Lesson 11

Lesson Outline:
Exercise #1 - Basic Functions
Exercise #2 - Phylogenetic Trends
Exercise #3 - Case Studies to Compare

Objective:

References:
Chapter 8: 143-161

Reading for Next Lesson:
Chapter 9: 163-198

Axial Skeleton

Throughout the course what you need to master is an understanding of:

1)the form and function of structures,

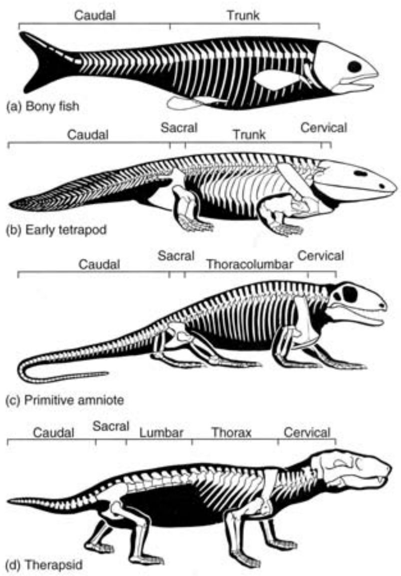
2) the phylogenetic and ontogenetic origins of structures, and

3) the extend to which various structures are homologous, analogous and/or homoplastic.

<u>Exercise #1</u> List the basic functions of the axial skeleton :

The axial skeleton (vertebral column) gives the body support and protects the nerve cord. It's original function was to protect the spinal cord and dorsal aorta. The structural support for the longitudinal axis of the body came from the notochord. Later, vertebrae take over the role of axial support and become important attachment sites for body musculature. As such, the axial skeleton becomes critically important for transferring muscle contraction into body movement for locomotion. In tetrapods, the role expands to include suspension of the body

<u>Exercise #2</u> Describe the evolutionary trends that we see in the axial skeleton - from the fishes to the birds and mammals:



Vertebrae

The general trends that we see in vertebrate evolution from the fishes to the birds and mammals are:

Agnathans have a large and prominent notochord. Vertebral elements are absent in hagfish. In lampreys, they exist as small cartilaginous elements resting dorsally upon the notochord.

In sharks there is a cartilaginous vertebral column surrounding the notochord. The vertebral elements are the main structural elements.

The first components of the vertebra to appear were the dorsal and ventral arches that rested on the notochord. The notochord provides support. The dorsal arches, (neural and interneural (intercalary)) protected the neural tube. The ventral arches, (hemal and interhemal) protected the blood vessels.

The next step in the evolution of the basic elements of the vertebra was the formation of the two centra, the hypo(inter)centrum and the pleurocentrum.

This was the situation in primitive chondrichthyans but in extant sharks, these vertebral elements enlarge to become the predominant structural element of the body axis. The hypo(inter)centrum fuses with the pleurocentrum and the two grow to meet the neural and interneural arches.

In aquatic animals support is provided by the water. The vertebral column serves primarily as a "compression girder resisting telescoping of the body during locomotion. In advanced fishes, the vertebral column is ossified and the centra become more prominent and replace the notochord as the major structural support for the body.

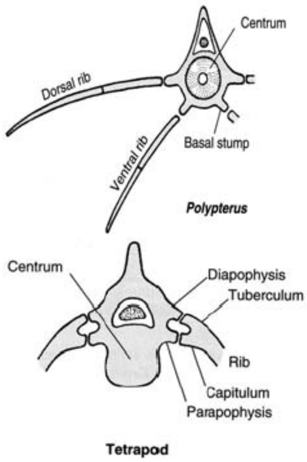
Remember that the vertebral column must be both strong for support – yet have some flexibility for movement. The trend is to reduce the contribution from the notochord while leaving intervertebral bodies (cartilage) or intervertebral disks (mammals) between the vertebrae. The different shapes of the centra allow different degrees of flexibility and restrict the direction in which the cord will flex.

Torque becomes a problem in tetrapods and anti-torque features appear in the design of the column in the form of the zygapophyses. The height and direction of neural spines reflect their role as levers, delivering forces to the vertebral centra and moving or stabilizing the vertebral column.

The column becomes regionalized reflecting functional demands.

In tetrapods, now limbs are used for locomotion and the vertebral column is used for support. Locomotor forces are, however, still transmitted to the body through the vertebral column.
A cranial region differentiates first for cranial mobility. A sacral region differentiates for attachment of the hips. The lumbar region becomes differentiated from the thoracic region due to the demands of locomotion and the caudal region retains much of its original role.

