



2
0000



3 1293 01812 9464



This is to certify that the

thesis entitled

Teaching the Classification of Vertebrate
Animals by Comparing the Anatomy within
Each System

presented by

Pamela R. Lehman-Nutt

has been accepted towards fulfillment
of the requirements for

Masters degree in Biological Science

Major professor

Date August 10, 1999

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.
MAY BE RECALLED with earlier due date if requested.

DATE DUE	DATE DUE	DATE DUE

**TEACHING THE CLASSIFICATION OF VERTEBRATE ANIMALS BY
COMPARING THE ANATOMY WITHIN EACH SYSTEM**

By

Pamela R. Lehman-Nutt

A THESIS

**Submitted to
Michigan State University
In partial fulfillment of the requirements
For the degree of**

MASTER OF SCIENCE

Division of Science and Math Education

1999

ABSTRACT

TEACHING THE CLASSIFICATION OF VERTEBRATE ANIMALS BY COMPARING THE ANATOMY WITHIN EACH SYSTEM

By

Pamela R. Lehman-Nutt

This thesis determines whether students understand vertebrate classification better if they study, compare, and contrast anatomical systems (digestive, reproductive, skeletal, etc.) versus the typical way this material is taught in the high school. Vertebrate classification is normally taught by the “Classes” like birds, reptiles, and mammals. I will compare the vertebrate Classes by their anatomical systems, thereby showing similarities and differences within each system. Students used materials I developed at Michigan State University in 1997. Pretests, posttests, notes, performance evaluations, educational videos, slides of vertebrate dissections, and laboratory dissections of a dogfish shark and a pigeon were part of this unit. To evaluate this approach, I focused on 3 higher-level students, 3 middle-level students, and 3 lower-level students over a two-year period. These students did show significant improvement in their understanding of the Classes of vertebrate animals after the teaching of this unit.

Copyright by
PAMELA RUTH LEHMAN-NUTT
1999

To my mom and dad, for always making sure that I knew how important education is.
Thank you.

To my husband and son, Dale and Tyler, for their patience and understanding. I love you
both.

ACKNOWLEDGEMENTS

I would like to thank Dr. Merle Heidemann and Dr. Ken Nadler for all of their help, knowledge, and patience as I tried to complete my thesis. I would also like to thank my family and friends for their constant support and understanding of my lack of time while I finished up my degree.

Last, I would like to thank my tenth grade advanced biology students at Eaton Rapids High School, the class of 2000 and 2001, for allowing me to carry out my graduate work with them.

TABLE OF CONTENTS

LIST OF FIGURES.....	viii
INTRODUCTION.....	1
Statement of Problem and Rational for Study.....	1
Demographics of the Classroom.....	5
Review of Scientific Principles.....	5
Classification.....	6
Comparing Essential Anatomical Systems.....	6
Trends In Evolution.....	9
IMPLEMENTATION OF UNIT.....	10
Notes.....	12
Slides.....	12
Weekly-Outline.....	13
Audio Visuals Aids.....	15
Laboratory Investigations.....	15
Classification Bingo.....	17
EVALUATION.....	18
Pretests	19
Posttests	22
Analysis of the Pretest and Posttest of Eighteen Target Students: 9/1997-98; 9/1998-99.....	23
Student Questionnaires.....	27
Results.....	29
DISCUSSION AND CONCLUSIONS.....	34
Aspects of the Unit Effective in Conveying Key Information.....	35
Aspects of the Unit that Need Improvement and Strategies Used for Making Changes.....	37
Overall Evaluation.....	40

APPENDICES

Appendix A

Notes.....	43
------------	----

Appendix B

Pretest.....	74
--------------	----

Appendix C

Posttest - Part I.....	78
------------------------	----

Appendix D

Pigeon and Dogfish Shark Dissection Questions.....	86
--	----

Appendix E

Slide Structures.....	87
-----------------------	----

Appendix F

Free Response Pretest – 1998-99.....	92
--------------------------------------	----

Appendix G

Daily Calendars.....	95
----------------------	----

Appendix H

An Example of a Classification Bingo Game Card.....	110
---	-----

Appendix I

Post Test	112
-----------------	-----

Appendix J

Students Questionnaire.....	120
-----------------------------	-----

Appendix K

Student Questionnaire Responses – 1997-98 and 1998-99.....	123
--	-----

Appendix L

Classification Quiz.....	137
--------------------------	-----

AUDIO VISUAL REFERENCES.....	139
------------------------------	-----

BIBLIOGRAPHY.....	141
-------------------	-----

LIST OF FIGURES

Figure 1 – Item Analysis of Number Right on Selected Questions of the Pretest and Posttest – 1997-1998.....	20
Figure 2 – Comparison of the 1997-1998 Nine Target Students Test Scores.....	25
Figure 3 – Comparison of the 1998-1999 Nine Target Students Test Scores.....	26
Figure 4 – Comparison of Pretest, Posttest and Average Test Scores for 1997-1998 and 1998-1999.....	28

INTRODUCTION

A. STATEMENT OF PROBLEM AND RATIONALE FOR STUDY

The goal of my unit was to make understandable a high school science topic that was hard to teach and complex due to its large content. I chose to teach seven anatomical systems by comparing each system across various vertebrate Classes. The main question proposed to students was what are the similarities and dissimilarities of basic anatomical systems of various Classes of vertebrates?

I chose this problem because I believe that when students are able to compare different anatomical systems across organisms, they get a better understanding of the organism itself and the organism's evolutionary relationships. I wanted to see if I would increase my student's ability to comprehend than when I first taught this unit for five weeks to tenth grade students in the 1996-1997 school year. No formal comparison is used to this group due to a change in textbooks and no data were kept on their performance.

I decided to teach this unit for a total of 2 years (1997-98 and 1998-99). I used highly organized notes (Beecher, 1988) after researching ways to provide a lot of information to students. I deleted certain phrases or words so that my students would have to fill in key words, follow along and listen as Beecher suggested. Beecher also suggested using a lecture format that allows space in the notes for students to include additional information as I talked, inserting verbal and nonverbal clues, writing important material on the blackboard and avoiding informational overload. By doing my notes and lecture in this format, I was able to present a large amount of information by using an

outline form that would be easy to read, understand, and organized according to appropriate grouping of ideas and facts. As stated by Rogers (1983), "Generalizations are then presented in a brief but accurate framework upon which details of the anatomical system are in an orderly and predictable pattern. The purpose of the notes is to present basic concepts of comparative anatomy in a streamlined form that is easily used as a supplement to classroom work". Most comparative anatomy books teach one anatomical system per chapter in too much detail even for a high school advanced biology course. Students also lack adequate background in chemistry to understand many of the ideas used in a college comparative anatomy textbook since chemistry is not offered to them until they are eleventh graders. These comparative anatomy textbooks differ due to the emphasis put on phylogenetic relationships, structure and function, principles of organization, speciation, or morphology.

In this unit, I also wanted to revisit the theory of evolution studied earlier in the school year of 1997-98. I wanted my students to apply deductive reasoning to evolution by recalling premises of natural selection and applying this to vertebrate adaptation. By looking at the structures of different vertebrate organisms, students should be able to deduce that many of them have homologous structures. According to Arnold Klunge (1977) in his first chapter of Chordate Structure and Function, "Deduction in a logical sense is the form of reasoning by which a conclusion is derived or inferred from a physical law, biological theory or principle. In deductive reasoning one begins with a general truth and seeks to connect it to some individual case by a logical extension". This author also believes that by using the comparative approach in studying anatomy, deductive reasoning must be involved to see a correlation between structure and function.

For most learners, knowledge is constructed. Intellectual sense is made of physical and biological environments based upon ones experience (Roth, 1993). I wanted my students to see, based on their own anatomical work, similarities between vertebrate anatomical systems and understand that through adaptations these systems have become modified and more complex when comparing “lower” to “higher” vertebrates. For example, the comparative anatomy of the heart and circulatory system is treated, not as evidence for the evolution of mammals from fish and amphibians, but as one aspect of a functional system, adapted differently in the various Classes of vertebrates for the same basic need (Griffith, 1962).

My teaching style or the way the class was run was not changed from previous years, except for the way I prepared notes for the students. The notes were given in outline to provide a large amount of well-organized information in a form that was easy to read. In 1996-97, my students took notes based on material presented on the overhead with me talking and explaining as I went through them. This is not the ideal way to lecture and give notes. Research on note-taking states that the student should copy notes to ensure that their thought processes do not wander. Those students that do take their own notes seem to be able to retain information better and recall the information that they copied down (Beecher, 1988). In this unit, I developed notes with a considerable amount of information not found in the textbook for my students. Therefore, I had to give the students prepared notes, as time was constrained. We then went through these notes on the overhead projector together in discussion, as I pointed out major ideas and added some extra notes (Appendix A). The students were still required to do vocabulary definitions, laboratory dissections, read different sections within their textbook, and

hands-on activities. The latter was crucial since “Hands-on activities are necessary for developing concrete, experiential background especially for students who have had little exposure to experiences important for learning about the natural world” (Haury and Rillero, 1994). Evidence based on science instruction of activities and lab work has shown effectiveness in fostering scientific literacy and understanding of science processes and critical thinking (Haury, 1993).

For most of the year I teach a unit by a chapter in the textbook, which is organized by major ideas such as cellular and molecular biology. Each student is required to define vocabulary terms on which they will be later quizzed. Worksheets pertaining to the chapter and ideas that I want to emphasize are discussed. Students do at least one laboratory activity per chapter, though I usually try to include two laboratory experiments per chapter lasting about two weeks. These laboratory experiments develop skills necessary for problem-solving which helps students investigate based on the logical and sequential thought processes often referred to as the ‘scientific method’ (Kanis, 1992). On their own time, my students were to read the chapter and answer the questions that were asked in every section of the chapter. At the end of every chapter there was a review consisting of: multiple choice, true/false questions, word relationships, short answer questions, and critical and creative thinking essay questions. After students completed the chapter review, the class and I would review for the test together as I questioned them about main ideas and processes within the chapter. The test for each chapter consisted of multiple choice, fill in the blank, diagrams and/or tables, short essays, and at least two critical thinking essay questions. The students were told that they must read over notes, vocabulary, worksheets, and laboratory activities and look over

their chapter review to adequately study for their test. The vocabulary and textbook reading activities reinforced the lesson (Haury and Rillero). I wanted to analyze this way of teaching and make some changes when teaching a complex unit.

B. DEMOGRAPHICS OF THE CLASSROOM

I teach at Eaton Rapids High School located approximately 15 miles south of Lansing. This is a Class B school consisting of 3200 students in the school district and 1000 students at the ninth through twelfth grade high school. The students at Eaton Rapids are of European ancestry with less than 1% minorities. I chose my advanced biology tenth grade class for the study of this unit. The first year, the 1997-98 class, consisted of 27 students: 17 girls and 10 boys. This unit was taught in the last five weeks of school. The 1998-99 advanced biology class, or the second year of this study, consisted of 20 students: 14 girls and 6 boys. The unit for this class was taught at the beginning of the school year.

C. REVIEW OF SCIENTIFIC PRINCIPLES

The scientific concepts explained and demonstrated in this unit are: (1) classification of an organism, in the case of vertebrates, based on its internal and external structures; (2) comparison of the ways in which vertebrates carry out their essential life functions; (3) description of trends in the evolution of vertebrate systems. Background information on each of the three objectives is presented below.

CLASSIFICATION

To be classified as a vertebrate, the organism must have a combination of four unique characteristics: (1) a notochord, at least in embryonic development; (2) a pharynx with slits or pouches in the lateral walls in the embryonic stage at least; (3) a dorsal, hollow, central nervous system; and (4) a vertebral column.

All vertebrates fall under the kingdom Animalia, the phylum Chordata, and the subphylum Vertebrata. In the classification scheme, the next taxon is the Classes, which consists of Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, and Mammalia. Each of these Classes is broken up into Orders, Families, Genus, and Species. For example the classification of a grizzly bear is Kingdom – Animalia, Phylum – Chordata, Class – Mammalia, Order – Carnivora, Family – Ursidae, Genus – *Ursus*, Species – *arctos*. Conventional classification is an attempt to relate hierarchies phylogenetically on genealogical relationships and morphologically. This classification scheme has been successful over the years, but as new tools for classification, such as DNA testing, are being developed, organisms are being reclassified according to relatedness of proteins and DNA sequences.

COMPARING ESSENTIAL ANATOMICAL SYSTEMS

Besides the four unique characteristics, vertebrates share many anatomical features that can be compared. These features are; the integument or skin, the muscular system, the skeletal system, the nervous system, the reproductive system, the circulatory system, and the respiratory system.

Integument

The vertebrate skin is unique with two layers consisting of an epidermis and a dermis.

Within these two layers are defensive, pheromonal, lubricating, and homeostasis-maintaining glands. The skin can be modified to become scales, nails, hair, and feathers.

The epidermis of a land vertebrate must protect against dehydration whereas a water vertebrate must be protected from hydration.

Muscular System

There are three types of muscle tissue; smooth, cardiac, and striated. Smooth muscle is usually found in blood vessels and tubes. Cardiac muscle is striated and only found in the heart. Cardiac muscle shows characteristics of both smooth and striated muscle.

Both smooth and cardiac muscle are controlled involuntarily by the brain. Striated muscle appears striped when viewed under the microscope and contains many nuclei.

This muscle type is controlled voluntarily and moves the skeleton when needed.

Skeletal System

The skeletal system is composed of bone, cartilage, and ligaments that make up a strong framework that provides the shape and protection of the organism. The skeleton itself is also a place for attachment of muscles that move the jointed framework

Nervous System

A variety of sense organs are found in vertebrates. These monitor the changing environment, internally and externally. The receptors are responsible for chemical,

electrical and thermostatic change and are widely distributed throughout the body. These receptors are connected to the brain and regulate the body's response, thereby enhancing the ability to survive.

Reproductive System

Reproductive organs include gonads, ducts, accessory glands, storage chambers, and copulatory mechanisms. All vertebrates are sexual and have either external or internal fertilization.

Circulatory System

The vertebrate body tissue must be supplied with oxygen and other organic chemicals and be able to get rid of carbon dioxide and organic wastes. To achieve this the body contains blood made up of red blood cells, white blood cells, and platelets and plasma that run through tubes called arteries, veins, or capillaries. These tubes are named according to their position in the body and their thickness and elasticity. Blood is pumped throughout the body by the heart, composed of cardiac muscle, which is located close to the respiratory system in all vertebrate body plans. Vertebrates can have a two, three, or four chambered hearts. The top chamber(s) is called the atrium (pl. atria) and the lower chamber(s) is the ventricle(s).

Fish have a single-loop circulatory system, meaning it goes from the heart to the gills, to the body, then back to the heart. All the other vertebrates, with the exception of the salamander, have a double-loop circulatory system. One loop moves blood from the

heart to the lungs and back to the heart with oxygenated blood. The other loop moves blood to the body, returning it to the heart.

Respiratory System

An exchange of oxygen and waste products like carbon dioxide takes place either in the gills, skin, or lungs of vertebrates. Some animals use a combination of these organs.

TRENDS IN EVOLUTION

The more primitive an organism, the less complex their anatomical systems tend to be. Species that evolved later seem to have more advanced features with the exception of animals that are parasitic. Parasitic animals have a reversed trend. Some lineage's of organisms have become more specialized over time with modified structures due to adaptations that occurred by the process of natural selection or by genetic drift.

IMPLEMENTATION OF UNIT

I developed a five-week unit on vertebrate anatomy taught to an advanced biology class in May of 1998 and a revised version of this unit, taught in September of 1998 to another advanced biology class. The basic biological ideas of this unit, for both years, were the different anatomical systems within an organism, how the systems are similar within each Class, and the taxonomic classification of vertebrate animals. Evolution was emphasized in the first year also. The class met everyday for 55-minute periods. The components I prepared for this unit were the notes, pretests, posttests, laboratory dissection questions, and slides of vertebrate dissections. These items are appended.

Teaching of the new unit began in May of 1998 by pre-testing (Appendix B) what students knew about vertebrate classification, external morphology, and the skeletal and muscular systems. The results of the pretest were later compared to the posttest (Appendix C) to see if there was a significant difference between the two. We then discussed the pretest results in class. I used the pretest as a guide to help me emphasize information in which students were deficient in knowledge. For this unit the students were given: key terms for each system, notes, laboratory activities to do, worksheets that accompanied each anatomical system, movies that showed the different Classes, laboratory dissections of the perch, dogfish shark, and pigeon. The students were also shown slides of the dissections of the perch, lamprey, dogfish shark, mudpuppy, and turtle, which I made in preparation to teaching this unit.

In preparation for teaching this unit, I extracted laboratory investigations, activities and background information from a wide source of materials. I also developed

questions to accompany the dissections of the pigeon and dogfish shark (Appendix D). To review for the Classes and Orders of vertebrates, I made up a bingo game to help my students learn the names. All the laboratory investigations were taken from my classroom textbook and Biology: The Living Science(1998), except for the dissections which were taken from college comparative anatomy laboratory books (Harrison, 1970 and Wischnitzer, 1988).

