



ADMIN:

AMAAN KHAN

ANIMAL FORM & FUNCTION-I

ZOO 301 PPT

VU Medical Zone

Module 1



Animal Form and Function 1

Introduction to Protection, Support and Movement

Introduction to Protection, Support and Movement

Definition of Animal:

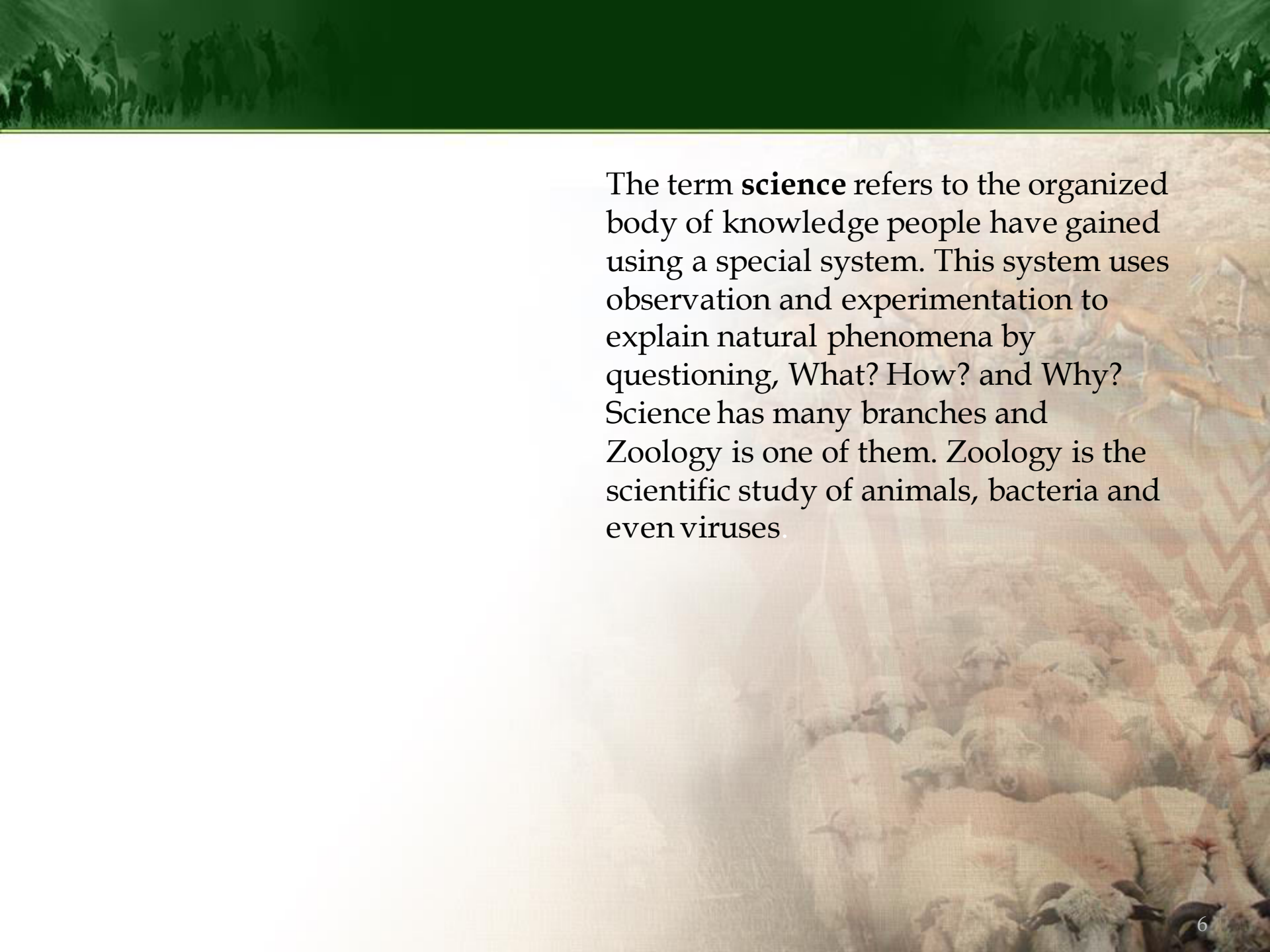
A thing having all the properties of life and is heterotroph.

- Protection, Support and Movement
- Communication I
(Nervous and Sensory Systems)
- Communication II
(Endocrine System and Chemical Messengers)

Introduction to Protection, Support and Movement

- Circulation and Gas Exchange
- Nutrition and Digestion
- Temperature and body fluid regulation
- Reproduction and development

END



The term **science** refers to the organized body of knowledge people have gained using a special system. This system uses observation and experimentation to explain natural phenomena by questioning, What? How? and Why? Science has many branches and Zoology is one of them. Zoology is the scientific study of animals, bacteria and even viruses.

Module 2



Animal Form and Function 1

**Form and Function:
Evolutionary Concept**

An abstract architectural sculpture made of large, white, curved panels that overlap and curve in various directions, creating a dynamic, organic form. The sculpture is set against a background of a modern building with large glass windows and a clear blue sky.

Form and Function: Evolutionary Concept

Evolution:

Evolution is a scientific theory that explains How living things change over a long time and how they have come to be the way they are?

Form and Function: Evolutionary Concept

Comparative perspective:

It is based on the idea that a system cannot be fully understood without comparing it with the systems in different animals.

Form and Function: Evolutionary Concept

Protection, Support & Movement

Protection: Integumentary system

- In Protozoa
- In Multicellular Invertebrates Animals
- In Vertebrates

Support: Skeletal system

- Hydrostatic skeleton
- Exoskeleton
- Endoskeleton

Form and Function: Evolutionary Concept

Integumentary system of animals consist of an outer body covering called the integument. The integument of most multicellular invertebrates consist of single layer of cells. The vertebrate integument is multilayered and is called Skin. Skin contains nerves and blood vessels as well as derivatives such as gland , hair and nails.

END

Protection, Support & Movement

Movement: Non Muscular and Muscular System

- **An Introduction to Animal Muscles**
- **Muscular System of Invertebrates**
- **Muscular System of Vertebrates**

Module 3



Animal Form and Function 1

Protection:
Integumentary Systems

An abstract architectural sculpture composed of large, white, angular, and curved panels that overlap and interlock, creating a complex, organic form. The sculpture is set against a background of a modern building with large glass windows and a clear blue sky.

Protection: Integumentary Systems

Introduction

- Integument is the external covering of the animal.
- It protects the animals from mechanical and chemical injury.
- It protects the animal from the invasion of microbes.

Protection: Integumentary Systems

Introduction

- It also regulates the body temperature and excretion of wastes.
- Also responsible for the conversion of sunlight into Vitamin D

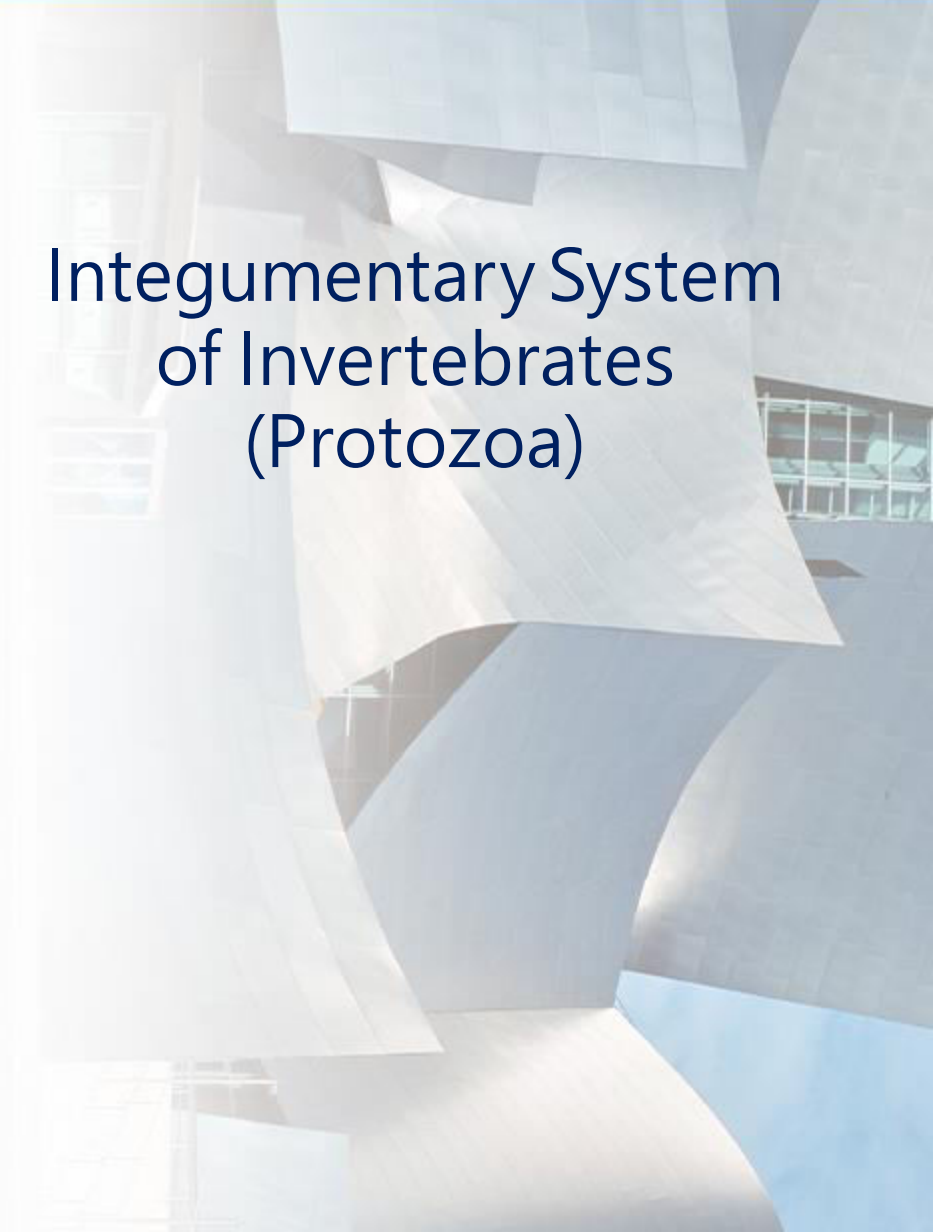
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Module 4



Animal Form and Function 1

Integumentary System of Invertebrates (Protozoa)



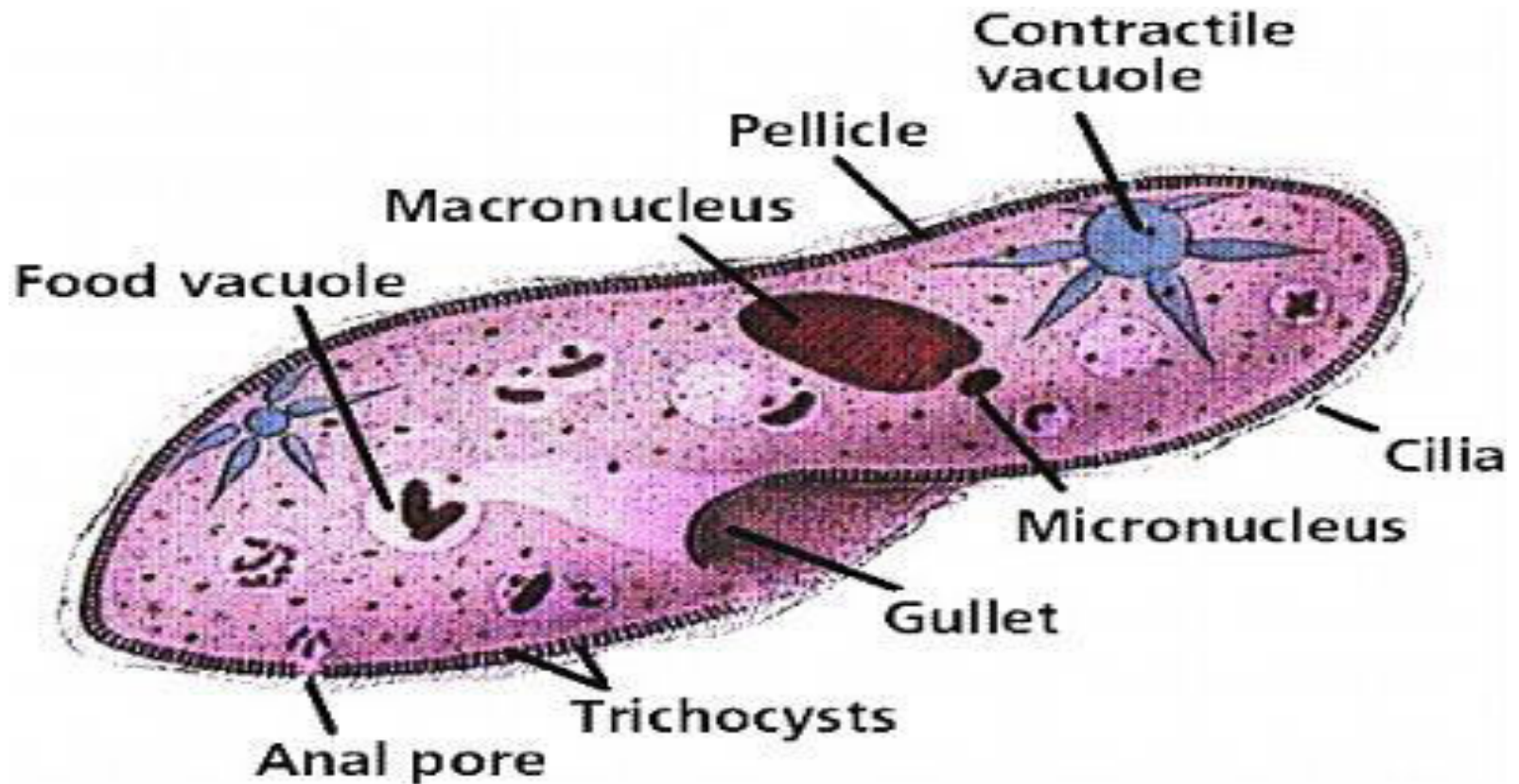
Integumentary System of Invertebrates (Protozoa)

- Plasma Membrane
- Pellicle
- Calcium Carbonate shell

Integumentary System of Invertebrates (Protozoa)

Integument in Protozoa

Pellicle in Paramecium




Integumentary System of Invertebrates (Protozoa)

Integument in Protozoa

Calcium carbonate shell in Protozoa (Foraminifera)





Some Protozoa belonging to Foraminifera have external shells of CaCO_3 which secreted by the body. Foraminifera are exclusively marine protozoans and have mollusk-like shells. These are the only protozoa which are found fossilized.

Module 5



Animal Form and Function 1

Integumentary System in Multicellular Invertebrates



Integumentary System in Multicellular Invertebrates

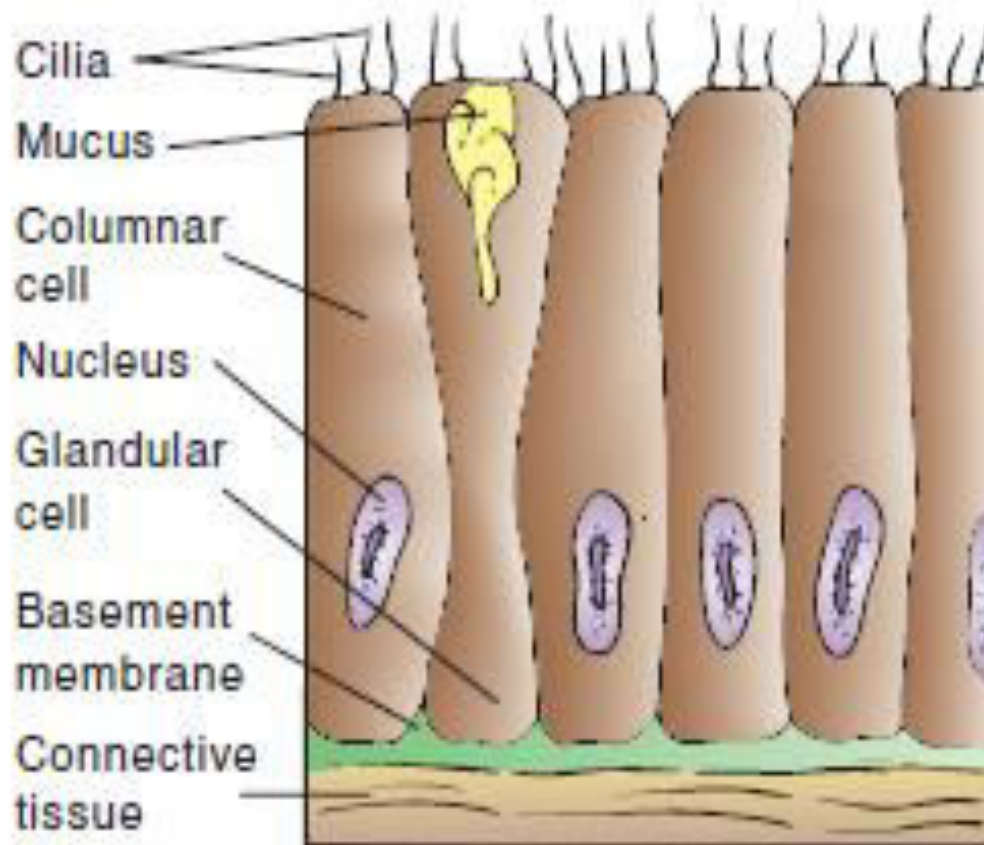
- **Epidermis:** single layer of columnar cells.
- **Cuticle:** may be thin or elastic as in rotifers or thick and rigid as in crustaceans and insects.
- **Calcium Carbonate Shell:** as in Cnidarians (corals)

Integumentary System in Multicellular Invertebrates

- **Tegument:** a complex syncytium- found in parasitic flukes and tapeworms.
- **Exoskeleton:** most complex integument found in Arthropods

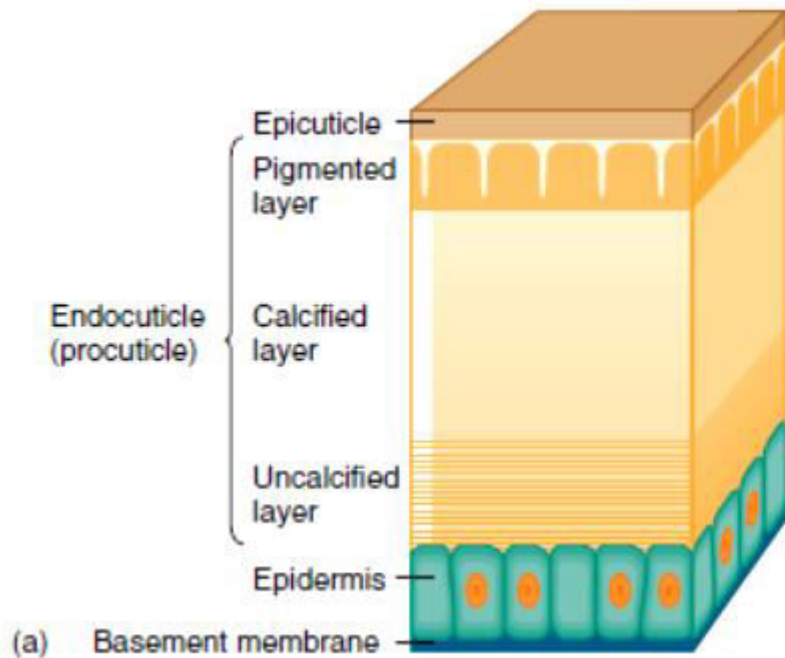
Integumentary System in Multicellular Invertebrates

Epidermis: single layer of columnar cells.

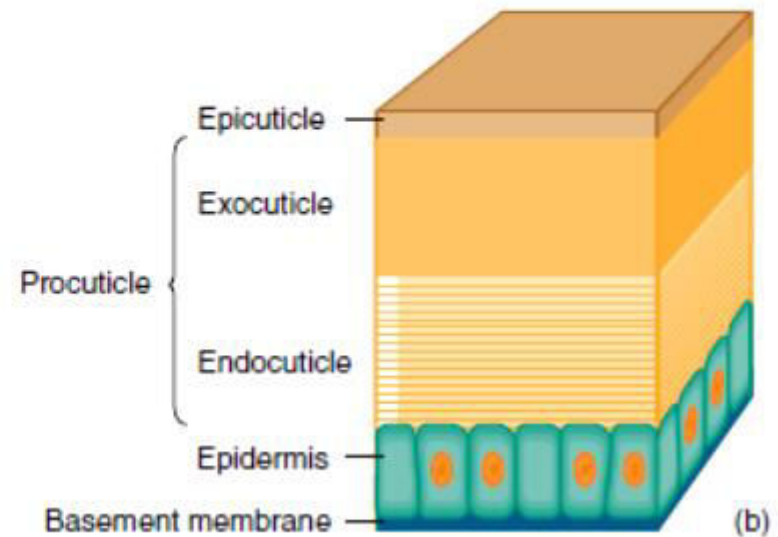


Integumentary System in Multicellular Invertebrates

Cuticle: may be thin or elastic as in rotifers or thick and rigid as in crustaceans and insects.



Crustacean



Insect

Integumentary System in Multicellular Invertebrates

Calcium Carbonate Shell: as in Cnidarians (corals)



A Coral

Integumentary System in Multicellular Invertebrates

Integumentary system of animals consists of outer protective body covering called integument.

Integument of most multicellular invertebrates consist of single layer of cells.

- **Tegument:** a complex syncytium- found in parasitic flukes and tapeworms.
- **Exoskeleton:** most complex integument found in Arthropods

Integumentary System in Multicellular Invertebrates

Exoskeleton: most complex integument found in Arthropods



Module 6



Animal Form and Function 1

Integumentary System of Vertebrates

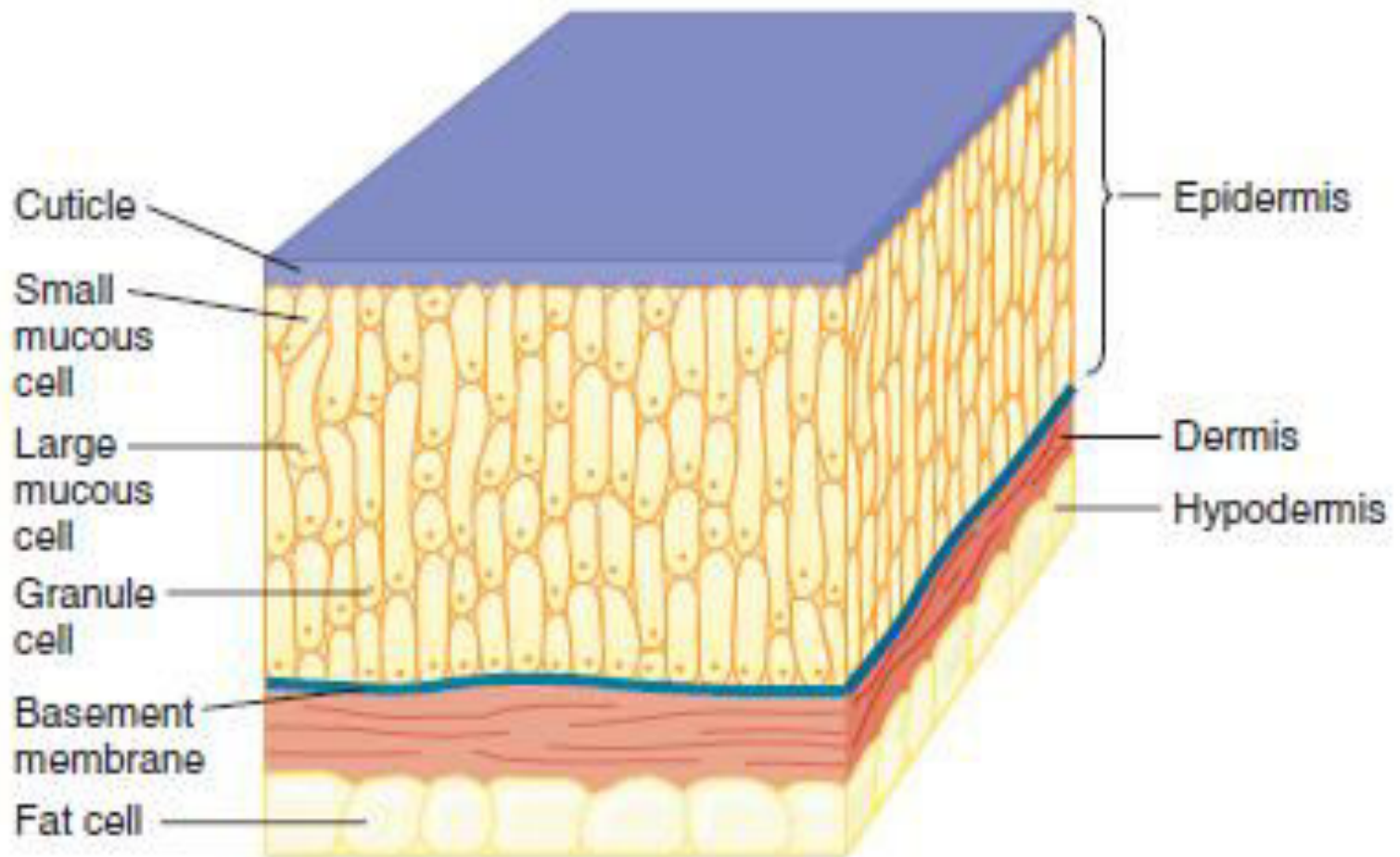
Skin of Jawless & Cartilaginous Fishes

Integument of vertebrates is called the skin.

Skin of Jawless of Fishes

- Jawless fishes include Lamprays and Hagfishes.
- Of several types of epidermal glands, one secretes cuticle.
- In Hagfishes, slime is secreted by multicellular epidermal glands and covers the body surface.

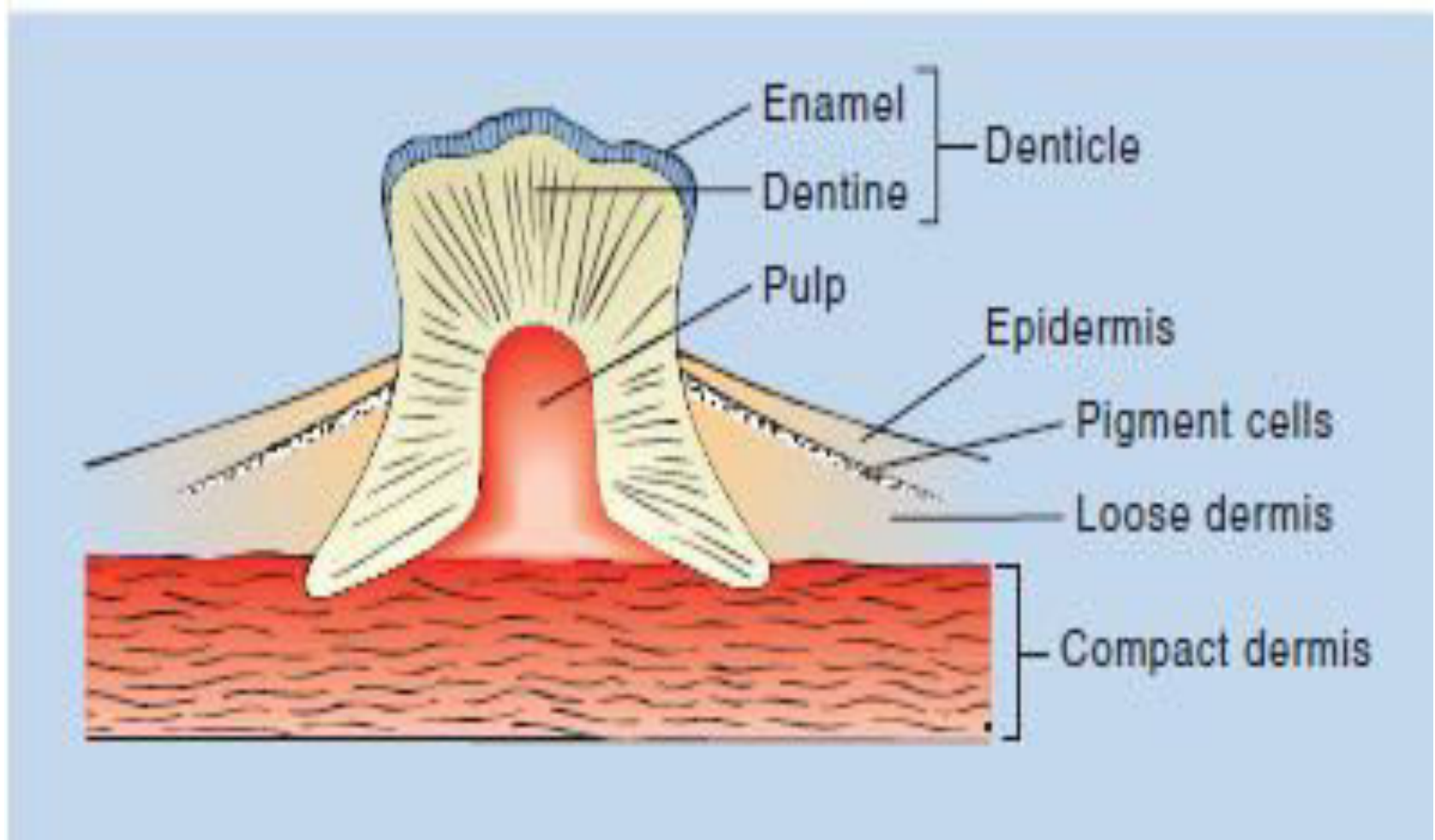
Skin of Jawless of Fishes



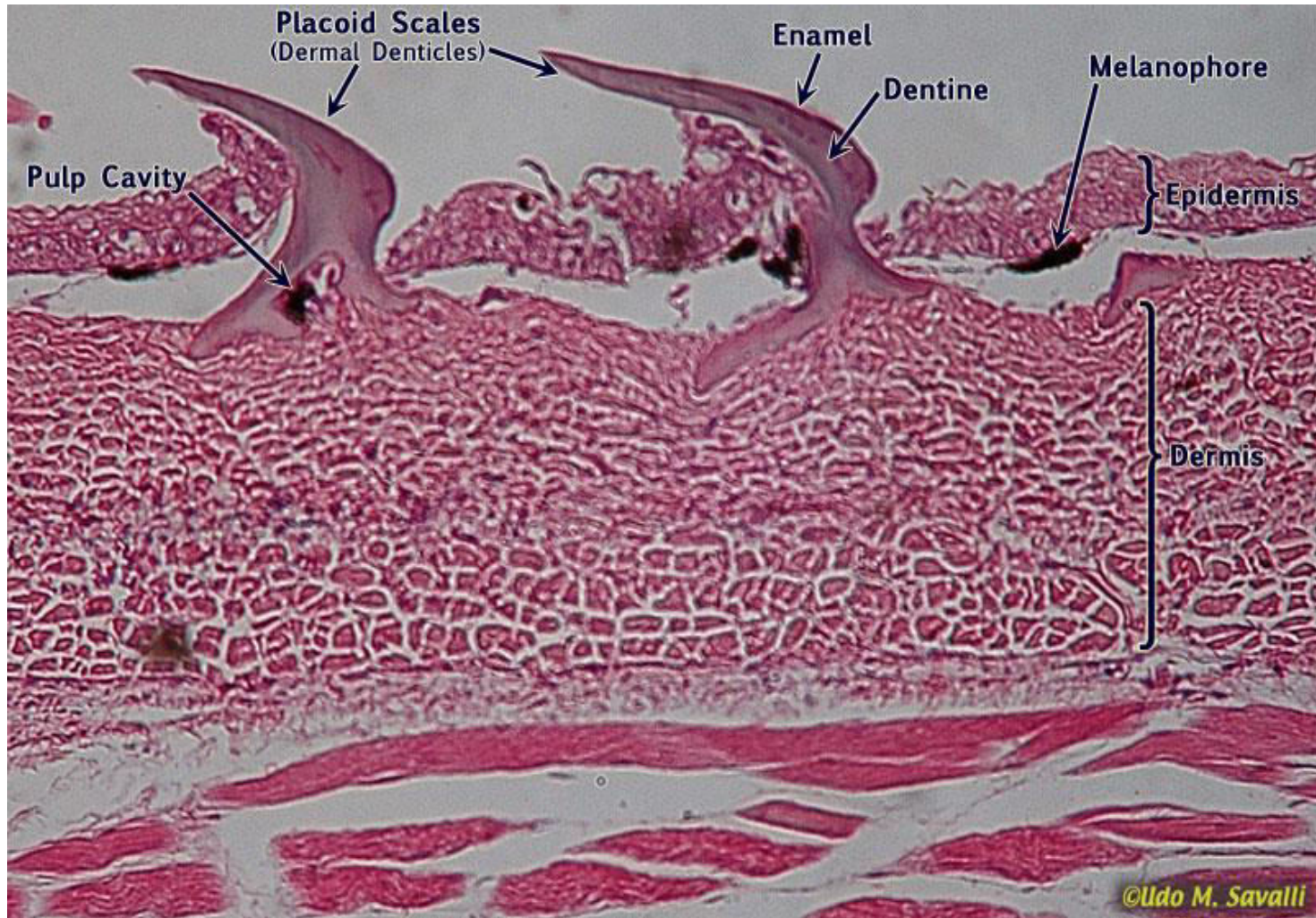
Skin of Cartilaginous Fishes

- Skin of Cartilaginous fishes (sharks) is multilayered and contains mucous cells and sensory cells.
- Dermis contains small placoid scales in the form of denticles similar to vertebrate teeth.
- The denticles are protective in function

Skin of Cartilaginous Fishes



Skin of Cartilaginous Fishes



Histology of Shark Skin

Integumentary System of Vertebrates

Module 7



Animal Form and Function 1

**Integumentary System of
Vertebrates**

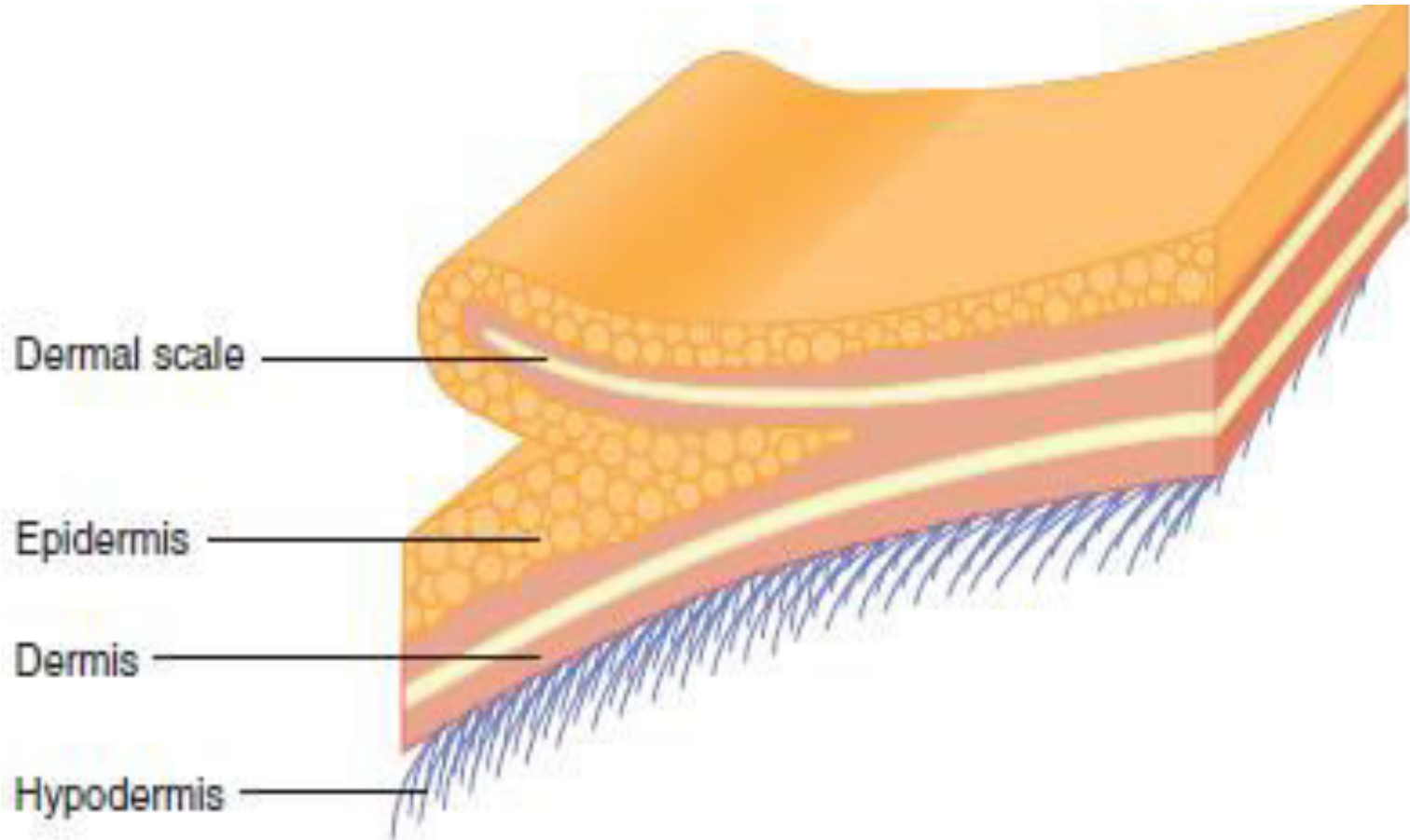
Bony Fishes

Bony Fishes

Bony fishes (teleosts) contain dermal scales.

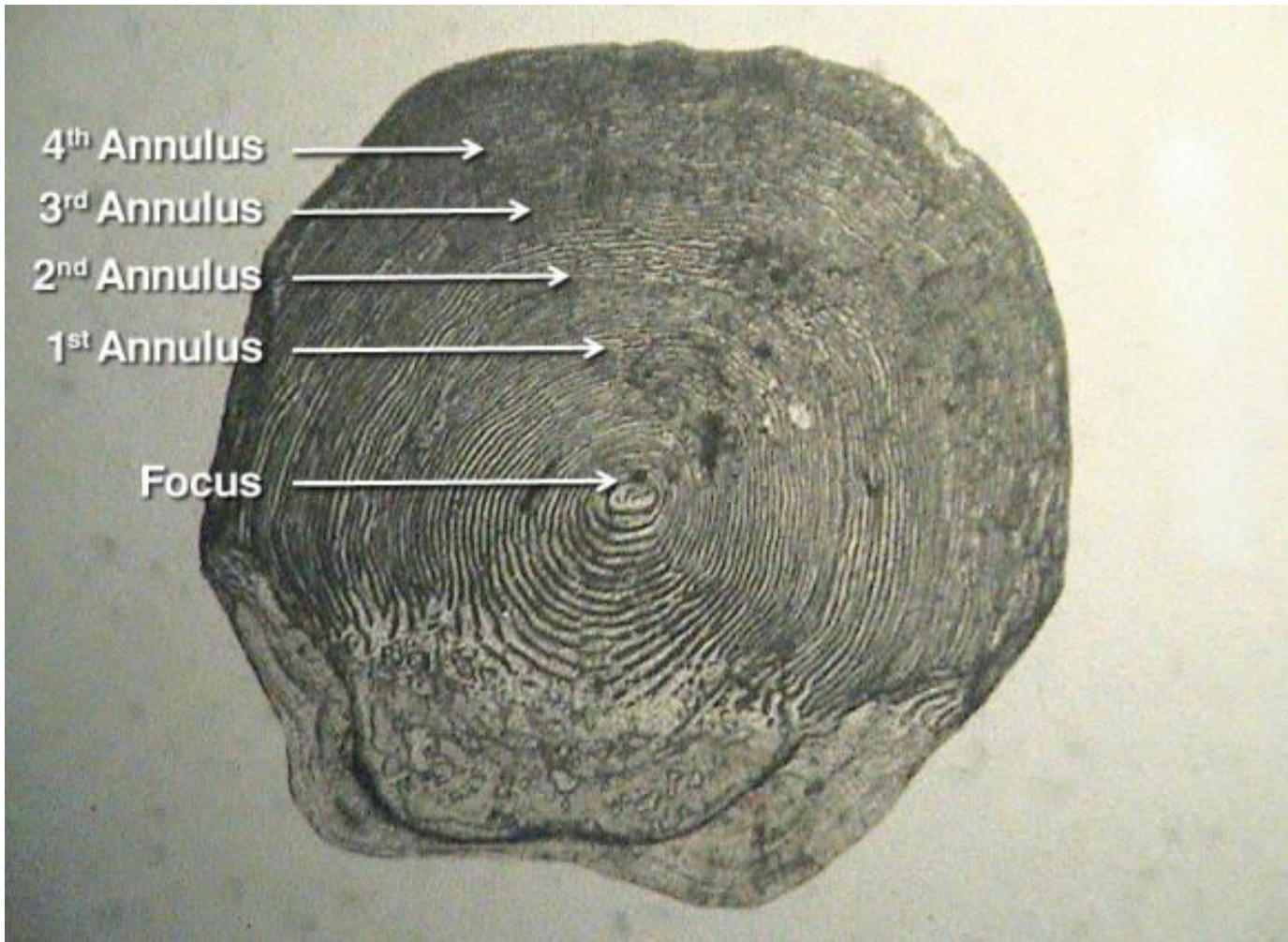
- The dermal tissue is covered over by epidermis.
- The scales grow at the margins and at the lower surface.
- Growth lines thus developed are useful to determine the age of the fish.
- The skin of the bony fishes is permeable to gases.

Bony Fishes



Skin of Bony Fish

Bony Fishes



Scale of Fish Showing Lines of Growth

Bony Fishes

- The dermis is richly supplied with blood to facilitate in respiration.
- The epidermis also contains mucous glands.
- Mucus prevents the fish from infection.
- In some species the mucus contains poisonous alkaloids.
- Deep water fishes have rhodophores that help lures and warnings

Module 8



Animal Form and Function 1

In Hydra (a Cnidarian) the epidermis is a few layers thick. The outer layer has cuboidal cells where the inner layer are columnar cells. It is outer layer that protect the animal. In corals (also Cnidarian) have mucous glands that secrete Calcium carbonate shell, The shell is hard protective covering that acts as an integument.

Integumentary System of Vertebrates

Skin of Amphibians and Reptiles

Skin of Amphibian

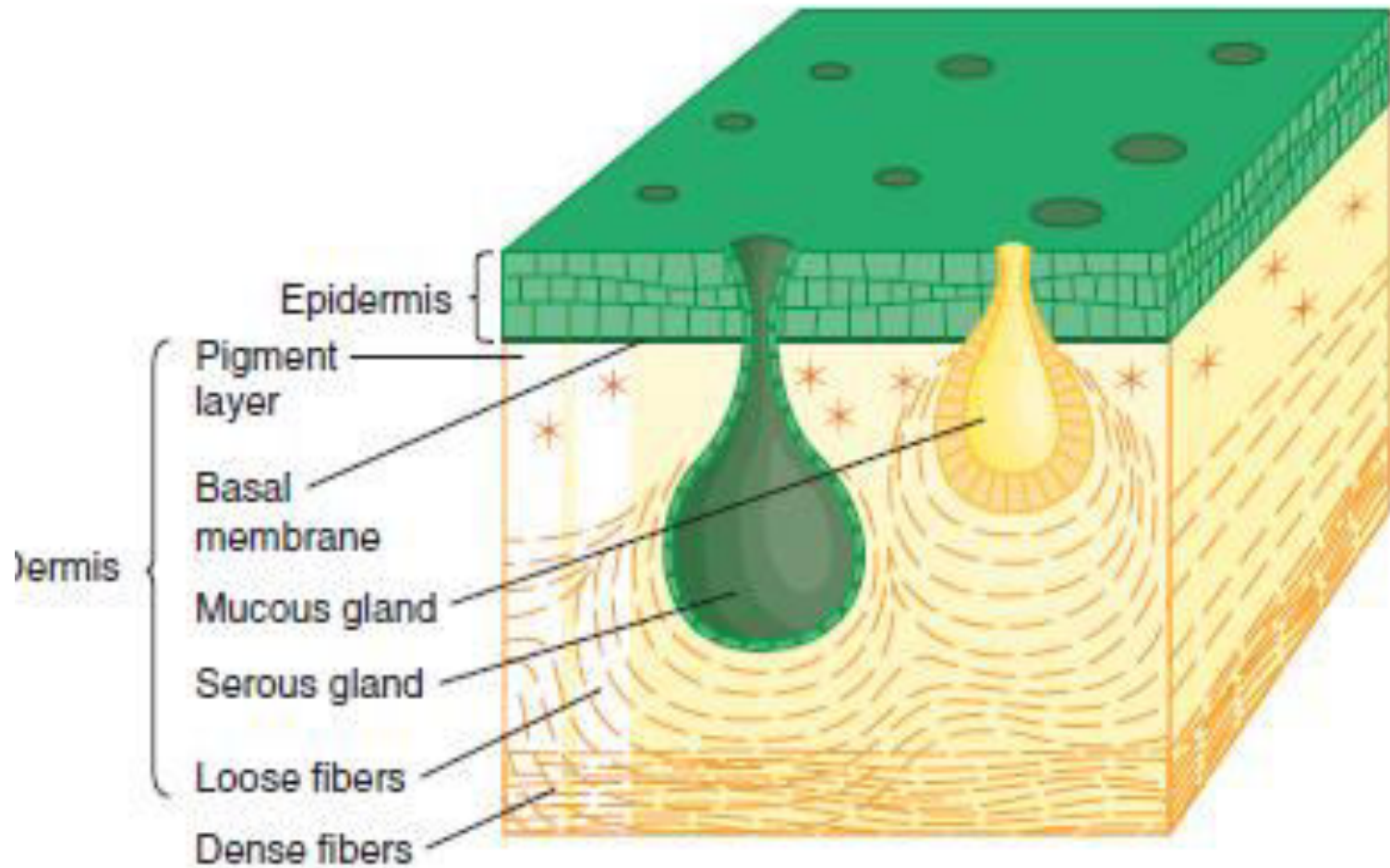
Amphibian skin has layers

i) Epidermis

ii) Dermis

- Epidermis is stratified.
- Dermis is thick containing, pigment layer, mucous & serous glands.
- During evolution keratin production increased in outer layers of the skin.

Skin of Amphibian



Skin of Amphibian

Skin of Amphibian

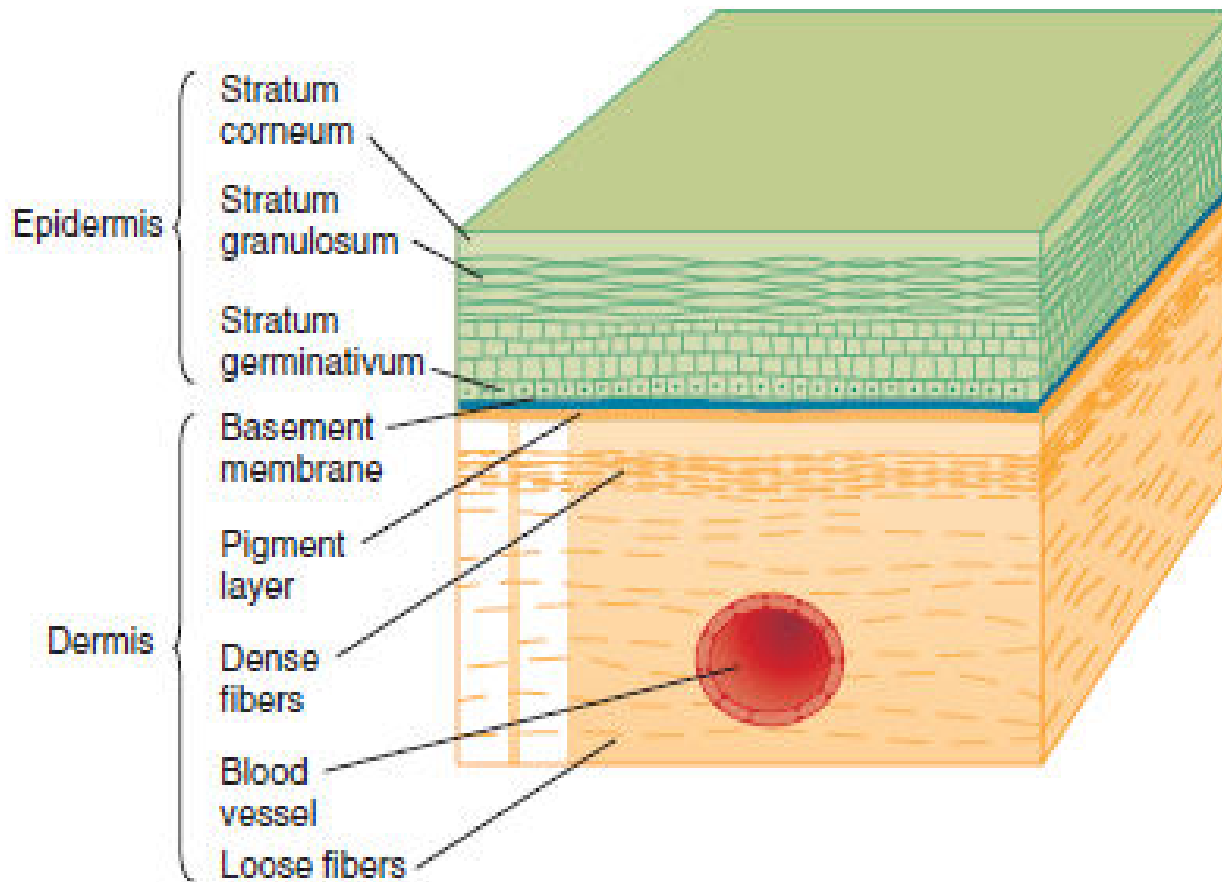
- Keratin is impermeable protein structure thus protects the skin.
- The mucus produced by the glands help prevent desiccation.
- Also facilitates in gas exchange.
- Within dermis of some amphibians, poisonous glands are also present.
- Its secretions acts as predator deterrent.

Skin of Amphibian

Skin of Reptiles:

- i) Epidermis is thick, outer most layer is stratum corneum.
- Epidermis is modified into keratinized structures e.g. scales, scutes, rattles, claws plaques and spiny crests.
- These structures are protective in function.

Skin of Amphibian



Skin of Reptiles

Skin of Amphibian

Skin of Reptiles:

- Molting or shedding of skin also occurs in reptiles e.g. snakes.
- The skin of reptiles reflects their greater commitment to a terrestrial existence.

Skin of Amphibian

Skin of Reptiles



Molting in snake

Skin of Mammals

Module 10



Animal Form and Function 1

**Integumentary System
of Vertebrates**

Skin of Mammals

Skin of Mammals

Notable features of mammalian skin are:

1. Epidermis
2. Epidermal glands.
3. Hair
4. Dermis

Skin of Mammals

- Rapid cell division occurs in the deeper parts of epidermis.
- As these cells come up the surface they die and become keratinized.
- Later these cells become the outer skin layer, and called the **stratum corneum**.

Skin of Mammals

- As these cells come on the surface and die and become keratinized.
- Later these cells become the outer skin layer, and called the **stratum corneum**.
- The SC is the first line of defense against toxins and microbes.

Skin of Mammals

Dermis is the thicker portion of mammalian skin.

- It contains blood vessels, lymphatic vessels, nerve endings, hair follicles, small muscles and glands.

Skin of Mammals

The **Hypodermis** lies underneath the dermis that consists of loose connective tissue, adipose tissue, and skeletal muscles.

Skin of Mammals

Main functions of Mammalian skin:

- Main barrier of the body
- Regulates body temperature by sweating.
- On exposure to sunlight a chemical present in the skin is converted into Vitamin D.
- Skin is an important sense organ containing sensory receptors for heat, cold, pressure and pain.

Skin of Mammals

Mammalian Skin Glands:

- Sudoriferous glands (sweat glands)
- Sebaceous glands secrete sebum.

Sebum is a:

Lubricant,
skin-softening agent
and

also acts as a
pheromone.

Skin of Mammals

Pigmentation of the skin:

- Chromatophores-
Melanin in human skin.
- Other skin colors in various mammals help camouflaging, communication, reproductive status etc,
- Some colors is due to color of blood.
- Bright colors is toxic mammals may deter potential predators.

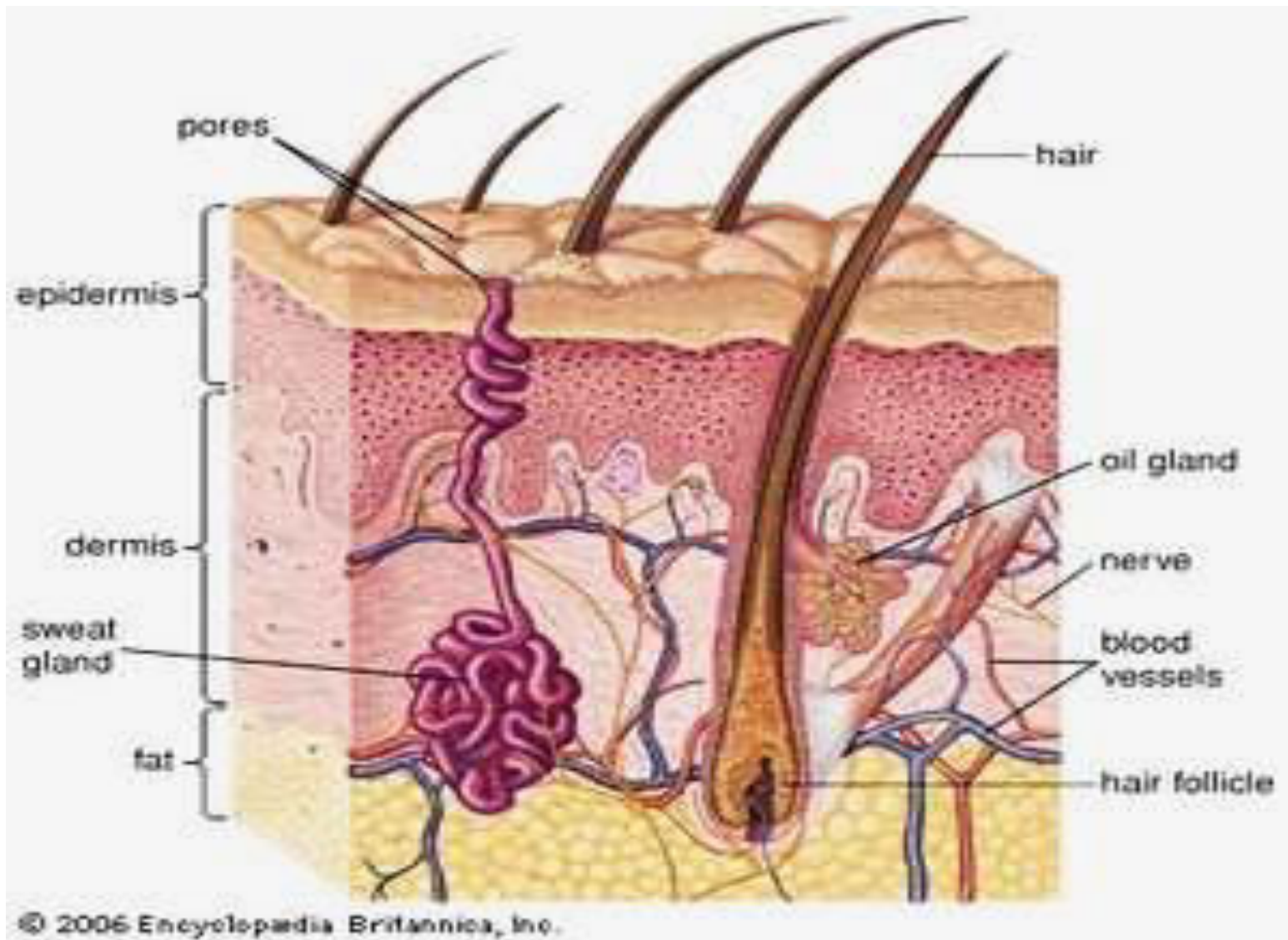
Skin of Mammals

- Hair is composed of keratin-filled cells that develop from epidermis.
- Arrector pili muscles are attached to the connective tissue surrounding the hair follicle.
- On contraction of pili muscles the hair gets erect. This condition is called "Goose hump" in human.
- In other mammals this condition helps warm the animal in cold environment.

Skin of Mammals

- **Nail**, is one of the characters of Pimates. like hair, nails are the modifications of epidermis.
- Other mammals have claws and hoofs.
- **Horns** are keratinized derivatives of mammalian skin. (Horns are not to be confused with the bony antlers).

Skin of Mammals



Module 11



Animal Form and Function 1

**Movement and
Support:**

**Skeletal System in
Invertebrates**

Skeletal Systems in Invertebrates

- Body size increased dramatically as organisms evolved from unicellular to multicellular animals.
- Systems involved in movement and support evolved simultaneously.

Skeletal Systems in Invertebrates

- With respect to support, organisms have three kind of skeletons:
 1. Hydrostatic
 2. Exoskeleton
 3. Endoskeleton

Skeletal Systems in Invertebrates

- Four cell types contribute to movement:
 1. Amoeboid cells
 2. Flagellated cells
 3. Ciliated cells &
 4. Muscle cells

End

Module 12



Animal Form and Function 1

Support and Movement of Invertebrates

Hydrostatic Skeleton

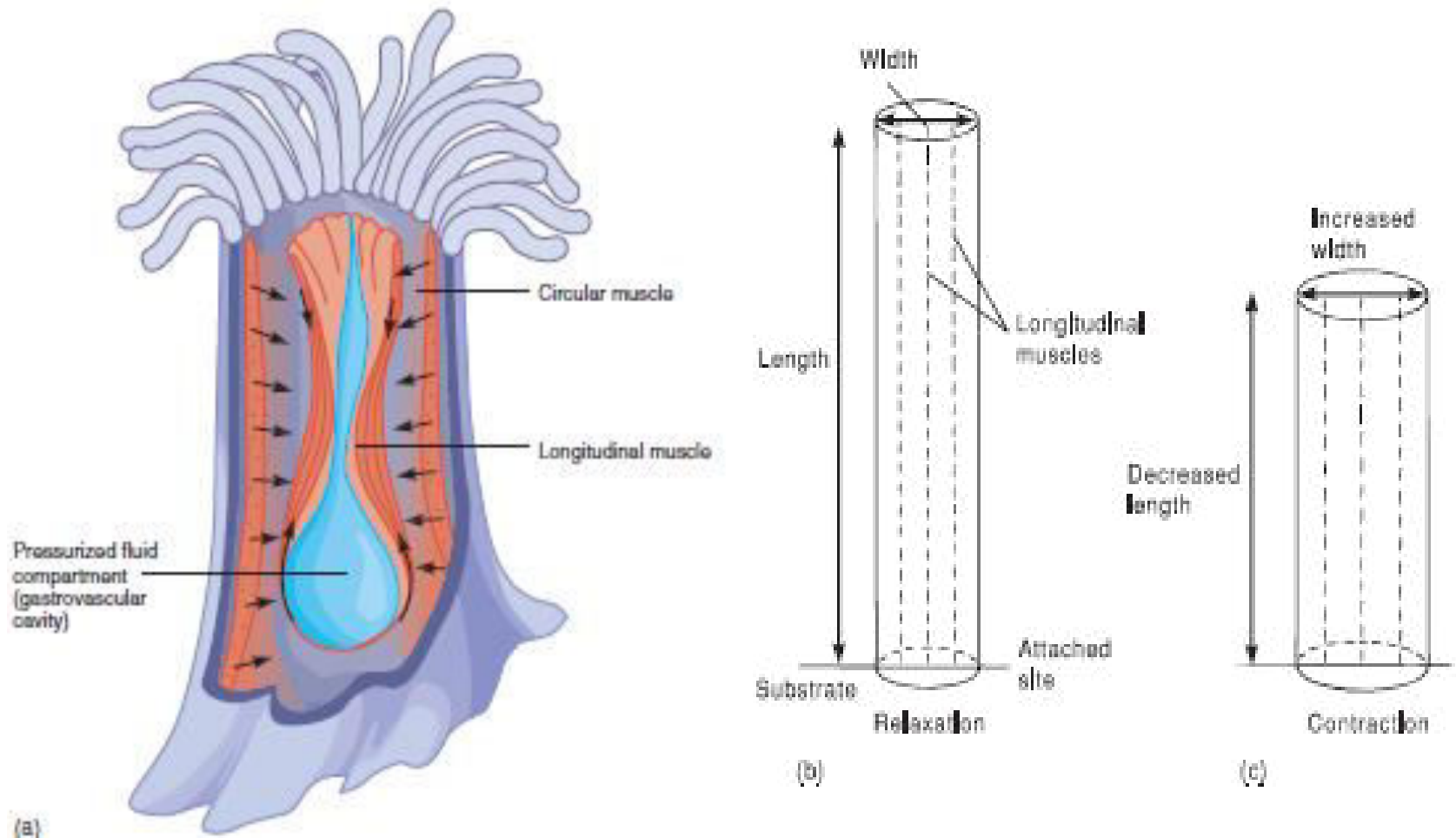


Hydrostatic Skeleton

Internal support using body fluid.

- It is core of liquid (body fluid) surrounded by sheath of longitudinal/circular muscles.
- For example sea anemone

Hydrostatic Skeleton



Hydrostatic Skeleton of Sea anemone

Hydrostatic Skeleton

Earthworm:

- Longitudinal and circular muscles contract alternately creating a rhythm that moves the earthworm.
- Hydro skeleton keeps the body from collapsing when the muscles contract.

End

- **Module 13**



Animal Form and Function 1

**Skeletal System of
Invertebrates**

Exoskeleton

Exoskeleton

Exoskeleton is a rigid external frame-work of the body.

Functions:

- Provides site for muscle attachment.
- Supports and protects the body like a shield.
- Prevents internal soft tissues from drying out.
- Provides protection from enemies.

Exoskeleton

Exoskeleton in Arthropods:

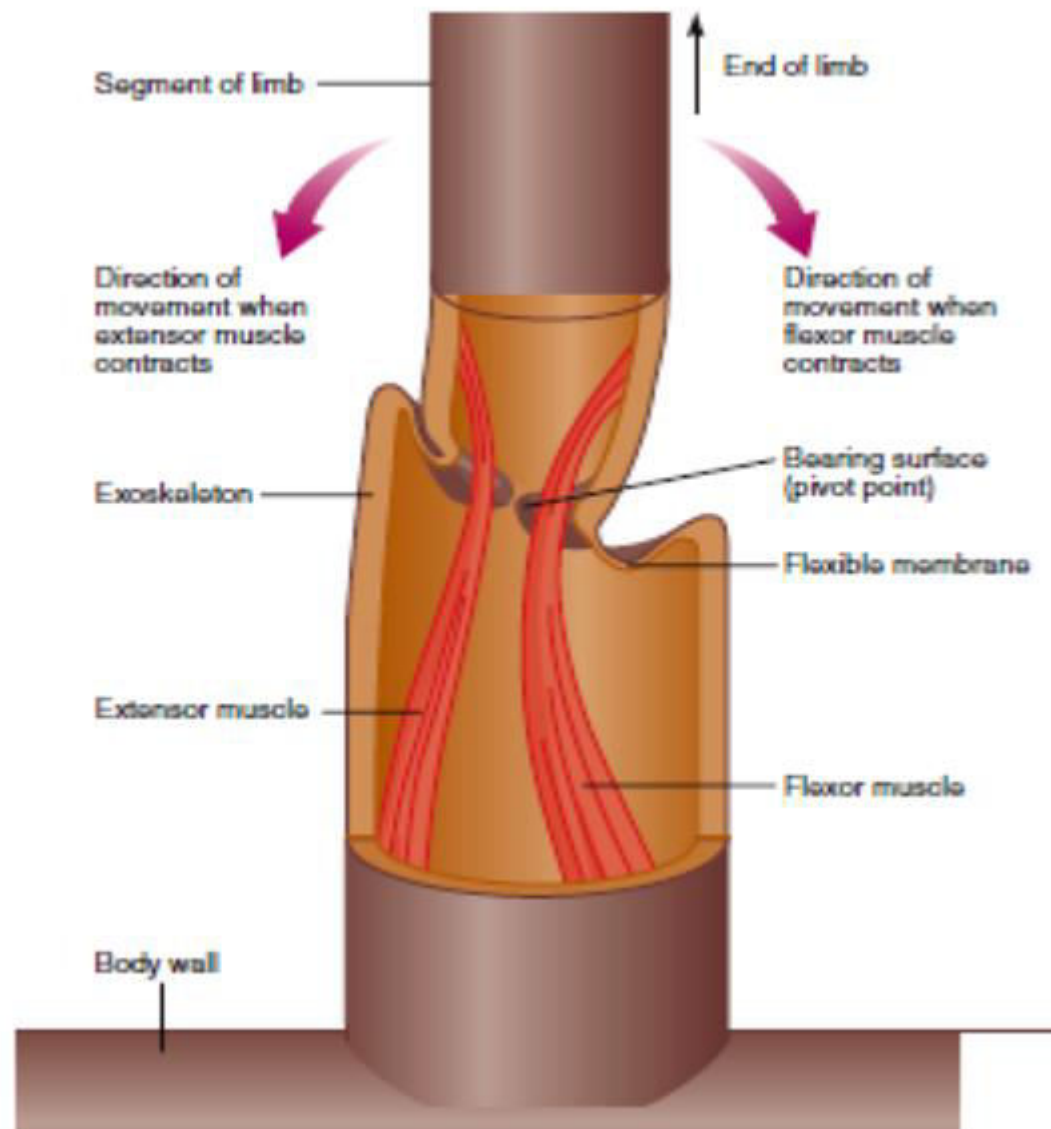
- Cuticle waterproofs the body.
- It limits the animal growth.
- Periodic shedding of exoskeleton.
- At the joint regions the cuticle is flexible, where the antagonistic muscles function.

Exoskeleton

Exoskeleton in Arthropods:

- At wing joints, a protein, resilin, stores energy on compression and then releases energy to produce movement.
- This is reason for success of arthropods.

Exoskeleton



Exoskeleton



Periodic shedding or molting in an insect

Module 14



Animal Form and Function 1

Skeletal System of Invertebrates

Endoskeleton

Endoskeleton

Introduction:

- Endoskeleton is the internal framework of the body.

Examples:

- Spicules in Sponges.
- Calcareous plates (ossicles) in echinoderms
- Bones in vertebrates.

Endoskeleton

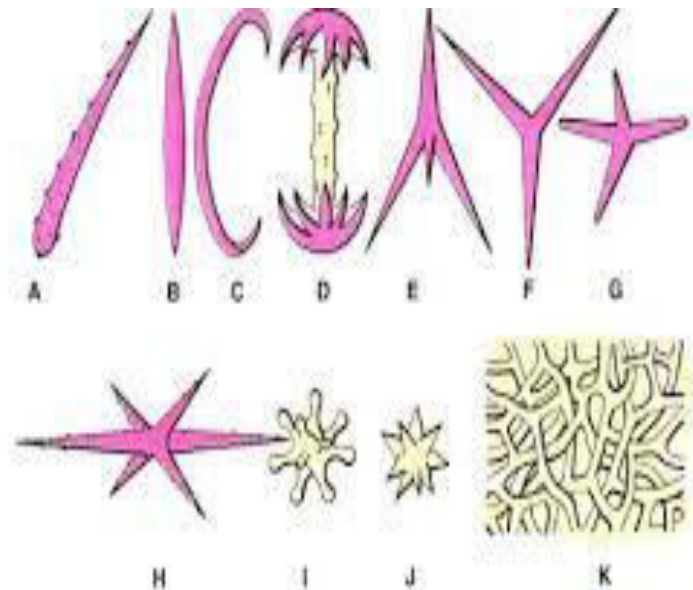
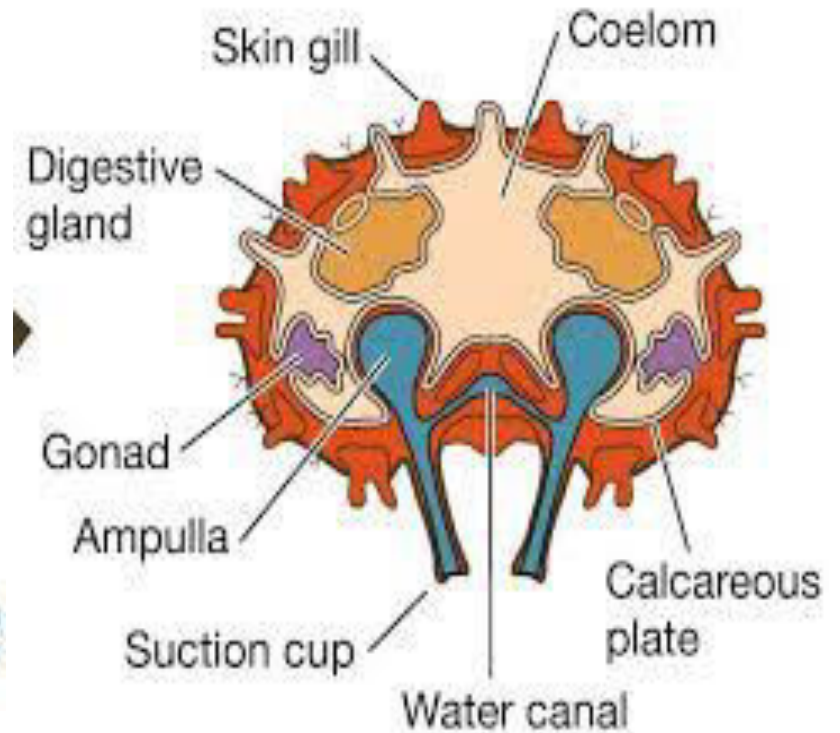
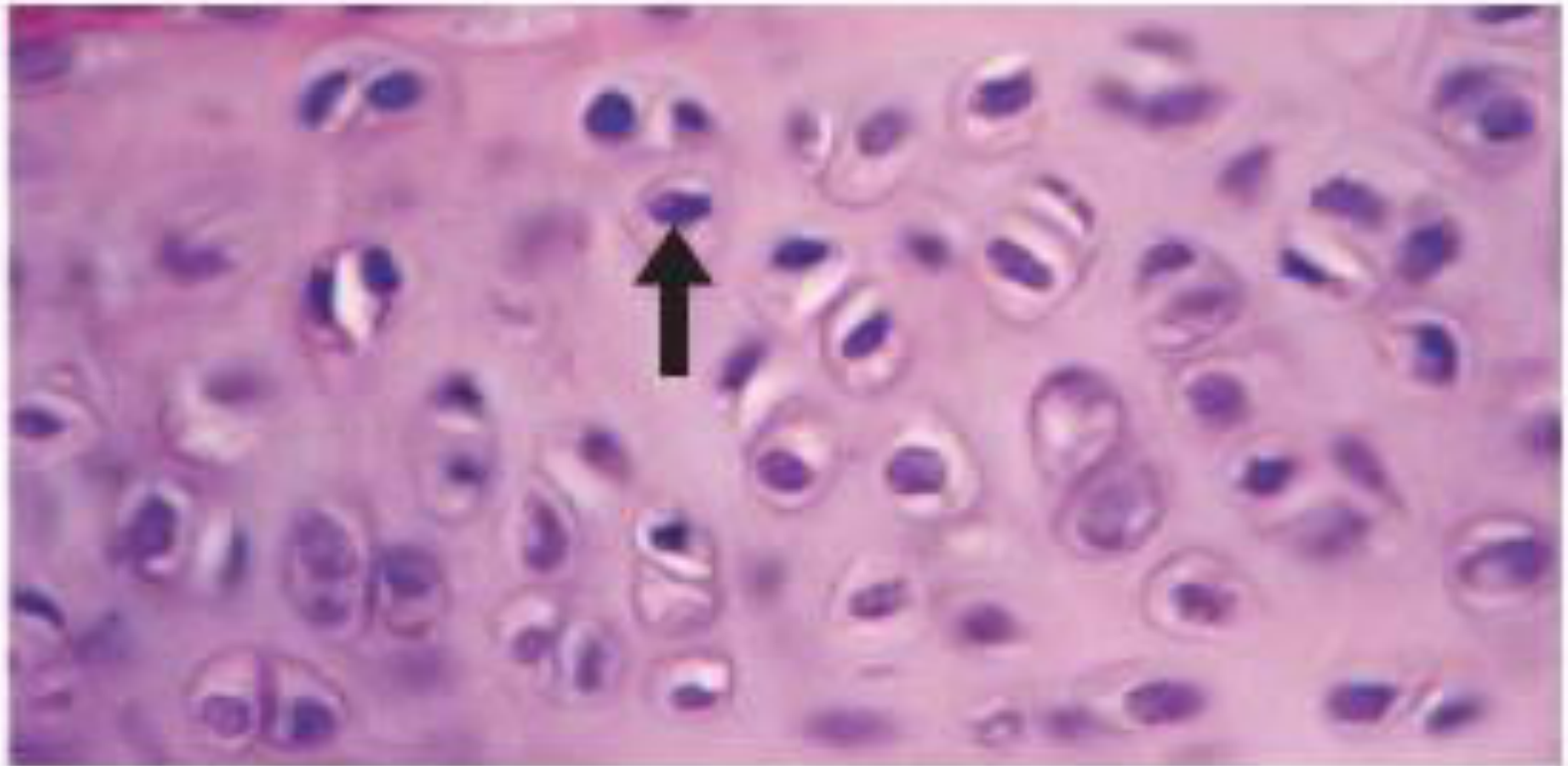


Fig. 28.9. Spicules and spongin. A—Monactinal monaxon; B—Diacinal monaxon; C—Curved monaxon; D—Monaxon with hooked ends; E—Tetragon; F—Triadiate; G—Cathrops; H—Hexactinal triaxon; I and J—Polyaxon; K—Spongin fibres.

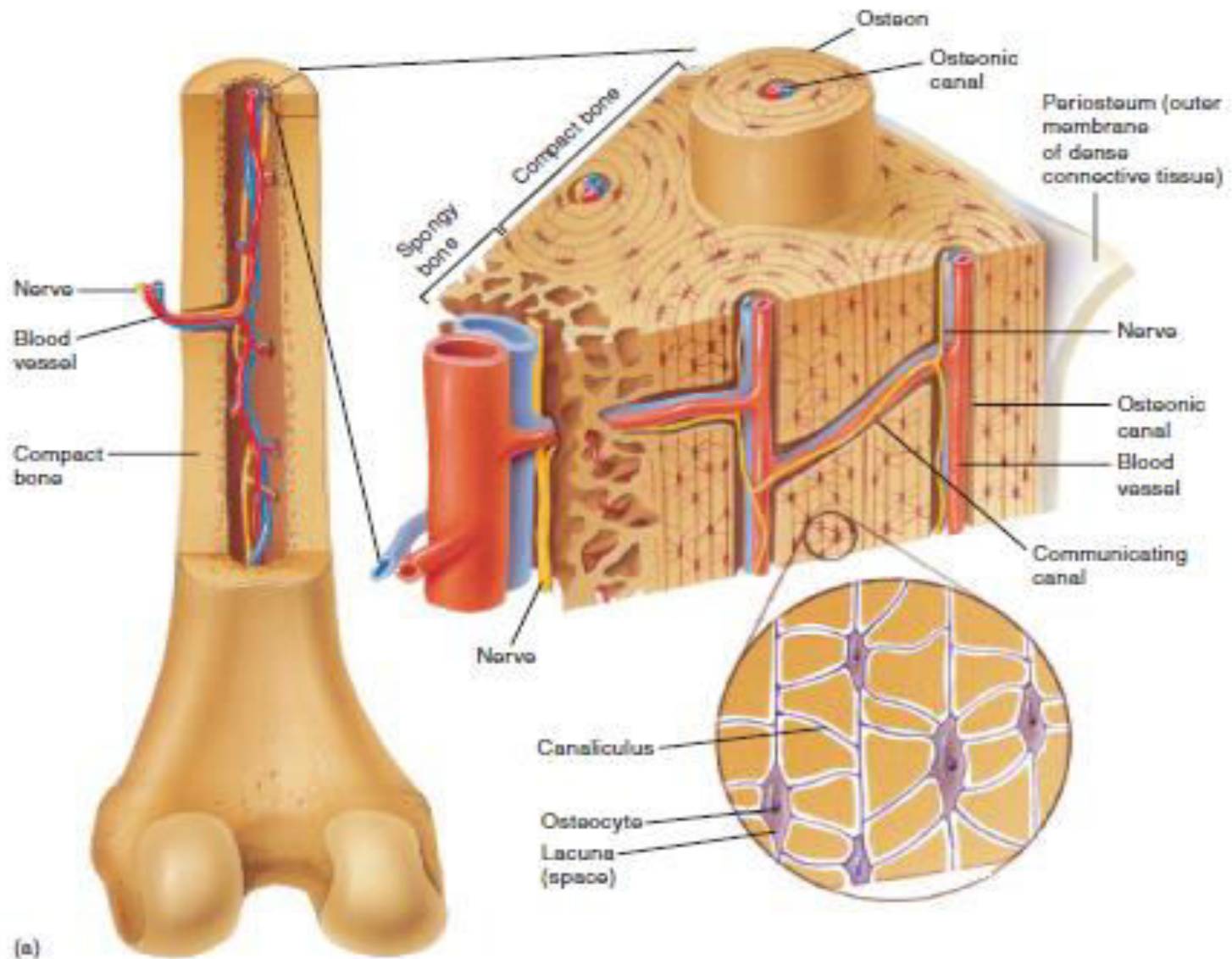


Endoskeleton

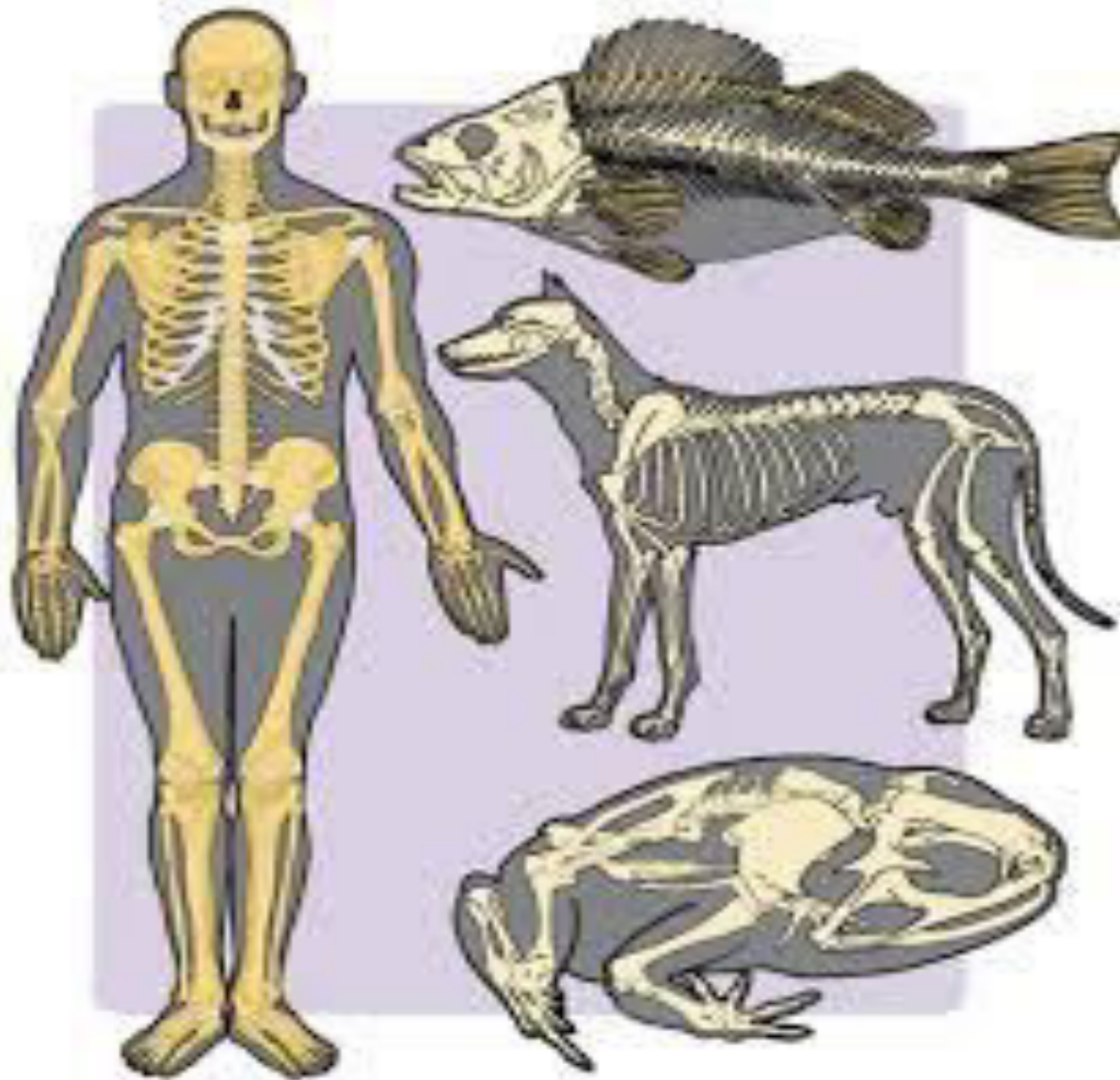


(i) **Hyaline cartilage cells** are located in lacunae (arrow) surrounded by intercellular material containing fine collagenous fibers (LM $\times 250$).
Location: Forms embryonic skeleton; covers ends of long bones; and forms cartilage of nose, trachea, and larynx. **Function:** Support and reinforcement.

Endoskeleton



Endoskeleton

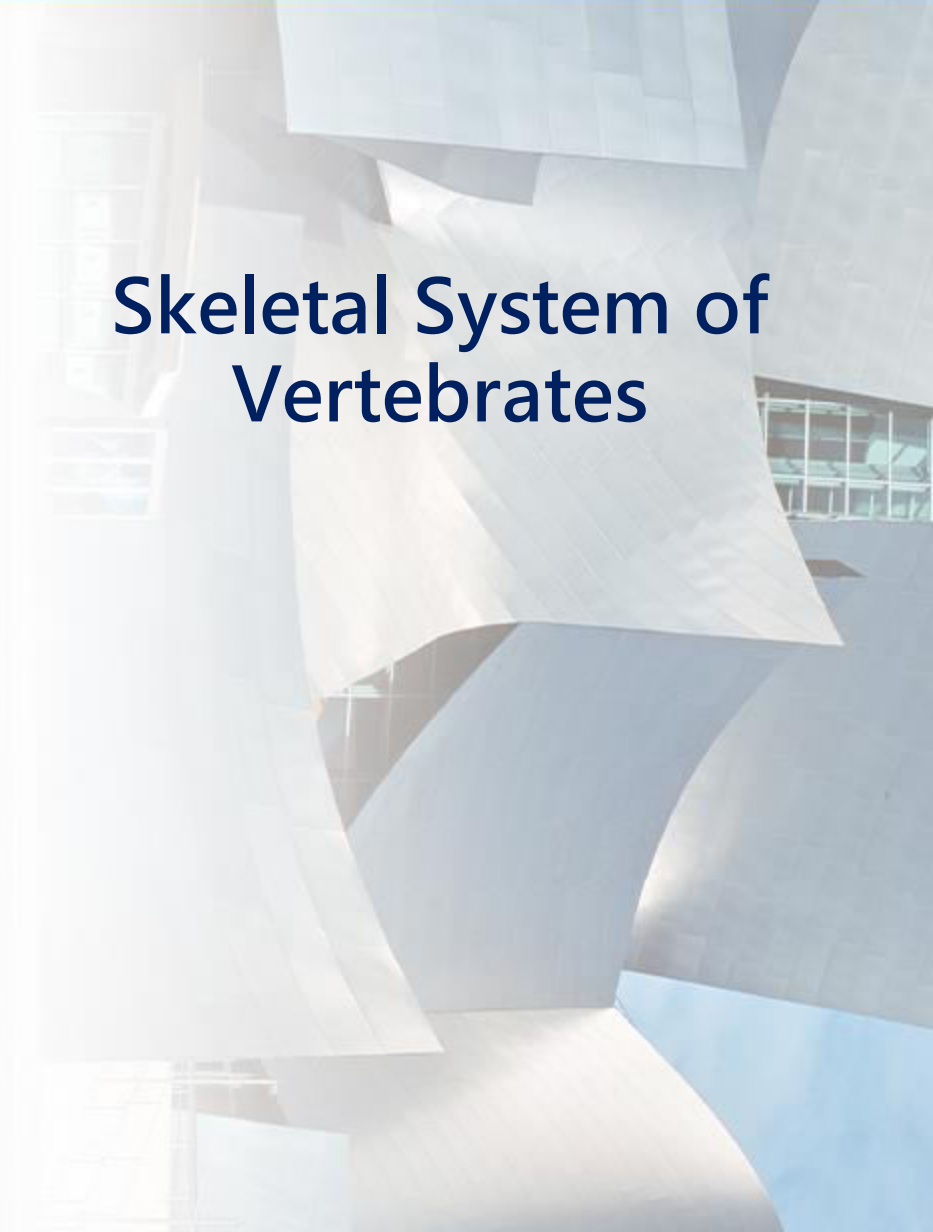


Module 16



Animal Form and Function 1

Skeletal System of Vertebrates



Skeletal System of Vertebrates

Introduction:

- SSV is an endoskeleton enclosed by other tissues.
- The endoskeleton consists of:
 - cartilage and
 - bone.

Skeletal System of Vertebrates

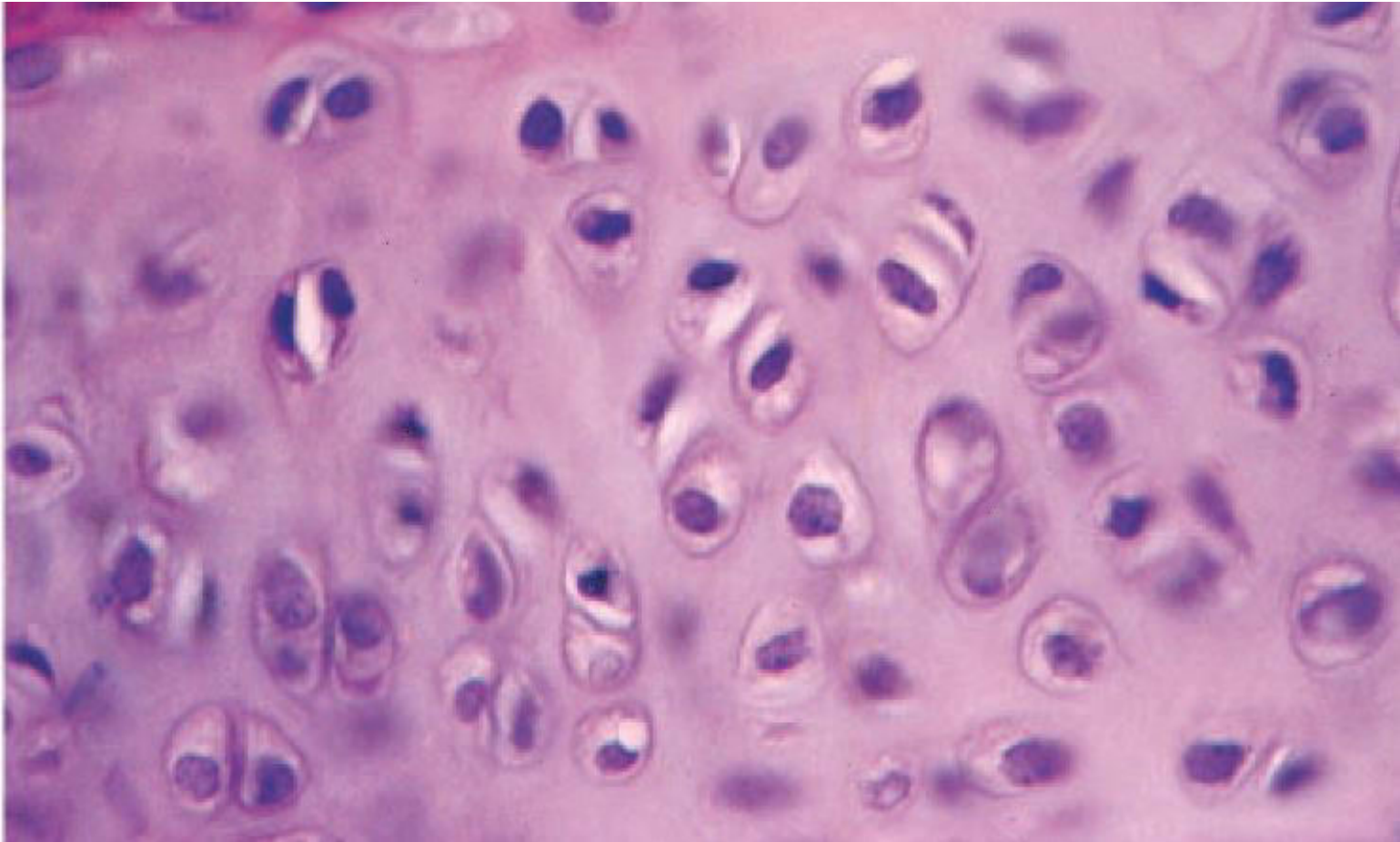
- **Cartilage** is a specialized type of connective tissue that provides:
 - Support
 - Helps in movement at joint
 - Site for muscle attachment.

Skeletal System of Vertebrates

- Histologically it consists of:
 1. Cells
(chondrocytes)
 2. Fibers and
 3. Cellular matrix

Skeletal System of Vertebrates

Cartilage



Hyaline Cartilage

Skeletal System of Vertebrates

Bone or Osseous tissue has the following functions.

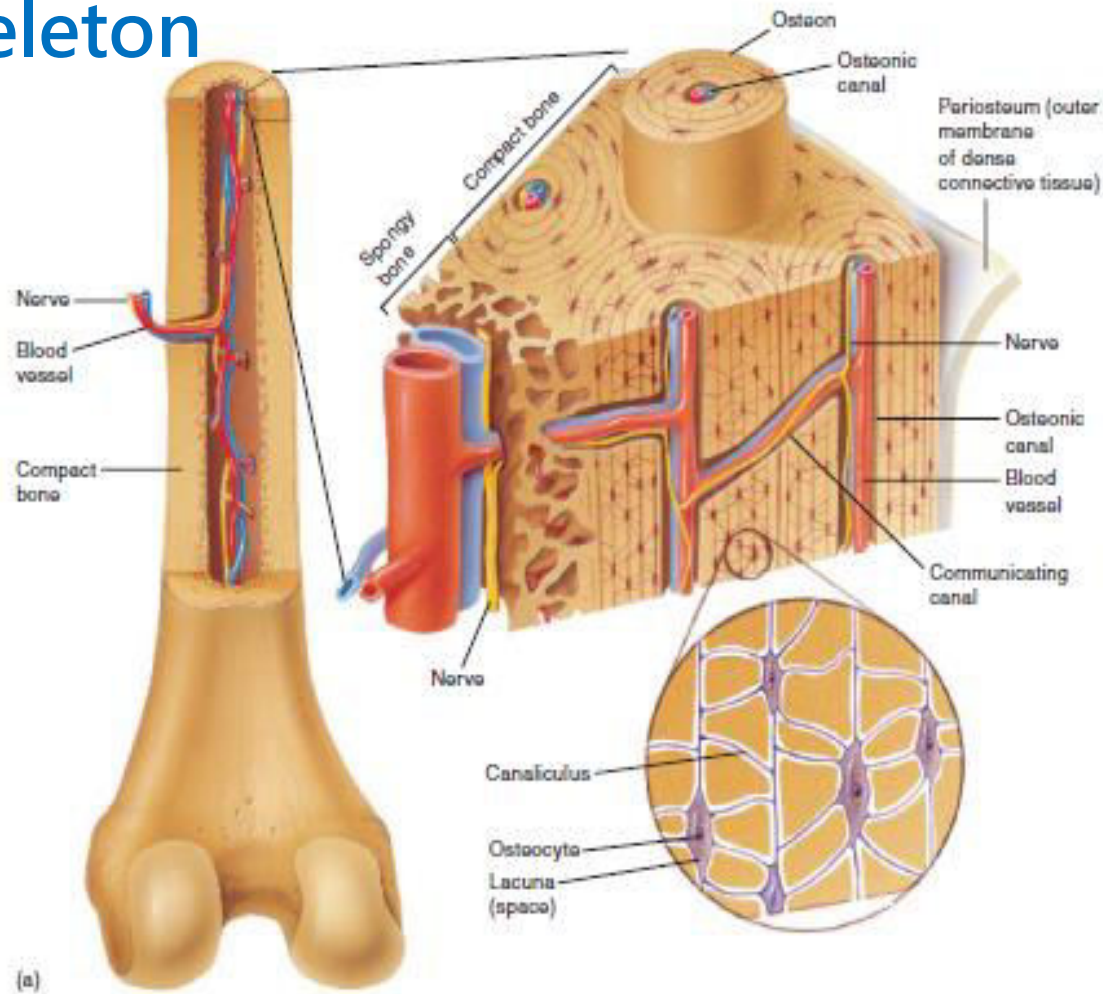
- Provides a point of attachment for muscles.
- Support the internal organs of the animal.
- Store reserves calcium and phosphate.
- Manufactures blood cells.

Skeletal System of Vertebrates

- Bone cells also called osteocytes are located in minute chambers called **lacunae**, which are arranged in concentric rings around the osteonic canals.
- These cells communicate with near by cells through small channels called canaliculae.

Skeletal System of Vertebrates

Endoskeleton



Structural organization of long bone

Skeletal System of Vertebrates

Endoskeleton



Endoskeleton of various vertebrates

Module 17



Animal Form and Function

Skeletal System of Vertebrates

Skeleton of Fishes

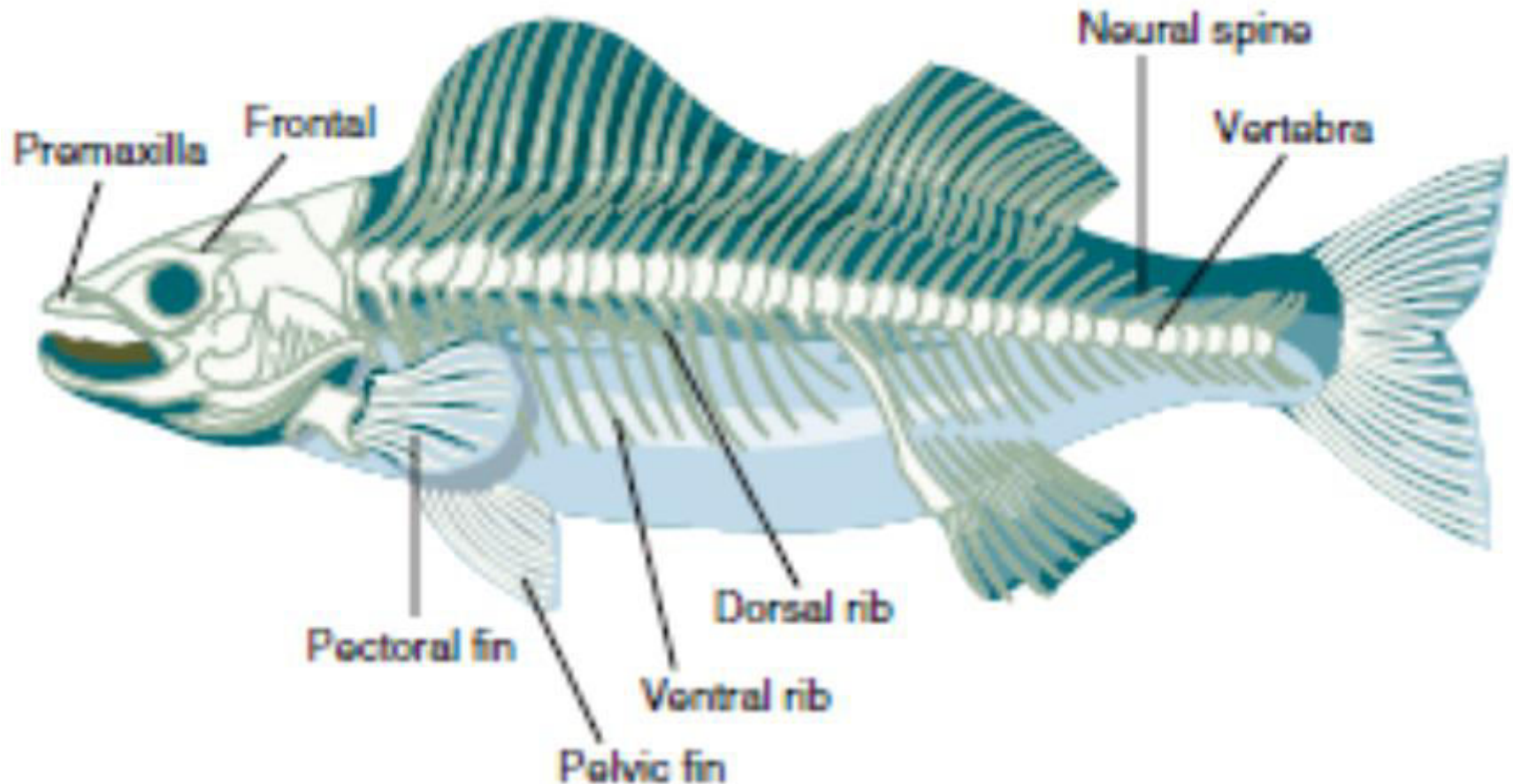
Skeleton of Fishes

- Water has buoyant effect on fish body, therefore, support is not demanding in these vertebrates.
- Primitive or jawless fishes do not have well defined vertebral column.

Skeleton of Fishes

- Instead they have isolated cartilaginous blocks along the notochord.
- Jawed fishes have the axial skeleton that is ribs and the vertebrae.

Skeleton of Fishes



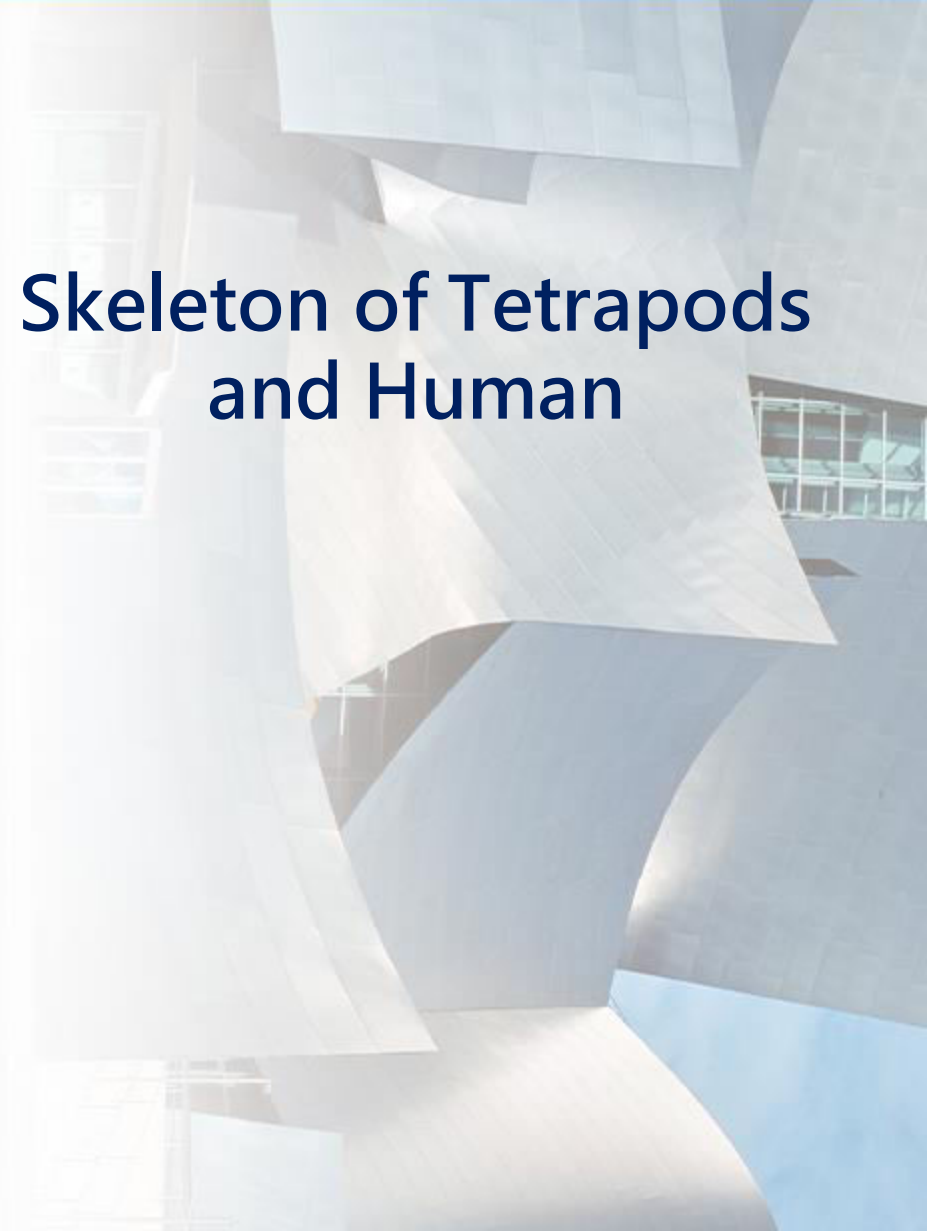
Fish Skeleton

Module 18



Animal Form and Function 1

Skeleton of Tetrapods and Human



Endoskeleton of Tetrapod and Human

- **Axial Skeleton:**
 - Skull
 - Vertebral Column
 - Ribs
- **Appendicular Skeleton**
 - Appendages
(Fore and hind limbs)
 - Girdles
(Pectoral and Pelvic)

Endoskeleton of Tetrapod and Human

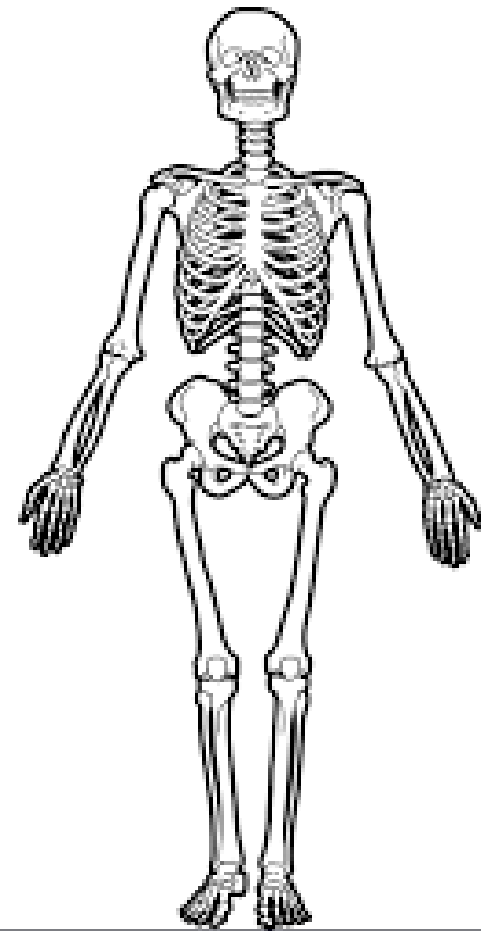
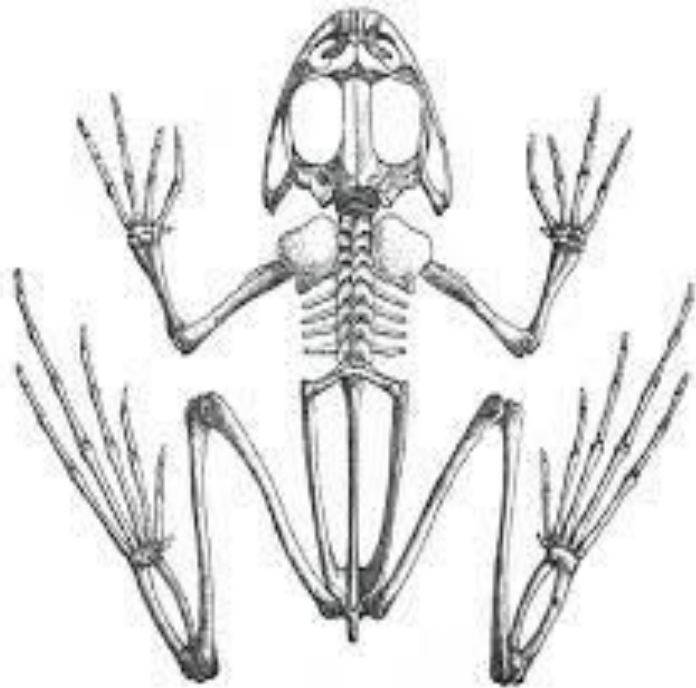
Skeleton of Tetrapods

- Amphibians needed support to replace buoyancy.
- The adaptations for support on land are:
 - Intervertebral discs
 - Rigid bony skeleton

Endoskeleton of Tetrapod and Human

- Elongated appendages
- Various types of connective tissue.
- Changes in shoulder for free movement of neck.

Endoskeleton of Tetrapod and Human



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Endoskeletons of a tetrapod and human



Module 19

Effort by

AMAN KHAN

Animal Form and Function 1

**Movement:
Nonmuscular and
Muscular Systems**

Movement: Nonmuscular & Muscular Systems

How Movement is different from Locomotion?

- Movement is the act of changing location from one place to another.
e.g. a trolley, a ship
- Locomotion is the movement of an organism by its natural means.
e.g. fish, insect, bird

Movement: Nonmuscular & Muscular Systems

- Movement is one of the characteristics of certain cells, protists and animals:
For example:
 Certain WBCs
 Coelomic cells and
 Protists.

Movement: Nonmuscular & Muscular Systems

Movement of WBCs:

- Migration of WBCs out of blood stream.
- Phagocytosis by WBCs
- Attraction by chemical stimulants

Movement by Coelomic Cells:

- Cells that line coelom show movements to make organ rudiments.

Movement: Nonmuscular & Muscular Systems

Movement in Protozoans:

- BY Flagella
- By Pseudopodia and
- By Cilia
- That involve contractile proteins (actin and myosin).

Movement in invertebrates and vertebrates:

- This is due to the muscles and muscular systems.

END

Module 20



Animal form and Function 1

Non-muscular Movements

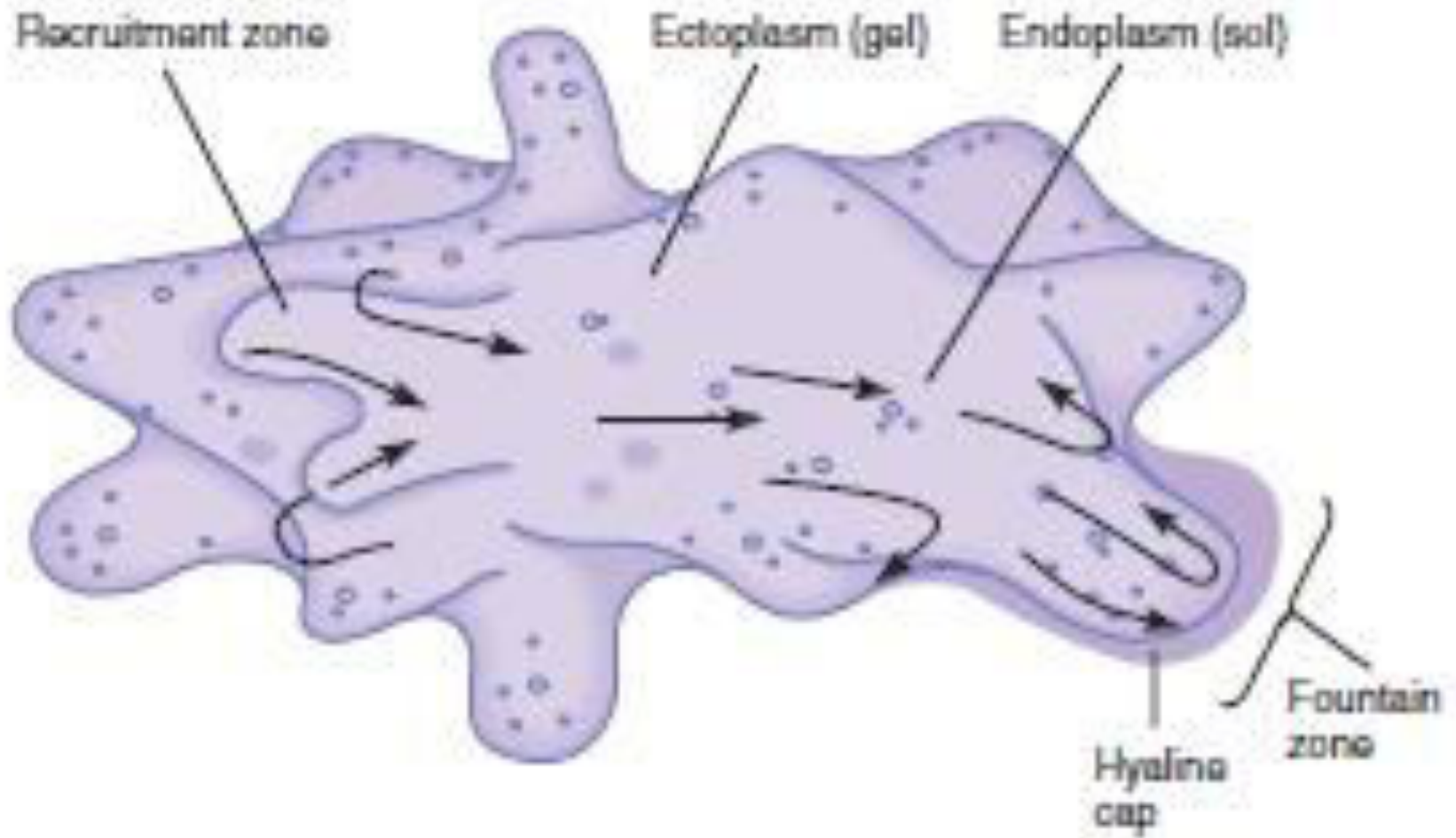


Non-muscular Movement

Amoeboid Movements:

- Plasma membrane of Amoeba has adhesive properties.
- Plasma membrane slides over the underlying layer of cytoplasm.
- The plasma membrane seems 'rolling' analogous to a bulldozer rolling over the wheels.

Non-muscular Movement



Non-muscular Movement

- In amoeboid movement, the fluid endoplasm flows forward into the fountain zone of an advancing pseudopodium.
- As it reaches the tip of pseudopodium endoplasm changes into the ectoplasm.

Non-muscular Movement

- At the same time the ectoplasm near the opposite end in the recruitment zone changes into endoplasm and begins flowing forward.

Non-muscular Movement

Flagellar and Ciliary Movement:

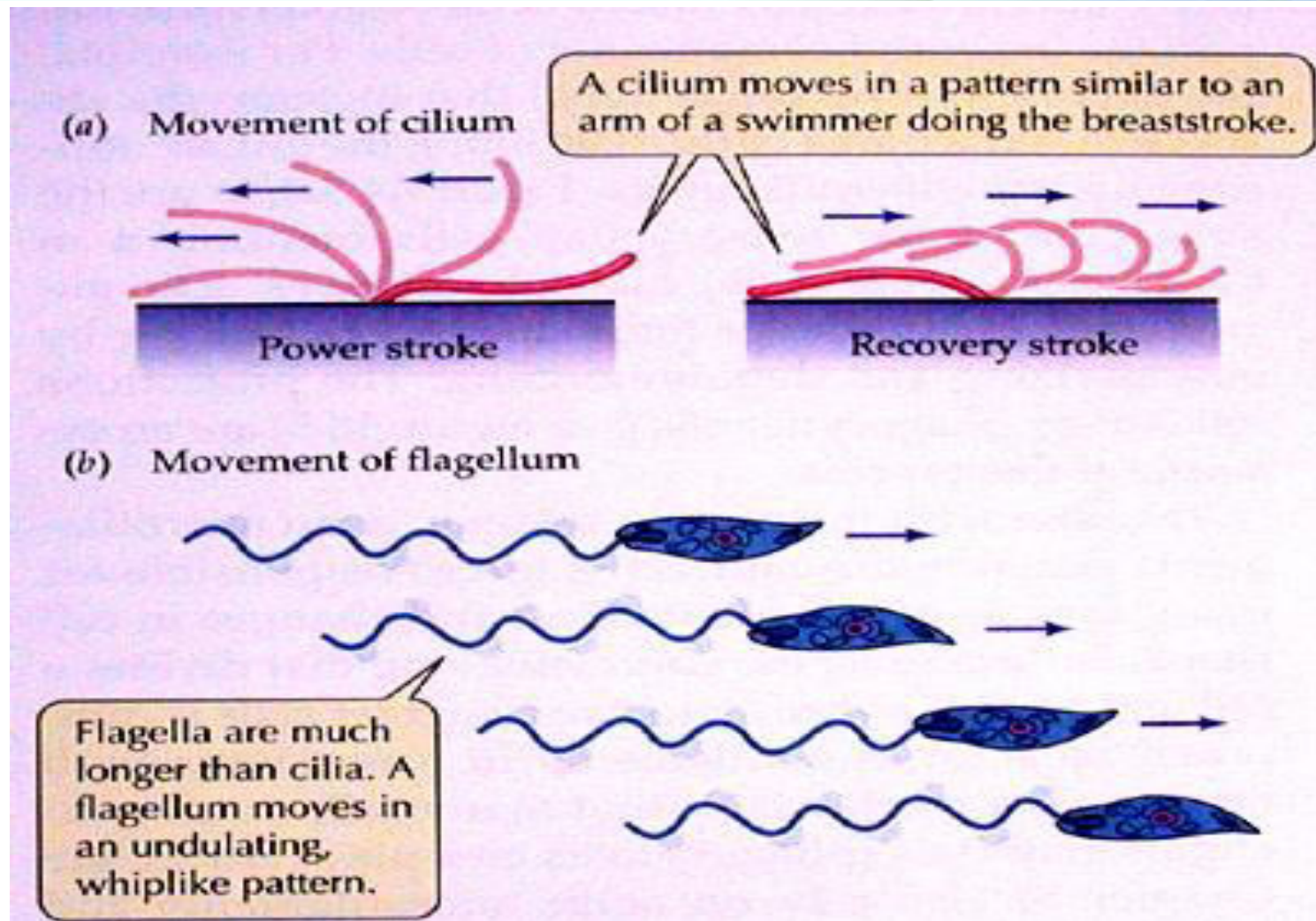
- Structurally, cilia and flagella are similar.
- The difference is that cilia are shorter and numerous where as flagella are long and occur singly or in pairs
- Cilia and flagella occur in every animal phyla except Arthropoda.

Non-muscular Movement

Ciliary movements:

- CM are well coordinated, in Protozoa.
- Cilia occur in rows.
- Rows of cilia beat out of phase with one another with the result waves periodically pass over the surface.
- Direction of movement is brought about by beating the cilia in reverse direction.

Non-muscular Movement



- Flagellar and Ciliary Movements

Non-muscular Movement

- In free living flat worms the epidermis is abundantly ciliated thus locomotion is efficient,
- Larger flat worm exhibit ciliary creeping locomotion. e.g. Nemertines.
- Muscular activities are also involved in locomotion in these animals.

END

Module 21



Animal Form and Function 1

Animal Muscles

⋮

Animal Muscles

Introduction:

Muscle is a contractile tissue, having cells the muscle fibers.

Physiological properties of muscle tissue are:

- Contractility or elasticity
- Extensibility
- Excitability or irritability.

Animal Muscles

Types of muscle tissue:

- Smooth
- Skeletal and
- Cardiac

Animal Muscles

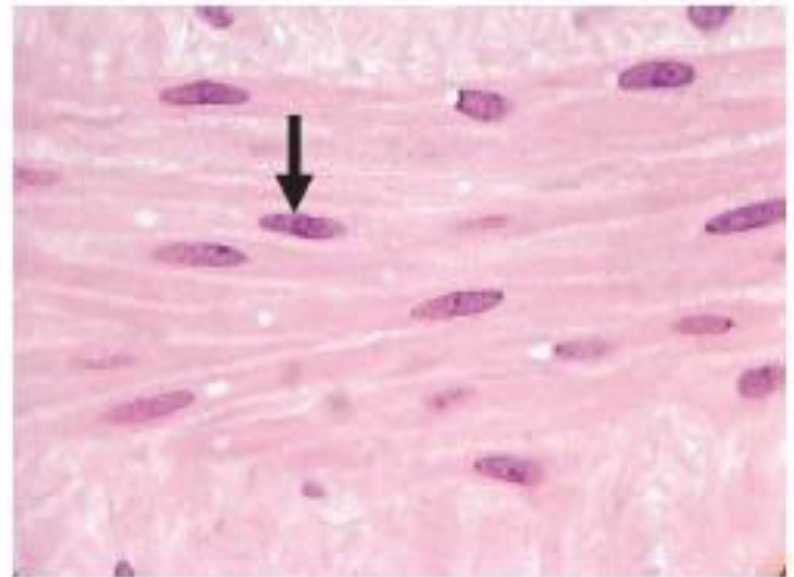
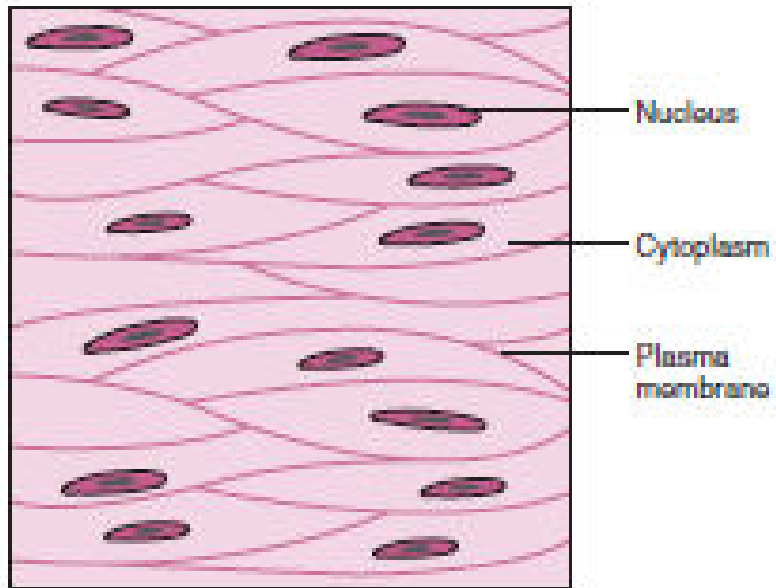
Smooth Muscles:

- Smooth muscles are involuntary.
- They are uni-nucleated & spindle shaped.
- They contract slowly and sustain prolonged contraction and do not fatigue easily.
- Can maintain good tone without nervous stimulation.

Animal Muscles

- Smooth muscles are predominant muscle type in invertebrates.
- Example is adductor muscles in clams and bivalves.

Animal Muscles

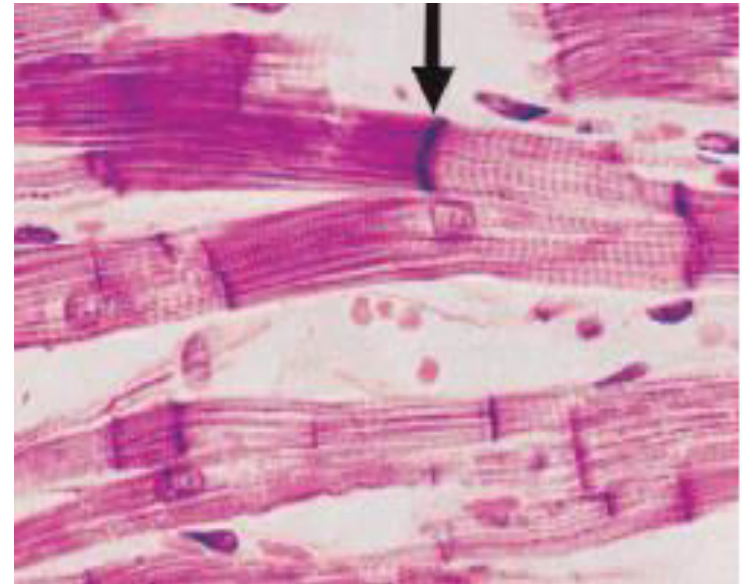
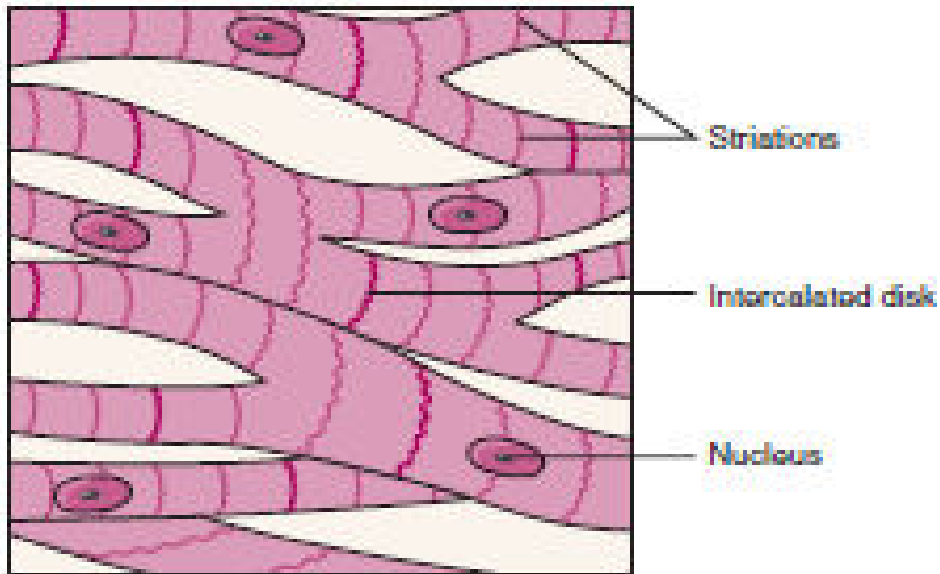


Animal Muscles

Cardiac Muscles:

- Cardiac muscles fibers are involuntary.
- Striated and have single nucleus.
- They are branched.
- This branching allows the fibers to interlock for greater strength during contraction.
- They do not fatigue because relax between contractions

Animal Muscles

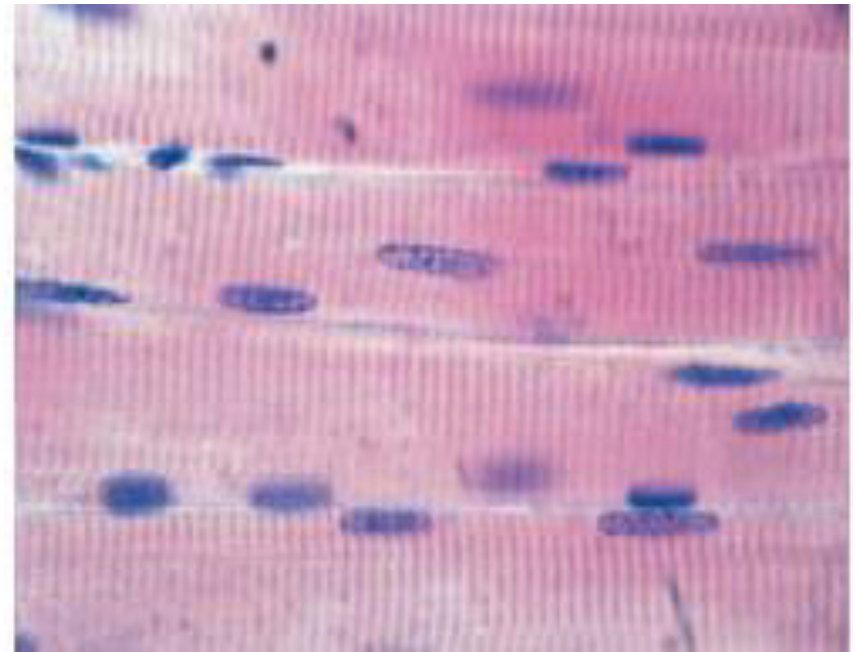
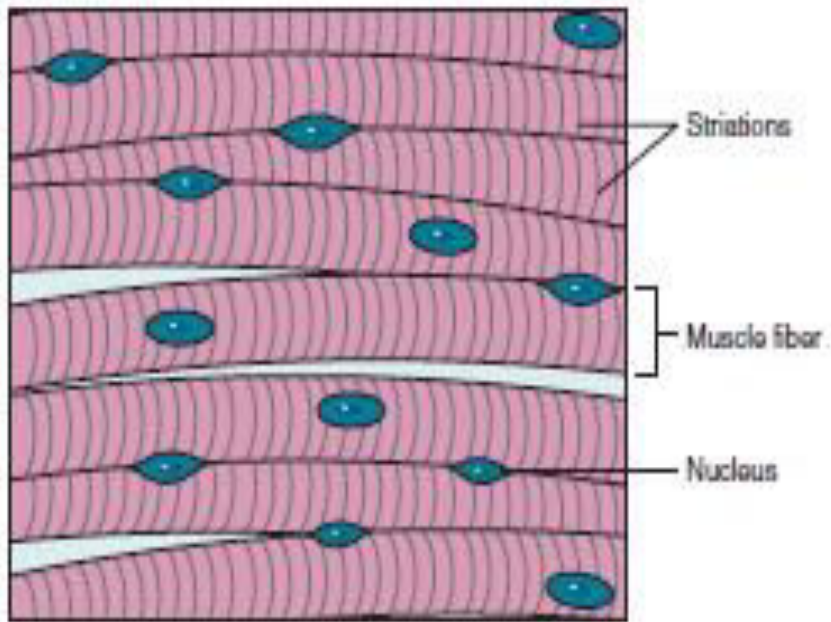


Animal Muscles

Skeletal Muscles:

- SM are voluntary.
- Skeletal muscle cells or fibers are multinucleated and striated.
- These muscles are associated with skeleton.
- The skeletal muscles work in antagonistic pairs.

Animal Muscles



Module 22

Animal Form and Function 1

**Muscular System of
Invertebrates**

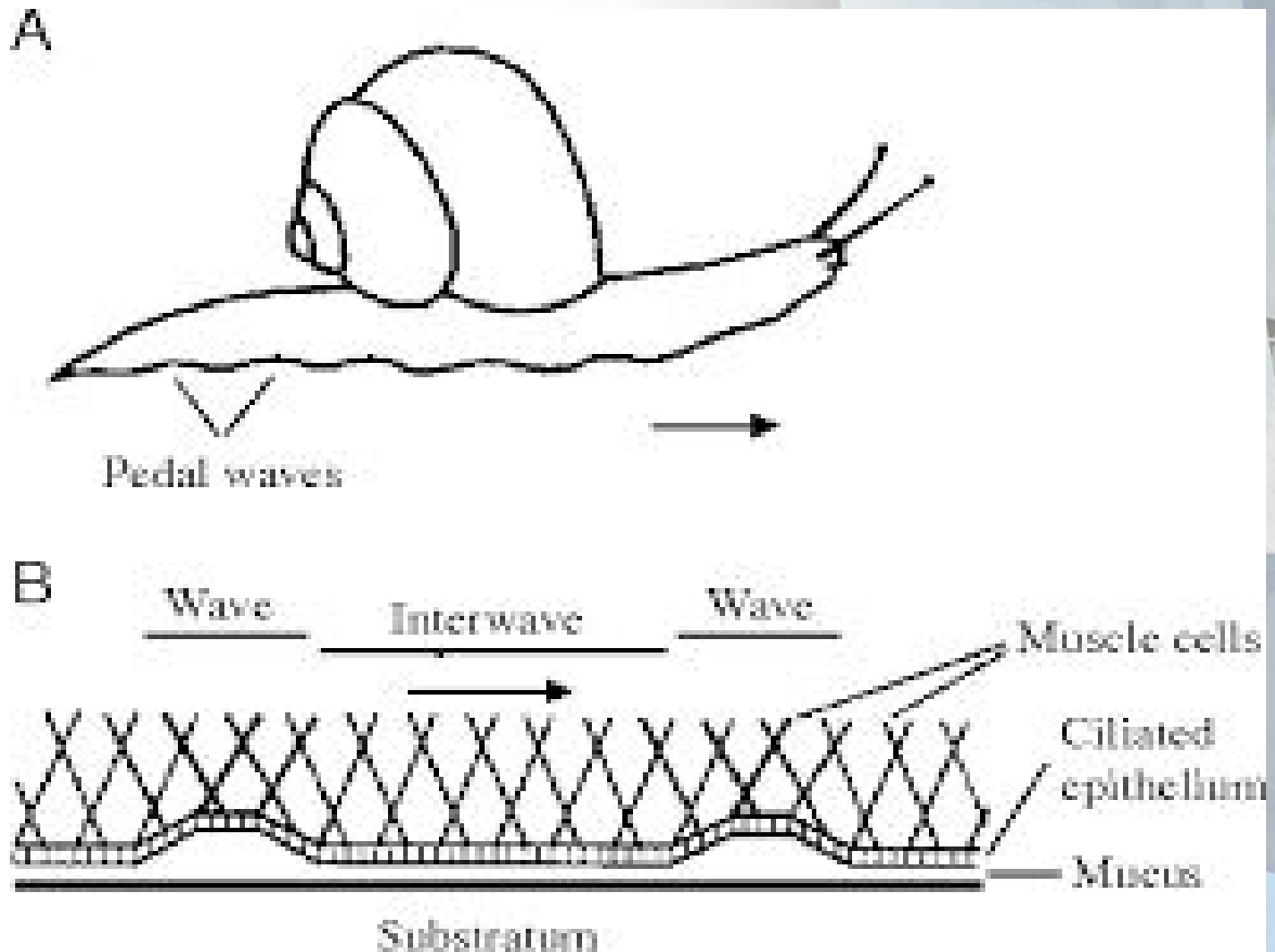
**Locomotion of Soft
Bodied
Invertebrates**

Muscular System of Invertebrates I

Pedal Locomotion:

- It is the movement by means of waves of activity in muscular system
- It is a type of locomotion that occurs in flatworms, some cnidarians and certain gastropods.

Muscular System of Invertebrates I

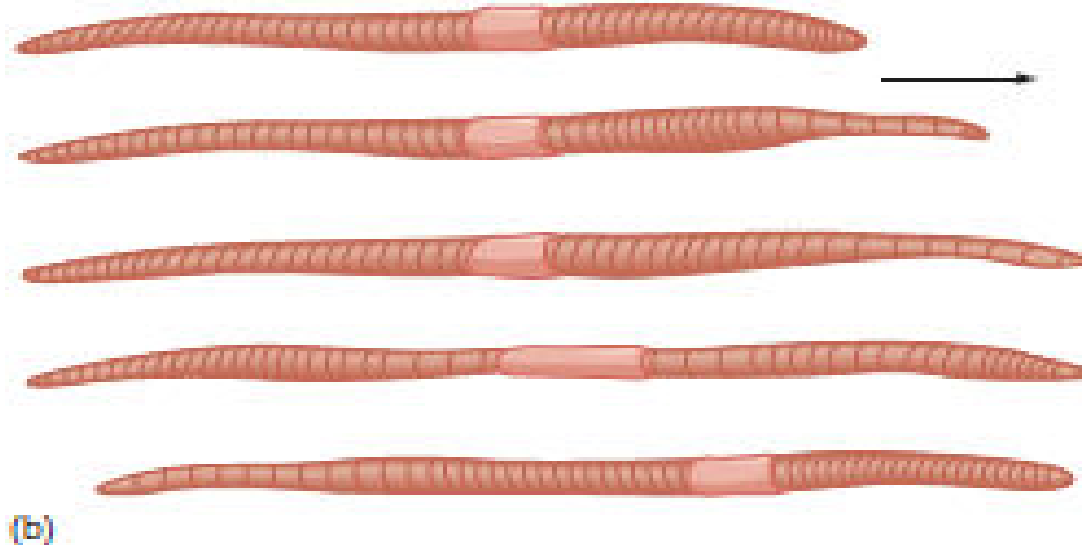
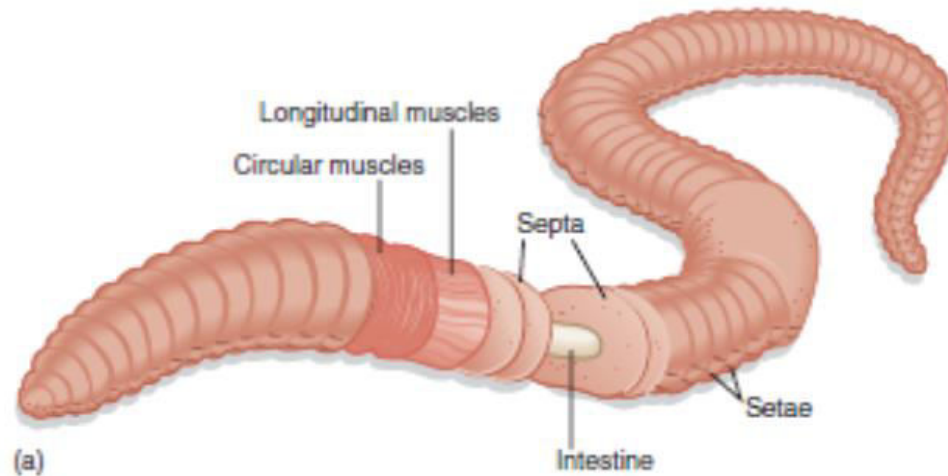


Muscular System of Invertebrates I

Accordion-Like Locomotion:

- Example is earthworm. The longitudinal and circular muscles generate accordion-like waves

Muscular System of Invertebrates I

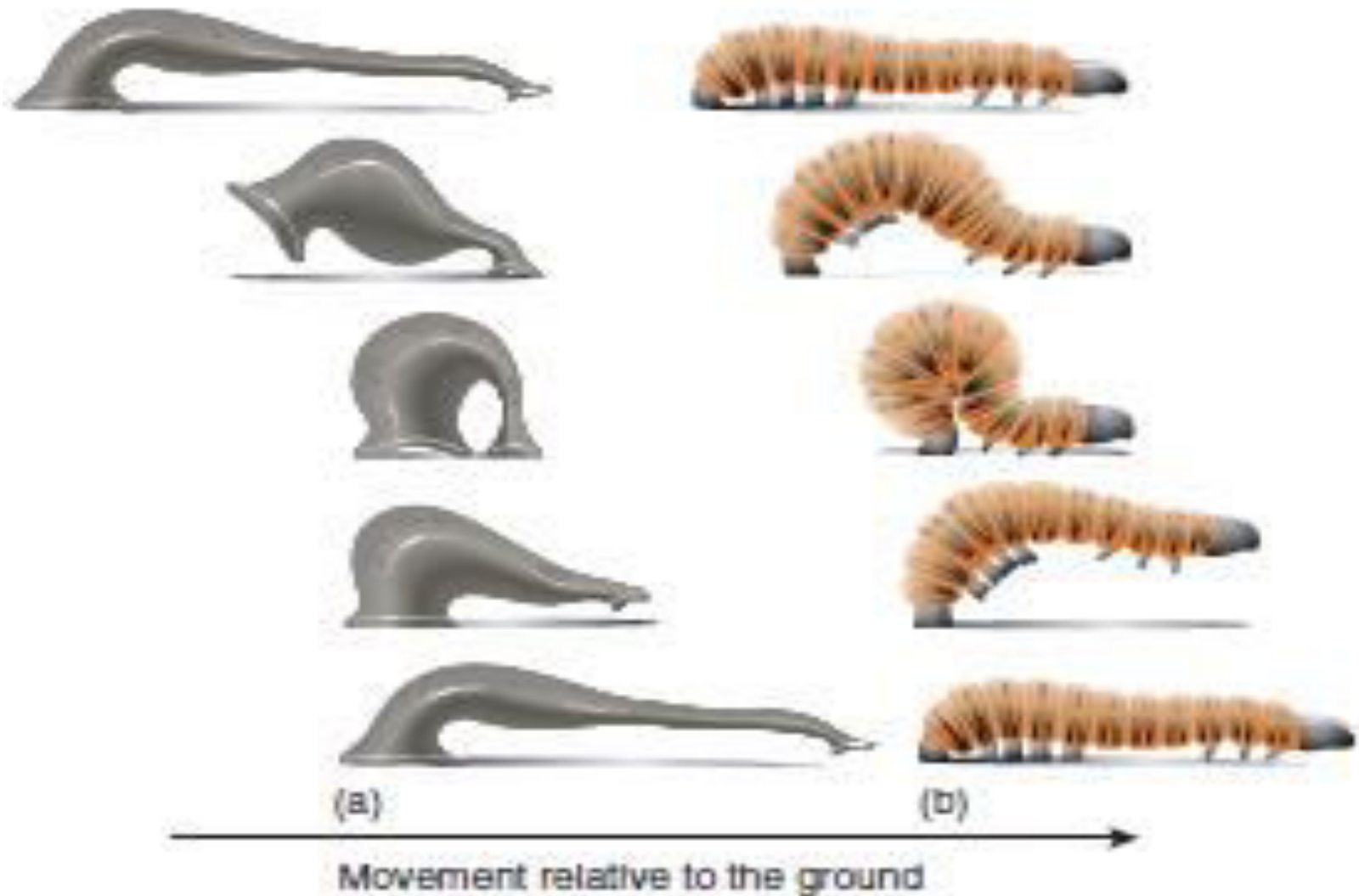


Muscular System of Invertebrates I

Looping Movements:

- Anterior and posterior suckers in leeches provide alternating points of attachments.
- Caterpillars exhibit same type of locomotion.

Muscular System of Invertebrates I

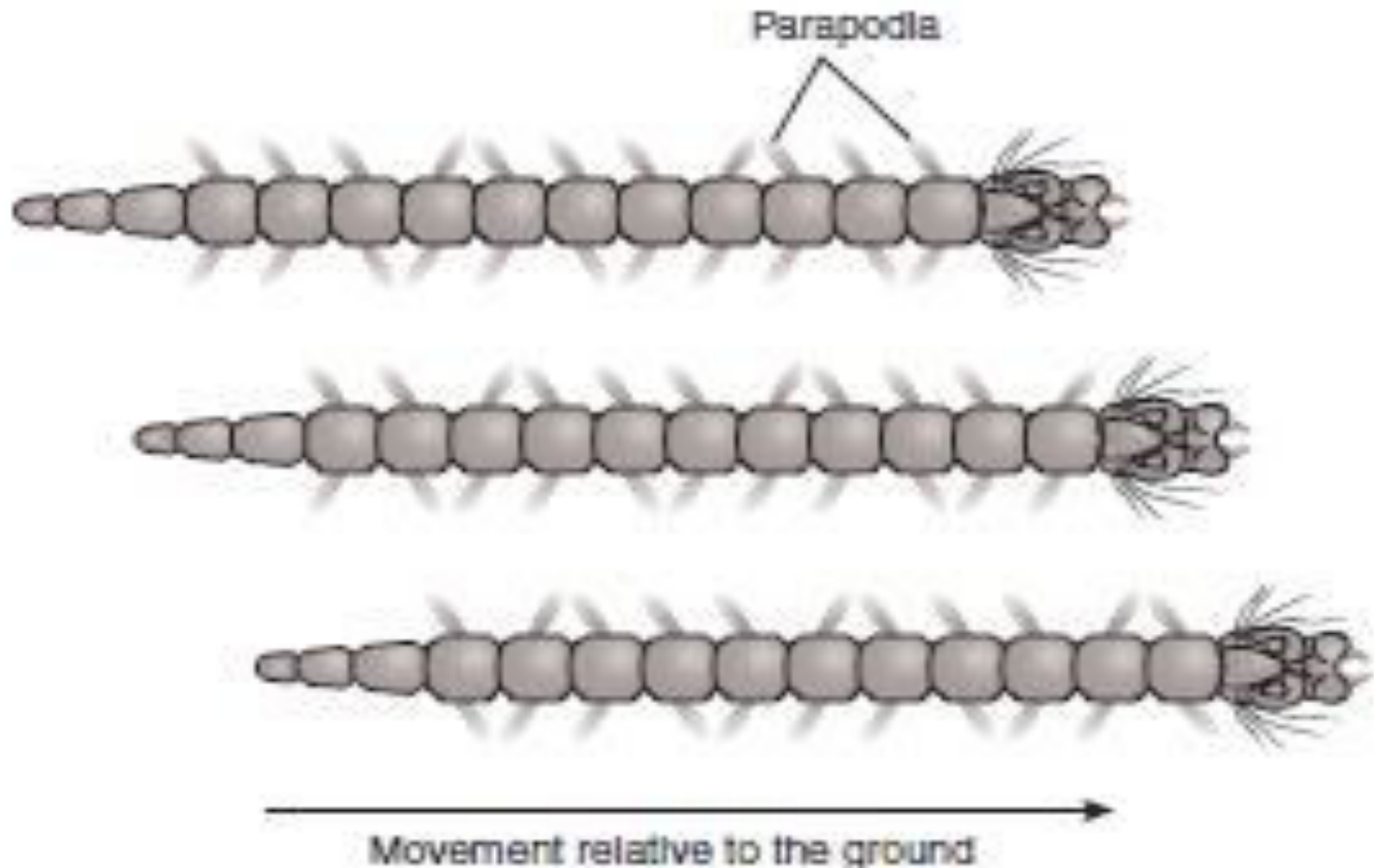


Muscular System of Invertebrates I

Movement by Parapodia:

- *Nereis* move by means of multiple limbs called parapodia.
- They move backward relative to the body.
- Since the tips are temporarily attached to ground, the worm move forward.

Muscular System of Invertebrates I

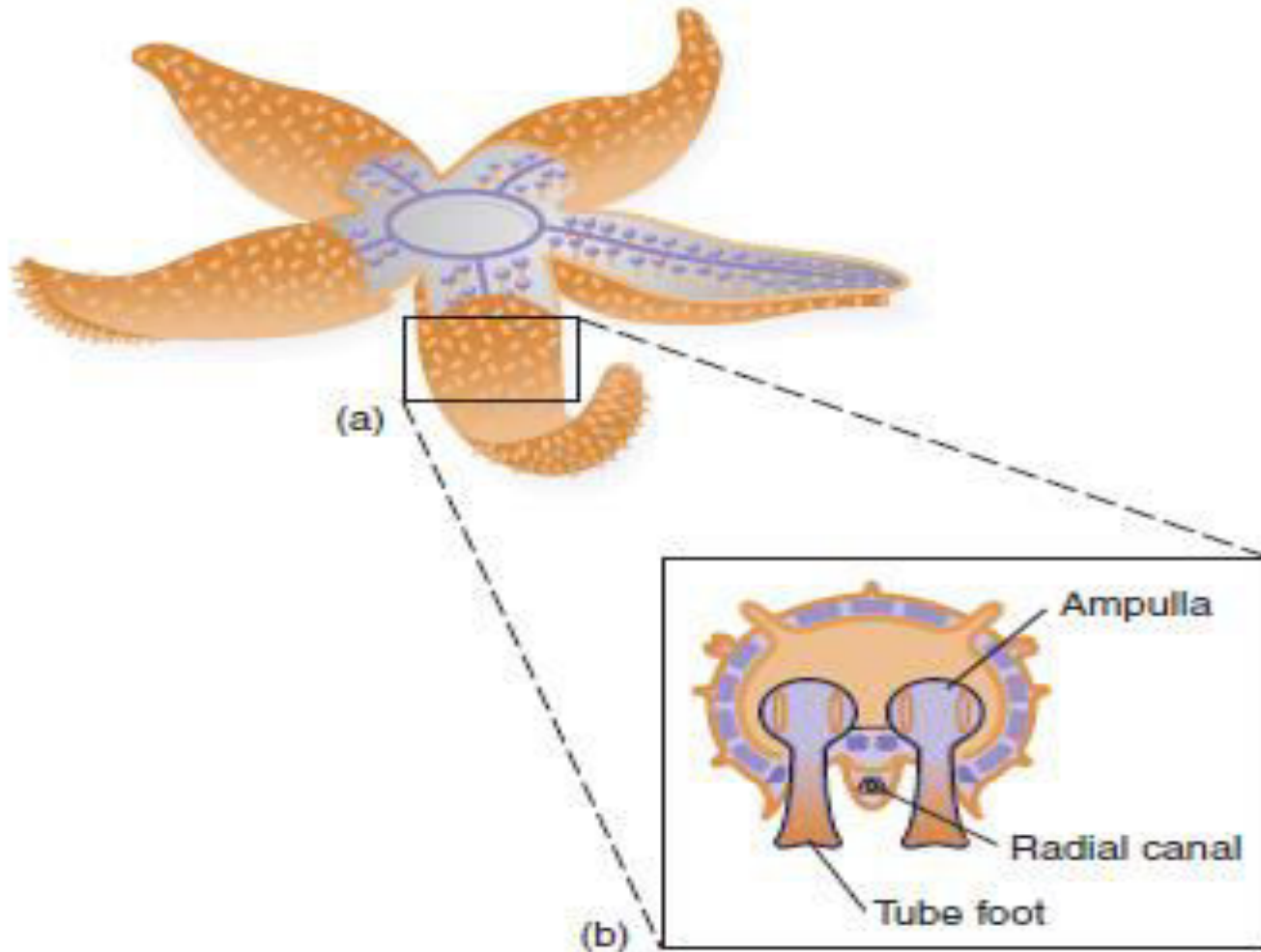


Muscular System of Invertebrates I

Movement by Tube Feet

- Water vascular system in echinoderms is a unique means for locomotion.
- Along each canal there are reservoir ampullae and tube feet.
- Water is driven into the tube feet after passing through the ampullae.

Muscular System of Invertebrates I



Module 23



Animal Form and Function 1

Muscular System of Invertebrates

Terrestrial Locomotion in Invertebrates

Terrestrial Locomotion in Invertebrates

Three types of Locomotion
in terrestrial invertebrates:

1. Walking
2. Jumping
3. Flight

Terrestrial Locomotion in Invertebrates

Walking: The elements required for walking are:

- Flexible joints
- Tendons and
- Muscles that attach to the exoskeleton.

Walking limbs of highly evolved arthropods are uniform in structure.

Terrestrial Locomotion in Invertebrates

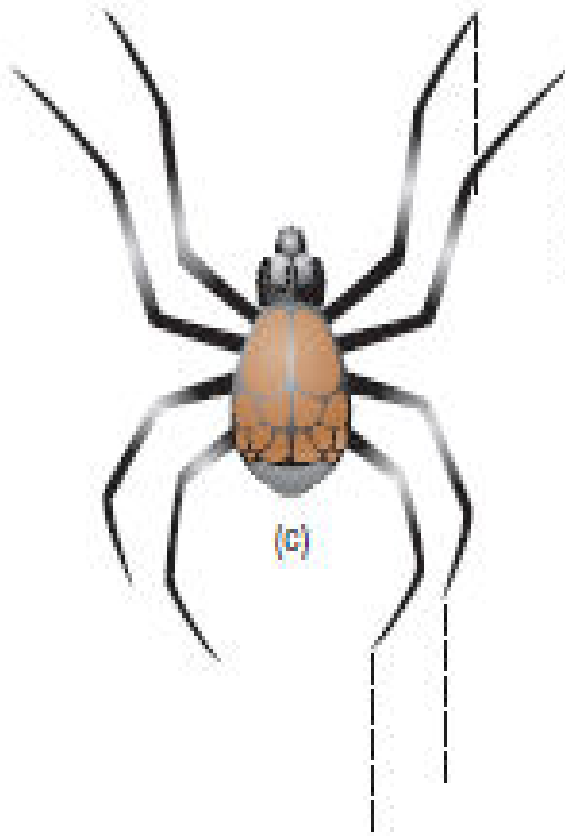
Limbs:

- These are composed of series of jointed elements that become less massive toward the tip.
- Each joint is articulated to allow movement in only one plane i.e. flexion and extension.

Terrestrial Locomotion in Invertebrates

- The limb plane at the basal joint with the body can also rotate, this rotation is responsible for forward movement.

Terrestrial Locomotion in Invertebrates

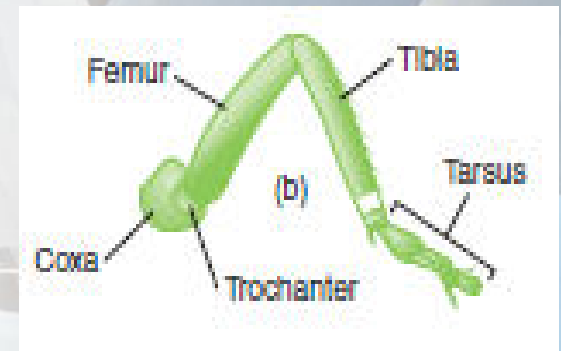


Walking in arthropods

Terrestrial Locomotion in Invertebrates

Jumping:

- To jump, the insect exerts a force against the ground to take off with a velocity greater than weight.
- Jumping insects have relatively long legs having femur, tibia and tarsus.



Terrestrial Locomotion in Invertebrates

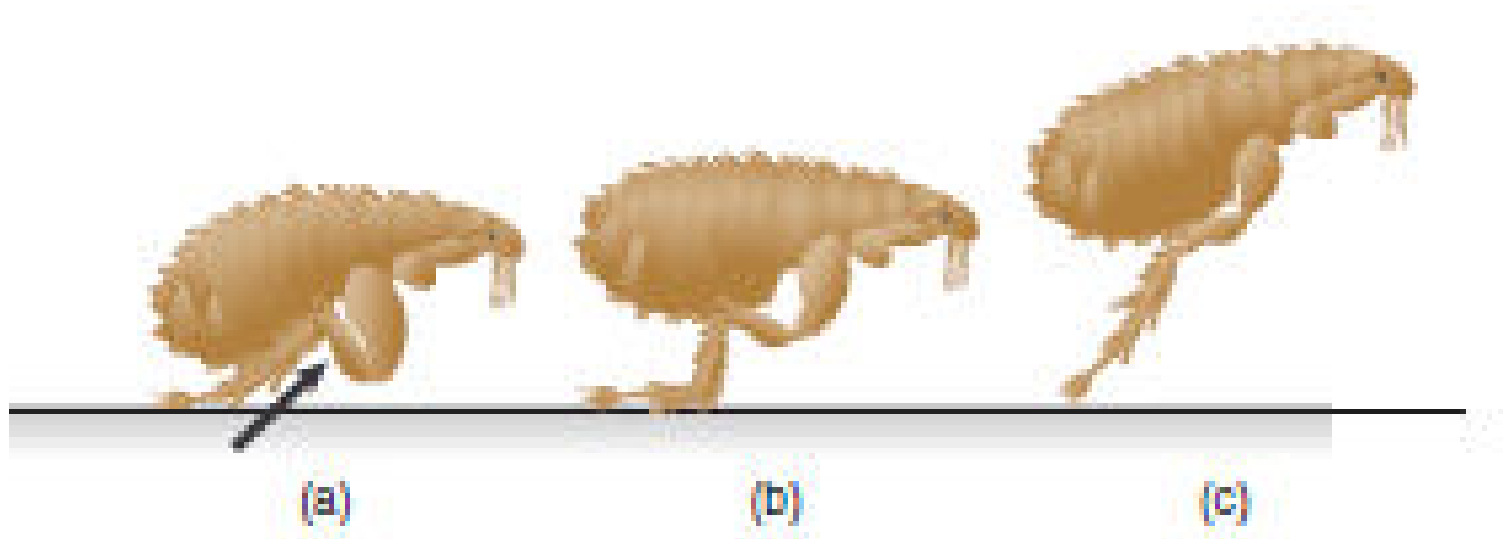
- When a flea is resting, the femur of the leg is raised, joints are locked and energy is stored in the protein, resilin.
- As it begins to jump joints are unlocked.
- The force exerted against the ground by the tibia gives the flea a jump.

Terrestrial Locomotion in Invertebrates

- The jump is the result of explosive release of the energy stored in the resilin.
- The legs with cuticle act as levers in this system.

For example: Flea,
Grasshopper etc.

Terrestrial Locomotion in Invertebrates



Jumping in Flea

Terrestrial Locomotion in Invertebrates

Flight:

- Among insects there are two mechanisms of flight:
 - i) Synchronous
 - ii) Asynchronous

Terrestrial Locomotion in Invertebrates

- In synchronous flight the muscles at the base of the wings cause the upward and downward thrust by their contraction and relaxation.
- This depends upon the nerve impulse.

Terrestrial Locomotion in Invertebrates

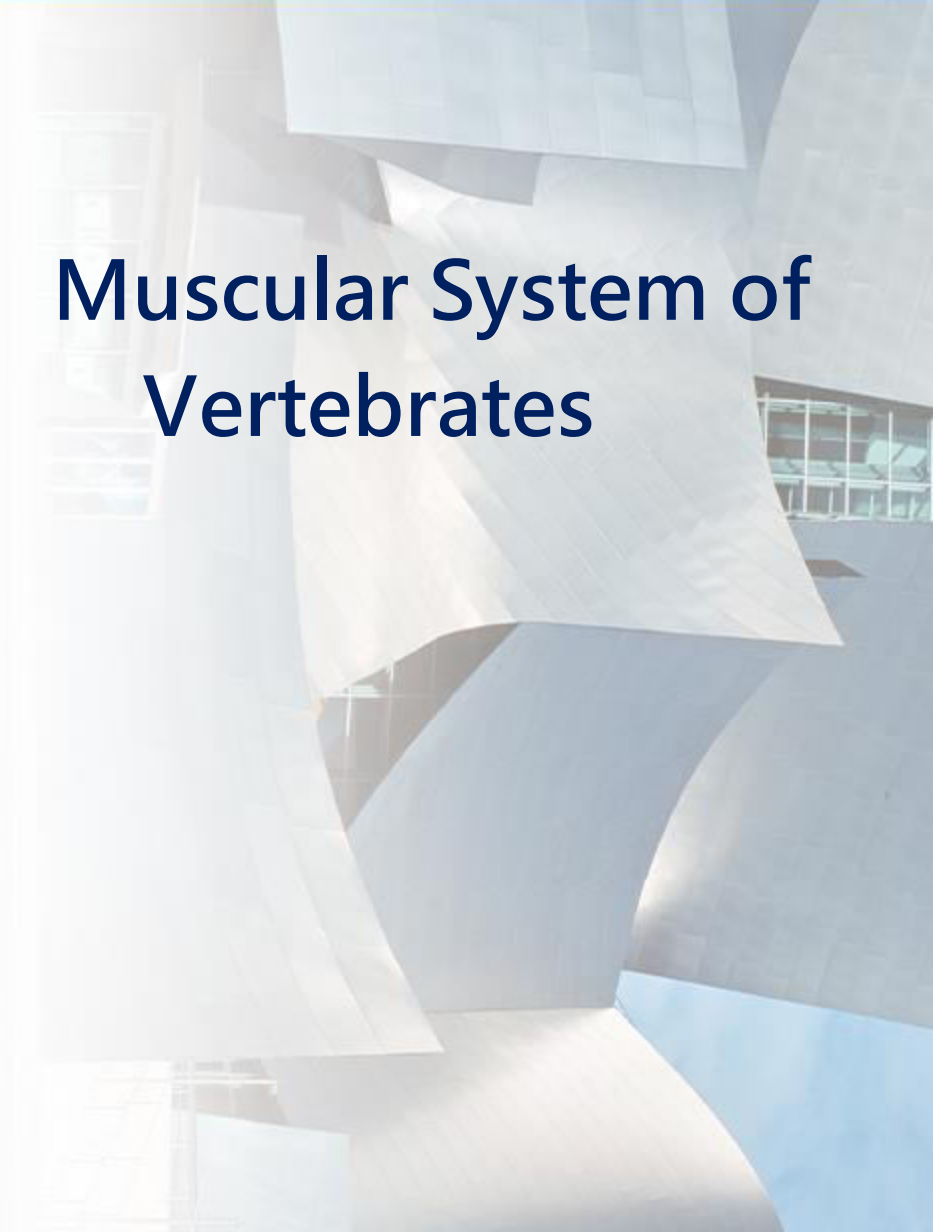
- In asynchronous flight muscles act to change the shape of the exoskeleton (thorax) for both upward and downward wing strokes.
- 1000 cycles per sec.
Examples :
Flies, wasps

Module 24



Animal Form and Function 1

Muscular System of Vertebrates



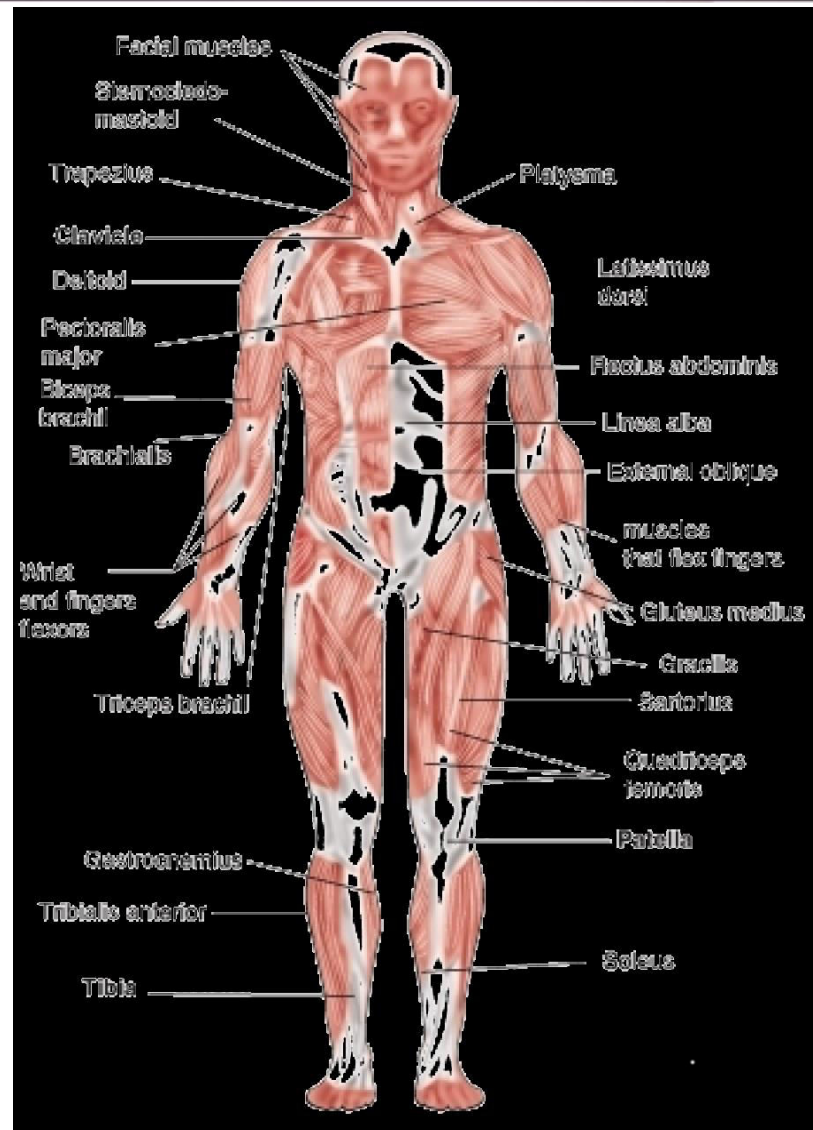
Muscular System of Vertebrates

In vertebrates,
Locomotion occurs by the
combined association of:

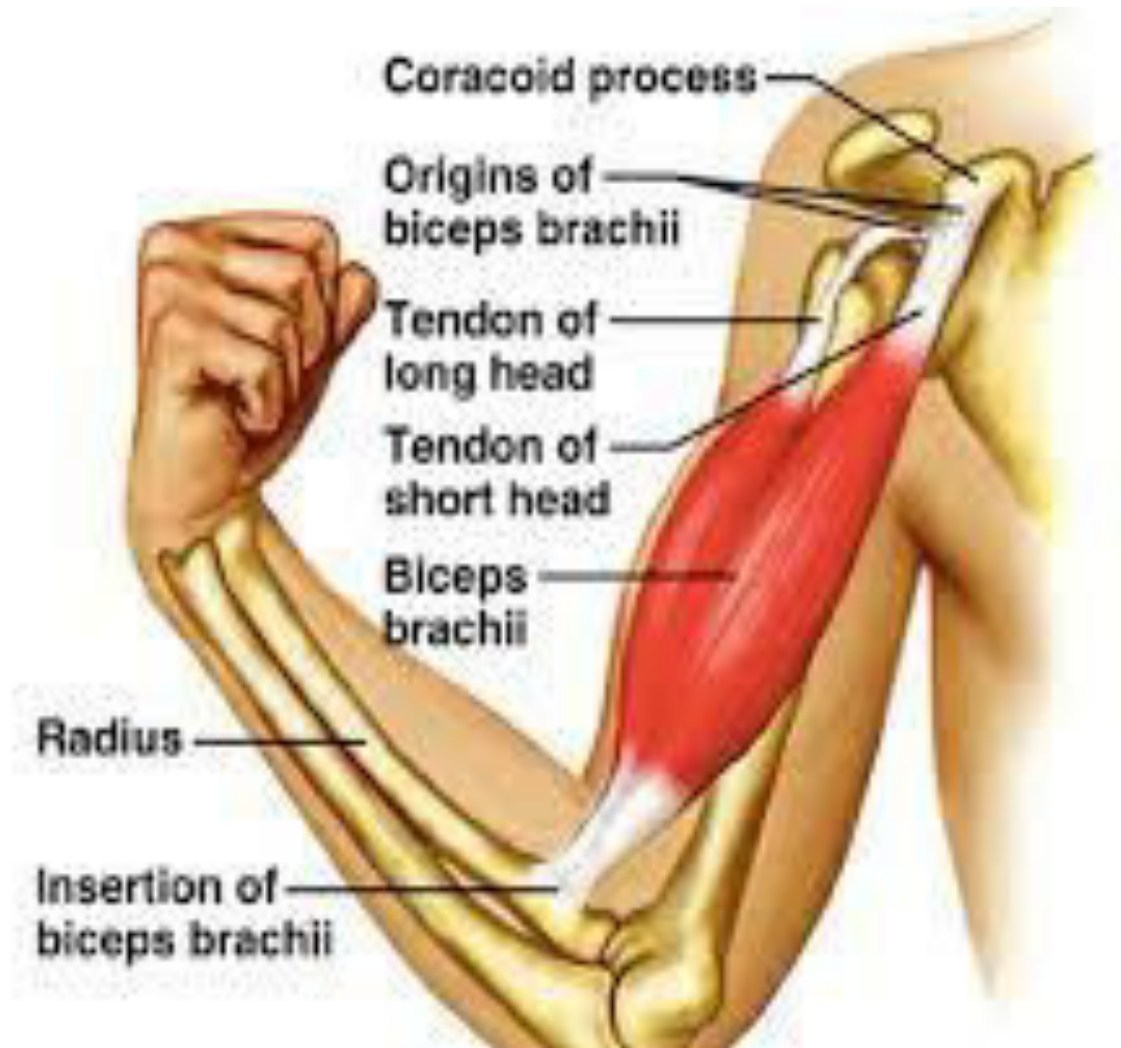
Endoskeleton,
Skeletal muscles,
Tendons

Tendons are tough
fibrous bands that attach
muscles to the skeleton.

Muscular System of Vertebrates



Muscular System of Vertebrates



Muscular System of Fish

Module 25



Animal Form and Function 1

Fish Musculature



Fish Musculature

- In fish the musculature consists of segmental myomeres.
- The myomeres are arranged along the vertebral column in 3D 'W' shaped blocks separated by collagenous sheaths also myosepta.

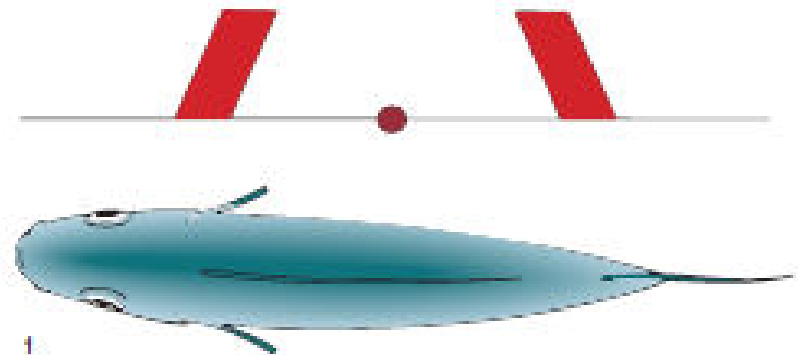
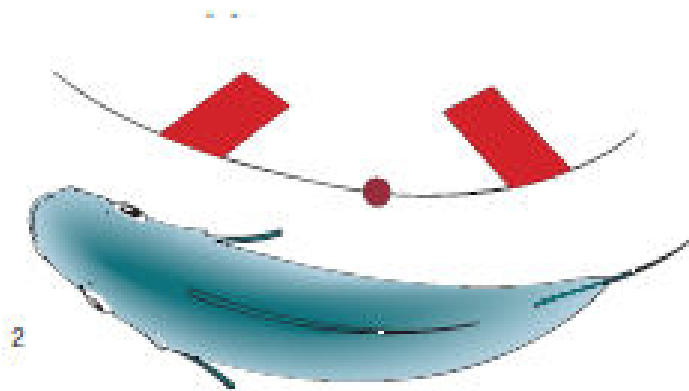
Fish Musculature

- Embedded in the myosepta are distinct tendons.
- With in teleosts these tendons often ossify.
- These ossified myoseptal tendons are homologous to inter muscular bones.
- These intermuscular bones are of various shapes, some are Y shapes, some are brush like etc.

