The Vertebrate Body Plan

An overview of vertebrate anatomy

Richard Owen (1848) *On the Archetype and Homologies of the Vertebrate Skeleton*
Vertebrate paleontology is a multidisciplinary science
Anette Mossbacher, 2021

(Paulo Brandao, 2011)
Anatomical directions

Kardong, 1995, *Vertebrates*
The basic layout of a vertebrate

- head with sensory organs
- dorsal notochord
- mouth and pharynx with gill arches
- heart and dorsal aorta
- body with segmented muscles
- digestive tract running from pharynx to anus
- fins or limbs

Radinsky, 1987, *The Evolution of Vertebrate Design*
somatic vs. visceral

Romer & Parsons, 1977, *The Vertebrate Body*
Developmental components of the skull

Dermatocranium (pink)
Chondrocranium or neurocranium (blue)
Splanchnocranium (visceral or branchial arches) (yellow)

Kardong, 1995, Vertebrates
bone (mostly dermocranium)
cartilage (mostly chondrocranium + visceral arches)
eye tissue (brain outpocketing)

Comparison of visceral arches

agnathan

derived gnathostome

reptile

ancestral gnathostome

amphibian

mammal

Kardong, 1995, *Vertebrates*
Anaspid internal anatomy

Pharyngolepis (Silurian)
Carroll, 1988, *Vertebrate Paleontology and Evolution*

Kardong, 1995, *Vertebrates*
Visceral arches in mammal development

Mouse embryo, 9 days

Fate of branchial arches in humans
Central nervous system

Kardong, 1995, Vertebrates
Vertebrate senses

General Sensory Organs
- Free sensory receptors
- Encapsulated sensory receptors
- Associated sensory receptor
  - Proprioception in muscles

Specialized Sensory Organs
- Chemoreceptors
  - Smell (olfaction)
  - Taste
- Radiation receptors
  - Photoreceptors
  - Infrared receptors
- Mechanoreceptors
  - Lateral line system (pressure)
  - Vestibular system (balance)
  - Auditory system
- Electroreceptors
- Magnetic field receptors

Electroreception in electric fish *Gymnarchus*
Pineal eye

*Crotaphytus collaris*, Collared Lizard
Peripheral nervous system

a map of body segmentation

nerve paths in generalized cross section

muscle development in mouse embryo

dermatomes (innervation of the skin)

Kardong, 1995, Vertebrates
Circulatory system

Kardong, 1995, Vertebrates
Circulatory system in a shark

Kardong, 1995, *Vertebrates*
Transformation of aortic arches in human development

early embryo

Diagrammatic representation of fetus

Anatomical diagram of fetus

Moore, The Developing Human
Comparison of aortic arches

amphibian  mammal  lizard  crocodile

Romer & Parsons, 1977, *The Vertebrate Body*
Living deuterostomes

- Urchin (echinodermata)
- Acorn worm (hemichordata)
- Branchiostoma (cephalochordate)
- Pterobranch (hemichordata)
- Tunicates (urochordata)
- Teleost fish (vertebrata)
Deuterostome phylogeny

Vertebrates’ closest relatives are all filter feeders

Chordate characteristics
Tunicates and their larvae

Kardong, 1995, *Vertebrates*
The “new head” hypothesis
Gans & Northcutt, 1983

- sensory placodes, body wall and limb muscle, and neural crest tissue are unique to vertebrates
- structures derived from these tissues allowed shift from filter feeding to active predation
- the head is a derived feature of vertebrates
- neural crest evolved from interaction of nerve and epithelial tissues
Richard Owen’s *Vertebrate Archetype*

Owen, 1850

Richard Owen (1848) *On the Archetype and Homologies of the Vertebrate Skeleton*
Homology

[homology is] “the same organ in different animals under every variety of form and function” -Richard Owen, 1843

“a feature in two or more organisms is homologous when it is derived from the same (or corresponding) feature in their common ancestor” -Ernst Mayr, 1982
Types of homology

Homology- the same structure in different organisms under every variety of form and function inherited from the common ancestor of those organisms.

Serial homology- repetition of the same structure within an organism, such as vertebrae, ribs, legs in arthropods, gills in fish, etc.

Deep homology- similar structures derived from the same underlying patterns of gene expression, even if the structures have different evolutionary origins and losses.

Primary homology- a homology recognized based on structural similarity, but whose inheritance from a common ancestor has not been tested by phylogenetic analysis.

Secondary homology- a homology whose evolution from a common ancestor has been confirmed by phylogenetic analysis.
Descent with modification

Ornithischian ancestor evolved pelvis that was a modification of the ones possessed by the last common ancestor of all dinosaurs

Ornithischian

Archosaur close to dinosaur ancestor

*Edmontosaurus* (from Victoria Museum)

*Asilisaurus* (from Sues, 2019)