In additional preparation, I had to organize the slides of dissections that I had taken during my research. The slides were organized in order of their anatomical systems so as the prepared notes were discussed, specific structures (Appendix E) from each of the vertebrate classes could be shown to the students.

Before teaching this unit in September of 1998, I modified the pretest and posttest to be in the form of a free response (Appendix F). I also added a frog and fetal pig dissection to the unit.

The main focus of evaluation for the first year was observing and documenting responses from three high-level achieving students, 3 middle-level achieving students and 3 low-level achieving students. I selected the students for each level by their grades in the class throughout the school year. The higher-level students had an A average, the middle-level students had a C average, and the low-level students I chose were those receiving a D/E average in the class. These students were picked at random from each level, except the D/E students of which there were only three.

In the second year, 1998-1999, three students of each grade average were picked also. They were not chosen until after the first semester, since this unit was taught at the

beginning of the year and I had no baseline grade data on which to base choosing students for monitoring.

A. NOTES

The notes (Appendix A) used in this unit were developed by me with reference to many books listed in the bibliography. I spent much time trying to make sure that they were not inappropriately long or in-depth for my students. The notes were constructed in outline form to make sure that the general concepts of vertebrate structure and the characteristics of each Class were organized and easy to read. The students seemed to like the notes this way, except a few who liked to prepare their own notes. I made overheads of each anatomical system and, as I discussed the notes with my students, I had them star or underline key ideas. I also added some small pieces of information to keep their minds from wandering. Most of the students listened very well as evidence from their responses and questions asked. For the 1998-99 school year, I changed the notes (Appendix A) by deleting some of the information and having each student fill in the information as it was discussed in class.

B. SLIDES

I took a series of 35mm slides of dissected vertebrate animals as part of my 1997 summer research experience. The animals that I dissected were a perch, a lamprey, a mudpuppy, a turtle, and a dogfish shark. I also dissected a cow's heart with the help of another graduate student. As I went through each dissection, I stopped at certain points to label main structures that I wanted my students to know. A list of all the structures

labeled can be seen in Appendix E. The slides developed from my research were useful, but did not come out as well as I would have liked. The slide background was too dark and the labels that I had placed on the animals were too hard to read because of their size. The reason for taking the slides of the dissections was to make sure that I had some visual materials to show my students. Also, I was not sure if my school could afford to purchase all the animals for dissection that I would like to include in my unit. My students said during the showing and discussion of the slides that the slides were useful and helped to show them what to look for inside each dissected animal.

C. WEEKLY OUTLINE

This is a short summary of weekly activities for the 1997-98 unit. The activities listed are those that I provided for the unit. A complete daily calendar for both years can be seen in Appendix G. For the 1998-1999 school year, two weeks time was added to the schedule to accommodate a more productive learning environment.

Week 1

During the first week of this unit, my students took a multiple-choice pretest. We discussed the results of the pretests. The students were given notes on classification, external morphology, and the skeletal system and we discussed them as a group. Slides were shown on external morphology of the lamprey, perch, turtle, mudpuppy and dogfish shark.

Week 2

The notes related to the muscular system were handed out and discussed. The students examined skeletons and participated in a prepared laboratory investigation defining the two types of muscle tissue. Students then did a laboratory investigation comparing vertebrate skeletons of the cat, pigeon, alligator, human and frog. Toward the end of the week, we looked at prepared slides of different muscle and skin cells under the microscope.

Week 3

At the beginning of the third week, the class reviewed for the classification part of the test by playing games of classification bingo (Appendix H). The students took the posttest (Appendix C) for this section after reviewing for it. We discussed the prepared notes of the nervous system. The pigeon dissection was started on Friday and continued the following week.

Week 4

At the beginning of the week, we discussed the reproductive, circulatory, and respiratory systems in detail from the prepared notes handed out. The students participated in two laboratory investigations: examining an unfertilized egg and comparing different respiratory systems. The pigeon dissection was finished. Toward the end of the week, the students were shown slides of a dissected cow's heart and started the dogfish shark dissection.

Week 5

The students finished up the dogfish shark dissection and accompanying questions at the beginning of the week. Students watched a movie about the classification and unique characteristics of mammals, and were shown slides of the dissections covering the respiratory, circulatory, reproductive system of the lamprey, perch, mudpuppy, turtle, and dogfish shark. Then the students reviewed for the second posttest (Appendix I). On Friday, after the posttest, all of my students completed a student questionnaire (Appendix J) asking factual questions and about their perceptions of the unit that they had just finished.

D. AUDIO VISUAL AIDS

I incorporated a series of Eyewitness videos (Dorling Kindersley, 1994) on the Classes of vertebrates including; fish, amphibian, reptiles, birds, and mammals. All of my students found this series to be intellectually motivating and interesting. Personally, I found the series to be extremely interesting and one of the better series that I have found. A wide variety of facts, history, and species are shown in each video. The videos themselves are only thirty-five minutes long so they do not take up an entire period.

E. LABORATORY INVESTIGATIONS

All of the laboratory investigations and dissections for this unit are based on prepared written materials. The laboratory investigations all are from the teacher's resources from either of my biology textbooks, Biology and Biology: The Living Science published by Prentice Hall (1998). Both book resources were useful since they both have

the same authors, Kenneth Miller and Joseph Levine. One of the textbooks, Biology: The Living Science is for a lower level reading ability. When targeting laboratory material for this unit, a criterion I used was that the content of the laboratory investigation comparing different vertebrate anatomical systems.

There were five laboratory stations spread around the outside walls of the classroom. I allowed my students to pick their own laboratory partners, with two or three in a group. The students in each group knew that they were responsible for completing the laboratory investigation and for cleaning their station at the end of the period. I walked around the classroom to each station answering and asking questions concerning their activity. By walking from station to station, I made sure students were on task, participating in the laboratory investigation.

The laboratory dissection went very well, except for two aspects. The first problem was with the pigeon and dogfish shark dissection that I was not able to locate a dissection guide written to the ability and level of my students. The dissection guides that I located contained low-level information and not enough detail or were too in-depth and contained too much detail. I ended up using the dissection guide with too much information from a comparative anatomy dissection guide that normally accompanies a college textbook. The pigeon dissection and the dogfish shark dissection guides were 20 and 30 pages long, respectively. Neither of these guides were what I truly wanted for my students due to their length and excess information. My second problem was that most of the questions that accompanied these dissection guides were about information I did not perceive to be important to my students so, I developed questions that my students could answer at the end of their dissection (Appendix D).

F. CLASSIFICATION BINGO

I decided to structure a review for the classification part of the posttest by playing games of classification bingo. My students mentioned that they were having a hard time remembering taxonomic Classes and Orders. I thought a game with candy rewards would motivate them enough to learn the different taxa. I made up the game by using key animals, Classes, and Orders that I had listed on the notes for classification and placing questions about them on index cards. I shuffled the cards and read off the questions. I provided a blank bingo sheet for each of them to fill out (Appendix H). The students had to fill out their bingo sheets with any of the names on their notes. The students could win across, down, or diagonally. This was a lot of fun. Most of my students wanted to continue playing all period but I had to review for the rest of the posttest with them.

EVALUATION

The evaluation of this unit was based on both objective and subjective data. In the first trial (1997-1998) of this unit, the students took a pretest and a posttest for the first part of the unit which was two and one half weeks long. However, I did not give a pretest for the second half of the unit, though a second posttest was taken. This was due to an end-of-the-year time constraint. I also had to allow time for all of my students to give feedback on a questionnaire with regards to the unit itself which I gave them after the unit was completed. All of the data from this questionnaire (Appendix K) were analyzed after the 1997-98 school year.

The evaluation of the second trial of this unit was completed after the first semester of the 1998-1999 school year. The students took a different pretest and posttest than the students of the first year. I changed the pretest/posttest to a free response form so I could identify misconceptions and make changes to the unit according to the classes individual needs. The pretest and posttest were exactly the same but neither was used as a grade for the class. The pretest and posttest were used to evaluate the effectiveness of the unit. The pretest was administered at the beginning of the unit and the posttest was taken at the end of the seven weeks. The information pertaining to vertebrate Classes and Orders of vertebrate animals was given as a quiz (Appendix L), instead of being covered on the unit test. This change was based on student feedback from the previous year analysis.

A. PRETESTS

The 1997-98 pretest (Appendix A) consisted of 29 multiple choice questions that were also included on the posttest along with additional multiple-choice questions, two diagrams, and three essay questions. The results of the pretest show that there were some questions about material content that the majority of my students did not understand or have any previous knowledge. These test questions were #1, 5, 7, 9, 13, 16, 18, 24, and 27. Of all my students, anywhere from 42% up to 73% of each individual question did not get answered correctly. The nature of these questions pertained to the taxonomy of the vertebrate Classes or specific information about each taxonomic Class. Data from an item analysis of these nine questions for all my students is shown in Figure 1. The figure shows that most of the questions were answered correctly on the posttest, except #7. My students scored lower on this posttest question than on the pretest. The reason for this is that the students guessed correctly on the pretest. On questions #5 and #9, my students showed a noteworthy improvement in their correct answers on the posttest.

The 1997-98 pretest gave me some insight to what students knew previously. I found it amazing that some of my students did not know basic information about vertebrate organs as I expected. The pretest indicated that all of my students scored in a similar range. Most of the students came to the unit without much background information on the Classes and Orders of vertebrates. Students guessed when answering the pretest questions and voiced their frustration to me after they took the test. By having my students guess on the pretest, I am not sure if they got the question right due to knowledge or just by chance, therefore I do not believe I received adequate information

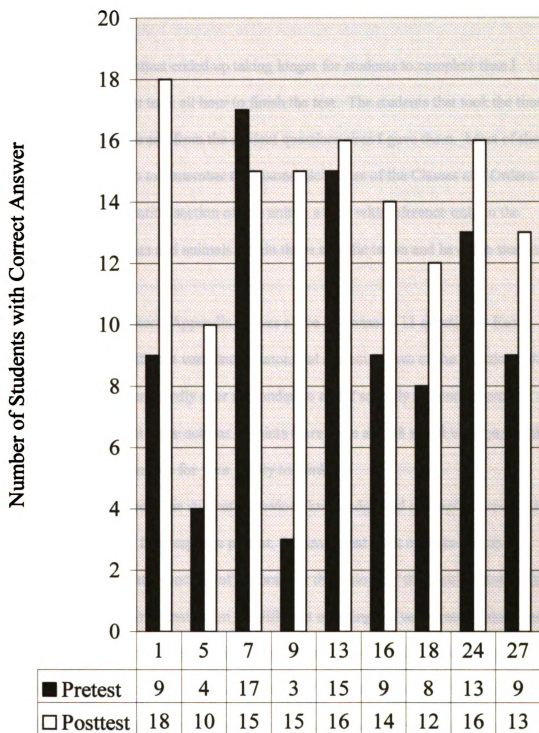


Figure 1 - Item Analysis of Number Right on Selected Questions on Pretest and Posttest 1997-1998

about their previous knowledge. The pretest results are at best, an overestimate of their prior knowledge.

The 1997-98 posttest ended up taking longer for students to complete than I anticipated. One student took all hour to finish the test. The students that took the time to study did well as I learned from the student questionnaires I gave them. Most of them said the hardest part was to remember the taxonomic names of the Classes and Orders. I will change the classification section of this unit to a quiz with reference only to the vertebrate Classes, Orders and animals within those specific taxon and have the students take it in the beginning.

The 1998-99 pretest (Appendix F) was a free response to 11 questions. Each question pertained to different vertebrate anatomical systems. Two of the questions, #4 and #8 on the pretest were hardly ever responded to and if so, only in general terms. Questions #4 asked what some actions of joints there were and #8 asked what part of the nervous system is responsible for your ability to blink.

I learned a lot about the student's previous knowledge and concepts of anatomical systems on the 1998-99 free response pretest. I learned that most of them had no knowledge of the parts and function of the brain or the actions of the joints. Most of the students could give me information on the different coverings of vertebrate animals and could list two of the ways to get rid of wastes. Some students definitely knew more information than others. Most of these students had one specific science teacher in the junior high. I had asked them to write down the name of their previous science teachers so that I had a general idea of who was doing a good job at the lower level.

B. POSTTESTS

The 1997-98 posttest consisted of the same 29 multiple choice questions that I used for the pretest, but I included 17 more multiple choice questions, two diagrams that the students had to analyze, and 3 essay questions. Two of the essays were related to laboratory investigations that the students had completed. The first essay question asked students about different types of muscle. The second essay question asked the students to compare and contrast the different skeletal systems of the various vertebrate Classes.

The first diagram to be analyzed on the posttest was based on a chart showing the change in population size of the five vertebrate Classes over the last 500 million years. The students were asked questions about the evolution of certain Classes and the time periods in which the Classes evolved. The second diagram on the posttest was of a chicken skeleton. Students were asked to recognize similarities between structures of the pigeon they had dissected and those of the chicken.

The 1998-99 posttest (Appendix F) was a free response to the same 11 questions given on the pretest. All of the students answered each question. Some of the students went into great detail to answer the question completely. I believe that this type of evaluation helped me to see the difference in their starting knowledge to their ending knowledge. This test was a useful tool, though it took considerable time to read. By comparing their pretest to their posttest, I could tell that they learned a lot more information that I could assess on a multiple-choice test. By giving the students a free response question posttest, I was able to identify gaps in their knowledge and was able to fill in the blanks missing in their knowledge.

**C. ANALYSIS OF THE PRETEST AND POSTTEST OF EIGHTEEN
TARGET STUDENTS: 9/1997-98; 9/1998-99**

In order to obtain more about student learning, I analyzed the pre- and post- test data of nine students per year. All of the information presented below is from my study group of nine target students consisting of 3 high-level achieving students, 3 average-achieving students, and 3 low-level achieving students. These nine target students were chosen by their consistent grades throughout the first, second, and third quarters of the 1997-98 school year. The high-achieving students maintained a grade of an A, the average-achieving students maintained a C, and the low-achieving students maintained a D and/or E average. For the rest of this document, I will refer to the students by a symbol shown in the key below.

Key for the 1997-98 Nine Target Students:

H1 = high-achieving student #1

H2 = high-achieving student #2

H3 = high-achieving student #3

A1 = average-achieving student #1

A2 = average-achieving student #2

A3 = average-achieving student #3

L1 = low-achieving student #1

L2 = low-achieving student #2

L3 = low-achieving student #3

For the 1998-99 school year I chose nine target students by their grades as in the year before. These students were chosen after the completion of the first semester so that I could use their testing scores as a measurement of their success. I will refer to them as a symbol shown in the key below.

Key for the 1998-99 Nine Target Students:

H4 = high-achieving student #4

H5 = high-achieving student #5

H6 = high-achieving student #6

A4 = average-achieving student #4

A5 = average-achieving student #5

A6 = average-achieving student #6

L4 = low-achieving student #4

L5 = low-achieving student #5

L6 = low-achieving student #6

The data in Figure 2 is a comparison of the 1997-98 nine target students' pretest scores, posttest scores, and their semester average test scores. Remember that these students were chosen by their grade in the class and for their consistent test scores and overall grade scores.

The nine 1997-98 target students did not show improvement in their posttest percentages when compared to the mean of their second semester test percentages. The average semester test score was 84.3%. Only three of the nine target students showed an increase in their posttest scores when compared to their average test scores. All of the

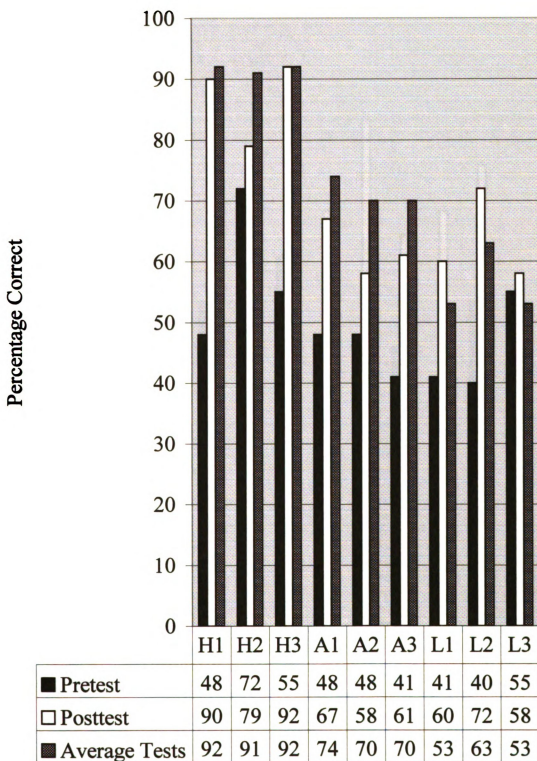


Figure 2 - Comparison of the 1997-98 Nine Target Students Test Scores

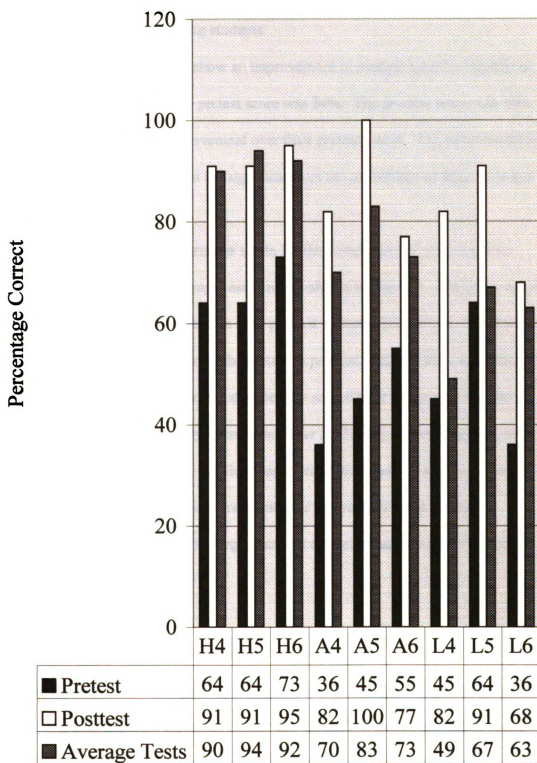


Figure 3 - Comparison of the 1998-99
NineTarget Students Test Scores

three were the low-achieving students. The method of teaching in this thesis could be beneficial to these lower-achieving students.

