References (Textbook - pages 557-576, Lab Manual pages 198-205)

Major Characteristics of Chordata

1. Possess a **notochord** at least some time in their lives
   - The **notochord** can be thought of as a **skeletal rod**
   - **Replaced** by **vertebral column** in **Vertebrates**

2. Possess **pharyngeal gill slits** at least some time in their lives

3. Have a **dorsal hollow nerve cord** at least some time in their lives

4. Have a **post anal tail** at least some time in their lives

Classification of Chordata

Subphylum **Urochordata** - (tunicates) - **note these are still considered invertebrates**

Subphylum **Cephalochordata** - (lancelets) - **note these are still considered invertebrates**

Subphylum **Vertebrata** - (animals with backbones, the vertebrates)

  Superclass **Pisces** (fishes and fishlike animals)

     Class **Agnatha** (jawless fish like lampreys and hagfish)

     Class **Chondrichthyes** (cartilaginous fishes like sharks and dogfish)

     Class **Osteichthyes** (bony fish like bass, perch, tuna)

Superclass **Tetrapoda** (vertebrates with 2 pair of appendages)

     Class **Amphibia** (frogs, toads, salamanders)

     Class **Reptilia** (turtles, lizards, snakes, crocodiles, alligators)

     Class **Aves** (birds)

     Class **Mammalia** (squirrels, monkeys, bats, and man)
3 Groups Linking Invertebrates to Vertebrates

1. There are 3 **groups** or **taxons** that **link invertebrates** to **vertebrates**. These are
   - phylum *Hemidordata* - **never** have a **notochord**
   - subphylum *Urochordata* - **have a notochord**, but **never vertebrae**
   - subphylum *Cephalochordata* - **have a notochord**, but **never vertebrae**

2. The subphyla *Urochordata* and *Cephalochordata* are often **referred** to as the "**invertebrate chordata**".

**Subphylum Urochordata**

1. Includes the **tunicates** or **sea squirts**

2. They are **sessile, barrel shaped, marine animals**

3. *Urochordates* are sometimes **mistaken** for **sponges**

4. **Adults** develop **tunics** (a loose gown-like garment worm in ancient Greece) that are **thick coats** composed principally of **cellulose**

5. **Most** species are **filter feeders**.

**Subphylum Cephalochordata**

1. Includes the **lancelets** or **Amphioxus**

2. These are small, translucent, fishlike animals.

3. They are segmented and pointed at both ends

4. They are found in shallow seas where they burrow in the sand

5. Like the tunicates, they are filter feeders.
Subphylum Vertebrata

- **Characteristics** (1st four same as for phylum Chordata)
  1. Possess a **notochord** at least some time in their lives
    - Notochord in vertebrates usually replaced by **vertebrae** in Vertebrates
    - Forms the **chief skeletal axis** of the body
  2. Possess **pharyngeal gill slits** at least some time in their lives
  3. Have a **dorsal hollow nerve** cord at least some time in their lives
  4. Have a **post anal tail** at least some time in their lives
  5. **Body** can be divided into **three regions**. These are
    - **Head**
    - **Trunk**
    - **Post anal tail**
  6. Possess an **endoskeleton** made up of **cranium** (skull), **vertebral column** (spine), **visceral arches** (rib cage), **limb girdles** (hip & collar bone), and two **pairs of jointed appendages** (arms & legs).
  7. **Endoskeleton** composed of **bone** or **cartilage**.
  8. Have a well developed, **closed circulatory system** with a **dorsal heart**
  9. Possess a **centralized nervous system** with a **brain**
  10. Have **2 image forming eyes**
  11. The **excretory system** is **compact** with **paired kidneys**
  12. **Sexes** are **distinct** and **separate**
  13. The **digestive system** is **complete**, is **ventral** to the **spinal column**, and **possesses two** large **digestive glands**, the **liver** and **pancreas**
  14. **Coelom** is **large** and **well developed** and **filled** with internal **organ systems**.
• **Classification**

