

ZOOLOGY

**Diversity of Chordates
and
Comparative Anatomy
for
B.Sc. Sem. V
(Paper 2)**

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UNIT 1

Origin of Chordates and Hemicordata

ORIGIN OF CHORDATES

Chordates (phylum Chordata) are a diverse group of animals that include vertebrates (e.g., fish, mammals), cephalochordates (e.g., lancelets), and urochordates (e.g., tunicates). Their origin is a major topic in evolutionary biology, bridging invertebrate and vertebrate evolution.

Defining Features of Chordates

All chordates share five key characteristics (at least during some life stage):

1. **Notochord:** A flexible, rod-like structure providing skeletal support.
Replaced by vertebrae in most vertebrates.
2. **Dorsal Hollow Nerve Cord:** Develops into the brain and spinal cord.
3. **Pharyngeal Slits:** Openings in the pharynx (become gills in fish, ear/jaw parts in mammals).
4. **Post-anal Tail:** Extends beyond the anus (reduced in humans).
5. **Endostyle/Thyroid Gland:** Secretes mucus for filter-feeding (in protochordates) or hormones (in vertebrates).

Hypotheses for Chordate Origins

Two leading theories explain the evolution of chordates from invertebrates:

A. Auricularia Hypothesis (Garstang, 1928)

- **Proposes:** Chordates evolved from a larval tunicate (urochordate) via paedomorphosis (retention of juvenile traits in adults).
- **Evidence:**
Tunicate larvae have tadpole-like bodies with notochords and tails.
Sessile adult tunicates resemble non-chordate filter-feeders.

B. Calcichordate Hypothesis (Jefferies, 1986)

- **Proposes:** Chordates arose from sessile, echinoderm-like ancestors (e.g., extinct carpoids).
- **Evidence:**
Fossil carpoids show similarities to early chordates in symmetry and skeletal plates.
Molecular data now disputes this idea (echinoderms are deuterostomes but not direct ancestors).

Key Fossil Evidence

Fossil Group	Age	Significance
Pikaia	Mid-Cambrian (~505 Ma)	Earliest chordate fossil (Burgess Shale).
Haikouella	Cambrian (~530 Ma)	Possessed a notochord and gill slits.
Mylokunmingia	Cambrian (~535 Ma)	Early vertebrate (jawless fish).
Conodonts	Ordovician (~450 Ma)	Tooth-like fossils now linked to early vertebrates.

Modern Protochordates: Closest Living Relatives

A. Urochordates (Tunicates)

- **Larvae:** Motile, with notochords (resemble ancestral chordates).
- **Adults:** Sessile, lose notochord (e.g., sea squirts).
- **Genomic Insight:** Share 80% of vertebrate gene families but lack key developmental genes (e.g., Hox clusters).

B. Cephalochordates (Lancelets, e.g., Branchiostoma)

- Retain all chordate features as adults.
- **Genetic Link:** Have a proto-vertebrate genome (e.g., Amphioxus shares Hox genes with vertebrates).

Evolutionary Transitions to Vertebrates

1. **Neural Crest Cells:** Unique to vertebrates; form skull, teeth, and sensory organs.
2. **Duplication of Hox Genes:** Enabled complex body plans (single cluster in lancelets 4+ in vertebrates).

3. **Mineralized Skeleton:** Appeared in early fish (e.g., Haikouichthys).

Molecular Evidence

- **Deuterostome Ancestry:** Chordates, echinoderms, and hemichordates share:
Radial cleavage in embryos.
Blastopore forms the anus.
- **Gene Families:** Brachyury (notochord development), Otx (brain patterning) are conserved.

Controversies and Debates

- **Tunicate vs. Lancelet Ancestry:**
Earlier models favored lancelets as the closest vertebrate relatives.
Recent molecular data suggests tunicates are sister to vertebrates.
- **Role of Hemichordates:** Share pharyngeal slits but lack notochords; may represent a "pre-chordate" stage.

Timeline of Chordate Evolution

Era	Event
Ediacaran (~600 Ma)	Deuterostome divergence.
Cambrian (~535 Ma)	First chordate fossils (Pikaia).
Ordovician (~450 Ma)	Jawless fish (ostracoderms) appear.
Silurian (~420 Ma)	Jawed vertebrates (gnathostomes) evolve.