These target students did show an improvement in posttest scores compared to pretest scores. The class average pretest score was 54%. The posttest mean was 76%. A 24% increase shows a clear improvement over their pretest scores. The t-test results from the pretest and posttest shows that the significance or the probability of error to be less than 0.001%.

The nine 1998-99 target student's data for the comparison of pretest scores, posttest scores, and semester average test scores is shown in Figure 3. The entire target student group showed improvement on their posttest versus pretest scores. The lowest percentage increase when comparing the pretest to posttest is 22%, which was obtained by a high-achiever and is to be expected since they scored high on the pretest. The largest increase, 55%, is shown by average-achiever 2. The class average pretest score was a 53.8%, the posttest 86.3%, and the class average test scores first semester were 85.8%. These percents show an improvement over last years posttest scores (Figure 4). All of the nine 1998-99 target students did better on their posttest, just like in the previous year.

D. STUDENT QUESTIONNAIRES

At the end of the unit I gave all of my students in both years a questionnaire about the unit. The students were told to comment only on the last five (1997-98) or seven (1998-99) week unit, but some of them commented on things from the whole school year in 1997-98. Therefore, I could not include all the students' comments in my analysis

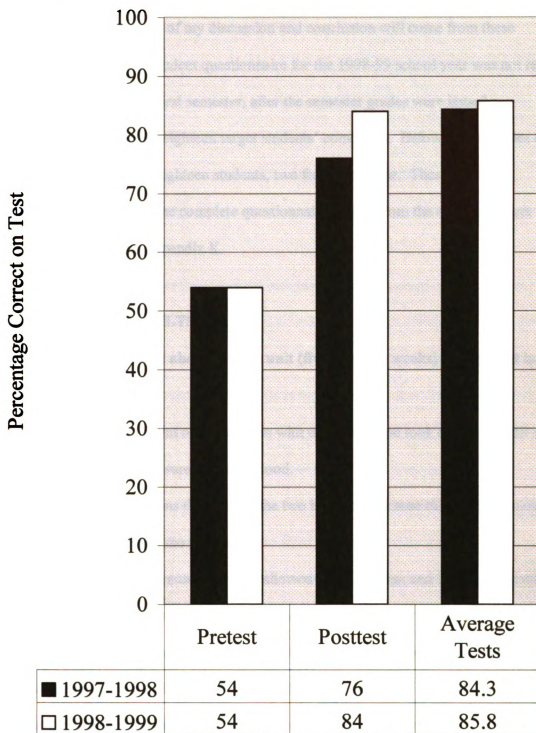


Figure 4 - Comparison of Pretest, Posttest and Average Test Scores for 1997-1998 and 1998-1999

unless it directly related to the new unit. I read all of my students' comments after the school year ended and some of my discussion and conclusion will come from these students' comments. The student questionnaire for the 1998-99 school year was not read until the completion of the first semester, after the semester grades were issued.

I analyzed all of my eighteen target students' comments. Below are examples of responses from four of the eighteen students, two from each year. These are representative responses. The complete questionnaire results from the eighteen target students can be found in Appendix K.

QUESTIONNAIRE RESULTS:

1. What did you like most about the last unit (five or seven weeks) that we did in class? Why?

A1 – I liked how you went over the notes with us in class and took the time on all of the information to make sure we understood.

L1 – I liked the dissections the most in the two last units because the visual learning involved in them helped me the most.

H4 – The dissections because you were allowed to really relax and have fun but still learn things. Also not having to write out the notes.

A4 – I liked the dissections the most. They were interesting because instead of seeing the pictures you could actually feel and see the body parts.

2. What did you like the least (about this unit)? Why?

H1 – The tests. They had too much information to cram for one test. I think they should have been broken up. I also didn't like plucking Fred, our pigeon.

A2 – The lack of reference in the book. The book couldn't really help with the questions on the labs. And not having the lab books to study from.

A4 – I didn't like the Classes and Orders. It takes me way more time than one night to remember that information.

A6 – The reading because it is time consuming.

3. What did you like about the tests? What didn't you like about the tests?

H3 – A test is a test; they are always the same. Either you know what you are talking about or you don't.

A1 – They were multiple choice and the essays were understandable(liked). They covered too much material and there was so much information to study that we never seemed to study the right things.

H5 – I liked the multiple choice on the test because I had a 25% chance. I liked the dissection labeling the least because you couldn't study for it.

L4 – What I liked about the tests was that most were multiple choice and if you studied, you should get it right if you have more options. I didn't like the long essay questions because some things we did, we didn't go over in class much.

4. Did the comparison of all the different Classes and systems make sense to you?

Was this hard to compare due to your lack of previous knowledge about different anatomical systems (like the circulatory or reproductive systems)?

A1 – Yes. It wasn't hard to compare, it just got a little confusing with organisms that are alike and when you ask a very specific question. There could be multiple answers as far as we know.

L1 – Most of the comparison made sense to me. This was hard because of my lack of previous knowledge.

H6 – I think if we took a test on two of them at a time we could spend more time and better retain information about the comparison. Yes, the comparisons of different Classes systems did make sense.

L5 – In some Classes the names made sense to me. Yes, due to some lack of knowledge, it was a bit difficult to make sense of things.

5. What would you have liked to seen done differently? Why?

H2 – An in-depth section about the human body would help a lot!

L1 – I would have liked smaller tests when we had to memorize Classes and such because there was a lot to memorize

H4 – Nothing, it is good. Nothing (was) outrageously hard but, nothing that was extremely easy.

A5 – It would be easier to learn if you taught amphibians, then everything about them

6. Were the labs helpful in your understanding of each unit?

A3 – Yes, I got to learn more hands on.

L3 – Yes, the labs were very helpful and aided in the understanding of the animals.

However, time constraints were very restraining.

H5 – Yes . The labs gave me an opportunity to see it in real life. Instead of our reading about a shark, we get to take one apart. Those types of things help.

L4 – Yes, because you could look at what you are studying more extensively.

7. Do you believe that this being the end of the year, that you did not apply yourself as well as you normally do?

H1 – I think this possibly occurred. It was just harder to push through everything and to concentrate solely on science things.

L1 – No, actually I worked harder to help bring my grade up.

8. Which do you prefer, going chapter by chapter or trying to see comparison and differences within the various vertebrate Classes (the way I did it)?

H2 – Comparisons would be OK if there wasn't so much (information) because there was so much, I probably preferred going by chapter instead.

A1 – I'd prefer to go by classes, but with more clarity. Some differences were so minuscule that people constantly got them mixed up.

H4 – Going by chapter. That way it is easier to keep clear which group has what.

L5 – Trying to see comparison and differences within the Classes.

9. Anything else you would like to say or comment on, put in here.

H1 – I enjoyed the last two units the best because they dealt with animals and systems.

A6 – The movies on the animals were both informative and interesting.

For the 1998-99 questionnaire, I did not have the students answer question 7, which asks about the unit being at the end of the year, since they did this unit at the beginning of the school year. I would have to say that in the 1998-99 year, my students were split on whether they liked going by chapter or the way the unit was set up, by systems. Most of the students that preferred the chapter method were my A and B students. Their main

reasoning was that then they could read along and knew exactly what to study. In 1997-98, most of my students liked the fact that we did the unit by a comparison method. They enjoyed this more due to it being at the end of the school year and that it wasn't the same thing they had been doing all year.

DISCUSSION AND CONCLUSION

After reading all my students' questionnaires and listening to comments that they made throughout the unit, I know that this unit taught them a lot (see Figures 1–4). I was disappointed that the 1997-98 posttest scores for most of my nine target students were lower than their average test scores. On the other hand, I was surprised that two of my low-achieving students performed better than average. I would assume that this approach might be a better method of relaying information to this group of students. Overall, I do believe that they liked the way the unit was taught and most agreed that they liked the comparison of anatomical systems method better than the chapter by chapter method of organism method in the 1997-98 school year. In the 1998-99 school year, they had nothing to base this on since it was the first unit that they did.

I was very pleased with the results of the 1998-99 posttest. I believe that the unit taught my students a great deal. All of my students did very well on this unit and most of them did better on the posttest compared to their average test scores. I believe that this unit could become one of my favorites with a few more refinements, which I will discuss later in this section.

The one piece of information that I did get from hard data was that both classes scored the same percentage on their pretest, a 54%. I did not notice this information until I was looking at the graph from Table 4. I was quite surprised about this information. I can conclude that whether the test was multiple-choice or a free response form, most of my students came into my classroom with approximately the same basic biology knowledge.

From many of my student's comments on their questionnaires, I learned that previous knowledge of the anatomical system was lacking. I have only been teaching in this school district for two and a half years, and I have assumed that vertebrate body systems were taught in the junior high level. As we proceeded into this unit, I realized through conversation, group discussions, and tests that they had a lot of misconceptions about anatomical function and structure within different groups of animals. They also had a lack of knowledge regarding certain anatomical systems. For example, one of my students did not know that blood cells were produced inside the bone marrow of their bodies and the functions of the different type of blood cells. This is only one example of a misconception; many of the students had more. Because these are advanced biology students, or college preparatory tenth graders, their lack of knowledge of some basic biology surprised me.

A. ASPECTS OF THE UNIT EFFECTIVE IN CONVEYING KEY INFORMATION

The most effective aspects of the unit were the notes that I wrote in advance and handed out and the animal laboratory dissections with questions that accompanied this unit. This analysis is based on my discussion with students and the answers to the questionnaires that they all filled out. The notes were typed and given to students to save time. I do not usually like to simply give my students notes that I prepared as a hand out. I believe students learn more from participating. My students found the notes to be useful, because they did not 'waste' their time taking notes and they could pay attention to me as I discussed the content. I received positive comments about the notes on their

questionnaires. I found the notes to be helpful because I could get my students to focus on some key ideas that I wanted to emphasize.

In the 1998-99 school year, the notes were redesigned to leave out key words and ideas so that the students had to follow along and listen. I had many positive comments on the notes in the students' questionnaires in this year also. I found these notes made the students more involved and pay attention better than did the previous years notes.

From the discussion based on these notes, I noticed a lack of basic knowledge among my students about some parts of anatomical systems. For example, during our discussion of the reproductive system in the 1997-98 school year, one of my male students did not know what the gestation period was for a human. I was shocked to learn this. We ended up spending an extra half an hour going over the human reproductive system and the process of birth. I had no problem with spending the time going over the human reproductive system, but it made me realize that only some of my students had any background about anatomical systems. After this discussion, I asked if any of them had gone over the human body systems in the junior high and only one-third raised their hands. Those students that had some previous knowledge all had the same teacher.

The students did say in conversation with me that the slides were helpful but were hard to see. They said it helped them identify certain structures that they otherwise would have had a hard time identifying during the dissections.

The animal dissections were extremely engaging for my students and myself. I found their enthusiasm to be very uplifting. The students would have liked more time to dissect the pigeon and dogfish shark in the 1997-98 school year, but time restrictions did not permit this. They also found the chicken wing dissection to be interesting as they

looked at the muscles and tendons. They got to break the bone and see its interior, which many had never seen or noticed before the 'blood' on the inside.

The fetal pig and frog dissection was added in the 1998-99 school year and enjoyed by most. Out of all the animals, the fetal pig was hard for many because they see it more as a pet. I was glad to be able to incorporate one organism from each Class to dissect in this unit.

A suggestion made by a 1998-99 student on her questionnaire about dissections made me wonder. The suggestion she made was that it would be more beneficial to dissect each animal per system as we were discussing that specific system. I think this would be beneficial but I have no idea how to keep the animals from rotting within the seven-week time frame.

B. ASPECTS OF THE UNIT THAT NEED IMPROVEMENT AND STRATEGIES USED FOR MAKING CHANGES

There are many things about this unit that I would like to refine. I believe the idea of teaching various vertebrate Classes by comparing their anatomical systems to be a good one, but improvements must be made to do this unit well. These include:

1. More time to teach this unit. I believe 6 to 7 weeks would be a more effective time frame. I felt too rushed to effectively teach the material. The students must have felt this also. This was accomplished in the 1998-99 school year.
2. More time for dissections, not just 1 or 2 days to study an animal's anatomical systems. Some students asked for more time and I could not allow it because of the time restrictions in 1997-98. More time was given to dissections in the 1998-99

school year. If our school district changes the class schedule to a block schedule format, this would also allow for more time dissecting. This is a possibility for the 2000-2001 school year.

3. Since there was a lot of information in the unit, I would like to break the tests up into smaller tests or quizzes. I probably will put the Classes and Orders on a quiz by themselves. It was too much information for my students to retain with all the other information I asked them to learn. The Classes and Orders were made into a quiz for the 1998-99 school year. The other information will be made into smaller tests for the year 1999-2000.
4. I would like to find some supplementary reading material, which would accompany the book and explain the additional information that I included in their notes. I have yet to find anything worthwhile.
5. Dissecting a mammal (a cat or fetal pig) would have been helpful to compare and contrast anatomical systems. This was accomplished in the 1998-99 school year. I hope to have one representative animal for each Class.
6. Small laboratory groups would have been helpful. I had anywhere from 3 to 7 students at a station due to a small number of animals to dissect. I would like to have 2 or 3 students per animal. When the group gets too large, less learning and more talking goes on. Usually in a large group only 2 people end up doing the dissection. Unfortunately, this situation is brought about by the number of students placed in my classroom and the lack of money in our science department's budget. I am hoping to have the opportunity to go on the Internet and to find dissections that my students would be able to access in our computer classroom. This should put less strain on

department's budget. I would still include 2 or 3 vertebrate animal dissections in the unit.

7. Since most of my students commented that they did not have a sufficient background in the different anatomical systems, I will probably have to change the notes by going through each anatomical system in more detail and providing more background information by explaining the different organs and their functions. This may be more helpful if I went through the systems of the human body first so there may be a correlation between them and other vertebrate organisms. I am hoping to include this in the school year 1999-2000. This would mean that I would have to redesign some of the notes and develop additional notes to be used in the beginning of the unit.
8. I did not get enough information from the multiple-choice pretest given in the 1997-98 school year so for the 1998-99 school year I changed the pretest to a free response instrument. I found this to be a much better tool to look for misconceptions, misunderstandings, or no previous knowledge of students, even though the students scored the same on both instruments.
9. I would like to write my own laboratory dissection manuals to accompany the dissections that my class participates in, so I would have just the right amount of information for them to learn and study. My students would also be able to take one of these manuals home for their own personal use.

C. OVERALL EVALUATION

I did not see much difference in my student's learning in this unit compared to other units taught in the 1997-98 school year. I do think the idea of teaching my students

Classes of vertebrates on a comparative basis is a good one, but I would have to change a lot of parts of the unit to make it much better, as I stated in the previous list. My students liked the comparison style because it was different than the way we normally went through a chapter. By having to make comparisons the students had to have some previous knowledge of anatomical systems. Many of my students did not have a point from which to start, which was unfortunate for the success of the unit. Like all new units, a lot of refinement is needed until you believe that the content that you are covering is worthwhile and meets your objectives.

There are still some refinements needed to make this unit a great one. I would still like to administer the tests over only two systems at a time and find some more supplemental reading for my students. I have looked through many high school textbooks, but none of them cover anatomical systems by comparison of the Classes. My book does have one chapter that compares the anatomical systems but this would follow chapters pertaining to each Class.

I believe that the improvements made in the 1998-99 school, listed previously, helped to make the unit a success. I noticed a change in how the ideas were perceived and more time was spent learning. The number one improvement was not having a time restriction. The seven weeks allowed me to spend more time teaching, dissecting, and questioning the students thought processes. I enjoyed this unit more this year because there were no time restrictions. I was more prepared and wanted the unit to succeed. And succeed it did.

