Biology 204
Summer Session 2005

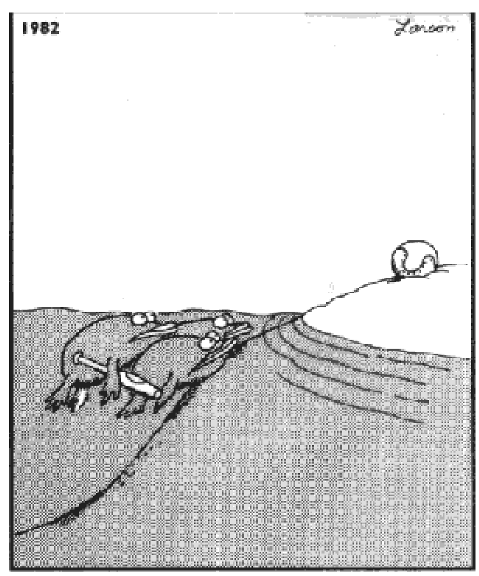
Mid-Term Exam
7 pages

ANSWER KEY

***** This is exam is worth 10% of your final grade******
The class average was 54%
Time to start studying for your final exam!!!

The answer key was taken directly out of the lecture notes. Marks were awarded for clear, concise, logical answers that incorporated the facts presented in lecture. Each question was marked by a TA who generated their own marking criteria based on the lecture notes. Please read over your answer and compare with the answer key provided. If you have any issues or concerns about your assigned mark please contact the TA who marked the particular question and they will help you sort out any problems.

Marker for question:
A - Ken Savage
B - Catalina Reyes
C - Emily Coolidge
D - Colin Sanders
E - Ken Savage



Great moments in evolution

A. 1) The following questions refer the cladogram above.

For each of the letters in this cladogram, indicate the name of the taxon (5 marks). <Easy>

A Craniata
B Gnathostomata
C Agnatha
D Cephalochordata
E Sarcopterygii

Give one synapomorphy (shared derived character) for each of the following taxa (5 marks). <Medium-hard>

Taxon A: Cranium, cartilage, muscular pharyngeal pump (food bearing water current
Taxon B: jaws, paired pectoral/pelvic fins and girdles
Chondrichthyes: secondary loss of bone (cartilage ok), notocord replaced by cartilage
Taxon D: mesoderm forms somites (Flexible answers)
Taxon E: fleshy fins, internal bony elements, muscles controlling fins are outside body wall (flexible answers)

A. 2) The following questions refer the cladogram above.

For each of the letters in this cladogram, indicate the name of the taxon (9 marks). <Easy – hard>

A Amniota
B Synapsida
C Archosauria
D Prototheria
E Theria
F Testudinata (Chelonia)
G Squamata
H Dinosaurs
I Metatheria (marsupials)

For each of the following skulls, indicate where the trait arose in this cladogram (give the number – 4 marks.) <easy – hard>

1, 9, 4, 3

Give one synapomorphy (shared derived character) for each of the following taxa (7 marks).

Any one of the following characters was accepted.

Taxon A: Amniotic egg: reproduction is no longer tied to water, bear embryos enveloped in extraembryonic membranes, embryo with these membranes is usually packaged in a calcareous or leathery shelled egg. <easy>

Taxon B: hair, mammary glands, dentary-squamosal jaw joint (= dentary-temporal), endothermy, sebaceous glands, specialized teeth (heterodonty), inner ear w/ 3 bones (malleus, incus or stapes), lower jaw is dentary, etc. <easy>

Sauropsida (Reptilia): Anapsid skulls (**diapsid** in derived taxa), epidermal scales. <easy>

Parareptilia: Anapsid skull w/ otic notch/emarginate, eardrum supported by squamosal and retroarticular, unique digit-ankle articulation. <hard>

Eureptilia: diapsid skull (2 temporal fossae), palatine fenestra. <easy>

Aves: feathers, endothermy, pneumatized skeleton, etc. <easy>

Taxon I: yolk sac placenta, marsupium, (young born at very immature stage). <easy>

B: For the following structures, state: (20 marks)

1) **whether they are homologous, analogous and/or homoplastic**
2) **what their function is (be specific)**
3) **what they develop from**

The shark tooth and the shark scales are homologous, whereas the alligator scales are not. None of them are homoplastic and none are analogous.

Alligator scales function for protection (against abrasion, water loss, foreign bodies). Shark teeth function to capture and manipulate (mainly to cut) prey. Shark scales function to reduce friction and drag during swimming. For these reasons, the structures are not analogous (to some degree, the shark scales also function for protection, as in the alligator scales, so the students might consider them analogous. Give part marks here if you feel their explanation deserves it).