Significance of Chordate Origins

- **Medical Research:** Understanding Hox genes aids developmental biology.
- **Conservation:** Lancelets are model organisms for studying gene regulation.
- **Paleontology:** Fossils like Haikouella bridge invertebrate- vertebrate gaps.

CLASSIFICATION OF CHORDATES

Chordates are divided into three subphyla:

Subphylum	Example	Key Features
Urochordata	Sea squirts (tunicates)	Notochord in larval stage only
Cephalochordata	Branchiostoma (Amphioxus)	Notochord extends into head region
Vertebrata	Fishes, reptiles, mammals	Notochord replaced by vertebral column

Evolutionary Background

Probable Ancestors of Chordates

There are several hypotheses about the origin of chordates, mainly based on embryological, anatomical and molecular evidence:

Theories of Chordate Origin

A. Echinoderm Ancestry Hypothesis (Auricularian Hypothesis)

- Proposed by Garstang (1928).
- Suggests that chordates evolved from a dipleurula-like echinoderm larva (auricularia).
- The larval form became sexually mature (paedogenesis), giving rise to the chordate lineage.
- Supported by:
 - Deuterostome development (blastopore becomes anus)
 - Similarities in larval structures and coelom formation.

Concept: Chordates and echinoderms share a common deuterostome ancestor.

B. Annelid Ancestor Hypothesis

- Earlier theory proposing that chordates evolved from segmented annelids.
- Based on:
 - Segmentation (metamerism)
 - Bilateral symmetry

- Rejected due to differences in nerve cord position and embryonic development patterns.

C. Arthropod Ancestry Hypothesis

- Proposed due to structural similarities (segmentation, symmetry).
- Rejected because:
 - Arthropods are protostomes
 - Have ventral nerve cord and exoskeleton, unlike chordates.

D. Hemichordate Hypothesis

- Hemichordates (like *Balanoglossus*) possess some chordate features:
 - Pharyngeal gill slits
 - Dorsal nerve cord
- But they lack a true notochord.
- Suggests that hemichordates and chordates share a common ancestor.

Deuterostome Lineage and Molecular Evidence

Molecular phylogenetics supports that:

- Chordates, echinoderms, and hemichordates belong to the Deuterostomia group.
- Shared features:
 - Radial, indeterminate cleavage
 - Enterocoelous coelom formation
 - Anus forms from the blastopore
- DNA and RNA sequencing supports a monophyletic origin of deuterostomes.

Evolutionary Pathway to Chordates

- Deuterostome ancestor
- Dipleurula-like larva
- Paedomorphic tunicate-like organism
- Cephalochordate-like animal (*Amphioxus*)
- Early vertebrates (Agnatha - jawless fish)

Significance of Tunicates and Amphioxus

- Tunicates show chordate characters only in larval stage (notochord, tail).
- Amphioxus (cephalochordate) is considered the closest living model to ancestral chordates.
- Vertebrates likely evolved from cephalochordate-like ancestors.

Theories of Chordate Origin

Theory	Proposed Ancestor	Support	Limitations
Echinoderm (Auricularian)	Echinoderm larva	Embryology, molecular data	Widely accepted
Annelid	Segmented worms	Metamerism, symmetry	Nerve cord and blastopore differences
Arthropod	Jointed-legged animals	Segmentation	Ventral nerve cord; exoskeleton
Hemichordate	Acorn worms	Gill slits, nerve cord	No true notochord

Classification of Phylum Chordata (Up to Class Level)

Phylum Chordata is classified into three major subphyla, with vertebrates (Subphylum Vertebrata) being the most diverse. Below is a detailed hierarchical classification, including key characteristics and examples for each group.

1. Subphylum: Urochordata (Tunicates)

Characteristics:

- **Notochord:** Present only in the larval tail (lost in adults).
- **Body:** Sessile or free-living, enclosed in a tunic (cellulose-like covering).

- **Feeding:** Filter-feeders using pharyngeal slits.
- **Reproduction:** Hermaphroditic; some undergo metamorphosis.

