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 sleading 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**

\[ \text{inurrent siphon} \rightarrow \text{pharynx (branchial sac)} \rightarrow \text{slits} \rightarrow \text{atrium} \rightarrow \text{excurrent siphon} \]

water is drawn in through the inurrent 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 adult nervous system develop

loses its tail and most chordate features and becomes an adult
some believe vertebrates arose from a **neotenous** tunicate

**Human Impacts of Tunicates**

antiviral, antitumor

including possible treatment for malignant melanoma

→ the most dangerous form of skin cancer
Suphylum 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 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) and 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 mout 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 atriorpore

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:

<table>
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<th><strong>Group</strong></th>
<th><strong>Species</strong></th>
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