Fish Musculature

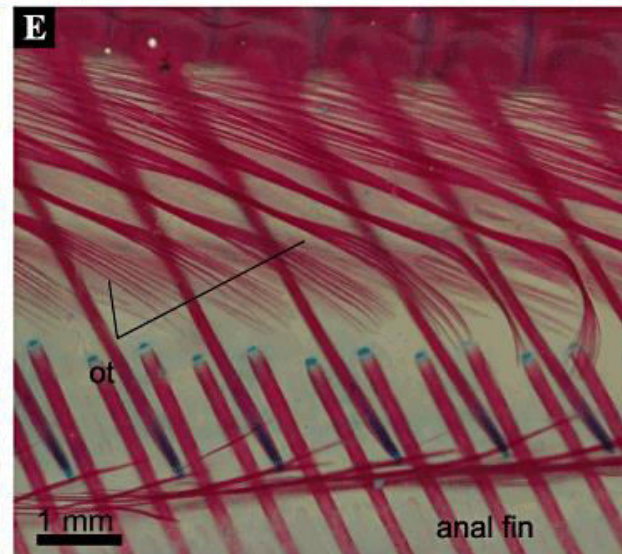
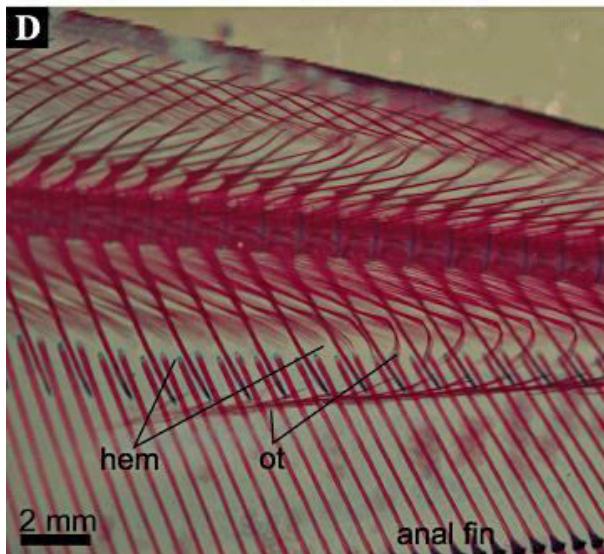
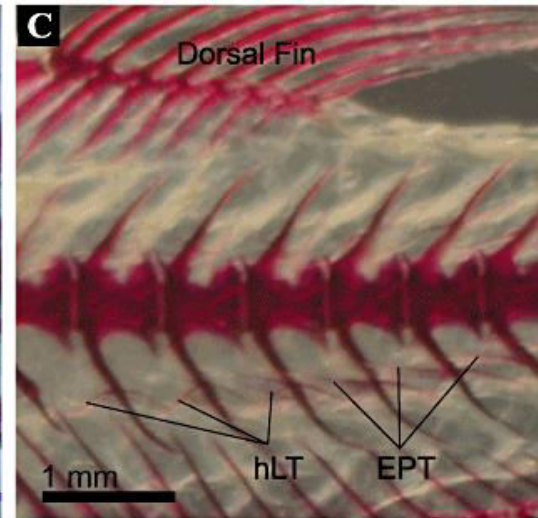
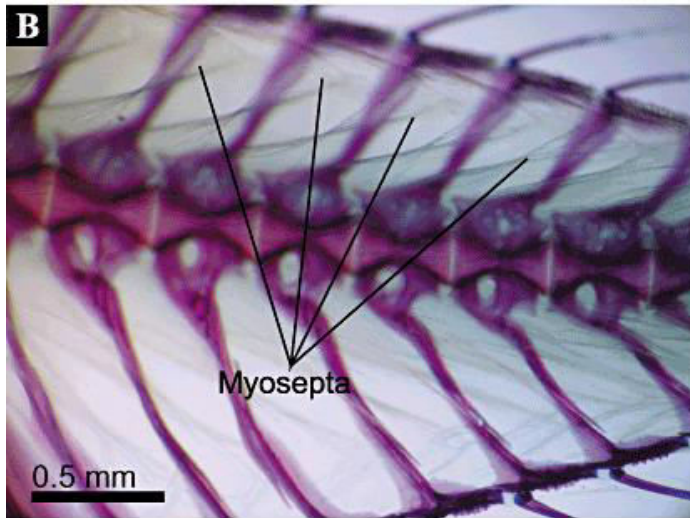
- Fish movements are based on myomere contraction.
- These myomeres cause the lateral undulations of the trunk and the tail.
- These undulations bring about fish locomotion.

Fish Musculature



Fish Musculature

Fish Musculature



Module 26



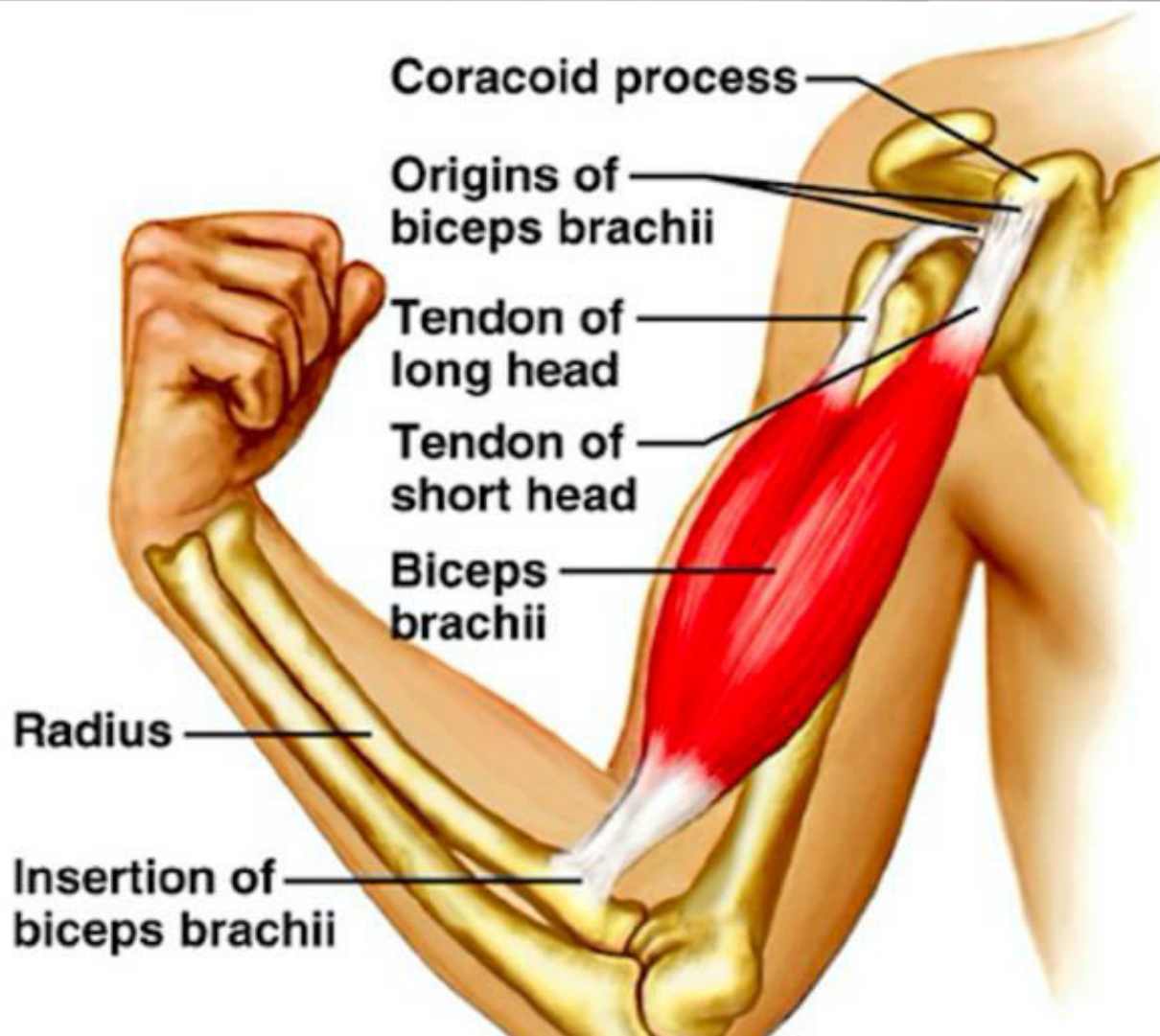
Animal Form and Function 1

Structure of Skeletal Muscle I

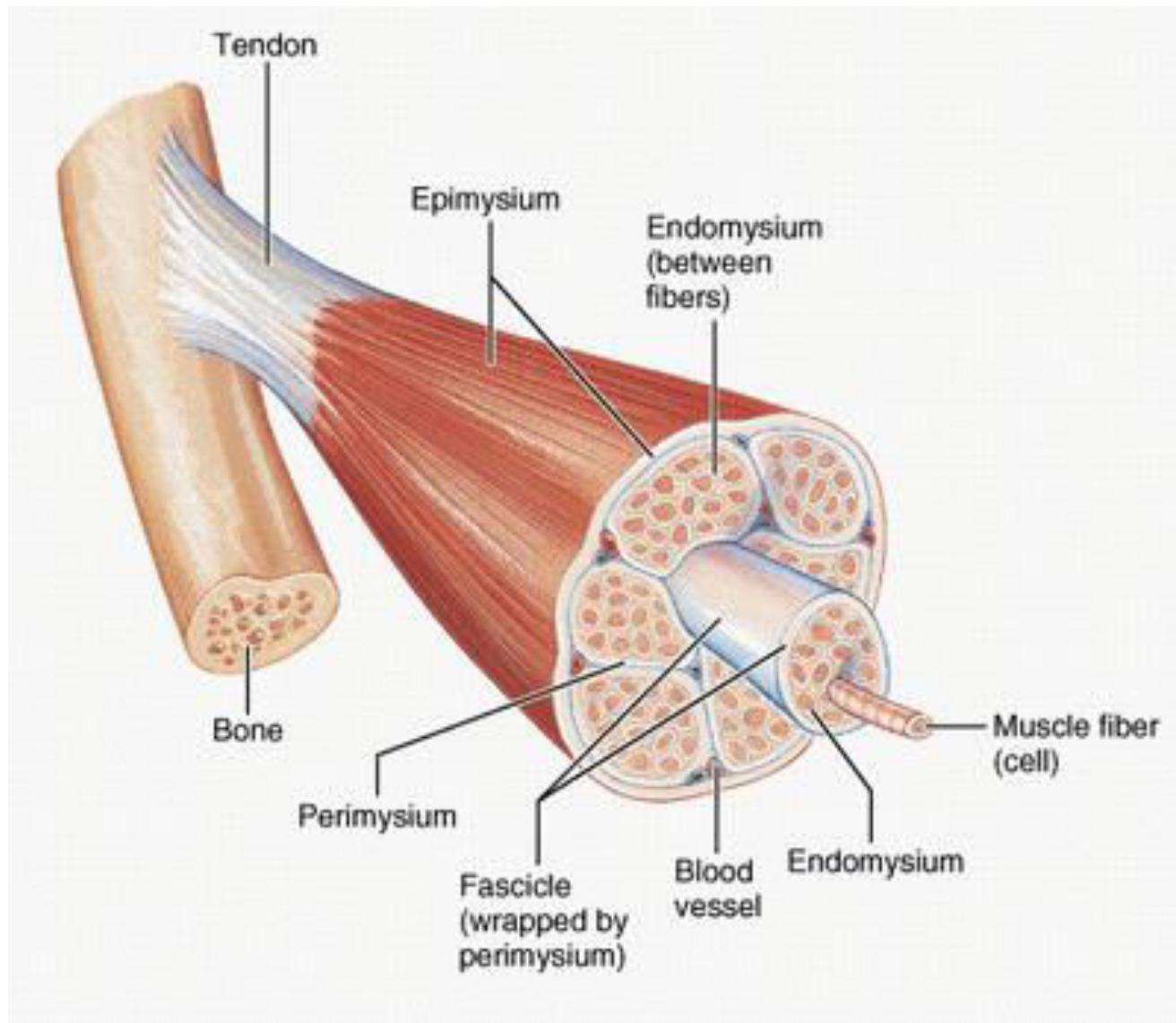
Structure of Skeletal Muscle I

- Skeletal muscle consists of a bundle of long fibers running the length of muscle.
- Each muscle fiber is a single cell with many nuclei below the cell membrane, the **sarcolemma**.

Structure of Skeletal Muscle I



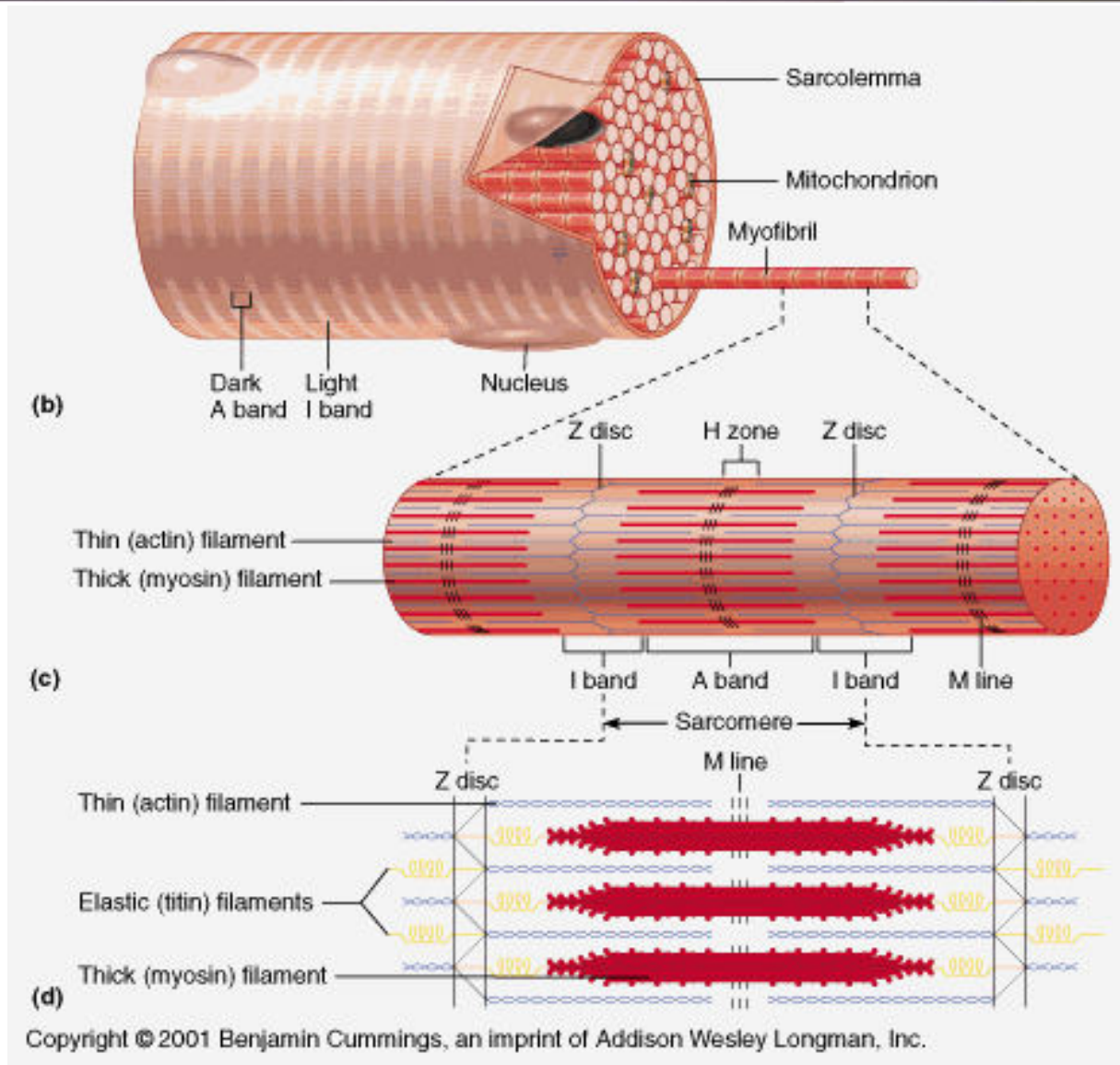
Structure of Skeletal Muscle I



Structure of Skeletal Muscle I

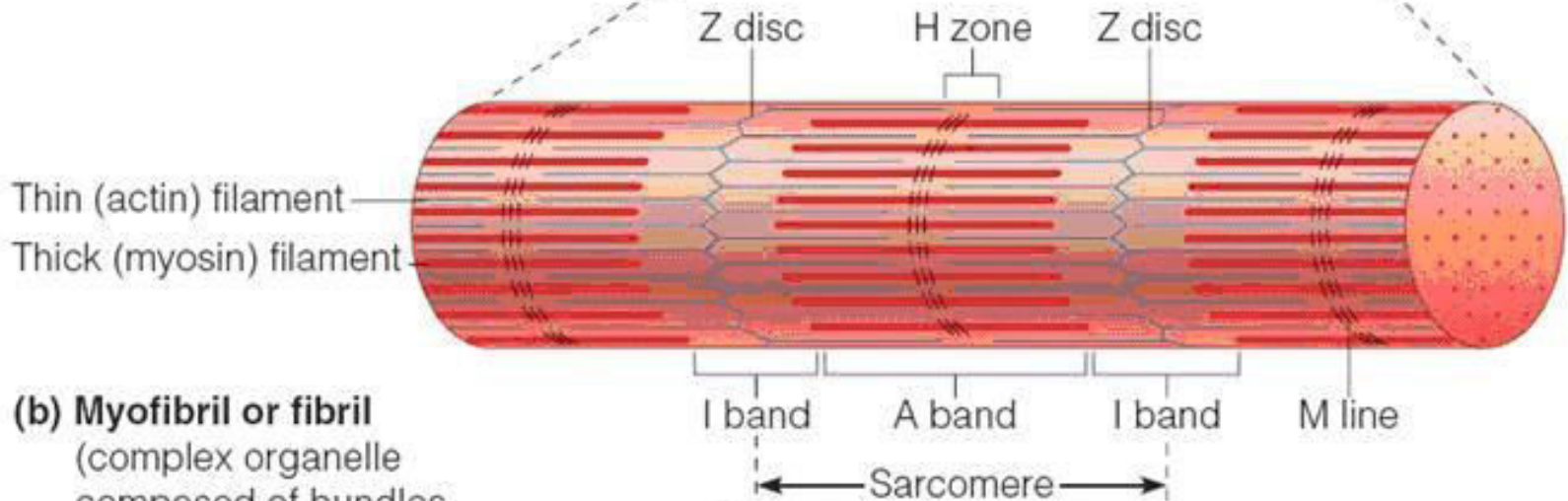
- This reflects its formation by the fusion of many embryonic cells.
- Each muscle fiber is surrounded by connective tissue called **Endomycium**.
- **Perimycium** is connective tissue that wraps bundles of muscle fibers.
- **Epimycium** wraps the whole muscle.

Structure of Skeletal Muscle I

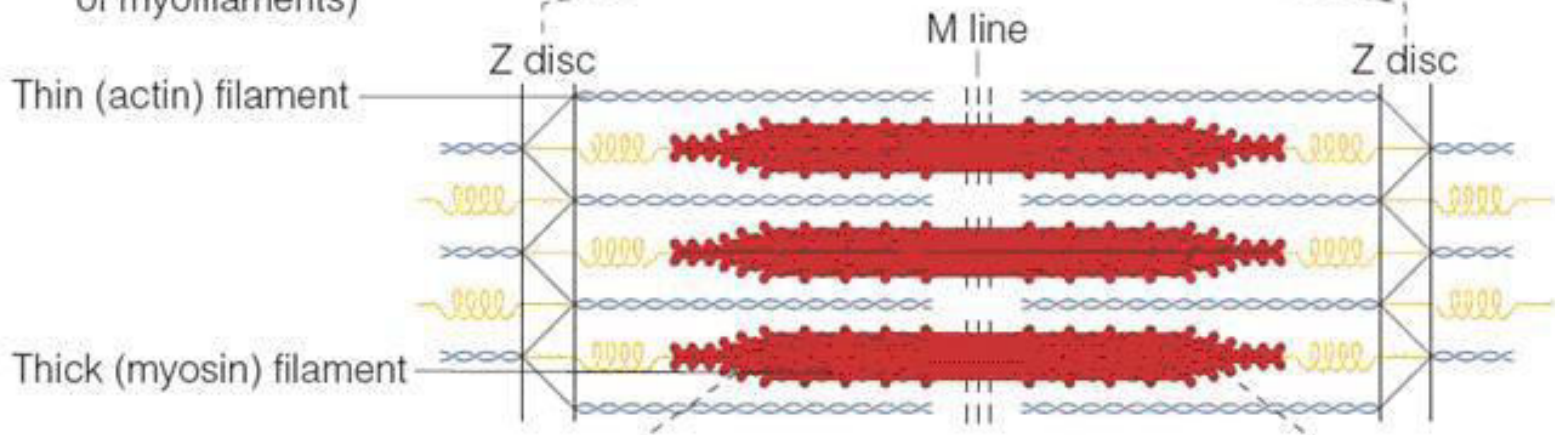


Structure of Skeletal Muscle I

(a) Segment of a muscle fiber (cell)

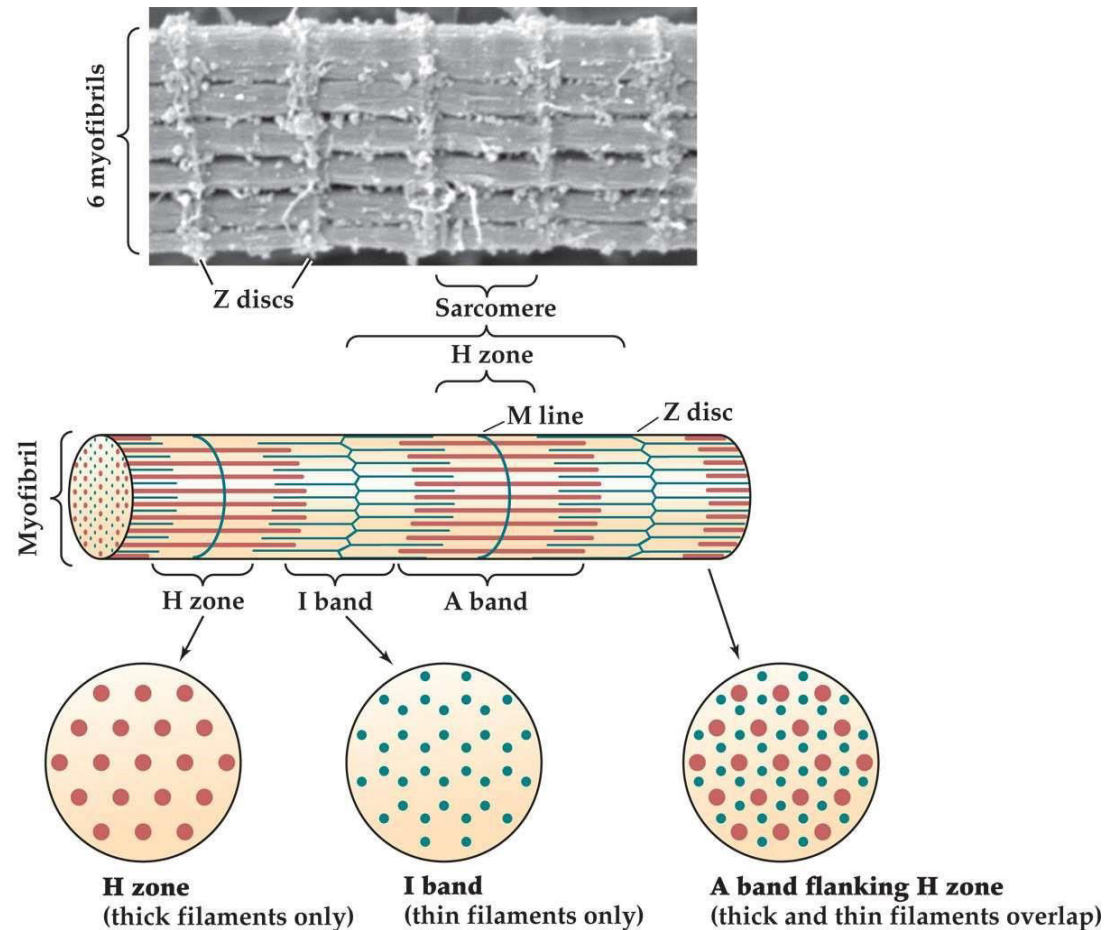


(b) Myofibril or fibril
(complex organelle composed of bundles of myofilaments)



Structure of Skeletal Muscle I

Myofibril organization



ANIMAL PHYSIOLOGY 3E, Figure 20.2
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Structure of skeletal muscle tissue

Structure of Skeletal Muscle I

- Each muscle fiber is itself composed of smaller **myofibrils** arranged longitudinally.
- The myofibrils, in turn , are composed of myofilaments, which are
 - i) Thin and
 - ii) Thick

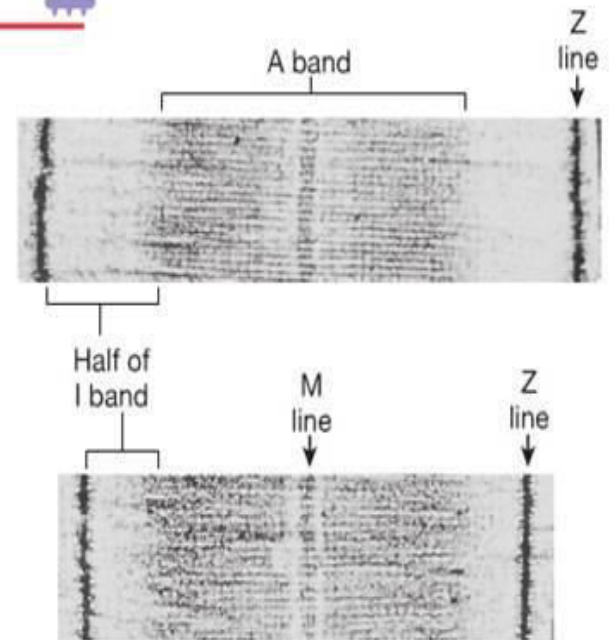
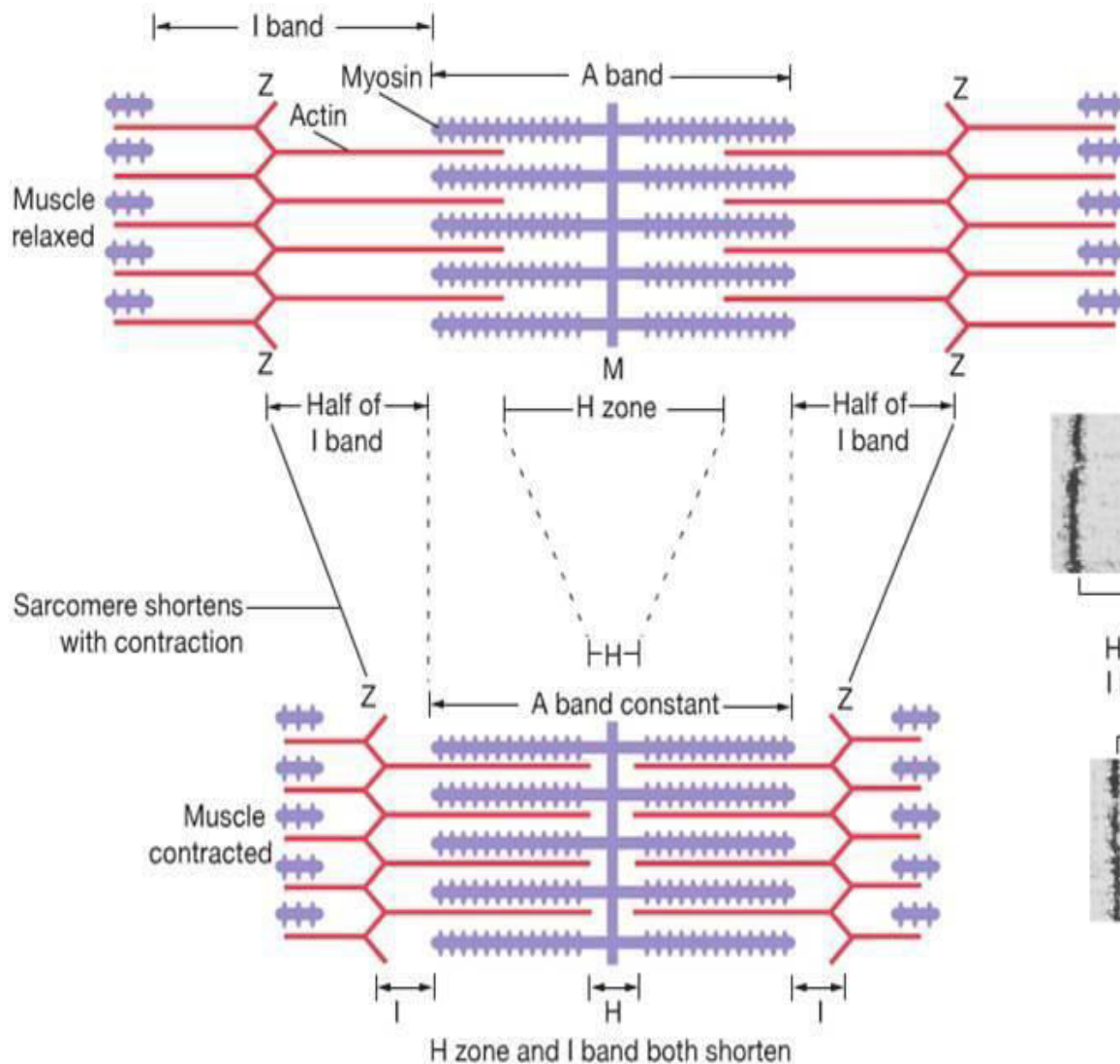
Structure of Skeletal Muscle I

- Skeletal muscle is also called **striated muscle** because of repeating pattern of light and dark bands.
- Each repeating unit is called a **sarcomere**.
- Sarcomere is a basic functional unit of the muscle.
- The borders of sarcomere is called Z-line.

Structure of Skeletal Muscle I

- The Z-lines of adjacent myofibrils contribute to the striations visible with light microscope.
- Thin filaments are attached to Z lines and project towards the center of the sarcomere. They are 7-8 nm in dia.
- Thick filaments are centered in the sarcomere and are 16nm in diameter.

Structure of Skeletal Muscle I

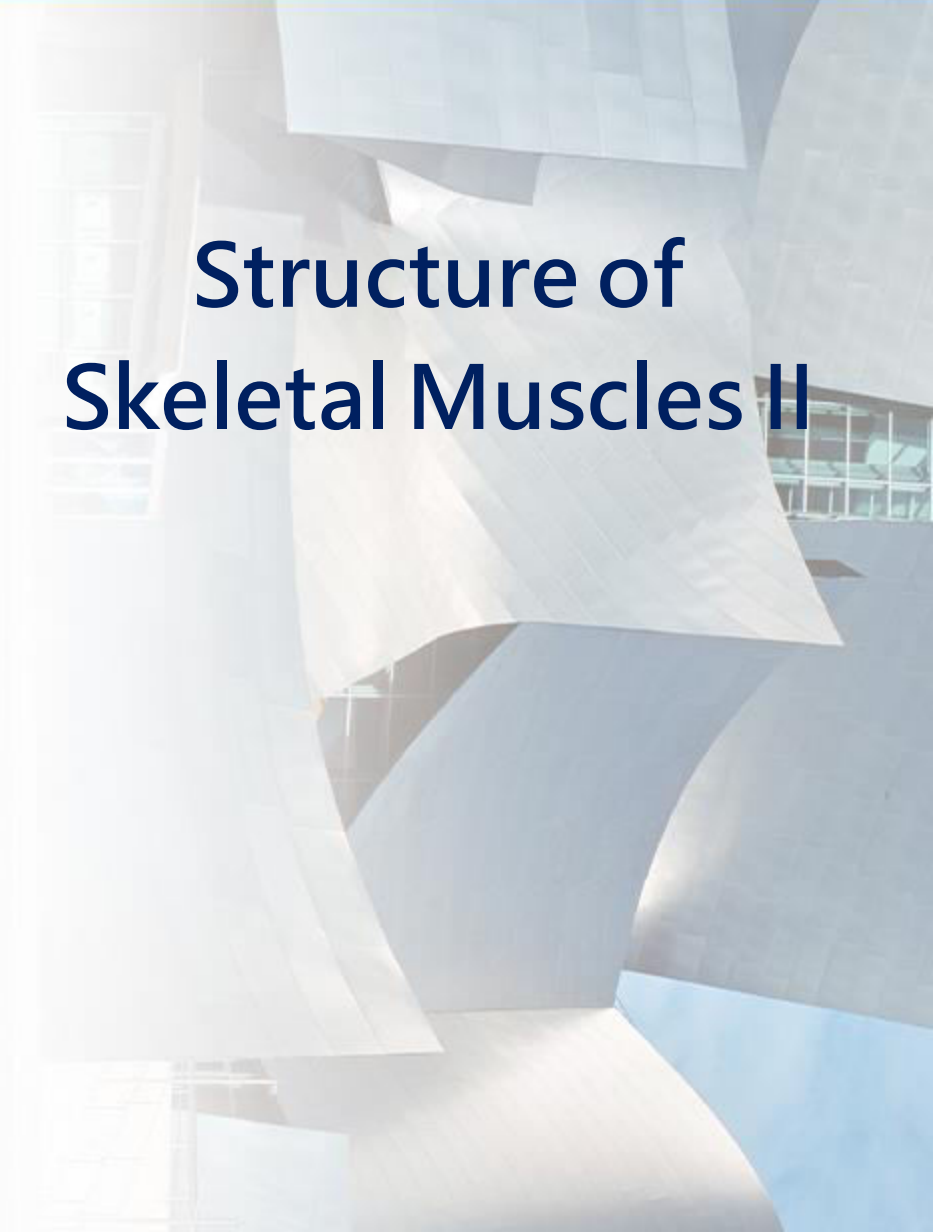


Module 27



Animal Form and Structure 1

Structure of Skeletal Muscles II



Structure Of Skeletal Muscle II

- EM reveals the placement of muscle proteins-actin and myosin within the sarcomere.
- The EM also reveals the detail of A and I bands in the myofibril.
- A-band is the broad region that corresponds to length of thick filament.

Structure Of Skeletal Muscle II

- I-band corresponds to the thin or actin filaments.
- H-Zone is in the center of A-band and contains only thick or myosin filaments.
- Arrangement of thick and thin filaments:
Each thick filament is surrounded by six thin filaments.

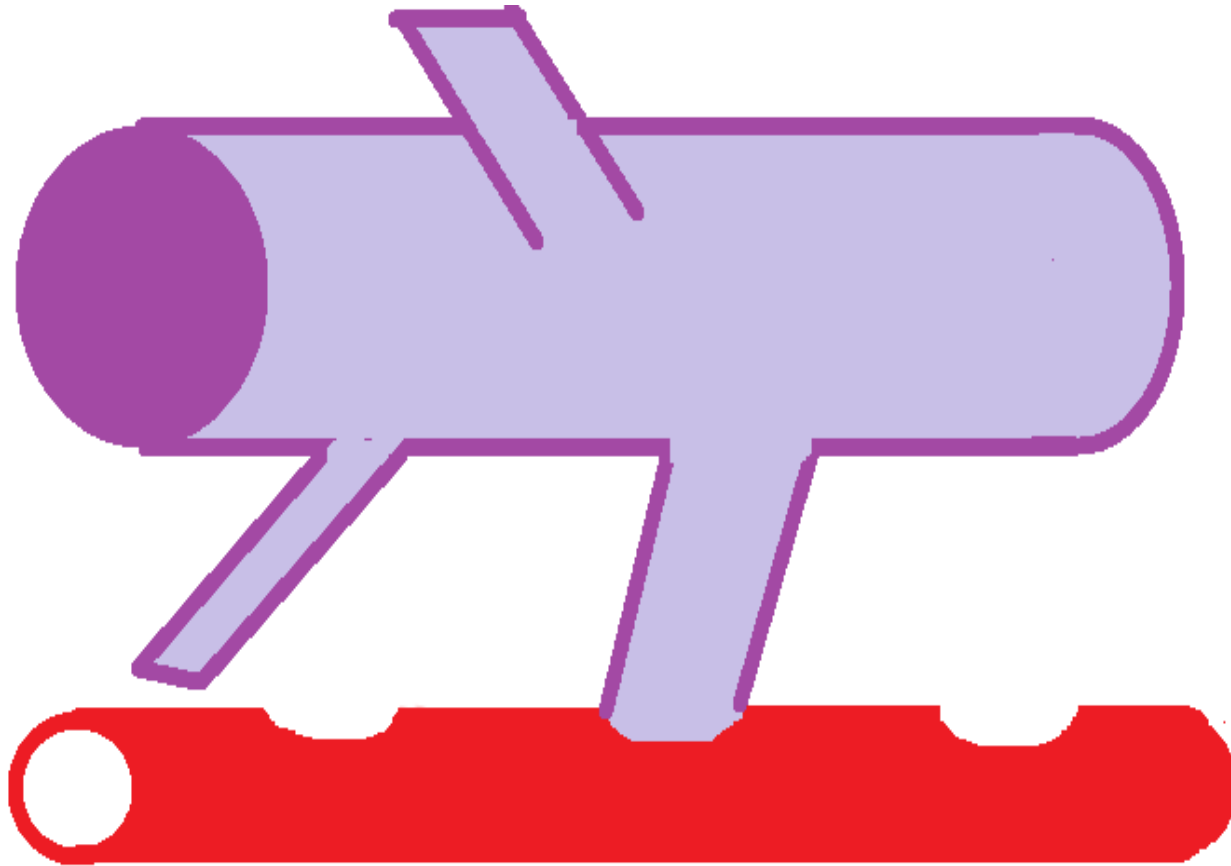
Structure Of Skeletal Muscle II

- Ultra structure of muscle proteins:
- The actin molecules are arranged in two chains, which twist around each other.
- Twisting around the actin chains are two strands of other protein, tropomyosin.
- Another protein in thin filament is the troponin.

Structure Of Skeletal Muscle II

- The thick filament which is about 16 nm in diameter is composed of myosin molecules.
- Each myosin molecule has a tail terminating in two globular heads.
- The myosin tail consists of two polypeptide chains coiled together. The heads are called **cross bridges**.

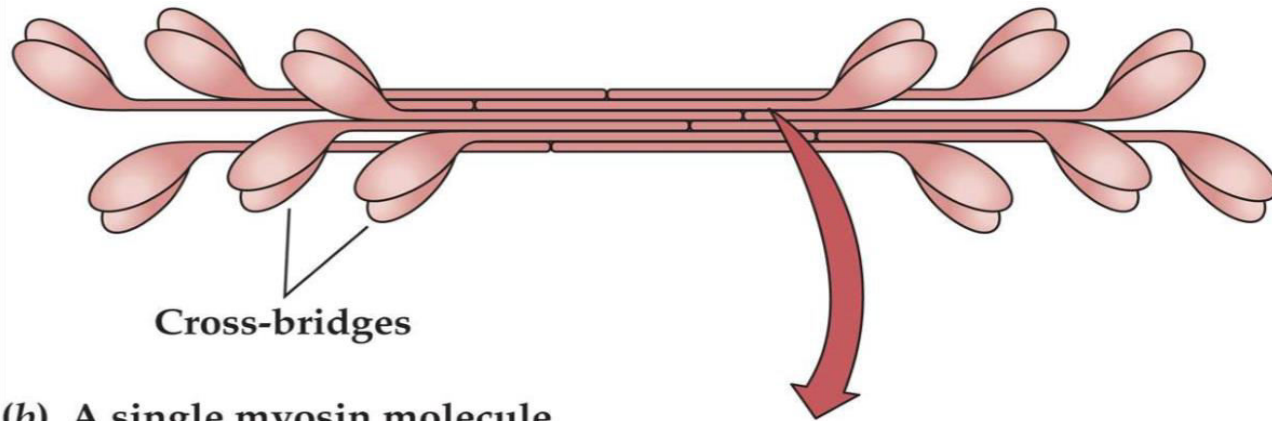
Structure Of Skeletal Muscle II



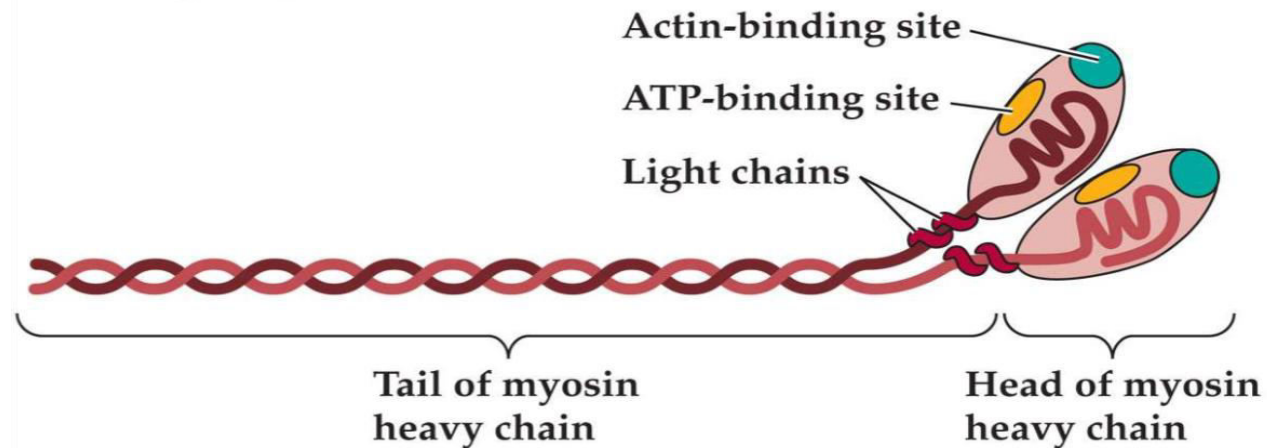
Structure Of Skeletal Muscle II

Thick filament organization

(a) Myosin molecules of a thick filament

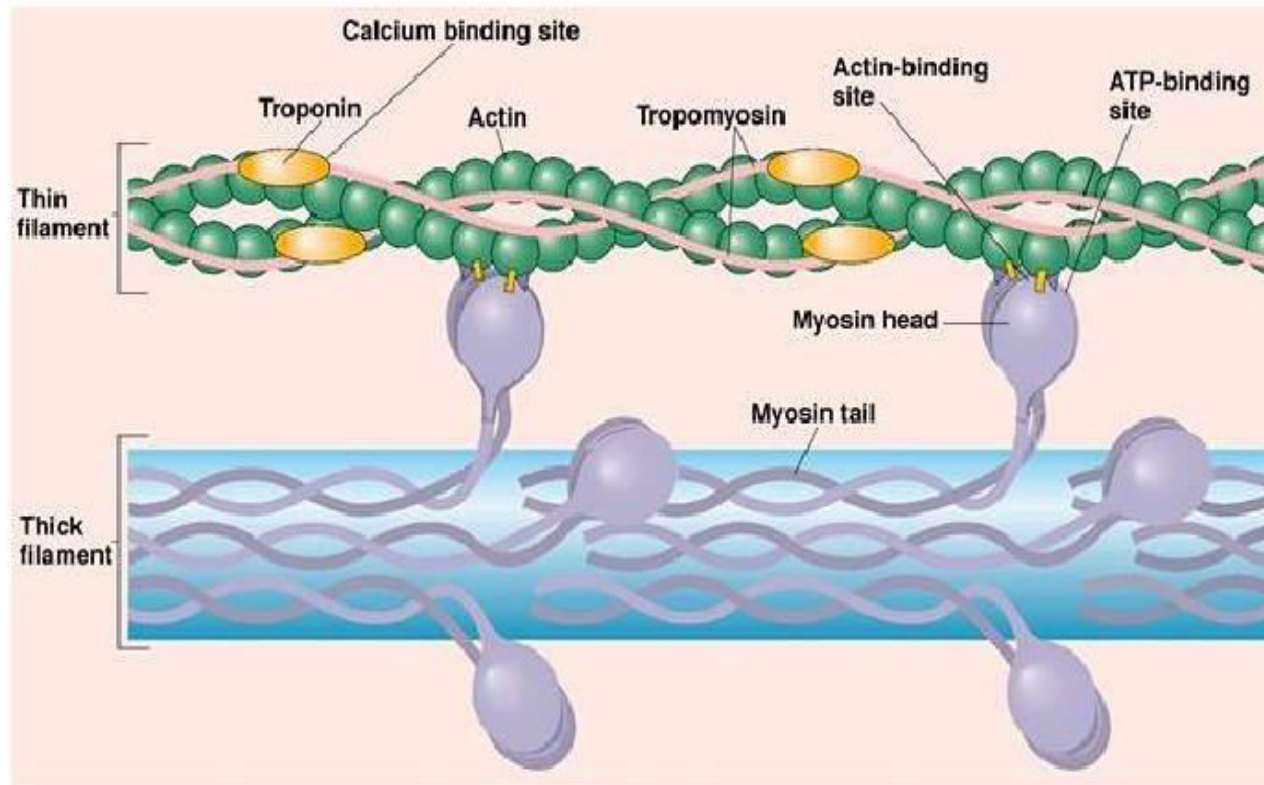


(b) A single myosin molecule

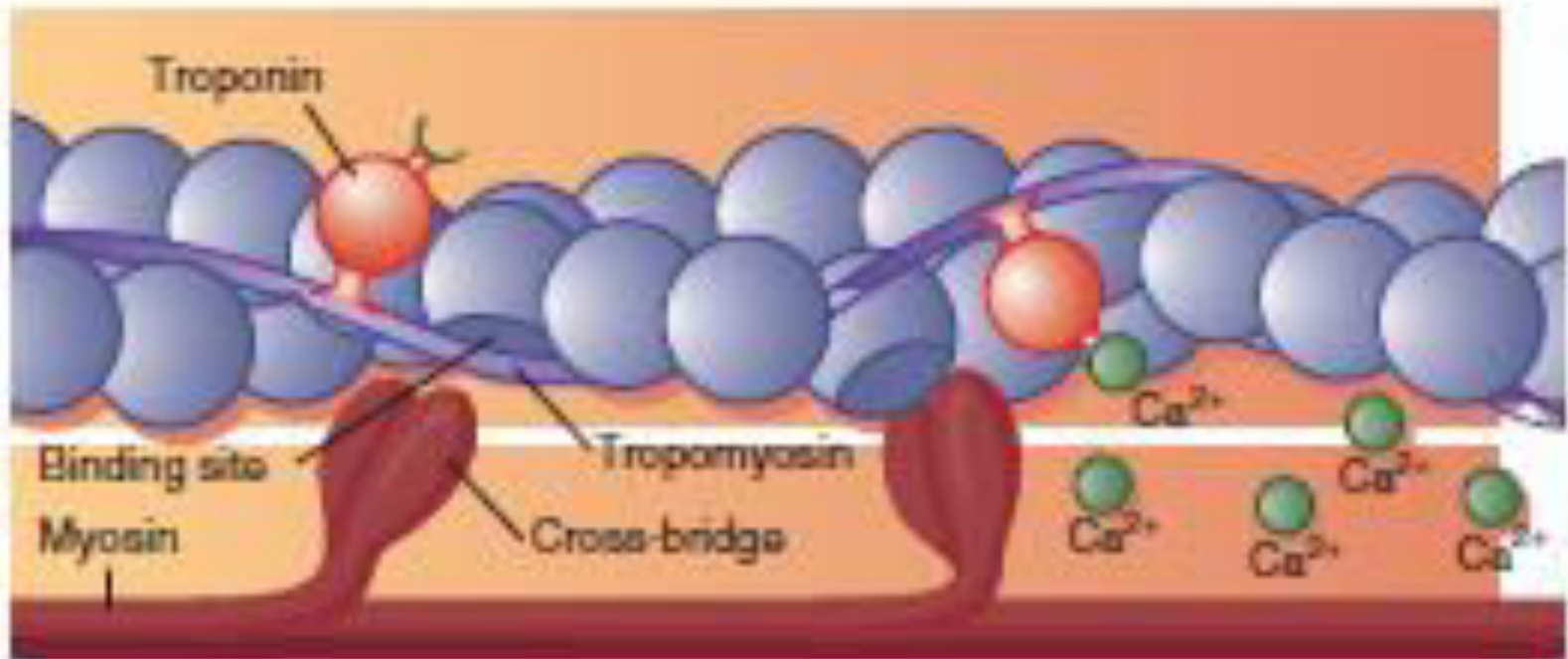


Structure Of Skeletal Muscle II

Cross-Bridge Formation in Muscle Contraction



Structure Of Skeletal Muscle II



Troponin, Tropomyosin and cross bridges

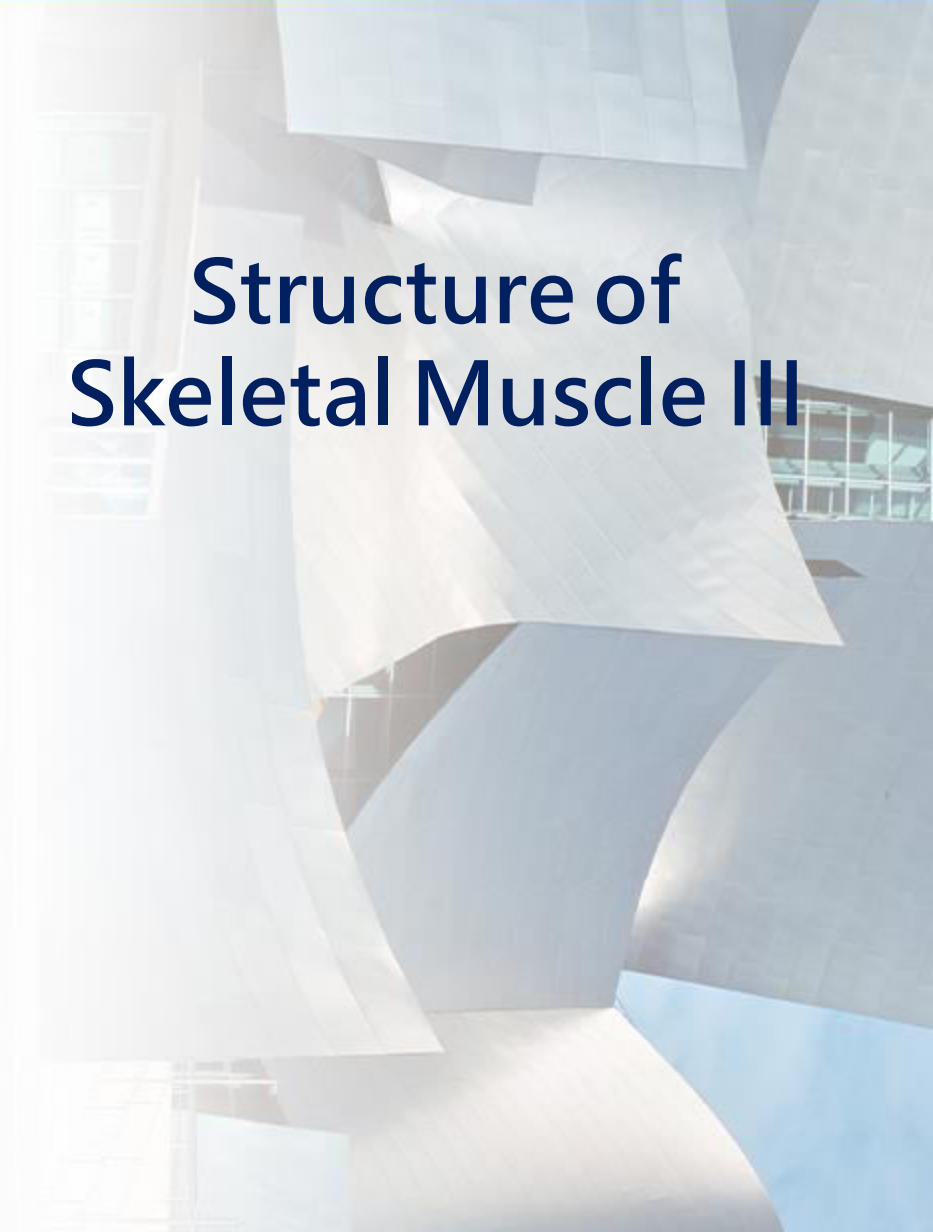
Animal Form and Structure 1

Module 28



Animal Form and Function 1

Structure of Skeletal Muscle III



Structure of Skeletal Muscle III

T –System:

- Each muscle fiber is surrounded by membrane called sarcolemma.
- Sarcoplasmic reticulum is a system like endoplasmic reticulum around each muscle fibril.
- SR lacks ribosomes.

Structure of Skeletal Muscle III

- The sarcolemma of muscle fiber cell penetrates deep into the cell to form hollow elongated tubule, the T-tubule, collectively called T-System.
- T-system extend and encircles the myofibril at level of Z-line.
- The lumen of T-tubule is continuous with extra cellular fluid.

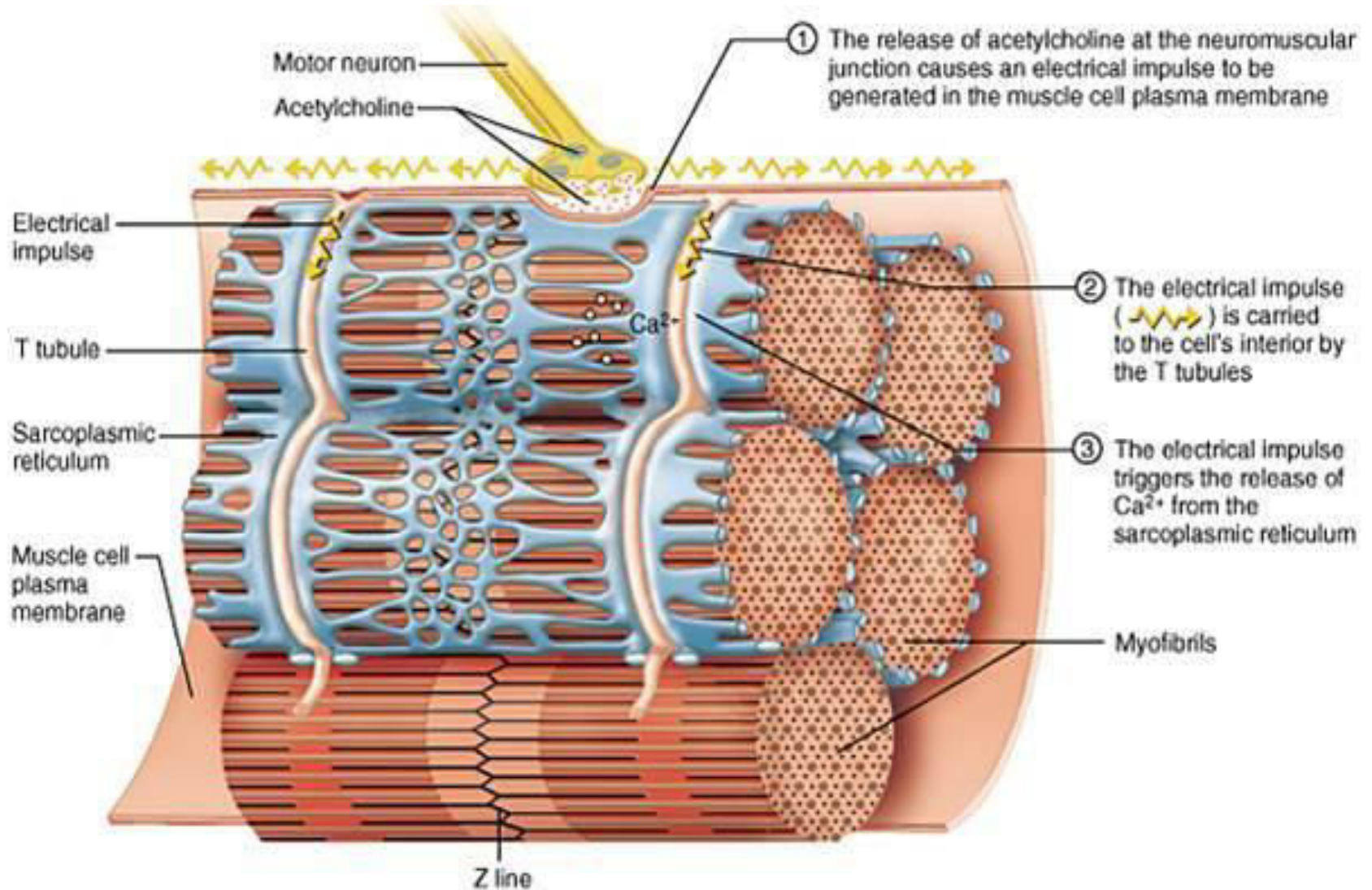
Structure of Skeletal Muscle III

- The T-tubule and the terminal portion of the adjacent envelop of SR form Triad at regular interval along the length of fibril.
- The nerve impulse is carried through the T-tubule to the adjacent SR.

Structure of Skeletal Muscle III

- Myosin contains globular projections that attach to actin at specific active binding sites forming cross bridges.
- Once cross bridges are formed, they exert a force on the actin filament and cause it to move.

Structure of Skeletal Muscle III



Structure of Skeletal Muscle III

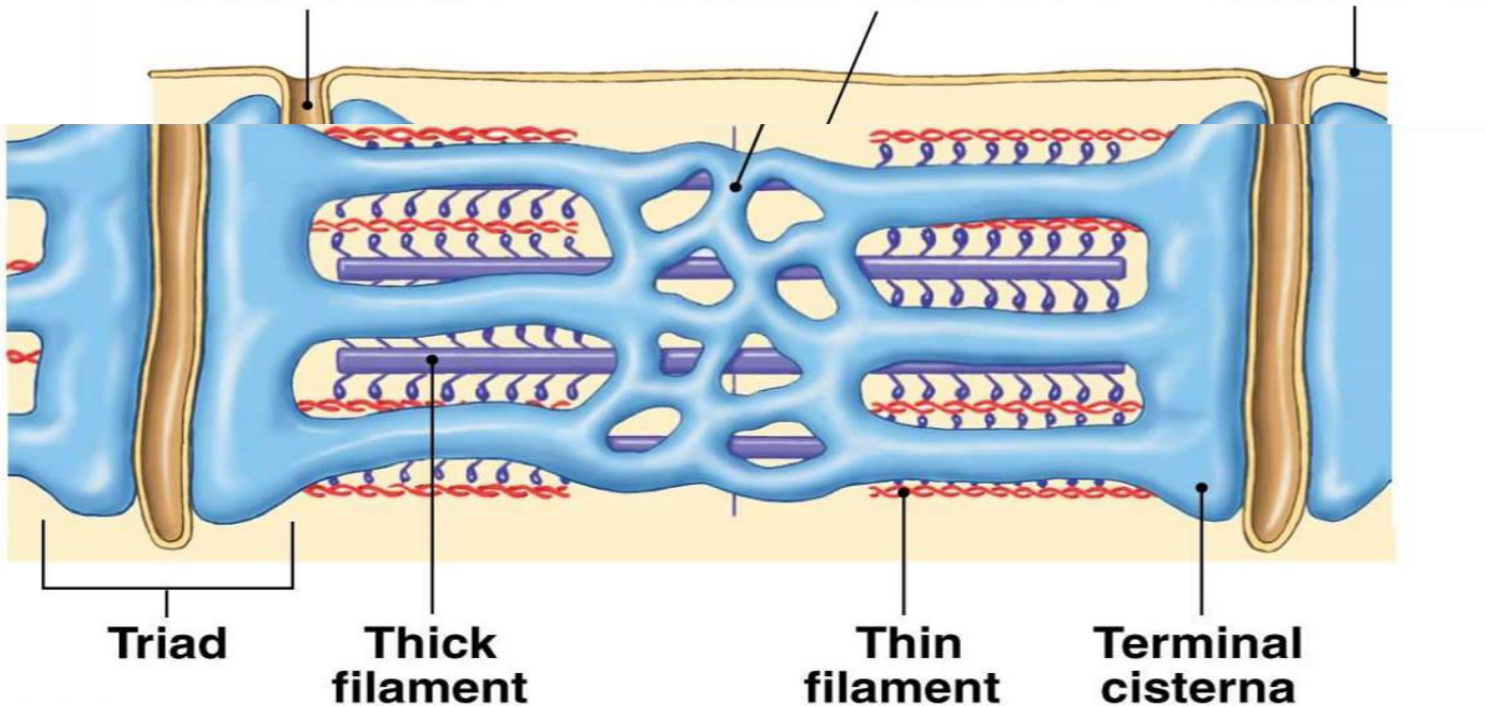
T-TUBULES

T-tubules are extensions of the cell membrane (sarcolemma) that associate with the ends (terminal cisternae) of the sarcoplasmic reticulum.

T-tubule brings action potentials into interior of muscle fiber.

Sarcoplasmic reticulum stores Ca^{2+} .

Sarcolemma



Animal Form and Structure

Module 29



Animal Form and Function 1

Sliding Filament Model of Muscle Contraction

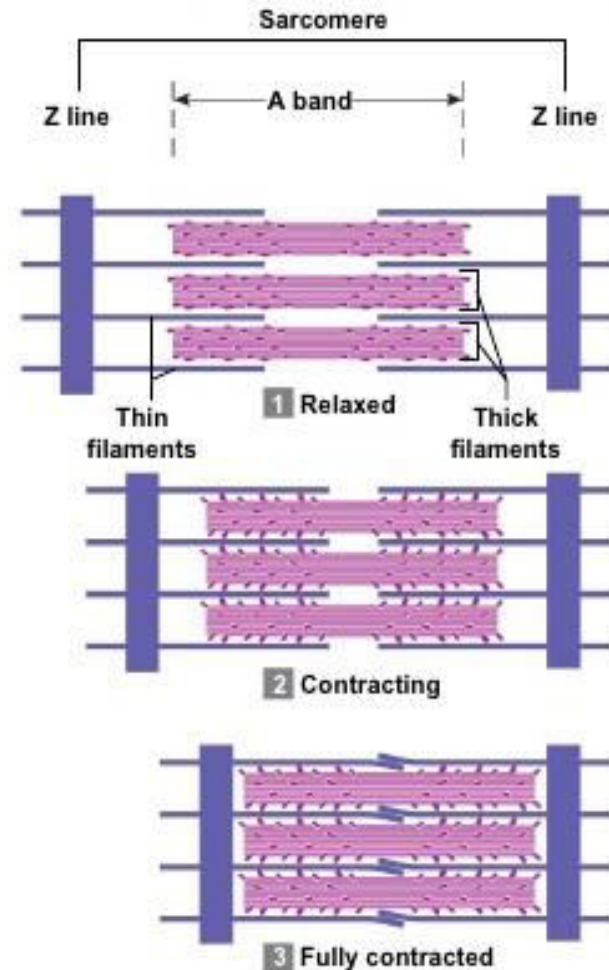
Sliding Filament Model

- When a muscle contracts sarcomere is reduced i.e. Z-lines are brought closer to gather.
- In a contracted sarcomere A-band does not change in length but the I-band shortens and the H-band disappears.
- The behavior can be explained by the SF Model

Sliding Filament Model

Sliding Filament Theory

- When sarcomeres shorten, thick and thin filaments slide past one another
- H zones and I bands narrow
- Z lines move closer together

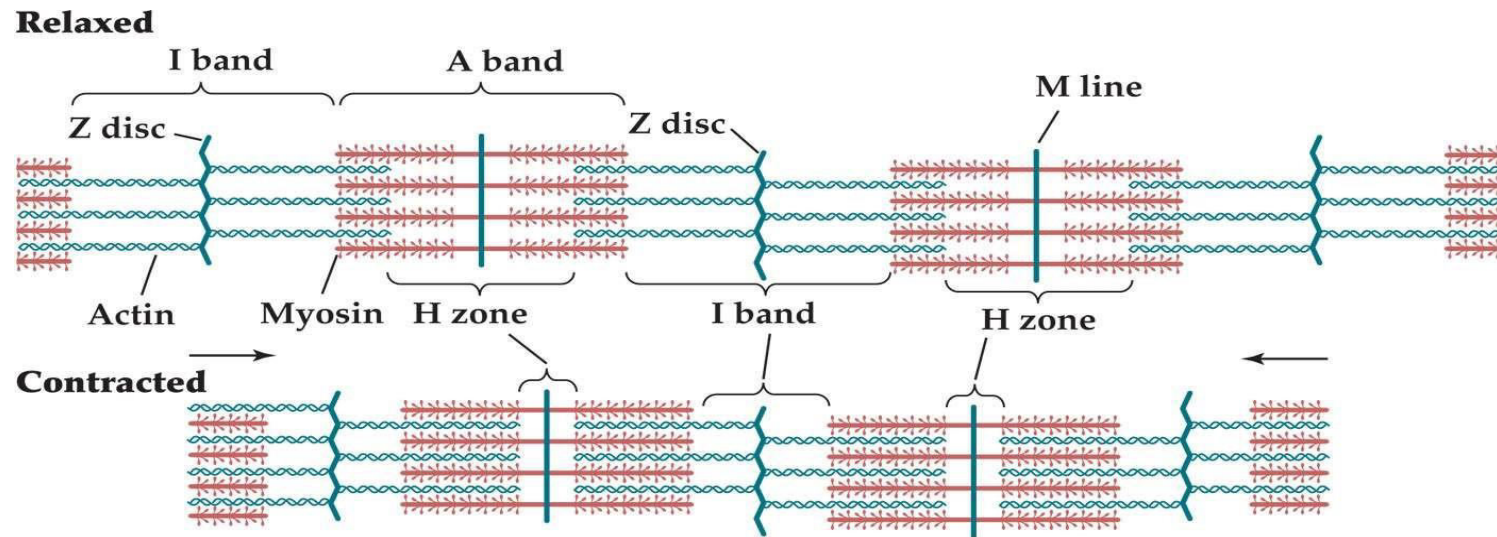


Sliding Filament Model

- According to this model neither the actin nor the myosin filaments change in length, rather they slide past each other.
- The sliding of the filaments is based on the interaction of the actin and myosin molecules that make up actin and myosin filaments.

Sliding Filament Model

Sliding filaments produce contraction



ANIMAL PHYSIOLOGY 3E, Figure 20.3
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Sliding Filament Model

- A ratchet mechanism or the interaction between the two – actin and myosin filaments produces the actual contraction.

Sliding Filament Model

- Cyclic Interaction Between Myosin and Actin in Muscle contraction:
- To start with, Myosin head is bound to ATP.
- Myosin head hydrolysis ATP to ADP and P_i .
- Myosin head binds to Actin forming a Cross bridge.

Sliding Filament Model

- The releasing ADP and Pi relaxes myosin to low energy state, sliding the actin filament.
- Binding of a new molecule of ATP releases the myosin head.
- The myosin head then returns to high energy level and begins a new cycle.

Sliding Filament Model

- Approximately 350 heads of thick filaments form and reform about 5 cross bridges per second driving filaments past each other.

Sliding Filament Model

Step A

- Myosin head attaches to actin. (High energy ADP + P configuration)

Step B:

Power stroke:

- Myosin head pivots pulling the actin filament toward the center.

Sliding Filament Model

Step C:

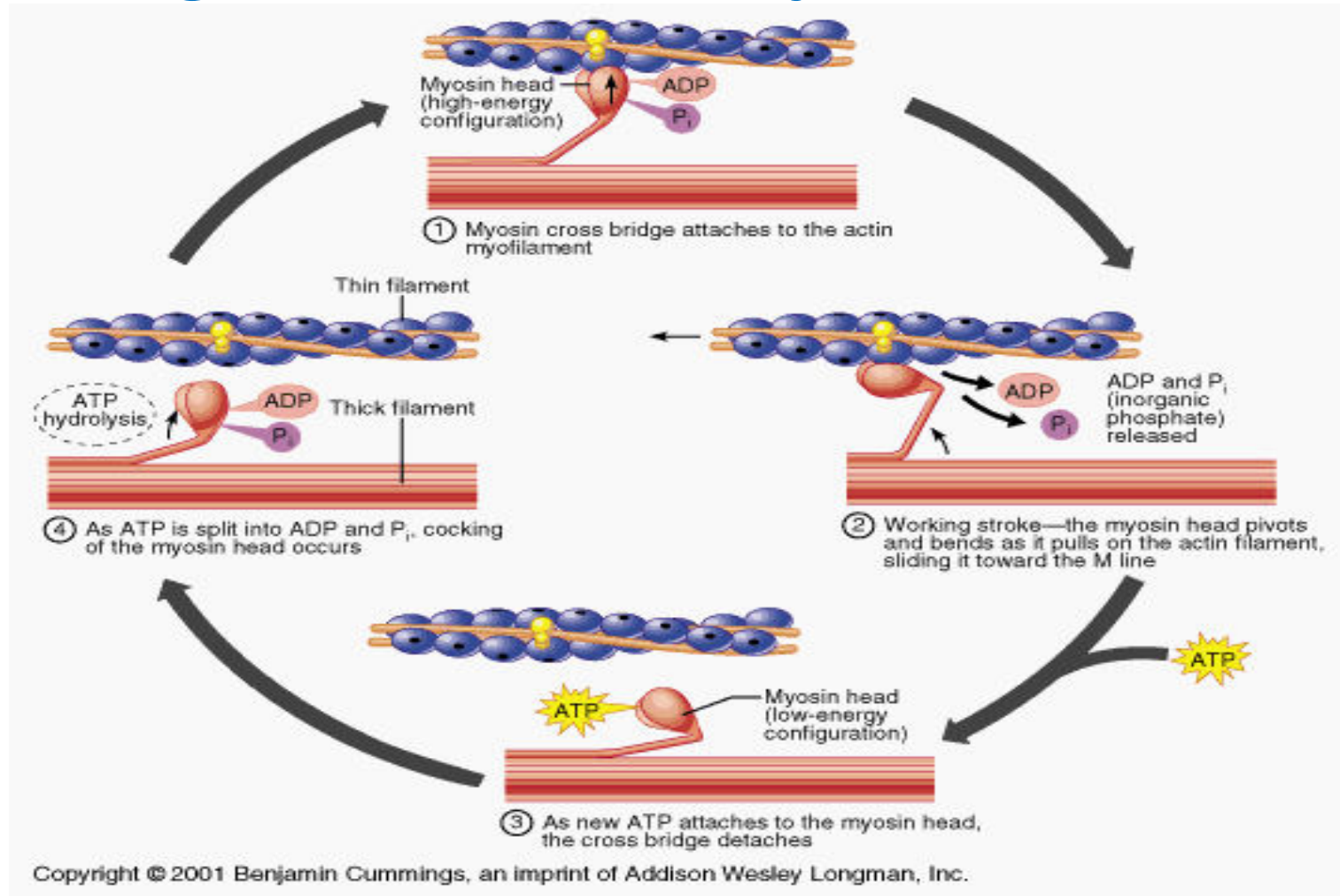
- The cross bridge detaches when a new ATP binds with the myosin.

Step D:

- Cocking of the myosin head occurs when $\text{ATP} \rightarrow \text{ADP} + \text{P}$. Another cross bridge can form.

Sliding Filament Model

Sliding Filament Theory



Animal Form and Function I

Module 30



Animal Form and Function I

Role of Calcium and Regulatory Proteins in Muscle Contraction

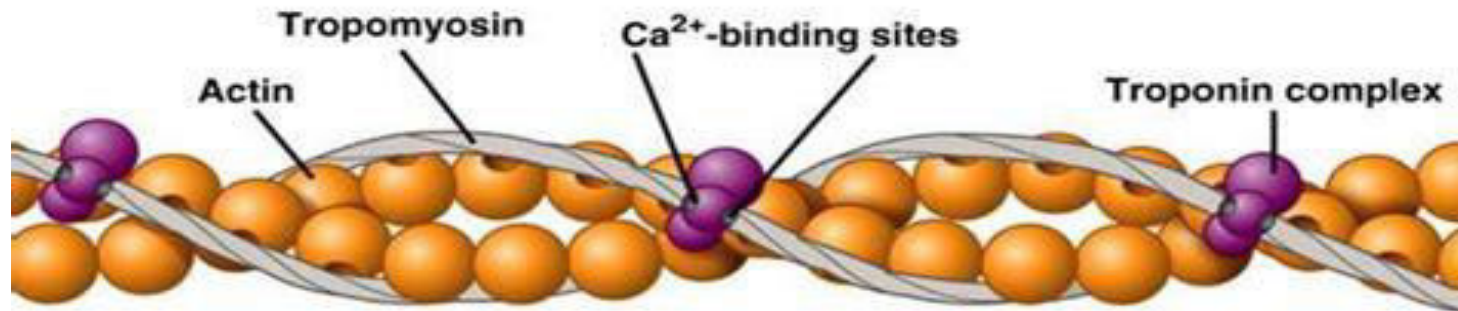
Role of Ca^{++} & Regulatory Proteins in M/Contraction

- Skeletal muscle contracts only when stimulated by a motor neuron.
- When muscle is at rest, the binding sites on the actin molecule are blocked by the regulatory protein the **tropomyosin**.

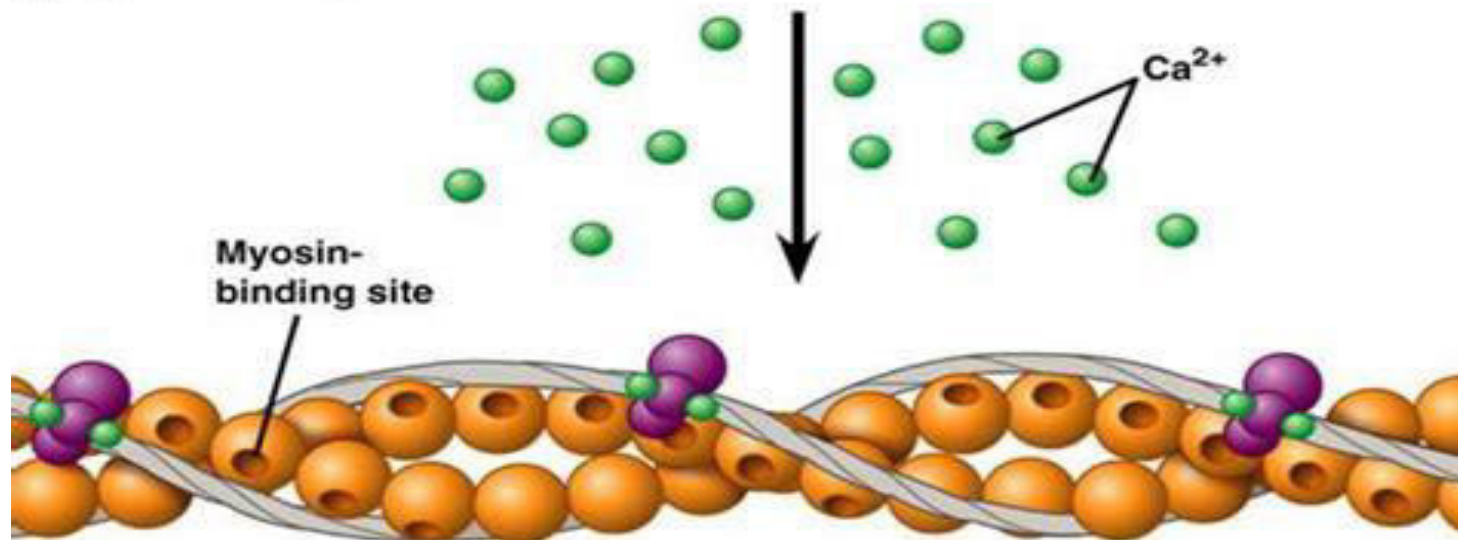
Role of Ca^{++} & Regulatory Proteins in M/Contraction

- Another set of regulatory proteins, the **troponin complex**, control the position of tropomyosin on the actin filament.
- For a muscle to contract Ca ions bind to troponin, that causes the whole tropomyosin-troponin complex to change shape and expose the myosin binding site on actin

Role of Ca^{++} & Regulatory Proteins in M/Contraction

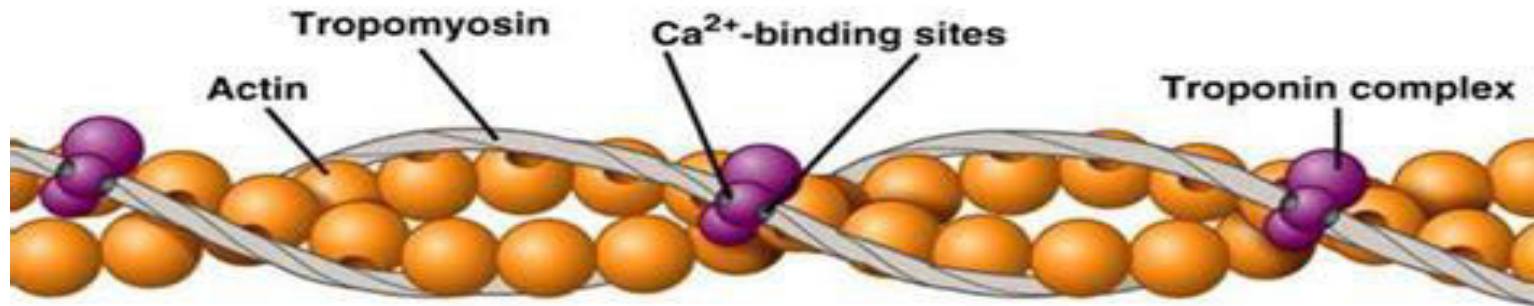


(a) Myosin-binding sites blocked

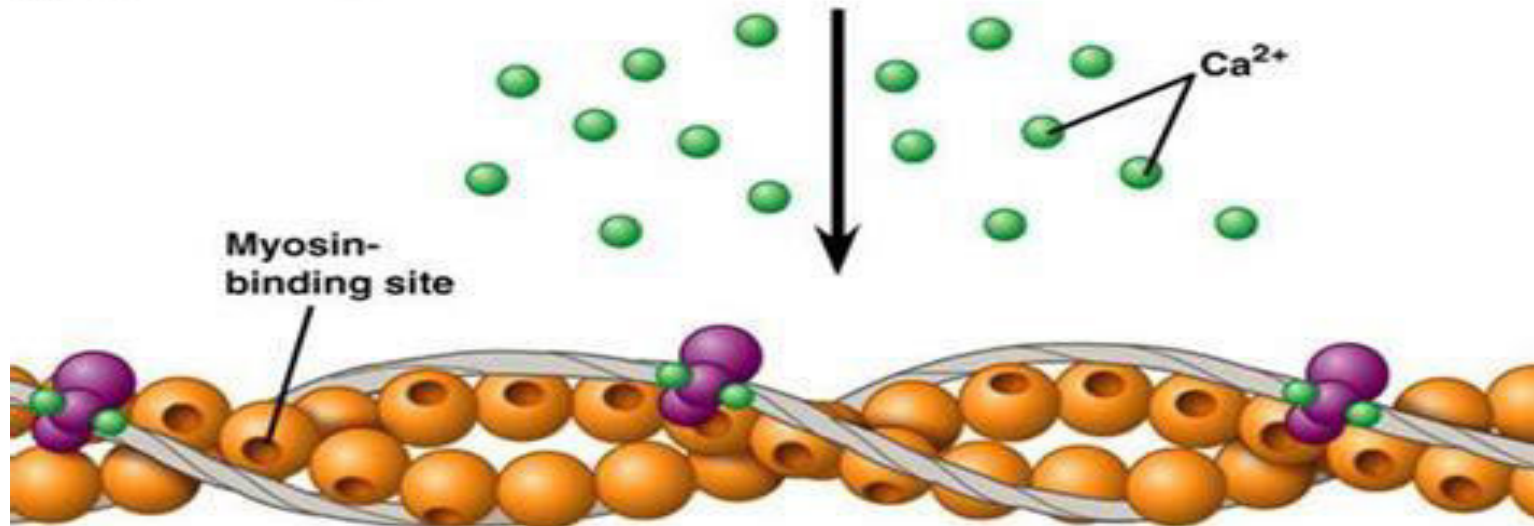


(b) Myosin-binding sites exposed

Role of Ca^{++} & Regulatory Proteins in M/Contraction



(a) Myosin-binding sites blocked



(b) Myosin-binding sites exposed

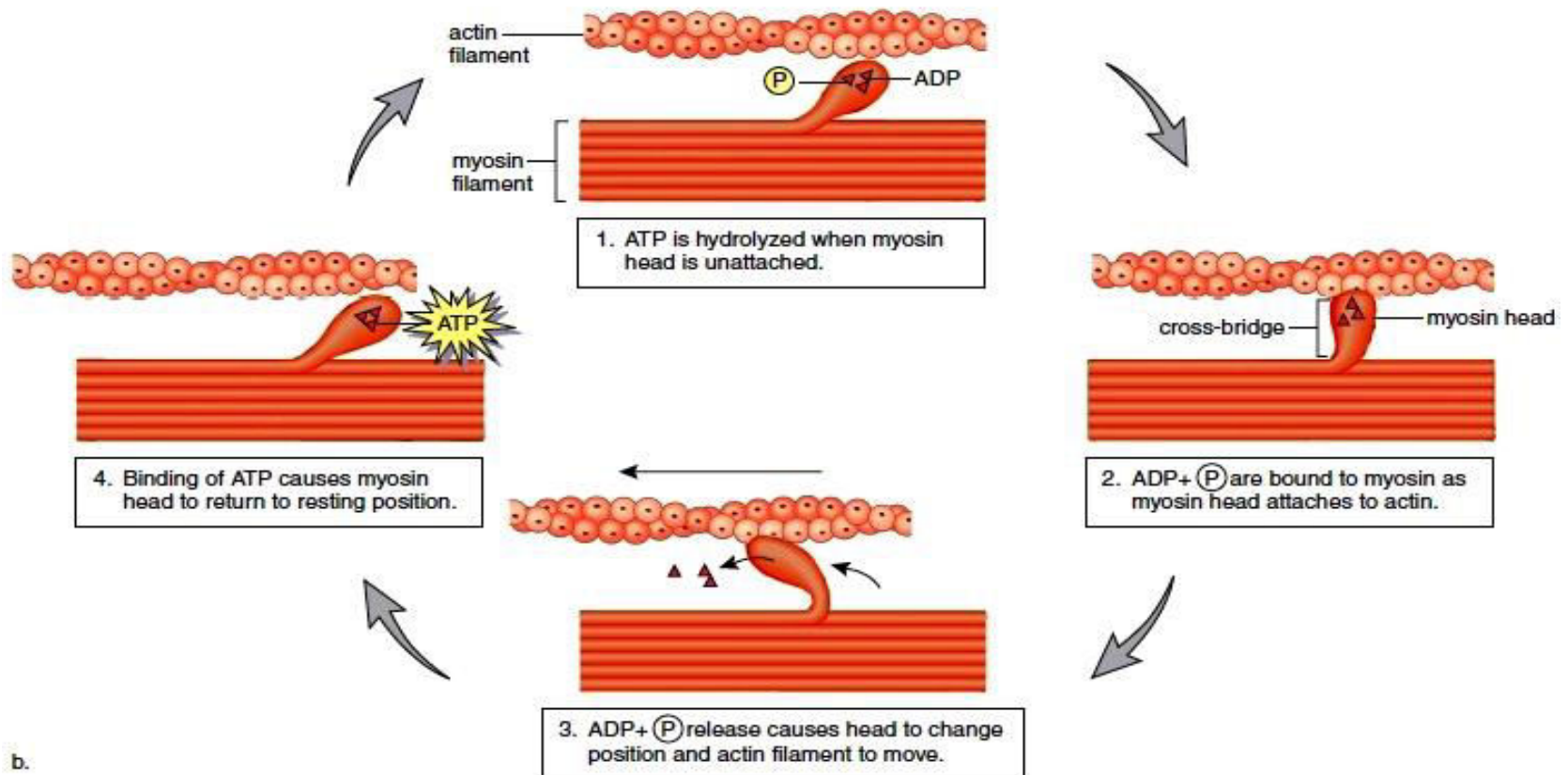
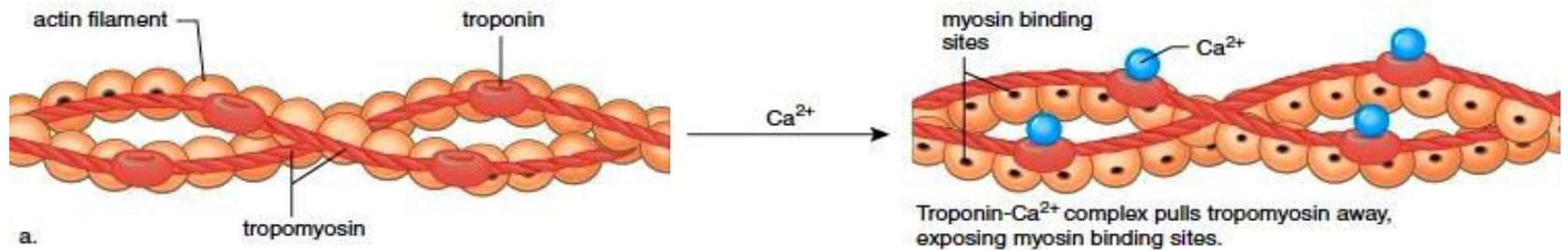
Role of Ca^{++} & Regulatory Proteins in M/Contraction

- When Ca^{++} is present, the sliding of thin and thick filaments occurs and the muscle contracts.
- When internal Ca^{++} concentration falls, the binding sites of actin are covered and contraction stops.

Role of Ca^{++} & Regulatory Proteins in M/Contraction

- Ca^{++} concentration in the cytoplasm of the muscle cell is regulated by the sarcoplasmic reticulum.
- Transportation of Ca^{++} from cytoplasm into the SR is by active transport.

Role of Ca^{++} & Regulatory Proteins in M/Contraction



Module 31



Animal Form and Function 1

Regulation of Skeletal Muscle Contraction

Regulation of Skeletal Muscle Contraction

- There may be hundreds of neurons controlling a muscle each with its own pool of muscle fibers.
- When a motor neuron produces an action potential all the muscle fibers in the motor unit contracts as a group.

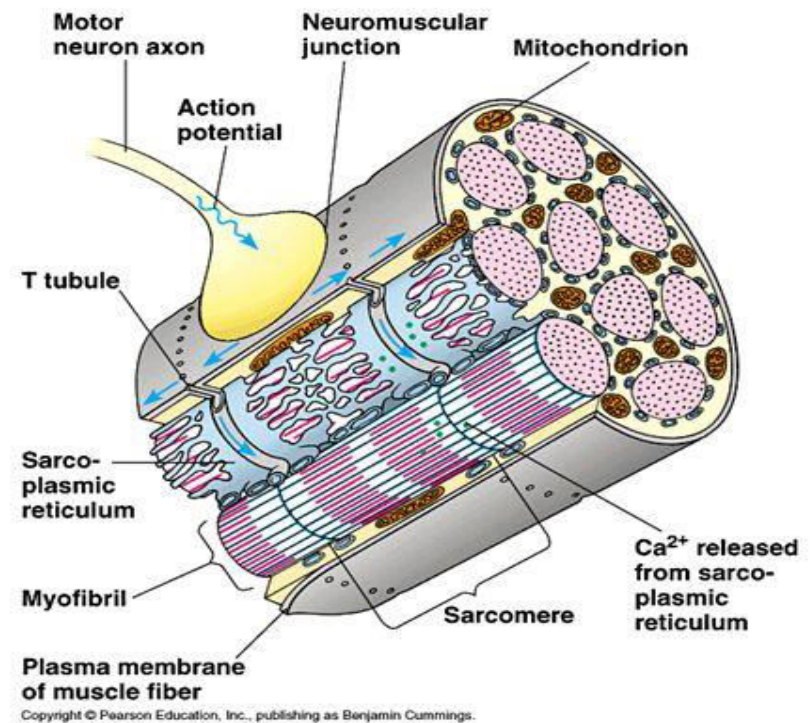
Regulation of Skeletal Muscle Contraction

- Action potential triggered by the motor neuron sweeps across the muscle fiber and into it along T-tubule starting the movement of Ca that regulates the muscle activity.
- The events that regulate the skeletal muscle contraction are electrical, chemical and molecular.

Regulation of Skeletal Muscle Contraction

**Muscle contraction regulation

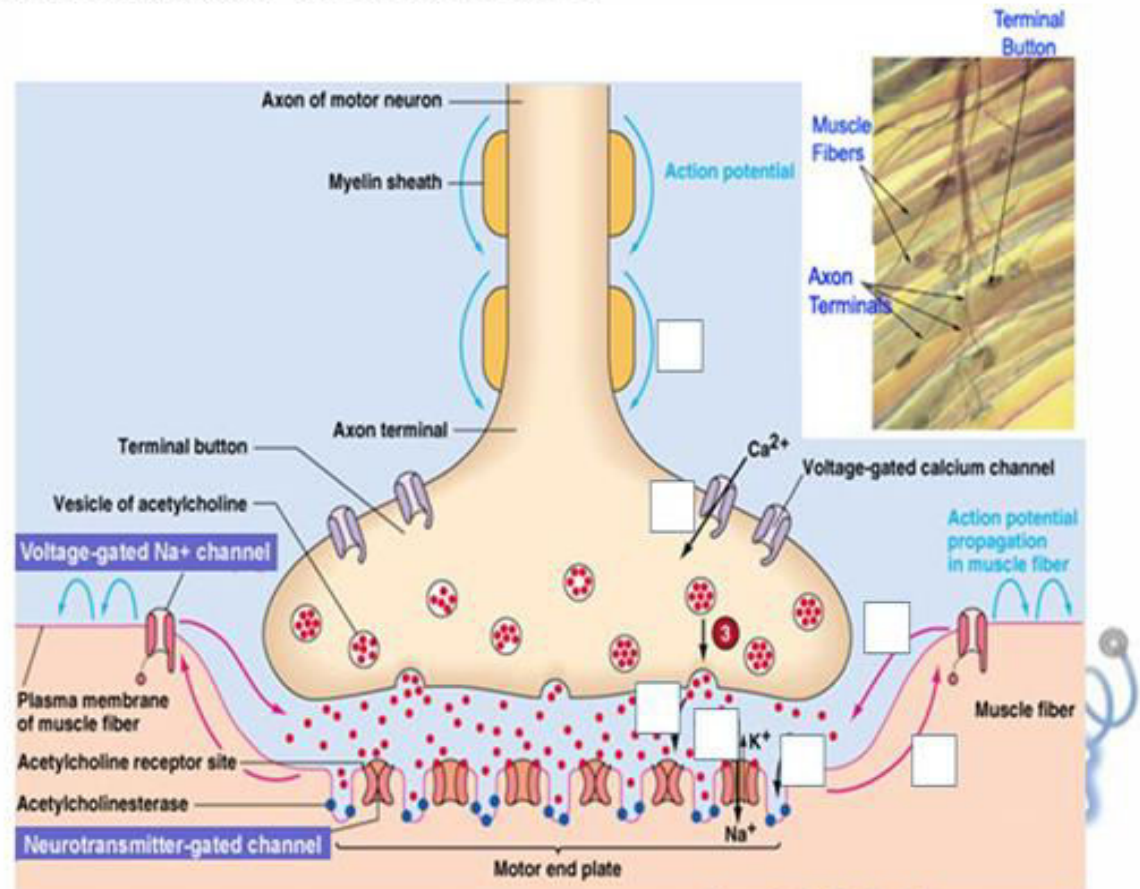
- Calcium (Ca^{+})~ concentration regulated by the....
- **Sarcoplasmic reticulum**~ a specialized endoplasmic reticulum
- Stimulated by action potential in a motor neuron
- T (transverse) tubules~ travel channels in plasma membrane for action potential
- Ca^{+} then binds to troponin



Regulation of Skeletal Muscle Contraction

The Neuromuscular Junction

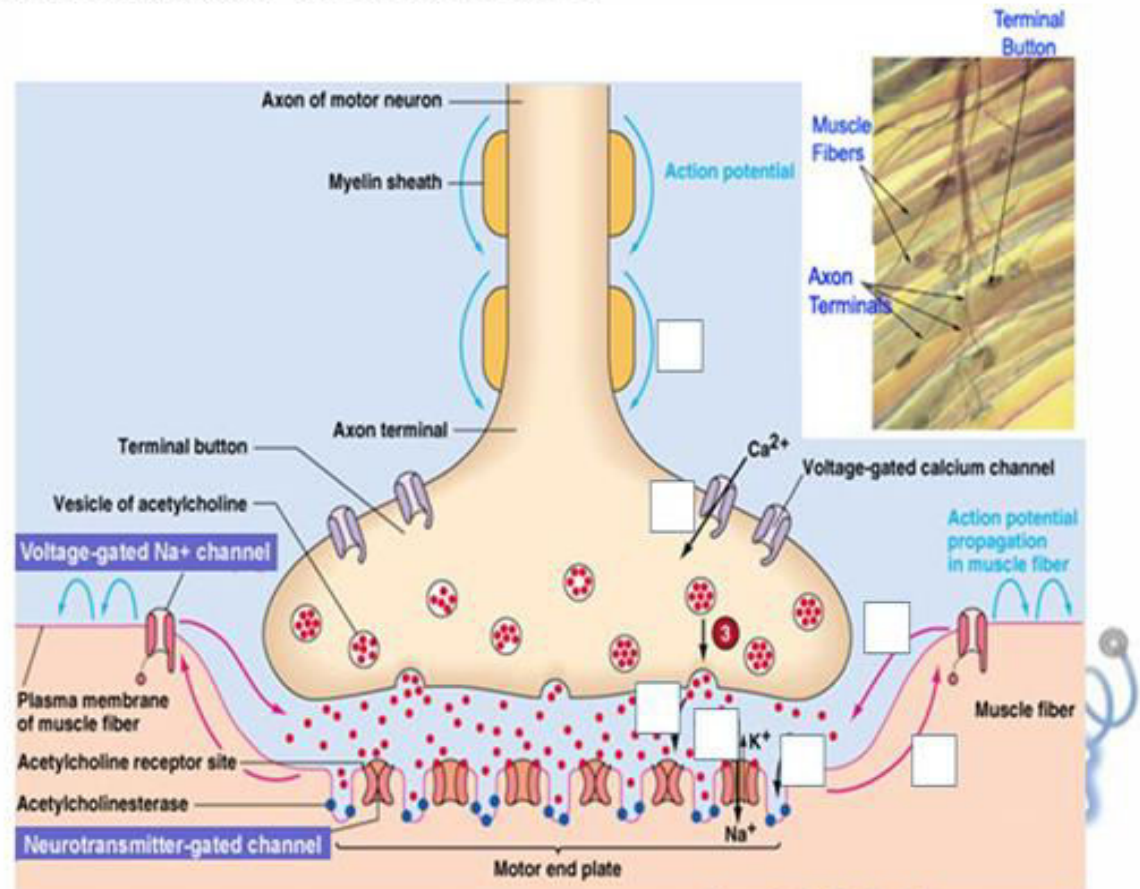
1. Action potential travels down axon to NMJ
2. Depolarisation opens voltage-gated Ca^{2+} channels
3. Influx of Ca^{2+} causes exocytosis of ACh vesicles
4. ACh travels across the synaptic cleft and binds nicotinic ACh receptors which open.
5. Na^+ moves into the motor end plate, through nAChR, propagating the action potential.



Regulation of Skeletal Muscle Contraction

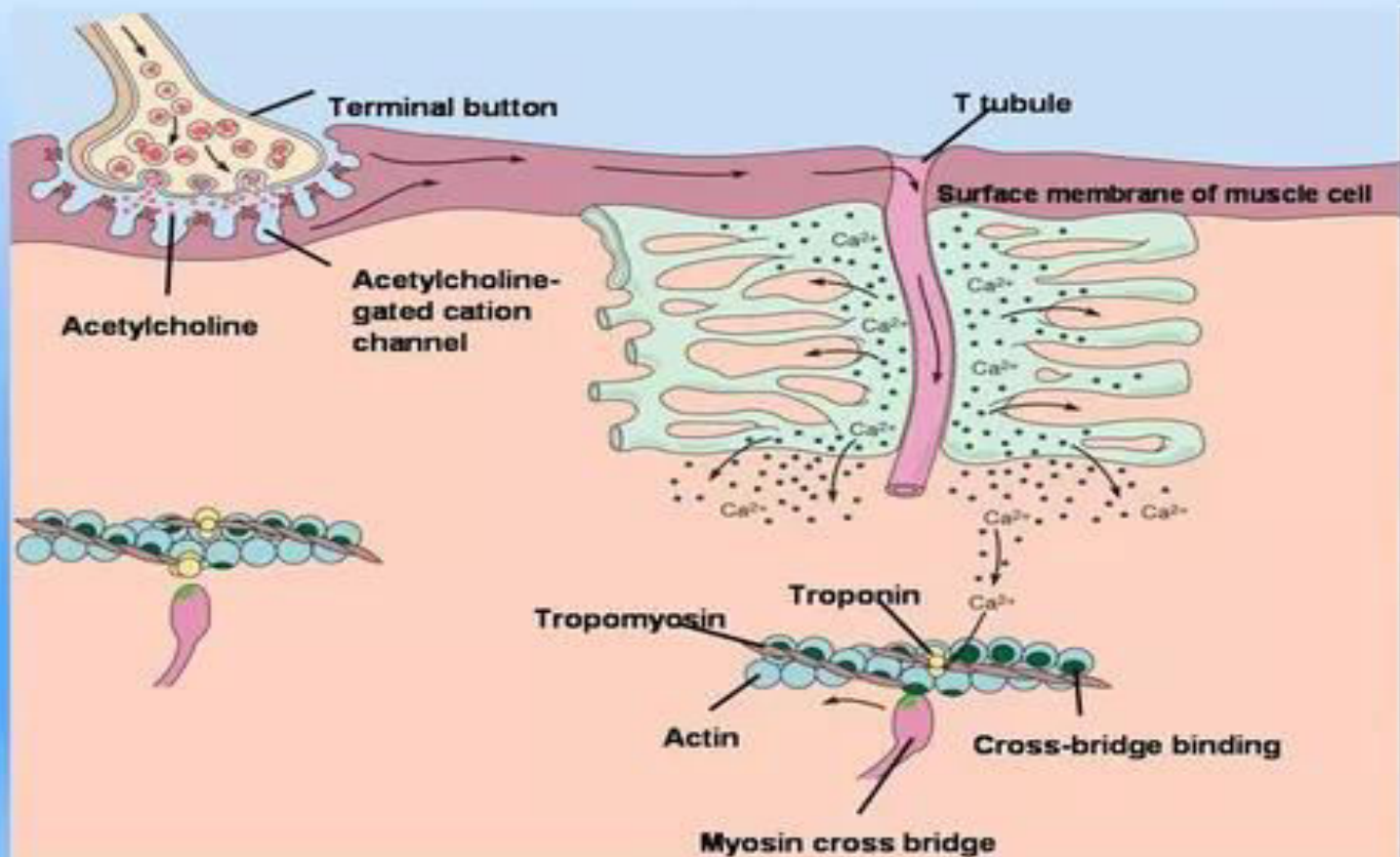
The Neuromuscular Junction

1. Action potential travels down axon to NMJ
2. Depolarisation opens voltage-gated Ca^{2+} channels
3. Influx of Ca^{2+} causes exocytosis of ACh vesicles
4. ACh travels across the synaptic cleft and binds nicotinic ACh receptors which open.
5. Na^+ moves into the motor end plate, through nAChR, propagating the action potential.



Regulation of Skeletal Muscle Contraction

The muscle impulse causes the release of calcium from the SR. Calcium binds to troponin and tropomyosin is repositioned exposing the actin filaments.



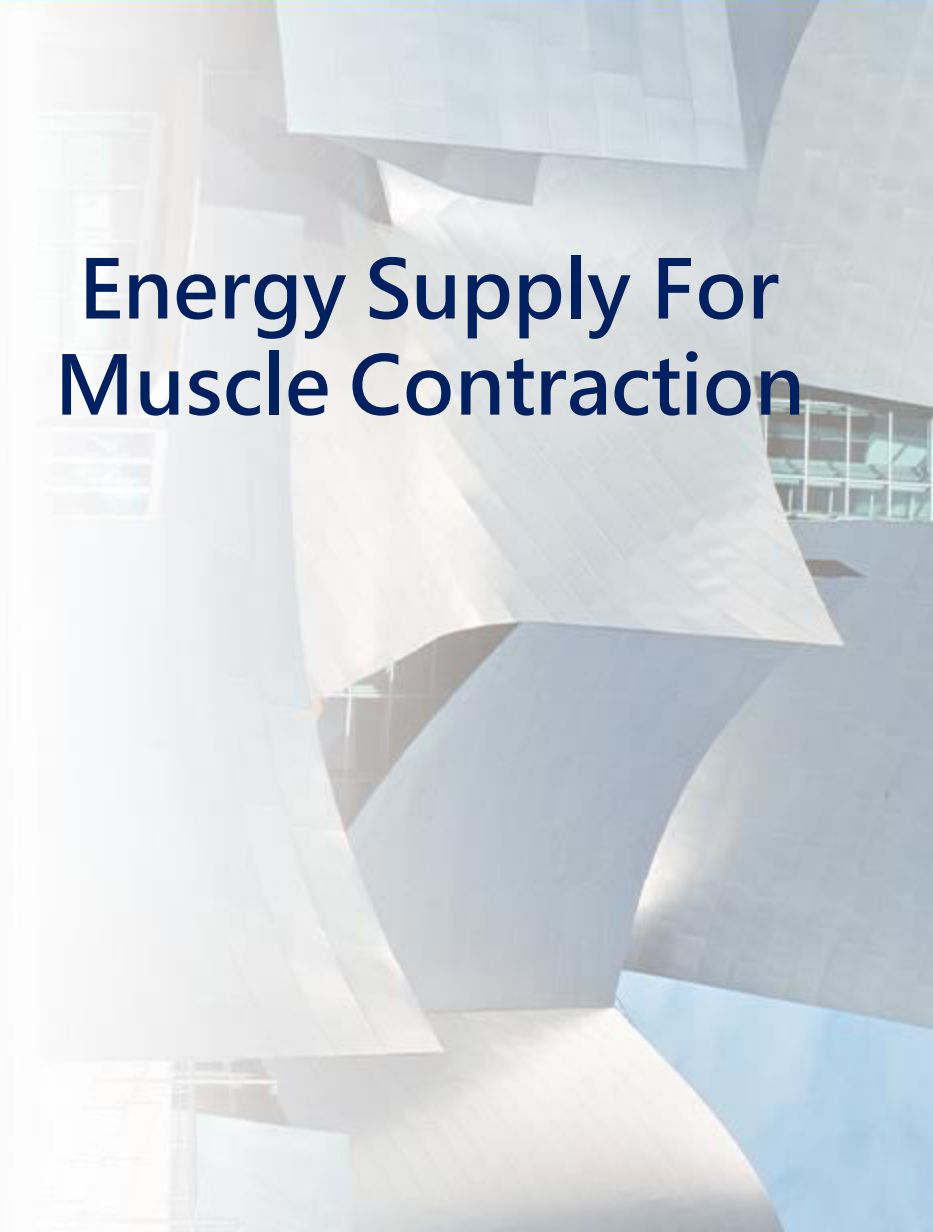
Animal Form and Function I

Module 32



Animal Form and Function 1

Energy Supply For Muscle Contraction



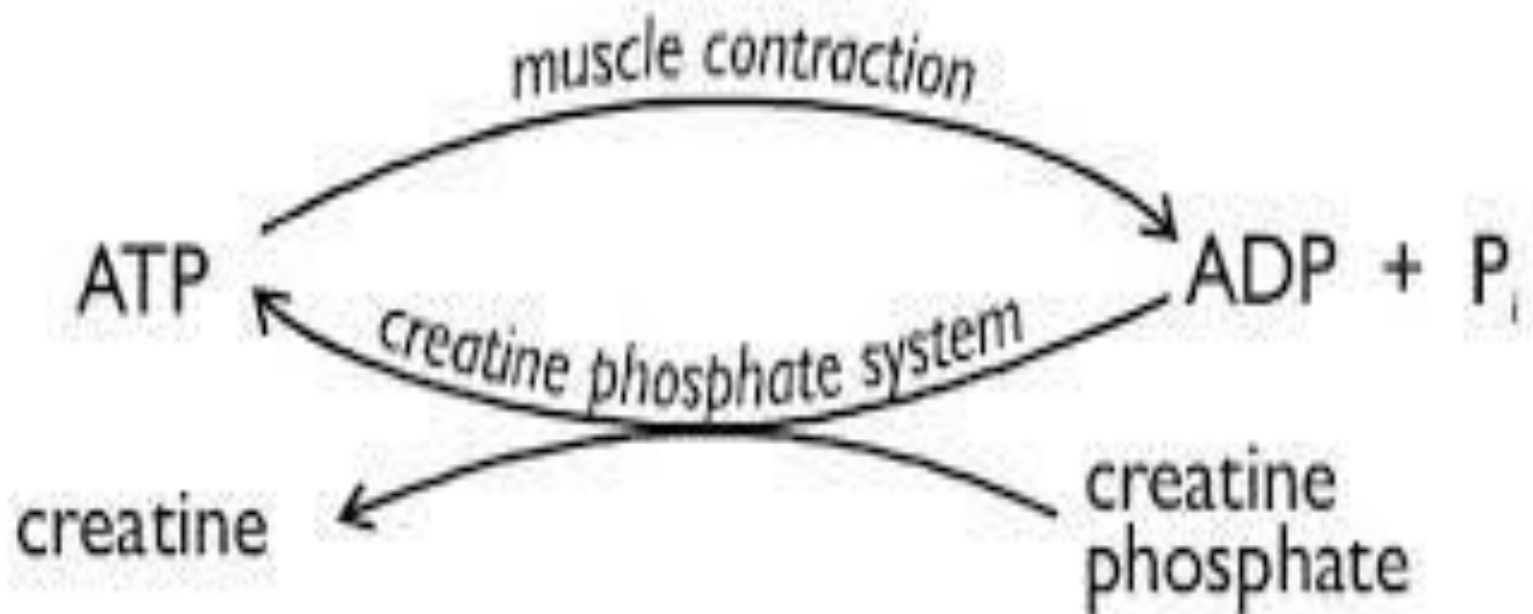
Energy Supply for Muscle Contraction

- Immediate source of energy for muscle contraction is ATP.
- Supply of ATP is maintained by the Aerobic breakdown of glucose in muscle cell.
- During exercise, when more energy is required, it comes from **Creatine Phosphate**.

Energy Supply for Muscle Contraction

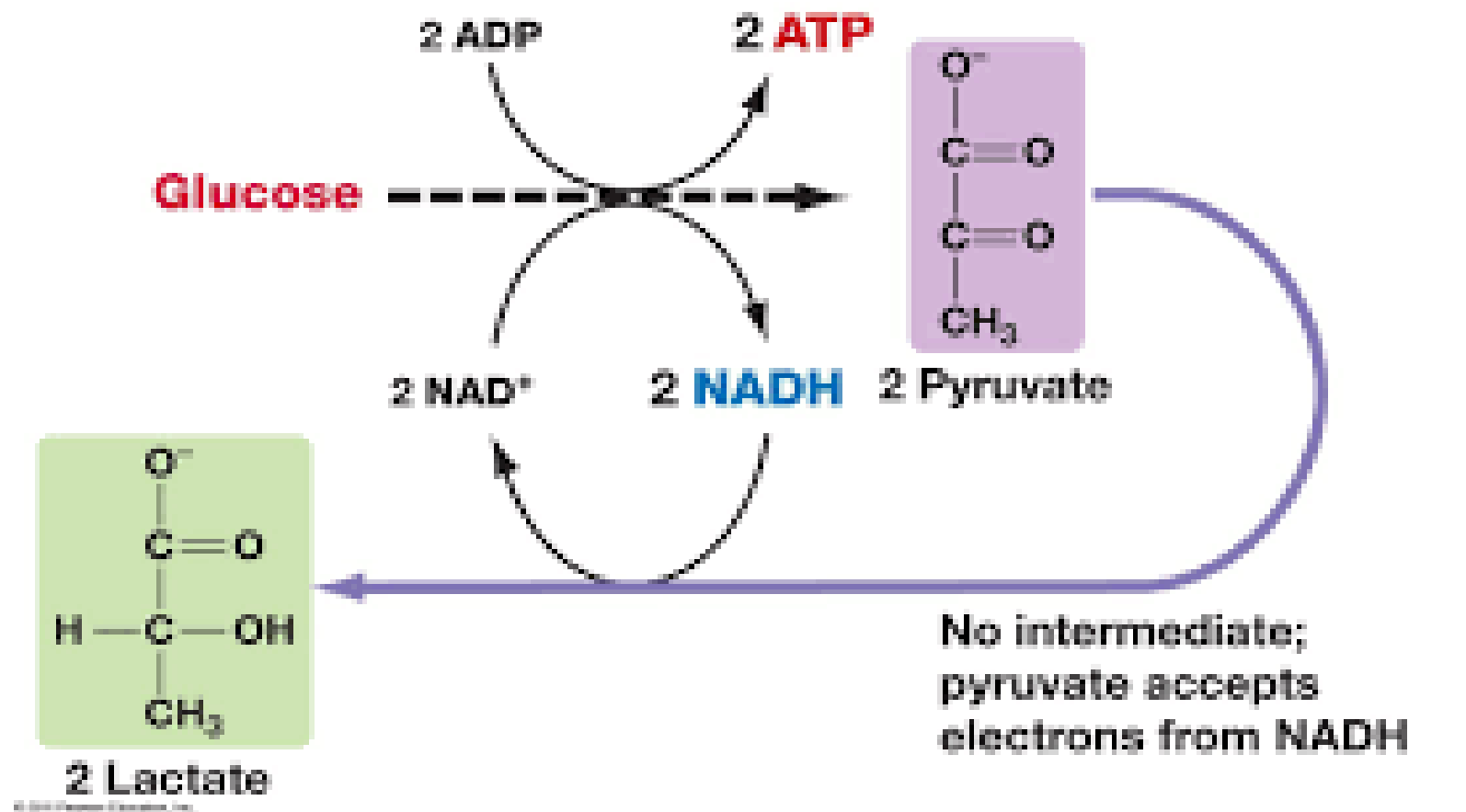
During Exercise

creatine phosphate used up



Energy Supply for Muscle Contraction

(a) Lactic acid fermentation occurs in humans.



Energy Supply for Muscle Contraction

- Sometimes during strenuous exercise ATP requirement is met by anaerobic breakdown of glucose into **Lactic acid**.
- Accumulation of Lactic acid cause muscle fatigue.
- This also represents Oxygen debit.

Energy Supply for Muscle Contraction

Structure of Different Kinds of Neurons I

- At rest i.e. after exercise 1/5 of Lactic acid is broken aerobically and its energy is used to change the remaining 4/5 Lactic acid into glucose and later into muscle glycogen.
- Thus glycogen is replenished again.

END

Animal Form and Function 1

Module 33



Animal Form and Function 1

Frequently Asked Questions About Muscles

Frequently Asked Questions About Muscles

Muscle Fatigue:

- It is a state of physiological inability of muscle to contract. It results from deficit of ATP. When no ATP is available state of continuous contraction results.
- Excess of Lactic acid also contribute to muscle fatigue and aching.

Frequently Asked Questions About Muscles

Cramps:

- A muscle cramp is a sudden and involuntary contraction of one or more muscles.
- Muscle cramps cause severe pain.
- Overuse of a muscle, dehydration, inadequate blood supply and nerve compression may cause cramps.

Frequently Asked Questions About Muscles

- Mineral depletion, such as Ca, K or Mg in diet contribute to leg cramps.
- Diuretics deplete these minerals

Frequently Asked Questions About Muscles

- Tetany or Hypocalcemia
- A condition due to low calcium (hypoglycemia) and is characterized by spasm of the hands and legs.

Frequently Asked Questions About Muscles

Muscular Hypertrophy:

- This involves an increase in size of Skeletal muscle through growth in size of its components.
- Following are the factors that contribute to hypertrophy:
 - i) Sarcoplasmic and myofibrillar hypertrophy.
- Increase in glycogen and blood capillaries.

Frequently Asked Questions About Muscles

Tetany



Frequently Asked Questions About Muscles

Muscle Cramps



Animal Form and Function 1

Module 34



Animal Form and Function 1

Frequently Asked Questions about Skeleton

Frequently Asked Questions About Skeleton

Arthritis is inflammation of joints. The main symptom of arthritis are joint pains and stiffness, which worsens with age. The most common types are Osteoarthritis and rheumatoid arthritis.

Frequently Asked Questions about Skeleton

Disc Slip:

Displacement of intervertebral disc which is composed of nucleus pulposus surrounded by a ring of fibrocartilage. It becomes painful when the protrusion presses the spinal nerve.

Frequently Asked Questions About Skeleton

Sciatica:

It is characterized by severe pain radiating over the sciatic nerve. It may be due to the herniated disc.

Frequently Asked Questions

Disc slip



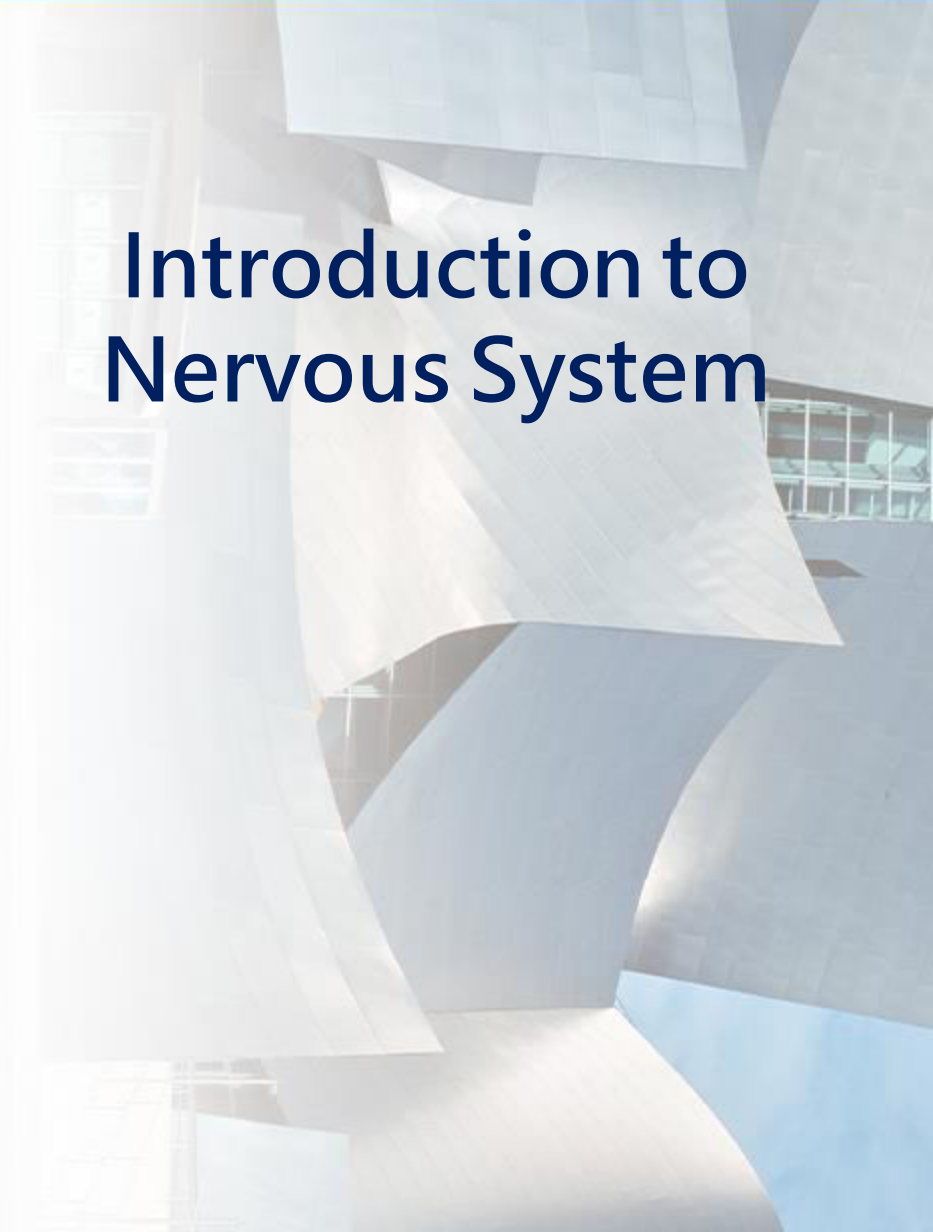
Animal Form and Function 1

Module 36



Animal Form and Function 1

Introduction to Nervous System



Introduction of Nervous System

- Nervous System helps to communicate, integrate and coordinate the functions of various organs and organ systems in animal body.
- Information flow through NS has three main steps:

Introduction of Nervous System

- i) **Collection of** information from outside and inside the body. (receptors).
- ii) **Processing of** information in the NS.
- iii) **Initiation of** appropriate response. (effectors).

Introduction of Nervous System

- The two forms of communication that integrate body functions to maintain homeostasis are:
 - i) Neurons
 - ii) Hormones.
- In this chapter i.e. **Communication I** focuses on the anatomical organization and function of neurons.

Introduction of Nervous System

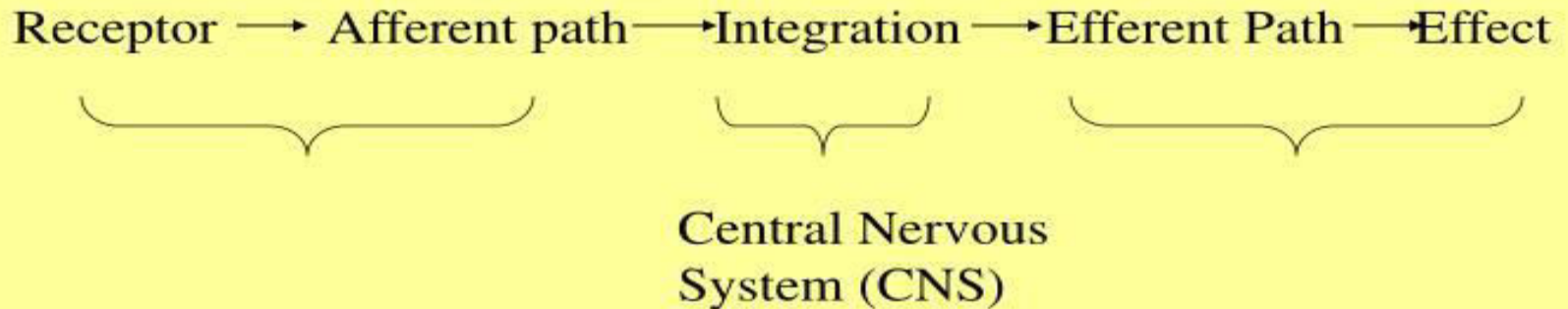
Reception by sensory receptor → transmission by afferent neuron → integration by interneurons in CNS → transmission by efferent neuron → action by effectors

Information flow through the nervous system

Introduction of Nervous System

Nervous System

- Brain, spinal cord, efferent and afferent neurons
- Pattern of information flow:



- Main cell types are neurons and glial cells

Module 37



Animal Form and Function 1

Basic Functional Units of Nervous System

Basic Functional Units of NS

- **Neurons** are the basic functional Unit of NS
- Neurons are specialized cells to produce signals.
- The signals are communicated to short and long distances.

Basic Functional Units of NS

- **Neurons** have Two properties:
 - i) Excitability and
 - ii) Conductivity
- Excitability is the ability to respond.
- Conductivity is the ability to conduct a signal.

Basic Functional Units of NS

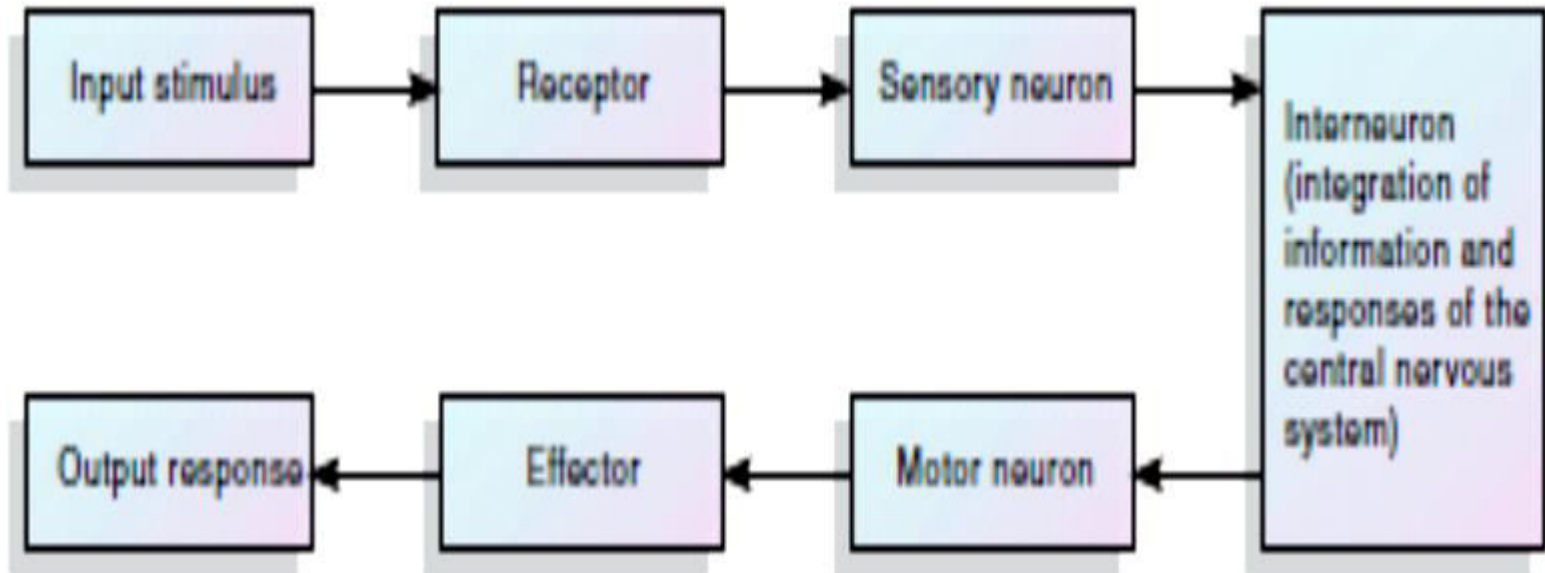
Types of Neurons:

- i) Sensory (receptors)
- ii) Interneurons (CNS)
- iii) Motor (effectors).
- Sensory Neurons act as receptors themselves or activated by receptors.
- Interneurons comprise the integrating centers.

Basic Functional Units of NS

- Motor Neurons send the processed information to effectors (muscles or glands)

Basic Functional Units of NS



Generalized pathway for the flow of information within the NS

Animal Form and Function

Module 38



Animal Form and Function 1

Neural Pathway Between Receptors and Effectors

Neural Pathway b/w Receptors and Effectors

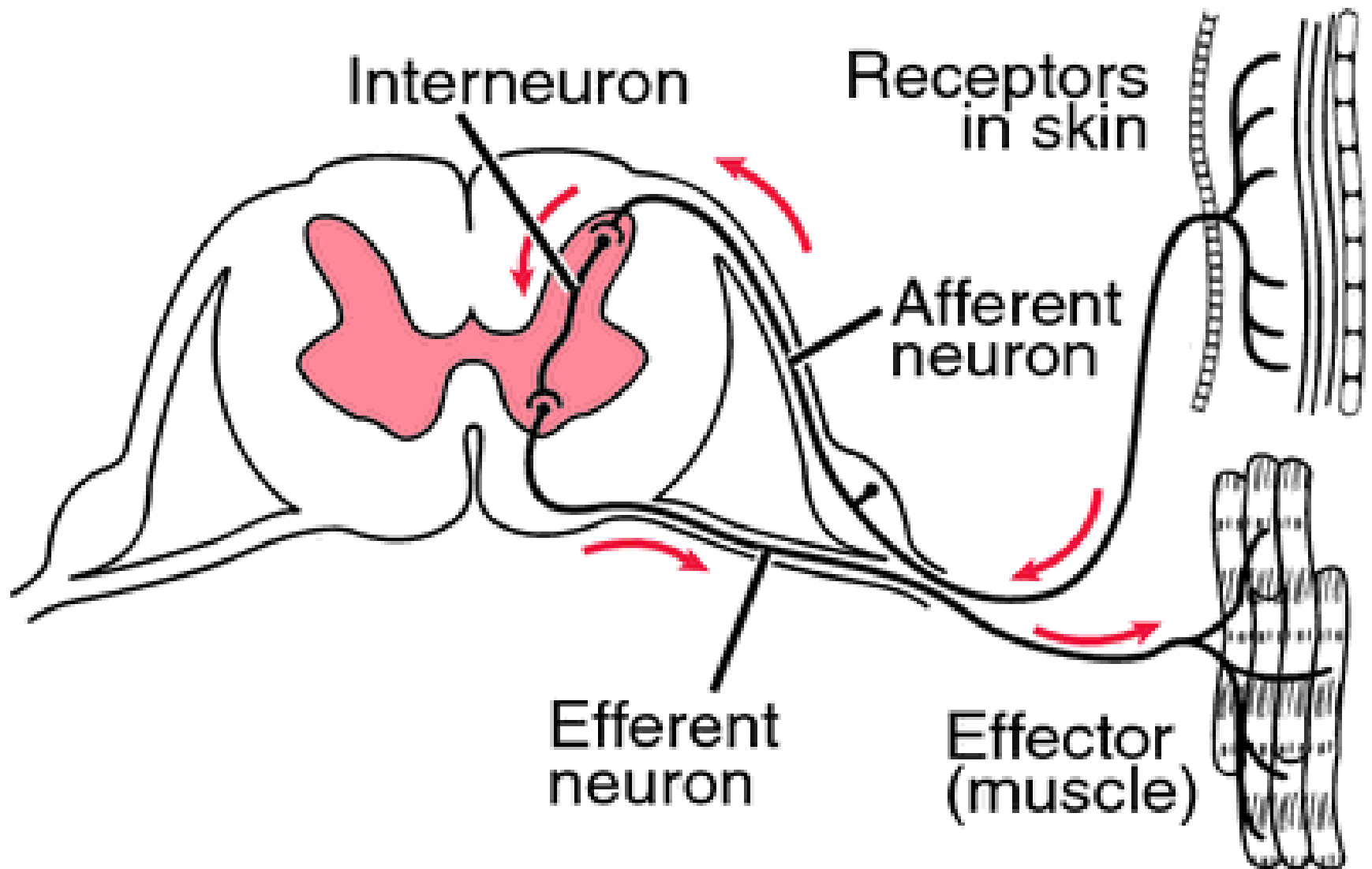
- A stimulus initiates impulse within some sensory structure (receptor).
- The impulses are then transferred via sensory neurons to interneurons.
- After response nerve impulses are generated and transferred via motor neuron to an effector (Muscle/gland)

Neural Pathway b/w Receptors and Effectors

Reflex Action:

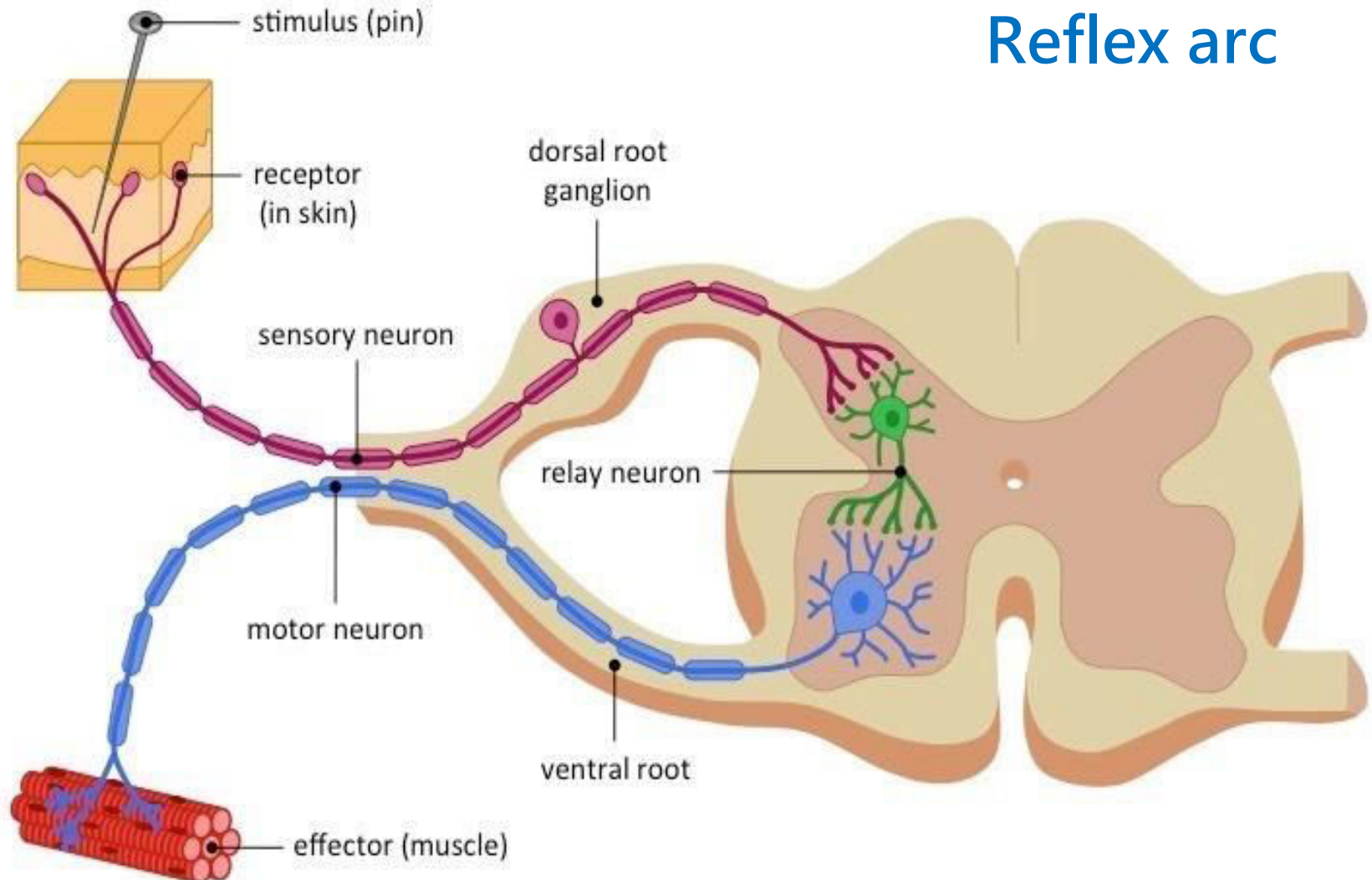
- An action which is carried out at once with the interaction of the will of the animal.
- or
- Automatic involuntary motor response.
- The path of reflex action is the reflex arc.

Neural Pathway b/w Receptors and Effectors



Neural Pathway b/w Receptors and Effectors

Reflex arc

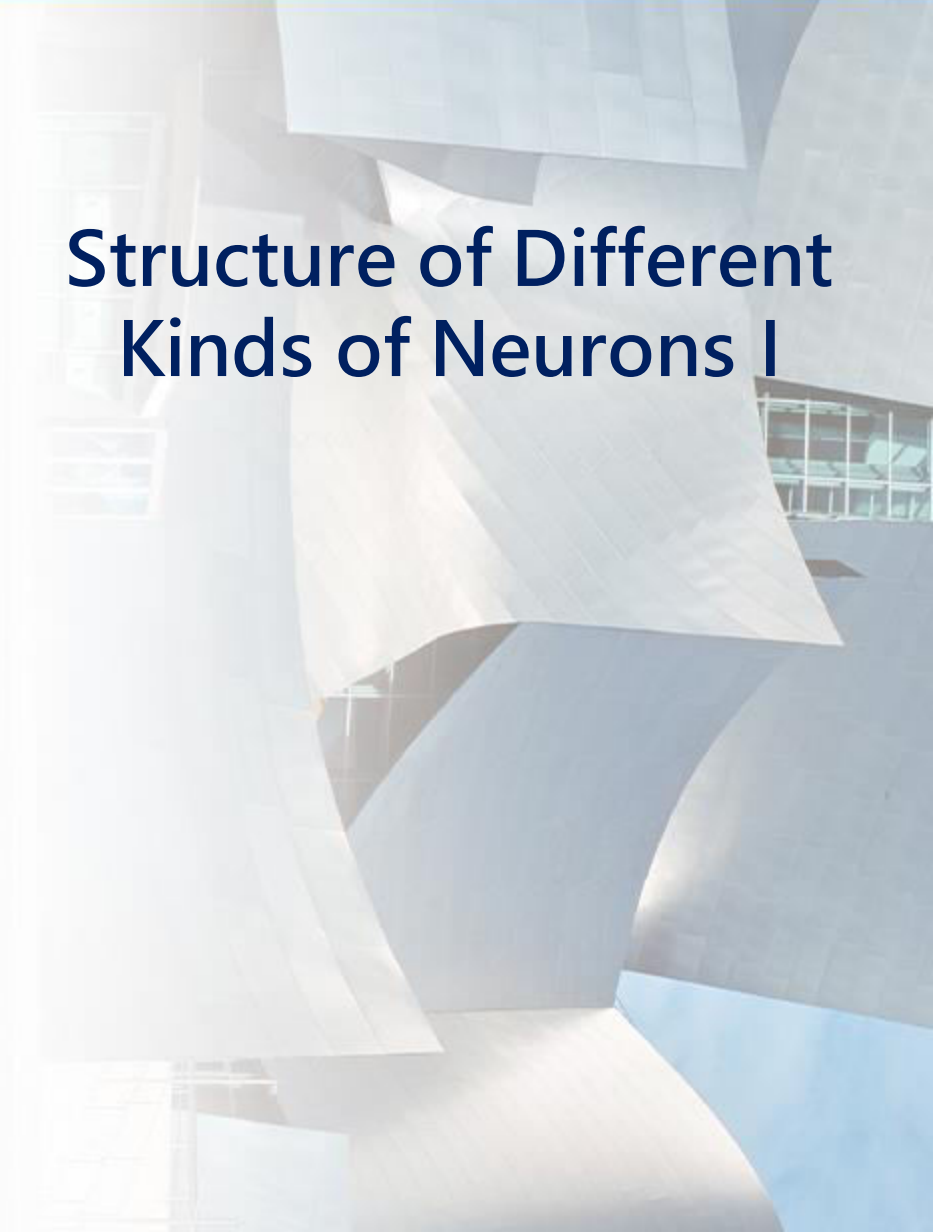


Module 39



Animal Form and Function 1

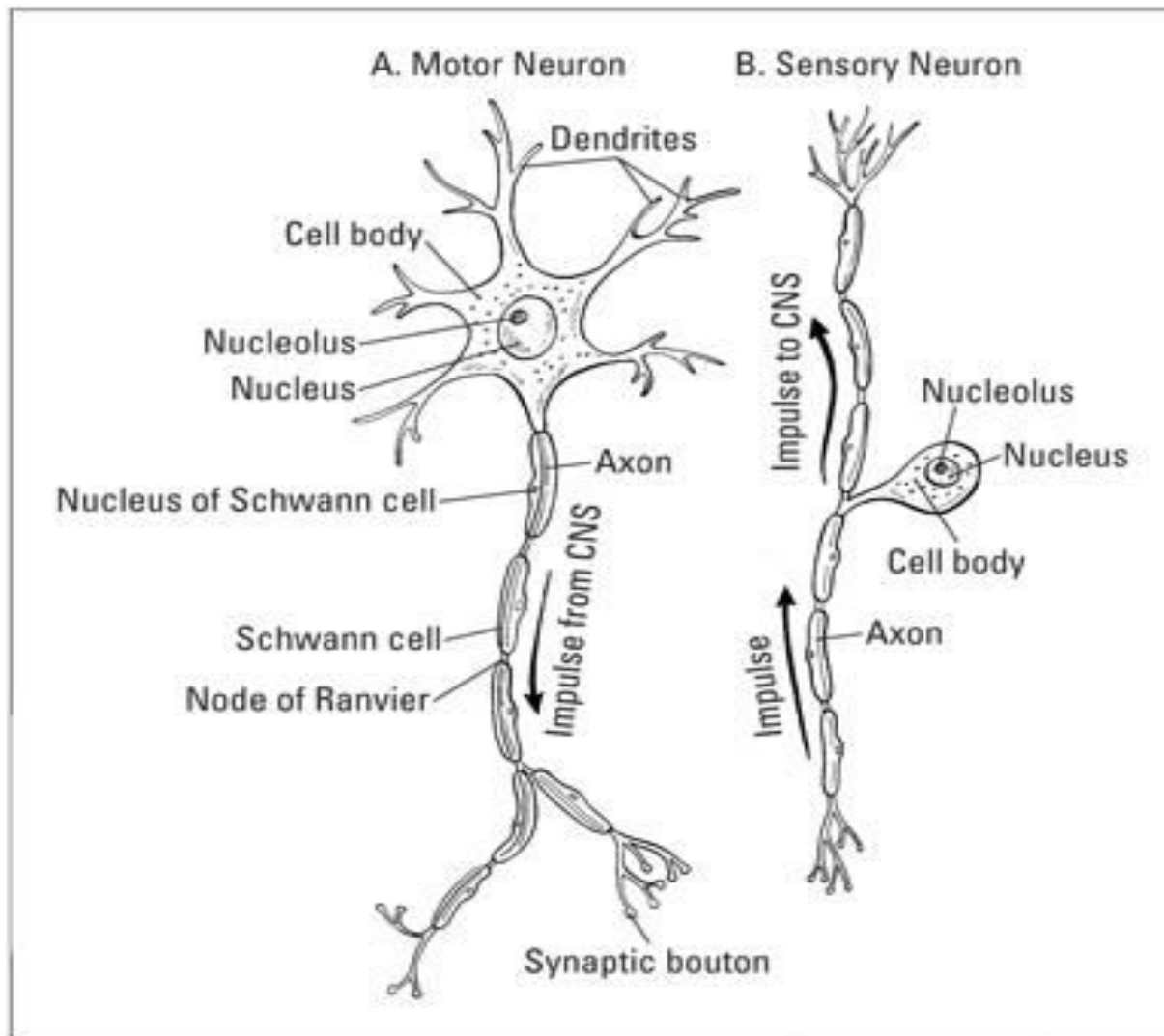
Structure of Different Kinds of Neurons I



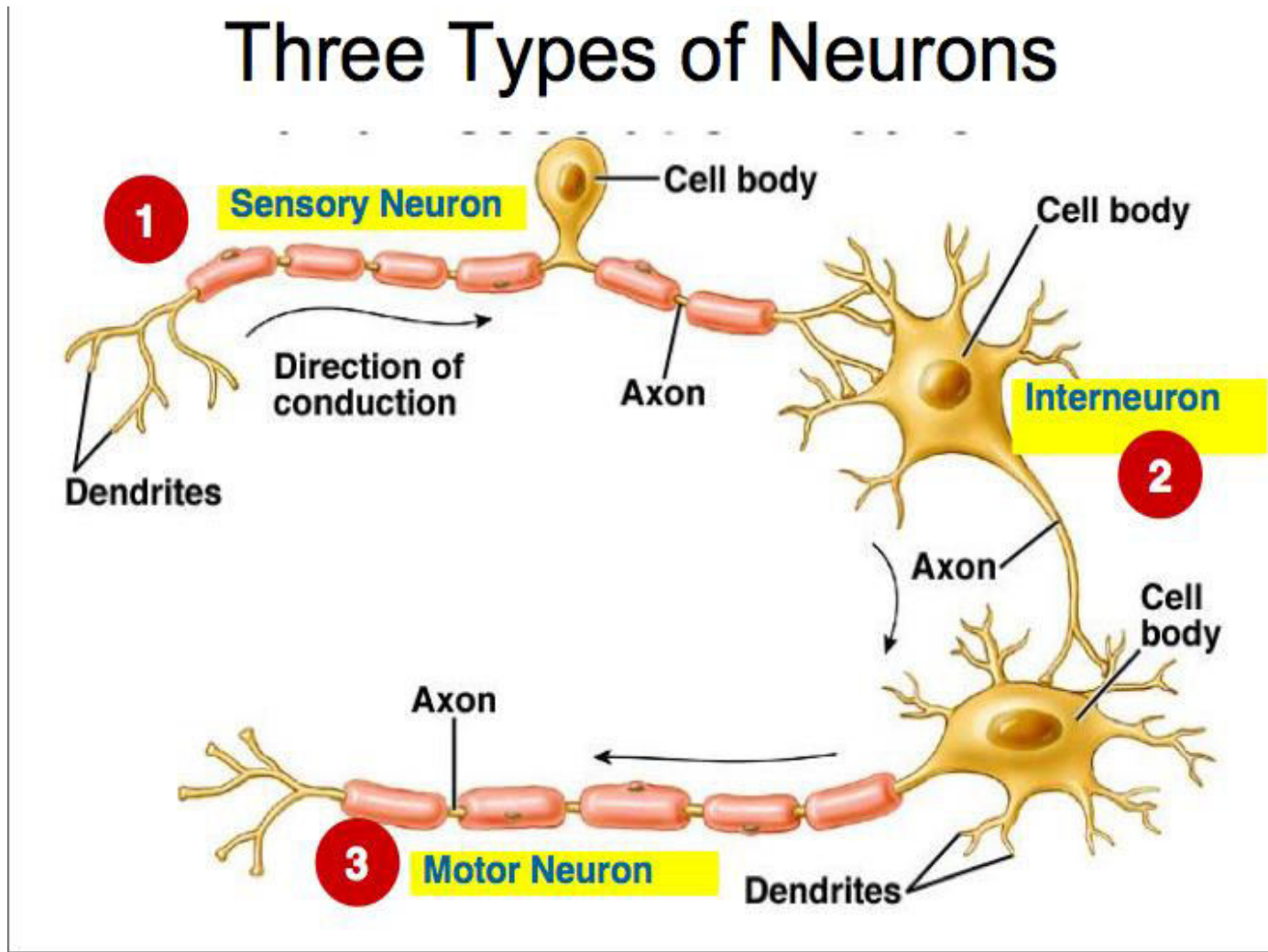
Structure of Different Kinds of Neurons I

- Neurons are composed of:
 - i) *Cell Body*
 - ii) *Dendrites*
 - iii) *Axon*
- Cell Body: Central body that contains Nucleus.
- Dendrites: Short thread like branches extending from cell body.
- Axon is a long cylindrical process that extends from cell body.

Structure of Different Kinds of Neurons I



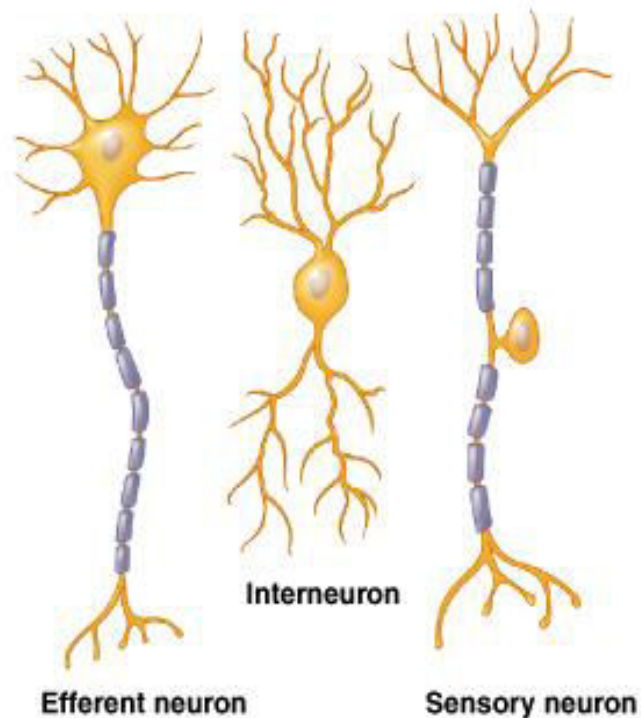
Structure of Different Kinds of Neurons I



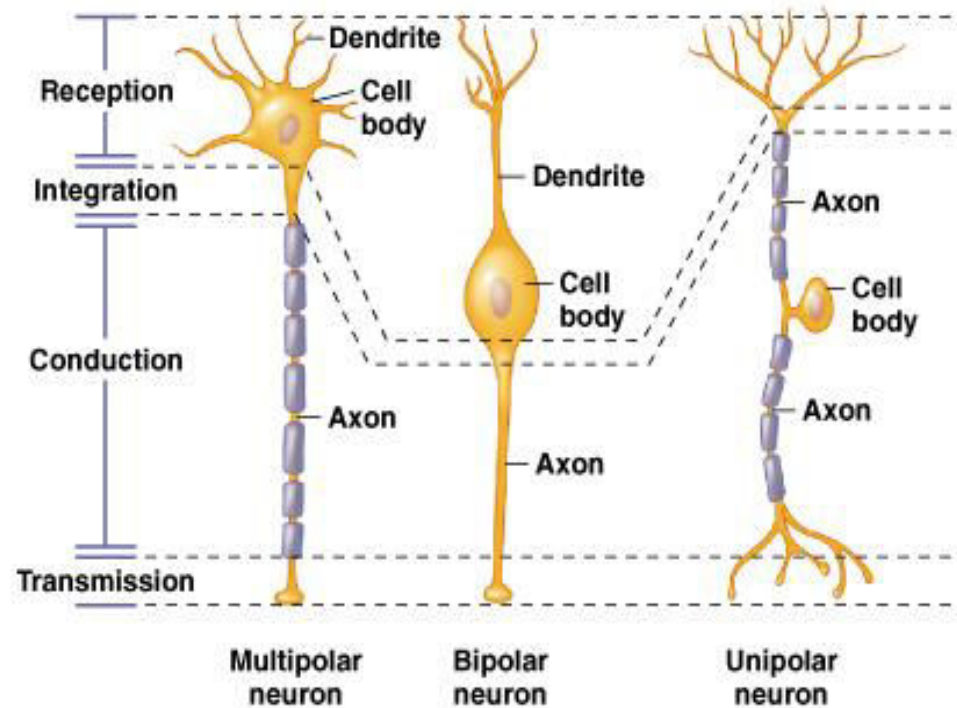
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Types of vertebrate neurons

Structure of Different Kinds of Neurons I

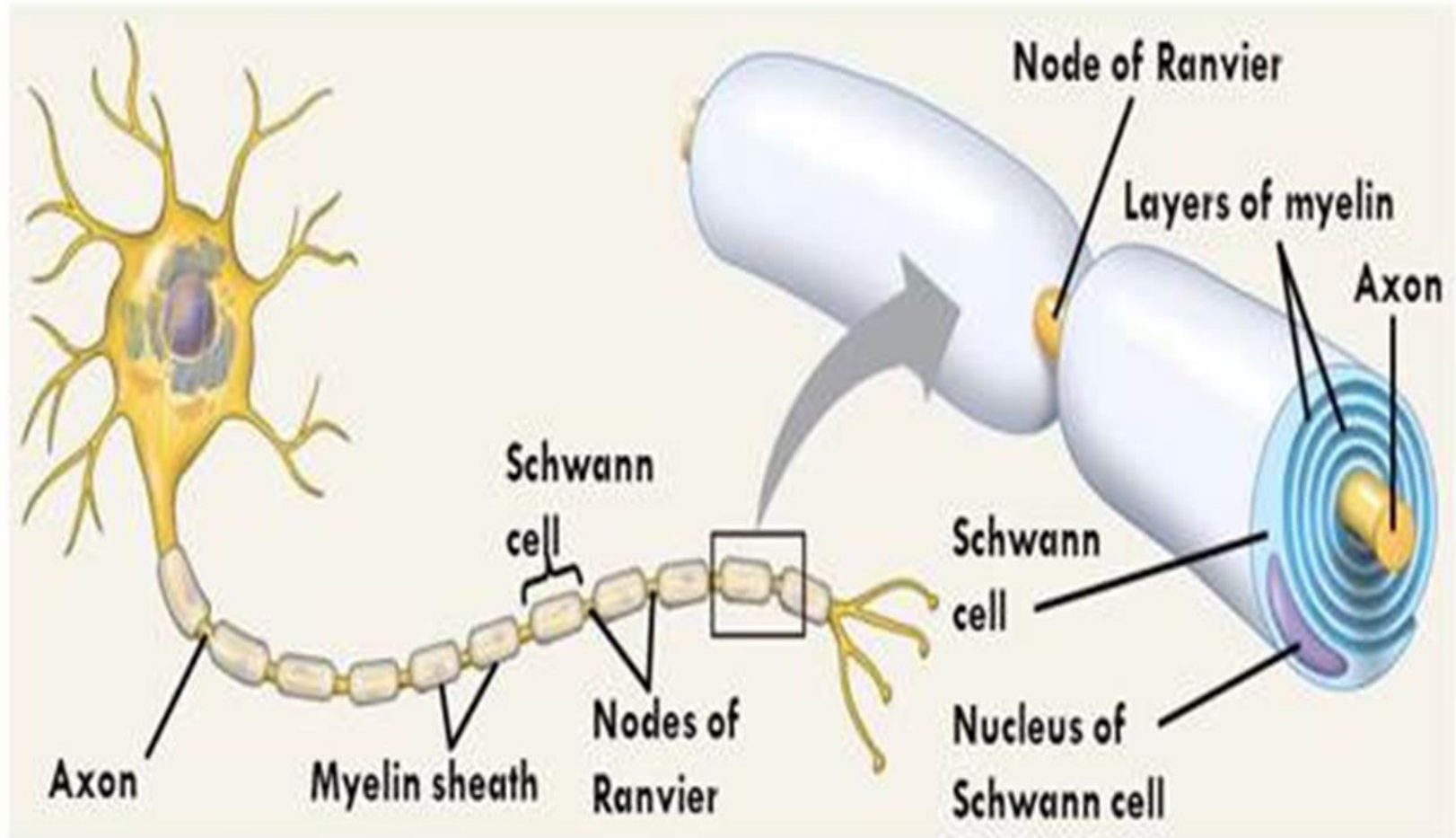


(b) Functional classes of neurons



(c) Structural classes of neurons

Structure of Different Kinds of Neurons I



j

Types of vertebrate neurons

Structure of Different Kinds of Neurons I

- Neurolemmocyte (Schwann Cell):

These are the chain of supporting cells that surround the axon forming insulation layer, the Myelin Sheath.

- Neurofibril node (Node of Ranvier):

A gap in the myelin sheath between adjacent Schwan Cells.

Structure of Different Kinds of Neurons I

Synapse:

Is the junction where the one neuron communicates with the other neuron or muscle or gland cell. Also called Neronal Junction.

END

Animal Form and Function

Module 40



Animal Form and Function 1

Structure of Different Kinds of Neurons II

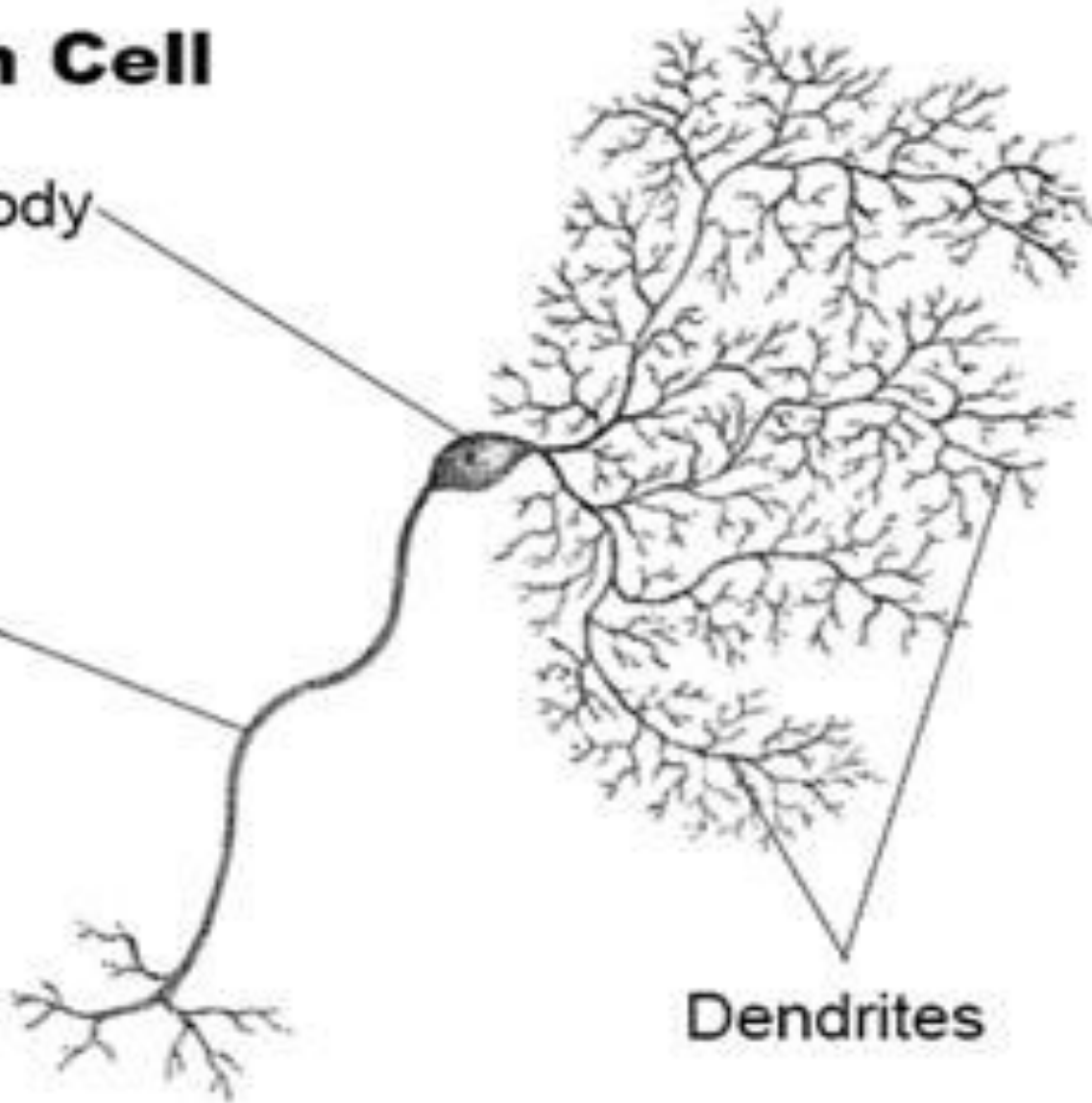
Structure of Different Kinds of Neurons II

Brain Cell

Cell body

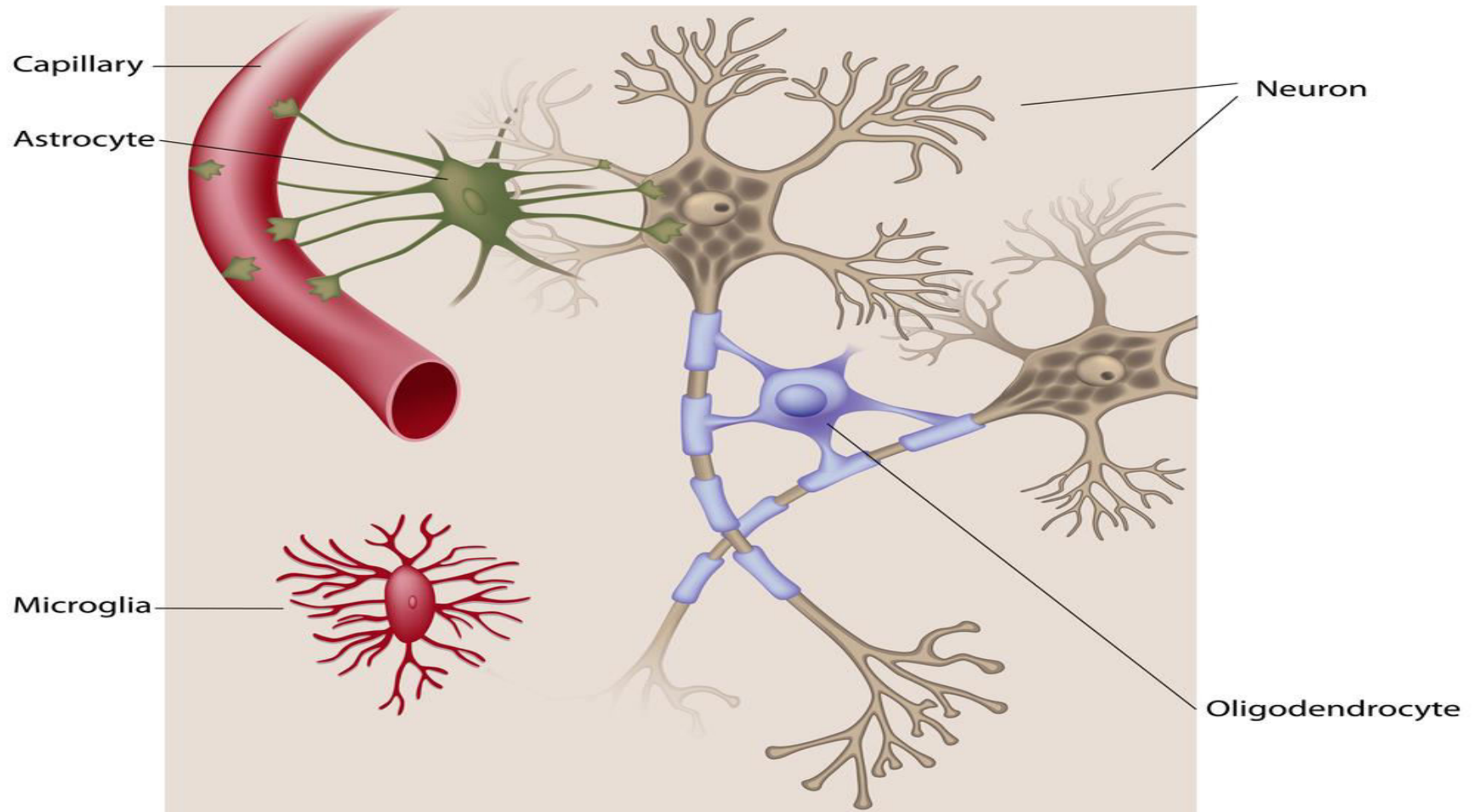
Axon

Dendrites



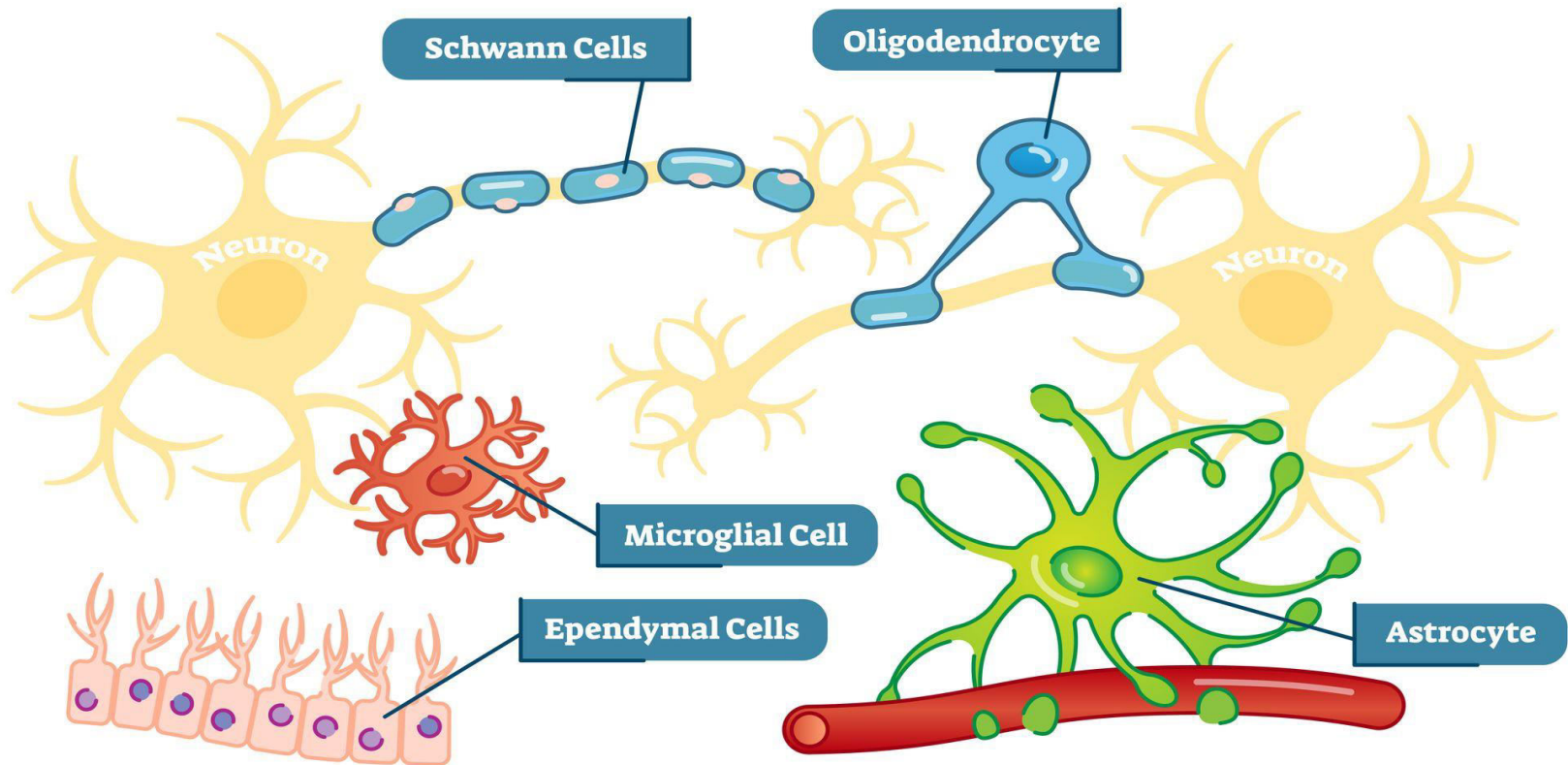
Structure of Different Kinds of Neurons II

Cells of the Central Nervous System



Structure of Different Kinds of Neurons II

Glial Cells



Structure of Different Kinds of Neurons II

They are thus known as the "supporting cells" of the nervous system.

Main functions of glial cells are:

- To surround neurons and hold them in place.
- To supply nutrients and oxygen to neurons,

Structure of Different Kinds of Neurons II

- To insulate one neuron from another, and
- To destroy and remove the carcasses of dead neurons (clean up).

END

Animal Form and Function

Module 41



Animal Form and Function

Resting and Action Potential

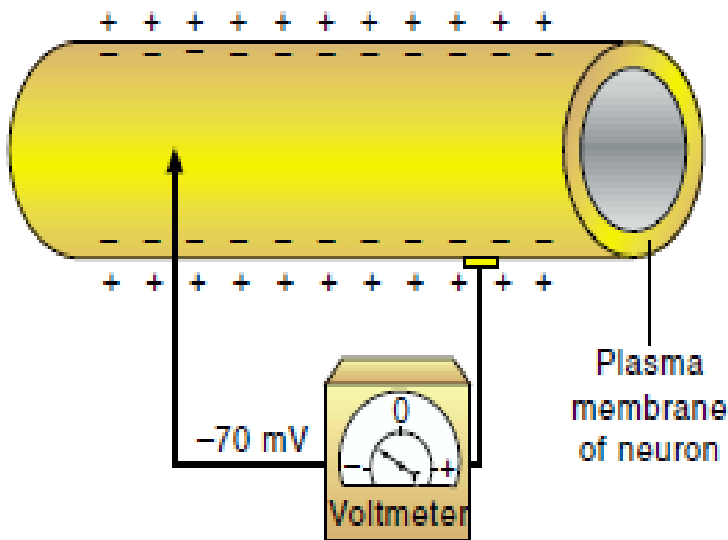
Resting and Action Potential

Resting Potential:

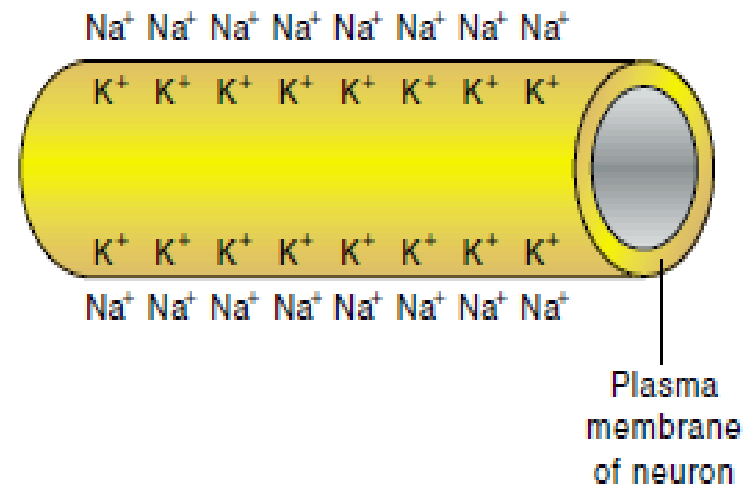
- The plasma membrane of neuron is polarized, Positive outside and negative inside.
- R/ potential is measured in mV i.e. 1/1000 volt.
- Normally R/potential is -70mV.

Resting and Action Potential

Resting Membrane Potential



Polarity



Distribution of ions

Resting and Action Potential

- The potential is due to unequal distribution of various electrically charged ions Na^+ and K^+ .
- Na ions are more outside than inside K ions. Cl ions and negative protein are also more concentrated inside.

Resting and Action Potential

- The pump works to establish the resting potential -70 mV across the membrane.

Resting and Action Potential

Action Potential:

- When a threshold stimulus is applied to a point along the resting plasma membrane the permeability of Na^+ ions increases at that point.
- This causes the Resting Potential from -70mV towards 0.

