# Evolution As A Complex System
# Survey of Vertebrate History

**Spring, 2003**
**Bio/Geol 405:**
**Test # 1**

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
☐ 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 MidTerm**

# Evolution As A Complex System

# Survey of Vertebrate History

**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

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

**MULTIPLE CHOICE QUESTIONS:**

1. Life is a dissipative structure, and what it dissipates is energy, and information, but what kind of information? Which of the following constitutes biological information that is dissipated. None, ones, some, or all choices that apply.
   A. DNA
   B. RNA
   C. Proteins/Enzymes
   D. Sense organs
   E. Families/Communities

2. Gould's **Eternal Metaphors** include which of the following? None, ones, some, or all choices that apply.
   A. Directional vs Steady State
   B. Fractal vs Linear
   C. Gradual vs Punctuational
   D. Internal vs Environmental
   E. Organocentric vs Genocentric

3. **Eternal Metaphors** (again); according to Gould: None, one, some, or all choices that apply.
   A. As new problems were recognized in evolutionary issues each eternal metaphor came on line in historical sequence.
   B. At any one time history has always tended to accept one side of an eternal metaphor over the other.
   C. The history of the eternal metaphors has largely been dominated by scientific theoretical arguments as evolutionary theory evolved over time.
   D. If one side of an eternal metaphor turns out to be right, then the other position must be wrong.
   E. With time we have gotten closer to discovering which side of the eternal metaphor is true.

4. **Punctuated Equilibrium** argues: None, one, some, or all choices that apply.
   A. Species appear abruptly and fully developed.
   B. Species undergo little or no change until they go extinct.
   C. New major groups appear suddenly in the history of life.
   D. All evolution takes place with the origin of new species.
   E. New principles must be added to Darwin's theory of natural selection to explain punctuated equilibrium.

5. Which of the following are used to measure **entropy**? None, one, some, or all choices that apply.
   A. The "r" value of the system.
   B. The amount of disorder in the system.
   C. The amount of energy available to do work.
   D. How open or closed the system is.
   E. How rapidly the system can evolve.
6. ***Additional answers for above question.***
   A. How irreversible the system is.
   B. How steady energy/information dissipation is in the system.
   C. How complex the system is.

7. The ***computational view point*** includes which of the following ideas: None, one, some, or all choices that apply.
   A. The outcome of an algorithm is unknowable before calculating it.

B. The material world and the dynamic systems in it act like computers.
C. All systems are nonequilibrium systems.
D. The outcome of a calculation is deterministic and predictable.
E. Evolution is incompressible; that is, the shortest description of the system is simply the behavior of the system.

**GENERAL TRUE/FALSE QUESTIONS; 2 points each:**

8. T/F. The Genocentric view argues that Darwin's vision leads naturally and inevitably to the conclusion that everything we need to know is in the information in the organisms' genes.
9. T/F. From the Organocentric view life can only be understood by understanding the feedback mechanisms that regulate the system.
10. T/F. Life seems to defy the second law because it uses more energy than non-living systems.
11. T/F. Positive feedback means the following: if a change in A produces a change in B in the same direction - for example, an increase in A increases B, and a decrease in A decreases B then the system is undergoing positive feedback.
12. T/F. A vicious circle is an example of negative feedback.
13. T/F. Things went from bad to worse is an example of negative feedback.
14. T/F. Life can go against the second law of thermodynamics only because it increases the entropy in the environment faster than it would otherwise increase.

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**MULTIPLE CHOICE QUESTIONS:** At the back of the test is a page containing 14 illustrations dealing with chaos and complexity. Of the ***14 choices*** in each box, ***choose as many*** as are appropriate and necessary to answer the questions in the boxes below. Note that some questions may end up with no answer at all, and some illustrations may answer more than one question.

