I. Where did Vertebrates Come From?
   • Phylum Chordata

   • Common Anatomical Structures (present in at least one stage in development):

II. Major Innovations in Animal Evolution
   • Symmetry (radial, bilateral, five-part)
   • Presence and form of body cavity (acoelomate, pseudocoelomate, eucoelomate)
   • Fate of blastopore (becomes mouth or anus)
   • Pattern of cleavage (radial, spiral)

III. Vertebrate Phylogenetics

IV. Characteristics of Chordates
   • Dorsal hollow nerve tube
   • Notochord
   • Pharyngeal gill slits and gill arches
   • Ventral heart
   • Post anal tail

V. Living Vertebrate Taxa
   • Pisces - “Fishes”
   • Amphibia - Amphibians
   • Reptilia - Reptiles
   • Aves - Birds
   • Mammalia - Mammals

VI. Trends in the Evolution of Vertebrates
   • Shift from dominance of solid, cartilaginous notochord to bony, segmented vertebral

   • Anterior dorsal hollow nerve cord expanded into brain (Craniata ? Vertebrata)
   • Evolution of jaws from anterior gill arches (“Agnatha” ? Gnathostomes)

   • Paired fins gave rise to limbs with digits
   • Respiratory gills used in aquatic forms
   • Swim bladder used as lungs
VII. Evolution of Jaws
• First fishes lacked jaws
• Jaws are modifications of the anterior gill supports

VIII. Living “Fishes”
• Gills
  • Jaws and feeding mechanism
  • Cartilaginous or bony skeleton
  • Median (dorsal and ventral) and paired fins (pectoral, pelvic)
• Swim bladder (only bony fishes)
• Dermal scales

IX. Modern Amphibians
• All require water at some stage in the life cycle; most live and
• Skin, which is highly permeable, serves as auxiliary respiratory organ
• Lungs are present - derived from swim bladder; enables aerial respiration
• Living Amphibian Groups:

X. Modern Reptiles
• Adaptations to life on land
  – Tough, scaly skin - epidermal scales; water impermeable;
  – Amniotic eggs - extraembryonic membranes for gas exchange and waste storage
  – Internal fertilization
  – Water-conserving kidneys
Living Reptiles:

XI. Turtles and Tortoises
• Armor-like shell; dorsally fused to vertebral column
• Horny plates instead of teeth

XII. Tuataras
• Only two living species
• Live on islands off the coast of New Zealand
• Look like lizards

XIII. Lizards and Snakes
• Largest group of reptiles (95 % of living reptiles)
• Limb loss in snakes
• Most lizards are insectivores with small peg-like teeth; in snakes
• All snakes are carnivores with highly movable jaws
• Highly developed sensory organs in snakes

XIV. Living Birds
• Skeleton and muscles modified for flying
• Four-chambered heart - more capacity to pump blood for oxygen transport
• Air sacs (modified lungs, in hollow bones)
XV. Feathers
   – Composed of keratin; subdivided into fibrils
   – Derived from reptilian scales
   – Feather structure is an adaptation to increase surface area to provide lift for flight
   – Feather color is used for communication between mates

XVI. Skeletal Adaptations of Birds

XVII. Mammals: Phylum Mammalia

XVIII. Mammalian Origins
   • 200 million years ago, during the Triassic
   • The first mammals had evolved by the Jurassic; they were small, nocturnal and “rodent-like”
   • Three Mammalian Lineages:

XIX. Living Monotremes
   • Duck-billed platypus
   • Two kinds of spiny anteater
   • Echidna

XX. Living Marsupials
   • Young are born in an undeveloped state
   • Most of the 260 species are native to Australia and nearby islands
   • Only the opossums are found in North America

XXI. Living Placental Mammals
   • Most diverse mammalian group
   • Young develop internally in mother’s uterus
   • Placenta composed of maternal and fetal tissues; nourishes fetus, delivers oxygen, and removes wastes
   • Placental mammals develop more quickly than marsupials

XXII. Earliest Primates
   • Primates evolved more than 60 million years ago during the Paleocene
   • First primates resemble tree shrews:

XXIII. Hominoids??