Module 42



Animal Form and Function 1

Ion Channel and Sodium Potassium Pump

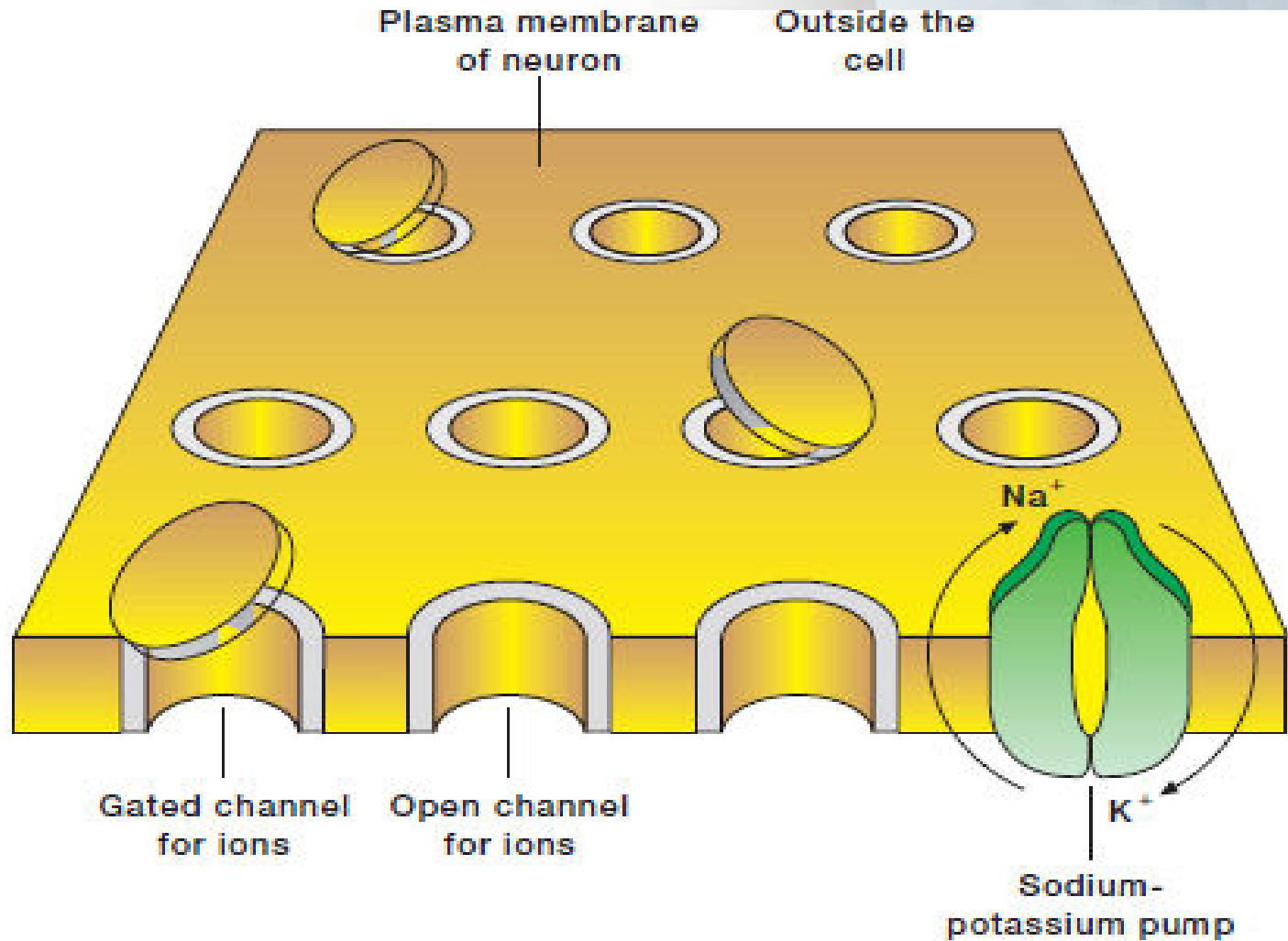
Ion Channel and Sodium Potassium Pump

- However, the concentration of Na and K ions remain constant on both sides of the membrane.
- This is due to the action of Na, K, ATPase pump, which is powered by ATP.
- The pump actively moves 3 Na ions out for each 2 K in.

Ion Channel and Sodium Potassium Pump

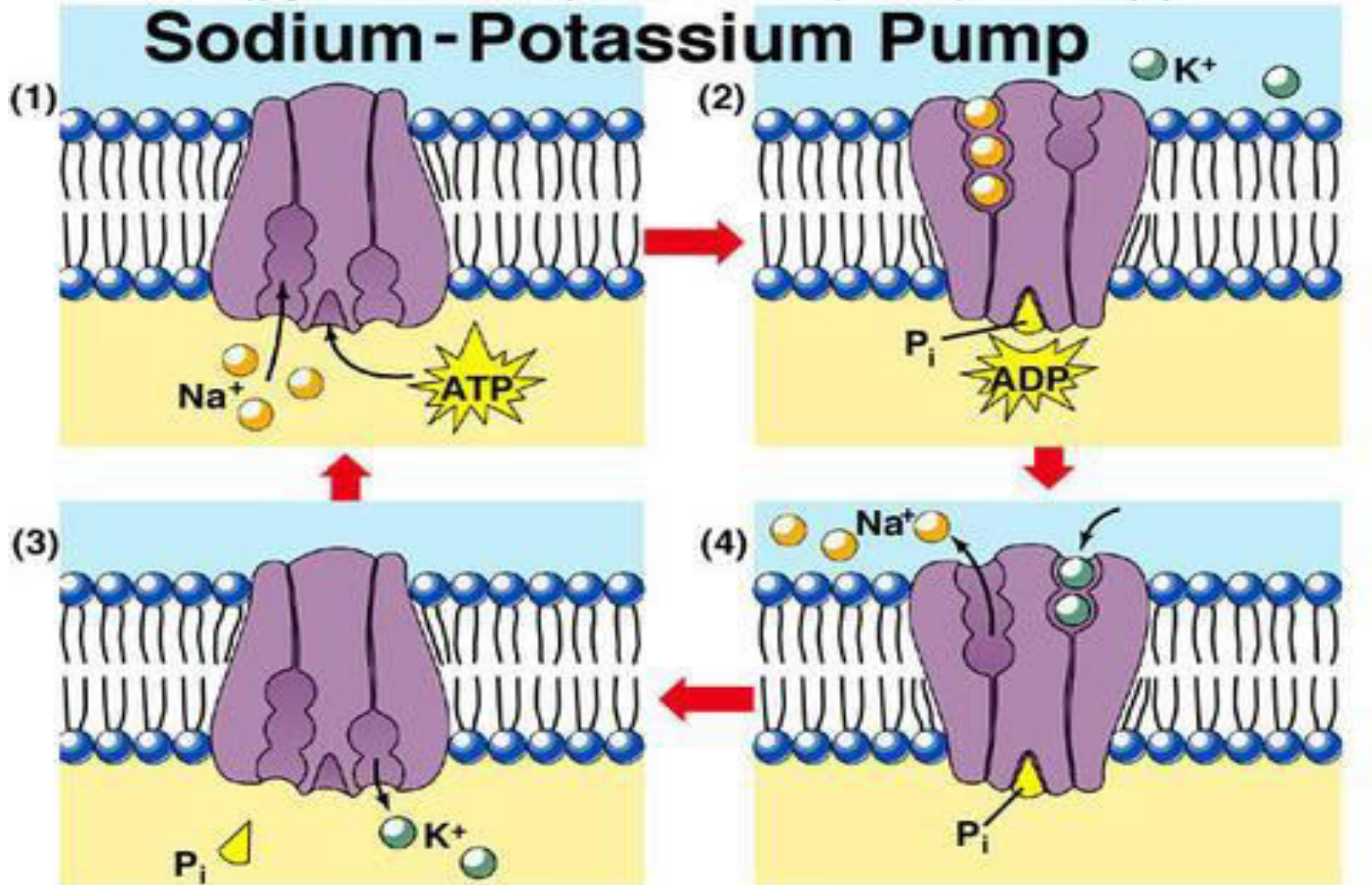
- This loss in membrane polarity is called **depolarization**.
- When depolarization reaches a certain level special Na Channels quickly open and more Na ions rush to the inside and K ions diffuse outside.
- This movement of K outside the cell build up the +ve charge again

Ion Channel and Sodium Potassium Pump



Ion Channel and Sodium Potassium Pump

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Ion Channel and Sodium Potassium Pump

- This movement of K^+ outside the cell build up the +ve charge again.
- This causes the membrane repolarized.

Ion Channel and Sodium Potassium Pump

The Sodium-Potassium Pump ($\text{Na}^+/\text{K}^+ - \text{ATPase}$)

- A specific case of **active transport**
- This is one of the *best examples* of active transport in animal cells
- This pump transports Na^+ ions *out* of the cell and K^+ ions *into* the cell. Thus keeping the intracellular concentration of Na low compared to outside, and the intracellular concentration of K high
- The pump is driven by hydrolysis of ATP
- It uses about 30% of the energy available to any one animal cell!
- The pump is a **transmembrane carrier protein** made up of 4 subunits (2 large and 2 small)

Animal Form and Function

Module 43



Animal Form and Function 1

An abstract architectural sculpture made of large, light-colored, angular blocks and panels, some of which are curved or folded, creating a complex, organic form. The sculpture is set against a background of a modern building with large windows and a clear blue sky.

Nerve Impulse

Nerve Impulse

- It is a wave of electrochemical change.
- Or
- It is the transmission of an action potential along the neuron plasma membrane.
 - It is a wave of depolarization and repolarization.

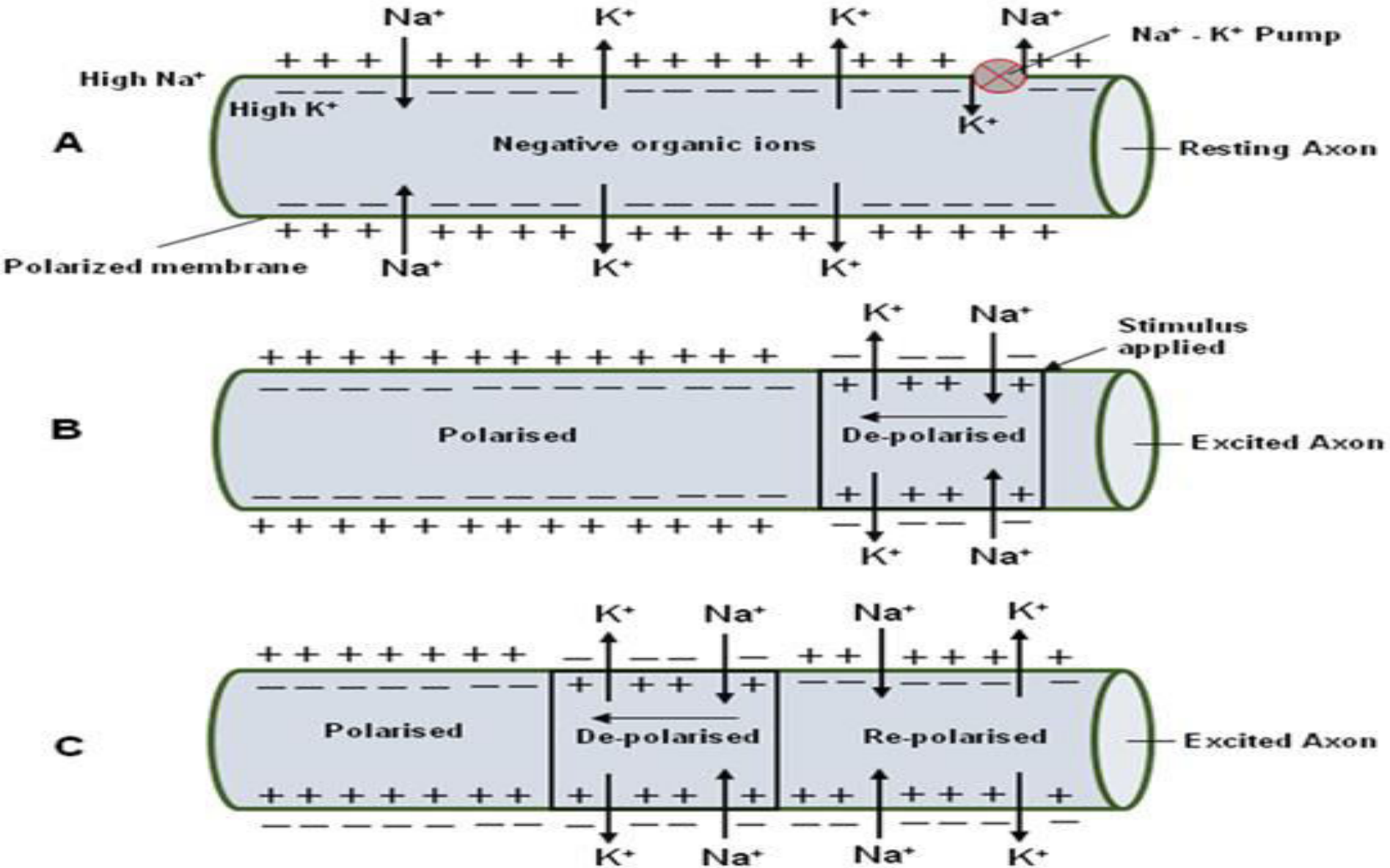
Nerve Impulse

- After each A/Potential, there is an interval of time when it is more difficult for another action potential to occur because the membrane has become hyperpolarized (more -ve than -70 mV).
- This brief period is called **refractory period**.

Nerve Impulse

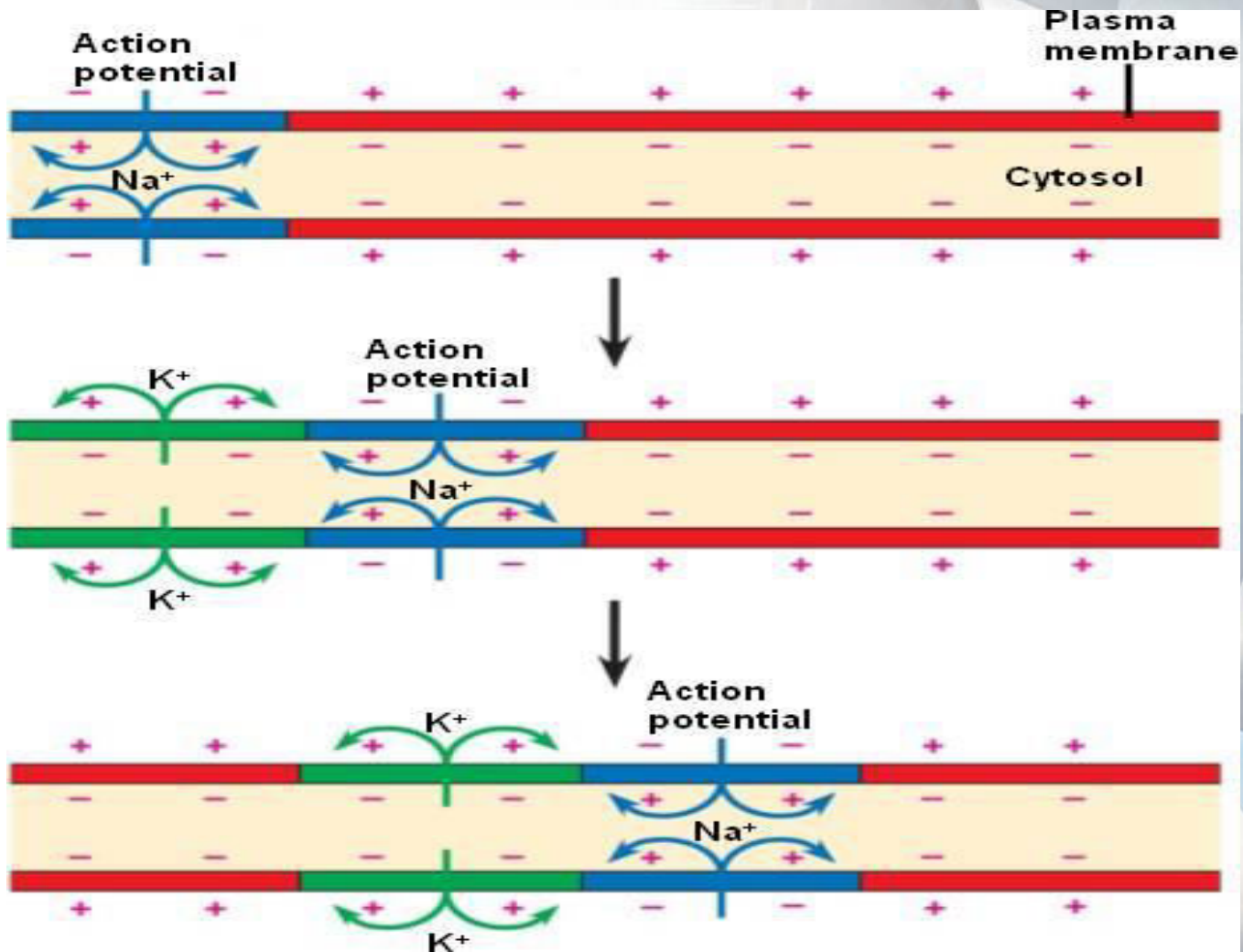
- **All or none principle:**
The principle states that an axon will 'fire' at full power or not at all.
- **Saltatory conduction:**
Action Potential jump from one node to the next node. This conduction along the myelinated fibers is called Saltatory conduction

Nerve Impulse

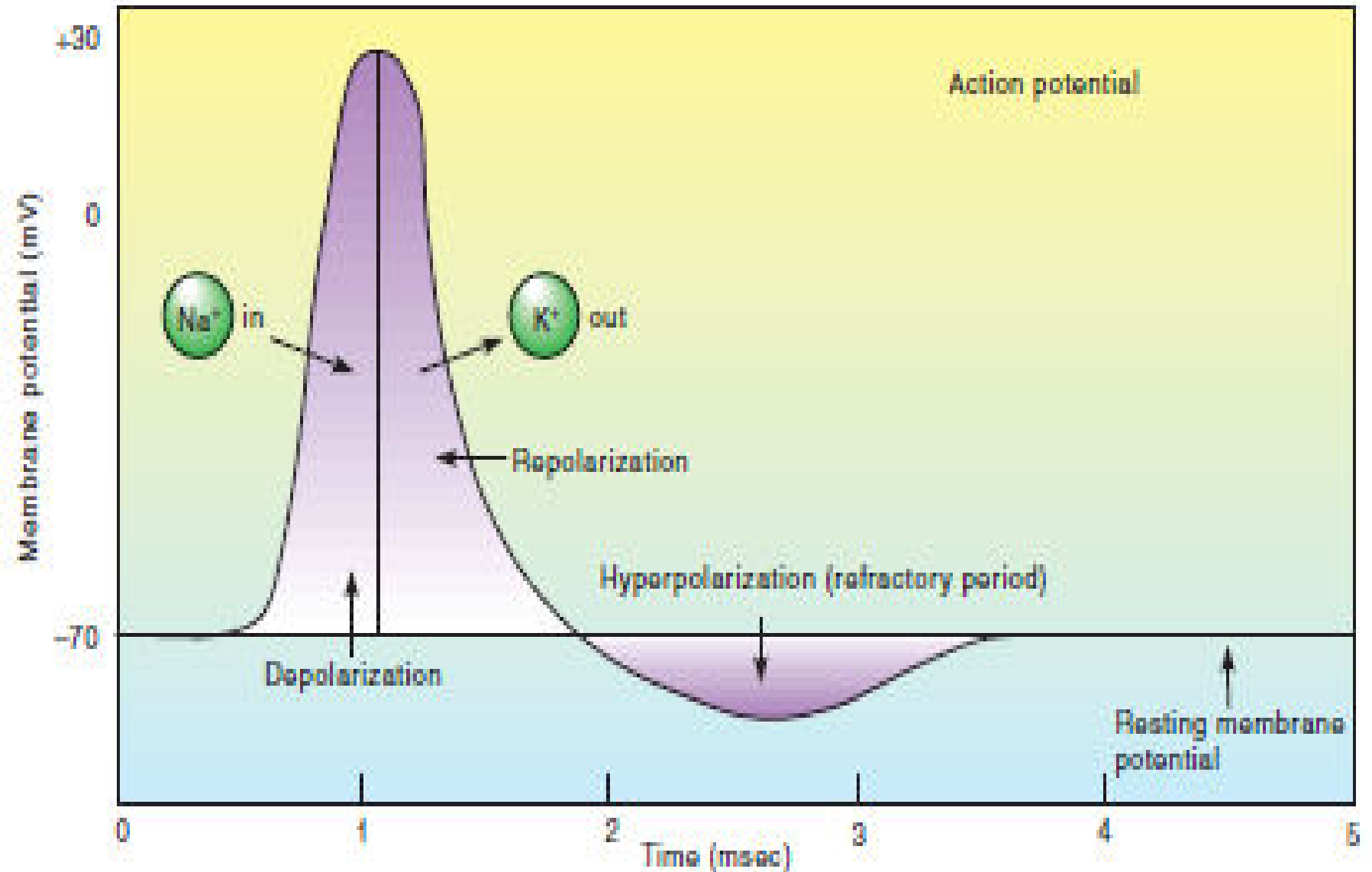


Nerve Impulse

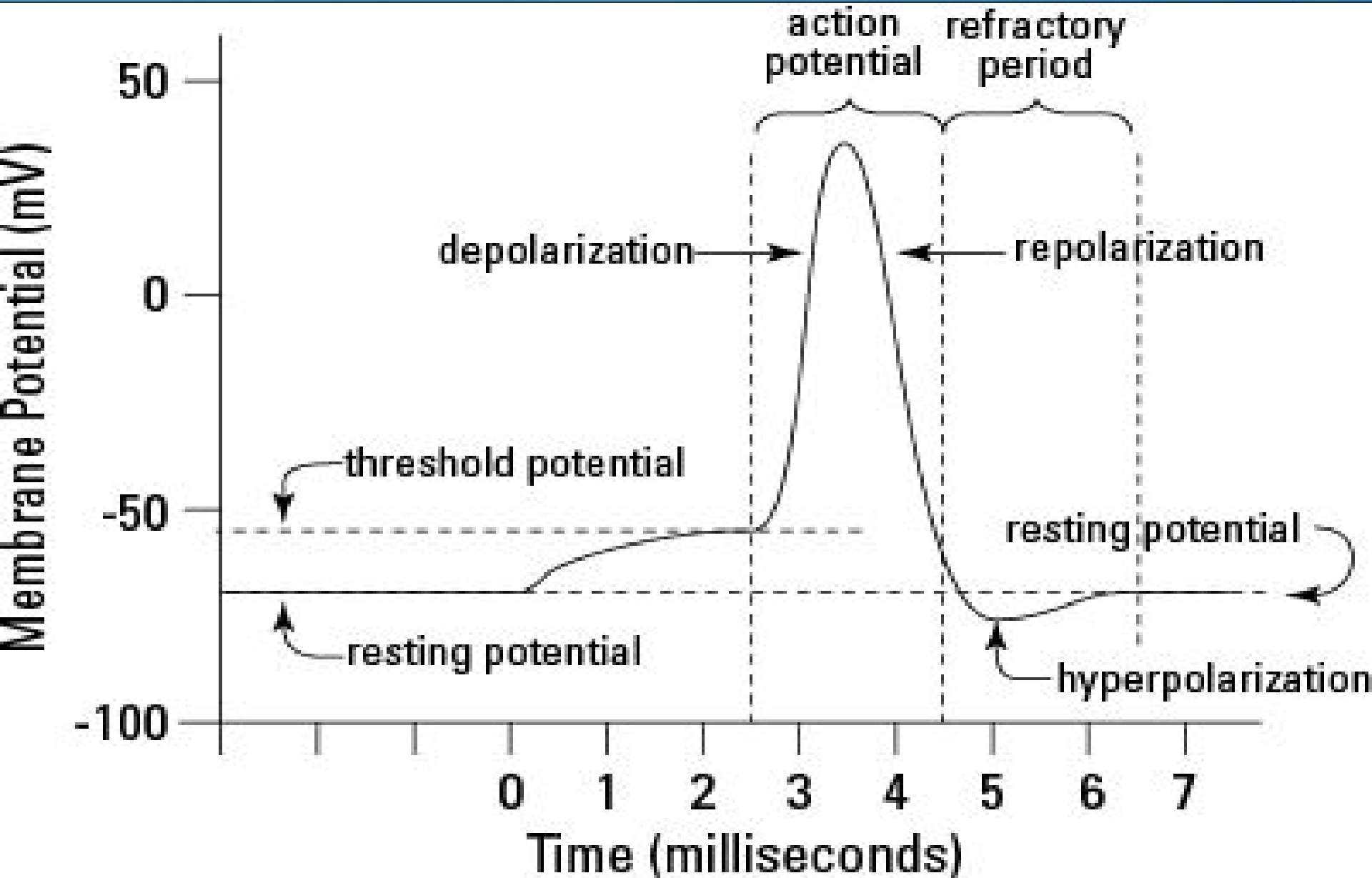
Propagation of Nerve Impulse



Nerve Impulse



Nerve Impulse



Animal Form and Function

Module 44



Animal Form and Function 1

**Synapse And Its
Role In Nervous
System**

Synapse & Its Role In Nervous System

Definition of Synapse:

- It is the junction between two adjacent neurons.
- There is no cytoplasmic connection between the two neurons.
- A microscopic gap or synaptic cleft is present between them.

Synapse & Its Role In Nervous System

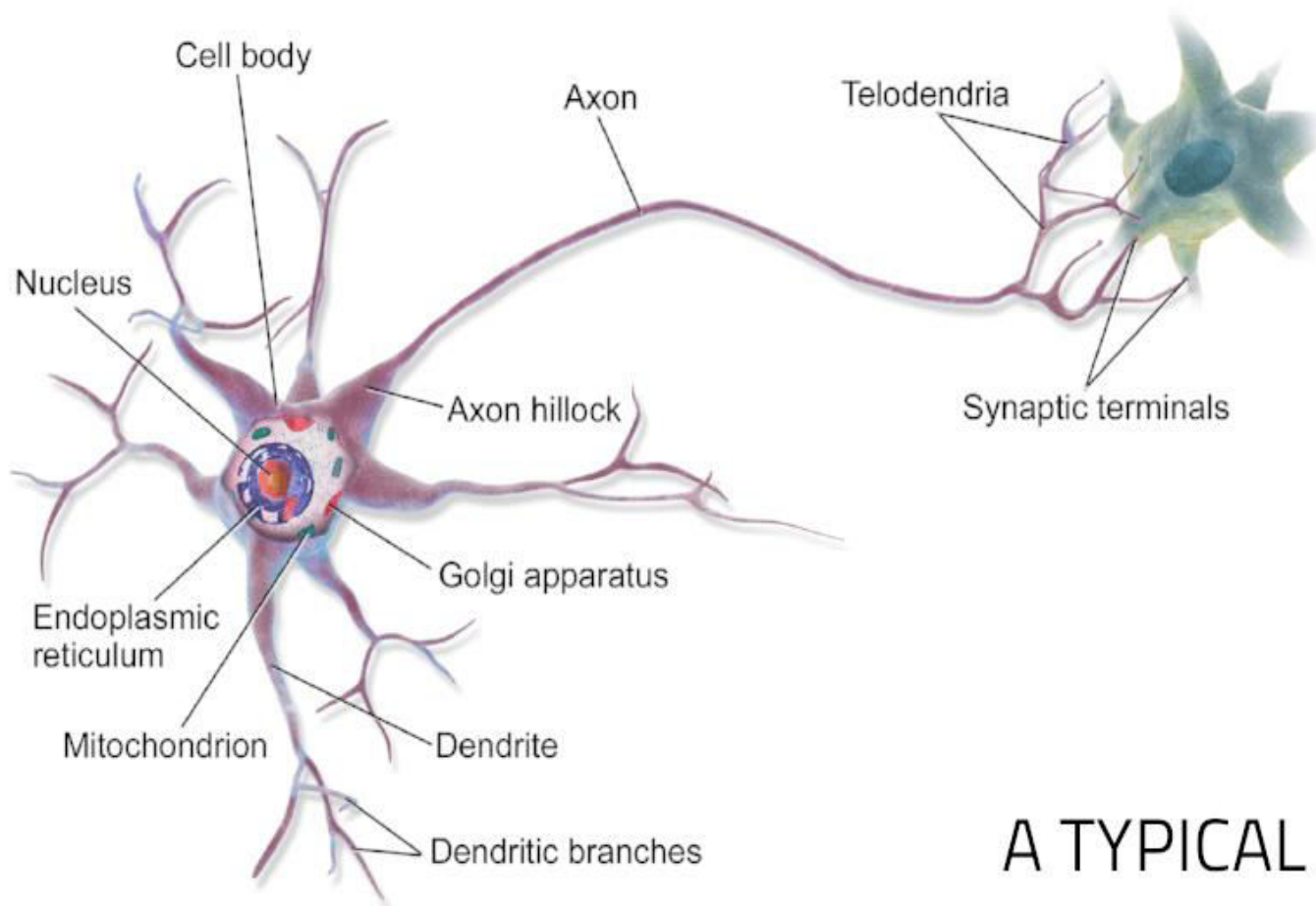
- The cytoplasmic knob contains numerous mitochondria and small vesicles (50 nm)
- The vesicles contain neurotransmitter substance Acetyl - choline
- There is 20 nm gap called synaptic cleft between pre and post synaptic membranes.

Synapse & Its Role In Nervous System

Transmission of action potential:

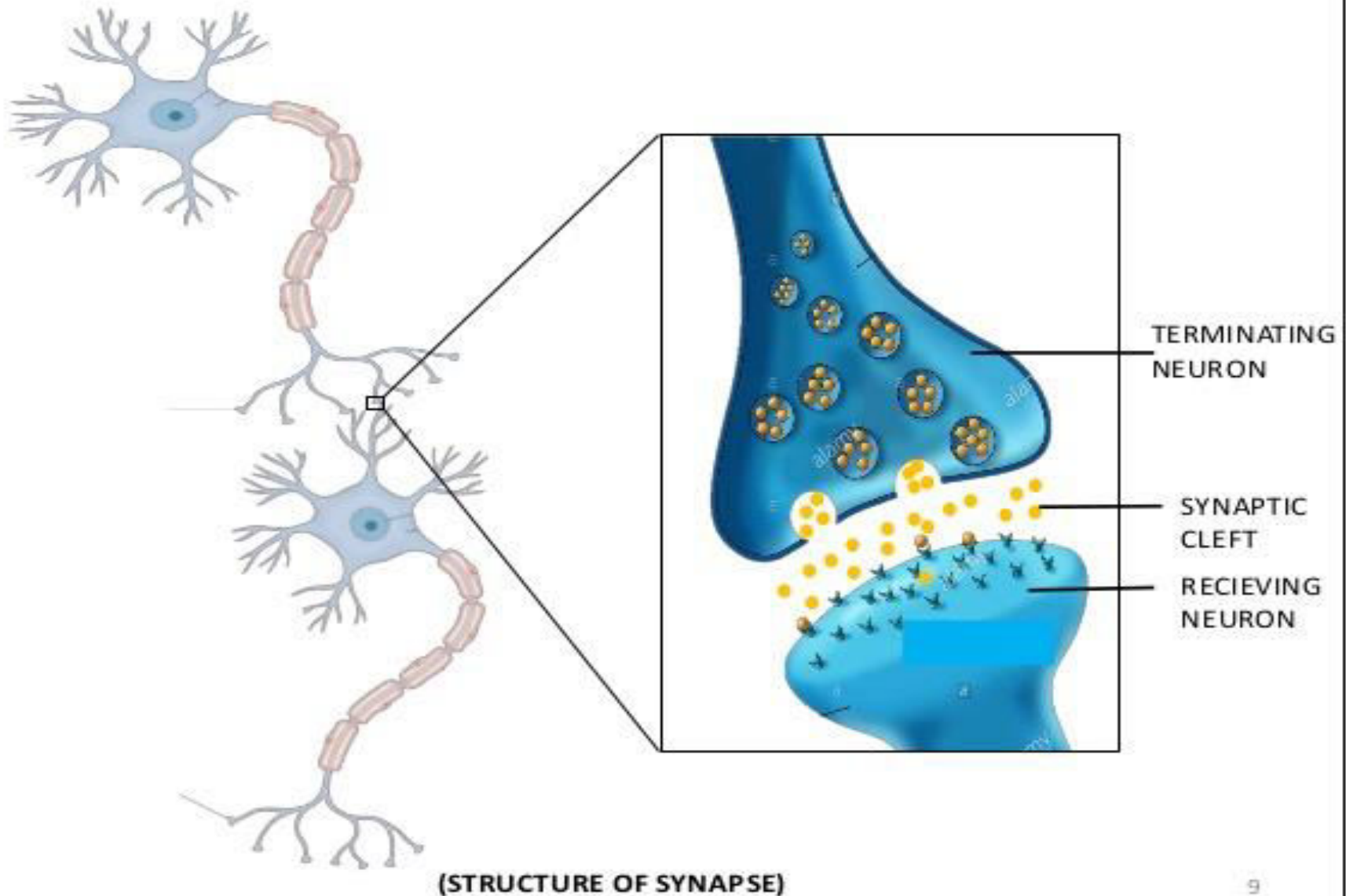
- On reaching the nerve impulse at the Pre synaptic knob, the vesicle release the neurotransmitter into synaptic cleft.
- The neurotransmitter molecules bind to the receptor on the post synaptic membrane

Synapse & Its Role In Nervous System

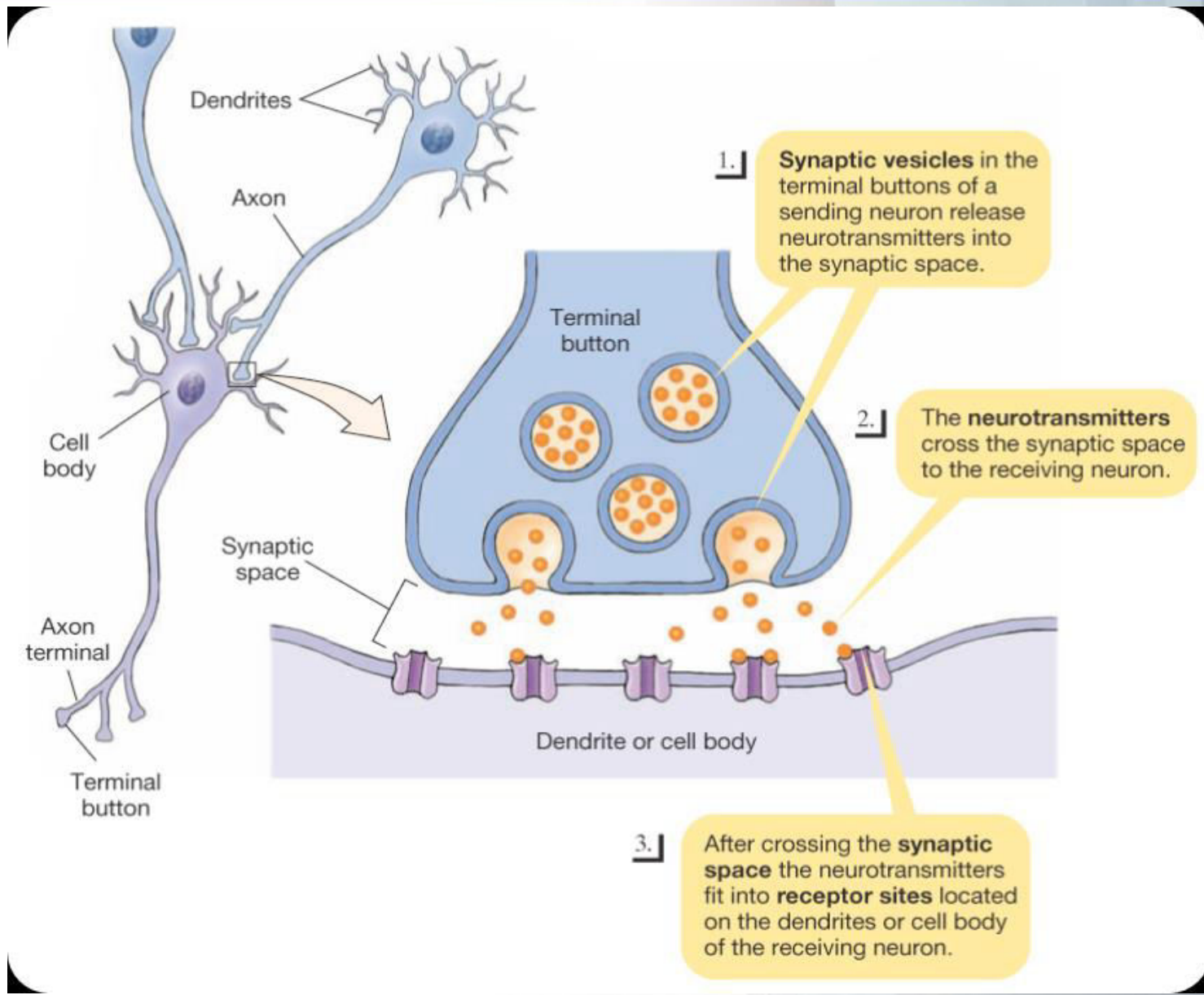


A TYPICAL NEURON

Synapse & Its Role In Nervous System



Synapse & Its Role In Nervous System



Synapse & Its Role In Nervous System

- This triggers action potential in the post synaptic neuron.
- Presynaptic membrane is always of a neuron but the postsynaptic membrane can be a neuron, muscle or gland.

Nerve Impulse

Functions of Synapse:

- Allow strong signals to pass
- Block weak signals
- Select and amplify weak signals.
- Channel the signals in many directions

Animal Form and Function

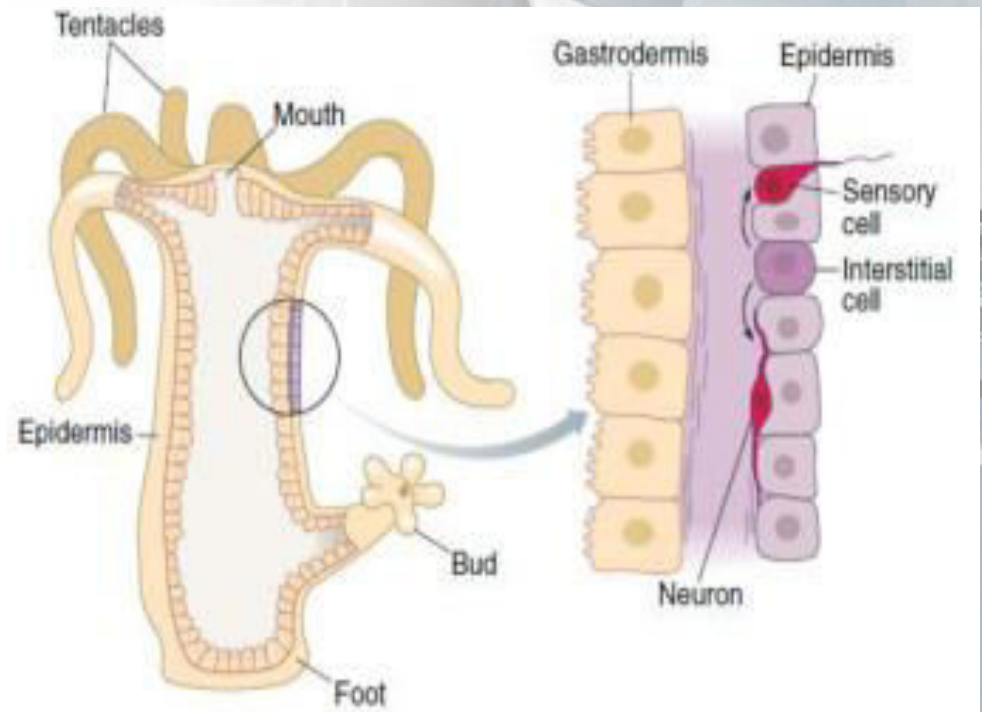
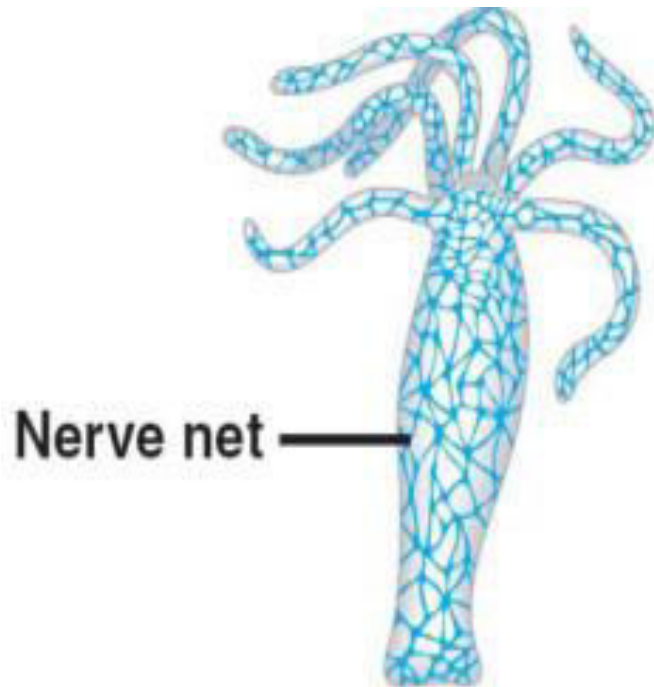
Module 45



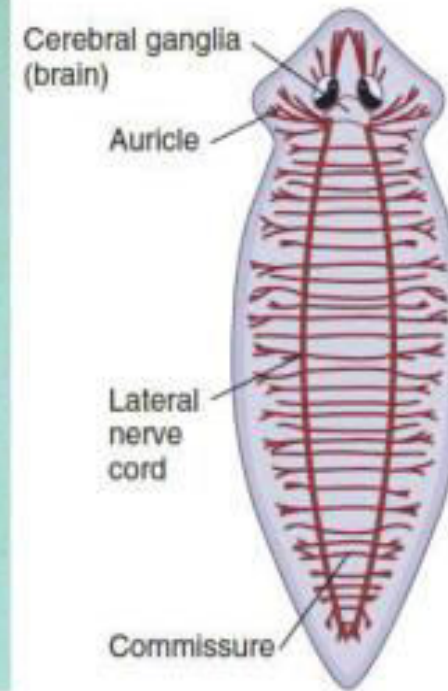
Animal Form and Function 1

Nervous System of Some Invertebrates

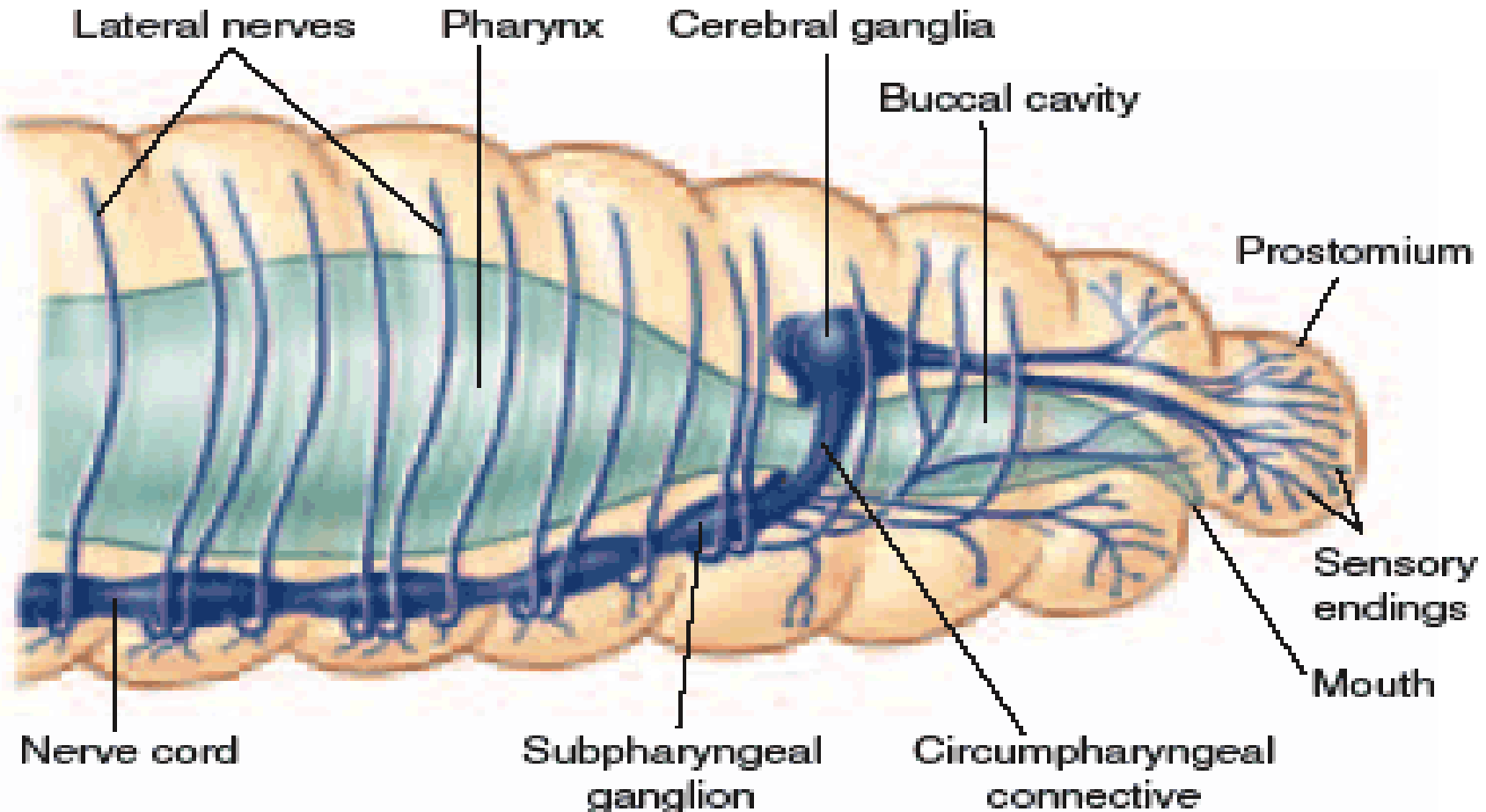
Nervous System of Invertebrates I



Nervous System of Invertebrates I



Synapse & Its Role In Nervous System



Anterior portion of earthworm and its nervous system. Note concentration of sensory endings in this region.

Animal Form and Function 1

Module 46



Animal Form and Function 1

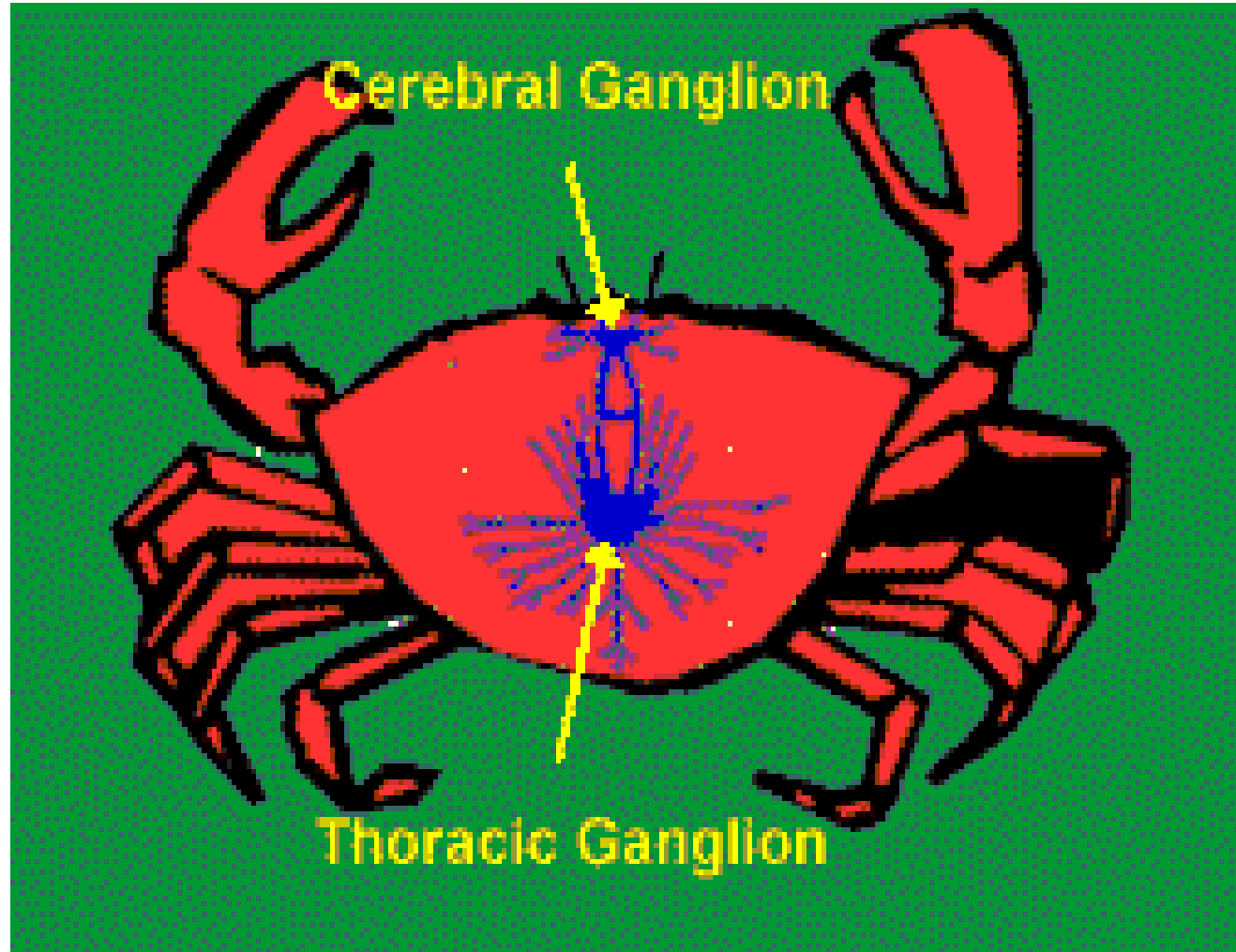
Nervous System of some Invertebrates II

Nervous System of Invertebrates II

- NS in crab differs from that of vertebrates (mammals, birds, fish, etc.) in that it has a dorsal ganglion (brain) and a ventral ganglion.
- The ventral ganglion provides nerves to each walking leg and all of their sensory organs.

Nervous System of Invertebrates II

Crab

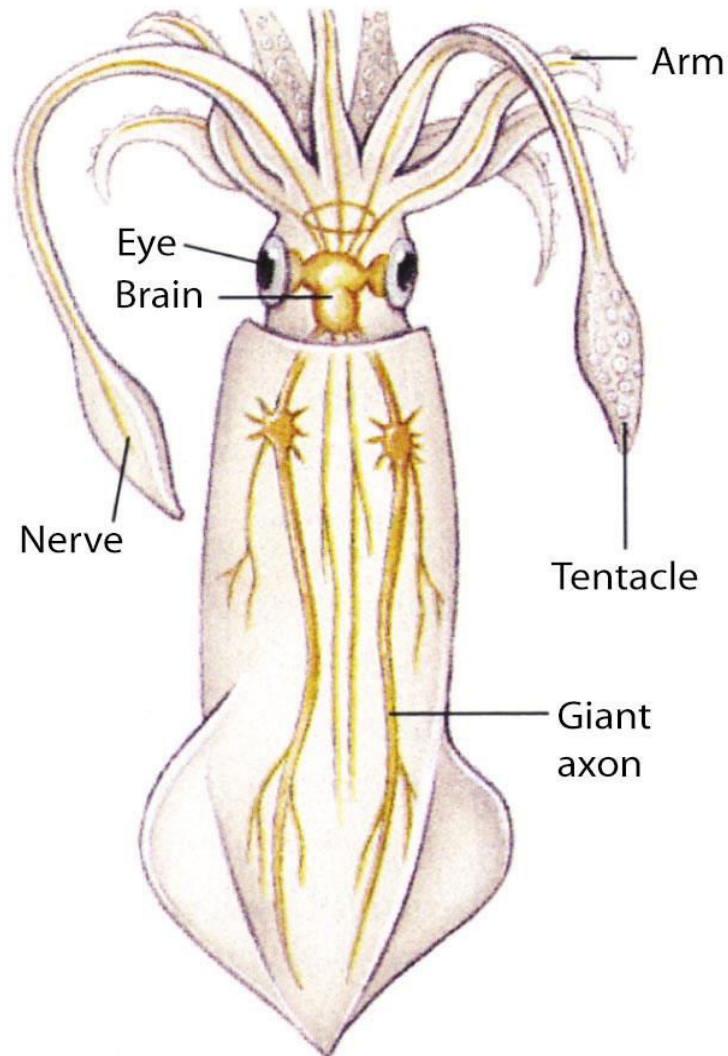


Nervous System of Invertebrates II

- **Cephalopods** have the most highly developed nervous systems among invertebrates.
- Squids have a complex brain in the form of a nerve ring encircling the esophagus, enclosed in a cartilaginous cranium.
- Neuron size in squid is one meter long and one mm in diameter.

Nervous System of Invertebrates II

Squid



Nervous System of Invertebrates II

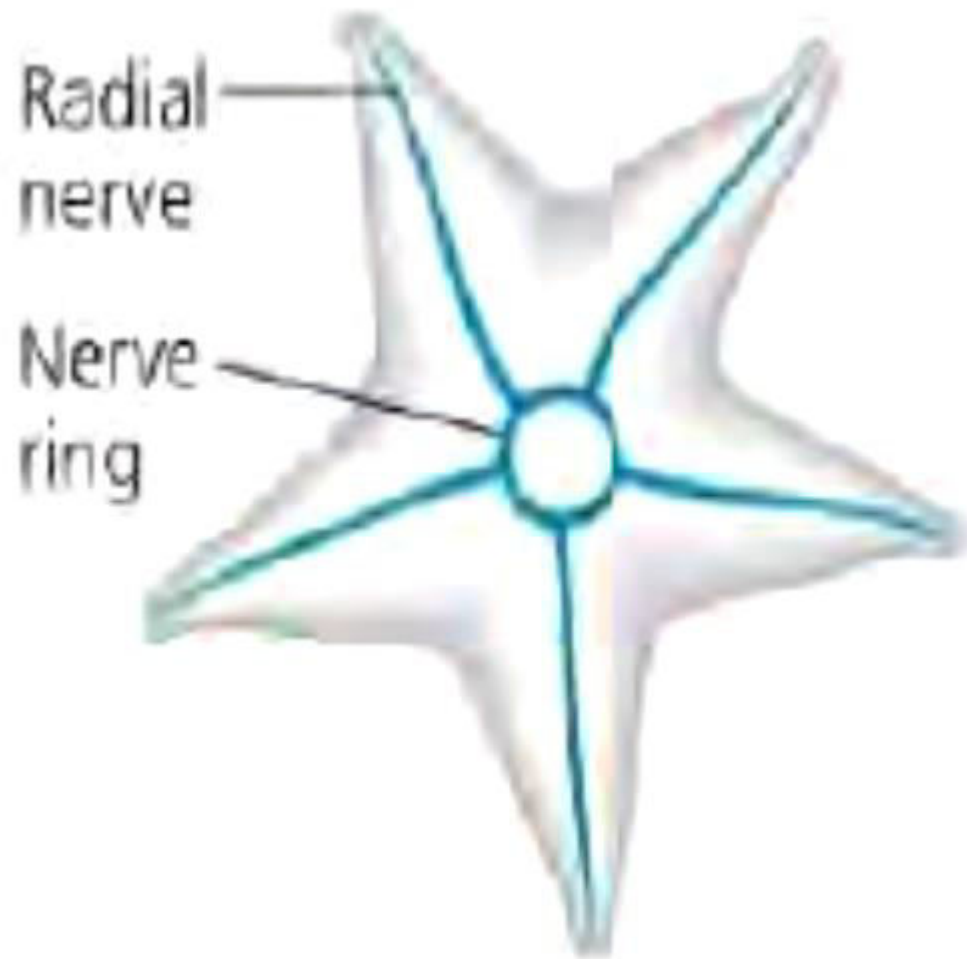
- The nervous system of the starfish is very simple.
- There is no brain and not even any ganglia to coordinate movement.
- The nervous system is characterized by a nerve ring that surrounds the mouth.
- A radial nerve branches off of the nerve ring and extends to each arm.

Nervous System of Invertebrates II

Synapse & Its Role In Nervous System

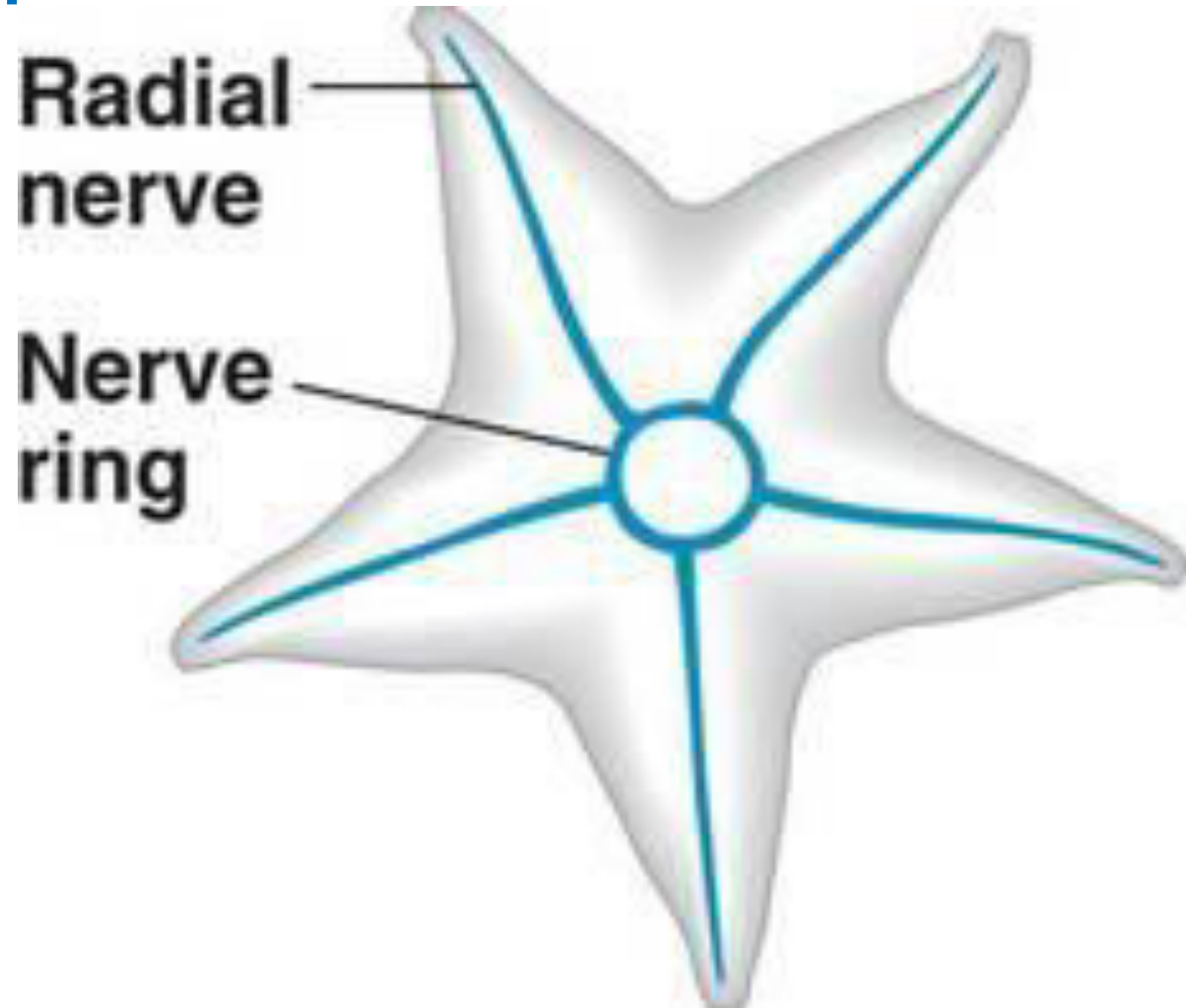
- **Ectoneural system:**
- **Pertaining to the oral part of the nervous system.**
- **Hyponeural system:**
- **Part of the nervous system deeper and more weakly developed than the ectoneural system..**

Nervous System of Invertebrates II



Nervous System of Invertebrates II

Star fish



Nervous System of Invertebrates II



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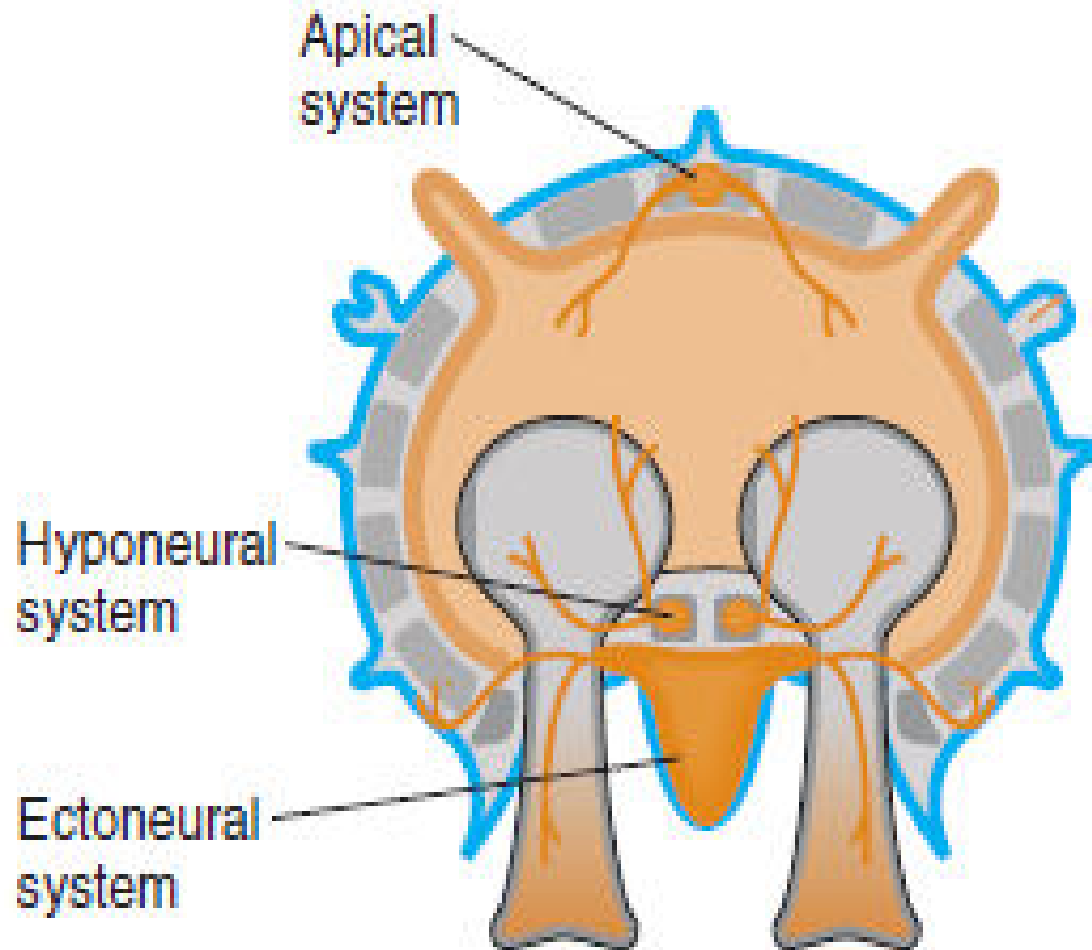
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Nervous System of Invertebrates II

Synapse & Its Role In Nervous System



Animal Form and Function 1

Module 47



Animal Form and Function 1

Nervous System in Vertebrates: Basic Organization

Nervous System in Vertebrates: Basic Organization

Characters of Vertebrate Nervous System:

- Bilateral Symmetry
- Notochord
- Tubular Nerve cord

Nervous System in Vertebrates: Basic Organization

Bilateral Symmetry:

- A body form which is divided into two equal but opposite halves with a central longitudinal plane.

Notochord:

- A rod of mesodermally derived tissue encased in a firm sheath, located ventral to neural tube.

Nervous System in Vertebrates: Basic Organization

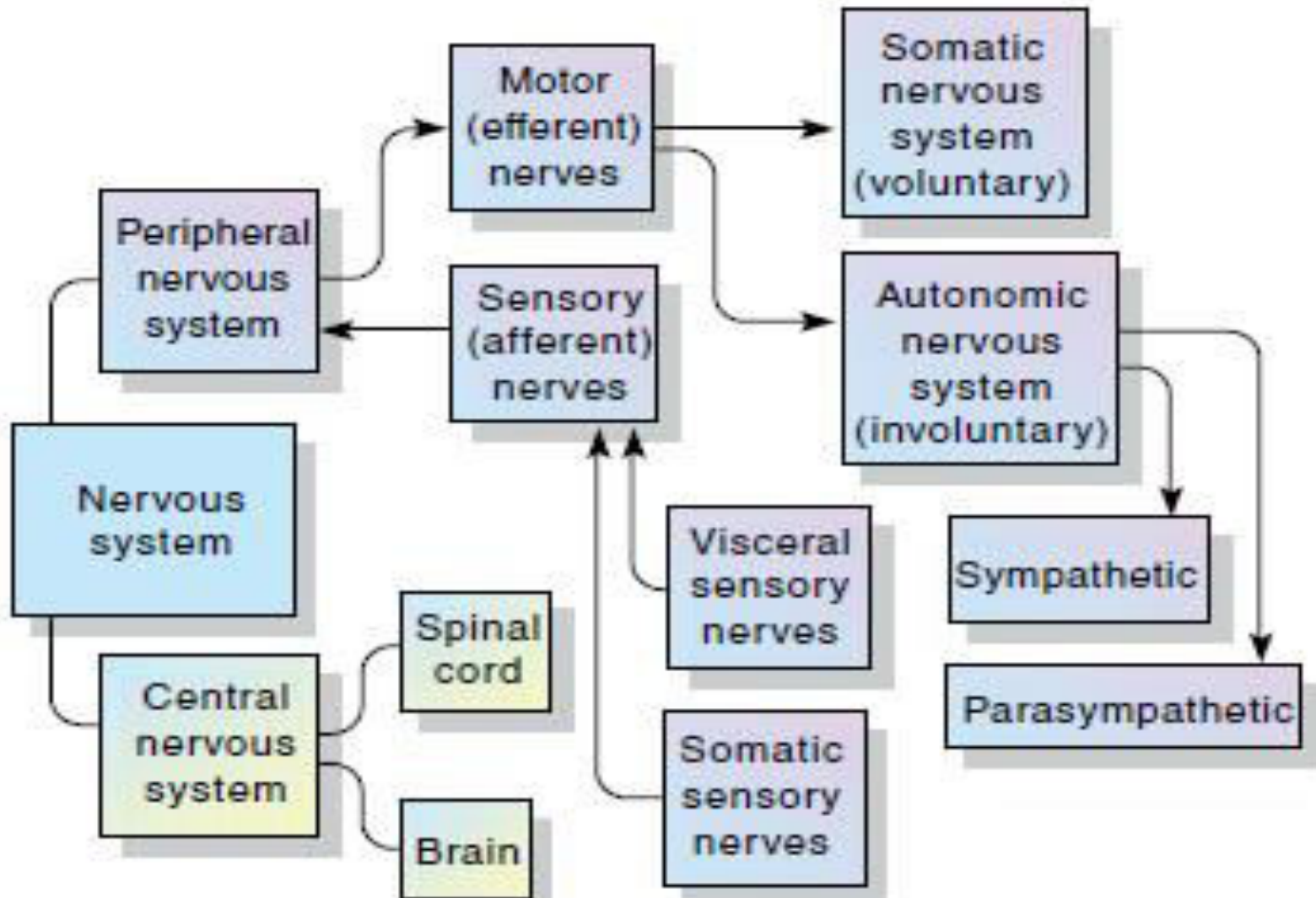
- First appeared in marine chordates and is present in all vertebrate embryos and is greatly reduced or absent in adults.
- In vertebrates vertebral column replace the notochord.
- VC led to the development of strong muscles.

Nervous System in Vertebrates: Basic Organization

Tubular Nerve Cord:

- It is a tube like structure which underwent expansion, modification and specialization into spinal cord and brain.
- Overtime the anterior end thickened with nervous tissue and divided into fore, mid and hind brain.

Nervous System in Vertebrates: Basic Organization



Nervous System in Vertebrates: Basic Organization

NS has two main divisions:

- CNS (Brain and Spinal cord)
- PNS (Peripheral NS): All the nerves of the body outside the brain and SC.
- Nerves are commonly divided into Sensory (afferent) and Motor (Efferent) nerves.

Nervous System in Vertebrates: Basic Organization

- Motor nerves divide into:
- **Voluntary Nerves** (Somatic) and
- **Involuntary Nerves** (Visceral or autonomic)

Nerves of autonomic NS divide into:

Sympathetic and Parasympathetic NS.

Nervous System in Vertebrates: Basic Organization

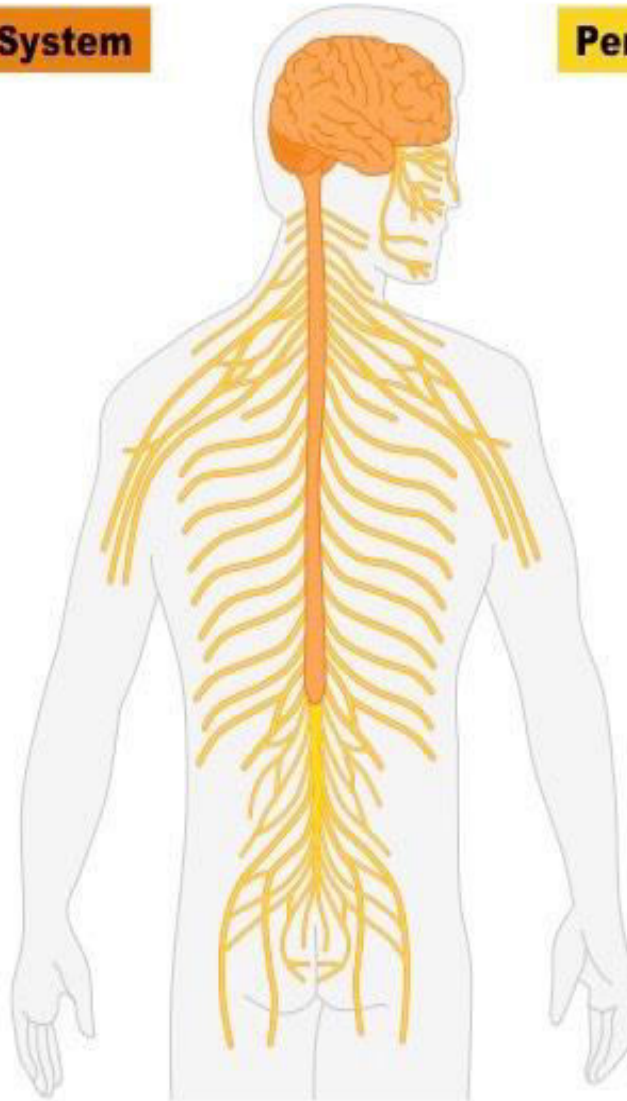
Central Nervous System

Composed of:

- Brain
- Spinal cord

Contains:

- Relay neurons (interneurons)



Peripheral Nervous System

Composed of:

- Cranial nerves
- Spinal nerves
- Peripheral nerves

Contains:

- Sensory neurons
- Motor neurons

Animal Form and Function 1

Module 48



Animal Form and Function 1

Spinal Cords and Spinal Nerves of Vertebrates

Spinal Cords and Spinal Nerves of Vertebrates

Spinal cord:

- It extends through hollow opening in each vertebra in the vertebral column.
- In cross section the spinal cord shows neural canal that contains cerebrospinal fluid.
- Gray matter ,which consists of cell bodies and dendrites

Spinal Cords and Spinal Nerves of Vertebrates

- White matter contains nerve processes and axon.
- Extending from the spinal cord are dorsal and ventral roots, which contain sensory and motor fibers respectively.
- Meninges (sing meninx) surround the spinal cord

Spinal Cords and Spinal Nerves of Vertebrates

- Dura mater-tough and fibrous
- Arachnoid- delicate
- Pia mater-contain blood vessels that nourish the Spinal cord.

Spinal Cords and Spinal Nerves of Vertebrates

Spinal Nerves:

- The number of spinal nerves is related with the number of segments in the trunk and of a vertebrate.
- For example
- In frog there are only 10 pairs of spinal nerves. In snake due long trunk and tail have several hundred pairs.

Spinal Cords and Spinal Nerves of Vertebrates

Spinal Cord and Peripheral Nervous System

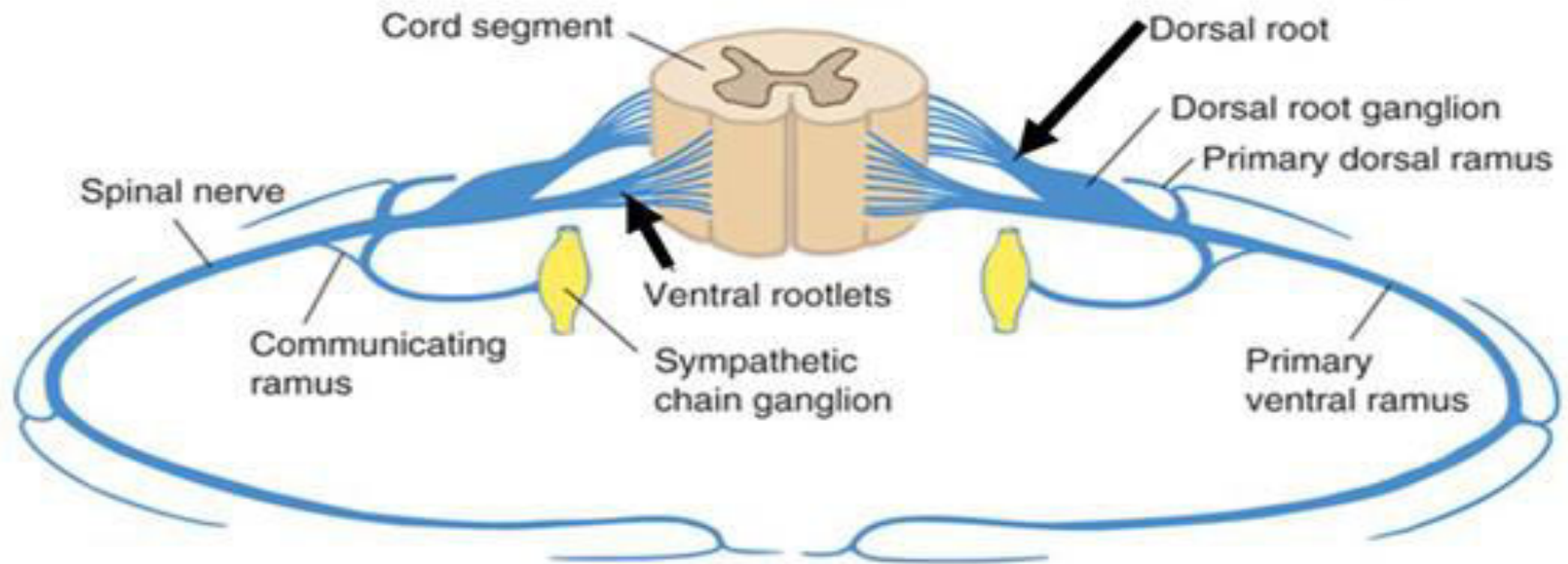
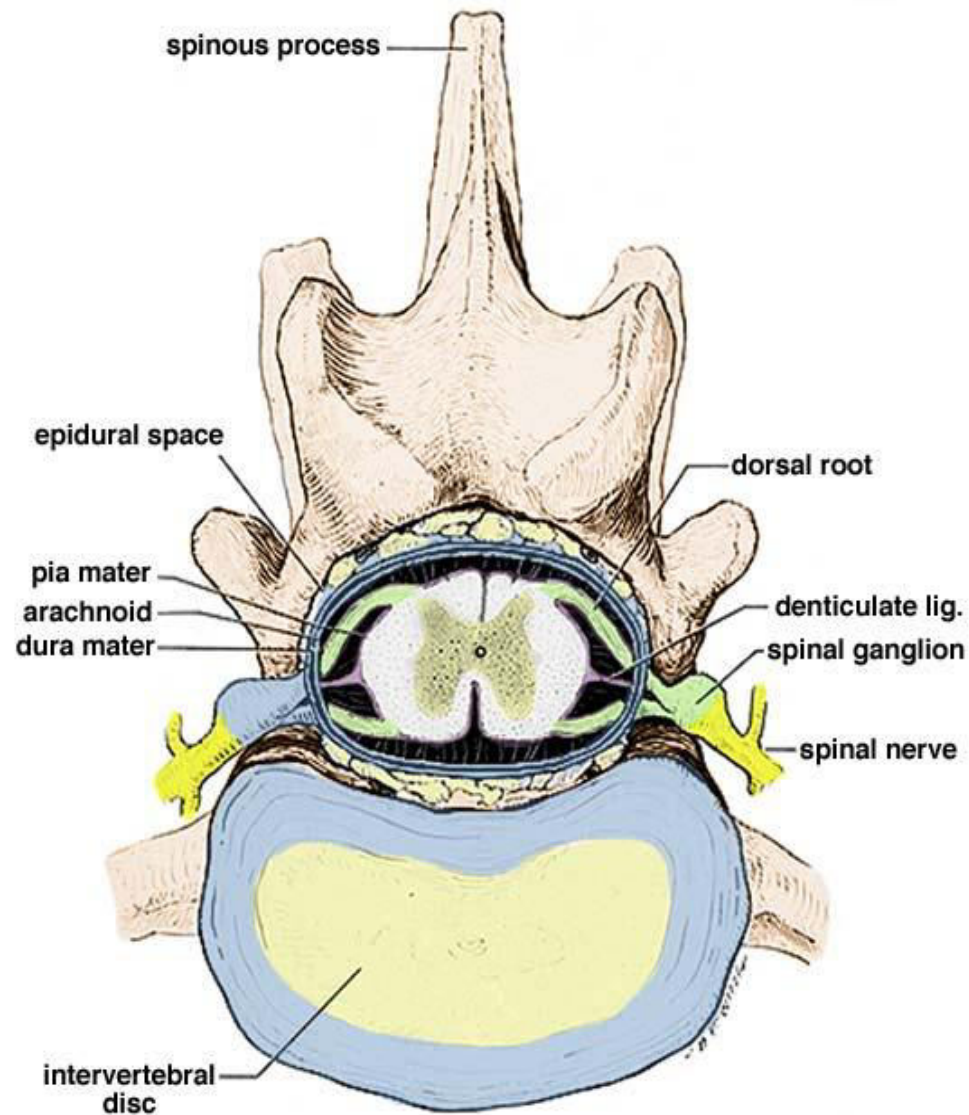
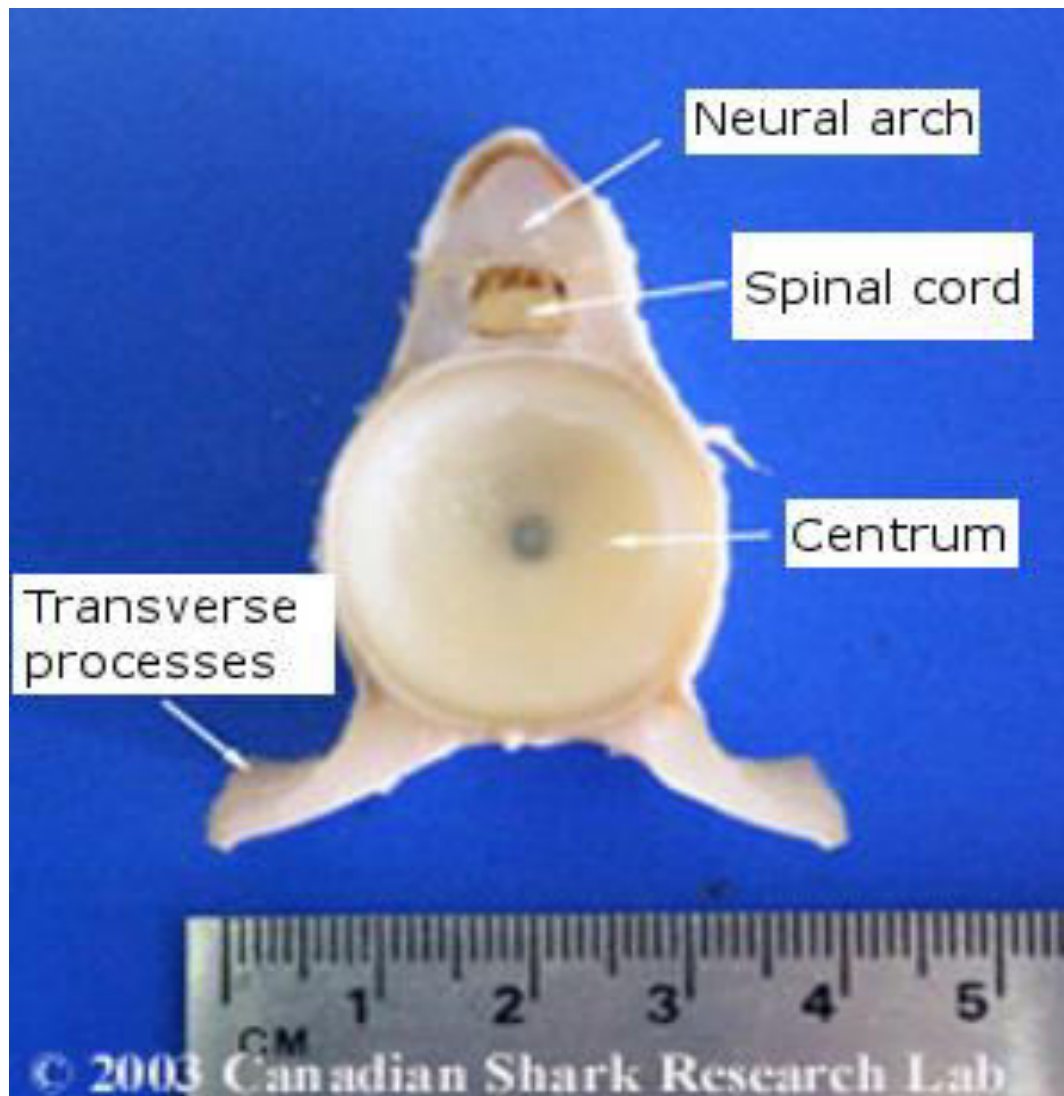


Figure 5-6. Schematic illustration of a cord segment with its roots, ganglia and branches.
In: Waxman SG. *Clinical Neuroanatomy*. 25th ed. <http://www.accessmedicine.com>. Accessed October 20, 2009.

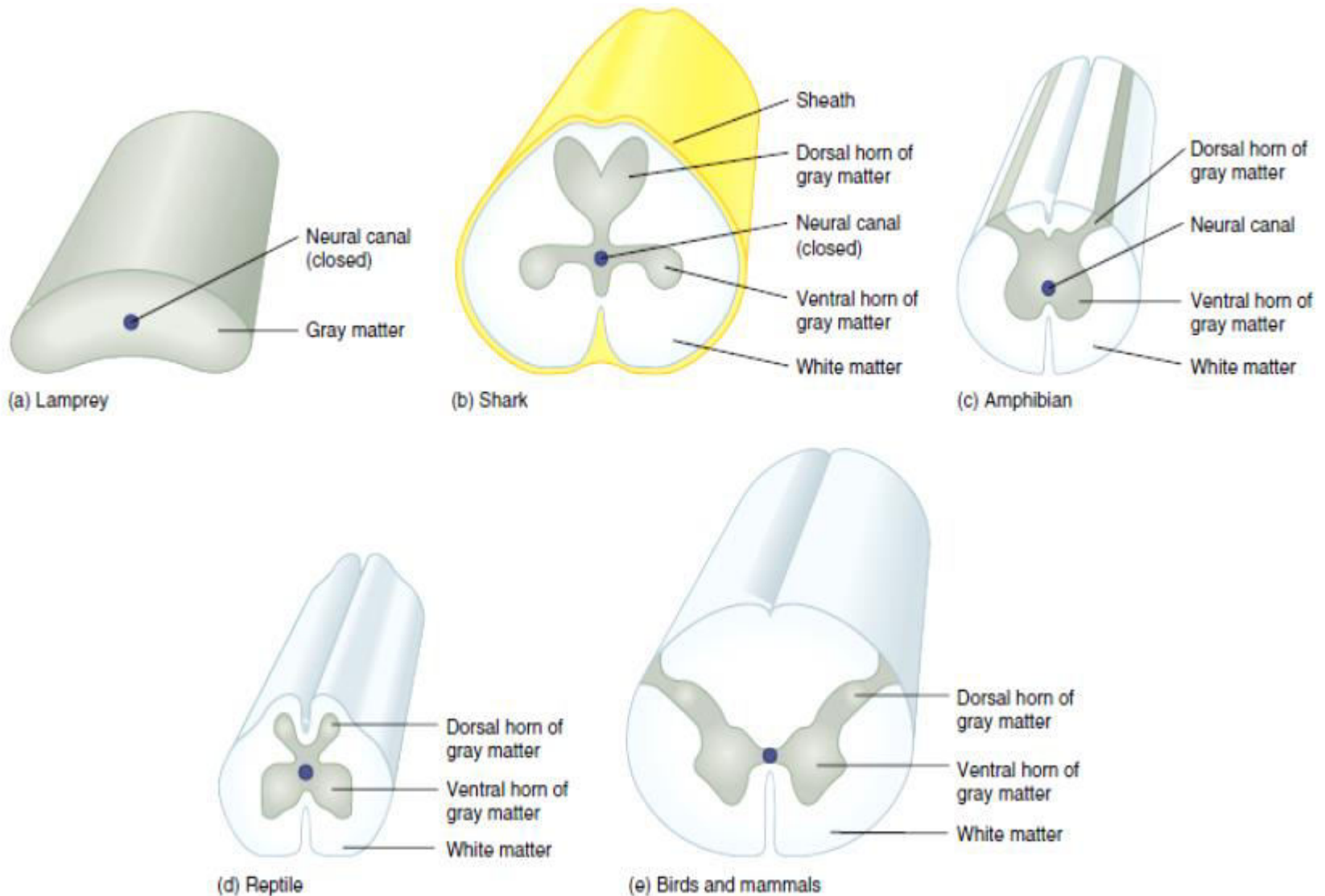
Spinal Cords and Spinal Nerves of Vertebrates



Spinal Cords and Spinal Nerves of Vertebrates



Spinal Cords and Spinal Nerves of Vertebrates



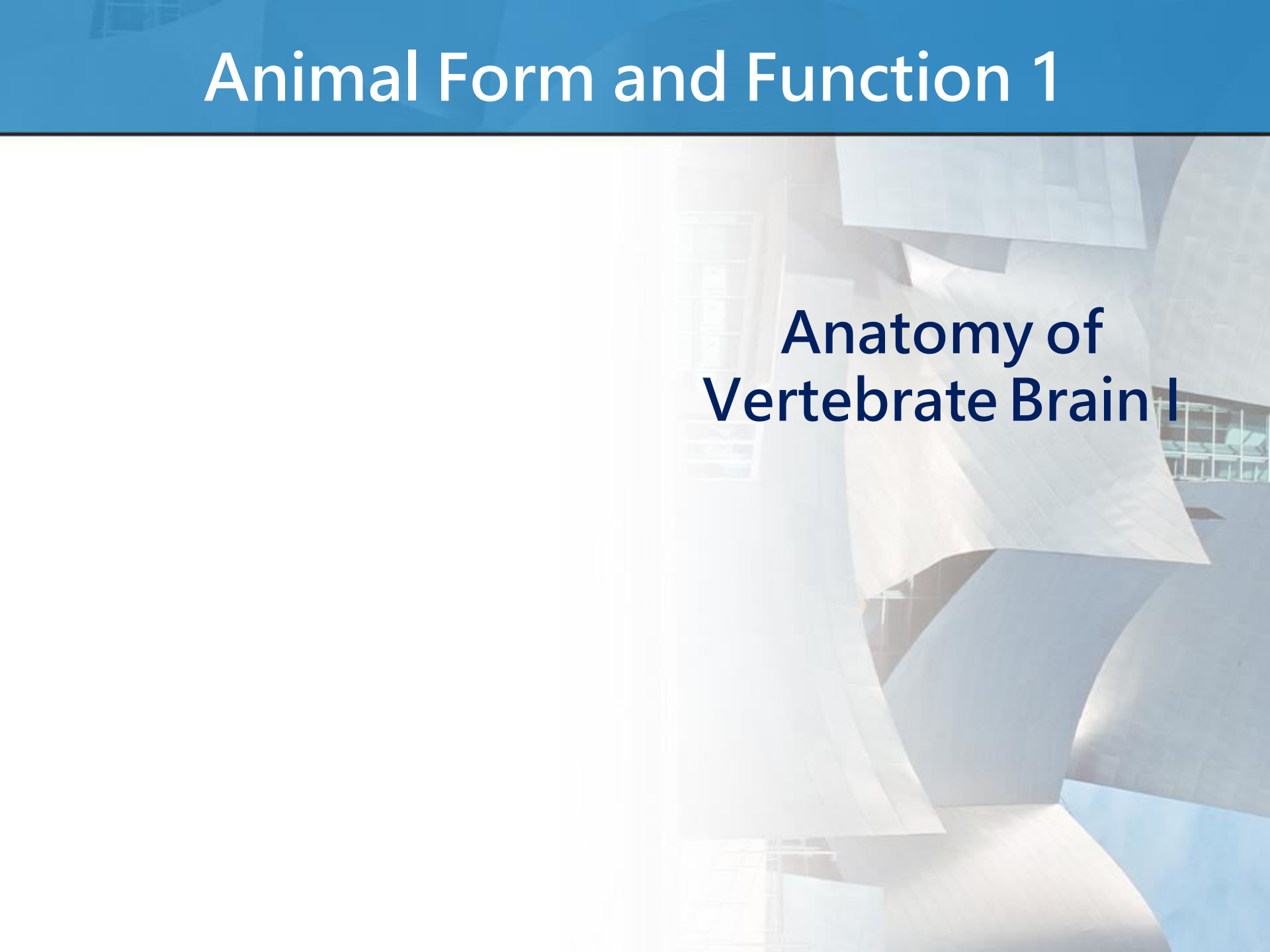
Animal Form and Function 1

Module 49

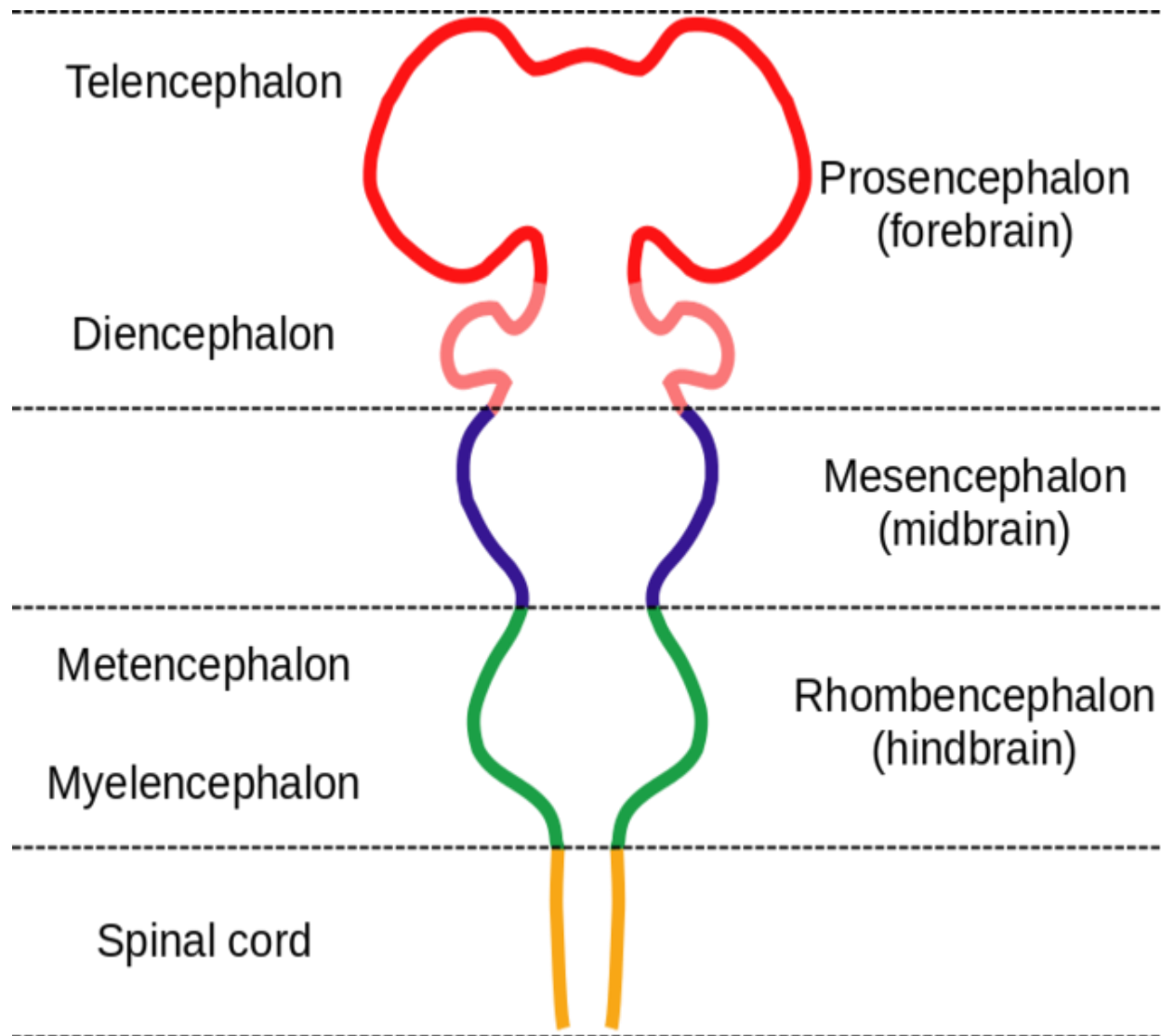


Animal Form and Function 1

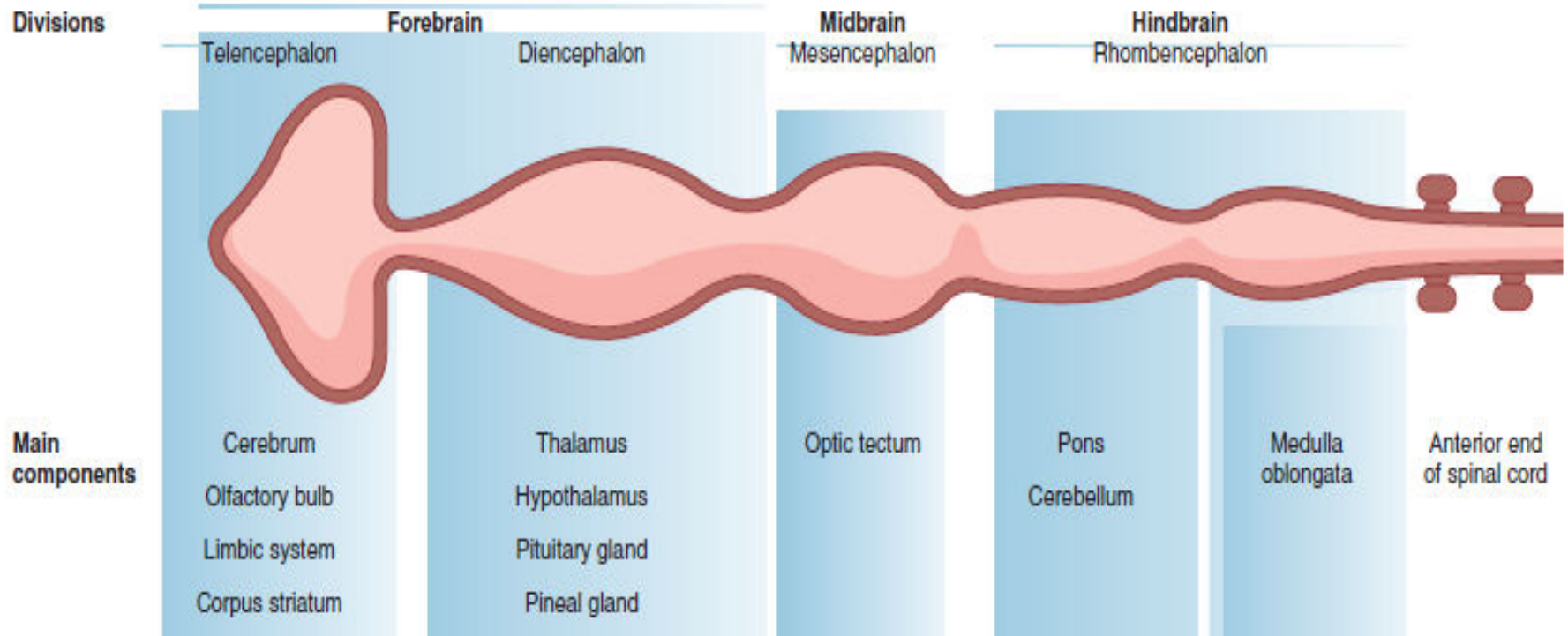
Anatomy of Vertebrate Brain I



Anatomy of Vertebrate Brain



Anatomy of Vertebrate Brain



Anatomy of Vertebrate Brain

Brain:

- During development the brain undergoes regional expansion as a hollow tube of nervous tissue.
- The tube develops into Forebrain, Mid brain and Hind brain.

Anatomy of Vertebrate Brain

Forebrain:

- The vertebrate fore brain has changed a great deal during evolution.
- The forebrain has two main parts- and **telencephalon and diencephalon**.
- Telencephalon, the front part of the fore brain expanded rapidly in size and complexity.

Anatomy of Vertebrate Brain

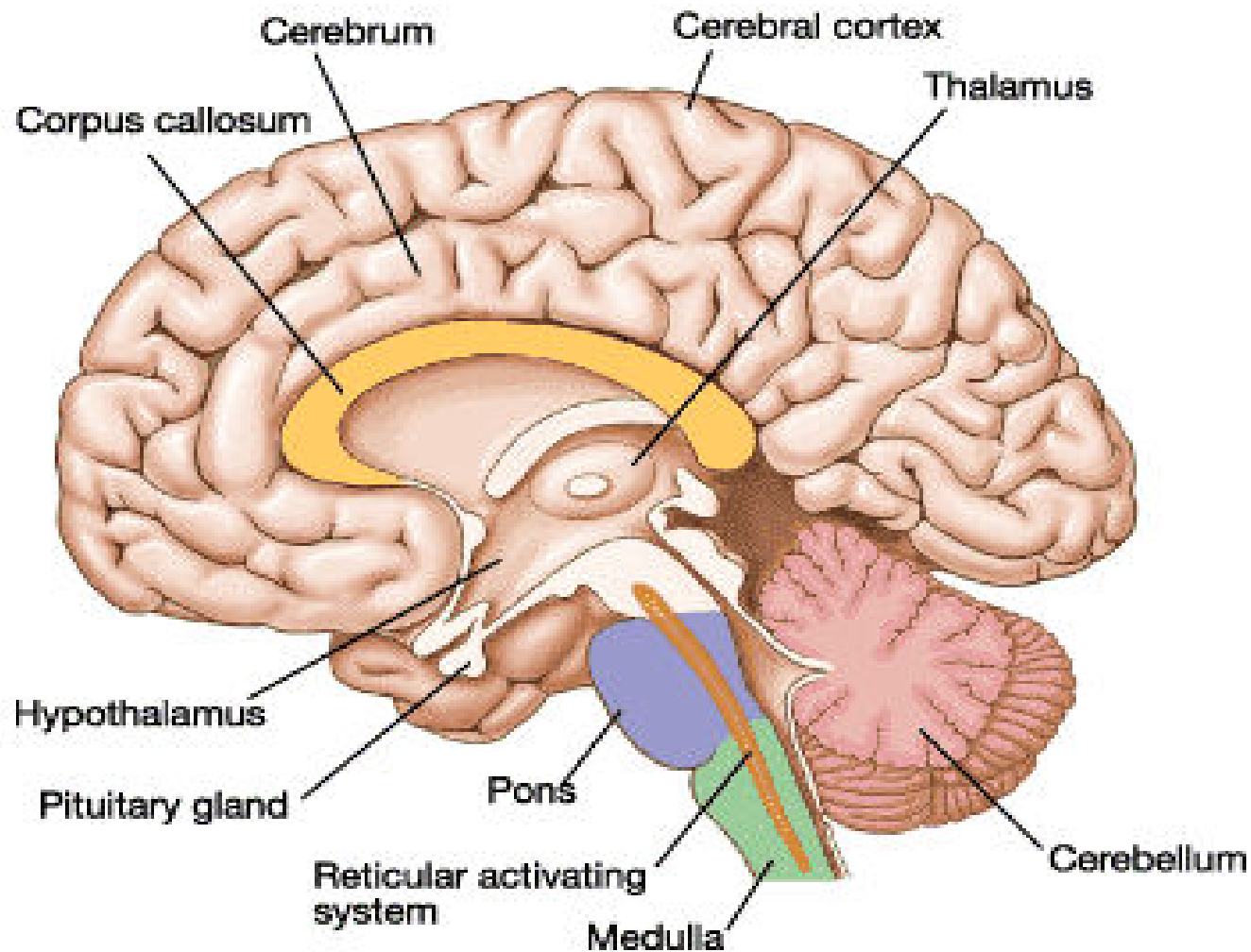
Telencephalon consists of :

- a. Cerebrum,
- b. Olfactory bulb,
- c. Limbic system and
- d. Corpus Striatum
- Cerebrum is divided by a deep groove into Rt and Lt Cerebral hemispheres.
- In mammals, the outer most part of cerebrum is called cortex.

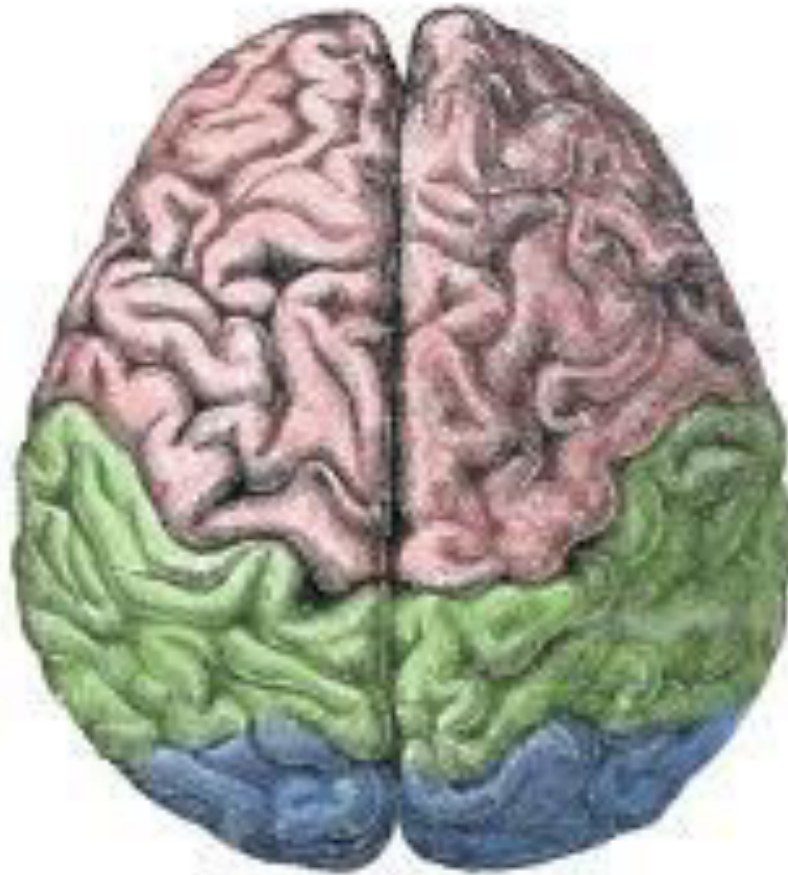
Anatomy of Vertebrate Brain

- **Cerebrum**
progressively increased in size and complexity.
- Cerebrum has different parts having specific functions:
- Cerebral cortex contains primary sensory and motor areas.

Anatomy of Vertebrate Brain



Anatomy of Vertebrate Brain



Anatomy of Vertebrate Brain

- Cortex also contains areas involved in perception of visual, auditory signals from the environment. In man ability to use language-both written and spoken.
- Increasing importance of cerebrum affected many other brain regions, especially cerebellum and thalamus.

Anatomy of Vertebrate Brain

- The **diencephalon** expanded slowly as compared to telencephalon.
- Diencephalon contains-thalamus. Hypothalamus, Pineal gland and Pituitary gland,

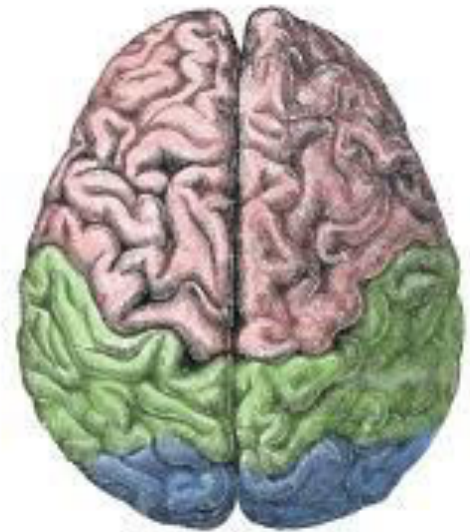
Anatomy of Vertebrate Brain

- The thalamus relays all the sensory information to higher brain centers.
- The hypothalamus regulates many functions, sexual drive, Carbohydrate metabolism, hunger and thirst.
- Pineal gland controls some body rhythms.

Anatomy of Vertebrate Brain

- Pituitary gland is a master endocrine gland and produce about 9 hormones.

END



Animal Form and Function 1

Module 50



Animal Form and Function 1

Anatomy of Vertebrate Brain II

Anatomy of Vertebrate Brain II

Mid Brain:

- Mid brain contains reticular formation, which is a relay center connecting hind brain with the fore brain.
- Mid brain did not change in size. The roof of the mid brain is a thickened region of grey mater that integrates visual and auditory signals.

Anatomy of Vertebrate Brain II

Hind Brain:

- Hind brain is continuous with the spinal cord and includes:
 - a. Pons ,
 - b. Cerebellum and
 - c. Medulla oblongata

Pons is a bridge of transverse nerve tracts from cerebrum to cerebellum.

Anatomy of Vertebrate Brain II

Cerebellum:

- It is an outgrowth of medulla oblongata.
- In tetrapods the cerebellum is laterally expanded.
- They provide locomotor control of muscles of appendages.
- Cerebellum is much larger in birds and mammals.

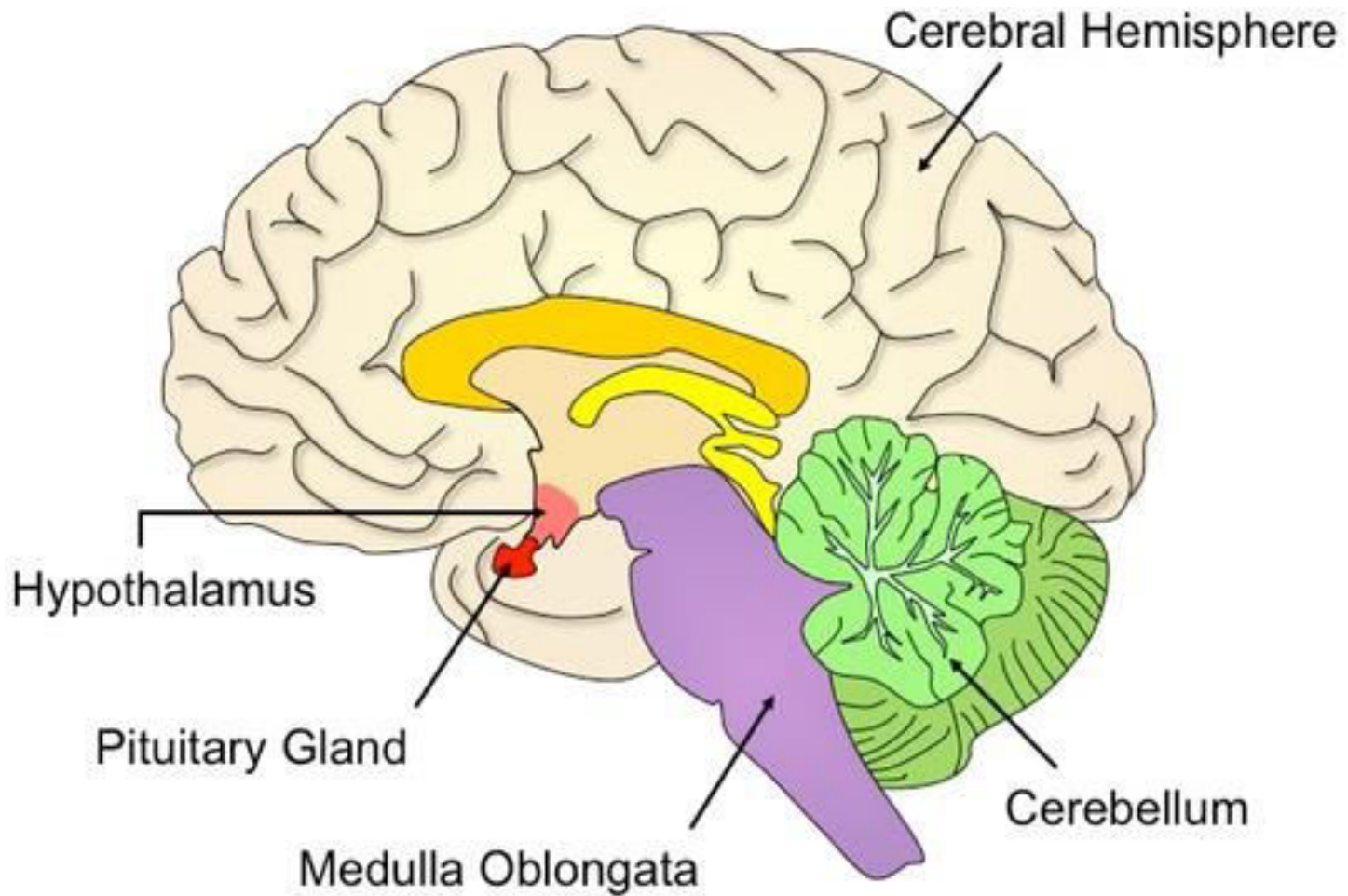
Anatomy of Vertebrate Brain II

Medulla oblongata:

- MO is the enlargement where the spinal cord enters the brain.
- It contains reflex centers for breathing, swallowing, cardiovascular .
- It is well developed in jawed vertebrates.



Anatomy of Vertebrate Brain II



Animal Form and Function 1

Module 51



Animal Form and Function 1

Comparison of Vertebrate Brains



Comparison of Vertebrate Brains

- **Evolution of Forebrain:**
The forebrain expanded rapidly in both size and complexity.
- Many function shifted from the optic tectum to the expanding cerebrum.
- The increasing importance of the cerebrum affected many brain regions especially thalamus and cerebellum.

Comparison of Vertebrate Brains

- In mammals outermost part of cerebrum progressively increased in size and complexity.

Comparison of Vertebrate Brains

Evolution of Cerebellum:

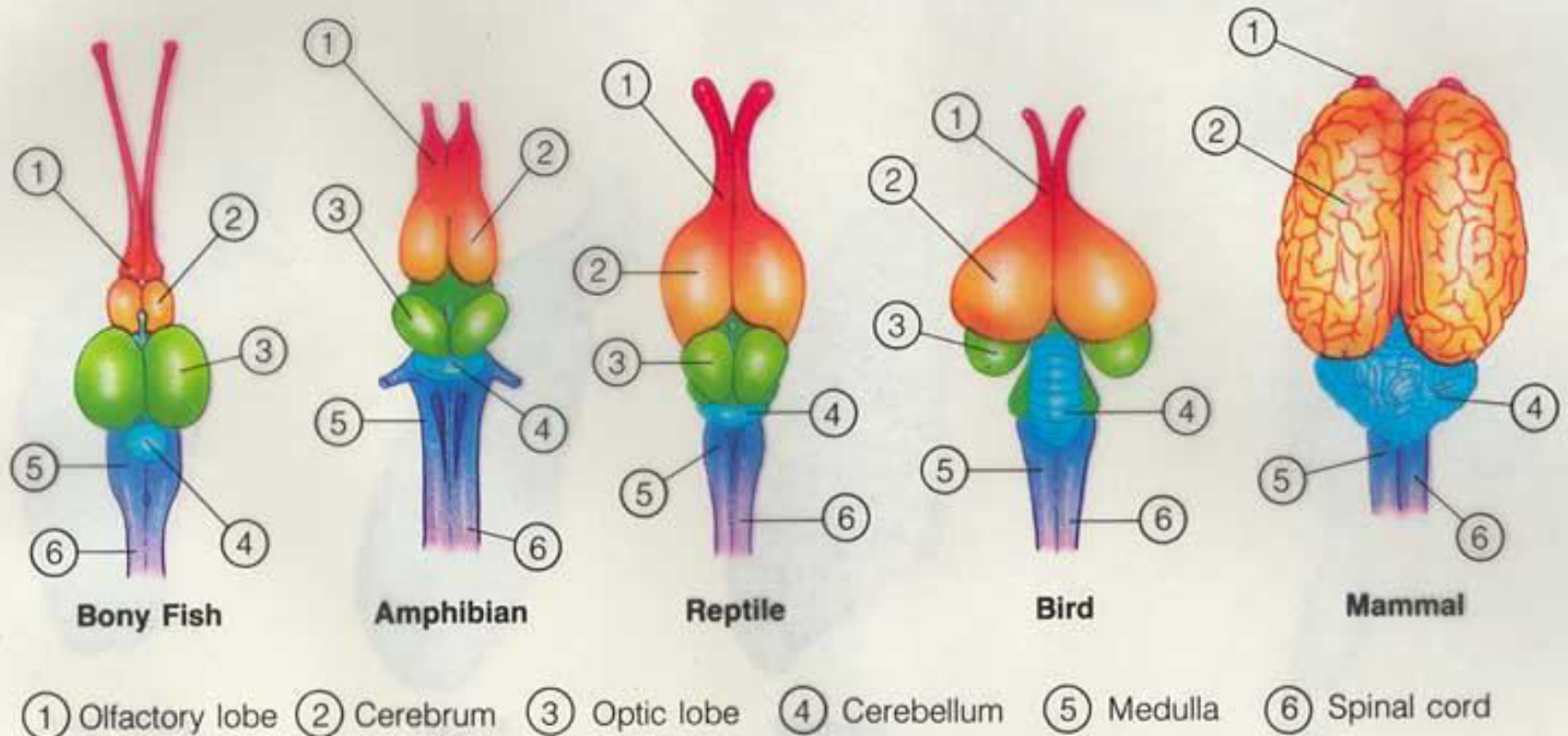
- In cartilaginous fishes the cerebellum has distinct anterior and posterior lobes.
- In teleosts the cerebellum is large in size in active swimmers and small in relatively inactive fishes.

Comparison of Vertebrate Brains

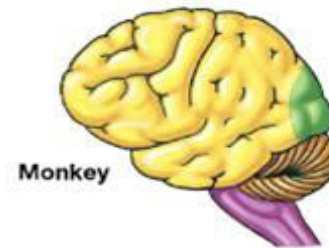
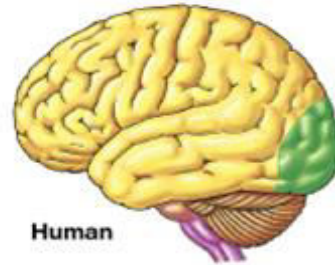
- In **tetrapods** the cerebellum is relatively expanded, that provide locomotor control of appendages muscles.
- In birds and mammals. the cerebellum is much larger. This is reflection of complex locomotor pattern of limb development.

Comparison of Vertebrate Brains

50. The Brain Structure of Vertebrates

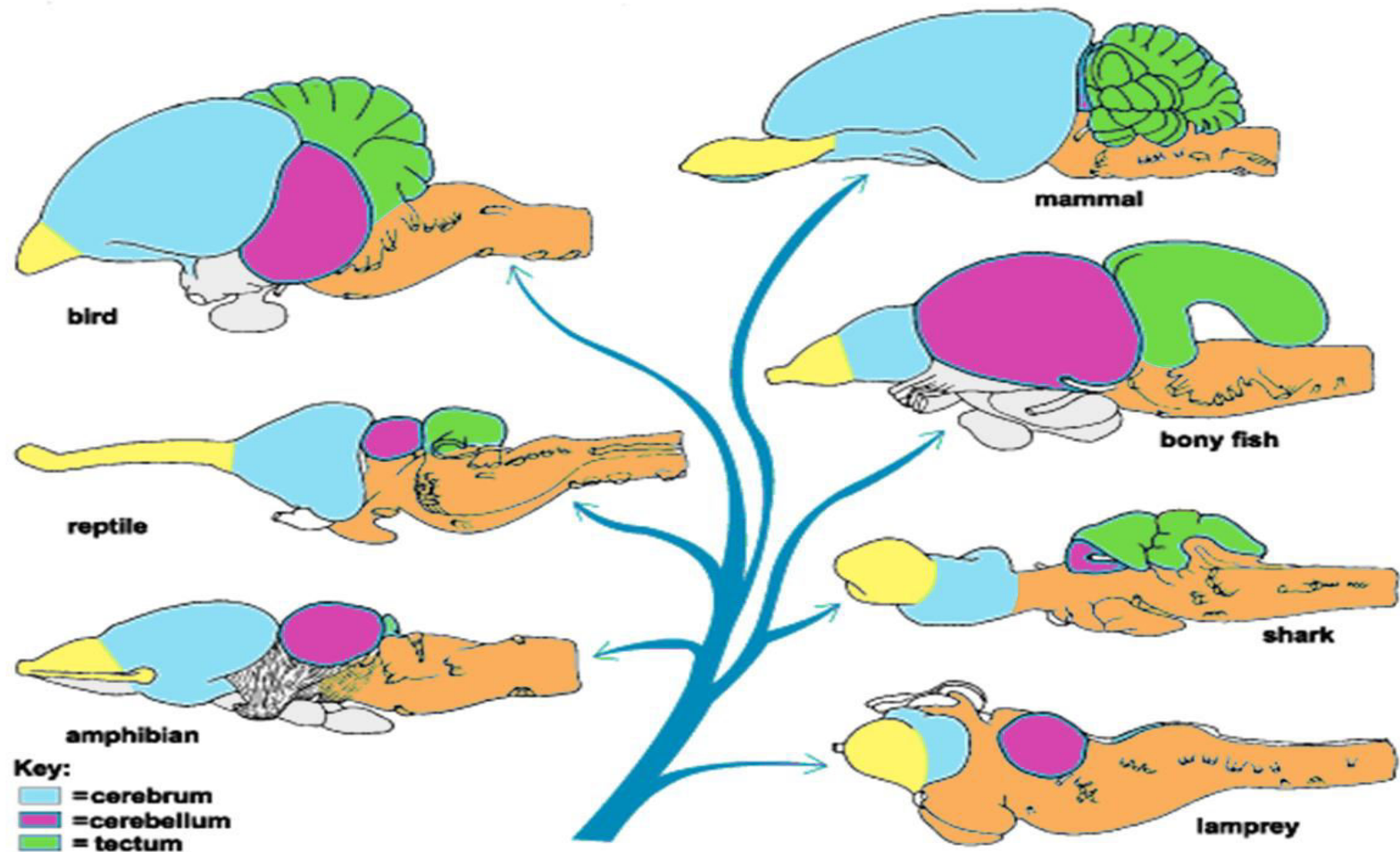


Comparison of Vertebrate Brains



- Forebrain
- Visual Cortex
- Cerebellum
- Medulla
- Midbrain
- Pituitary

Comparison of Vertebrate Brains



Comparison of Vertebrate Brains



(a) Bass



(b) Frog



(c) Pit viper



(d) Warbler



(e) Opossum



(f) Bobcat



(g) Macaque



(h) Chimpanzee



(i) Human

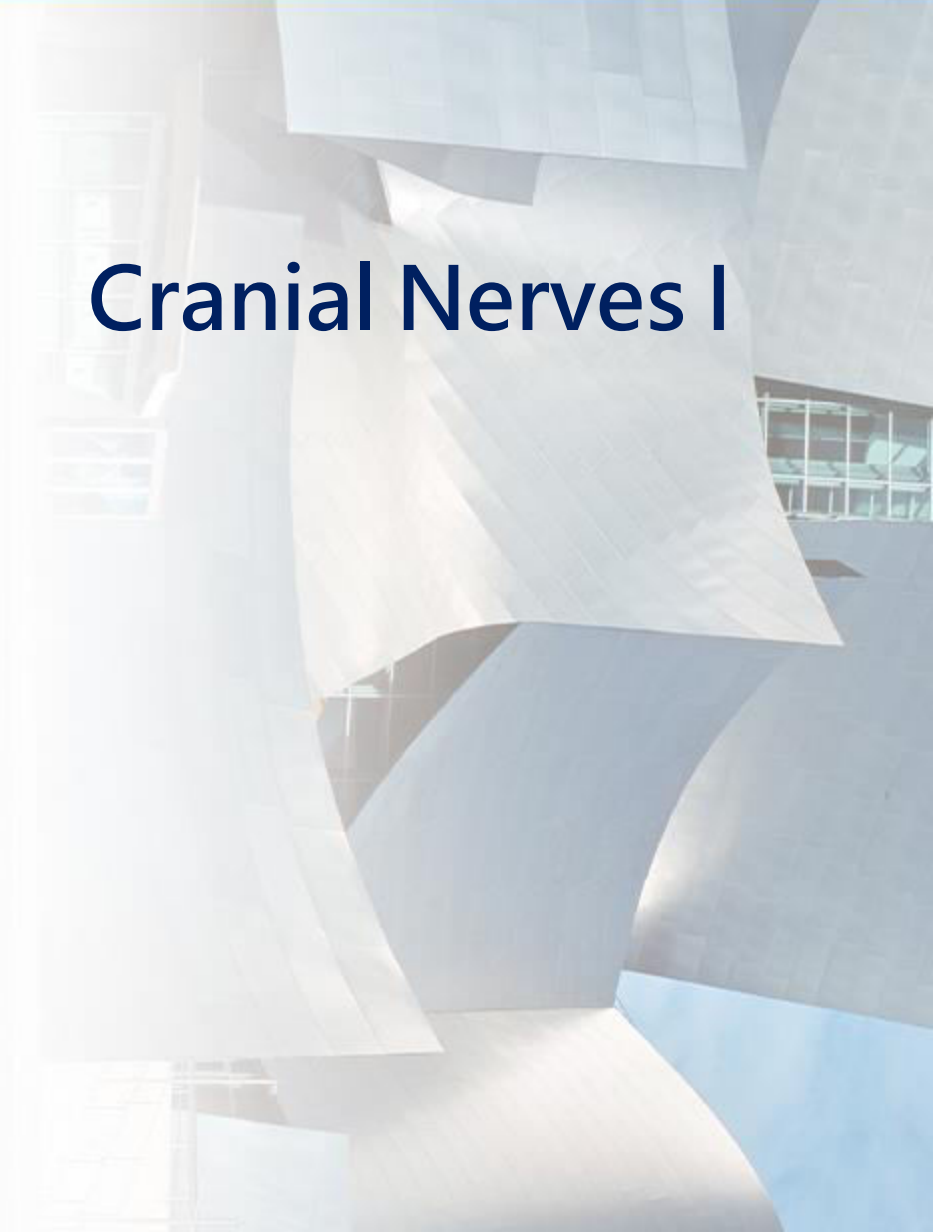
Animal Form and Function 1

Module 52

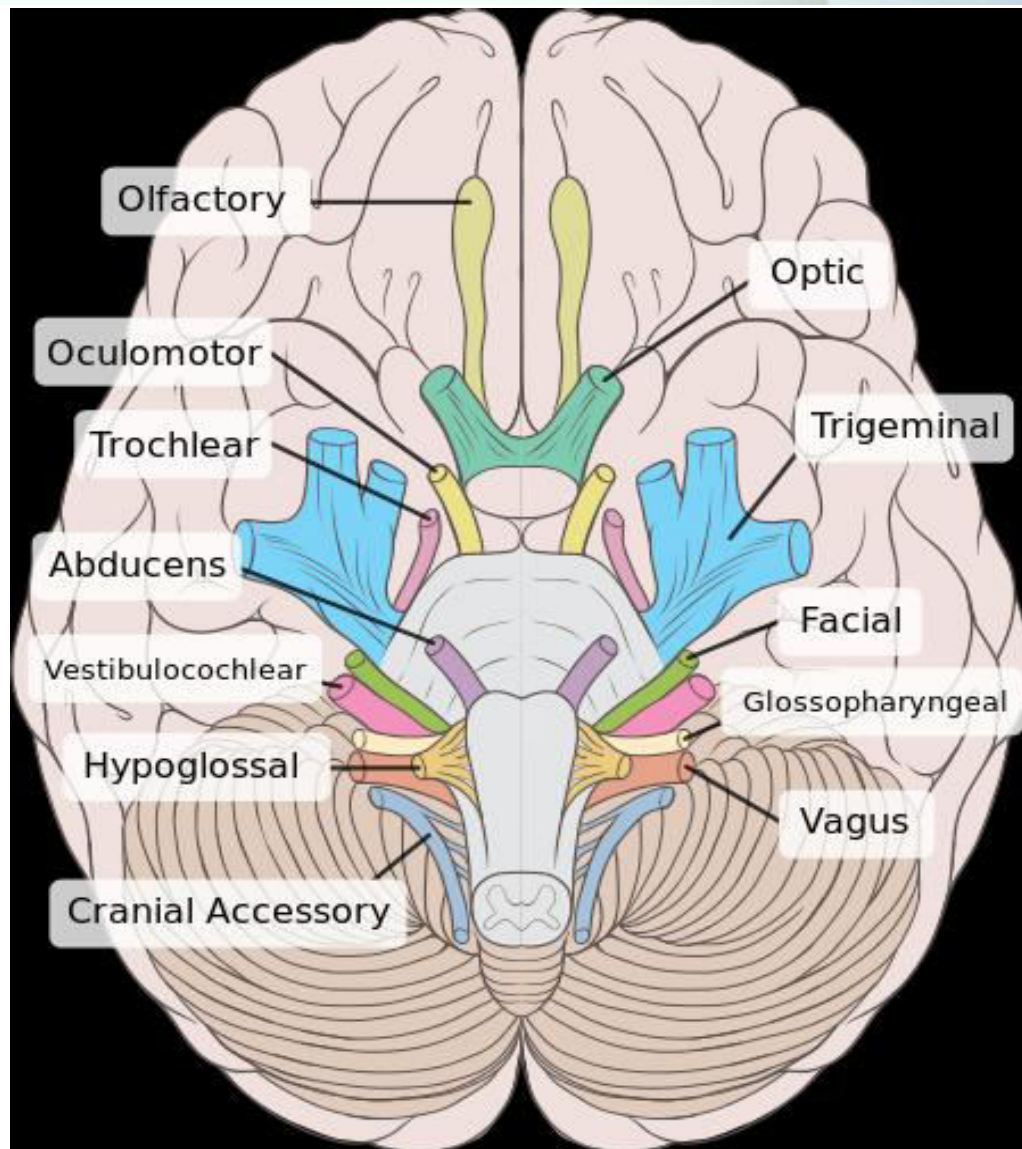


Animal Form and Function 1

Cranial Nerves I



Cranial Nerves I



Cranial Nerves I

I. Olfactory nerve:

- **Olfactory Nerve** is the first cranial nerve and conveys special sensory information related to smell. It is the shortest of the cranial nerves and passes from its receptors in the nasal mucosa to the forebrain.

Cranial Nerves I

II. Optic nerve:

It transmits visual information from the retina to the brain.

III. Oculomotor:

It enters the orbit and innervates muscles that enable most movements of the eye and that raise the eyelid.

Cranial Nerves I

IV Trochlear:

- **It innervates only single superior oblique muscle of the eye. Controls the downward movement of the eye ball.**

Cranial Nerves I

V Trigeminal:

- A nerve responsible for sensation in the face and motor functions such as biting and chewing.
- Its three major branches are:
 - a. Ophthalmic nerve
 - b. Maxillary and
 - c. Mandibular

Cranial Nerves I

- **Ophthalmic division**
Innervates eyes, tear glands, head and upper eyelids.
- **Maxillary division**
Supplies upper teeth, upper gum, upper lip, lining of palate and skin of face.

Cranial Nerves I

- **Mandibular division**
Supplies Scalp, skin of jaw, lower teeth, lower gum and lower lip.

VI Abducens:

- It is motor nerve.
- Supplies jaws, floor of mouth and eye muscles.

END

Animal Form and Function 1

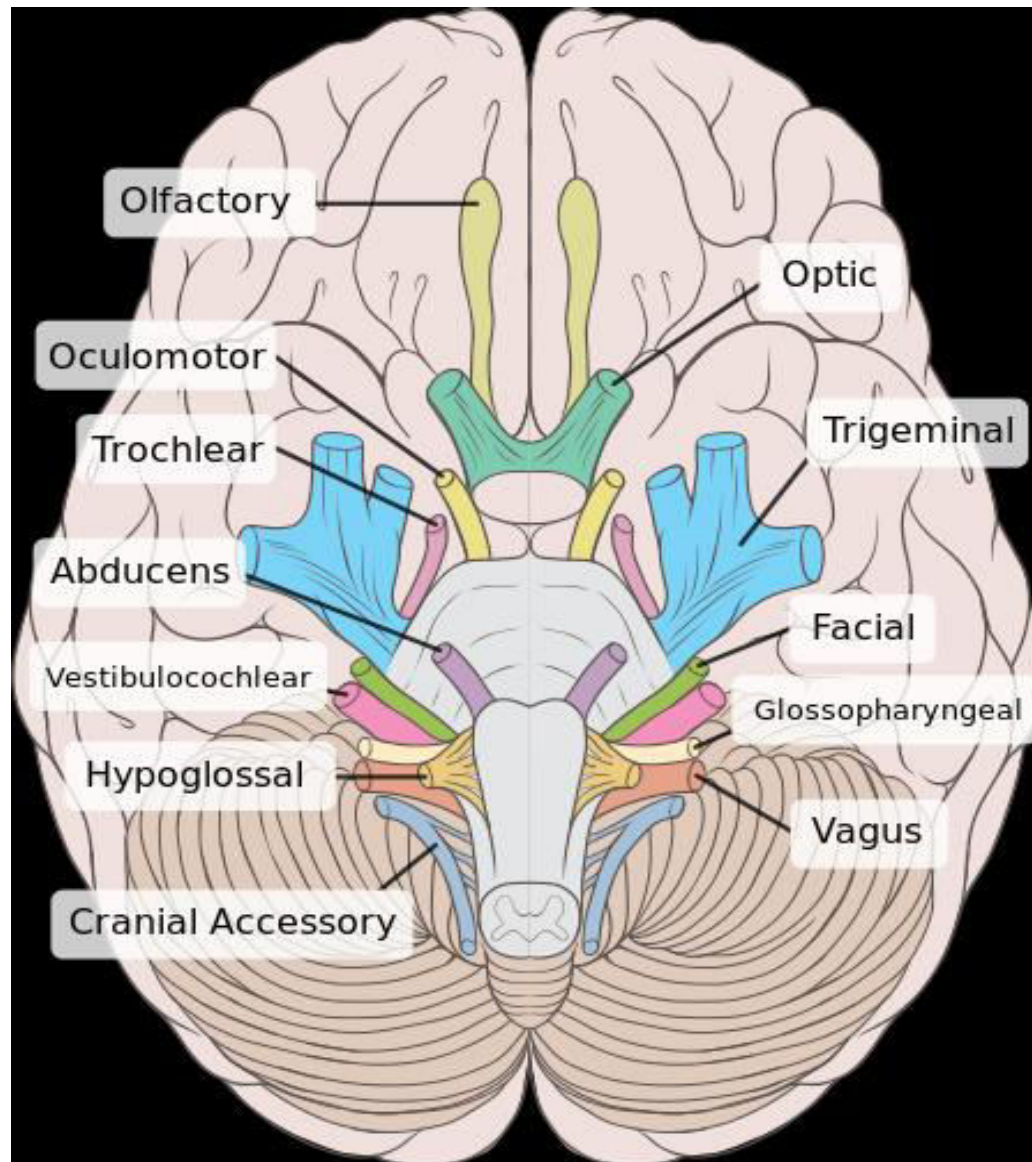
Module 53



Animal Form and Function 1

Cranial Nerves Part II

Cranial Nerves Part II



Cranial Nerves Part II

VII Facial :

- It emerges from Pons of the brainstem.
- Controls the muscles of facial expression, taste receptors of anterior 2/3 of tongue, tear glands and salivary glands.
- Inflammation or damage of this nerve cause Bell's Palsy

Cranial Nerves Part II

Bell's Palsy



Cranial Nerves Part II

VIII Vestibulocochlear.

- It has two branches - Vestibular and Cochlear.
- The **vestibular nerve** innervates the vestibular system of the ear.
- It is responsible for equilibrium.
- **Cochlear** supplies the inner ear and serves the sense of hearing.

Cranial Nerves Part II

IX Glossopharyngeal:

- The glossopharyngeal nerve as its name suggests is related to the tongue, pharynx and the tonsils. It is a mixed nerve.

X Vagus:

- It is the longest cranial nerve. It is a mixed nerve. Involved in speech, swallowing, hearing and visceral organs.

Cranial Nerves Part II

XI Accessory Nerve:

- Has two branches-
 - a) Cranial branch
 - b) Spinal branch
- Innervates soft palate, pharynx and larynx. It is motor nerve.

XII Hypoglossal:

- It is a motor nerve.
- Comes from tongue muscles.

END

Animal Form and Function 1

Module 54



Animal Form and Function 1

Introduction of Autonomic Nervous System

Introduction of Autonomic NS

- Autonomic nervous system (ANS) is the part of peripheral nervous system.
- PNS also includes Somatic nervous system (SNS).
- The SNS consists of motor neurons that stimulate skeletal muscles.

Introduction of Autonomic NS

- In contrast, the ANS consists of motor neurons that control smooth muscles, cardiac muscles and glands.
- In addition, the ANS monitors visceral organs and blood vessels.

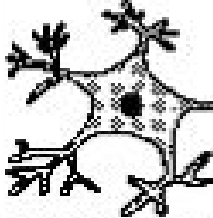

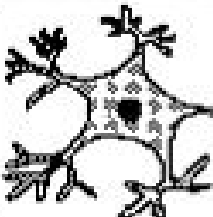



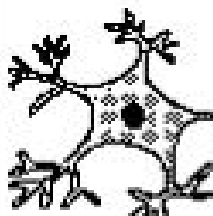



Introduction of Autonomic NS

- In the ANS, the connection between the CNS and its effector consists of two neurons—the preganglionic neuron and the postganglionic neuron.
- The synapse between these two neurons lies outside the CNS, in an autonomic ganglion.

Introduction of Autonomic NS

- The ANS is further divided into the sympathetic nervous system and the parasympathetic nervous system.

Introduction of Autonomic NS

	central nervous system	peripheral nervous system			target organs
somatic nervous system					skeletal muscle
sympathetic nervous system		 paravertebral or prevertebral ganglion		 NE	smooth muscle glands
para-sympathetic nervous system		 myelin sheath	 terminal ganglion	 ACh	cardiac muscle
ACh = acetylcholine NE = norepinephrine		pre-ganglionic axon	ganglion	post-ganglionic axon	

Animal Form and Function 1

Module 55



Animal Form and Function 1

Sympathetic and Parasympathetic Nervous System

Sympathetic and Parasympathetic NS

Autonomic NS is divided into divisions:

Sympathetic and Parasympathetic NS.

- These two divisions generally make synaptic contacts with the same organ but usually produce opposite effects.

Sympathetic and Parasympathetic NS

Sympathetic NS:

- It consists of ganglia, nerves and plexues that supply involuntary muscles.
- This NS arise from middle portion of spinal cord and terminate in ganglia.
- This system is important during emergency situation.
- 'Fight and flight''

Sympathetic and Parasympathetic NS

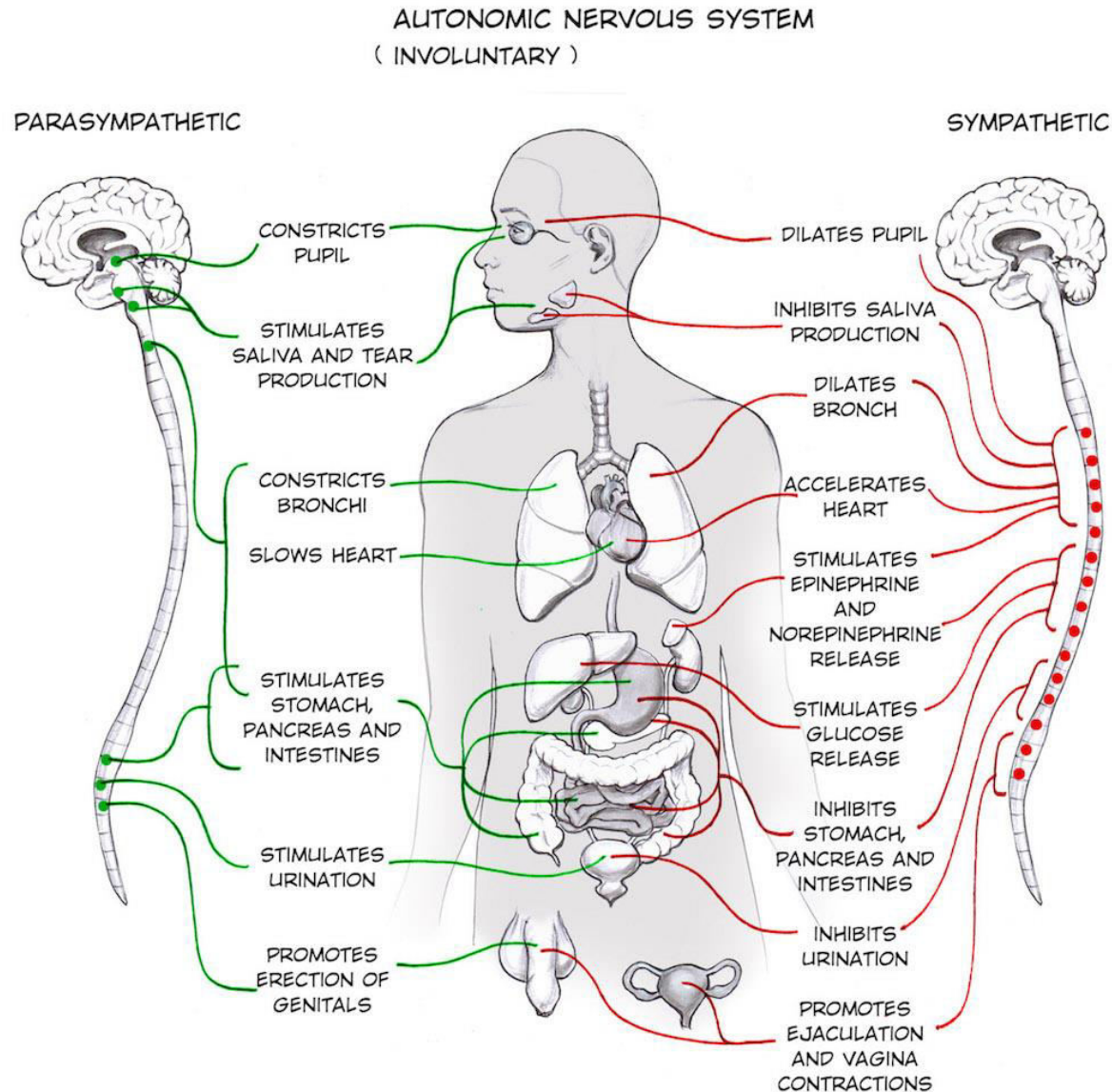
- However neither kind of nerve is exclusively excitatory or inhibitory,
- For example, the sympathetic fibers increase heart beat but inhibit intestinal peristaltic movements.

Sympathetic and Parasympathetic NS

Parasympathetic NS:

- This system consists of nerves some of which emerge from brain and others from sacral or pelvic region of the spinal cord.
- PS division is associated with non stressful activities e.g. resting, eating, digestion & urination.
- Retards heart beat.

Sympathetic and Parasympathetic NS



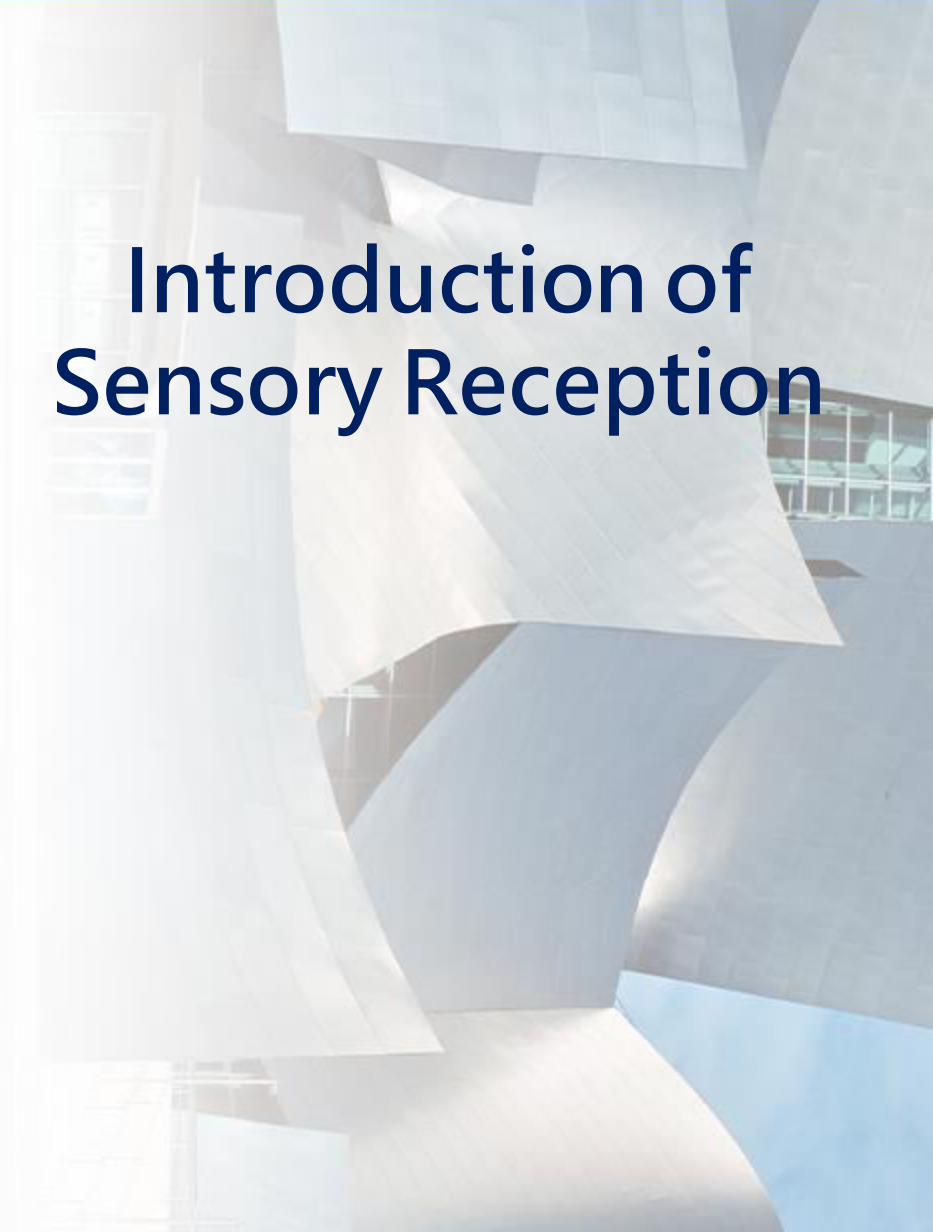
Animal Form and Function 1

Module 56



Animal Form and Function 1

Introduction of Sensory Reception



Introduction of Sensory Reception

- In human five senses-sight, smell, hearing, taste and touch are commonly known.
- Apart from these there are other senses also found in animals
- For example:
Invertebrates possess the following sensory receptors:

Introduction of Sensory Reception

- i) Tactile receptors that sense touch.
- ii) Hygroreceptor that detect content of air.
- iii) Georeceptors That sense pull of gravity.
- iv) Proprioceptors- that respond to compression, stretching, bending, and tension.
- v) Phonoreceptors- That are sensitive to sound

Introduction of Sensory Reception

- **vi) Baroreceptors-** that respond to pressure changes.
- **vii) Chemoreceptors-** that are sensitive to air and water borne chemicals.
- **viii) Photoreceptors-** that are sensitive to light.
- **ix) Thermoreceptors-** that are sensitive to temp changes.

Introduction of Sensory Reception

- Sensory receptors convert stimuli into nerve impulse.
- All receptors are **transducers** i.e. that convert one form of energy into another.
- All nerve impulses are of same nature.

Introduction of Sensory Reception

- Different types of receptors convert different kinds of stimuli into local electrical potential called **generator potential**.
- When the GP reaches the neuron threshold potential , it causes the channels in plasma membrane to open and creates an action potential.

Introduction of Sensory Reception

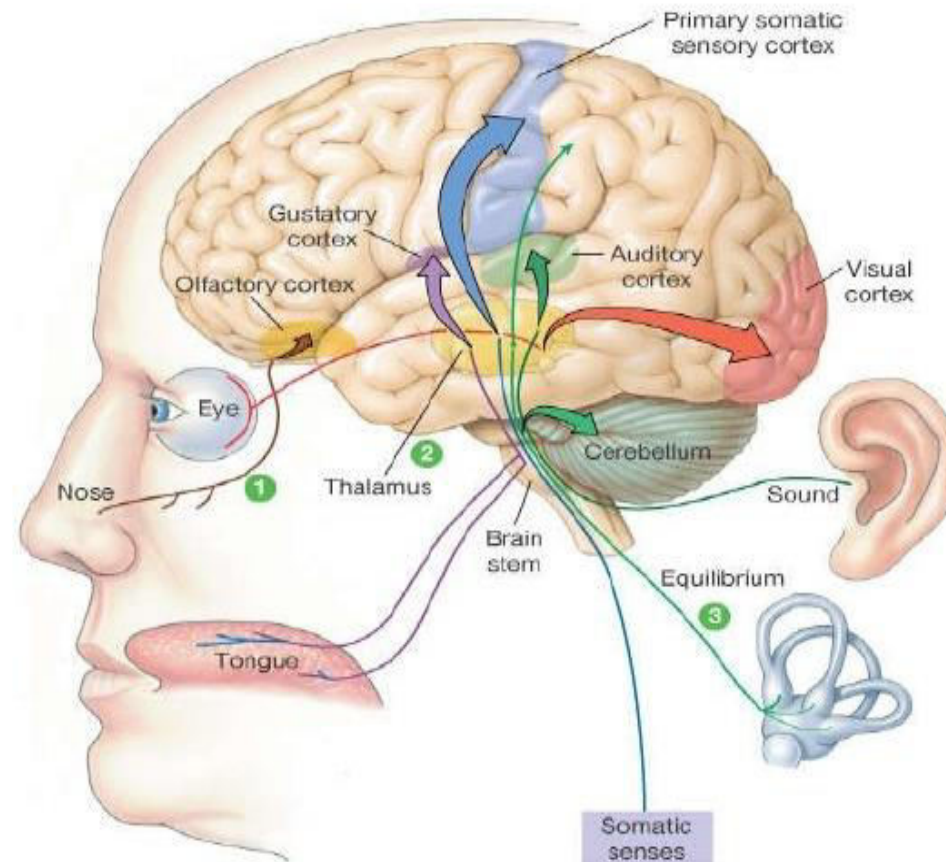
- The impulse then travels along the axon towards a synaptic junction and becomes information going to the CNS.
- The nature of the nerve impulse is the same.
- How then action potential give rise to different sensations?

Introduction of Sensory Reception

- Animals that have, nerve signals from specific receptors always end up in a specific part of brains for interpretation.
- For example a stimulus that goes to the optic center is interpreted as visual sensation. And so on.

Introduction of Sensory Reception

Sensory Receptor Types



Animal Form and Function 1

Module 57



Animal Form and Function 1

Invertebrate Sensory Receptors



Invertebrate Sensory Receptors

- An animal's behavior is largely a function of its responses to environmental information.
- Invertebrates possess a variety of receptors through which they receive information about their environment.

Invertebrate Sensory Receptors

- (a) Baroreceptors**
- (b) Chemoreceptors**
- (c) Georeceptors**
- (d) Hygroreceptors**
- (e) Phonoreceptors**
- (f) Photoreceptors**
- (h) Tactile receptors**
- (d) Thermoreceptors**

END

Animal Form and Function 1

Module 58



Animal Form and Function 1

Baroreceptors



Baroreceptors

Baroreception

- A **barometer** is a scientific instrument used to measure air pressure.
- Pressure tendency can forecast short term changes in the weather.
- The Zoologists have not identified any specific structures for baroreception in invertebrates.

Baroreceptors

- Nevertheless responses to pressure changes have been identified in ocean swelling copepod crustaceans, Ctenophores, jelly fishes medusa and squids.
- Some crustaceans that live between the tides respond to water pressure changes

Baroreceptors

and coordinate with
daily tidal movements.



Baroreceptors



Animal Form and Function 1

Chemoreceptors



Chemoreceptors

- Chemoreceptors are sensitive to chemicals.
- Chemoreception is the oldest and most universal sense in animal kingdom.

Examples:

- Protozoans show avoiding response to acid, alkali and salt stimuli.

Chemoreceptors

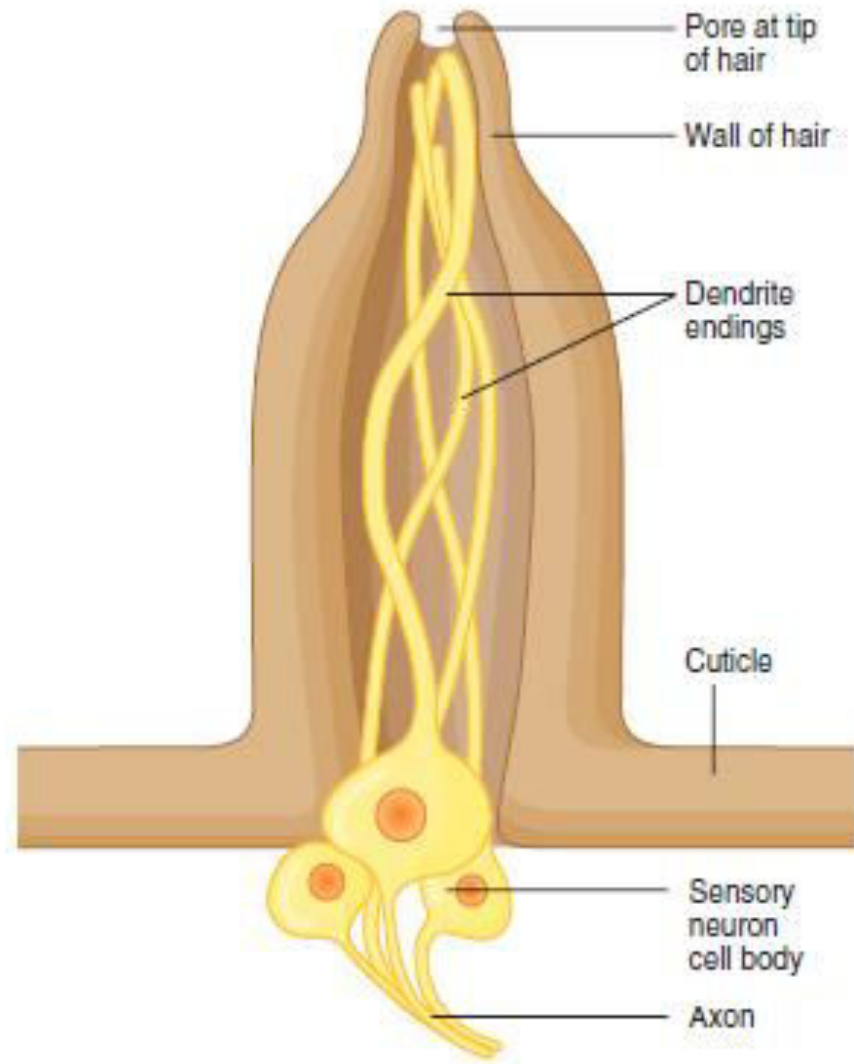
- Specific chemical attract predatory ciliates to their prey
- Location of chemoreceptors:
- In aquatic invertebrates they are located in pits or depressions, through which water carrying the specific chemicals may be circulated.

Chemoreceptors

- In **arthropods**, the receptors are usually located on the antennae, mouthparts, and legs in the form of hollow hairs called **Sensilla** containing chemosensory neurons.

Chemoreceptors

Sensillum, a Chemoreceptor



Chemoreceptors

- The types of chemicals to which invertebrates respond are closely associated with their life styles.
- For example: chemoreceptors are sensitive to humidity; pH, prey tracking, food recognition, and mate location.

Chemoreceptors

- With respect to mate location the antennae of male silkworm moth detect one **bombykol** molecule in over a trillion molecules of air.
- Female silk moth secrete **bombykol** as a sex attractant.
- This enables a male to find a female at night from several miles down wind.

END

Animal Form and Function 1

Module 60



Animal Form and Function 1

Geo receptors

An abstract architectural sculpture made of large, white, curved panels that create a complex, organic form. The sculpture is set against a background of a modern building with large windows and a clear blue sky.

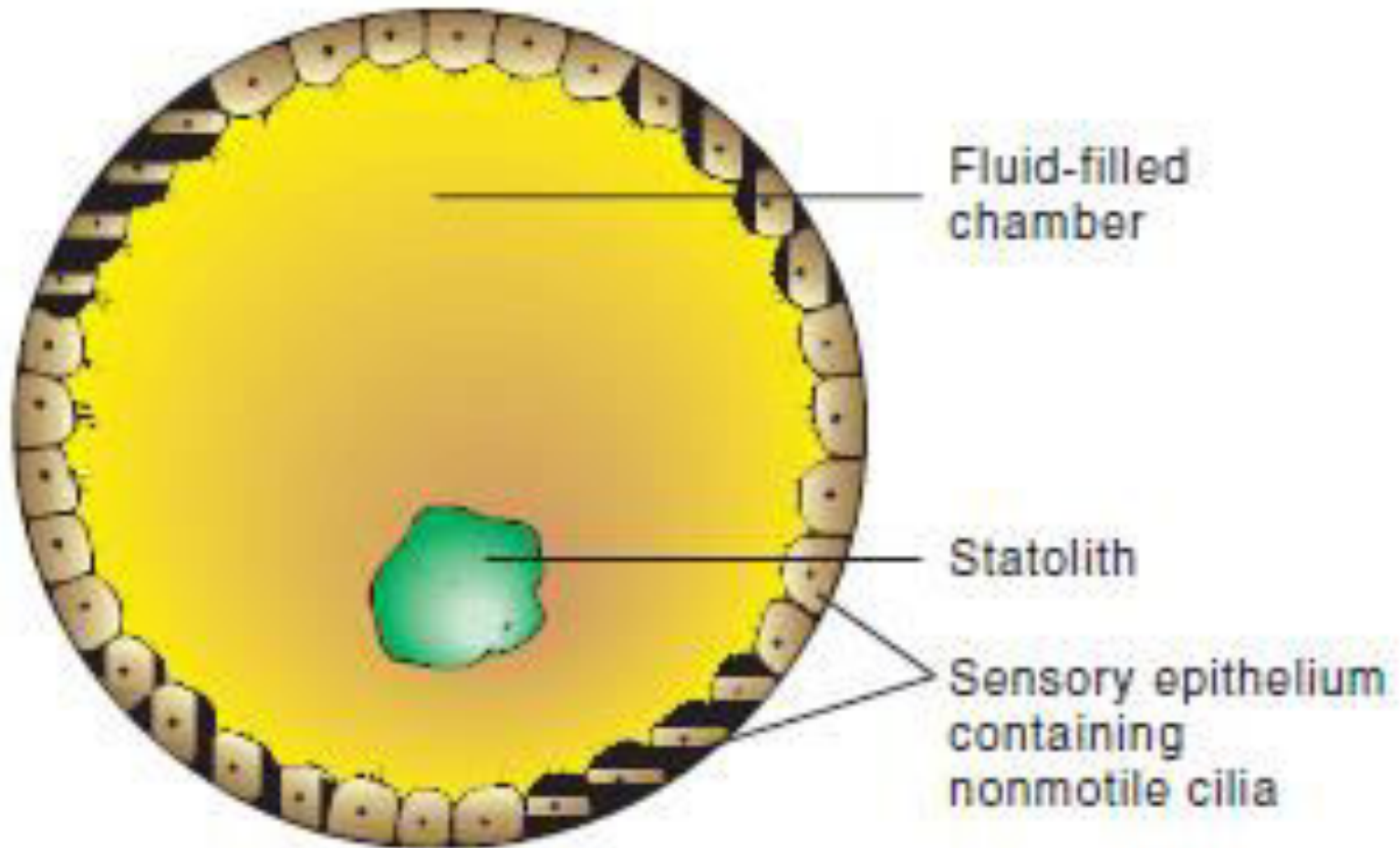
Georeceptors

Georeceptors;

- Respond to the pull of gravity giving animals information about their orientation relative to up and down.
- Most georeceptors are statocysts. (standing bladder).
- Statocyst is a fluid filled chamber lined with cilia bearing sensory epithelium.

Georeceptors

Invertebrate Georeceptor



Georeceptors

- Within the chamber is a solid granule called **statolith**.
- When animal moves, both the movement of statolith and the flow of fluid over the sensory epithelium provide information about the animal's linear and rotational acceleration relative to the environment.

Georeceptors

Occurrence of georeceptors:

They are found in various gastropods, cephalopods, crustaceans, nemertines, polychaetes and scyphozoans.

- Burrowing animals can not rely on photo for orientation instead they rely on georeceptors within the substratum.

Georeceptors

- Planktonic animals orient in their environment using statocysts.
- They are important at night and deep waters.
- Most of aquatic insects detect gravity from air bubbles entrapped in tracheal tubes, which stimulate sensory bristles that line the tubes.

END

Animal Form and Function 1

Module 61



Animal Form and Function 1

Hygroreceptors



Hygroreceptors

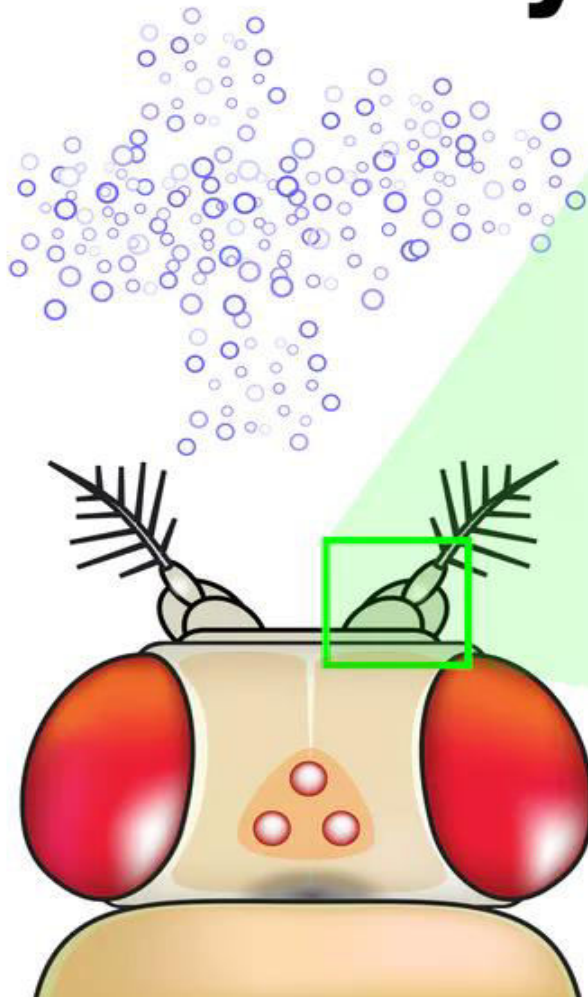
- **Hygroreceptors** are sensitive to water content of air.
- Some insects have hygroreceptors that can detect small changes in the ambient relative humidity.
- Their hygroreceptors have been identified on the antennae, palps, underside of the body and near the spiracles.

Hygroreceptors

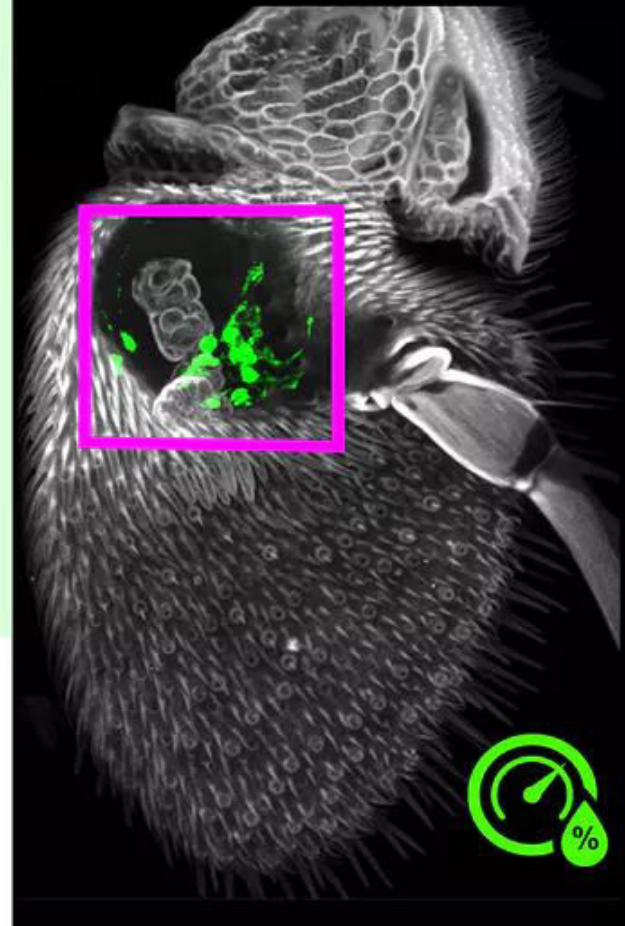
- Hygroreceptors enables the insects to seek an environment with a specific humidity to modify their physiology or behavior with respect to humidity.

Hygroreceptors

Humidity



Antenna sacculus



Hygroreceptors

- *Drosophila* detect air humidity through hygroreceptors located in a sac like invagination of the antenna.
- These receptors rapidly respond to a puff of dry air, potentially alerting the animal to the fact that dangerous dry conditions are looming.

Hygroreceptors

- Swarming, in termite is humidity dependent.

END

Animal Form and Function 1

Module 62



Animal Form and Function 1

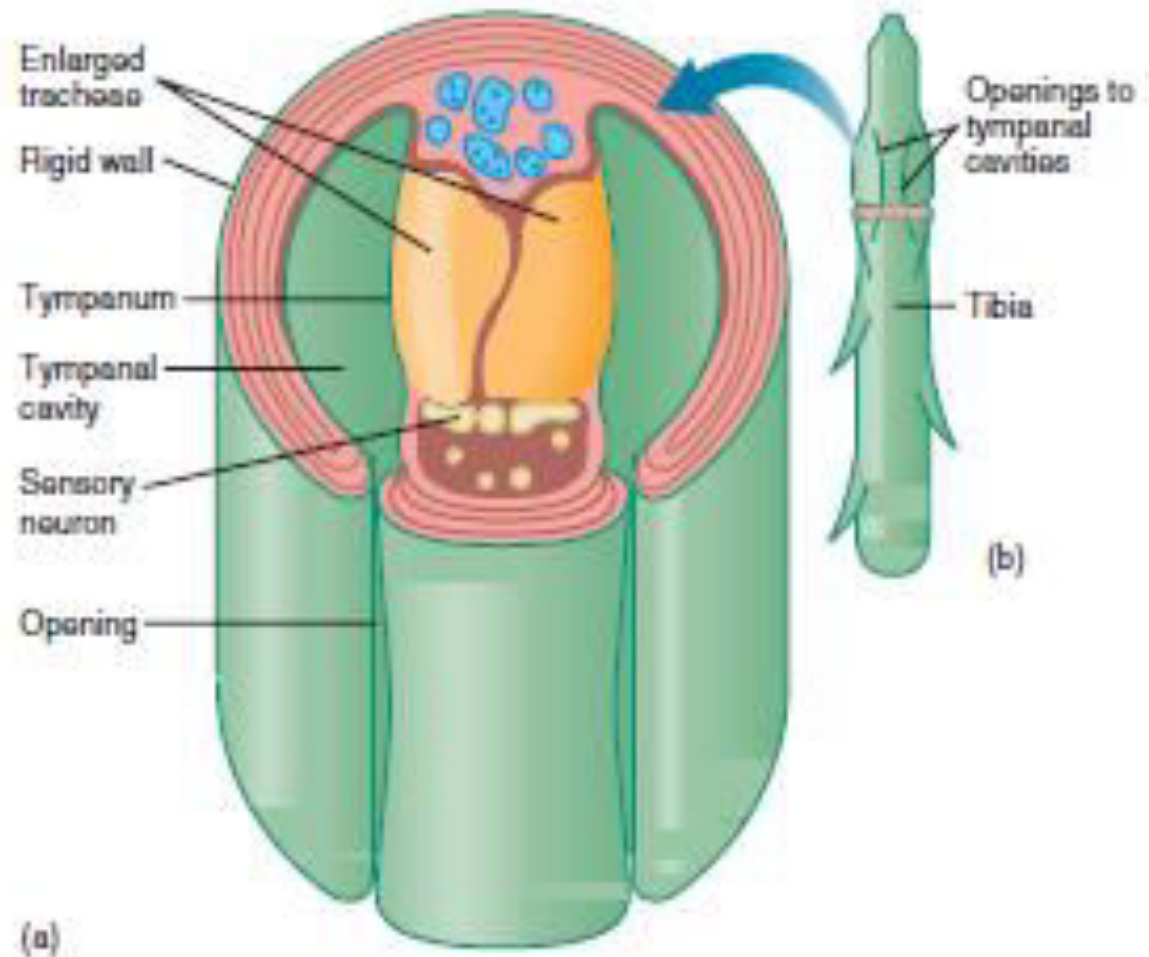
**Phonoreceptors:
(Tympanal Organs)**

Phonoreceptors (Tympanal Organs)

- **Phonoreceptors** are the receptors that respond to sound.
- They have been identified only in insects, archnids and centipedes.
- Some other invertebrates seem to respond to sound-induced vibrations of the substratum.

Phonoreceptors (Tympanal Organs)

Tympanic Organ



Phonoreceptors (Tympanal Organs)

- Crickets, grasshoppers possess phonoreceptors called **tympanic or tympanal organs**.
- This organ consists of tough, flexible tympanum that covers internal sac. The sensory neurons are attached to the tympanum.

Phonoreceptors (Tympanal Organs)

- When sound waves strike the tympanum it vibrates.
- When sensory neurons are stimulated by these vibrations generator potential is produced.
- Most arachnids possess phonoreceptors in their cuticle called **slit sense organs** that are sensitive to vibrations.

Phonoreceptors (Tympanal Organs)

- Centipedes have **organs of Tomosvary**, which are sensitive to sound.
- However, the physiology of these organs i.e. the organs of Tomosvary and slit like organs are poorly known.