APPENDICES

APPENDIX A

APPENDIX A

Teacher Generated Notes—1997-1998

I. Classification of Vertebrates

Kingdom Animalia

Phylum Chordata

-Notochord and pharyngeal gill slits during at least part of development; hollow dorsal nerve cord

Subphylum Vertebrata

-most possess a vertebral column (backbone) that supports and protects dorsal nerve cord; endoskeleton; distinct head with a skull and a brain

A. Superclass Agnatha—jawless fish (A & B only)
-long eel-like bodies and a circular mouth

1. Class Myxini—hagfish
2. Class Cephalaspidomorphi—lamprey
3. Class Chondrichthyes—cartilaginous fish
 - a. sharks, rays and skates
4. Class Osteichthyes—bone-bearing fish
 - a. most fish: perch, blue-gill, salmon
5. Class Amphibia—
 - a. Order Urodela—salamanders
 - b. Order Anura—frogs and toads
 - c. Order Apoda—legless amphibians
6. Class Reptilia
 - a. Order Rhynchocephalia—*tuatara* (only species left)
 - b. Order Squamata—lizards and snakes
 - c. Order Crocodilia—crocodiles and alligators
 - d. Order Chelonia—turtles

7. Class Aves—birds
-about 27 orders (you don't have to know these—YEAH!!)

8. Class Mammalia

- a. Order Monotremata—(monotremes)—egg laying mammals
-duck billed platypus, spiny anteater
- b. Order Marsupalia—pouched mammals
-opossum, kangaroo, and koals

Placental Mammals:

- c. Order Insectivora—insect eating mammals
- d. Order Chiroptera—bats
- e. Order Primates—monkey, chimpanzee, human
- f. Order Edentata—anteater, armadillo
- g. Order Lagomorpha—rabbit, pika, hare
- h. Order Rodentia—rat, beaver, guinea pig, hamster, gerbil, squirrel
- i. Order Cetacea—whale, porpoise, dolphin
- j. Order Carnivora—dog, seal, cat, bear, raccoon, weasel, skunk, panda
- k. Order Proboscidea—elephants
- l. Order Perissodactyla—horse, donkey, rhinoceros, tapir
- m. Order Sirenia—manatee, sea cow
- n. Order Artiodactyla—sheep, cow, hippopotamus, antelope, camel giraffe, pig

II. External Morphology

A. Fish Skin (p. 687 bottom)

1. Scales—modified epidermal skin and fins
2. Mucous glands—within the epidermis
 - a. protects from drying out
 - b. capture prey
 - c. keeps appropriate internal environment
3. Photophore—light emitting organ in epidermis and invade dermis
4. No keratin—a protein

B. Amphibians Skin (p. 692-695 and 700-701)

1. Mucous glands within dermis
 - a. protects from drying out when on land
2. Granular glands—found in terrestrial toads
 - a. poisonous or
 - b. noxious (rotten smelling or irritating)
3. Keratin—not found in aquatic animals
 - a. require a moist habitat

C. Reptiles Skin (p. 707-710 and 715-719)

1. Granular glands—produce either:
 - a. poisonous or noxious smell
 - b. pheromones—substance that affects the behavior or physiology of other organisms
 - (1) examples: crocodiles-along the back; lizards-encircle vent, smear it on trees to attract insects
2. Epidermal scales—thick skin layers
 - a. overlapping
 - b. new scale developing underneath (4-5 layers thick)
 - c. protection—against abrasion (offensively and defensively)
 - d. helps to thermoregulate
3. Crocodiles—small heavily thickened, non-overlapping scales.
4. Turtles—large thin quadrilateral or polygonal scales called SCUTES.
Small non-overlapping scales elsewhere
5. Lizards and Snakes—two distinctive layers
 - a. inner layer getting thickened
 - b. outer layer, hardened which will eventually molt
6. No molting in crocodiles and turtles. Skin will eventually wear off like human

D. Aves Skin—Birds (p. 723-725)

- 1. Covered of Feather and leg scales**
 - a. thin integument of epidermis and dermis**
 - b. no sweat glands**
 - c. oil or preen gland at base of tail**
 - d. pinna of ear rudimentary**
 - e. molt usually once a year after nesting**

E. Mammals Skin (p. 737-739)

- 1. Body covered with hair; reduced in some**
- 2. Skin contains sweat, scent, sebaceous (oil) and mammary (milk producing) glands**

III. Muscular Systems

A. Control of Muscles – 2

1. Voluntary—you control
 - a. striated muscle—looks striped
 - (1) contains many nuclei
 - (2) complete coat of this muscle lies beneath skin
 - (3) divided into dorsal and ventral parts
 - (4) major function is to move skeleton, or close openings in tissue (mouth, eyes, etc)
 - (5) contraction takes place due to nerve cell
 - (6) made up of thick/thin filaments that alternate
 - (a) thick – myosin
 - (b) thin – actin
2. Involuntary—controlled by brain
 - a. smooth muscle—NOT striated
 - (1) single nuclei
 - (2) digestive tract and internal organs
 - (3) in skin
 - (4) cardiac muscle—special type, found only in heart
 - (a) one nuclei
 - (b) found ONLY in the heart
3. General information
 - a. all muscles are surrounded by a delicate connective tissue sheath
 - b. muscle names can be based on shape (ex. Deltoid), function, origin, or fanciful resemblance
 - c. muscle system have become more specific and specialized as you progress through the animals

B. Attachment Points and Actions of Muscles

1. Tendon—bone to connective tissue
2. Ligament—muscle to muscle
3. Actions: specific movement is its function or action: work in pairs
 - a. flexion—bending of a joint
 - b. extension—opposite of a flex; straighten out joint
 - c. adduction—drawing limb toward midline
 - d. abduction—away from midline
 - e. rotation—rotate a limb
 - f. elevation (levator)—closing of jaw
 - g. depression—opening of lower jaw
 - h. constriction—compressing an opening

C. Muscle Arrangement

1. Parallel
 - a. provides the greatest possible excursion of the insertion with minimum nonphysiological loss of power during contraction

2. Pinate-fibered

- a. advantageous—more muscles fibers, therefore more power in a given volume

D. Types of Muscle—3

1. White

- a. large diameter
- b. not a lot of blood flow to
- c. low fat

2. Red

- a. small diameter
- b. gets a lot of blood flow
- c. high fat

3. Intermediate—mixture between red and white

- a. mixture of the two above

IV. Skeletal System

A. Skeletal System of all Classes

- 1. Jawless Fish**
 - a. fibrous and cartilaginous skeleton
 - b. notochord persistent
 - c. no vertebrae
- 2. Chondrichthyes**
 - a. entire cartilage skeleton
- 3. Osteichthyes**
 - a. skeleton bony
 - b. vertebrae numerous; end near base of fish
 - c. tail with upper and lower lobes symmetrical
- 4. Amphibia**
 - a. bony in most
 - b. vary in amount of vertebrae in each species
 - c. ribs present in some, absent or fused to vertebrae in others
- 5. Reptilia**
 - a. skeleton well ossified or becomes bony
 - b. ribs with sternum (except in snakes) which form a complete thoracic
 - c. skull with one occipital condyle-an attachment point between skull and backbone
- 6. Aves**
 - a. fully ossified skeleton with air cavities
 - b. skull bones fused with one occipital condyle
 - c. each jaw covered with a horny sheath, forming a BEAK
 - d. no teeth
 - e. ribs with strengthening processes
 - f. tail not elongated
 - g. sternum well developed with KEEL or reduced with no keel
(1) muscles attached here
 - h. single bone in middle ear

- 7. Mammals**
 - a. skull with 2 occipital condyles and secondary bony palate (mouth region)**
 - b. middle ear with 3 tiny bones**
 - (1) malleus**
 - (2) incus**
 - (3) stapes**
 - c. 7 cervical vertebrae**
 - d. pelvic bone fused**

V. Nervous System

A. Basic role

1. acquaints the organism with its external environment and stimulates the organisms to orient itself favorably in that environment
2. participates in regulation of internal environment - homeostasis
3. serves as storage site for information

B. Parts of N.S.

1. nerves
2. spinal cord
3. brain in association with
 - a. receptor – sense organs
 - b. effectors – muscles and glands

C. Division of N.S.

1. Central N.S. – brain and spinal cord
2. Peripheral N.S. – cranial

D. Classes

1. Jawless Fish
 - a. dorsal nerve cord with differentiated brain
 - b. 8 to 10 cranial nerves
2. Chondrichthyes
 - a. brain with 2 olfactory lobes – (smell)
 - b. two cerebral hemispheres (controls behavior)
 - c. 2 optic lobes (sight)
 - d. cerebellum (regulates conscious functions like movement)
 - e. medulla oblongata (breathing and heart rate: unconscious functions)
 - f. 10 pairs of cranial nerves
 - g. 3 pairs of semicircular canals
 - (1) sense of smell
 - (2) vibration reception (lateral line system)
 - (3) electroreception – well developed
3. Osteichthyes
 - a. brain with:
 - (1) small olfactory lobes
 - (2) cerebrum
 - (3) large optic lobes
 - (4) cerebellum
 - (5) 10 pairs of cranial nerves

4. Amphibians
 - a. small brain well developed
 - (1) 10 pairs of cranial nerves
 - (2) olfactory lobes more sensitive
5. Reptiles
 - a. more specialized than amphibians
 - b. optic lobes on dorsal side of brain
 - c. 12 pairs of cranial nerves
 - d. small brain
 - (1) cerebrum **larger relative** to the rest of the brain
 - e. Jacobson's organ -
 - (1) a specialized olfactory chamber present; highly developed in lizards and snakes
 - (2) odors carried to Jacobson's organ by the tongue
6. Aves
 - a. well developed
 - b. 12 pairs of cranial nerves
7. Mammals
 - a. Most developed brain; cerebrum highly developed
 - b. 12 pairs of cranial nerves

VI. Reproductive Systems

A. Reproductive Structures

- 1. Ovaries**
 - a. produce eggs**
 - b. eggs are discharged into the ovarian cavity by the oviducts**
- 2. Testes**
 - a. small unless in mating season, except in placental mammals**
 - b. produce sperm**
 - (1) more numerous by millions**
 - (2) move by flagella**
 - c. flow into seminiferous tubules before leaving the body**

B. Classes

- 1. Jawless Fish**
 - a. external fertilization**
 - b. both ovaries and testes present, but only one is functional**
- 2. Chondrichthyes (sharks and rays)**
 - a. separate sexes**
 - b. internal fertilization**
 - c. direct development**
 - d. types of development could be (three):**
 - (1) oviparous – eggs released outside of female and development of offspring occurs outside the maternal body**
 - (2) ovoviviparous – eggs are developed within the maternal body without the additional nourishment from the parent or hatch within the parent or after laying**
 - (3) viviparous – eggs develop within the female body, with nutritional aid of maternal parent; offspring are born as juveniles**
- 3. Osteichthyes (bony fish)**
 - a. fertilizations usually external**
 - b. sexes separate**
 - c. gonads paired**
 - d. most produce a cyst of sperm; after spawning sex organs collapse until next year**

- 4. **Amphibians**
 - a. **separate sexes**
 - b. **internal fertilization**
 - (1) **salamanders and legless amphibians**
 - c. **external fertilization**
 - (1) **frogs and toads**
 - d. **eggs yolky with jelly-like membrane coverings**
- 5. **Reptiles**
 - a. **separate sexes**
 - b. **internal fertilization**
 - c. **eggs covered with a calcareous or leathery shells;**
 - (1) **extra embryonic membranes (amnion, chorion, allantois) present during embryonic life**
 - (2) **supports young with nourishment during development**
 - d. **no larval stages**
- 6. **Birds**
 - a. **separate sexes**
 - (1) **females have left ovary and oviduct only**
 - (2) **males have paired testes**
 - b. **internal fertilization**
 - c. **amniotic egg with much yolk and hard calcareous shells**
 - e. **incubation external**
 - (1) **young active at hatching**
 - (2) **or helpless and naked**
 - f. **sex determination by female**
- 7. **Mammals**
 - a. **separate sexes**
 - b. **internal fertilization**
 - (1) **embryos develop in uterus with a placental attachment**
 - (a) **placenta absent in monotremes (egg-laying mammals)**
 - (b) **undeveloped in marsupials**
 - (2) **ovulation (release of eggs) controlled by hormone, **estrogen****
 - (3) **after ovulation, hormone **progesterone** alters egg so that it may be fertilized**
 - c. **fetal membranes (three)**
 - (1) **amnion**
 - (2) **chorion**
 - (3) **allantois**
 - d. **young nourished by milk from **mammary glands****

VII. Circulatory System

Blood carries oxygen from lungs; nutrients from digestive track and storage sites; hormones and immunity to disease; and wastes to create homeostasis within the body.

A. Consists of

1. heart – pump with highly muscular walls made of cardiac muscle

B. Arteries

1. carry blood away from heart
2. muscular and elastic
3. dilate and constrict reflexly; regulate blood pressure
4. valves to stop back flow
5. arterioles – small arteries

C. Veins (or venous sinuses)

1. carry blood to heart
2. less muscle and elastic tissue; more fibrous tissue can't constrict
3. have valves to stop back flow
4. veinules-small veins

D. Capillaries

1. cell walls – one layer thick
2. blood cells go through single file

E. Blood

1. Connective tissue

Human blood is: 55% plasma, 45% cells (red, white and platelets), 90% oxygen, and 10% dissolved solids

2. Red Blood Cells (erythrocytes)

Oval nucleated in most vert.

No nuclei in most

Contain iron protein: **hemoglobin** which oxygen attaches to

Produces in center of long bones in red bone marrow

Average life under on month

25 trillion RBC in human body

3. WBC (leukocytes)

Less numerous

Abundant in lymph nodes and other lymphatic tissue

Source on antibodies, fight infection and disease

4. **Platelets (thrombocytes)**
 Cell pieces involved in clotting
 Cell fibrinogen in to help clot
 5-10% body weight of amphibians, reptiles, birds and mammals
 1.5-30% body weight of fishes

Classes

A. Fish

1. 2 chambered heart-atrium (upper), and ventricle (lower)
2. single loop system: (heart to gills to body parts to heart)
3. aortic arches in most
4. bony fish have arterial and venous system
5. **ectothermic** – cold blooded

B. Amphibians

1. 3 chambered heart (left and right atrian, ventricle)
2. double loop circulation: through heart, goes to lungs and back to heart and then to the rest of the body
3. skin abundantly supplied with blood vessels
4. **ectothermic**

C. Reptiles

1. three chambered heart
2. double loop circulatory
3. usually one pair of aortic arteries
4. crocodiles (4 chambered heart) mix deoxygenating and oxygenated
5. **ectothermic**

D. Aves

1. 4 chambered heart (2 atria and 2 ventricles)
2. double loop circulatory system
3. aortic arch is well defined
4. nucleated red blood cells
5. **endothermic** – warm blooded

E. Mammals

1. 4 chambered heart
2. double loop
3. well defined left aorta
4. red blood cells
 - a. nonnucleated when mature
 - b. biconcave – (shape)
5. **endothermic**

VIII. Respiratory System

A. Chief organs in adult vertebrates

1. External or Internal gills-
 - a. water enters and leaves through gill slits (1-7 slits)
 - b. surrounded by the operculum, protective gill covering
 - c. visible and line up in rows
 - d. water is drawn across gills that contain many blood vessels
2. Swim Bladder
 - a. may be paired or unpaired
 - b. connects to esophagus and lies close to kidneys
 - c. composed of elastic tissue and smooth muscle
 - d. used chiefly as a hydrostatic organ
 - (1) if the volume goes up or down, it alters the specific gravity of the fish, thereby increasing or decreasing its buoyancy
3. Lungs
 - a. main point of gas exchange in most terrestrial species
 - b. oxygen passes through the trachea into the bronchial tubes and eventually to the alveoli
 - c. at the alveoli is the point where oxygen and carbon dioxide is exchanged with the capillaries
 - d. become more complex as you progress through the vertebrates
 - e. lungs are unequal in size
 - f. one may be absent, usually paired
4. Skin
 - a. extensive in or out of the water by amphibians (90% excreted through their skin) and fish that lack scales
 - b. release urea through pores

B. Classes

1. Jawless Fish
 - a. 5-16 pairs of gills and a single pair of gill apertures in hagfish
 - b. 7 pairs in lamprey
2. Chondrichthyes
 - a. 5-7 pairs of gills with separate and exposed gill slits
 - b. no operculum
 - c. no swim bladder or lung

