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 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 inwater

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 o skin = **metapleural folds**

live in sandy bottomx 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 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
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

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)

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**

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, phayrnx, dorsal nerve cord

also some vertebrate features but not a vertebrate:
pharyngeal muscles
paired eyes
enalrged 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	jawless fish	35sp;	>500MY
	sharks and rays	850sp;	
	bony fish	21,000sp;	420MY

amphibians	4300sp;	360MY
reptiles	7000sp;	280MY
birds	9700sp;	150MY
mammals	4600sp;	