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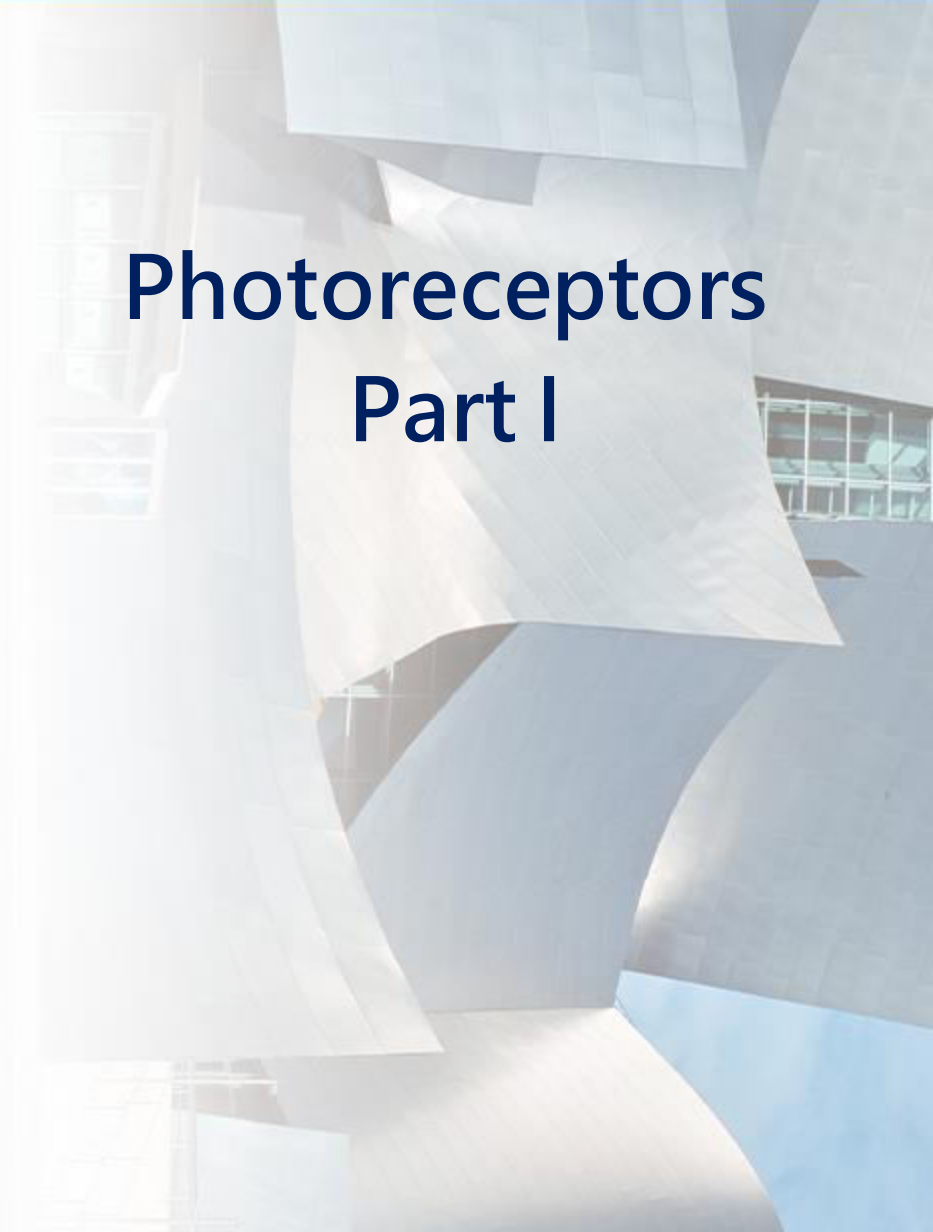
Animal Form and Function 1

Module 63



Animal Form and Function 1

Photoreceptors Part I



Photoreceptors Part I

Photoreceptors are sensitive to light.

- All photoreceptors possess light-sensitive pigments e.g. **rhodopsin** and **carotenoids**.
- These pigments absorb photons of light energy and then produce generator potential.
- This is basic commonality.

Photoreceptors Part I

Photoreceptors in various organisms:

Euglena:

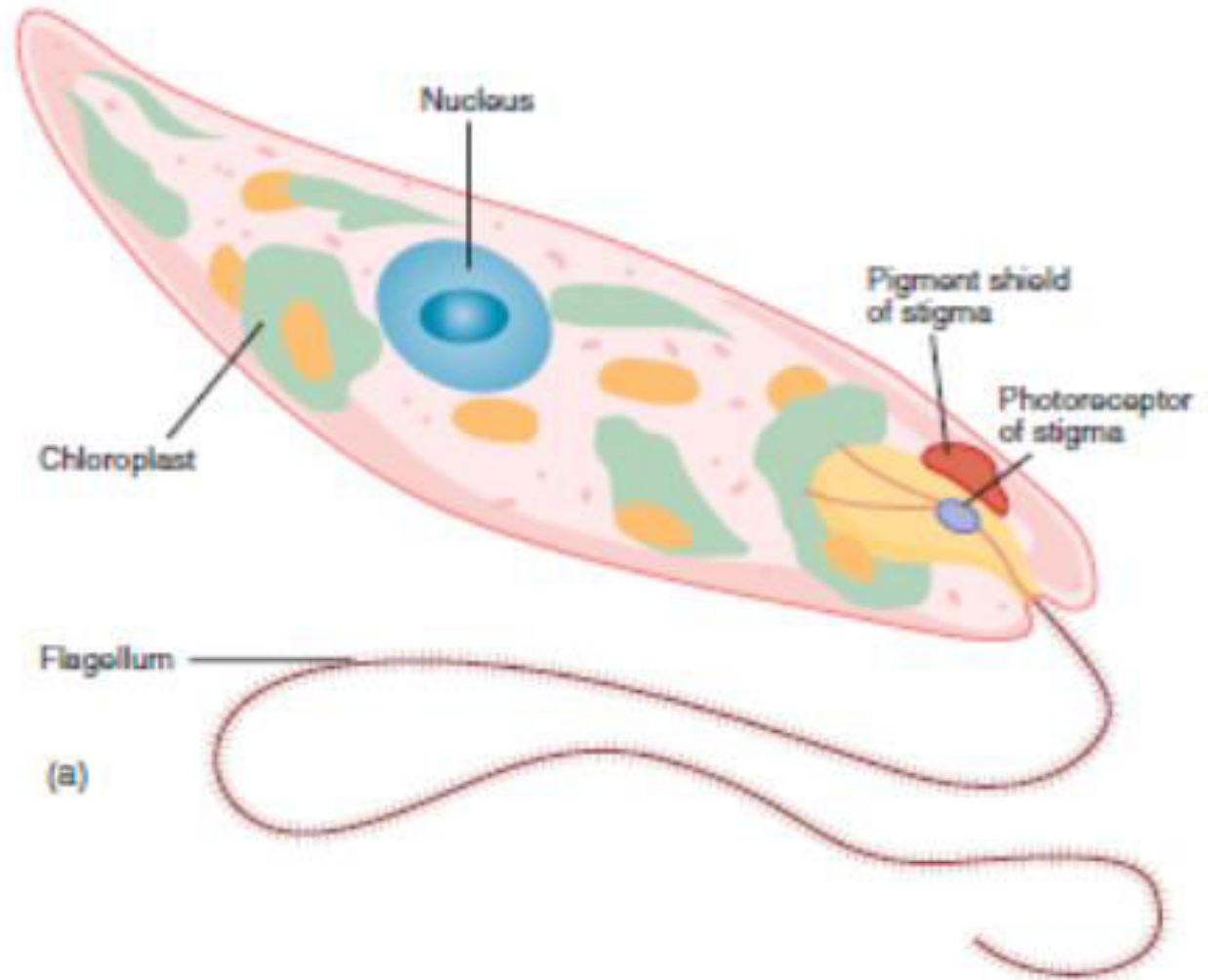
- Stigma (mass of bright red granule containing carotenoid).
- Actual photoreceptor is the **swelling** at the base of the flagellum.
- Stigma serves as a shield, which is essential if the receptor is to detect light.

Photoreceptors Part I

- Thus the photoreceptor plus stigma enable euglena to orient itself so that its receptor is exposed to light.
- This helps the protozoan maintain itself in the region where sufficient light is available.

Photoreceptors Part I

Euglena



Photoreceptors Part I

- In earthworm *Lumbricus*, simple unicellular photoreceptor cells are scattered over the epidermis or concentrated in particular areas of the body.

Photoreceptors Part I

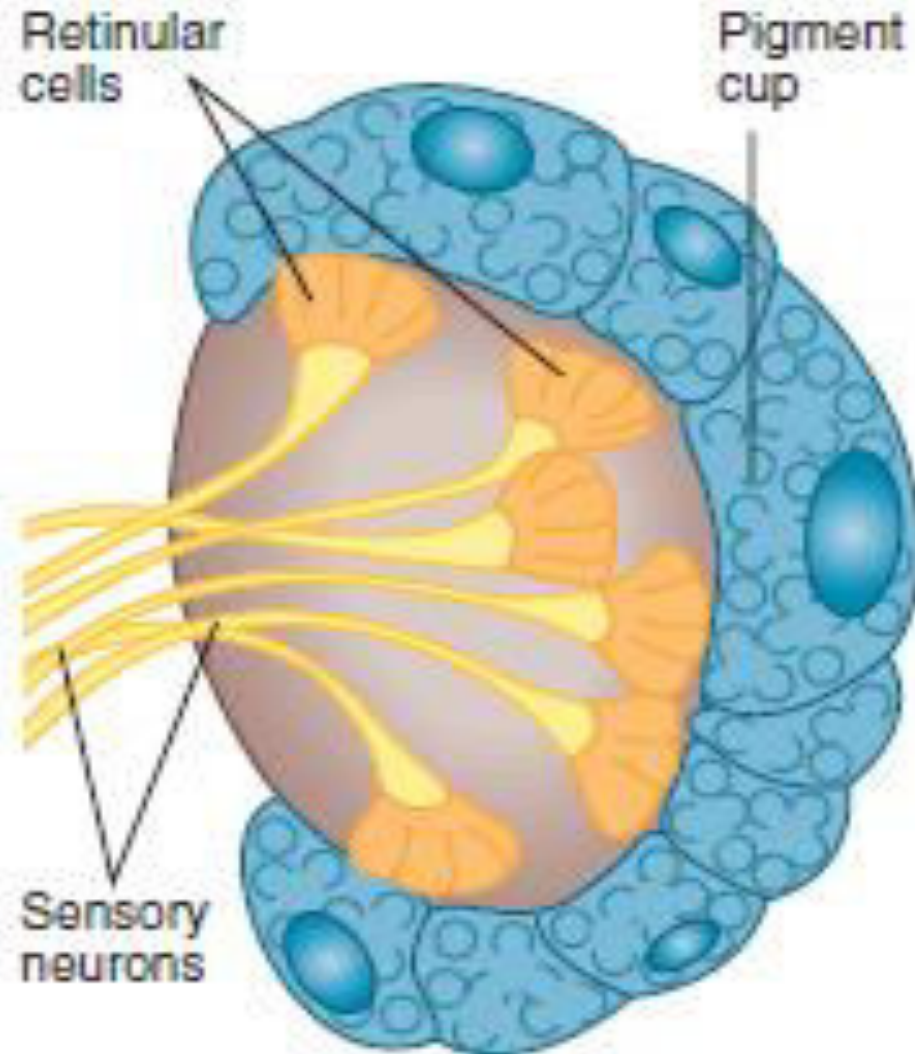
- Other animals possess multicellular photoreceptors that can be classified into:
 - ocelli,
 - compound and
 - complex eyes.

Photoreceptors Part I

- **Ocellus** is simply a small cup lined with light sensitive receptors (retinular cells) and backed by light absorbing pigment.
- The retinular cells contain photosensitive pigments.
- Stimulation by light causes a chemical change in the pigment.

Photoreceptors Part I

Ocellus



Photoreceptors Part I

- This stimulation leads to generator potential then action potential that sensory neurons carry.
- This type of visual system gives animal an information about the direction and intensity of light only but no image.
- Ocelli are common in phyla such as Annelida, Mollusca and arthropoda.

END

Animal Form and Function 1

Module 64



Animal Form and Function 1

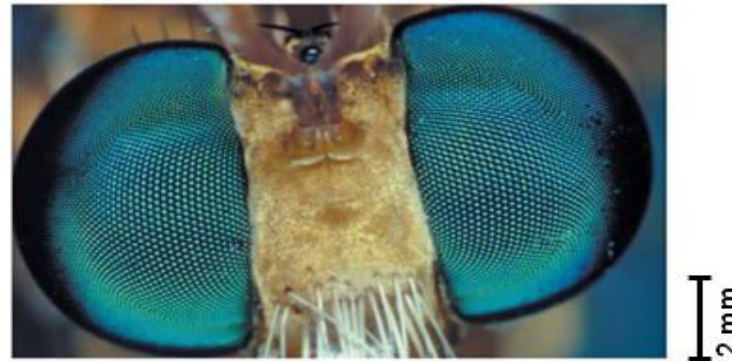
Photoreceptors Part II (Compound Eyes)

Photoreceptors Part II (Compound Eyes)

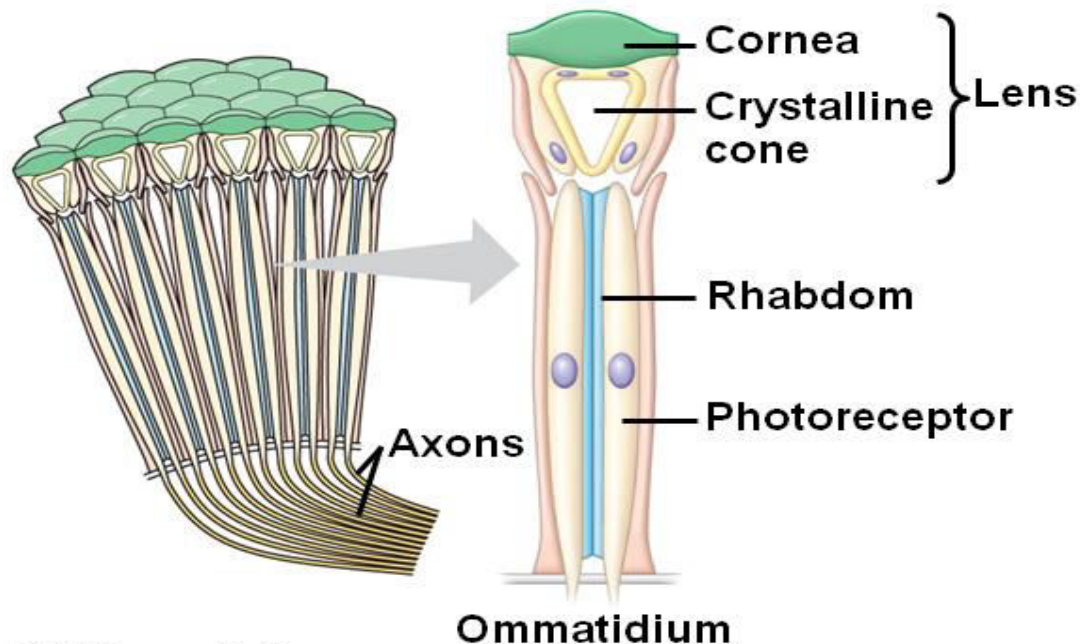


Photoreceptors Part II (Compound Eyes)

Compound eyes

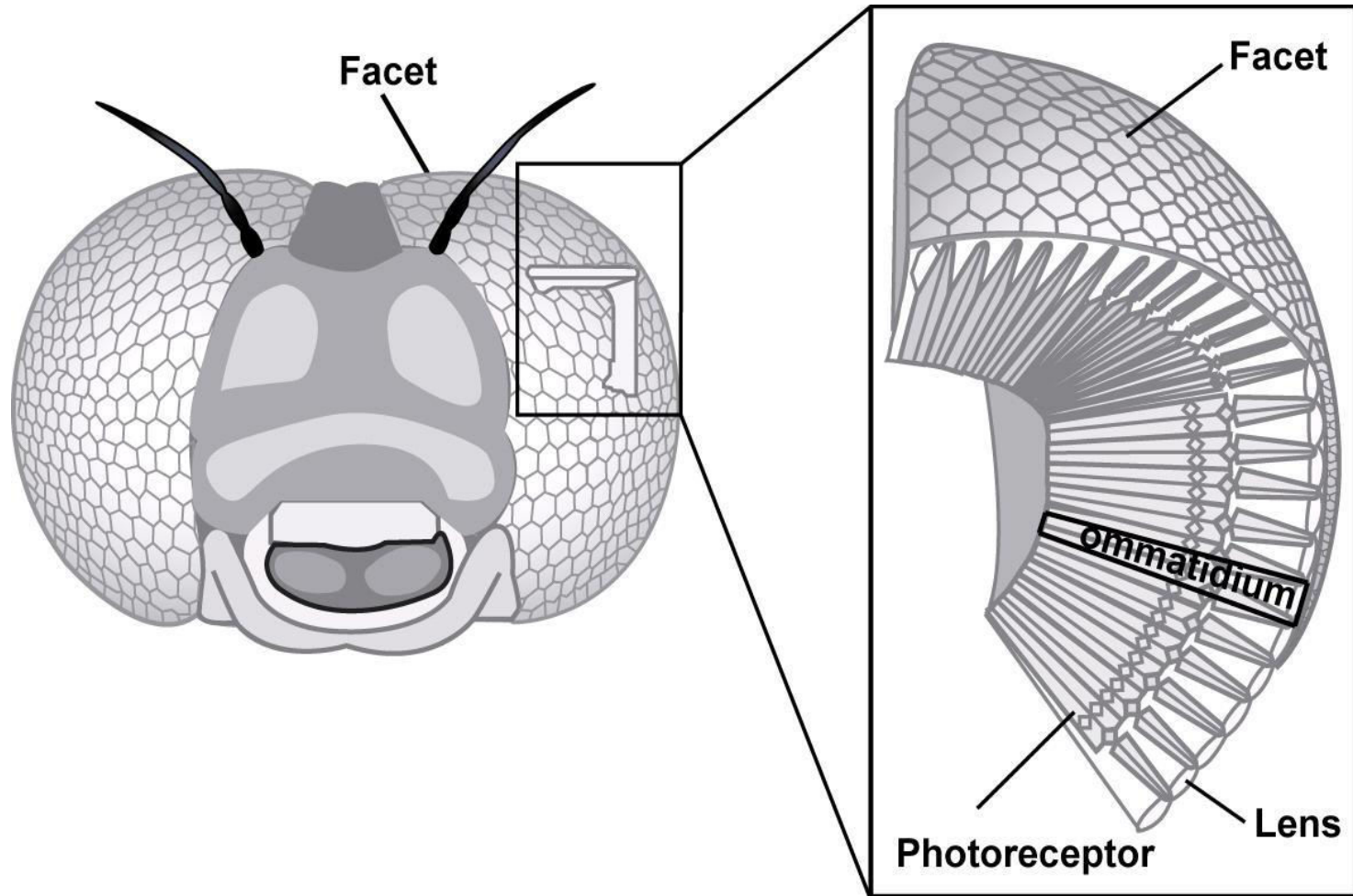


(a) Fly eyes



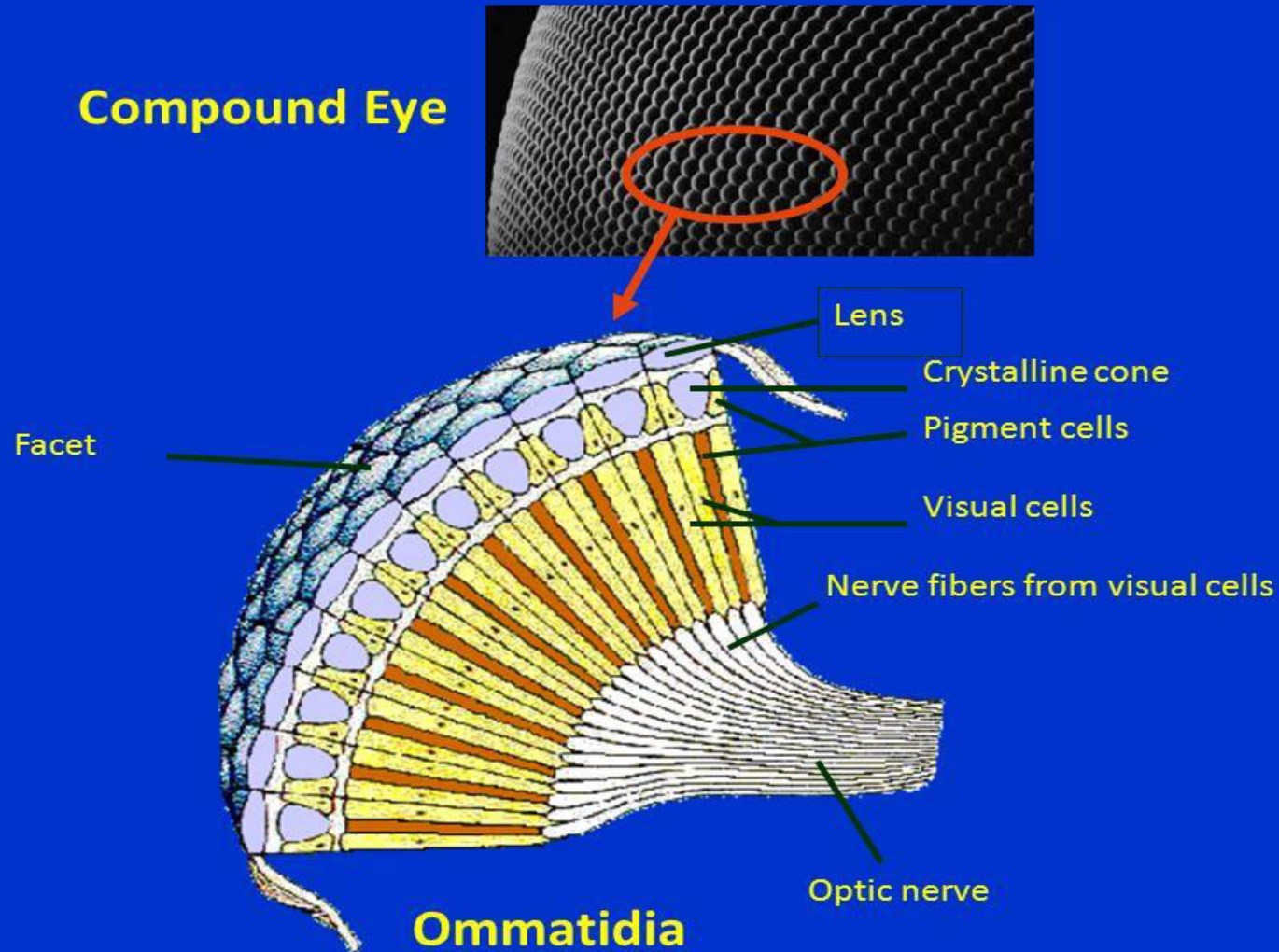
(b) Ommatidia

Photoreceptors Part II (Compound Eyes)



Photoreceptors Part II (Compound Eyes)

Compound Eye



Photoreceptors Part II (Compound Eyes)

- Compound eyes consist of many clear units called Ommatidia.
- Compound eyes occur in some annelids and bivalve molluscs.
- Best developed and understood in arthropods.
- Compound eyes may contain thousands of ommatidia each oriented differently.

Photoreceptors Part II (Compound Eyes)

- The visual field of a compound eye is very wide.
- Each ommatidium has its own nerve tract leading to large optic nerve.

END

Animal Form and Function 1

Module 65



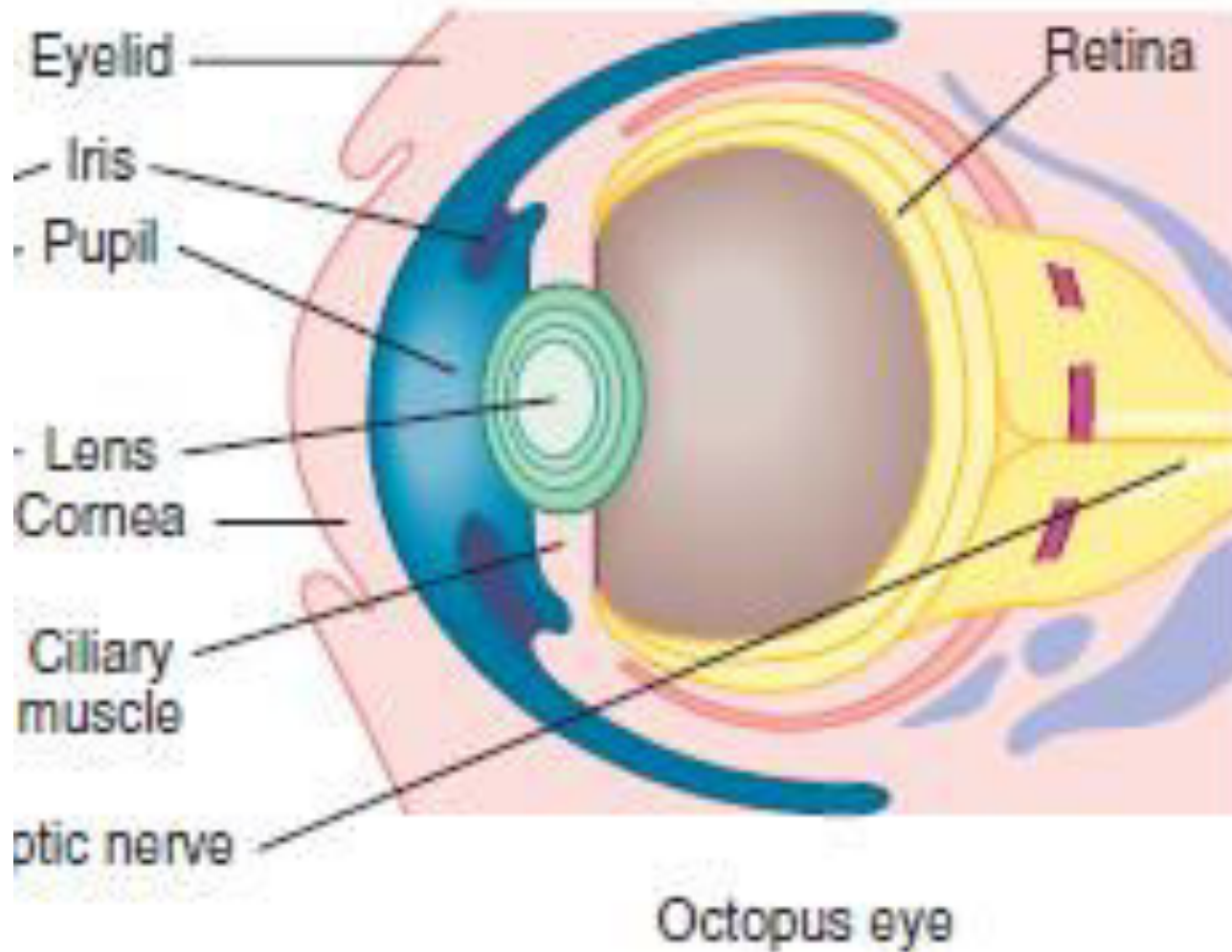
Animal Form and Function 1

Photoreceptors Part III (Complex Camera Eyes)

Photoreceptors Part III (Complex Camera Eyes)

- **Complex Camera Eyes** occur in squids and octopuses.
- These eyes are best image forming eyes among invertebrates.
- Largest eye size is 25 to 30 cm in diameter 45 ft squid.
- Cephalopod eye is often compared with vertebrate eye in its structure.
-

Photoreceptors Part III (Complex Camera Eyes)



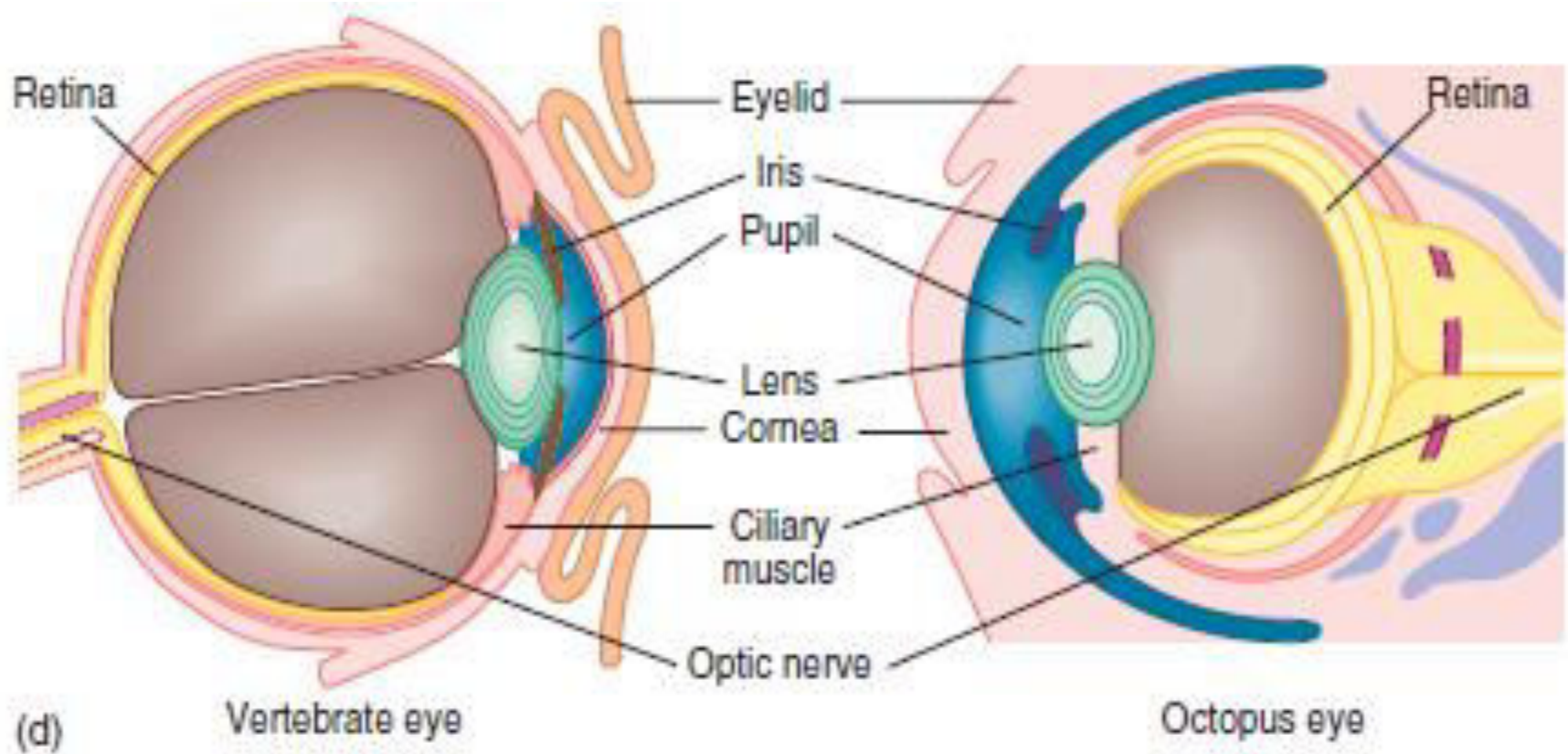
Photoreceptors Part III (Complex Camera Eyes)

- The eye is composed of thin transparent cornea and a lens that focuses light on retina.
- Lens is suspended and controlled by ciliary muscles.
- The eye of squid, however, differs from vertebrate eye in that the receptor site on the retina face the direction of light entering the eye.

Photoreceptors Part III (Complex Camera Eyes)

- In the vertebrate eye the retinal layer is inverted and the receptors are the deepest cells in the retina.
- In cephalopods light is focused by muscles which move the lens toward or away from the retina and by altering the shape of the eye ball.

Photoreceptors Part III (Complex Camera Eyes)



Animal Form and Function 1

Module 66



Animal Form and Function 1

Proprioceptors

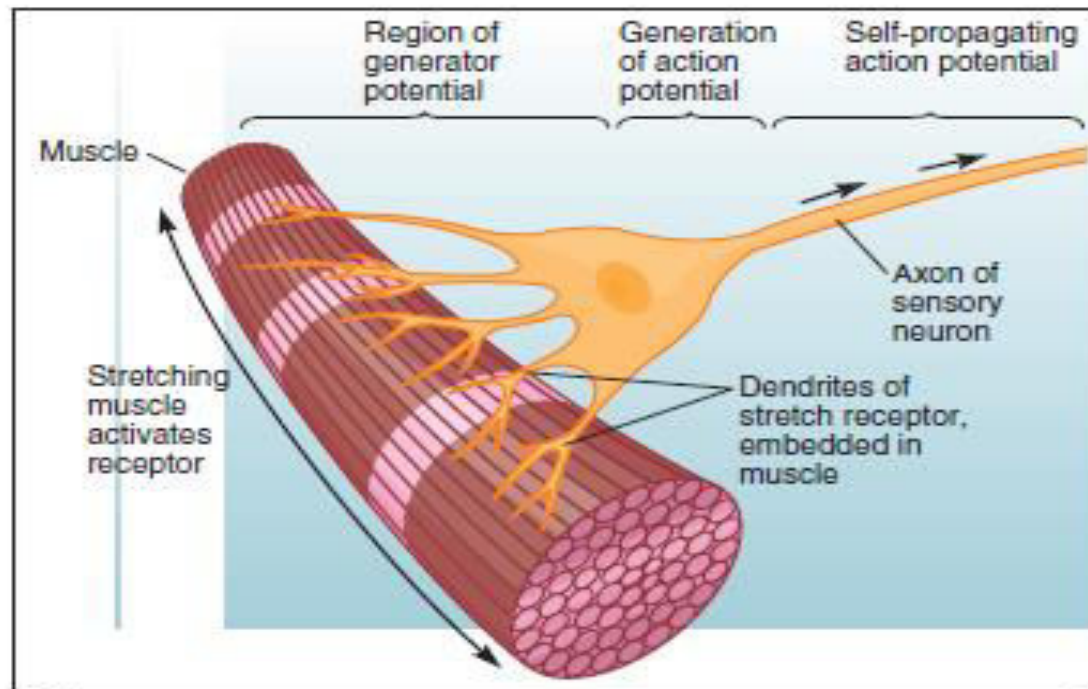


Proprioceptors

Proprioceptors commonly called stretch receptors.

- Located internally.
- Sensitive to mechanically induced changes caused by stretching, bending compression or tension.
- These receptors give an animal information about the movement of its body parts and their position relative to each other.

Proprioceptors



Proprioceptors

- Proprioceptors are associated with appendage joints and body extensor muscles.
- In these animals the sensory neurons may be attached to the muscles, elastic connective tissue fibers or various membranes that span joints.
- As shape changes, generator potential starts.

Module 67



Animal Form and Function 1

Tactile Receptors



Tactile Receptors

- **Tactile receptors** are general derived from modifications of epithelial cells associated with sensory neurons.
- Most tactile receptors of animals involve projections from the body surface.
- These projections include: bristles, spines and tubercles.

Tactile Receptors

- When an animal contacts an object in the environment, these receptors are mechanically deformed.
- These deformations activate the receptors, which in turn activates underlying sensory neuron initiating generator potential

Tactile Receptors

- Most tactile receptors are also sensitive to mechanically induced vibrations propagated through water or a solid substrate.
- Examples:
- Tube swelling Annelids bear receptors that allow them to retract quickly into their tubes in response to any movement in surroundings.

Tactile Receptors

- Web-building spiders have tactile receptors that can sense struggling prey in webs through vibrations of the web threads.

Tactile Receptors



Module 68



Animal Form and Function 1

Thermoreceptors

An abstract architectural sculpture made of large, white, curved panels that create a complex, organic form. The sculpture is set against a background of a modern building with large windows and a clear blue sky.

Thermoreceptors

- **Thermoreceptors** respond to temperature changes.
- Protozoans can directly sense differences in environmental temperatures.
- Paramecia avoid temperature extremes.
- Gather in areas where temperature is moderate.

Thermoreceptors

- Leeches and ticks possess heat sensing mechanism that can recognize warm blooded hosts.

Thermoreceptors

- Certain insects, some crustaceans and the horse shoe crabs can also sense thermal variations
- In all of the above mentioned cases specific receptors have not been identified.

Module 69



Animal Form and Function 1

Introduction of Vertebrate Sensory Receptors

Introduction of Vertebrate Sensory Receptors

- Vertebrate sensory receptors reflect adaptations to the nature of sensory stimuli in environment.
- The environment has chemical and physical characteristics that affect the kinds of energy and molecules that carry sensory information

Introduction of Vertebrate Sensory Receptors

- For example, your external environment consists of the media that surrounds you: the earth that you stand on and the air that you breathe.
- Other animals may have different external environments: a trout may be immersed in the cool, clear water of a mountain stream.

Introduction of Vertebrate Sensory Receptors

- A turtle may be submerged in the turbid water of a swamp; and a salmon may be swimming in the salty water of the sea.

Introduction of Vertebrate Sensory Receptors

- Air transmits light very well and conducts sound waves rather efficiently.
- It can carry only a limited assortment of small molecules detectable using the sense of smell and can pass little or no electrical energy.

Introduction of Vertebrate Sensory Receptors

- In water, however, sound travels both faster and farther than in air, and water dissolves and carries a wide range of chemicals. Water, especially seawater, is also an excellent conductor of electricity, but it absorbs (and hence fails to transmit) many wavelengths of light.

Introduction of Vertebrate Sensory Receptors

- Water, especially seawater, is also an excellent conductor of electricity, but it absorbs (and hence fails to transmit) many wavelengths of light.

Introduction of Vertebrate Sensory Receptors

- As these examples indicate, vertebrate sensory receptors (organs), like invertebrate sensory receptors, have evolved in ways that relate to the environment in which they must function.

Introduction of Vertebrate Sensory Receptors

- Water, especially seawater, is also an excellent conductor of electricity, but it absorbs (and hence fails to transmit) many wavelengths of light.

END

Animal Form and Function 1

Module 70



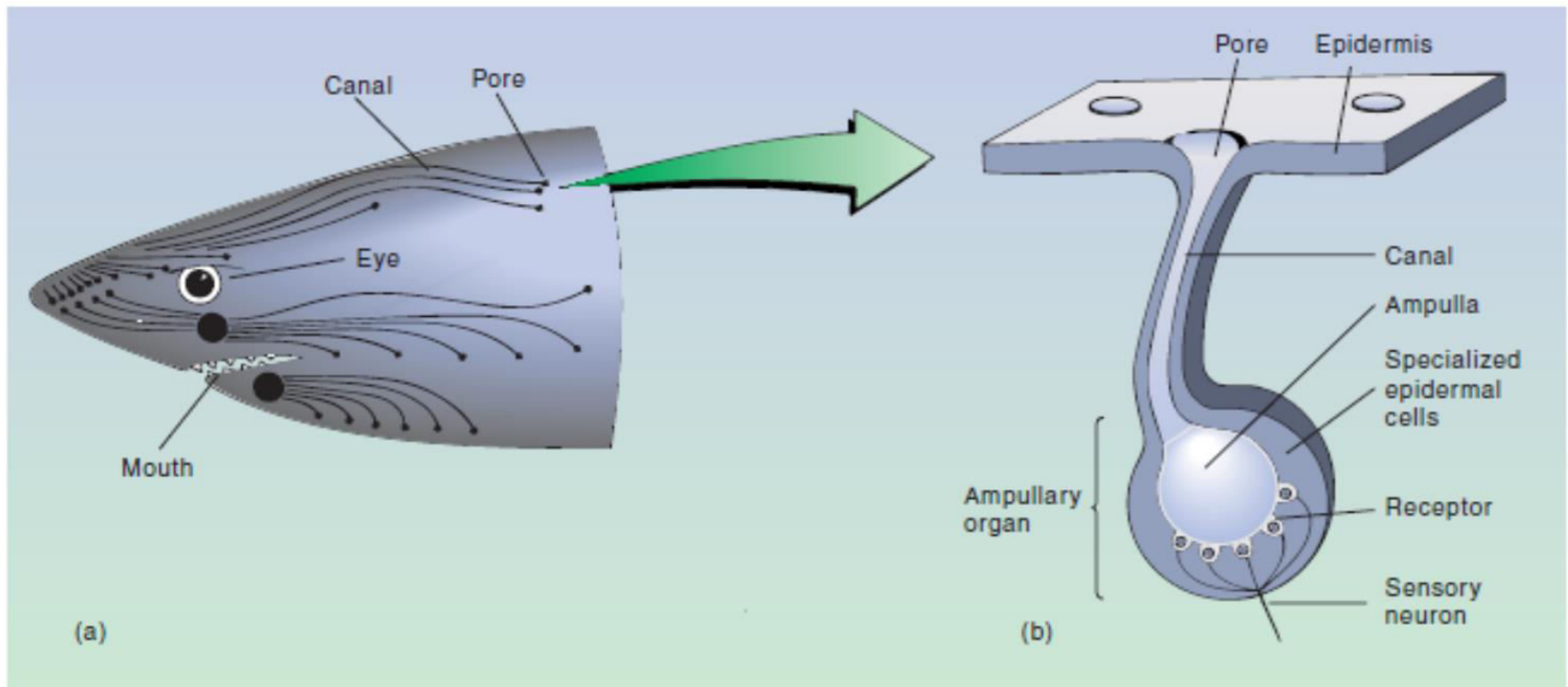
Animal Form and Function 1

Lateral Line System and Electrical Sensing

Lateral-Line System & Electrical Sensing

- **The lateral line system** is electrical sensing that occurs both in jawless and jawed fishes and some amphibians, along the sides of head and body
- It consists of sensory pores in the epidermis of the skin that connect to canals leading into electroreceptors called **ampullary organs**.

Lateral-Line System & Electrical Sensing



Lateral-Line System & Electrical Sensing

- These organs can sense feeble electrical field produced by organisms living in surrounding water.
- This ability to detect these fields help a fish to find mate, capture prey or avoid predators.

Lateral-Line System & Electrical Sensing

- This is especially valuable sense in deep, turbulent or murky water where vision is of little use.
- In fact, some fishes actually generate fields and then use their electroreceptors to detect how surrounding objects distort the field

Lateral-Line System & Electrical Sensing

- This allows these fishes to navigate in murky or turbulent waters.

END

Module 71



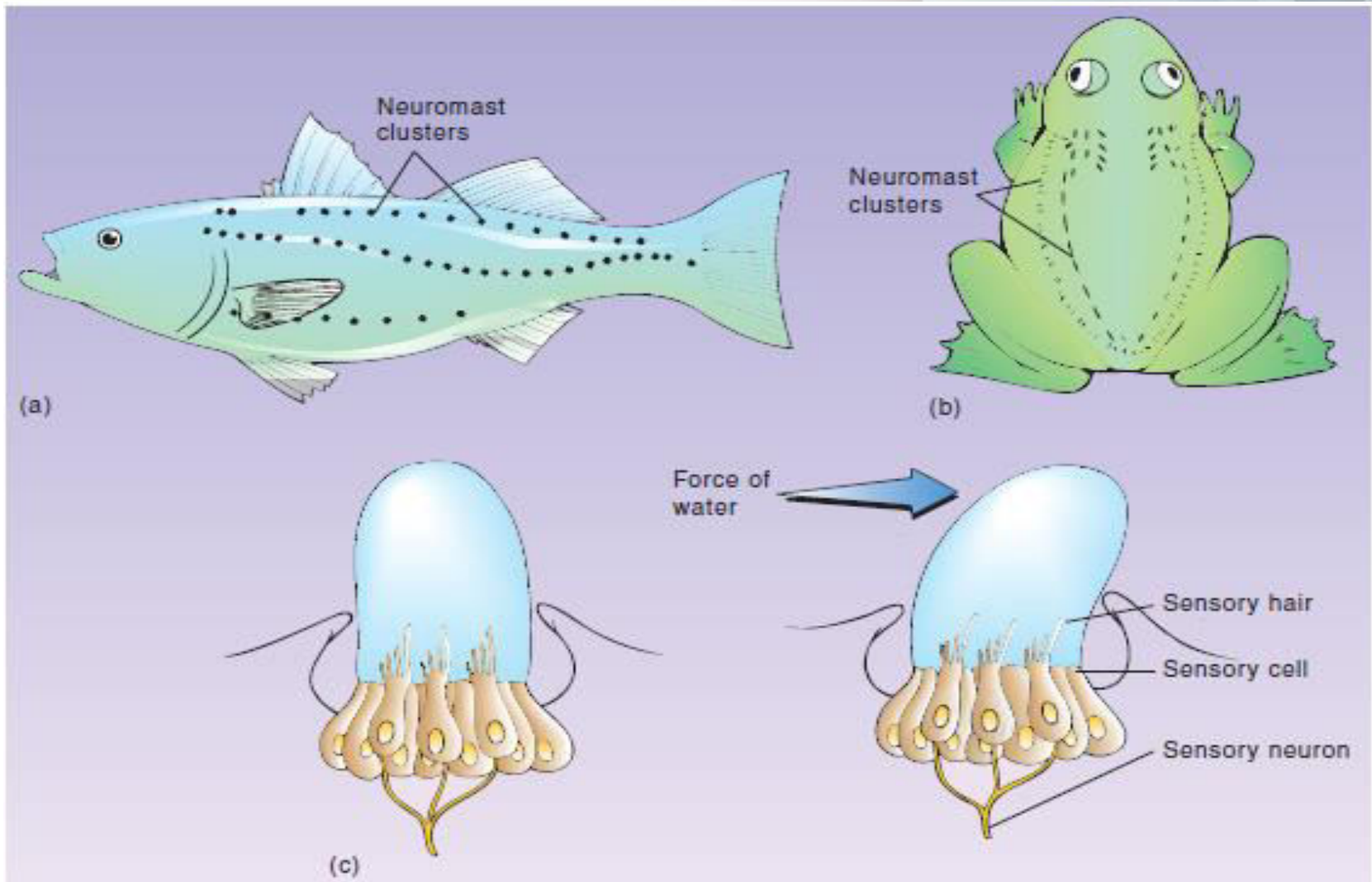
Animal Form and Function 1

Lateral Line System and Mechanoreception

Lateral-Line System and Mechanoreception

- Mechanoreceptor also called **Neuromasts** are the part of Lateral Line system.
- These receptors are found in cyclostomes, sharks, aquatic amphibians and some advanced fishes.
- Neuromasts are located in pits along the body but not in head region.

Lateral-Line System and Mechanoreception



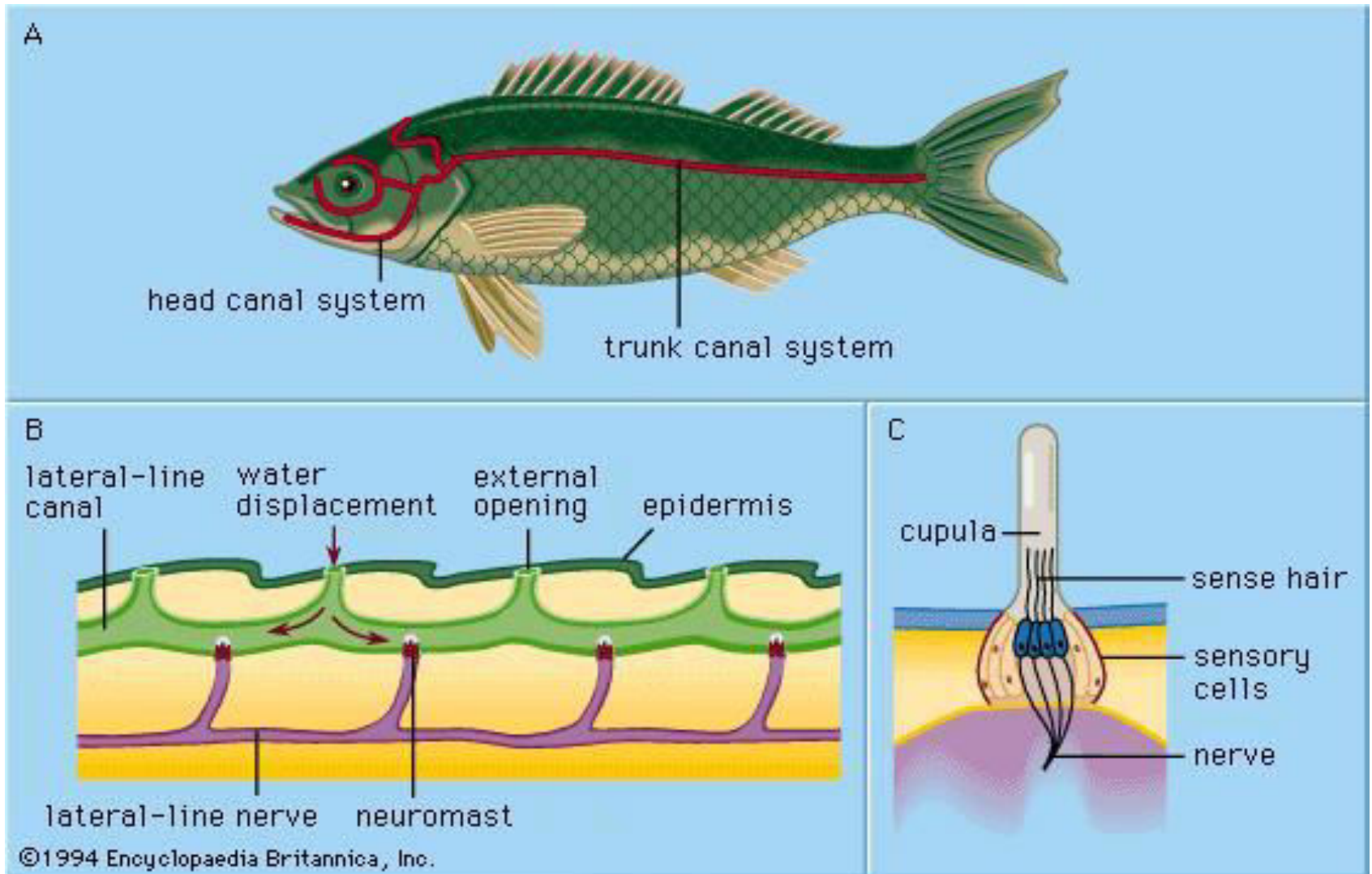
Lateral-Line System and Mechanoreception

- Neuromasts are responsive to local water disturbance.
- When water near the lateral line moves, water in the pits also moves.
- This movement disturbs hair like cells of the neuromasts causing the generator potential in the associative sensory neurons.

Lateral-Line System and Mechanoreception

- This helps the animal to detect the direction and force of water currents and thus the movement of other animals in the vicinity and become alert from the predators.
- For example this sense enables a trout to orient the head upstream in water.

Lateral-Line System and Mechanoreception



Animal Form and Function 1

Module 72



Animal Form and Function 1

Hearing and Equilibrium in Air



Hearing and Equilibrium in Air

- **Hearing** is important to vertebrates as a mechanism to:
- a) become alert against nearby or faraway dangerous activity.
- b) become important for the location of food communicated by other animals e.g. Crows.
- c) respond the calls for mating e.g. cats, cows

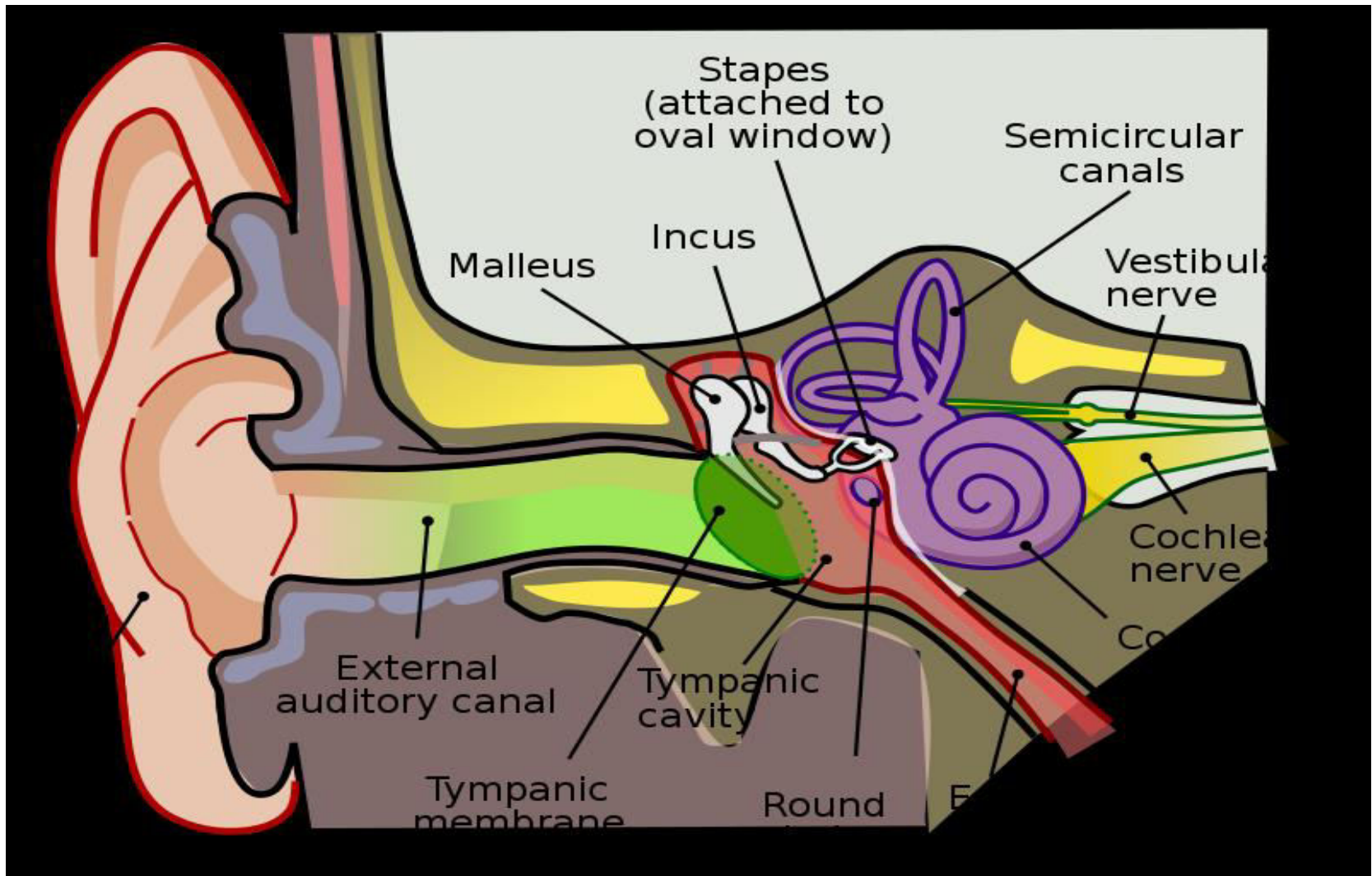
Hearing and Equilibrium in Air

- Hearing and Equilibrium are the sensations that occur together in the same vertebrate organ, ear.
- For hearing it is the **Auditory organ** and for equilibrium and posture, the **Vestibular apparatus**.

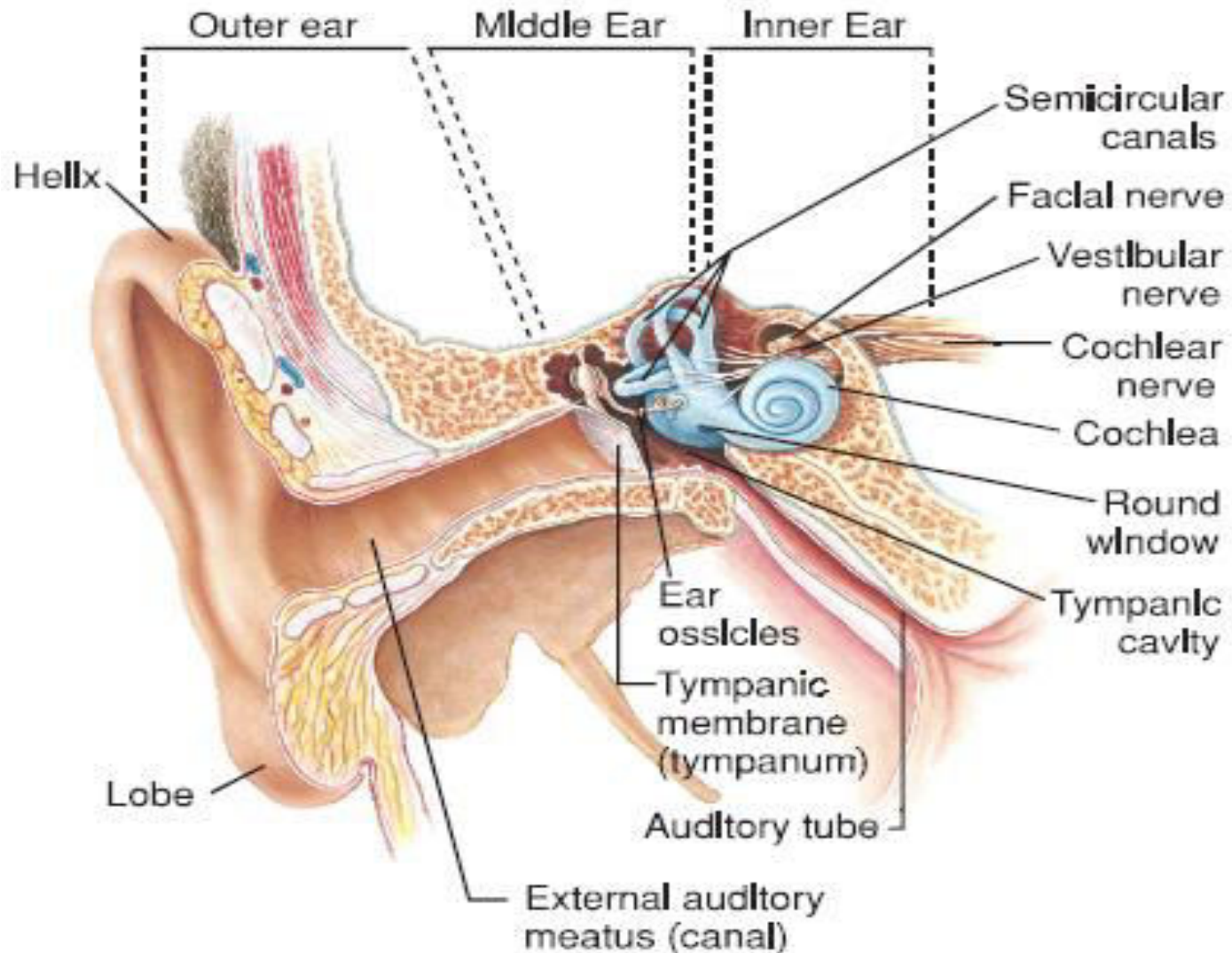
Hearing and Equilibrium in Air

- The main part of auditory apparatus which is involved with hearing is the cochlea.
- The part of the ear which is involved with equilibrium are the semicircular canals.

Hearing and Equilibrium in Air



Hearing and Equilibrium in Air



Hearing and Equilibrium in Air

- Sound results when waves transmit energy through some medium such as air or water.
- Adaptation of hearing in air resulted from the evolution of an acoustic transformer that incorporates a thin membrane that is exposed to air.

END

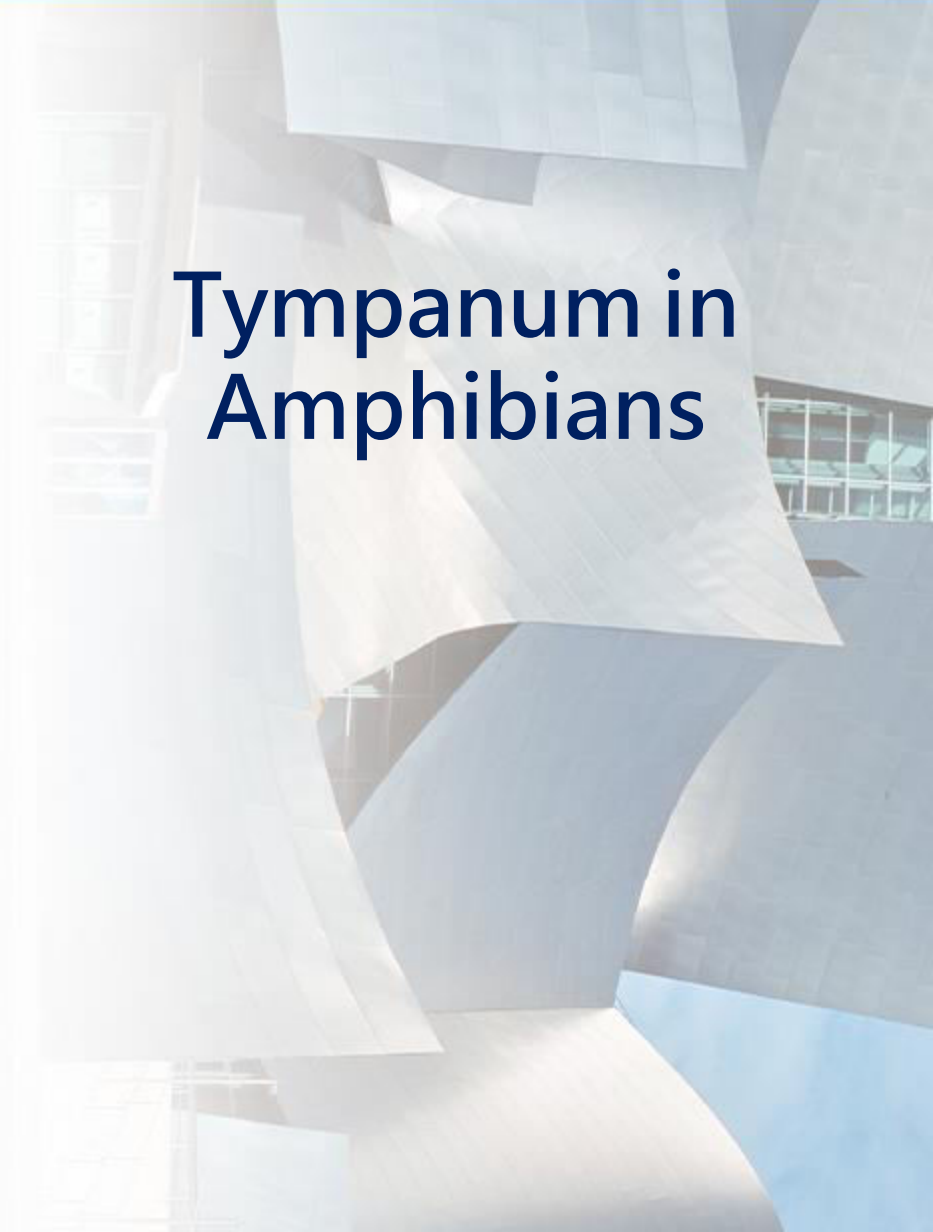
Animal Form and Function 1

Module 73



Animal Form and Function 1

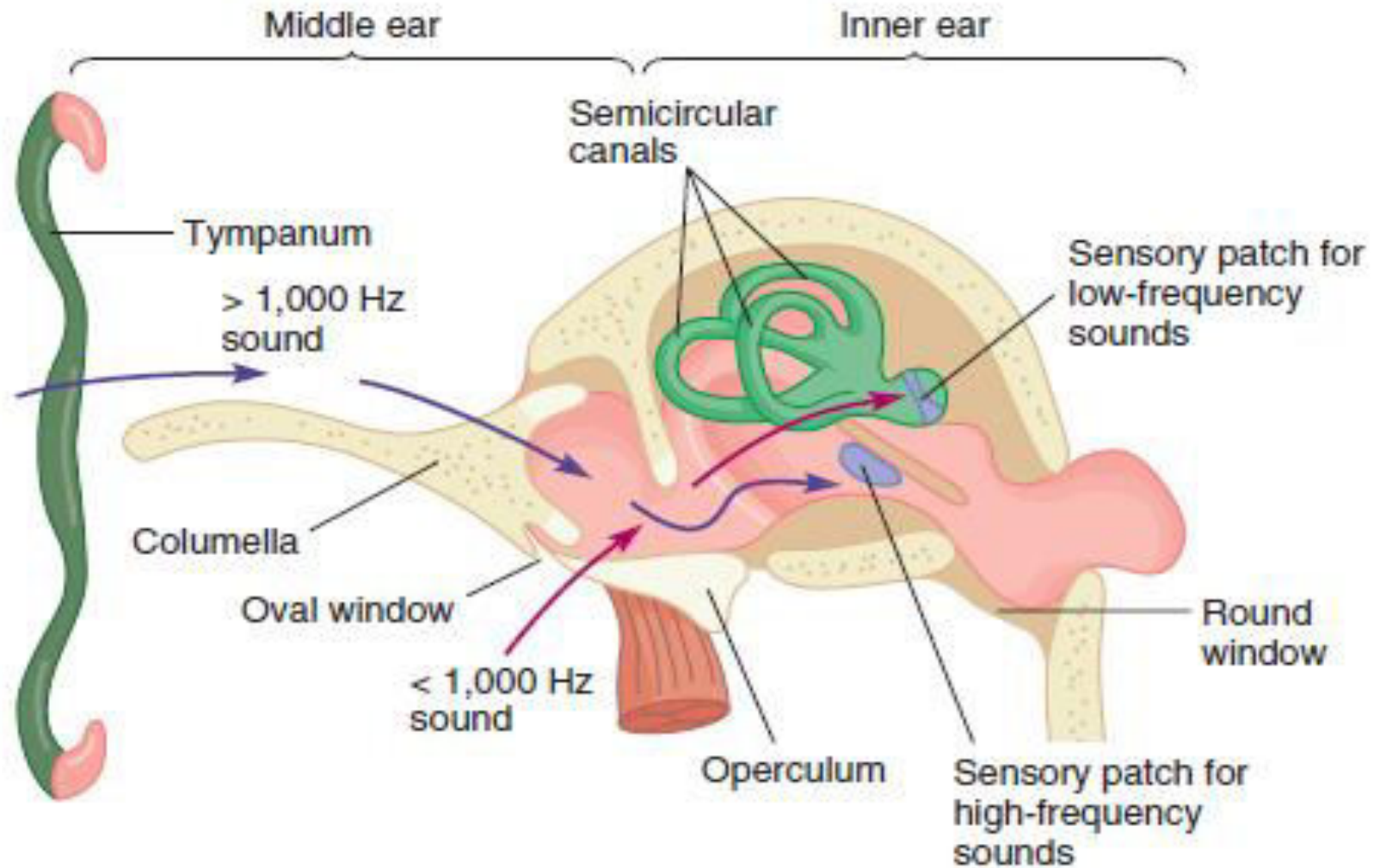
Tympanum in Amphibians



Tympanum in Amphibians

- **Tympanum** or the ear drum first evolved in Amphibians.
- Ears of Anurans consists of:
 - a) Tympanum
 - b) Middle ear and
 - c) Inner ear
- Tympanum is modified integument stretched over cartilaginous ring.

Tympanum in Amphibians



Tympanum in Amphibians

- Touching the tympanum is an ossicle, called columella or stapes.
- The opposite end of the stapes touches the membrane of the oval window that stretches between middle and inner ear.
- There are 3 semicircular canals which attached by their end.

Tympanum in Amphibians

- The semicircular canals are fluid filled.
- A second small ossicle, the operculum, also touches the oval window.
- Muscles attached to the operculum and columella can lock either or both of these ossicles, allowing a frog to screen out either high or low frequency sounds.

Tympanum in Amphibians

- This mechanism is adaptive because frogs use low and high frequency sounds in different situations.
- Mating calls are high frequency sounds.
- At other times low frequency sound may warn approaching predators.

Tympanum in Amphibians

- Salamanders lack Tympanum and middle ear.
- There is no mating calls and the only sound they hear are probably transmitted through the substratum and skull to inner ear.

END

Animal Form and Function 1

Module 74



Animal Form and Function 1

Hearing in Reptiles

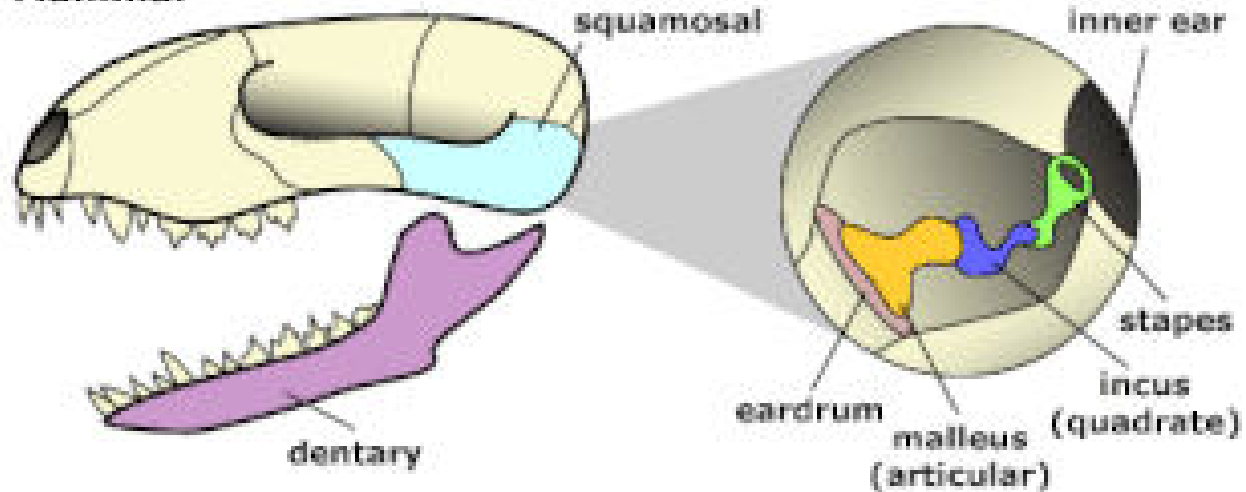


Hearing in Reptiles

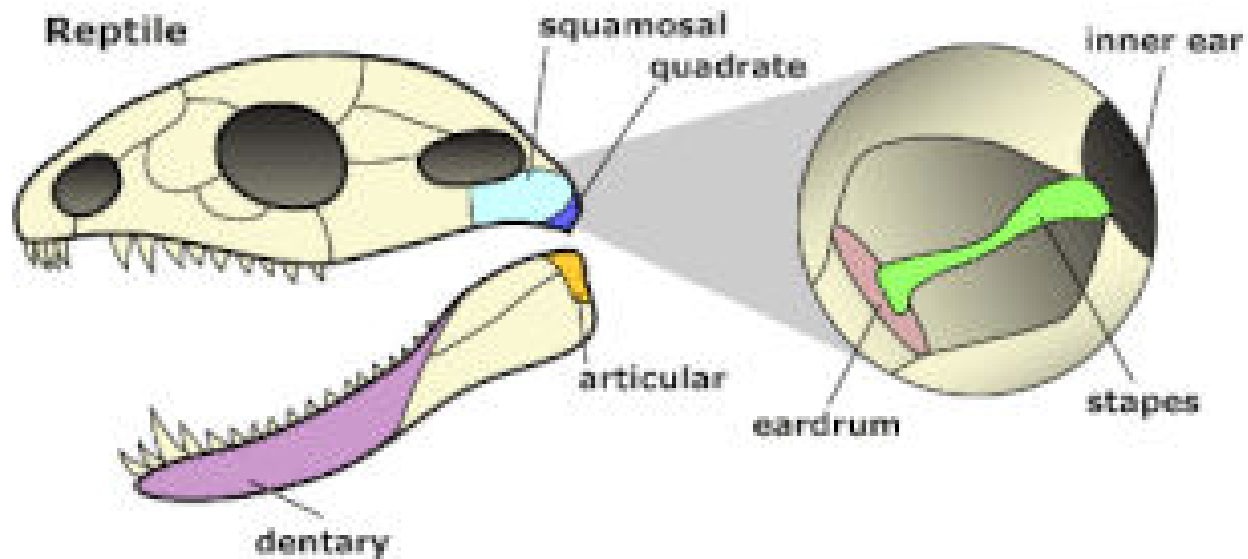
- Reptilian ears vary in structure.
- Ears of snakes lack a middle ear cavity and tympanum.
- They have vestiges of the hearing apparatus inside their heads. A bone of jaw articulates with the **stapes** and receives vibrations of the ground or substratum.

Hearing in Reptiles

Mammal



Reptile



Hearing in Reptiles

- Snakes have two ways of detecting sound:
- Earth borne and Air borne
- The earth borne vibrations are passed through the belly muscles to special receptors along the spine and then transmitted to the brain.

Hearing in Reptiles

- Airborne sounds are transmitted from the skin receptors to the lungs and then to the inner ear and 8th cranial nerve to the brain.
- Snakes hear low frequency sounds.

Hearing in Reptiles

- In some reptiles tympanum or ear drum may be on the surface or in small depression in the head.
- The structure of the inner ear is similar to that of amphibians.

END

Animal Form and Function 1

Module 75



Animal Form and Function 1

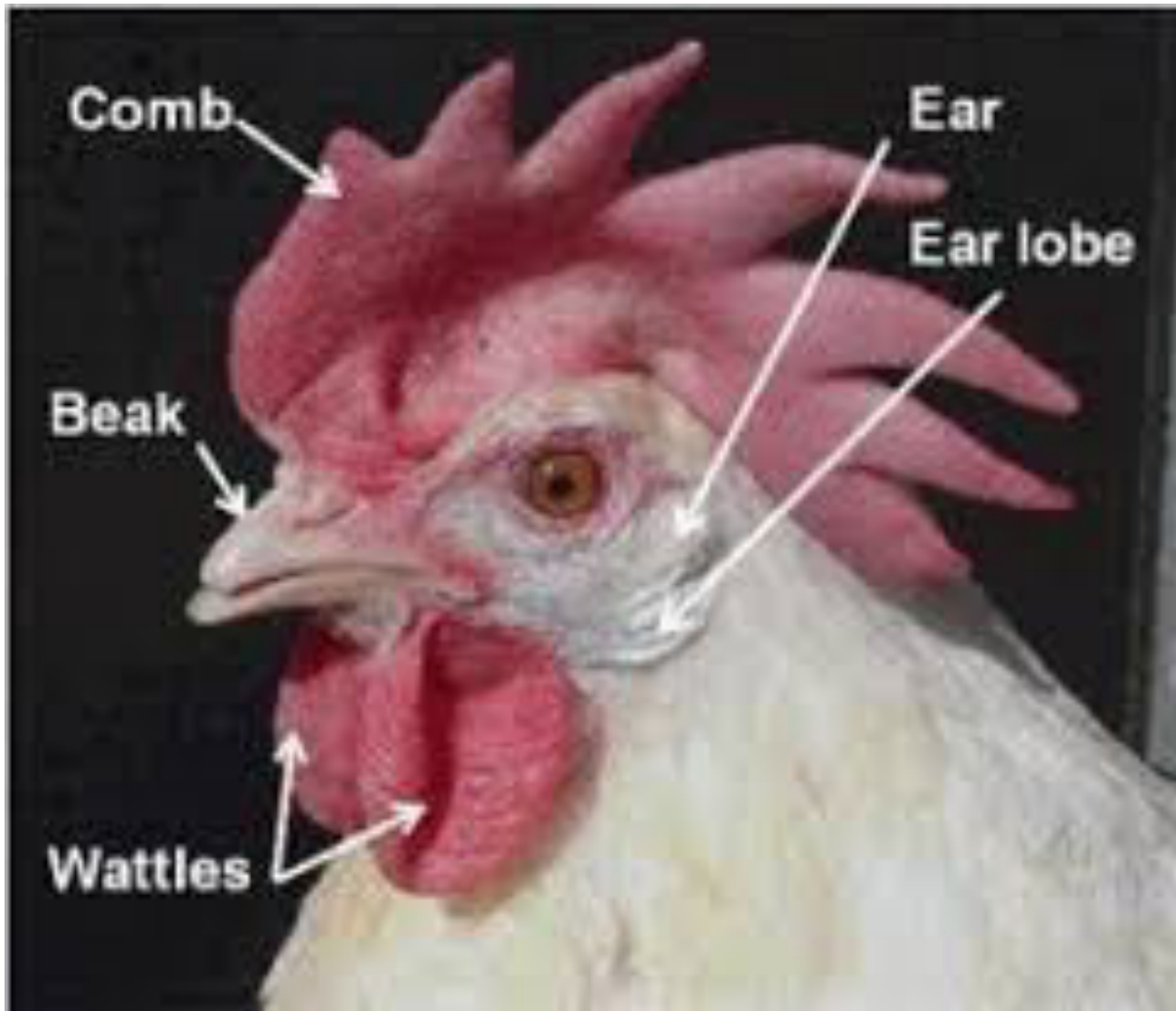
Hearing in Birds



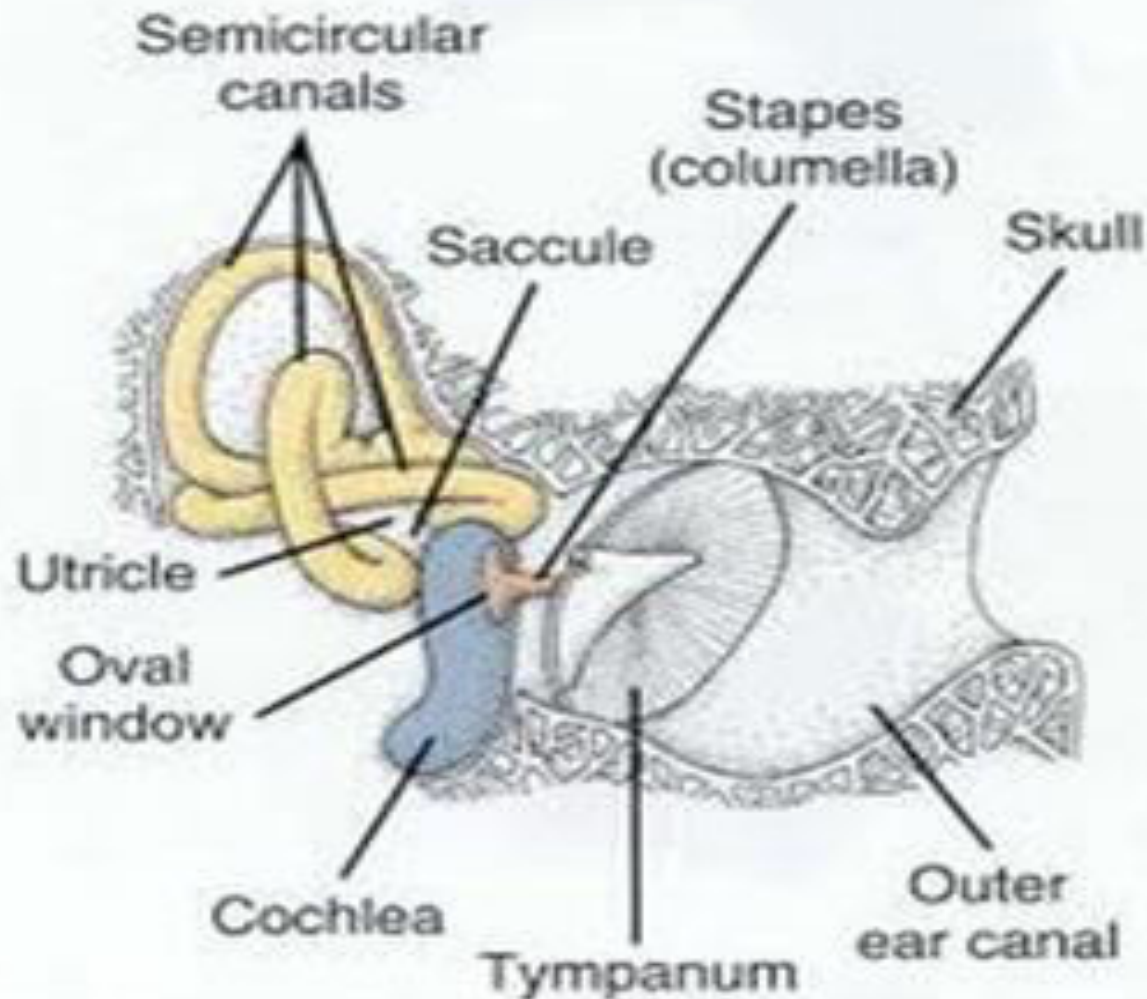
Hearing in Birds

- The ear openings in birds are just below and behind the eyes and are covered by fine feathers called auriculars or ear coverts.
- These ear coverts funnel sounds from to the ear opening down to the eardrum.

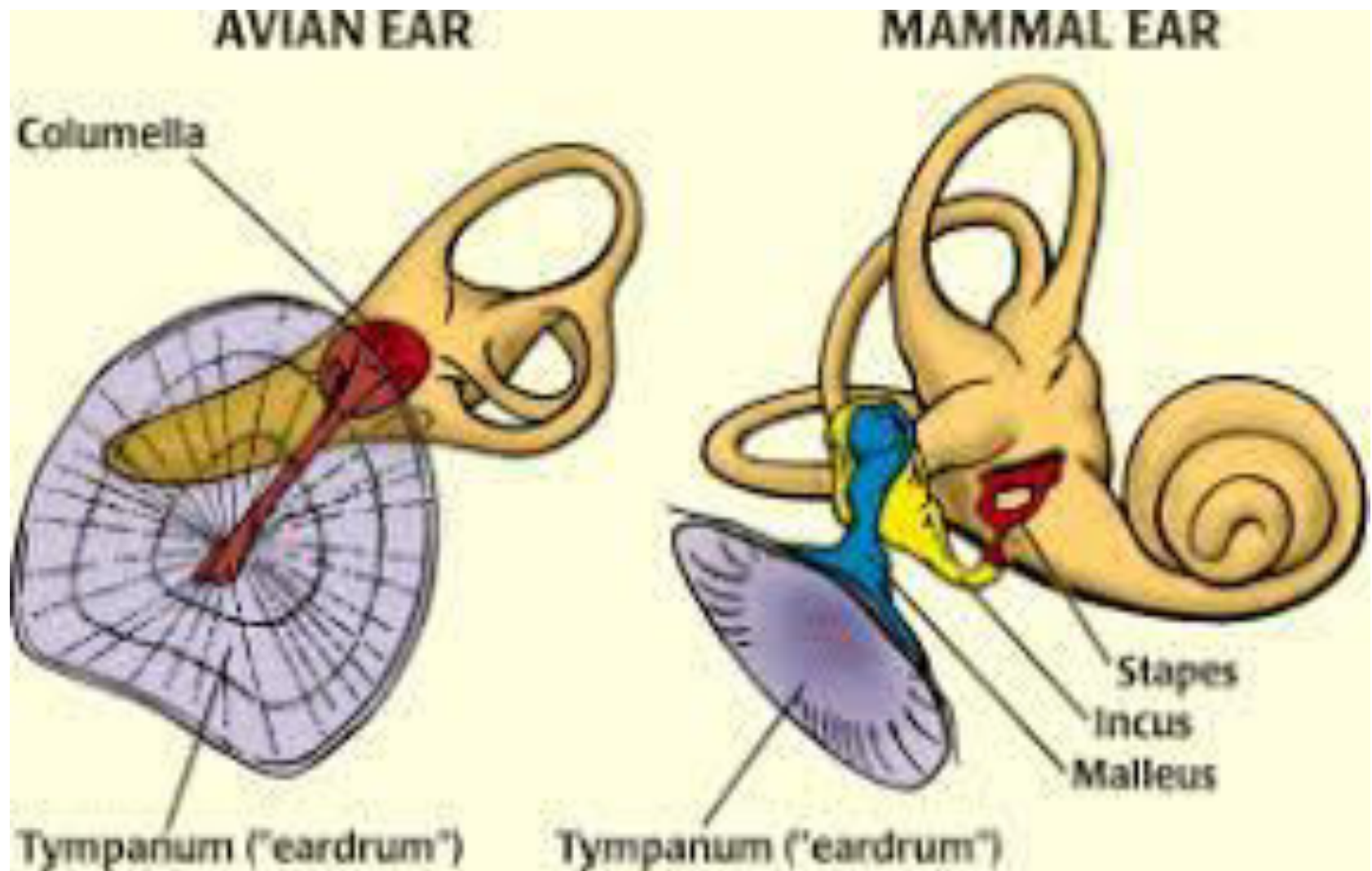
Hearing in Birds



Hearing in Birds



Hearing in Birds



Hearing in Birds

- In birds there is just one stapes or columella, which transmits vibrations from the eardrum to the membrane across the oval window in the cochlea of the inner ear.
- The cochlea is a hair lined, fluid-filled chamber.

Hearing in Birds

- Movement of the fluid caused by the vibration of the membrane moves these hairs, or cilia.
- The movement of these hairs excites nerve endings to transmit signals to the brain where it is translated and interpreted as sound.

Hearing in Birds

- There is another opening in the cochlea, the round window, which is covered by yet another membrane and this allows the pressure waves moving the cilia to dissipate.
- Also in the inner ear are the semicircular canals used to determine orientation and to regulate balance.

END

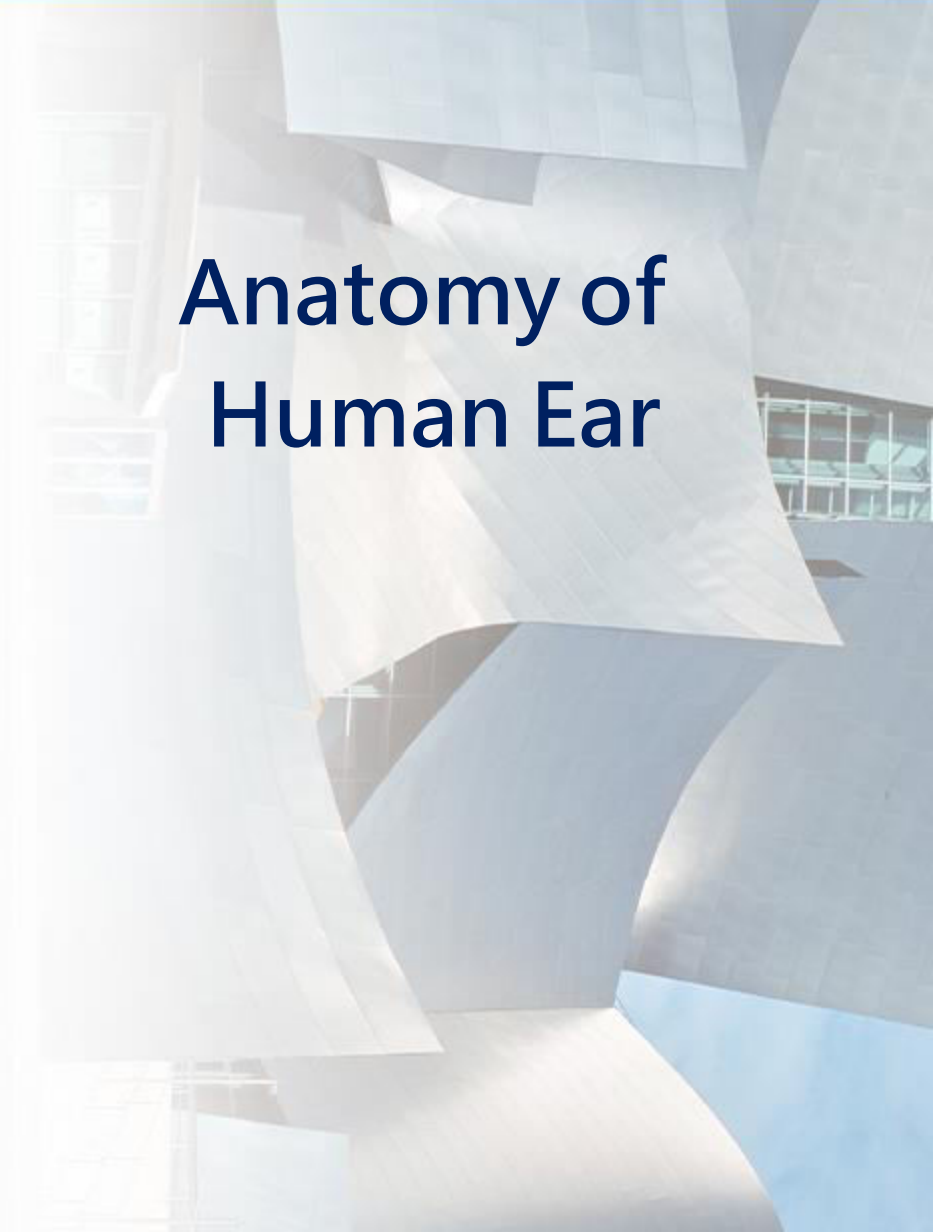
Animal Form and Function 1

Module 76



Animal Form and Function 1

Anatomy of Human Ear



Anatomy of Human Ear

- Human ear has three divisions:
 - a) Outer ear
 - b) Middle ear and
 - c) Inner ear
- **Outer ear** consists of pinna and auditory canal.
- **Middle ear** begins at tympanic membrane, and ends in side the skull where oval and round windows are located

Anatomy of Human Ear

- Three small ossicles are the parts of middle ear.
- These ossicles include:
malleus (hammer)
incus (anvil)
stapes (stirrup)
- The malleus adheres the tympanic membrane and connects to the incus.
- The incus connects to the stapes which adheres to the oval window.

Anatomy of Human Ear

- Auditory or eustachian tube extends from the middle ear to the nasopharynx.
- This equalizes air pressure between middle ear and throat.

Anatomy of Human Ear

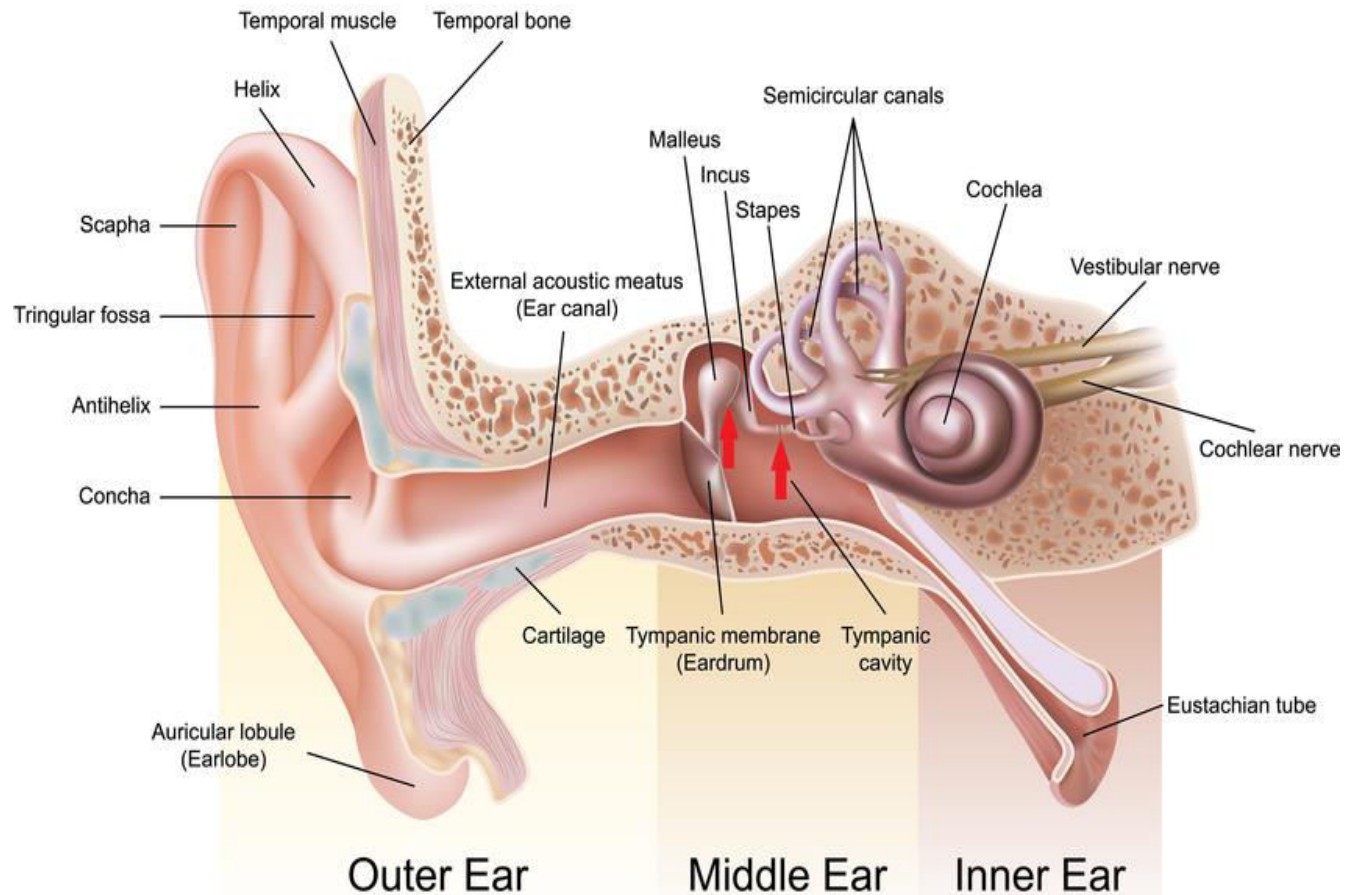
- The inner ear or **Membranous labyrinth** has three components:
Vestibule
Semicircular canals &
Cochlea
- The first two are involved in equilibrium
- Cochlea is the only part involved in hearing.
- Cochlea is a coiled duct resembling that of snail shell.

Anatomy of Human Ear

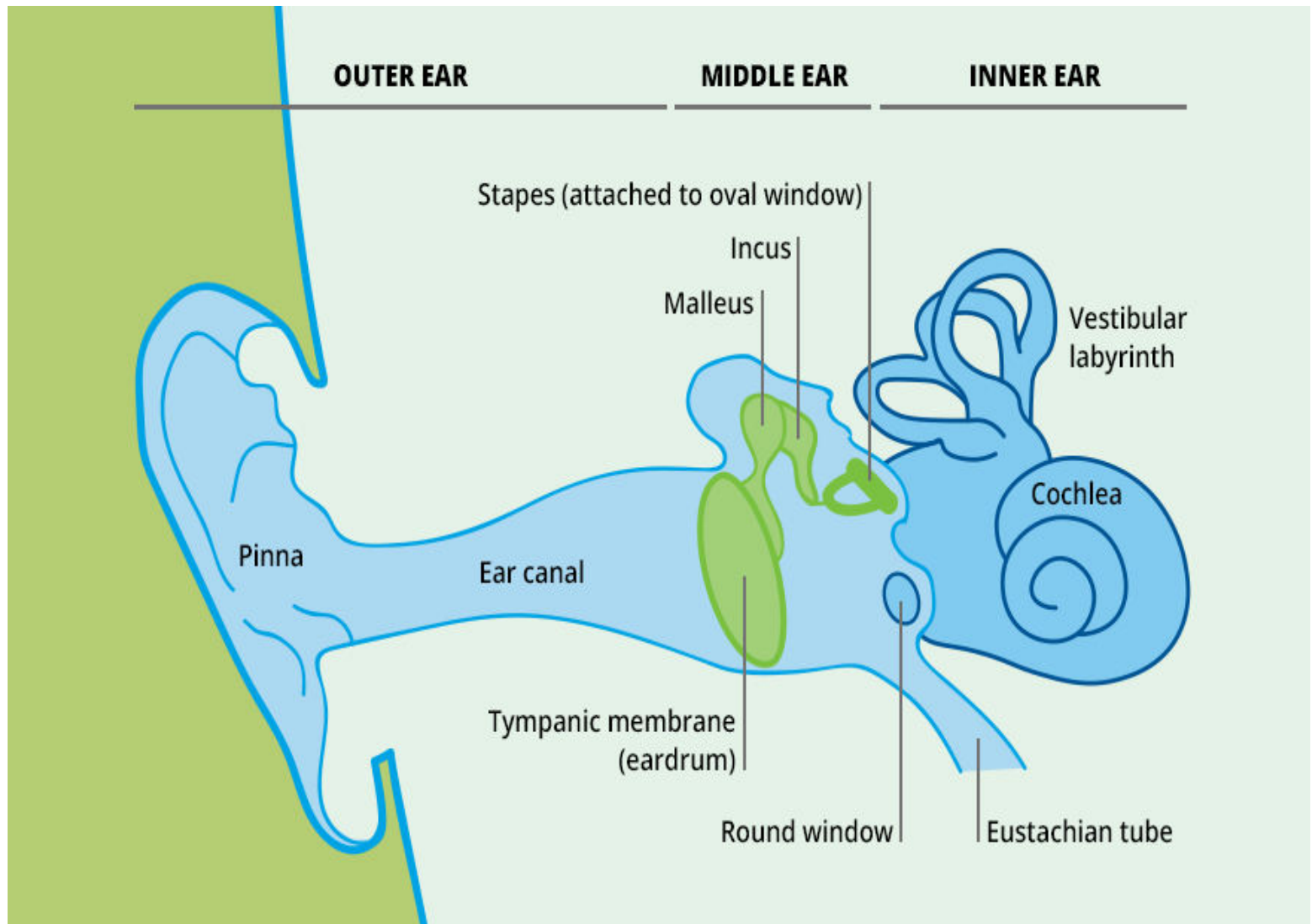
- The entire inner ear is bathed in a cushioning fluid, the endolymph.
- The sensory cells which have hair-like projections are called **Organs of Corti**.
- These organs are located on the basilar membrane that forms the base of cochlea.

Anatomy of Human Ear

Anatomy of the Ear



Anatomy of Human Ear



Animal Form and Function 1

Module 77



Animal Form and Function 1

Hearing and Equilibrium in Man

Hearing and Equilibrium in Man

- Sound waves enter the outer ear and reach the tympanic membrane to vibrate.
- These vibrations move the ossicles one after the other against the oval window.
- When the middle ear transfers the vibrations to the cochlea the fluid in the cochlea is displaced.

Hearing and Equilibrium of Man

- This displacement of the fluid make the hair cells move.
- Signals from the cells are converted into nerve impulse and sent to the brain through the auditory nerve, thereby helping the process of hearing
- .

Hearing and Equilibrium in Man

- Receptor cells of the organ of Corti which have hair-like projections bend causing generator potential, which leads to action potential that travels along the vestibulocochlear nerve to the brain for interpretation.

Hearing and Equilibrium in Man

- When the body is still, the otoliths in the semilunar canals rest on hair cells.
- When the head horizontally or vertically the granules are displaced. This displacement bends the hair slightly so that hair cells initiate generator potential.
- Continuous movements cause motion sickness.

Hearing and Equilibrium in Man

- The sense of equilibrium can be divided into two equal senses- Static and Dynamic
- Static refers to sense movement in one plane (vertical or horizontal).
- Dynamic refers to angular or rotation movements.

Hearing and Equilibrium in Man

- Humans are not able to hear low-pitched voice below 20 cycles per second.
- Young children can hear high pitched sound up to 20,000 cycles per second.
- Dog can easily detect sound of 40,000 cycles per second.

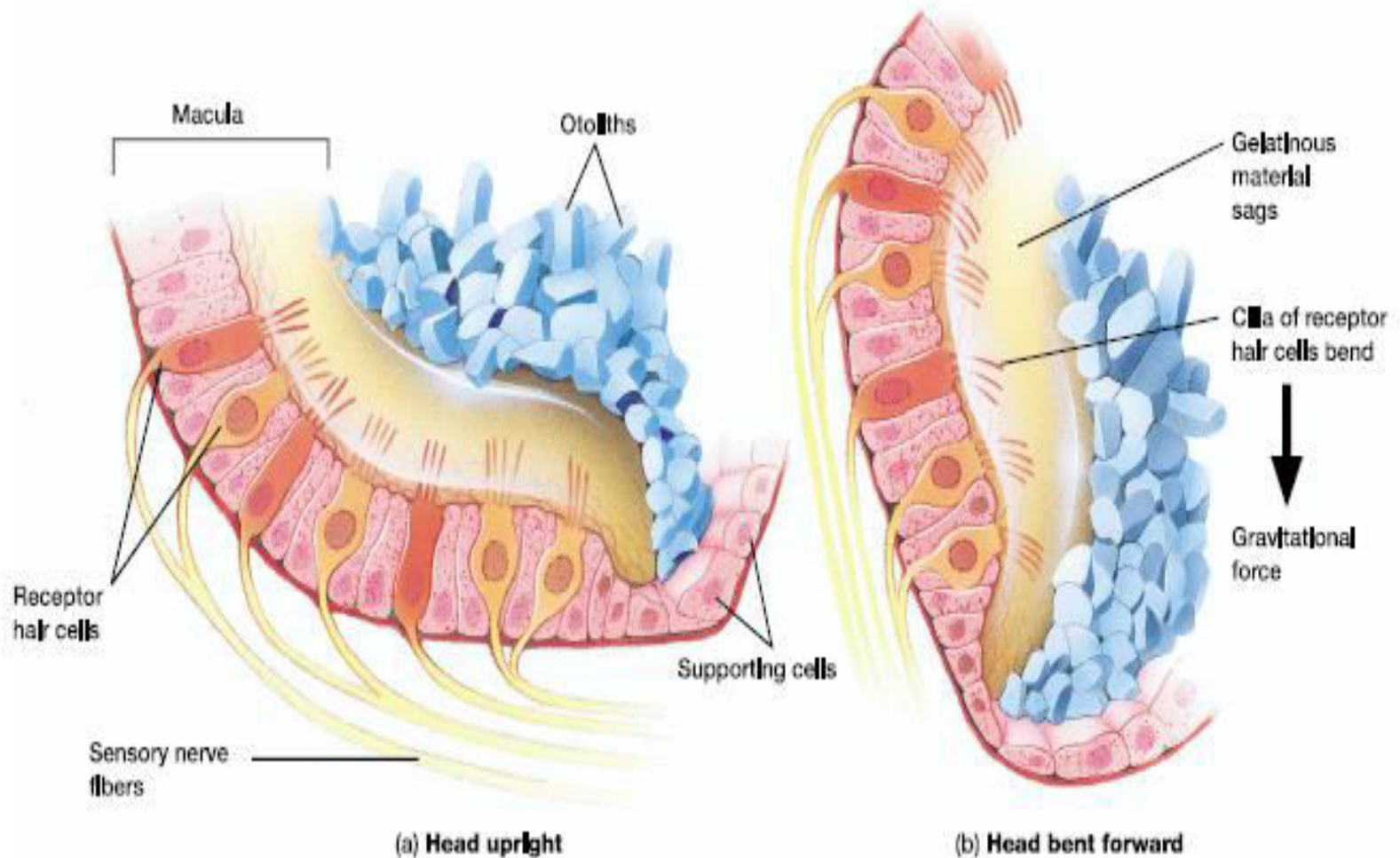
Hearing and Equilibrium in Man

- **An otolith also called statoconium or otoconium or statolith, is a calcium carbonate structure in the saccule or utricle of the inner ear, specifically in the vestibular system of vertebrates.**

Hearing and Equilibrium in Man

- **In mammals, otoliths are small particles, composed of a combination of a gelatinous matrix and calcium carbonate in the viscous fluid of the saccule and utricle. The inertia of these small particles causes them to stimulate hair cells when the head moves.**

Hearing and Equilibrium in Man



Animal Form and Function 1

Module 78



Animal Form and Function 1

Hearing and Equilibrium in Water

Equilibrium and Hearing in Water

- In bony fishes, the receptors for equilibrium and hearing are in the inner ear.
- Semicircular canals detect the rotational movements by detecting the direction of gravitational pull.

Equilibrium and Hearing in Water

- Since the fishes lack the outer and middle ears, the vibrations pass from the water through the bones of the skull to the inner ear.
- A few fishes have chains of bony ossicles that pass between the swim bladder and back of the skull.

Equilibrium and Hearing in Water

- Sound waves that enter the pharynx are transmitted to swim bladder causing it expand and contract according to the intensity of incoming waves.
- The vibrations of contraction pass forward along the chain of ossicles and then to the inner ear.

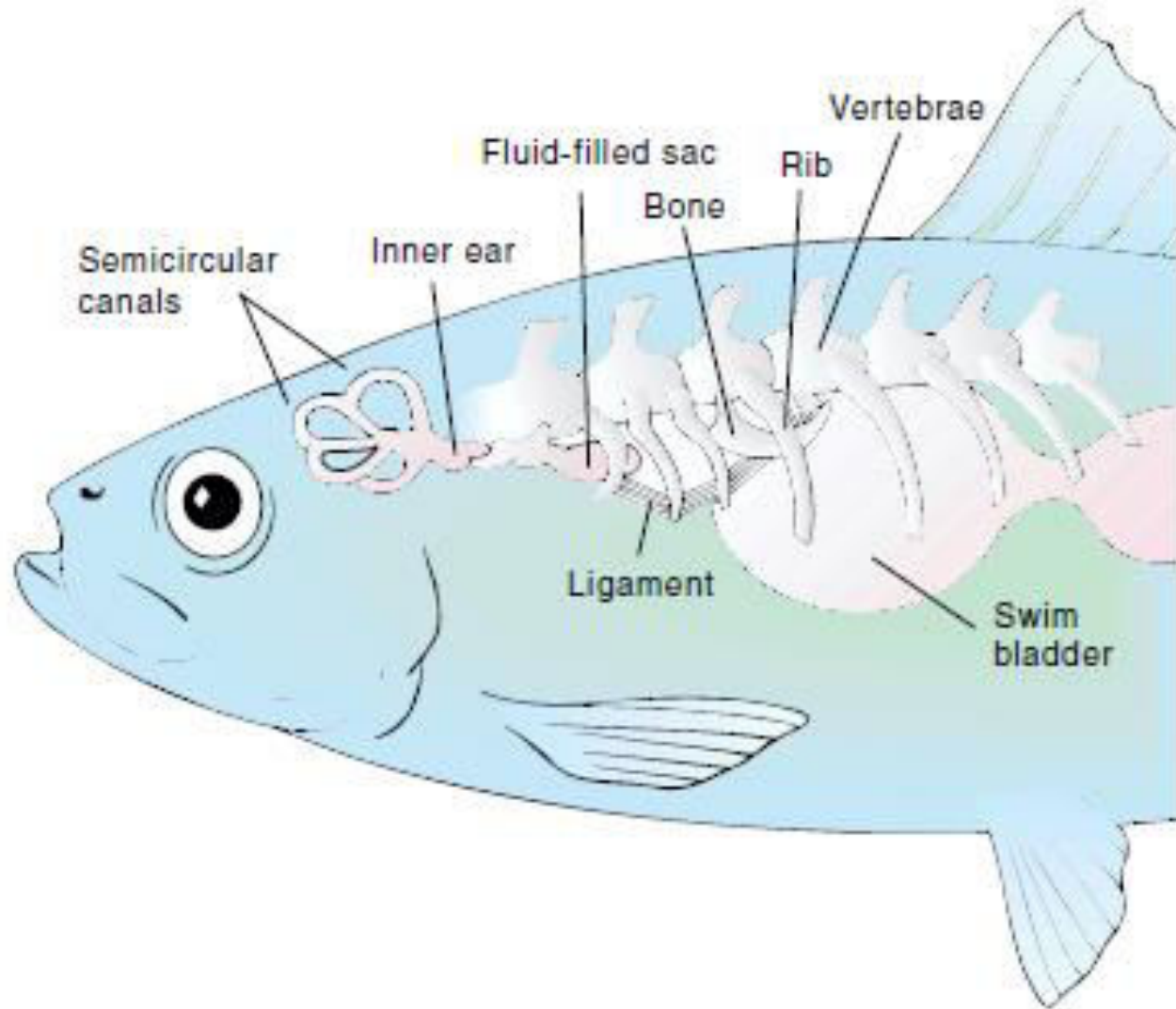
Equilibrium and Hearing in Water

- Sharks' hearing, have a sharp sense of hearing and can possibly hear prey many miles away in water.
- Some species of carp and herring, hear through their swim bladders, which function like a hearing aid.

Equilibrium and Hearing in Water

- Fish can also sense sound through their lateral lines and their otoliths (ears).

Equilibrium and Hearing in Water



Animal Form and Function 1

Module 79



Animal Form and Function 1

Skin Sensors of Damaging Stimuli

Skin Sensors of Damaging Stimuli

- Pain receptors are bare or naked nerve endings through out the body of mammals except for the brain & intestine.
- These nerve endings are called Nociceptors.
- They may be:
- External nociceptors- found in tissue such as the skin, the corneas, and the mucosa.

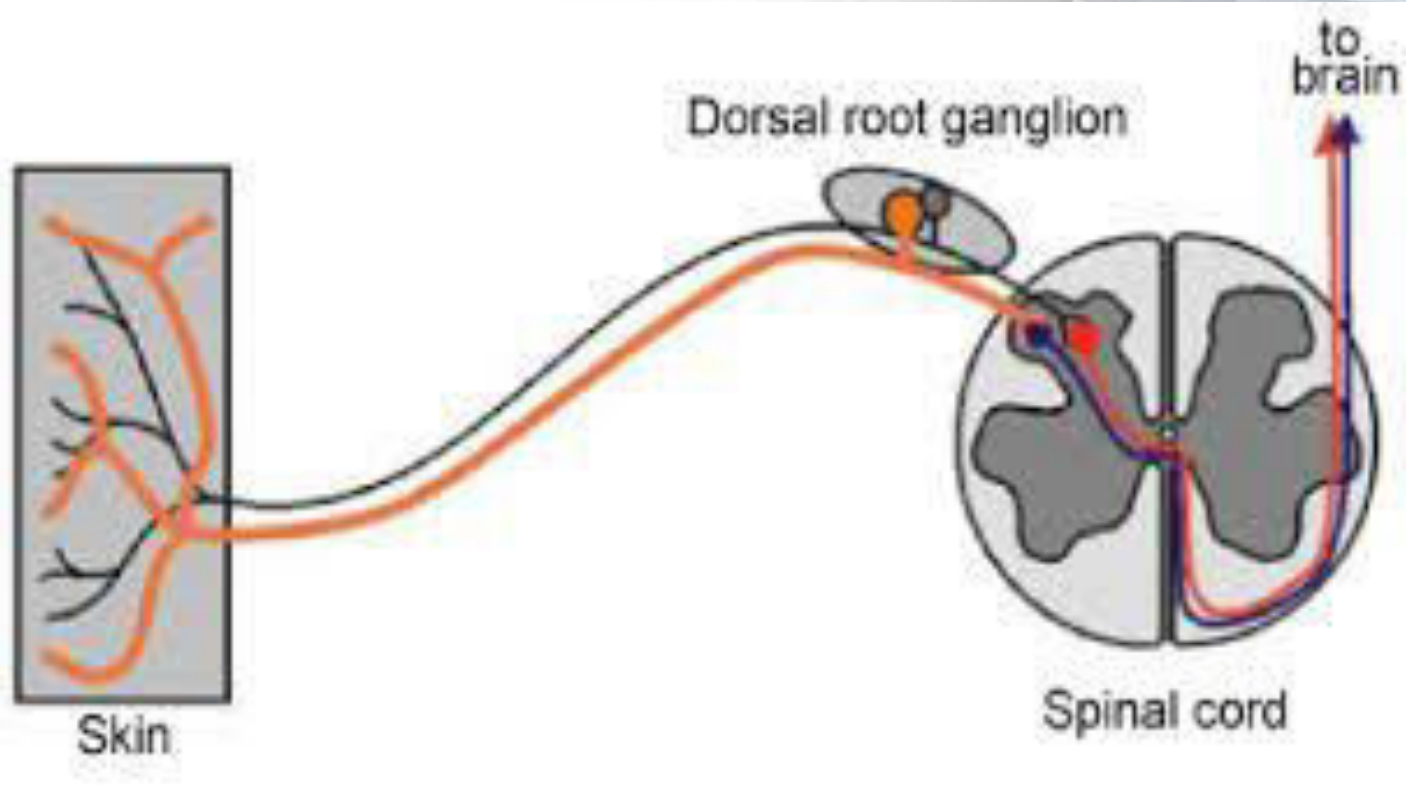
Skin Sensors of Damaging Stimuli

- Damaging or noxious stimulus is actually or potentially tissue damaging event.
- Noxious stimuli can either be:
- **Mchanical** (pinching or other tissue deformation),
- **Chemical** (exposure to acid or irritant), or
- **Thermal** (high or low temperatures).

Skin Sensors of Damaging Stimuli

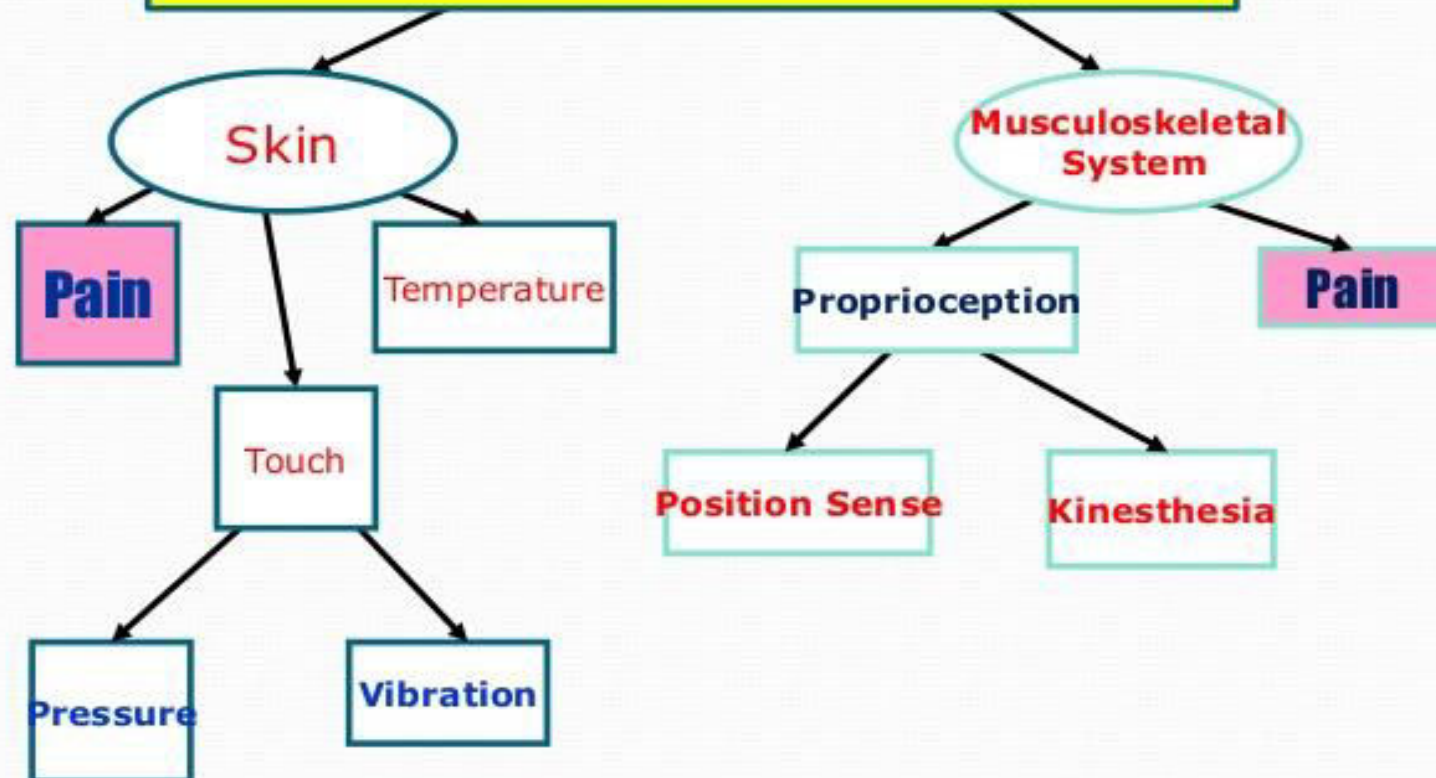
- Internal nociceptors—found in a variety of organs, such as the muscles, the joints, the bladder, the gut, and the digestive tract.
- Severe heat, cold, irritating chemicals, and strong mechanical stimuli may elicit a response from nociceptors that the brain interprets as pain or itching.

Skin Sensors of Damaging Stimuli



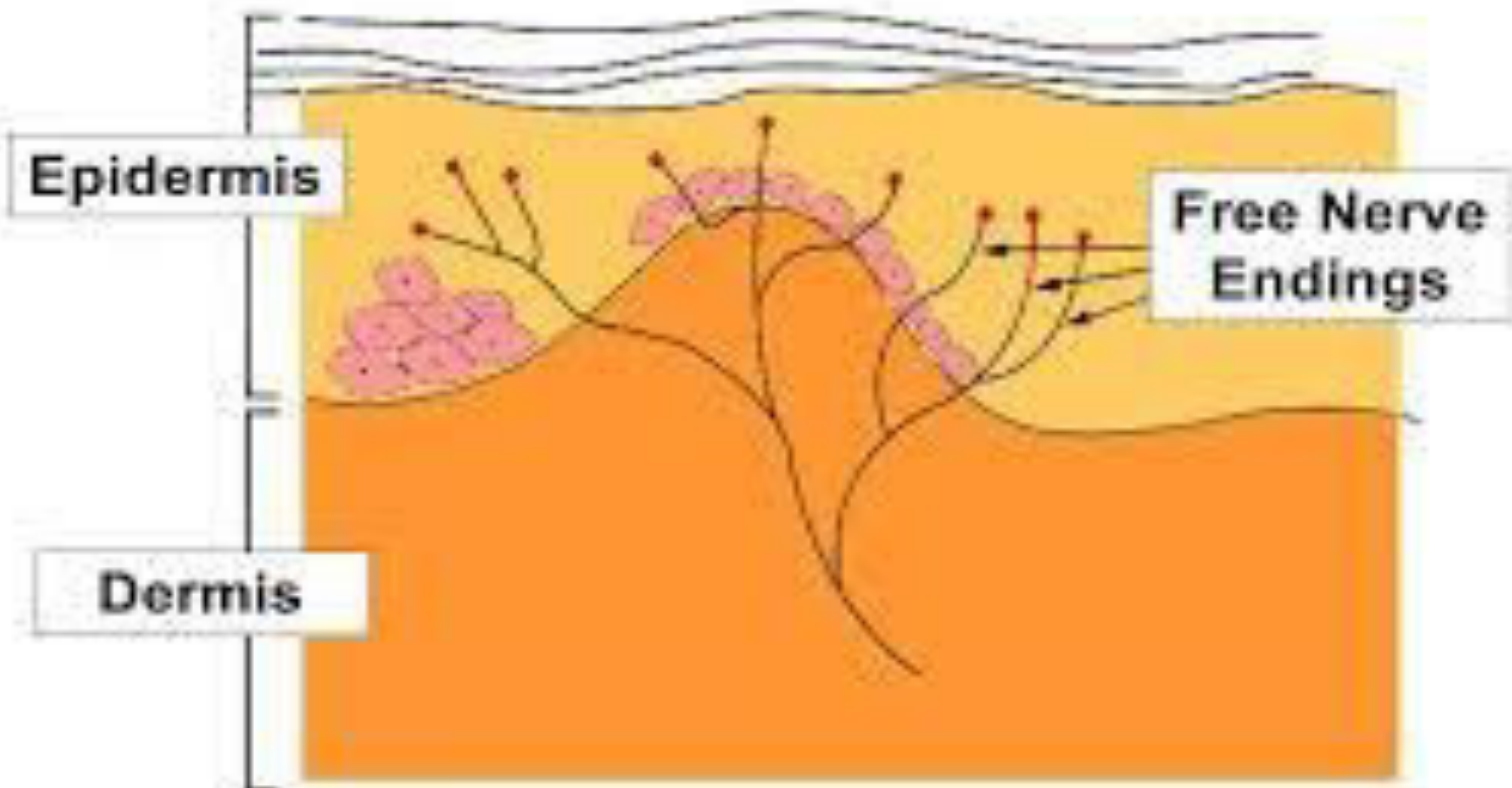
Skin Sensors of Damaging Stimuli

Types of Somatic Sensations

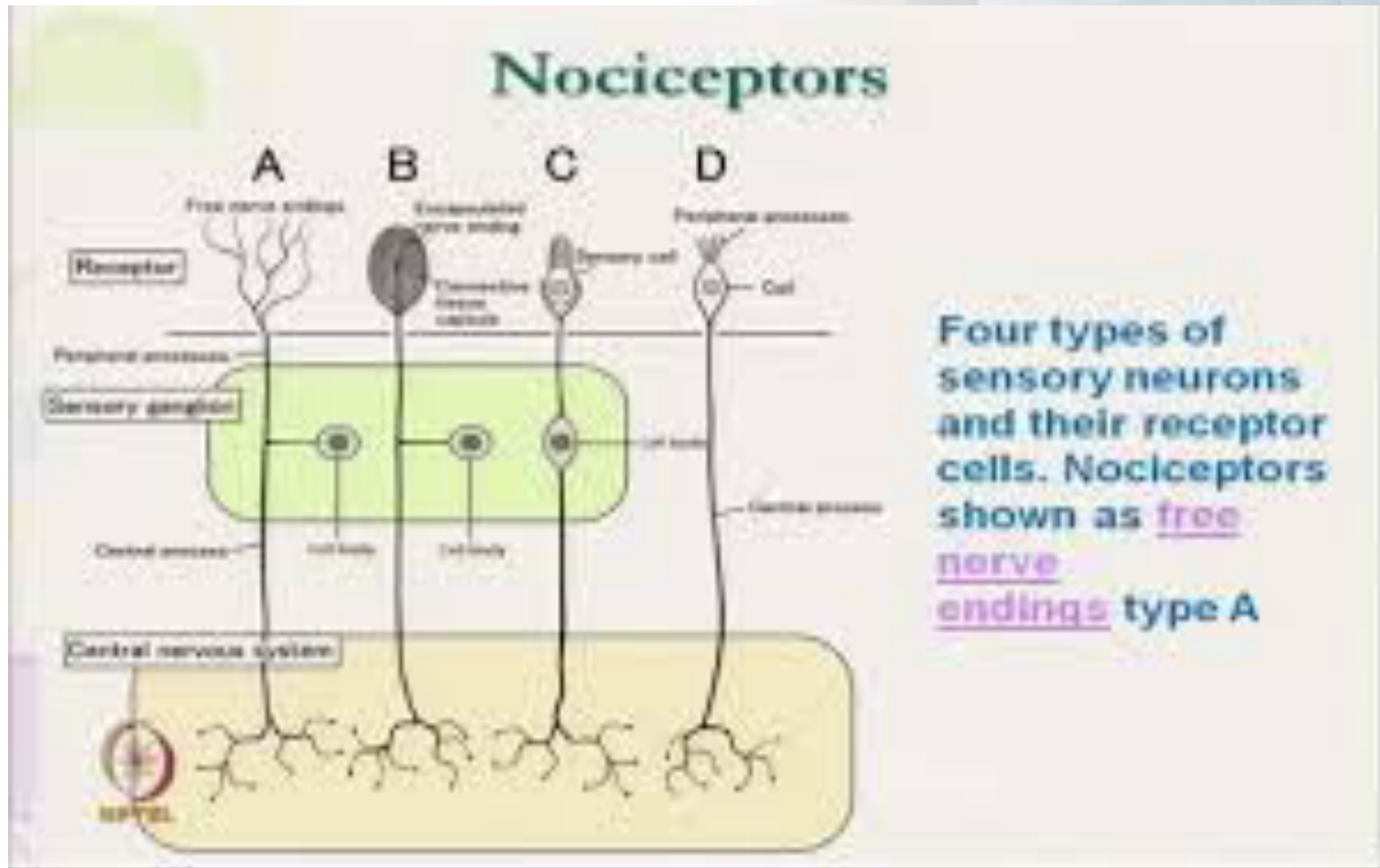


Skin Sensors of Damaging Stimuli

Nociceptors in Skin



Skin Sensors of Damaging Stimuli



Animal Form and Function 1

Module 80



Animal Form and Function 1

Skin Sensors of Heat and Cold



Skin Sensors of Heat and Cold

- Sensors of temperature or Thermoreceptors are also bare nerve endings.
- They are located in epidermis or dermis of the mammalian skin.
- Mammals have different areas sensitive to heat and cold.
- Cold receptors respond to temperature below skin temperature.

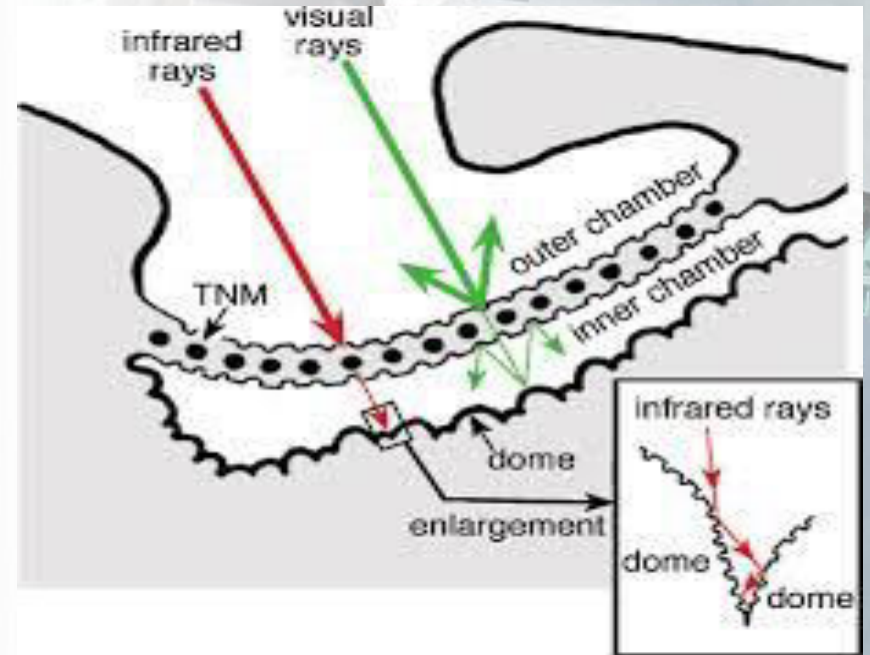
Skin Sensors of Heat and Cold

- Heat receptors respond to temperature above skin temperature.
- The ability to detect changes in temperature has become well developed in a number of animals.
- For example **Pit organs** in rattlesnakes and vipers.

Skin Sensors of Heat and Cold

- These organs are heat-sensitive and are located on each side of the face between eye and nostril.
- These depressions are lined with sensory epithelium containing receptor cells that respond to temperature.
- Snake use these pit organs to locate warm blooded prey.

Skin Sensors of Heat and Cold



Animal Form and Function 1

Module 81



Animal Form and Function 1

Skin Sensors of Mechanical Stimuli

The background of the slide is an abstract, low-poly 3D rendering. It features various geometric shapes like cubes and prisms in shades of light blue, white, and pale yellow. The lighting is soft, creating subtle shadows and highlights that give the shapes a three-dimensional appearance. The overall composition is clean and modern, typical of a professional presentation.

Skin Sensors of Mechanical Stimuli

- To obtain information from the environment, the animals rely on tactile stimuli.
- Following are the mechanical receptors found in the skin.
- i) Bare sensory nerve endings: These are widely distributed receptors in the vertebrate body and are involved in pain, heat and feeble pressure.

Skin Sensors of Mechanical Stimuli

- ii) **Tactile (Meissner's) corpuscles:** They are a type of nerve endings in the skin that are responsible for sensitivity to light touch.
- iii) **Bulbs of Krause:** the receptors found in dermis in certain parts of the body that respond to physical position changes

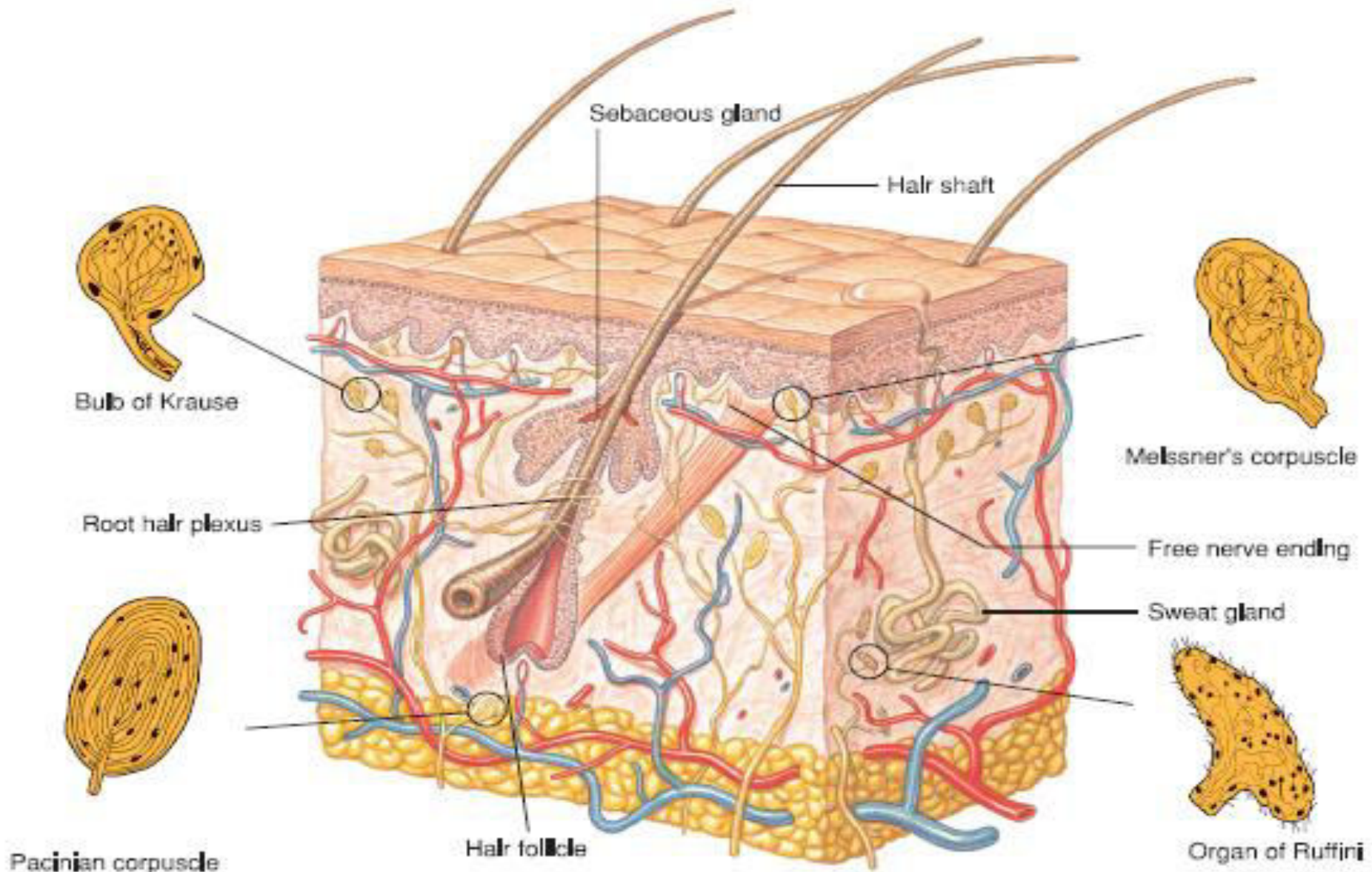
Skin Sensors of Mechanical Stimuli

- iv) **Pacinian corpuscles:**
These are responsible for sensitivity to vibration and pressure.
- v) **Organs of Ruffini:**
Detect stress deformation within joints and warmth.
- Many mammals have specially adapted **sensory hairs called Vibrissae** on their wrists, snout, eye brows and whiskers.

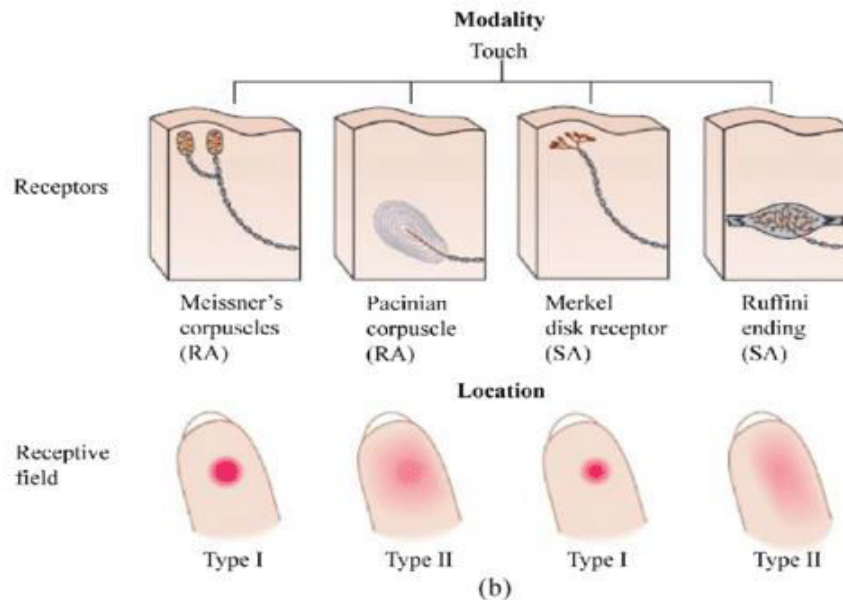
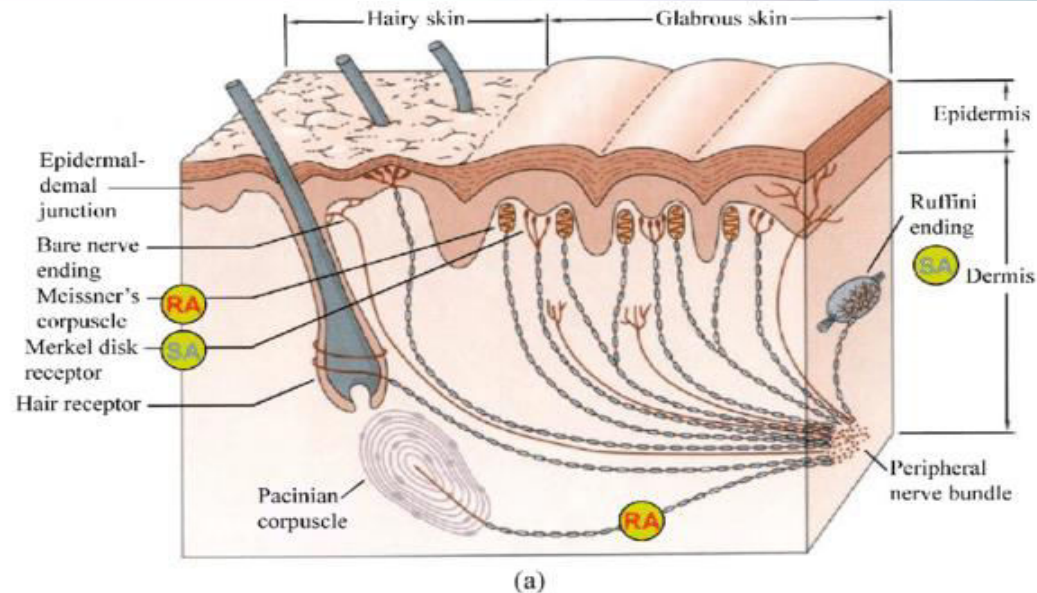
Skin Sensors of Mechanical Stimuli

- Around the base of each vibrissa is a blood sinus.
- Nerves bordering the sinus carry impulses to the brain for interpretation.

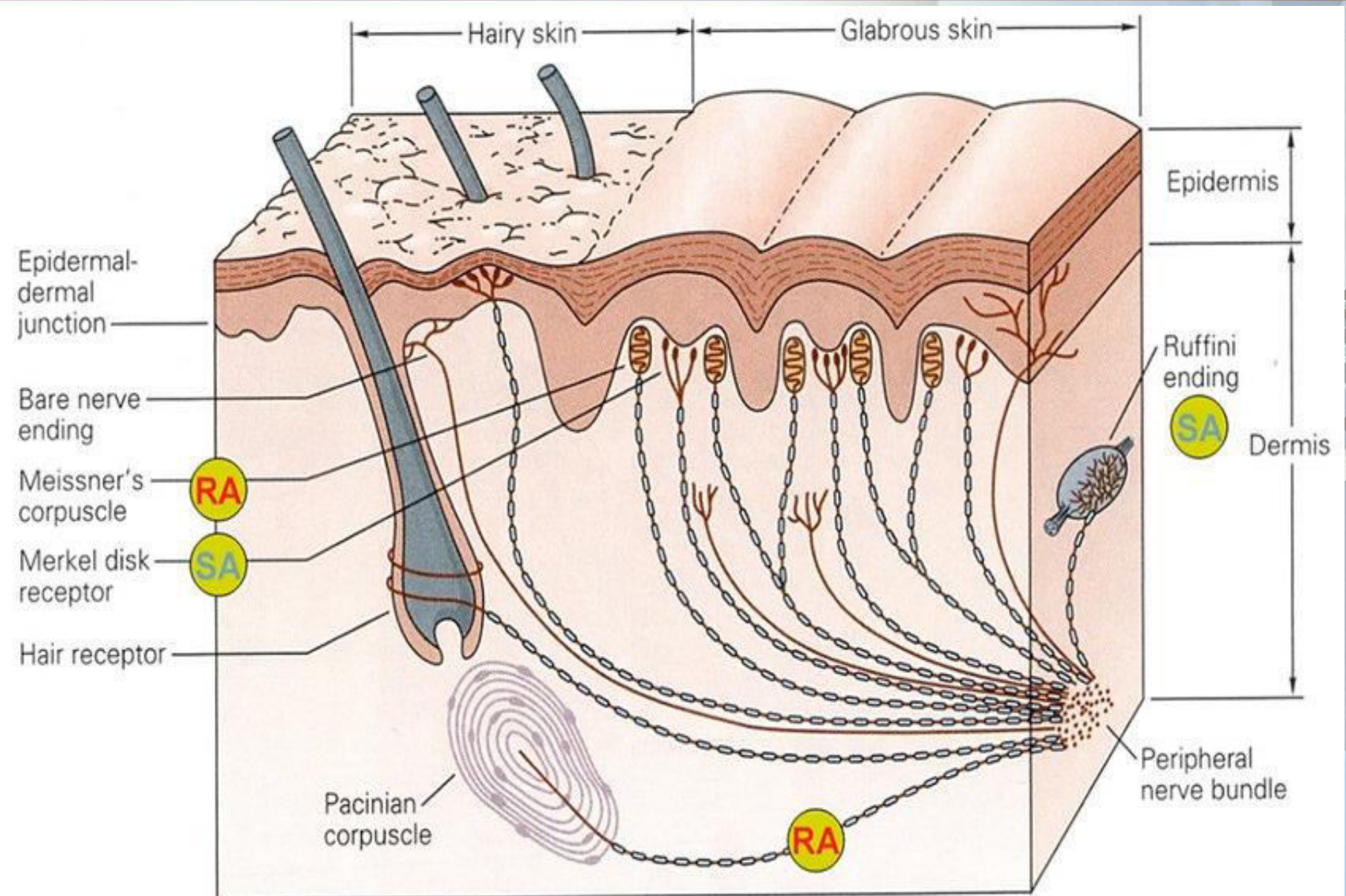
Skin Sensors of Mechanical Stimuli



Skin Sensors of Mechanical Stimuli

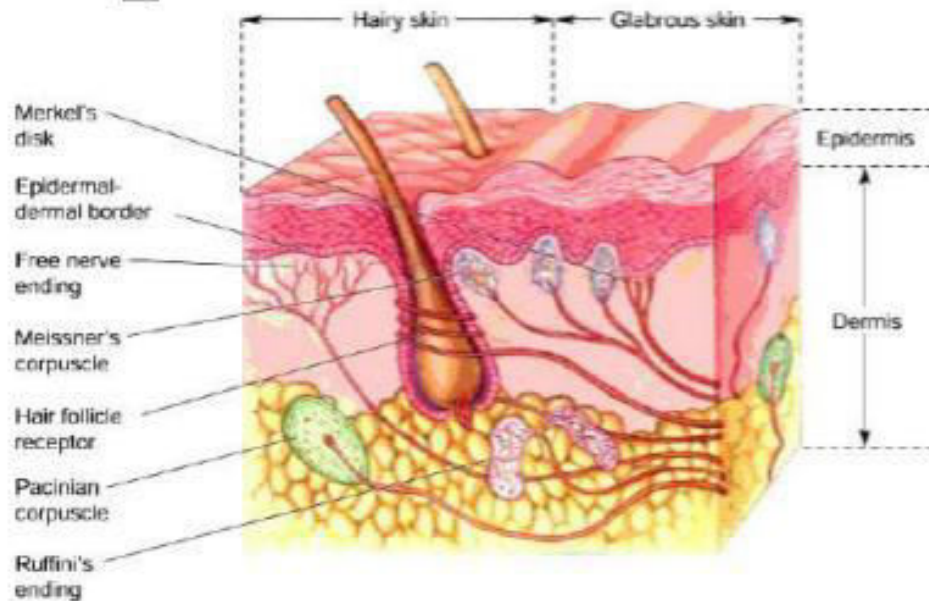


Skin Sensors of Mechanical Stimuli



Skin Sensors of Mechanical Stimuli

[Mechanoreceptors of Skin]



- **Merkel's disk**
 - Skin Curvature
- **Meissner Corpuscle**
 - Light Touch
- **Free Nerve Endings**
 - Pain
 - Chemicals
- **Ruffini's ending**
 - Heat
 - Stretch
- **Pacinian Corpuscle**
 - Deep Pressure
 - Vibrations

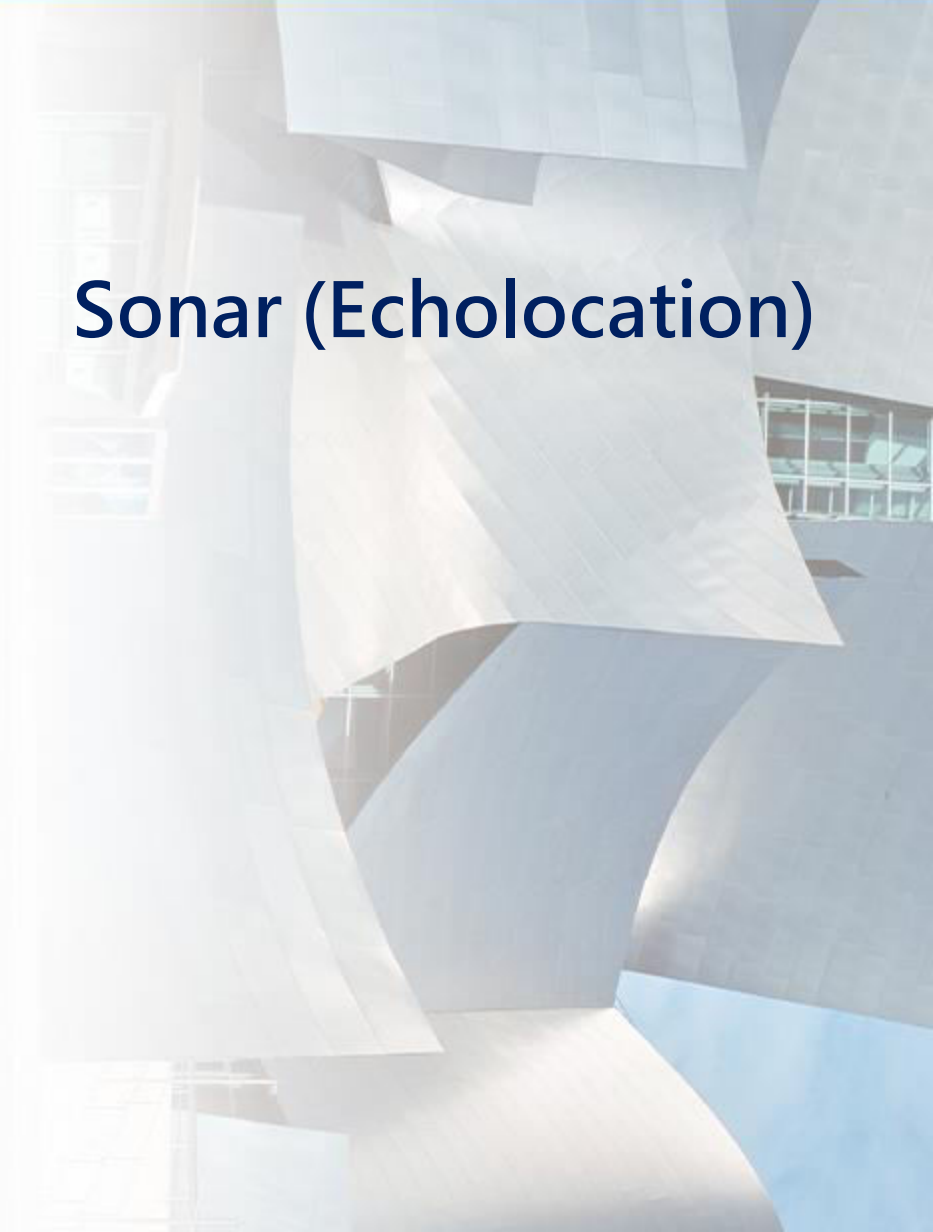
Animal Form and Function 1

Module 82



Animal Form and Function 1

Sonar (Echolocation)



Sonar (Echolocation)

- Sonar/biosonar/
Echolocation is a physiological process for locating distant objects by means of sound waves reflected back to the emitter (such as a bat) by the objects.
- Echolocation is used for orientation, obstacle avoidance, food procurement, and social interactions.

Sonar (Echolocation)

- Other animals which have this sense of sonar are, shrews, several cave dwelling birds, whales, and dolphins.
- These animals emit high frequency sounds which return after bouncing off objects in the environment.

Sonar (Echolocation)

- The returning waves from the object (e.g. flying insect) provide enough information for the bat to locate and catch the prey.
- This process lasts for 2-3 milliseconds and are repeated several hundred times per second

Sonar (Echolocation)



Animal Form and Function 1

Module 83



Animal Form and Function 1

Smell or Olfaction



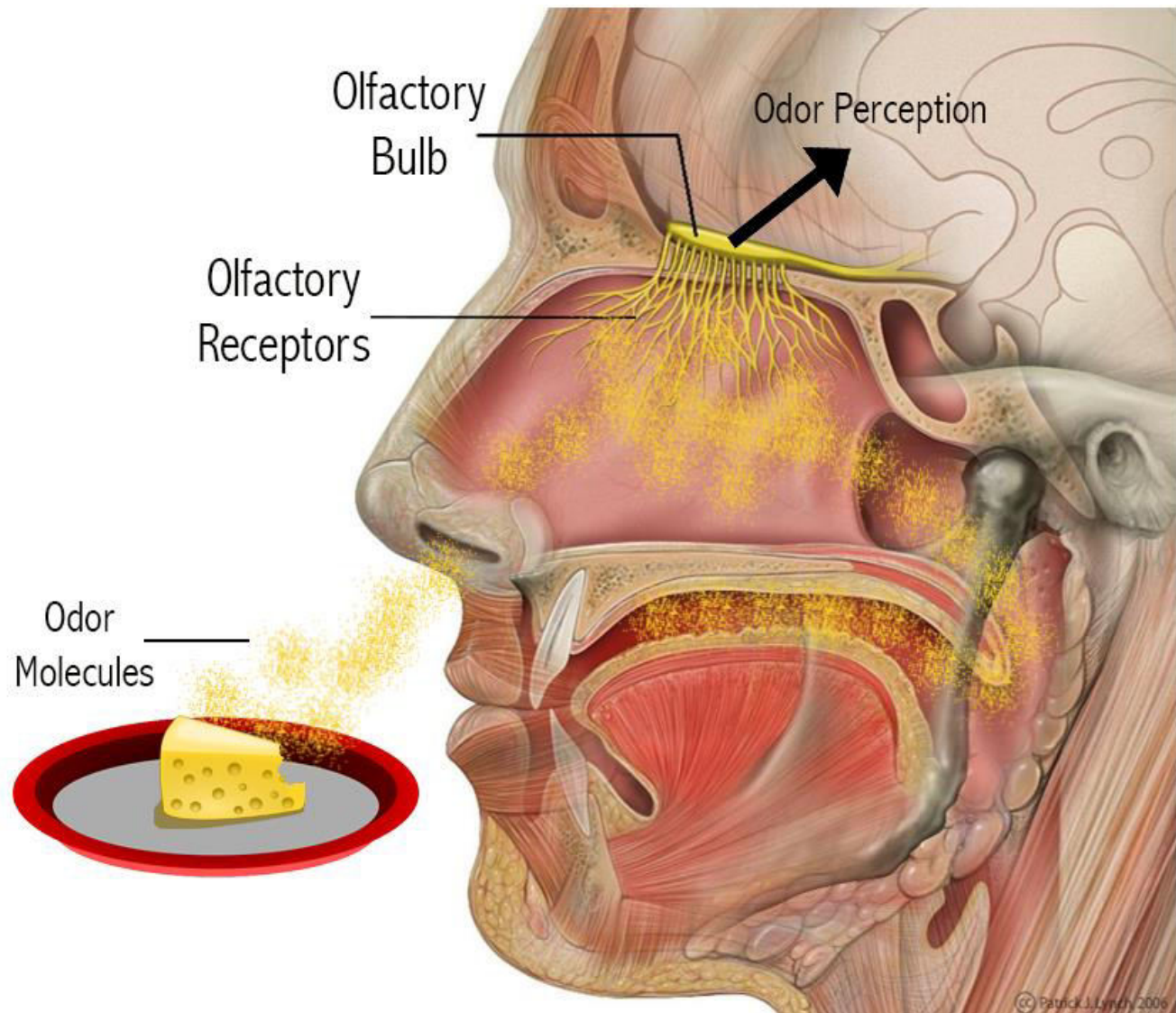
Smell or Olfaction

- The sense of smell or olfaction is due to the olfactory neurons (receptor cells) present in the roof of nasal cavity of the vertebrates.
- These receptor cells are densely packed.
- In dog, there are more than 40 million olfactory receptor cells per square centimeter.

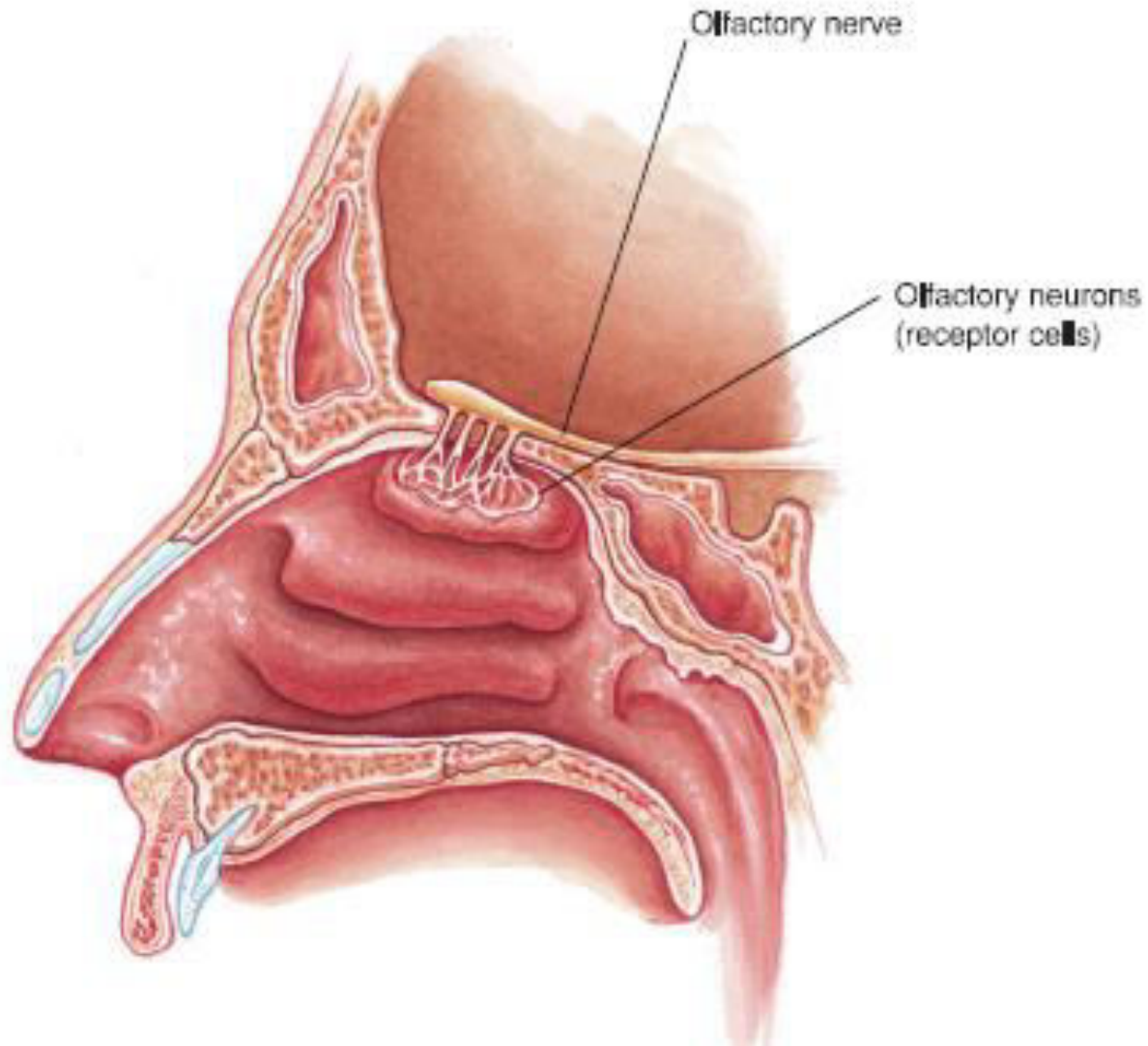
Smell or Olfaction

- Each olfactory cell ends in a tuft of cilia containing receptor site for various chemicals.
- How odor is perceived?
- Odor molecules physically interact with protein receptors on the plasma membrane.
- This interaction alters membrane permeability and leads to generator potential.

Smell or Olfaction



Smell or Olfaction



Animal Form and Function 1

Module 84



Animal Form and Function 1

Olfactory Senses in Various Vertebrates

Olfactory Senses in Various Vertebrates

Fishes

- Most of the fishes such as Lamprey and Salmon return to spawn in the same stream in which they hatched years earlier.
- Their migration in the streams often involve distances of hundreds of km.

Olfactory Senses in Various Vertebrates

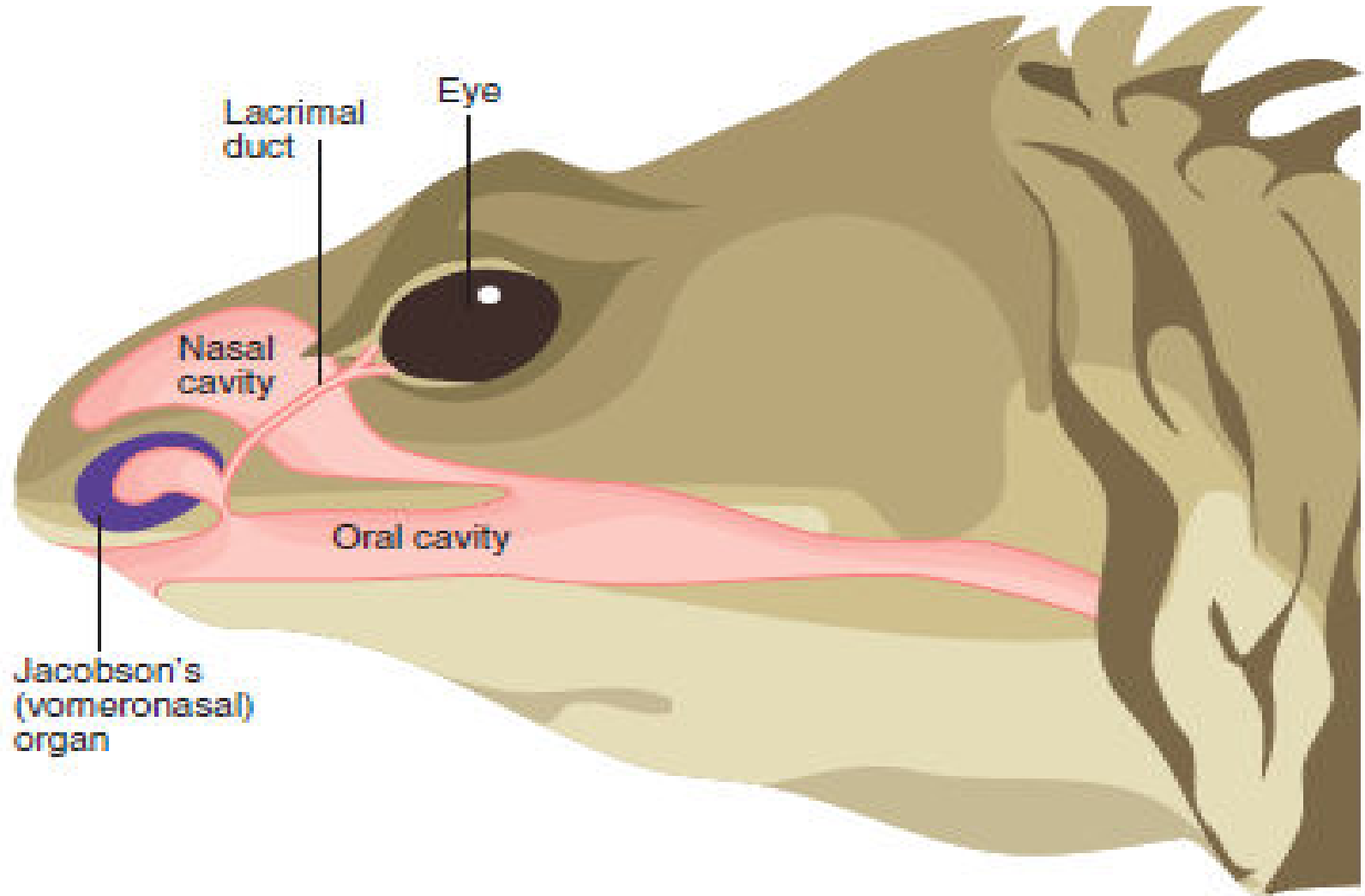
Smell or Olfaction

- This migration is guided by fishes' perception of characteristic odor of their spawning stream
- In amphibians olfaction is used to detect noxious chemicals, food and mate.
- In reptiles olfaction is better adapted than in amphibians.

Olfactory Senses in Various Vertebrates

- Jacobson's (vomeronasal) organ:
- Apart from olfactory epithelium most reptiles possess Jacobson's organs.
- These organs are best developed in snakes and lizards.
- Jacobson's organ is a spherical structure having a narrow duct that opens into mouth.

Olfactory Senses in Various Vertebrates



Olfactory Senses in Various Vertebrates

Smell or

Olfaction

- The protrusible, forked tongue of snakes is used to take sample of air borne chemicals.
- Snake flicks the tongue out take the sample and then moves to the Jacobson's organ which perceive odor molecules.
- Turtles and Tuatara use the Jacobson's organ to taste objects held in oral cavity

Olfactory Senses in Various Vertebrates

Smell or

- In **bird olfaction** **epithelium is poorly developed**, so olfaction plays minor role in the lives of birds.
- Exceptions are vultures. **They locate dead and dying prey largely by smell.**

Olfactory Senses in Various Vertebrates

Smell or

- Many animals can feel smell over long distances.
- They use this sense to locate food, mate and predator to avoid

End

Animal Form and Function 1

Module 85



Animal Form and Function 1

Taste or Gustation



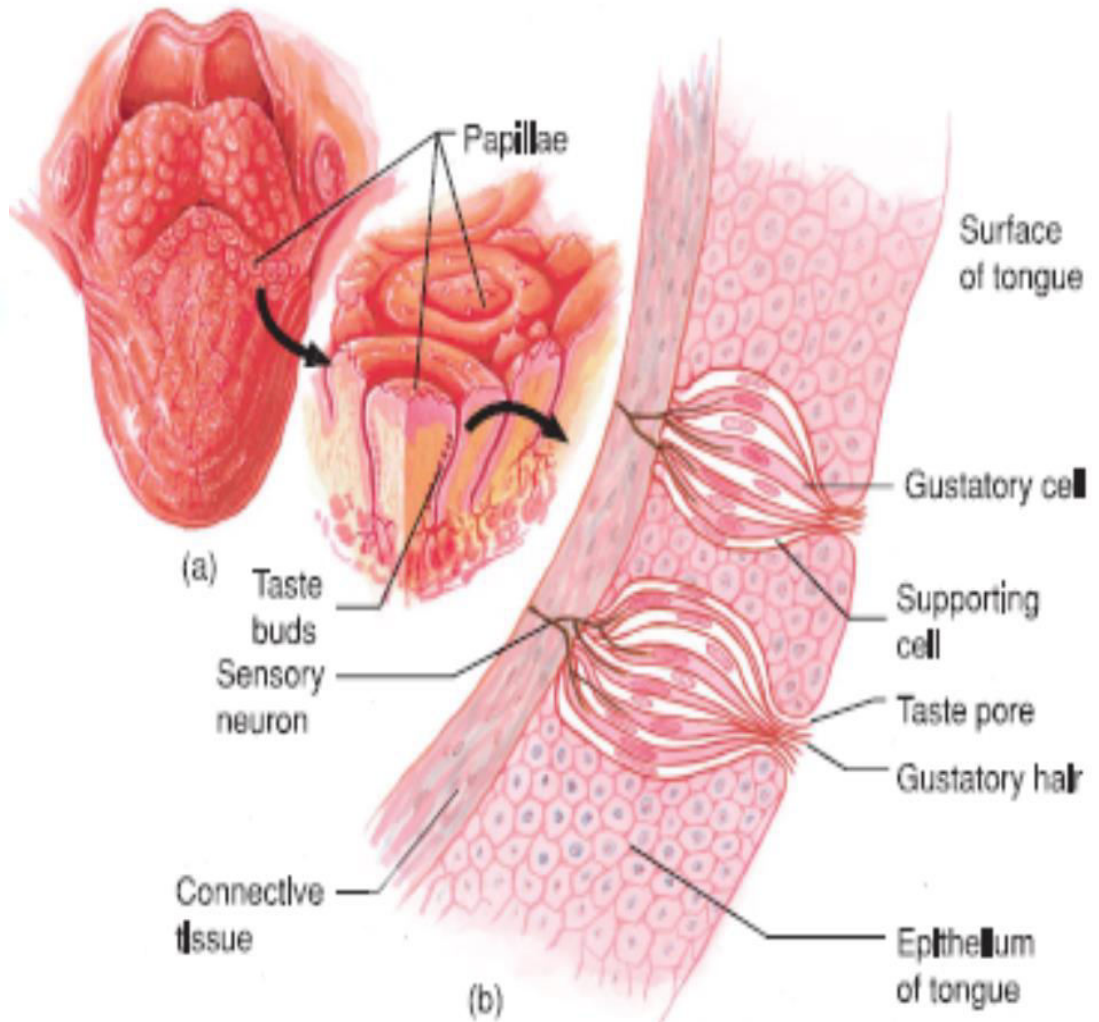
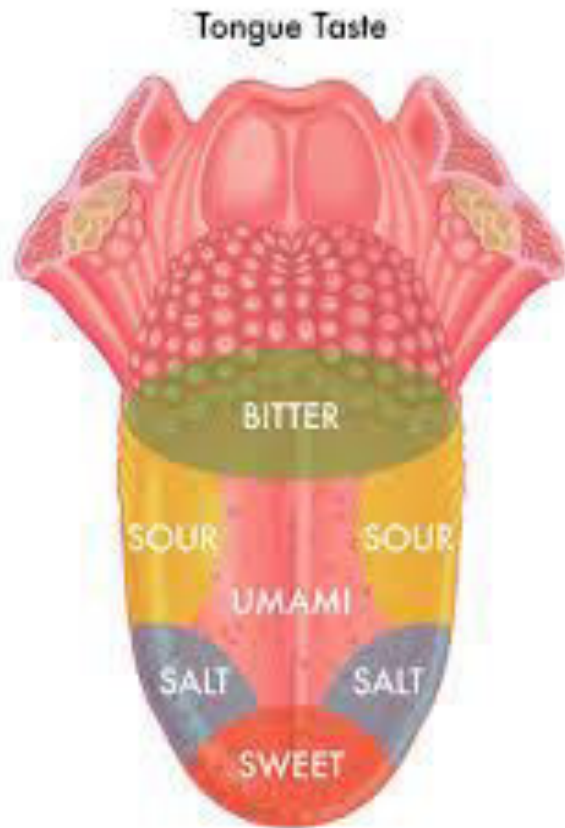
Taste or Gustation

- Taste receptors are the chemoreceptors.
- Tongue is the primary organ of taste.
- The tongue is equipped with many taste buds housed in papillae on its dorsal surface.
- Papillae give the tongue a bumpy appearance.