***Strange Attractor:*** mark one or more of the 14 choices directly exhibiting this property. If none leave all blank.

15. **1A** **1B** **1C** **1D** **1E**
16. **2A** **2B** **2C** **2D** **2E**
17. **3A** **3B** **3C** **3D**

***Fractal Geometry:*** mark one or more of the 14 choices directly exhibiting this property. If none leave all blank.

18. **1A** **1B** **1C** **1D** **1E**
19. **2A** **2B** **2C** **2D** **2E**
20. **3A** **3B** **3C** **3D**

***Power law distribution:*** mark one or more of the 14 choices which illustrate this phrase. If none leave all blank.

21. **1A** **1B** **1C** **1D** **1E**
22. **2A** **2B** **2C** **2D** **2E**
23. **3A** **3B** **3C** **3D**

***"Random walk":*** mark one or more of the 14 choices which illustrate this phrase.

24. **1A** **1B** **1C** **1D** **1E**
25. **2A** **2B** **2C** **2D** **2E**
26. **3A** **3B** **3C** **3D**

***"Sensitive Dependence":*** mark one or more of the 14 choices which illustrate this phrase.

27. **1A 1B 1C 1D 1E**
28. **2A 2B 2C 2D 2E**
29. **3A 3B 3C 3D**

**SAME ILLUSTRATIONS AS LAST QUESTIONS, BUT TRUE/FALSE QUESTIONS; 2 points each:**

30. T/F. ***Non-linear phenomena:*** Illustration 1C is an example of a non-linear phenomena.
31. T/F. ***Bifurcation:*** Illustration 2C is an example of bifurcation.
32. T/F. ***Iteration:*** Illustration 1A is produced by iteration.
33. T/F. ***Negative Feedback:*** 1D is an example of a system experiencing Negative Feedback.
34. T/F. ***Power-Law:*** Illustration 3B shows that extinction follows a power law distribution.
35. T/F. An attractor like 1A illustrates the flow of genetic information in a species over multiple generations.
36. T/F. ***Adaptive Radiation:*** 1E represents the pattern an adaptive radiation might take.

**TRUE/FALSE QUESTIONS; 2 points each: General Questions Connecting Complexity with Evolution.**

37. T/F. ***Positive Feedback:*** A good example of positive feedback in evolution is the Red Queen effect.
38. T/F. ***Stratified Stability:*** Species sorting is an example of a stratified stability at work.
39. T/F. ***Period doubling*** is a good model for the creation of new species.
40. T/F. ***Bifurcation*** is a good model for the generation of new species in the allopatric speciation model.
41. T/F. ***Self Referencing System:*** A species is a self-referencing system.
42. T/F. ***Strange Attractor:*** A species is an example of a strange attractor.
43. T/F. ***Allopatric speciation*** requires small isolated populations living under new environmental conditions because only under these conditions is information sensitive dependent enough.
44. T/F. ***Stasis*** is most characteristic of large populations of organisms, and ecosystems.
45. T/F. The ***founder effect*** occurs when two unrelated species come together in a new environment.
46. T/F. In the quote below, the italicized, underlined text is the positive feedback in the system.

    "As many more individuals of each species are born than can possibly survive; and as consequently, there is a frequently recurring struggle for existence, it follows that *any being, if it vary however slightly in any manner profitable to itself*, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be naturally selected."

47. T/F. In the equation X-next = rX (1-X), the (1-X) part of the equation is equivalent to natural selection.

**MULTIPLE CHOICE QUESTIONS:** To the right are 5 concepts/principles we employed to study the behavior of various systems. For each system or component of a system below, select the one concept/principle that is most germane (relevant, applicable) to the system. In none apply, leave all blank.

Choose From Among These

| | |
|---|---|
| A | Positive and/or Negative Feedback |
| B | Sensitive Dependence |
| C | Emergent Properties |
| D | Local Rules/Global Behavior |
| E | Universality |

| | |
|---|---|
| 48. The controlling principle behind the behavior of X-next. If none, leave blank. A B C D E | 49. Allopatric Speciation Model. If none, leave blank. A B C D E |
| 50. The species as a strange attractor. If none, leave blank. A B C D E | 51. A bifurcation. If none, leave blank. A B C D E |

52. The principle behind this Stuart Kauffman quote: *"The critical point is not, as Stuart Kauffman once described it, "a nice place to be." So "survival of the fittest" does not imply evolution to a state where everybody is well off. On the contrary, individual species are barely able to hang on"* A B C D E

53. A well established species consisting of a large number of individuals occupying a stable environment. A B C D E

From the choices at the right select those features characteristic of a generalized species.