1. Class *Agnatha*
   - These are the *jawless* (no jaws) fishes
   - They have *no paired appendages*
   - They are *cold blooded* and *fish-like*
   - *Living* examples include *lampreys* and *hagfish*
   - Members of this *class* are often called the *first fishes*
   - *Fossil* members of this group represented by the *ostracoderms* which were *armor plated fishes* living on the *bottom*, obtaining food by sucking up sediments and sorting out nutrients, *essentially filter feeders.*

2. Class *Chondrichthyes*
   - This class includes fishes *with jaws* with *cartilaginous skeletons*. Their skeleton is *made of cartilage* and is *not* made of *bone*
   - *Possession of jaws* gives organisms a *distinct advantage* over those without jaws.
     1. Many biologist believe the *front gill arches* of *jaw-less fishes* are *homologous* to the *upper* and *lower jaws* of more advanced vertebrates.
     2. *Evolutionists* believe the *front and lower gill arches* were *modified over time* to *form* the *jaws* of more advanced vertebrates.
   - Members of this class are *commonly called* the *cartilaginous fish.*
   - They are *cold-blooded*
   - They usually have *powerful swimming muscles*
   - Includes *sharks, rays, dogfish*
   - With the exception of the *whale, sharks* are the *largest living vertebrates* and *large sharks* may reach 40 to 50 feet in *length.*
3. Class *Osteichthyes*

- These are fishes with jaws and skeletons made of bone.
- Members of this class are called the **bony fishes**.
- They are **cold blooded**
- **Respiration** is accomplished by **gills** covered by a **bony gill flap** called the **operculum**.
- Most have a **swim bladder**
- Usually has **paired fins** that may be of the **ray-finned** or **lobe-finned** type.
- Includes **bass, perch, eel, bluegill, catfish**, and most of the other common fish in Tennessee.

4. Class *Amphibia*

- Usually have **4 limbs** (tetrapod)
- Are **cold-blooded**
- **Amphibia** means "both life" or "double life" and members of the class usually have **aquatic** and **terrestrial stages** in their life cycles.
- **Aquatic larval forms** usually **breath** by **gills** that are **lost** during **metamorphosis** and **adults breathe** by **lungs**.
- skin is **moist** and **susceptible to desiccation**
- **limbs** usually have **5 fingers**
- Includes **frogs, toads, and salamanders**

5. Class *Reptilia*

- Usually have **4 limbs** (tetrapod)
- Are **cold-blooded**
- **Reptilia** means to "creep" or "crawl"
- Reptiles have dry scaly skin that is not normally susceptible to desiccation.

- Reptiles breath by means of lungs

- Includes turtles, lizards, snakes, crocodiles, and alligators

6. Class Aves

- Usually have 4 limbs (tetrapod)

- Are warm-blooded

  1. This is the first time we have used the term warm-blooded and its time to discuss what it means to be cold-blooded or warm-blooded.

  2. A cold-blooded animal is one whose body temperature varies according to the temperature of its surroundings.

  3. A warm-blooded animal is one that can regulate its body temperature within narrow limits.

  4. Discuss importance in distribution of species in northern climates.

  - Aves means "a bird".

  - forelimbs modified into wings

  - body covered with feathers

7. Class Mammalia

- Usually have 4 limbs (tetrapod)

- Are warm-blooded

- Mammalia means "breast"

  1. Young are nourished after birth by secretions of the mammary glands of the mother

- Bodies normally covered by hair at some stage of their existence

- Examples include squirrels, bats, monkeys, and man
THE FROG  
Phylum—Chordata  
Sub-phylum—Vertebrata  
Class—Amphibia

- Anatomy and Physiology (The frog as representative example)

We will discuss the anatomy and physiology of the phylum Chordata using the frog as an example. To follow along with this discussion use the handout from page 205 of our lab manual.

External Anatomy

1. Body is divided into two regions
   - The head
   - The trunk

2. There are a pair of eyes (A1)

3. A pair of eardrums, called tympanum (A4)

4. A pair of nostrils or external nares (A2) in the dorsal area near the end of the snout

5. A large mouth (Figure B) which internally includes:
   - Vomerine teeth (B1)
   - Eyesockets (B2)
   - An esophagus (B3) that opens into the digestive tract
   - A glottis (B4) that opens into the respiratory system
   - A pair of internal nares (B5) that connect to the external nares and allow air passage between outside and inside mouth, even with mouth closed.
   - A pair of eustachian tubes openings (B6) that open into the middle ear and equalize air pressure on each side of the typanum.
   - The vocal sac openings (B7) that open into the vocal sacs
   - And the tongue that is used for capturing prey.

