# Vertebrate History and Evolution

## Spring, 2003
## Bio/Geol 405:
## Final Exam

Name:_____

Date:_____

Time Begun:_____ Time Ended:_____

***Write Your People Soft (Not Social Security) Number on the Scantron Card***

Lynn S. Fichter
James Madison University

This is a CLOSED NOTE/CLOSED BOOK TEST. You may have nothing with you while taking it except writing materials, and any snacks you need for the duration.

- You ***must*** SIT AND WORK ALONE while taking the test.
- You ***must*** TAKE THE TEST IN ONE SITTING. Pit stops allowed.

Other Conditions Include:

☐ You may **not** peek at these questions in any way until just at the moment you are ready to take the test.

☐ You have a several day period in which to take this test. You may take it any time during that several day period. The days available will be announced in lecture.

☐ You may start this test any time you want and may take as long as you wish to do it.

☐ Once you have taken the test you are **expressly forbidden talk about it in any way, shape, or form with anyone else**, except me, until everyone has finished taking the test.

**HONOR: SCIENTIFIC AND PERSONAL**

Science and honesty must go hand in hand. Science is the search for a true understanding of the universe, not what we wish it to be, or need it to be. But the universe is complex and for all our success science has had to struggle mightily to learn what it has. Dishonesty thus is very detrimental. Not only does it deliberately lead us down the wrong path, actions taken on the basis of that false knowledge can be deadly. Besides good ideas are hard enough to discover even when struggling honestly. Dishonesty in science, when discovered, destroys a career, and ruins a reputation. And dishonesty is always discovered because science's goal is to uncover false ideas.

Because each of you take this test individually, and without supervision, whether you cheat or are honest is your very personal and private responsibility. Not cheating means no notes, and not talking with anyone until everyone has finished the test - following the spirit of the law rather than just the letter. Putting your name at the top of the test page is equivalent to signing the James Madison University Honor Pledge.

Total points _____

Test score _____

Grade/12 point scale _____

Name:_____

Date:_____

**Biology/Geology 405 - Vertebrae Paleontology Final**

# Vertebrate History and Evolution

**Spring, 2003**

**L. S. Fichter - James Madison University**

## Instructions For Tests

### Scantron Portion

- ☞ Most questions are True/False and Multiple Choice.
- ☞ Drawing, diagrams, figures required for certain questions are often at the back of the test. You may pull those sheets off to make it easier to answer questions, but they must be turned in with the test.
- ☞ Different questions may have different values, as indicated with each set of questions.
- ☞ Multiple choice questions may have 3, 4, 5, or as many as 20 choices. When there are more than 5 choices they are distributed among more than one question number, as below. These questions are always placed in a box to indicate that they belong together to answer one question, as in the example below.
- ☞ Unlike other Scantron tests given on campus, many or most questions on these tests must be left blank to have a correct answer. Often on other tests a blank row means a wrong answer. That is not true here. For example, the 15 choices below require only one answer, so at least two rows must be left blank.

  Some multiple choice questions may have more than one answer scattered among the 15 to 20 choices available. This means that some rows may have more than one answer chosen, while another row may have no answers chosen. This is normal on these tests.

**Feature A** on the cross section is identified by which **ONE** of the terms.

| | | | | | |
|---|---|---|---|---|---|
| 1. | 1A, | 1B, | 1C, | 1D, | 1E |
| 2. | 2A, | 2B, | 2C, | 2D, | 2E |
| 3. | 3A, | 3B, | 3C, | 3D, | 3E |

- ▸ Observe that on some of the questions the scoring will be **"Rights minus Wrongs."** Such questions are labeled. That is, you get points for a right answer (typically 3), zero for no answer, and a negative score for wrong answers (typically -1). Don't guess!
- ▸ Wrong spellings are not part of the test. I do not deliberately make minor errors, or try to be confusing or ambiguous. If something seems strange assume it is an honest mistake and answer the question as best you can.
- ▸ However, questions may be subtle and complex, read them carefully.