54. **1A 1B 1C 1D 1E**

55. **2A 2B 2C 2D 2E**

| | | | |
|---|---|---|---|
| 1A | Biomass greater | 2A | Niches small |
| 1B | Environment sensitive | 2B | Range wide |
| 1C | Evolution opportunistic | 2C | Resources many |
| 1D | Information flow low | 2D | Speciate quickly |
| 1E | Long lived | 2E | Species few |

The Effect Hypothesis of Elizabeth Vrba is in the box to the right. Identify the type of feedback for the steps identified below.

56. Step ① in the hypothesis; identify the kind of feedback: **A=Positive, B=Neutral, C=Negative**

57. Step ④ in the hypothesis; identify the kind of feedback: **A=Positive, B=Neutral, C=Negative**

58. Step ⑥ in the hypothesis; identify the kind of feedback: **A=Positive, B=Neutral, C=Negative**

*ARGUMENTS IN THE EFFECT HYPOTHESIS*

① Stasis is the norm for both species and ecosystems.

② Ecosystems undergo periodic disruption.

③ Ecosystem disruption results in extinctions.
- ☞ Extinction hurts specialists more than generalists.

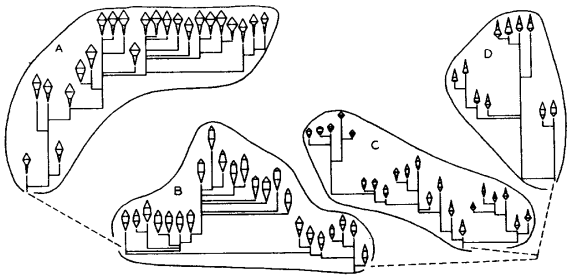
④ Extinction either . . .
- ☞ Creates new opportunities in environments, or . . .
- ☞ Results in new environments with opportunities.

⑤ New opportunities result in a rapid pulse of opportunistic and essentially random speciation of specialists.

⑥ Species sorting determines the ultimate direction of the new evolution.
- ☞ Evolution is historical, not teleological.

⑦ Rapid speciation and species sorting quickly leads to a new stasis, with more specialists in marginal niches than generalists in broad niches.

## EVOLUTION TRUE/FALSE QUESTIONS; 2 points each:

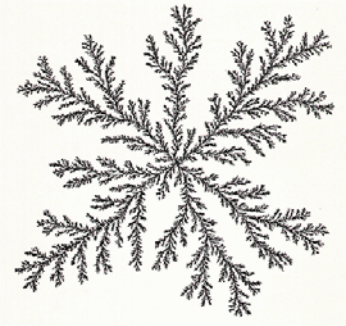



*Triloboid evolution*

59. T/F. We argued that the Triloboid diagram to the right generated by computer, is a good argument that evolutionary progress occurs.

60. T/F. Fossil species tend to be more "primitive" - less evolved - than modern species.

61. T/F. The diagram to the right is an example of the DLA (Diffusion Limited Aggregate) we generated in class and discussed; it is used to argue that evolution is a truly random process.



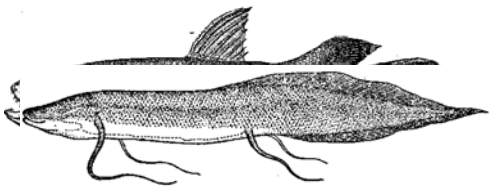
*A DLA (Diffusion Limited Aggregate)*

# SURVEY OF VERTEBRATE HISTORY

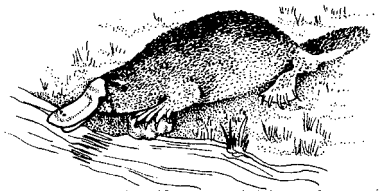
**The questions below are a mixture of True/False and Multiple Choice; same point values as above.**