Ribs



The general trends that we see in vertebrate evolution from the fishes to the birds and mammals are:

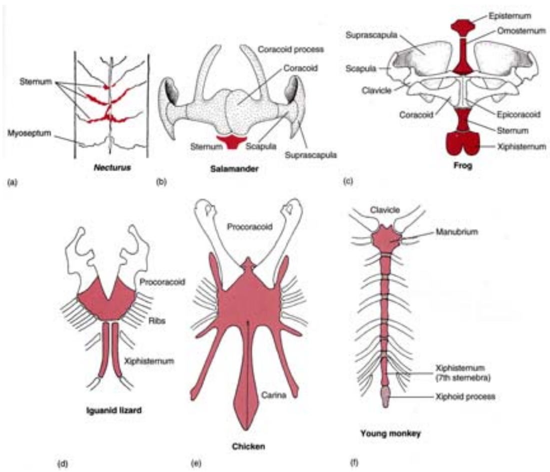
Agnatha have no ribs. Ribs develop in other vertebrates as struts that can either fuse with the vertebrae or articulate with them (one or two heads). They provide sites for muscle attachment, and form a protective case around the viscera.

In some fishes, there are two sets of ribs with each vertebral segment in the trunk region. The dorsal ribs separate the epaxial and hypaxial musculature of each segment and grow out in the horizontal septum. The ventral ribs form along the lining of the coelomic cavity. They are serially homologous with the hemal arches of the caudal region.
In some they only occur in the dorsal position while in others they only occur in the ventral position

In tetrapods, the ventral ribs are lost and the dorsal ribs persist but take up the position of protecting the body cavity. While they play a role in locomotion in tetrapods, they become important for producing respiration. They are bicipital, having two heads, the tuberculum and the capitulum.

In amniotes, in the thorax, the ribs consist of two parts, a costal rib that articulates with the vertebrae, and a sternal rib that often articulates with the sternum. The latter may remain cartilagenous. This combination of vertebrae, costal and sternal ribs and sternum, forms a basket that protects the thoracic viscera.

Sterna



The general trends that we see in vertebrate evolution from the fishes to the birds and mammals are:

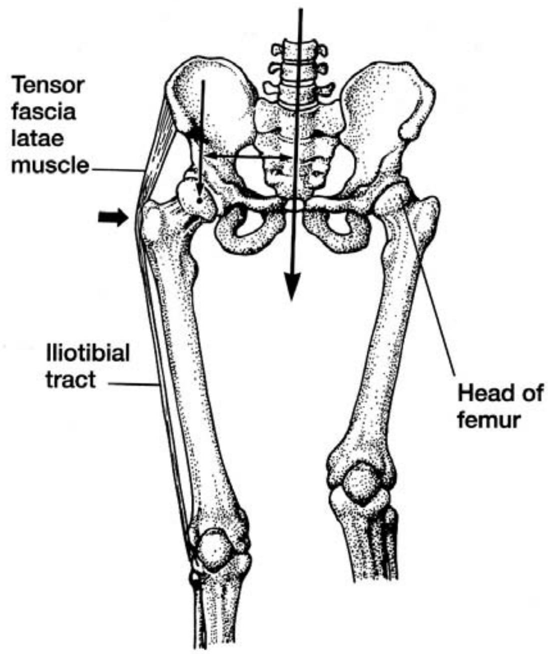
This structure is absent in fish and first appears in tetrapods. It is derived from either the ribs or the pectoral girdle and becomes associated with both. It has evolved independently several times and confers stability to weight bearing girdle elements. Its size is a function of the extent to which the forlimbs are used for locomotion. It serves for flight muscle attachment in birds.

<u>Exercise #3</u> – Comparisons – For the following structures:

Case 1

What is the function of the iliotibial tract?

Summer 2005 - You are not responsible for this question.



Case 2

How do the differences you see affect function?