### Written Portion: Written Question are at the back

**Remember to Do**
**Mammal Teeth Identification Question**

**Multiple Choice questions are Rights (3 pts) Minus Wrongs (-1),**
**Except where noted otherwise; All True/False are worth 2 points.**

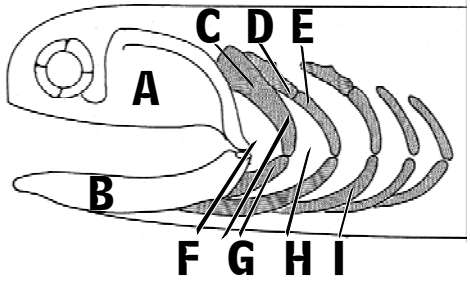
## Origin of Bone and Jaws

1. T/F. Endochondral bone in the skull is eventually replaced by dermal bone during vertebrate evolution.
2. T/F. The neurocranium is formed as pericondral bone.
3. T/F. The sensory capsules (olfactory, optic, otic) are embryologically part of the neurocranium.
4. T/F. Most of the bones in the skull of a modern vertebrate, for example a reptile or mammal, originally formed in the skin.
5. T/F. The primitive function of the hymandibula is to support the upper jaw.

**MULTIPLE CHOICE QUESTIONS:** ***For the illustration below right identify choices to the question.*** (none. one, some, all)

Choose From Among These

| | | | | | |
|---|---|---|---|---|---|
| 1A | Ceratobranchial | 2A | Hyomandibular | 3A | Notochord |
| 1B | Ceratohyle | 2B | Hypobranchial | 3B | Palatoquadrate |
| 1C | Epibranchial | 2C | Mandibular arch | 3C | Phryngiobranchial |
| 1D | Epihyle | 2D | Mandibular cartilage | 3D | Quadrate |
| 1E | Gill arch | 2E | Meckelian | 3E | Spiracle |




**Structure A:** mark one or more of the choices identifying this structure.
6. **1A** **1B** **1C** **1D** **1E**
7. **2A** **2B** **2C** **2D** **2E**
8. **3A** **3B** **3C** **3D** **3E**

**Structure C:** mark one or more of the choices identifying this structure.
9. **1A** **1B** **1C** **1D** **1E**
10. **2A** **2B** **2C** **2D** **2E**
11. **3A** **3B** **3C** **3D** **3E**

**Structure F:** mark one or more of the choices identifying this structure.
12. **1A** **1B** **1C** **1D** **1E**
13. **2A** **2B** **2C** **2D** **2E**
14. **3A** **3B** **3C** **3D** **3E**

**Structure H:** mark one or more of the choices identifying this structure.
15. **1A** **1B** **1C** **1D** **1E**
16. **2A** **2B** **2C** **2D** **2E**
17. **3A** **3B** **3C** **3D** **3E**

# Osteichthian Evolution

***To spark your memory a classification of the Actinopterygii is presented in the box to the right; it might help answer the questions.***

18. T/F. Neopterygian fish lineages are according to modern understanding polyphyletic in origin.
19. T/F. Pre-neopterygian lineages have species abundance/diversity as great as neopterygians.
20. T/F. On the other hand, the spiny finned fish including *Perca* and percoids (Acanthomorpha) are much more diversified than other neopterygians.
21. T/F. Sarcoptergyians and Actinopterygians derive from a known common ancestor.
22. T/F. Most neoptergyian orders are extinct.

***Subclass: Actinopterygii***
- *Order: Polypteriformes*

*Actinopteryi*
- **Infraclass: Chondrostei**
  - *Order: Paleonisciformes*
  - *Order: Haplolepiformes*
  - *Order: Dorypteriformes*
  - *Order: Acipenseriformes*
    - *Suborder: Acipenseriodei*
    - *Suborder: Polyodontoidei*
- **Infraclass: Neopterygii**
  - *Order: Lepisosteiformes*
  - *Order: Amiformes*
  - **Division: Teleostei**
  - *Order: Semionotiformes*
  - *Order: Osteoglossomorpha*
  - *Order: Elopomorpha*
  - **Division: Clupeocephala**
  - *(Basal Euteleosts)*
    - *Order: Clupeomorpha*
    - *Order:Gonorhynchiformes*
    - *Order: Otophysi (Ostariophysie)*
    - *Order: Esociformes*
  - *(Lower Euteleosts)*
    - *Order: Salmoniformes*
    - *Order: Stomiformes*
    - *Order: Aulopiformes*
    - *Order: Myctophiformes*
  - *(Higher Euteleosts)*
    - *Order: Acanthomorpha*