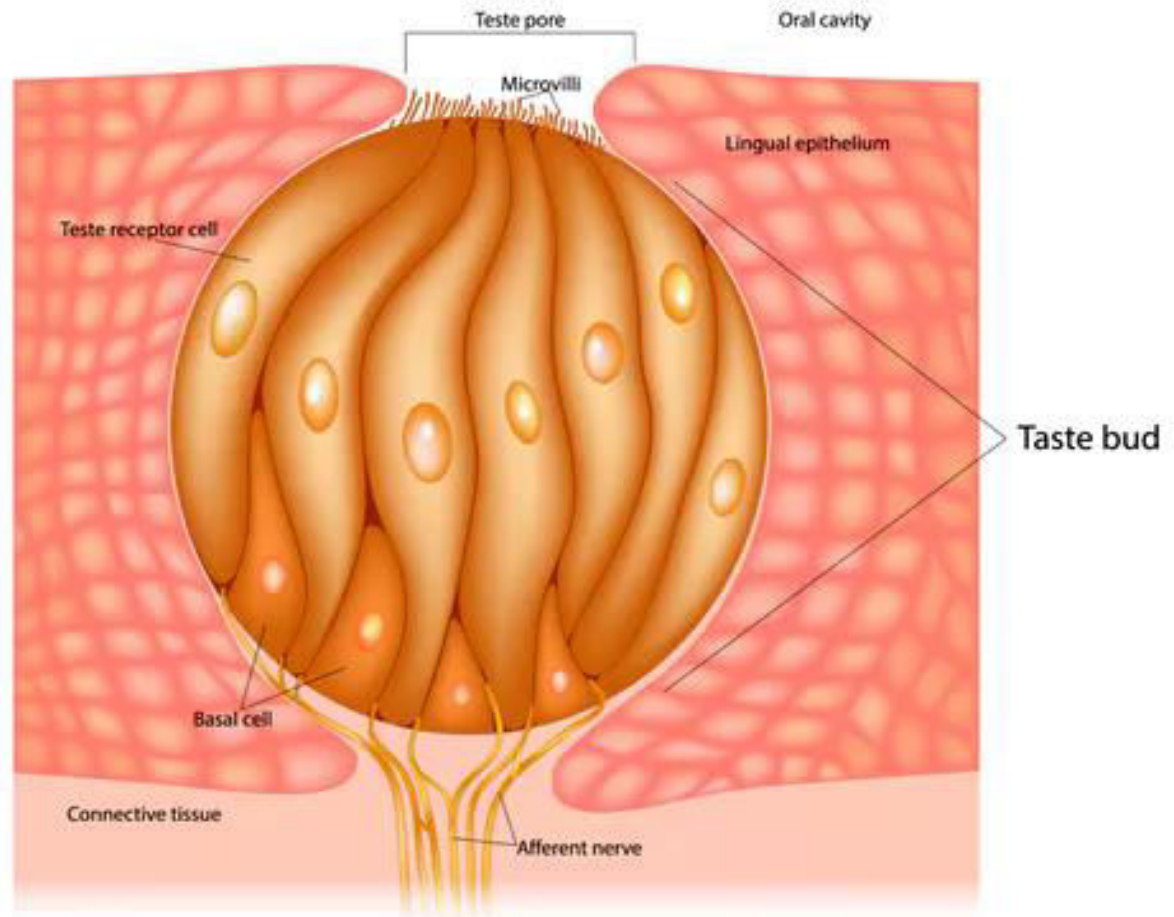
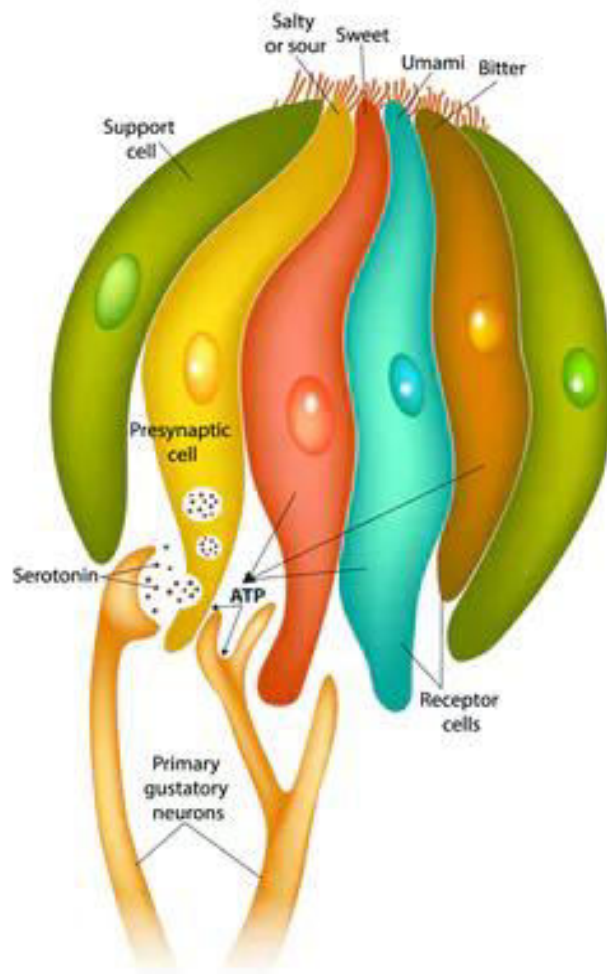
Taste or Gustation

- All sugars are sweet because they contain OH groups with a particular orientation that can interact with the taste receptor for sweetness in our tongues.

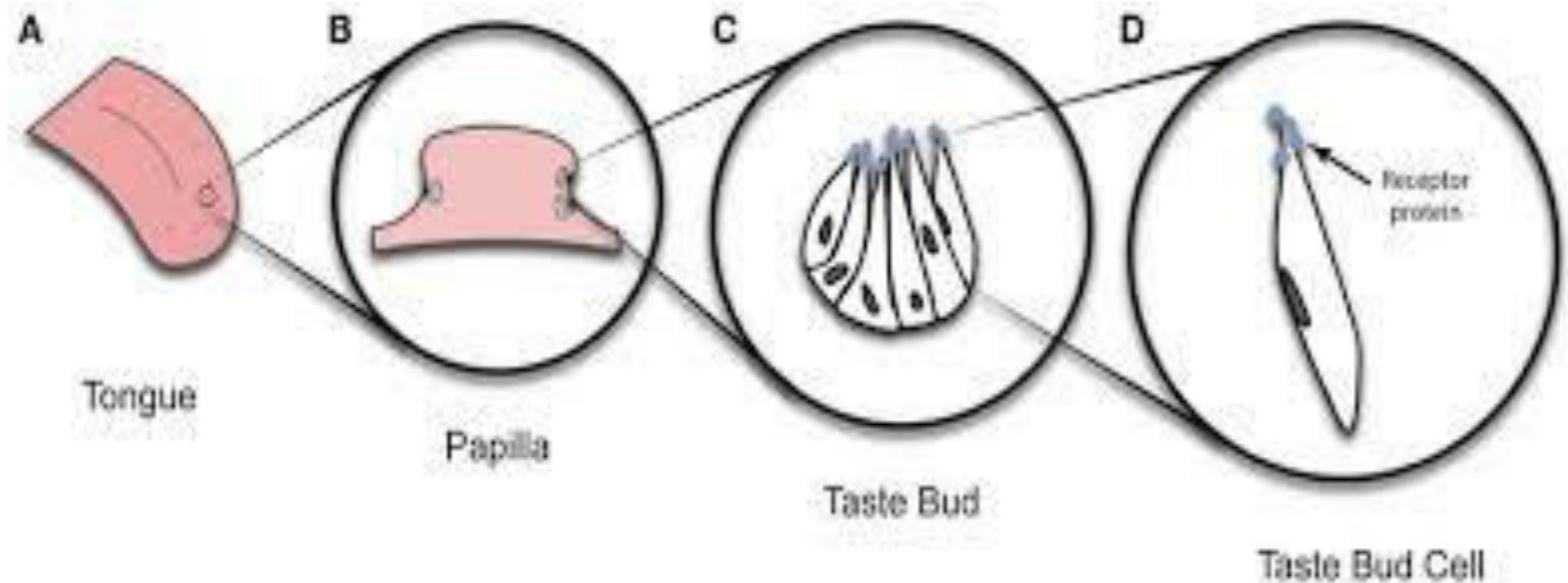
Taste or Gustation



Taste or Gustation



Taste or Gustation



Animal Form and Function 1

Module 86



Animal Form and Function 1

Taste in Various Vertebrates



Taste in Various Vertebrates

- Vertebrates other than mammals may have taste buds on other parts of the body.
- Taste buds are inside the fish's mouth, on its tongue and scattered all over the body including barbels and fins.

Taste in Various Vertebrates



Taste in Various Vertebrates

- All amphibians have taste buds on their tongue.
- When an amphibian has captured its prey, it uses its senses of smell and taste to find whether its catch is toxic or not.

Taste in Various Vertebrates

- Reptiles taste and smell using Jacobson's organ, a small cavity line with sense detectors that recognize chemical changes in and around the mouth.
- Birds do not have taste buds on the tongue instead they are present in the pharynx.

Taste in Various Vertebrates

- However, some birds have an acute sense of taste.
- Extensive research into bird senses has shown that vultures, seabirds, kiwis and parrots have well-developed olfactory glands, giving them some sense of smell and taste.

END

Animal Form and Function 1

Module 87



Animal Form and Function 1

Vision or Photoreception

An abstract architectural sculpture made of large, white, curved panels that create a sense of depth and movement. The sculpture is set against a background of a modern building with large windows and a clear blue sky.

Vision or Photoreception

- Photoreception/Vision is defined as any of the biological responses of animals to stimulation by light.
- Photoreception refers to mechanisms of light detection that lead to vision
- Vision depends on specialized light-sensitive cells called photoreceptors, which are located in the eye.

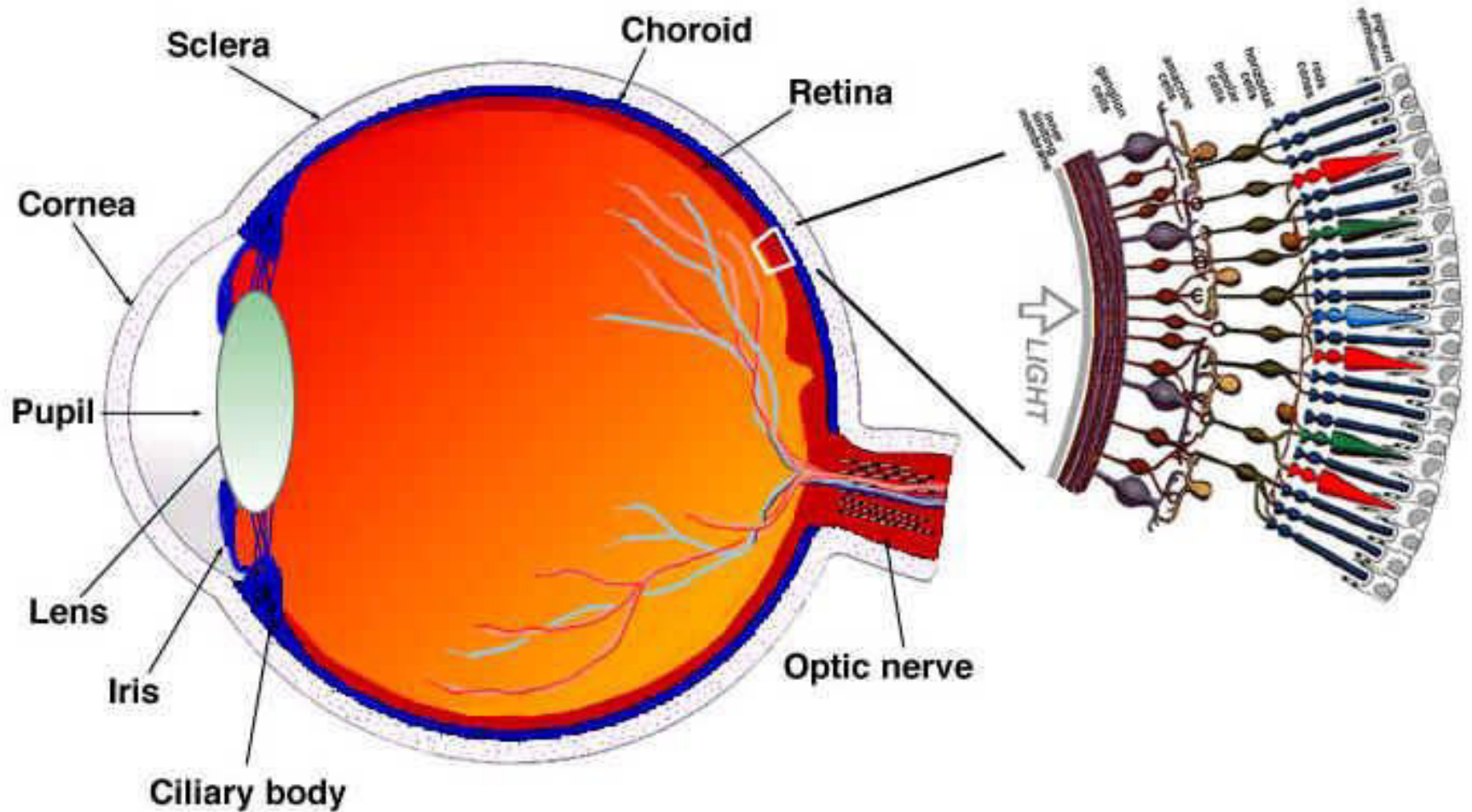
Vision or Photoreception

- The quality of vision provided by photoreceptors varies enormously among animals.
- Some simple eyes such as those of flatworms have few photoreceptors and are capable of determining only the approximate direction of a light source.

Vision or Photoreception

- In contrast, the human eye has 100 million photoreceptors and is about 4,000 times better than the resolution achieved by the flatworm eye.

Vision or Photoreception



Animal Form and Function 1

Module 88



Animal Form and Function 1

Anatomy of Human Eye

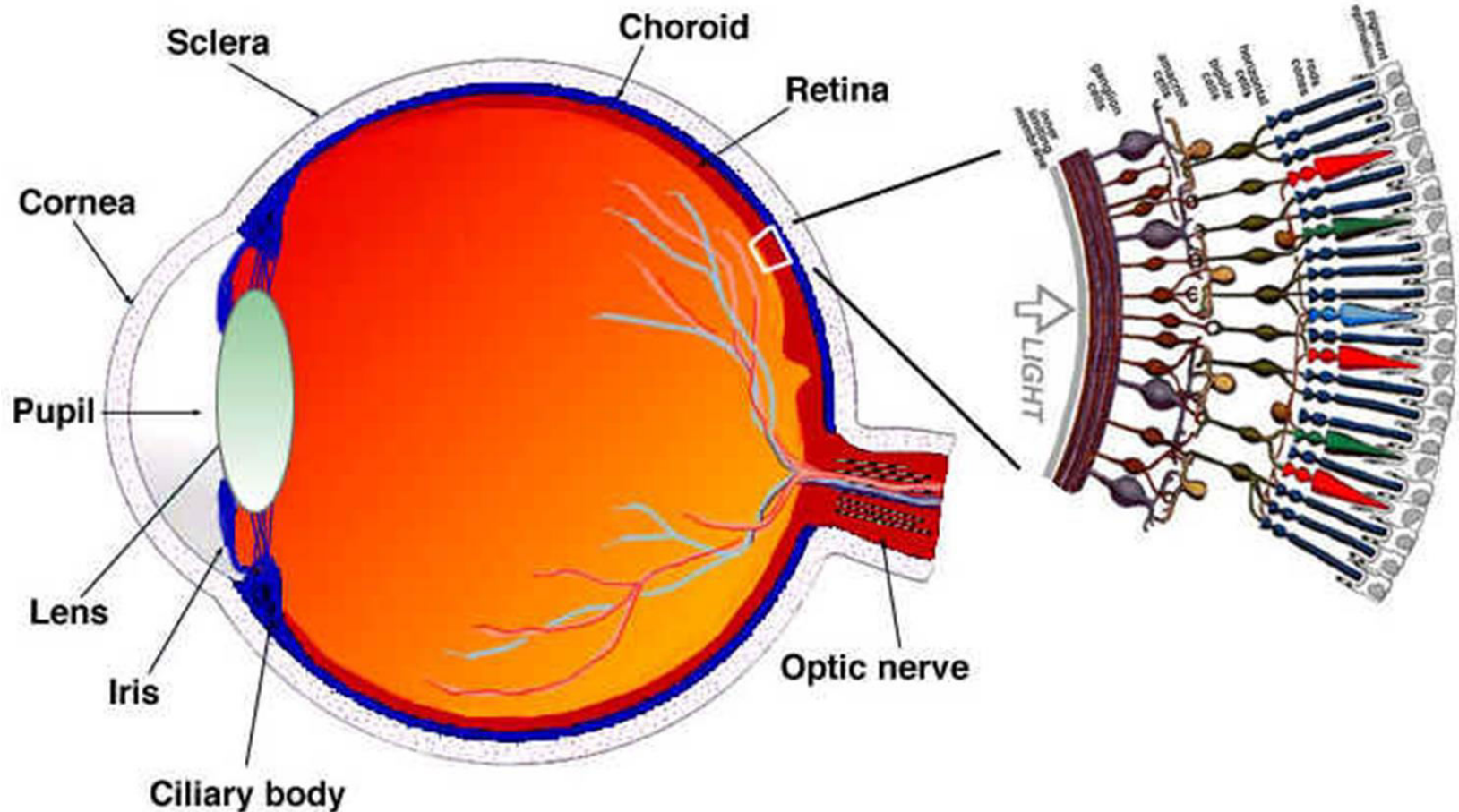


Anatomy of Human Eye

- The eye is composed of the anterior and the posterior segments.
- The anterior segment is made up of the cornea, iris and lens.
- The cornea is transparent and more curved, and is linked to the larger posterior segment.

Anatomy of Human Eye

Vision or Photoreception



Anatomy of Human Eye



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Anatomy of Human Eye

- The posterior segment is composed of the vitreous, retina, choroid and the outer white shell called the sclera.
- The transparent cornea is continuous with the sclera and covers the front of the eye ball.
- Choroid tissue also extends the front of the eye ball to form iris, ciliary body and suspensory ligaments.

Anatomy of Human Eye

- The cornea is about 11.5 mm in diameter, and 1/2 mm in thickness.
- The iris is the circular pigmented structure which is composed of radial and circular muscles surrounding the center of the eye.

Anatomy of Human Eye

- The pupil is an aperture which appears to be black present in the center of iris The size of the pupil is adjusted by the iris muscles.
- A clear fluid, the aqueous humor fills the anterior chamber and jelly-like vitreous humor fills the posterior chamber.

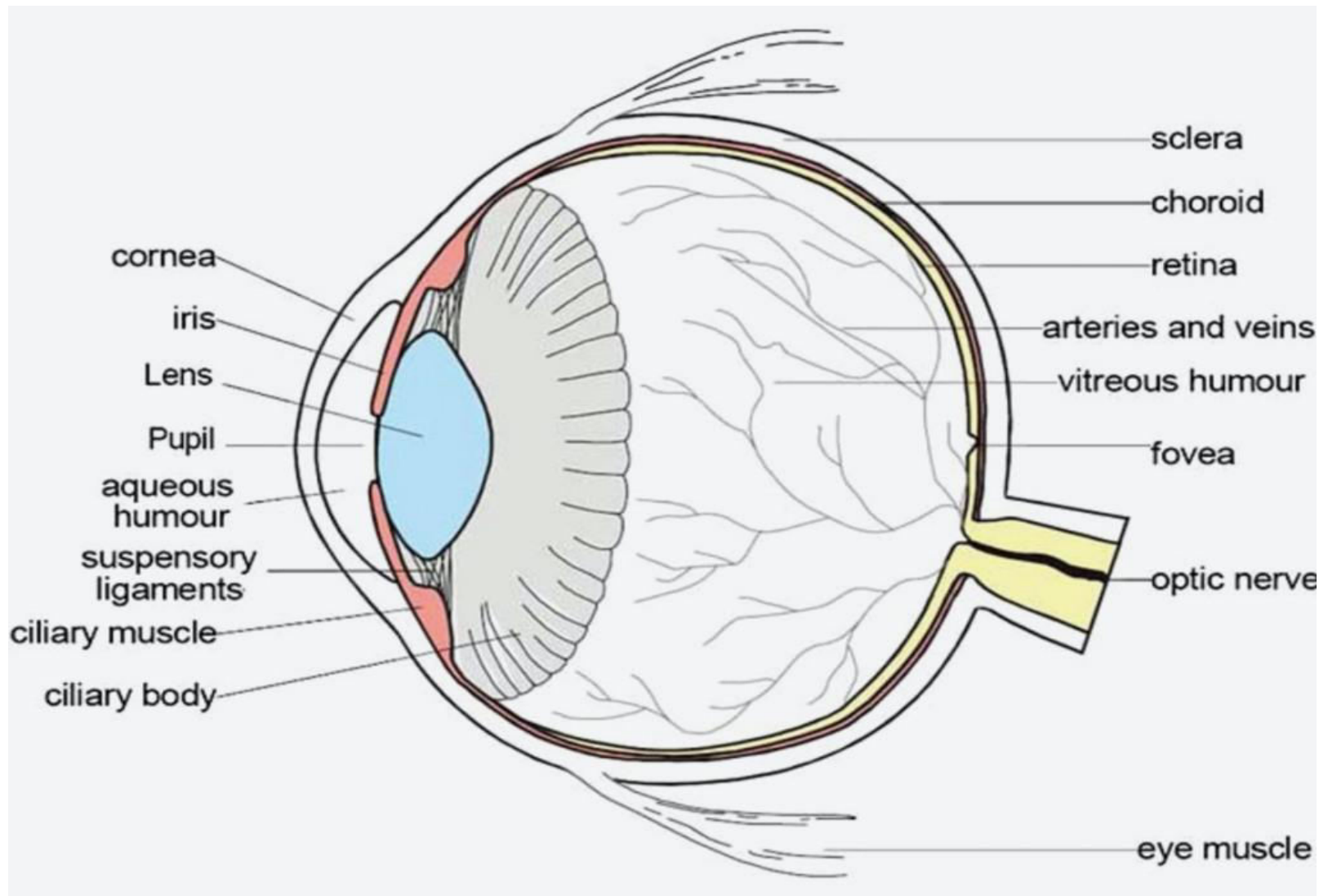
Anatomy of Human Eye

- The retina is the innermost light sensitive layer composed of rods and cones.
- The size of the eye ball is about 24 mm in diameter.
- At birth it is 16-17 mm and attains maximum size by 12 years of age. However, the maximum increase is within three years.

Anatomy of Human Eye

- The moist mucous membrane that covers the eye ball is the conjunctiva.
- The fovea is a tiny pit in the retina aligned with the central axis of the lens.
- Fovea contains closely spaced cones (no rods) and produces the highest visual resolution anywhere on the retina.

Anatomy of Human Eye



Animal Form and Function 1

Module 89



Animal Form and Function 1

Accommodation of Human Eye



Accommodation of Human Eye

- Accommodation is the adjustment of the optics of the eye to keep an object in focus on the retina as its distance from the eye varies.
- It is the process of adjusting the focal length of a lens.

Accommodation of Human Eye

- Accommodation is the ability of the eye lens to see both near and distant objects by adjusting its focal length.
- The minimum distance at which the eye can see objects clearly is called near point vision.
- The farthest at which the eye can see objects clearly is called far point vision

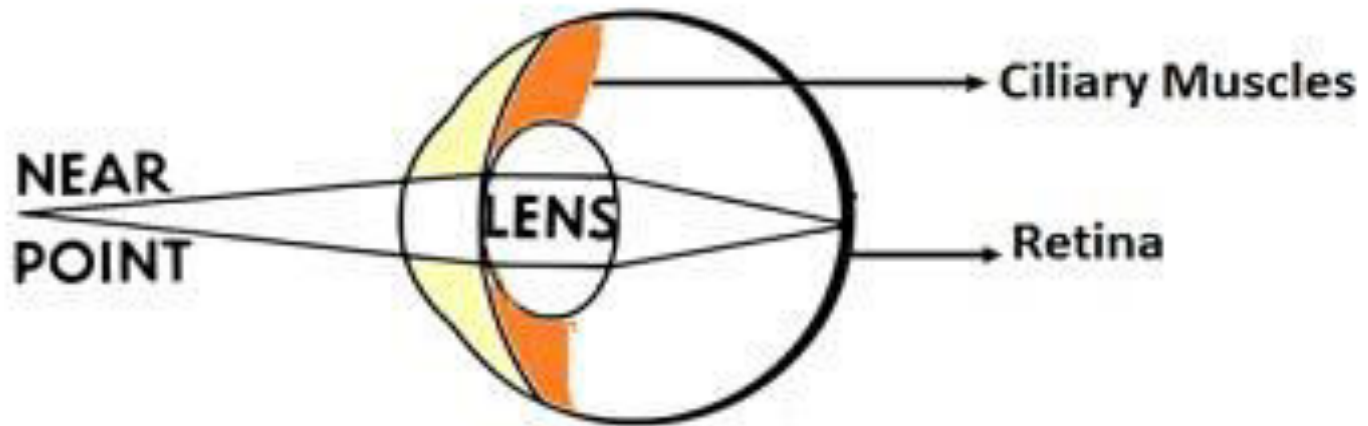
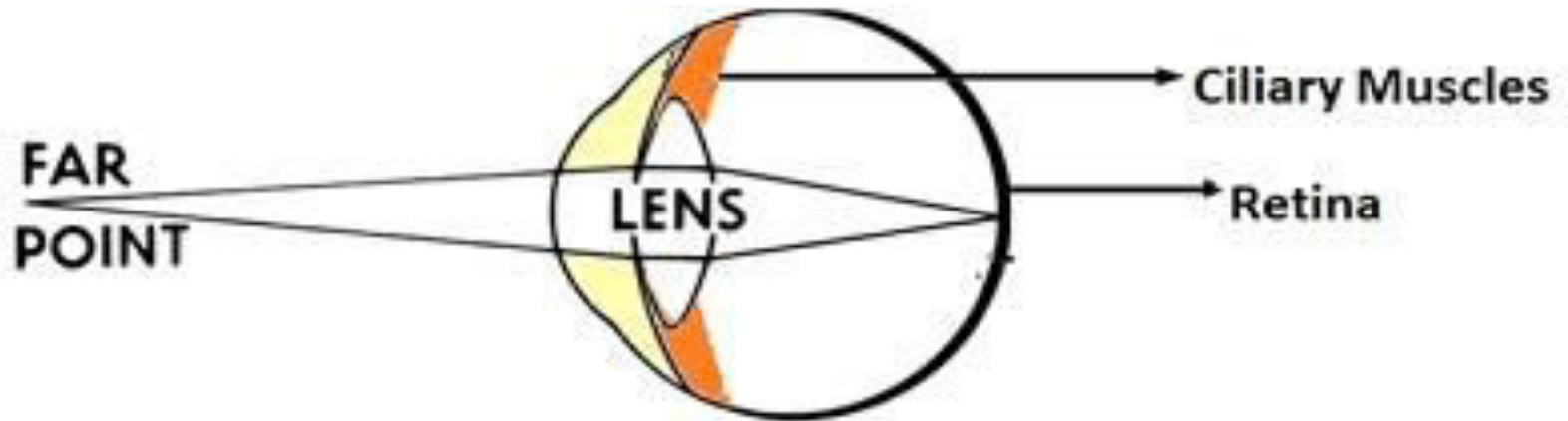
Accommodation of Human Eye



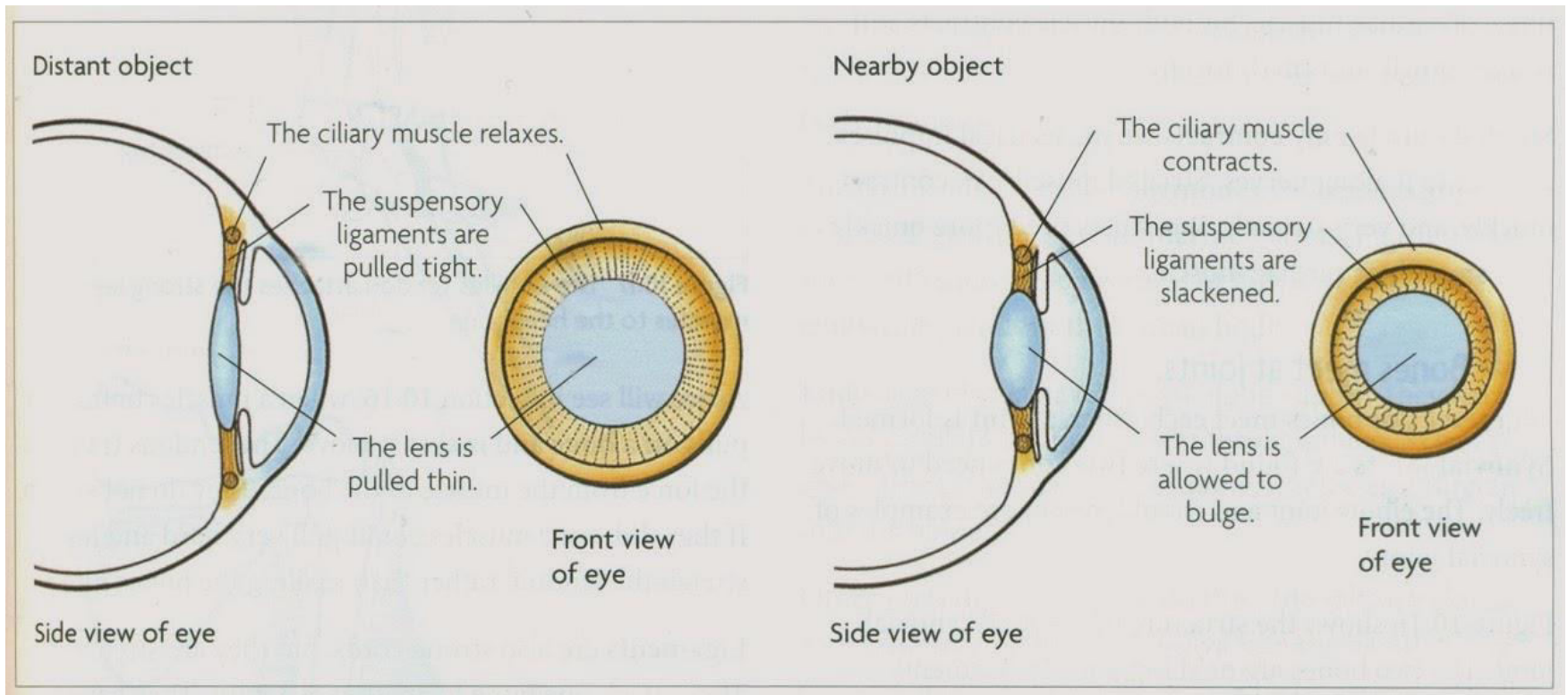
How accommodation works...

Object	Light rays	Lens	Suspensory ligaments	Ciliary Muscles
Distant	Parallel	Thinner; less convex	Taut	Relax
Near	Diverging	Thicker; more convex	Slacken	Contract

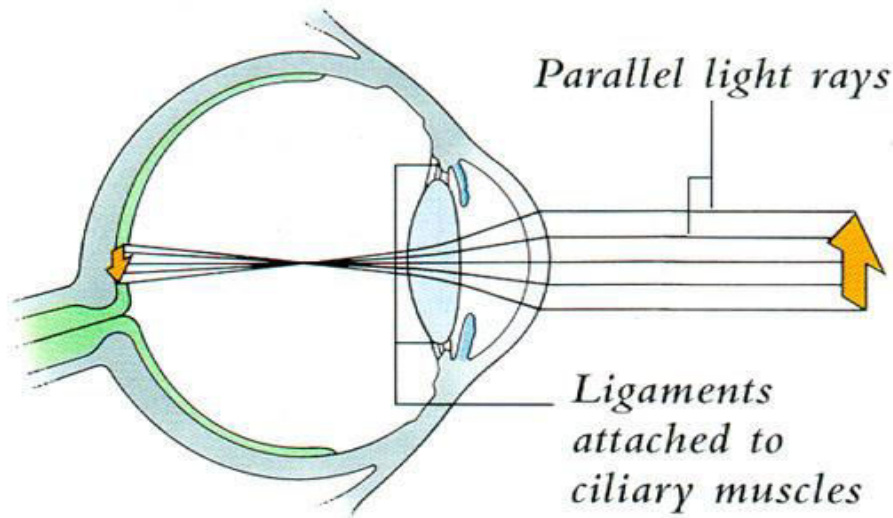
Accommodation of Human Eye



Accommodation of Human Eye

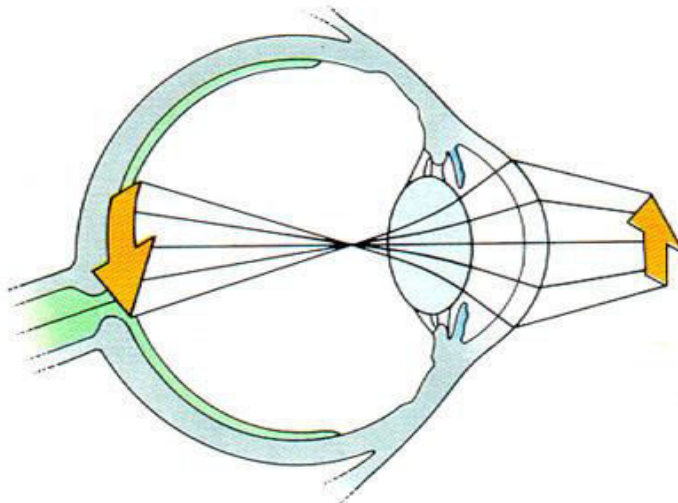


Accommodation of Human Eye



Distant objects

To focus on objects in the distance, the ciliary muscles relax and the lens flattens and thins. Light rays are slightly refracted (bent) by the lens.



Nearby objects

To view objects that are nearby, the ciliary muscles contract and the lens becomes more rounded. The point at which the image of a close object becomes blurred is called the near point of vision; it occurs when the lens reaches its maximum curvature.

Animal Form and Function 1

Module 90



Animal Form and Function 1

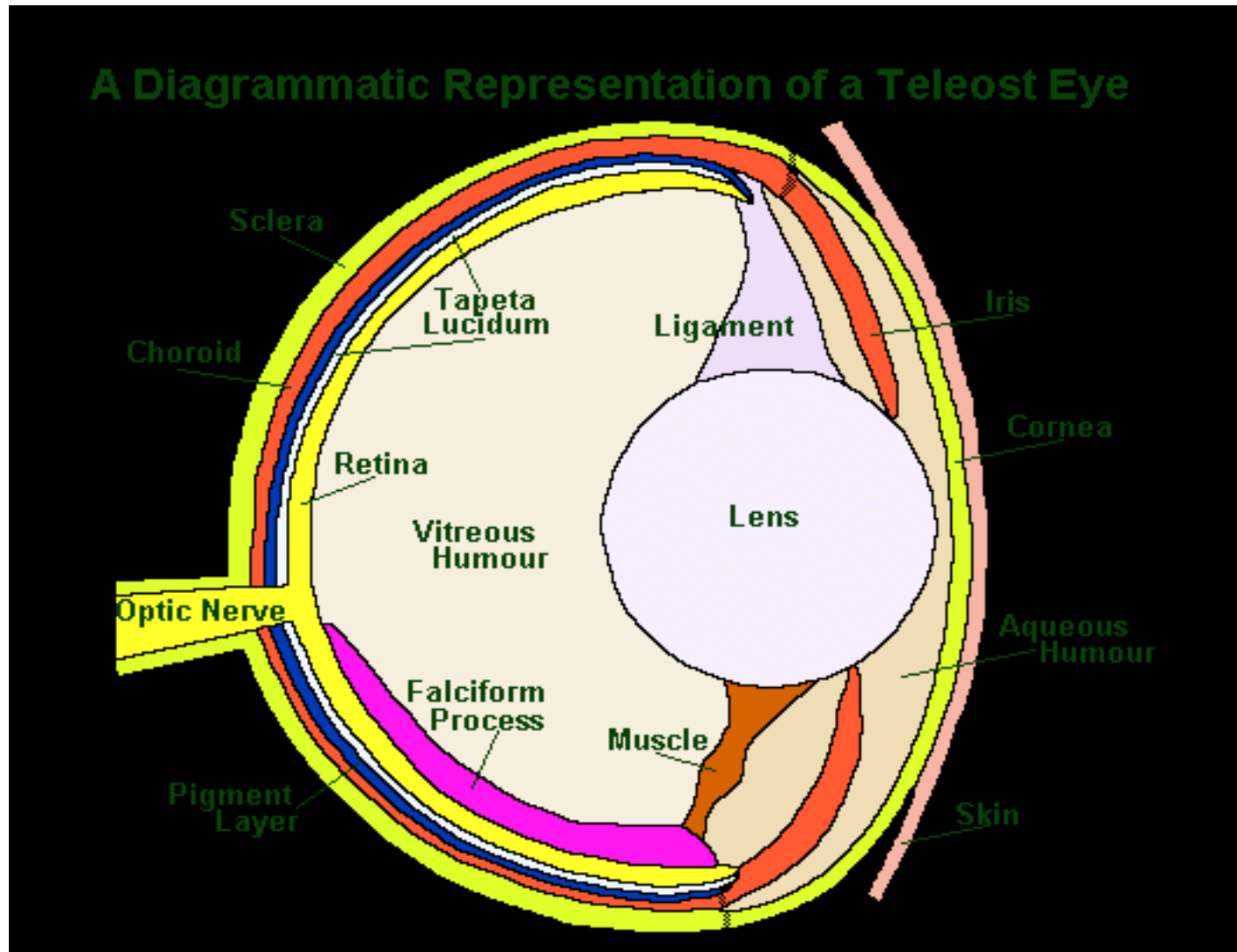
Adaptations of Fish and Amphibian Eyes

Adaptations of Fish & Amphibian Eyes

Fish eyes:

- Eyes of fishes are similar in most respects to the eyes of other vertebrates in both structure and function.
- However, fish eyes are without eye lids.
- Lens is spherical and close to cornea.
- Focusing requires moving the lens forward and backward.

Adaptations of Fish & Amphibian Eyes



Adaptations of Fish & Amphibian Eyes

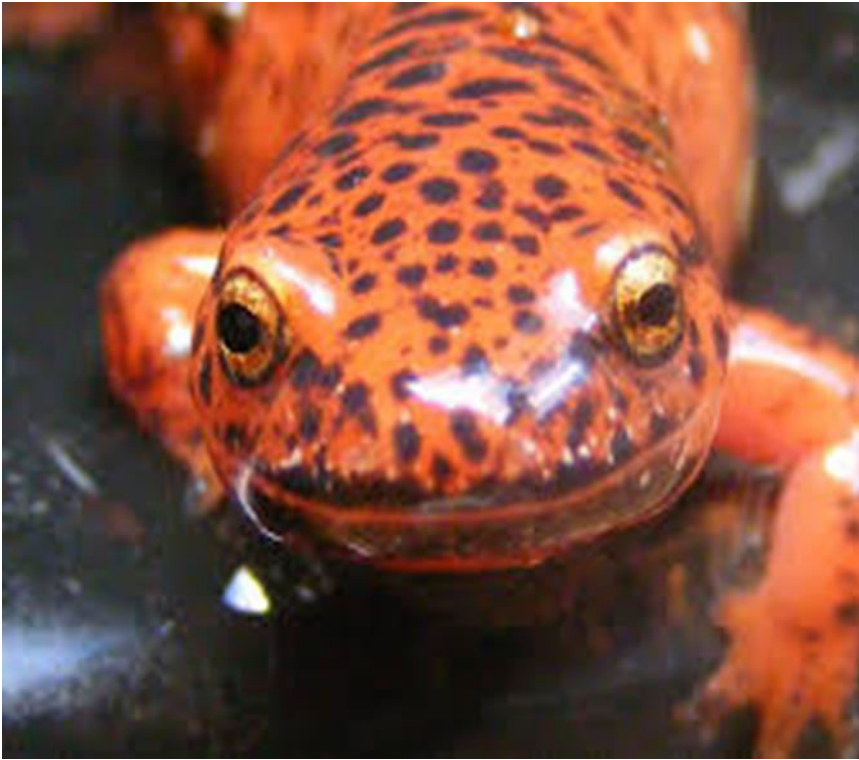
Amphibian Eye:

- In anurans and salamander eyes are close together on the front of head and have binocular vision.
- Some salamanders have smaller and lateral eyes and lack binocular vision.
- Laterally placed eyes permit such animals to see well off to their sides.

Adaptations of Fish & Amphibian Eyes

- Binocular vision is a type of vision in which an animal having two eyes is able to perceive a single three-dimensional image of its surroundings.

Adaptations of Fish & Amphibian Eyes



Animal Form and Function 1

Module 91



Animal Form and Function 1

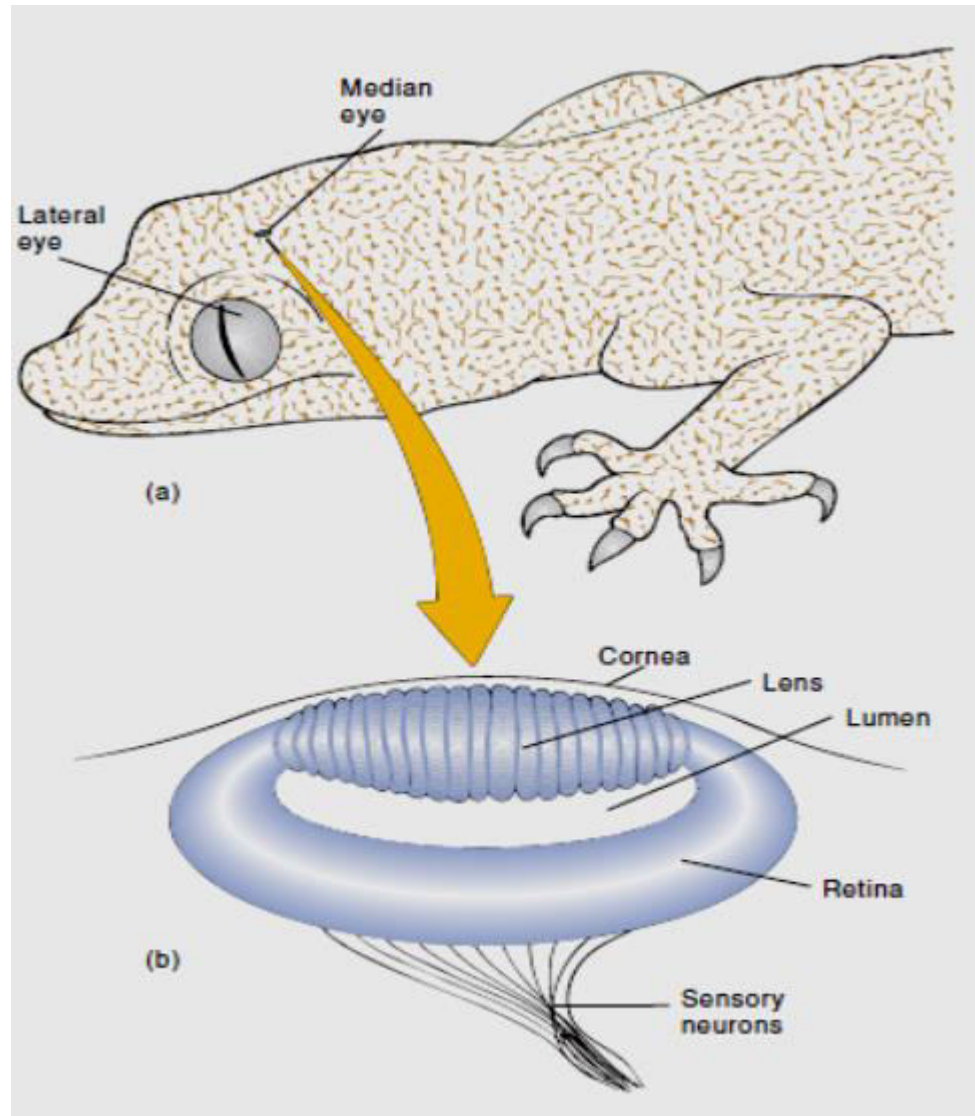
Vision in Reptiles



Vision in Reptiles

- Eye in Reptiles are similar in structure to those of amphibians.
- Most reptiles have a ring of bones around each eye that supports the eyeball except crocodiles and snakes.
- Some lizards and tuatara contain a third eye called a parietal eye, located on the top of their head.

Vision in Reptiles



Vision in Reptiles

- This eye develops from optic tectum (midbrain)
- This eye contains a cornea, lens, and retina like the lateral eyes.
- Snakes do not possess eyelids. A scale that is actually part of the skin, a spectacle, protects the eye

Vision in Reptiles

- Most reptiles possess upper and lower eye lids, nictitating membrane that protect and cleanse the surface of the eye.
- Usually, non-poisonous snakes have round pupils while poisonous snakes have elliptical pupils.

Vision in Reptiles

- A crocodilian's pupil can close to a narrow, slit-like aperture in bright light, while in dark pupil opens to a full, circular pupil to allow maximum light.
- So, they can hunt both during the day and at night.
- However, they prefer to hunt at night and bask at day time.

END

Animal Form and Function 1

Module 92



Animal Form and Function 1

Vision in Birds



Vision in Birds

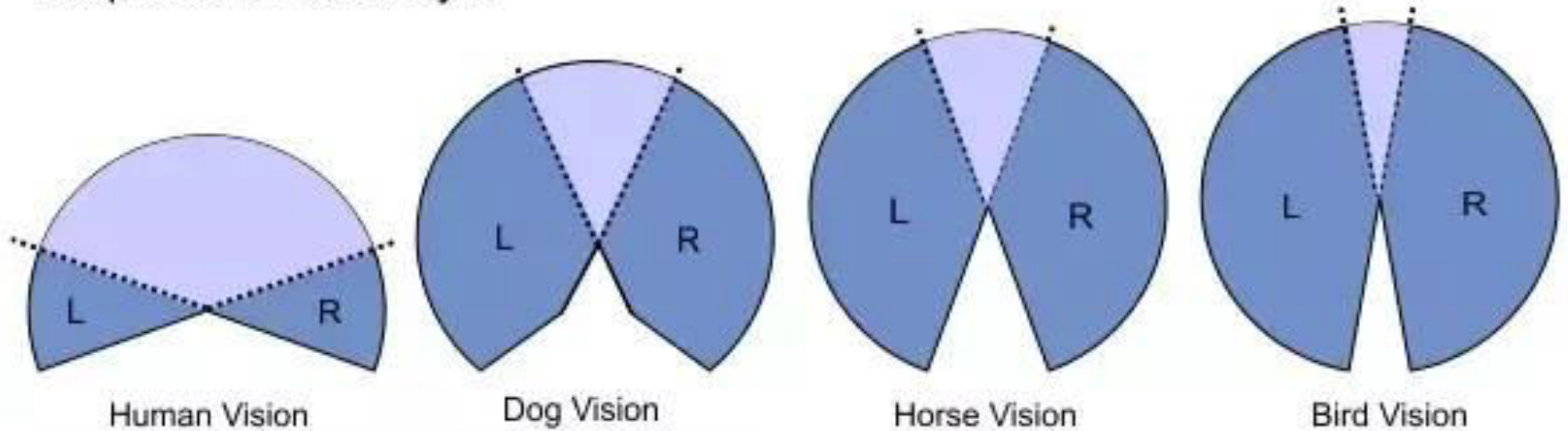
- The structure of bird eye is similar to that of other vertebrates.
- Birds are highly visual animals with unique features and adaptations that allow them to fly.
- But they have a number of adaptations which give visual acuity superior to that of other vertebrate groups.

Vision in Birds


- Birds of prey have a very high density of receptors that maximize visual acuity.
- The placement of their eyes gives them good binocular vision enabling accurate judgment of distances.
- Nocturnal species have but a high density of rod cells which function well in poor light.


Vision in Birds

Peripheral vision of Eyes



Area:  Not Visible

 Visible to One Eye only

 Visible to both Eyes

Vision in Birds

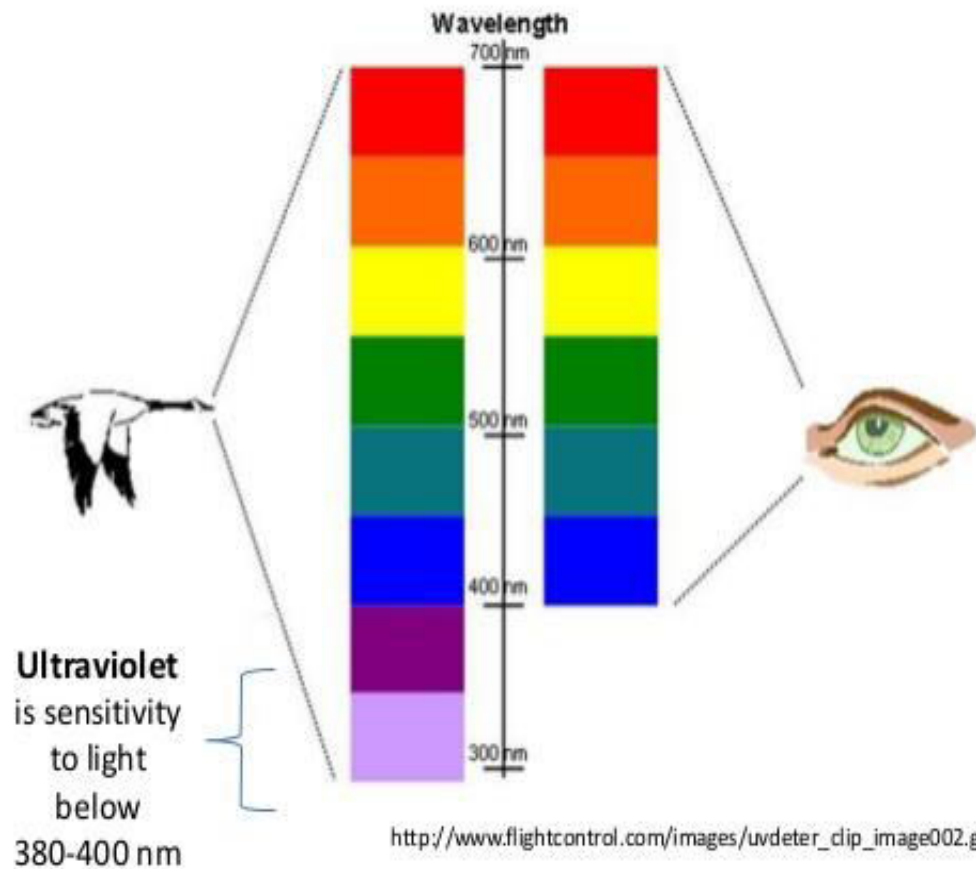
- Birds have unique double focusing mechanism
- Padlike structures control the curvature of the lens and ciliary muscles.
- Also change the curvature of the cornea.
- Instantaneous focusing of both allows the bird of prey to descend down rapidly to catch fish.

Vision in Birds

- Birds can see ultraviolet (UV) light because their lenses and other ocular media transmit UV,
- They possess a class of photoreceptor, which is maximally sensitive to violet or UV light, depending on the species.

Vision in Birds

Electromagnetic Spectrum



Vision in Birds



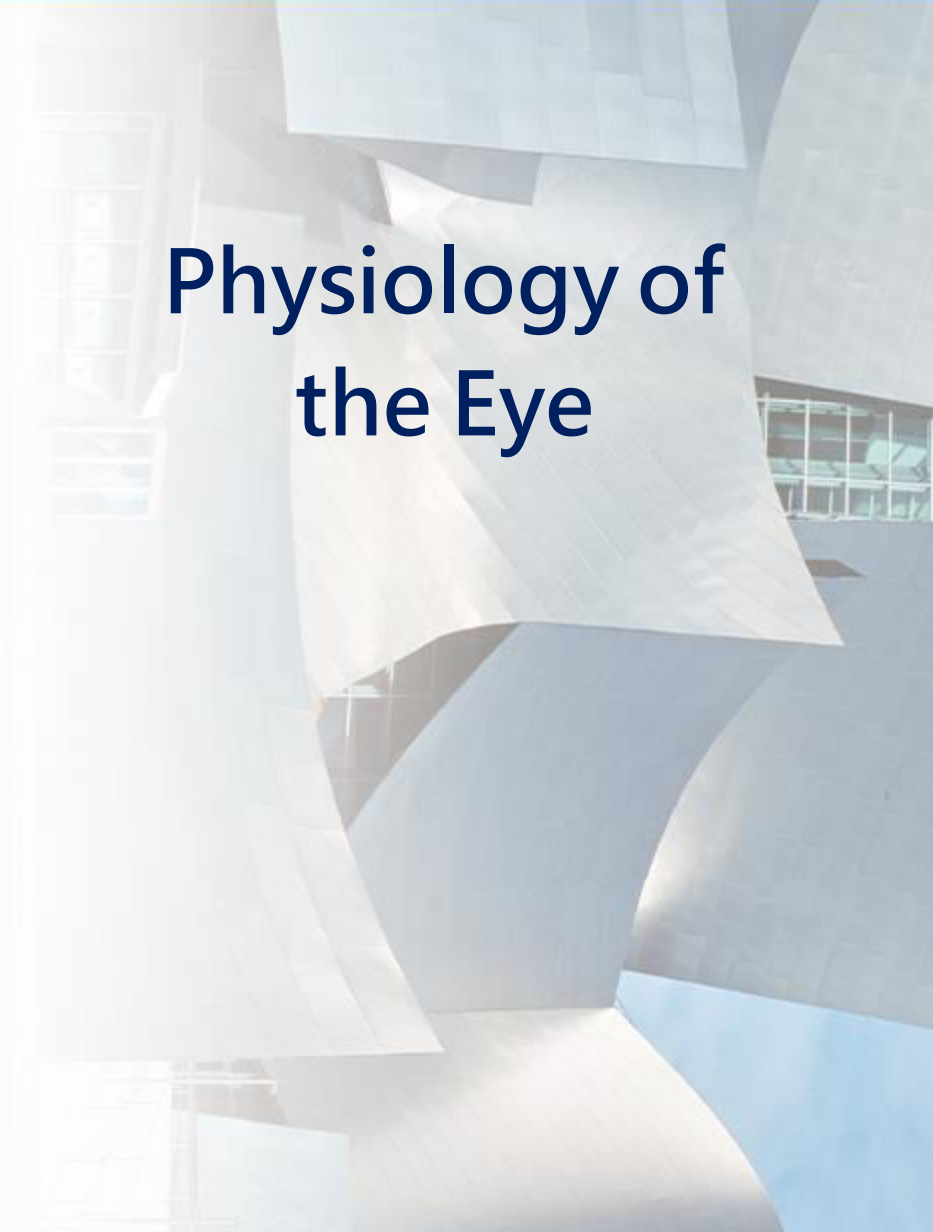
Animal Form and Function 1

Module 93



Animal Form and Function 1

Physiology of the Eye



Physiology of the Eye

- The retina is a thin layer of tissue that lines the back of the eye on the inside.
- The retina is a light-sensitive layer which is composed of pigmented epithelium, that covers the choroid layer.
- Nervous tissue that contains photoreceptor cells lies on this basement layer.

Physiology of the Eye

- The photoreceptor cells are called rod and cone cells.
- Rods are sensitive to dim light whereas cones respond to high intensity light and involved in color perception.

Physiology of the Eye

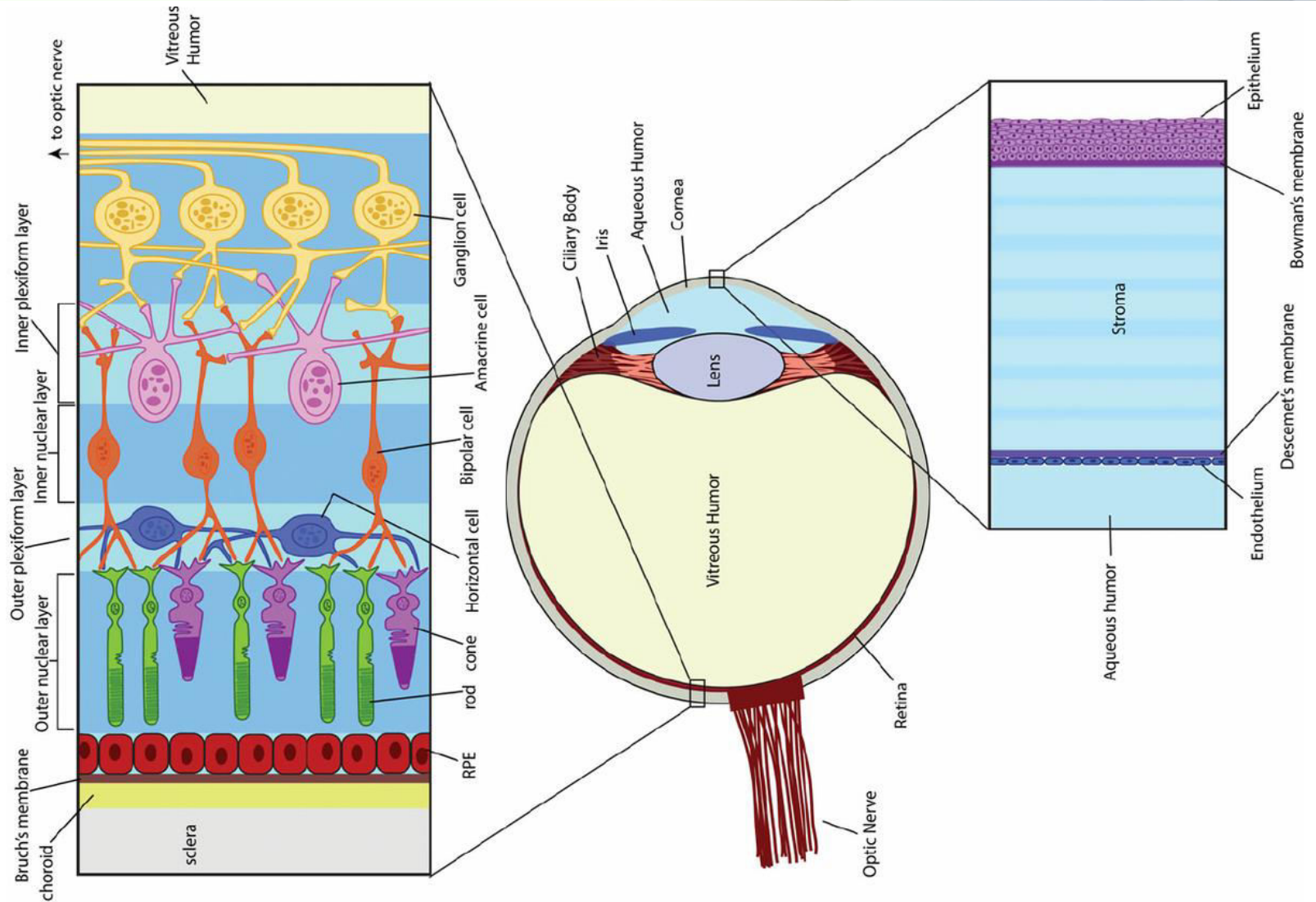
- With the help of the cornea and crystalline lens, image is formed on the retina which transforms it into nerve impulses and sent to the brain.

Physiology of the Eye

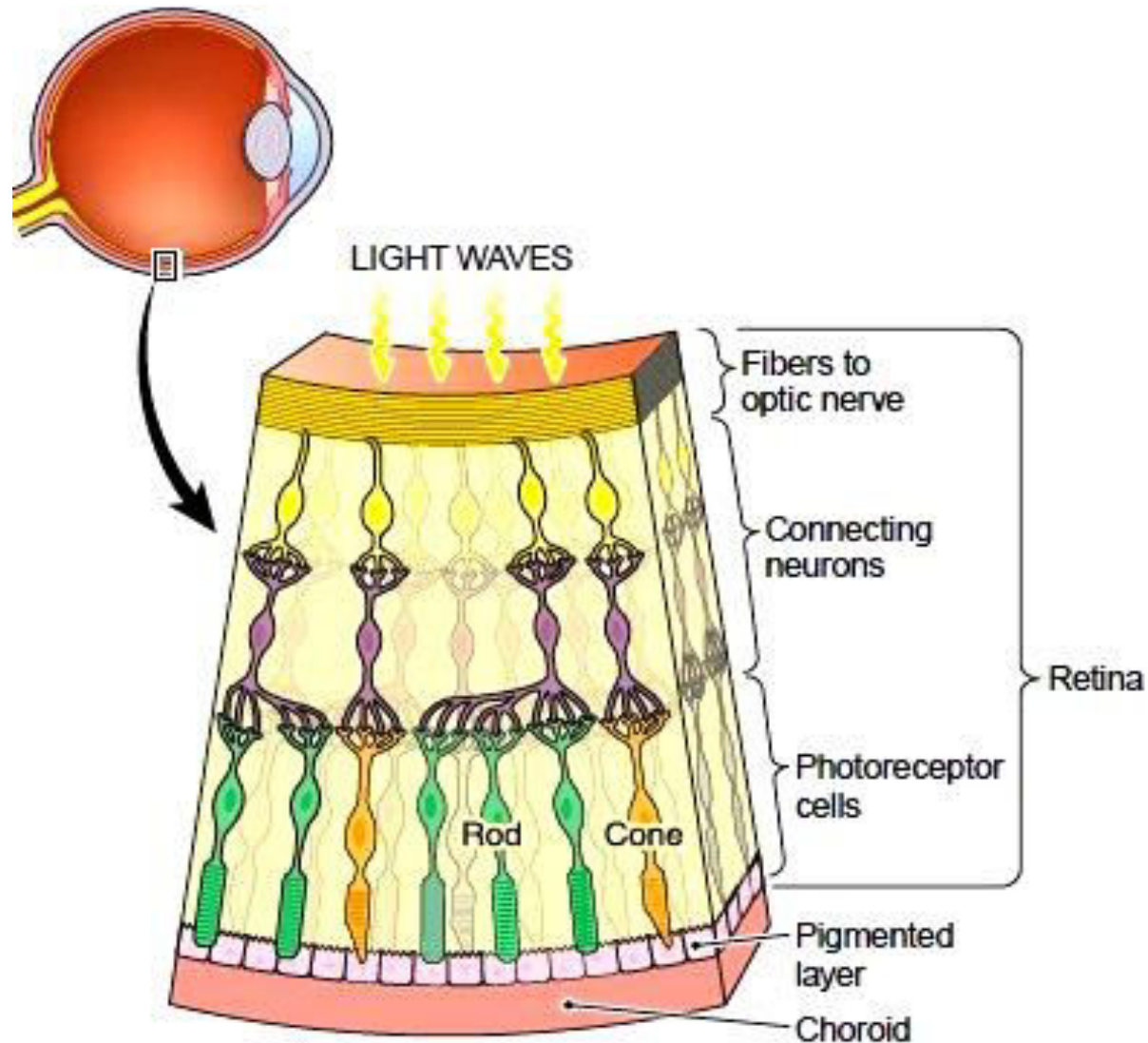
Chemistry of Vision:

- Visual perception in humans occurs through the absorption of electromagnetic radiations by photoreceptors in the retina.
- When rhodopsin, a pigment in rod cells, absorb light energy

Physiology of the Eye



Physiology of the Eye



Animal Form and Function 1

Module 94



Animal Form and Function 1

Light, Eye and Vision



Light, Eye and Vision

- Light is electromagnetic radiation that has properties of waves.
- The electromagnetic spectrum can be divided into several bands based on the wavelength.
- As we have discussed before, visible light represents a narrow group of wavelengths between about 380 nm and 730 nm.

Light, Eye and Vision

- Nature of light is said to dual i.e. it shows characteristics of both waves and particles.
- These particles are called photons when comes into contact with matter.

Light, Eye and Vision

- Photon as the particle of light has no charge and always move at the speed of light.
- The photon has only energy and no mass.

Light, Eye and Vision

- When a pigment (rhodopsin) in a rod cell absorbs light energy, the energy that this reaction releases triggers the generator potential in an axon and then an action potential that leaves the eyeball via the optic nerve to the brain.

Light, Eye and Vision

- When the photoreceptor cells are not being stimulated (i.e., in the dark), vitamin A and energy from ATP convert rhodopsin back to its light-sensitive form.

Light, Eye and Vision

Fovea

- In the middle of the retina is a small dimple called the fovea or fovea centralis.
- This is the center of the eye sharpest vision and the location of most color perception.

Light, Eye and Vision

- Our perception of color is based on perception of the light wavelength.
- Blue, yellow and red are the primary colors.
- These colors contain only one wavelength so they are called pure colors.

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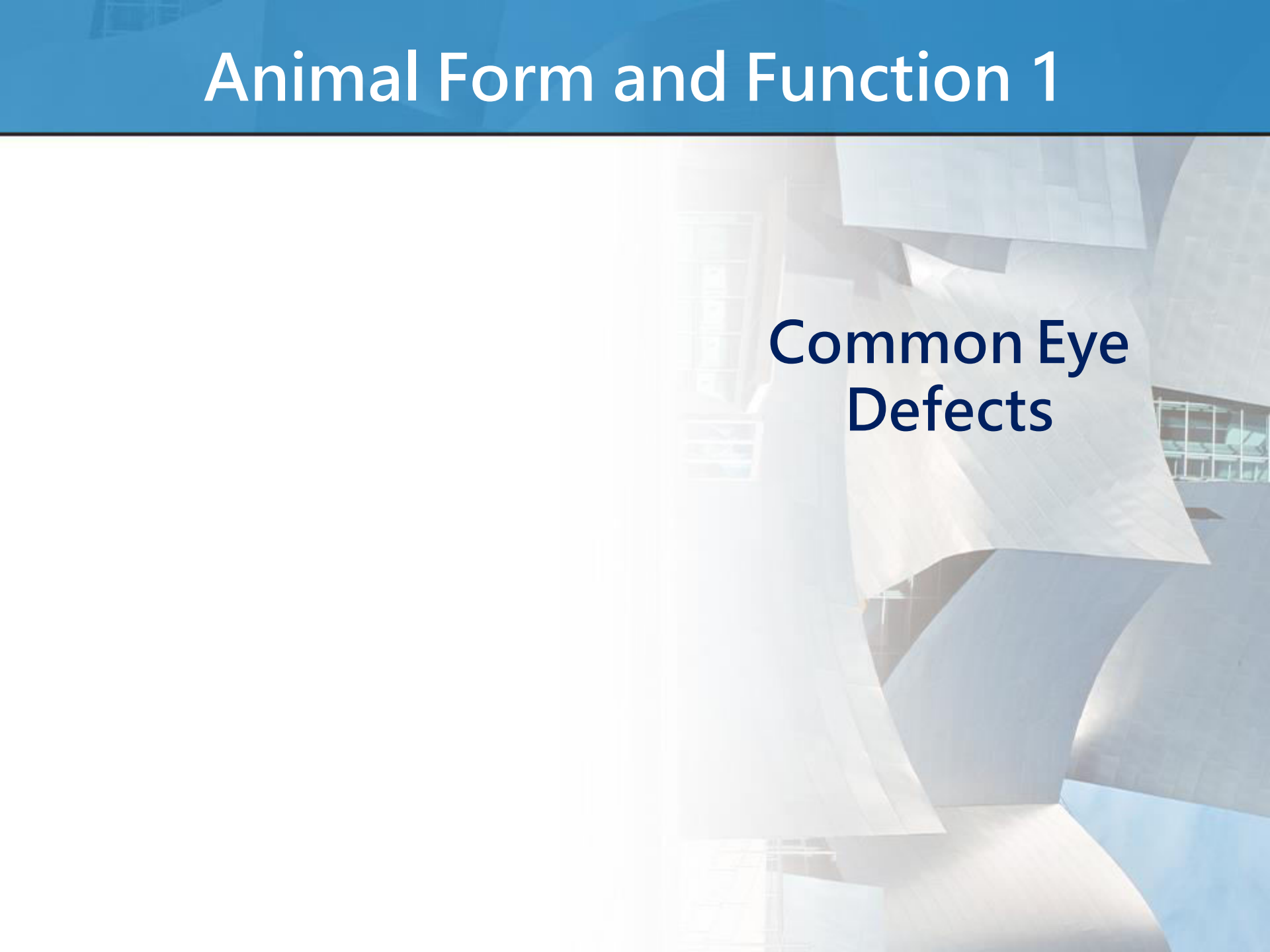
Animal Form and Function 1

Module 95



Animal Form and Function 1

Common Eye Defects



Common Eye Defects

- Myopia
(nearsightedness),
- Hyperopia
(farsightedness) and
- Astigmatism are common eye defects. They are often called "refractive errors".
- Cataract
- Glaucoma

Common Eye Defects

- **Nearsightedness or Myopia**, is a vision condition in which close objects are seen clearly, but objects farther away appear blurred.
- Myopia occurs if the eyeball is too long. As a result, the light entering the eye is not focused correctly and distant objects look blurred.

Common Eye Defects

- **Farsightedness or hyperopia**, is a vision condition in which distant objects are seen clearly, but close objects does not come into proper focus.
- **Hyperopia occurs if the eyeball is too short.**
- Light entering the eye is therefore, not focused correctly.

Common Eye Defects

- **Astigmatism** is a vision condition that causes blurred vision due to the irregular shape of the cornea or the curvature of the lens inside the eye.
- An irregular shaped cornea or lens prevents light from focusing properly on the retina. As a result, vision becomes blurred at any distance.

Common Eye Defects

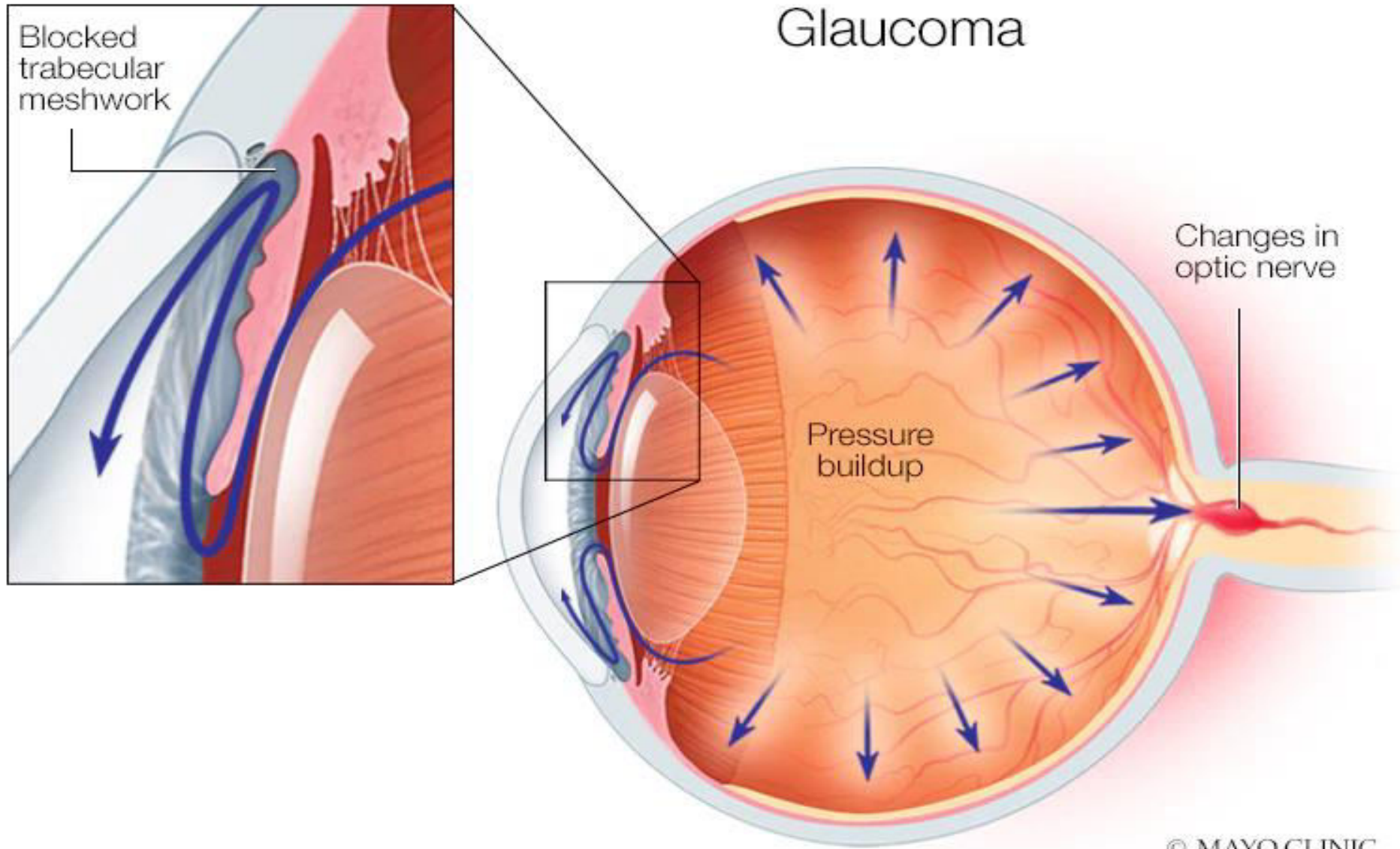
Cataract:

- Cataract is a condition that occurs when the inner lens of the eye becomes darkened or opaque.

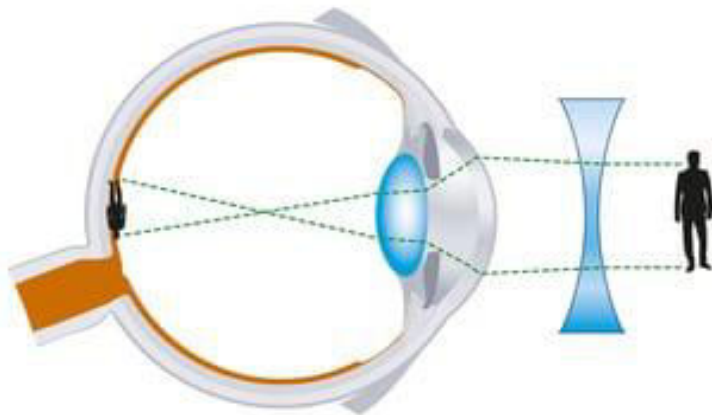
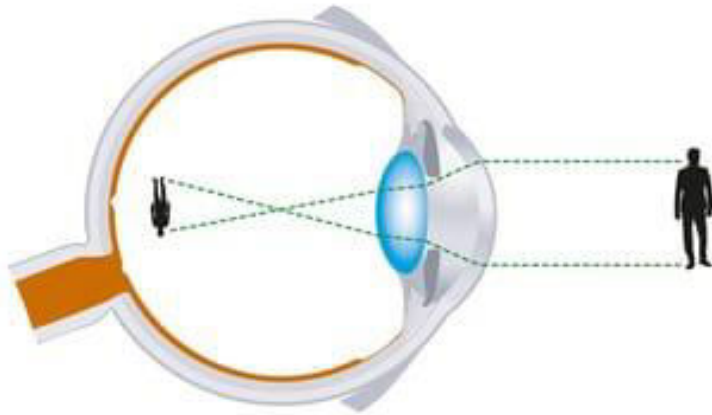
Glaucoma:

- Glaucoma is a disease which damage the eyes optic nerve and can result in vision loss and blindness.

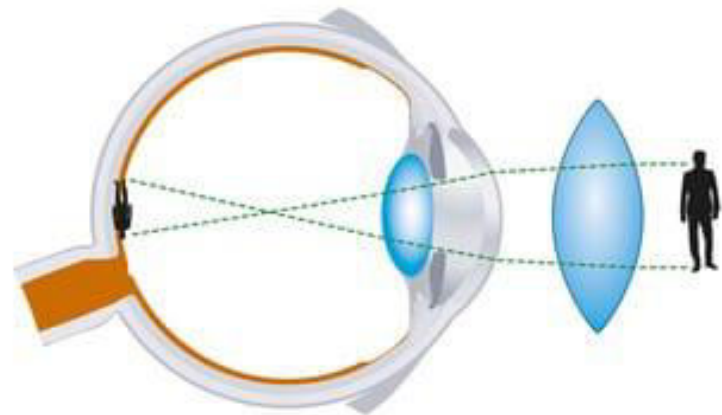
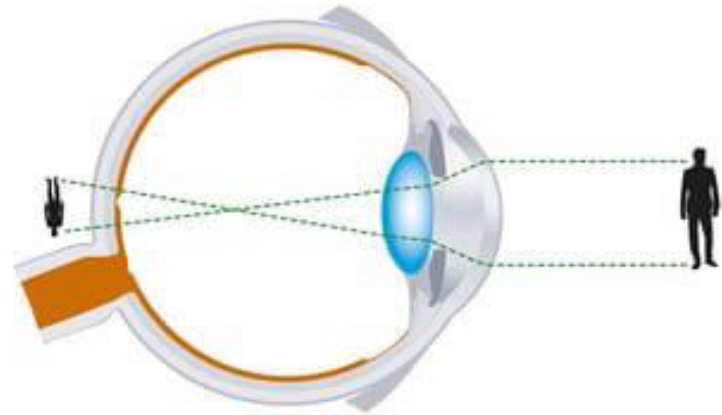
Common Eye Defects



Common Eye Defects

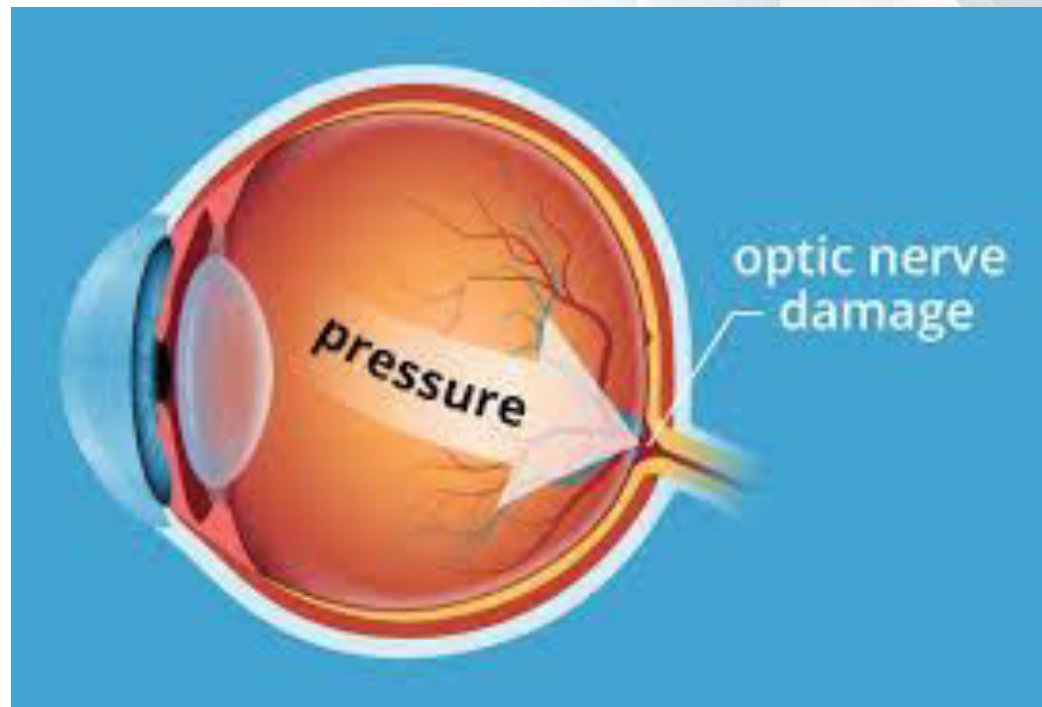


Myopia



Hyperopia

Common Eye Defects



Animal Form and Function 1

Module 96



Animal Form and Function 1

Shining Eyes



Shining Eyes

- Eye shine can be seen in many animals.
- Eye shine occurs in a wide variety of colors including white, blue, green, yellow, pink and red.
- Eye shine is a type of iridescence. E.g Soap bubbles, sea shells

Shining Eyes



Shining Eyes

- Eyeshine is a visible effect of the tapetum lucidum
- Tapetum is a layer of tissue in the eye of many vertebrates.
- It lies immediately behind the retina.
- When light shines into the eye of an animal having a tapetum, the pupil appears to glow.

Shining Eyes

- The tapetum lucidum functions as a retroreflector.
- It reflects visible light back through the retina, increasing the light available to the photoreceptors.

END

Animal Form and Function 1

Module 97



Animal Form and Function 1

Summary of the Chapter (Nervous and Sensory Systems) Part I

Summary of the Chapter Part I

- **NERVOUS SYSTEM:** The system that integrates, coordinates and communicates the various systems of the organism.
- **Neurons-Functional unit of Nervous system**
- **They are specialized cells to produce signals,** which are communicated from one part to the body to other.

Summary of the Chapter Part I

- Neurons have two important properties- the excitability and conductivity.
- Structurally the neuron is composed of dendrites, cell body and axon.
- The language of neuron in the nerve impulse or action potential.

Summary of the Chapter Part I

- The plasma membrane of a living neuron is polarized i.e. there is trans membrane potential.
- Outside is positively charged and inside negatively charged.
- The sodium-potassium ATPase pump and diffusion of ions across membrane channels maintain this polarization.

Summary of the Chapter Part I

- When a stimulus is applied to a resting neuron, the neuron depolarizes causing an action potential.
- In myelinated neuron the conduction of impulse is saltatory.
- Nerve impulse is transmitted from one neuron to the next through synapsis, which involve neurotransmitters.

Summary of the Chapter Part I

- The more complex an animal, the more detailed its
 - i) Nervous System
 - ii) Cephalization
 - iii) Bilateral symmetry
 - iv) More interneurons
 - v) The more complicated behavior.

Summary of the Chapter Part I

- THE VERTEBRATE NERVOUS SYSTEM
- 1. The Central Nervous System (CNS) has two main divisions: brain and spinal cord.
- 2. Peripheral Nervous System (PNS)- all the nerves outside the brain and spinal cord.

Summary of the Chapter Part I

- THE VERTEBRATE BRAIN is divided into:
 - fore brain,
 - mid brain and the
 - hind brain.
- The fore brain is composed of cerebrum, thalamus, hypothalamus, pineal gland and the pituitary.

Summary of the Chapter Part I

- The mid brain is a thickened region of grey matter that integrates visual and auditory signals.
- The hind brain is continuous with spinal cord and includes the cerebellum, pons and medulla oblongata.

Summary of the Chapter Part I

- **THE SPINAL CORD**
serves two functions:
- a) It is the connecting link between brain and the body.
- b) It is involved in the reflex actions.

END

Animal Form and Function 1

Module 98



Animal Form and Function 1

Summary of the Chapter (Nervous and Sensory Systems) Part II

Summary of the Chapter Part II

- **CRANIAL NERVES:**
- In reptiles, birds and mammals the CNs are 12 pairs:
 - I. Olfactory S
 - II. Optic S
 - III. Oculomotor M
 - IV. Trochlear M
 - V. Trigeminal Mix
 - VI Abducens M
 - VII. Facial Mix
 - VIII. Vestibulocochlear S

Summary of the Chapter Part II

IX.	Glossopharyngeal	Mix
X.	Vagus	Mix
XI.	Accessory	Mix
XII	Hypoglossal	Mix

- **Fishes and Amphibians have 10 pairs of Cranial Nerves.**

Summary of the Chapter Part II

- AUTONOMIC NERVOUS SYSTEM:

- ANS consists of:

- a) Sympathetic and

- b) Para sympathetic NS

These are antagonistic to each other.

Summary of the Chapter Part II



- **PARASYMPATHETIC NS:**
- It contains nerves that arise from the brain and sacral region of the spinal cord.
- It relaxes the body and inhibits or slows many energy functions.
- Rest and digest

Summary of the Chapter Part II

- **SYMPATHETIC NS:**
- It contains nerves that arise from the thoracic and lumbar regions of the spinal cord.
- It prepares body for intense physical activity.
- **Fight and Flight**

Summary of the Chapter Part II

- **Sensory Reception:**
- **Identification of five senses-sight, hearing, smell , taste and touch.**
- **Features of Sensory Receptors:**
- **1. Contain sensitive receptor cells** or finely branched peripheral endings of sensory neurons that respond to a stimulus by creating a generator potential.

Summary of the Chapter Part II

- 2. Their structure is designed to receive a specific stimulus.
- 3. Their receptor cells synapse with afferent nerve fibers that travel to the CNS along specific neural pathways.
- 4. In the CNS the nerve impulse is translated into a recognizable sensation, such as sound.

Summary of the Chapter Part II

- **INVERTEBRATE
SENSORY RECEPTORS:**
 - Baroreceptors
 - Chemoreceptors
 - Georeceptors
 - Hygroreceptors
 - Photoreceptore
 - Proprioceptors
 - Tactile receptors

Summary of the Chapter Part II

- VERTEBRATE SENSORY RECEPTORS
- Lateral-line system and mechanoreceptors
- Hearing & Equilibrium in air and water.
- Skin sensors of heat and cold.
- Skin sensors of mechanical stimuli.
- Sonar.
- Smell
- Taste
- Vision

END



MIDTERM EXAM

Merge By

AMMAN KHAN

Animal Form and Function 1

Module 99



Animal Form and Function 1

Summary of the Chapter (Nervous and Sensory Systems) Part III

Summary of the Chapter Part III

- **SENSORY RECEPTION:**
- Identification of five senses-sight, hearing, smell , taste and touch.
- **Features of Sensory Receptors:**
- 1. Contain sensitive receptor cells or finely branched peripheral endings of sensory neurons that respond to a stimulus by creating a generator potential.

Summary of the Chapter Part III

- 2. Their structure is designed to receive a specific stimulus.
- 3. Their receptor cells synapse with afferent nerve fibers that travel to the CNS along specific neural pathways.
- 4. In the CNS the nerve impulse is translated into a recognizable sensation, such as sound.

Summary of the Chapter Part III

- INVERTEBRATE SENSORY RECEPTORS:
- Baroreceptors-statocysts
- Chemoreceptors-
- Georeceptors-statocysts, that respond to gravity
- Hygroreceptors-detect water content of air.
- Phonoreceptors-such as tympanic organs.

Summary of the Chapter Part III

- **Photoreceptors**- such as stigmata, ocelli, compound eyes, complex camera eyes that respond to light.
- **Proprioceptors**- that respond to mechanically induced changes caused by stretching.
- **Tactile receptors**- such as bristles, sensilla, spines, setae and tubercles that sense touch.

Summary of the Chapter Part III

- VERTEBRATE SENSORY RECEPTORS
- Lateral-line system- contain neuromasts. They are present in the head area of most fishes, some amphibians and platypus. They are sensitive to water disturbance.

Summary of the Chapter Part III

- **Lateral Line System** in jawless fishes, jawed fishes and certain amphibians contain ampullary organs, which are sensitive to electric currents in water and production of generator potential.

Summary of the Chapter Part III

- **Hearing & Equilibrium in air and water.**

Hearing (audition) and equilibrium (balance) are considered together because both sensations are received in the same vertebrate organ—the ear.

Summary of the Chapter Part III

- Skin Sensors of Heat and Cold.
- Pit organs in snakes
- Skin Sensors of Mechanical Stimuli-
They are:
 - Bare sensory nerve endings,
 - Meissner's corpuscles,
 - Bulbs of Krause,
 - Paccinian Corpuscle
 - Vibrissae

Summary of the Chapter Part III

- Vision:
- Eyes, Median eye
- Photoreceptor cells- rods and cones
- Monocular and Binocular vision,
- Accommodation,
- Rhodopsin.

Summary of the Chapter Part III

- Sonar-
- Echolocation in bats, whales, dolphin, cave dwelling birds.
- Smell-
- Receptor in nasal cavity
- Jacobson's organs.
- Taste or gustation:
- Taste buds on tongue.
- Barbles in fishes
- Pharynx in birds

END

Animal Form and Function 1

Module 100



Animal Form and Function 1

Introduction of Chemical Messengers

Introduction of Chemical Messengers

- Chemical messengers are involved in:
 - 1. Communication
 - 2. Maintenance of homeostasis in an animal's body,
- 3. Body's response to various stimuli.
- One type of chemical messenger is a hormone.

Introduction of Chemical Messengers

- Only those cells that have specific receptors for a hormone can respond to that hormone.
- Hormones work with nerves to communicate, coordinate, and integrate activities within the body of an animal.
- Almost every invertebrate produces hormones

Introduction of Chemical Messengers

- However, the physiology of invertebrate hormones is often quite different from that of vertebrate hormones.
- The major endocrine glands of vertebrates include:
 - hypothalamus, pituitary, thyroid, parathyroids, adrenals, pineal, thymus, pancreas, and gonads.

Introduction of Chemical Messengers

- Various other tissues, however, such as the kidneys, heart, digestive system, and placenta also secrete hormones.

Animal Form and Function 1

Module 101



Animal Form and Function 1

Evolution in Coordination



Evolution in Coordination

- Evolutionarily, new messengers are uncommon.
- Instead, “old” messengers are adapted to new purposes.
- For example, some ancient protein hormones are in species ranging from bacteria to human

Evolution in Coordination

- Scientists suggest that chemical messengers may initially have evolved in single-celled organisms to coordinate feeding or reproduction.

Evolution in Coordination

- As multicellularity evolved, more complex organs also evolved to govern the many individual coordination tasks, but control centers relied on the same kinds of messengers that were present in the simpler organisms

Evolution in Coordination

- Some of the messengers worked fairly slowly but had long-lasting effects on distant cells; these became the modern hormones.

Evolution in Coordination

- Others worked more quickly but influenced only adjacent cells for short periods; these became the neurotransmitters and local chemical messengers.

Evolution in Coordination

- Clearly, chemical messengers have an ancient origin and must have been conserved for hundreds of millions of years.
- It seems likely that the chemical messengers regulating growth and reproduction were among the first to appear.

Evolution in Coordination

- These messengers were probably
- Later, specific hormones developed to play important regulatory roles in molting, growth, reproduction and metamorphosis, in various invertebrates.

Evolution in Coordination

- Chemical messengers and their associated secretory structures became even more complex with the appearance of vertebrates.

END

Animal Form and Function 1

Module 102



Animal Form and Function 1

Chemical Messengers Part I



Chemical Messengers Part I

- The development of most animals commences with fertilization and the subsequent division of the zygote.
- Further development then depends on continued cell proliferation, differentiation and growth.

Chemical Messengers Part I

- Integration communication, and coordination of all physiological processes, such as metabolism, respiration, excretion, movement, and reproduction, depend on chemical messengers.

Chemical Messengers Part I

- The chemical messengers are the molecules that are synthesized and secreted by specialized cells.

END

Animal Form and Function 1

Module 103



Animal Form and Function 1

Chemical Messengers Part II

Chemical Messengers Part II

- Chemical messengers can be categorized as follows:
 - i) Local chemical messengers.
- Many cells secrete chemicals that alter physiological conditions in the immediate vicinity.
- Most of these chemicals act on adjacent cells and do not accumulate in the blood.

Chemical Messengers Part II

- Vertebrate examples include some of the chemicals called **lumones** that the gut produces and that help regulate digestion.
- In a wound, mast cells secrete a substance called **histamine** that participates in the inflammatory response.

Chemical Messengers Part II

- ii) **Neurotransmitters.**
Neurons secrete chemicals called neurotransmitters (e.g., nitric oxide and acetylcholine) that act on immediately adjacent target cells.
- These chemical messengers reach high concentrations in the synaptic cleft, act quickly, and are actively degraded and recycled.

Chemical Messengers Part II

- **iii) Neuropeptides.**
Some specialized neurons (called neurosecretory cells) secrete neuropeptides (neurohormones). The blood or other body fluids transport neuropeptides to nonadjacent target cells, where neuropeptides exert their effects

Chemical Messengers Part II

- In mammals, for example, certain nerve cells in the hypothalamus release a neuropeptide that causes the pituitary gland to release the hormone oxytocin, which induces powerful uterine contractions during the delivery of offspring.

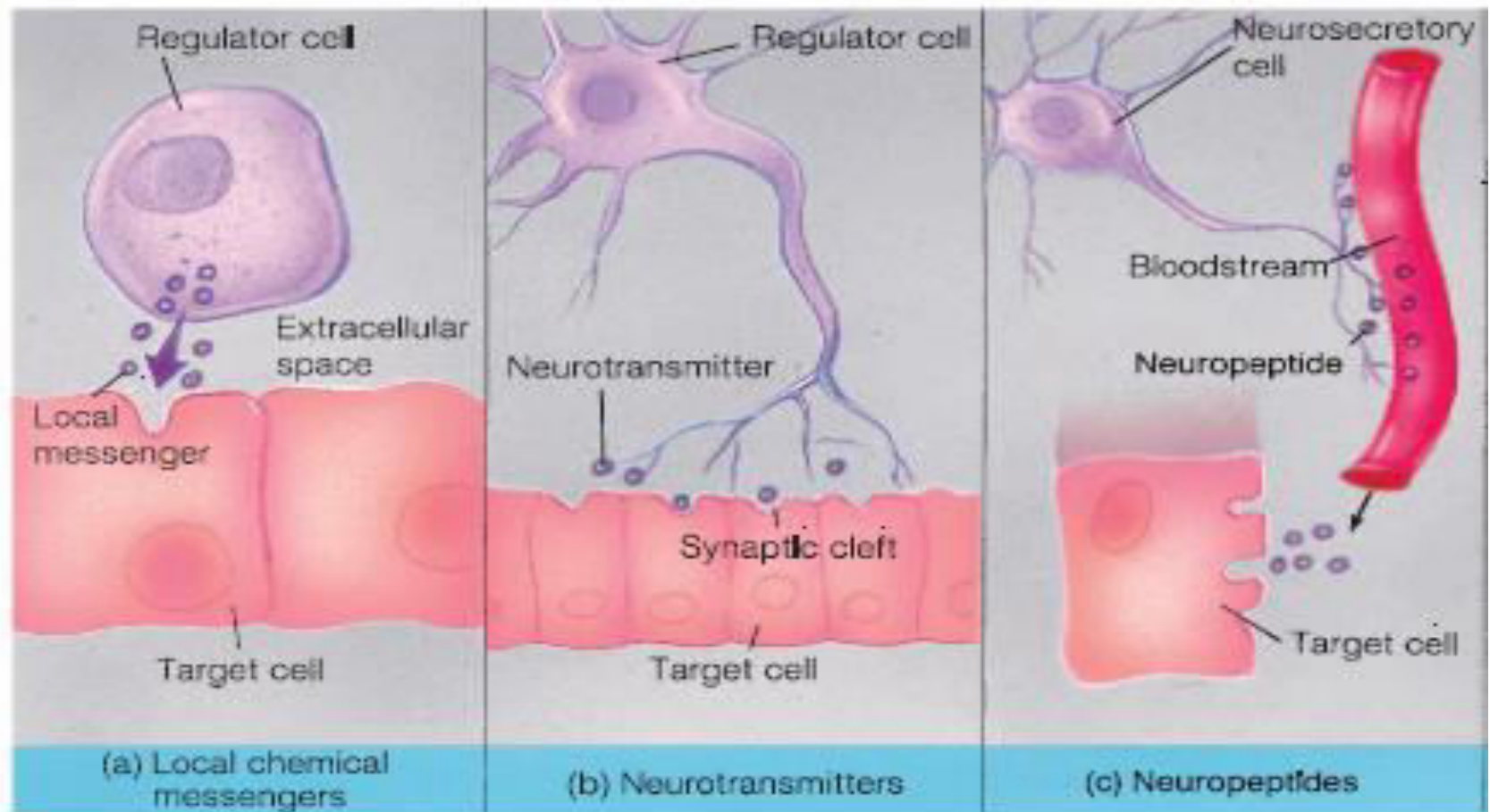
Chemical Messengers Part II

- iv) Hormones.
Endocrine glands or cells secrete hormones that the bloodstream transports to nonadjacent target cells.
- Many examples are given in the rest of this chapter.
- Thyroxin, Insulin, Glucagon, FSH, LH etc.

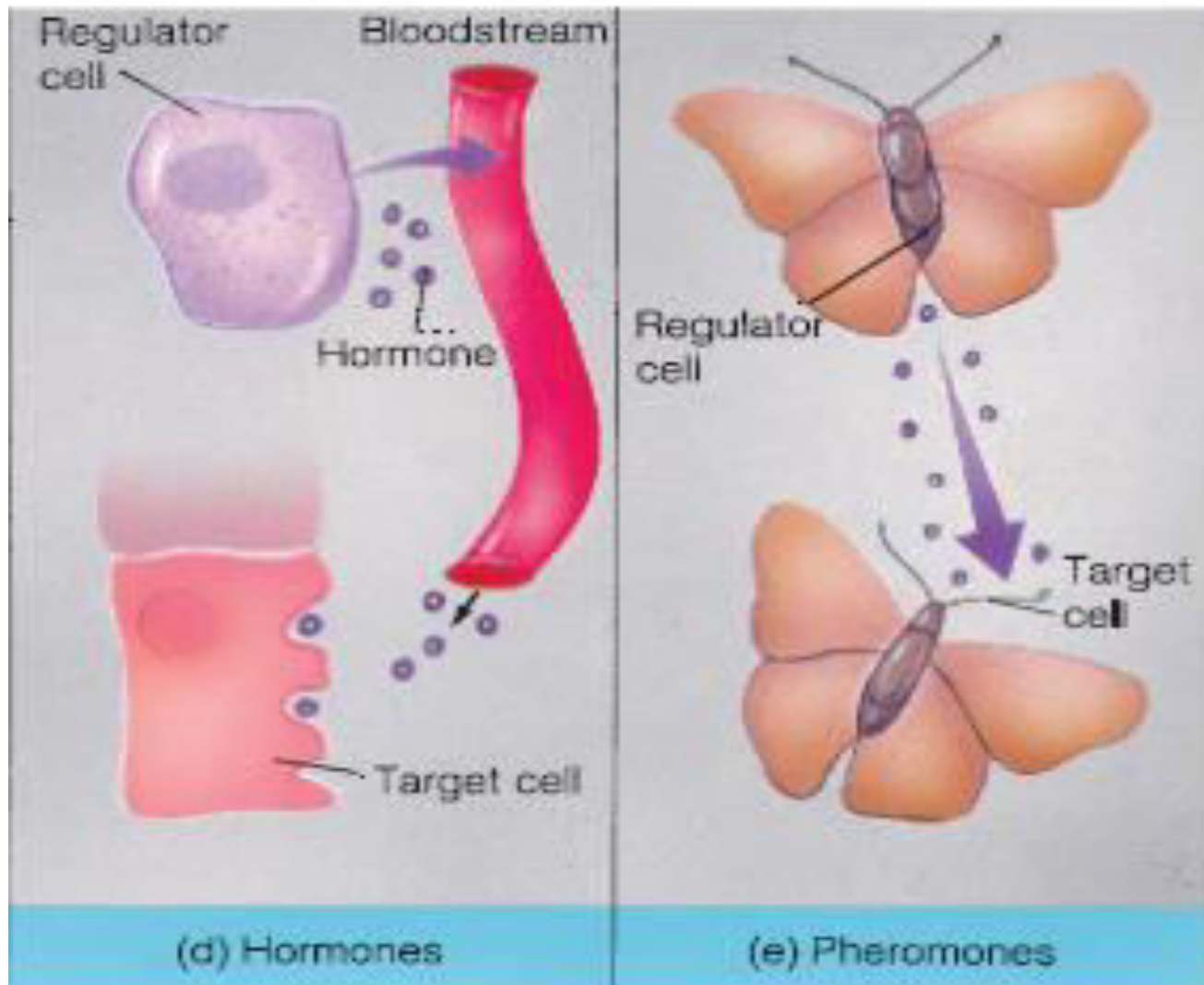
Chemical Messengers Part II

- v) **Pheromones.**
Pheromones are chemical messengers released to the exterior of one animal that affect the behavior of another individual of the same species.

Chemical Messengers Part II



Chemical Messengers Part II



Animal Form and Function 1

Module 104



Animal Form and Function 1

Biochemistry of Hormones

An abstract architectural sculpture made of large, light-colored, angular blocks, possibly concrete or stone, arranged in a complex, overlapping structure. The sculpture is set against a background of a modern building with large glass windows and a blue sky. The overall aesthetic is clean and modern.


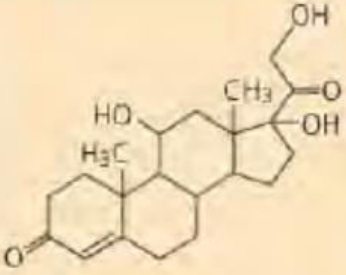
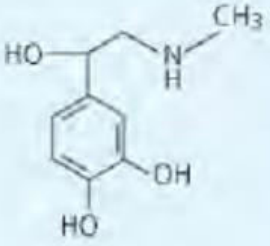
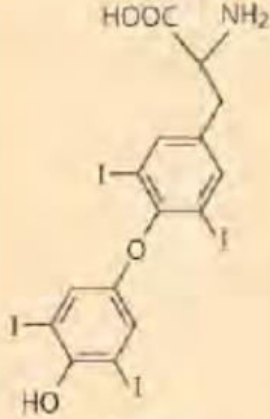
Biochemistry of Hormones

- Biochemically the hormones may be the
 - i) Proteins (polypeptides) e.g. insulin
 - ii) Derivatives of amino acids (amines), e.g. TSH
 - iii) Steroids e.g. Sex hormones and adrenocortical hormones.

Biochemistry of Hormones

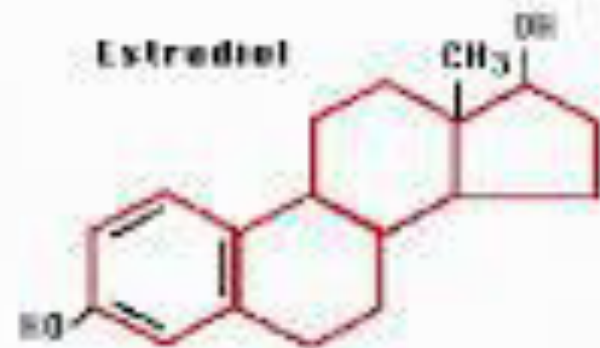
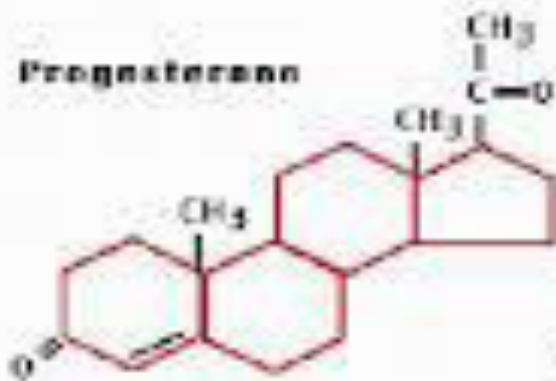
- iv) A few are fatty acid derivatives. For example- Prostaglandins
- They are synthesized in the walls of blood vessels.
- Regulate the contraction of smooth muscle tissue.
- Involved in inflammation.

Biochemistry of Hormones

Water-soluble	Lipid-soluble
 <p>Polypeptide: Insulin</p>	 <p>Steroid: Cortisol</p>
 <p>Amine: Epinephrine</p>	 <p>Amine: Thyroxine</p>

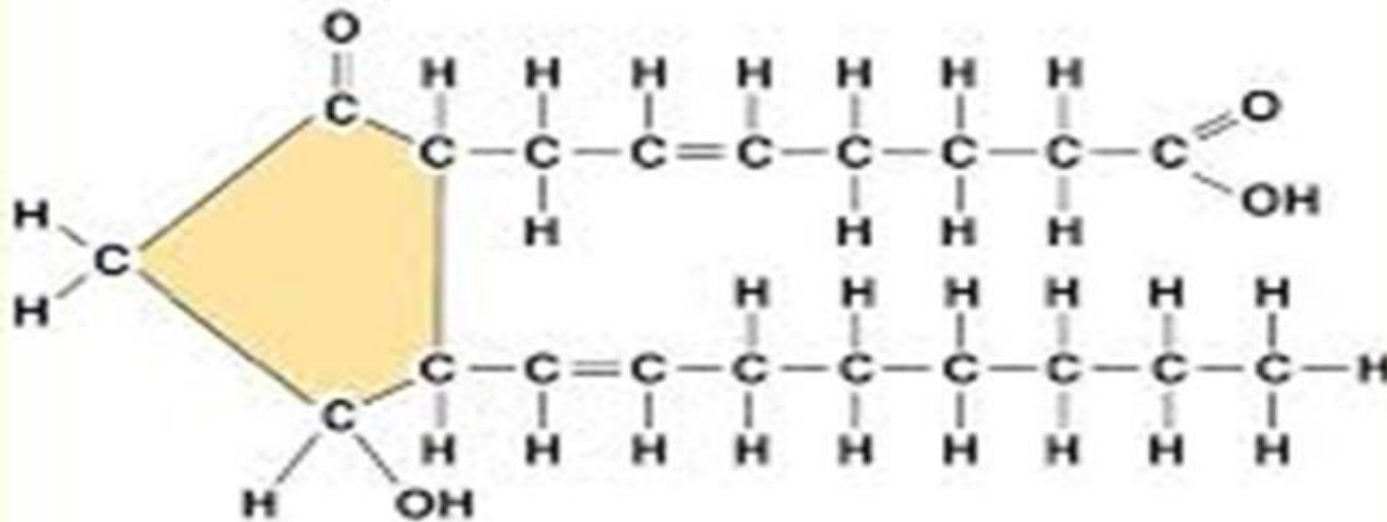
Biochemistry of Hormones

Structures of steroid hormones- Natural steroids-



Biochemistry of Hormones

Prostaglandin Structure



(e) Prostaglandin PGE₂

Fig. 13.4e

- **Prostaglandins** are lipid hormones: paracrine substances derived from the fatty acid arachidonic acid, a polyunsaturated fatty acid
- Hormones can stimulate target cells even at very low concentrations

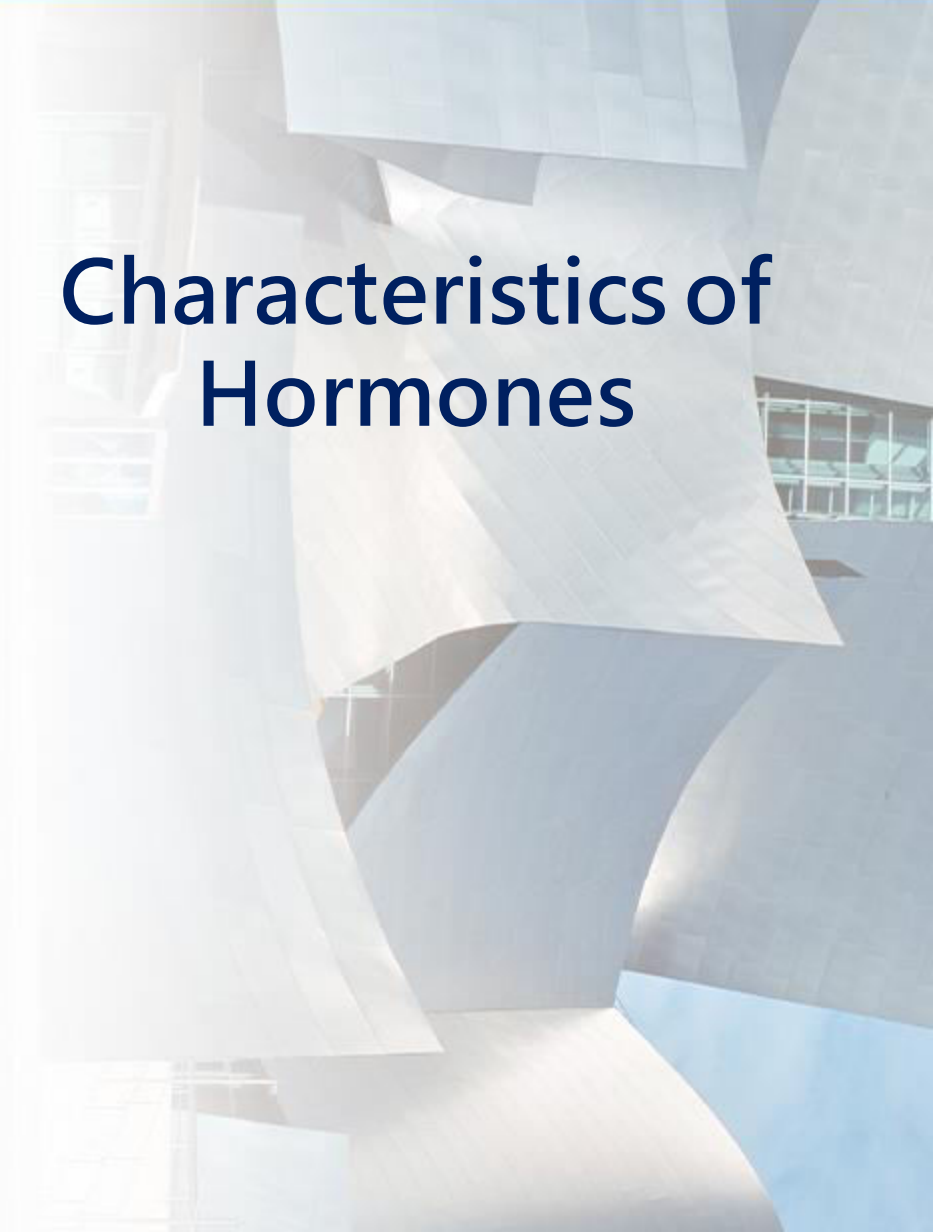
Animal Form and Function 1

Module 105



Animal Form and Function 1

Characteristics of Hormones



Characteristics of Hormones

- General characteristics of hormones are as follows:
- i) Hormones are secreted by specialized cells, the endocrine cells.
- ii) Hormones are chemical messengers. They are chemical signals that circulate in the body fluids.

Characteristics of Hormones

- iii) Hormones are directly secreted into the blood stream and are carried by the blood throughout the entire body, yet they affect only certain cells.
- iv) Specific cells that respond to a given hormone have receptor sites for that hormone.

Characteristics of Hormones

- v) Hormones are required in very minute quantities.
- vi) Steroid hormones help control
 - Metabolism,
 - Inflammation,
 - Immune functions,
 - Salt and water balance,
 - Development of sexual characteristics and
 - Ability to withstand illness and injury.

END

Animal Form and Function 1

Module 107



Animal Form and Function 1

Feedback control of Hormone Secretion Part II

Feedback Control of Hormones Secretion II

- Hormones are not released in a constant, steady stream.
- Rather they are secreted in fluctuations depending on the physiological demand for their actions.
- A negative feedback system is used to regulate the secretion of hormones.

Feedback Control of Hormones Secretion II

- Such as that the release of a specific hormone is increased or decreased in response to physiologic changes.
- Some hormones are released in short bursts in periods, showing daily or even monthly cycles (such as a menstrual cycle).

Feedback Control of Hormones Secretion II

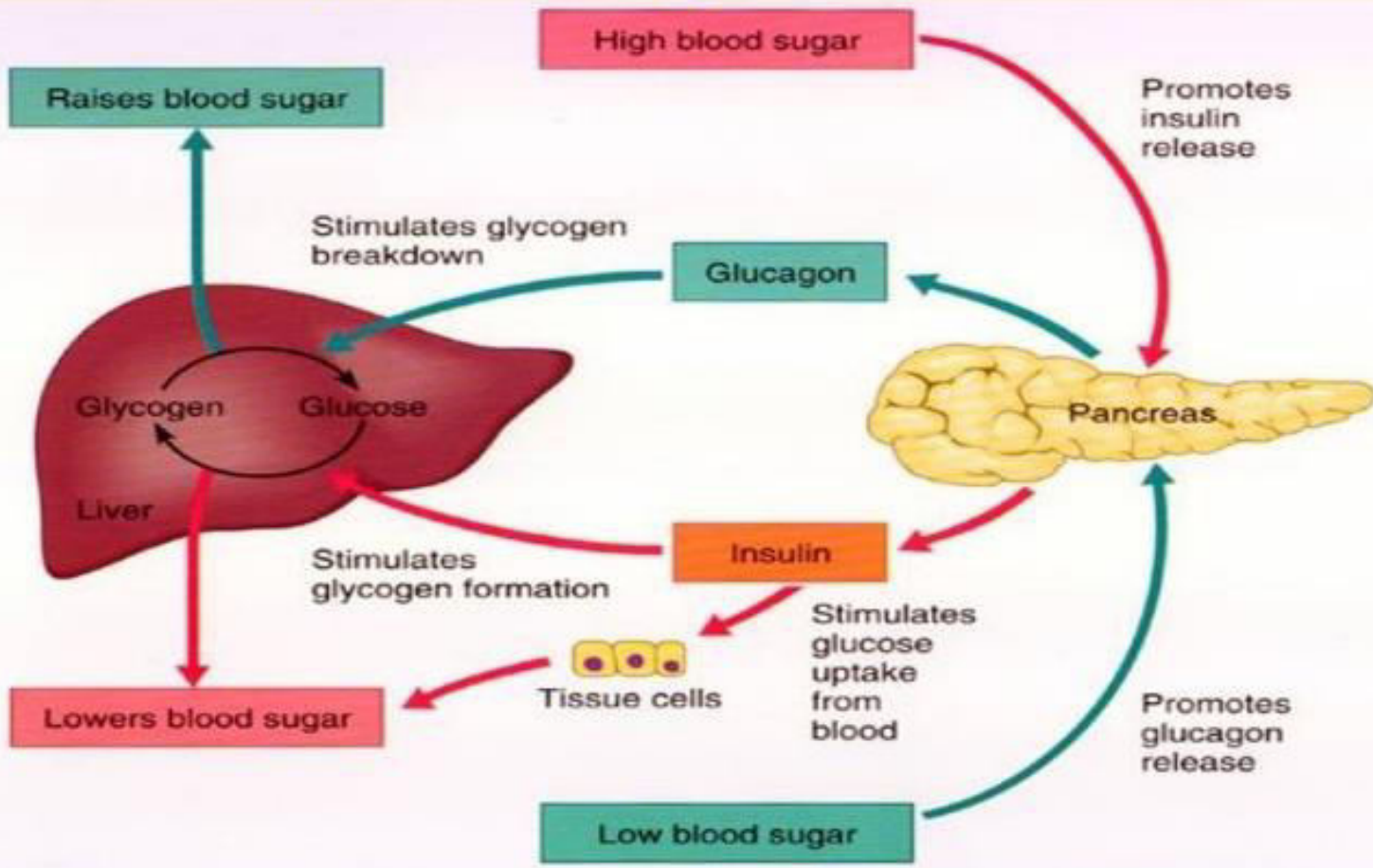
- The regulation of blood glucose concentration is an example of how the endocrine system uses negative feedback to maintain homeostasis.
- When blood glucose concentration is high, insulin is released by the pancreas in response to the negative feedback of elevated blood glucose levels

Feedback Control of Hormones Secretion II

- In response to insulin, cells take up glucose, thereby returning blood glucose concentration back to normal.
- Insulin release is then inhibited until blood glucose levels rise again.

Feedback Control of Hormones Secretion II

Examples of Negative Feedback



Animal Form and Function 1

Module 108



Animal Form and Function 1

Mechanisms of Hormone Action Part I

Mechanisms of Hormone Action Part I

- Hormones modify the biochemical activity of a target cell or tissue. Two basic mechanisms are involved.
- 1. Fixed membrane-receptor mechanism.
- 2. Mobile-receptor mechanism.

Mechanisms of Hormone Action Part I

- **Fixed membrane-receptor mechanism**
- In this mechanism, **an endocrine cell secretes a water-soluble hormone.**
- At the cells of the target organ, the hormone binds to a specific receptor site on the plasma membrane.
- **This forms a complex called hormone-receptor complex.**

Mechanisms of Hormone Action Part I

- This complex activates the enzyme-adenylate cyclase in the membrane.
- The activated enzyme converts ATP into a nucleotide called cyclic AMP.
- Cyclic AMP diffuses throughout the cytoplasm and activates an enzyme called protein kinase.

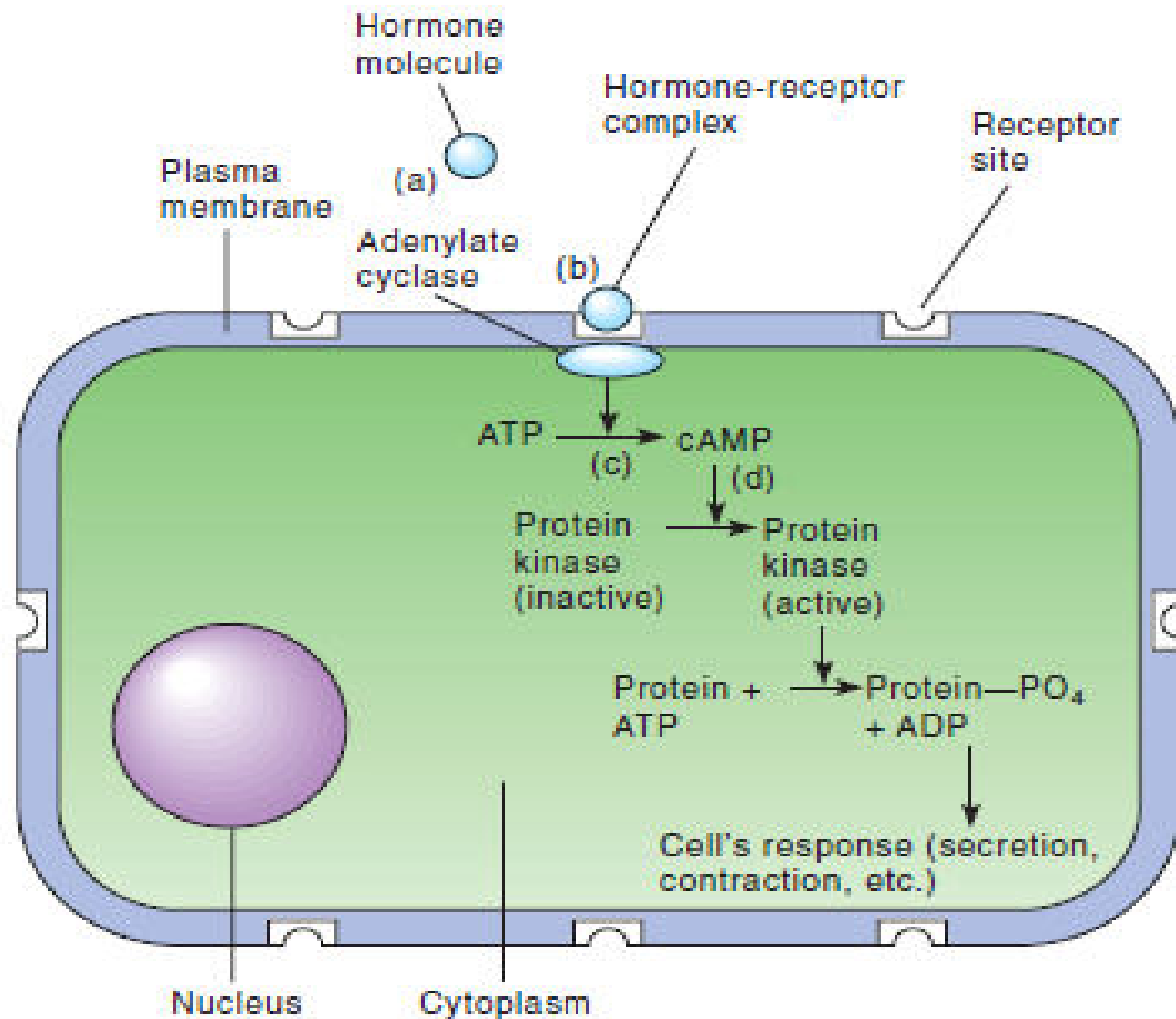
Mechanisms of Hormone Action Part I

- Which then phosphorylates specific proteins in the cell, thereby triggering the biochemical reaction, leading ultimately to the cell's response.
- After inducing the target cell to perform its specific function, the phosphodiesterase inactivates cyclic AMP

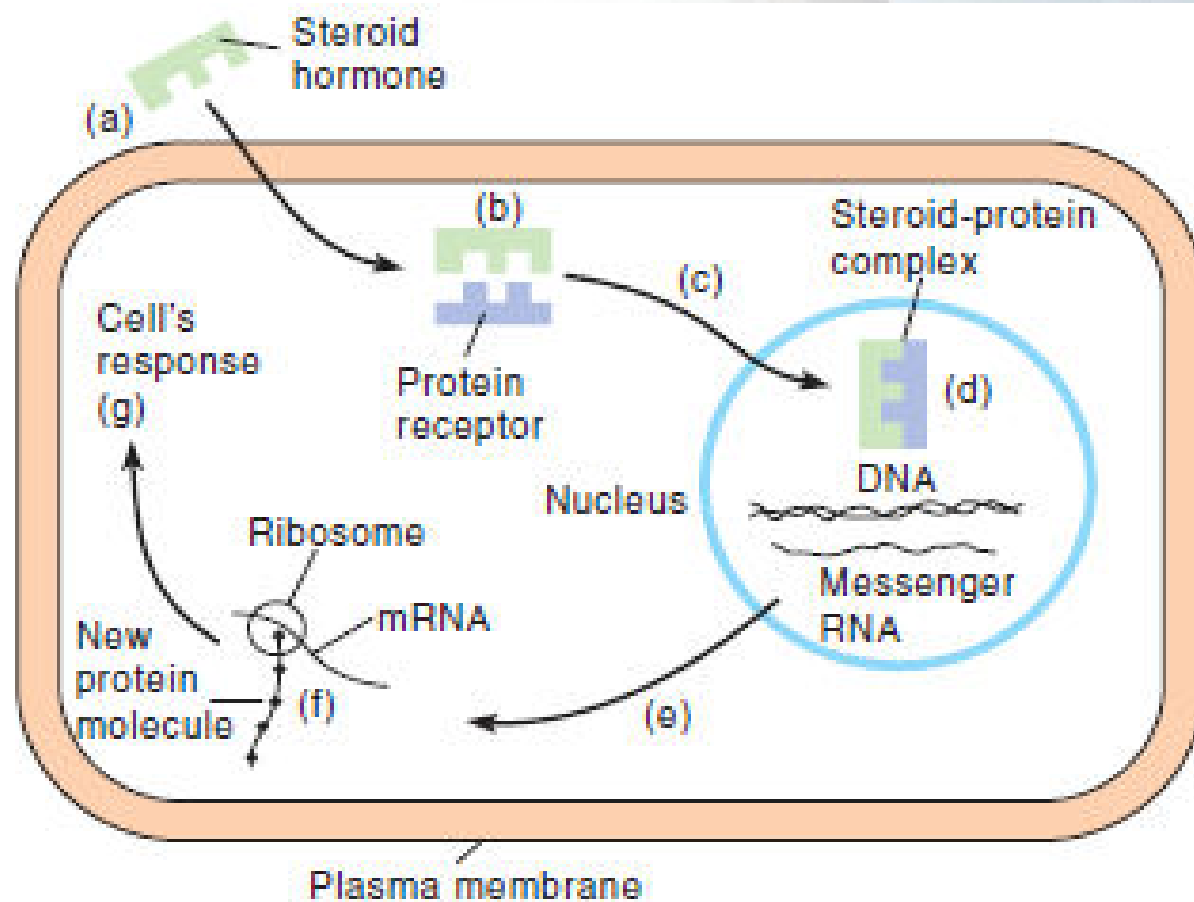
Mechanisms of Hormone Action Part I

- In the meantime, the receptor on the plasma membrane loses the first messenger and now becomes available for a new reaction.

Mechanisms of Hormone Action Part I



Mechanisms of Hormone Action Part I



Animal Form and Function 1

Module 109



Animal Form and Function 1

Mechanisms of Hormone Action Part II

Mechanisms of Hormone Action Part II

- Hormones modify the biochemical activity of a target cell or tissue. Two basic mechanisms are involved.
- 1. Fixed membrane-receptor mechanism.
- 2. Mobile-receptor mechanism.

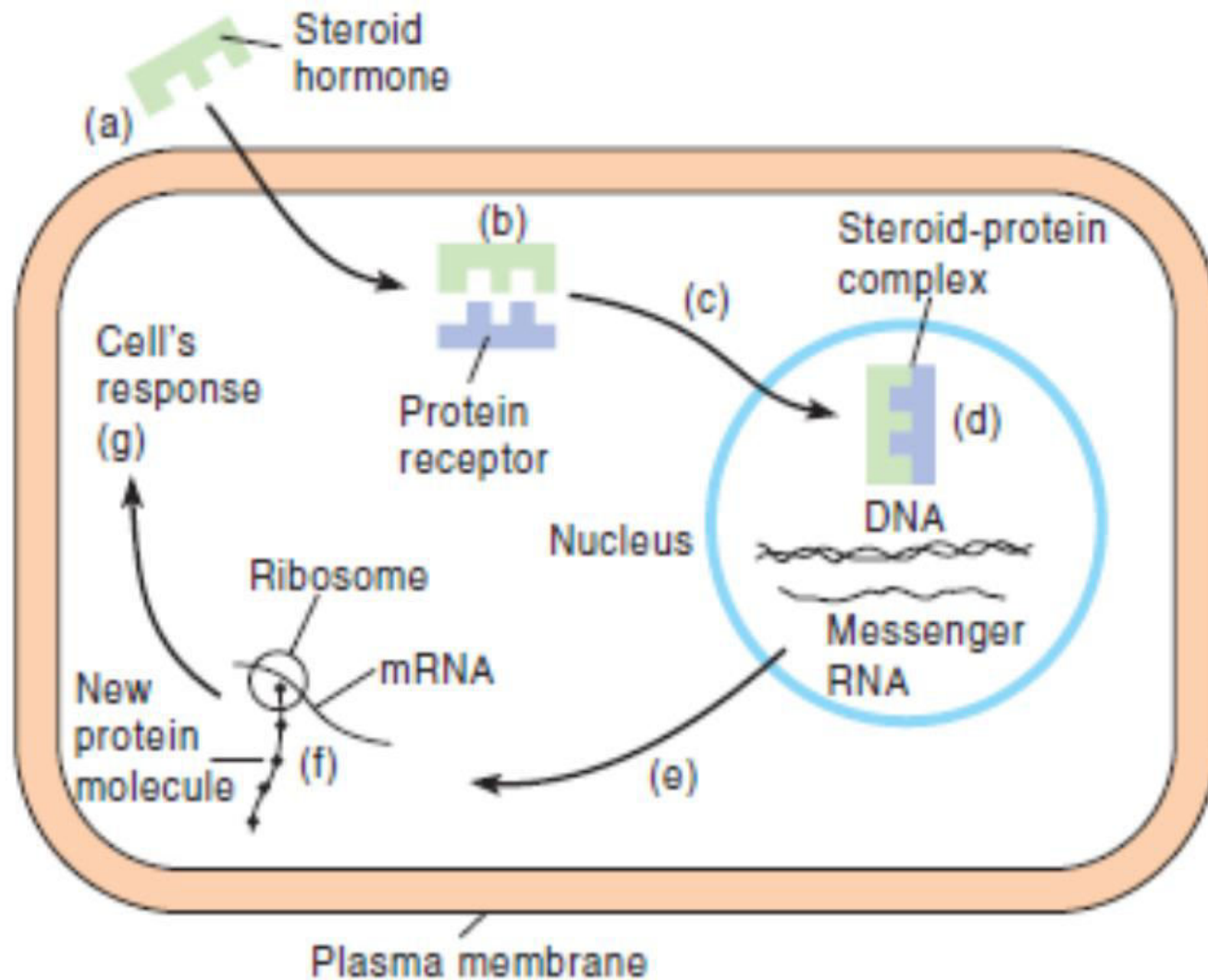
Mechanisms of Hormone Action Part II

- Mobile-receptor mechanism.
- A steroid hormone molecule (e.g., testosterone) diffuses from the blood to a target cell across the plasma membrane of the target cell.
- Once in the cytoplasm, the hormone binds to a receptor that carries it into the nucleus.

Mechanisms of Hormone Action Part II

- This steroid-protein complex triggers transcription of specific gene regions of DNA.
- The messenger RNA transcript is then translated into a gene product via protein synthesis in the cytoplasm.
- The new protein then mediates the cell's response.

Mechanisms of Hormone Action Part II



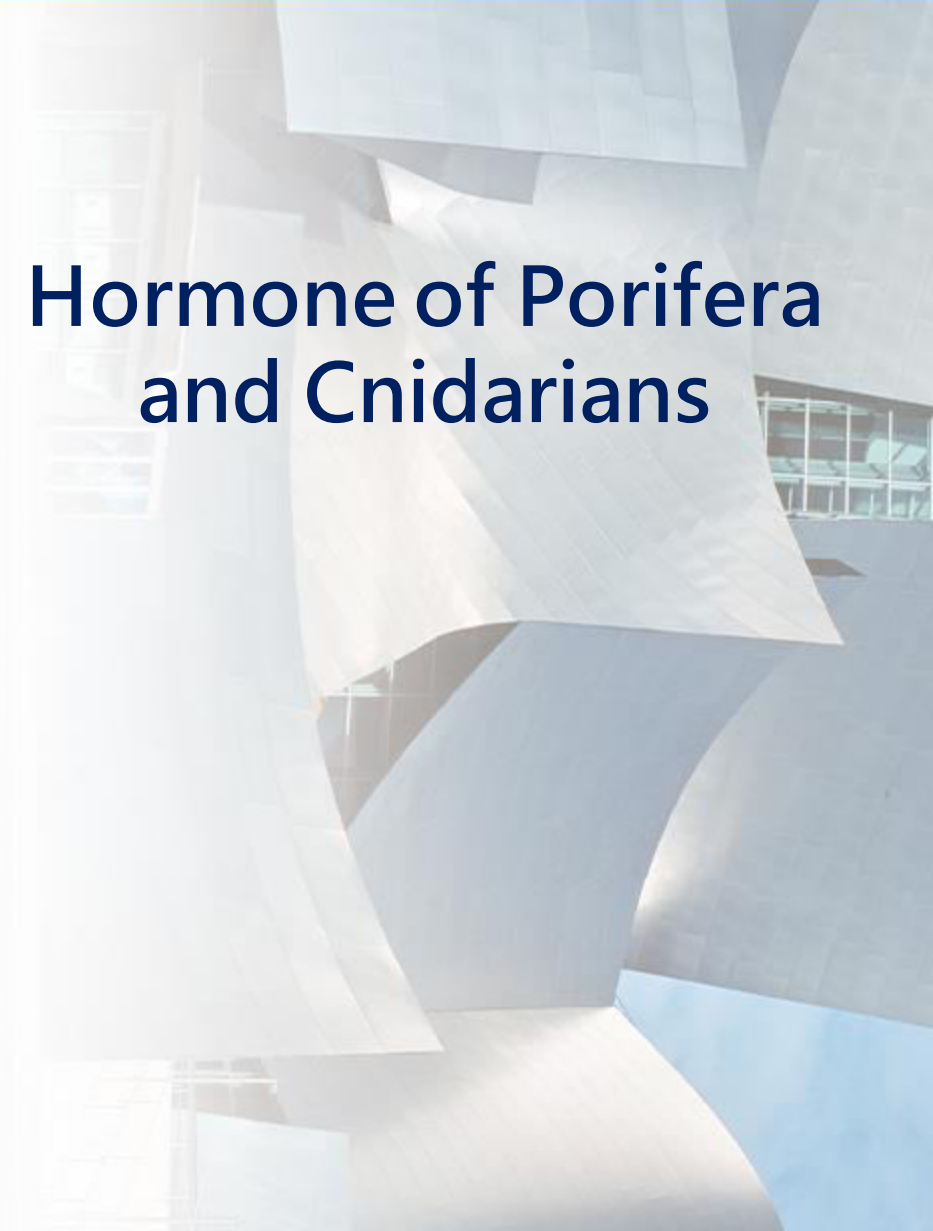
Animal Form and Function 1

Module 110



Animal Form and Function 1

Hormone of Porifera and Cnidarians



Hormones of Porifera and Cnidarians

- The survival of any group of animals depends on growth, maturation, and reproduction.
- Thus, chemicals regulating growth, maturation, and reproduction probably were among the first hormones to appear during the course of animal evolution.

Hormones of Porifera and Cnidarians

- The first hormones were probably neurosecretions.
- Most of the chemicals functioning as hormones in invertebrate animals are neurosecretions called neuropeptides.
- Molluscs, arthropods, echinoderms have hormones other than neurosecretions.

Hormones of Porifera and Cnidarians

- The porifera (sponges) do not have classical endocrine glands.
- Since sponges do not have neurons, they also do not have neurosecretory cells.

Hormones of Porifera and Cnidarians

- The nerve cells of Hydra contain a growth-promoting hormone that stimulates budding, regeneration, and growth. For example, when the hormone is present in the medium in which fragments of Hydra are incubated, "head" regeneration is accelerated. This so-called "head activator" also stimulates mitosis in Hydra.

Hormones of Porifera and Cnidarians

- For example, when the hormone is present in the medium in which fragments of Hydra are incubated, “head” regeneration is accelerated.
- This so-called “head activator” also stimulates mitosis in Hydra.

END

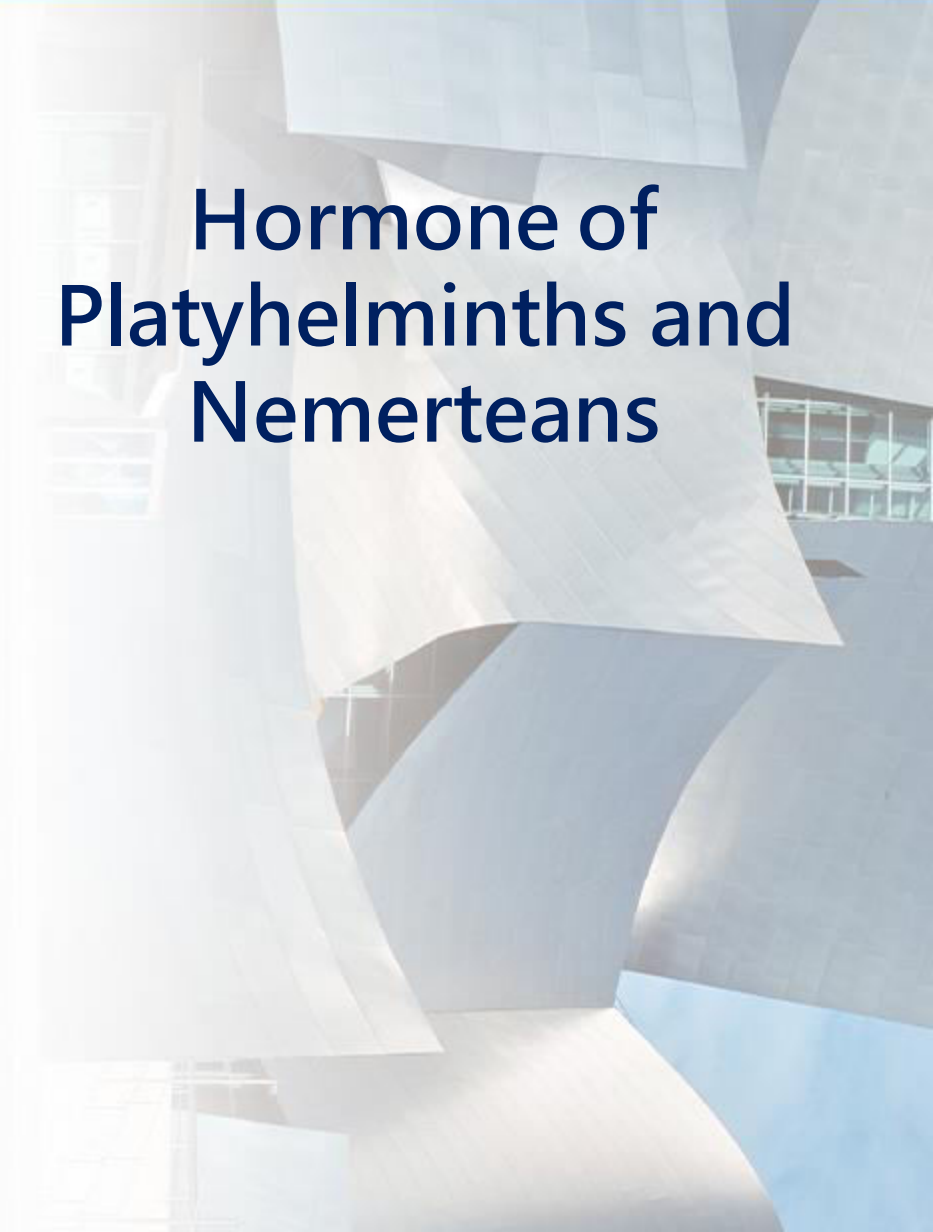
Animal Form and Function 1

Module 111



Animal Form and Function 1

Hormone of Platyhelminths and Nemertean



Hormones of Platyhelminths and Nemertean

- **Platyhelminths:**
- **Zoologists identified neurosecretory cells in various flatworms** These cells are in the cerebral ganglion and along major nerve cords.
- **The neuropeptides that the cells produce** function in regeneration, asexual reproduction, and gonad maturation.

Hormones of Platyhelminths and Nemertean

- For example, neurosecretory cells in the scolex of some tapeworms control shedding of the proglottids or the initiation of strobilization.

Hormones of Platyhelminths and Nemerteans

- **NEMERTEANS**
Nemerteans (ribbon worms) have more cephalization than platyhelminths and a larger brain, composed of a dorsal and ventral pair of ganglia connected by a nerve ring.
- The neuropeptide that these ganglia produce appears to control gonadal development and to regulate water balance.

END

Animal Form and Function 1

Module 112



Animal Form and Function 1

Hormone of Nematodes and Annelids

Hormones of Nematodes and Annelids

- **NEMATODES:**
- **No classical endocrine glands have been identified in nematodes.**
- **However, they do have neurosecretory cells associated with the central nervous system.**
- **The neuropeptide that this nervous tissue produces apparently controls ecdysis of the old cuticle.**

Hormones of Nematodes and Annelids

- The neuropeptide is released after a new cuticle is produced.
- It stimulates the excretory gland to secrete an enzyme (leucine aminopeptidase) into the space between the old and new cuticle.
- The accumulation of fluid in this space causes the old cuticle to split and be shed.

Hormones of Nematodes and Annelids

- ANNEDIDS
- Annelids have a well-developed and cephalized nervous system, a well-developed circulatory system, and a large coelom.
- Correspondingly, they have well-developed endocrine control of physiological functions.

Hormones of Nematodes and Annelids

- The various endocrine systems of annelids are generally involved with morphogenesis, development, growth, regeneration, and gonadal maturation.
- For example, in polychaetes, juvenile hormone inhibits the gonads and stimulates growth and regeneration.

Hormones of Nematodes and Annelids

- Another hormone, gonadotropin, stimulates the development of eggs.
- In leeches, a neuropeptide stimulates gamete development and triggers color changes.
- Hormones for osmoregulation have been reported in oligochaetes.

Hormones of Nematodes and Annelids

- Hormone that maintains a high concentration of blood glucose has been reported in oligochaete, *Lumbricus*.
"Hyperglycemic hormones"

END

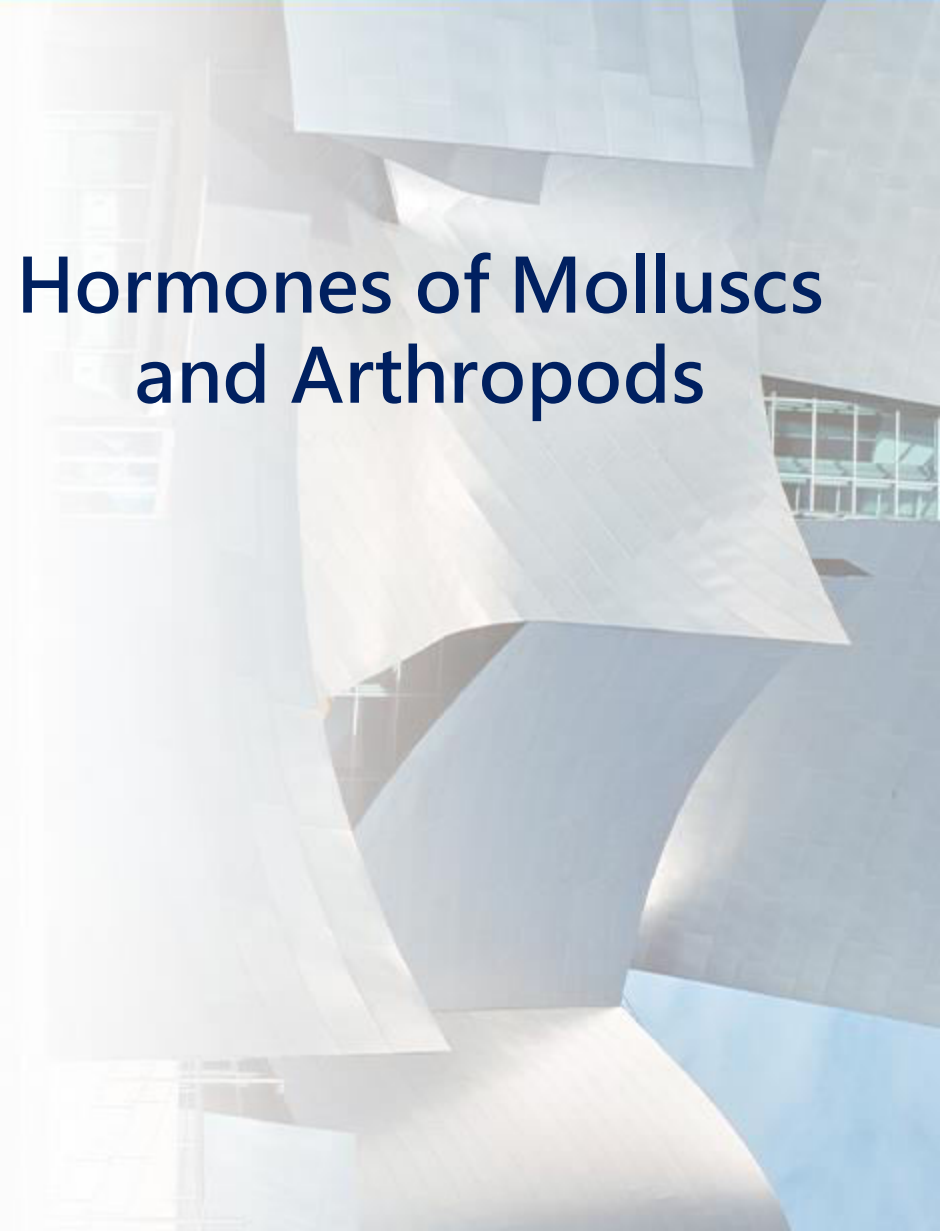
Animal Form and Function 1

Module 113



Animal Form and Function 1

Hormones of Molluscs and Arthropods



Hormones of Molluscs and Arthropods

- **MOLLUSCS**
- The ring of ganglia that constitutes the central nervous system of molluscs is richly endowed with neurosecretory cells.
- The neuropeptides that these cells produce help regulate heart rate, kidney function, and energy metabolism.

Hormones of Molluscs and Arthropods

- In certain gastropods, such as the common land snail *Helix*, a specific hormone stimulates spermatogenesis.
- Another hormone, termed egg-laying hormone, stimulates egg development; and hormones from the ovary and testis stimulate accessory sex organs.

Hormones of Molluscs and Arthropods

- In all snails, a growth hormone controls shell growth.
- In cephalopods, such as the octopus, and squid, the optic gland in the eye stalk produces one or more hormones.
- These hormones stimulate gametogenesis and the development of secondary sexual characteristics.

END

Animal Form and Function 1

Module 114



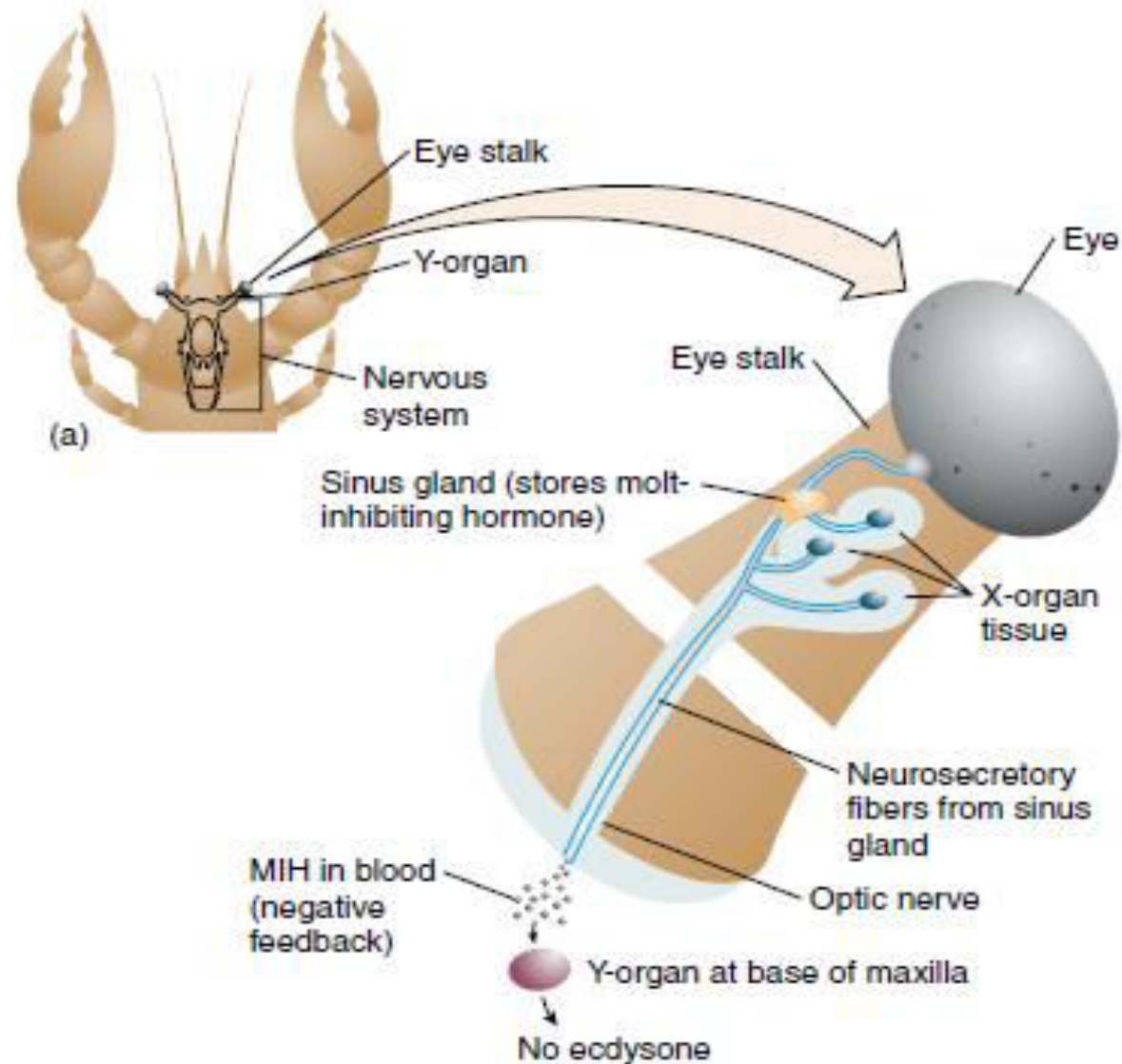
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Hormones of Arthropods (Crustacean)

Hormones of Arthropod-Crustacean

- **Crustacean:**
- The endocrine systems of advanced invertebrates (crustaceans and insects) are excellent examples of how hormones regulate growth, maturation, and reproduction.
- **The endocrine system of crayfish, controls functions such as ecdysis, color changes & sex determination.**

Hormones of Arthropod-Crustacean



Hormones of Arthropod-Crustacean

- Here we discuss only Ecdysis.
- X-organs are neurosecretory tissues in the crayfish eye stalks.
- Associated with each X-organ is a sinus gland that accumulates and releases the secretions of the X-organ.
- Other glands, called Y-organs, are at the base of the maxillae.

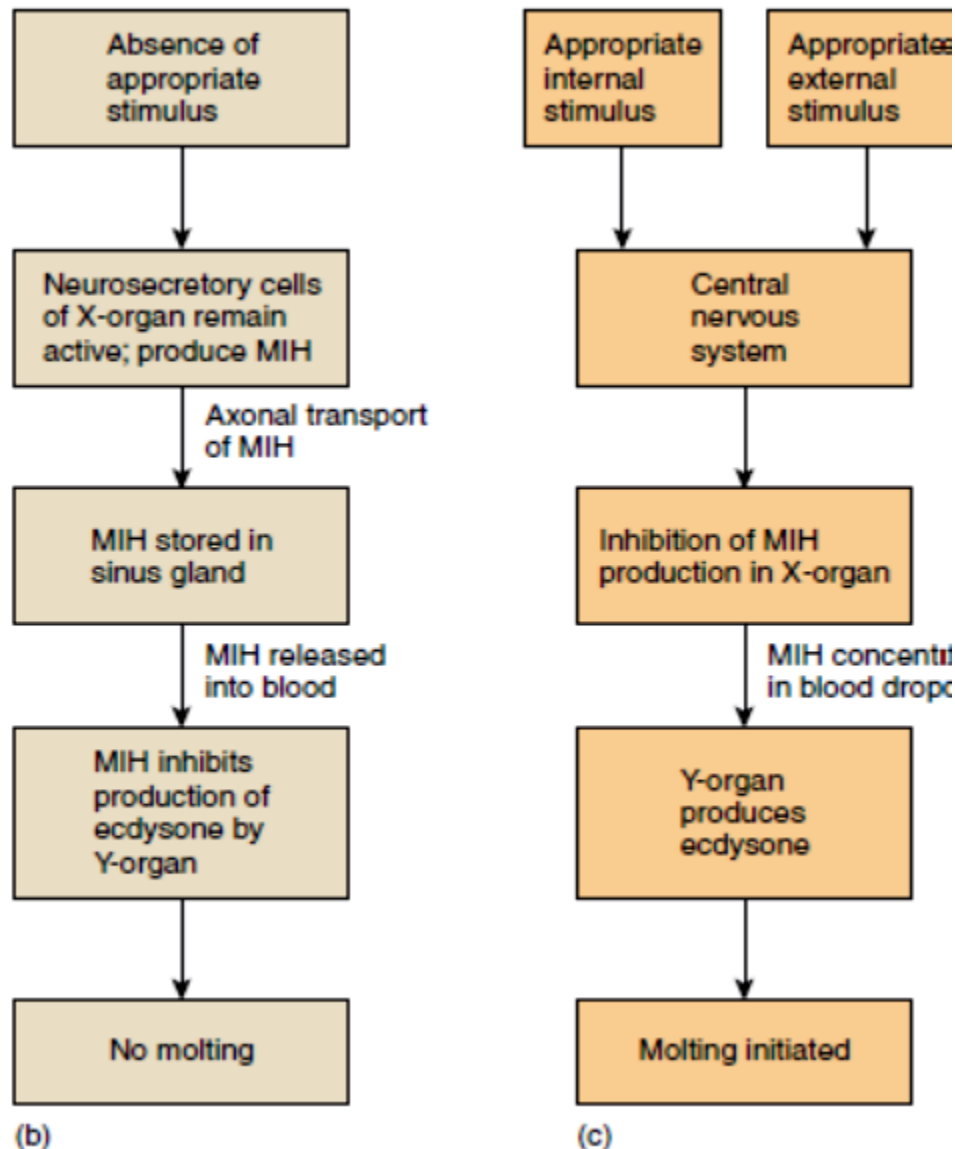
Hormones of Arthropod-Crustacean

- X-organs and Y-organs control ecdysis as follows.
- In the absence of an appropriate stimulus, the X-organ produces molt-inhibiting hormone (MIH), and the sinus gland releases it.
- The target of this hormone is the Y-organ.
- When MIH is present in high concentrations, the Y-organ is inactive.

Hormones of Arthropod-Crustacean

- Under appropriate internal and external stimuli, MIH release is prevented, and the Y-organ releases the hormone ecdysone, which leads to molting.

Hormones of Arthropod-Crustacean



Animal Form and Function 1

Module 115



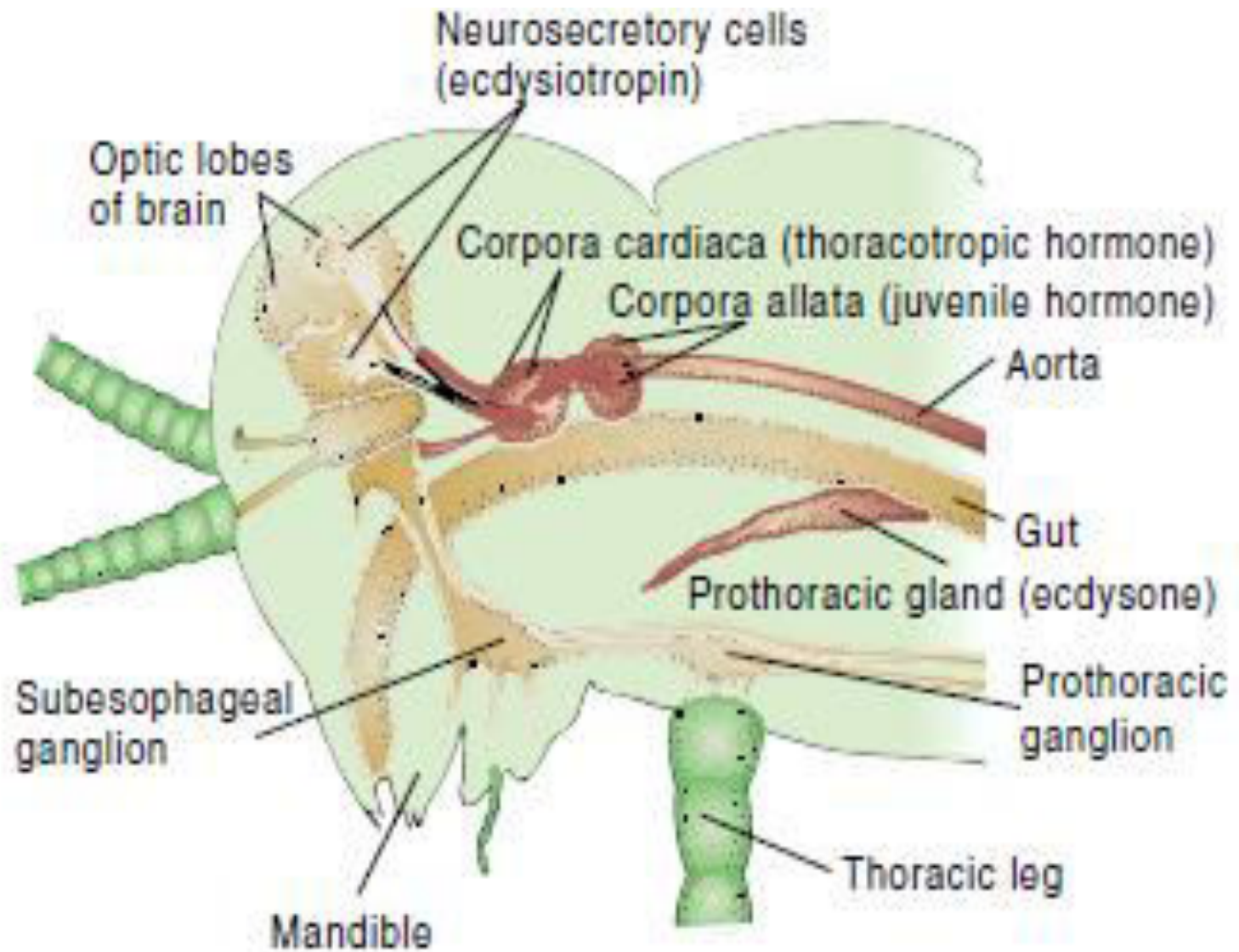
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Hormones of Arthropods (Insect)

Hormones of Arthropod-Insect

- **INSECTS**
- The sequence of events in insects is similar to that of crustaceans, but it does not involve a molt-inhibiting hormone.
- The presence of an appropriate stimulus to the central nervous system activates certain neurosecretory cells (pars intercerebralis) in the optic lobes of the brain.

Hormones of Arthropod-Insect



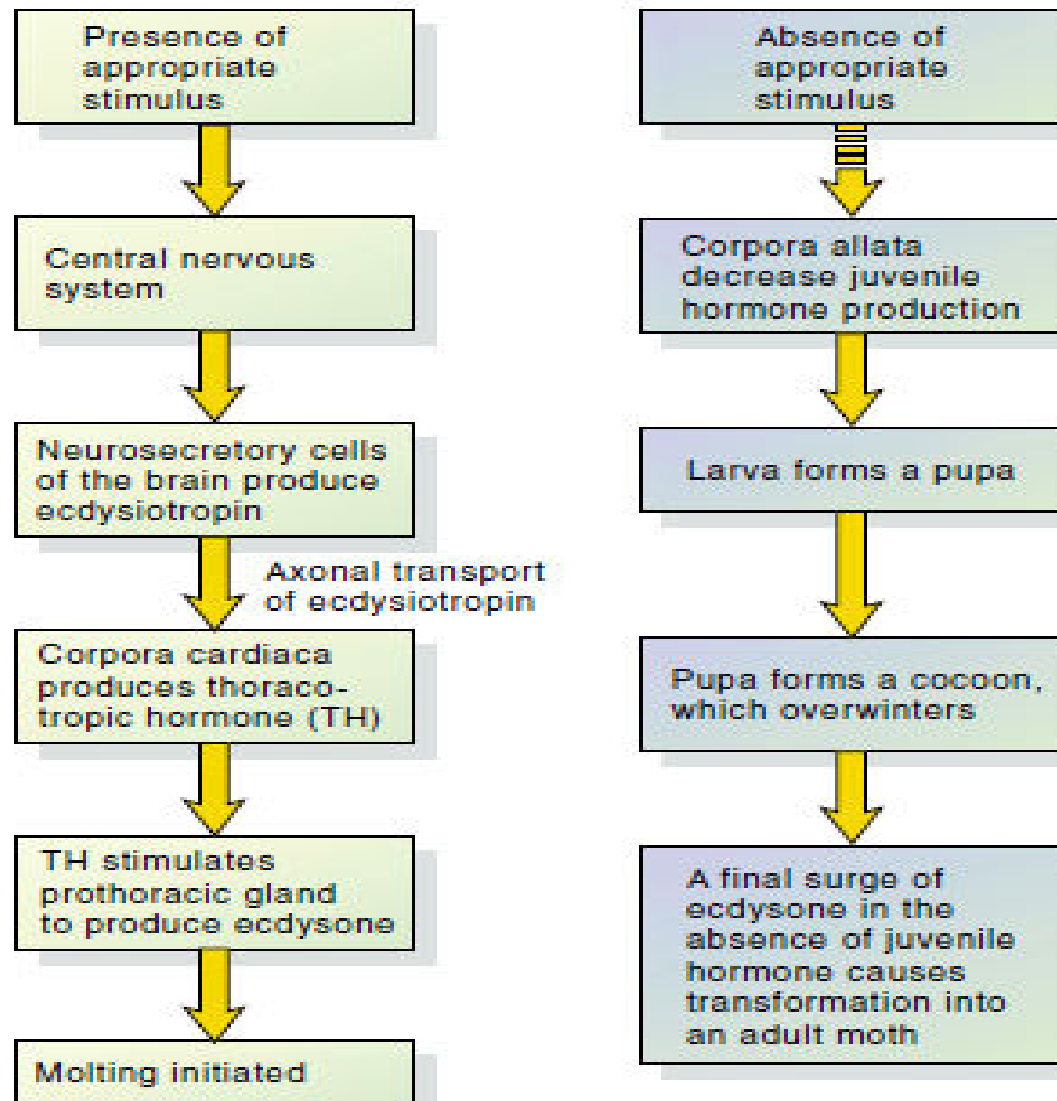
Hormones of Arthropod-Insect

- These cells secrete the hormone ecdysiotropin, which axons transport to the corpora cardiaca (a mass of neurons associated with the brain).

Hormones of Arthropod-Insect

- The **Corpora Cardiac** produces **thoracotropic hormone, which** is carried to the prothoracic glands, stimulating them to produce and release **ecdysone, which induces molting, the reabsorption of some of the old cuticle and the development of a new cuticle.**

Hormones of Arthropod-Insect



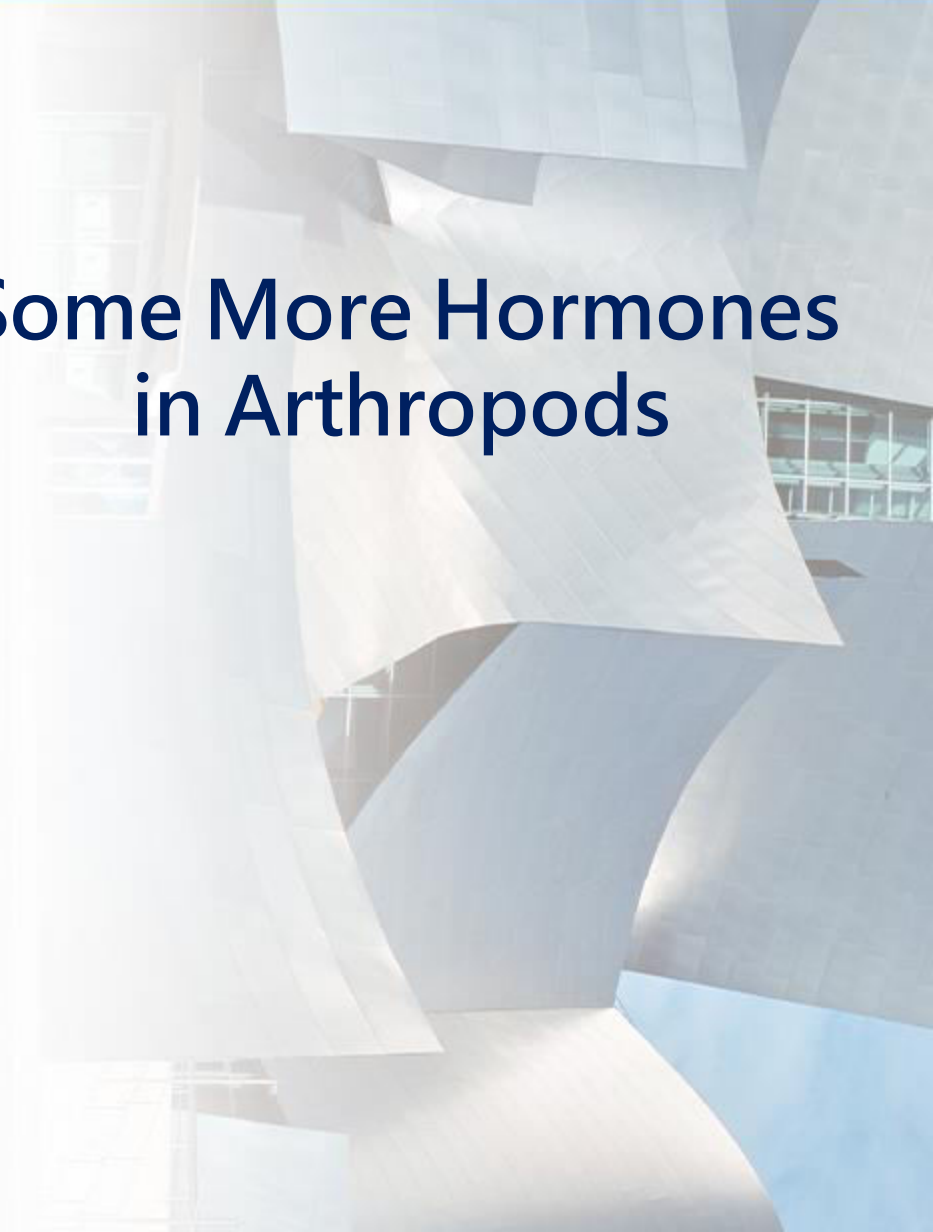
Animal Form and Function 1

Module 116



Animal Form and Function 1

Some More Hormones in Arthropods



Some More Hormones in Arthropods

- Other neurosecretory cells in the brain and nerve cords produce the hormone **bursicon**
- **Bursicon influences certain aspects** of epidermal development, such as tanning (i.e., hardening and darkening of the chitinous outer cuticle layer).
- **Tanning is completed several hours after each molt.**

Some More Hormones in Arthropods

- Another hormone, juvenile hormone (JH), is also involved in the morphological differentiation that occurs during the molting of insects.
- Just behind the insect brain are the paired corpora allata

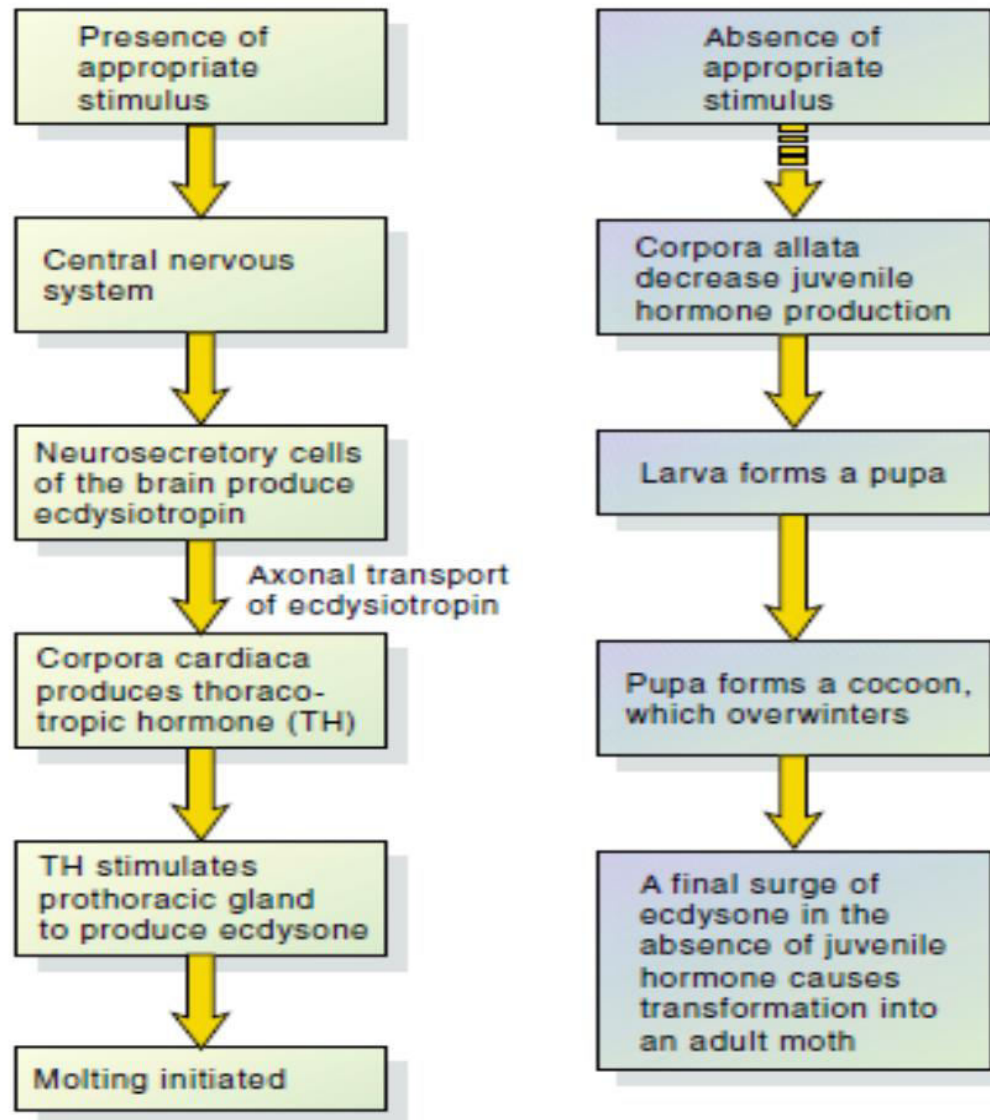
Some More Hormones in Arthropods

- These structures produce JH. High concentrations of JH in the blood of an insect inhibit differentiation.
- In the absence of an appropriate environmental stimulus, the corpora allata decrease JH production, which causes the insect larva to differentiate into a pupa.

Some More Hormones in Arthropods

- The pupa then forms a cocoon to overwinter. In the spring, a final surge of ecdysone, in the absence of JH, transforms the pupa into an adult moth.