6. The cloacal opening or anus is at the posterior end of the body (A5)

7. Fore limbs (hands) possess 4 digits and remnants of a 5th
8. *Hind limbs* (feet) have *5 toes connected* by a *web*

**Digestive System**

1. The *frog* digestive system is *typical* of other *vertebrates*.

2. Its primary *function* is to *break up* by physical and chemical means the *complex foods* into *products* that can be *used* by the *body*.

3. *Major organs* include:

   (B3) (C2) (C5) (A5)
   mouth pharynx esophagus stomach small intestine colon cloaca

4. *Important organs* that empty *digestive enzymes* into the *system* include the *liver* (C13), *pancreas* (C3), and *gall bladder* (C12).

**Circulatory System**

1. The *circulatory system* is *closed* and carries *red blood* cells in its circuit.

2. The frog has a *3 chambered heart* (figure D) with
   
   - 2 atria, a *left* and *right* (D10, D5)
   - and a *ventricle* (D7)

3. *Major arteries* that *distribute blood* from the heart include the *carotid artery* (D1), *systemic artery* (D2), and *pulmocutaneous artery* (D3).

4. *Major veins* that drain the body include the *paired anterior vena cava* and the *single posterior vena cava*.

**Excretory System**

1. *Waste* products of *metabolism* are *removed* from the blood by *kidneys* (C8)

2. *Urea* is the primary *waste product*

3. *Kidneys filter urea* from *blood* and pass it through *mesonephric ducts* (C7) to the *urinary bladder* (C6) where it is *stored* temporarily

4. Finally empties into *cloaca* and then *expelled* outside the body.
Reproductive System

1. Frogs are *dioecious*

2. There are usually *no external sex organs*

3. *Fertilization* is *external* with sperm and eggs being *ejected* into water

4. *Life cycle* can be summarized as

   \[\text{sperm} + \text{egg} \rightarrow \text{zygote} \rightarrow \text{embryo} \rightarrow \text{tadpole} \rightarrow \text{adult}\]

   - the *tadpole* breaths by *gills* and is *aquatic* and undergoes *metamorphosis* (similar to insects) to become a *terrestrial air breathing adult*.

5. The primary *male sex organs* are the *testis* (C9)

6. The primary *female sex organs* are the *ovaries*.

Respiratory System

1. *Breathing*

   - Unlike mammals, *frogs* have *no muscular diaphragm*

   - *Breathing* occurs in *two phases*. These are
     
     1. *inspiration* or taking *air into* the *lungs* and
     2. *expiration* or passing *air out of* the *lungs*

   - *Inspiration* in the frog

     1. the frog *closes* its *glottis* and *depresses* or lowers the *floor of its mouth*. This results in *air* being drawn *into mouth cavity* through *external* and *internal nares*.

     2. The *external nares* are then *closed* and the *floor of the mouth raised* which *forces air* through the *glottis* and *into the lungs*. 
• *Expiration* in the frog

1. The flanks of the frog’s body are drawn in compressing the lungs and forcing the air out.

2. *Gaseous exchange* (O2 and CO2), which results in oxygenation of the blood, occurs in small chambers in the lungs called alveoli.

3. The skin is rich with blood vessels and gaseous exchange can also occur across the skin. When a frog is hibernating on the bottom of a pond, the skin is where most of the respiration is occurring.

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**LIFE HISTORY OF FROG**

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This diagram shows the life history of the frog. The length of time for metamorphosis varies in different species of frogs.
Proposed evolution of gills

Proposed evolution of gill-supporting structures, as found in jawless fishes (a), into the hinged vertebrate jaw (c). The first gill opening of the mud-dwelling jawless fishes was converted into a spiracle through which water could be drawn. The first gill bars in the series, no longer required as supporting structures, became enlarged and equipped with teeth. The embryonic development of sharks reflects such a sequence.

and limbs

Evolution of bony or cartilaginous structures of ancestral finned fishes (a) into the limbs of early amphibians (b).