***At the back is a page labeled Osteichtinan Fish, including whole fish and skulls. The next questions deal with those.***

23. T/F. Specimens I and K represent the same stage of evolutionary development.
24. T/F. Specimens A and G represent the same stage of evolutionary development.
25. T/F. The skeletons of H and L are at about the same level of development.
26. T/F. B is likely a faster swimmer than G, but not likely faster than J.
27. T/F. Skull N is significantly more developed than O.
28. T/F. Skull M is more advanced than skull Q.

***These questions for same Osteichthian Fish illustrations at back.***

Identify all those fish that are members of the Chondrostei.

29. **A=A B=B C=C D=D E=E**
30. **A=F B=G C=H D=I E=J**
31. **A=K B=L C=M D=N E=O**
32. **A=P B=Q**

Identify all those fish that are members of the old "holostean" group (i.e. Neopterygians below the Clupeocephala Division)

33. **A=A B=B C=C D=D E=E**
34. **A=F B=G C=H D=I E=J**
35. **A=K B=L C=M D=N E=O**
36. **A=P B=Q**

Identify all those osteichthyes that get most of their swimming thrust from motion of the tail rather than motion of the whole body.

37. **A=A B=B C=C D=D E=E**
38. **A=F B=G C=H D=I E=J**
39. **A=K B=L**

# The Fish-Amphibian Transition

***The fish-amphibian transition took place under which of the following 15 conditions (none, one, some, or all choices).***

40. First set:
    A. Time of major Acadian mountain building.
    B. Drying up of the shallow sea lying on the continents.
    C. In rivers and coastal environments during the wet seasons.
    D. While in search for food.
    E. To lay eggs on land.
41. Second set:
    A. From bottom feeding fish.
    B. From anadromous fish.
    C. From oxygen poor waters.
    D. Because of population pressures.
    E. By the accumulation of preadaptations in a terrestrial environment.
42. Third set:
    A. After tetrapod limbs evolved.
    B. During drought conditions, as indicated by mass morality fossil deposits.
    C. Only afer terrestrial vegetation was established.
    D. During migration to new lakes and ponds

43. *Ichthyostega* is in a sister group to the other Labyrinthodont lineages because:
    A. It still possesses small functional gills.
    B. The intertemporal bone is absent from the skull.
    C. Post parietal bones are fused at the back of the skull.
    D. Pectoral girdle is disconnected from the skull.
    E. No well defined atlas vertebrae.

***Paleontology cannot often say much about the physiology of fossil organisms, but understanding the physiology of living organisms commonly helps us understand the fossils. Thus, our discussion of osmotic balance and kidney function. One of the lessons is that simple deductions are often not accurate.***

44. T/F. The first agnatha fish existed without a complex kidney is in osmotic balance in a marine environment because the salt outside the body balances the osmotic ions in the body.
45. T/F. In a freshwater environment a fish from the last question would bloat because the net flow of water is in.
46. T/F. The solution for the fish in the last question is to develop a special kidney with a large glomerulus.
47. T/F. However, a fish with a large glomerulus would be at a distinct disadvantage if it migrated back into the marine environment because it would dehydrate.
48. T/F. One solution to the problem of dehydration is to raise the osmotic pressure inside the body to match the outside of the body, and chondrichthyes do this by retaining urea in the body to concentrations hundreds of time greater than what we consider "normal".
49. T/F. On the other hand, water regulation is not the main function of a kidney anyway.
50. T/F. Ammoniotelic nitrogen excretion is relatively inexpensive physiologically which is why it evolved in freshwater fish.