**Supplied at the back of the test is a copy of the name phylogeny we used you may use to help answer questions.**

62. T/F. The invertebrate phyla vertebrates are most likely related to include Annelida and Arthropoda.
63. T/F. *Amphioxus* is an example of the oldest chordate fossil we have from the Burgess shale.
64. T/F. The chordates evolved from their sessil invertebrate ancestors only because they were able to evolve a brain.
65. T/F. The oldest Agnatha, the ostracoderms, lacked jaws but had developed good pelvic and pectoral girdles.
66. T/F. Neither of the first fish with true jaws - Acanthodians and Placoderms - have any living representatives, although the Agnatha do.
67. T/F. The evidence indicates that the Agnatha we have records of were probably not ancestral to any of the jawed groups.
68. T/F. All five fish classes - agnatha, acanthodians, placoderms, chondrichthyes, osteichthyes - existed together simultaneously only during the Devonian.
69. T/F. The best evidence indicates that the Osteichthyes were derived from the Acanthodians and the Chondrichthyes from the Placoderms.
70. T/F. Once more advanced sharks evolved from the Paleozoic sharks, sharks were advanced enough to not undergo any significant further evolution.
71. T/F. Even though there is no fossil record, the origin and evolution of jaws is one of the best and most thoroughly understood evolutionary histories.
72. T/F. The coelacanth (*Latimaria*, picture to right) is the only living Sarcopterygian.
73. T/F. *Protopterus* (picture to right) is the only living lungfish.



74. T/F. The Labrynthodonts are called labrynthodonts because their evolutionary history is so complex, labyrinthine.
75. T/F. The first tetrapods arose during the Devonian in the river systems draining the Caladonian/Acadian mountain building event.
76. T/F. Labrynthodonts once they appeared adaptively radiated to environments that were fully terrestrial, fully aquatic, as well as the half-in/half-out adaptations we associate with amphibians.
77. T/F. Lung fish are the best ancestors from which to derive the amphibia.
78. T/F. Based on the best evidence we have the Labrynthodonts, Lepospondyls, and Lissamphibia do not have common ancestors and are not closely related.
79. T/F. Lissamphibian (frog, toads, salamanders) ancestry is traced back to the Paleozoic.
80. T/F. There is fossil evidence that both major groups of marine reptiles, the plesiosaurs and ichthyosaurs, gave live birth.
81. T/F. Being so long lived and successful means that crocodilian evolution was generalized and conservative.
82. T/F. Despite being well adapted to terrestrial environments reptiles have shown the ability to return to aquatic niches numerous times, including plesiosaurs, ichthyosaurs, placodonts, mososaurs, and crocodiles at least.
83. T/F. Despite the fact that Labrynthodonts, Synapsids, and Anapsids are evolutionarily markedly different groups, they all appear at about the same time geologically.
84. T/F. Ichthyosaurs and porpoises have almost identical adaptations, including a sonar system, but differ in that the ichthyosaurs tail flukes are horizontal not vertical.
85. T/F. Although mammals and dinosaurs existed together for a long time, mammals evolved before dinosaurs.
86. T/F. The first dinosaur adaptive radiation in the Jurassic was dominated by brontosaurs, carnivors, and ankylosaurs.
87. T/F. Egg laying, such as in the platypus (picture to right) is a definitive enough character to clearly makes monotremes reptiles.



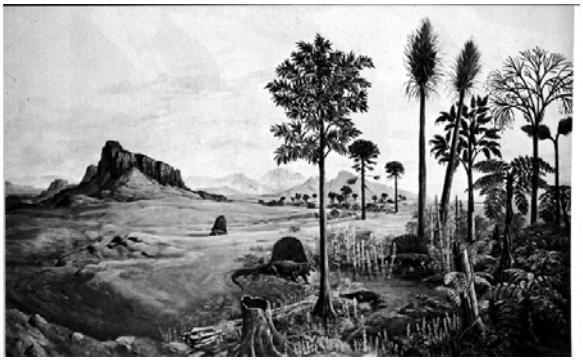
88. T/F. Since we cannot know the physiology of extinct animals the mammalian grade of evolution is arbitrarily marked by when the lower jaw reduces to a single bone, the dentary.
89. T/F. The oldest bird, Archaeopteryx, appeared in the record after dinosaurs became extinct.
90. T/F. Pterosaurs and birds were probably flying about the world together for must of the late Mesozoic.
91. T/F. Archaeopteryx is the first anatomically developed bird we have.
92. T/F. Snakes first appear in the fossil record in the Mesozoic and so crawled about the earth at the same time dinosaurs existed.
93. T/F. Mammals remained tiny, nocturnal, secretive animals until the dinosaurs went extinct.
94. T/F. Modern placental mammals first appeared in North America and then adaptively radiated to the rest of the world.
95. T/F. Marsupials originated in the southern hemisphere - Australia, Antarctica, and South America - and only late in their history did some move northward into North America.
96. T/F. During the Cenozoic mammal evolution was driven by changes from tropical jungles across all of North America, to grasslands with gallery forests, and finally to Arctic tundra.