3. Osteichthyes
 - a. gills supported by bony gill arches and covered by operculum
 - b. swim bladder often present with or without duct connected to pharynx
4. Amphibians
 - a. lungs (absent in some salamanders)
 - b. skin
 - c. gills in some, either separately or in combination with the two above
5. Reptiles
 - a. lungs
 - b. NO gills
 - c. Cloaca used for respiration by some
 - (1) posterior chamber of digestive tract, receiving feces and urogenital products
6. Aves
 - a. slightly expansible lungs, with thin air sacs among the organs and skeleton
 - b. syrinx (voice box) near junction of trachea and bronchi
7. Mammals
 - a. lungs with alveoli and voice box (larynx)
 - c. soft tissue separates the air and food passages
 - d. muscular diaphragm for air exchange separates thoracic and abdominal cavities
 - (1) contracts-expels air
 - (2) relaxes-lungs fill with air

APPENDIX A

Teacher Generated Notes—1998-1999

I. External Morphology

A. Fish Skin (p. 687 bottom)

1. _____ - modified epidermal skin and fins
2. Mucous glands—within the epidermis
 - a. protects from drying out
 - b. capture prey
 - c. keeps appropriate internal environment
3. _____—light emitting organ in epidermis and invade dermis
4. No keratin—a protein

B. Amphibians Skin (p. 692-695 and 700-701)

1. Mucous glands within dermis
 - a. protects from drying out when on land
2. _____—found in terrestrial toads
 - a. _____
 - b. _____ (rotten smelling or irritating)
3. Keratin—not found in aquatic animals
5. _____

C. _____ (p.707-710 and 715-719)

1. Granular glands—produce either:
 - a. poisonous or noxious smell
 - b. _____

(1) examples: crocodiles-along the back; lizards-encircle vent, smear it on trees to attract insects
2. _____—thick skin layers
 - a. _____
 - b. new scale developing underneath (4-5 layers thick)
 - c. _____—against abrasion (offensively and defensively)
 - d. _____
3. Crocodiles—small heavily thickened, non-overlapping scales.
4. Turtles—_____

5. Lizards and Snakes—two distinctive layers
 - a. inner layer getting thickened
 - b. outer layer, hardened which will eventually molt
6. _____

D. Aves Skin—Birds (p. 723-725)

1. Covered of Feather and leg scales

a. thin integument of epidermis and dermis

b. _____

c. _____

d. pinna of ear rudimentary

e. _____

E. Mammals Skin (p. 737-739)

1. _____

2. _____

II. Muscular Systems

A. Control of Muscles – 2

1. _____—you control
 - a. striated muscle—looks striped
 - (1) _____
 - (2) complete coat of this muscle lies beneath skin
 - (3) divided into dorsal and ventral parts
 - (1) _____
 - (5) _____
 - (6) made up of thick/thin filaments that alternate
 - (a) _____
 - (b) _____
2. Involuntary—controlled by brain
 - a. _____—NOT striated
 - (1) single nuclei
 - (2) digestive tract and internal organs
 - (3) _____
 - (4) _____-special type, found only in heart
 - (a) one nuclei
 - (b) _____
3. General information
 - a. _____
 - b. muscle names can be based on shape (ex. Deltoid), function, origin, or fanciful resemblance
 - c. muscle system have become more specific and specialized as you progress through the animals

B. Attachment Points and Actions of Muscles

1. _____—bone to connective tissue
2. Ligament—_____
3. Actions: specific movement is its function or action: work in pairs
 - a. flexion—bending of a joint
 - b. _____—opposite of a flex; straighten out joint
 - c. adduction—drawing limb toward midline
 - d. abduction—away from midline
 - e. rotation—_____
 - f. elevation (levator)—closing of jaw
 - g. _____—opening of lower jaw
 - h. constriction—compressing an opening

- C. _____
1. _____
 - a. provides the greatest possible excursion of the insertion with minimum nonphysiological loss of power during contraction
 2. _____
 - a. advantageous—more muscles fibers, therefore more power in a given volume
- D. Types of Muscle—3
1. White
 - a. _____
 - b. not a lot of blood flow to
 - c. _____
 2. _____
 - a. small diameter
 - b. gets a lot of blood flow
 - c. _____
 3. Intermediate—mixture between red and white
 - a. mixture of the two above

Advanced Biology

Read pages: 713-714, 728, 743, and 837-842

III. Skeletal System

A. Skeletal System of all Classes

1. _____
 - a. fibrous and cartilaginous skeleton
 - b. notochord persistent
 - c. _____
2. Chondrichthyes
 - a. _____
3. Osteichthyes
 - a. _____
 - b. _____
 - c. tail with upper and lower lobes symmetrical
4. Amphibia
 - a. _____
 - b. vary in amount of vertebrae in each species
 - c. _____
5. Reptilia
 - a. skeleton well ossified or becomes bony
 - b. _____
 - c. skull with one occipital condyle-an attachment point between skull and backbone
6. _____
 - a. _____
 - b. skull bones fused with one occipital condyle
 - c. each jaw covered with a horny sheath, forming a BEAK
 - d. _____
 - e. ribs with strengthening processes
 - f. tail not elongated
 - g. _____
 - (1) _____
 - h. single bone in middle ear

7. _____
- a. skull with 2 occipital condyles and secondary bony palate (mouth region)
 - b. middle ear with 3 tiny bones
 - (1) _____
 - (2) _____
 - (3) _____
 - c. 7 cervical vertebrae
 - d. _____

IV. Reproductive Systems

A. _____

- 1. Ovaries**
 - a. produce eggs**
 - b. _____**
- 2. _____**
 - a. small unless in mating season, except in placental mammals**
 - b. produce sperm**
 - (1) _____**
 - (2) _____**
 - c. flow into seminiferous tubules before leaving the body**

B. Classes

- 1. _____**
 - a. external fertilization**
 - b. both ovaries and testes present, but only one is functional**
- 2. Chondrichthyes (sharks and rays)**
 - a. _____**
 - b. internal fertilization**
 - c. direct development**
 - d. _____**
 - (1) _____ – eggs released outside of female and development of offspring occurs outside the maternal body**
 - (2) _____ – eggs are developed within the maternal body without the additional nourishment from the parent or hatch within the parent or after laying**
 - (3) _____ – eggs develop within the female body, with nutritional aid of maternal parent; offspring are born as juveniles**
- 3. Osteichthyes (bony fish)**
 - a. fertilizations usually external**
 - b. _____**
 - c. _____**
 - d. most produce a cyst of sperm; after spawning sex organs collapse until next year**

4. _____
 - a. **separate sexes**
 - b. **internal fertilization**
 - (1) _____
 - c. _____
 - (1) _____
 - d. **eggs yolky with jelly-like membrane coverings**

5. **Reptiles**
 - a. **separate sexes**
 - b. _____
 - c. **eggs covered with a calcareous or leathery shells;**
 - (1) _____
 - (2) **supports young with nourishment during development**
 - d. _____

6. **Birds**
 - a. **separate sexes**
 - (1) _____
 - (2) _____
 - b. **internal fertilization**
 - c. **amniotic egg with much yolk and hard calcareous shells**
 - d. _____
 - (1) **young active at hatching**
 - (2) **or helpless and naked**
 - e. _____

7. _____
 - a. **separate sexes**
 - b. **internal fertilization**
 - (1) _____
 - (a) **placenta absent in monotremes (egg-laying mammals)**
 - (b) **undeveloped in marsupials**
 - (2) _____
 - (3) **after ovulation, hormone progesterone alters egg so that it may be fertilized**
 - c. **fetal membranes (three)**
 - (1) _____
 - (2) _____
 - (3) _____
 - d. **young nourished by milk from mammary glands**

V. Respiratory System

A. Chief organs in adult vertebrates

1. _____
 - a. water enters and leaves through gill slits (1-7 slits)
 - b. _____
 - c. visible and line up in rows
 - d. _____
2. Swim Bladder
 - a. _____
 - b. connects to esophagus and lies close to kidneys
 - c. _____
 - d. used chiefly as a hydrostatic organ
(1) _____

3. Lungs
 - a. _____
 - b. oxygen passes through the trachea into the bronchial tubes and eventually to the alveoli
 - c. _____
 - d. become more complex as you progress through the vertebrates
 - e. lungs are unequal in size
 - f. _____
4. _____
 - a. extensive in or out of the water by amphibians (90% excreted through their skin) and fish that lack scales
 - b. _____

B. Classes

1. _____
 - a. 5-16 pairs of gills and a single pair of gill apertures in hagfish
 - b. 7 pairs in lamprey
2. Chondrichthyes
 - a. 5-7 pairs of gills with separate and exposed gill slits
 - b. _____
 - c. _____
3. _____
 - a. _____
 - b. swim bladder often present with or without duct connected to pharynx

4. Amphibians

- a. _____
- b. skin
- c. _____

5. Reptiles

- a. _____
- b. _____
- c. Cloaca used for respiration by some
(1) _____

6. Aves

- a. slightly expansible lungs, with thin air sacs among the organs and skeleton
- b. _____

7. Mammals

- a. _____
- b. soft tissue separates the air and food passages
- c. _____

(1) contracts-expels air
(2) _____

VI. Nervous System

A. Basic role

1. acquaints the organism with its external environment and stimulates the organisms to orient itself favorably in that environment
2. participates in regulation of internal environment - _____
3. serves as storage site for information

B. Parts of N.S.

1. _____
2. spinal cord
3. brain in association with
 - a. _____
 - b. effectors – muscles and glands

C. Division of N.S.

1. Central N.S. - _____
2. Peripheral N.S. - _____

D. Classes

1. _____
 - a. dorsal nerve cord with differentiated brain
 - b. 8 to 10 cranial nerves
2. Chondrichthyes
 - a. brain with 2 olfactory lobes – (smell)
 - b. _____
 - c. 2 optic lobes (sight)
 - d. cerebellum (_____)
 - e. medulla oblongata (_____)
 - f. 10 pairs of cranial nerves
 - g. 3 pairs of semicircular canals
 - (1) _____
 - (2) vibration reception (lateral line system)
 - (3) _____
3. _____
 - a. brain with:
 - (1) small olfactory lobes
 - (2) cerebrum
 - (3) _____
 - (4) cerebellum
 - (5) _____

4. Amphibians

- a. _____
 - (1) 10 pairs of cranial nerves
 - (2) olfactory lobes _____

5. Reptiles

- a. more specialized than amphibians
- b. _____
- c. 12 pairs of cranial nerves
- d. _____
 - (1) cerebrum **larger relative** to the rest of the brain
- e. _____
 - (1) a specialized olfactory chamber present; highly developed in lizards and snakes
 - (2) odors carried to Jacobson's organ by the tongue

6. _____

- a. well developed
- b. 12 pairs of cranial nerves

7. Mammals

- a. _____
- b. 12 pairs of cranial nerves

VII. Circulatory System

Blood carries oxygen from lungs; nutrients from digestive track and storage sites; hormones and immunity to disease; and wastes to create homeostasis within the body.

A. Consists of

1. heart - _____

B. _____

1. carry blood away from heart
2. _____
3. dilate and constrict reflexly; regulate blood pressure
4. valves to stop back flow
5. _____

C. Veins (or venous sinuses)

1. _____
2. less muscle and elastic tissue; more fibrous tissue can't constrict
3. _____
4. veinules-small veins

D. Capillaries

1. _____
2. blood cells go through single file

E. _____

1. _____
Human blood is: 55% plasma, 45% cells (red, white and platelets), 90% oxygen, and 10% dissolved solids

2. Red Blood Cells (_____)
Oval nucleated in most vert.

Contain iron protein: _____
Produces in center of long bones in red bone marrow
Average life under on month

3. WBC (_____)
Less numerous
Abundant in lymph nodes and other lymphatic tissue

4. Platelates (_____)

Cell pieces involved in clotting

5-10% body weight of amphibians, reptiles, birds and mammals

1.5-30% body weight of fishes

Classes

A. Fish

1. _____-atrium (upper), and vertricle (lower)
2. _____ (heart to gills to body parts to heart)
3. aortic arches in most
4. bony fish have arterial and venous system
5. _____

B. Amphibians

1. _____ (left and right atrian, ventricle)
2. _____ : through heart, goes to lungs and back to heart and then to the rest of the body
3. skin abundantly supplied with blood vessels
4. _____

C. Reptiles

1. three chambered heart
2. double loop circulatory
3. _____
4. _____
5. ectothermic

D. Aves

1. _____ (2 atria and 2 ventricles)
2. double loop circulatory system
3. aortic arch is well defined
4. _____
5. _____

E. Mammals

1. _____
2. _____
3. well defined left aorta
4. red blood cells
 - a. _____
 - b. _____
5. endothermic

APPENDIX B

APPENDIX B

Advanced Biology: Pretest Classification/Integument/Skeleton/Muscles

1. An animal can be a typical vertebrate without having
 - a. a notochord
 - b. a hollow dorsal nerve cord
 - c. a bony skeleton
 - d. pharyngeal slits
2. During the development of most vertebrates, the notochord is replaced by a
 - a. spinal cord
 - b. large artery
 - c. backbone
 - d. large vein
3. If a vertebrate has moist skin but lacks scales and claws it is probably a (an)
 - a. amphibian
 - b. coelacanth
 - c. osteichthye
 - d. chondrichthye
4. Two groups of fish in the class Chondrichthyes is
 - a. sharks and rays
 - b. lampreys and hagfish
 - c. skates and latuneria
 - d. carps and chimaeras
5. The coelacanth is a member of the only living species of
 - a. lungfish
 - b. lobe-finned fish
 - c. jawless, armored fish
 - d. cartilaginous fish
6. Snakes belong to the order
 - a. Squamata
 - b. Rhyncocephalia
 - c. Crocodilia
 - d. Chelonia
7. One adaptation that enables reptiles to live out of water is the development of
 - a. moist, smooth skin
 - b. dry, scaly skin
 - c. four legs
 - d. toes with claws
8. The dorsal part of a turtles shell is the
 - a. plastron
 - b. allantois
 - c. carapace
 - d. chorion
9. In birds, the chest muscles are attached directly to the
 - a. sternum
 - b. rib cage
 - c. keel
 - d. backbone

10. The only surviving member of the order Rhyncocephalia is the
a. sea turtle c. tuatara
b. Komodo dragon d. cobra
11. Flight feathers are a type of
a. oily feather c. powder feathers
b. down feathers d. contour feathers
12. Egg-laying mammals are
a. monotremes c. placental mammals
b. marsupials d. extinct
13. The chest cavity is expanded by chest cavity muscles and by the
a. diaphragm c. heart
b. lungs d. abdomen
14. Whales and dolphins are in the order
a. Cetacea c. Chiroptera
b. Sirenia d. Lagomorpha
15. All animals in the order Artiodactyla have
a. no molar teeth c. one toe on each foot
b. long canine teeth d. two toes on each foot
16. Each of the following is used to classify mammals into orders except
a. their method of reproduction c. the structure of their teeth
b. whether they are herbivores d. the type of bones in their head
17. If an amphibian has a tail after it undergoes metamorphosis, it is probably a
a. toad c. snake
b. frog d. salamander
18. As adults, both frogs and toads have
a. hind legs for jumping c. a two-chambered heart
b. fairly short tails d. a single-loop circulatory system
19. The jawless fish include
a. skates and rays c. skates and lampreys
b. lungfish and rays d. lampreys and hagfish
20. The tuatara is the only surviving member of the order
a. Crocodilia c. Squamata
b. Chelonia d. Rhyncocephalia

21. The only place on Earth that lacks reptiles are very
a. hot areas c. dry areas
b. cold areas d. wet areas
22. The ventral part of a turtle's shell is the
a. flipper c. plastron
b. allantosis d. carapace
23. The term that is least closely related to the other is
a. contour feathers c. general body feathers
b. down feathers d. flight feathers
24. The most primitive mammals are
a. marsupials c. monotremes
b. primates d. placentals
25. To release heat from their body when necessary, mammals use their
a. sweat glands c. fur
b. fat tissue d. hair
26. The size of the chest cavity increases when the
a. ribs move down c. diaphragm contracts
b. air leaves the lungs d. abdominal cavity contracts
27. The pelvic girdle of the fish evolved into:
a. the shoulder bones of the amphibians
b. the pelvic bones
c. the legs and pelvis region
d. the arms and shoulder blade region
28. Birds that catch prey in sharp talons and have pointed beaks are:
a. herbivores c. omnivores
b. carnivores d. detritus feeders
29. The most important characteristic in classifying an animal as a mammal is the presence of:
a. a backbone c. fur
b. mammary glands d. canine teeth

