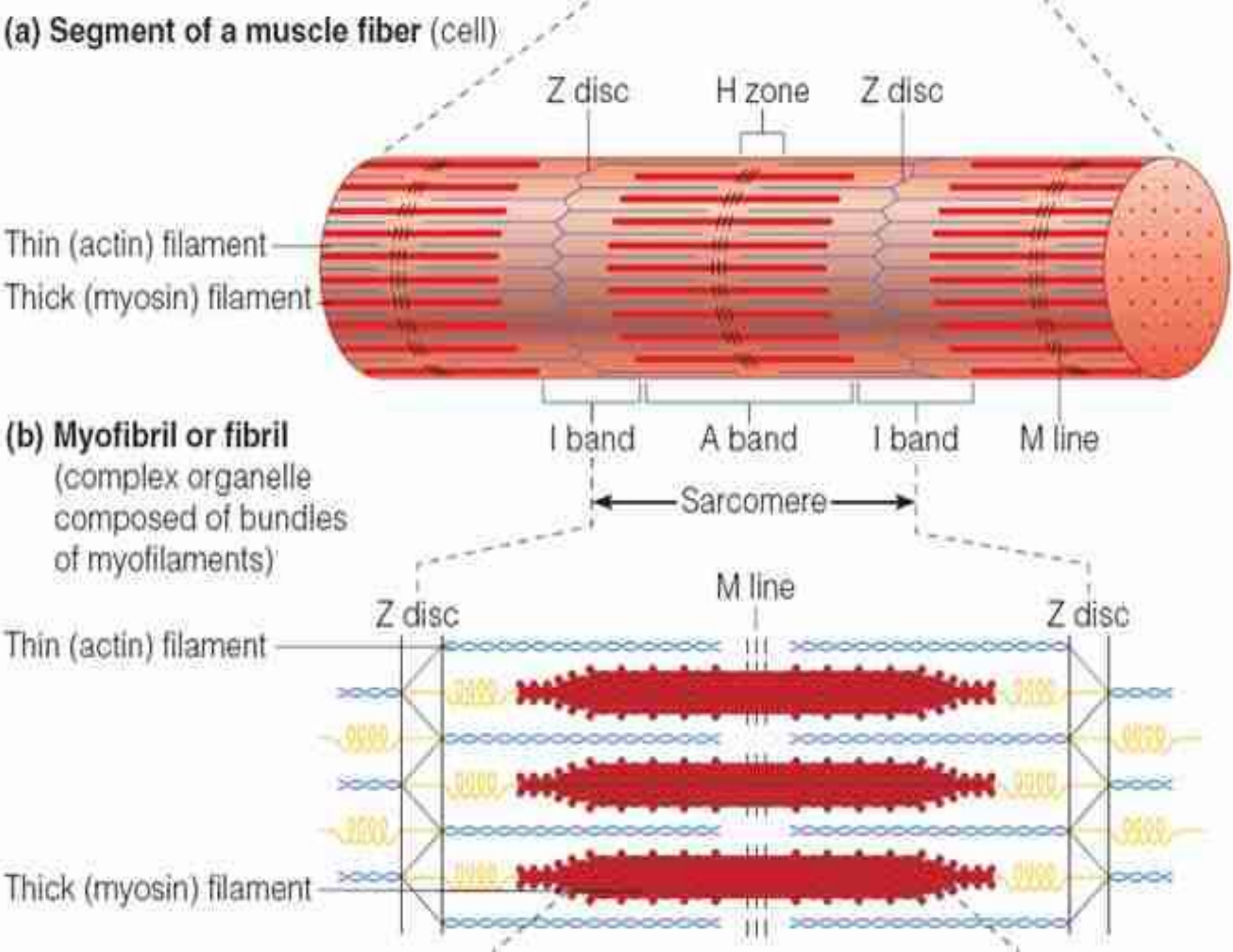

Myomeres

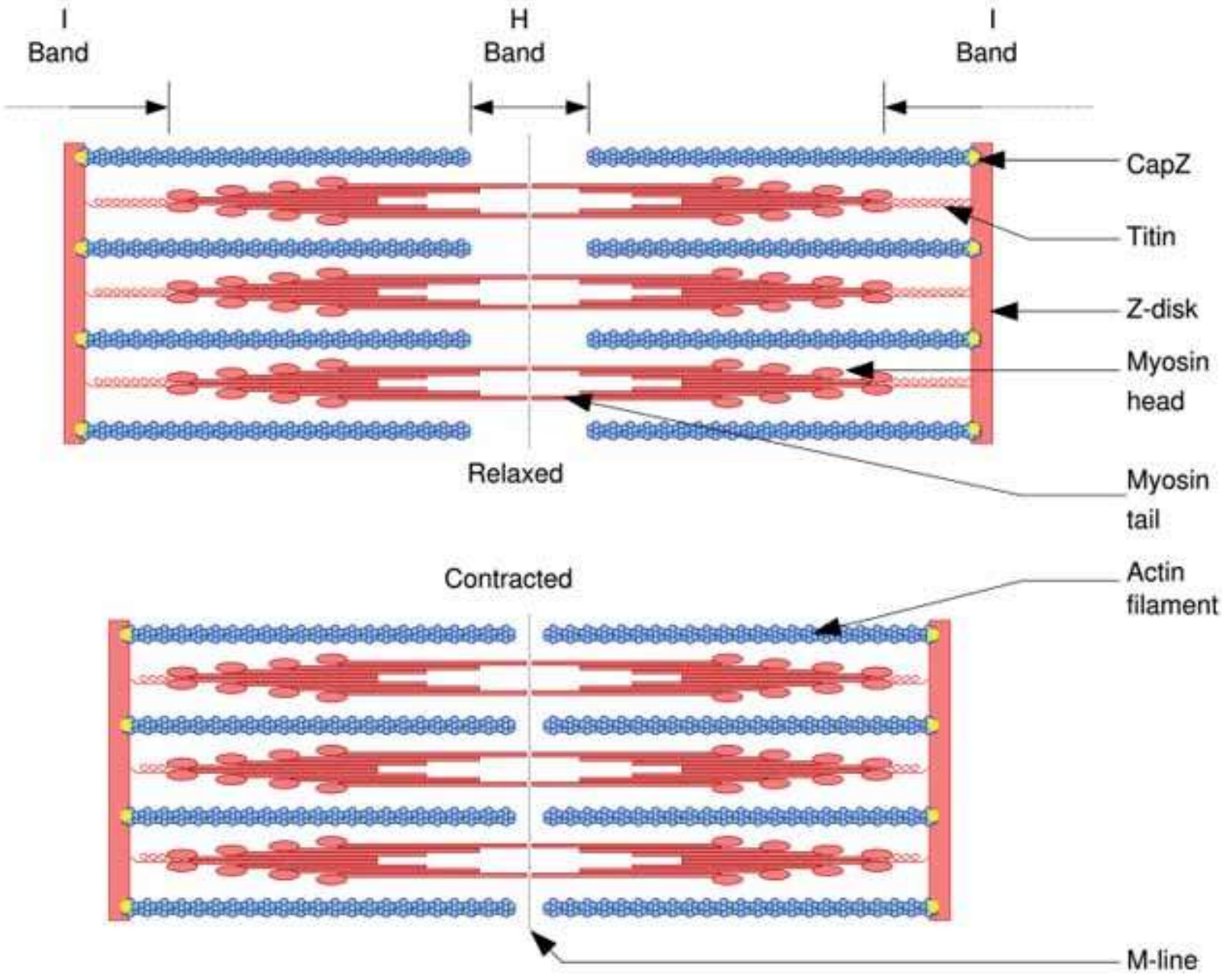
Fish movement based on the myomere contraction:

1. The muscular forces cause the myomere segment to rotate rather than constrict.
2. The rotation of cranial and caudal myomere segments bend the fish's body about a point midway between two segments.
3. Alternate bends of the caudal end of the body propel the fish forward.