Classes:

1. Class Ascidiacea (Sea Squirts)

Example: *Ciona intestinalis*.

Features: Sessile adults, motile larvae.

2. Class Thaliacea (Salps)

Example: *Salpa maxima*.

Features: Free-floating, barrel-shaped, jet propulsion.

3. Class Appendicularia (Larvaceans)

Example: *Oikopleura dioica*.

Features: Retain larval form, secrete gelatinous houses.

2. Subphylum: Cephalochordata (Lancelets)

Characteristics:

- **Notochord:** Extends from head to tail (retained throughout life).
- **Body:** Fish-like but lack true vertebrae.
- **Habitat:** Buried in sand, filter-feeders.
- **Class:** Leptocardii
- **Example:** *Branchiostoma* (Amphioxus).
- **Features:** Segmented muscles, no paired fins.

3. Subphylum: Vertebrata (Craniata)

Characteristics:

- **Notochord:** Replaced by vertebral column (except in hagfish).
- **Neural Crest:** Unique cells forming skull, teeth, and sensory organs.
- **Brain:** Encased in a cranium.

A. Superclass: Agnatha (Jawless Vertebrates)

Class 1: Myxini (Hagfish)

- **Example:** *Myxine glutinosa*.
- **Features:**
 - No vertebrae (cartilaginous skull only).
 - Slime-producing glands for defense.

Class 2: Petromyzontida (Lampreys)

- Example: *Petromyzon marinus*.
- Features:
Primitive vertebrae (cartilaginous).
Parasitic adults with oral suckers.

B. Superclass: Gnathostomata (Jawed Vertebrates)**Class 1: Chondrichthyes (Cartilaginous Fish)**

- Examples: Sharks (*Squalus*), rays (*Raja*).
- Features:
Cartilaginous skeleton.
Placoid scales, 5-7 gill slits.

Class 2: Actinopterygii (Ray-Finned Fish)

- Examples: Salmon (*Oncorhynchus*), goldfish (*Carassius*).
- Features:
Bony skeleton, fins supported by rays.

Class 3: Sarcopterygii (Lobe-Finned Fish)

- Examples: Coelacanth (*Latimeria*), lungfish (*Protopterus*).
- Features:
Muscular fins with bones (ancestral to tetrapod limbs).

Class 4: Amphibia (Amphibians)

- Examples: Frogs (*Rana*), salamanders (*Ambystoma*).
- Features:
Moist skin, larval stage in water (e.g., tadpoles).

Class 5: Reptilia (Reptiles)

- Examples: Snakes (*Python*), turtles (*Chelonia*).
- Features:
Dry scaly skin, amniotic eggs.

Class 6: Aves (Birds)

- Examples: Eagle (*Aquila*), sparrow (*Passer*).
- Features:
Feathers, beak, hollow bones.

Class 7: Mammalia (Mammals)

- Examples: Humans (*Homo sapiens*), dolphins (*Tursiops*).
- Features:
Hair, mammary glands, diaphragm.

Chordata Classification

Subphylum	Class	Key Features	Example
Urochordata	Ascidiacea	Sessile adults, cellulose tunic	Sea squirt (<i>Ciona</i>)
	Thaliacea	Free-floating, jet propulsion	Salp (<i>Salpa</i>)
	Appendicularia	Retains larval form	Larvacean (<i>Oikopleura</i>)
Cephalochordata	Leptocardii	Notochord lifelong, no skull	Lancelet (<i>Branchiostoma</i>)
Vertebrata	Myxini (Hagfish)	No jaws, slime glands	Myxine glutinosa
	Petromyzontida (Lampreys)	Jawless, parasitic	Petromyzon
	Chondrichthyes	Cartilaginous skeleton	Shark (<i>Squalus</i>)
	Actinopterygii	Ray-finned fish	Goldfish (<i>Carassius</i>)
	Sarcopterygii	Lobe-finned fish	Coelacanth (<i>Latimeria</i>)
	Amphibia	Dual life (water/land)	Frog (<i>Rana</i>)
	Reptilia	Scaly skin, amniotic eggs	Snake (<i>Python</i>)
	Aves	Feathers, flight	Eagle (<i>Aquila</i>)
	Mammalia	Hair, mammary glands	Human (<i>Homo</i>)

Evolutionary Significance

- **Urochordates:** Closest invertebrate relatives of vertebrates.
- **Cephalochordates:** Model organisms for studying chordate origins.
- **Vertebrates:** Dominant due to adaptations like jaws (gnathostomes) and limbs (tetrapods).