During the transition from Therapsids to Mammals which of the transitions took place.

97. *Begin here . . .*
A Only dentary in lower jaw
B Give live birth
C Warm blooded
D Complex teeth
E Small size

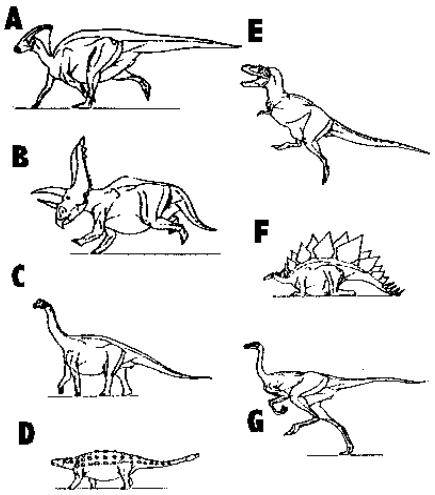
98. *End here*
A Enlarged brain
B Bad eyes
C Enhanced smell
D Complex teeth
E Develop whiskers

99. For the scene to the right which of the following statements are true.
A Synapsid pelycosaurs were common.
B Mammals existed.
C Climates were turning colder.
D Took place at the end of the Mesozoic.
E Existed in the southwest U.S.

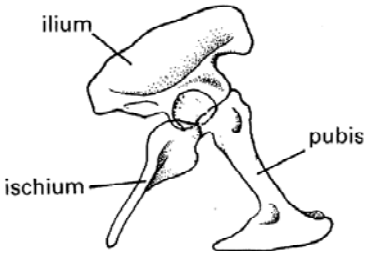


100. *(Continues last question)*
A Lissamphibia were common.
B Some labrynthodonts survived.
C Angiosperm plants were evolving.
D The supercontinent Pangaea existed.
E. Coal swamps present in eastern North America.

Select the dinosaurs in the illustration to the right belonging to the Order: Saurischia.
101. **A=A B=B C=C D=D E=E**
102. **A=F B=G**




Which group of dinosaurs posses the pelvis to the right.
103. **A= Saurischia**
**B=Ornithischia**




**"A Random Assortment of Tetrapods."** At the back of the test is a page labeled "A Random Assortment of Tetrapods." The questions below apply to those animals.

104. T/F. **Specimen A**, although built like a crocodile, and living like a crocodile, is not really a crocodile.
105. T/F. **Specimen B**, based on a fossil impression, is an example of a Labrynthodont neoteric animal, one that sexually matures, but does not metamorphose to the adult, as evidenced by the external gills.
106. T/F. **Specimen C** is one of the oldest dinosaurs.
107. T/F. **Specimen D** was a warm blooded (endothermic) animal using the "sail" primarily as a cryptic colored camouflage.
108. T/F. **Specimen E** looks more like a reptile than an amphibian.
109. T/F. **Specimen F**, *Ichthyostega*, is ancestral to the Labyrinthodont amphibians.
110. T/F. **Specimen G** is typical of a mainline ancestral quadrupedal Thecodont diapsid reptile.

111. T/F. **Specimen G** is likely to be a facultative biped.
112. T/F. **Specimen H** is more likely to be bipedal than **specimen C**.
113. T/F. **Specimen H:** based on its posture in the reconstruction it is more likely this animal would have held its tail stiffly off the ground, and down as shown in the illustration.
114. T/F. **Specimen I** is an example of an early amphibian that returned to a fully aquatic existence.
115. T/F. **Specimen J** is a typical grab-and-gulp Therapsid Synapsid with a half waddling gate.

