**J**ames **M**adison **U**niversity

**D**epartment of **G**eology & **E**nvironmental **S**cience and **D**epartment of **B**iology

Syllabus
Biology 350 / Geology 350

# INVERTEBRATE PALEONTOLOGY

## *(THE HISTORY OF LIFE ON EARTH)*

Spring, 2000

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|---|---|
| INDEX NUMBER: | Biology 24950 / Geology 24706 |
| CREDIT HOURS: | 04 |
| BUILDING: | Miller Hall |
| ROOM: | Room 209; MWF 11:15-12:05 |
| LABORATORY: | Thursday 12:00 - 2:00 |
| INSTRUCTOR: | Lynn S. Fichter, Professor |
| OFFICE: | Miller Hall, Room No. 233 |
| CONTACTING: | 568-6531 or Fichtels@jmu.edu |
| OFFICE HOURS: | M 10-11; TT 10-12; by Appointment |
| FINAL EXAM: | Monday, May 4 from 10:30 12:30 |
| TEXTS: | ▸ Lecture notebook: duke's duplicates<br>▸ Lab notebook: duke's duplicates<br>▸ Diversified reading list. |

**LABORATORY VOUCHERS:** This semester the university is assessing a charge for chemicals and other consumable items used in laboratory courses. Consequently, during the first two weeks of classes, each student in this course must obtain a paid "laboratory voucher" from the bookstore. Failure to obtain a voucher will lead to administrative withdrawal.

## INTRODUCTION

Two horror questions for a comprehensive exam:

**1. Describe the Universe, and give two examples.**

**2. Define Life. Be sure to include its complete range of diversity.**

Scary questions, aren't they? But it is the second question, at least, that we are about this semester.

How can we adequately discuss in one semester a record of life as rich and diverse and prolific as the one on this Earth. And how can one come to understand how life has transformed this planet. If it were not for life the earth today would be more akin to Mars or Venus or the Moon, than to the blue planet it is, with abundant liquid water, a very unstable atmosphere with abundant oxygen, and life in virtually every nook and cranny that we can find, from miles below the surface, to the coldest arctic, to the hottest hotsprings, to the deepest oceans, to many miles in the atmosphere. Join me on the journey. We are going to make a brave attempt to understand the phenomena of life.

## TRADITIONAL PALEONTOLOGY ... VS. WHAT WE ARE GOING TO DO HERE

In the past 50 years every area of science has undergone such profound growth that they have been transformed in ways most scientists of the time could not have imagined. In geology these changes have been so pervasive that what has been considered the traditional subject matter of various disciplines has either faded to insignificance, been replaced by totally new knowledge, or been completely transformed by new understanding.

As a result it is frequently difficult to find agreement among specialists on what is appropriate to teach in a course like this, or to figure out how to find the time to cover all the new knowledge while retaining the traditional knowledge too. And actually it is not possible, either to agree, or to cover everything.

Traditional paleontology, that taught prior to about 15-20 years ago, consisted of:

- ☻ Systematics and classification (interminable lists of tongue-twisting Latin names.)
- ☻ Descriptive morphology (more long lists).
- ☻ Biostratigraphy (dating rocks: the major reason to study fossils, and still more list memorization).

Paleontology today includes:

- ☺ Taxonomy (evolutionary theory and theories of classification - there isn't one system written in the stars, just waiting to be discovered).
- ☺ Functional morphology/physiology (not what it is, but why...).
- ☺ Integration with evolutionary biology (they are, or were, living, growing reproducing, evolving organisms - not just "figured stones").

- ☺ Biogeochemical evolution (the earth, atmosphere, and hydrosphere are not a neutral background but intimately coupled and evolving with the biosphere).
- ☺ Paleoecology (...and they had to make a living).
- ☺ Mathematical paleontology (turning more and more to mathematical analysis and modeling in all aspects of the fossil record)

The preoccupation is less with facts than with relationships, less with numbers than arrangements, less with structure than with processes.

So . . . if paleontology was a big subject two decades ago it has exploded in depth and complexity since then. Simply, it is an enormous subject, much too big to be covered in one semester - even in survey.