HEMICHORDATA

General Characteristics of Hemichordata

Hemichordata is a small phylum of marine deuterostomes that shares some characteristics with both chordates and echinoderms. They are often considered an evolutionary link between non-chordates and chordates.

Key Features:

Body Plan:

- Tripartite body division: Proboscis (protosome), collar (mesosome), and trunk (metasome).
- Bilaterally symmetrical with a soft, unsegmented body.

Coelom:

- Enterocoelous coelom (derived from the archenteron) divided into three regions:
- Protoel (in proboscis)
- Mesocoel (in collar)
- Metacoel (in trunk)

- **Digestive System:**

Complete digestive tract (mouth to anus).

Pharynx with gill slits (pharyngeal clefts) in some species (resembling chordates).

Nervous System:

Primitive nerve net with a dorsal nerve cord in the collar region (similar to chordates).

Subepidermal nerve plexus (similar to echinoderms).

- **Circulatory System:**

Open circulatory system with a dorsal heart and blood sinuses.

- **Respiration:**

Through gill slits (when present) or body surface.

- **Excretion:**

Glomerulus (proboscis gland) acts as an excretory organ.

- **Reproduction:**

Mostly dioecious (separate sexes). External fertilization with a free-swimming tornaria larva (resembles echinoderm bipinnaria larva).

Affinities:

- Similarities with Chordata:
 - Pharyngeal gill slits.
 - Dorsal nerve cord (partial).
- Similarities with Echinodermata:
 - Deuterostome development.
 - Tornaria larva resembles bipinnaria larva.

Classification of Hemichordata

Hemichordata is divided into two main classes:

Class 1: Enteropneusta (Acorn Worms)

- **Examples:** Balanoglossus, Saccoglossus, Ptychodera
- **Characteristics:**
 - Worm-like, burrowing or free-living.

Proboscis used for digging and feeding.

Numerous gill slits in the pharyngeal region.

Well-developed digestive tract.

No true notochord, but a buccal diverticulum (stomochord) was once thought homologous.

Mostly solitary and benthic (live in sediments).

Class 2: Pterobranchia

- **Examples:** Rhabdopleura, Cephalodiscus, Atubaria
- **Characteristics:**
 - Small, colonial, tube-dwelling organisms.
 - Filter feeders with lophophore-like tentacles (ciliary feeding).
 - Few or no gill slits (reduced or absent).
 - U-shaped gut (anus near mouth).
 - Secretes a chitinous tube for protection.
 - Mostly sessile (attached to substrates).

Class 3: Planctosphaeroidea (Extinct or Rare)

- **Example:** Planctosphaera pelagica (only known from larvae)
- **Characteristics:**
 - Free-floating, spherical larvae.
 - Uncertain adult form (possibly related to Pterobranchia).

Evolutionary Significance

- Hemichordates provide insights into the origin of chordates.

- The stomochord was once considered homologous to the chordate notochord, but this is now disputed.
- Their gill slits and dorsal nerve cord suggest a close relationship with Chordata.

Ecological Role

- Enteropneusta play a role in sediment turnover (bioturbation).
- Pterobranchs contribute to deep-sea benthic communities.