Some More Hormones in Arthropods



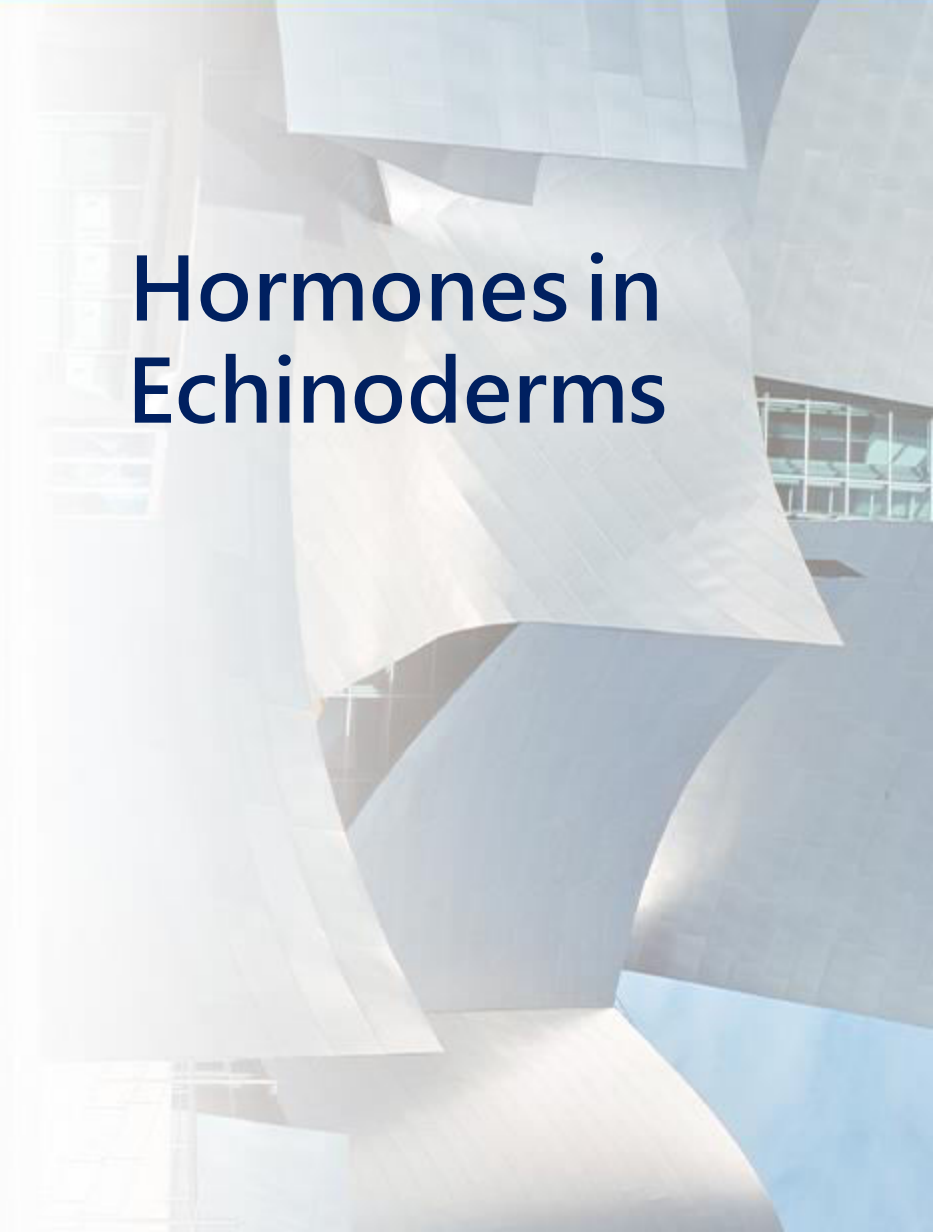
Animal Form and Function 1

Module 117



Animal Form and Function 1

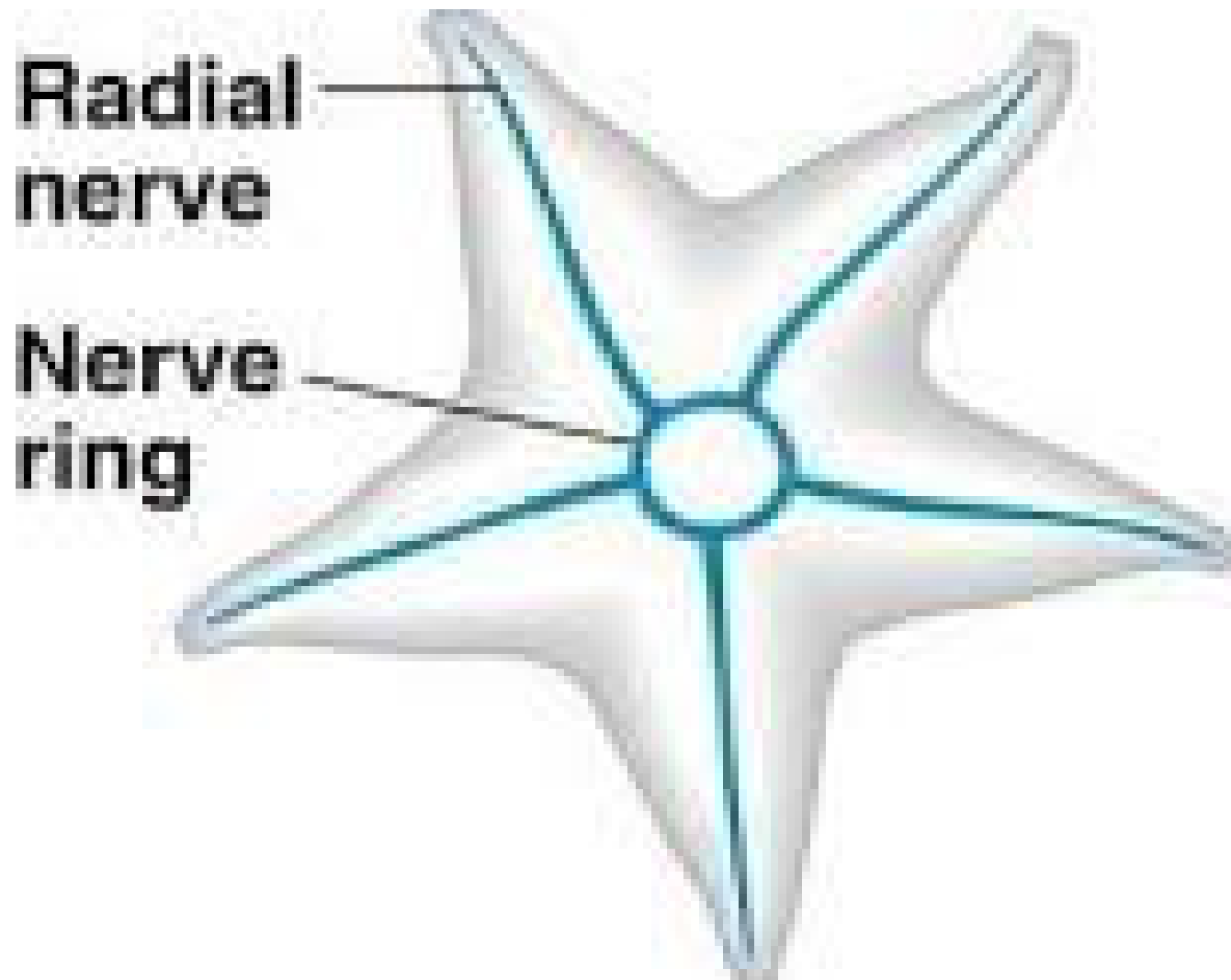
Hormones in Echinoderms



Hormones in Echinoderms

- The echinoderms are deuterostomes, they are more closely allied with chordates than are the protostome invertebrates.
- However, the endocrine systems of echinoderms provide few insights into the evolution of chordate endocrine systems, because echinoderm hormones and endocrine glands are very different from those of chordates.

Hormones in Echinoderms



Hormones in Echinoderms

- Zoologists do know, however, that the radial nerves of sea stars contain a neuropeptide called gonad-stimulating substance.
- When this neuropeptide is injected into a mature sea star, it induces immediate shedding of the gametes, spawning behavior, and meiosis in the oocytes.

Hormones in Echinoderms

- The neuropeptide also causes the release of a hormone called maturation-inducing substance, which has various effects on the reproductive system.

End

Animal Form and Function 1

Module 118



Animal Form and Function 1

An Overview of Vertebrate Endocrine System

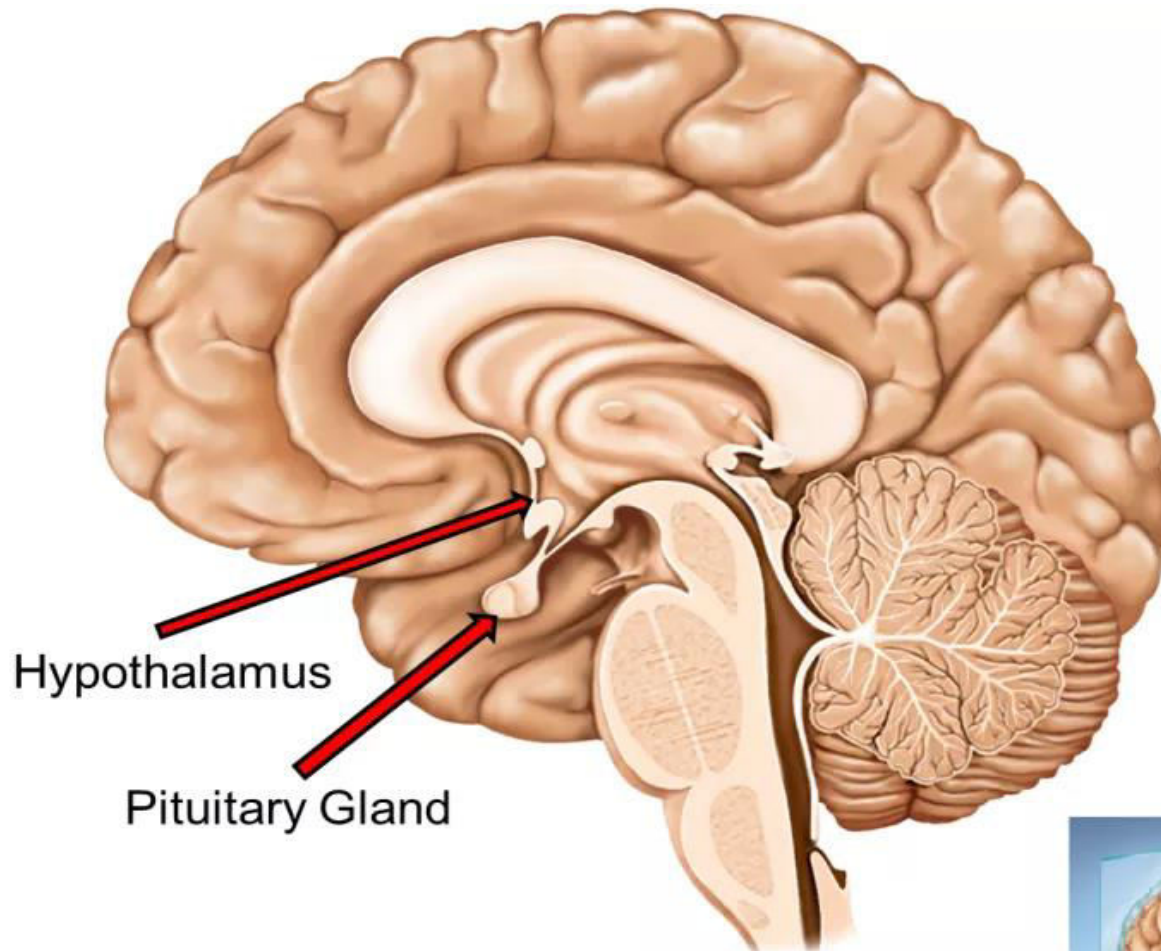
An Overview of Vertebrate ES

- Vertebrates have the best understood system of hormonal control.
- As the earliest vertebrates evolved, hormone-producing cells and tissues developed.
- Sets of nerve cells in the brain direct some endocrine tissues, such as the medullary areas of the adrenal glands.

An Overview of Vertebrate ES

- The hypothalamus of the brain stimulates the pituitary gland (hypophysis), which in turn control others.
- Still others function independently of either nerves or the pituitary gland.

An Overview of Vertebrate ES



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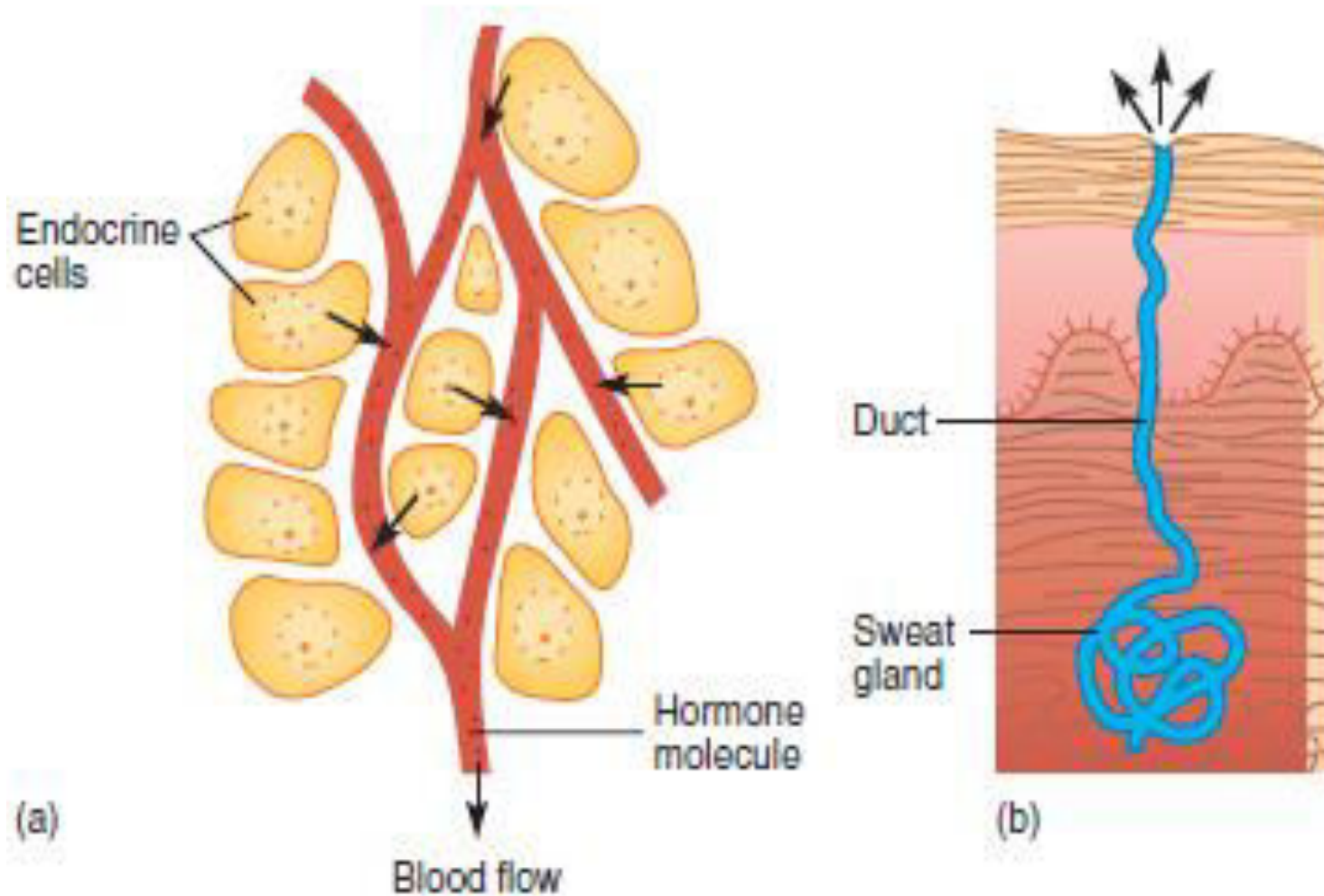
An Overview of Vertebrate ES

- Vertebrates possess two types of glands:
- 1. Exocrine glands,
- 2 Endocrine glands
- Exocrine Glands: These glands secrete chemicals into ducts that, in turn, empty into body cavities or onto body surfaces (e.g., mammary, salivary, and sweat glands).

An Overview of Vertebrate ES

- Endocrine Glands:
- These glands, have no ducts and secrete chemical messengers, the hormones, directly into the tissue space next to each endocrine cell.
- The hormones then diffuse into the blood stream, which carries them throughout the body to their target cells.

An Overview of Vertebrate ES



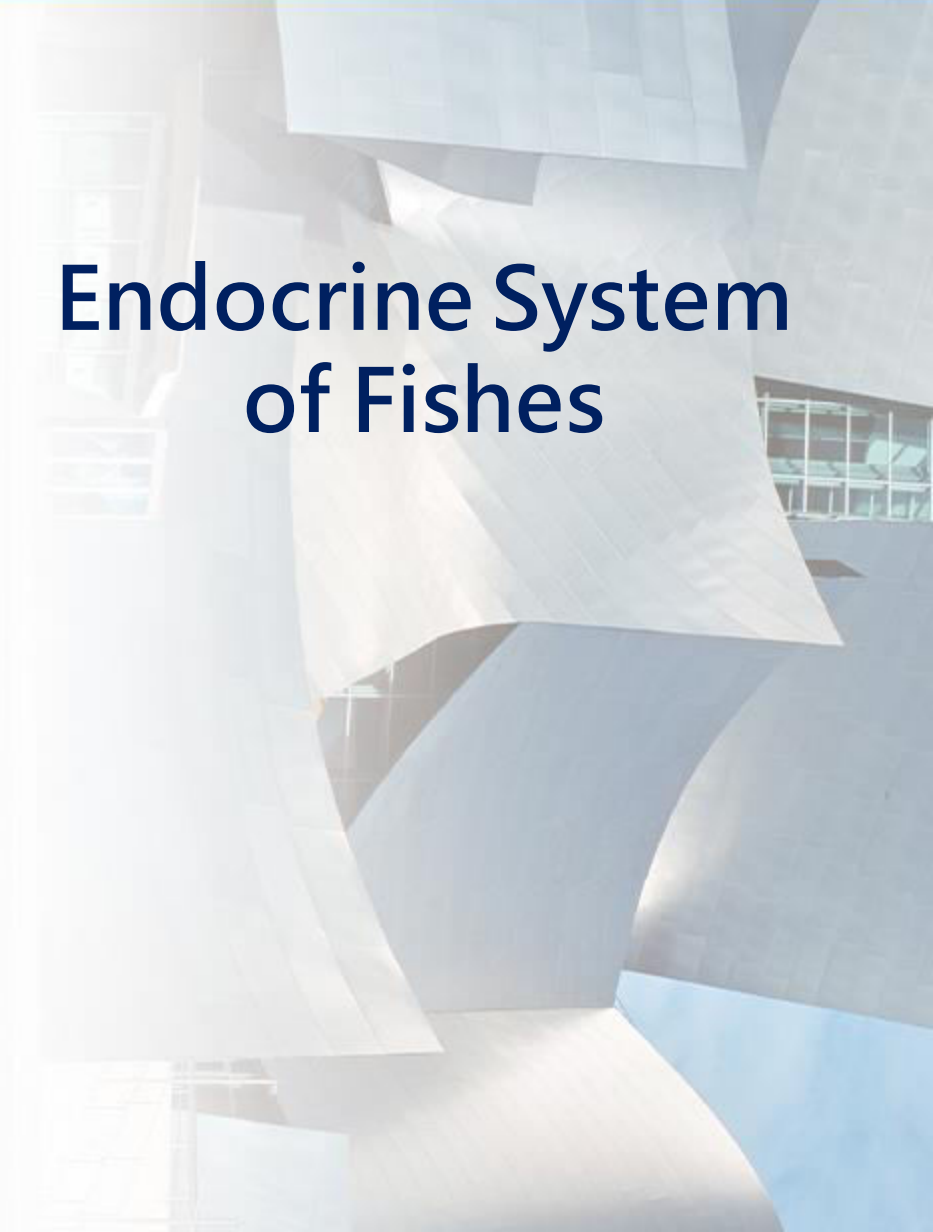
Animal Form and Function 1

Module 119



Animal Form and Function 1

Endocrine System of Fishes



Endocrine System of Fishes

- Vertebrates other than birds or mammals have somewhat similar endocrine systems, but differences do exist.
- In fishes, the brain and spinal cord are the most important producers of hormones, with other glands being rudimentary.

Endocrine System of Fishes

- In jawed fishes, three major regions that secrete neuropeptides:
 - 1. Pineal gland
 - 2. Preoptic nuclei
 - 3. Urophysis

Endocrine System of Fishes

- The pineal gland: It is located in the epithalamus of the brain.
- It produces neuropeptides that affect pigmentation.
- One specific hormone that the pineal gland produces is melatonin.
- Melatonin has broad effects on body metabolism by synchronizing activity patterns with light intensity and day length.

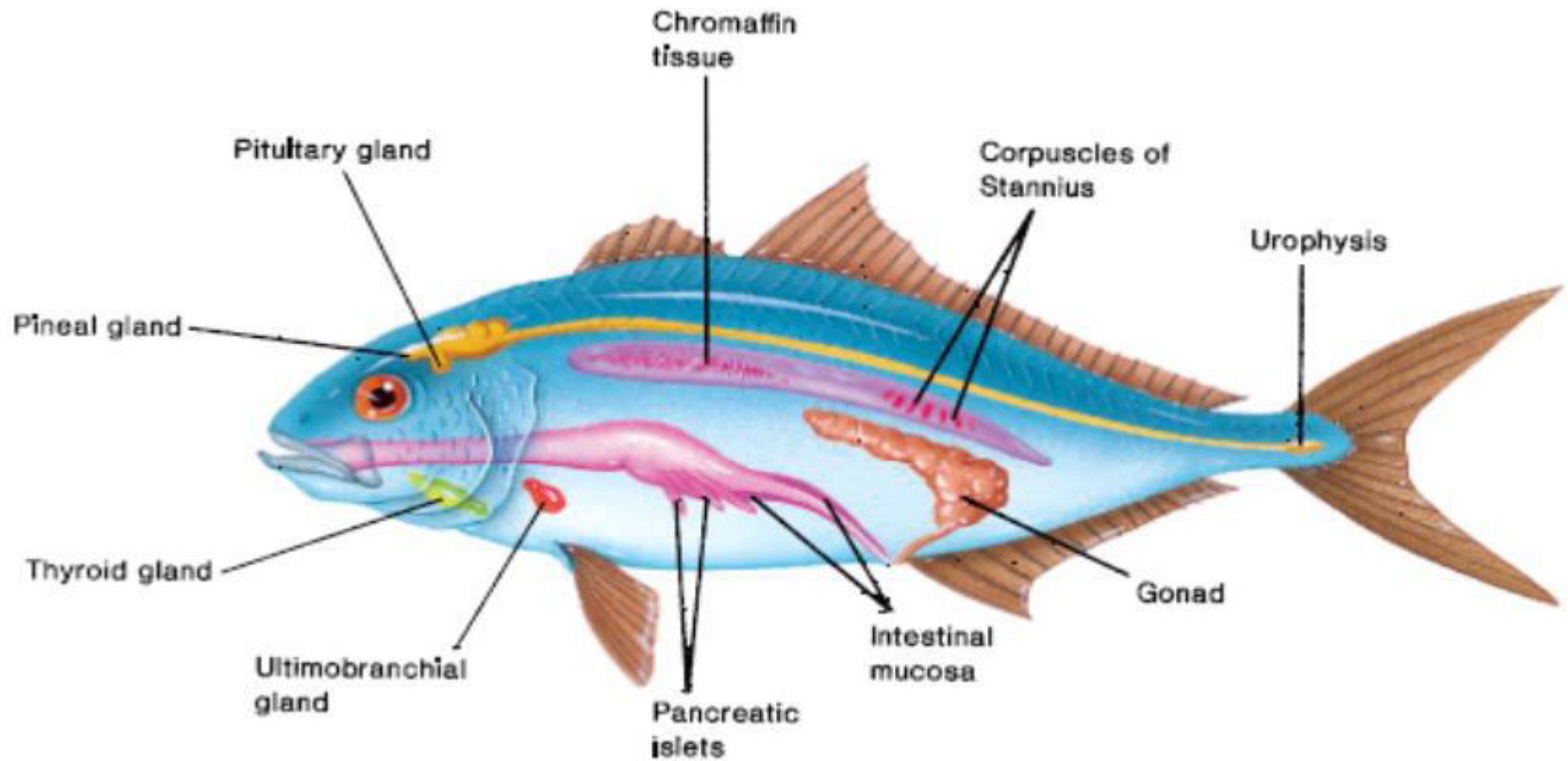
Endocrine System of Fishes

- **The Preoptic Nuclei:**
These are present in the hypothalamus of the brain.
- Produce various other neuropeptides that control different functions in fishes (e.g., growth, sleep, locomotion).

Endocrine System of Fishes

- **Urophysis.**
- **This is a discrete structure in the spinal cord of the tail.**
- **It produces neuropeptides** that help control water and ion balance, blood pressure, and smooth muscle contractions.

Endocrine System of Fishes



Animal Form and Function 1

Module 120



Animal Form and Function 1

Endocrine System of Amphibians and Reptiles

ES of Amphibians and Reptiles

- Endocrine System in amphibians and reptiles is very much like many fishes.
- For example the melatonin from the pineal gland control variations in skin color.
- When this hormone produced by one species is injected into another species, it can induce dramatic color changes.

ES of Amphibians and Reptiles

- This type of experiment indicates that some hormones have a close chemical similarity despite the distant evolutionary relationships among the animals producing them.
- Another example is the hormone prolactin produced by the pituitary gland).

ES of Amphibians and Reptiles

- Prolactin stimulates reproductive migrations in many animals (e.g., the movement of salamanders to water).
- It also helps control water and salt balances,

ES of Amphibians and Reptiles

- Prolactin causes brooding behavior in some fishes.
- It is also essential for certain saltwater fishes to enter freshwater during spawning.

ES of Amphibians and Reptiles

- **Hormonal Control of Frog** When frog is immersed in water containing the hormone melatonin light-color is exhibited.
- When melanocyte stimulating hormone is injected in frog dark color is exhibited.

ES of Amphibians and Reptiles



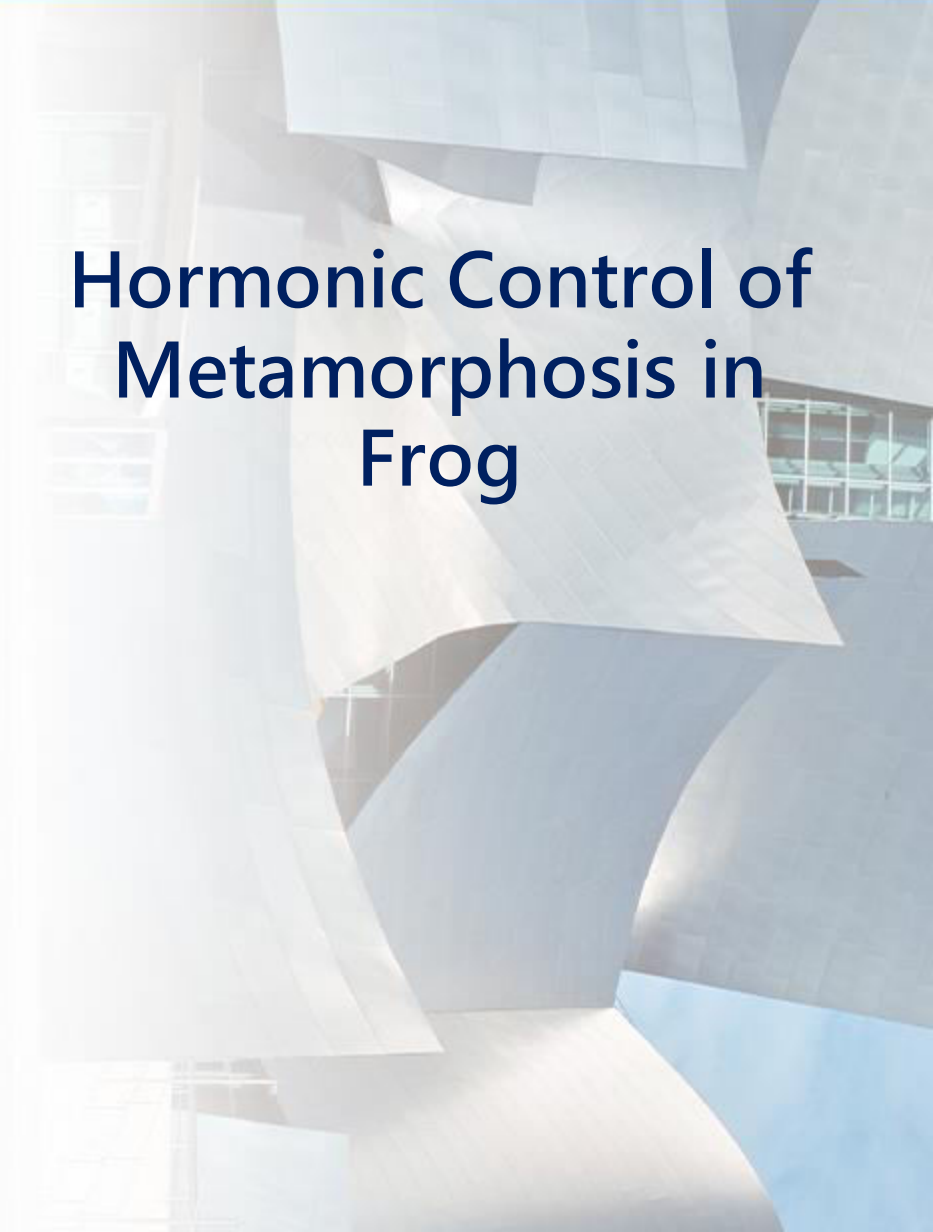
Animal Form and Function 1

Module 121



Animal Form and Function 1

Hormonic Control of Metamorphosis in Frog



Hormonic Control of Metamorphosis in Frog

- In vertebrates thyroxine(T4) and triiodothyronine (T3) regulate metabolism, growth, and tissue differentiation.
- In amphibians, they play an additional role in metamorphosis.
- Specifically timed changes in the concentrations of three hormones--

Hormonic Control of Metamorphosis in Frog

- prolactin, thyroxine, and triiodothyronine—control metamorphosis in the frog.
- Low thyroxine and triiodothyronine concentrations and high prolactin concentrations in young tadpoles stimulate larval growth and prevent metamorphosis.

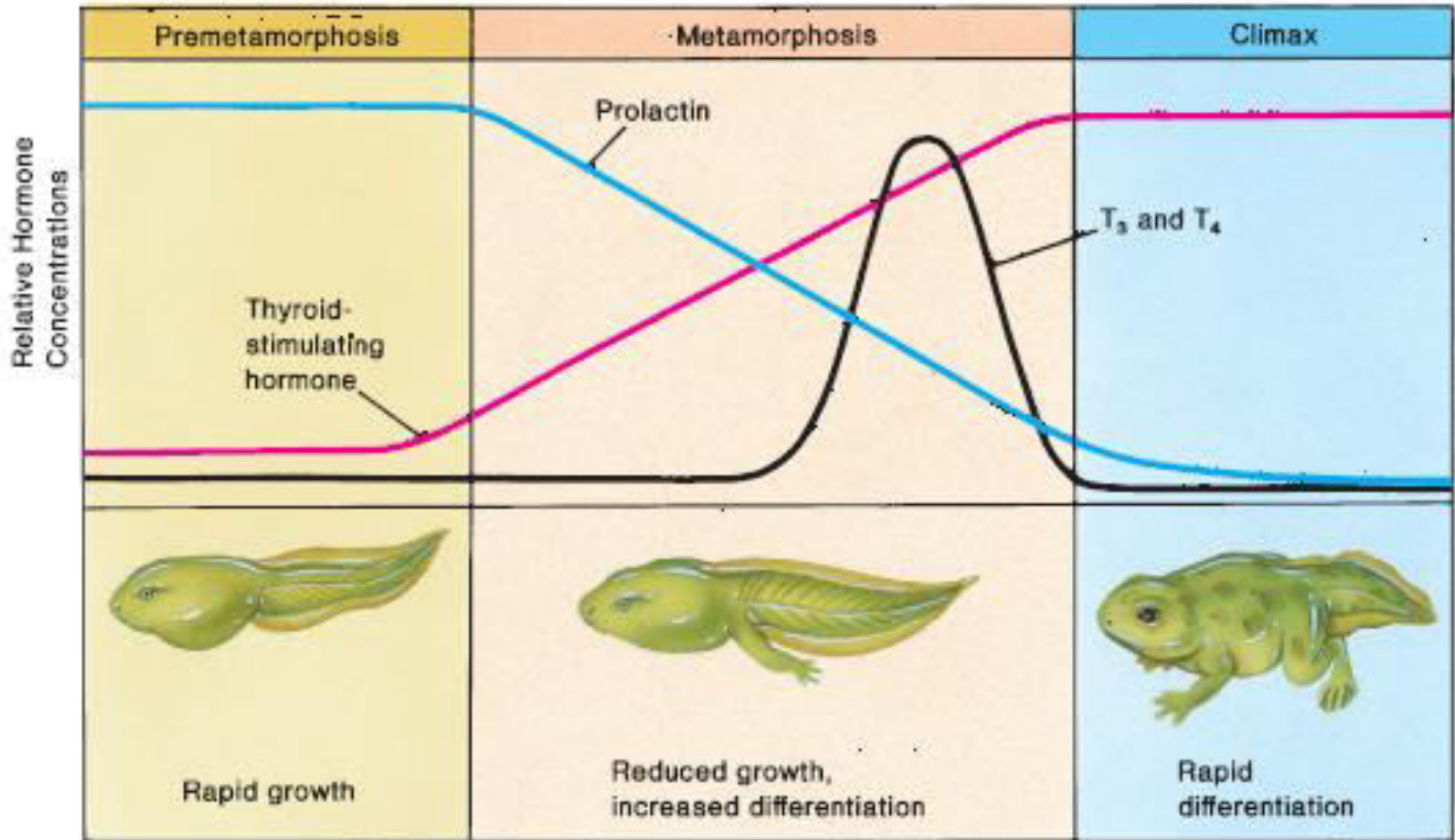
Hormonic Control of Metamorphosis in Frog

- As the hypothalamus and pituitary glands develop in the growing tadpole, the hypothalamus releases thyroid-stimulating hormone and prolactin-inhibiting hormone.
- Their release causes the pituitary gland to release thyroid-stimulating hormone and to cease production of prolactin.

Harmonic Control of Metamorphosis in Frog

- This results the concentrations of thyroxine and triiodothyronine to rise.
- This triggers the onset of metamorphosis i.e.tail resorption and other changes follow.

Hormonic Control of Metamorphosis in Frog



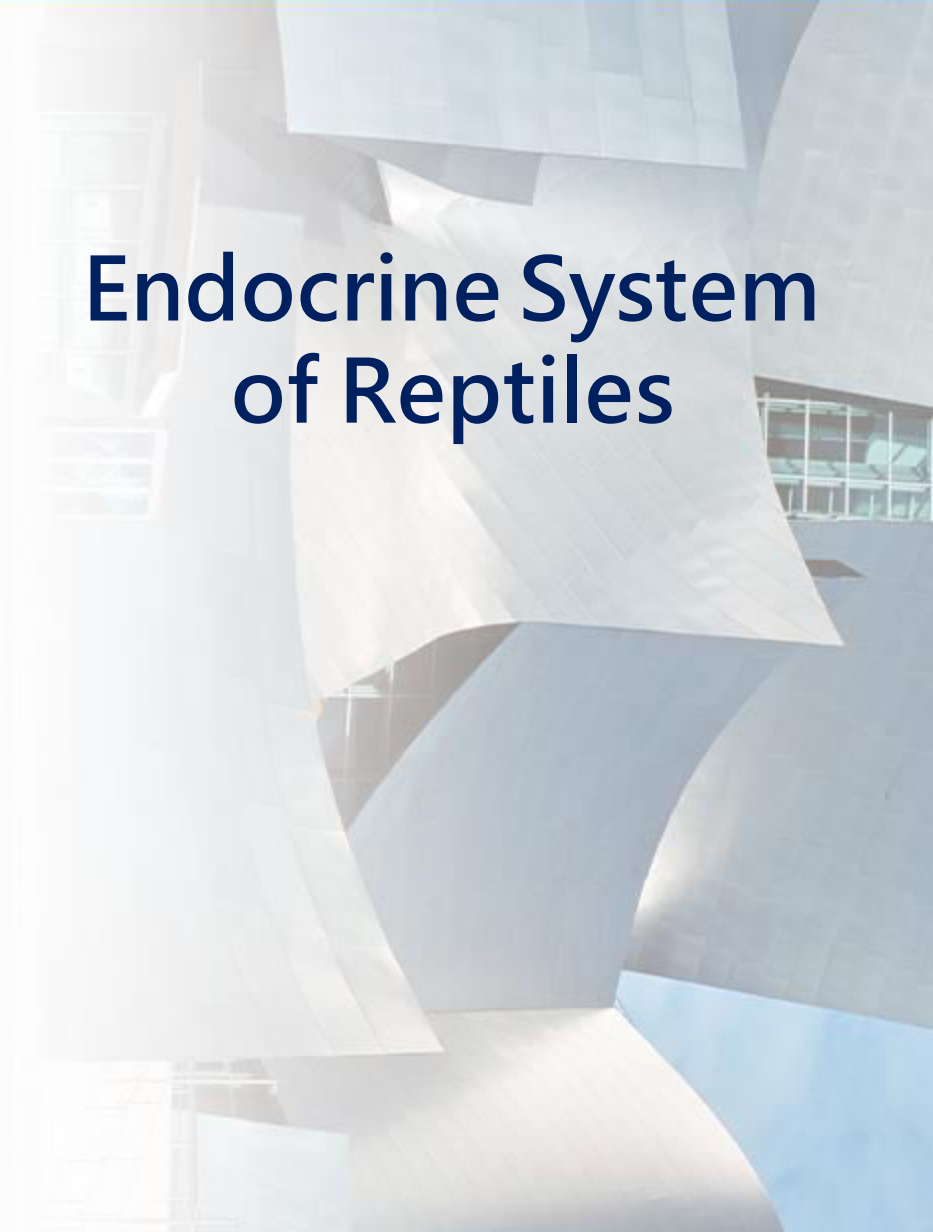
Animal Form and Function 1

Module 122



Animal Form and Function 1

Endocrine System of Reptiles



Endocrine System of Reptiles

- Reptiles have slightly different ES as compared to Amphibians and Fishes.
- The thyroids vary with the species and may be single, bilobed or paired. and the parathyroids are paired.

Endocrine System of Reptiles

- In turtles, snakes, and Sphenodon it is unpaired; in Crocodilia it is markedly bilobed.
- Among lizards there is wide diversity in thyroid morphology and position.
- Hyperparathyroidism are commonly diagnosed diseases in captive reptiles.

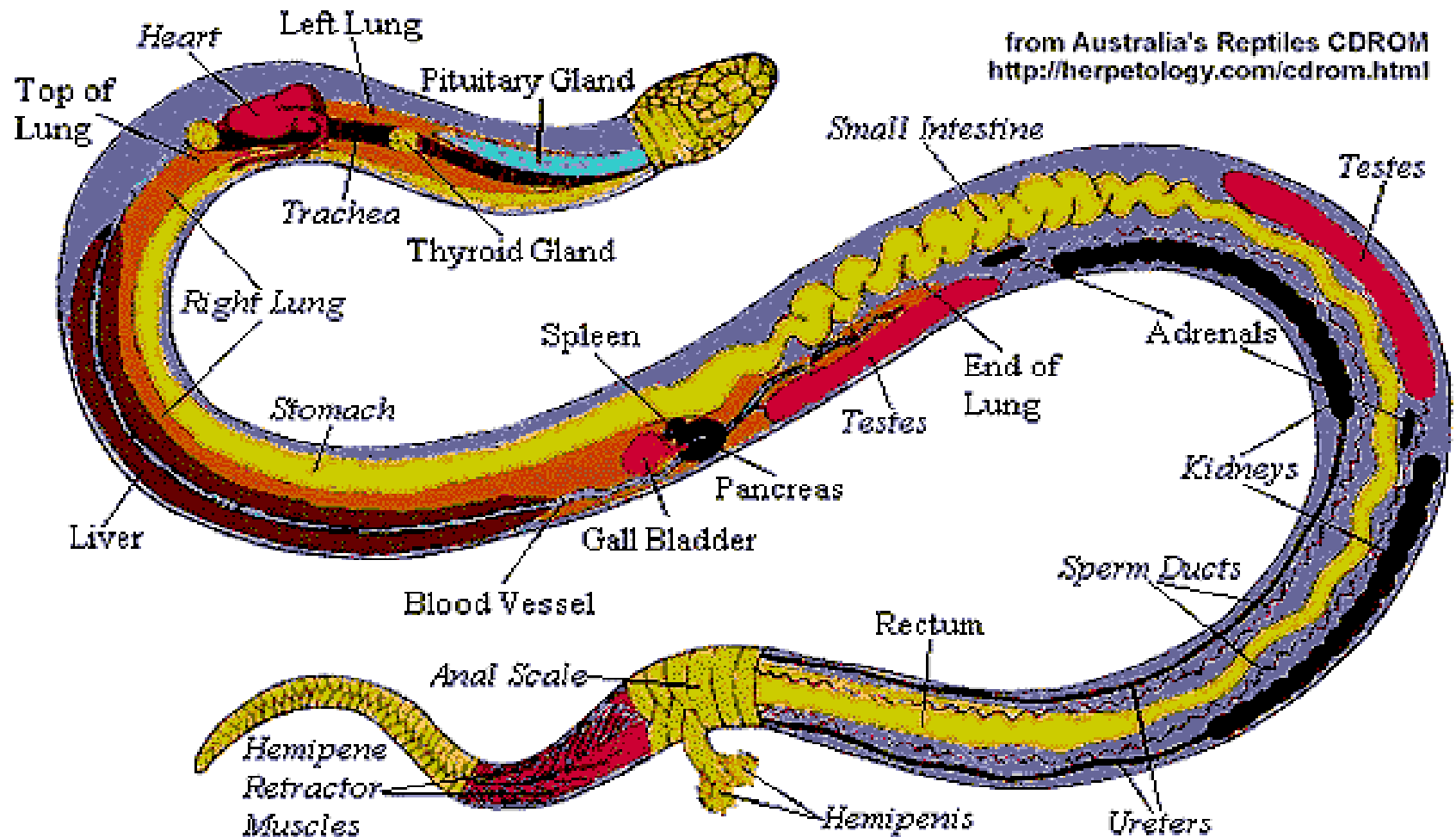
Endocrine System of Reptiles

- The thyroids are involved in control of ecdysis.
- The pancreas is usually attached to the duodenum and may be pale pink in colour.
- It contains alpha and beta cells that produce glucagon and insulin.

Endocrine System of Reptiles

- The cells are not grouped into islets and diabetes appears to be relatively rare.
- It is both an endocrine and exocrine organ.

Endocrine System of Reptiles



Animal Form and Function 1

Module 123



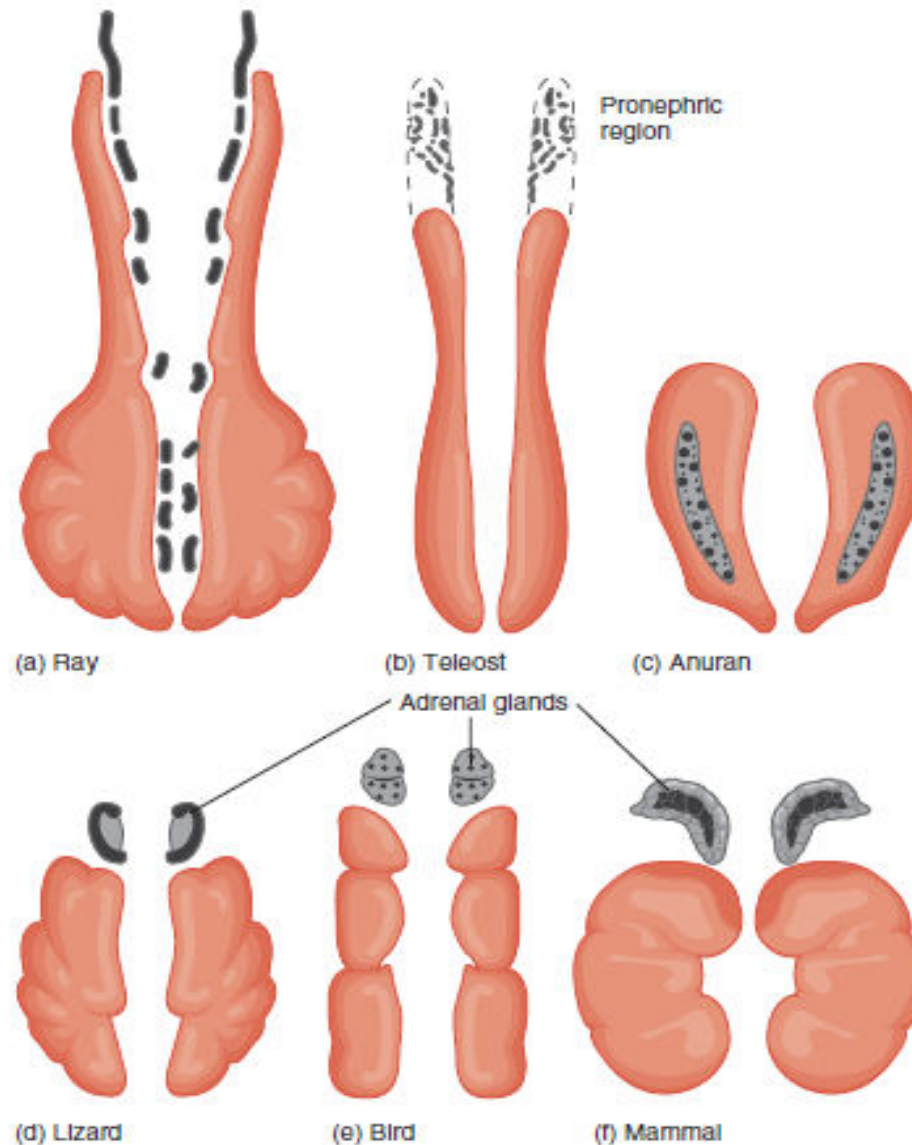
Animal Form and Function 1

Chromaffin Tissues in Selected Vertebrates

Chromaffin Tissues in Selected Vertebrates

- Chromaffin tissue is a group of neuroendocrine cells in the adrenal medulla that synthesizes steroid hormones.
- These hormones are adrenaline (epinephrine) and noradrenaline (norepinephrine)
- These hormones prepare some vertebrates for stressful emergency situations (fight and flight)

Chromaffin Tissues in Selected Vertebrates



Chromaffin Tissues in Selected Vertebrates

- In jawless and cartilaginous fishes chromaffin tissue develops as clusters near the kidneys.

Chromaffin Tissues in Selected Vertebrates

- In teleosts, the chromaffin tissue is generally at the anterior end of the kidney (pronephric region).
- In anurans, the chromaffin tissue is interspersed in a diffuse gland on the ventral surface of each kidney.

Chromaffin Tissues in Selected Vertebrates

- In lizards, the chromaffin tissue forms a capsule around the steroidogenic-producing tissue.
- In birds, the chromaffin tissue is interspersed within an adrenal capsule.

Chromaffin Tissues in Selected Vertebrates

- In most mammals, the chromaffin tissue forms adrenal medulla, and the steroidogenic tissue forms the cortex.

END

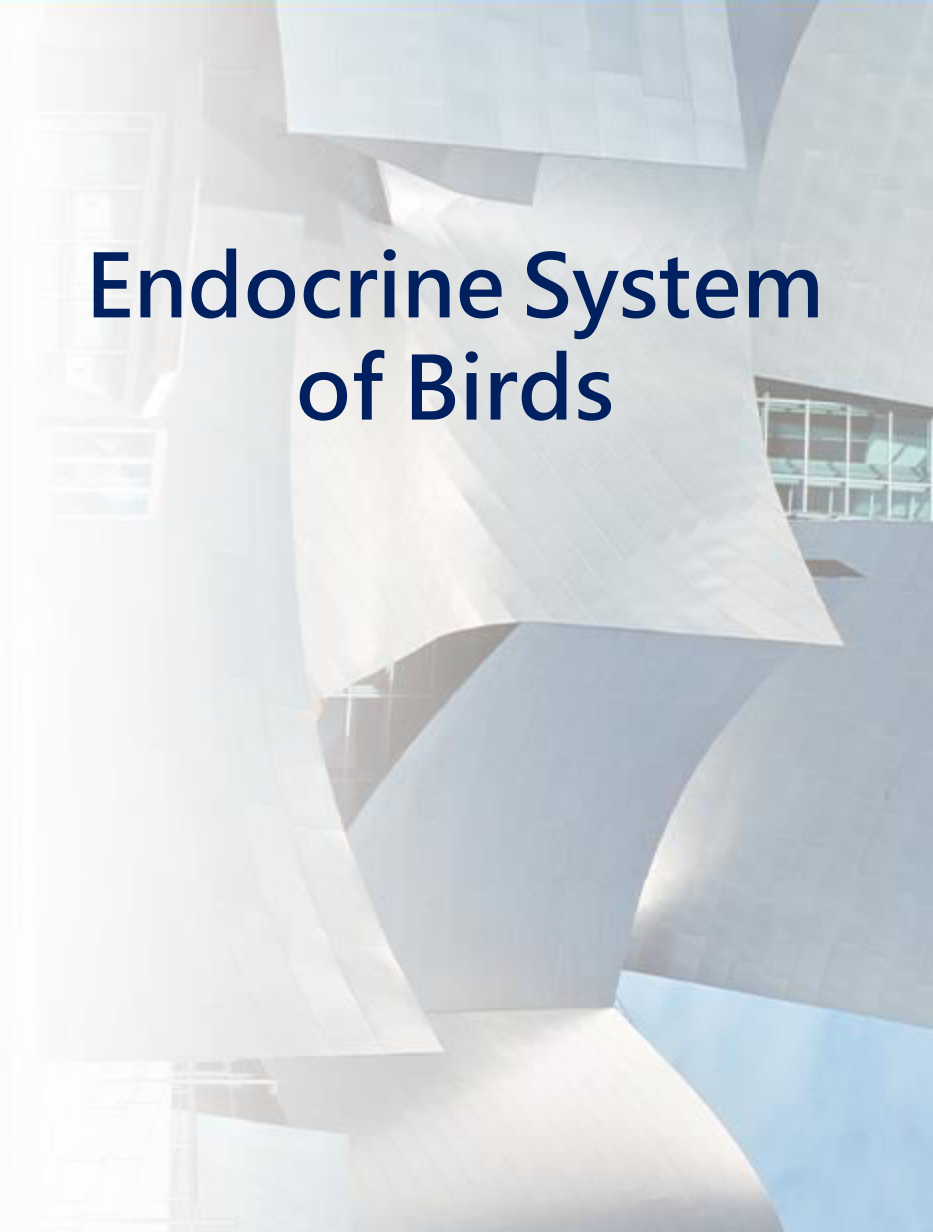
Animal Form and Function 1

Module 124

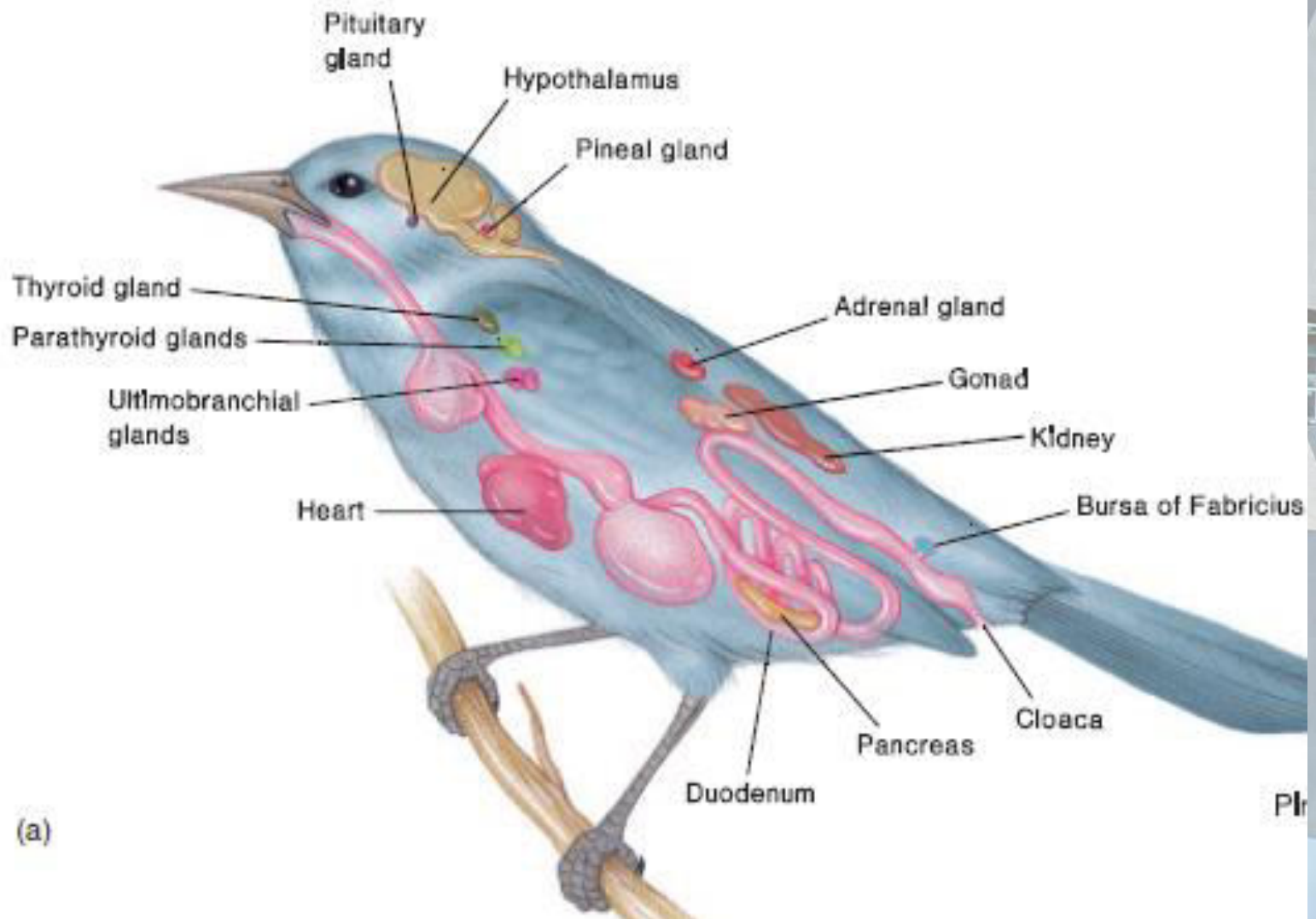


Animal Form and Function 1

Endocrine System of Birds



Endocrine System of Birds



Endocrine System of Birds

- The endocrine glands in birds include:
 - pituitary,
 - thyroid,
 - parathyroids,
 - adrenals,
 - pancreas,
 - pineal,
 - hypothalamus,
 - thymus,
 - testes
 - ovaries

Endocrine System of Birds

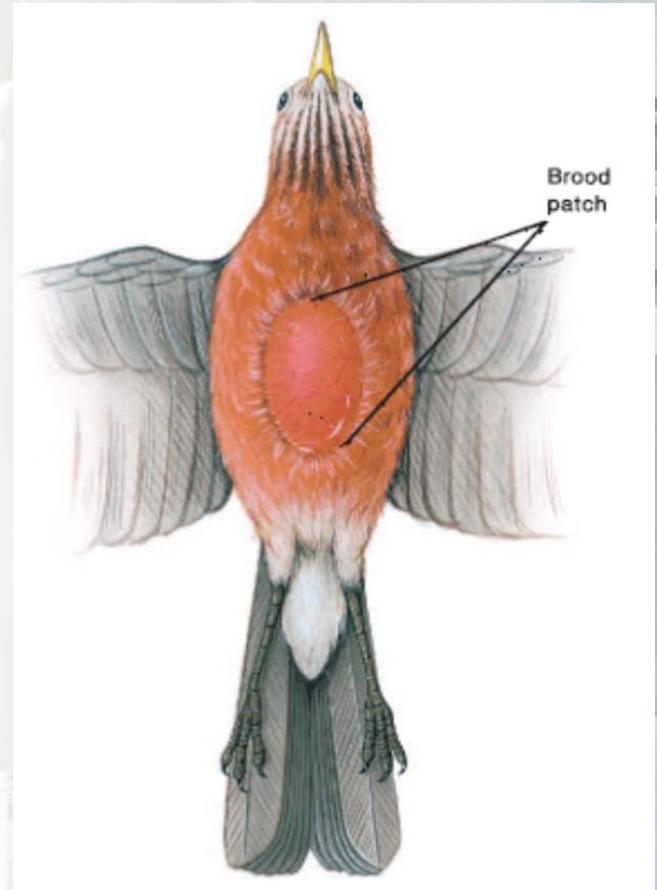
- ultimobranchial and
- bursa of Fabricius.
- The hormones that most of these glands produce and their effects on target tissues are nearly the same as in mammals.

Endocrine System of Birds

- Some unique hormones and their functions in birds are:
- In some birds (e.g., pigeons and doves), the pituitary gland secretes the hormone prolactin.
- Prolactin stimulates the production of "pigeon's milk" by desquamation (sloughing off cells) in the pigeon's crop.

Endocrine System of Birds

- Prolactin also stimulates the development of the brood (incubation) patch



Endocrine System of Birds

- The brood patch helps keep the eggs at a temperature between 33 and 37° C.
- In birds thyroxine regulates the normal development of feathers, molt cycle, and plays a role in the onset of migratory behavior.
- These are in addition to the regular functioning of thyroxine.

Endocrine System of Birds

- In male birds, the testes produce the hormone testosterone.
- Testosterone controls the secondary sexual characteristics of the male, such as bright plumage color, comb (when present), and spurs—all of which strongly influence sexual behavior.

Endocrine System of Birds

- The **ultimobranchial** glands are small, paired structures in the neck just below the parathyroid glands.
- They secrete the hormone, **calcitonin**, which is involved in regulating blood calcium concentrations.

Endocrine System of Birds

- The **bursa of Fabricius** is a sac that lies just dorsal to the cloaca.
- During the bird's embryological development it is well developed and it begins to shrink soon after hatching.

Endocrine System of Birds

- Its tissues produce secretions that are responsible for the maturation of white blood cells (B lymphocytes), which play an important role in immunological reactions.

END

Animal Form and Function 1

Module 125



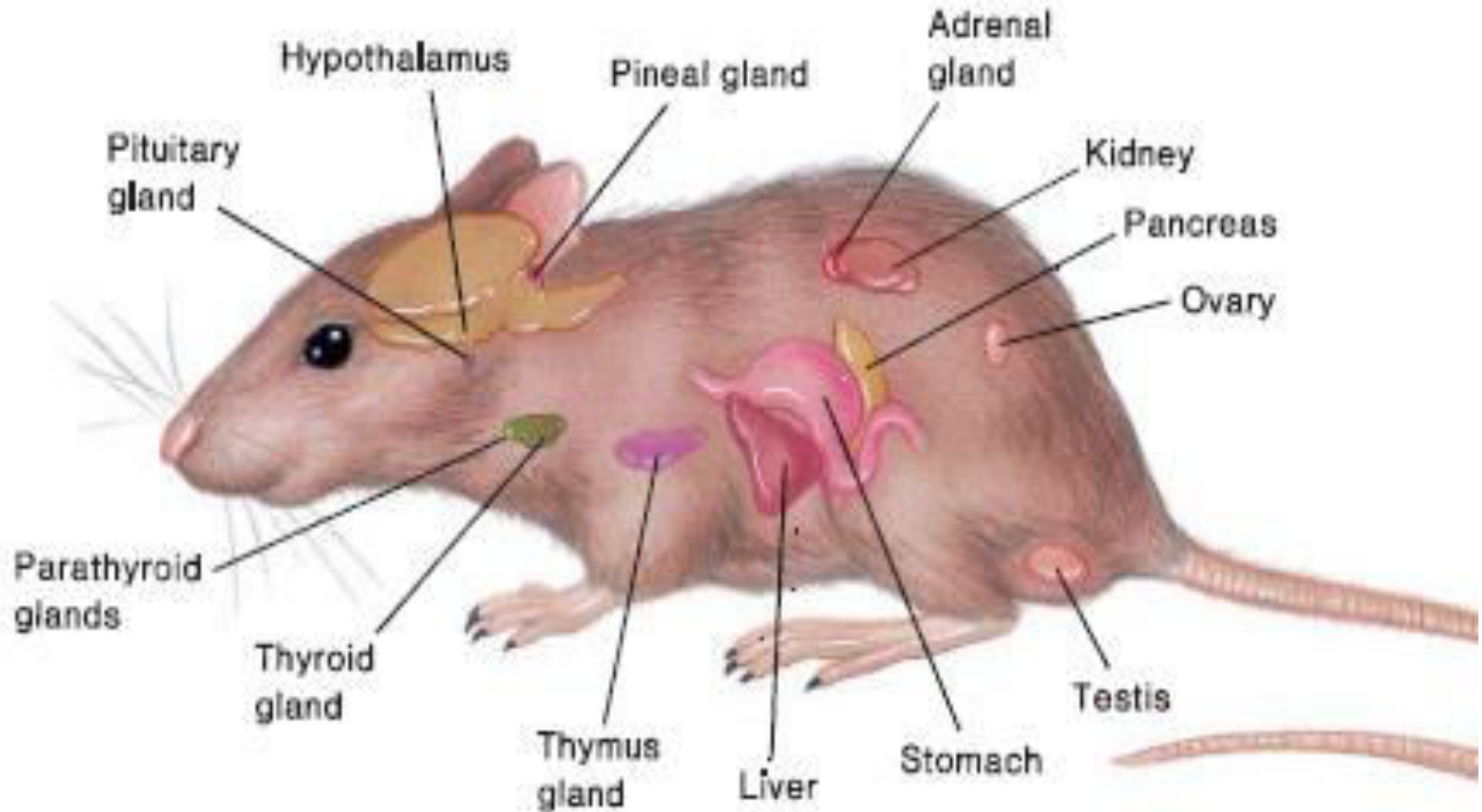
Animal Form and Function 1

Endocrine System of Mammals Part I

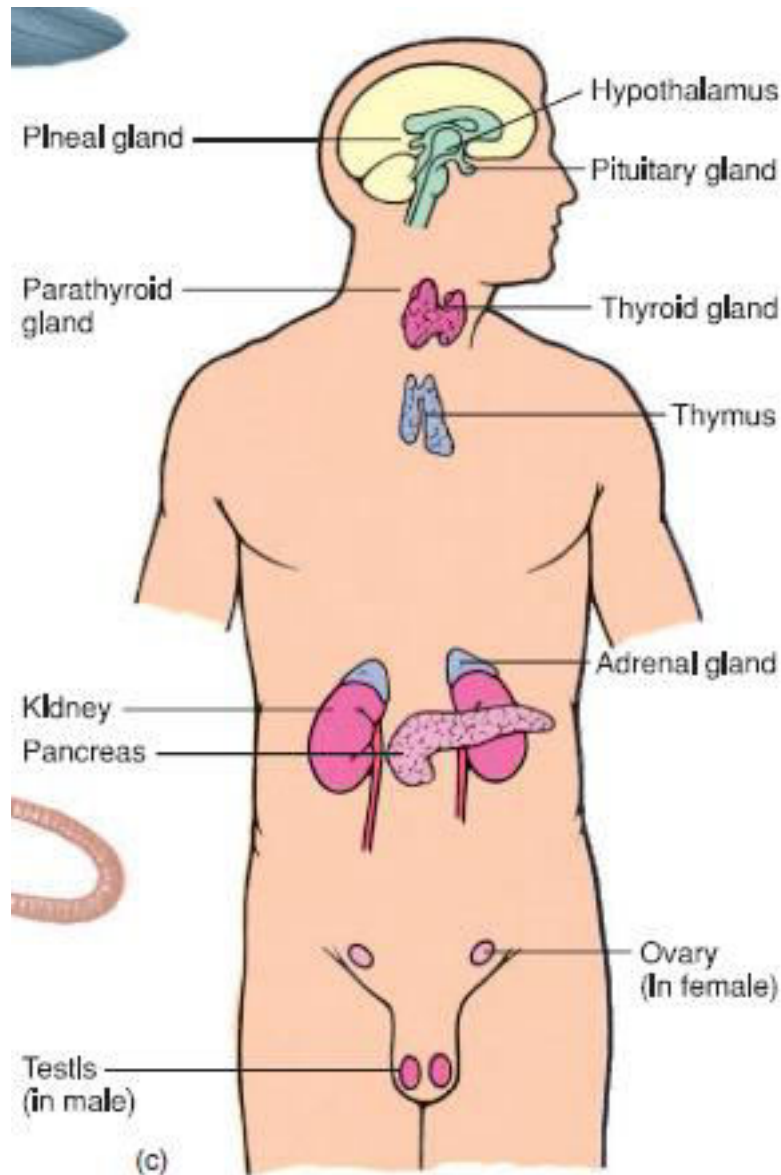
Endocrine System of Mammals Part I

- The endocrine glands in mammals include:
 - pituitary,
 - thyroid,
 - parathyroids,
 - adrenals,
 - pancreas,
 - pineal,
 - hypothalamus,
 - thymus,
 - Testes
 - Ovaries

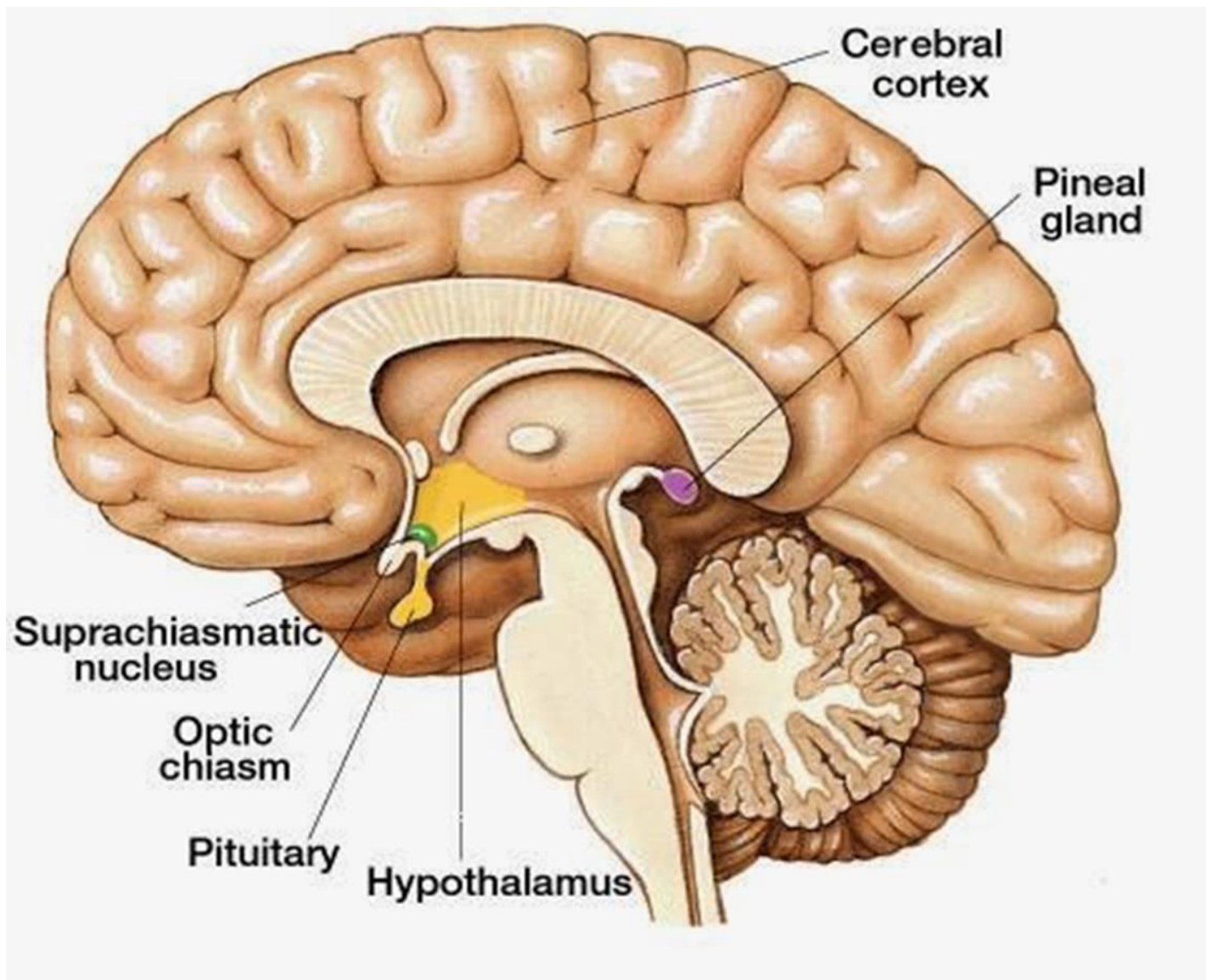
Endocrine System of Mammals Part I



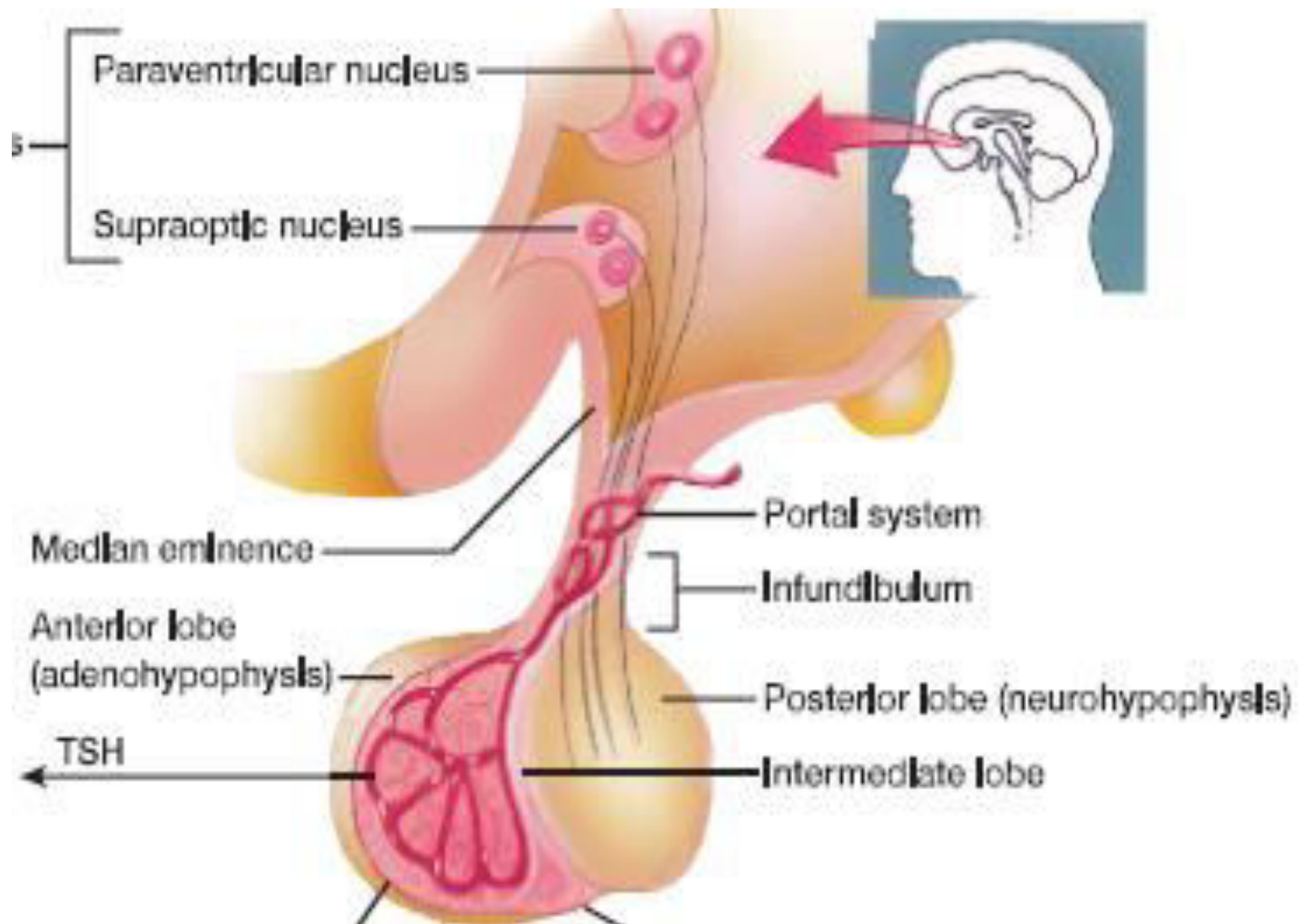
Endocrine System of Mammals Part I



Endocrine System of Mammals Part I



Endocrine System of Mammals Part I



Endocrine System of Mammals Part I

- The pituitary gland (also known as the hypophysis) is directly below the hypothalamus. The pituitary has two distinct lobes:
 - a) the anterior lobe (adenohypophysis) and
 - b) the posterior lobe (neurohypophysis).

Endocrine System of Mammals Part I

END

- Differences Between these lobes:
- i) The adenohypophysis is larger than the neurohypophysis.
- ii) Secretory cells called pituicytes are in the adenohypophysis, but not in the neurohypophysis.
- iii) The neurohypophysis has a greater supply of nerve endings.

Animal Form and Function 1

Module 126



Animal Form and Function 1

Hormones of Adenohypophysis Part I

Hormones of Adenohypophysis Part I

- The true endocrine portion of the pituitary is the adenohypophysis, which synthesizes six different hormones:
- All of these hormones are polypeptides.
- Produce two types of hormones:
 - A) Tropic and
 - B) Non tropic

Hormones of Adenohypophysis Part I

- Tropic Hormones are the hormones whose primary target is another endocrine gland. e.g TSH, ACTH, LH and FSH
- Nontropic hormones are the growth hormone (GH) and prolactin.
- (TSH) thyroid-stimulating hormone stimulates the thyroid gland to secrete thyroxine, which is the main thyroid hormone.

Hormones of Adenohypophysis Part I

- **Adrenocorticotrophic hormone (ACTH) stimulates the adrenal gland to produce and secrete steroid hormones called glucocorticoids (cortisol).**

Hormones of Adenohypophysis Part I

- Secretion of ACTH is regulated by the secretion of corticotropin-releasing factor (CRF) from the hypothalamus.
- CRF in turn, is regulated by a feedback system that involves factors such as stress, insulin, ADH, and other hormones.

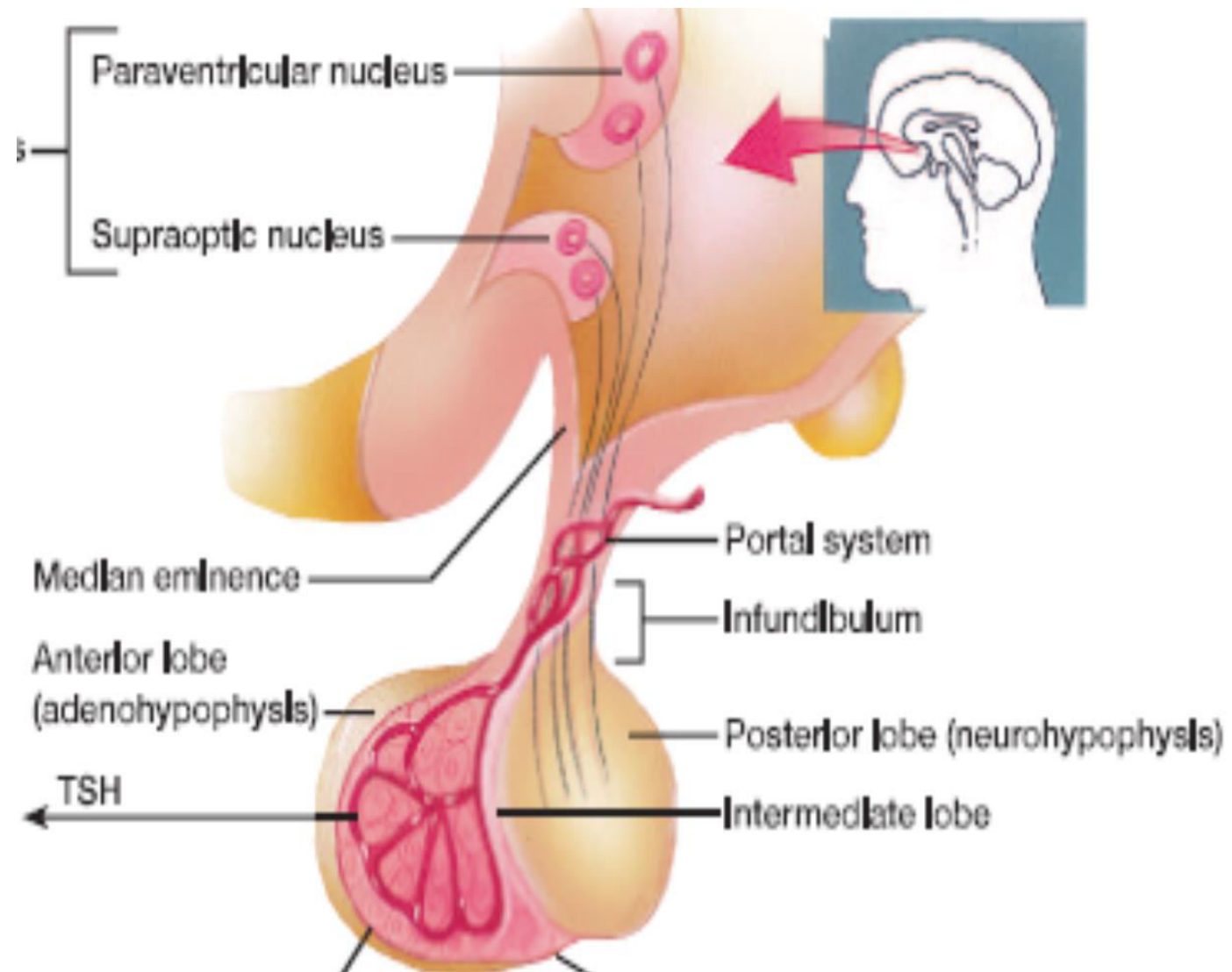
Hormones of Adenohypophysis Part I

- Luteinizing hormone (LH), in females, stimulate ovulation i.e. cause the release mature ova from the ovary.
- LH also stimulates corpus luteum, a temporary endocrine tissue in the ovaries.
- In response the ovaries secretes the female sex hormones, the estrogen and progesterone.

Hormones of Adenohypophysis Part I

- In the male, the LH, stimulates Leydig cells in testes that secrete the male hormone, the testosterone.
- FSH (Follicle Stimulating Hormone) regulates the development, growth, pubertal maturation and reproductive processes of the body.
- LH and FSH are called gonadotropins.

Hormones of Adenohypophysis Part I



Animal Form and Function 1

Module 127



Animal Form and Function 1

Hormones of Adenohypophysis Part II

Hormones of Adenohypophysis Part II

- Adenohypophysis, synthesizes six different hormones:
- Produce two types of hormones:
 - a) Tropic and
 - b) Non tropic
- Non Trophic Hormones are:
 - a. Growth Hormone
 - b. Prolactin

Hormones of Adenohypophysis Part II

- **Growth Hormone (GH)** or Somatotrophic Hormone does not influence a particular target tissue.
- It affects all parts of the body that are concerned with growth.
- It **directly induces the cell division necessary for growth.**

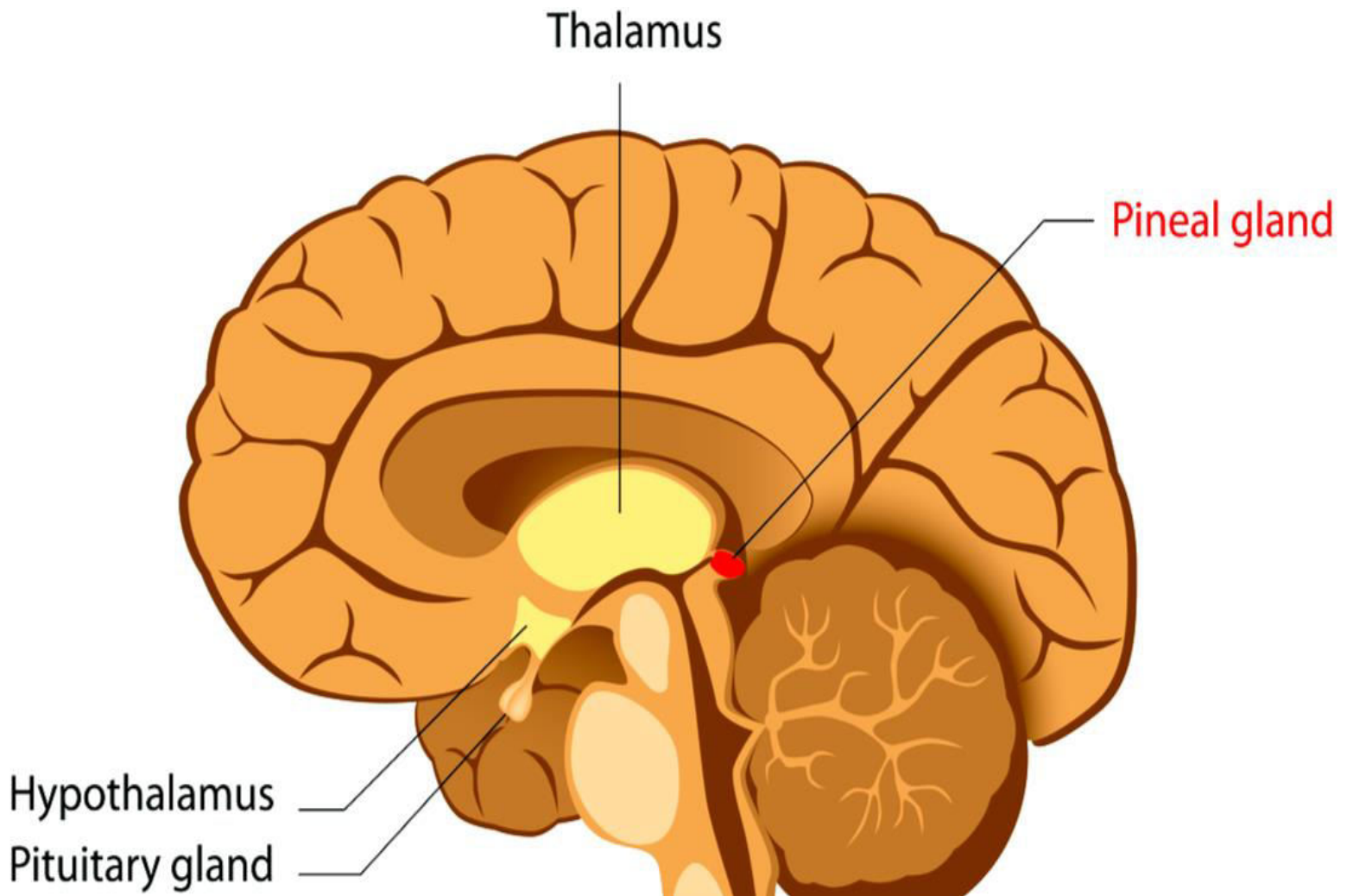
Hormones of Adenohypophysis Part II

- It also influences protein synthesis in most types of cells by stimulating the uptake of amino acids, RNA synthesis, and ribosome activity.
- Prolactin (PRL) has the widest range of actions of the adenohypophyseal hormones.
- It plays an essential role in many aspects of reproduction.

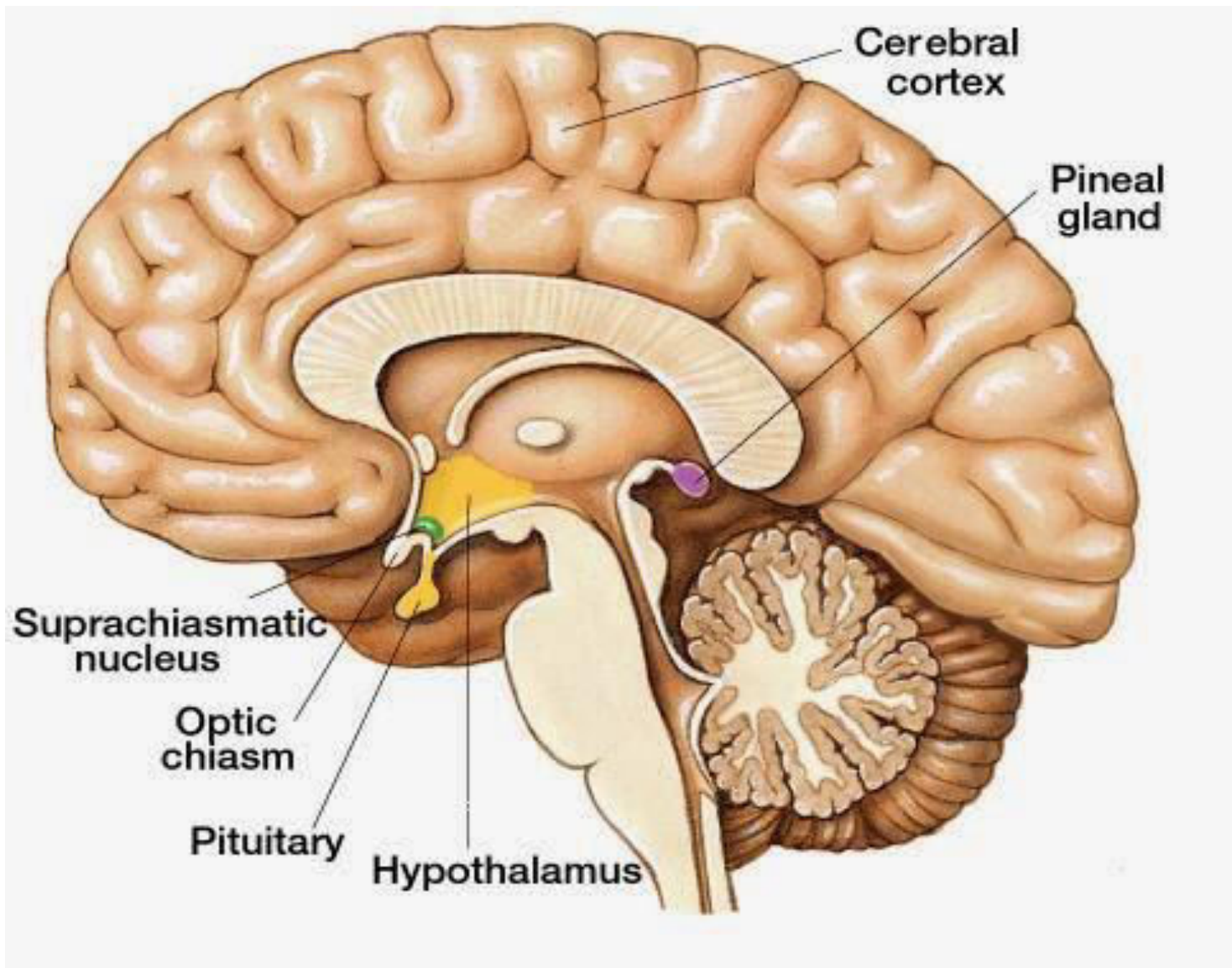
Hormones of Adenohypophysis Part II

- For example, it stimulates reproductive migrations in many mammals, such as elk and caribou.
- Prolactin also enhances mammary gland development and milk production in female mammals.

Hormones of Adenohypophysis Part II



Hormones of Adenohypophysis Part II



Animal Form and Function 1

Module 129



Animal Form and Function 1

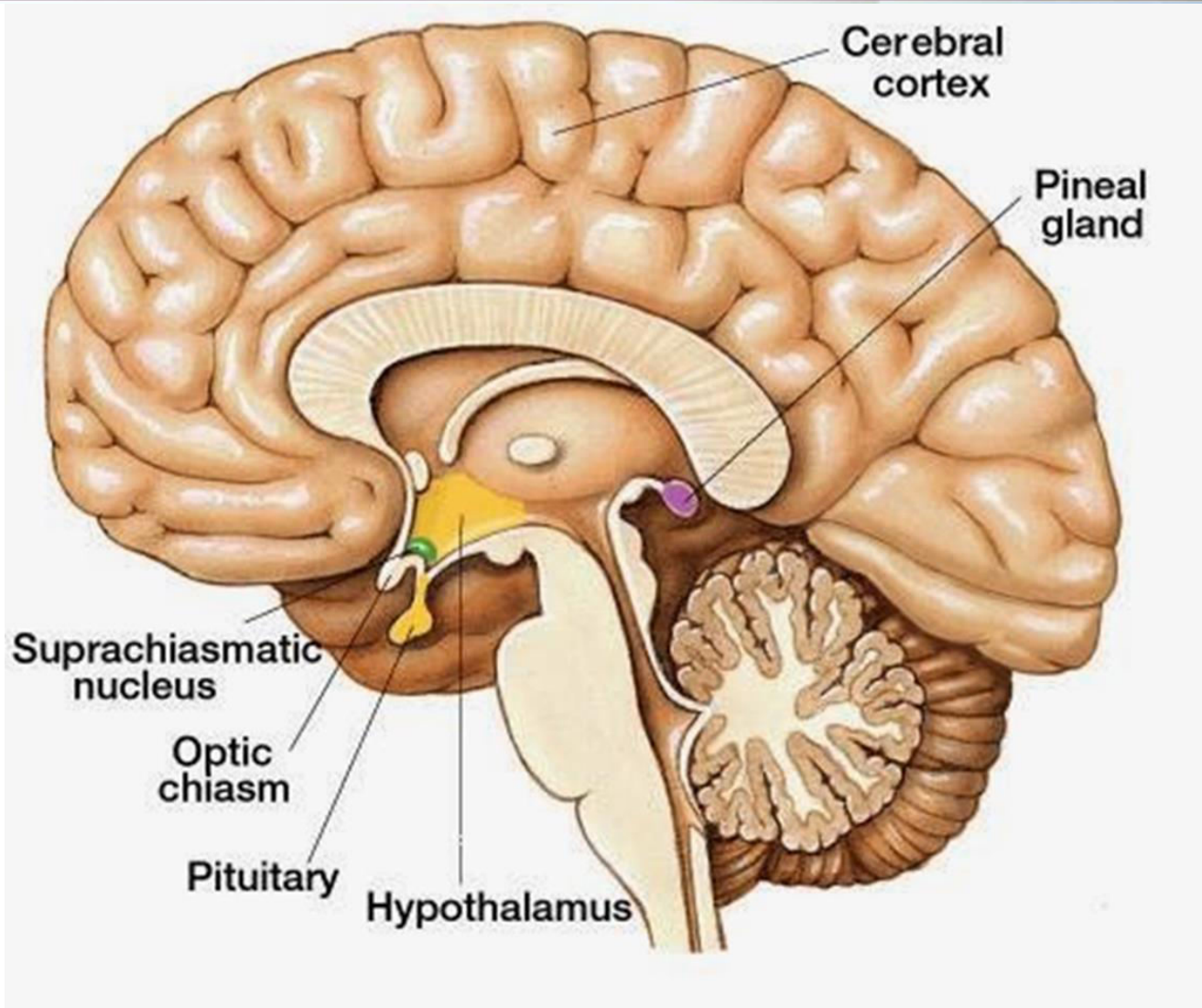
Pineal Gland

The background of the slide features a large, abstract architectural structure with white, curved, and angular forms, resembling a modern building or a large sculpture. The structure is set against a clear blue sky. The overall aesthetic is clean and modern.

Pineal Gland

- The pineal gland is also known as the third eye.
- It is an endocrine gland in the Brain.
- The pineal gland is located behind the third cerebral ventricle in the brain between the two cerebral hemispheres.
- Darkness makes Pineal gland to produce Melatonin.

Pineal Gland



Pineal Gland

- Melatonin hormone modulates wake/sleep and seasonal changes.
- Light inhibits the enzymes needed for melatonin synthesis.
- Because of its cyclical production, melatonin can affect many physiological processes and adjust them to diurnal and seasonal cycles.

Pineal Gland

- In humans, decreased melatonin secretion may help trigger the onset of puberty.
- Melatonin is best known for the role it plays in regulating sleep patterns. Sleep patterns are also called circadian rhythms.

Pineal Gland

- If one has sleep disorder, it is the symptom that pineal gland is not producing the correct amount of melatonin.
- Some health providers believe that sleep can be improved by the use of detox.
- This activates the pineal gland to improve sleep and to open third eye.

Animal Form and Function 1

Module 130



Animal Form and Function 1

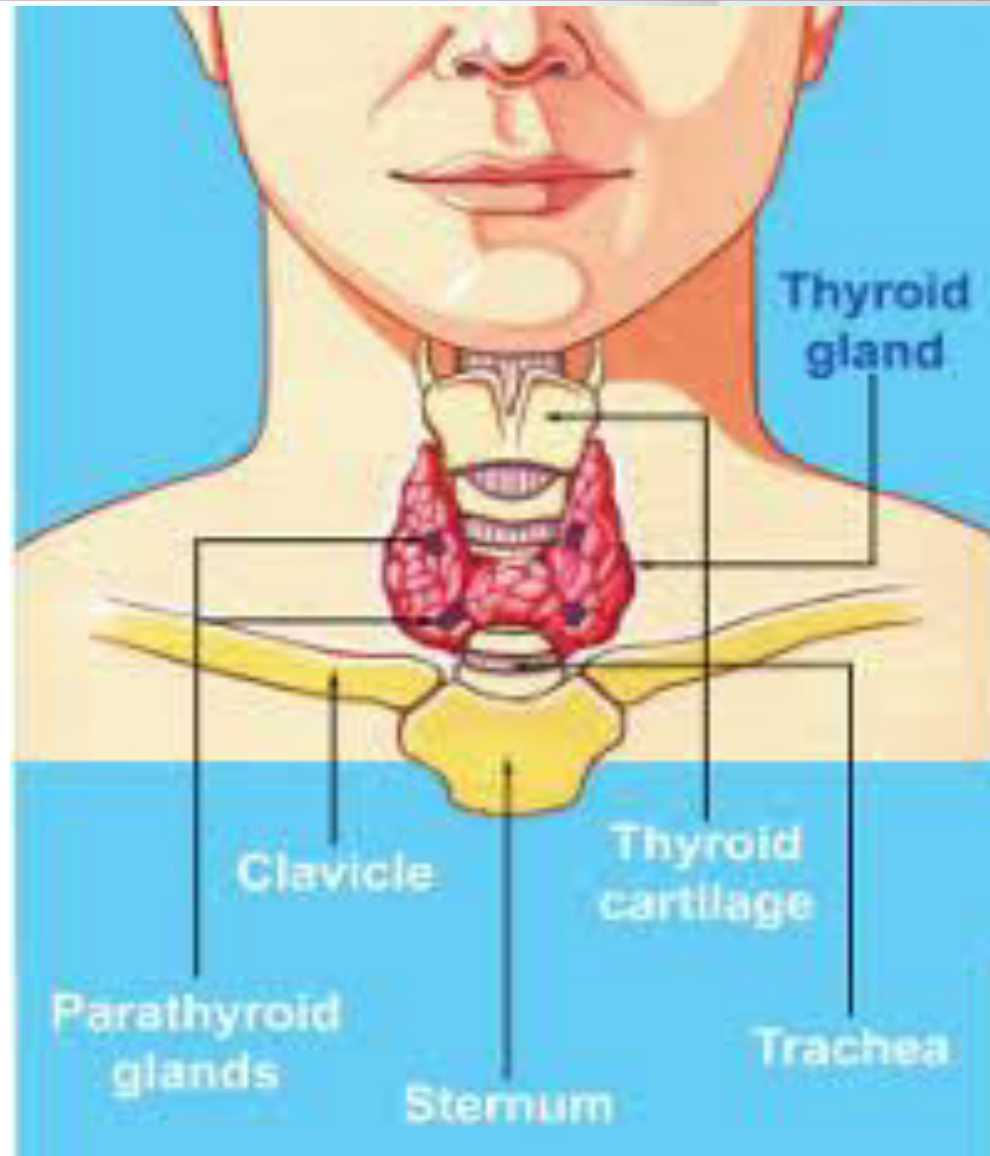
Thyroid Gland



Thyroid Gland

- The thyroid gland is located in the neck, anterior to the trachea.
- Two of its secretions are thyroxine and triiodothyronine, both of which influence overall growth, development, and metabolic rates.
- Another thyroid hormone, calcitonin, helps control extracellular levels of calcium ions.

Thyroid Gland



Thyroid Gland

- This helps promoting the deposition of these ions into bone tissue when their concentrations rise.
- Once calcium returns to its homeostatic concentration, thyroid cells decrease their secretion of calcitonin.

Thyroid Gland

- Since the main purpose of thyroid hormone is to "run the body's metabolism," it is understandable that people with low thyroxine will have symptoms associated with a slow metabolism.

END

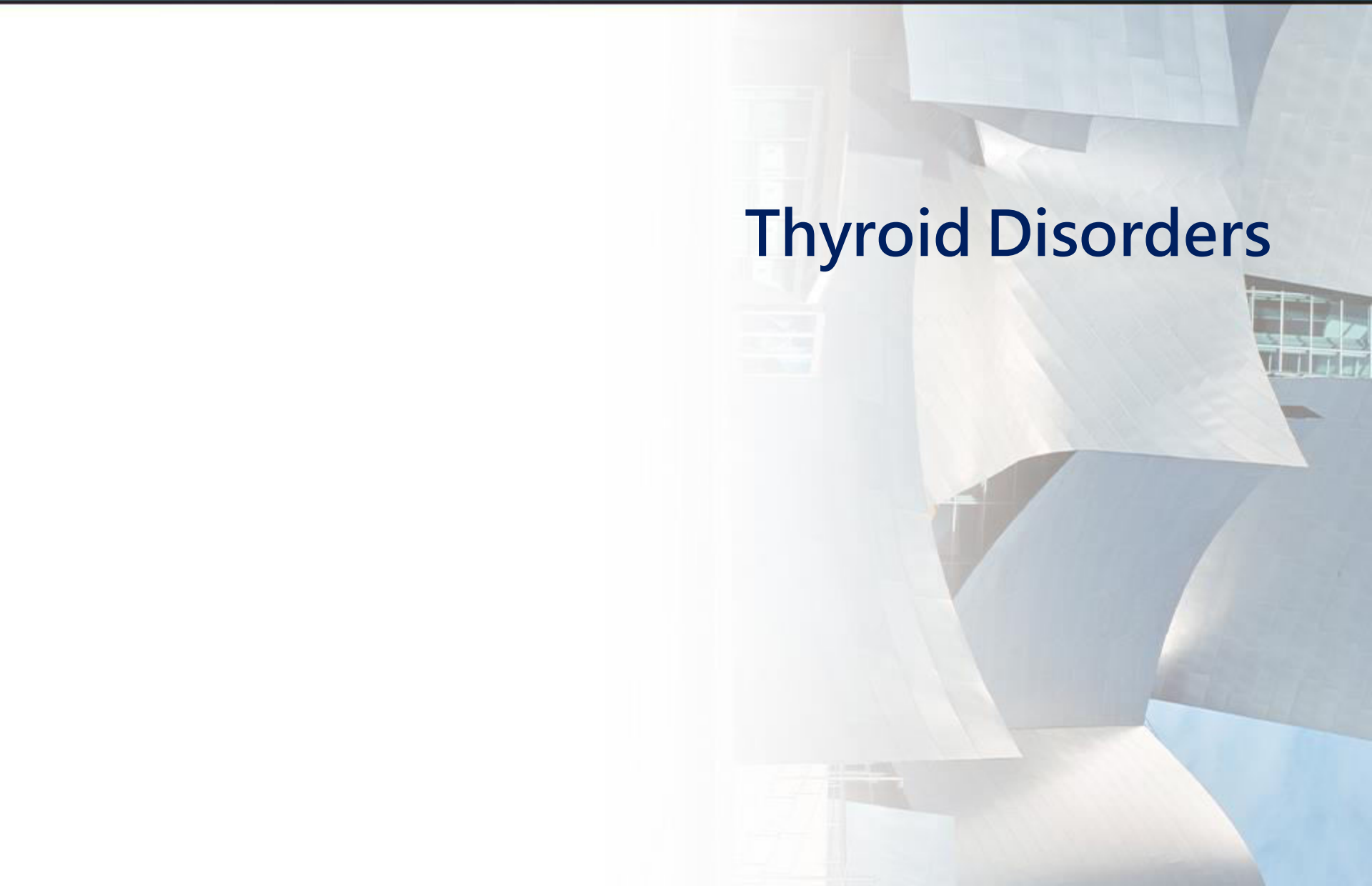
Animal Form and Function 1

Module 131



Animal Form and Function 1

Thyroid Disorders



Thyroid Disorders

- Several different disorders can arise when thyroid produces too much hormone (hyperthyroidism) or not enough (hypothyroidism)
- Goitre is associated with thyroid when it is not functioning properly.

Thyroid Disorders

- Several different disorders can arise when thyroid produces too much hormone (hyperthyroidism) or not enough (hypothyroidism).
- **Hyperthyroidism (overactive thyroid) occurs when thyroid gland produces too much of the hormone thyroxine.**

Thyroid Disorders

- Hyperthyroidism can accelerate your body's metabolism, causing unintentional weight loss and a rapid or irregular heartbeat. nervousness, anxiety, rapid hand tremor.
- Goitre may occur may occur associated with a thyroid that is not functioning properly.

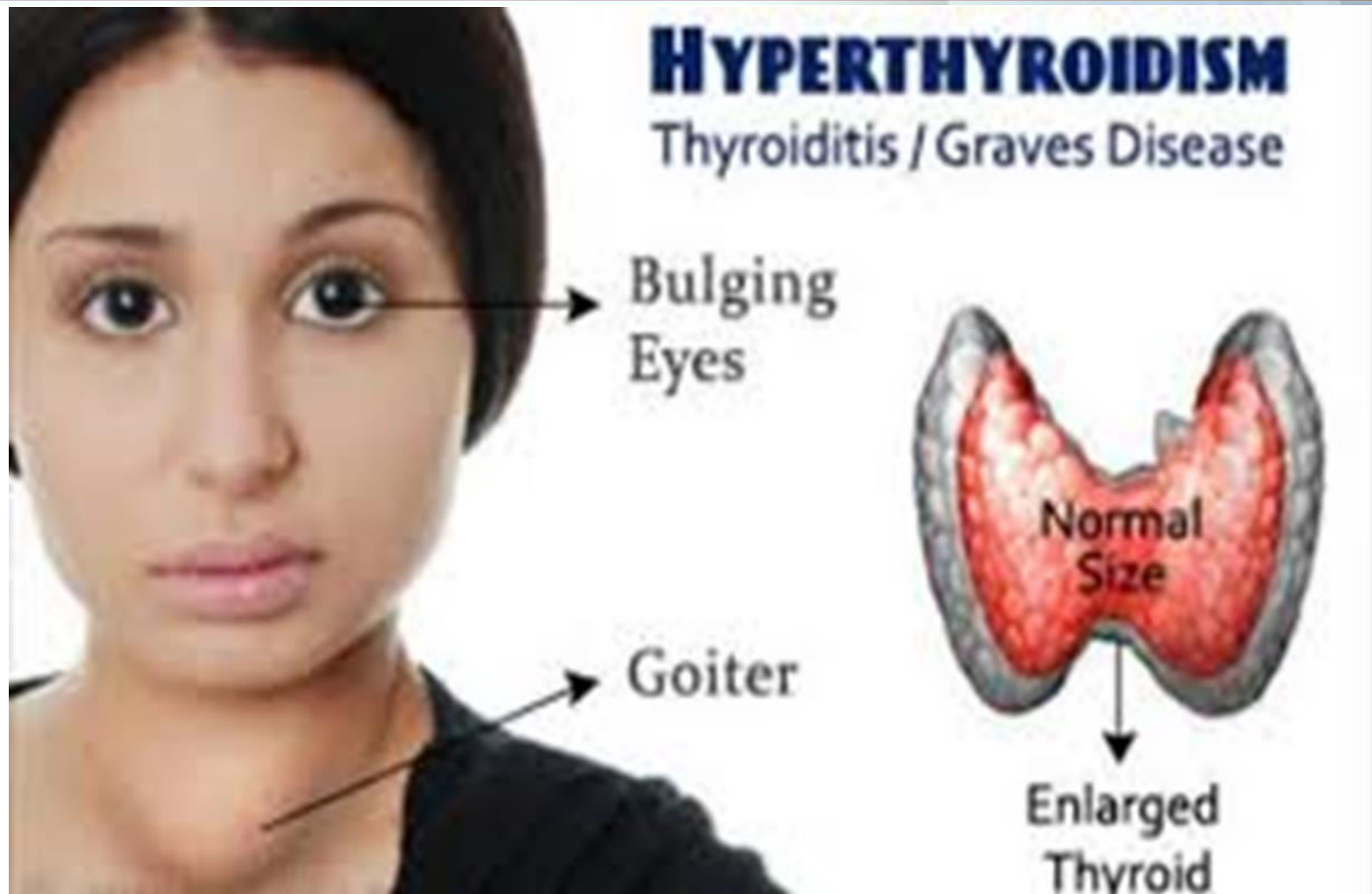
Thyroid Disorders



Thyroid Disorders

- Hypothyroidism:
- Its symptoms are
 - Fatigue. Weakness.
 - Weight gain or difficulty losing weight (despite reduced food intake)
 - Coarse, dry hair and dry skin.

Thyroid Disorders



Thyroid Disorders



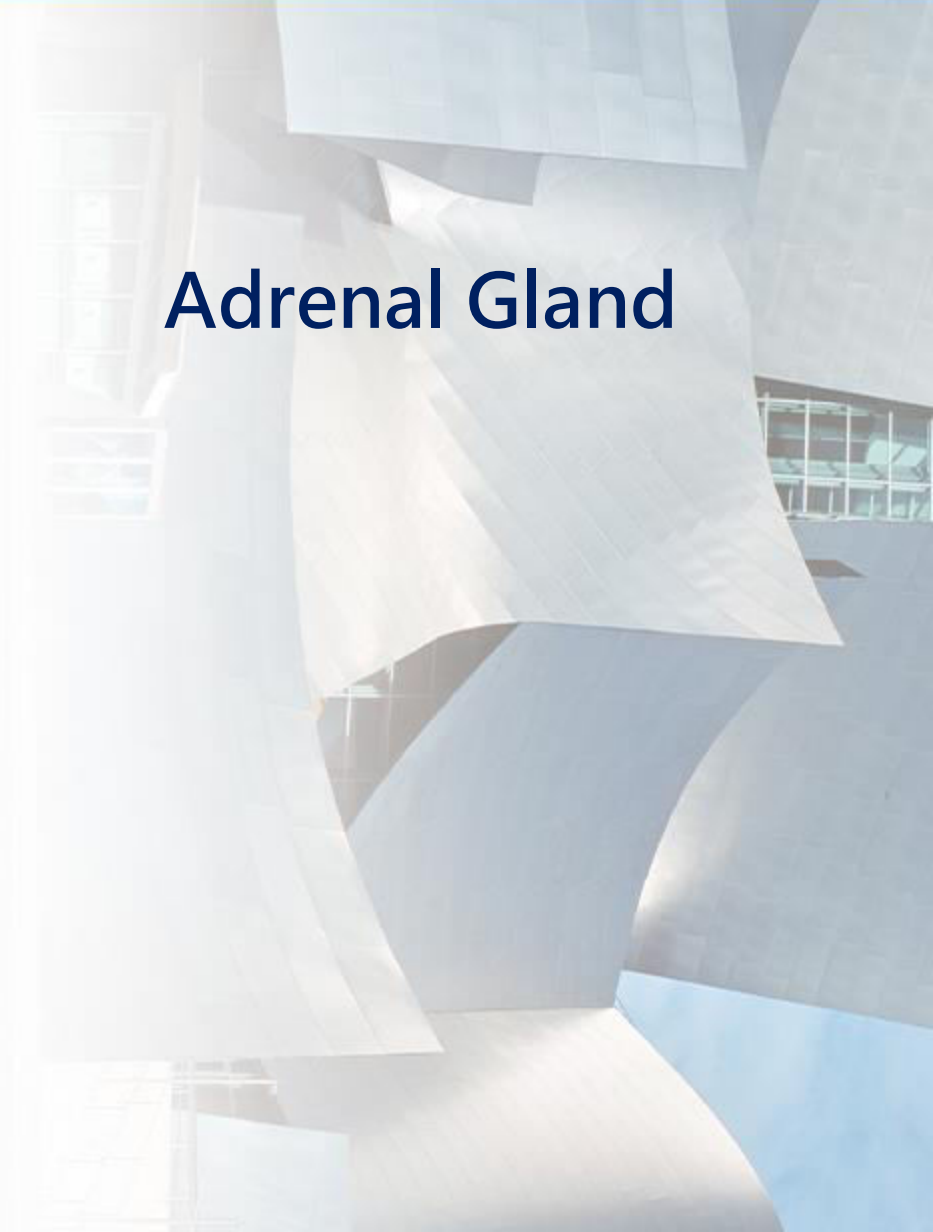
Animal Form and Function 1

Module 133



Animal Form and Function 1

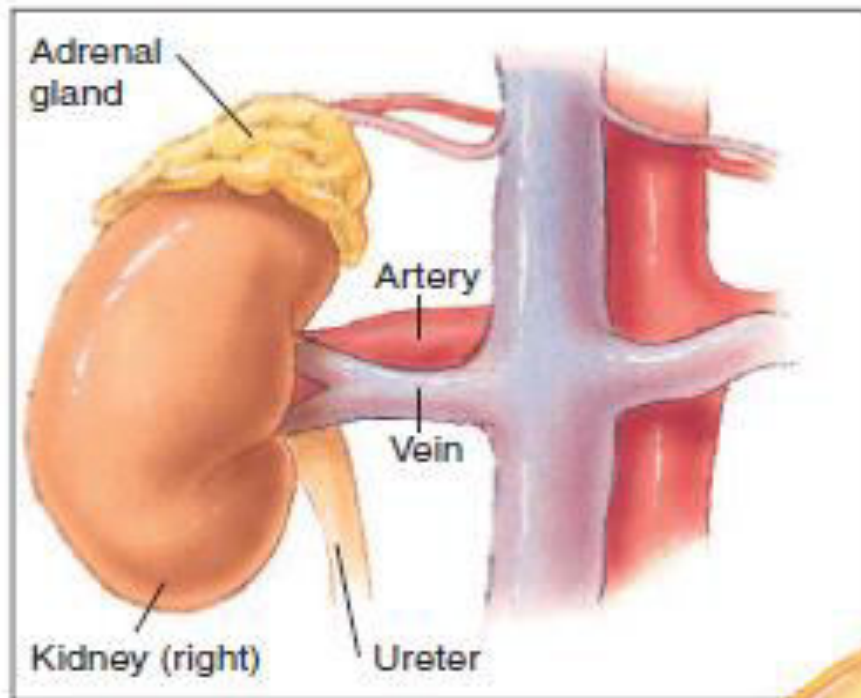
Adrenal Gland



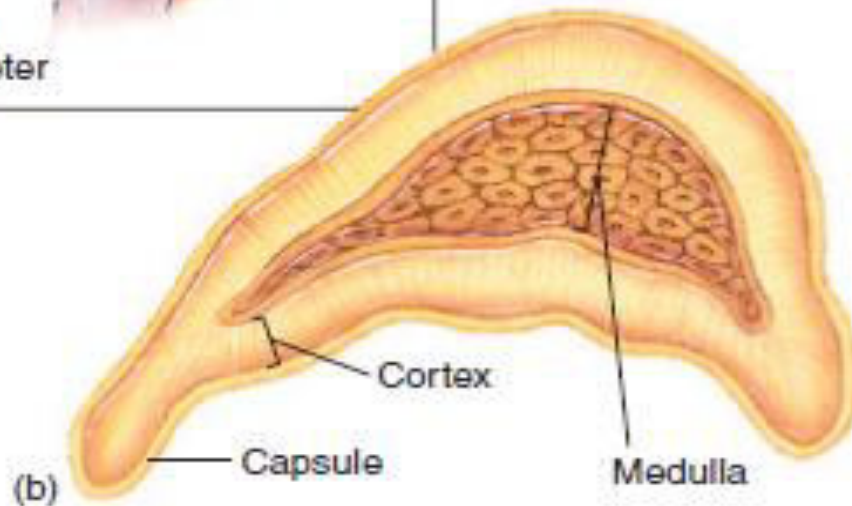
Adrenal Gland

- In mammals, two adrenal glands rest on top of the kidneys.
- Each gland consists of two separate glandular tissues.
- The inner portion, the medulla, and the outer portion the cortex.

Adrenal Gland



(a)



Adrenal Gland

- The adrenal cortex secretes three classes of steroid hormones:
 - 1. Glucocorticoids (cortisol),
 - 2. Mineralocorticoids (aldosterone), and
 - 3. Sex hormones (androgens, estrogens).

Adrenal Gland

- The glucocorticoids, such as cortisol, help regulate overall metabolism and the concentration of blood sugar.
- They also function in defense responses to infection or tissue injury.
- Aldosterone helps maintain concentrations of solutes (Na^+) in the extracellular fluid.

Adrenal Gland

- It plays a major role in maintaining the homeostasis of extracellular fluid.
- The sex hormones consist of male hormones called androgens (mainly dehydroepiandrosterone)
- Lesser amounts of female hormones called estrogens.

Adrenal Gland

- The adrenal medulla is under neural control.
- It contains neurosecretory cells secrete epinephrine (adrenaline) and norepinephrine (noradrenaline).
- Both of which help control heart rate and carbohydrate metabolism.

Adrenal Gland

- Brain centers and the hypothalamus govern the secretions via sympathetic nerves.
- During times of excitement, emergency, or stress, the adrenal medulla contributes to the overall mobilization of the body through the sympathetic nervous system.

Adrenal Gland

- In response to epinephrine and norepinephrine, the heart rate increases, blood flow increases to many vital organs.
- The airways in the lungs dilate, and more oxygen is delivered to all cells of the body.

Adrenal Gland

- This group of events is sometimes called the “fight-or flight” response and permits the body to react strongly and quickly to emergencies.

END

Animal Form and Function 1

Module 134



Animal Form and Function 1

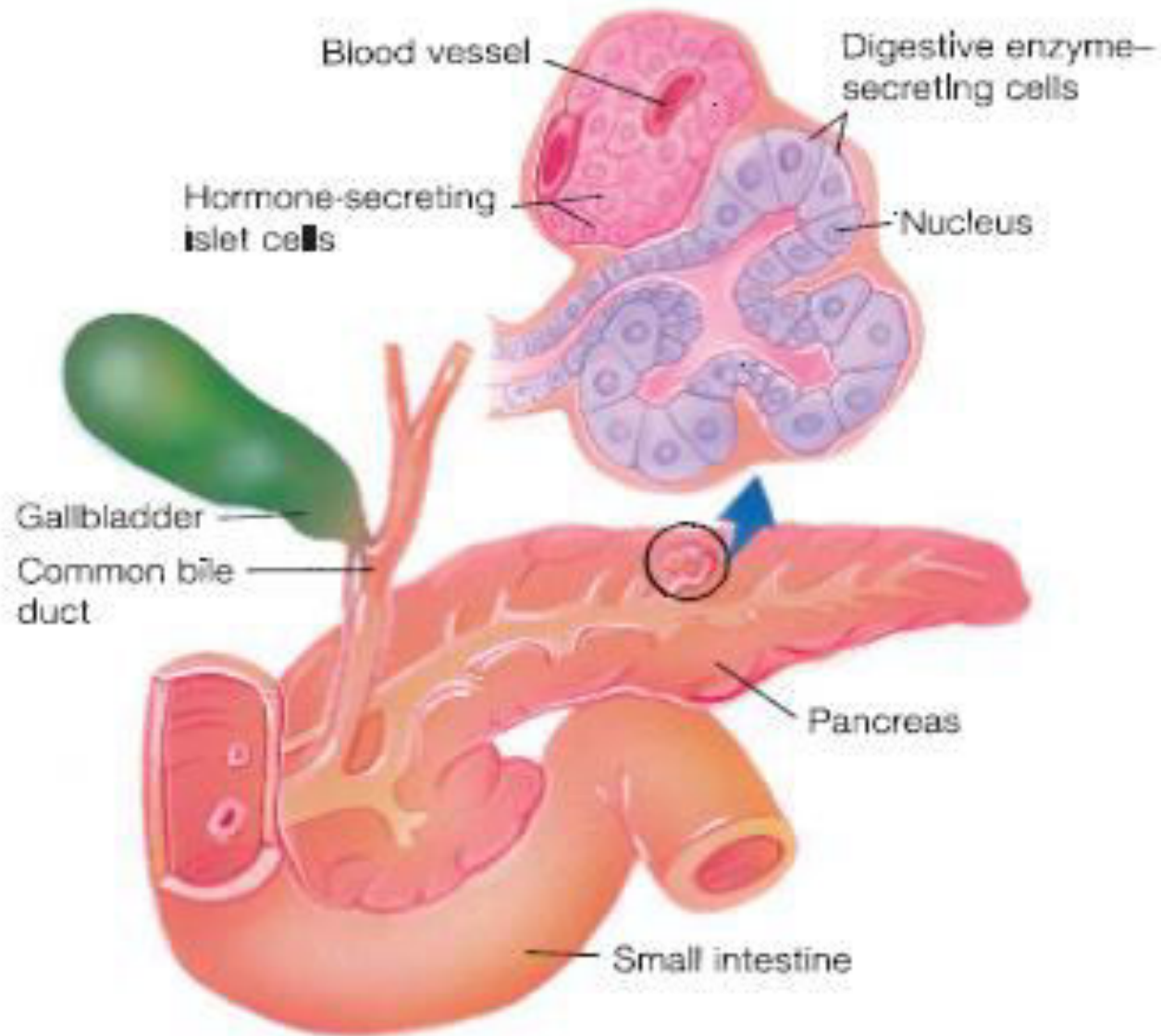
Pancreas



Pancreas

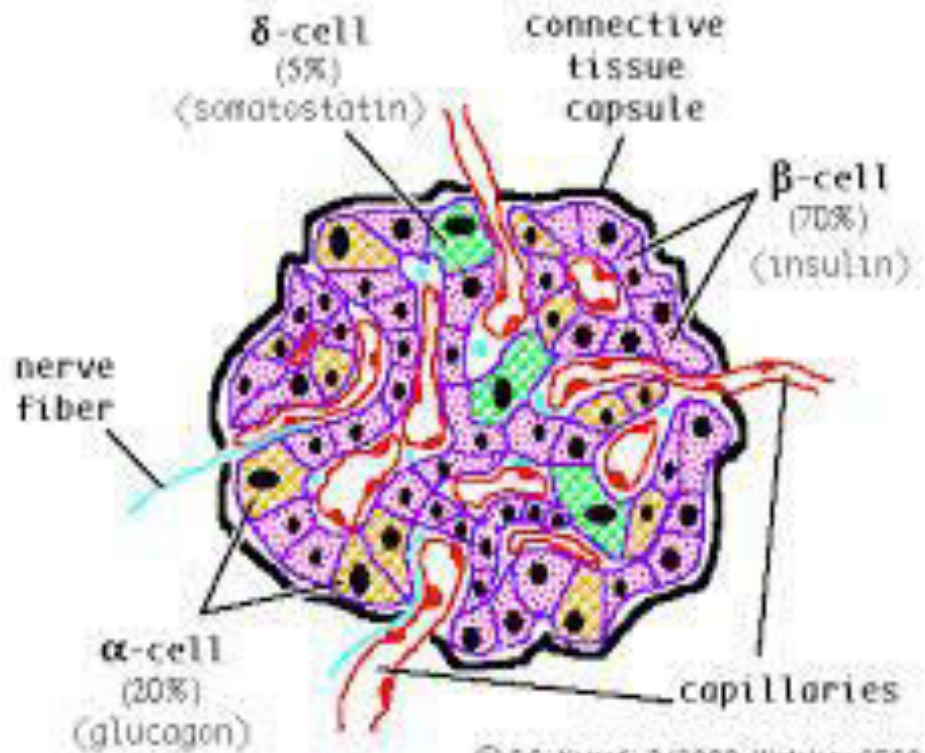
- The pancreas is an elongated, fleshy organ posterior to the stomach.
- It functions both as an exocrine and endocrine gland.
- The endocrine portion of the pancreas makes up only about 1% of the gland.

Pancreas

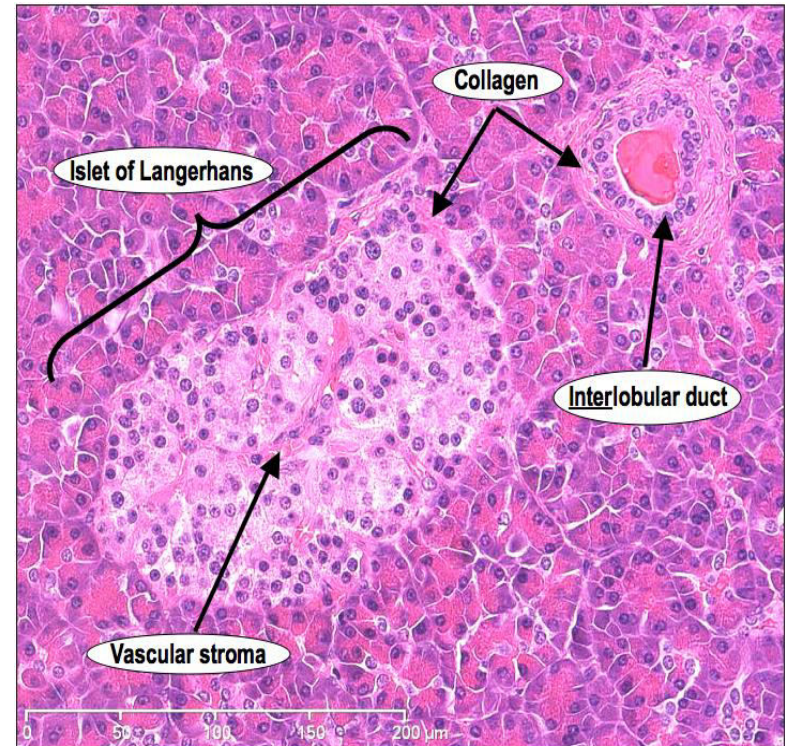


Pancreas

Islet of Langerhans



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Pancreas

- This portion synthesizes, stores, and secretes hormones from clusters of cells called pancreatic islets of Langerhans.
- The pancreas contains 200,000 to 2,000,000 pancreatic islets scattered throughout the gland. Each islet contains four special groups of cells, called alpha, beta, delta and F cells.

Pancreas

- The Alpha cells produce the hormone glucagon,
- Beta cells produce insulin.
- The delta cells secrete somatostatin, (the hypothalamic growth-hormone inhibiting factor) that also inhibits glucagon and insulin secretion.

Pancreas

- F-cells secrete a pancreatic polypeptide that is released into the bloodstream after a meal and inhibits somatostatin secretion, gallbladder contraction, and the secretion of pancreatic digestive enzymes.

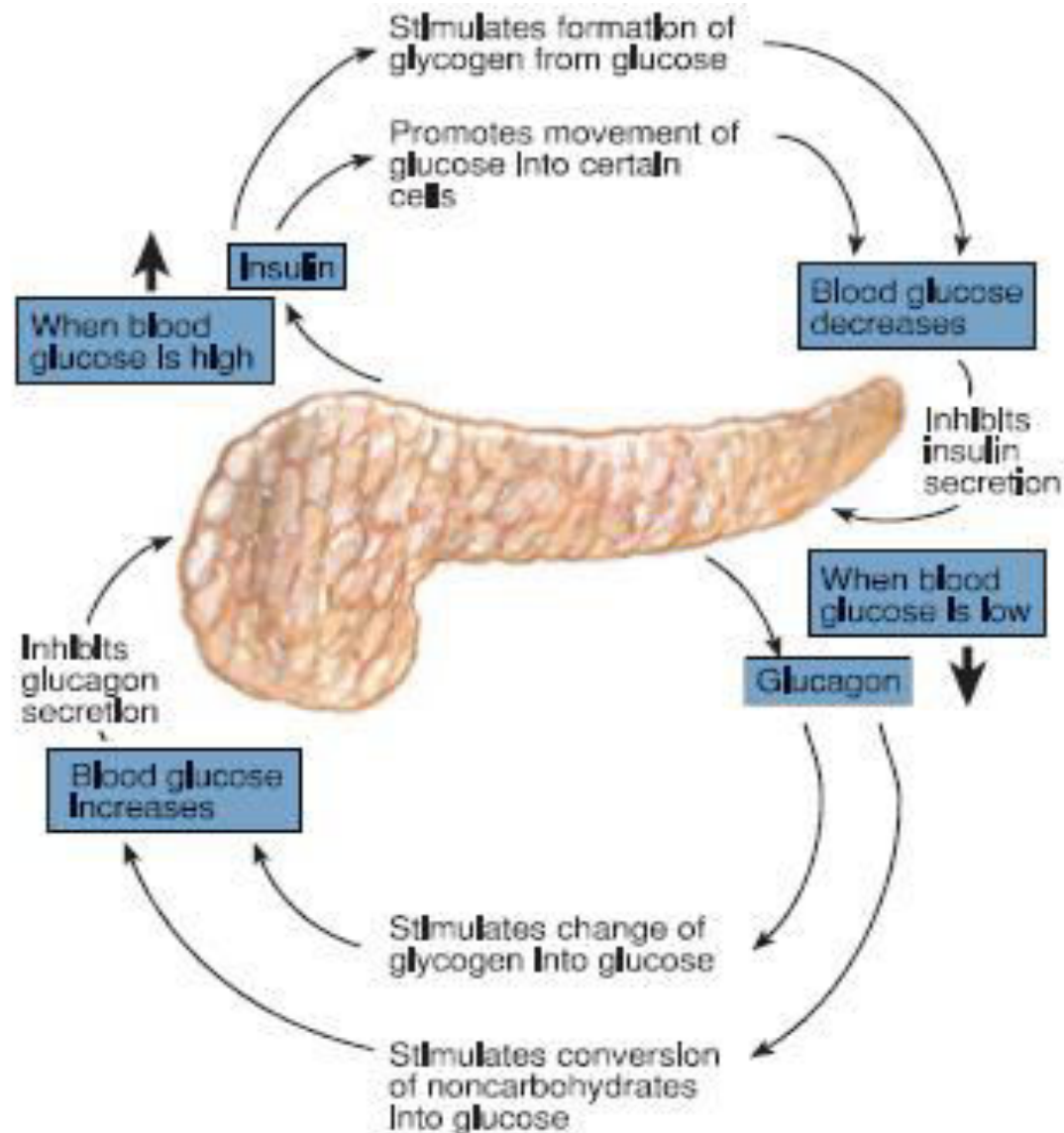
Pancreas

- When glucose concentrations in the blood are high, such as after a meal, beta cells secrete insulin.
- Insulin promotes the uptake of glucose by the body's cells, including liver cells, where excess glucose can be converted to glycogen (a storage polysaccharide).

Pancreas

- Insulin and glucagon are crucial to the regulation of blood glucose concentrations.
- When the blood glucose concentration is low, alpha cells secrete glucagon.
- Glucagon stimulates the breakdown of glycogen into glucose, which is released into the blood to raise the blood glucose level.

Pancreas



Pancreas

- The figure shows the negative feedback system that regulates the secretion of glucagon and insulin and the maintenance of appropriate blood glucose concentrations.

END

Animal Form and Function 1

Module 135



Animal Form and Function 1

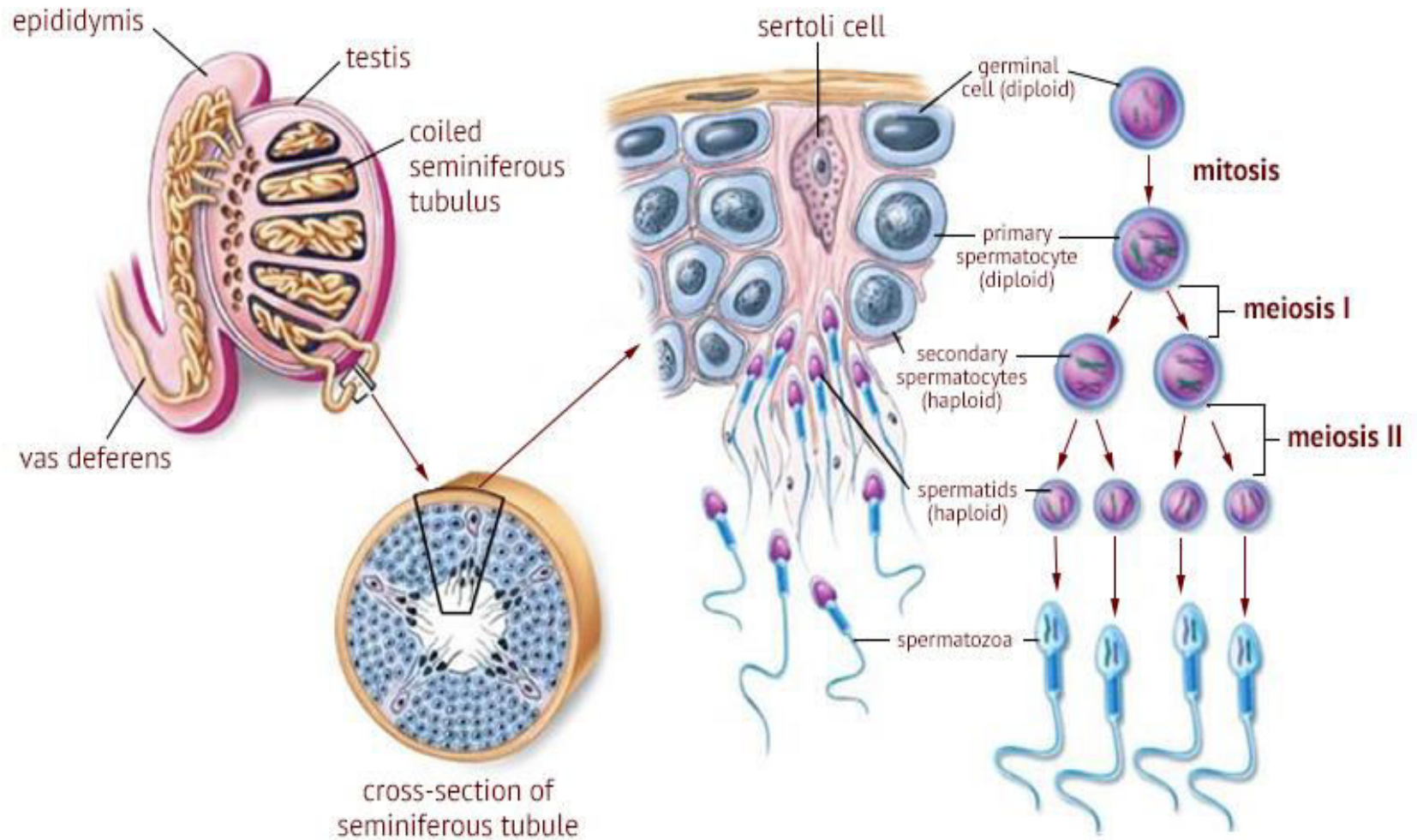
Testes

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Testes

- In humans the testes occur as a pair of oval-shaped organs lodged in the out pocketing of the skin, the scrotum.
- Testes, also called testicles, in animals, the organ that produce sperms and male hormones, the androgens.

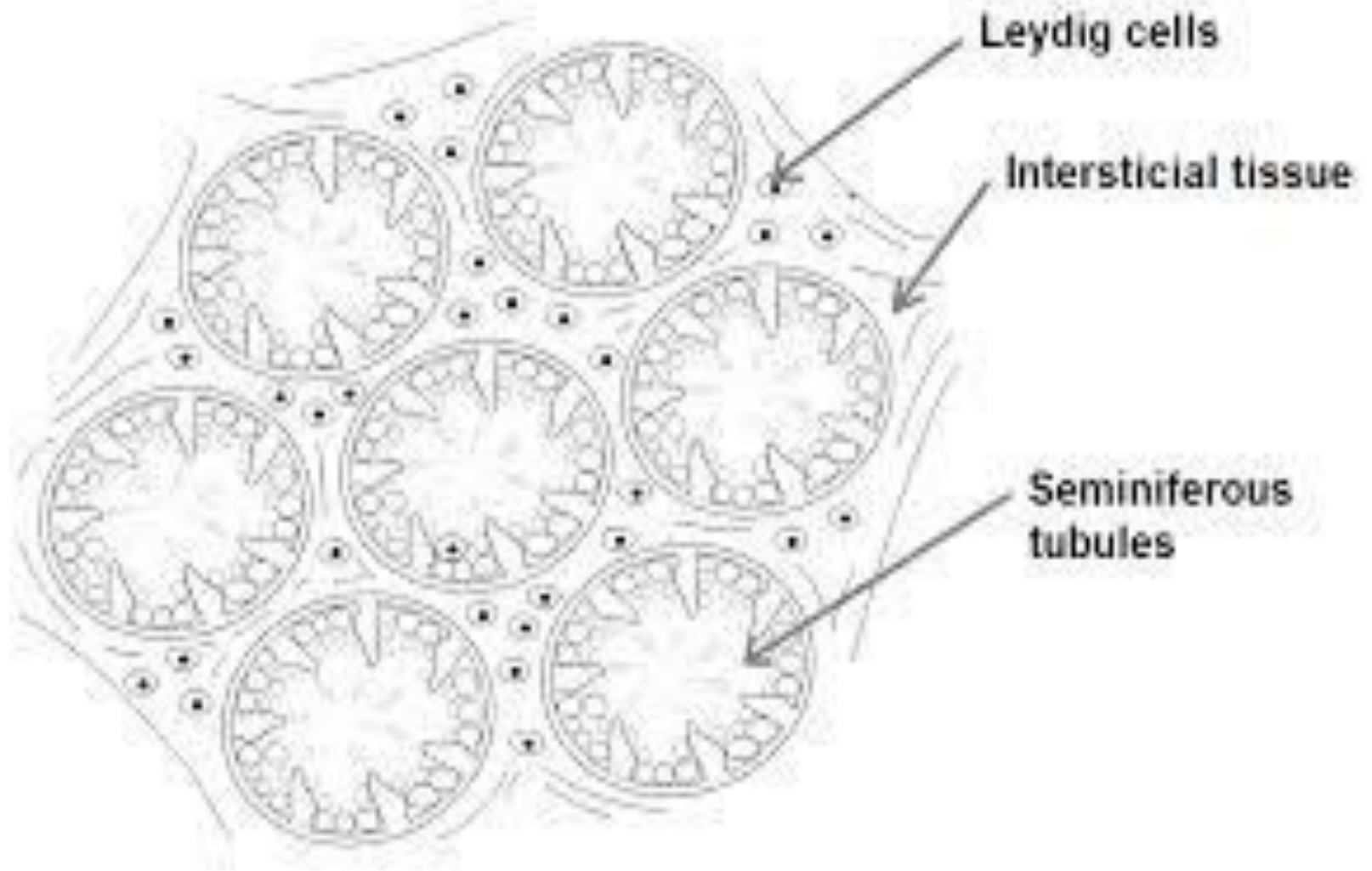
Testes



Testes

- The gonads (ovaries and testes) secrete hormones that help regulate reproductive functions.
- In the male, the testes secrete testosterone, which acts with luteinizing and follicle-stimulating hormones.
- LH and FSH are produced by adenohypophysis to stimulate spermatogenesis.

Testes



Testes

- Testosterone is also necessary for the growth and maintenance of the male sex organs.
- Promotes the development and maintenance of sexual behavior.
- In humans, it stimulates the growth of facial and pubic hair,

Testes

- It also stimulates the enlargement of the larynx, which deepens the voice.
- The testes also produce inhibin, which inhibits the secretion of FSH.

END

Animal Form and Function 1

Module 136



Animal Form and Function 1

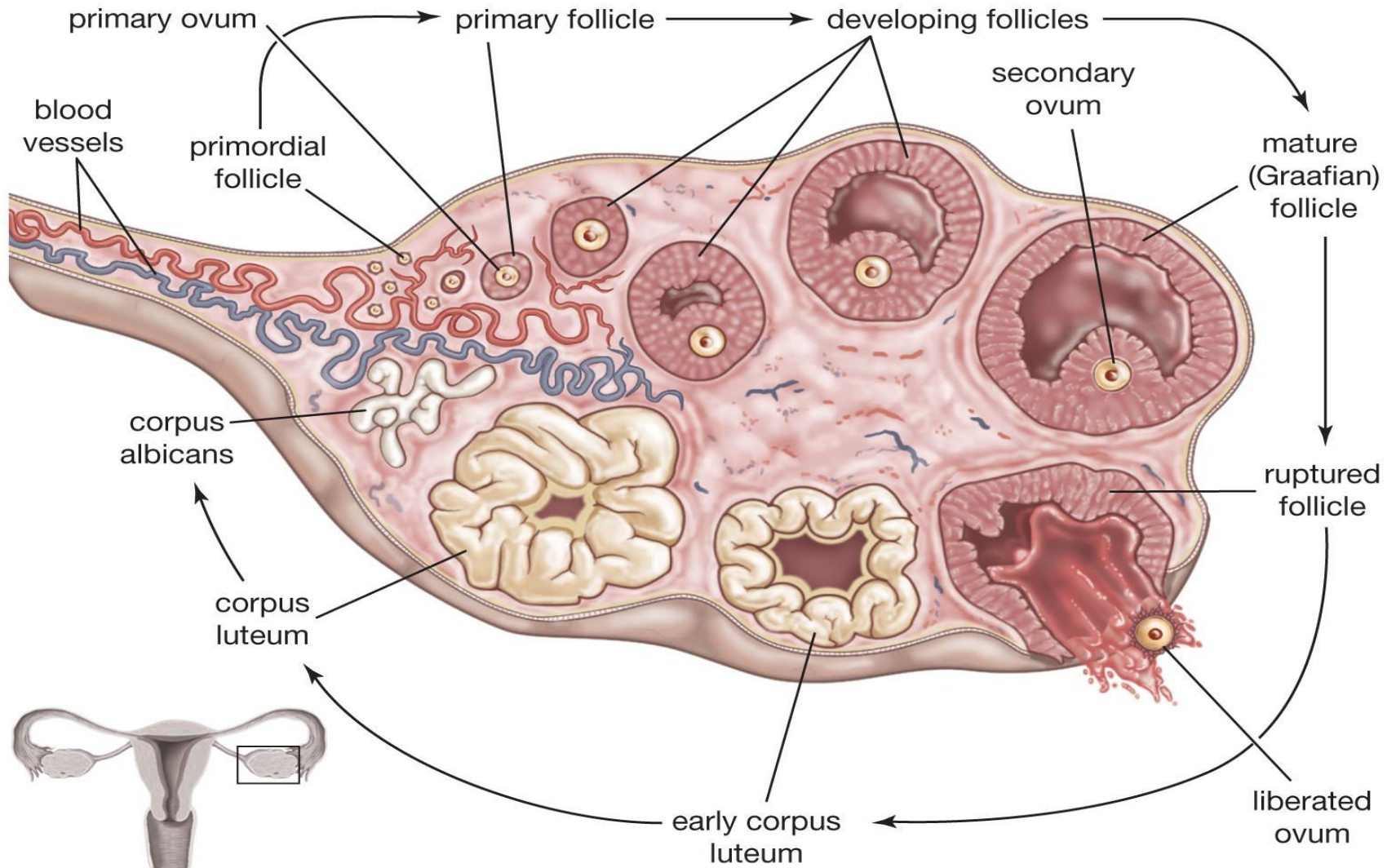
Ovaries

An abstract architectural sculpture made of large, curved, metallic-looking panels in shades of grey and blue. The structure is complex and organic, with many sharp angles and curves. It is set against a background of a modern building with large windows and a clear blue sky.

Ovaries

- The gonads (ovaries and testes) secrete hormones that help regulate reproductive functions.
- Four major classes of ovarian hormones help to regulate female reproductive functions.
 - 1. Estrogens (estrin, estrone, and estradiol).
 - 2. Progestins
 - 3. Relaxin
 - 4. Inhibin

Ovaries



Ovaries

- The **estrogens** help regulate the menstrual and estrus cycles and the development of the mammary glands and other female secondary sexual characteristics.
- The **progestins** (primarily progesterone) also regulate the menstrual and estrus cycles, and the development of mammary glands.

Ovaries

- It also aid in placenta formation during pregnancy.
- **Relaxin**, which is produced in small quantities, softens the opening of the uterus (cervix) at the time of delivery.
- The ovaries also produce **inhibin**, which inhibits the secretion of FSH.

END

Animal Form and Function 1

Module 137



Animal Form and Function 1

Thymus

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Thymus

- The thymus gland is a small organ behind the breastbone (sternum) that plays an important function both in the immune system and endocrine system.
- It is only active until puberty.
- After puberty, the thymus starts to shrink slowly and become replaced by fat.

Thymus

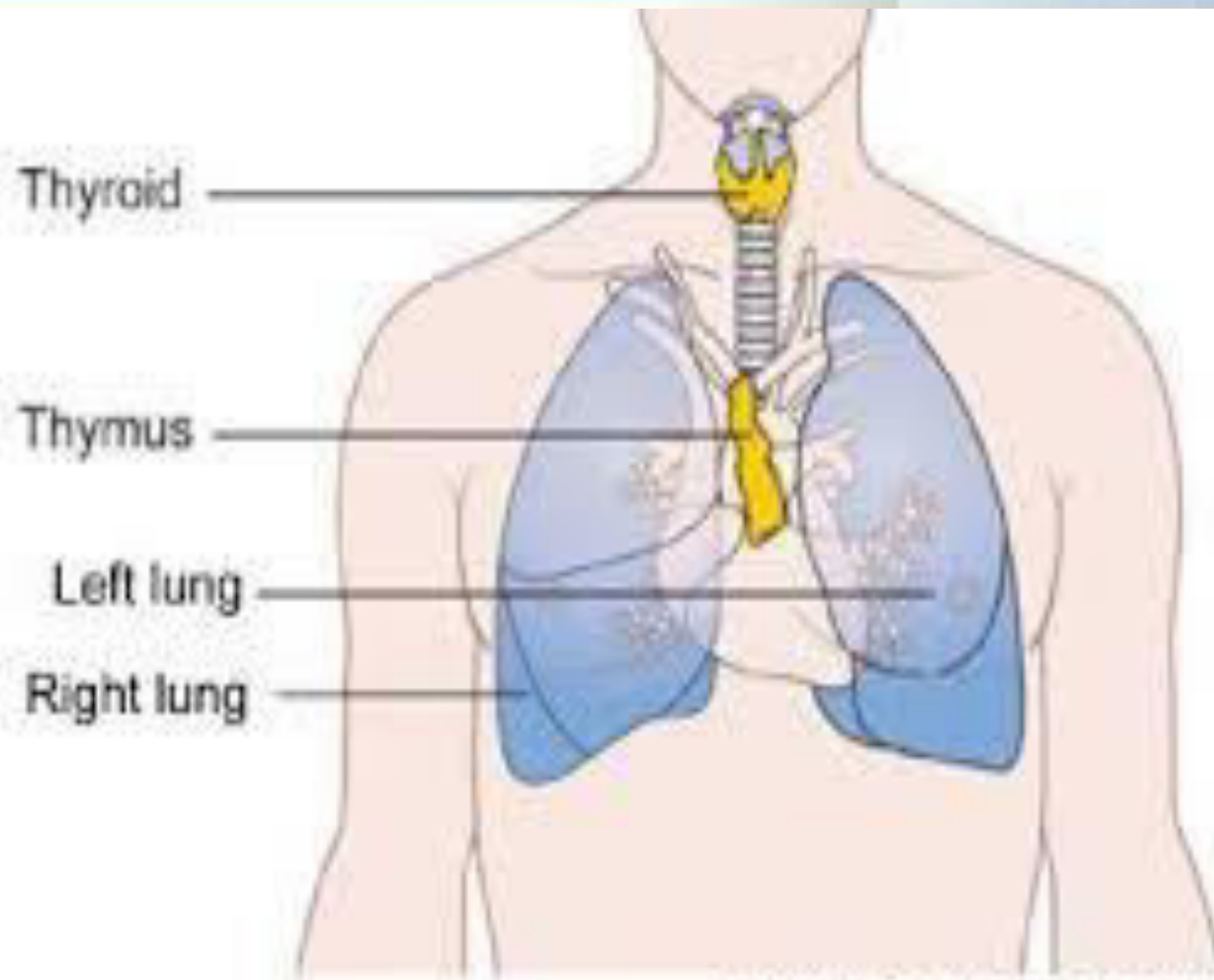


Diagram showing the position
of the thymus gland
Copyright © CancerHelp UK

Thymus

- Thymus produces, the hormone **thymosin**.
- It stimulates the development of white blood cells, called **T- lymphocytes**, which protect the body against infections.
- **T-cells created by the thymus also help other organs in the immune system grow properly.**

Thymus

- There are two types of T-cells in your body:
- Helper T-cells and
- Killer T-cells.
- Killer T-cells do the work of destroying the infected cells.
- The Helper T-cells coordinate the attack.

END

Animal Form and Function 1

Module 138



Animal Form and Function 1

Other Sources of Hormones Part I

Other Sources of Hormones Part I

- Placenta
- Digestive Tract
- Heart
- Kidneys and
- Adipose tissue are some more major organs that produce hormones.

Other Sources of Hormones Part I

- **PLACENTA:**
- **Produces estrogens, progesterone, human chorionic gonadotropin (hCG), human chorionic somatomammotropin (hCS).**
- **Maintain pregnancy.**
- **Target areas are the Ovaries, mammary glands and uterus.**

Other Sources of Hormones Part I

- **DIGESTIVE TRACT**
- Produce Secretin, Gastrin and Cholecystikin (CCK).
- Secretin stimulates the release of pancreatic juice to neutralize stomach acid.
- Gastrin stimulates digestive enzymes and HCl in stomach.

Other Sources of Hormones Part I

- Cholecystokinin (CCK).
- It stimulates the release of pancreatic enzymes and bile from gallbladder.
- HEART
- Produces the hormone, Atriopeptin that lowers blood pressure and maintains fluid balance.
- Streptokinase

Other Sources of Hormones Part I

- **HEART**
- Produces the hormone, Atrial natriuretic peptide that lowers blood pressure and maintains fluid balance.
- This is in response to a rise in blood pressure, the heart releases two peptides:

Other Sources of Hormones Part I

- **A-type Natriuretic Peptide (ANP)** This hormone of 28 amino acids is released from stretched atria (hence the "A").
- **B-type Natriuretic Peptide (BNP)** This hormone (29 amino acids) is released from the ventricles.

Other Sources of Hormones Part I

- Streptokinase is a protein (but, despite its name, not an enzyme).
- Streptokinase is used to dissolve blood clots that have formed in the blood vessels.
- Because of its antigenic nature, streptokinase is quickly removed from circulation.

END

Animal Form and Function 1

Module 139



Animal Form and Function 1

Other Sources of Hormones Part II

Other Sources of Hormones

- **KIDNEYS**
- Produce three hormones:
 1. Erythropoietin
 2. Urotensin and
 3. Calcitrol
- Erythropoietin
- stimulates red blood cell production, the target is bone marrow.
- Urotensin Stimulates constriction of the arteries.

Other Sources of Hormones

- **Calcitriol** aids in the absorption of dietary calcium and phosphorus from small intestine.
- **ADIPOSE TISSUE**
- It produces the hormone **leptin** that suppresses appetite by targeting brain.

END

Animal Form and Function 1

Module 140



Animal Form and Function 1

Summary of the Chapter Part I

Summary of the Chapter Part I

- For smooth metabolic activity to proceed in an animal, the chemical environment of each cell must be maintained within fairly narrow limits (homeostasis).
- This is accomplished using negative feedback systems.

Summary of the Chapter Part I

- This involves integration, communication, and coordination.
- **Specialized cells secrete messenger molecules.**
- These chemical messengers can be categorized as

Summary of the Chapter Part I

- 1. Local chemical messengers (lumones),
- 2. neurotransmitters (e.g., acetylcholine),
- 3. Neuropeptides,
- 4. Hormones and
- 5. Pheromones (e.g., sex attractant).

Summary of the Chapter Part I

- A hormone is a specialized chemical messenger that an endocrine gland or tissue produces.
- Hormones are usually steroids, amines, proteins, or fatty acid derivatives.

Summary of the Chapter Part I

- **Negative feedback systems often regulate hormone secretion.**
- Hormones modify the biochemical activity of a target cell or tissue.
- Mechanisms of hormone action are:

Summary of the Chapter Part I

- 1. the fixed-membrane receptor mechanism (water-soluble hormones).
- 2. the mobile receptor mechanism (steroid hormones).

End

Animal Form and Function 1

Module 141



Animal Form and Function 1

Summary of the Chapter Part II

Summary of the Chapter Part II

- Most of the chemicals functioning as hormones in invertebrate animals are neurosecretions called neuropeptides.
- Advanced invertebrates (e.g., molluscs, arthropods, echinoderms) have non neurosecretory hormones.

Summary of the Chapter Part II

- In all vertebrates there is a neuroendocrine control center.
- This center coordinates, communicates and integrate activities for the entire body.
- This center consists of the hypothalamus and pituitary gland. .

Summary of the Chapter Part II

- The vertebrate endocrine system consists of several major glands:
 - Hypothalamus,
 - Pituitary gland,
 - Pineal gland,
 - Thyroid gland,
 - Parathyroid glands,
 - Adrenal glands,
 - Pancreas,
 - Gonads, and
 - Thymus.

Summary of the Chapter Part II

- In addition to these major glands, other glands and organs that carry on hormonal activity include:
 - Placenta,
 - Digestive tract,
 - Heart, and
 - Kidneys
 - Mind-body link occurs through the hypothalamus.

Summary of the Chapter Part II

- Mental states strongly affect the function of many endocrine glands.
- This mind-body link occurs through the hypothalamus.
- Try to describe yourself, how thoughts are transformed into physiological responses?

Summary of the Chapter Part II

- Compared to enzymes and genes, hormones are remarkably small molecules.

END

Animal Form and Function 1

Module 142



Animal Form and Function 1

Introduction of Transport System in Animals

Introduction of Transport System in Animals

Evolutionary Perspective:

- Unicellular animals have a large surface area to volume ratio.
- There is sufficient area available for the transport of substances which move into and out of the bodies.
- This transport in by different ways:
 - Diffusion, Osmosis, Active transport.

Introduction of Transport System in Animals

- Thus there is no special transport system in unicellular animals.
- Same is true with simple aquatic multicellular animals. E.g. Hydra.
- On the contrary, multicellular animals possess well developed and well arranged transport system in the form of blood transport system.

Animal Form and Function 1

Module 143



Animal Form and Function 1

Transport System in Protozoa, Porifera and Cnidaria

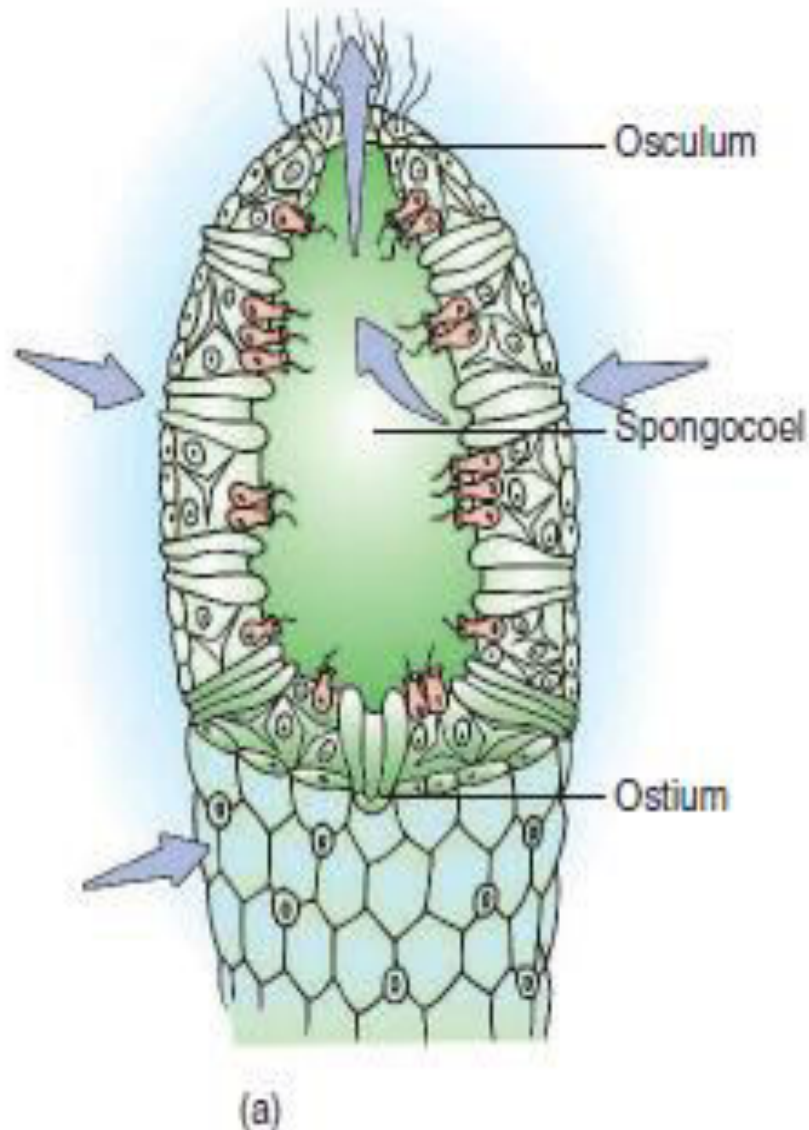
Transport System in Protozoa, Porifera & Cnidaria

- **Protozoa are small, with high surface area-to-volume ratios.**
- Plasma membrane and cytoplasm are the media through which materials such as gas, nutrients and wastes diffuse to various parts of the organism, or between the organism and the environment.

Transport System in Protozoa, Porifera & Cnidaria

- **Sponges** circulate water from the external environment through their bodies, instead of circulating an internal fluid.
- **Cnidarians**, such as Hydra, have a fluid-filled internal gastro vascular cavity.

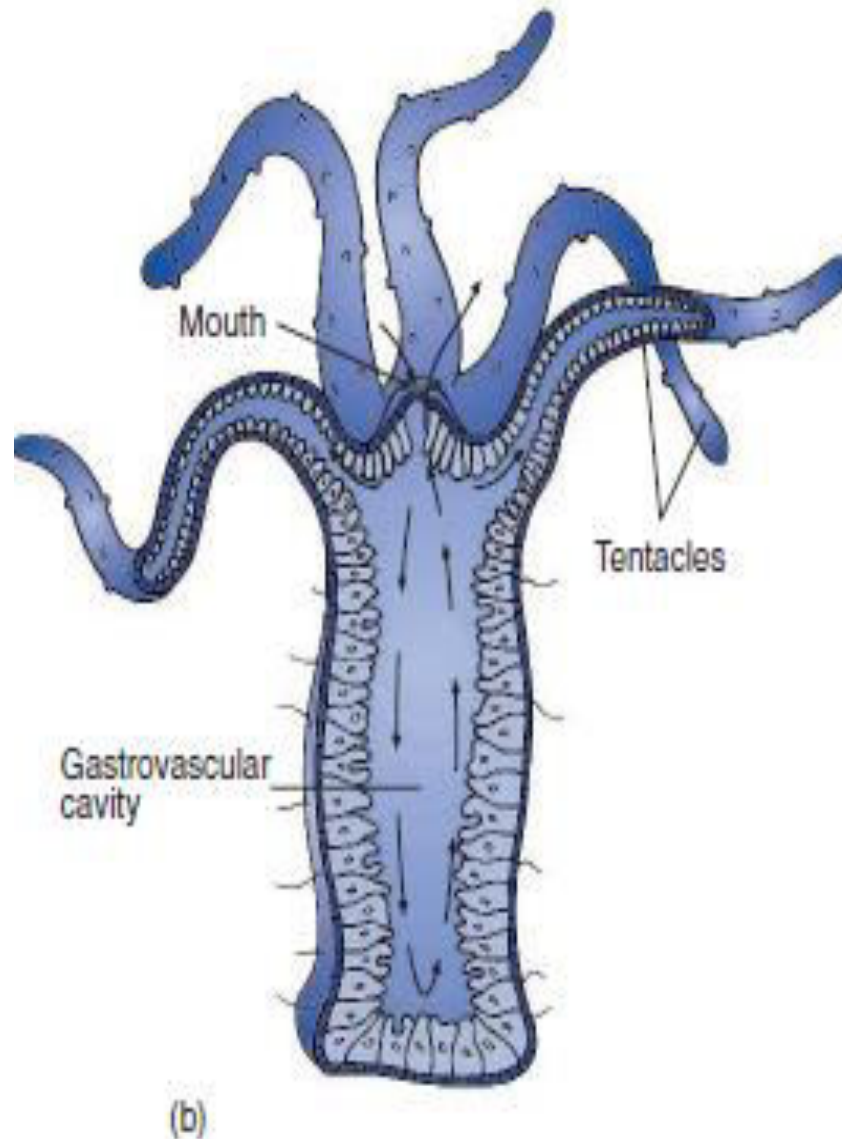
Transport System in Protozoa, Porifera & Cnidaria



Transport System in Protozoa, Porifera & Cnidaria

- This cavity supplies nutrients for all body cells lining the cavity, provides oxygen from the water in the cavity.
- It is a reservoir for carbon dioxide and other wastes.
- Simple body movement moves the fluid.

Transport System in Protozoa, Porifera & Cnidaria



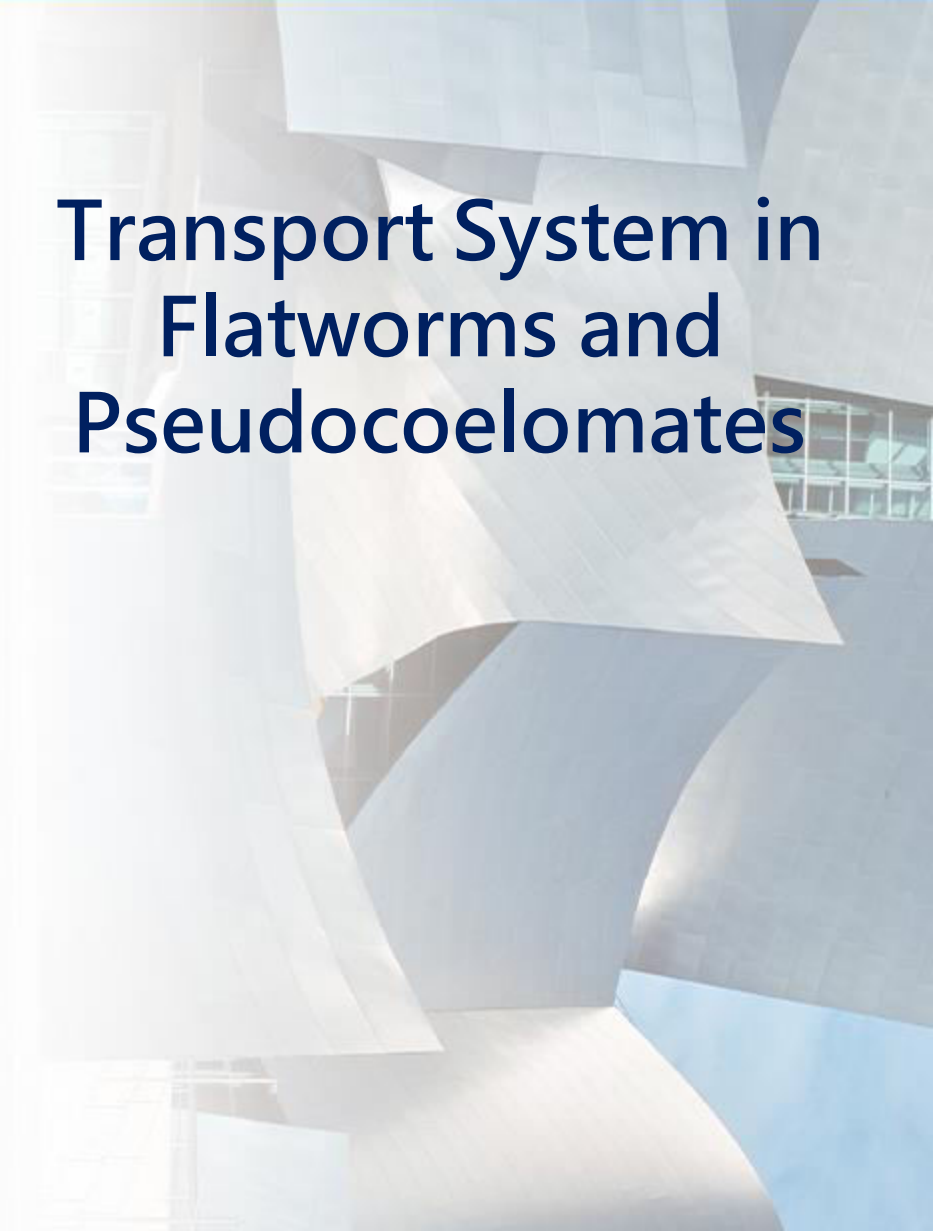
Animal Form and Function 1

Module 144



Animal Form and Function 1

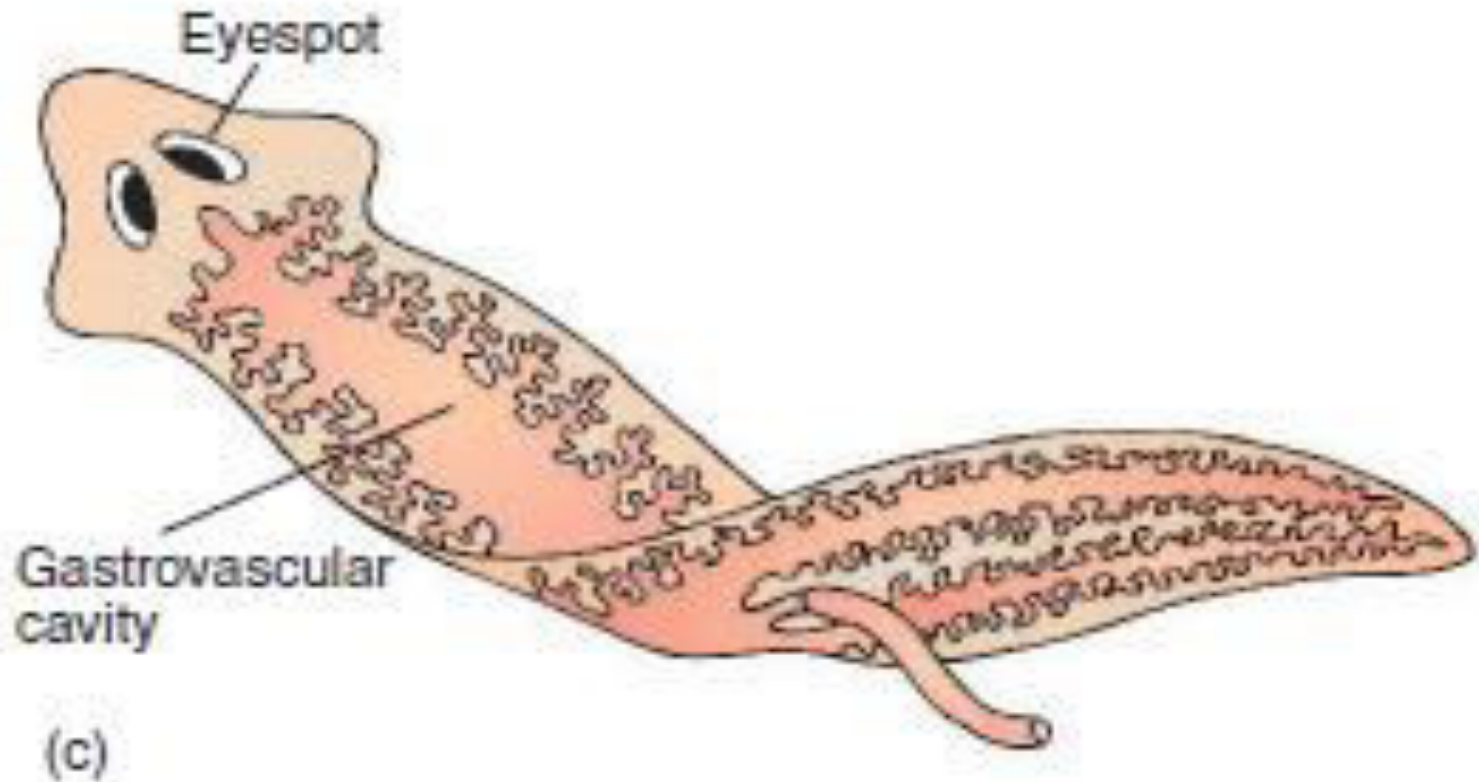
Transport System in Flatworms and Pseudocoelomates



TS in Flatworms & Pseudocoelomates

- In flatworms, such as the planarian the gastrovascular cavity is more complex than that of Hydra.
- In planarian, branches penetrate to all parts of the body.
- The branched gastrovascular cavity runs close to all body cells.

TS in Flatworms & Pseudocoelomates



TS in Flatworms & Pseudocoelomates

- Diffusion is effective for the transport of nutrients, gases, and wastes.
- Body movement helps distribute materials to various parts of the body.