What I want to do with this course is come to understand the phenomena of life, what it is, how and why it evolved, and how it transformed and continues to affect the planet. It is fair to say that if life had not originated on earth this planet would be as dry, cold, and barren a ball of rock as the other planets in the solar system. We want to come to understand why this planet is so different, and how living systems pervasively pervade every aspect of the planet. Geologists who remain ignorant of the relationship between life and the earth can never genuinely understand earth systems. And biologists who remain ignorant of the large scale patterns and processes over geologic time spans can never really understand life today. It is not a matter of liking or not liking this topic, its a matter of not being ignorant about it or its importance. I, of course, happen to like it, and I hope that even if you do not you will come to appreciate its importance, and develop a little of the awe that comes as we try to explain and understand what we can barely grasp when we think about it hard.

One of the things many people are apprehensive about with a paleontology class is all those trays and trays of fossils. In this sense introductory paleontology is like introductory mineralogy or introductory biology. There is a lot to learn just to be able to talk intelligently about the subject. Life has been abundantly, lavishly, bounteously, prolific. Estimates vary, but between 5 and 50 billion species have existed on this planet, . . .and 99% of them are extinct. Things have evolved that no amount of imagination could dream up - some organisms are just bizarre. And the richness of even the "common" familiar organisms can be daunting. (Could there be some significance to all this?)

But there is no gratuitous memorization in this class. You will have to learn a lot, and I will do everything I can to make it as easy as possible. But everything I ask you to learn has a purpose.

## TESTING AND GRADING[1]

The final grade in this class is based on the following criteria:

40 % Lecture Exams: probably 4, including a non-comprehensive Final Exam
15 % Lab Test # 1 - Monera, Protoctists, Early Metazoans
15 % Lab Test # 2 - Arthropods, Molluscs, etc.
20 % Final Lab Test-Comprehensive, plus Brachiopods, Bryozoans, Echinoderms
10 % Periodic Review Questions
100 %

Field Trip Requirement: No grade is received for the field trip, but failure to complete requirement results in loss of one final letter grade. See below

## LECTURE TESTS

All lecture tests are take home and are run by the following procedures and rules.

❶ All exams are essay.
❷ All exam questions are available to you before the exam to allow you to prepare.
❸ You will not write answers to all the questions, but must be prepared to answer any of them.
❹ You may bring with you to each exam one (and only one) 3 x 5 inch index card, written on both sides, with outlines of all your answers to the questions (prose statements, drawing or diagrams are prohibited.) These must be turned in with you answers.
❺ You will not know which questions to answer until just at the moment you are ready to take the exam. At the exam time I will give you a folded piece of paper, inside which are written the questions you are to answer. You open the paper when ready to take the exam.
❻ Normally I try to give some choices of questions to answer so you are not completely stuck with questions you do not like or are not well prepared for.

[1] All tests are required. Failure to complete any of the test results in the loss of one final letter grade for each one not taken. I.e. the average semester grade is calculated, including the "0" for the missed test, and then one grade subtracted from the final average for each test missed.

On the designated test days you may take the test any time you find convenient but must obey the following rules:

### Rules For All Exams

1. You may take the exam any time in the several day period assigned.
2. You must sit alone while taking the test.
3. You may not peek at the questions until just at the moment you are ready to take the exam.
4. If the question states information will be provided with the exam slip, that information is attached to the exam slip.
5. There are no time limits but you must take the entire exam in one sitting, pit stops allowed.
6. You may have only the following with you:
   - ☺ The exam paper
   - ☺ Writing instruments
   - ☺ Copies of any blank illustrations allowed by the questions.
   - ☺ Refreshments for the duration
   - ☺ One (and only one) 3 x 5 inch index card with an outline of your answers to any question. There may be no drawings or prose statements.

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

## TEST GRADING

Your lecture grade is an average of all your scores on the test questions (including the final) you answer during the semester. Last time I taught the course we had four exams, including a non-comprehensive final. That will probably be the case this time. Each test has plus or minus a half dozen questions.

Also, because you sometimes have an option of how many questions you answer on a test it is possible your lecture grade may be based on a different number of questions than someone else in the class.