APPENDIX C

APPENDIX C

Advanced Biology: Posttest Classification/Integument/Skeleton/Muscles

1. An animal can be a typical vertebrate without having
 - a. a notochord
 - b. a hollow dorsal nerve cord
 - c. a bony skeleton
 - d. pharyngeal slits
2. During the development of most vertebrates, the notochord is replaced by a
 - a. spinal cord
 - b. large artery
 - c. backbone
 - d. large vein
3. If a vertebrate has moist skin but lacks scales and claws it is probably a (an)
 - a. amphibian
 - b. coelacanth
 - c. osteichthye
 - d. chondrichyte
4. Two groups of fish in the class Chondrichthyes is
 - a. sharks and rays
 - b. lampreys and hagfish
 - c. skates and latuneria
 - d. carps and chimaeras
5. The coelacanth is a member of the only living species of
 - a. lungfish
 - b. lobe-finned fish
 - c. jawless, armored fish
 - d. cartilaginous fish
6. Snakes belong to the order
 - a. Squamata
 - b. Rhyncocephalia
 - c. Crocodilia
 - d. Chelonia
7. One adaptation that enables reptiles to live out of water is the development of
 - a. moist, smooth skin
 - b. dry, scaly skin
 - c. four legs
 - d. toes with claws
8. The dorsal part of a turtles shell is the
 - a. plastron
 - b. allantois
 - c. carapace
 - d. chorion
9. In birds, the chest muscles are attached directly to the
 - a. sternum
 - b. rib cage
 - c. keel
 - d. backbone

10. The only surviving member of the order Rhyncocephalia is the
a. sea turtle c. tuatara
b. Komodo dragon d. cobra
11. Flight feathers are a type of
a. oily feathers c. powder feathers
b. down feathers d. contour feathers
12. Egg-laying mammals are
a. monotremes c. placental mammals
b. marsupials d. extinct
13. The chest cavity is expanded by chest cavity muscles and by the
a. diaphragm c. heart
b. lungs d. abdomen
14. Whales and dolphins are in the order
a. Cetacea c. Chiroptera
b. Sirenia d. Lagomorpha
15. All animals in the order Artiodactyla have
a. no molar teeth c. one toe on each foot
b. long canine teeth d. two toes on each foot
16. Each of the following is used to classify mammals into orders except
a. their method of reproduction c. the structure of their teeth
b. whether they are herbivores d. the type of bones in their head
17. If an amphibian has a tail after it undergoes metamorphosis, it is probably a
a. toad c. snake
b. frog d. salamander
18. As adults, both frogs and toads have
a. hind legs for jumping c. a two-chambered heart
b. fairly short tails d. a single-loop circulatory system
19. The jawless fish include
a. skates and rays c. skates and lampreys
b. lungfish and rays d. lampreys and hagfish
20. The tuatara is the only surviving member of the order
a. Crocodilia c. Squamata
b. Chelonia d. Rhyncocephalia

21. The only place on Earth that lacks reptiles are very
a. hot areas c. dry areas
b. cold areas d. wet areas
22. The ventral part of a turtle's shell is the
a. flipper c. plastron
b. allantosia d. carapace
23. The term that is least closely related to the other is
a. contour feathers c. general body feathers
b. down feathers d. flight feathers
24. The most primitive mammals are
a. marsupials c. monotremes
b. primates d. placentals
25. To release heat from their body when necessary, mammals use their
a. sweat glands c. fur
b. fat tissue d. hair
26. The size of the chest cavity increases when the
a. ribs move down c. diaphragm contracts
b. air leaves the lungs d. abdominal cavity contracts
27. The pelvic girdle of the fish evolved into:
a. the shoulder bones of the amphibians
b. the pelvic bones
c. the legs and pelvis region
d. the arms and shoulder blade region
28. Birds that catch prey in sharp talons and have pointed beaks are:
a. herbivores c. omnivores
b. carnivores d. detritus feeders
29. The most important characteristic in classifying an animal as mammal is the presence of:
a. a backbone c. fur
b. mammary glands d. canine teeth

Advanced Biology

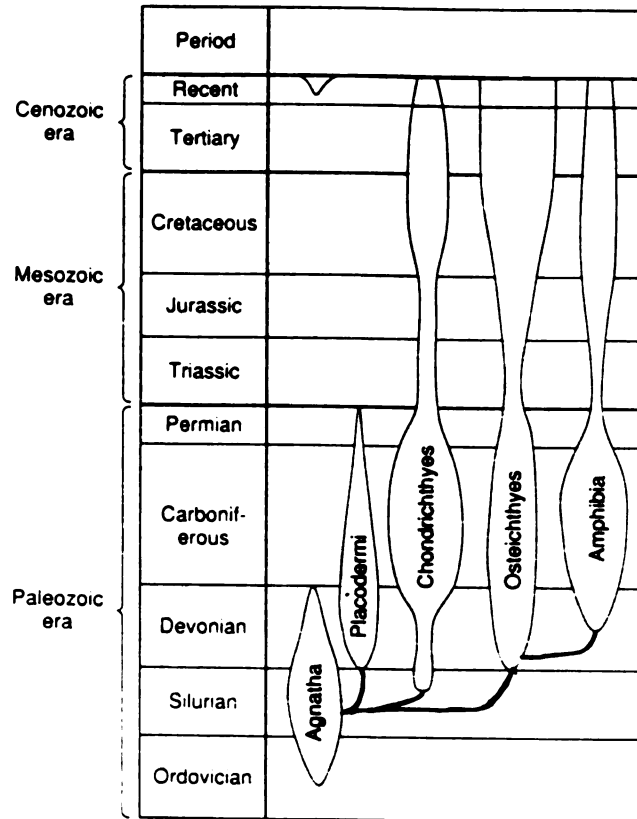
Part B – ext. morphology/skeletal/muscular/classification

30. A preen gland at the base of the tail of a bird contains
a. poison c. mucous
b. pheromones d. oil
31. What kingdom do vertebrates belong to
a. Monera c. Animalia
b. Vertebrata d. Chordata
32. An example of an animal that does not molt is a
a. snake c. lizard
b. crocodile d. amphibian
33. Mucous glands are used for
a. capture prey c. keeps approximate internal environment
b. protect from drying out d. all of the above
34. Birds have skeletal systems that are
a. ossified c. fibrous and cartilaginous
b. cartilaginous d. ossified with air cavities
35. An occipital condyle is
a. a fused skull
b. attachment point between a skull and vertebral column
c. a bone in the middle ear
d. the keel
36. An animal with large quadrilateral or polygonal scales called scutes is a (an)
a. alligator c. turtle
b. lizard d. snake
37. A gland that produces a poison or noxious smell is
a. mucous c. pheromone
b. keratin d. granular
38. The thin integument of the bird is composed of the
a. dermis c. epidermis and dermis
b. epidermis d. none of these
39. An example of an animal with a skeleton composed completely of cartilage is a
a. lamprey c. blue-gill
b. skate d. hagfish

40. Mammals skin contains
 a. sweat glands c. sebaceous glands
 b. scent glands d. all of the above
41. Birds have _____ number of bones in their middle ear.
 a. 1 c. 3
 b. 2 d. 4
42. A characteristic of the mammal skeleton in
 a. 2 middle ear bones c. 10 cervical vertebrae
 b. pelvic bones fused d. a skull with 1 occipital condyle
43. Two types of control of muscle is
 a. smooth and cardiac c. voluntary and involuntary
 b. striated and smooth d. striated and smooth
44. Which class has no teeth?
 a. Osteichthyes c. Reptilia
 b. Amphibia d. Aves
45. An animal with the body covered with hair is a (an)
 a. Aves c. Reptile
 b. Mammal d. Amphibian
46. Which muscle arrangement will have a longer endurance?
 a. striated c. pinnate
 b. parallel d. smooth
47. On a chicken, the muscle of the breast is
 a. red c. intermediate
 c. white
48. Your blood vessels are
 a. smooth muscle c. striated muscle
 b. cardiac muscle d. voluntary
49. The action of muscle movement is by the filaments
 a. tendons and ligament c. ligaments and myosin
 b. tendons and actin d. actin and myosin
50. A general statement about muscles:
 a. less specialized and specific through the animal kingdom
 b. move specialized and less specific
 c. become more specialized and specific through the animal kingdom
 d. stay very similar in all animals

Interpreting Diagrams:

The chart shows changes in the populations of five classes of vertebrates over the last 500 million years. The thickness of the line indicates the relative number of organisms living at a particular time.

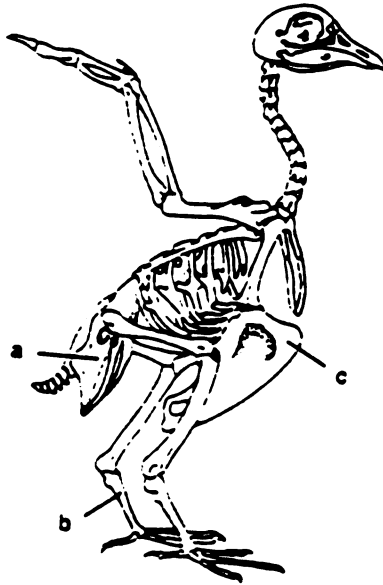


51. During what period did the amphibians evolve? _____

52. Did the Osteichthyes evolve from early placoderm-type fish or an early Chondrichthyes type fish? _____

53. Which class or classes of fishes have increased greatly in number in recent years? _____

54. What class of armored, jawless fishes is completely extinct? _____



55. In the figure above, what is the function of the structure labeled C?

56. What is the structure labeled A? _____

57. In the figure, is the structure of B a leg bone or an anklebone? Why?

ESSAYS:

1. What characteristics would enable you to distinguish a salamander and a small lizard?
2. Explain the different types of muscles, what they affect, how they work, how they are attached, and their different actions.
3. Differentiate between the forearms of the human, cat, crocodile, frog and bird. Explain their differences and similarities.

APPENDIX D

APPENDIX D

PIGEON DISSECTION QUESTIONS

1. Name three of the most distinctive structural characteristics of a bird.
2. What value are air sacs in a bird?
3. State the structure and function of the crop in a bird.
4. Describe the beak of the pigeon. Is there any unique characteristics shown?
5. What organ in the bird compensates for its lack of teeth? Name and describe internally and externally this organ.
6. After cutting the heart lengthwise how many chambers did you see?
7. List in order the digestive system of the pigeon.
8. Describe the structure of a bone after breaking it.
9. What is the advantage to a bird being covered in feathers?
10. How is it that a bird can walk on its hind legs so easily?

APPENDIX D

DOGFISH SHARK DISSECTION QUESTIONS

1. State three ways in which the shark is structurally different from most invertebrates.
2. State the function of the lateral line system.
3. Name some of the structures on the integument (skin) of the shark.
4. Name the parts of the sharks' heart.
5. In what structures do the male and female sharks reproductive systems differ?
6. Name the parts of the typical gill.
7. Trace the path food would take through the dogfish shark. What accessory organs are helpful to the digestive system?
8. What is the two dark-colored structures covering most of the digestive tract?
9. How is the stomach and intestine different internally? Of what significance are they different?

APPENDIX E

APPENDIX E

LIST OF STRUCTURES CONTAINED IN SLIDE DISSECTIONS

TURTLE

CARAPACE
MOUTH
ESOPHAGUS
LARYNX
BRONCHUS
STOMACH
BLADDER
LARGE INTESTINE
SMALL INTESTINE
CLOACA
PANCREAS
GALL BLADDER
LIVER
PLASTRON
LEGS
TAIL

PERCH

SCALES
MOUTH
GILLS
SPINAL CORD
KIDNEY
SWIM BLADDER
VERTEBRA
MUSCLE
GONADS
ANUS
STOMACH
INTESTINES
GALL BLADDER
LIVER
ESOPHAGUS
HEART
EYES
OPERCULUM
FINS

DOGFISH SHARK

SCALES
GILL SLITS
ANAL FIN
EYES
PECTORAL/PELVIC FINS
MOUTH
SPINAL CORD
KIDNEY
SWIM BLADDER
VERTEBRA
MUSCLE TISSUE
GONADS
ANUS
STOMACH
INTESTINES
GALL BLADDER
LIVER
ESOPHAGUS
HEART
EYES

MUDPUPPY

EARS
EXTERNAL GILLS
LEGS
EYES
VERTEBRA
MUSCLE
INTESTINES
HEART
GONADS
STOMACH
ESOPHAGUS
LIVER
GALL BLADDER
SPINAL CORD
KIDNEY
ANUS

LAMPREY

HEAD
TAIL FIN
MUSCLE
MOUTH
VERTEBRA
GILL SLITS
EXTERNAL SKIN

COW HEART

LEFT ATRIUM
RIGHT ATRIUM
LEFT VENTRICLE
RIGHT VENTRICLE
AORTA
PULMUNARY ARTERY
SEPTUM
VALVES
TENDONS

APPENDIX F

APPENDIX F

Advanced Biology: Pretest Vertebrate Unit – 1998-99

1. Describe the path blood flows through the body. Try to be specific.
2. What system is used for defense and helps to collect lost fluid?
3. What do bones produce?
4. List some actions of joints?
5. How are animals classified (Put into smaller categories)?
6. What causes our bodies to move? Explain.

7. What are the different types of coverings on animals? How are they important to each animal?
8. What part of your nervous system is responsible for you to blink?
9. List the major parts of the brain. List each parts function.
10. List some of the different types of ways animals breathe and get rid of waste products?
11. Do all animals reproduce the same way? If not, describe the different ways animals reproduce and have their young.

APPENDIX G

APPENDIX G

DAILY CALENDAR – 1997-1998

WEEK 1

- MONDAY:** Check for previous knowledge on classification, the muscular system, external morphology, and the skeletal system
- ACTIVITY:** Pre-test
Go over pre-test
- TUESDAY:** Discuss the usefulness of classification systems
Identify the different taxa that make up the classification system developed by Linneaus
Discuss how taxa show evolutionary relationships among different organisms.
List the function of the integument.
Discuss the different characteristics of the integument of all classes.
- ACTIVITY:** Notes on classification and external morphology
Slide show on external structures of each vertebrate class
Demonstration: How do we classify fish

- WEDNESDAY:** Describe the basic characteristics of fish
- Explain how different animals can be, even within the same Order
- ACTIVITY:** Movie: Fish
- Comparing external morphology of primate hands
- THURSDAY:** Explain how fish carry out essential life functions
- ACTIVITY:** Laboratory Dissection: Perch
- FRIDAY:** List the parts and functions of the skeletal system
- Describe the structure of different skeletal systems
- ACTIVITY:** Notes on the skeletal system
- Laboratory: Comparing primates—looked at external and internal similarities

WEEK 2

- MONDAY:** Describe the similarities between the different classes skeletons
- ACTIVITY:** Laboratory: A comparison of vertebrate skeletons
- TUESDAY:** Describe how a typical amphibian carries out its essential life functions
- Describe the structure of bone
- ACTIVITY:** Movie: Amphibians
- Worksheet on what is in a bone

WEDNESDAY: Describe the structure and function of each of the three muscles
State several specific locations of each of the three muscle types in the human body

ACTIVITY: Notes on muscles
Demonstration: Show the different types of muscle tissue
Short Laboratory: Defining the two types (red and white) muscle tissue

THURSDAY: Predict what is the main purpose of the skeleton
Describe the three types of muscles

ACTIVITY: Laboratory: Skin cells and muscle cells under the microscope

FRIDAY: Describe the interaction of muscles, bone and tendons

ACTIVITY: Laboratory Dissection: Chicken wing

WEEK 3

MONDAY: Review for Classes and Orders

ACTIVITY: Bingo on classification (Classes and Orders)
Quiz over key terms

TUESDAY: Identify the distinguishing characteristics of reptiles
Compare the similarities and differences of some specific reptiles

ACTIVITY: Movie: Reptiles

Start the review for test

WEDNESDAY: Reconstruct learned knowledge

ACTIVITY: Review for test

THURSDAY: Reconstruct learned knowledge

ACTIVITY: Test

FRIDAY: Identify the two major divisions of the nervous system

Describe the function of the nervous system

Describe the changes that occur across the cell membranes of a
Neuron during the transmission of a nerve impulse

ACTIVITY: Go over post-test

Notes on nervous system

Demonstration: How the nerve cell works

Start Pigeon Dissection

WEEK 4

MONDAY:

ACTIVITY: Finish Pigeon Dissection

- TUESDAY:** Discuss the function of the reproductive system
- ACTIVITY:** Notes on the reproductive system
- Laboratory: Examining an unfertilized chicken egg
-
- WEDNESDAY:** Name and discuss the structures of the male and female reproductive systems
- ACTIVITY:** Laboratory: Under a microscope, look at the ovaries and testes of the cat and rat
-
- THURSDAY:** Describe the main characteristics of the class Aves
- Explain the homeostatic functions performed by blood tissue
- Describe the blood cells and their functions
- Describe the types of blood vessels involved in circulation
- ACTIVITY:** Movie: Birds
- Notes on the circulatory system
- Demonstration: Goldfish's circulatory system under the microscope
- Show slides of dissected cow heart
-
- FRIDAY:** Describe the structure of the respiratory system
- Explain how gases are transferred between the respiratory system and the circulatory system

ACTIVITY: Notes on respiratory system
Demonstration: How the swim bladder functions
Start Dissection of dogfish shark

WEEK 5

MONDAY:

ACTIVITY: Finish dogfish shark Dissection

TUESDAY: Describe the main characteristics of mammals

ACTIVITY: Movie: Mammals
Start to review for the test

WEDNESDAY: Reconstruct learned knowledge

ACTIVITY: Review for the test

THURSDAY: Reconstruct learned knowledge

ACTIVITY: Test

FRIDAY: Evaluate the unit on the vertebrate classes

ACTIVITY: Student questionnaire on how the unit went

DAILY CALENDAR – 1998-1999

WEEK 1

DAY 1: Check for previous knowledge on all vertebrate systems.