# Labrynthodonts and The Early Reptile Grade

***At the back of the test is a page titled* Amphibian and Reptile Skulls (in alphabetical order). *The next questions deal with them.***

**Reptile skulls:** identify all the skulls that belong to this taxonomic division.

51. A=A B=B C=C D=D E=E
52. A=F B=G C=H D=I E=J

**Anthracosaur skulls:** identify all the skulls that belong to this taxonomic division.

53. A=A B=B C=C D=D E=E
54. A=F B=G C=H D=I E=J

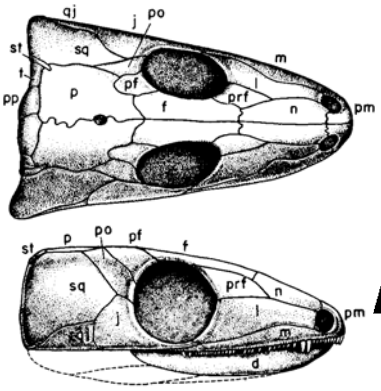
**Temnospondyl skulls:** identify all the skulls that belong to this taxonomic division.

55. A=A B=B C=C D=D E=E
56. A=F B=G C=H D=I E=J

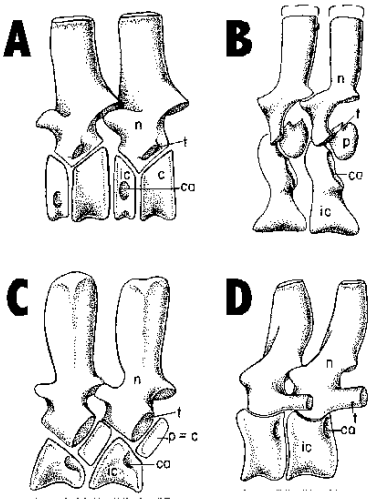
**Most derived Temnospondyl skull:** identify the ***one skull*** that represents the last and most derived of the temnospondyls.

57. A=A B=B C=C D=D E=E
58. A=F B=G C=H D=I E=J

59. The feature(s) that makes the skull to the right reptilian and not labyrinthodont is/are which of the following (none, any, or all that apply):
    A. Well developed pineal eye.
    B. No otic notch.
    C. Parietal contacts post orbital.
    D. Post parietal not fused.
    E. Eyes on side of head.



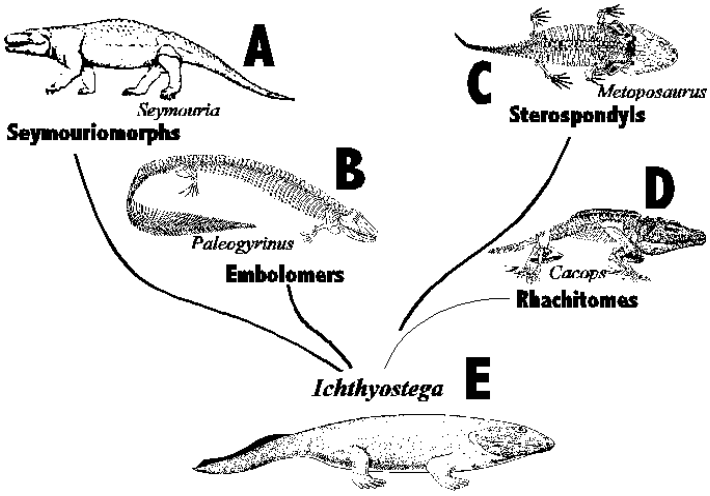

***The five vertebrae to the right are from various tetrapods, and are in no particular order. Questions below refer to these.***




60. ***Ichtyhyostega:*** identify the one vertebrae that belongs to this organism (in none leave all blank.).
    **A B C D E**

61. **Reptile grade:** Identify all the vertebrae that belong to this group (if none leave all blank).
    **A B C D E**