Grading of lecture questions is based on two criteria: first, written answers, and second, illustrations.

Written answers are evaluated on their quality and accuracy. You are expected to take all the information dealing with each question, including that from the readings and lecture notes, and synthesize and boil it down to its essential points, and concisely and definitively express it in your own writing.

In many instances it is necessary for you to make illustrations to accompany an answer. The illustrations must be accurate, realistic, and clearly and fully labeled. Grades are lost for ambiguous, sloppy, and/or unrealistic drawings.

All grading is done anonymously to insure impartiality. To facilitate this each student is to write their name on the back, bottom, right of the last of their answer pages.

The answers should thoroughly, logically, and consistently develop the ideas so that a person with no knowledge of the subject could understand it. Thus, minor inaccuracies may be critical, and clarity and erudition of expression is as important as correctness.

Illustrations must be integrated into the discussion. Only those answers that are accurate and clearly expressed and have excellent illustrations receive full credit. Accurate but muddled answers receive less than full credit.

To determine the final grade, the letter grade for each question is converted to a numerical value on a 12 point scale, see below. The numbers for all questions is then summed and divided by the number of questions you answered to arrive at the final lecture grade.

The first test contains a complete set of guidelines and suggestions for preparing for and taking the tests.

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|---|---|---|---|
| 12 - 11 = A+ | 8.9 - 8 = B+ | 5.9 - 5 = C+ | 2.9 - 2 = D+ |
| 10.9 - 10 = A | 7.9 - 7 = B | 4.9 - 4 = C | 1.9 - 1 = D |
| 9.9 - 9 = A- | 6.9 - 6 = B- | 3.9 - 3 = C- | 0.0 - .9 = D- |

## LABORATORY PROCEDURE AND TESTS

Studying and learning the basic morphology and classification of over three dozen groups of fossil organisms is a formidable task (but compare that with the fact that there are about 3 dozen phyla of animals, and we will cover bacteria and protists too.) For the lab to run with some balance and grace I have evolved over the years a number of procedures.

Detailed study guides are found in the Lab Notebook. I have tried to find a compromise between the enormous volume of potential laboratory knowledge, and what you can reasonably accomplish in one semester and I summarized it in these study guides.

Although there is a specific laboratory meeting it is frequently not possible for everyone in a class to work on the same specimens at once. Our collection has a good sampling of the diversity of most fossil groups but many specimens for us are "one of a kind." If too many people attempt to work at once, the collection would degenerate to total chaos much faster than it now does.

Also, two hour labs are not enough time each week to spend studying the collection. You will need several hours a week. You should schedule time in your week which is most convenient for you, and which does not correspond to a lot of other people working at the same time...and religiously do the work.

Lab Reviews. Confronting a tray of unrecognizable fossils can be a daunting experience. Where to begin? Sorting everything out is usually much more discouraging and frustrating than the actual studying and learning. To minimize, if not prevent, this experience I begin each lab introducing a major group. We review the basic morphology of the group, and then examine some specimens in the trays. I will show you what to look, and look out, for, and some tricks and procedures to make you study easier.

The grades for each laboratory test are curved. Because of the complexity of the tests there is no absolute scale, like 100 points, to provide a standard A, B, C, D, F split. This class has in the past had people who have been curve breakers, and although they may get the A+ grade, I attempt to not let such exceptional work damage the rest of you. Nonetheless, I have developed a sense over the years of what is good performance on each lab test, and draw the curves with that experience in mind.

In general, laboratory knowledge is of three kinds:

- ☺ Specimen identification - to phylum, class, order, family, and (in many cases) genus, plus other special categories in the classification hierarchy.
- ☺ Kinds of fossilization
- ☺ Morphology identification - identifying morphology from specimens, or knowing which morphology is typical of particular groups of fossils.

Also for each lab test you may bring with you one (and only one) 3" x 5" index card with anything you want written (but NO drawings) ***on one side only***; this card must be turned in with your test paper.

## CURATING THE COLLECTION

There is a special problem with studying for lab tests. At the beginning of each semester the fossil collection is put in order, but for the most part after that the collection will not be curated again until the end of the semester.