ACTIVITY: Pretest

Go over pretest

DAY 2: Discuss the usefulness of classification systems
Identify the different taxa that make up the classification system
developed by Linneaus.
Discuss how taxa show evolutionary relationships among different
Organisms

ACTIVITY: Notes on classification
Demo: How we classify fish
Classifying mammals

DAY 3: Review for classification

ACTIVITY: Play bingo for most of period
Vertebrate Quiz on Classes, Orders and animals

DAY 4: List the function of the integument
Discuss the different characteristics of the integument of all classes

ACTIVITY:

Notes on external morphology (integument)

Slide show on external structures of each vertebrate class

Laboratory investigation: Examining the Typical Mammalian
Body Covering.

DAY 5:

Discuss the different characteristics of the integument of all classes

ACTIVITY:

Looking at frogs/toads with different skin colors/types

WEEK 2

DAY 1:

Describe the basic characteristics of fish

Explain how different animals can be, even within the same Order

ACTIVITY:

Movie: Fish

Comparing external morphology of primate hands

Classifying mammals

DAY 2:

Explain how fish carry out essential life functions

ACTIVITY:

Dissection of perch

DAY 3:

List the parts and function of the skeletal system

Describe the structure of different skeletal system

ACTIVITY:

Notes on the skeletal system

Laboratory investigation: comparing primates from gorillas to
humans – looked at external and internal similarities.

DAY 4: Describe the similarities between the different Classes and their skeletal systems

ACTIVITY: Laboratory: a comparison of vertebrate skeletons

DAY 5: Describe how a typical amphibian carries out its essential life functions

Describe the structure of bone

ACTIVITY: Movie: Amphibians

Look at what a bone consists of

WEEK 3

DAY 1: Examine the external and internal anatomy of a frog

ACTIVITY: Dissection of a frog

DAY 2: Examine the external and internal anatomy of a frog

ACTIVITY: Finish frog dissection

DAY 3: Describe the structure and function of each of the 3 types of muscle

State several specific locations of each of the three muscle types in the human body

ACTIVITY:

Notes on muscles

Demonstration: show the different types of muscle tissue

Short laboratory: Defining the two types (red and white) muscle tissue

DAY 4:

Predict what is the main purpose of the skeleton

Describe the three types of muscles

ACTIVITY:

Laboratory: skin cells and muscle cells under the microscope

DAY 5:

Describe the interaction of muscles, bone, and tendons

ACTIVITY:

Laboratory Dissection: chicken wing

WEEK 4

DAY 1:

Identify the distinguishing characteristics of reptiles

Compare the similarities and differences of some specific reptiles

ACTIVITY:

Movie: Reptiles

Investigating how reptiles regulate the temperature of their bodies

Exploring the body temperature of birds

DAY 2:

Reconstruct learned knowledge

ACTIVITY:

Review for test

DAY 3:

Reconstruct learned knowledge

ACTIVITY:

Test

DAY 4:

Reviewing previous knowledge

ACTIVITY:

Go over posttest

DAY 5:

Identify the two major divisions of the nervous system

Describe the function of the nervous system

Describe the changes that occur across the cell membranes of a neuron during the transmission of a nerve impulse.

ACTIVITY:

Go over post-test

Notes on nervous system

Demonstration: how the nerve cell works

Start Pigeon Dissection

WEEK 5

DAY 1:

Describe the main characteristics of the class Aves

ACTIVITY:

Finish Pigeon Dissection

DAY 2:

Discuss the function of the reproductive system

ACTIVITY:

Notes on the reproductive system

Laboratory: examining an unfertilized chicken egg

DAY 3:

Name and discuss the structures of the male and female reproductive system.

ACTIVITY:

Laboratory: under a microscope, look at the ovaries and testes of the cat and rat.

DAY 4:

Describe the internal and external structures of a shark

ACTIVITY:

Start dogfish shark dissection

DAY 5:

Describe the internal and external structures of a shark

ACTIVITY:

Finish dogfish shark dissection

WEEK 6

DAY 1:

Describe the main characteristics of the class Aves

Explain the homeostatic functions performed by blood tissue

Describe the blood cells and their functions

Describe the types of blood vessels involved in circulation

ACTIVITY:

Movie: Birds

Notes on the circulatory system

DAY 2:

Explain the function and structure of the circulatory system

ACTIVITY:

Demonstration: goldfish's circulatory system under the microscope.

Show slides of dissected cow heart.

DAY 3:

Describe the structure of the respiratory system.

Explain how gases are transferred between the respiratory system
and the circulatory system.

ACTIVITY:

Notes on respiratory system.

Demonstration: how the swim bladder functions.

DAY 4:

Explain how gases are transferred between the respiratory system
and the circulatory system.

ACTIVITY:

Lab: Observing the respiration in fish

DAY 5:

Describe the main characteristics of mammals.

ACTIVITY:

Movie: Mammals

Start dissection of fetal pig

WEEK 7

DAY 1:

Describe the main characteristics of mammals.

ACTIVITY:

Fetal pig dissection

DAY 2:

Describe the main characteristics of mammals

ACTIVITY:

Fetal pig dissection

DAY 3:

Reconstruct learned knowledge.

ACTIVITY:

Review for the test

DAY 4:

Reconstruct learned knowledge.

ACTIVITY:

Test

DAY 5:

Evaluate the unit on the vertebrate classes

ACTIVITY:

Student questionnaire on how the unit went

APPENDIX H

APPENDIX H

AN EXAMPLE OF A CLASSIFICATION OF BINGO GAME CARD

B	I	N	G	O
salamander	Amphibia	Frog	turtle	bird
chiroptera	primate	lamprey	shark	Marsupalia
carnivora	Osteichthyes	FREE	Aves	lizard
beaver	monotreme	edentata	rabbit	Mammalia
koala	crocodilia	Reptilia	manatee	cow

APPENDIX I

APPENDIX I

Advanced Biology: Test – Part II Vertebrates: Reproduction/Nervous/Circulatory/Respiration

1. A fish or amphibian that lays eggs is
 - a. oviparous
 - b. viviparous
 - c. ovoviviparous
 - d. nonviviparous
2. The circulatory system of an adult amphibian has a
 - a. single loop
 - b. double loop
 - c. two-chambered heart
 - d. four-chambered heart
3. The parts of the fish's brain involved primarily with the sense of smell are the olfactory lobes and the
 - a. cerebellum
 - b. cerebrum
 - c. optic lobe
 - d. medulla
4. Each of the following serves as an organ of gas exchange in frogs, toads, and many salamanders except the
 - a. skin
 - b. mouth cavity
 - c. lungs
 - d. gills
5. Most fish breathe by pumping water first
 - a. over the gill filaments
 - b. through pharyngeal slits
 - c. through the protective gill cover, the operculum
 - d. through the mouth
6. In fishes, the part of the brain that coordinates movements involved in swimming is the
 - a. medulla
 - b. olfactory lobe
 - c. cerebellum
 - d. cerebrum
7. Almost all fish that are active during the day have
 - a. excellent color vision
 - b. large eyes
 - c. excellent hearing
 - d. electricity detectors
8. Amniotic eggs are found among
 - a. amphibians and birds
 - b. birds and reptiles
 - c. reptiles and amphibians
 - d. amphibians, reptiles and birds

9. In birds, the area of the digestive system in which food is stored is the
a. gizzard c. crop
b. small intestine d. upper stomach
10. Birds are unable to remove oxygen from air during exhalation because they have
a. lungs c. a three-chambered heart
b. air sacs d. a four-chambered heart
11. Animals whose hard-shelled eggs develop outside the body
a. exhibit external fertilization c. are ovoviviparous
b. exhibit hermaphroditism d. are oviparous
12. The circulatory system of every reptile has a
a. single loop c. three-chambered heart
b. double loop d. four-chambered heart
13. The part of your brain that coordinates your movements as you swim is the
a. cerebrum c. medulla
b. optic lobe d. cerebellum
14. If an animal is classified as a mammal, it must be
a. ectothermic c. oviparous
b. endothermic d. viviparous
15. Egg laying mammal are
a. monotremes c. placental mammals
b. marsupials d. extinct
16. Each side of the mammalian heart consists of
a. two atria c. one atrium and one ventricle
b. two ventricles d. two atria and two ventricles
17. In dogs, horses and humans, nutrients oxygen, carbon dioxide, and wastes are exchanged between the embryo and the mother through the
a. placenta c. chorion
b. amnion d. allantois
18. The mammalian heart pumps deoxygenated blood to the
a. brain c. intestine
b. lungs d. kidneys
19. The platypus is classified as a mammal because the female
a. lays eggs c. nurses its young on milk
b. is ovoviviparous d. is fertilized internally

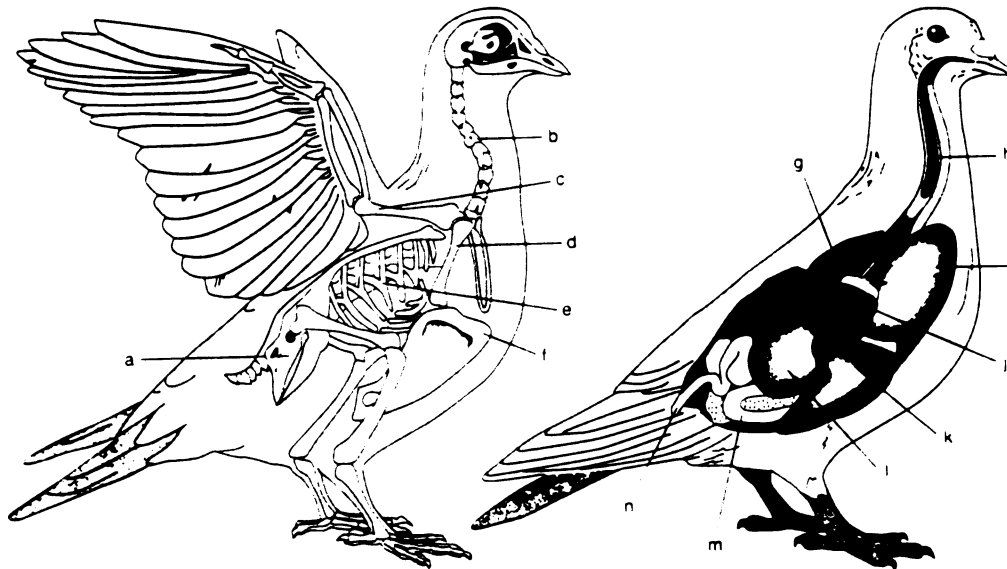
20. The part of the brain you are using to read and understand this question is the
a. cerebellum c. medulla
b. olfactory lobe d. cerebrum
21. When the blood leaves the lungs, it
a. is oxygenated c. flows to the brain
b. is deoxygenated d. flows to the kidneys
22. When the diaphragm contracts,
a. the chest cavity collapses c. air rushes into the lungs
b. the abdominal cavity collapses d. air rushes out of the lungs
23. In mammals, the composition and levels of body fluids are controlled by the
a. lungs c. blood
b. kidneys d. heart
24. Ectotherms must obtain the heat they need
a. by producing it c. from their bodies
b. from the environment d. from food
25. A heart with a partial partition in the ventricle is found in most
a. birds c. mammals
b. amphibians d. reptiles
26. The lungs of mammals contain many thousands of bubblelike structures called
a. alveoli c. bronchial tubes
b. bronchi d. gills
27. Vertebrates that have a single-loop circulatory system have a (an)
a. one-chambered heart c. three-chambered heart
b. two-chambered heart d. four-chambered heart
28. Almost all vertebrates practice
a. asexual reproduction c. internal fertilization
b. sexual reproduction d. external fertilization
29. In a mammalian heart, blood is moved through the lung loop by the
a. upper chambers c. left chambers
b. lower chambers d. right chambers
30. Vertebrates in which fertilized eggs develop outside the mother's body are
a. viviparous c. ovoviviparous
b. oviparous d. nonviviparous

31. The cerebellum is best developed in
a. fish and amphibians c. reptiles and birds
b. amphibians and reptiles d. birds and mammals
32. To breathe, adult amphibians, unlike larvae, use their
a. gills c. ceca
b. skin d. lungs
33. In the circulatory systems of adult amphibians, the first loop carries
a. oxygen-poor blood to the lungs
b. oxygen-poor blood to the ventricles
c. oxygen-rich blood from the body
d. oxygen-rich blood to the ventricles
34. In fish, blood from the muscles and organs collects in the
a. atrium c. ventricle
b. sinus venosus d. aorta
35. The circulatory system of a fish has a
a. single loop c. single-chambered heart
b. double loop d. three-chambered heart
36. In frogs and toads, the part of the brain that coordinates movements involved in jumping is the
a. cerebrum c. medulla
b. cerebellum d. olfactory lobe
37. Birds maintain an extremely efficient gas exchange system because they have
a. air sacs c. feathers
b. paired ovaries d. cloaca
38. Reptilian eggs, unlike amphibian eggs
a. are fertilized externally c. have a jelly-like covering
b. are shed in water d. have a leathery shell
39. A four-chambered heart is found among reptiles in the
a. Chelonia c. Rhynchocephalia
b. Crocodilia d. Squamata
40. Snakes have a pair of special organs in the roof of their mouth that aids in the sense of
a. sound c. smell
b. sight d. taste
41. To control their body temperature, reptiles cannot
a. bask in the sun c. hide under a rock
b. change their metabolic rate d. absorb heat from the environment

42. An endotherm uses more food than an ectotherm of the same size because the endotherm
- a. has a lower metabolic rate
 - b. lacks effective insulation
 - c. has a lower body temperature
 - d. burns more calories to generate heat
43. The blood pumped from the heart to the lungs
- a. is oxygenated
 - b. is deoxygenated
 - c. returns to the kidneys
 - d. returns to the liver
44. The heart of a mammal has
- a. one atrium and one ventricle
 - b. two atria and one ventricle
 - c. one atrium and two ventricles
 - d. two atria and two ventricles
45. The mammalian circulatory system consists of
- a. one open circuit
 - b. one closed circuit
 - c. two open circuits
 - d. two closed circuits
46. Body functions such as breathing and heart rate are under the control of the
- a. cerebrum
 - b. spinal cord
 - c. medulla
 - d. cerebellum

Advanced Biology
Test –Part IIB
Vertebrates:

Name _____
Date _____ Hour _____



1. What label has been given to the keel? _____
2. What is the structure labeled i? _____
3. What label has been given to the structure that often contains bits of gravel that aid in digestion? _____
4. The excretory and reproductive systems open into a single structure. What label has been given to this structure? _____

Essay Questions:

1. Describe the digestion system of the dogfish shark. Give details of the internal structures and their shape and function. Try to do this in order, starting with the mouth.
2. Explain the different types of blood cells found in the mammalian body, their function, where they are found, how they are produced. Then, give the different types of circulatory systems found in animals and their hearts structure.

APPENDIX J

APPENDIX J

STUDENT QUESTIONNAIRE

Advanced Biology

Name _____

1. What did you like most about the last two units that we did in class? Why?
2. What did you like least? Why?
3. What did you like about the tests? What didn't you like about the tests?
4. Did the comparison of all the different classes and systems make sense to you? Was this hard to compare due to your lack of previous knowledge about different systems (like the circulatory or reproductive systems)?

5. What would you have liked to see done differently? Why?
6. Were the labs helpful in your understanding of each unit?
7. Do you believe that this being the end of the year, that you did not apply yourself as well as you normally do?
8. Which do you prefer, going by chapter or trying to see comparison and differences within the classes (the way I did it)?
9. Anything else you would like to say or comment on, put it here.

APPENDIX K

APPENDIX K

STUDENT QUESTIONNAIRE RESULTS – 1997-98:

1. What did you like most about the last two units that we did in class? Why?

H1 – I liked doing the dissections because I need to do them sooner or later if I go on to vet school.

H2 – I liked the dogfish shark dissection because it was fun to stick my fingers through the gills, make his heart pump, and open up his mouth and insides. It was the best dissection of the year!

H3 – I liked how you went over the notes with us in class and took time on all of the information to make sure we understood.

A1 – The notes were typed out for us, not as many worksheets and work to turn in, and certain dissections, but not all.

A2 – They were more involved and had fewer bookwork

A3 – I liked all the labs. They were cooler because we got hands on and I could learn more.

L1 – I liked the dissections the most in the two last units because the visual learning involved them helped me the most.

L2 – They were interesting and hands on.

L3 – I enjoyed the dissections because it was hands on and we got to learn not just on paper but on real life.

2. What did you like the least? Why?

H1 – The tests. They had too much information to cram for one test. I think they should have been broken up. I also didn't like plucking Fred, our pigeon.

H2 – Combination.. Big 4 page note tests, they should be broken up into 4 quizzes maybe. And the pigeon dissection, it was too much like a household pet to cut up.