Alligator scales are keratinized overlappings of the epidermis (ectodermal origin). Folding of the epidermis forms the scales, which are continuous. Shark teeth are composed of dentin, enamel and contain a pulp core. They develop from an interaction of the dermis and epidermis (interaction of both the ectoderm and dermatome of the mesoderm). Shark scales (placoid scales) are also composed of enamel, dentin and a pulp core and form from an interaction between ectoderm and dermatome of the mesoderm.

4) **now state what they evolved from**

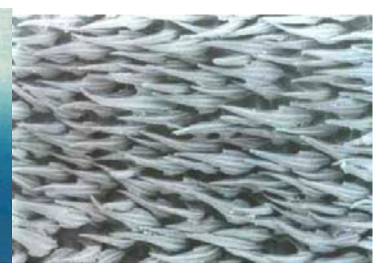
Alligator scales are derived from the epidermis through keratinization. They are believed to have arisen due to mechanical abrasion and friction of the epidermis in terrestrial vertebrates.

Shark teeth are believed to have arisen from dermal fish scales (placoid scales).

Shark scales are believed to have arisen from dermal fish scales (cosmine scales of the ostracoderms and placoderms).

alligator scales

shark teeth



shark scales

C. 1) Describe the form and function of the regionalized axial skeleton in teleost fish (10 marks)

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. In aquatic animals, **support of body mass** is provided by the water.

The centra are undifferentiated reflecting the fact that the column is not used for support of body mass, as in terrestrial vertebrates, rather it serves for muscle attachment for locomotion. Amphicoelous vertebrae allow for limited flexion in all directions, therefore, the vertebral column serves primarily as a 'compression girder' resisting telescoping of the body during locomotion.

This means that the vertebral column is flexible enough to bend a little, becoming compressed on the bent side. If it couldn't compress, it couldn't bend. It is also stiff enough to resist collapse or buckling or folding. It doesn't compress too much. Thus alternating contractions of muscles on each side of the body produce lateral undulations that provide the propulsive force to push fish forward through the water. As such, the axial skeleton is critically important for transferring muscle contraction into body movement for locomotion.

In fishes the vertebral column is differentiated into two regions, the trunk and the tail. The only differentiation is whether the vertebrae receive ribs or hemal arches. Ribs in the trunk region provide protection for visceral organs and hemal arches in the tail protect the dorsal aorta. Some species of fish have ventral ribs (protect the viscera) and/or dorsal ribs (for muscles attachment, horizontal septum). No movement is possible between the first vertebra and the skull.

2) Describe the specializations of the cervical region of tetrapods (10 marks)

The first two regions to specialize in early vertebrates are the cervical region allowing some freedom for the head to turn independently of the body and the sacral region for the attachment of the pelvic girdle and the hindlimbs.

Flexibility between the skull and vertebral column was achieved by development of a more mobile joint, and eliminating ribs in this area. The first vertebra, or atlas, is highly modified in all vertebrates. It is missing a centrum making it ring-like. It has one or two concavities at the cranial end for articulation with the occipital condyle(s) of the skull. This allows the skull to rock in a nodding motion only. The second vertebra, the axis, has a cranial extension, the odontoid process which is believed to be the centrum of the atlas. It projects forward and inserts into the floor of the atlas. There is usually a reduction in zygapophyses and ribs on which the skull and atlas rock.

Subsequent cervical vertebrae also have more mobile articulations giving rise to a highly flexible neck, which reaches its greatest in birds and turtles.

The combination of

1)the atlas-axis complex,

2)a mobile articulation between cervical vertebrae and

3)a large number of cervical vertebrae

-give rise to a very flexible neck.

D. Describe the changes in the design of limbs and girdles of tetrapods that allow for efficient and fast terrestrial locomotion. (20 marks)

Points were awarded if your answer incorporated the following points:

The changes seen in the pelvic girdle reflect the evolution of the hind limbs as the major source of propulsion and the powerful hindlimbs now transmit their propulsive force directly to the bony axial skeleton.

At the front, however, the axial column is slung by muscles from the shoulder girdle. It is the muscles that support the weight of the body at the front and they do it in such a way that they also act as shock absorbers.
As a result, during locomotion, these muscles soften the forelimb's impact with the ground and these sudden forces are not transmitted to the skull.

Most of the adaptations that one sees in the design of girdles and limbs in terrestrial vertebrates are associated with efficiency and/or speed of locomotion.