Thus, if you and your classmates are not careful (as has happened in the past) the collection quickly becomes disorganized. What that means is that some of you are studying the right specimens but the wrong identification, and vice versa. This really plays havoc when taking lab tests and some of you may suffer as a result.

**Keep the collection organized ! !, for you own sakes if for no one else.**

## REVIEW QUESTIONS

Scattered through the semester are a series of periodic review questions. The questions are designed primarily to get you to think about recent subject matter and clarify and come to understand some critical models, or facts, or strategies for solving problems of evolutionary biology. Also, during the grading I can let you know the standards to be striven for in answering the exam questions. More information to follow.

## FIELD TRIPS

Studying fossils in a dusty museum tray does not begin to give an appreciation of the nature and interpretation of the fossil record. To give a different dimension to what you are studying we take one, or both, of two field trips. The first is a fossil hunting field trip, the second is a trip to the Natural History Museum, Smithsonian Institution. You are required to attend one of these.

**FOSSIL COLLECTING FIELD TRIP**: Seeing fossils in the field gives an appreciation of the fossil record than can be obtained in no other way. We have a couple of choices here. First, we are tentatively planning a weekend field trip out to Kentucky, Tennessee, Ohio or some such place. These areas have some of the most spectacular fossil collecting you can imagine and are well worth visiting.

Second, we have a couple of local formations which provide good fossil hunting and if the weekend trip does not come off this is the alternative option.

Information of scheduling later.

**SMITHSONIAN FIELD TRIP:** We are fortunate to have so close an outstanding museum with excellent displays of very rare fossils, as well as imaginative reconstructions. The Smithsonian has exhibits dealing with many of the things we study during the semester. If this trip becomes an option it will be in the last week or two of the semester, as late as possible so that we have as much background as possible.

No assignments to be turned in for grade accompany these field trips. For the most part simple attendance and participation is all that is required. What we may do, though, is have an informal contest. like who can find the rarest fossil, or divide into teams to see which can find the greatest diversity of fossils. All in the spirit of learning for fun.

## CLASS READINGS

If you peruse the beginning of the Lecture Notebook and the Lab Notebook you will observe very long reading lists. It is not meant or expected that you will read all the things on those lists. It is just that there is a stunning array of paper, books and articles out there that deal with the topics we discuss - and new ones keep avalanching out. They are here primarily as references in case you want to learn more about some of these topics, or do not understand something in the lecture and desire readings for background. **Learn to quickly peruse the readings to get what you want from them, or to find what to concentrate on in more detail.** No matter what discipline you go into professionally, you will be overwhelmed by the volume of literature available. Use this as an opportunity to learn how to wade through it quickly and efficiently for the information you need.

# Invertebrate Paleontology

Semester Schedule Based on Last Time Course Was Taught

Because this course continues to evolve, the schedule below is tentative and subject to change. Any significant changes will be announced in class.

## WEEK 1 — LAB: NONE

JANUARY

10 M . . . . . Introduction
12 W . . . . . Gould's Eternal Metaphors
14 F . . . . . Evolution of Evolutionary Theory

## WEEK 2 — LAB: STROMATOLITES

17 M . . . . . Major Developments in the History of Life and Earth
19 W . . . . . Fractal Geometry and the Patterns of Life
. . . . . The Problem of Problems
. . . . . Non-Equilibrium Thermodynamics - Getting around the 2nd Law
21 F . . . . . Determinism
. . . . . Chaos Theory - The Period Doubling Route to Chaos
. . . . . Strange Attractors

## WEEK 3 — LAB: CALCAREOUS ALGAE

24 M . . . . . Artificial Life Systems
. . . . . Computer Simulations on Life3000
26 W . . . . . Positive and Negative Feedback and Evolution
. . . . . Evolution of Evolutionary Theory
28 F . . . . . Evolution of Evolutionary Theory