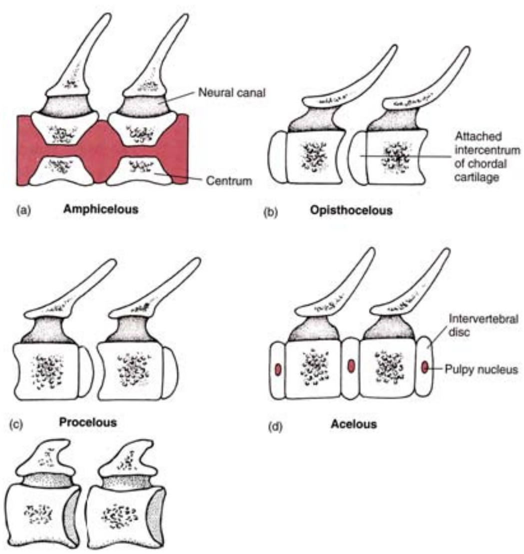
Amphicoelous-

Centrum is concave both anteriorly and posteriorly with notochord prevalent between successive vertebrae as well as running through each centrum. This type of arrangement allows for limited flexibility in most directions; flexion being limited by adjacent centra. When flexed, one side of column is compressed, the other is stretched and the nerve cord will can also become stretched.

b) opisthocoelous- centrum is concave posteriorly and convex anteriorly. Successive vertebrae fit together like a ball and socket, permitting extensive motion in most directions without stretching the nerve cord.
c)procoelous-concave anteriorly and convex posteriorly. See b above.

d) acoelous- centra have flat ends. Suited to receive and distribute compressive forces. If flexed extensively, will stretch the nerve cord.

e) heterocoelous- saddle-shaped articular surfaces allows for lateral flexion and prevents wringing or rotation of vertebral column in the long axis.



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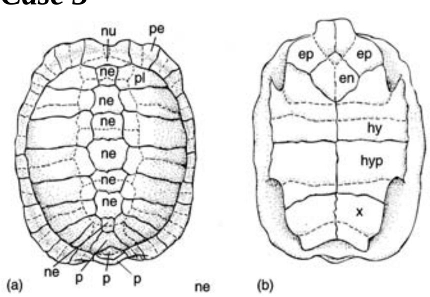
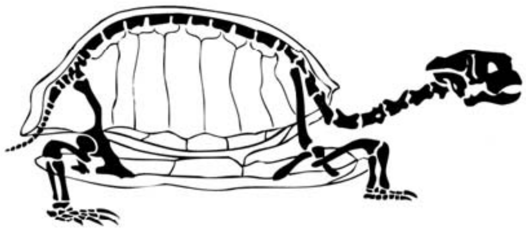
Case 3



1) state whether they are homologous, analogous and/or homoplastic.
 2) what their function is.

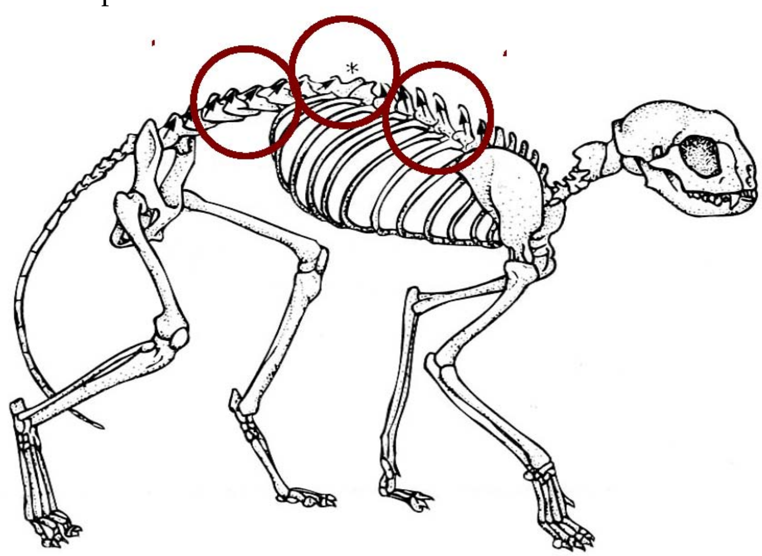
3) what they develop from and what they have evolved from.



Summer 2005- You are not responsible for this question.

Case 4

Describe the net forces that have led to the differences seen here in the shape and size of neural spines.



Direction of the spine is related to the direction of the net resultant forces (from muscle attachment) acting upon the spine. The spines are oriented in line with the net resultant force such that the spine experiences theses forces as a compressive force, the direction of stress loading that is strongest for bone.

Lumbar vertebrae – largest muscle force is from posterior region (muscles from pelvis and limbs) and thus vertebral spines project forward.

Thoracic vertebrae- largest muscle force is from anterior region (head and neck), spines project backward.

The middle, starred, portion represents the point of trade-off in weight distribution.