Comparison of Enteropneusta and Pterobranchia

Feature	Enteropneusta (Acorn Worms)	Pterobranchia
Body Form	Worm-like, elongated	Small, colonial, tube-dwelling
Feeding	Deposit feeders (proboscis)	Filter feeders (tentacles)
Gill Slits	Numerous	Few or absent
Gut Shape	Straight	U-shaped
Locomotion	Burrowing or free-living	Sessile
Reproduction	Mostly dioecious	Asexual (budding) & sexual

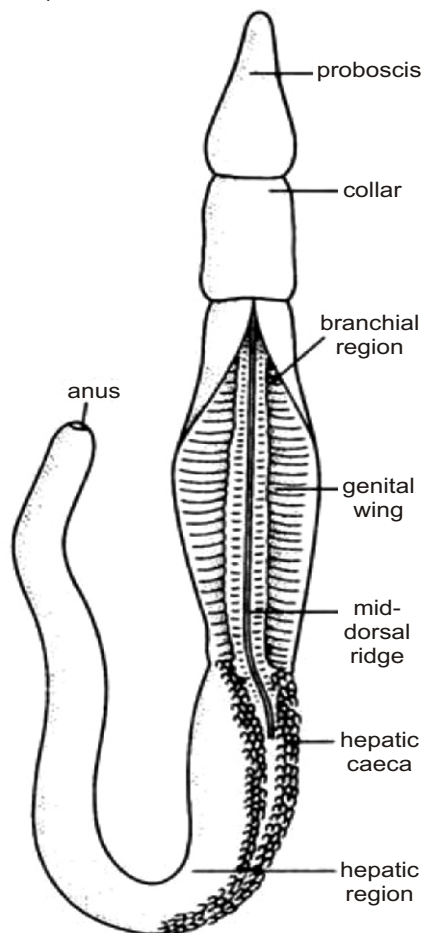
Conclusion

Hemichordata is a unique phylum that bridges echinoderms and chordates, offering key insights into deuterostome evolution. Their morphological and developmental traits make them crucial for understanding the origins of chordate features.

BALANOGLOSSUS

Habit and Habitat

- **Common Name:** Acorn worm
- **Habitat:**
Marine, found in shallow coastal waters (intertidal to subtidal zones). Burrows in soft sandy or muddy substrates. Often in U-shaped or spiral burrows lined with mucus.
- **Distribution:** Cosmopolitan (found worldwide in temperate and tropical seas).



Balanoglossus. External features in dorsal view

• **Feeding:**

Deposit feeder - ingests organic-rich sediment.

Extracts nutrients using ciliary-mucoid feeding mechanism.

• **Locomotion:**

Moves using peristaltic contractions of the body.

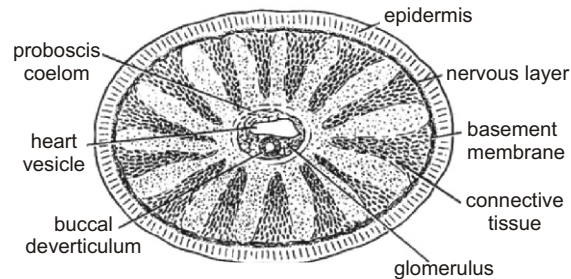
Proboscis helps in burrowing and feeding.

Morphology (External Structure)

Body Divisions:

1. Proboscis (Protosome)

- Anterior, muscular, conical structure.
- Contains the heart vesicle (glomerulus) for excretion.
- Used for digging and food collection.



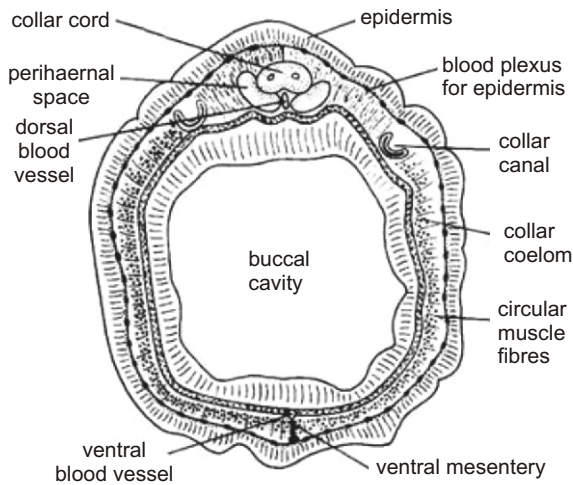
Balanoglossus. T.S. of proboscis.

2. Collar (Mesosome)

- Short, cylindrical region behind the proboscis.
- Bears the mouth ventrally.
- Houses the dorsal nerve cord (hollow in some species).

