Phylum Chordata

48,000 species

very diverse phylum but still more unity in major characteristics than in most other phyla

most advanced phylum of animal kingdom

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

some of the largest or most massive animals

true coelom

4 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

   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

additional, more variable, Chordate characteristics are also shared by many or most species:

6. bilateral symmetry

7. tube within a tube body plan

8. segmented muscles
called myomeres or **myotomes** in fish

9. cephalization

10. ventral heart

11. endoskeleton

most members have an internal skeleton of
cartilage and/or bone

<5% of all animals that have ever lived have backbones

**Origin of Phylum**

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

6 cm long

another early fossils of this phylum was *Pikaia* from the Burgess Shale (510 MY)

also:

vertebrate fossils:

560 MY old 2.5” long found in Australia

a similar 530 MY old fossil was found in China
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

most are sessile as adults

adults have tough, nonliving, **tunic** covering body
  secreted by mantle
  forms 2 **siphons**

adults have a highly specialized body plan
  but tadpole-like larva has typical chordata features

adults loses them, except for gill slits

adults resemble sponges more than they do other chordates

  → most are sessile
  → lack a coelom
  → pump water through 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

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

**Respiration**

**pharynx** also serves as a respiratory organ

**Circulation**

simple circulatory system with ventral heart and 2 major blood vessels
blood alternately flows in each directions

**Nervous System**

nerve with ganglia and plexus of nerve fibers

simple *excretory* system

**Reproduction & Development**

hermaphrodites with single ovary and testis

fertilization produces an elongated swimming larva

larva reveals true chordate nature

= “tadpole larva”

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

loses its tail and most chordate features and becomes an adult
Suphylum Cephalochordata  
(lancelets)

only 29 species (5 species in US)

closest living relatives to vertebrates

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

ventral side of body is flattened

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

live in sandy bottom of coastal waters

3-7 cm long

burrowers and swimmer

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 basic chordate characteristics:

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

**Movement**

with well developed “V”-shaped bundles of swimming muscles

= myotomes

provide fish-like movement by contracting against notochord

also have dorsal hollow nerve cord

**Feeding & Digestion**

are filter feeders

digestive system is similar to tunicates but slightly more developed

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

mouth surrounded by oral hood with tentacles

pharynx strains food from water and acts as respiratory 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

**Nervous System**

hollow nerve cord above notochord

pairs of spinal nerves innervate each myotome

single ocellus at front of head

**Excretion**

simple excretory system

**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

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

**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
eyg. 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 (= \textit{peristalsis}) to move food through GI tract
additional digestive glands:

\textbf{pancreas} & \textbf{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)
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

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 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 **chordates**

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

  5 cm long; “V” shaped myotomes

  probably a cephalochordate

- **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 legss**

*pisces* = paired fins for swimming
*tetrapods* = paired limbs for terrestrial locomotion

**C. offspring develop within fluid-filled sac of egg**

[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:

**fishes**

\[
\begin{align*}
\text{jawless fish} & \quad 35\text{sp;} & >500\text{MY} \\
\text{sharks and rays} & \quad 850\text{sp;} \\
\text{bony fish} & \quad 21,000\text{sp;} & 420\text{MY}
\end{align*}
\]
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