## WEEK 4 — LAB: ARTIFICIAL LIFE EXERCISES

31 M . . . . . Lovelock's Gaia Hypothesis

FEBRUARY

2 W . . . . . The Origin of Life
4 F . . . . . Archaean Ecosystems

## WEEK 5 — LAB: PROTISTS

7 M . . . . . Archean Daisyworld; Proterozoic Ecosystems
9 W . . . . . Proterozoic Ecosystems
11 F . . . . . Seminar: Archaean and Proterozoic Daisyworlds

## WEEK 6 — LAB: SPONGES

14 M . . . . . Benthic Moneran and Protoctist Fossil Record
16 W . . . . . Benthic Moneran and Protoctist Fossil Record
18 F . . . . . Pelagic Protists: Fossil Record and Paleoenvironmental Interpretations

## WEEK 7 — LAB: CNIDARIA [2]

**(end lab test one)**

21 M . . . . . Pelagic Protists: Fossil Record and Paleoenvironmental Interpretations
23 W . . . . . Pelagic Protists: Fossil Record and Paleoenvironmental Interpretations
25 F . . . . . The Phanerozoic Record of Life (Principles, Riphean,Vendian, Tommotian)

## WEEK 8 — LAB: GASTROPODA

28 M . . . . . The Phanerozoic Record of Life (Lower Paleozoic and Reefs)
MARCH
1 W . . . . . The Phanerozoic Record of Life (Paleozoic)
3 F . . . . . The Phanerozoic Record of Life (Paleozoic)

6 M - 11 S Recess

## WEEK 9 — LAB: BIVALVIA

13 M . . . . . The Phanerozoic Record of Life (Paleozoic)
15 W . . . . . The Phanerozoic Record of Life (Mesozoic)
17 F . . . . . The Phanerozoic Record of Life (Mesozoic)

## WEEK 10 — LAB: CEPHALOPODA

20 M . . . . . The Phanerozoic Record of Life (Mesozoic)
22 W . . . . . The Phanerozoic Record of Life (Cenozoic)
24 F . . . . . The Phanerozoic Record of Life (Cenozoic)

## WEEK 11 — LAB: TRILOBITA

**(end lab test two)**

27 M . . . . . Origin of Multicellularity (Biological Principles)
29 W . . . . . Origin of Multicellularity (Biological Principles)
31 F . . . . . Origin of Multicellularity (Biological Principles)

## WEEK 12 — LAB REVIEW

APRIL
3 M . . . . . Origin of Multicellularity (Geologic Record)
5 W . . . . . Origin of Multicellularity (Geologic Record)
7 F . . . . . Seminar on the Problem of the Origins of Multicellularity

[2] Observe that Tuesday the 24 is Student Assessment day and day classes are canceled. We will therefore reschedule this lab at another time. I suspect that an evening time would be best, and perhaps Tuesday evening the 24 is optimal. We will have to discuss this.

## WEEK 13 LAB: BRACHIOPODA

10 M ..... The Coelomate Grade of Evolution
..... Functional Organizations and Adaptations of Coeloms
12 W ..... Organization and Evolutionary Relationships of True Coelomates
14 F ..... Coelomate Evolutionary Record and Adaptive Strategies
..... Is There Progress in Coelomate Evolution?

## WEEK 14 LAB: BRYOZOA AND GRAPTOLITA

17 M ..... Extinction: Coming to Grips with the Fact Most Species Are Extinct
19 W ..... Extinction: Coming to Grips with the Fact Most Species Are Extinct
21 F ..... Extinction: Coming to Grips with the Fact Most Species Are Extinct

## WEEK 15 LAB: ECHINODERMATA

**(end lab test three: comprehensive)**

24 M ..... Paleoecology: A Silurian Example
26 W ..... Paleoecology: A Silurian Example
28 F ..... Reading Day/Snow Make-up Day

## Finals Week

**MAY**
**1 M** .....
**3 W** ..... Wednesday, May 3 from 10:30 12:30 [3]
**5 F** .....

[3] Since all lecture tests are take home, the final exam is also a take home. Which means that the final exam will not be due at the final exam time. Instead we will schedule the final lab test for the regularly scheduled exam time. The lecture portion will be due some time later in the week, at a mutually convenient time to the class members and myself.