

# Phylum Chordata

48,000 species

very diverse phylum but considerably less diverse than eg. arthropods or molluscs

also many fewer species than most other major phyla

most advanced phylum of animal kingdom; more complex anatomy

eg nervous system

eg. circulatory system

one to which we belong along with fish, amphibians reptiles, birds and other mammals

some of the largest or most massive animals

## major identifying characteristics:

### 1. Notochord

flexible rodlike structure

enclosed by a fibrous sheath

extends the length of the body

in larva and/or adult

provides **basic support** and serves as main axis for

**muscle attachments** to permit “fishlike” undulatory movements

first part of skeleton to form in embryo

in primitive chordates the notochord persists through life

in most chordates the notochord is replaced by a vertebral column of bone

remnants of the notochord remain as “intervertebral discs”

## 2. Dorsal tubular nerve cord

in most invert groups; nerve cord is **ventral** & paired with paired ganglia along it's length

in chordates the nerve cord is a single dorsal hollow nerve cord

front end usually enlarged to form brain

## 3. Pharyngeal (gill) slits

slit-like opening leading from throat to outside

first evolved as a filter feeding apparatus

still used by some to filter water for food

in others as gills

in some groups they are only found in embryo and lost as adults

## 4. Endostyle or Thyroid Gland

specific kind of tissue found only in chordates

was originally part of the feeding apparatus

endostyle secretes mucus and traps food inside the pharyngeal cavity

eg. lamprey larva

in most chordates the same tissue has become an endocrine gland in the neck region that helps control metabolism

## **5. Post-anal tail**

in aquatic chordates it provides motility

→ especially designed for propulsion in water

especially for larval forms and fish

fish later added fins to increase efficiency

in terrestrial chordates it became a tail for leverage and balance, not for movement

in humans "tailbones" is its remnant

## **Origin of Phylum**

oldest known chordate fossil is from the Ediacaran (600-543 MY) in Australia

6 cm long

Three major **Subphyla**:

**Subphylum: Urochordata (tunicates)**

**Subphylum: Cephalochordata (lancelets)**

# **Subphylum: Vertebrata (vertebrates)**

# Subphylum Urochordata (tunicates, sea squirts)

1600 sp

all marine

widely distributed in all marine waters

at all depths

size ranges from microscopic to 1 ft in diameter

most are bag-like sessile suspension feeders as adults

they often live in large colonies attached to rocks and other hard surfaces on the ocean floor

adult tunicates seem to lack the major characteristics of the phylum

adults resemble sponges more than they do other chordates

→ most are sessile

→ lack a coelom

→ pump water through siphons

but tadpole-like larva has typical chordata features

adults have tough, nonliving, **tunic** covering body

secreted by mantle

forms 2 **siphons**

one group, **salps**, are barrel shaped pelagic animals

with transparent gelatinous bodies

live singly or in colonial chains up to several meters long

## **Feeding & Digestion**

### **filter feeders**

incurrent siphon → pharynx (branchial sac) → slits → atrium  
→ excurrent siphon

water is drawn in through the incurrent siphon

into a basket-like **pharynx** (branchial sac)

mucus is secreted by glandular **endostyle** in groove along base of **pharyngeal basket**

uses **mucus** and **cilia** to move food toward mouth

complete digestive tract

food moves from the pharynx into the stomach for processing

the filtered water passes into the atrium and out the excurrent siphon

## **Respiration**

**pharynx** also serves as a respiratory organ

## **Circulation**

simple open circulatory system with small ventral heart and 2 major blood vessels

blood is pumped through sinuses within the animal's tissues

→ blood alternately flows in each directions

## **Nervous System**

nerve with ganglia and plexus of nerve fibers

## **Excretion**

no specialized excretory organs

nitrogens wastes are in the form of crystals deposited in the tunic

## **Reproduction & Development**

all tunicates are hermaphrodites with single ovary and testis

fertilization produces an elongated free-swimming larva

= **"tadpole larva"**

larva reveals true chordate nature

has all 5 major chordate characteristics

has digestive system but doesn't feed

swims about for hours to days, until it finds a suitable substrate to settle on

attaches to substrate by adhesive discs

once firmly attached the larva undergoes an exceptionally rapid metamorphosis into the adult:

in just 10-15 seconds the tail, notochord, nerve cord, brain sensory structures and muscles are crushed into a mass of tissue

over the next few hours, the internal organs change their positions, the siphons and adult nervous system develop

loses its tail and most chordate features and becomes an adult



some believe vertebrates arose from a **neotenus** tunicate

## **Human Impacts of Tunicates**

antiviral, antitumor

including possible treatment for malignant melanoma

→ the most dangerous form of skin cancer

# Supylum Cephalochordata (lancelets)

only 29 species (5 species in US)

closest living relatives to vertebrates

they display several intermediate characteristics  
between invertebrates and vertebrates

the adult animal has all major chordate  
characteristics

yet lacks the internal skeleton of vertebrae and  
bone that most vertebrates have

burrowers and swimmer

slender, translucent, laterally compressed, fishlike or  
eel-like body

ventral side of body is flattened

bears 2 folds of skin = **metapleural folds**

while they can swim they spend most of their time  
partially buried in sandy bottoms of coastal waters  
with their heads protruding

3-7 cm long

often found with tails buried in sand

instead of tunic, outer body is covered by soft epithelium

have fish-like **fins** with reinforcing **fin rays**

internal structure is very simple with with basic chordate characteristics:

springy **notochord** for support supports body while swimming or burrowing

## **Movement**

with well developed "V"-shaped bundles of swimming muscles

= **myotomes (=myomeres)**

provide fish-like movement by contracting against notochord

also have dorsal hollow **nerve cord**

## **Feeding & Digestion**

are **filter feeders**

**mouth** surrounded by **oral hood** with tentacles (=oral cirri) an a **wheel organ**

**cilia** on these structures draw in water and food

**pharynx** strains food from water

food is trapped in mucous and enters the mouth for processing

digestive system is similar to tunicates but slightly more developed

→ has **hepatic caecum** (or liver) as accessory digestive organ

food is drawn into the **intestine** by mucus and cilia

water passes through pharynx into **atrium** and out the **atriopore**

## **Circulation**

closed circulatory system

circulatory system similar to fish but no heart

## **Respiration**

some respiration occurs through the pharynx

but most gas exchange occurs by diffusion through the ventral body wall

## **Nervous System**

hollow nerve cord above notochord

anterior end of nerve cord = very small brain

→ almost no cephalization

pairs of spinal nerves innervate each myotome

single **ocellus** at front of head

## **Excretion**

simple excretory system of nephridia similar to those in annelids

## **Reproduction & Development**

all are dioecious with males and females

larvae resemble adults but are covered by cilia

cilia are used for swimming and drawing food toward the mouth

retain chordate features in adult

resemble small fish

# Subphylum Vertebrata

## General

most complex (?advanced) group of animals

larger, more active → need more food

one explanation for their diversity and dominance is that, in general, vertebrate species have a lot more genes

→ amphioxus has as many genes as an ant or fly

eg flies → 10,000 genes

eg. annelids → 13,000 genes

but mice and humans → ~20,000 genes

fish became the 1st true vertebrates

oldest known fossils of a vertebrate:

560 MY old 2.5" long found in Australia

a similar 530 MY old fossil was found in China

while only 1 invertebrate group (the insects) developed the powers of flight **all** vertebrate groups have developed some ability to fly or at least glide through the air

### **Major Characteristics:**

#### **1. internal jointed skeleton of bone or cartilage**

an **endoskeleton** permits unlimited growth

much more efficient design

is a **living** skeleton

grows with animals (not a case)

doesn't need to shed regularly

probably began as **cartilage** then later became calcified into bone

cartilage grows fast to form initial skeleton

a hardened skeleton is also ideal for **muscle attachments**

especially in areas of high mechanical stress

real bone emerged as external protective **dermal plates**

protected the head and brain and anterior part of the body

eg. ostracoderms, placoderms

these bony plates later became modified into **scales** of some fish

since bone is living tissue it also becomes important as a mineral reservoir (esp. phosphorus & calcium)

eg humans: calcium needed for:  
muscle contractions  
nerve impulses  
clotting  
secretions  
heart beat  
etc

in the most primitive vertebrates its not much more than a cartilage rod

**= notocord**

skeletons of lampreys and sharks and rays and some bony fish (eg. sturgeon) remains mainly cartilage in adults

in most vertebrates it is divided into:

**axial skeleton**

“braincase” - surrounds brain  
vertebral column  
ribcage

**appendicular skeleton (limbs)**

jointed appendages: pectoral & pelvic  
eg. fins, legs, wings,

## **2. Segmented skeletal muscles (myotomes)**



became "W" shaped instead of "V" shaped as in amphioxus

provided more control over body movements

### 3. complex skin

multilayered: epidermis, dermis

contains

numerous of sensory receptors

glands (oil, sweat, wax, scent, poison, etc)

keratin structures: scales, hair, feathers

### 4. more efficient digestive system

digestion shifts from moving food by cilia and mucus to using muscular contractions (= **peristalsis**) to move food through GI tract

vertebrates were the first to add an **acid producing stomach** that more effectively digests proteins

additional digestive glands:

**pancreas & liver** improve digestive efficiency

## **5. efficient respiratory systems closely tied to circulation of blood**

the original function of the pharyngeal slits to filter water for food becomes functional gills

## **6. increasingly efficient circulatory system with pumping heart (2,3, or 4 chambered)**

ventral heart

most inverts have dorsal heart

closed circuits of arteries and veins

RBC's (**erythrocytes**) containing hemoglobin for efficient distribution of oxygen to tissues

## **7. most complex and best developed nervous system of all animals**

usually well developed head with sense organs and brain (cephalization)

lifestyle shift from filter feeding to predation increased emphasis on brain and senses

better sensory and motor integration

CNS = brain & spinal cord  
→ central processing and coordination

PNS = nerves (eg. cranial nerves, spinal nerves)  
→ conduct impulses to brain from sense organs and from brain to muscles and glands

### **senses:**

complex **eyes**

inner **ears** for sound and balance

improved **taste** and **smell**

**lateral line** for water vibrations

**electroreceptors** to detect prey

## **8. Improved efficiency of excretory system**

paired true kidneys (most cephalochordates had none)

collect and get rid of metabolic wastes & toxins

greater role in salt and water balance

## **9. almost all are dioecious and reproduce only sexually**

# Origin and Evolution of Chordates

similarities with echinoderms & hemichordates:

- radial cleavage
- deuterostomes
- same coelom formation

oldest known fossils:

**a. *Pikaia*** (Burgess Shale; middle Cambrian, ~500 MY)

- 5 cm long; "V" shaped myotomes

- probably a cephalochordate

**b. *Haikonella*** (early Cambrian, 530 MY)

- chordate features: notochord, pharynx, dorsal nerve cord

- also some vertebrate features but not a vertebrate:

  - pharyngeal muscles
  - paired eyes
  - enlarged brain

urochordates are probably the most primitive surviving group

but adults are too specialized

**Neoteny ?**

→ larval form achieves sexual reproduction; accelerated development of reproductive organs

cephalochordates are clearly similar to ancestral vertebrate form

most primitive **vertebrates** were jawless

→ fossil agnathans predate all gnathostomes in fossil record (>500 MY)

→ oldest group = conodonts

conodonts are clearly related to group represented by living lampreys and hagfish

lampreys may have evolved from ostracoderms:  
small bottom dwellers  
covered with bony plates  
jawless  
extinct  
probably endoskeleton of cartilage not bone

## **Classification of Vertebrates**

the classes of vertebrates are often grouped into **clades** according to criteria of major evolutionary significance:

### **A. jaws present or absent**

**agnatha** = jawless

**gnathostomes** = mouth with jaws

### **B. fins versus walking legs**

**pisces** = paired fins for swimming

**tetrapods** = paired limbs for terrestrial locomotion

### **C. offspring develop within a fluid-filled sac (=amnion)**

**anamniotes** = do not develop within fluid filled sac; eg fishes and amphibians

**amniotes** = do develop within a fluid filled sac; eg. reptiles, birds, mammals

from most primitive to most advanced:

<b>fishes</b>	{	jawless fish	35sp;	>500MY
		sharks and rays	850sp;	
		bony fish	21,000sp;	420MY
<b>amphibians</b>			4300sp;	360MY
<b>reptiles</b>			7000sp;	280MY
<b>birds</b>			9700sp;	150MY
<b>mammals</b>			4600sp;	200MY