Elbows and Knees and Ankles and Wrists

To raise the body of the ground, and to allow the development of forces that are more in line with the direction of travel, one of the first adaptations is the development of elbows and wrists / knees and ankles. This allows the body to be raised off the ground for locomotion and also allows generation of tractive (pulling) and propulsive (pushing) forces.

Limb Posture

The sprawled posture of many amphibians and reptiles reflects the original style of locomotion based on lateral body undulations about pivot points. The shift in the position of the limbs to under the body allows the limbs to swing more easily and increases the efficiency of locomotion.

There are several other trends that accompany this:

Digit Orientation

The **femur** and especially the **humerus** show torsion at their distal ends which rotates the digits forward and more in line with the direction of travel. This increases **tractive** and propulsive forces.

Cursorial Locomotion

Accompanying this is the tendency to **restrict limb movement to the sagittal plane**. Instead of an overarm swing during the recovery phase of a limb movement, recovery is accomplished by a **pendulum like swing under the body**.
This leads to a reduction in the muscle mass required to lift and support the body in the sprawled position. This also improves the ease and efficiency of limb recovery.

Role and anatomy of the shoulder girdle

The change in posture also dramatically changes the forces placed on the pectoral or shoulder girdle. In the sprawled position the forces are directed medially and lead to enlargement of the **coracoid** and **interclavicular** bones - the medial elements that must resist these forces.
As the limbs are brought under the body, These forces are now directed upward in a vertical direction and we see an enlargement of the **scapula** (for locomotion and weight bearing) and a reduction in the medial pectoral elements.

Shape and position of the pelvic girdle

As the hindlimbs are drawn under the body, there is a **reduction in the adductor muscles** (no longer needed for support in the sprawled position) and this puts less force on the pelvic girdle and the bones are reduced.
The girdle also shifts its position or orientation so that the forces it receives (the thrust from the hindlimbs) is transferred to the axial skeleton more in line with the direction of travel. Several further modifications are seen to increase speed of locomotion. These involve changes in **stride length** and **stride rate**.

Stride length:

Foot Posture

One primary change that increases stride length, besides the lengthening of individual bones of the limb, is a change in foot posture. The change from **plantigrade to digitigrade to unguligrade** posture increases the length of the limbs.
Another change is increasing the angle of swing of the limbs, i.e. the arc of the pendulum or the distance through which the limbs move. This is a function of the freedom of the hip joint and the angle of muscle attachment.

Stride length:

Vertebral column

Increase stride length by increasing the distance the limbs move while off the ground.
For example, cheetahs flex and extend the vertebral column during a forward leap, thereby extending stride length.

Stride rate:

Position of limb Muscles

Increasing stride rate means the limbs must be moved faster.
One way to do this is by using faster muscles.
Another way is to **lighten the distal end of the limb** reducing mass and the inertia required to move the limb. This can be done in several ways. One is to **move the muscles closer to the torso** and have the forces transmitted to the distal parts of the limb through long tendons.

Stride rate:

Stride Reduction in Number of Digits

Another way to lighten the distal limb is to **reduce the number of digits**.
In highly **cursorial** animals the numbers are reduced and the remaining digits are greatly strengthened to withstand increased forces.

Number of joints and speed of locomotion

Finally, the last way to increase speed is to increase the number of ''joints' involved. If the limb were just one long bone, no matter how light, the distal end of the limb would not move as fast as it does in a limb of the same length with several joints about which muscles develop force. **This is because the speed of movement generated about each joint is additive**. A classic example is to compare the speed of movement when a ball is thrown using just the shoulder or elbow versus the speed with which it can be thrown by the coordinated use of all joints.

Number of joints and speed of locomotion

With the shift from lateral undulations to cursorial locomotion, there is a shift from lateral to vertical flexion of the vertebral column. Loss of ribs enhances the ability of the column to flex in a vertical fashion. In many animals this flexion is used to provide yet another "joint" to accelerate the movement of the limbs for high speed locomotion.

E. Skulls.

We considered in detail the embryological origins, phylogeny, form, and, function of the skull in craniates.

Place a check mark under a) splanchnocranium, b) neurocranium, or c) dermatocranium, to indicate the region of the head skeleton associated with the structure in the left column (10 marks).

	Splanchnocranium	Neurocranium	Dermatocranium
dentary			X
mesethmoid		X	
articular	X		
sclera of eye		X	
occipitals		X	
columella	X		
parachordal		X	
maxilla			X
squamosal			X
hyoid	X		