3. Trunk (Metasome)

- Longest part, divided into:
Branchiogenital region (anterior): Contains gill pores and gonads.
Hepatic region (middle): Greenish due to hepatic sacs (digestive glands).



Balanoglossus. T.S. of Collar

Abdominal region (posterior): No special structures.

External Features:

- Gill pores (dorsolateral) for respiration.
- Genital wings (in some species) for reproduction.
- Mucus-secreting epidermis aids in burrowing.

Anatomy (Internal Structure)

(A) Digestive System

- Complete alimentary canal (mouth anus).
- **Mouth** - Ventral, at the base of the proboscis.
- **Buccal cavity** - Leads to the pharynx with gill slits.
- **Pharynx** - Perforated with U-shaped gill slits (respiratory function).
- **Esophagus** - Connects pharynx to the intestine.
- **Intestine** - Divided into:
Hepatic region (with digestive glands).
Post-hepatic region (absorption).
- **Anus** - Terminal, at the posterior end.

(B) Respiratory System

- Gill slits (pharyngeal clefts) allow water flow.
- Gill pouches gill pores (for gas exchange).
- Respiration also occurs through the body surface.

(C) Circulatory System

- Open circulatory system (blood flows in sinuses).
- Dorsal heart (pulsatile vesicle) pumps blood.
- Blood - Colorless, with amoeboid cells.

(D) Excretory System

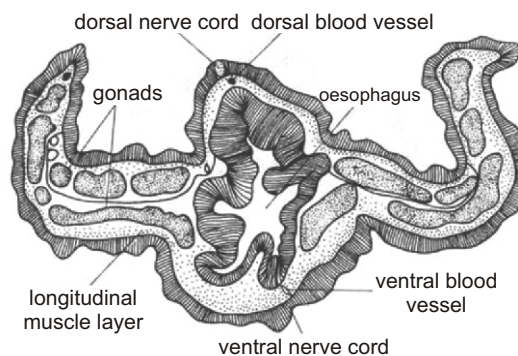
- Glomerulus (proboscis gland) - Acts as a filtration kidney.
- Excretory waste: Ammonia (diffuses through body wall).

(E) Nervous System

- Primitive nerve net (similar to echinoderms).
- Dorsal nerve cord in the collar (resembles chordate nerve cord).
- Ventral nerve cord in the trunk.

(F) Reproductive System

- Dioecious (separate sexes).
- Gonads (testes/ovaries) arranged in genital wings.
- External fertilization in seawater.
- Development includes a tornaria larva (free-swimming, resembles echinoderm larva).



Balanoglossus. T.S. through genital wings.

🔗 Physiology

(A) Feeding & Digestion

- **Deposit feeding:** Ingests sand/mud rich in organic matter.
- **Ciliary-mucoid mechanism:**
Proboscis secretes mucus to trap food.
Cilia direct food to the mouth.
- Extracellular digestion in the intestine.

(B) Respiration

- Water enters the mouth passes through gill slits exits via gill pores.
- Oxygen exchange occurs in the pharyngeal region.

(C) Excretion

- Glomerulus filters waste from blood.
- Waste expelled via diffusion through the body wall.

(D) Reproduction

- Sexual reproduction (external fertilization).
- Tornaria larva undergoes metamorphosis into adult.

🔗 Development (Life Cycle)

1. **Fertilization:** External, in seawater.
2. **Cleavage:** Holoblastic, radial.
3. **Gastrulation:** Invagination forms archenteron.
4. **Tornaria Larva:**
 - Free-swimming, ciliated.
 - Resembles echinoderm bipinnaria larva.
 - Has apical tuft and ciliary bands.

5. Metamorphosis:

- Larva settles develops into juvenile adult.

🔗 Evolutionary Significance

- Shares deuterostome features with echinoderms and chordates.
- Gill slits and dorsal nerve cord link it to Chordata.
- Stomochord (earlier thought to be notochord homolog) is now considered non-homologous.