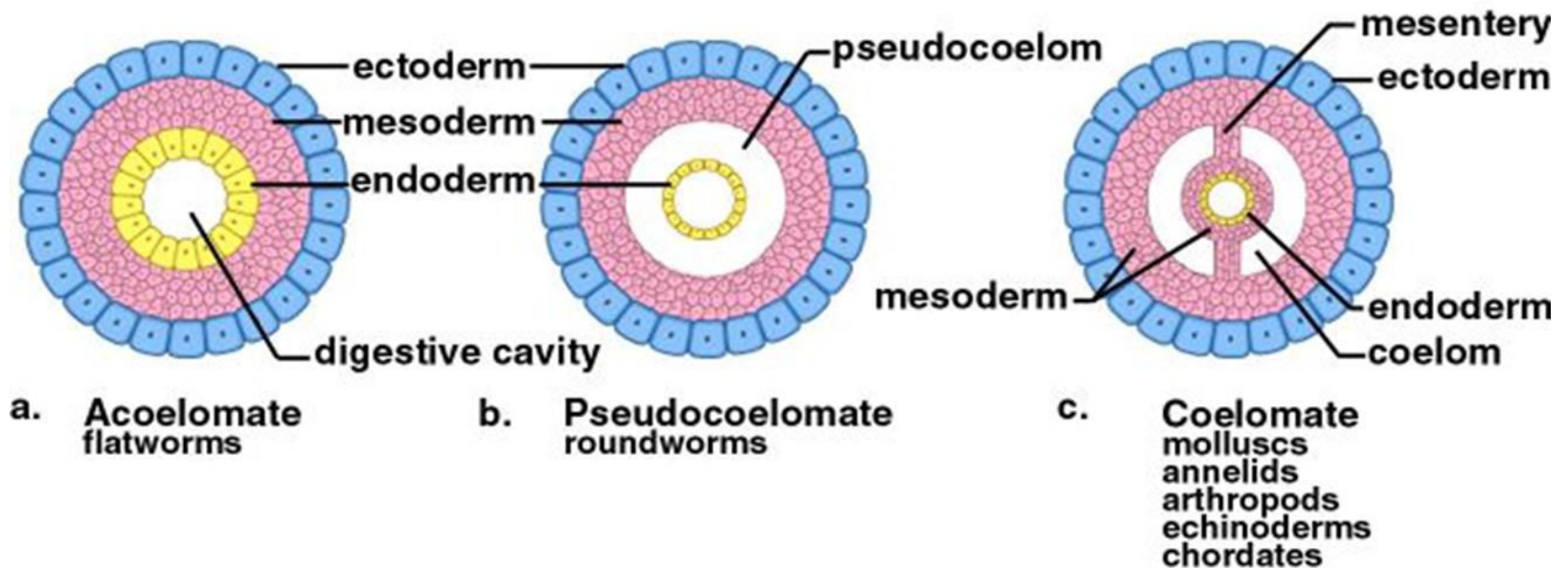
TS in Flatworms & Pseudocoelomates

- **Pseudocoelomate invertebrates, such as rotifers, gastrotrichs, and nematodes, use the coelomic fluid of their body cavity for transport.**
- Coelomic fluids, are in direct contact with the internal organs and, produce adequate transport

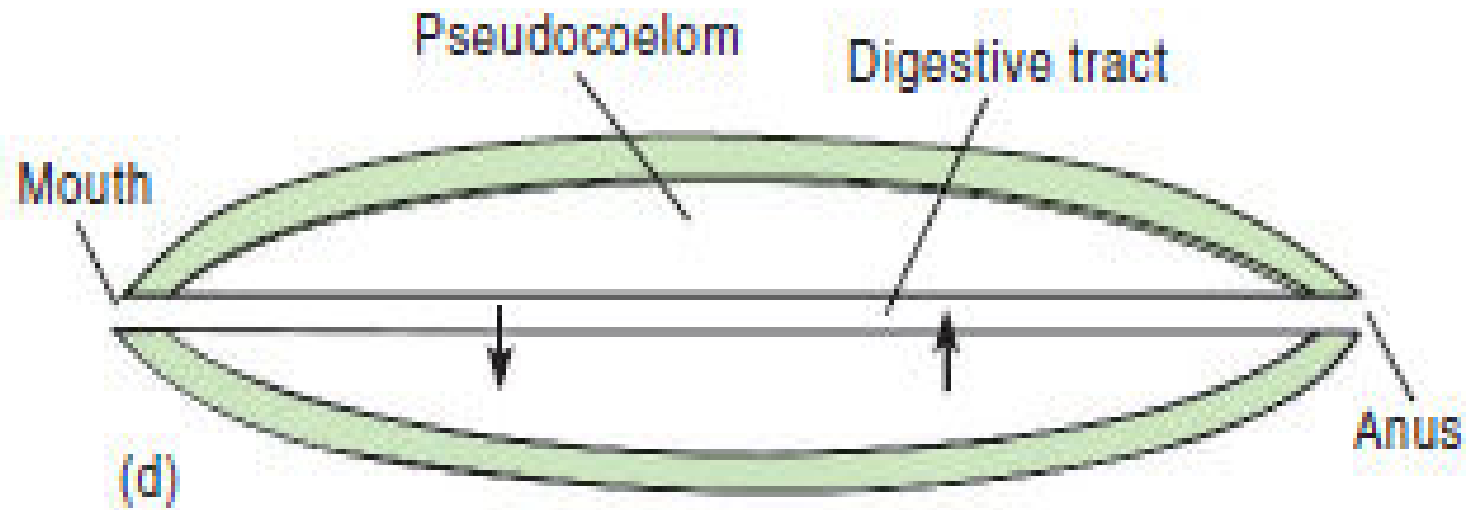
TS in Flatworms & Pseudocoelomates

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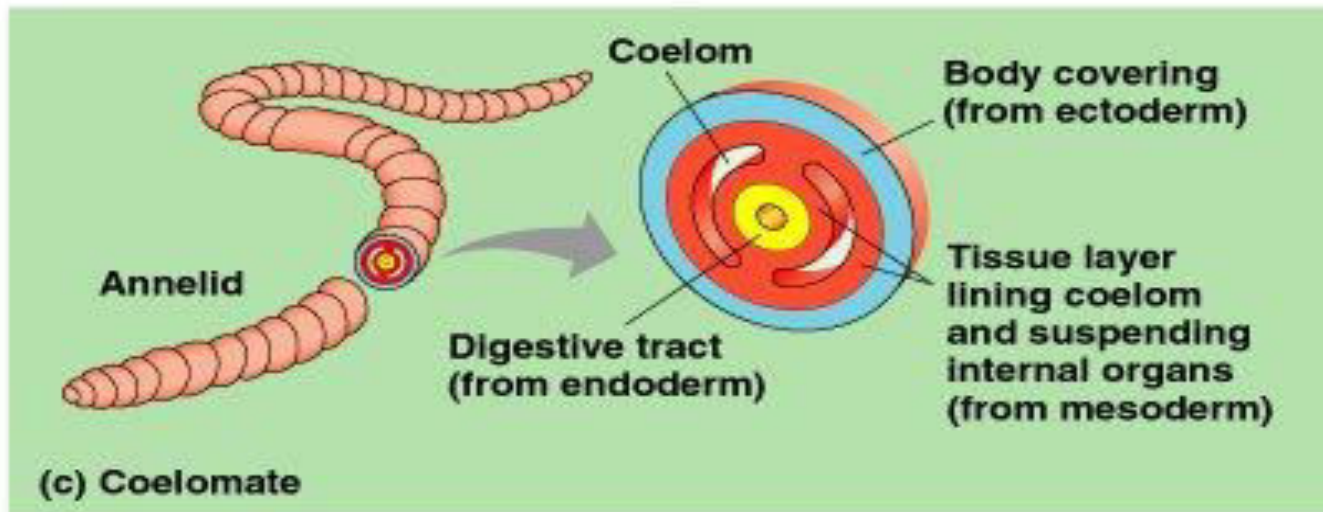
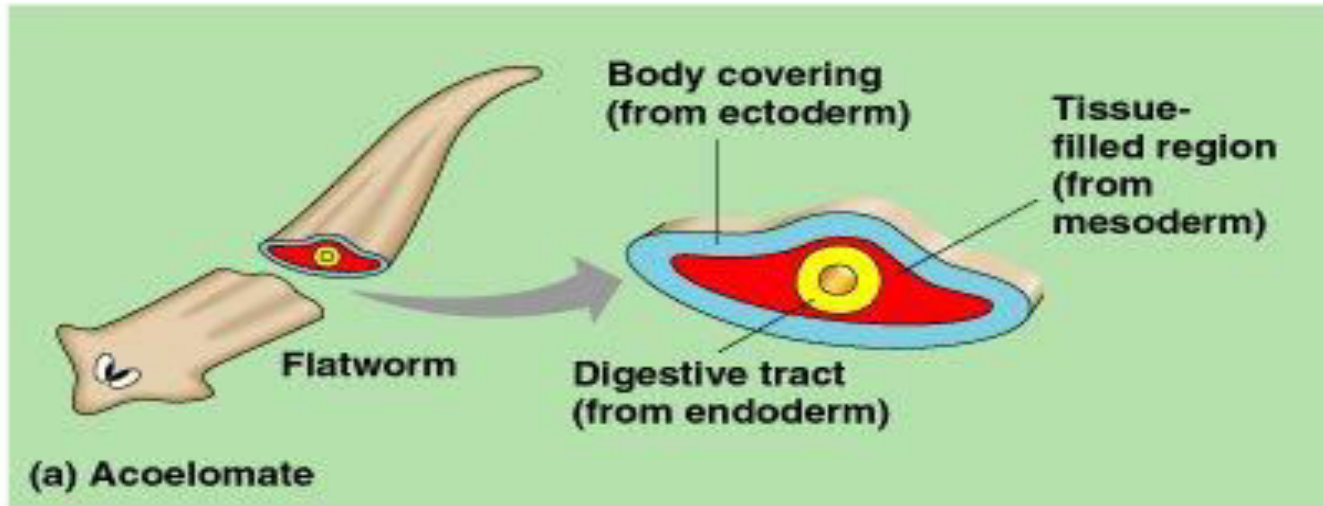
Acoelomate, pseudocoelomate, coelomate comparison



TS in Flatworms & Pseudocoelomates



TS in Flatworms & Pseudocoelomates



TS in Flatworms & Pseudocoelomates

- A few other invertebrates (e.g., ectoprocts, echinoderms) also depend largely on the body cavity as a coelomic transport chamber.

Animal Form and Function 1

Module 145



Animal Form and Function 1

Transport System and its Types



Transport System and its Types

- Larger and complex animals in which surface area-to-volume ratio is very little, diffusion is ineffective to transport materials.
- Therefore, these animals have evolved systems in the form of circulatory system.

Transport System and its Types

Components of Transport System:

1. Circulatory Fluid(blood)
2. Pumping device (heart)
3. Vessels (arteries, veins, capillaries)

Types of Circulatory System

Open CS and
Closed CS

Transport System and its Types

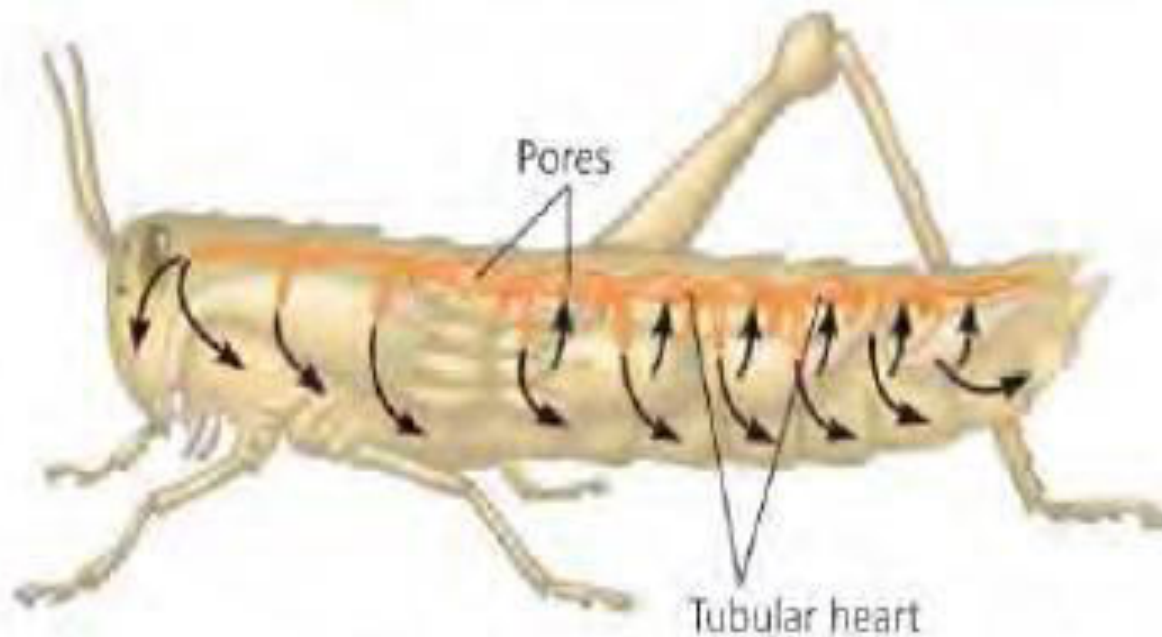
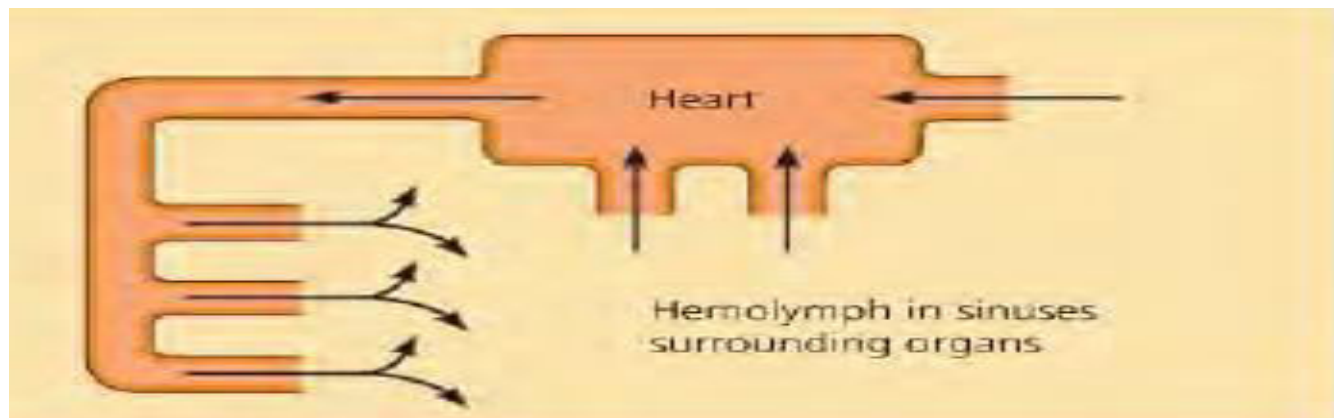
Open Circulatory System:

- In this system the circulatory fluid, the hemolymph is pumped out in the body cavity and comes in direct contact with other body cells. E.g arthropods, mollusks etc.

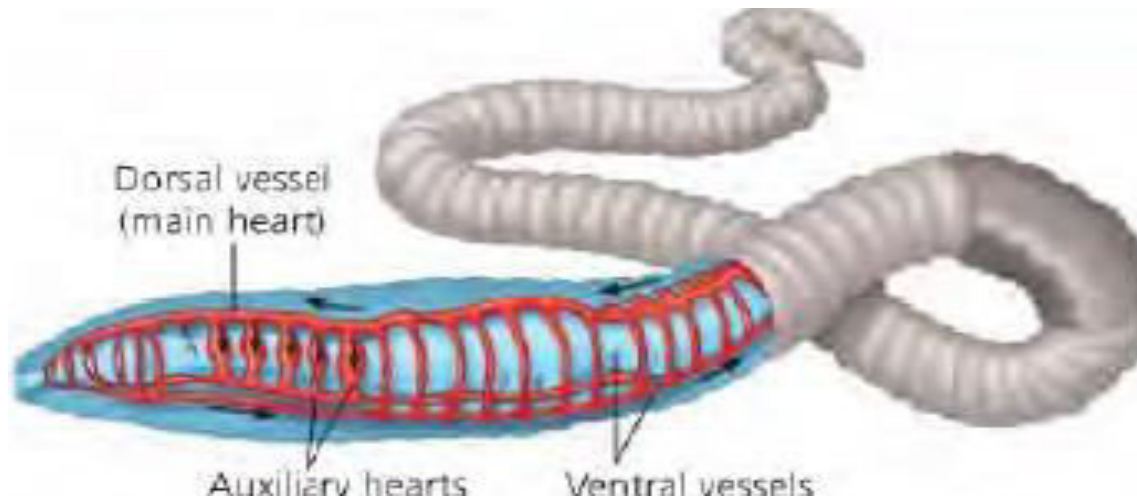
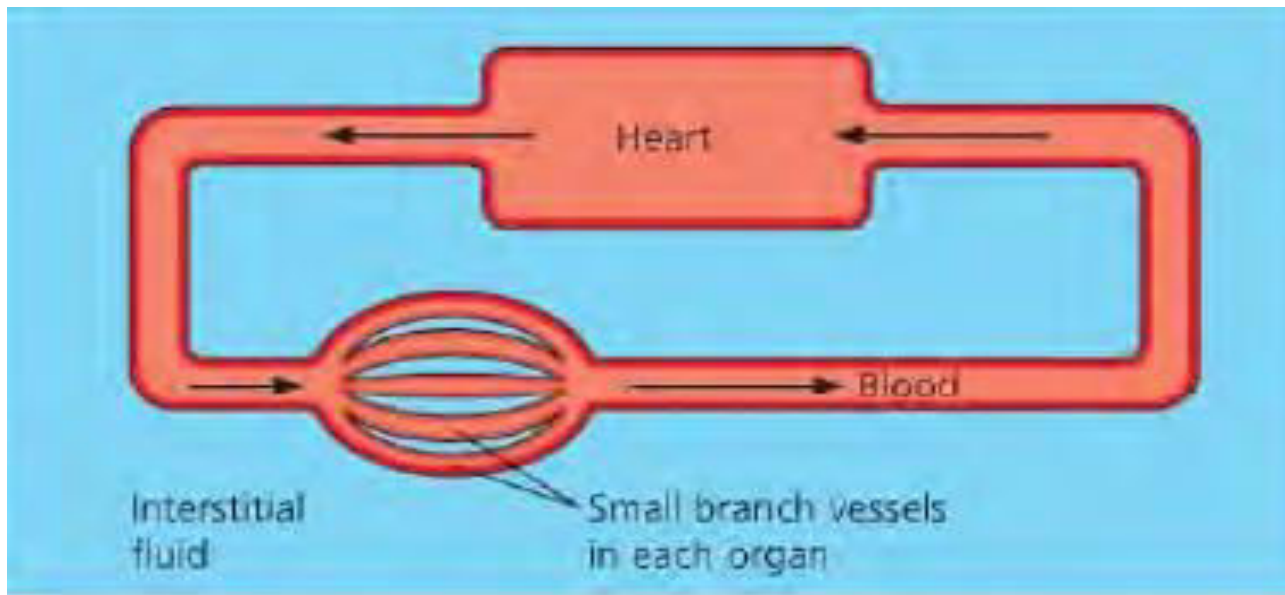
Closed Circulatory System:

- Blood circulates in vessels. E.g. Annelis and vertebrtaes.

Transport System and its Types



Transport System and its Types



Animal Form and Function 1

Module 146



Animal Form and Function 1

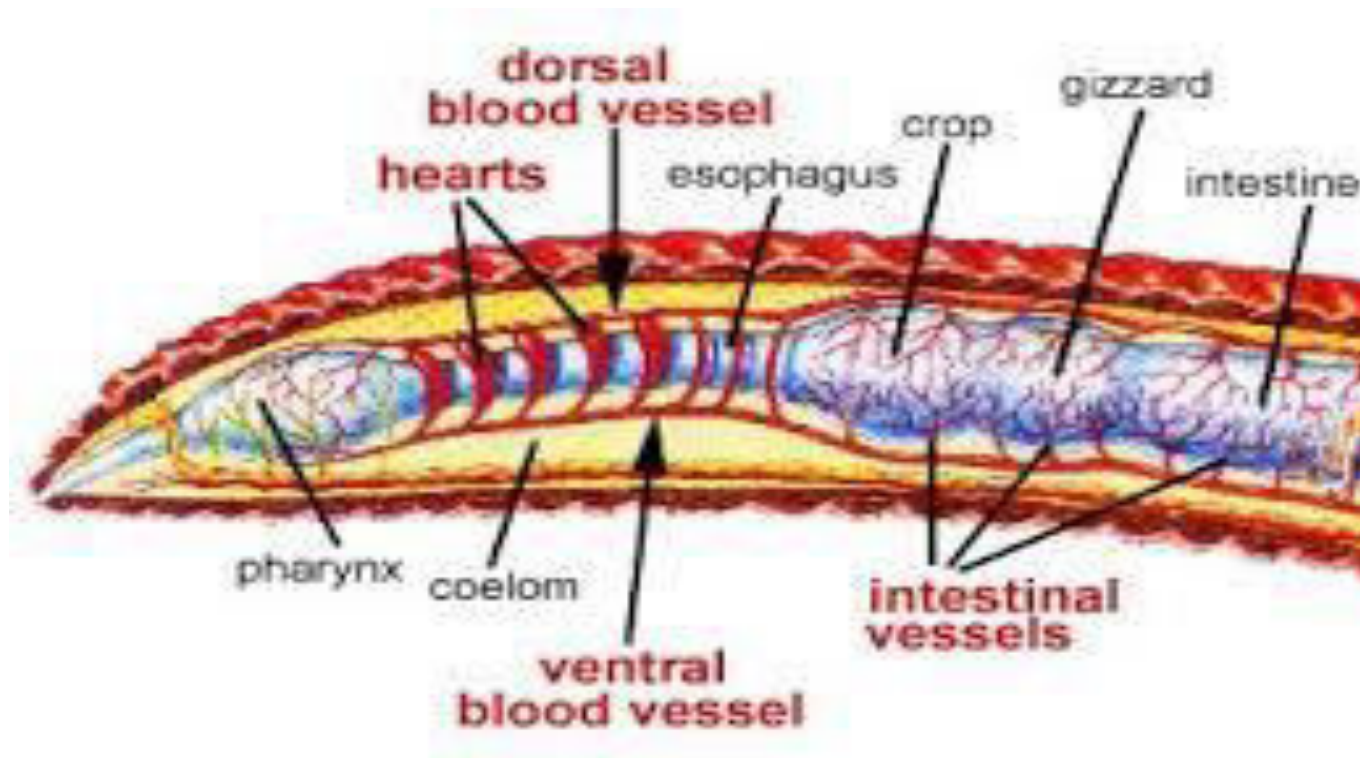
Transport System in Annelids, Molluscs and Arthropods

TS in Annelids, Molluscs and Arthropods

- The **annelids**, such as the earthworm, have a closed circulatory system in which blood travels through vessels delivering nutrients to cells and removing wastes.
- Most **molluscs** and arthropods have open circulatory systems

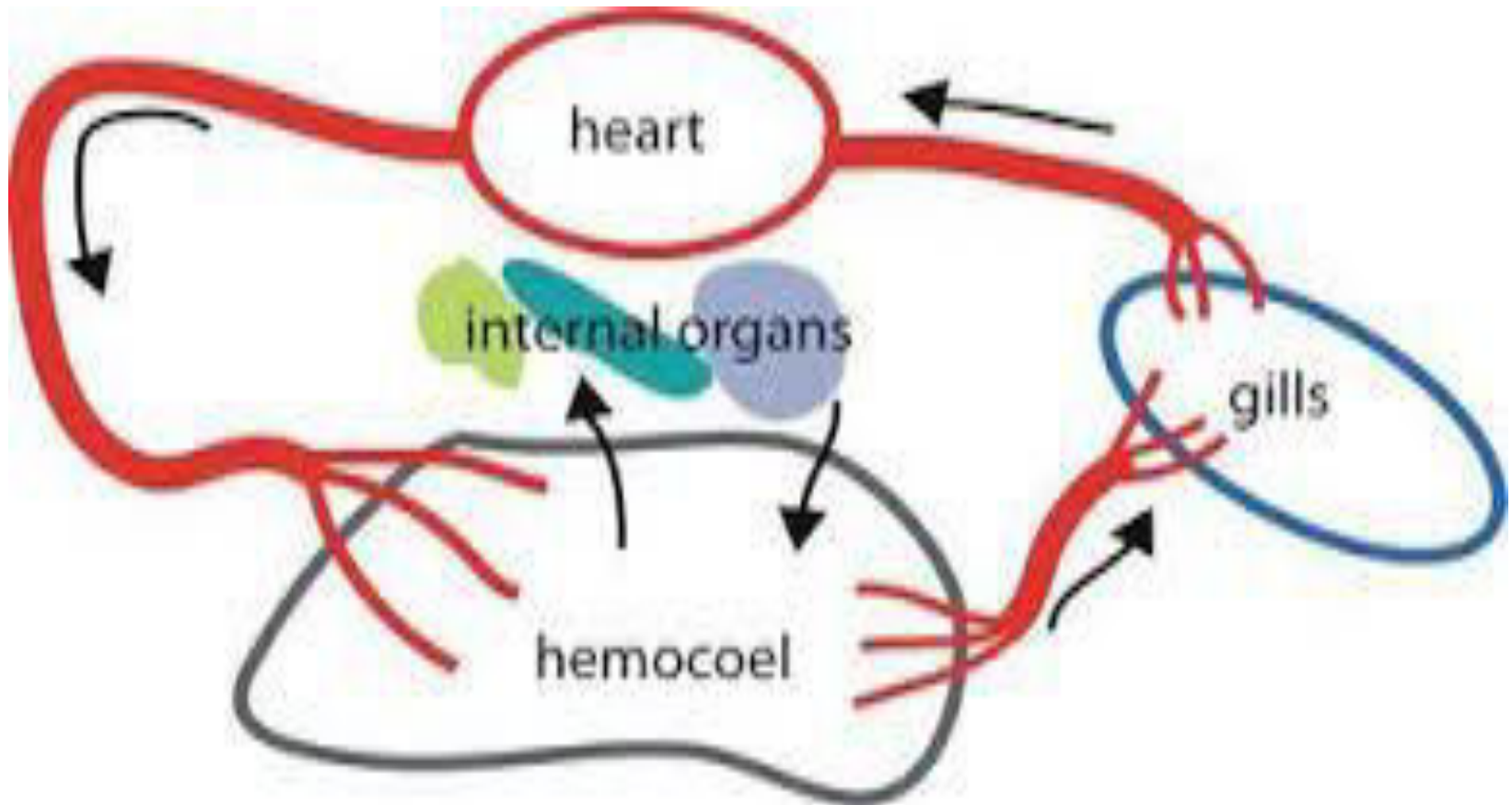
TS in Annelids, Molluscs and Arthropods

CS of earthworm



TS in Annelids, Molluscs and Arthropods

CS of a Mollusc

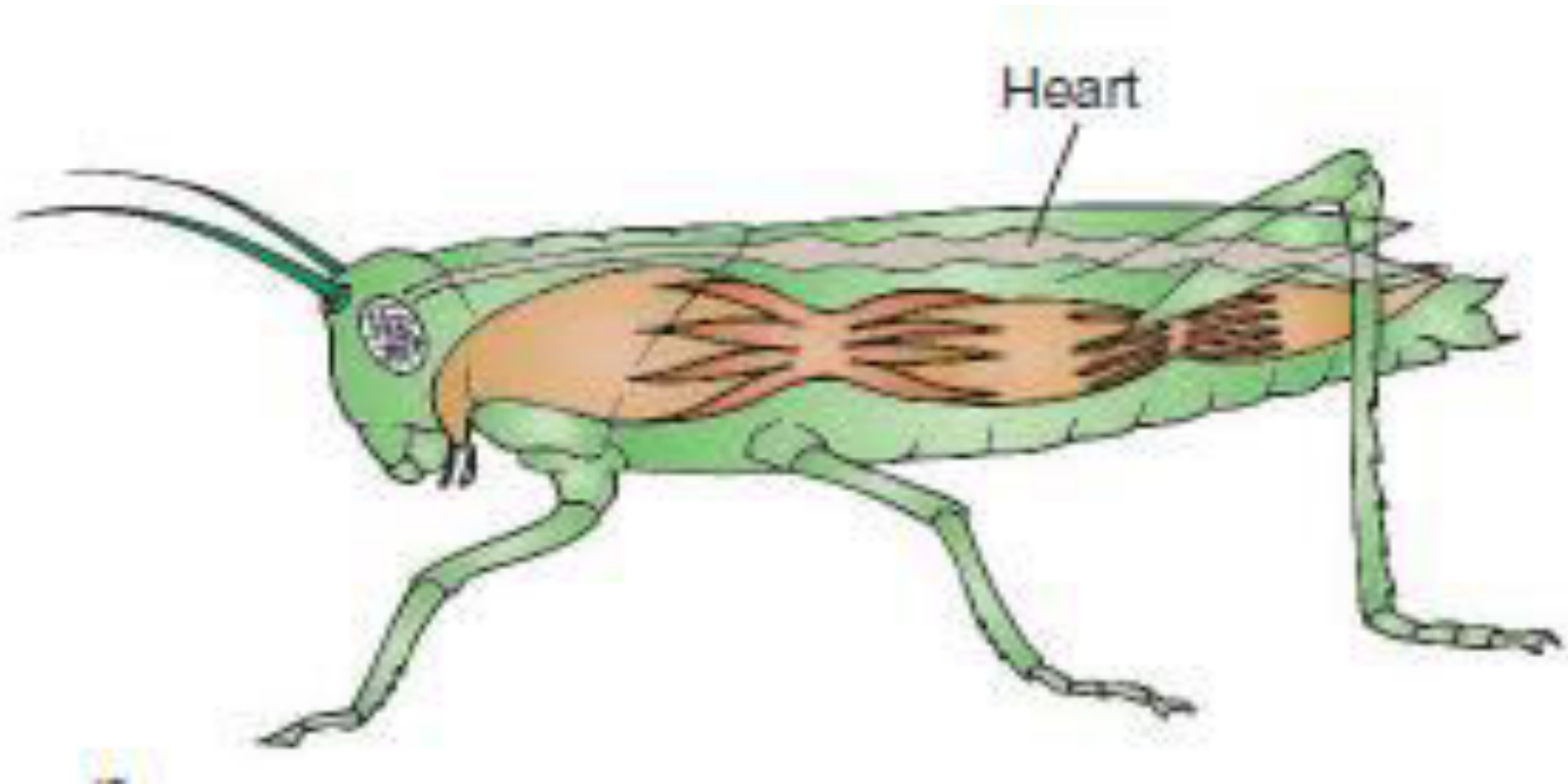


TS in Annelids, Molluscs and Arthropods

- In Insects heart pumps hemolymph through vessels that open into a body cavity (hemocoel).
- Hemolymph directly bathes the cells and tissues rather than being carried only in vessels.

TS in Annelids, Molluscs and Arthropods

CS of Grasshopper



Animal Form and Function 1

Module 147



Animal Form and Function 1

Coelomic Fluid, and Haemplymph in Invertebrates

Coelomic Fluid & Haemolymph in Invertebrates

- Some invertebrates e.g. annelids, echinoderms, use coelomic fluid as a sole circulatory or supplementary system.
- Coelomic fluid may be identical in composition to interstitial fluids or may differ, particularly with respect to specific proteins and cells.

Coelomic Fluid & Haemolymph in Invertebrates

- **Coelomic fluid** transports gases, nutrients, and waste products.
- It also may function as a hydrostatic skeleton in certain invertebrates such as in annelids.
- **Hemolymph** is the circulating fluid of animals with an open circulatory system.

Coelomic Fluid & Haemolymph in Invertebrates

- Most arthropods, ascidians, and many molluscs have hemolymph.
- In these animals, a heart pumps hemolymph at low pressures through vessels to tissue spaces (hemocoel) and sinuses.
- Generally, the hemolymph volume is high and the circulation slow.

Coelomic Fluid & Haemolymph in Invertebrates

- Essential gases, nutrients, and wastes are transported by hemolymph.
- Many times, hemolymph has non circulatory functions.
- For example, in insects, hemolymph pressure assists in molting of the old cuticle and in the movements of the wings.

Coelomic Fluid & Haemolymph in Invertebrates

- In certain jumping spiders, hydrostatic pressure of the hemolymph provides a hydraulic mechanism for limb extension.

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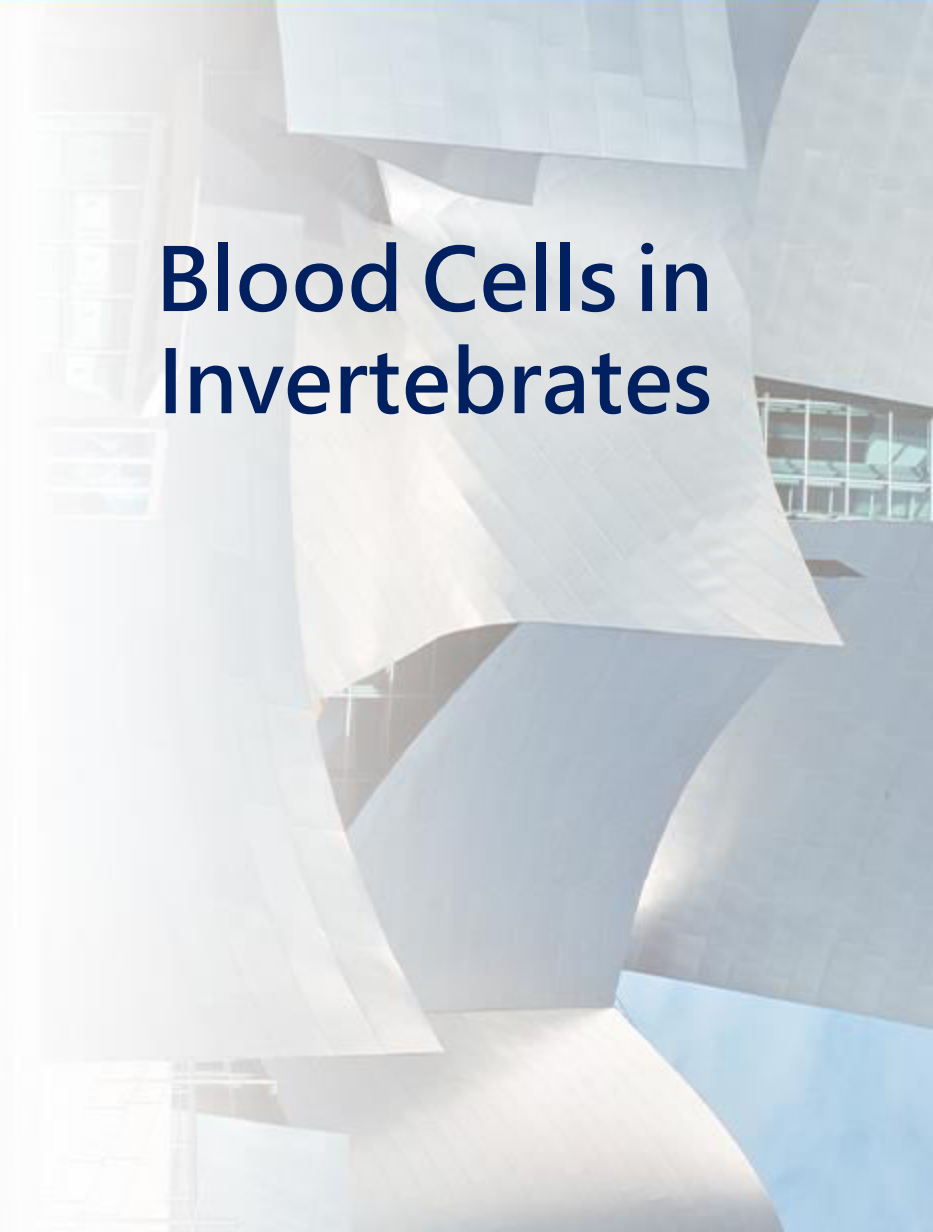
Animal Form and Function 1

Module 148



Animal Form and Function 1

Blood Cells in Invertebrates



Blood Cells in Invertebrates

- The coelomic fluid, hemolymph, or blood of most animals contains circulating cells called blood cells or hemocytes.
- Some cells contain a respiratory pigment, such as hemoglobin, and are called erythrocytes or red blood cells.

Blood Cells in Invertebrates

- These cells are usually present in high numbers to facilitate oxygen transport.
- Cells that do not contain respiratory pigments have other functions, such as blood clotting.
- The number and types of blood cells vary dramatically in different invertebrates.

Blood Cells in Invertebrates

- For example, annelid blood contains hemocytes that are phagocytic.
- The coelomic fluid contains a variety of coelomocytes:
 - 1. amoebocytes,
 - 2. eleocytes,
 - 3. lampocytes and
 - 4. linocytes

Blood Cells in Invertebrates

- They all function in phagocytosis, glycogen storage, encapsulation, defense responses, and excretion.
- The hemolymph of molluscs has two general types of hemocytes:
 - 1. Amoebocytes and
 - 2. Granulocytes)

Blood Cells in Invertebrates

- Apart from the functions already mentioned, they have another function called nacrezation (pearl formation) in some bivalves.
- Natural Pearls form when an irritant - usually a parasite is coated by a fluid as a defense. Layer upon layer of this coating, called 'nacre', is deposited until a lustrous pearl is formed.

Blood Cells in Invertebrates

- Insect hemolymph contains large numbers of various hemocyte types that function in phagocytosis, encapsulation, and clotting.

Blood Cells in Invertebrates

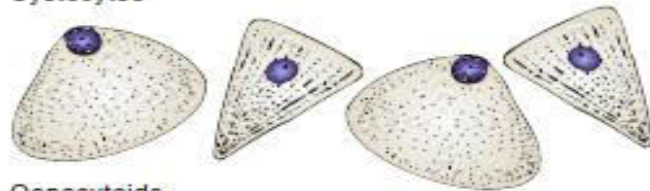
Invertebrate Hemocytes



Vermiform cell



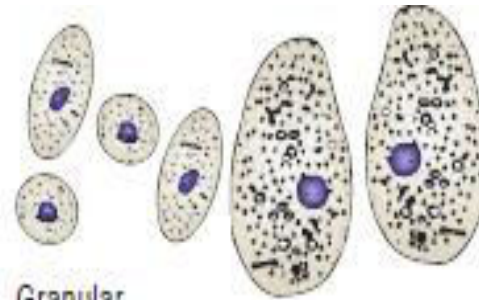
Cystocytes



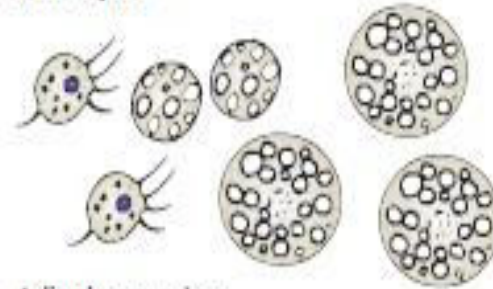
Oenocytoids



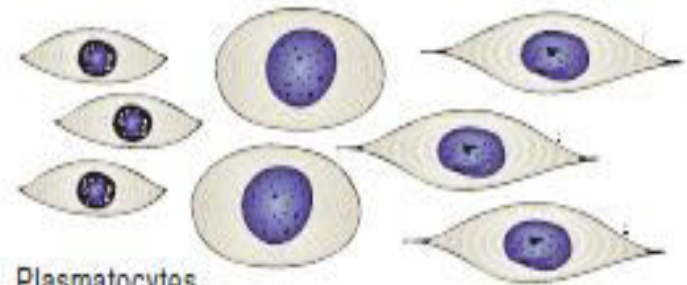
Spherule cells



Granular hemocytes



Adipohemocytes



Plasmatocytes

Animal Form and Function 1

Module 149



Animal Form and Function 1

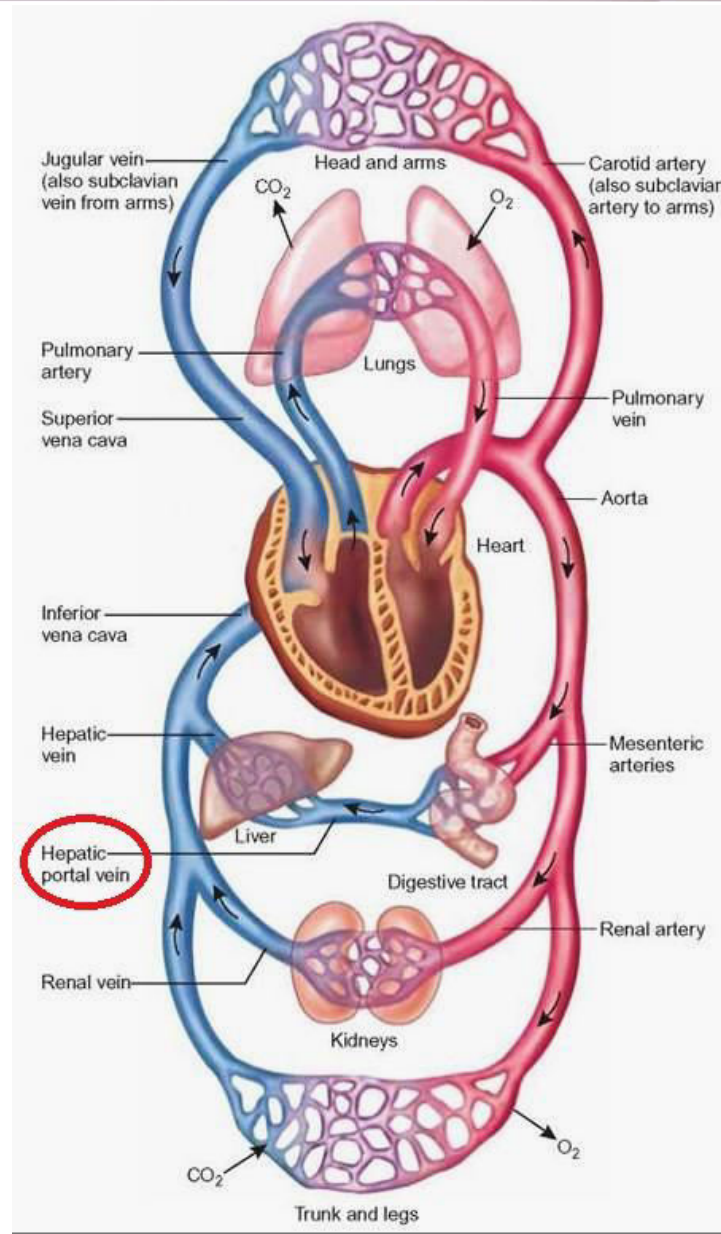
Transport System in Vertebrates



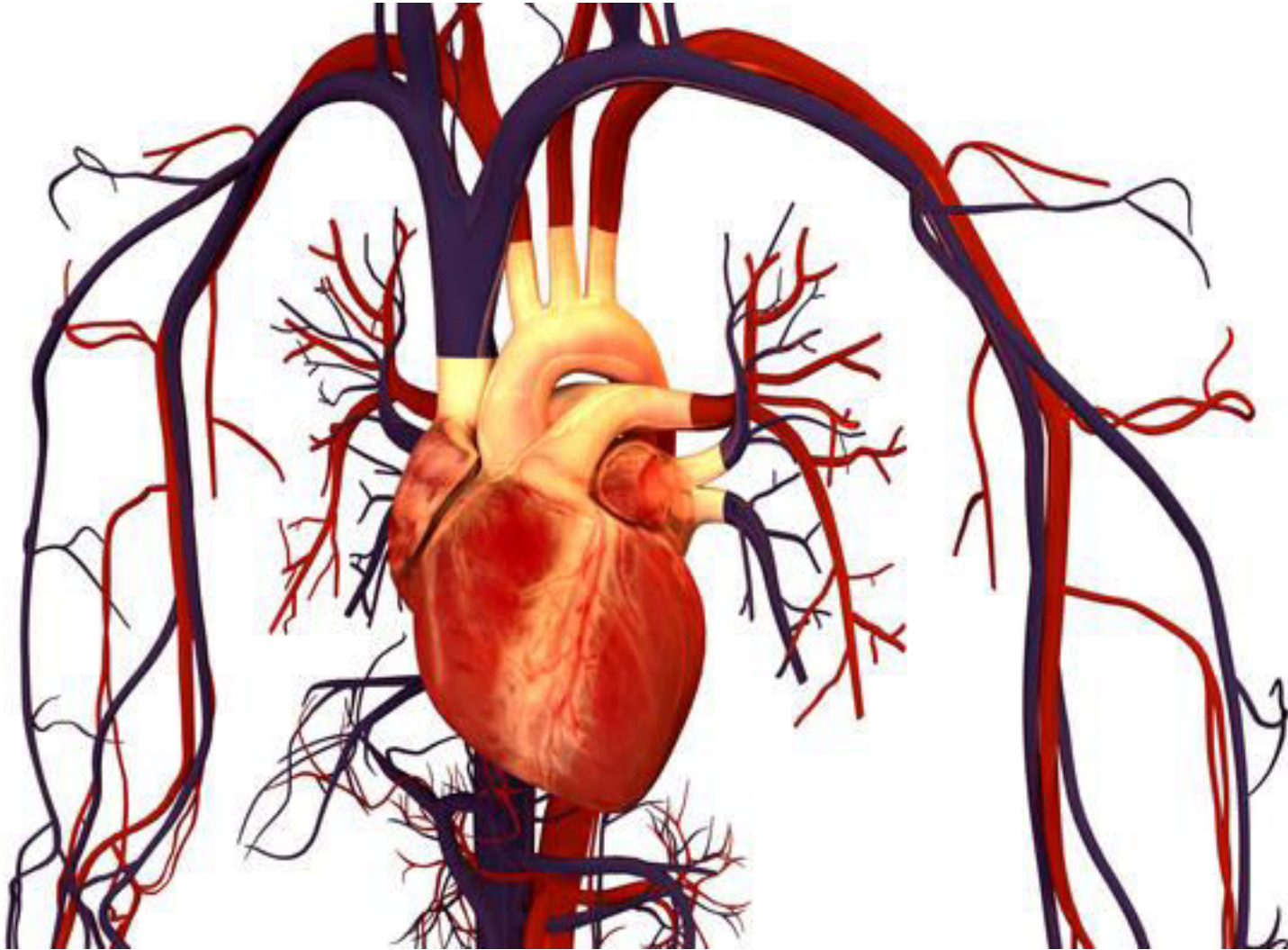
Transport System in Vertebrates

- All vertebrates have a closed circulatory system in which the blood never leaves the blood vessels.
- Blood moves from the heart, through arteries, arterioles, capillaries, venules, veins, and back to the heart.
- Exchange between the blood and extracellular fluid only occurs at the capillary level.

Transport System in Vertebrates



Transport System in Vertebrates



Transport System in Vertebrates

- The heart is the center to the circulatory system.
- It is fist-sized pump that circulates the blood throughout the body.
- As animals became more multicellular & complex the circulatory system evolved because simple diffusion was insufficient to supply all of the cells with nutrients.

Transport System in Vertebrates

- The coordination of the circulatory system and the respiratory system to ensure proper gas exchange is very important in animals that have lungs and gills.

END

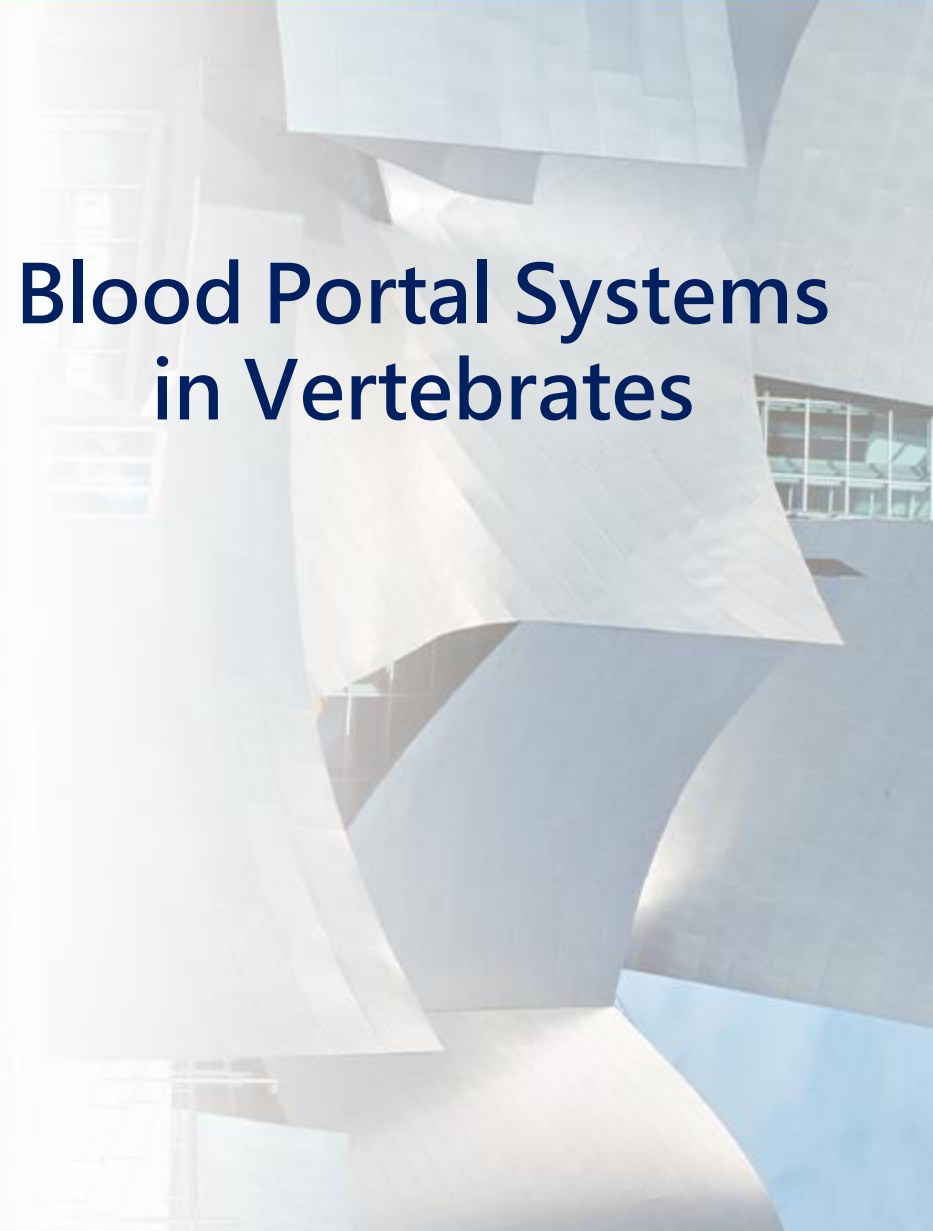
Animal Form and Function 1

Module 150



Animal Form and Function 1

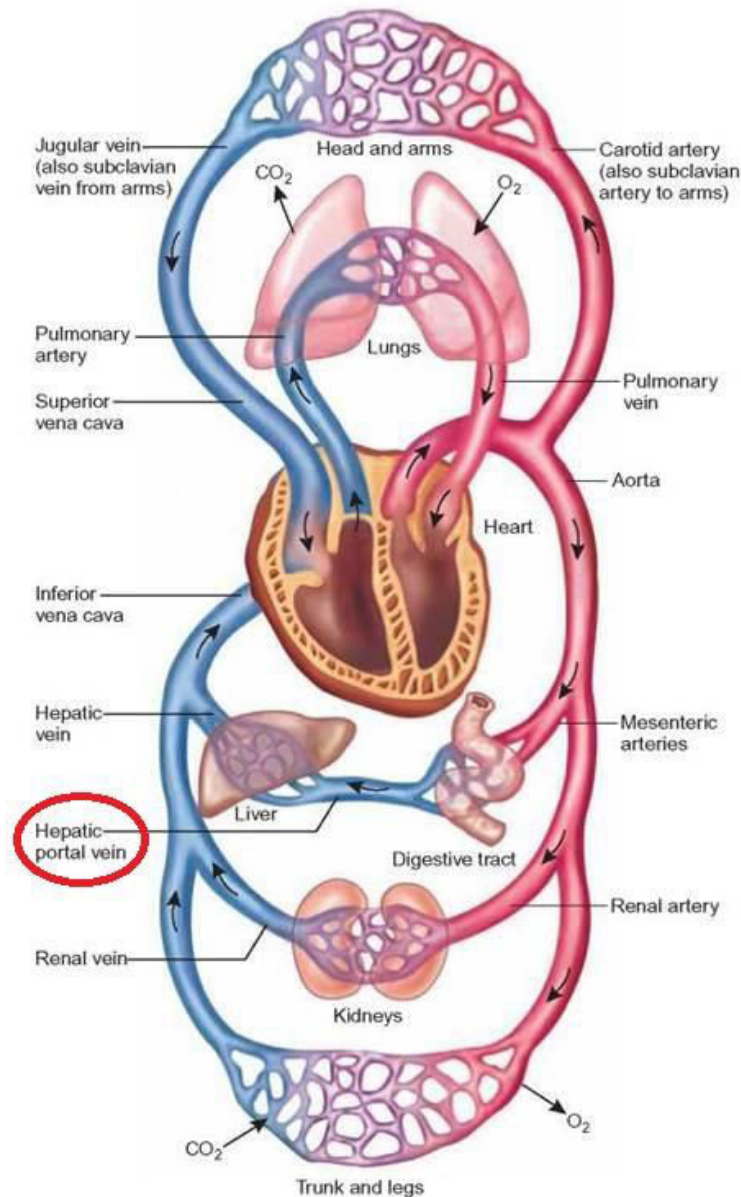
Blood Portal Systems in Vertebrates



Blood Portal Systems in Vertebrates

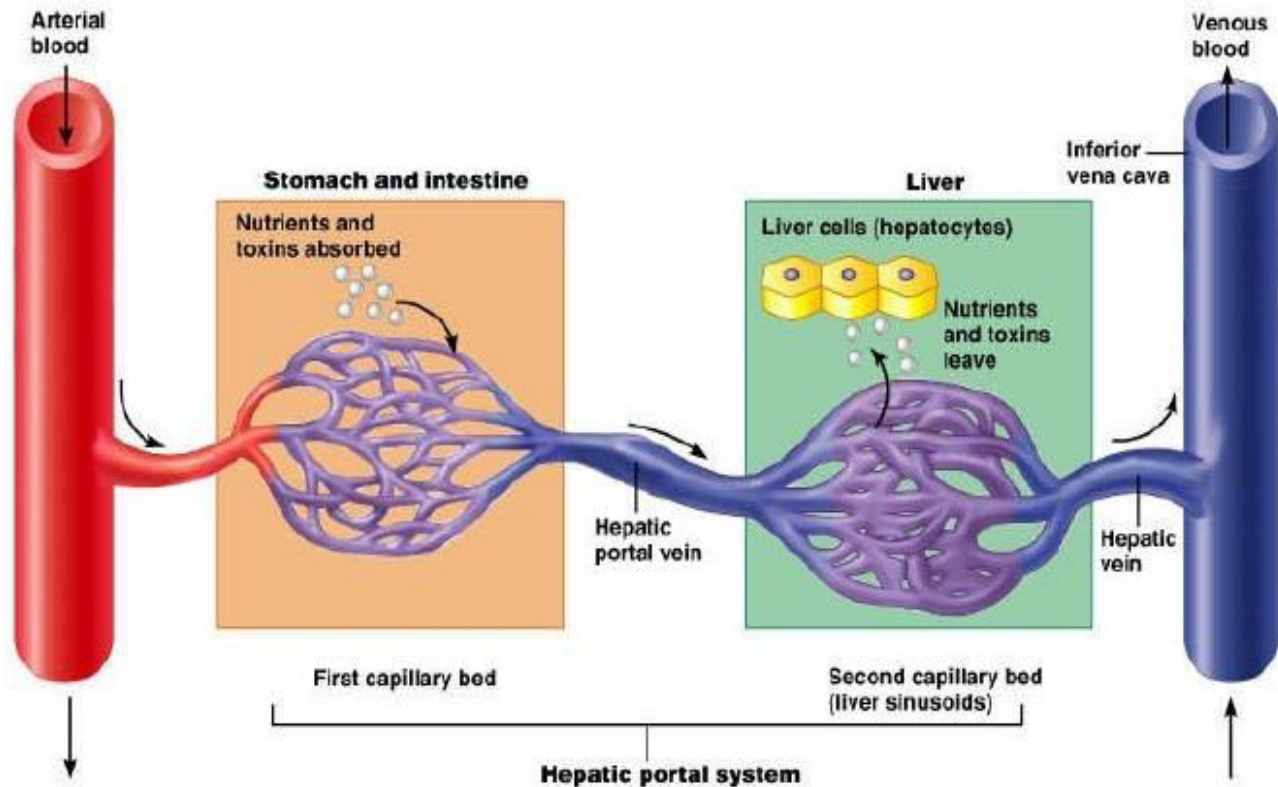
- Portal system is a system of blood vessels that carry blood from one bed of capillaries to the other bed of capillaries.
- Three portal systems are common:
 - 1. Hepatic portal system
 - 2. Renal portal system
 - 3. Hypophysial Portal System

Blood Portal Systems in Vertebrates



Blood Portal Systems in Vertebrates

The Basic Scheme of the Hepatic

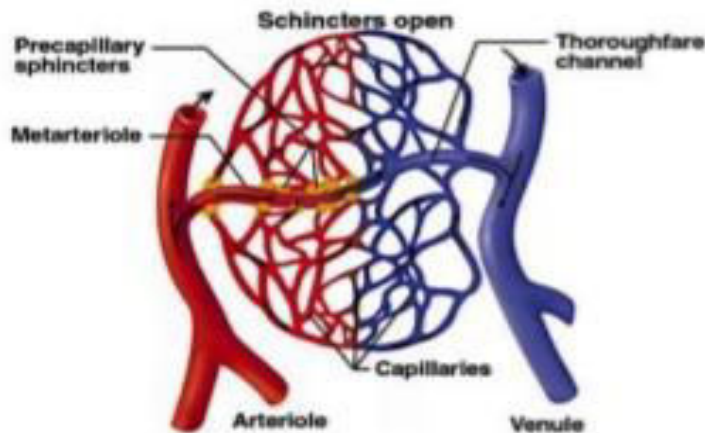


21-42
Figure 19.22

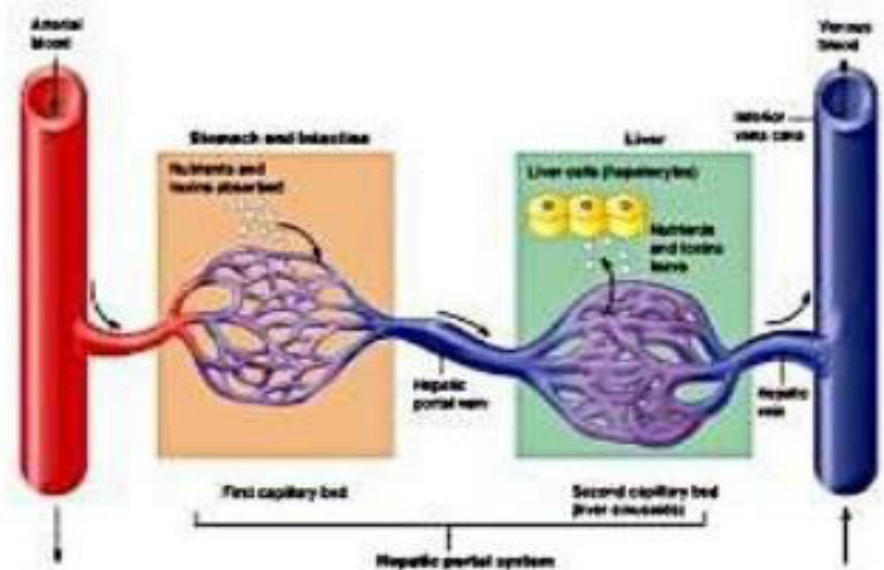
Blood Portal Systems in Vertebrates

Portal system

Usual circulation



Portal circulation



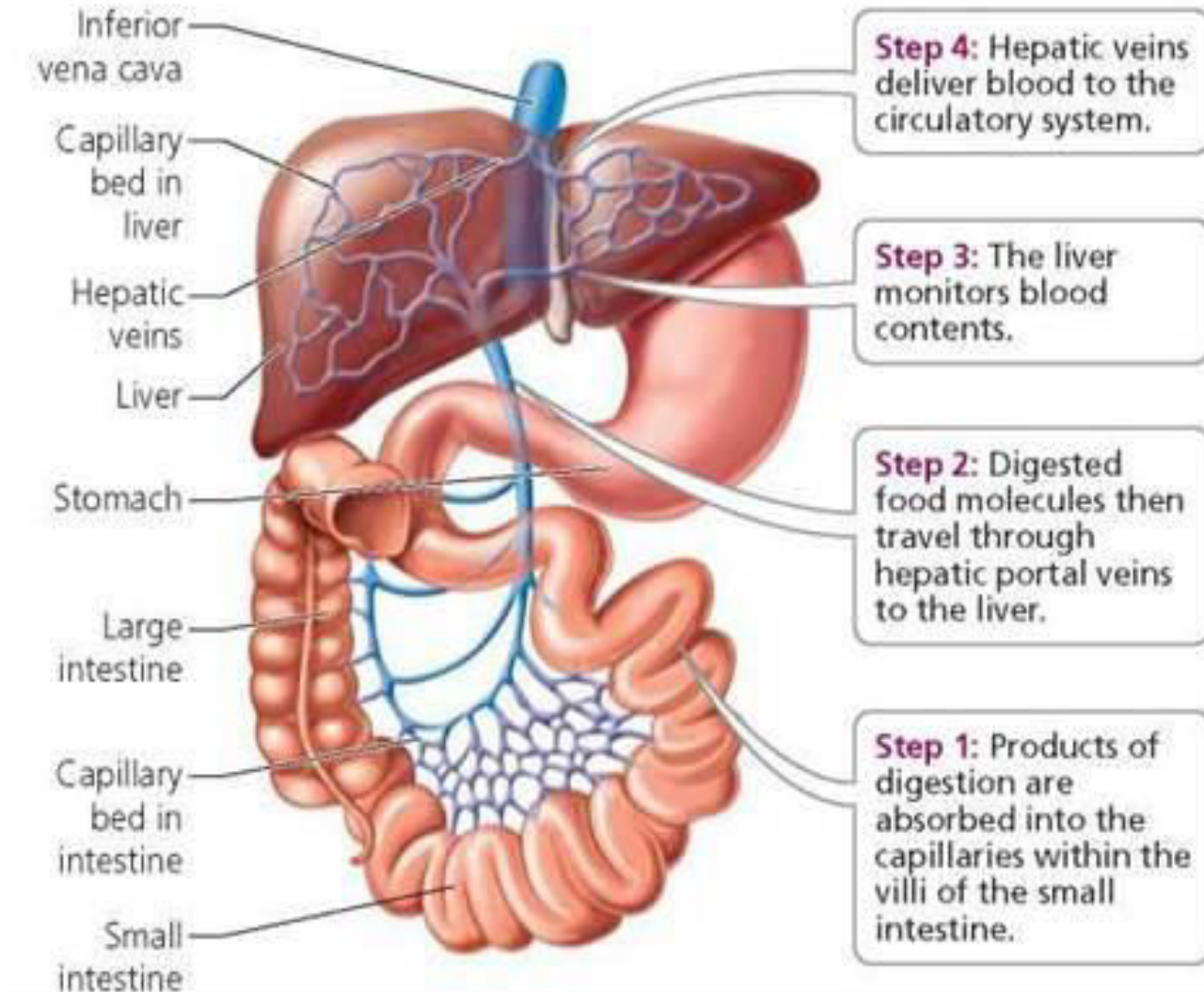
Blood Portal Systems in Vertebrates

- **Hepatic Portal System**
- Nutrients from the small intestine and the right half of the colon are absorbed into blood through the bed of capillaries.
- This blood then moves to the liver through the Hepatic Portal Vein to store and metabolize in liver.

Blood Portal Systems in Vertebrates

- From the liver the blood enters main blood stream via hepatic vein into the inferior vena cava to the heart.

Blood Portal Systems in Vertebrates



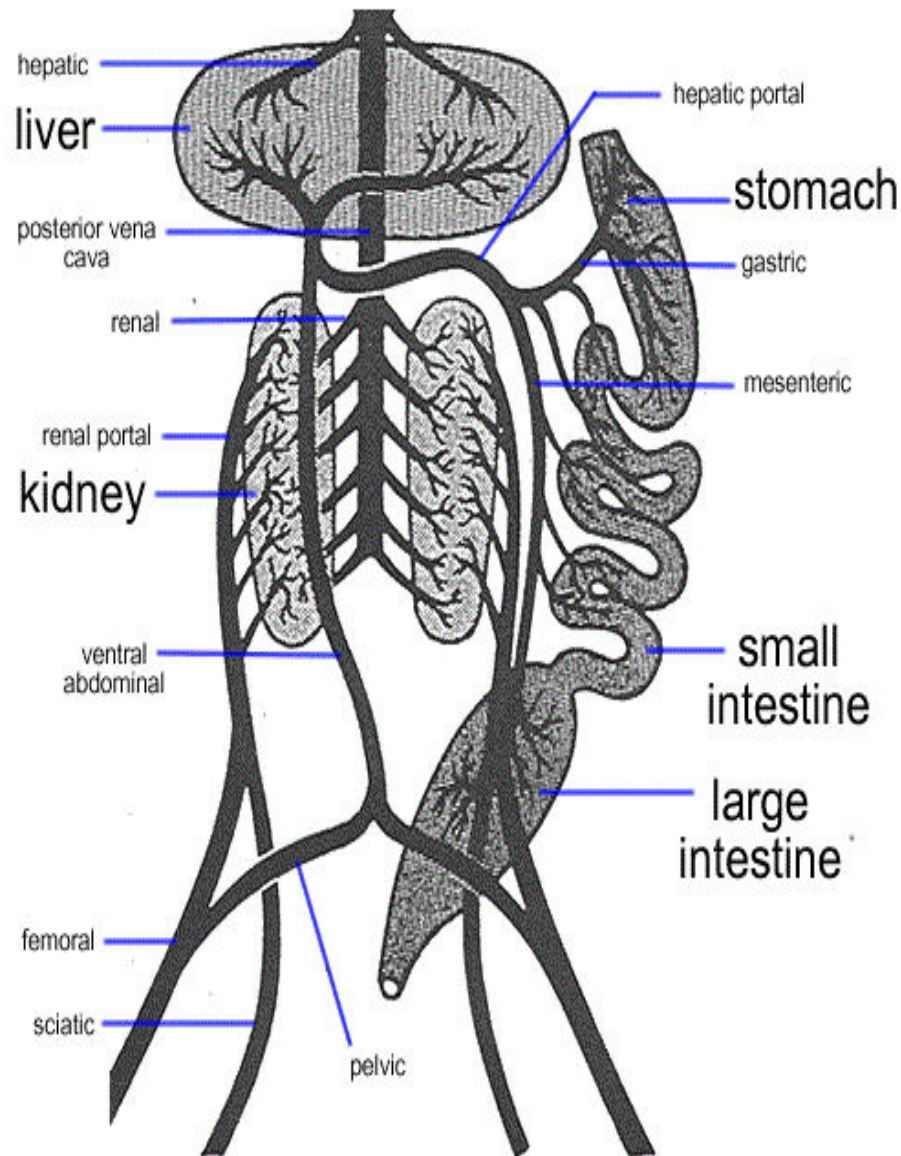
Blood Portal Systems in Vertebrates

- **Renal Portal System**
- The veins which carry blood to capillary system in kidneys constitute the renal portal system.
- The renal portal vein collects blood from all parts of the hind limbs and enters the kidney by number of branches from outer margin.

Blood Portal Systems in Vertebrates

- Inside the kidney these veins divide and redivide to form capillaries. These capillaries form 5 to 6 renal veins on emerging from the kidneys and open into post caval vein. All these veins forms renal portal system.

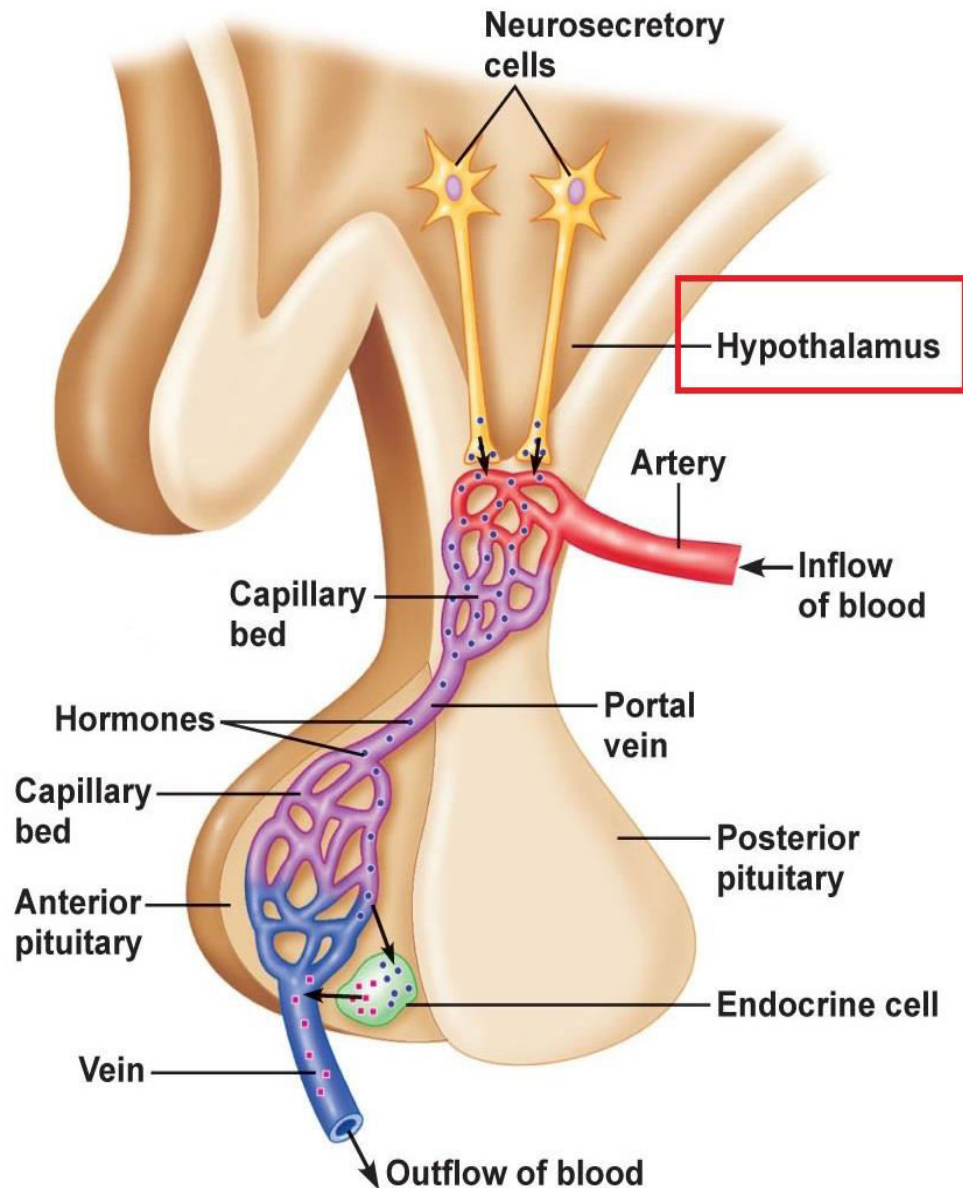
Blood Portal Systems in Vertebrates



Blood Portal Systems in Vertebrates

- **Hypophysial System:**
- A portal system between the hypothalamus and the anterior pituitary gland.

Blood Portal Systems in Vertebrates



Blood Portal Systems in Vertebrates

- pituitary gland
- .



Animal Form and Function 1

Module 151



Animal Form and Function 1

Vertebrate Blood

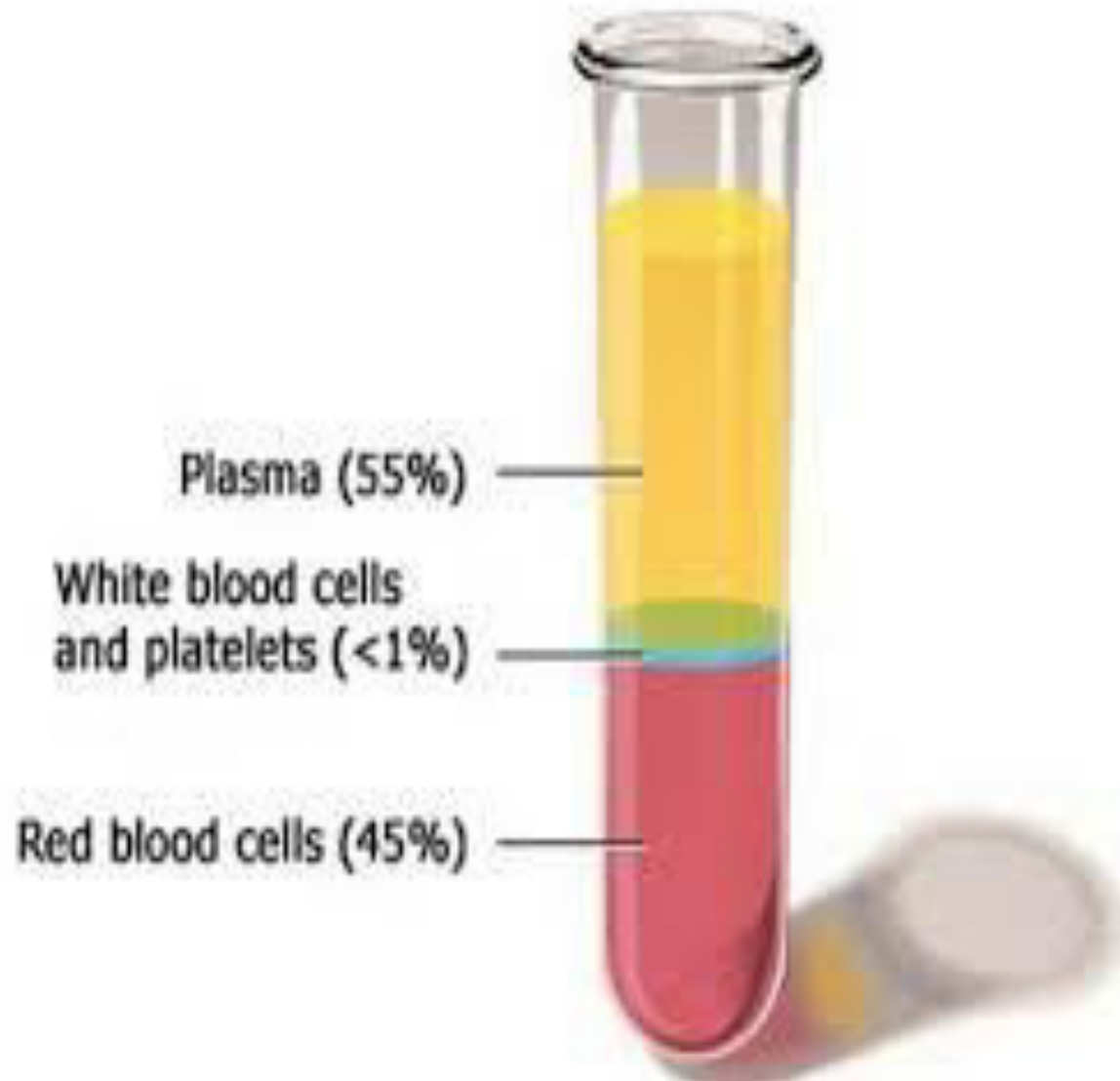


Vertebrate Blood

Blood (circulatory fluid)

- Blood is the medium in which the dissolved nutrients, gases, hormones and wastes are transported through the body.
- Blood defends against harmful microorganisms, cells and viruses.

Vertebrate Blood



Vertebrate Blood

- It also prevents blood loss through coagulation (clotting); and helps regulate body temperature and pH.

Vertebrate Blood

- It is a specialized type of connective liquid tissue which is composed of two main components:
 - 1. fluid matrix called plasma and
 - 2. formed elements- RBCs, WBCs and Platelets.

Vertebrate Blood

- Plasma is straw-colored liquid.
- In mammals, plasma is composed of:
 - 1. Water (about 90%)
 - 2. A group of proteins (albumin, fibrinogen and globulins)-7%.
 - 3. The remaining 3% of plasma is composed of:

Vertebrate Blood

- Electrolytes, amino acids, glucose and other nutrients, various enzymes, hormones, metabolic wastes, and traces of many inorganic and organic molecules.
- **Albumin** represents about 60% of the total plasma proteins, it plays important roles with respect to water movement.

Vertebrate Blood

- **Fibrinogen** is necessary for blood coagulation (clotting), and the
- **Globulins** include the **immunoglobulins**, which functions in the immune response because it consists mostly of antibodies.
- **Serum** is plasma from which fibrinogens have been removed.

END

Animal Form and Function 1

Module 152



Animal Form and Function 1

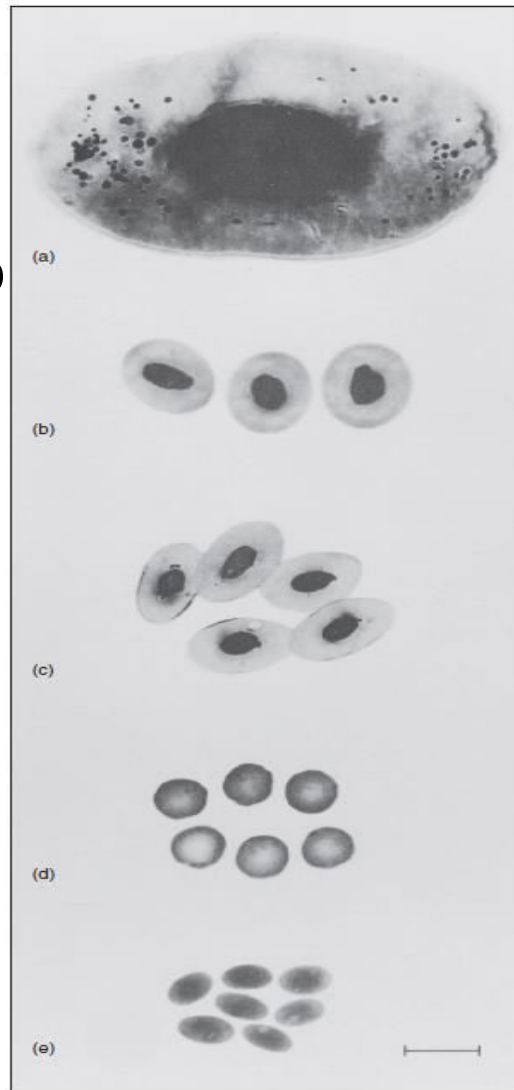
Vertebrate Blood Cells Part I

Vertebrate Blood Cells Part I

- The Vertebrate Blood Cells or formed-element fraction consists of:
- 1. **Erythrocytes**
(red blood cells or RBCs),
- 2. **Leukocytes**
(white blood cells or WBCs)
- 3. **Thrombocytes**
[Platelets]

Vertebrate Blood Cells Part I

- a. Salamander
- b. Snake
- c. Ostrich
- d. Red Kangaroo
- e. Camel



Human RBCs

Vertebrate Blood Cells Part I

Erythrocytes or RBCs

- RBCs vary dramatically in size, shape, and number in the different vertebrates.
- For example, the RBCs of most vertebrates are nucleated, but mammalian RBCs are enucleate.
- Among all vertebrates, the salamander, *Amphiuma* has the largest RBC.

Vertebrate Blood Cells Part I

- Among birds, the ostrich has the largest RBC.
- Most mammalian RBCs are biconcave disks however, the camel and llama have elliptical RBCs.

Vertebrate Blood Cells Part I

- 95% of mass of a RBC is hemoglobin, an iron-containing oxygen carrying protein.
- The remaining 5% consists of enzymes, salts and other proteins.
- The major function of hemoglobin is to transport oxygen in the form of oxyhemoglobin, from the environment to body tissues.

Vertebrate Blood Cells Part I

- Hemoglobin also carries waste carbon dioxide (in the form of carbaminohemoglobin) from the tissues to the lungs (or gills) for removal from the body.

END

Animal Form and Function 1

Module 153



Animal Form and Function 1

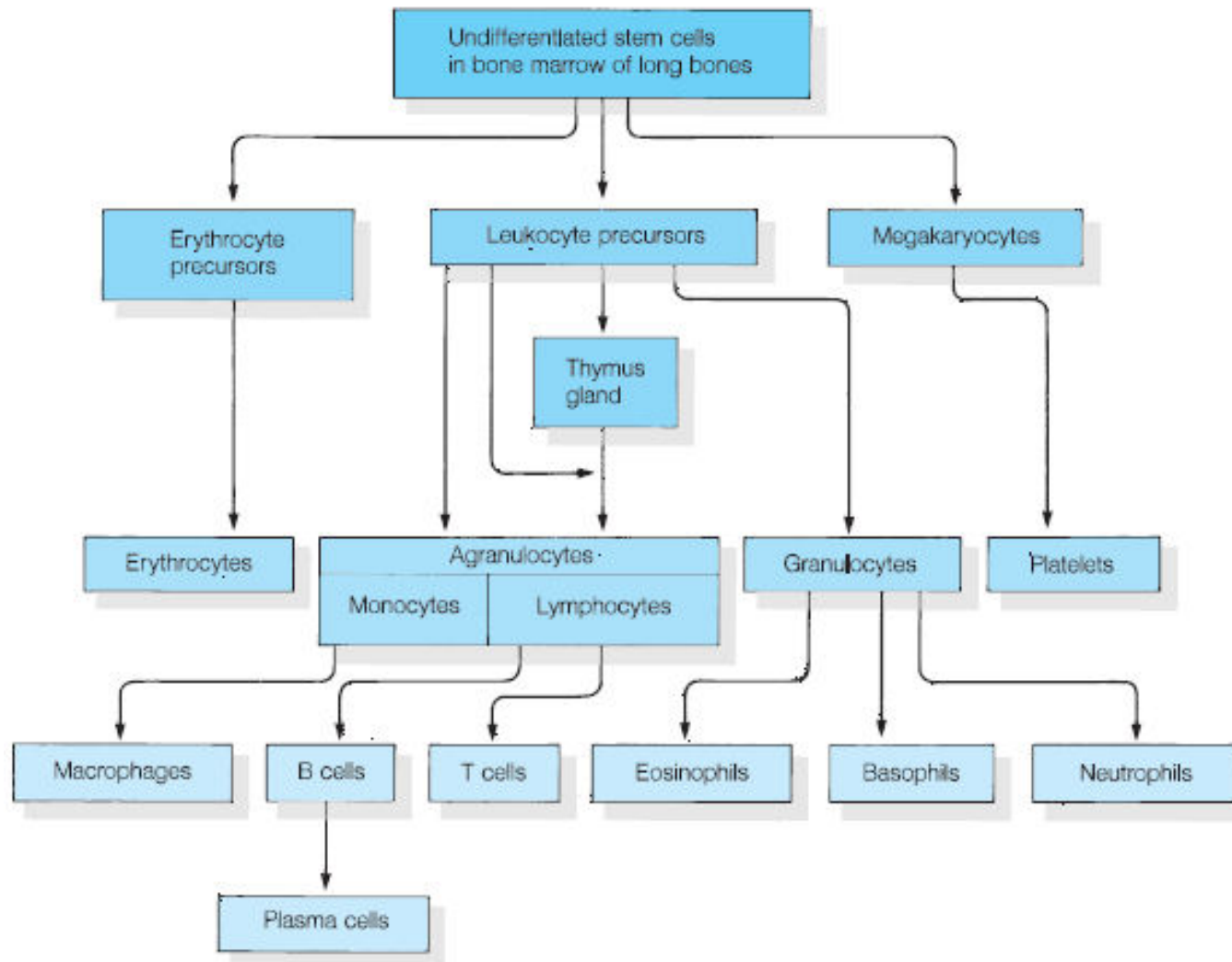
Vertebrate Blood Cells Part II

Vertebrate Blood Cells Part II

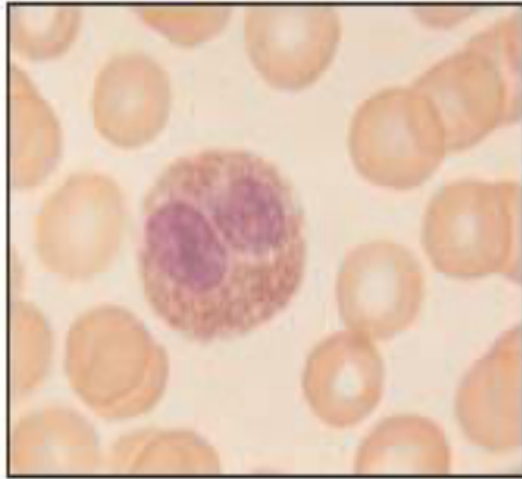
- **White Blood Cells** are scavengers that destroy microorganisms at infection sites, remove debris that results from dead or injured cells.
- All WBCs are derived from immature cells (called stem cells) in bone marrow by a process called hematopoiesis.

Vertebrate Blood Cells Part II

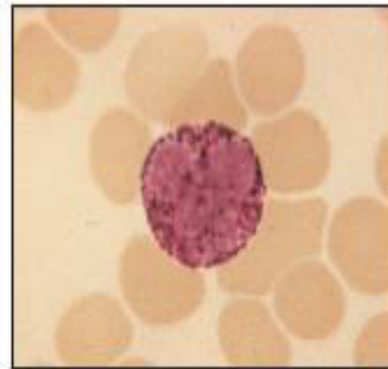
Cellular Components of Vertebrate Blood.



Vertebrate Blood Cells Part II



(b)



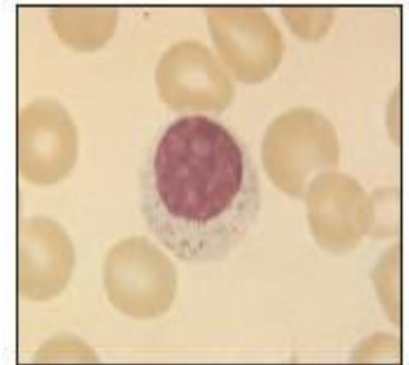
(c)



(d)



(e)



(f)

b. Eosinophil; c. Basophil; d. Neutrophil (granulocytes)
e. Monocytes; f. Lymphocyte (agranulocytes)

Vertebrate Blood Cells Part II

- RBCs can be grouped into two main types:
 - 1. Granulocytes
 - 2. Agranulocytes
- Granulocytes have granules in their cytoplasm and they include:
 - Neutrophils
 - Eosinophils
 - Basophils

Vertebrate Blood Cells Part II

- **Eosinophils are phagocytic, and ingest foreign proteins and immune complexes rather than bacteria.**
- In mammals, eosinophils also release chemicals that counteract the effects of certain inflammatory chemicals released during allergic reactions.

Vertebrate Blood Cells Part II

- **Basophils** are the least numerous WBC. When they react with a foreign substance, their granules release histamine and heparin.
- Histamine causes blood vessels to dilate and leak fluid at a site of inflammation, and heparin prevents blood clotting.

Vertebrate Blood Cells Part II

- **Neutrophils** are the most numerous of the white blood cells.
- They are chemically attracted to sites of inflammation and are active phagocytes.

Vertebrate Blood Cells Part II

- Agranulocytes have clear cytoplasm. These include:
 - 1. Monocytes and
 - 2. Lymphocytes.
 - Monocytes give rise to macrophages which destroy larger particles by phagocytosis.
 - Lymphocytes are of two types: B cells and T cells, both of which are central to the immune response.

Vertebrate Blood Cells Part II

- B cells originate in the bone marrow and colonize the lymphoid tissue, where they mature.
- T cells are associated with and influenced by the thymus gland before they colonize lymphoid tissue and play their role in the immune response.

Vertebrate Blood Cells Part II

- Platelets (Thrombocytes) are disk-shaped cell fragments that initiate blood clotting.
- When a blood vessel is injured, platelets immediately move to the site and clump, attaching themselves to the damaged area, and thereby beginning the process of blood coagulation.

END

Animal Form and Function 1

Module 155



Animal Form and Function 1

**Hearts and Circulatory
Systems of
Bony Fishes,
Amphibians and Reptiles**

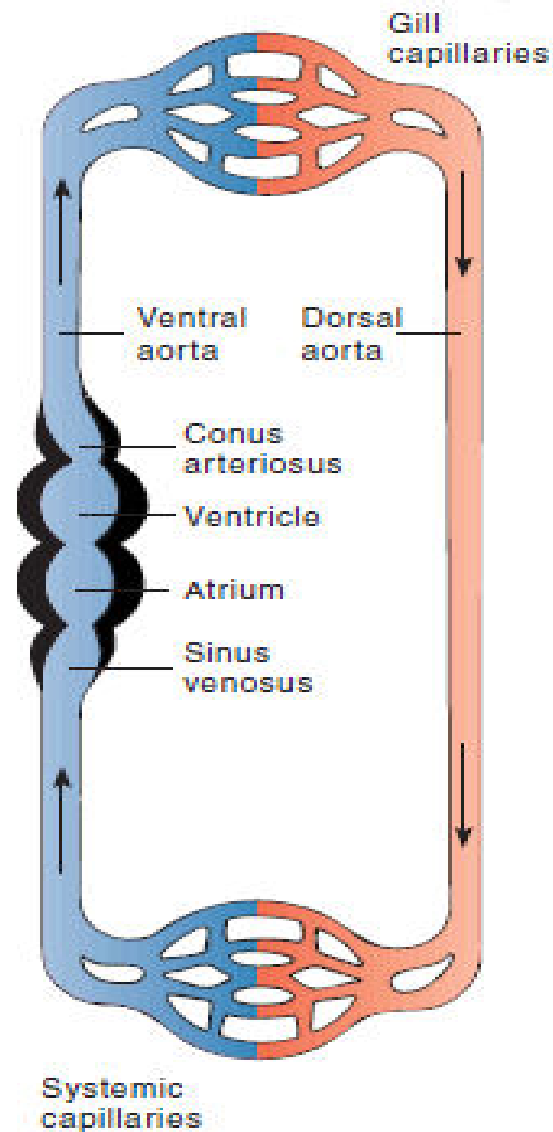
Hearts & Circulatory Systems of Bony Fishes....

- The bony fish heart has two chambers—the atrium and ventricle.
- Blood leaves the heart via the ventral aorta, which goes to the gills.
- In the gills, blood becomes oxygenated, loses carbon dioxide, and enters the dorsal aorta.

Hearts & Circulatory Systems of Bony Fishes....

- The dorsal aorta distributes blood to all of the body organs, and then blood returns to the heart via the venous system.
- Because blood only passes through the heart once, this system is called a single circulation circuit.

Hearts & Circulatory Systems of Bony Fishes....

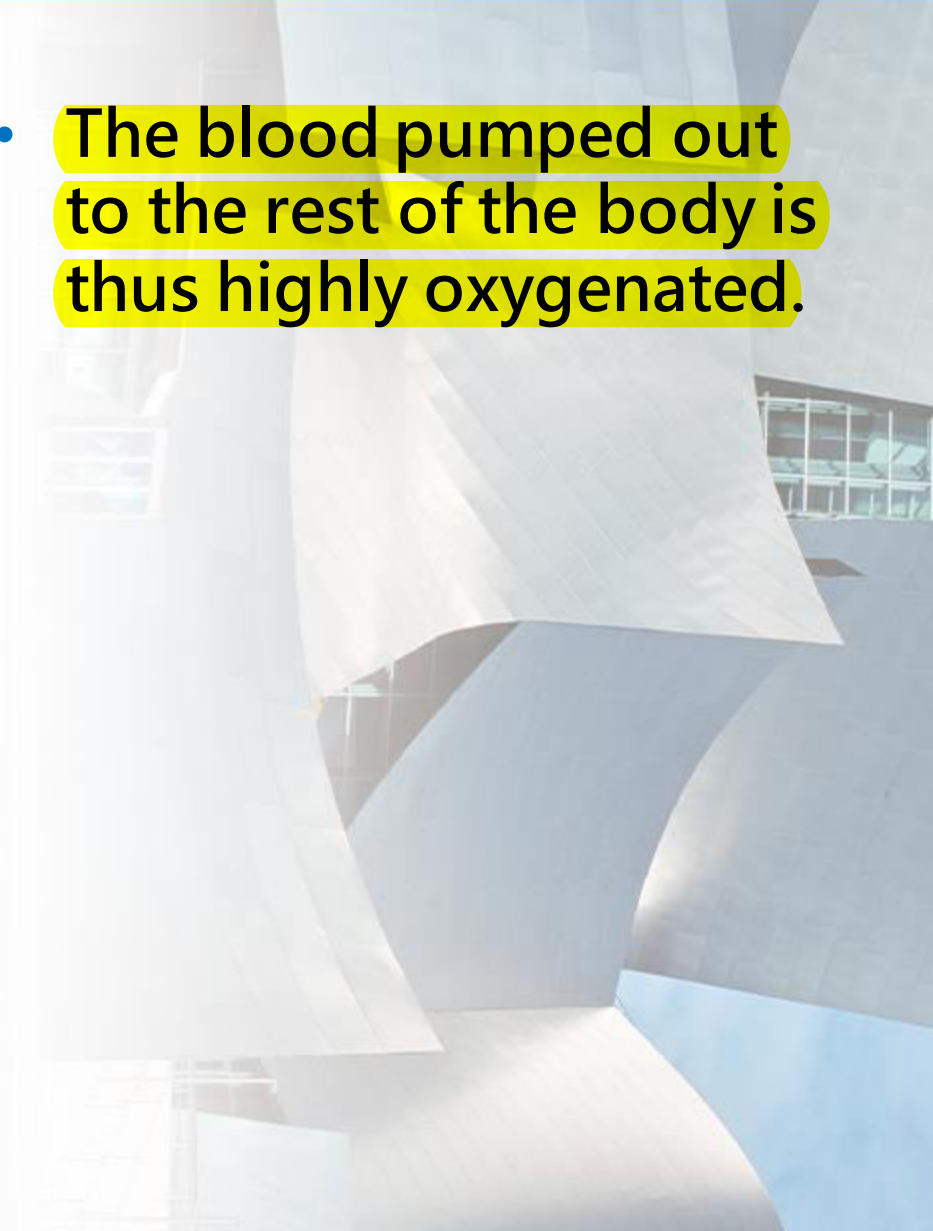


Hearts & Circulatory Systems of Bony Fishes....

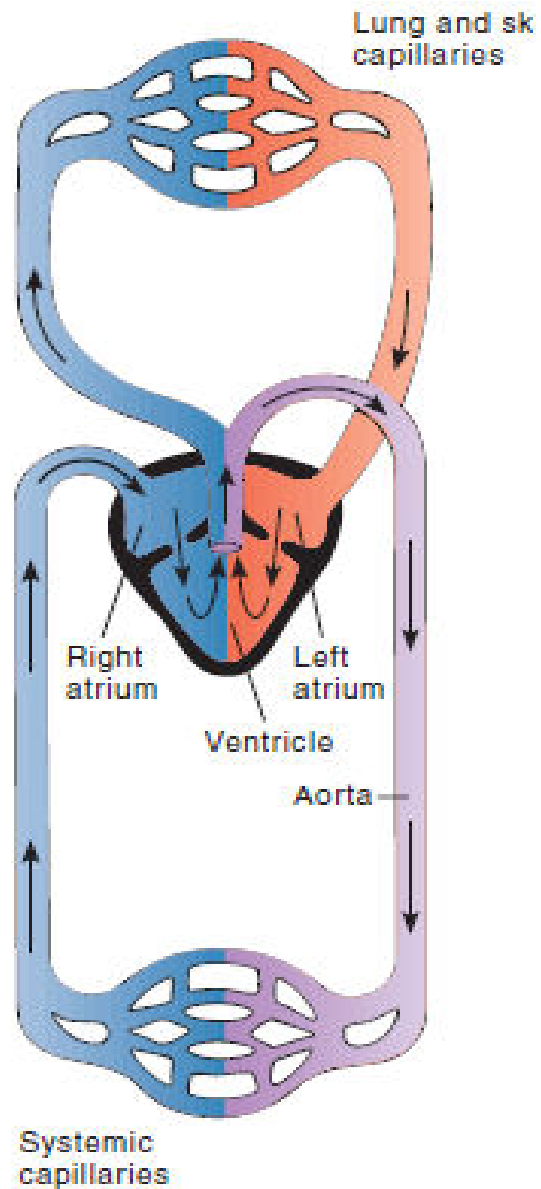
- In amphibians, a single ventricle pumps blood both to the lungs and to the rest of the body.
- However, because most amphibians absorb more oxygen through their skin than through their lungs or gills, blood returning from the skin also contributes oxygenated blood to the ventricle.

Hearts & Circulatory Systems of Bony Fishes....

- The blood pumped out to the rest of the body is thus highly oxygenated.



Hearts & Circulatory Systems of Bony Fishes....



Hearts & Circulatory Systems of Bony Fishes....

- In the heart of most reptiles, the ventricle is partially divided into a right and left side.
- Oxygenated blood from the lungs returns to the left side of the heart via the pulmonary vein and does not mix much with deoxygenated blood in the right side of the heart.

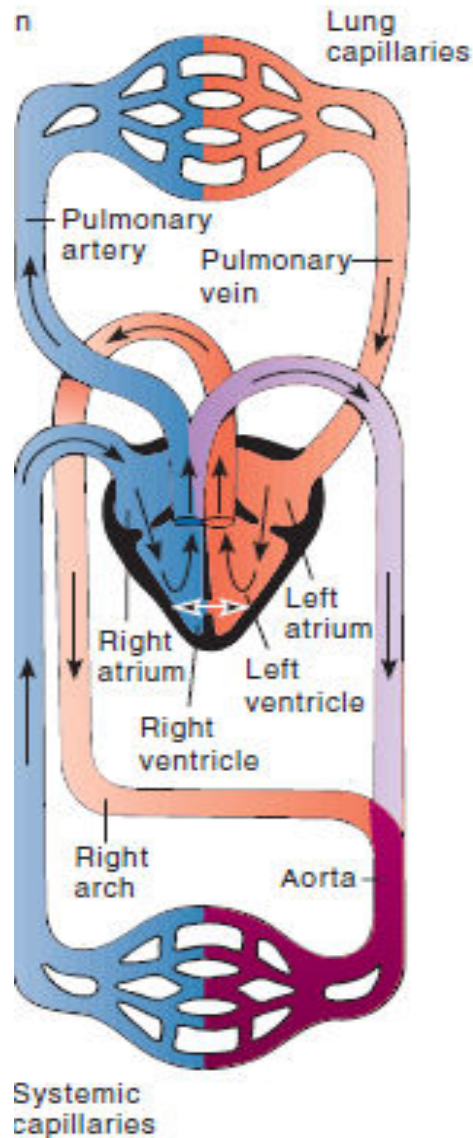
Hearts & Circulatory Systems of Bony Fishes....

- When the ventricles contract, blood is pumped out two aortae for distribution throughout the body, as well as to the lungs.
- The incomplete separation of the ventricles is an important adaptation for reptiles, such as turtles

Hearts & Circulatory Systems of Bony Fishes....

- Because it allows blood to be diverted away from the pulmonary circulation during diving and when the turtle is withdrawn into its shell.
- This conserves energy and diverts blood to vital organs during the time when the lungs cannot be ventilated.

Hearts & Circulatory Systems of Bony Fishes....



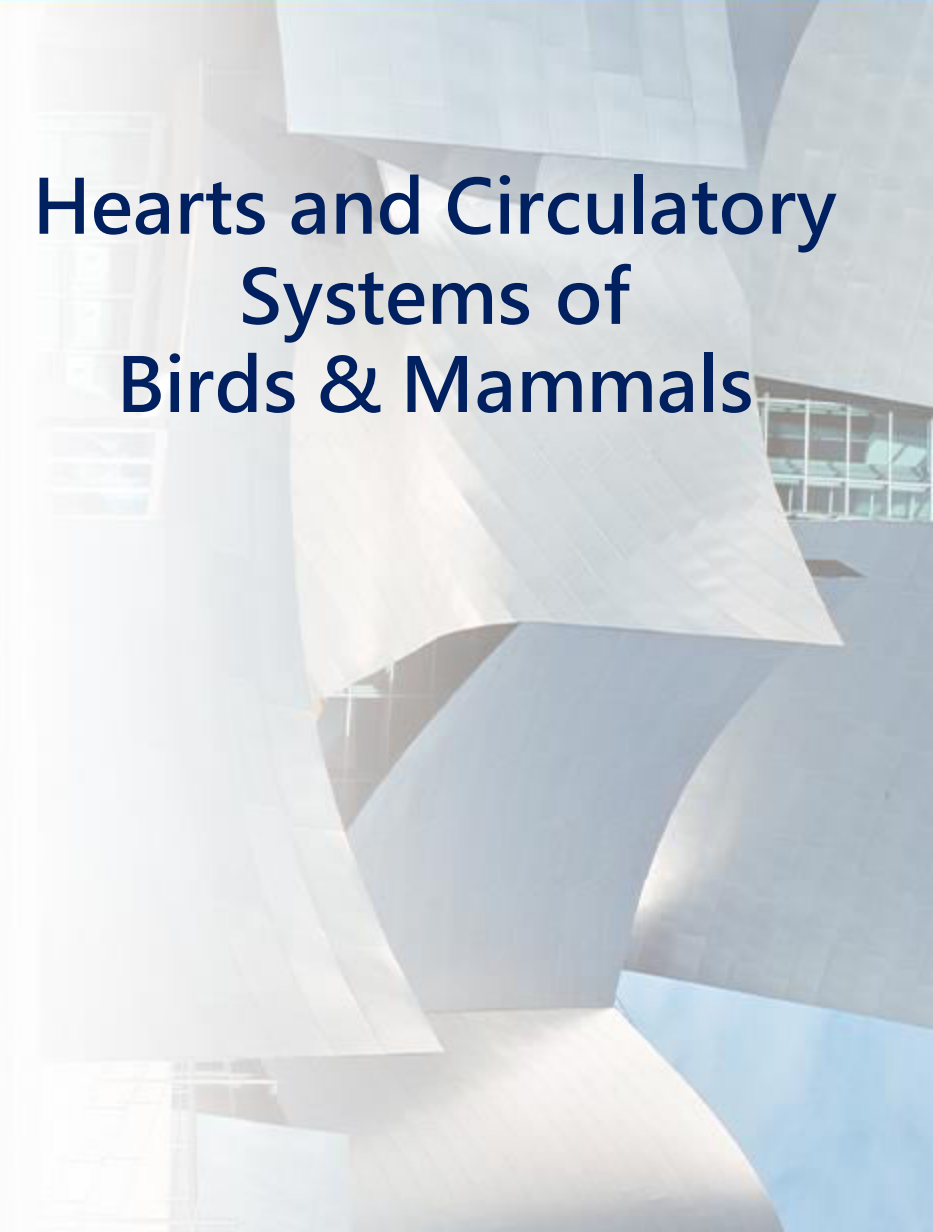
Animal Form and Function 1

Module 156



Animal Form and Function 1

Hearts and Circulatory Systems of Birds & Mammals



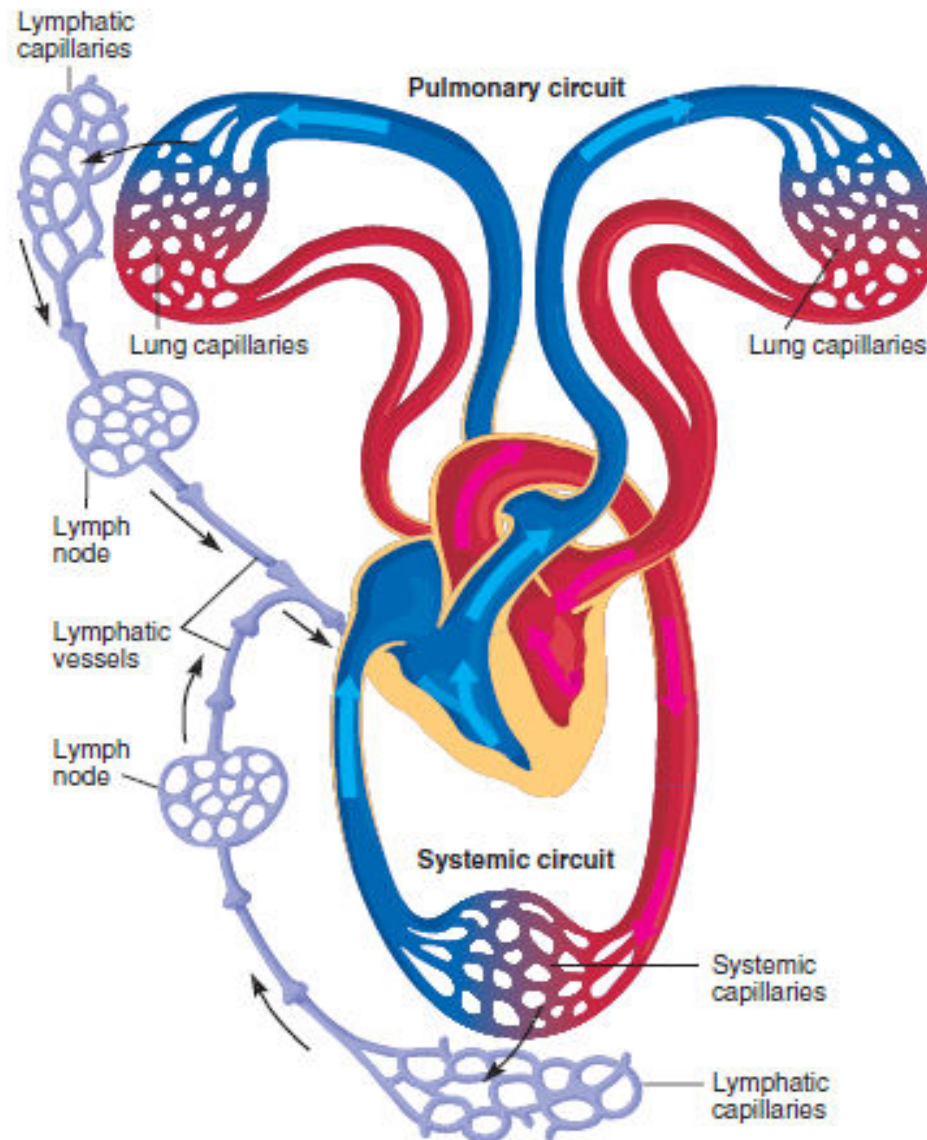
Hearts & Circulatory Systems of Birds & Mammals

- In Birds and Mammals blood circulates in two main circuits:
- 1. Pulmonary and
- 2. Systemic circuits.
- The pulmonary circuit supplies blood only to the lungs.
- It carries deoxygenated blood from the heart to the lungs, where carbon dioxide is removed, and oxygen is added.

Hearts & Circulatory Systems of Birds & Mammals

- It then returns the oxygenated blood to the heart for distribution to the rest of the body.
- The systemic circuit supplies all the cells, tissues, and organs of the body with oxygen-rich blood and returns oxygen-poor blood to the heart.

Hearts & Circulatory Systems of Birds & Mammals



Animal Form and Function 1

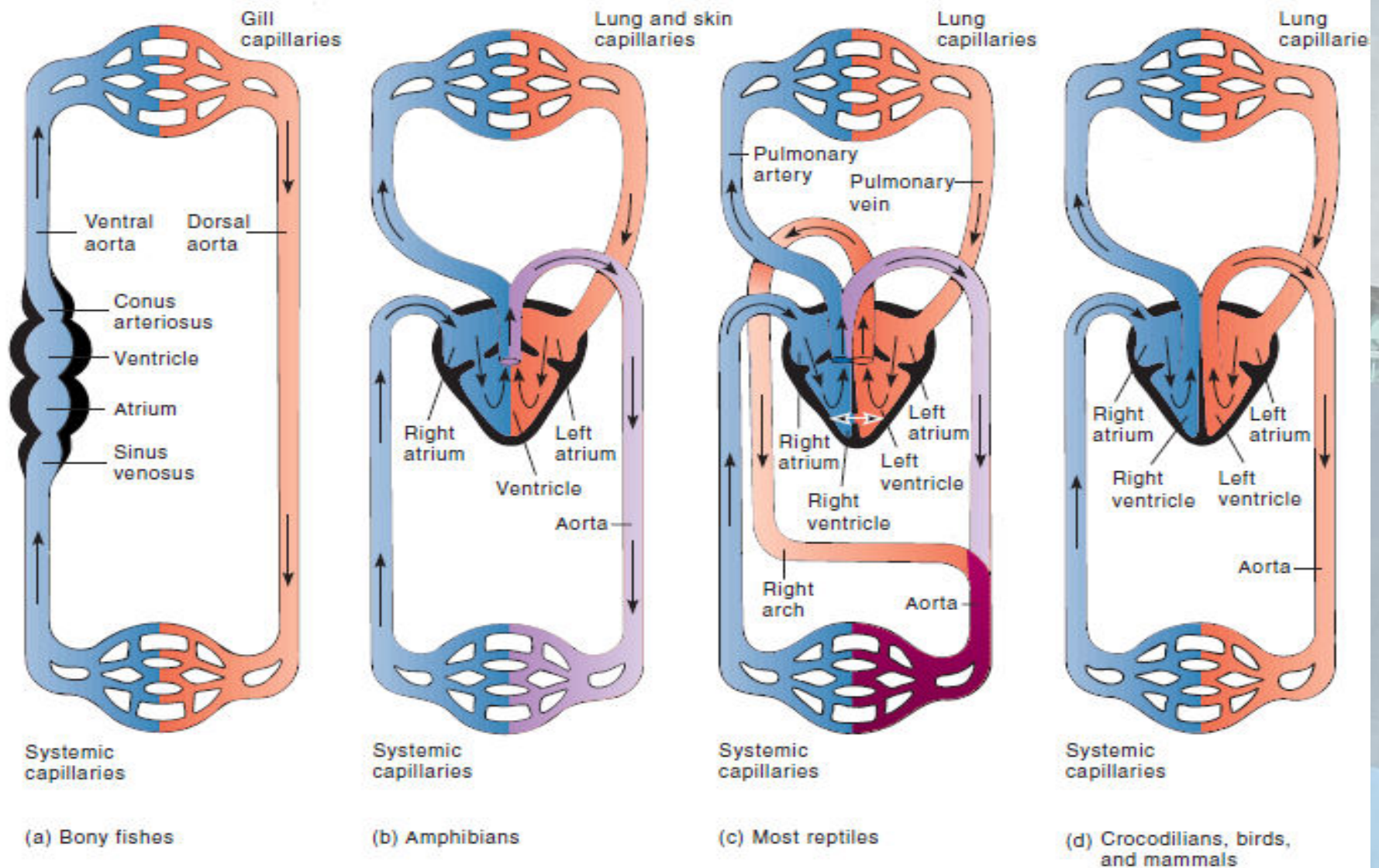
Module 157



Animal Form and Function 1

Evolutionary Perspective of Vertebrate Hearts

Evolutionary Perspective of Vertebrate Hearts



Evolutionary Perspective of Vertebrate Hearts

- In bony fishes, the heart's two chambers (atrium, ventricle) pump in series. Respiratory and systemic circulations are not separate.

Evolutionary Perspective of Vertebrate Hearts

- The amphibian heart has two atria and one ventricle. Blood from the lungs enters the left atrium, and blood from the body enters the right atrium.
- The blood from both atria empties into one ventricle, which then pumps it into the respiratory and systemic circulations.

Evolutionary Perspective of Vertebrate Hearts

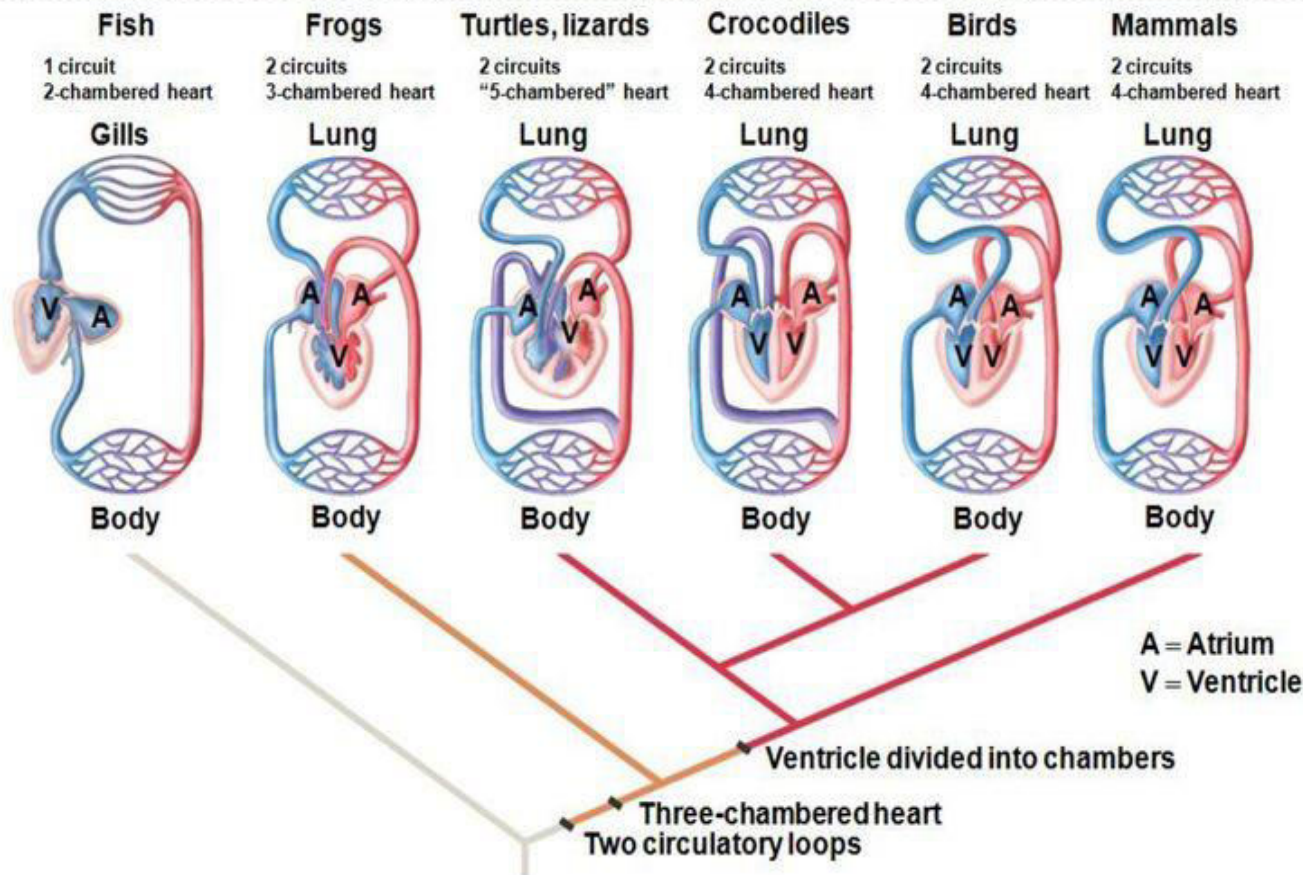
- Most reptiles exhibit a greater degree of anatomical division of the ventricle into two halves.

Evolutionary Perspective of Vertebrate Hearts

- In crocodilians, birds, and mammals, the ventricle is completely divided, forming a four-chambered heart.
- Blood flow through the lungs completely separated from the flow to other tissues.

Evolutionary Perspective of Vertebrate Hearts

Comparative Anatomy of Vertebrate Hearts



Animal Form and Function 1

Module 158



Animal Form and Function 1

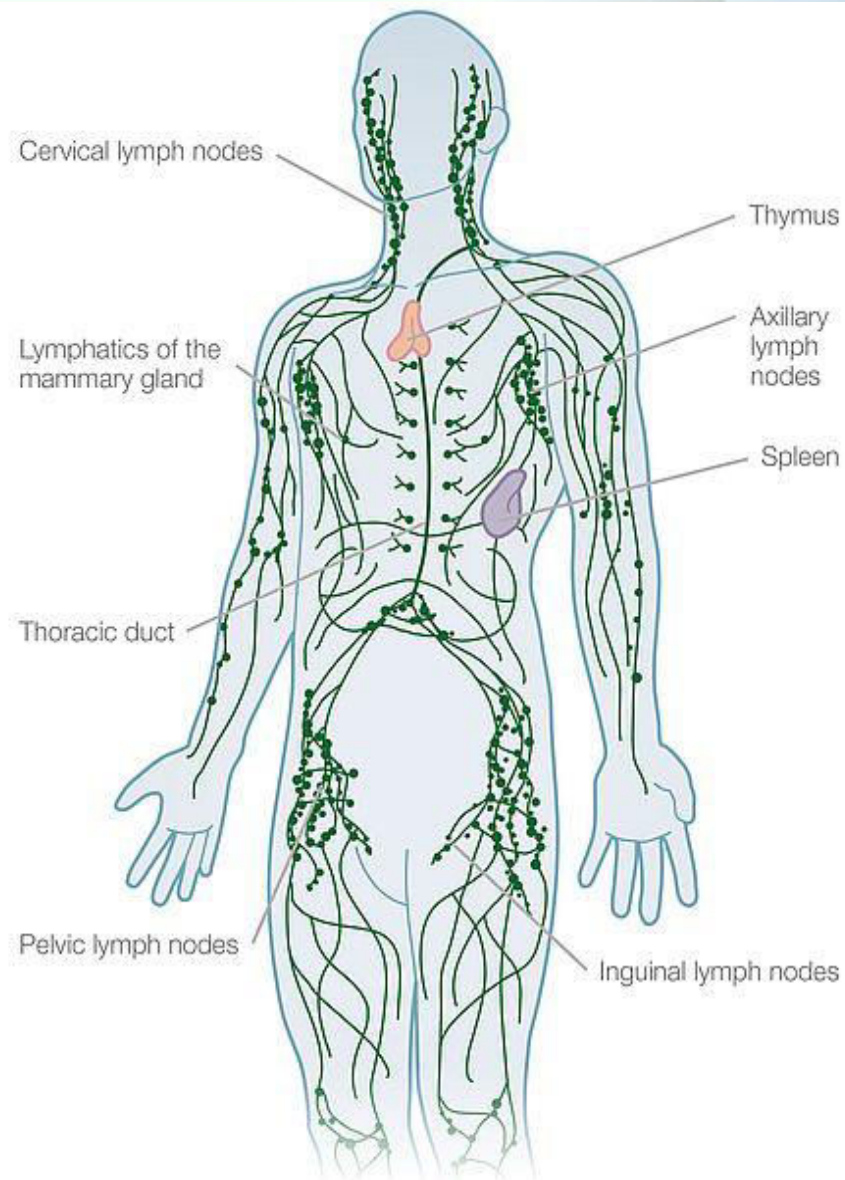
Vertebrate Lymphatic System

The background of the slide is an abstract, low-poly 3D rendering. It features several large, white, angular shapes that resemble folded paper or crystalline structures. These shapes are set against a light blue background that also contains faint, darker blue geometric patterns. The overall aesthetic is modern and architectural.

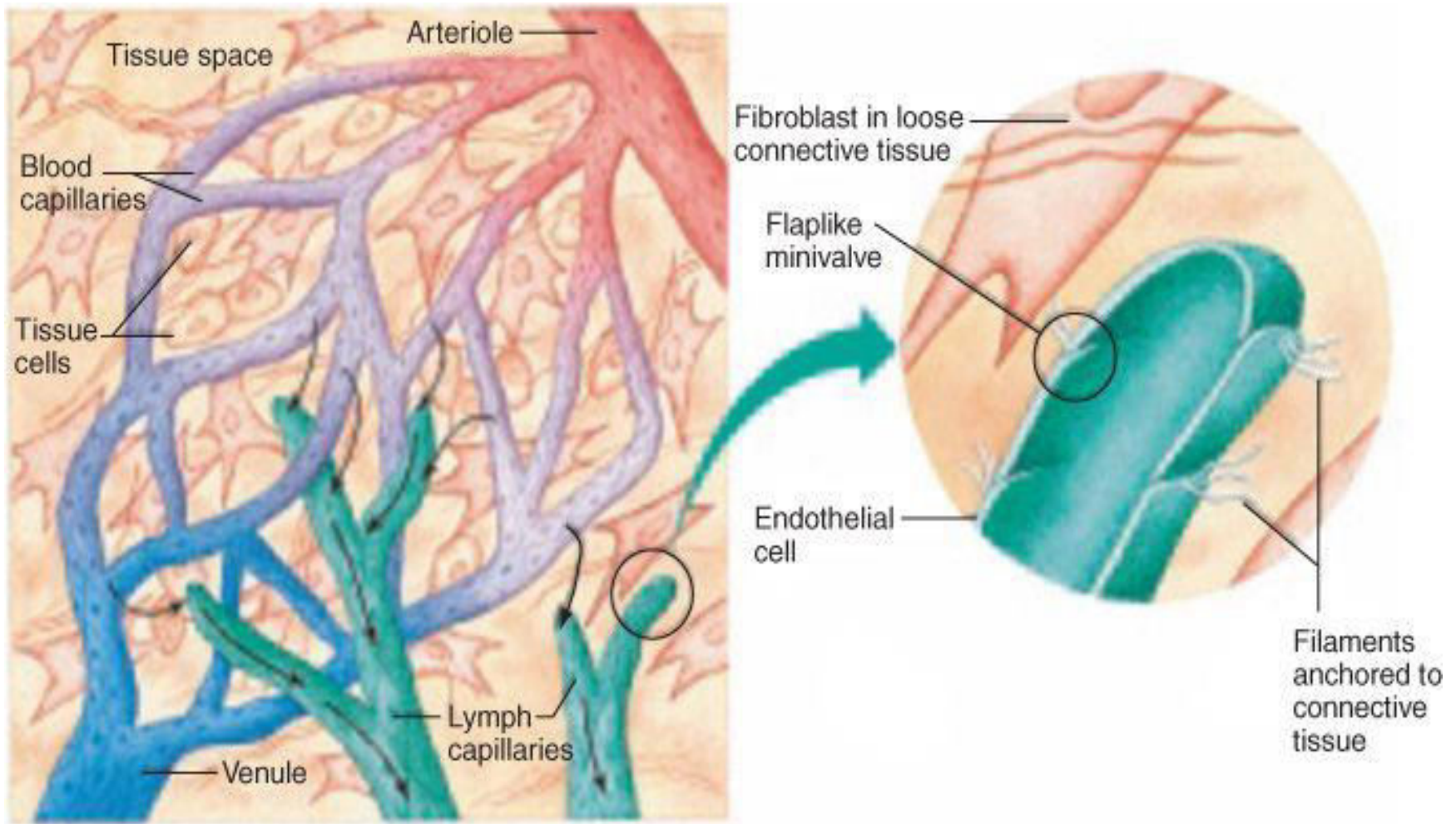
Vertebrate Lymphatic System

- The lymphatic system is part of the vascular system.
- The system begins with network of lymphatic vessels that carry a clear fluid called lymph.
- The small lymphatic capillaries merge to form larger lymphatic vessels called lymphatics.

Vertebrate Lymphatic System



Vertebrate Lymphatic System



Vertebrate Lymphatic System

- Lymphatics are thin-walled vessels with valves that ensure the one-way flow of lymph.
- Lymph is the extracellular fluid that seeps from the bloodstream and accumulates in the lymph vessels.
-

Vertebrate Lymphatic System

- The lymphatic vessels pass through the lymph nodes on their way back to the heart.
- **Lymph nodes** concentrate in several areas of the body and act as disposal centers for foreign particles and cellular debris.
- They play an important role in the body's defense against disease.

Vertebrate Lymphatic System

- The system also help transport lipids that have been absorbed from the small intestine.
- In addition to the lymph nodes, the mammalian lymphatic system consists of lymphoid organs—the spleen the thymus gland, tonsils, and adenoids.
- In birds the bursa of Fabricius is an additional lymphoid tissue.

Vertebrate Lymphatic System

- The system also help transport lipids that have been absorbed from the small intestine.
- In addition to the previously mentioned parts, the lymphatic system of birds and mammals consists of lymphoid organs—the spleen and or the thymus gland, tonsils, and adenoids in mammals.

END

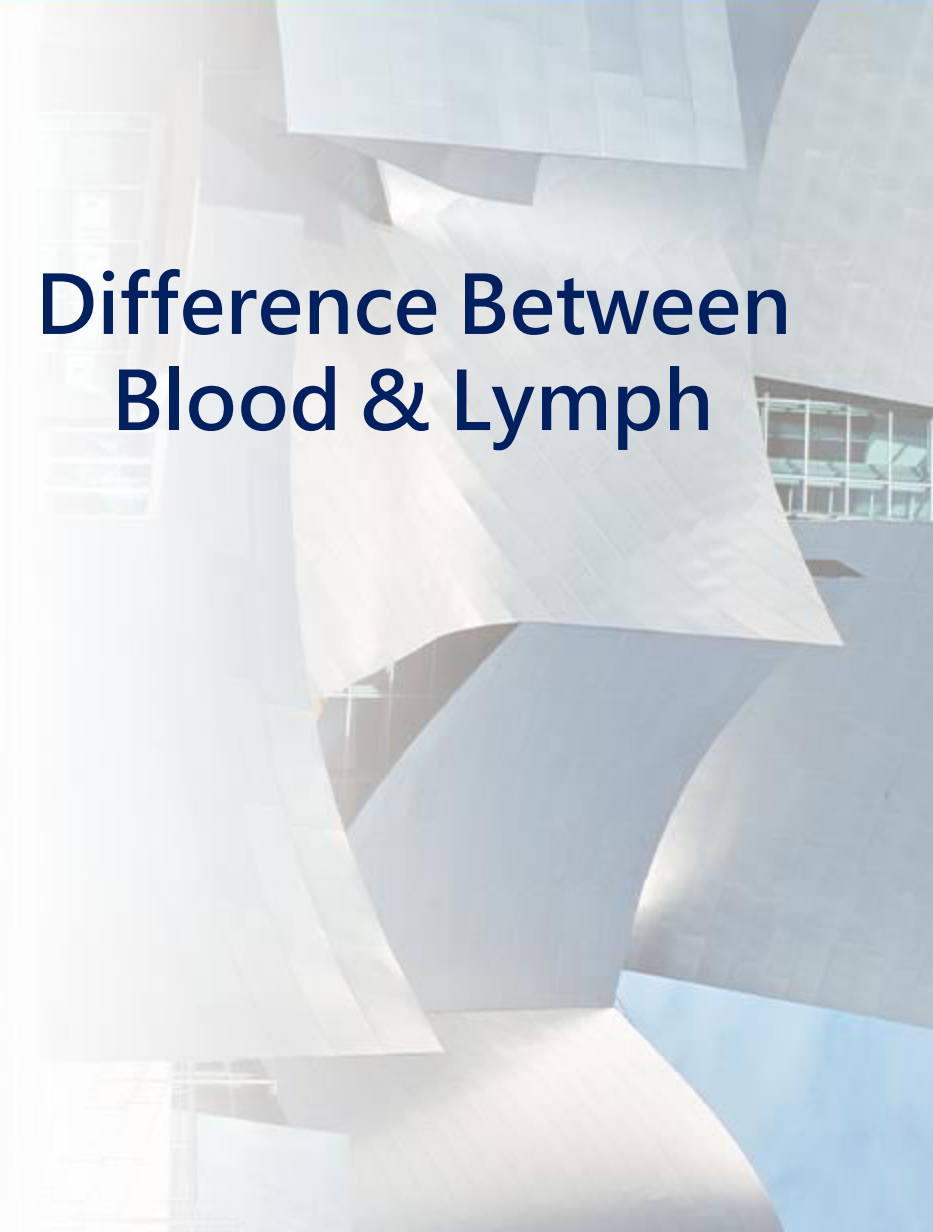
Animal Form and Function 1

Module 159



Animal Form and Function 1

Difference Between Blood & Lymph



Difference Between Blood and Lymph

- Lymph is colorless fluid where as
- Blood is colored fluid.
- Lymph is the part of lymphatic system whereas Blood is the part of Blood circulatory system.
- Lymph helps in the body's defence as it is the part of immune system. Where as, blood is associated with circulation of O_2 , CO_2

Difference Between Blood and Lymph

- Blood has RBCs, WBCs, platelets and fluid called plasma.
- Where as lymph has WBCs and watery fluid, both have immune and circulatory functions in them.

Difference Between Blood and Lymph

- substances like hormones waste products, products of digestion etc.
- Lymph contains plasma and a lesser number WBCs and platelets, whereas blood contains plasma, RBCs, WBCs and Platelets.
- Lymph contains low amount of O₂, blood carries large amount of O₂.

Difference Between Blood and Lymph

- Lymph lacks protein, whereas blood plasma has Ca^{+2} & PO_4^{-3} .
- Flow of lymph is slow where flow of blood is fast.
- Lymph clots slowly as less fibrinogen is present, whereas blood clots quickly as high amount of fibrinogen is present.

END

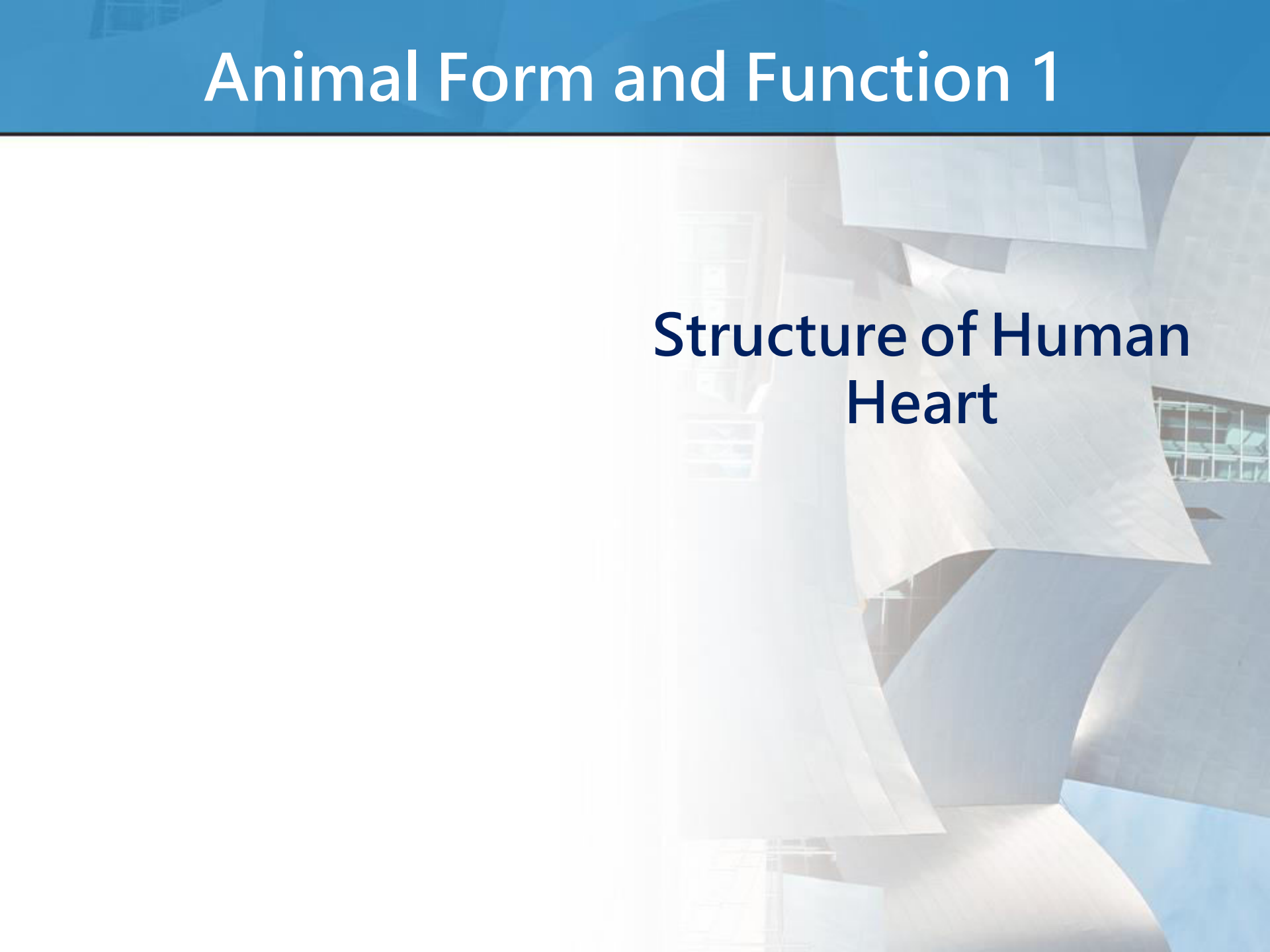
Animal Form and Function 1

Module 160



Animal Form and Function 1

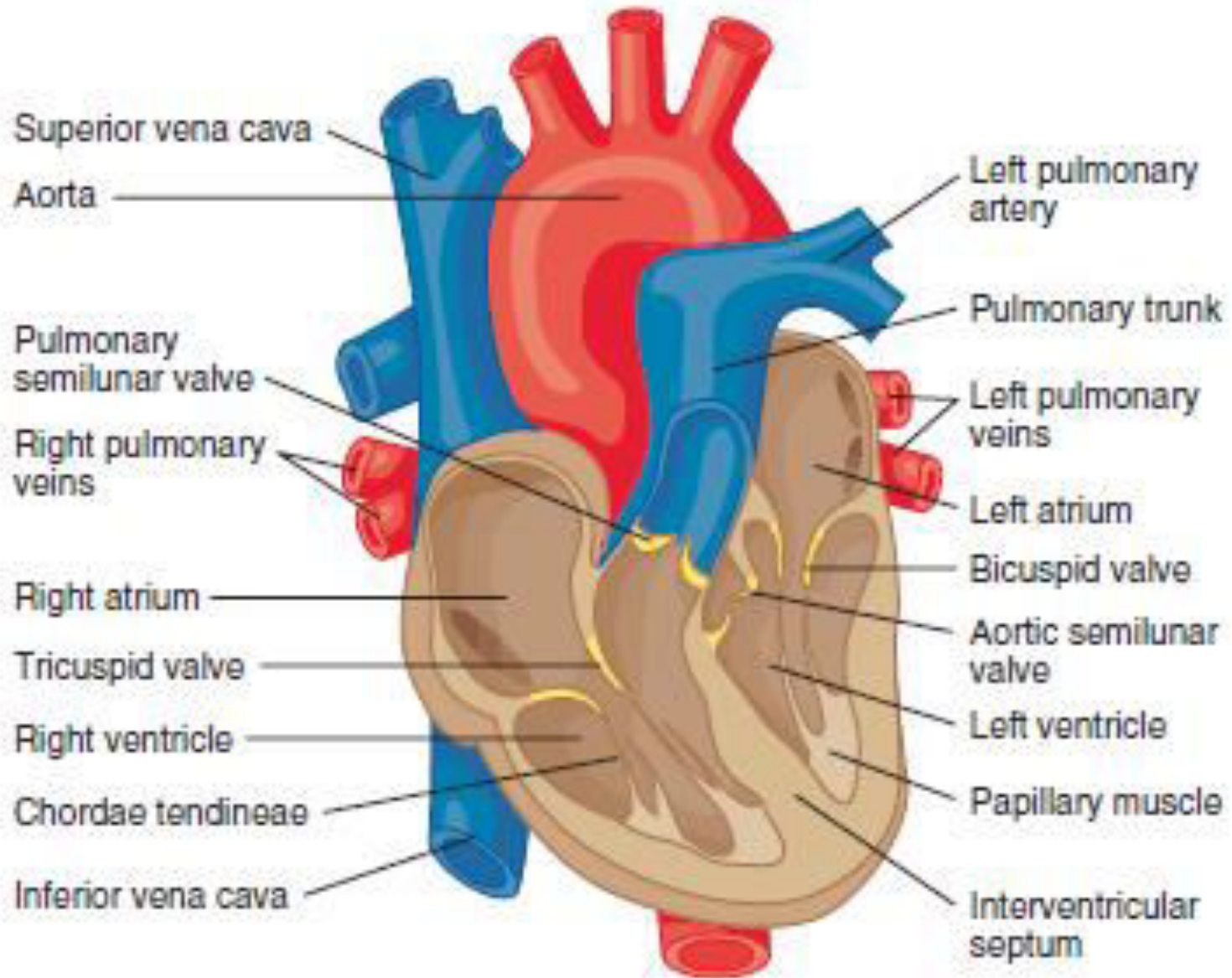
Structure of Human Heart



Structure of Human Heart

- The human heart is a hard-working pump located in the chest cavity.
- Heart is enclosed in double membrane sac called pericardium.
- Space between these membranes is filled up with pericardial fluid.
- The wall of the heart is composed of three layers:

Structure of Human Heart



Structure of Human Heart

- Epicardium(Connective .tissue)
- Myocardium (cardiac muscles)and
- Endocardium (single layer of cells).
- The heart has four chambers: 2 atria and 2 ventricles)
- The 2 atria are separated by Inter atrial septum.

Structure of Human Heart

- The two ventricle are separated by Inter ventricular septum.
- The two atria communicate with the ventricles through atrioventricular apertures.
- On the right side the apertures is provided with Tricuspid valve.
- On the left side it is bicuspid valve.

Structure of Human Heart

- The flaps of the valves are connected to the papillary muscles by means of chordae tendinae.
- The right atrium receives the inferior and superior vena cavae opening separately.
- The left atrium receives pulmonary veins, 2 from each lung.

Structure of Human Heart

- From the right ventricle arises the pulmonary artery and from the left ventricle, the Aorta.
- At the point of origins of aorta and pulmonary artery there are valves called semilunar valves.

END

Animal Form and Function 1

Module 161



Animal Form and Function 1

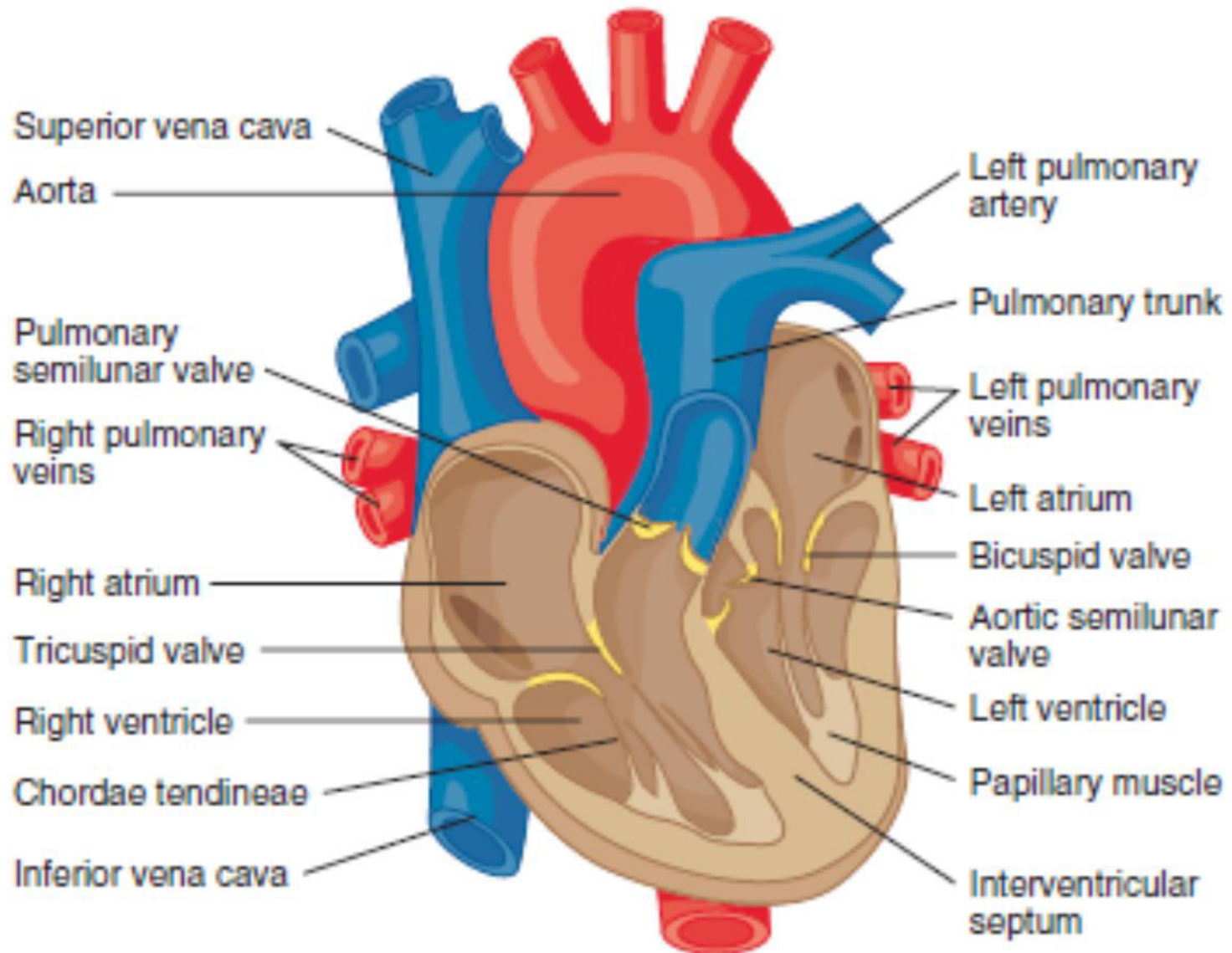
Pumping Action of Human Heart



Pumping Action of Human Heart

- Adult human heart beats or pumps 72 times a minute.
- In the beating of the heart the atria contract simultaneously and ventricles immediately after words.
- The deoxygenated blood from the lower and upper part of the body is brought into the right atrium.

Pumping Action of Human Heart



Pumping Action of Human Heart

- From the right atrium it is driven by atrial contraction into the right ventricle.
- At the same time the oxygenated blood brought by the pulmonary veins from the lungs into the left atrium and then driven into left ventricle.

Pumping Action of Human Heart

- On the contraction of the ventricles the blood from the right ventricle is taken to the lungs by the pulmonary artery.
- The valves open and close due to blood pressure changes when the heart contracts during each heartbeat.

Pumping Action of Human Heart

- Like the valves in veins, heart valves keep blood moving in one direction, preventing backflow.

END

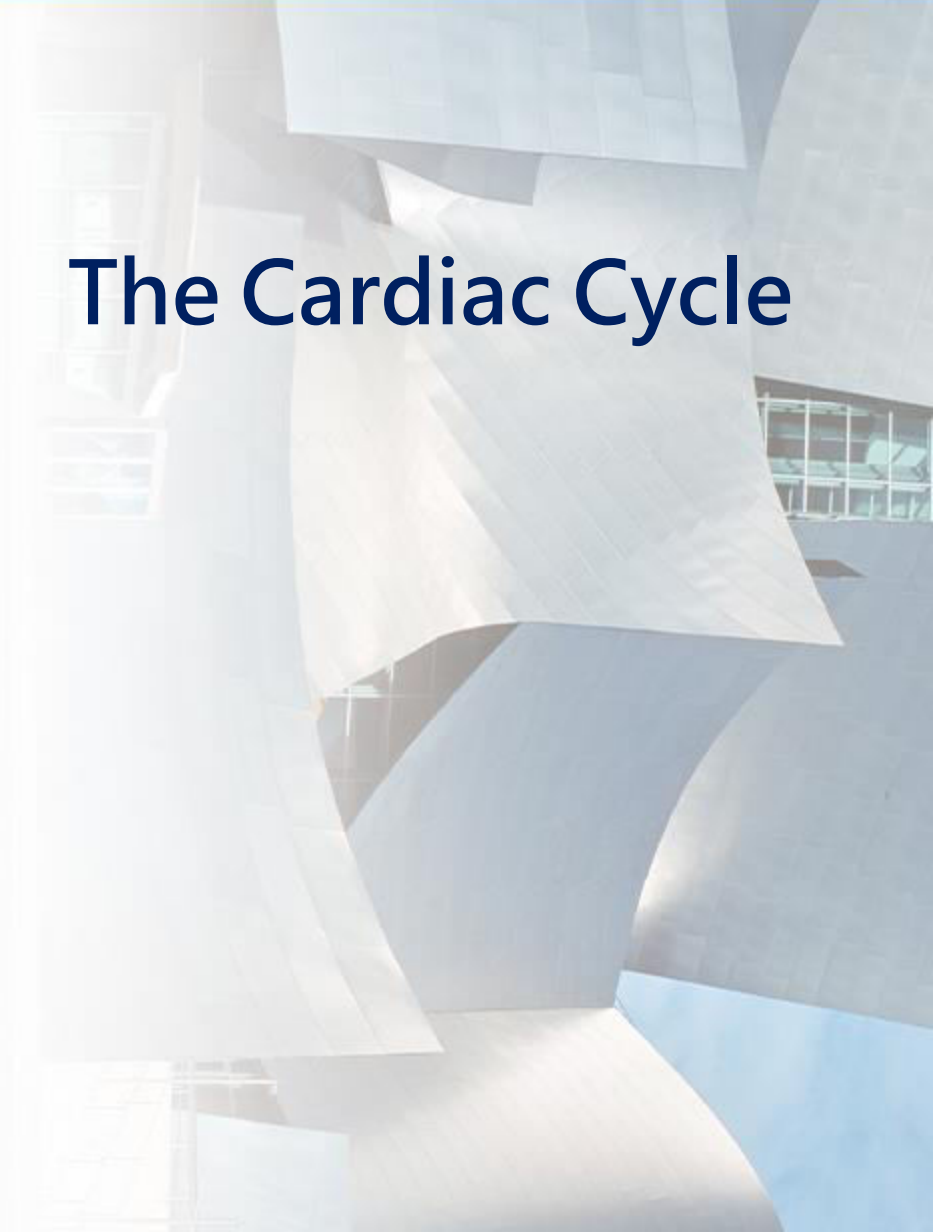
Animal Form and Function 1

Module 162



Animal Form and Function 1

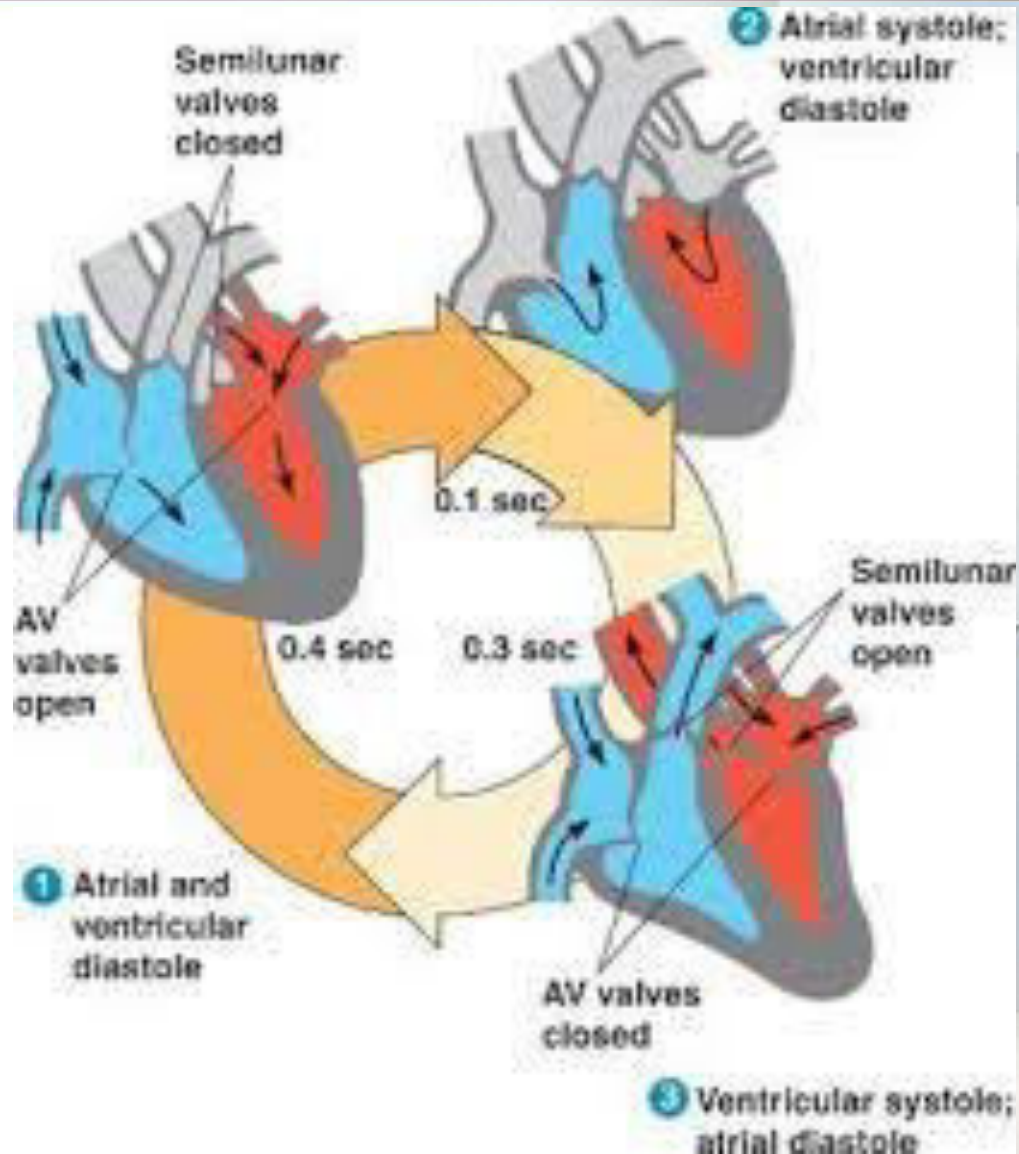
The Cardiac Cycle



The Cardiac Cycle

- The alternate contraction and relaxation of the heart chambers is called Cardiac Cycle.
- The contraction phase of the cycle is called Systole and the relaxation phase is called Diastole.
- Average heart beat of human when at rest is 72 beats a minute.

The Cardiac Cycle



The Cardiac Cycle

- One cardiac cycle take about 0.8 sec.
- Heart beat can be differentiated into three phases.
- **1. Relaxation Phase:**
This phase is also called *atrial and ventricular diastole*.
- During this phase the walls of the atria and ventricle relax,

The Cardiac Cycle

- The deoxygenated blood enters the right atrium through the vena cava and at the same time the oxygenated blood enters the Left atrium through the pulmonary vein.
- As the atria are filled up with blood, they have more pressure than the ventricles.

The Cardiac Cycle

- **2. Atrial Systole and Ventricular Diastole:** This phase lasts 0.1 sec. During this phase atria contract simultaneously forcing all the blood out of atria into the relaxed ventricles.
- **3. Atrial diastole and ventricular systole:** This phase lasts 0.3 sec. During this phase of the cycle both the ventricles contract simultaneously

The Cardiac Cycle

- pumping the blood to pulmonary arteries and aorta.
- This follow the first phase, the relaxation phase, again which lasts 0.4 sec.
- This completes the cardiac cycle extending over 0.8 sec.
- The heart of an average adult beats more than 100,000 times without fatiguing.

END

Animal Form and Function 1

Module 163



Animal Form and Function 1

Electrical Conduction System of the Human Heart

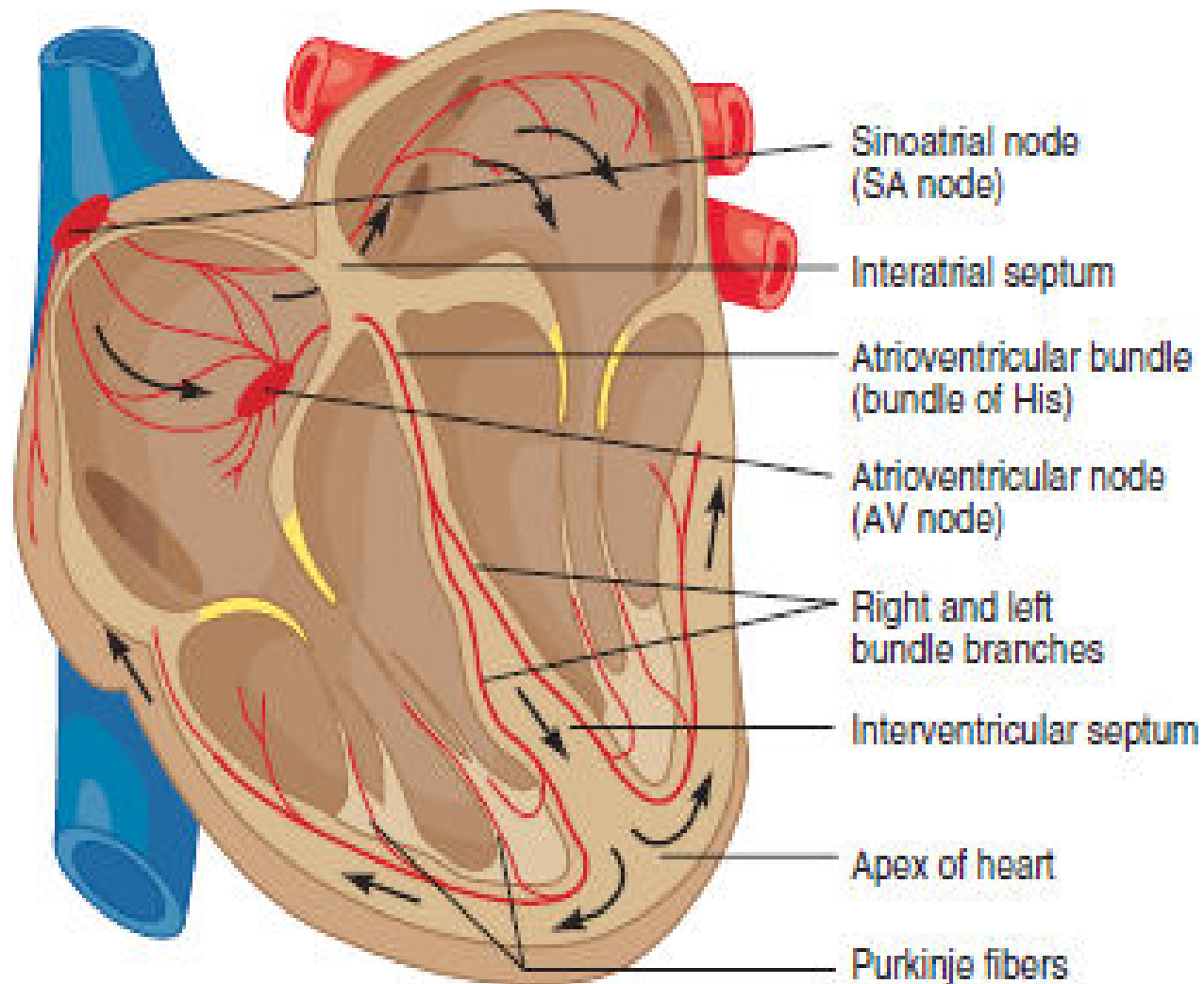
Electrical Conduction System of Human Heart

- Cardiac cycle is the sequence of muscle contractions and relaxations.
- A "pacemaker," is a small mass of tissue called the sin atrial node (SA node) at the entrance to the right atrium, initiates each heartbeat.

Electrical Conduction System of Human Heart

- The SA node initiates the cardiac cycle by producing an action potential that spreads over both atria, causing them to contract simultaneously.
- The action potential then passes to the atrioventricular node (AV node), near the inter atrial septum.

Electrical Conduction System of Human Heart



Electrical Conduction System of Human Heart

- From here, the action potential continues through the atrioventricular bundle (bundle of His), at the tip of the interventricular septum.
- The atrioventricular bundle divides into right and left branches, which are continuous with the Purkinje fibers in the ventricular walls.

Electrical Conduction System of Human Heart

- Stimulation of these fibers causes the ventricles to contract almost simultaneously and eject blood into the pulmonary and systemic circulations.

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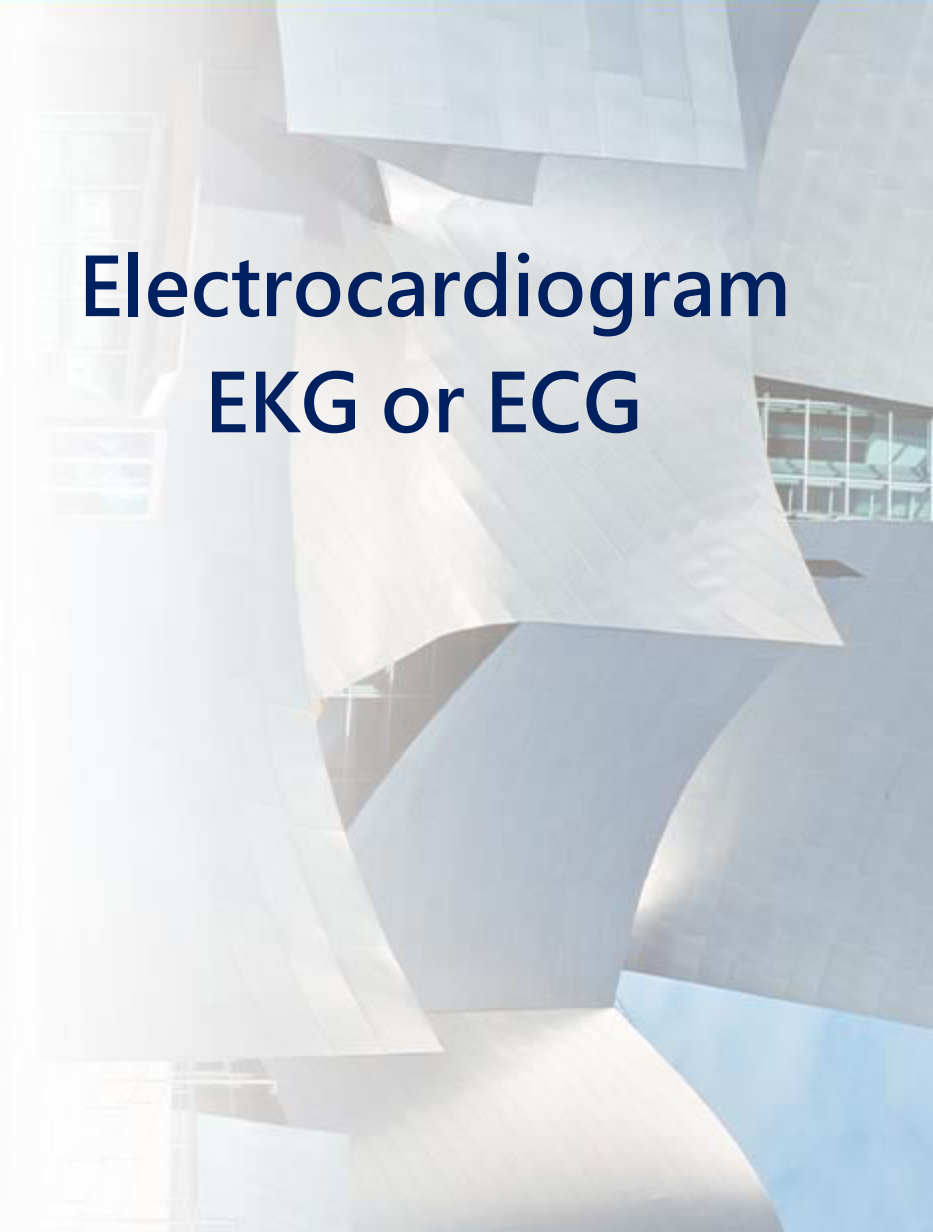
Animal Form and Function 1

Module 164



Animal Form and Function 1

**Electrocardiogram
EKG or ECG**



Electrocardiogram EKG or ECG

- ECG is the record of electrical activity or action potential over the surface of the heart as waves called P, Q, R, S and T. currents
- The electrical activity is produced when impulses travel through cardiac muscles during the heart cycle.

Electrocardiogram EKG or ECG

- The electrical activity thus produced in the form of electrical current through body fluids to the body surface.
- These currents can be detected by electrodes placed on the skin and recorded as waves- P,Q,R,S and T.

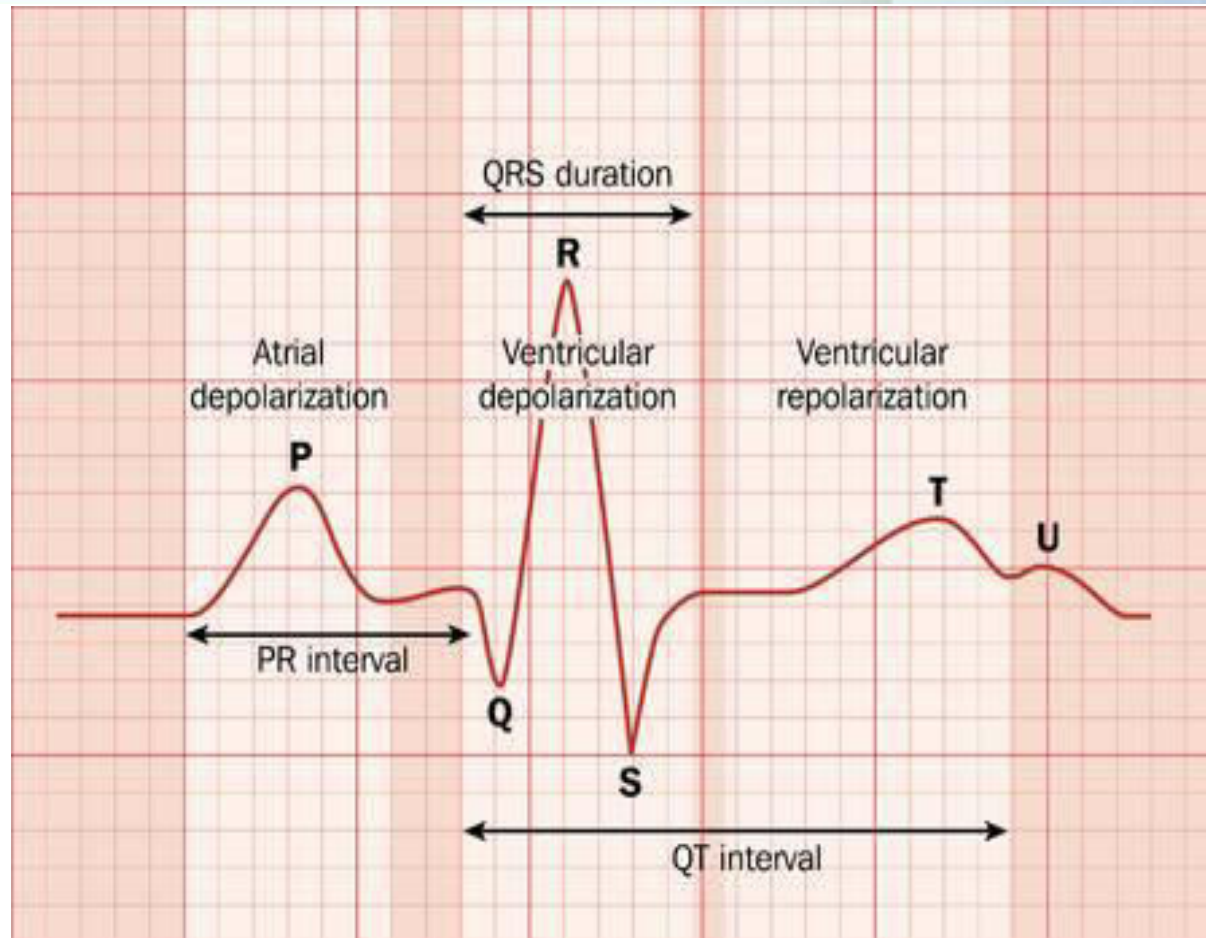
Electrocardiogram EKG or ECG

- ECG gives important information concerning the spread of excitation to different parts of the heart.
- ECG is of great value in the diagnosis of cases of abnormal cardiac rhythm and myocardial damage.
- ECG is recorded by a device called electrocardiograph.

Electrocardiogram EKG or ECG



Electrocardiogram EKG or ECG



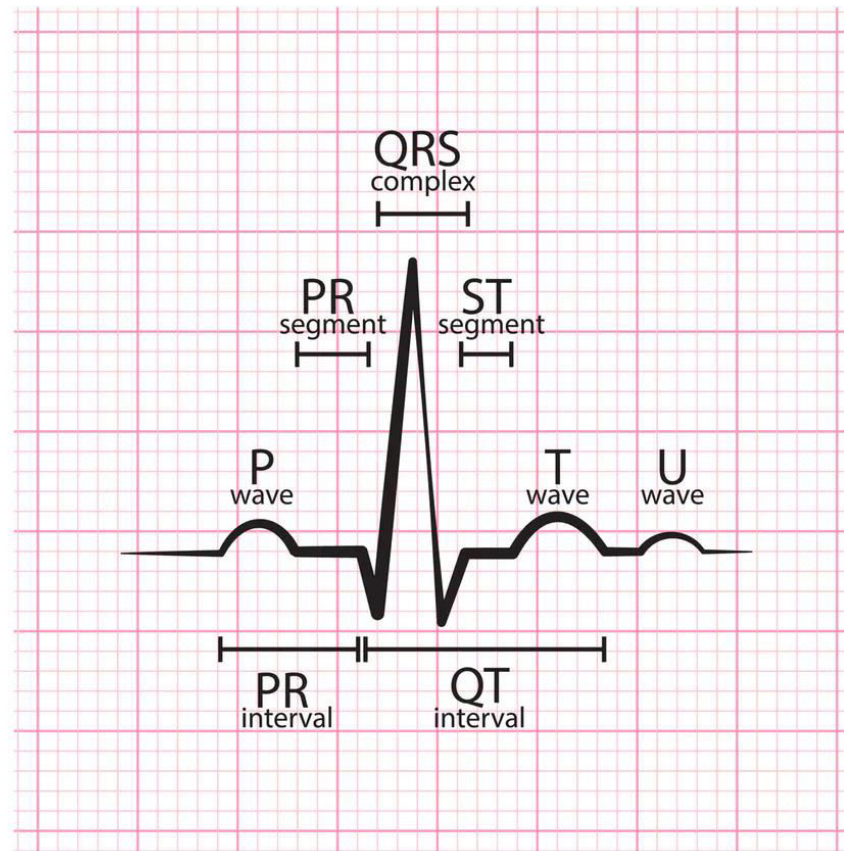
P- Atrial contraction;

QRS-Ventricular excitation

- PR-Ventricular filling
- T- Ventricular contraction

Electrocardiogram EKG or ECG

NORMAL ECG



Animal Form and Function 1

Module 166



Animal Form and Function 1

Some Cardiovascular Disorders

Some Cardiovascular Disorders

Leukemia

- It is the result of uncontrolled production of WBCs.
- It is caused by a mutation in the cells of bone marrow called myelogenous cells.
- These cell without completing the cell cycle, spread to other parts of the body by blood stream.

Some Cardiovascular Disorders

- This process is called metastasis.
- The undifferentiated cells are defective and produced at a faster than normal rate.
- It is a serious disorder. The patient needs regular change of blood.
- It can be cured by bone marrow transplant.