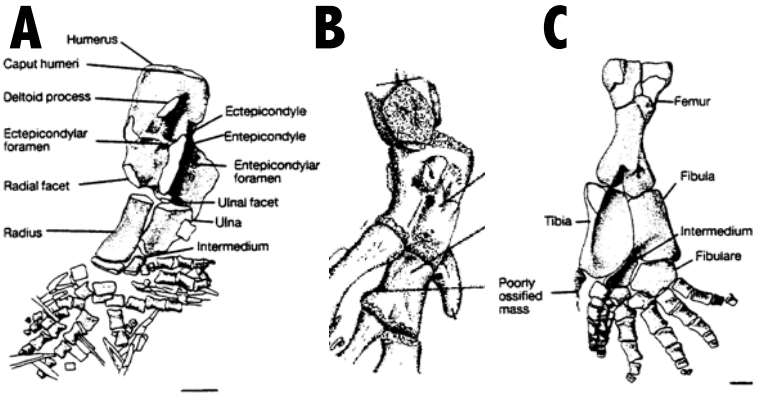
62. **Temnospondyls:** identify all those vertebrae that belong to this group (if none leave all blank).
    **A B C D E**




63. **D - *Cacops***: which vertebrae is associated with this fossil the left?
**A B C D E**

64. **A - *Seymouria*:** which vertebrae is associated with this fossil to the left?
**A B C D E**

65. Of the three early limbs below, which has crossed into the tetrapod condition (none, one, some, or all)
**A B C**




***Transitions: Fish ⇨ Amphibian. Amphibian ⇨ Reptile.***

66. Early amniotes (synapsids/reptiles) are ***different from*** amphibians by possessing which of the following 10 characteristics (none, one, some, all).
    A. Otic notch
    B. Labyrinthodont teeth
    C. Intertemporal bone in the skull.
    D. Fusion of centra and neural arch into one bone.
    E. Functional atlas and axis.

67. *more selections for above question*
    A Elongate interclavical bone.
    B Fused ilium, ischium, pubes.
    C Two bones in the sacrum.
    D Functionally developed astragalus and calcaneus.
    E Phalangeal formula 2-3-4-5-3(4).

68. T/F. Reflecting the difficulty of the water ⇨ land transition, the adaptive radiation of the early amphibians was slow and limited.

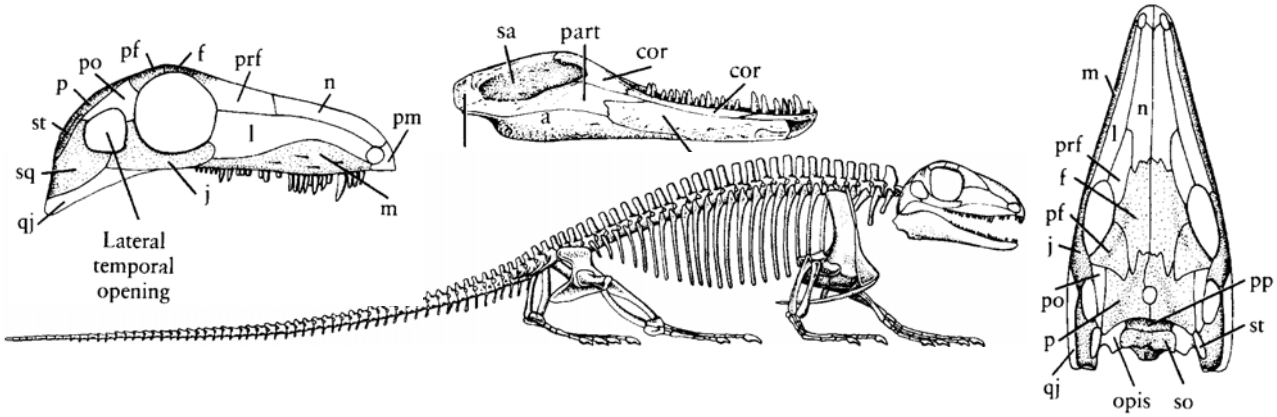
69. T/F. The fish ⇨ amphibian transition involved a lot of unsuccessful experimentation producing animals that superficially look like amphibians but that are not.

70. T/F. The heart of an amphibian has developed to the point where there exist arteries dedicated to feeding only the lungs.