Key Features of Balanoglossus

Feature	Description
Body Plan	Tripartite (Proboscis, Collar, Trunk)
Digestive System	Complete gut with gill slits
Respiration	Gill slits & body surface
Circulation	Open system with dorsal heart
Excretion	Glomerulus (proboscis gland)
Nervous System	Dorsal & ventral nerve cords
Reproduction	Dioecious, external fertilization
Development	Indirect (tornaria larva)

🔗 Conclusion

Balanoglossus is a key hemichordate model for studying deuterostome evolution. Its mix of chordate-like (gill slits, dorsal nerve cord) and echinoderm-like (tornaria larva) traits provides insights into the origin of vertebrates.

QUESTIONS



Section A: Very Short Answer Type Questions

1. **Balanoglossus belongs to which phylum?**

Ans. Hemichordata

2. **Which larva does Balanoglossus develop through?**

Ans. Tornaria larva

3. **The circulatory system in Hemichordata is of what type?**

Ans. Open type

4. **What are the three body divisions of Balanoglossus?**

Ans. Proboscis, collar, trunk

5. **Name one theory of origin of chordates that involves Hemichordates and Echinoderms.**

Ans. Echinoderm-Hemichordate (or Echinoderm-Hemichordate) theory

6. **In which parts of Balanoglossus is excretion performed?**

Ans. Glomerulus in the proboscis

7. **Hemichordata was earlier placed under which group of Chordata?**

Ans. Protochordata

Section B: Short Answer Type Questions

8. **Briefly describe the salient features and outline classification of Phylum Chordata up to class level.**

Ans. Phylum Chordata has characteristics like a notochord, dorsal tubular nerve cord, pharyngeal slits, post-anal tail, and endostyle or thyroid. The classification up to classes is:

- Subphylum Protochordata (Hemichordata, Urochordata, Cephalochordata)
- Subphylum Vertebrata (Classes: Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, Mammalia)

9. **What are the general characteristics of Hemichordata?**

Ans. Hemichordates are marine, worm-like animals with triploblastic, bilaterally symmetrical bodies. Their body is divided into proboscis, collar, and trunk. They have an open circulatory system, pharyngeal slits, dorsal neural elements (sometimes tubular), and develop via a tornaria larva.

10. **Describe the habit, habitat and external morphology of Balanoglossus.**

Ans. Balanoglossus lives in burrows in shallow marine sandy or muddy substrata. It is a burrowing worm-like animal. Externally it is elongated, with three regions (proboscis, collar and trunk), the body surface is ciliated, and it lacks segmentation.

11. Outline the anatomy and physiology of Balanoglossus (key organs & functions).

Ans. Internally, Balanoglossus has a digestive tract with mouth in proboscis, oesophagus, stomach, intestine. It possesses pharyngeal gill slits in the trunk, a dorsal nerve cord or neural plate, and an open circulatory system. Excretory function is via a glomerulus. Respiration is via pharyngeal gill slits. Reproduction is external, development indirect via tornaria larva.

12. Explain developmental stages of Balanoglossus.

Ans. Fertilisation is external. The embryo develops into a tornaria larva, which is planktonic, ciliated, and has features resembling echinoderm larva. Later it undergoes metamorphosis to settle and form the adult.

Section C: Long Answer Type Questions

13. Explain the origin of chordates with reference to Garstang's Auricularia Theory

Ans. Garstang's Auricularia Theory proposes that chordates originated from echinoderm larvae, specifically the auricularia larva, through a process called paedomorphosis (retention of juvenile features in the adult form).

- Walter Garstang suggested that instead of developing into typical adult echinoderms, some auricularia larvae reached sexual maturity while retaining their larval morphology (a phenomenon known as neoteny).
- These larval forms had bilateral symmetry, a ciliated band, and coelomic compartments-features similar to those of early chordates.
- Over time, these neotenous forms evolved features such as the notochord, dorsal nerve cord, and pharyngeal slits, giving rise to the first chordates.
- The dipleurula larva (ancestral larval form of echinoderms and hemichordates) is considered a key intermediate in this transition.

14. Describe the general characteristics and classification of Hemichordata

Ans. General Characteristics:

- Marine, deuterostome animals.
- Body divided into proboscis, collar and trunk.
- Possess pharyngeal gill slits and a stomochord (previously mistaken for a notochord).
- Bilateral symmetry, triploblastic body, coelomate.
- Open circulatory system.
- Mostly sedentary or burrowing.