Some Cardiovascular Disorders

- **Thalassemia** It is hereditary anemia produced by defective production of of alpha or beta Hb polypeptide chain.
- **Thalassemia** is characterized by fatigue, severe anemia, enlargement of heart and jaundice.
- It can be treated by bone marrow transplant.

Some Cardiovascular Disorders

- Myocardial Infarction commonly called heart attack.
- Occurs when blood flow decreases or stops to a part of the heart, causing damage to the heart muscle.
- The most common symptom is chest pain or discomfort which may travel into the shoulder, arm, back, neck or jaw.

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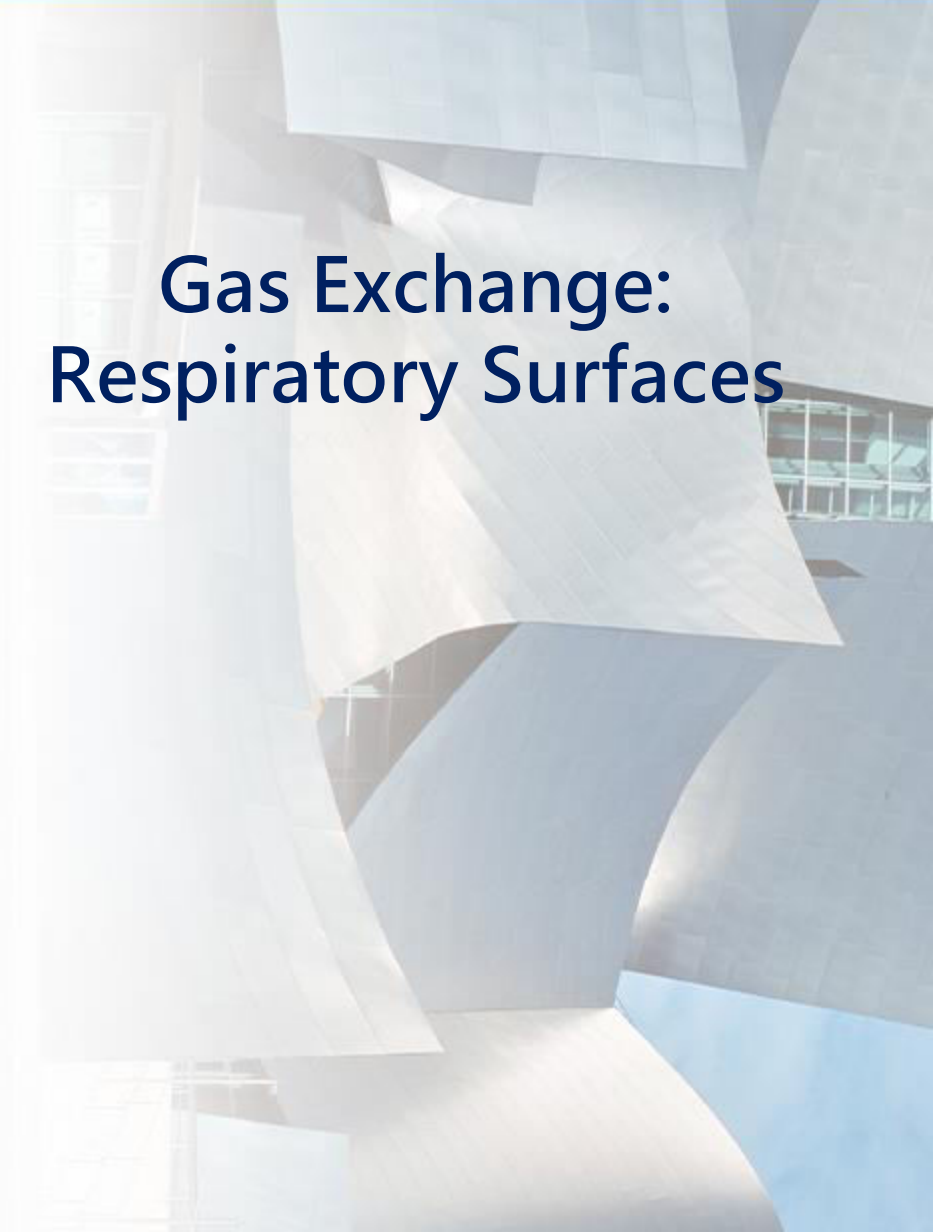
Animal Form and Function 1

Module 167



Animal Form and Function 1

Gas Exchange: Respiratory Surfaces



Gas exchange: Respiratory Surfaces

- Food is the rich source of chemical energy.
- How do animals utilize this chemical energy into useable form?
- First, they must digest the organic matter so that it can enter the cells.
- Second, they must provide cells with an adequate supply of oxygen.

Gas exchange: Respiratory Surfaces

- This is required for aerobic respiration and a way of eliminating the carbon dioxide that aerobic respiration produces.
- This process of gas exchange with the environment, also called external respiration or breathing is the subject of the rest of this chapter.

Gas exchange: Respiratory Surfaces

- **Respiratory Surfaces:** Protists and animals have five main types of respiratory systems (surfaces):
 - 1. Simple diffusion across plasma membranes,
 - 2. Tracheae
 - 3. Skin or cutaneous (integument or body surface) exchange,

Gas exchange: Respiratory Surfaces

- 4. Gills and
- 5. lungs.
- Each of these surfaces will be discussed in the next modules.

END

Animal Form and Function 1

Module 168



Animal Form and Function 1

Invertebrate Respiratory Systems Part I

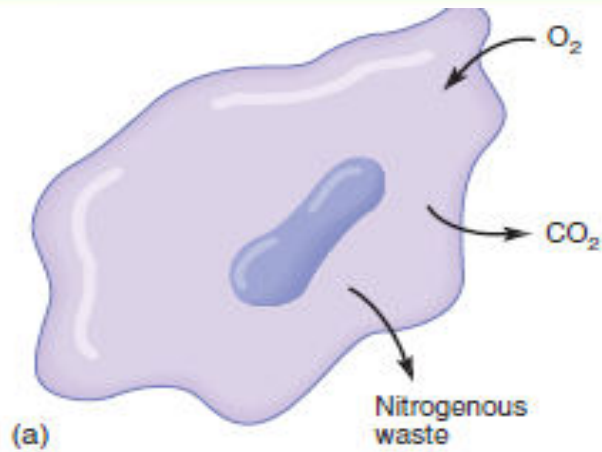
Invertebrate Respiratory Systems Part I

- Properties of Respiratory surfaces in animals:
 - 1. Large surface area
 - 2. Moist
 - 3. Thin epithelium
 - 4. Ventilation
 - 5. Capillary network

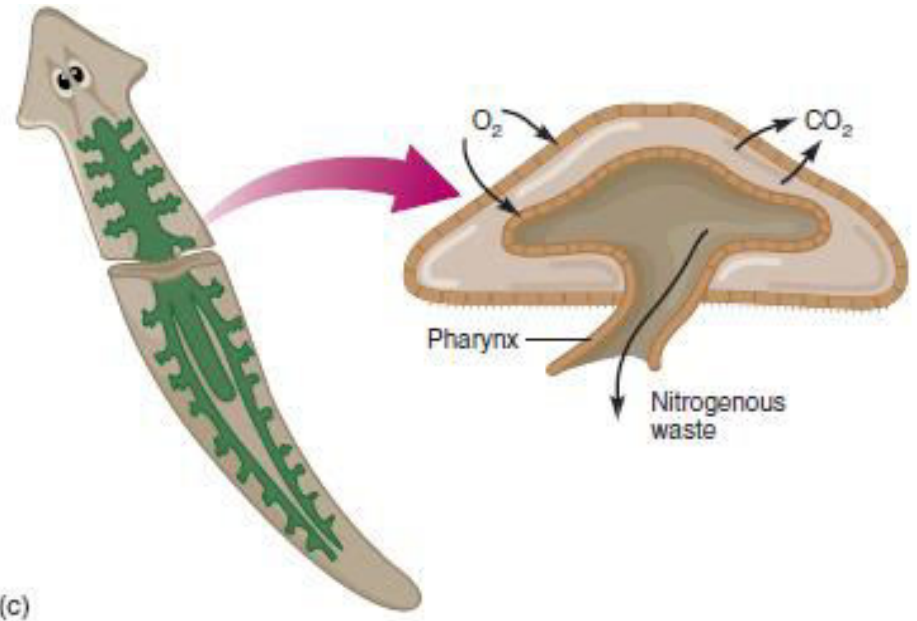
Invertebrate Respiratory Systems Part I

- In protozoa, gaseous exchange take place by diffusion across the plasma membrane
- Some multicellular invertebrates e.g. Hydra gases diffuse into and out of the animal cells through the entire inner and outer surfaces, which are in contact with water.

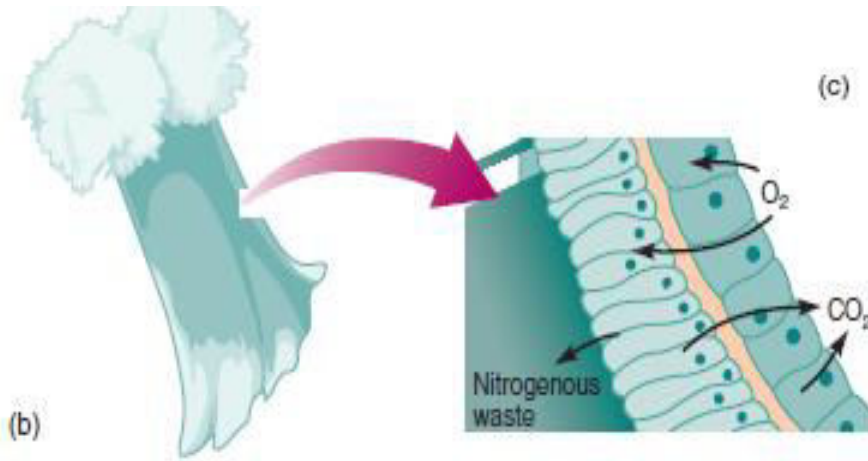
Invertebrate Respiratory Systems Part I



Amoeba



Planarian



Sea anemone

Invertebrate Respiratory Systems Part I

- In flat worms e.g. Planarian, body is thin-walled. Again, gases diffuse into and out of the animal.
- In earthworms that live in moist environments use integumentary exchange.
- Earthworms have capillary networks just under their integument, and they exchange gases with the air.

Invertebrate Respiratory Systems Part I

- Some annelid worms e.g. Nereis have prominent lateral projections called parapodia that are richly supplied with blood vessels and function as gills.

Invertebrate Respiratory Systems Part I

***Nereis* or *Neanthes* (Clamworm)**



Earthworm



Animal Form and Function 1

Module 169



Animal Form and Function 1

Invertebrate Respiratory Systems Part II

Invertebrate Respiratory Systems Part II

- Crustaceans and molluscs have gills that are compact and protected with hard covering devices.
- Such gills divide into highly branched structures to maximize the area for gas exchange.

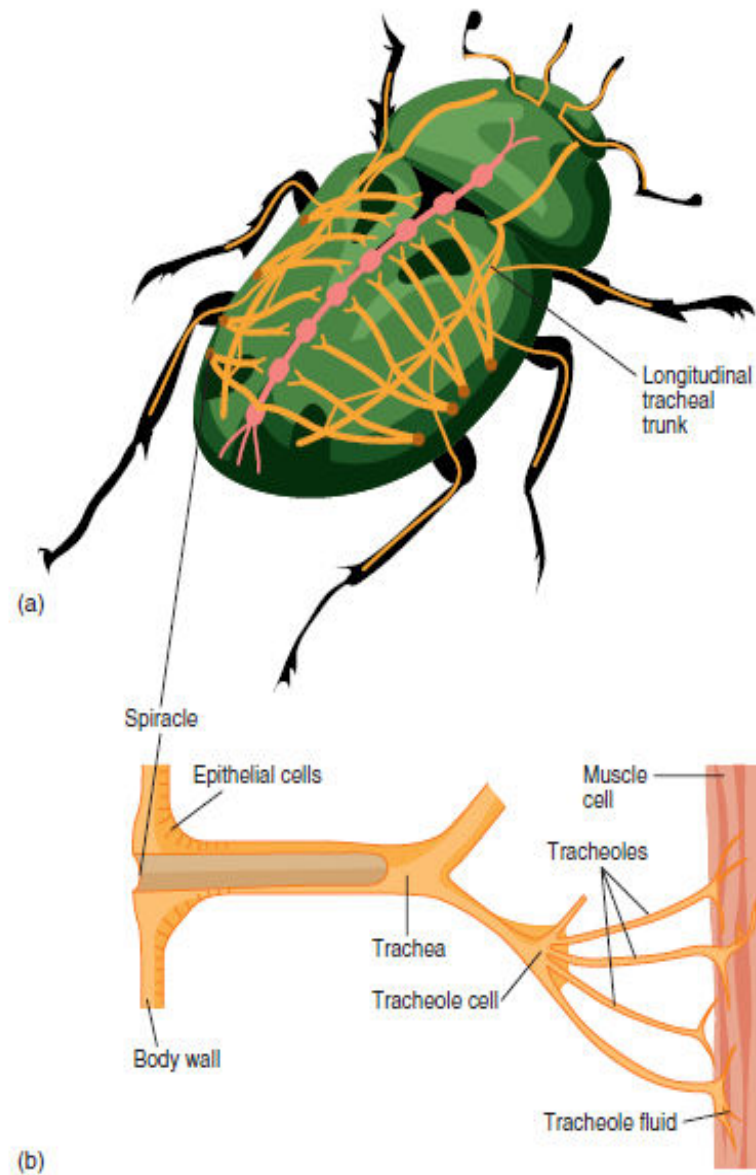
Invertebrate Respiratory Systems Part II

- Some terrestrial invertebrates (e.g., insects, centipedes and some mites, ticks, and spiders) have **tracheal systems** consisting of highly branched chitin-lined tubes called tracheae.

Invertebrate Respiratory Systems Part II

- Tracheae open to the outside of the body through spiracles, which usually have some kind of closure device to prevent excessive water loss.
- Spiracles lead to branching tracheal trunks that eventually give rise to smaller branches called tracheoles, whose blind ends lie close to all cells of the body.

Invertebrate Respiratory Systems Part II



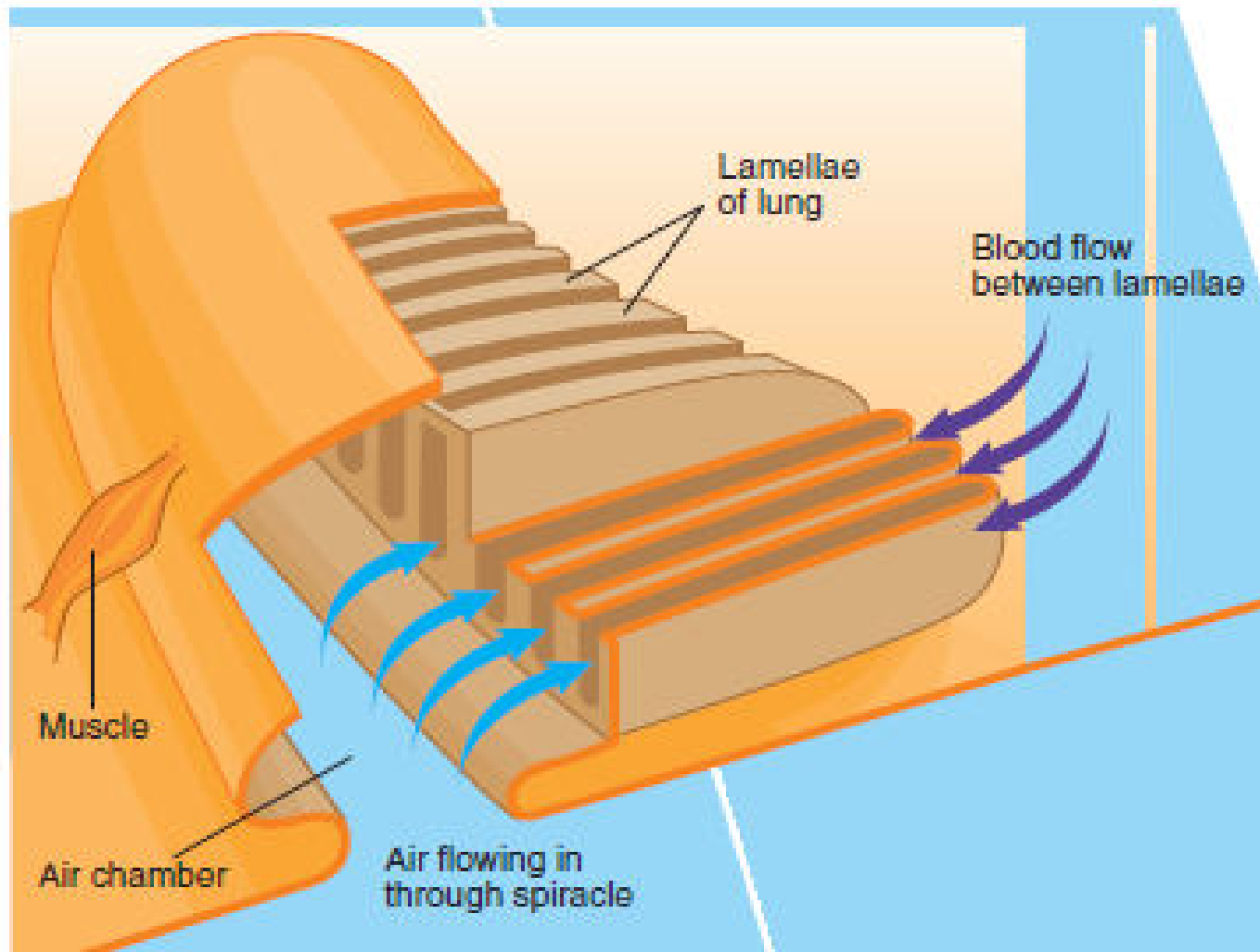
Invertebrate Respiratory Systems Part II

- Most insects have ventilating mechanisms that move air into and out of the trachea.
- For example, contracting flight muscles of insects alternately compress and expand the large tracheal trunks and thereby ventilate the tracheae.

Invertebrate Respiratory Systems Part II

- Arachnids possess tracheae, book lungs, or both.
- **Book lungs** are paired invaginations of the ventral body wall that are folded into a series of leaf-like lamellae.
- **The Pulmonate Lung.** The mantle cavity of the pulmonate snail, *Lymnaea*, is highly vascularized and functions as a lung.

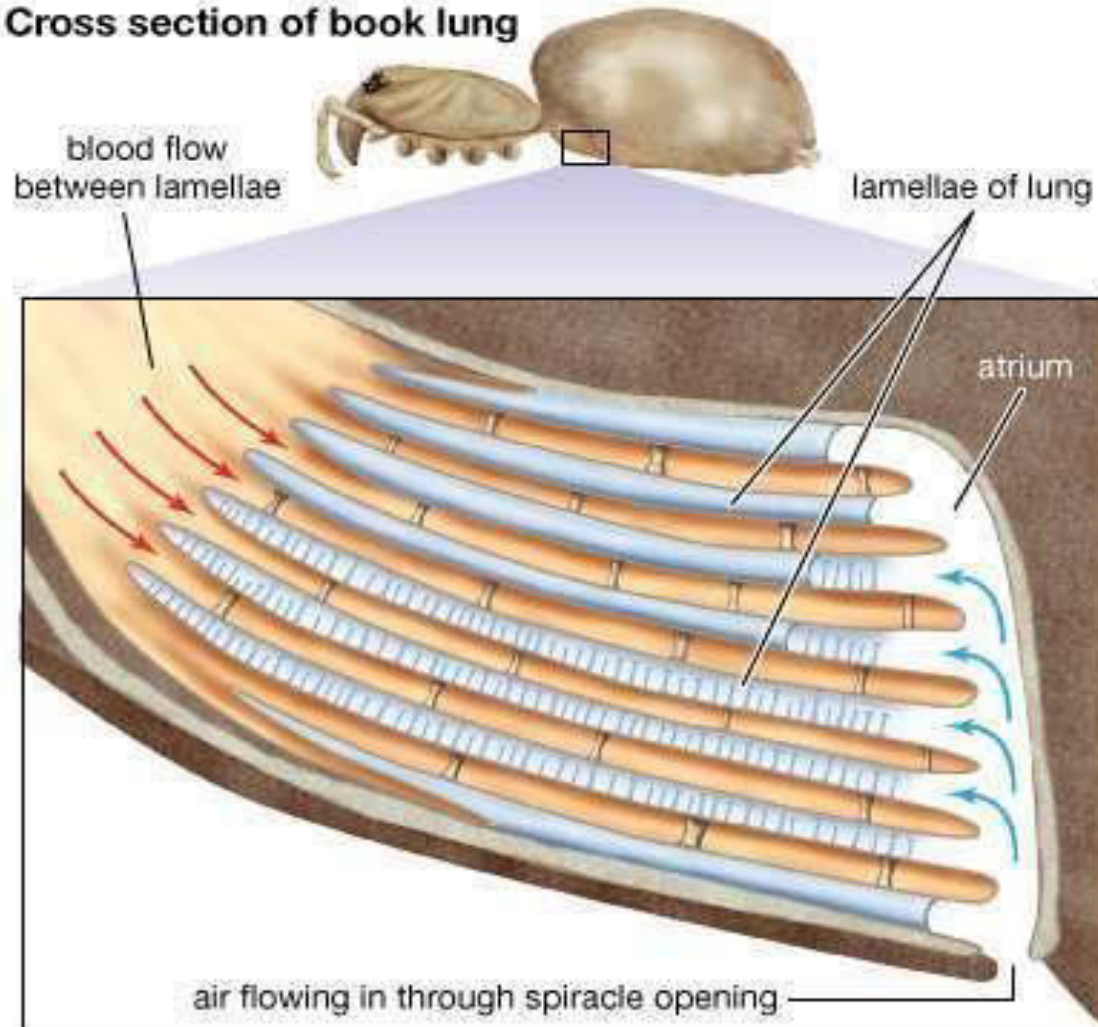
Invertebrate Respiratory Systems Part II



Book lung

Invertebrate Respiratory Systems Part II

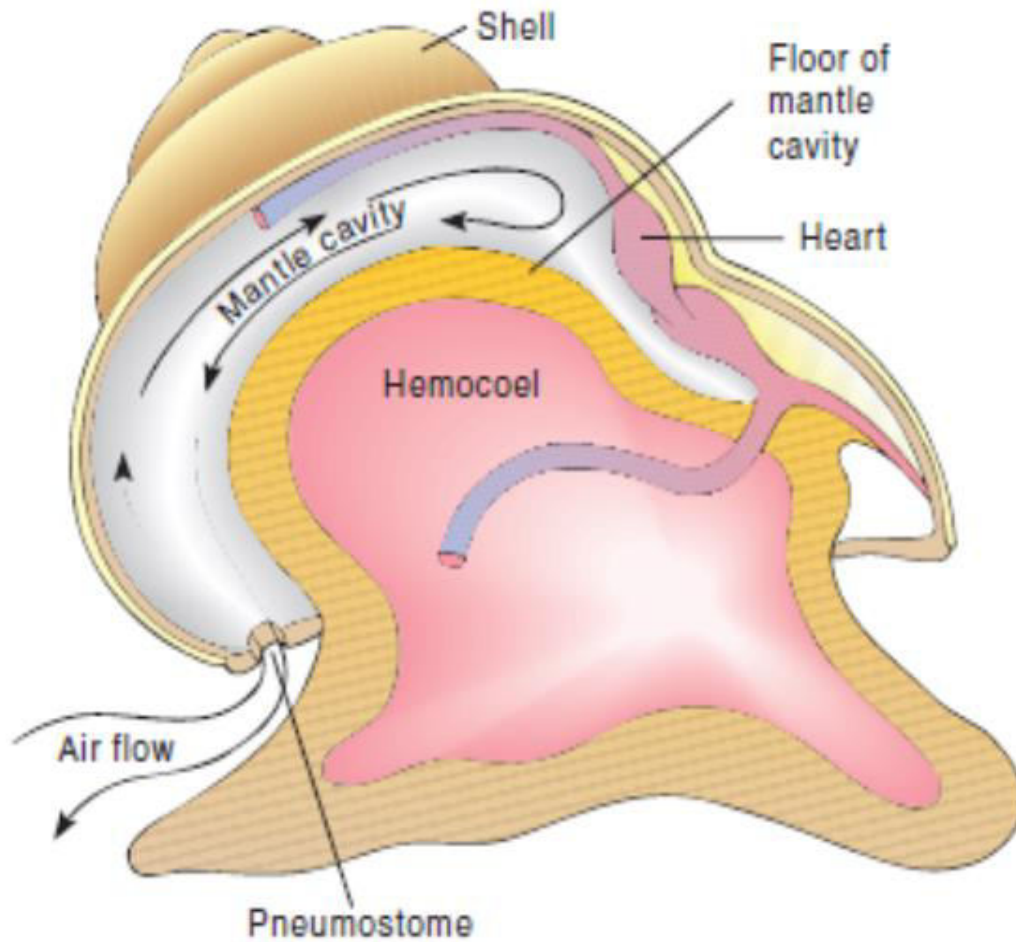
Cross section of book lung



Invertebrate Respiratory Systems Part II

- Air is drawn into the mantle cavity for respiration.
- Air flows into and out of the lung through a single pore called the pneumostome.

Invertebrate Respiratory Systems Part II



A Gastropod

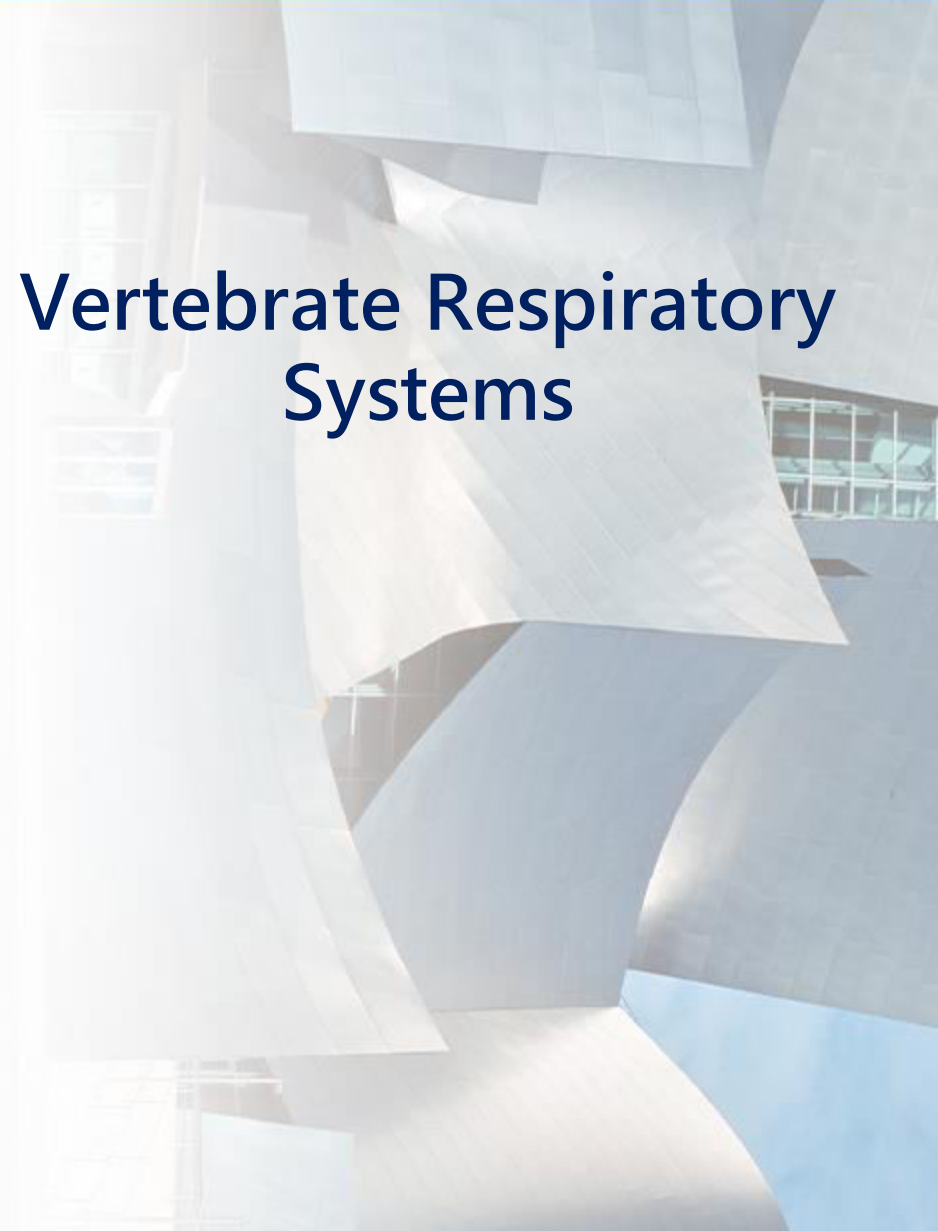
Animal Form and Function 1

Module 170



Animal Form and Function 1

Vertebrate Respiratory Systems



Vertebrate Respiratory Systems

- There are two models of breathing in vertebrates:
- 1. Bimodal breathing
2. Trimodal breathing
- Bimodal breathing is the ability of an organism to exchange respiratory gases simultaneously with both air and water.
e.g., some salamanders, crabs, barnacles, bivalve molluscs, and lung fishes.

Vertebrate Respiratory Systems

- These animals use gills for water breathing and lungs for air breathing.
- Trimodal Breathing is the ability of an organism to exchange respiratory gases through three surfaces i.e. skin, gills, and lungs.

Vertebrate Respiratory Systems

- Bimodal breathing was an important respiratory adaptation with evolutionary transition between aquatic and terrestrial habitats.
- Fundamental changes in the structure and function of the respiratory organs accompanied the transition from water to air breathing.

Vertebrate Respiratory Systems

- In terrestrial vertebrates i.e. reptiles, birds, and mammals, gills were replaced with lungs.
- Cutaneous, gills and lungs are the three vertebrate respiratory surfaces which will be discussed in upcoming modules.

END

Animal Form and Function 1

Module 171



Animal Form and Function 1

Cutaneous Respiration

The background of the slide is an abstract composition. On the right side, there is a blurred image of a modern building with a grid-like facade. Overlaid on this and extending towards the left are several large, semi-transparent, white geometric shapes that resemble folded paper or architectural elements. These shapes create a sense of depth and movement. The overall color palette is dominated by light blues, whites, and greys, with a solid blue header at the top.

Cutaneous Respiration

- **Cutaneous Respiration:**
It is the exchange of gases through skin.
- Cutaneous exchange is most highly developed in frogs, toads, lungless salamanders and newts
- Some more vertebrates such as some aquatic turtles, salamanders with lungs, snakes, fishes, and mammals (Bat).

Cutaneous Respiration



Salamander



Newt

Cutaneous Respiration

- These animals have lungs or gills, use cutaneous respiration to supplement gas exchange.
- Amphibian skin has the simplest structure of all the major vertebrate respiratory organs.
- In frogs, a uniform capillary network lies in a plane directly beneath the epidermis.

Cutaneous Respiration

- This vascular arrangement facilitates gas exchange between the capillary bed and the environment by both diffusion and convection.
- A slimy mucous layer that keeps amphibian skin moist and protects against injury and helps in gas exchange.

Cutaneous Respiration

- Some amphibians obtain about 25% or more of their oxygen by this exchange, and the lungless salamanders carry out all of their gas exchange through the skin and buccal-pharyngeal region.

END

Animal Form and Function 1

Module 172



Animal Form and Function 1

Gill Respiration



Gill Respiration

- Gills are respiratory organs that have thin, moist epidermis over highly vascularized dermis for gaseous exchange.
- Larval forms of a few fishes and amphibians have external gills projecting from their bodies.
- Adult fishes have internal gills covered with operculum.

Gill Respiration

- Below the operculum there are four gill arches, and each arch consists of many filaments.
- A filament houses capillaries within lamellae where the direction of water flow opposes that of blood flow.

Gill Respiration

- This counter current flow allows the fish to extract the maximal amount of oxygen from the water.

Gill Respiration

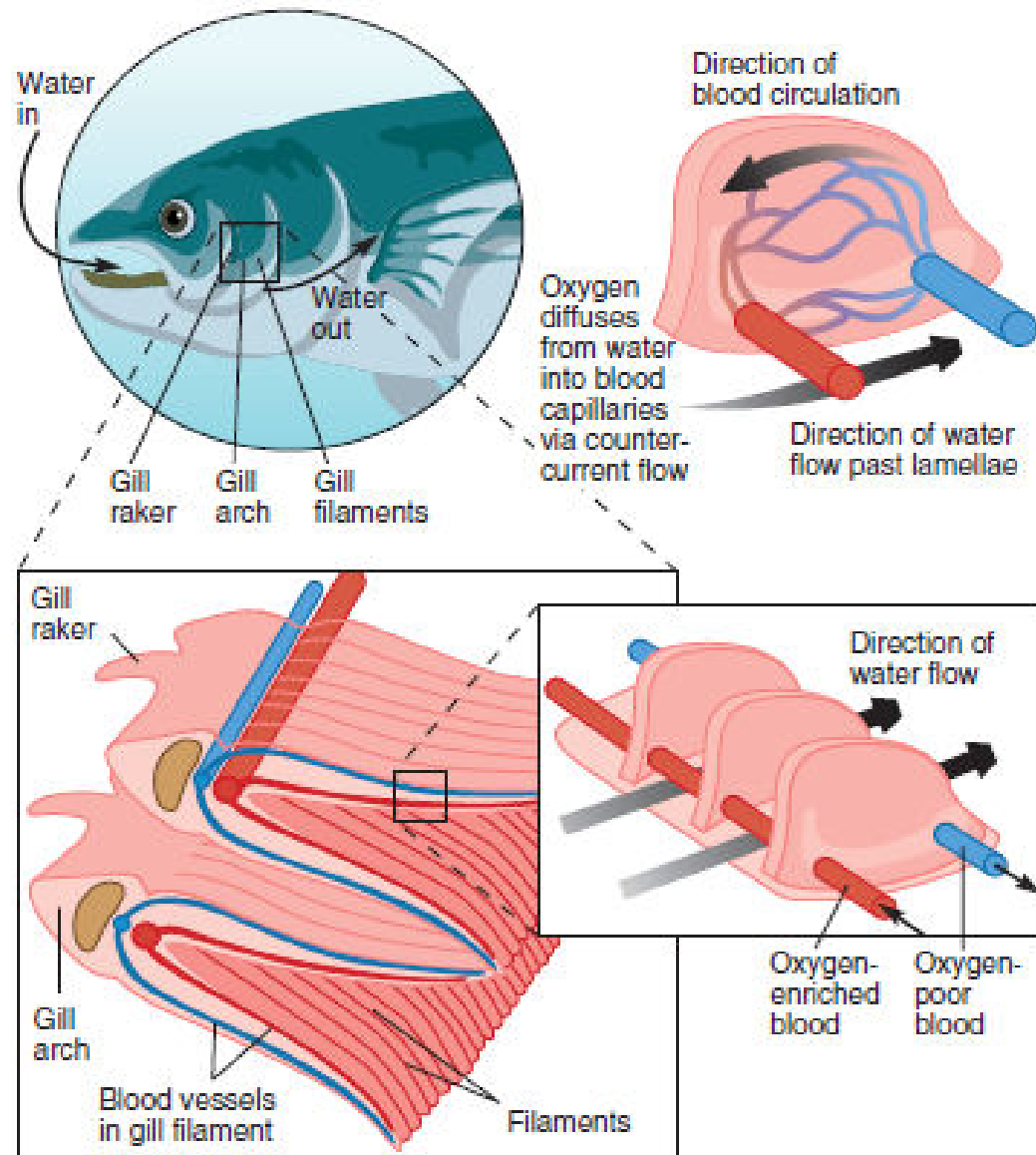


Axolotl larva



Tadpole larva

Gill Respiration



Animal Form and Function 1

Module 173



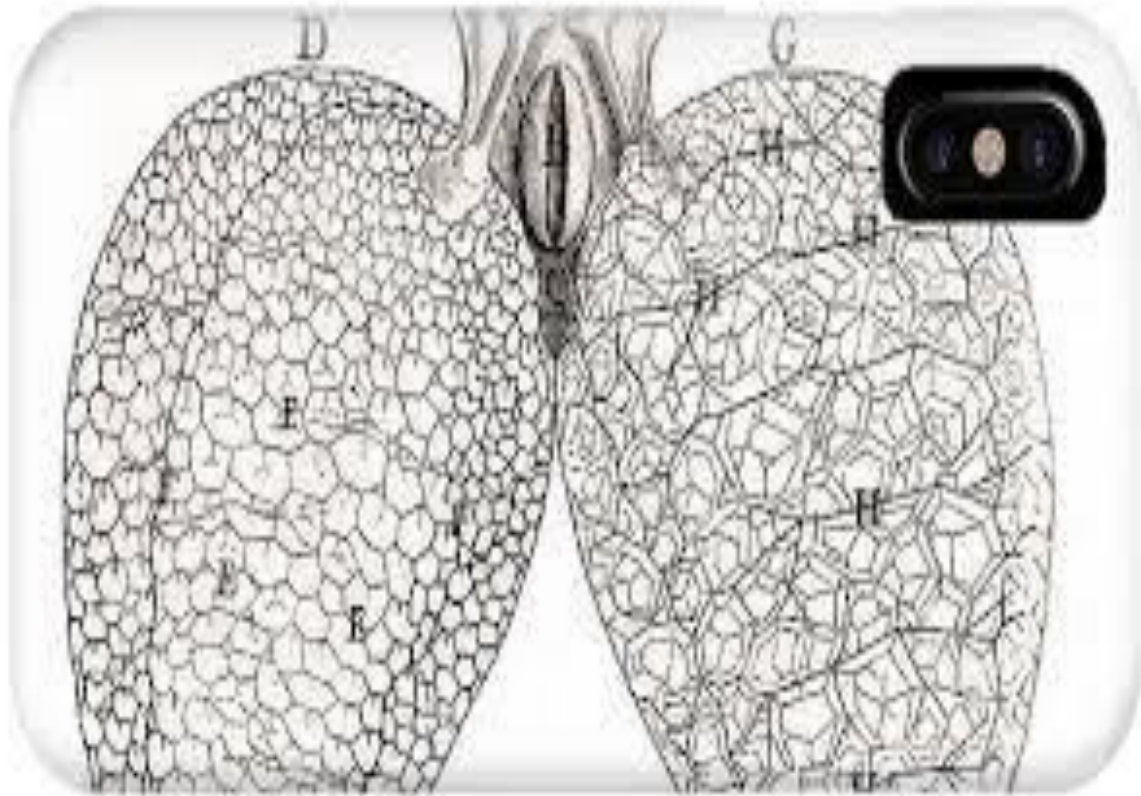
Animal Form and Function 1

**Lung Respiration in
Amphibians and
Reptiles.**

Lung Respiration in Amphibians and Reptiles

- Amphibian Respiration
- As the tadpole grows, the gills disappear and lungs grow.
- Amphibian lungs are simple saclike structures.
- Internally lungs lack the complex spongy appearance unlike the lungs of birds and mammals.

Lung Respiration in Amphibians and Reptiles

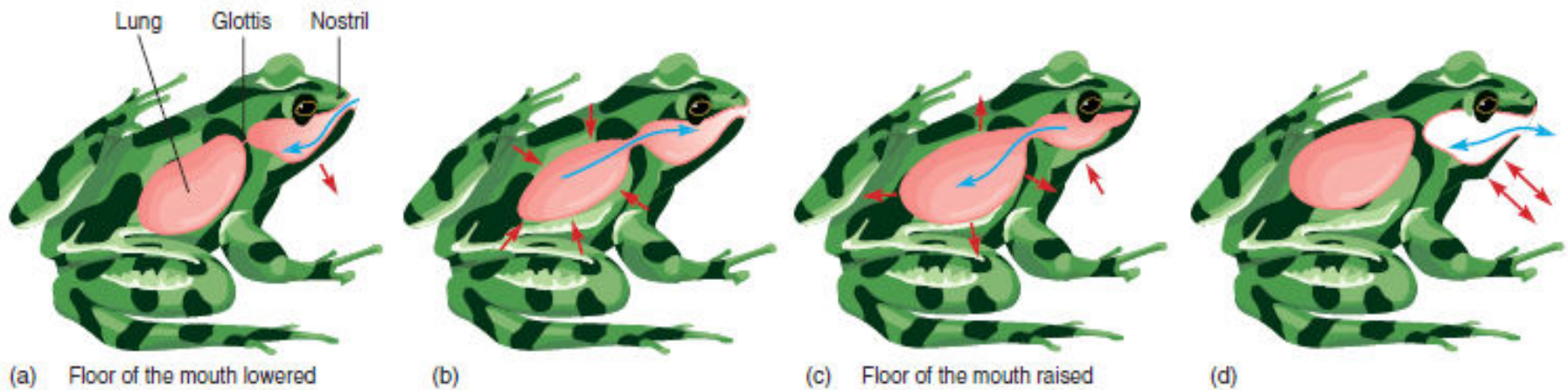


Amphibian lungs

Lung Respiration in Amphibians and Reptiles

- Adult amphibians lack or have a reduced diaphragm, so breathing through the lungs is forced.
- The lungs of most amphibians receive a large proportion of the total blood flow from the heart.

Lung Respiration in Amphibians and Reptiles

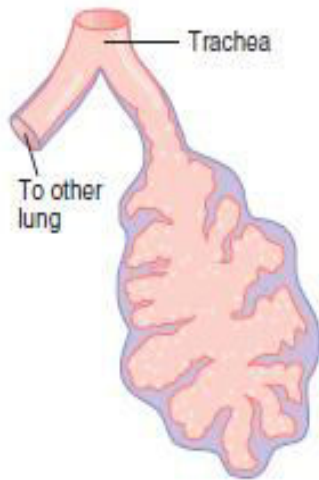


Lung Respiration in Amphibians and Reptiles

- Even though the amphibian ventricle is undivided, there is surprisingly little mixture of blood from the left and right atrial chambers within the single ventricle.
- As a result, the lungs are perfused primarily with deoxygenated blood from the systemic tissues.

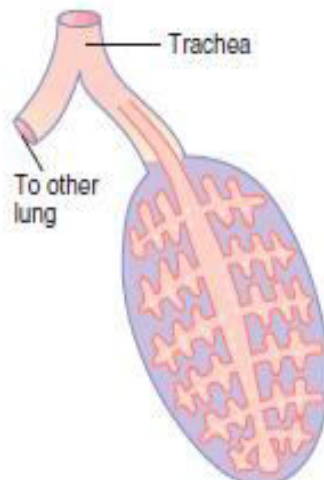
Lung Respiration in Amphibians and Reptiles

Lungs of



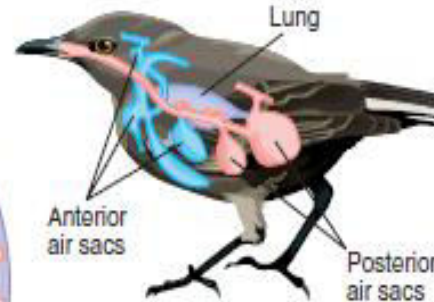
(a)

Amphibian

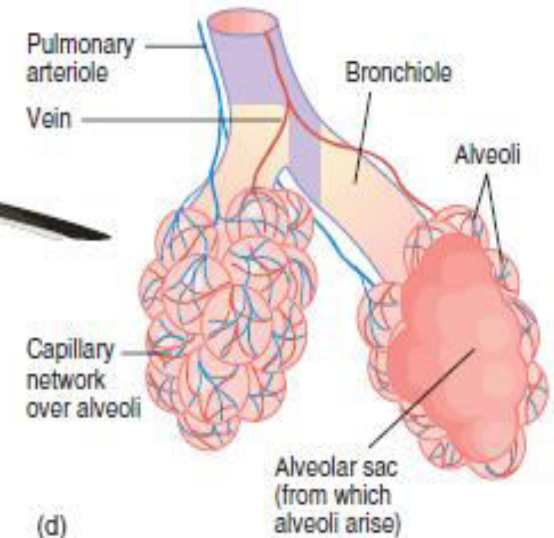


(b)

Reptilian



(c)



(d)

Birds

Lung Respiration in Amphibians and Reptiles

- All reptiles breathe using lungs.
- Aquatic turtles have developed more permeable skin, and some species have modified their cloaca to increase the area for gas exchange.
- Because of this constraint, most Lizards and snakes are forced to hold their breath during intense runs.

Lung Respiration in Amphibians and Reptiles

- In these reptiles the lungs are ventilated almost exclusively by the muscles of the chest wall.
- Crocodiles and alligators have a large sheet of muscle below the lungs, called a diaphragm, that controls their breathing.

END

Animal Form and Function 1

Module 174



Animal Form and Function 1

Respiration in Birds



Respiration in Birds

- Respiration in birds is complex and efficient.
- It consists of lungs , 5-6 pairs of air sacs and air passages.
- Trachea divides into right and left bronchi
- Bird lungs have tunnel-like passages called parabronchi, which lead to air capillaries in which gas exchange occurs.

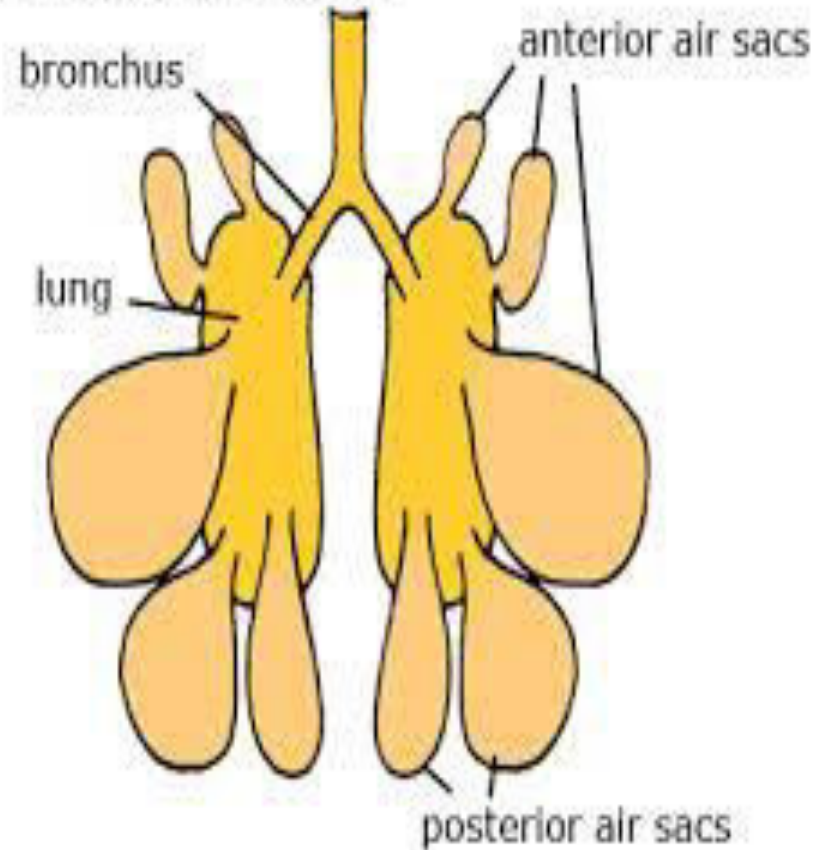
Respiration in Birds

- The end of each bronchus divides into small branches leading into air sacs.
- These sacs are collapsible, and open and close as a result of muscle contractions around them.
- The arrangement of air sacs make one-way flow possible.

Respiration in Birds



bird respiratory system



Respiration in Birds

- **Mechanism of Breathing**
- Inhaled air bypasses the lungs and enters the abdominal (posterior) air sacs.
- It then passes through the lungs into the thoracic (anterior) air sacs.
- Finally, air is exhaled from the thoracic air sacs. This whole process requires two complete breathing cycles.

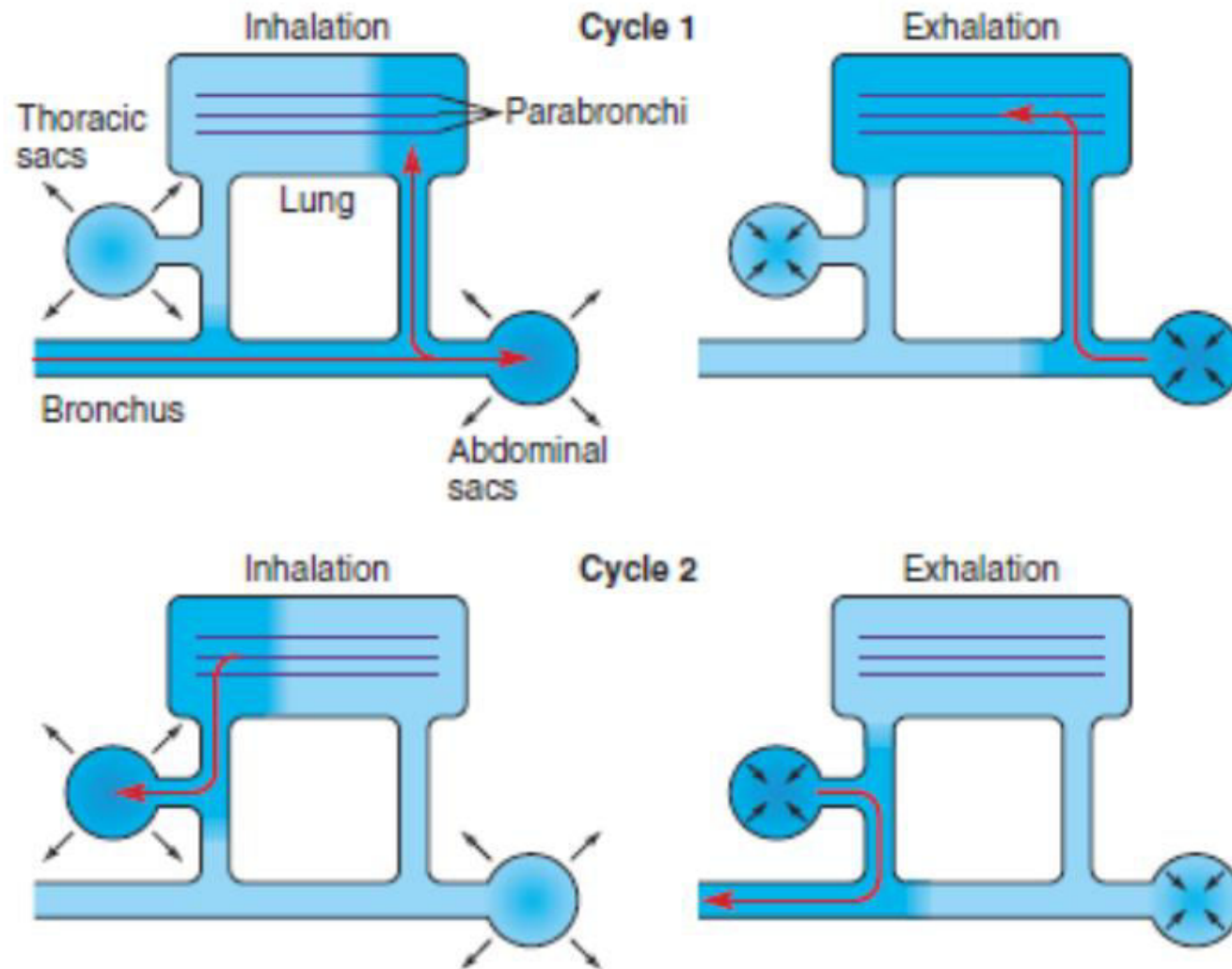
Respiration in Birds

- Mechanism of Breathing
- Inspiration and expiration result from alternate expansion and compression of the air sacs.
- Inhaled air bypasses the lungs and enters the abdominal (posterior) air sacs.

Respiration in Birds

- It then moves to the thoracic (anterior) air sacs after passing through the lungs.
- Finally, air is exhaled from the thoracic air sacs.
- This whole process requires two complete breathing cycles.
- Two cycles are required for the air to pass all the way through the system and out of the bird.

Respiration in Birds



(b)

Animal Form and Function 1

Module 175



Animal Form and Function 1

Human Respiratory System Part I

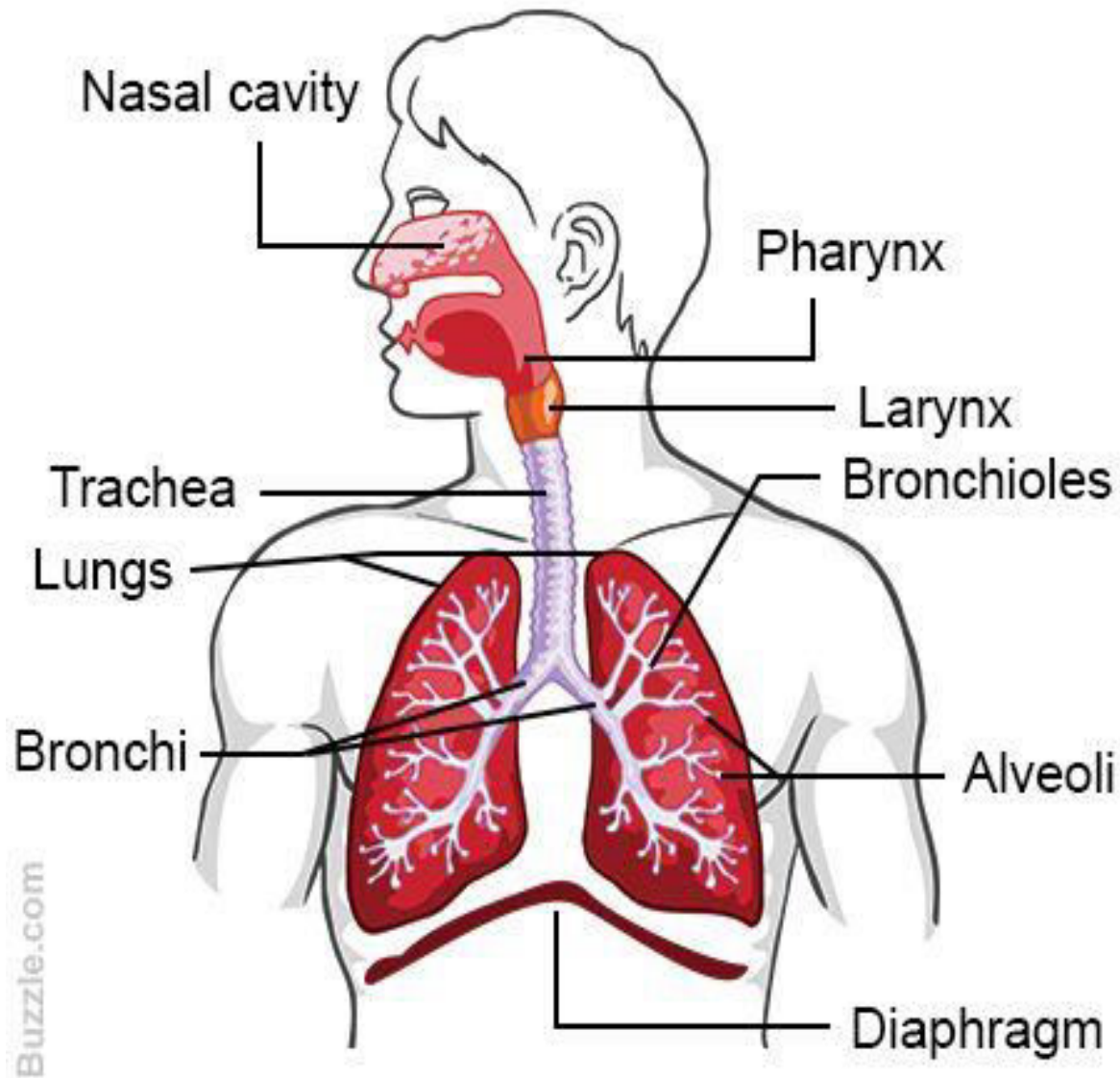
Human Respiratory System Part I

- Human respiratory system includes:

1. Air conducting portion
2. Gas exchange portion.

- Air Conducting portion are the air passage ways that consist of nostrils, nasal cavities, pharynx, larynx, trachea, bronchi, bronchioles and alveolar ducts which ultimately leads into the alveolar sacs.

Human Respiratory System Part I



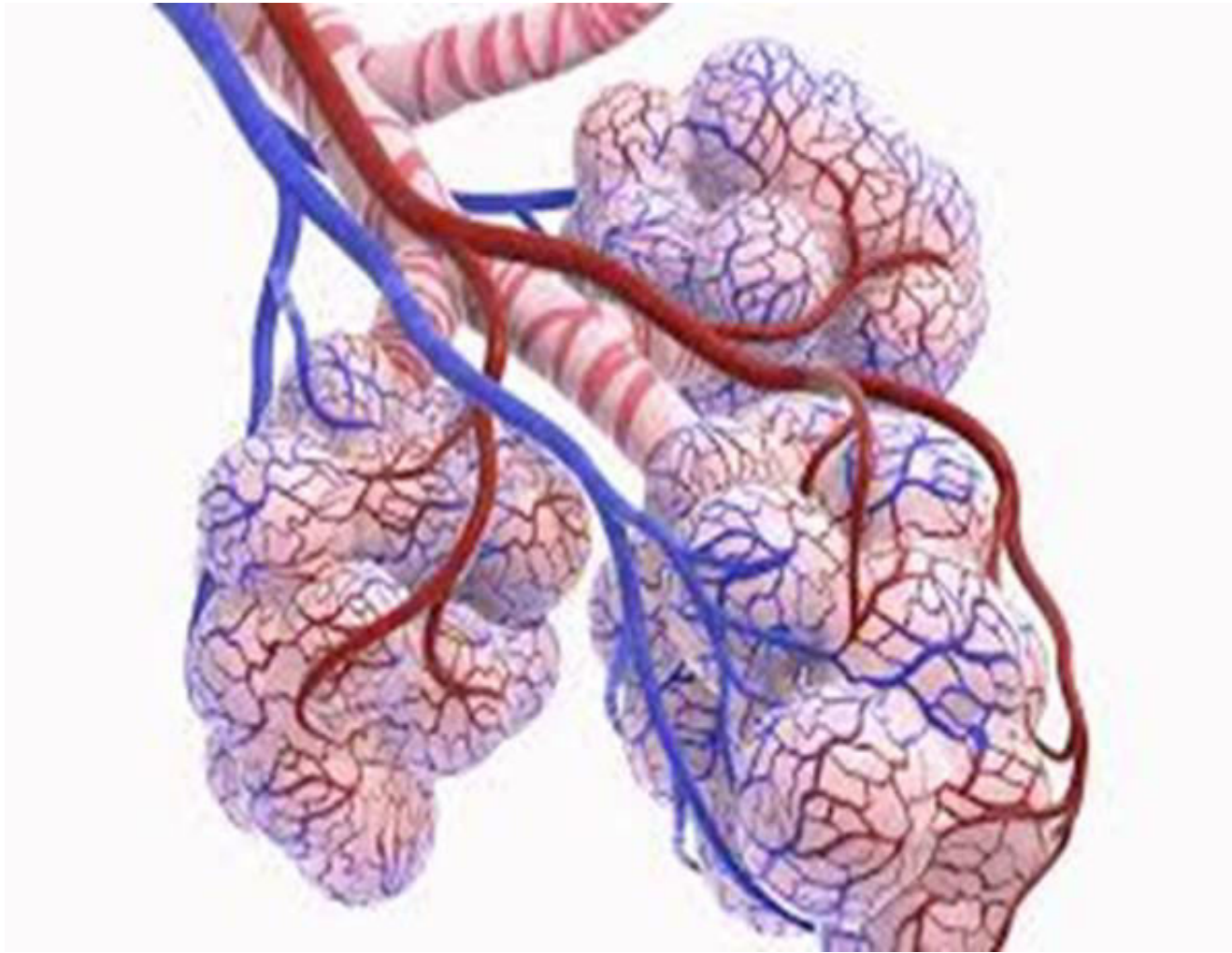
Human Respiratory System Part I

- As air enters through nostrils up to alveoli, air is filtered, moistened and conditioned.
- In the pharynx the traffic of air and food is kept properly channeled by flap called epiglottis.
- Alveoli are single layered endothelial walls.

Human Respiratory System Part I

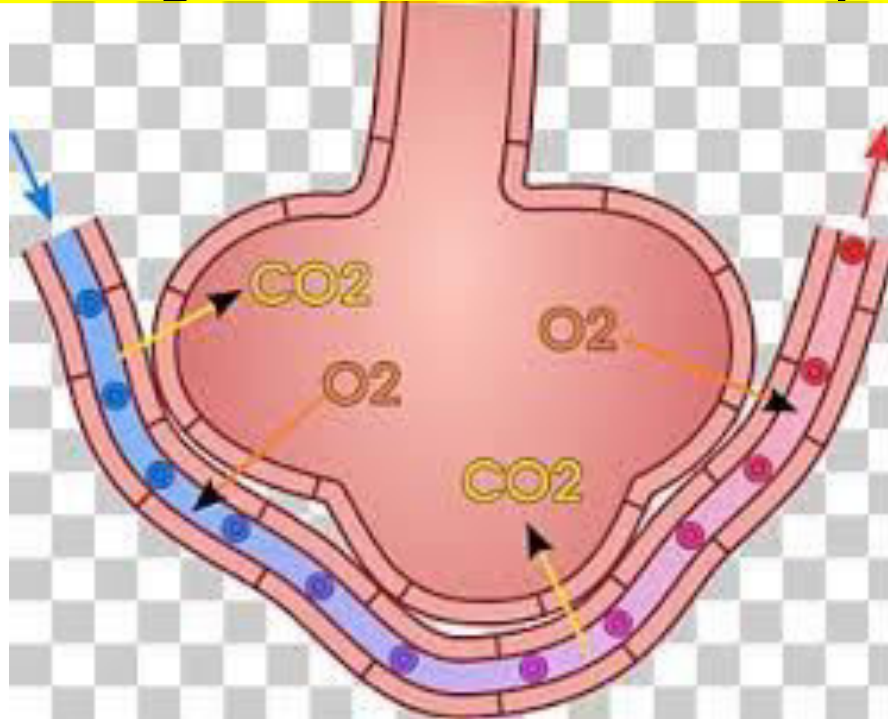


Human Respiratory System Part I



Human Respiratory System Part I

- Overlying the alveoli there is rich network of blood capillaries providing site for gaseous exchange.
- The air passage ways are kept from collapsing by cartilage C-shaped rings in trachea and complete rings in bronchi.



Human Respiratory System Part I

- The rings are progressively replaced by irregular cartilage plates.
- The bronchioles totally lack cartilage but made of mainly circular smooth muscles.

END

Animal Form and Function 1

Module 176



Animal Form and Function 1

Human Respiratory System Part II

Human Respiratory System Part II

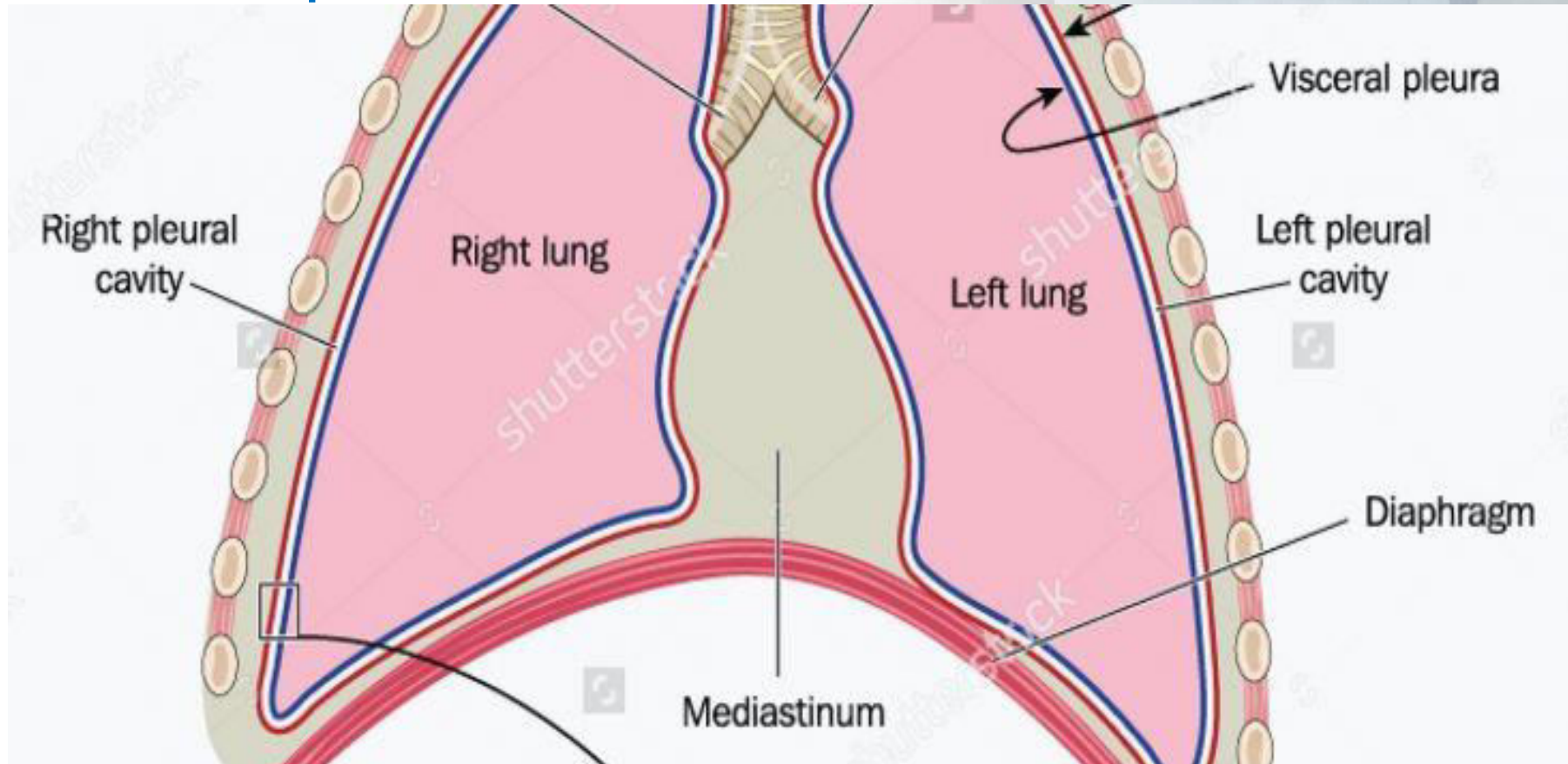
- Gas Exchange Portion of the Respiratory system: The Lungs
- Lungs are spongy closed sacs present in the chest cavity.
- They are composed of millions of alveoli, a great amount of connective tissue and some muscles.

Human Respiratory System Part II

- Lungs are covered by a thin layer of tough epithelium called **visceral pleura**.
- A similar layer, **parietal pleura** lines the inner surface of the wall of the chest.
- The cavity between these layers is called **pleural cavity**.

Human Respiratory System Part II

Parietal pleura



Human Respiratory System Part II

- The chest cavity is bounded by spine, ribs and sternum.
- The sides and floor are the intercostal muscles and muscular diaphragm.

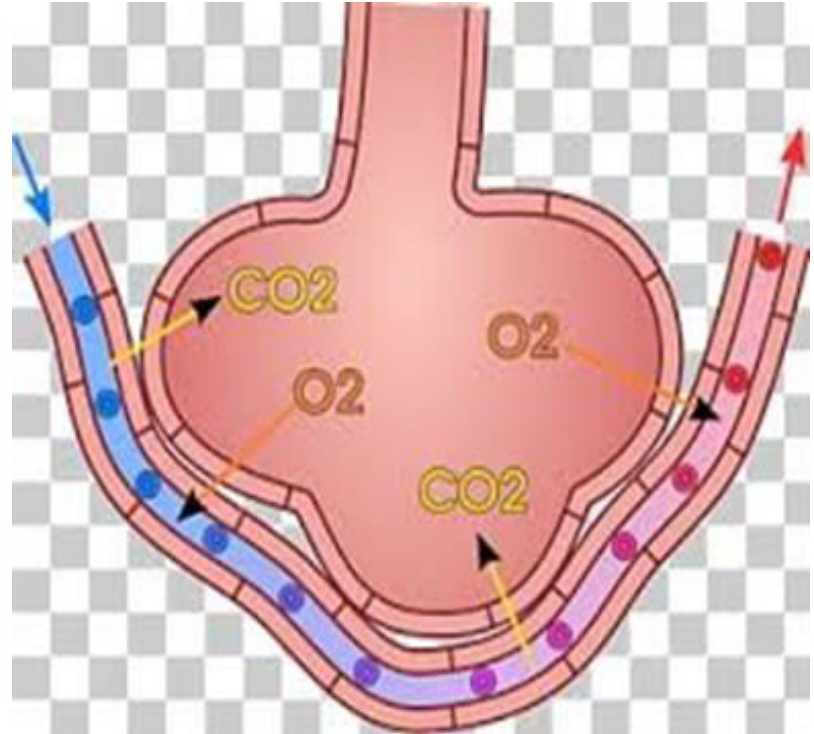
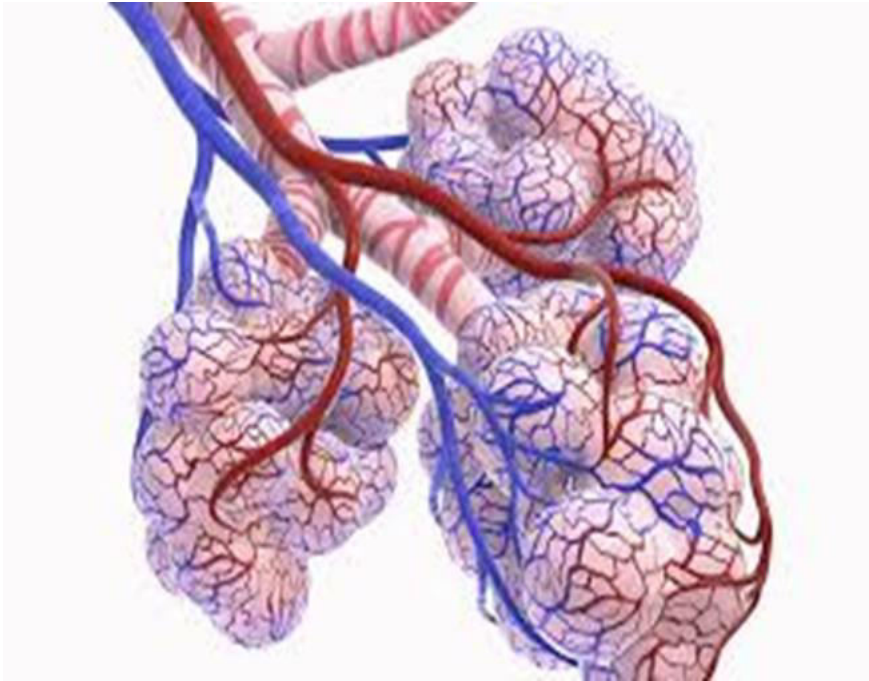
Human Respiratory System Part II



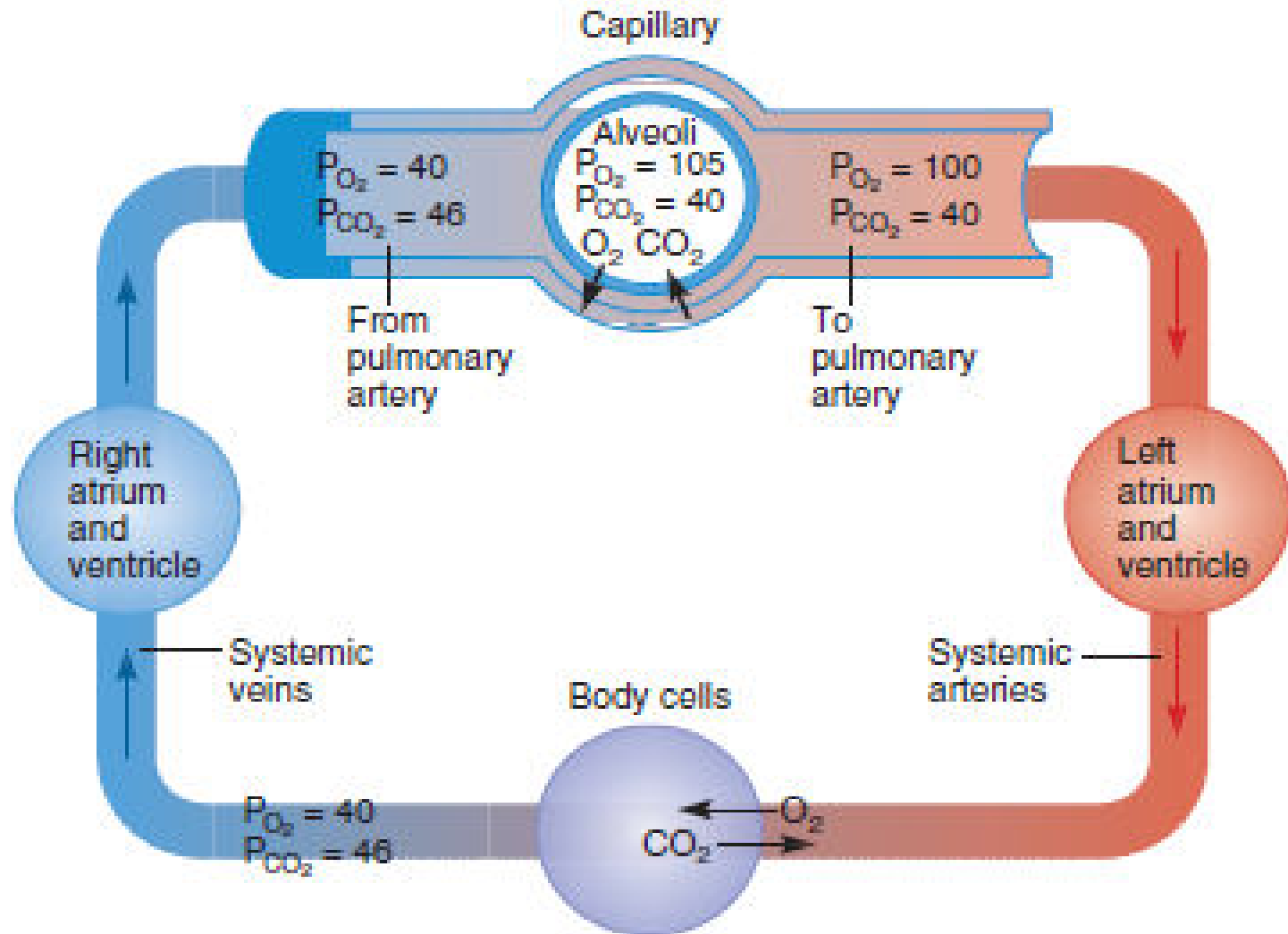
Human Respiratory System Part II

- Alveoli are the functional units of the lungs (gas exchange portion). Passive diffusion, driven by a partial pressure gradient, moves oxygen from the alveoli into the blood and moves carbon dioxide from the blood into the alveoli

Human Respiratory System Part II



Human Respiratory System Part II



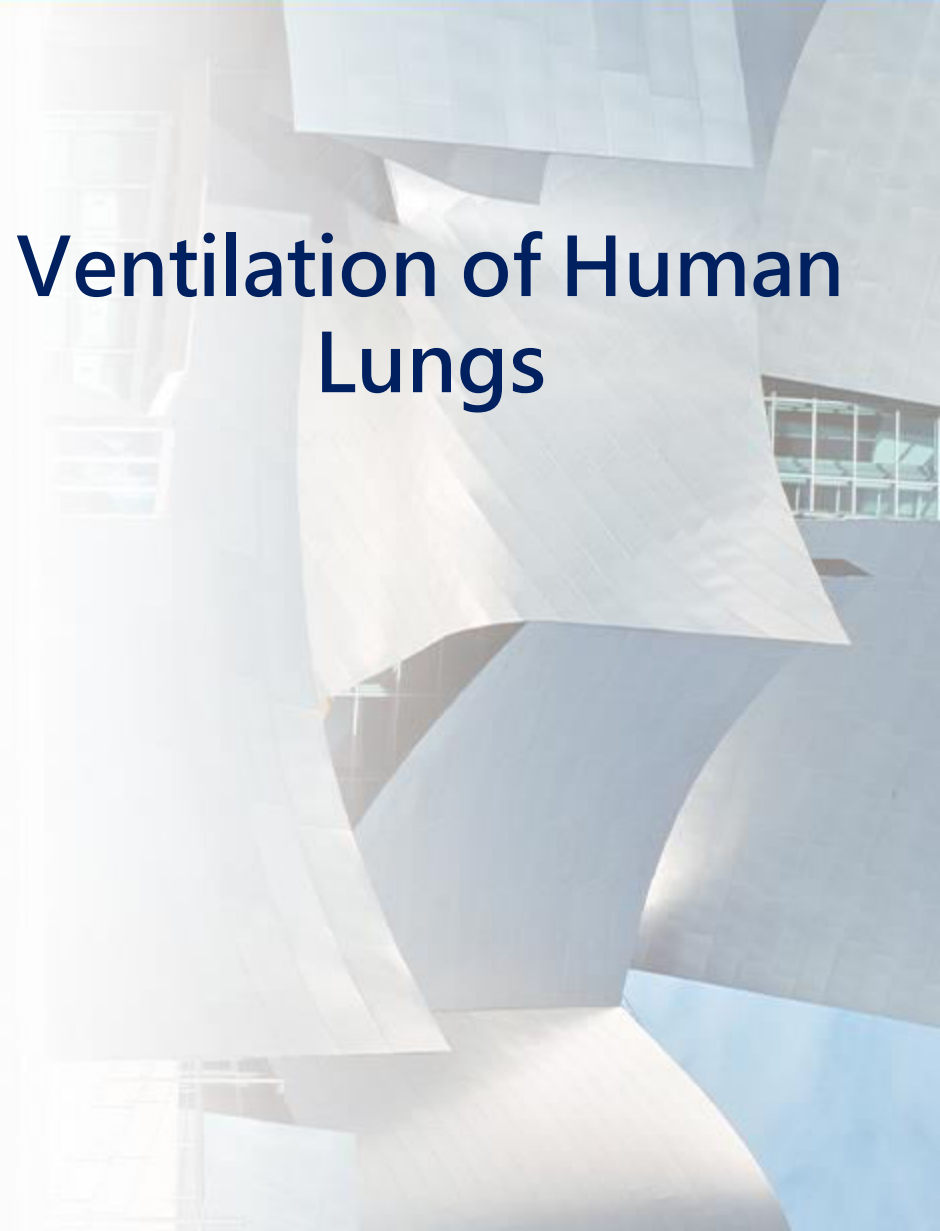
Animal Form and Function 1

Module 176



Animal Form and Function 1

Ventilation of Human Lungs



Ventilation of Human Lungs

- Ventilation or Breathing has two phases:
 - 1. inhalation, the intake of air; and
 - 2. exhalation, the outflow of air.
- These air movements result from the rhythmic increases and decreases in thoracic cavity volume.

Ventilation of Human Lungs

- Changes in thoracic volume lead to reversals in the pressure gradients between the lungs and the atmosphere; gases in the respiratory system follow these gradients.
- The mechanism of inhalation operates in the following way:

Ventilation of Human Lungs

- Several sets of muscles, the main ones being the diaphragm and intercostal muscles, contract.
- 1. The intercostal muscles stretch from rib to rib, and when they contract, they pull the ribs closer together, enlarging the thoracic cavity.

Ventilation of Human Lungs

- 2. The thoracic cavity further enlarges when the diaphragm contracts and flattens.
- 3. The increased size of the thoracic cavity causes pressure in the cavity to drop below the atmospheric pressure.
- Air rushes into the lungs, and the lungs inflate.

Ventilation of Human Lungs

- During expiration or exhalation, air is expelled from the lungs in the following way:
 - 1. The intercostal muscles and the diaphragm relax, allowing the thoracic cavity to return to its original, smaller size and increasing the pressure in the thoracic cavity.

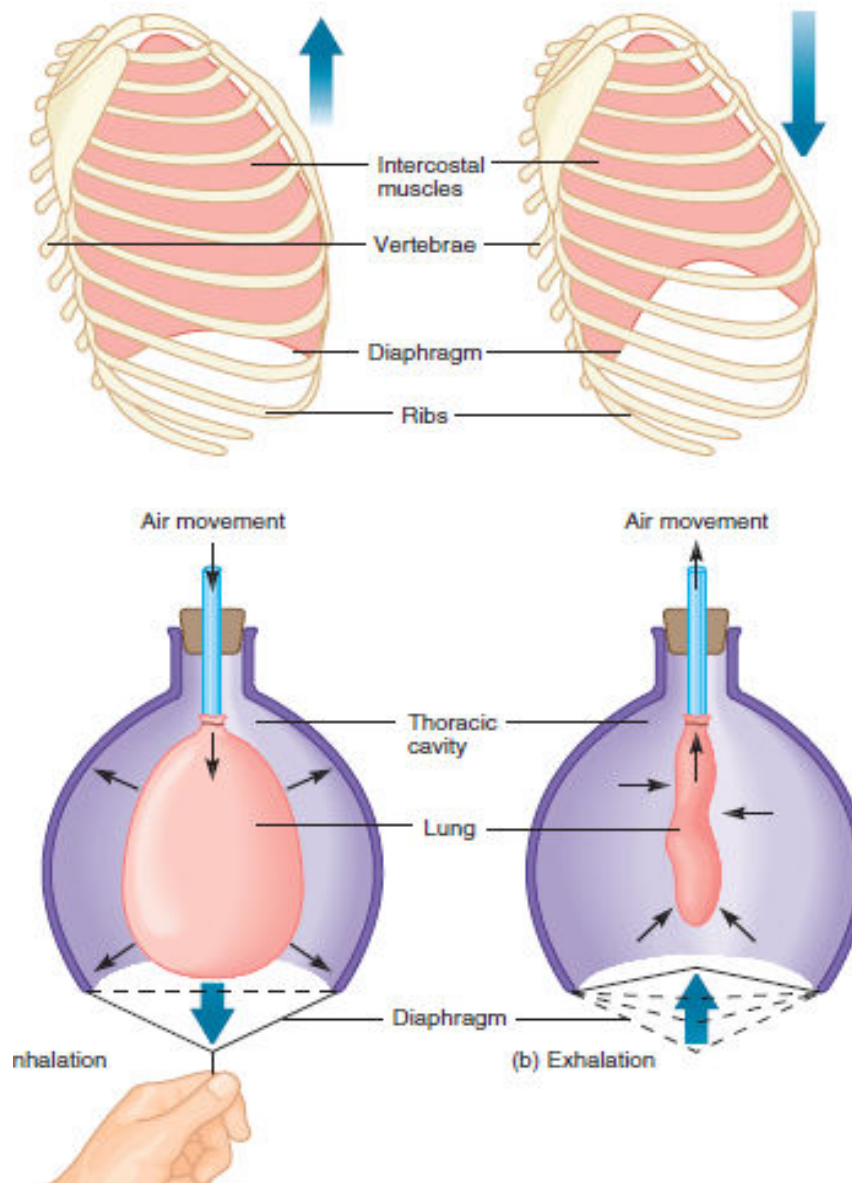
Ventilation of Human Lungs

- 2. Abdominal muscles contract, pushing the abdominal organs against the diaphragm, further increasing the pressure within the thoracic cavity.
- 3. The action in step 2 causes the elastic lungs to contract and compress the air in the alveoli

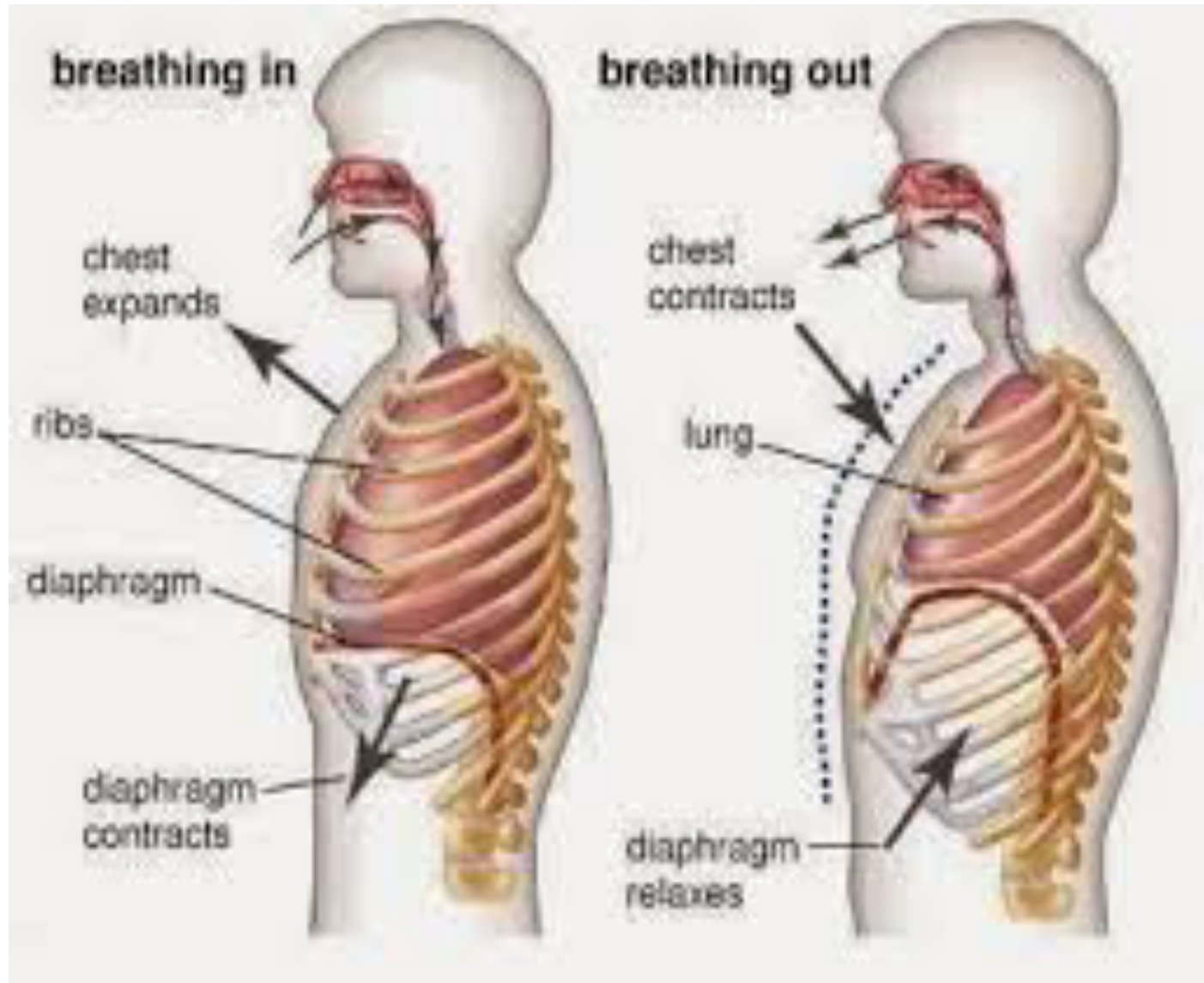
Ventilation of Human Lungs

- With this compression, alveolar pressure becomes greater than atmospheric pressure, causing air to be expelled (exhaled) from the lungs.

Ventilation of Human Lungs



Ventilation of Human Lungs



Animal Form and Function 1

Module 177



Animal Form and Function 1

The Control of Breathing



The Control of Breathing

- A breathing control center in the medulla sets the basic rhythm, of inhalations and exhalations.
- Nerves from the medulla's control center send impulses to the breathing muscles- diaphragm and rib muscles.

The Control of Breathing

- A person when at rest, these nerve impulses result in about 10 to 14 inhalations per minute.
- Between two inhalations the muscles relax and the person exhales.
- Sensors in the medulla detect changes in the pH of the blood and cerebrospinal fluid bathing the surface of the brain.

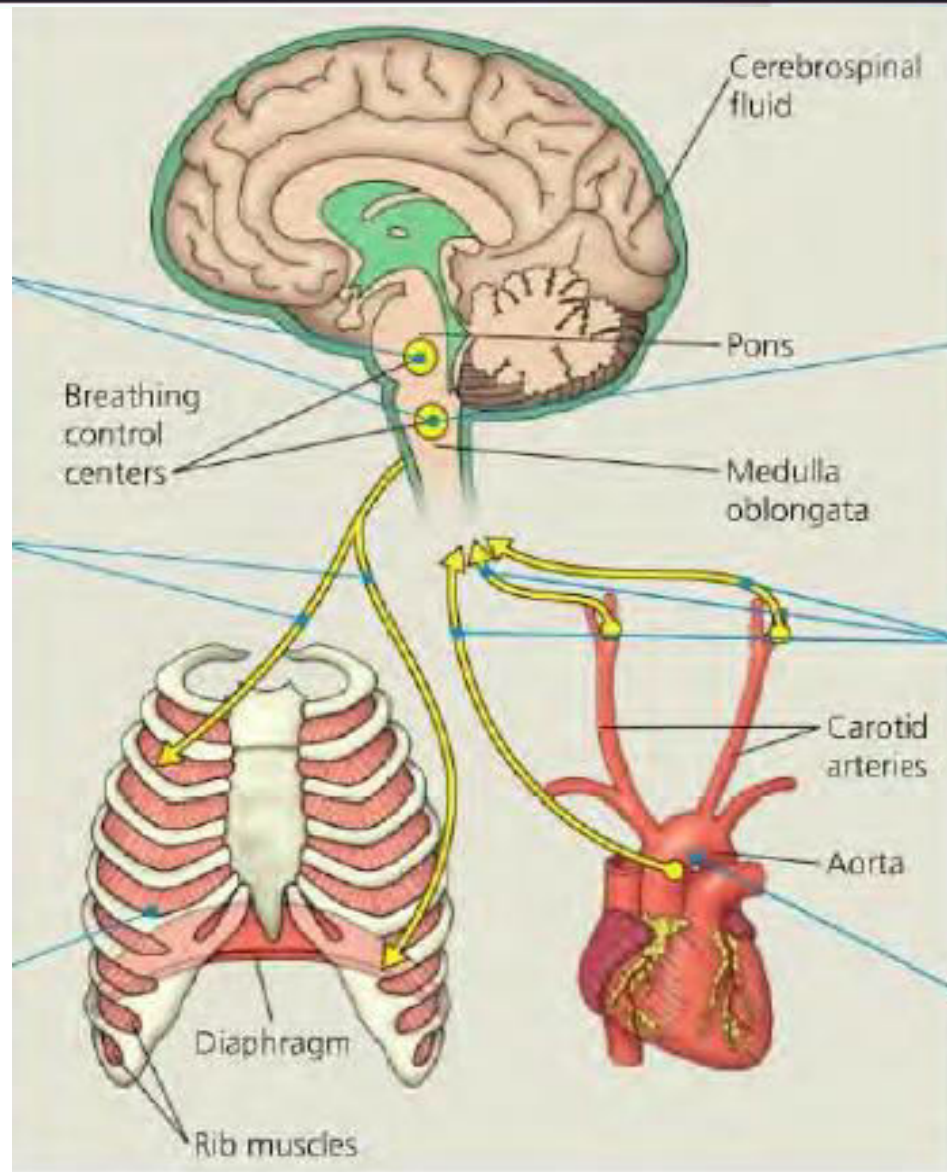
The Control of Breathing

- sensors in major blood vessels detect changes in blood pH and send nerve impulses to the medulla.
- In response, the medulla's control center alters the rate and depth of breathing, increasing both if CO₂ levels rise or decreasing both if CO₂ levels fall.

The Control of Breathing

- Other sensors in the aorta and carotid arteries signal the medulla to increase the breathing rate when O_2 levels in the blood become very low.

The Control of Breathing



Animal Form and Function 1

Module 179



Animal Form and Function 1

Transport of Respiratory Gas Oxygen



Transport of Respiratory Gas Oxygen

- As we know that oxygen must be transported from the environment to each and every cell of an animal's body.
- Various systems (e.g., tracheae, cutaneous exchange, gills, lungs) help accomplish this transport.

Transport of Respiratory Gas Oxygen

- As animals became larger and acquired higher metabolic rates, simple diffusion became increasingly inadequate as a means of delivering oxygen to the tissues
- In general, more active animals have an increased demand for oxygen.

Transport of Respiratory Gas Oxygen

- Water-based body fluid does not guarantee internal transport of sufficient oxygen to meet this increased demand.
- The reason is the low solubility of oxygen in water-based body fluids.
- Thus, fluid-borne respiratory pigments reversibly binding large quantities of oxygen evolved in most phyla.

Transport of Respiratory Gas Oxygen

- Four most common respiratory pigments are:
 1. Hemoglobin,
 2. Hemocyanin,
 3. Hemerythrin, and
 4. Chlorocruorin.

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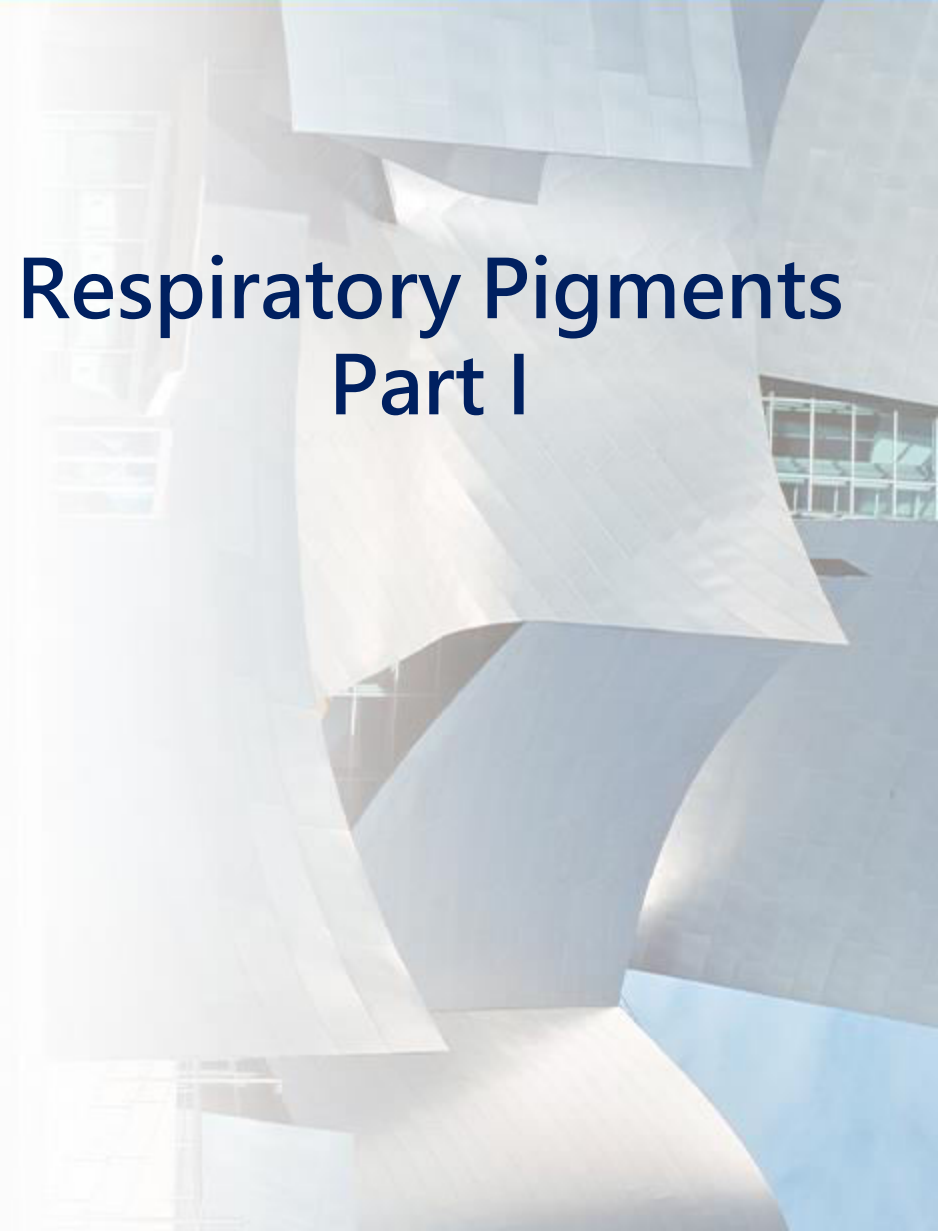
Animal Form and Function 1

Module 180



Animal Form and Function 1

Respiratory Pigments Part I



Respiratory Pigments Part I

- **Hemoglobin:** is a reddish pigment that contains iron as the oxygen-binding metal.
- It is the most common respiratory pigment in animals, being found in a variety of invertebrates (e.g., platyhelminths, nemerteans, nematodes, annelids, crustaceans, some insects, and molluscs

Respiratory Pigments Part I

- All vertebrates with the exception of a few fishes.
- Icefish (Channichthyidae) are the only known vertebrates that lack hemoglobin in their blood.
- This wide distribution suggests that hemoglobin evolved very early in the history of animal life.

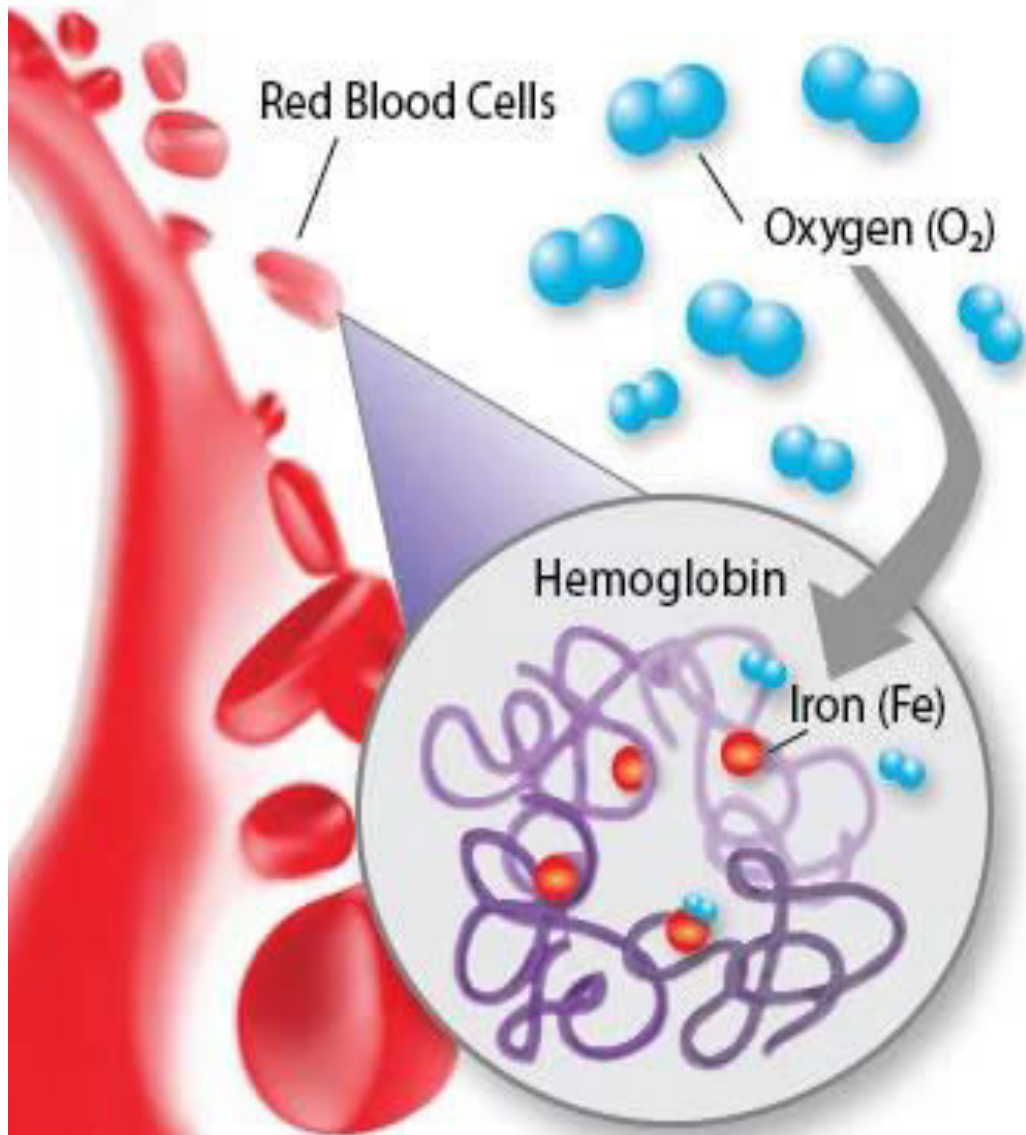
Respiratory Pigments Part I

- Hemoglobin may be carried within red blood cells (erythrocytes or simply dissolved in the blood or coelomic fluid.
- $\text{Hb} + \text{O}_2 = \text{HbO}_2$ under
(Under high O_2 concentration)
in lungs
- $\text{HbO}_2 = \text{Hb} + \text{O}_2$
- (Under high O_2 concentration)
- in tissues

Respiratory Pigments Part I

- Factor that affect oxygen combining capacity of Hb:
 1. Carbon Dioxide
 2. Temperature
 3. pH of blood
- 1% CO in blood cause death.
- Hb conc. increases at high altitudes.
- Human fetuses have high conc. of Hb.

Respiratory Pigments Part I



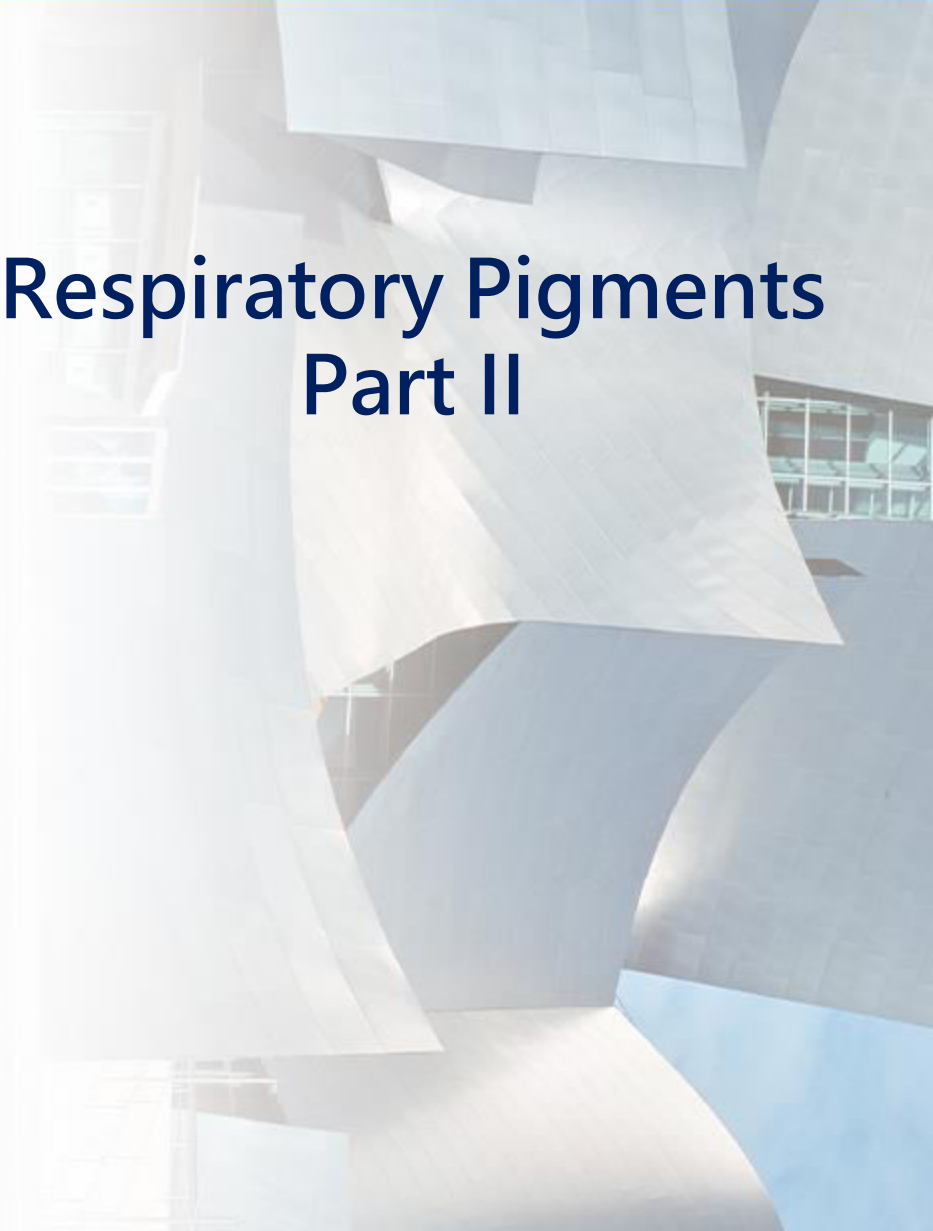
Animal Form and Function 1

Module 181



Animal Form and Function 1

Respiratory Pigments Part II



Respiratory Pigments Part I

- Hemocyanin is the most commonly occurring respiratory pigment in molluscs and certain crustaceans.
- Hemocyanin contains metallic copper, has a bluish color when oxygenated, and always occurs dissolved in hemolymph.

Respiratory Pigments Part I

- Unlike most hemoglobin, hemocyanin tends to release oxygen easily and to provide a ready source of oxygen to the tissues.

Respiratory Pigments Part I

- Hemerythrin contains iron and is pink when oxygenated.
- It is in nucleated cells, rather than free in body fluids or hemolymph.
- A few brachiopods and some polychaetes have hemerythrin.

Respiratory Pigments Part I

- Chlorocruorin also contains iron but is green when associated with low oxygen concentrations and bright red when associated with high oxygen concentrations.
- Chlorocruorin occurs in several families of polychaete worms.

END

Animal Form and Function 1

Module 182



Animal Form and Function 1

Transport of Respiratory Gas CO₂



Transport of Respiratory Gas CO₂

- Carbon dioxide produced within the respiring cells diffuse into blood, then transported to lungs from where exhaled.
- CO₂ is transported in the following three states:
 - 1. as carboxyhemoglobin (about 20% of CO₂) combines with amino group of Hb.
 - 2. CO₂ as such (5%)
 - 3. As bicarbonates (75%)

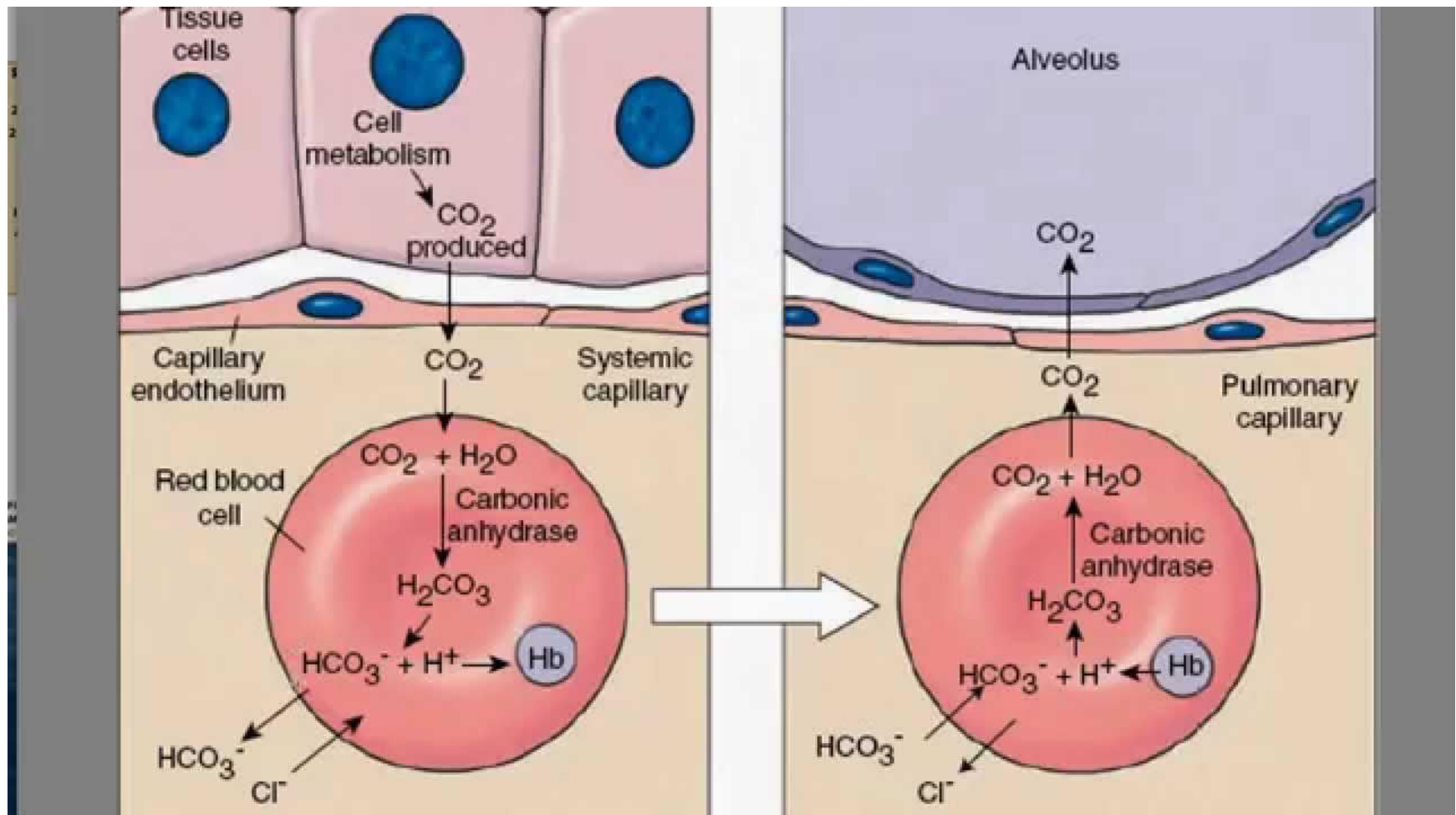
Transport of Respiratory Gas CO₂

- Bicarbonates are formed from CO₂ and H₂O in the tissues by the following reaction and Process.
- **Reaction in Tissues:** CO₂ and H₂O combine to form Carbonic acid.
- This reaction is catalyzed by carbonic anhydrase present in RBCs.
- Carbonic acid then ionizes into HCO₃⁻ and H⁺

Transport of Respiratory Gas CO₂

- Most of CO₂ is transported as HCO₃⁻ ions from the tissues to the lungs.
- Reactions in Lung Capillaries:
 - $\text{HCO}_3^- + \text{H}^+ = \text{H}_2\text{CO}_3$
 - $\text{H}_2\text{CO}_3 \rightleftharpoons \text{H}_2\text{O} + \text{CO}_2$
 - CO₂ thus formed passes out of the capillaries into the alveoli from where it is exhaled.

Transport of Respiratory Gas CO₂



Animal Form and Function 1

Module 183



Animal Form and Function 1

Summary of the Chapter Part I

Summary of the Chapter Part I

- Any system that supplies the body tissues with oxygen, nutrients, hormones, and removes waste products is called transport system or circulatory system.
- The two basic types of circulatory systems are open and closed. Open systems generally circulate hemolymph, and closed systems circulate blood.

Summary of the Chapter Part I

- Blood is a type of connective tissue made up of blood cells (red blood cells and white blood cells), plasma, and platelets.
- The heart pumps blood through a series of vessels in the following order: arteries, arterioles, capillaries, venules, veins, and back to the heart.

Summary of the Chapter Part I

- The action of the heart consists of cyclic contraction (systole) and relaxation (diastole). Systolic contraction generates blood pressure that forces blood through the closed system of vessels.
- The lymphatic system consists of one-way vessels that help return fluids and proteins to the circulatory system.

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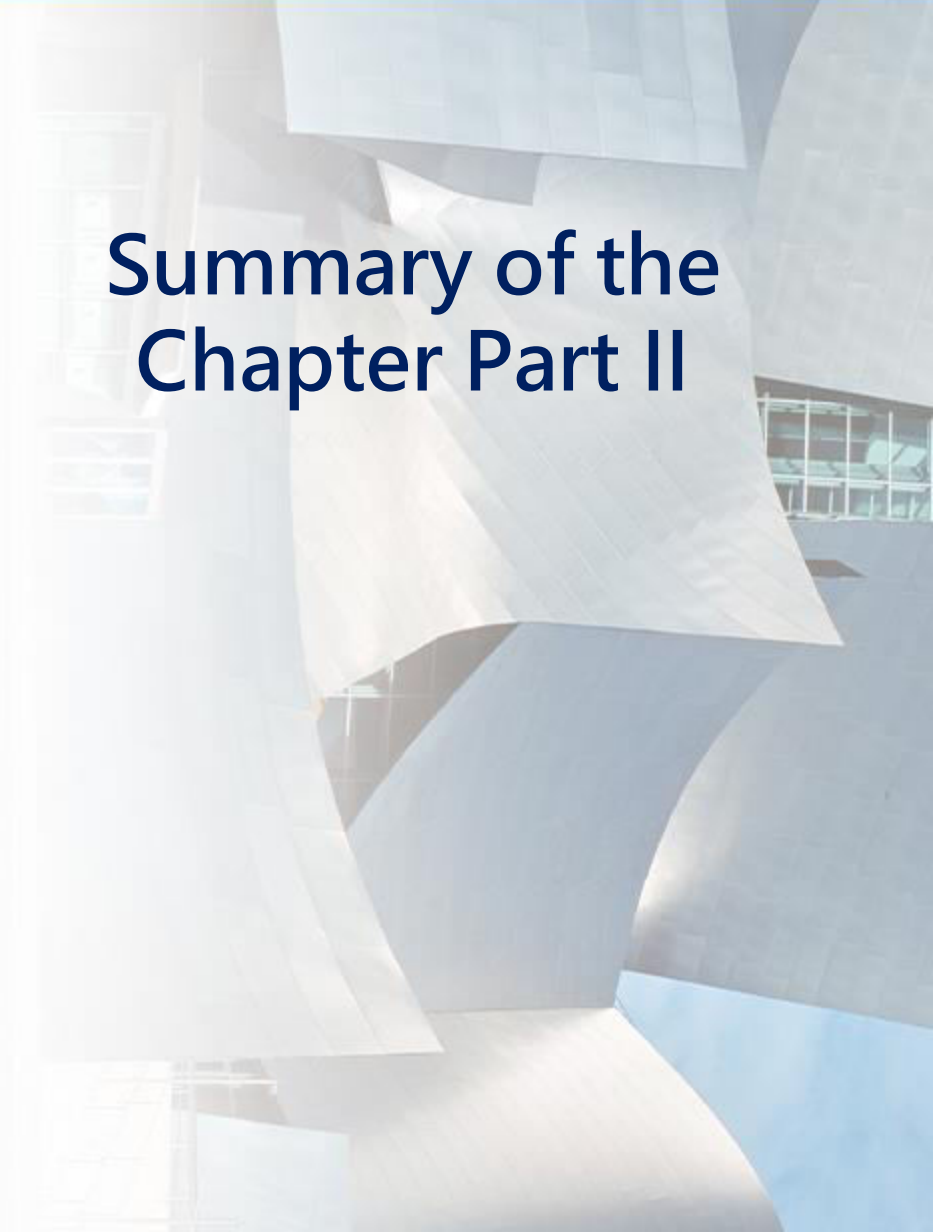
Animal Form and Function 1

Module 184



Animal Form and Function 1

Summary of the Chapter Part II



Summary of the Chapter Part II

- Animals that respire aerobically need a constant supply of oxygen.
- The process of acquiring oxygen and eliminating carbon dioxide is called external respiration
- The exchange of oxygen and carbon dioxide occurs across respiratory surfaces.

Summary of the Chapter Part II

- Such surfaces include gills, cutaneous surfaces, and lungs.
- The air-conducting portion of the respiratory system of air-breathing vertebrates moves air into (inhalation) and out of (exhalation) this system. This process of air movement is called ventilation.

Summary of the Chapter Part II

- Oxygen and carbon dioxide diffuse from areas of higher concentration to areas of lower concentration.
- Once in the blood, oxygen diffuses into red blood cells and binds to hemoglobin for transport to the tissues.

Summary of the Chapter Part II

- Carbon dioxide is transported bound to hemoglobin, as well as in the form of the bicarbonate ion and carbonic acid.
- Respiratory pigments are organic compounds that have either metallic copper or iron that binds oxygen.

Summary of the Chapter Part II

- Examples include hemoglobin, hemocyanin, hemerythrin, and chlorocruorin.

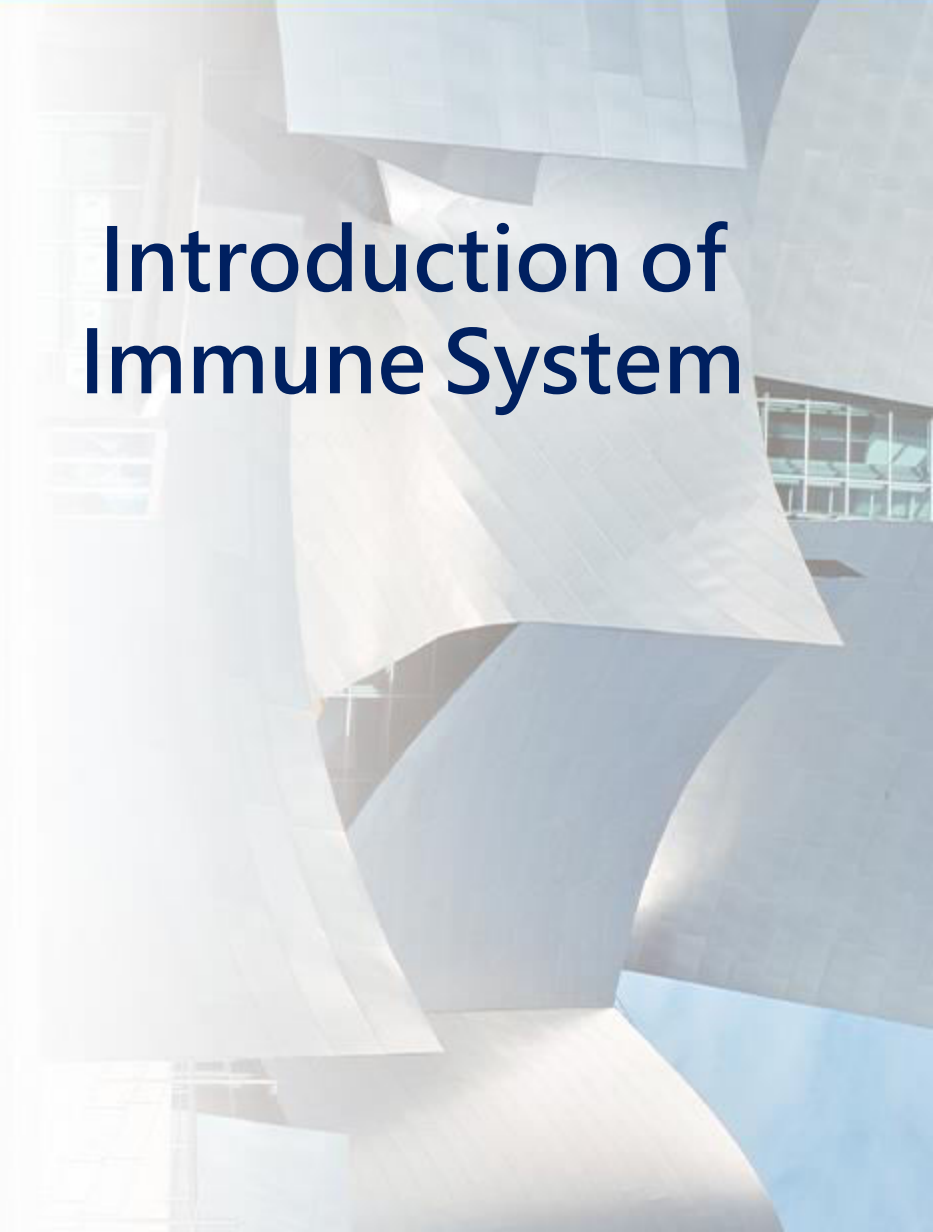
Animal Form and Function 1

Module 185



Animal Form and Function 1

Introduction of Immune System



Introduction of Immune System

- Animals are constantly under attack by infectious agents that cause disease.
- For a pathogen, an animal body is a nearly ideal habitat.
- The host offers a ready source of nutrients, a protected setting for growth and reproduction.
- Hosts also provide means of transport to new hosts and environments.

Introduction of Immune System

- Having this opportunity, pathogens, mostly viruses, bacteria, protists, and fungi, infect a wide range of animals, including humans.
- If not eliminated they may deal with abnormal cells and develop into cancer.
- To counter these threats animals have evolved defense systems.

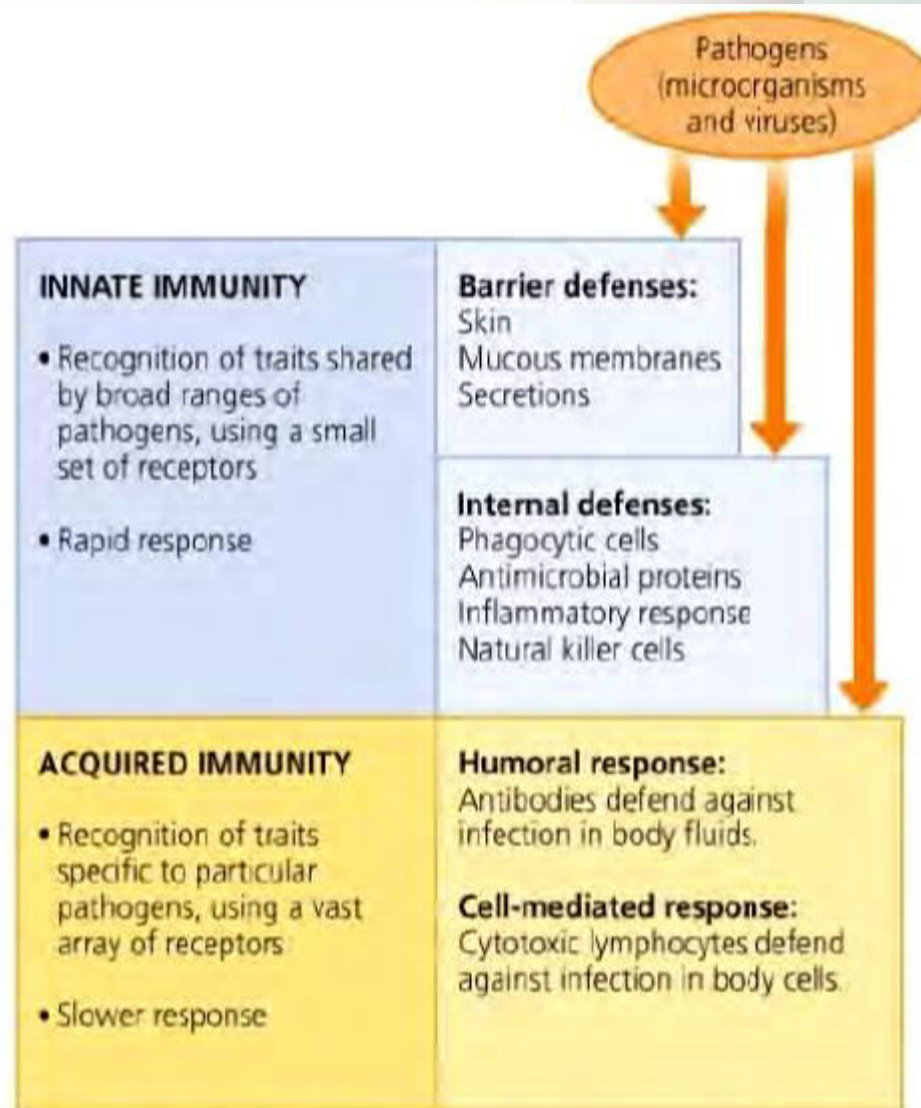
Introduction of Immune System

- Additional responses to infection take many forms, including proteins that punch holes in bacterial membranes or block viruses from entering body cells.
- These and other defenses make up an immune system, which enables an animal to avoid or limit many infections.

Introduction of Immune System

NONSPECIFIC DEFENSE MECHANISMS		SPECIFIC DEFENSE MECHANISMS (IMMUNE SYSTEM)
First line of defense	Second line of defense	Third line of defense
<ul style="list-style-type: none">• Skin• Mucous membranes• Secretions of skin and mucous membranes	<ul style="list-style-type: none">• Phagocytic white blood cells• Antimicrobial proteins• The inflammatory response	<ul style="list-style-type: none">• Lymphocytes• Antibodies

Introduction of Immune System



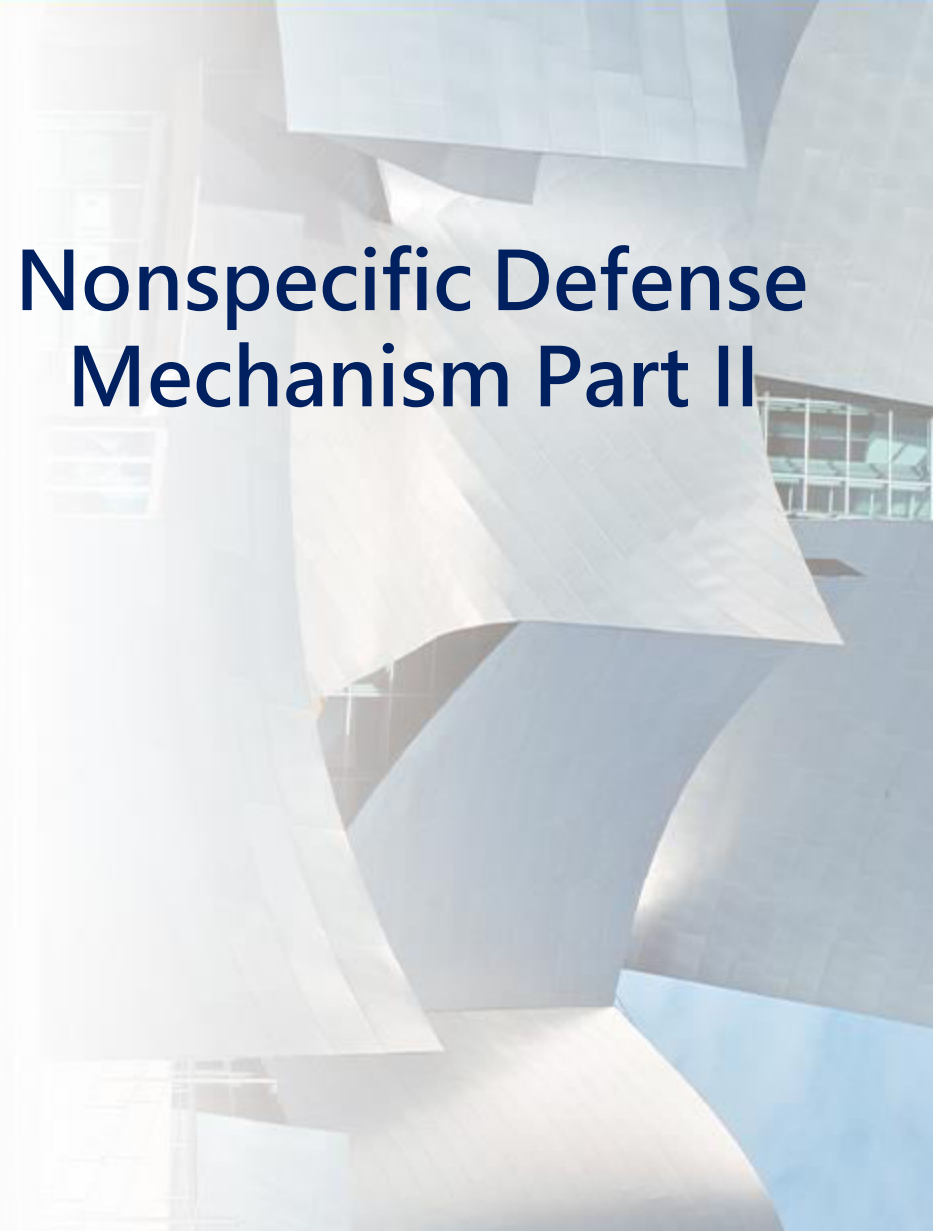
Animal Form and Function 1

Module 187



Animal Form and Function 1

Nonspecific Defense Mechanism Part II



Nonspecific Defense Mechanism Part II

Introduction of Immune System

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Nonspecific Defense Mechanism Part II

Phagocytic White Cells:

- Nonspecific internal defense mechanism depends mainly on Phagocytosis.
- It is the ingestion of invading particles by certain types of WBCs
- These phagocytic WBCs are the neutrophils (65%) and monocytes (5%).
- Monocytes soon enlarge and become macrophages.

Nonspecific Defense Mechanism Part II

- Neutrophils are attracted by chemotaxis in the infected tissue.
- Both these WBCs phagocytose the microbes like amoeba.
- Eosinophils have limited phagocytic activity but contain destructive enzymes to kill the invaders.

Nonspecific Defense Mechanism Part II

- **Antimicrobial Proteins:** either attack microorganisms directly or retard their reproduction.
- **Complement proteins** and interferon are important antimicrobial proteins present in tissues and blood.
- **Interferons** are most effective in controlling short term infections such as cold and flu.

Nonspecific Defense Mechanism Part II

- Interferons being very active antiviral agents are now mass produced by recombinant DNA technology.

Inflammatory Response

- Localized response is triggered by release of histamine when tissue is injured by a physical cut or microorganisms.
- Histamine induce the permeability of the capillaries causing redness

Nonspecific Defense Mechanism Part II

- Interferons being very active antiviral agents are now mass produced by recombinant DNA technology.

Inflammatory Response

- Localized response is triggered by release of histamine when tissue is injured by a physical cut or microorganisms.
- Histamine causes redness and swelling by the permeability of vessels.

Nonspecific Defense Mechanism Part II

- Certain chemicals also release that attract phagocytic cells.
- After their arrival at the site of injury, these phagocytes consume some pathogens and cell debris and the tissue heals.

Nonspecific Defense Mechanism Part II



1 Histamine & prostaglandins released



2 Capillaries dilate
Clotting begins



3 Chemotactic
factors attract
phagocytic cells



4 Phagocytes
consume
pathogens &
cell debris

Animal Form and Function 1

Module 188

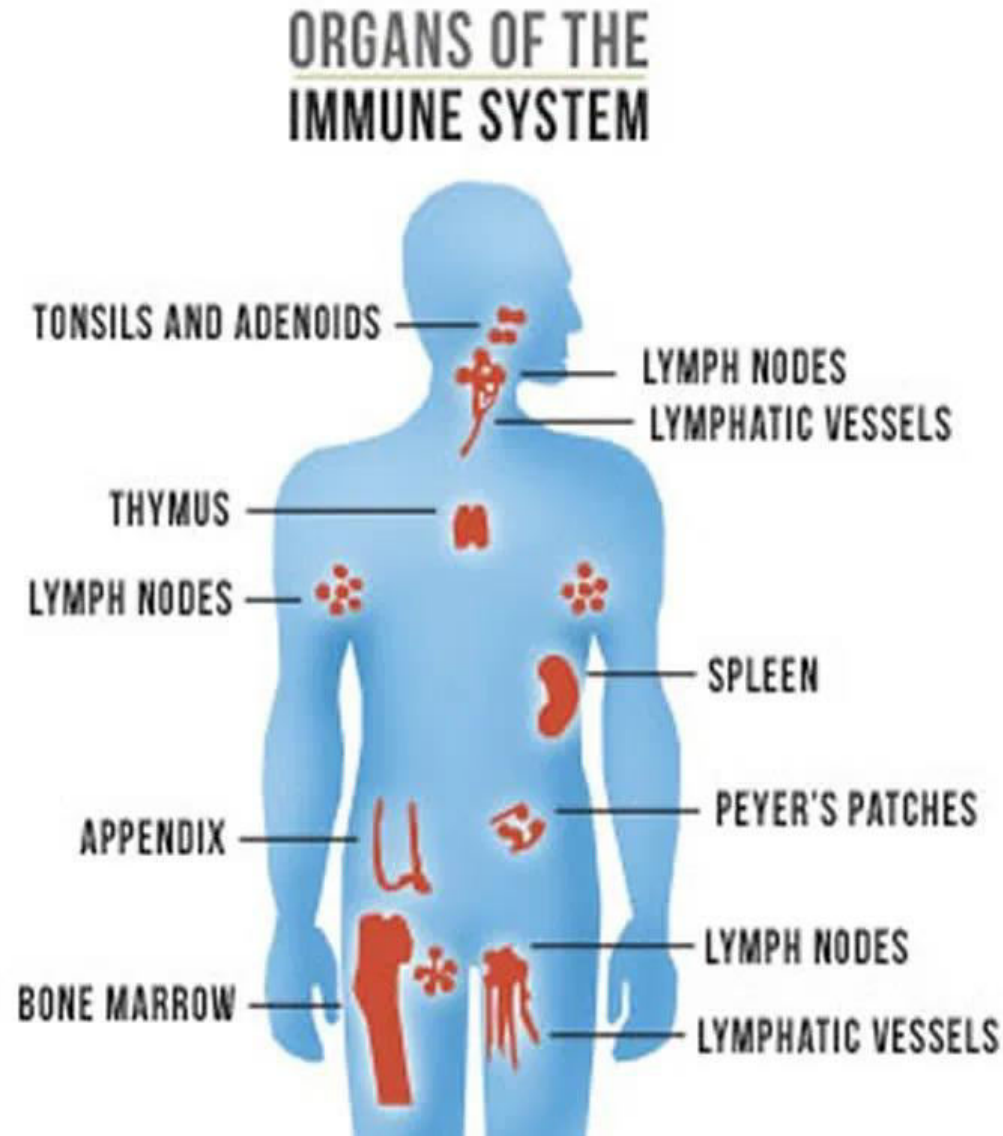


Animal Form and Function 1

Organs of Immune System



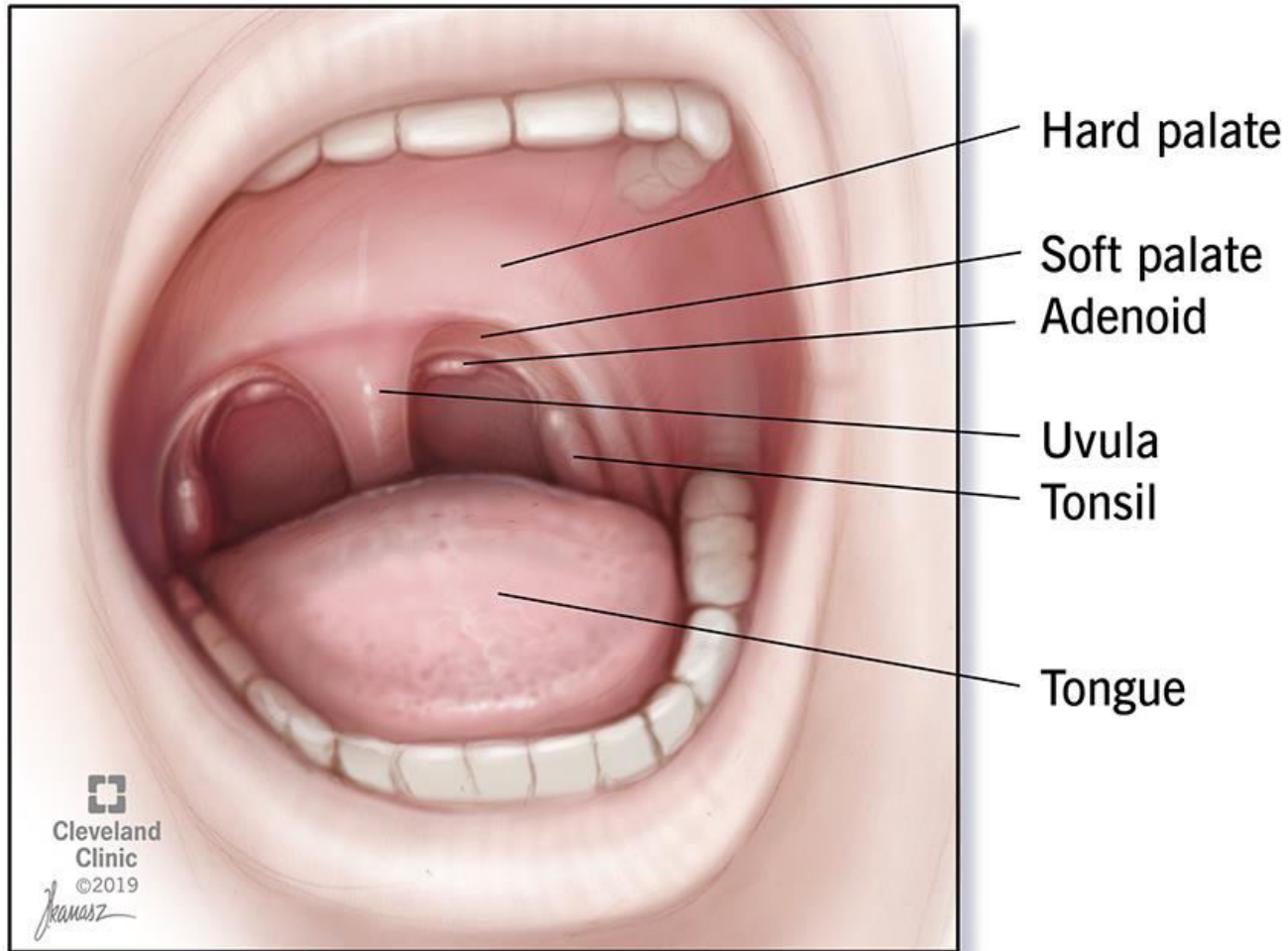
Organs of Immune System



Organs of Immune System

- The lymphatic system clears away infection and keeps body fluids in balance.
- Adenoids are a patch of tissue that is high up in the throat.
- They, along with the tonsils, are part of the lymphatic system.
- The adenoids and tonsils work by trapping germs coming in through the mouth and nose.

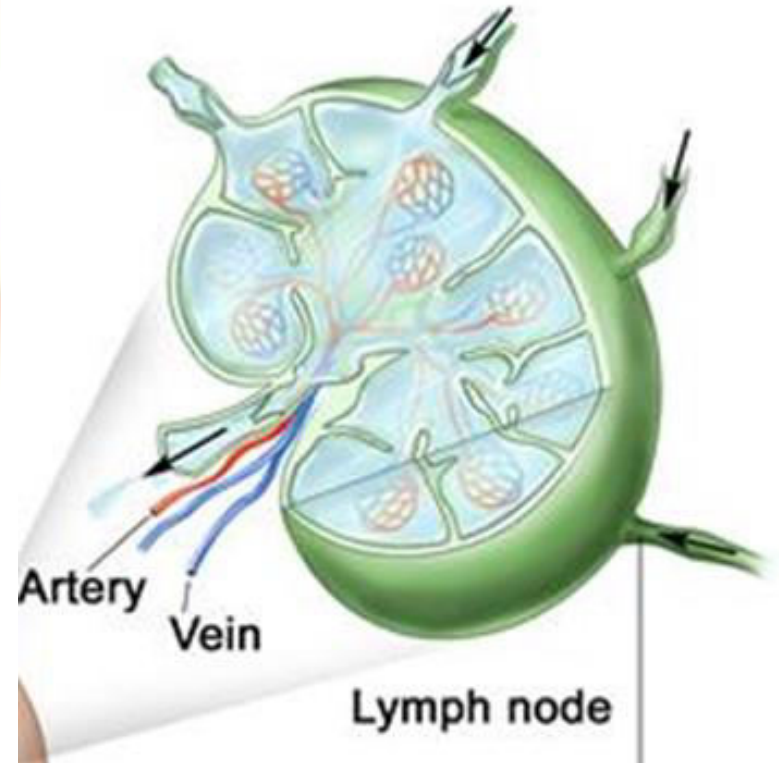
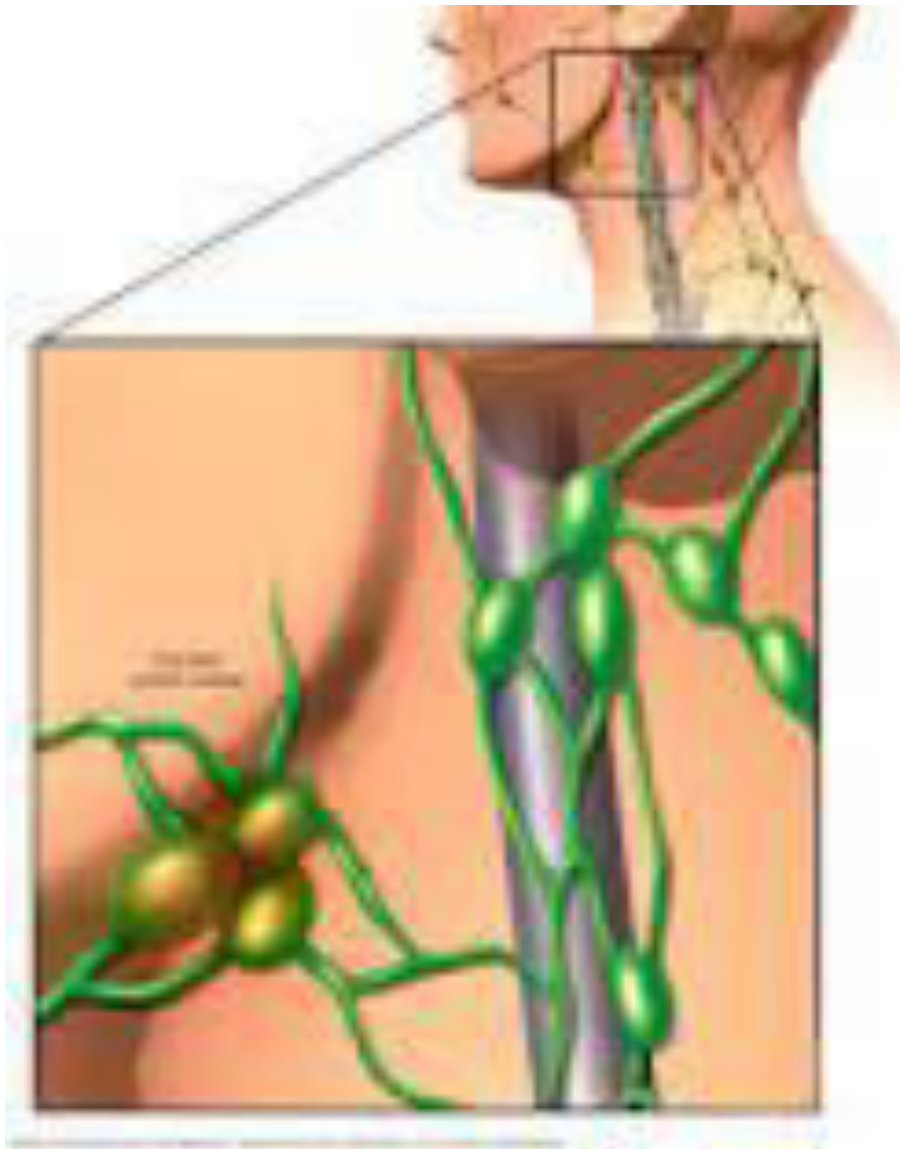
Organs of Immune System



Organs of Immune System

- Lymph nodes, are small, bean-shaped, soft nodules of tissue.
- There are several groups of lymph nodes in the body.
- Swollen lymph nodes may signal an infection.

Organs of Immune System



Organs of Immune System

- The thymus is a specialized primary lymphoid organ of the immune system.
- Within the thymus, T-lymphocytes or T cells, mature.
- T cells are extremely important type of white blood cell.
- It plays an important function both in the immune system and endocrine system.

Organs of Immune System

- The spleen plays multiple roles in the body.
- It acts as a filter for blood as part of the immune system.
- Old RBCs are recycled in the spleen and platelets and WBCs are stored there.
- The spleen also helps fight certain kinds of bacteria that cause pneumonia and meningitis.

Organs of Immune System

- Peyer's patches are small masses of lymphatic tissue found throughout the ileum region of the small intestine.
- They form an important part of the immune system and prevent the growth of pathogenic bacteria in the intestines.

Organs of Immune System

- **Appendix**
- **The appendix is a small, pouch-like sac of tissue that is located in the first part of the colon (cecum)**
- **Lymphatic tissue in the appendix aids in immune function.**
- **The appendix harbors bacteria.**

Organs of Immune System

- **Bone Marrow** is a semi-solid tissue which is found within the spongy or portions of bones.
- In birds and mammals, bone marrow is the primary site of new blood cell production or hematopoiesis.
- It is composed of hematopoietic cells and adipose tissue.

Organs of Immune System

- In adult humans, bone marrow is primarily located in the ribs, vertebrae, sternum, and bones of the pelvis.

END

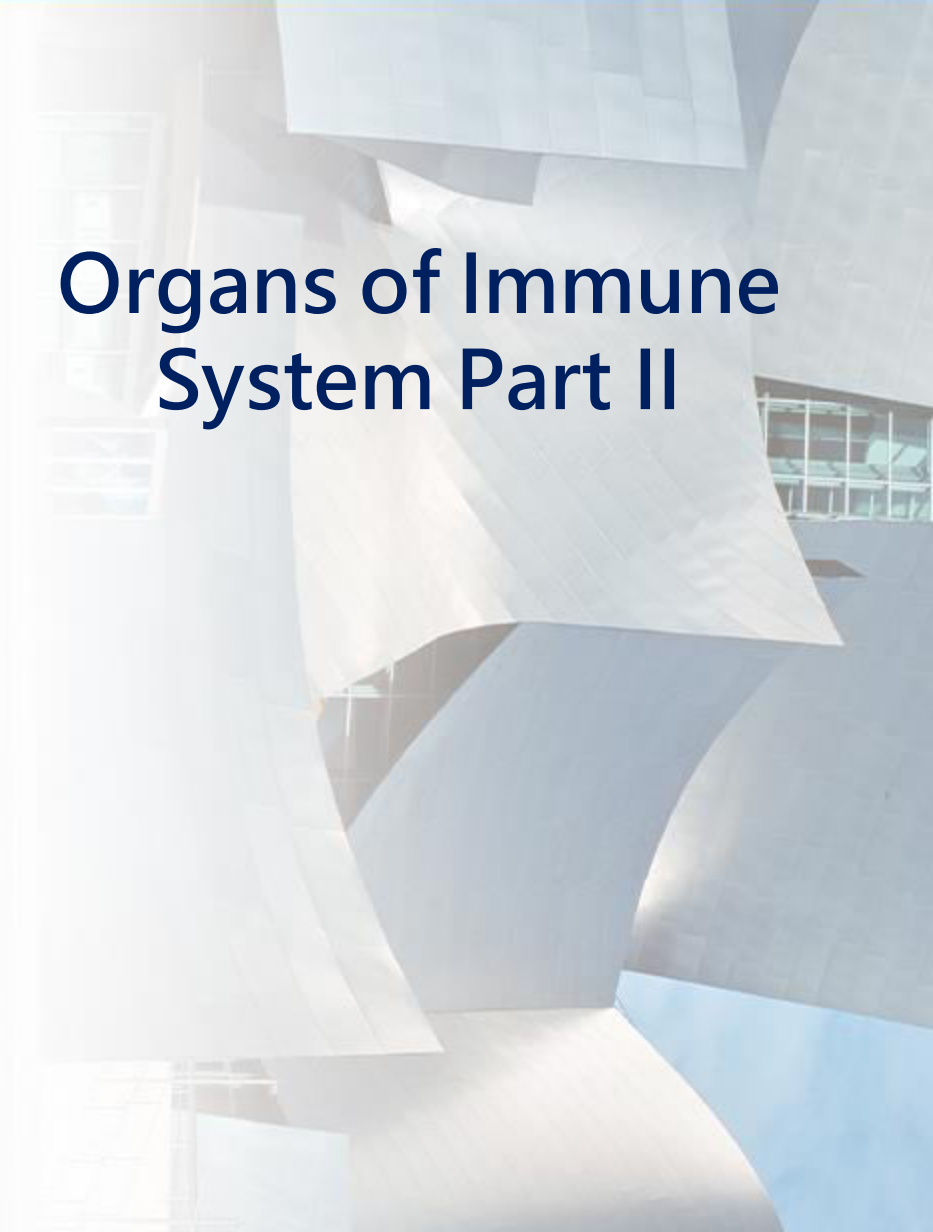
Animal Form and Function 1

Module 189



Animal Form and Function 1

Organs of Immune System Part II



Organs of Immune System Part II

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Organs of Immune System Part II

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Organs of Immune System Part II

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Organs of Immune System Part II

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Organs of Immune System Part II

- In adult humans, bone marrow is primarily located in the ribs, vertebrae, sternum, and bones of the pelvis.
- Human marrow produces approximately 500 billion blood cells per day.
- The red bone marrow is a key element of the lymphatic system.

Organs of Immune System Part II

- generate lymphocytes from immature hematopoietic progenitor cells.
- The bone marrow and thymus constitute the primary lymphoid tissues involved in the production and early selection of lymphocytes.

END

Animal Form and Function 1

Module 190



Animal Form and Function 1

**Specific Defense
Mechanism
(Immune System)**

Specific Defense Mechanism (Immune System)

NONSPECIFIC DEFENSE MECHANISMS		SPECIFIC DEFENSE MECHANISMS (IMMUNE SYSTEM)
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Specific Defense Mechanism (Immune System)

- Lymphocyte is a type of white blood cell (leukocyte) that is of fundamental importance in the immune system.
- Lymphocytes are the cells that determine the specificity of the immune response to pathogens and other foreign substances.

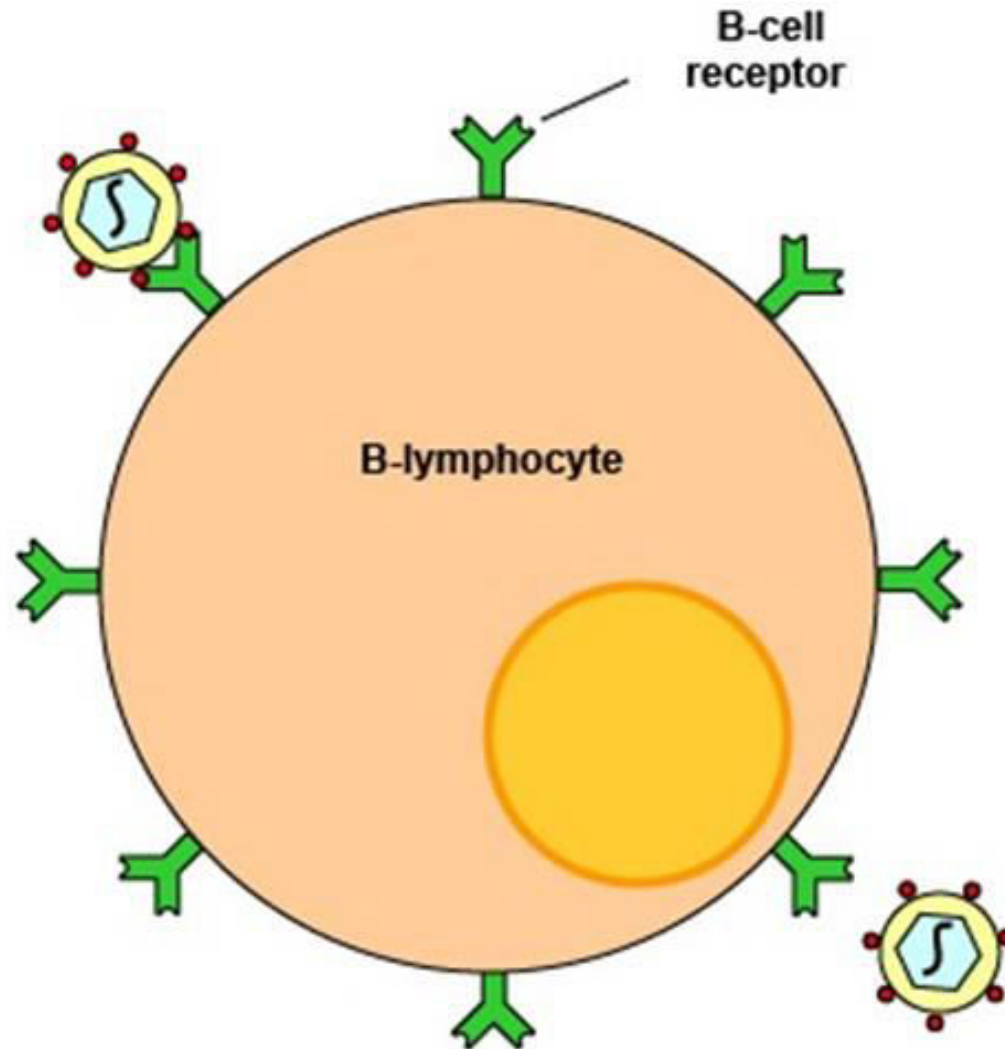
Specific Defense Mechanism (Immune System)

- There are three main types of lymphocytes:
 - 1. T cells,
 - 2. B cells, and
 - 3. Natural killer cells.
- A T cell is a type of lymphocyte which mature in the thymus .
- T cells are different from other lymphocytes by the presence of a T-cell receptor on the cell surface.

Specific Defense Mechanism (Immune System)

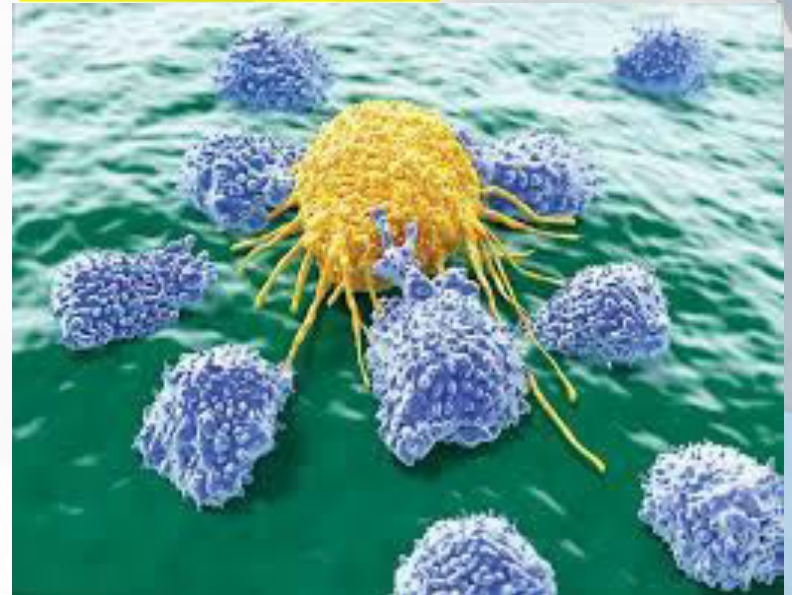
- B cells are responsible for generating antibodies to specific antigens, which they bind via B cell receptors (BCR).

Specific Defense Mechanism (Immune System)



Specific Defense Mechanism (Immune System)

- Natural killer cells is a component of innate immune system.
- NK cells play a major role in the host-rejection of both tumors and virally infected cells.



Specific Defense Mechanism (Immune System)

- **Antigens:** The foreign substance that elicits the immune response is called an antigen.
- The immune system responds to an antigen by producing specific proteins called antibodies.
- The antigens include molecules belonging to viruses, bacteria, fungi and parasitic worms.

Specific Defense Mechanism (Immune System)

- Each antigen has a unique molecular shape and stimulates the production of antibodies.
- Antigens are bound to antibodies through weak and non covalent interactions such as electrostatic interactions, hydrogen bonds, Van der Waals forces, and hydrophobic interactions.

END

Animal Form and Function 1

Module 191



Animal Form and Function 1

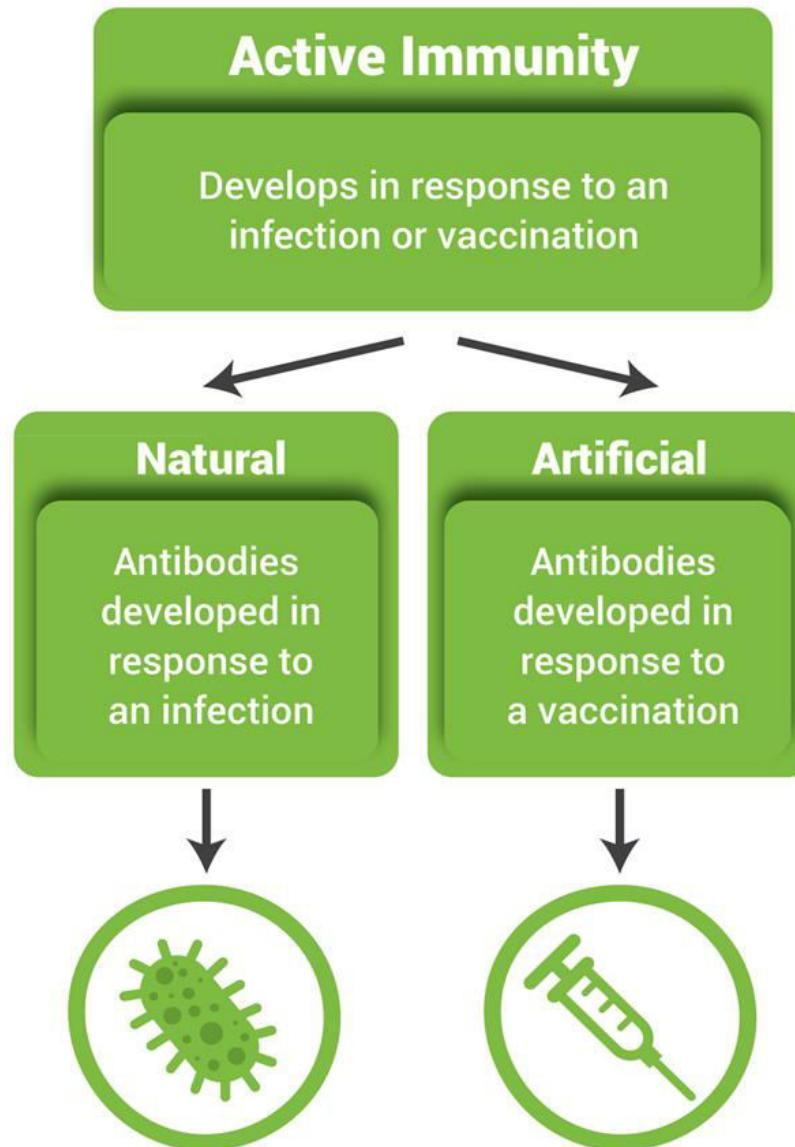
Acquired Immunity



Acquired Immunity

- **Acquired immunity:** Acquired or adaptive immunity is the body's third line of defense.
- This is protection against specific types of pathogens.
- Acquired immunity may be either natural or artificial in nature.
- Both natural and artificial immunity have active and passive components.

Acquired Immunity



Acquired Immunity

- **Active immunity** . the immunity which results from the production of antibodies by the immune system in response to the presence of an antigen.
- **Active immunity comes from exposure to a pathogen.**

Acquired Immunity

- E. Jenner, English physician and scientist was the pioneer of smallpox vaccine, the world's first vaccine.
- Vaccine contains a small amount of the disease germ (virus or bacteria) or parts of the germ. Examples are the measles virus, whooping cough bacteria and tetanus toxoid.

Acquired Immunity

- Surface markers on the pathogen surface act as antigens, which are binding sites for antibodies.
- Antibodies are Y-shaped protein molecules, which can exist on their own or attach to the membrane of special cells.
- The body doesn't keep a store of antibodies on hand to take down an infection immediately.

Acquired Immunity

- Naturally acquired active immunity occurs when the person is exposed to a live pathogen, develops the disease, and becomes immune as a result of the primary immune response.
- Once a microbe penetrates the body's skin, mucous membranes, or other primary defenses, it interacts with the immune system.

Acquired Immunity

- results from an infection or an immunization, while passive immunity comes from naturally or artificially gaining antibodies.

Acquired Immunity

- An example of **natural passive immunity** is a baby's protection against certain infections by getting antibodies through colostrum or breast milk.
- An example of **artificial passive immunity** is getting an injection of antisera, which is a suspension of antibody particles.

Acquired Immunity

- Artificially acquired active immunity can be induced by a vaccine, a substance that contains the antigen.

END

Animal Form and Function 1

Module 192



Animal Form and Function 1

Vaccines



Vaccines

- Vaccine is a substance used to stimulate the production of antibodies and provide immunity against one or several diseases.
- Vaccines are prepared from the causative agent of a disease or its products.
- It may be a synthetic substitute, treated to act as an antigen without inducing the disease.

Vaccines

- "there is no vaccine against the virus".
- Vaccine, suspension of weakened or killed microorganisms or toxins or of antibodies or lymphocytes that is administered to prevent disease.
- Vaccines contain a dead or weakened version of a microbe.

Vaccines

- There are 4 main types of vaccines:
- Live-attenuated vaccines.
- Inactivated vaccines.
- Subunit, recombinant, polysaccharide, and conjugate vaccines.
- Toxoid vaccines.

Vaccines

- The first inactivated polio vaccine (IPV) was produced by Salk using virus grown on monkey kidney cells and inactivated with formalin.
- Attenuated or Weakened
- Inactivated (Killing by formaline)
- measles, mumps, and rubella (MMR)

END

Animal Form and Function 1

Module 193



Animal Form and Function 1

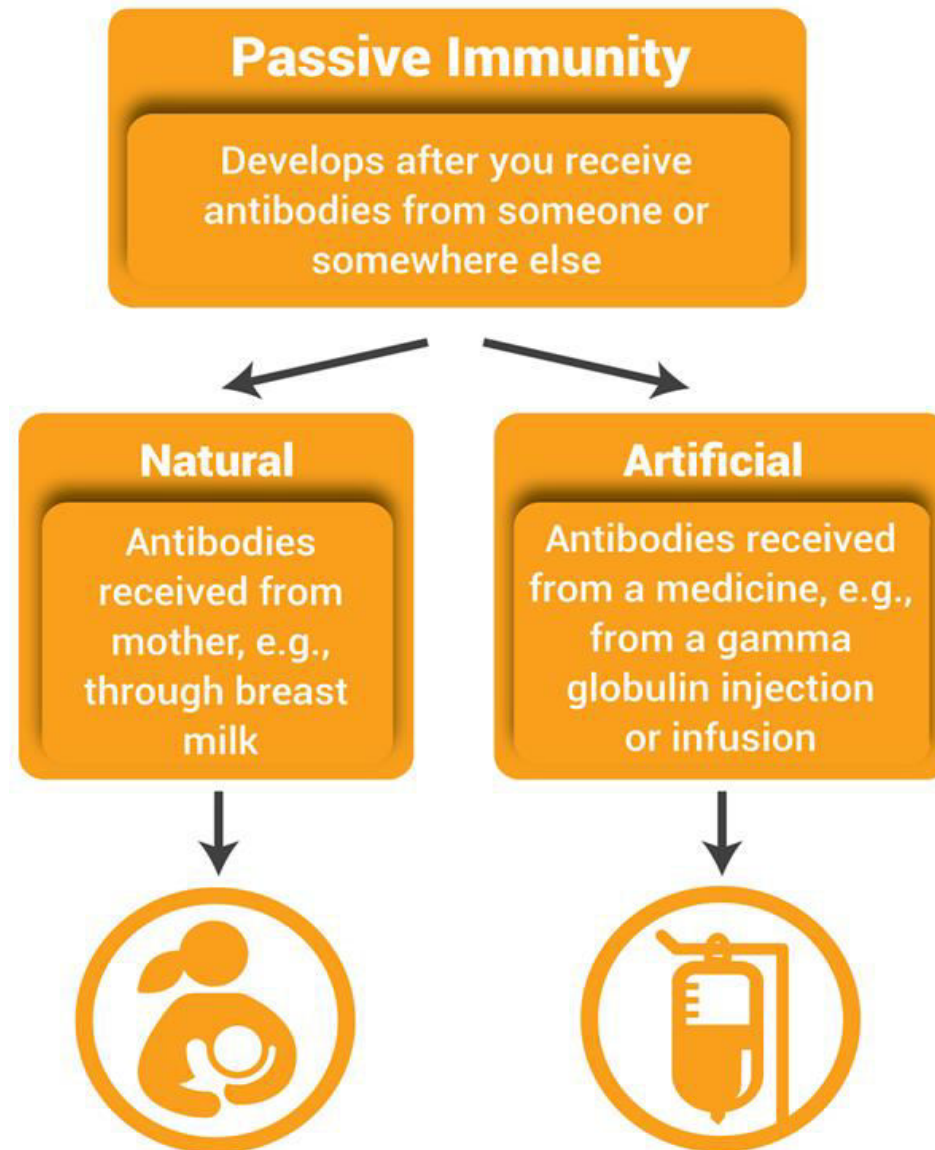
Passive Immunity



Passive Immunity

- **Passive immunity is conferred from outside the body, so it doesn't require exposure to an infectious agent or its antigen.**
- **There is no delay in the action of passive immunity. Its response to an infectious agent is immediate. Passive immunity is not as long-lasting as active immunity**

Passive Immunity



Passive Immunity

- An example of natural passive immunity is a baby's protection against certain infections by getting antibodies through colostrum or breast milk.
- An example of artificial passive immunity is getting an injection of antisera, which is a suspension of antibody particles.

Passive Immunity

- Artificially-acquired passive immunity is an immediate, but short-term immunization provided by the injection of antibodies, such as gamma globulin, that are not produced by the recipient's cells.
- These antibodies are developed in another individual or animal and then injected into another individual.

Passive Immunity

Active Immunity

VS

Passive Immunity

Natural



Infection

Artificial



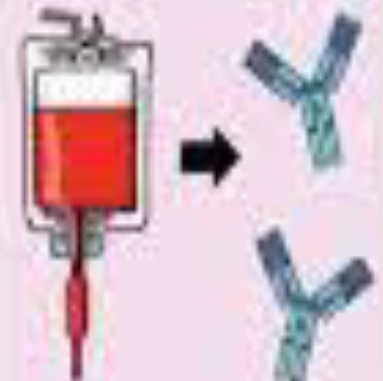
Vaccination

Natural



Maternal
antibodies

Artificial



Monoclonal
antibodies



VU MEDICAL ZONE

Merge By

AMMAN KHAN