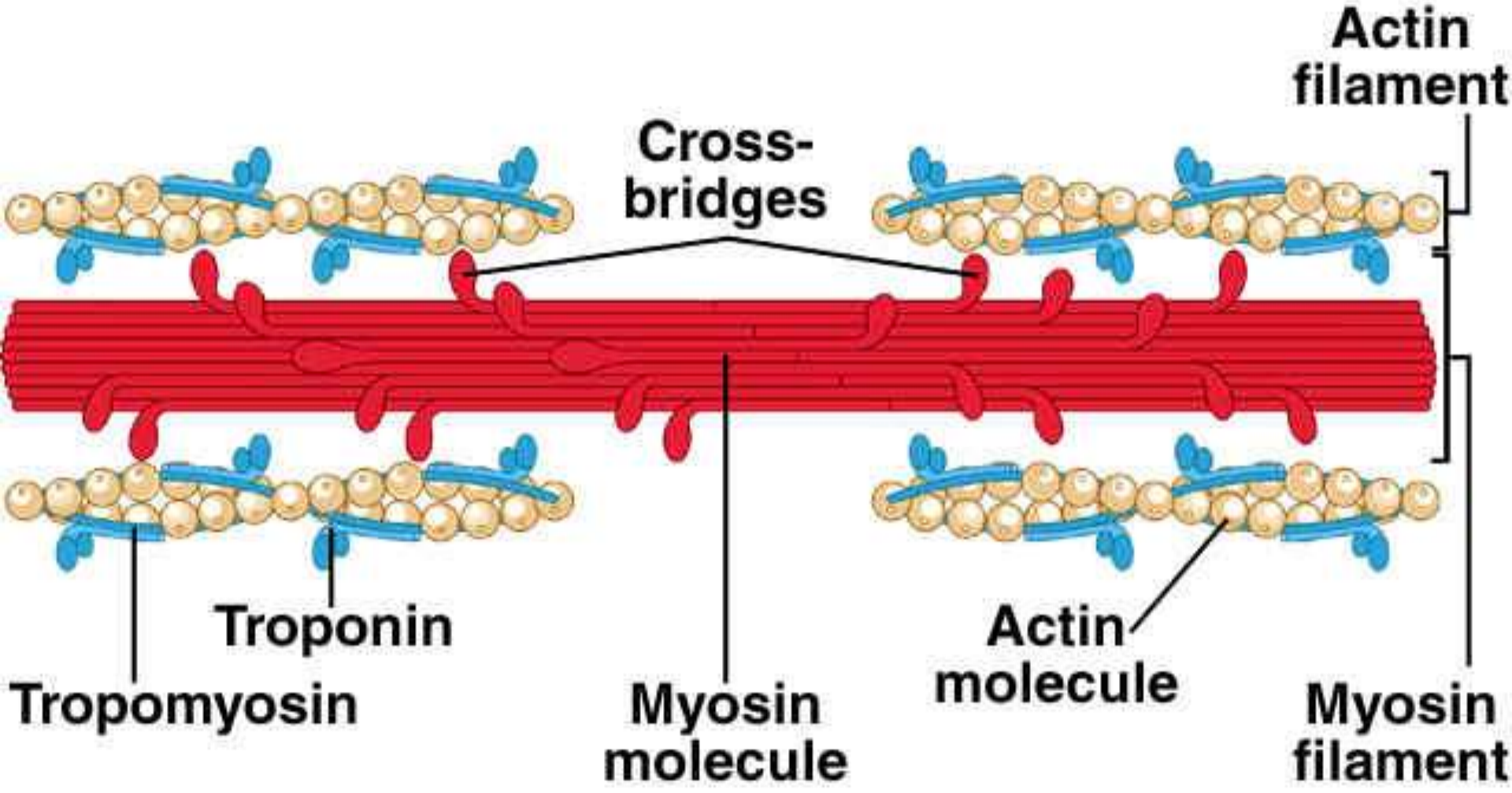
Skeletal Muscle Contraction

- Each skeletal muscle has a pattern alternate dark and light bands.
- This striation of whole fibers arises from the alternating dark and light of many smaller, threadlike **myofibrils** in each muscle fiber.
  - Myosin
  - Actin
    - I band
    - A band
  - Sarcomere
  - Cross bridges


(a) Segment of a muscle fiber (cell)
Z disc
H zone
Z disc
Thin (actin) filament
Thick (myosin) filament
I band
A band
I band
M line
Sarcomere
(b) Myofibril or fibril
(complex organelle
composed of bundles
of myofilaments)
M line
Z disc
Z disc
Thin (actin) filament
Thick (myosin) filament


I
Band
H
Band
I
Band
CapZ
Titin
Z-disk
Myosin
head
Myosin
tail
Relaxed
Contracted
Actin
filament
M-line

Thick Filaments



Control of Skeletal Muscle Contraction

- **Motor unit**

  - consist of one motor nerve fiber and all the muscle fibers with which it communicates.

- **Neuromuscular junction**

  - a space separates the specialized end body of the motor nerve fiber from the membrane of muscle fiber.

- **Acethylcholine**

  -released by the synaptic vesicles in the nerve ending

- **Transverse tubules**
  - conducting paths
- The calcium then binds with a regulatory protein called **troponin** that is on another protein called **tropomyosin**.