71. T/F. In reptiles the excretory anatomy and the reproductive anatomy have become separate and distinct, but this is not true for the amphibians.

72. T/F. The mammalian stem group (Synapsids) branched off from the amphibian lines before the reptiles did.
73. T/F. Amniotes refers to everything above the amphibian grade of evolution, regardless of the evolutionary relationships among these non-amphibian groups.
74. T/F. All fossil diapsid reptiles have both a lateral and a dorsal temporal opening.

***The features that make synapsids synapsids*** *(skull, lower jaw, and skeleton below are from different animals)* ***and not reptilian*** *(that is, are diagnostic of synapsids and not found in reptiles, OR are diagnostic of synapsids in general and not just found in these particular specimens)* ***are which of the following (none, one, some, or all)?***




Synapsid characters include:

75. *Begin choices*
A Single temporal opening.
B Well developed pineal eye.
C Orbits on side of head.
D Back of skull straight or sloping forward.
E Jaw articulation below tooth line.

76. *Continued - synapsid characters*
A Elongated lachrymal bone.
B Jaw articulation shifted to squamosal
C Differentiated dentition.
D Postorbital region shortened.
E Secondary palate

77. *Continued - synapsid characters*
A Large coronoid process.
B Double occipital condole.

***At the back of the test is a page titled "Therpsid Synapsids" with A-M skulls at the top, A-J skeletons/reconstructions at the bottom, and an early phylogeny of therapsid evolution in the middle. Next questions deal with these animals.***
***For the Skulls:***

**Eotitanosuchia:** identify the **two skulls** that represent this stage of evolution.
78. A=A B=B C=C D=D E=E
79. A=F B=G C=H D=I E=J
80. A=K B=L C=M

**Mammal:** identify the **skull(s)** that represent this stage of evolution.
81. A=A B=B C=C D=D E=E
82. A=F B=G C=H D=I E=J
83. A=K B=L C=M

**Dedicated Herbivores:** identify **all the skulls** that represent this grade of evolution.
84. A=A B=B C=C D=D E=E

85. A=F B=G C=H D=I E=J
86. A=K B=L C=M

**More developed:** of skulls **G** and **J** identify the **one** most evolutionarily derived.
87. A=A B=B C=C D=D E=E
88. A=F B=G C=H D=I E=J
89. A=K B=L C=M

**Spenacodont:** identify the **one skull** that is sphenacodont.
90. A=A B=B C=C D=D E=E
91. A=F B=G C=H D=I E=J
92. A=K B=L C=M

**Most derived harbivorous stage:** identify the **one skull** that is the most evolutionarily derived (advanced) herbivorous form.
93. A=A B=B C=C D=D E=E
94. A=F B=G C=H D=I E=J
95. A=K B=L C=M

***For the Skeletons/Reconstructions:***

**Eotitanosuchian carnivore:** identify the skeletons that represent this stage of evolution.
96. A=A B=B C=C D=D E=E
97. A=F B=G C=H D=I E=J

**Dicynodont:** identify the **two skeletons/reconstructions** that represent this stage of evolution.
98. A=A B=B C=C D=D E=E
99. A=F B=G C=H D=I E=J

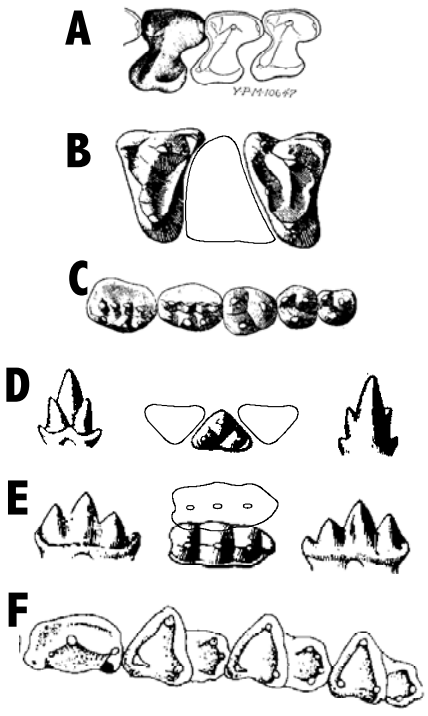
**Most-mammal-like:** Which **one** skeleton/reconstruction is closest to being a mammal, without actually being a mammal.
100. A=A B=B C=C D=D E=E
101. A=F B=G C=H D=I E=J