Classification of Hemichordata: Divided into two main classes:

1. Class Enteropneusta (Acorn worms)

- **Example:** Balanoglossus
- Solitary, burrowing marine worms.
- Well-developed proboscis and collar.

2. Class Pterobranchia

• Example:

- Rhabdopleura, Cephalodiscus
- Colonial, tube-dwelling, sessile.
- Tentacle-bearing arms for filter feeding.

15. Discuss the phylogenetic relationship between Hemichordata, Echinodermata, and Chordata. (CCSU 2021)

Ans. Deuterostomes: All three phyla-Hemichordata, Echinodermata, and Chordata-are deuterostomes, meaning they share embryological characteristics like radial cleavage, indeterminate development, and blastopore forming the anus.

Hemichordates and Echinoderms: Share dipleurula-like larva and similar coelomic compartmentalization, suggesting a close evolutionary relationship.

Hemichordates and Chordates: Hemichordates possess pharyngeal gill slits and a dorsal nerve cord (in some forms), features that align them with chordates, though the stomochord is not homologous to the chordate notochord.

Current understanding: Hemichordata and Echinodermata form a monophyletic group called Ambulacraria and Chordata is a sister group to this clade.

16. Give a detailed account of the morphology and anatomy of Balanoglossus

Ans. Morphology:

- Soft, cylindrical, worm-like body.
- Divided into three regions:
 - **Proboscis:** Used for burrowing and feeding.
 - **Collar:** Surrounds the proboscis stalk; bears the mouth.
 - **Trunk:** Longest part; contains gill slits, gonads, digestive organs.

Anatomy:

- **Digestive system:** Complete; mouth buccal cavity pharynx (with gill slits)
oesophagus intestine anus.
- **Respiratory system:** Pharyngeal gill slits lined with cilia and vascular lamellae aid in gas exchange.
- **Circulatory system:** Open type with a dorsal heart-like structure (heart vesicle).
- **Nervous system:** Primitive, includes a dorsal nerve cord and a nerve ring in the collar.
- **Reproduction:** Dioecious; external fertilization; indirect development with a tornaria larva.

17. Classify the Phylum Chordata up to classes with suitable examples. (CCSU 2020)

Ans. Phylum Chordata

- **Key features:** Notochord, dorsal nerve cord, pharyngeal gill slits, post-anal tail, endostyle/thyroid.

Subphyla:

1. Urochordata (Tunicates)

- **Example:** Herdmania, Ciona
- Larvae show chordate features; adults are sessile.

2. Cephalochordata (Lancelets)

- **Example:** Branchiostoma (Amphioxus)
- Retain chordate features throughout life.

3. Vertebrata (Craniata)

- Possess a vertebral column, brain protected by a cranium.

Vertebrata is further classified into:

Agnatha (Jawless fish)

- **Example:** Petromyzon, Myxine

Gnathostomata (Jawed vertebrates)

- **Pisces (Fishes)**
- **Chondrichthyes:** Cartilaginous fishes (e.g., Scoliodon, Shark)
- **Osteichthyes:** Bony fishes (e.g., Rohu, Catla)

Amphibia: Frog, Salamander

Reptilia: Lizard, Snake

Aves: Pigeon, Crow

Mammalia: Rat, Human

18. Write short notes on:

(a) **Affinities of Hemichordata**

Ans.

- **With Chordates:** Presence of pharyngeal gill slits, dorsal nerve cord (in some), and a stomochord (formerly thought to be homologous with the notochord).
- **With Echinoderms:** Similar larval forms (tornaria vs. bipinnaria), deuterostome development, tripartite coelom.
- **With Non-chordates:** Open circulatory system, body organization similar to some annelids in appearance.

(b) **Development of Balanoglossus**

- External fertilization.
- Cleavage is radial and holoblastic.
- Forms a free-swimming tornaria larva, which resembles echinoderm larvae.
- Metamorphosis leads to adult form
- Describe the salient features of Hemichordata and justify its inclusion as a separate phylum.