At the back is a page titled ***"Take this fish and looking at it."***

We spent a lot of time taking fish and looking at them. It was an exercise in learning how to observe, and an exercise in discriminating taxonomic characters. So, can you discriminate among the different groups of fish? Identify the fish as below.

| ***Agnatha:*** mark one or more of the 15choices that belong to this classification. If none leave all blank | | | | | |
|---|---|---|---|---|---|
| 116. | **1A** | **1B** | **1C** | **1D** | **1E** |
| 117. | **2A** | **2B** | **2C** | **2D** | **2E** |
| 118. | **3A** | **3B** | **3C** | **3D** | **3E** |

| ***Chondrichthyes:*** mark one or more of the 15choices that belong to this classification. If none leave all blank | | | | | |
|---|---|---|---|---|---|
| 119. | **1A** | **1B** | **1C** | **1D** | **1E** |
| 120. | **2A** | **2B** | **2C** | **2D** | **2E** |
| 121. | **3A** | **3B** | **3C** | **3D** | **3E** |

| ***Sarcoptergyian Osteichthyes:*** mark one or more of the 15choices that belong to this classification. If none leave all blank | | | | | |
|---|---|---|---|---|---|
| 122. | **1A** | **1B** | **1C** | **1D** | **1E** |
| 123. | **2A** | **2B** | **2C** | **2D** | **2E** |
| 124. | **3A** | **3B** | **3C** | **3D** | **3E** |

| ***Placoderms:*** mark one or more of the 15choices that belong to this classification. | | | | | |
|---|---|---|---|---|---|
| 125. | **1A** | **1B** | **1C** | **1D** | **1E** |
| 126. | **2A** | **2B** | **2C** | **2D** | **2E** |
| 127. | **3A** | **3B** | **3C** | **3D** | **3E** |

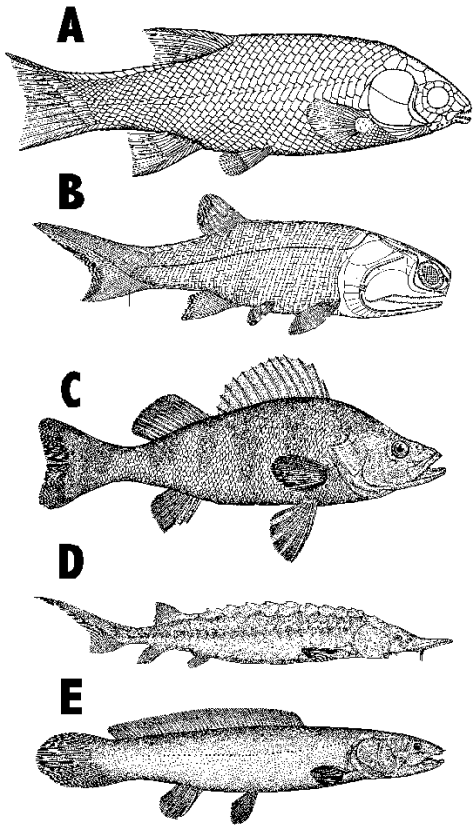
| ***Acanthodians:*** mark one or more of the 15choices that belong to this classification. | | | | | |
|---|---|---|---|---|---|
| 128. | **1A** | **1B** | **1C** | **1D** | **1E** |
| 129. | **2A** | **2B** | **2C** | **2D** | **2E** |
| 130. | **3A** | **3B** | **3C** | **3D** | **3E** |

The fish to the right are Actinopterygian Osteichthyes. The next few questions refer to them.

***Chondrostei:*** Mark one or more of the 5 choices that represent the earliest members of the Actinipterygian evolution.
131. A B C D E

***Holostei:*** Mark one or more of the 5 choices that represent the middle level of Actinipterygian evolution.
132. A B C D E

***Teleostei:*** Mark one or more of the 5 choices that represent the most advanced level of Actinipterygian evolution.
133. A B C D E




***Don't Forget to Write your People Soft number***

***On the Scantron card.***
***Do it now and double check for accuracy!***

# TWO 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.*

134. Discuss the issue of "progress" in evolution.

135. If the Labrynthodont, Lepospondyl, and Lissamphibia do not derive from a common ancestor, how does this affect vertebrate classification.

136. *Euparkeria*, the animal in the illustration, belonged to which taxonomic categories (all that apply).

A Synapsida
B Diapsida
C Thecodontia
D Dinosauria
E Crocodilia