***Evolution of complex teeth - illustrations to the right:***

**Most-mammal-like:** Which **one** dental set has reached the mammalian grade.
102. A=A B=B C=C D=D E=E
103. A=F

**Earliest:** Which **one** dental set first developed beyond the synapsid condition.
104. A=A B=B C=C D=D E=E
105. A=F

**Synapsid and Mammalian Dental Sets**




***Next questions also apply to the Therapsid Synapsid illustrations on skulls, skeletons, and teeth.***
106. T/F. **Skeleton B** is more highly developed than skeleton I.
107. T/F. **Skull L** is more likely a Dinocephalia than it is a Titanosuchia.

108. T/F. The animals represented by **skeletons E** and **F** represent the same grade of development
109. T/F. **Dental set B** most likely derived from set **C**.
110. T/F. **Dentition B** was adapted for both slicing and crushing.
111. T/F. **Dental sets:** the fact that most of the fossil record for these animals consists of scattered and isolated teeth means that we cannot deduce the patterns of tooth replacement for the animal.
112. T/F. All the dental sets would require or be functional only with shearing occlusion (def. the alignment of the teeth of the upper and lower jaws when brought together) possible only with an enlarged coronoid and massateric muscle.

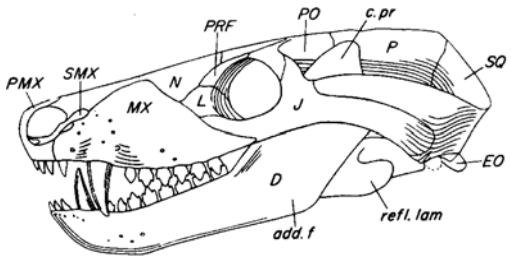
***In Orson's scenario of mammalian evolution two innovations are crucial in driving synapsids toward the mammalian condition. Which two?***

| 113. *Begin choices* | 114. *Continue choices* | 115. *Continue choices* |
|---|---|---|
| A Secondary palate. | A Double occipital condyle | A Single bone in lower jaw. |
| B Large coronoid process. | B Development of fur. | B Complex masticating dentition |
| C Three bones in the inner ear. | C Enlarged brain. | C Achievement of small size. |
| D Masseteric muscle. | D Homeothermy. | D Live birth. |
| E Reduction/loss of pineal eye. | E Turbinal bones. | E Deciduous and adult teeth. |

***On the other hand, the two main criteria for defining a fossil as a mammal are . . .***

| 116. *Begin choices* | 117. *Continue choices* | 118. *Continue choices* |
|---|---|---|
| A Secondary palate. | A Double occipital condyle | A Single bone in lower jaw. |
| B Large coronoid process. | B Development of fur. | B Complex masticating dentition |
| C Three bones in the inner ear. | C Enlarged brain. | C Achievement of small size. |
| D Masseteric muscle. | D Homeothermy. | D Live birth. |
| E Reduction/loss of pineal eye. | E Turbinal bones. | E Deciduous and adult teeth. |

119. T/F. The mammalian outcome was pretty well laid out and presaged (indicating or warning of a future occurrence) by the later stages of pelycosaur evolution, as indicated by the development of thermal regulation, tooth differentiation, pineal eye, and other anatomical precursors.
120. T/F. The primary driving mechanism for mammals to become nocturnal was the endothermy which allowed them to do it.
121. T/F. Development of a secondary palate first appears in the theriodont synapsids and is confined to them and mammals.
122. T/F. The mammalian jaw articulation is between the squamosal and the articular.
123. T/F. An important development for mammals was the merging of the lateral temporal opening and the eye opening.
124. T/F. Dental differentiation did not occur until the mammalian grade was achieved.
125. T/F. Although many lineages evolved in parallel toward the mammalian condition, only one lineage crossed the line to become ancestor to all mammals.