H3 –I didn't like how much information you gave us to learn in such little time. I felt like I was extremely rushed to learn all the information for the tests.

A1 – The dogfish shark dissection, it was nothing much to follow and I think all it did was waste time. Not having too much time to review.

A2 – The lack of reference. The book couldn't really help with the questions on the labs. And not having the labs to study from.

A3 – The tests. They were too hard.

L1 – The tests because I do not take tests very well.

L2 – The 24 page lab packets. It was just too darn long.

L3 – I didn't like having to learn all the names that I'll never know anyway and I don't think it's practical information.

3. What did you like about the tests? What didn't you like about the tests?

H1 – Nothing.

H2 – Nothing.

H3 – A test is a test; they are always the same. Either you know what you are talking about or you don't.

- A1 – They were multiple choice and the essays were understandable. They covered too much material and there was so much information to study that we never seemed to study the right things.
- A2 – They were easier to study for and the questions were clearer. They were difficult; there was a large amount of information to memorize. It was more memorization not intelligence.
- A3 – I liked absolutely nothing about the tests.
- L1 – I liked the multiple choice and the essays the most. I liked the diagrams the least.
- L2 – I liked the multiple choice. I didn't like the points assigned to the essays.
- L3 – Tests were long and it was also too specific regarding names and not practical regarding life. It was nice to have the information on stuff with actual experience with dissections.

4. Did the comparison of all the different classes and systems make sense to you?

Was this hard to compare due to your lack of previous knowledge about different systems (like the circulatory or reproductive systems)?

- H1 – The comparison was not too difficult, but sometimes it got tough because I didn't know a lot about the systems
- H2 – It somewhat made sense but it was hard to compare because most was new.
- H3 – The comparison did make sense to me because I had enough previous knowledge of the systems to be able to comprehend all of the information

- A1 – Yes. It wasn't hard to compare, it just got a little confusing with organisms that are alike and when you ask a very specific question. There could be multiple answers as far as we know.
- A2 – Yes. No, I had basic knowledge and your explanation were logical
- A3 – No, the comparisons made a lot of sense. No.
- L1 – Most of the comparisons made sense to me. This was hard because of my lack of previous knowledge
- L2 – Yes. No.
- L3 – The comparisons were comprehensible however, the memorization was difficult and not understandable to me.

5. What would you have liked to seen done differently? Why?

- H1 – I can't really think of anything. Everything was taught well and pretty much well laid out.
- H2 – An in-depth section about the human body would help a lot!
- H3 – I think that you should have given each class their own page (on notes) with their own system on it. When they were all separate like they were, they kind of hard to remember individual characteristics of classes.
- A1 – Make the tests more selective and using less information so that it wouldn't be as confusing. Take out pointless labs and dissections.
- A2 – No lab practicals. They are difficult to understand and they don't seem to serve a purpose.
- A3 – I would have liked the chance to retake tests. I think my grade would be better.

L1 – I would have liked smaller tests when we had to memorize classes and such because there was a lot to memorize.

L2 – The notes. Give them to us all the time.

L3 – Not so much memorization on classes and orders. More things that are practical and pertain more to the human species.

6. Were the labs helpful in your understanding of each unit?

H1 – Yes, the labs were helpful to me because I got to actually see what we were discussing.

H2 – Yes.

H3 – Yes, because they gave me a first hand look at all of the systems, so I understood them a little better.

A1 – For the most part, no. I think they took too much time away from studying and some didn't help anyone to learn at all.

A2 – Yes, they put what we were learning in a realistic frame.

A3 – Yes, I got to learn more hands on.

L1 - The labs were very helpful in my understanding the units.

L2 - Yes, then I would remember the lab when it came to the tests.

L3 – Yes, the labs were very helpful and aided in the understanding of the animals. However time constraints were very restraining.

7. Do you believe that this being the end of the year, that you did not apply yourself as well as you normally do?

- H1 – I think this possibly occurred. It was just harder to push through everything and to concentrate solely on science things.
- H2 – Possibly, but I did try to study like I normally did I guess. It was just harder.
- H3 – Yes, I slacked off more, but due to softball I tend to try to get stuff done faster and work a little bit harder.
- A1 – No, if anything I am applying and studying more and harder.
- A2 – I think I applied myself more.
- A3 – No, I applied myself enough to keep up my grades and still be able to do extracurricular activities.
- L1 – No, actually I worked harder to help bring my grade up.
- L2 – No, This class was very intense and difficult.
- L3 – Yes, I started getting spring fever and slacked off on some of my work

8. Which do you prefer, going chapter by chapter or trying to see comparison and differences within the vertebrate Classes (the way I did it)?

- H1 – I guess I like both ways but I'm glad that we changed things up a little. We needed to do something different after an entire year of the same thing.
- H2 – Comparisons would be ok if there wasn't so much because there was so much, I probably preferred going by chapter instead.

H3 – Seeing the comparison helped to learn the information, but I think I like going chapter more.

A1 – I'd prefer to go by classes, but with more clarity. Some differences were so miniscule that people constantly got them messed up.

A2 – Seeing the comparisons

A3 – I don't see a difference.

L1 – I liked the way you did it better than going by chapter.

L2 – Trying to see comparison and differences within the classes.

L3 – I can't honestly answer that question because I never tried the chapter method.

9. Anything else you would like to say or comment on, put it here.

H1 – I enjoyed the last units the best because they dealt with animals and systems.

STUDENT QUESTIONNAIRES – 1998-99:

1. What did you like most about the last two units that we did in class? Why?

H4 – The dissections because you were allowed to really relax and have fun but still learn things. Not having to write out the notes

H5 – I enjoyed the dissections the most. That was because it was a hands-on activity.

H6 – One thing is for sure, I learned a lot! I liked the way it was laid out and the way we took notes and discussed them.

A4- I liked the dissections the most. They were interesting because instead of seeing pictures you could actually feel and see the body parts.

A5 – They best part of course was the dissections. I learn better when I have to do something hands on and real.

A6 – The dissections, because it was interesting. (You) learn the animals up close.

L4 – On the last two units, the things I liked most were the dissections because it was very interesting to look at the animals we were studying.

L5 – I liked learning about the nervous system because I enjoy exploring the realm of thought, so to speak.

L6 – We got to dissect. I thought that was cool. I think that's a good way to learn.

2. What did you like the least? Why?

H4 – Test because you really did not have that good of an idea what the essays were going to be about. Although that is really just part of school I guess.

H5 – I liked handwriting the notes the least. Writing it out as compared to filling in blanks doesn't help at all. (Note: This class had to copy notes off the overhead due to out copy machine being out of service for a day)

H6 – I least liked the fact that on our second test, the one over circulatory, nervous, respiratory, and reproductive systems, we had 4 major systems to study for. It would have been better I think if spent more time on two at a time for a test. Otherwise it feels a little rushed.

A4 – I didn't like the Classes and Orders. It takes me way much more time than one night to remember that information.

A5 – Some of the worksheets were redundant and didn't apply very much.

A6 – The reading because it is time consuming.

L4 – The things I like least were nothing. I think that all were equal. (I am not sure what this statement meant)

L5 – There really wasn't anything I liked least. I enjoyed everything pretty equally.

L6 – Probably the vocabulary, because it was so long.

3. What did you like about the tests? What didn't you like about the tests?

H4 – The multiple choice. The essays because I am used to just regurgitating the essays when I have been given the questions earlier. All around, not knowing the essays ahead of time is good for us. It requires us to study more information.

H5 – I liked the multiple choice on the tests because I had a 25% chance. I liked the dissection labeling least, because you couldn't study for it.

H6 – I liked the format of the test with multiple choice and 2-4 essays.

A4 – The tests were taken before I forgot most the information, although I hate doing the essays.

A5 – The fact you gave easy to comprehend essays. The multiple choice focused too much on reading assigned instead of class work.

A6 – I liked the multiple choice. I did not like the essays.

L4 – What I liked about the tests was that most were multiple choice and if you studied you should get it right if you have more options. I didn't like the long essay questions because some things we did, (we didn't) go over in class much.

L5 – I didn't like much about the tests. The only thing I didn't like was taking them.

L6 – I liked the multiple choice on the tests but I didn't like the essays.

4. Did the comparison of all the different classes and systems make sense to you?

Was this hard to compare due to your lack of previous knowledge about different systems (like the circulatory or reproductive systems)?

H4 – Yes. No.

H5 – It made sense, but it was hard to compare, not because of lack of knowledge, but because we were comparing so many different Classes.

H6 – Like (I wrote) in question #2. I think if we took a test on two of them at a time, we could spend more time on and better retain information about the comparisons.

Yes, the comparisons of different Class systems did make sense.

A4 –It took awhile for me to understand because I didn't have much knowledge before.

A5 – It wasn't hard but it wasn't how I would like to learn it.

A6 – The comparisons made a little bit of sense. My lack of previous knowledge contributed to this.

L4 – The comparisons did make sense even though it was very hard to memorize as many Classes and Orders that were there were.

L5 – In some Classes the names made sense to me. Yes, due to some lack of knowledge, it was a bit difficult to make sense of things.

L6 – No, the name are way too confusing. Yes, it was hard to compare.

5. What would you have liked to seen done differently? Why?

H4 – Nothing, it is good. Nothing outrageously hard but nothing that was extremely easy.

H5 – I would have like to have seen it taught by chapters and not by systems.

H6 – I would like to see the dissections be compared to the systems we are learning. I feel if we could focus on making those connections, we might understand application better.

A4 – I don't really think there is anything you should change.

A5 – It would be easier to learn if you taught amphibians, then everything about them, like how there systems are. Then maybe mammals and all (of) their systems. I thought it was to broad to compare between them all. It would (be) easy to compare later after we learned them individually.

A6 – I am not sure.

L4 – I think that there should be less Classes studied at a time because it takes a while to memorize them.

L5 – Nothing at all.

L6 – Nothing, you did everything fine.

6. Were the labs helpful in your understanding of each unit?

H4 – Not really, they were just fun. You really did not learn a whole lot in the labs.

Yes, they were cool and you learned a little but, a lot of information just went in one ear and out the other.

H5 – Yes. The labs gave me an opportunity to see it in real life. Instead of just reading about a shark, we got to take one apart. Those types of things help.

H6 – I found some of the labs, such as the lizard/time of day and the birds heart rate/weight, to be not useful in my understanding of the units.

A4 – I love doing labs because they help me understand more deeply than worksheets.

A5 – Yes, they were helped a lot.

A6 – Yes, they were.

L4 – Yes, because you could look at what you are studying more extensively.

L5 – They helped somewhat.

L6 – Yes, they helped.

7. Do you believe that this being the end of the year, that you did not apply yourself as well as you normally do?

Note: Since this class did the unit at the beginning of the year, they were not asked to answer this question

8. Which do you prefer, going chapter by chapter or trying to see comparison and differences within the vertebrate Classes (the way I did it)?

H4 – Going by chapter. That way it is easier to keep clear which group has what.

H5 – I would have preferred going by chapter. That would have made things a lot less confusing and helped me to understand a little better.

H6 – I like your way. Looking at a system and comparing that system between Classes.

A4 – I liked seeing the comparison and differences because it helped me understand.

A5 – Chapter I think.

A6 – I like the way you did it better.

L4 – I think that going by chapter might be easier, although I can't be sure because we haven't tried that.

L5 – Trying to see comparison and differences within the Classes.

L6 – I don't know. We haven't gone by chapter.

9. Anything else you would like to say or comment on, put it here.

A6 – The movies on the animals were both informative and interesting.

L4 – I think that we should be given a chance to take things over like tests so we have a better chance of earning a better grade.

L5 – Keep up the enthusiasm and fine work.

L6 – I think you're a cool teacher, you're not mean and your class isn't boring. But it's just hard to understand a lot of this stuff.

APPENDIX L

APPENDIX L

Advanced Biology

Classification Quiz

1. What Kingdom are we studying? _____
2. Birds are in the class _____.
3. Alligators belong to the Order _____.
4. Give an example of the Class Chondrichthyes.
5. The Superclass of jawless fish is _____.
6. Salamanders, frogs and toads belong to the Class _____.
7. What Order are the egg-laying mammals?
8. The Order Chiroptera is the _____.
9. The kangaroo, koala, and opossum are examples of the Order _____.
10. Give an example of the Order Primate.
11. The beaver is an example of the Order _____.
12. The bony fish are in the Class _____.
13. Give an example of a Lagomorph (Order).
14. The cat and dog are examples of the Order _____.
15. What is the only animal in the Order Proboscidea?
16. Turtles are the only animals in the Order _____.
17. Lizards, alligators, and turtles belong to this Class _____.
18. The Order Anura contain the _____.
19. Hagfish belong to the Class _____.
20. All the animals we will be studying belong to the Subphylum _____.

AUDIO VISUAL REFERENCES

AUDIO VISUAL REFERENCES

Eyewitness: Amphibian. Videocassette. BBK Wildvision, BBC Lionheart Television, and DK Vision, 1994. 35 min.

Eyewitness: Bird. Videocassette. BBK Wildvision, BBC Lionheart Television, and DK Vision, 1994. 35 min.

Eyewitness: Fish. Videocassette. BBK Wildvision, BBC Lionheart Television, and DK Vision, 1994. 35 min.

Eyewitness: Mammal. Videocassette. Dorling Kindersley Ltd. and BBC Worldwide Americas, 1996. 35 min.

Eyewitness: Reptile. Videocassette. BBK Wildvision, BBC Lionheart Television, and DK Vision, 1994. 35 min.

BIBLIOGRAPHY

BIBLIOGRAPHY

Beck, D. Elden. Invertebrate Zoology Laboratory Workbook. Minneapolis: Burgess Publishing Company, 1960.

Beecher, Jeff. "Note-Taking: What Do We Know about the Benefits". 1988. Online. The Educational Resources Information Center. Available: www.indiana.edu/~eric_rec/ieo/digests/d37.html. 4 November 1998.

Cherney, Elaine, et al. Achieving Academic Success: A Learning Skills Handbook. Dubuque, Iowa: Kendall/Hunt Publishing Company, 1989.

Griffin, Donald R., Animal Structure and Function. New York: Holt, Rinehart and Winston, 1962.

Harrison, Bruce M., Manual of Comparative Anatomy: A General Laboratory Guide. St. Louis: The C.V. Mosby Company, 1970.

Haury, David L., "Teaching Science Through Inquiry". Online. The Educational Resources Information Center. March 1993. Available: www.ericse.org/digests/dse93-4.html. 4 November 1998.

Haury, David L., and Peter Rillero, "Perspective of Hands-On Science Teaching". Online. The Educational Resources Information Center. 1994. Available: www.ericse.org/Hands-on/WW20.html. 4 November 1998.

Hildebrand, Milton. Analysis of Vertebrate Structure. New York: John Wiley and Sons, 1962.

Hopkins, P. M., Introduction to Zoology: A Laboratory Manual. Englewood, Colorado: Morton Publishing Company, 1984.

Hyman, Libbie Henrietta. Comparative Vertebrate Anatomy. Chicago: The University of Chicago Press, 1979.

- Kanis, Ira B., "Science-Based Problem-Solving Activities for the Upper Elementary Grades." Science Activities. Fall, 1992:1.
- Kent, George C., Comparative Anatomy of the Vertebrates. St. Louis: Times Mirror/Mosby College Publishing, 1987.
- Kesselman-Turkel, Judi and Franklyn Peterson. Note-Taking Made Easy. Chicago: Contemporary Books, Inc., 1982
- Klunge, Arnold G., Chordate Structure and Function. New York: Macmillan Publishing Company, Inc., 1977.
- Miller, Kenneth R., and Joseph Levine. Biology. New Jersey: Prentice Hall, 1995.
- Miller, Kenneth R., and Joseph Levine. Biology Laboratory Manual. New Jersey: Prentice Hall, 1995.
- Miller, Kenneth R., and Joseph Levine. Biology: The Living Science. New Jersey: Prentice Hall, 1998.
- Miller, Kenneth R., and Joseph Levine. Biology: The Living Science Laboratory Manual. New Jersey: Prentice Hall, 1998.
- Rogers, Frances A., Comparative Vertebrate Anatomy: An Outline Text. Springfield, Illinois: Charles C. Thomas Publishers, 1983.
- Roth, W. M., "Problem-Centered Learning for the Integration of Mathematics and Science in a Constructivist Laboratory: A Case Study", School Science and Mathematics. 1993: 113-22.
- Tama, Carrol M. "Critical Thinking: Promoting It in the Classroom". June 1989. Online. The Educational Resources Informational Center. Available: www.indiana.edu/~eric_rec/leo/digests/d40.html. 4 November 1998.

Winchester, A. M., Biology Laboratory Manual. Dubuque, Iowa: Wm. C. Brown Publishers, 1975.

Wischnitzer, Saul. Atlas and Dissection Guide for Comparative Anatomy. New York: W. H. Freeman and Company, 1988.

MICHIGAN STATE UNIV. LIBRARIES



31293018129464