***Next 3 questions apply to the skull to the right.***

126. T/F. The animal to the right was probably warm blooded.
127. T/F. However, this animal was probably not a mammal.
128. T/F. Yet this animal appears to have the expanded brain.

***Questions of the origin, evolution, and functions of the brain.***

129. T/F. Mammalian brain size is largely independent of body weight, but instead is closely aligned with the specializations the particular animal has.

130. T/F. As with most evolutionary transitions, the transition from synapsid brain to mammalian brain was abrupt and we have no animals with transitional brain sizes.
131. T/F. In the lower vertebrate brains (fish, amphibian, reptile) the mesencephalon (middle brain) was the main coordinator of behavior, yet smell information is the one sense not reprocessed by other centers of the brain.
132. T/F. On the other hand, in modern mammals the old smell brain, the prosencephalon, is the main coordinator of behavior.
133. T/F. The enlarged mammalian brain evolved because functioning at night required a brain that was generally more flexible in its information processing.
134. T/F. Synapsids' behavior was probably largely "reptilian" in nature, with a selection of fixed action behaviors existing as ROM in the brain.
135. T/F. Ignoring the abilities of the other senses for the moment, for a synapsid "if it does not move it does not exist" is an accurate statement.
136. T/F. A reptile's world is strictly spatial; they just don't know the time of day.
137. T/F. However, just as with endothermy, precursors to a conscious mind early on developed in the synapsids.
138. T/F. It is fair to say that the brain enlarged in mammals simply because there was not enough room in the ears and nose to develop circuits that did similar complex of information processing done by the retina of the eye.
139. T/F. For the animal evolving to become nocturnal, the trouble with sound at night, or in the day for that matter, is that it has no spatial dimension—the ears were just not able to hear what was needed.
140. T/F. The fact that smell is so poorly developed in us is evidence that smell was not nearly as important as hearing in the mammalian brain's evolution.
141. T/F. The "consciousness" of the mammalian brain is, following the conservation principle, directly analogous with the "conscious eyes" of the reptilian grade.
142. T/F. The overriding, driving selection pressure on development of the mammalian brain was the memory storage required to create objects that the consciousness could manipulate.

## Whew! Man, am I glad that is done!

☺ Have a good summer ☺

***Don't Forget to Write your People Soft number***
***On the Scantron card.***
***Do it now and double check for accuracy!***

☺ ☺ ☺

# ESSAY QUESTIONS

## 20 points each

*Some ideas we discussed cannot easily be handled objectively, but require insightful explication, So, write concise, quintessential, rich, insightful, clear analyses for each question. Length of answer is not important A short answer that nails the issues with precision and power is much preferred to a rambling, unfocused argument.*

**Noto Bene:** Ok, Ok. I said there were just two questions, but when I brought them to class they had not been well proof read, and the second question one was internally contradictory. So, I have had to split that one out to make them reasonable.

Answer two of the three below.

143. Discuss the evolutionary transition from Chondrostei to the Neopterygian teleosts. Include discussions of specific anatomical adaptations and the reasons for those adaptations, or the advantages they conferred on the organisms possessing them.

You should use examples to support your arguments by referring to specific illustrations provided at the back of the test.

144. Discuss the fish-amphibian transition, the issue of preadaptation and the environmental conditions under which it probably occurred. You do not have to discuss the anatomical adaptations except as needed to discuss the above issues.

145. Discuss the amphibian-reptile transition, including the difficulty of evolving an amniote egg, and the anatomical changes that mark and define the transition from an amphibian skeletal grade to the reptilian skeletal grade.

A page of illustrations of Seymouria is at the back of the test if you want to use and refer to it.

146. We, of course, think that big brains and intelligence is important. After all, is that not what evolution has been heading toward all these millions of years - and animal as wonderful and profound as we are? Yeah, right!

Develop the scenario for the unusual expansion of the brain at the synapsid ⇨ mammal transition.