**COURSE SYLLABUS**

**BOT/GEOL 4280/5280 - Paleobotany**

**Spring 2016**

**Instructor Information: Ellen Currano**

**Phone:** 766-2819

**Office:** Williams Conservatory B03: From the ground floor of Aven Nelson, go up the ramp near the green couches in the middle of the building, all the way through the conservatory, and down the stairs. Take the first hallway on the left, and the Currano lab is at the end of the hallway. Go through the lab to reach Ellen’s office. If the conservatory is closed, there is an elevator just before its entrance that goes down to the basement.

 **E-mail:** ecurrano@uwyo.edu

 **Office Hours:** Tu 2:35-5, W 3-4, or by appointment

**TA information: Tony Jijina**

 **Email:** ajijina@uwyo.edu

 **Responsibilities:** Tony will be assisting with course logistics, particularly setting up and taking down the lab. If you would like additional time examining lab specimens, email Tony to arrange a time and location. All grading will be done by Ellen.

**Course Information:**

* Lecture/Discussion: Tu,Th from 1:20-2:35 PM in GE 318
* Laboratory: W from 1:10-3:00 PM in ESB 1038
* There will be a **required daylong field trip on February 19th** to the Denver Museum of Nature and Science. If you will need to miss another class to participate in this fieldtrip, please inform your instructors immediately. (If needed, Ellen can write to instructors to confirm your absence.)
* There is an **optional weekend** field trip to nearby paleobotanical sites in Wyoming. This trip will be towards the end of the semester and location will be determined by weather.

**Prerequisites:**LIFE 1010 or GEOL 1100

**Course Description:** An examination of the ecology and evolution of land plants throughout Earth history that emphasizes the profound impact plants have had on Earth’s surface and atmosphere. Through a combination of lecture, discussion, and laboratory, the course will explore fossilized plant communities, their ecological properties, and effects of major environmental upheavals.

**Objectives/Outcomes/Standards:** A successful student in this course will be able to:

* Recognize & describe the dominant plant life from different times in earth’s history
* Assess the relationship between life and climate in the geologic past and apply this knowledge to present-day earth
* Apply basic ecological principles and techniques to fossil data
* Analyze and critique scientific journal articles
* Effectively communicate and debate scientific ideas during weekly discussion groups

**Text(s) and Readings:** There is no ideal textbook for this course – maybe one of my post-tenure goals should be to write one... Instead,

* We will rely heavily on the primary scientific literature. For each week, several journal articles are posted as pdfs on WyoCourses.
* A cheap, fairly good overview of plant life through time is Kenrick and Davis’s *Fossil Plants* (Smithsonian Books, 2004; $21.45 on Amazon). It does a good and up-to-date job of explaining why fossil plants are interesting and has delightful photographs. The first four chapters of this book are posted on WyoCourses during the weeks they are assigned as supplemental reading for lecture.
* I just purchased *How the Earth Turned Green: A Brief 3.8 Billion-Year History of Plants* by Joseph Armstrong ($33.85 from an Amazon-affiliated distributor). It just came out last year and received good reviews, although I cannot yet vouch for it.
* If you plan to continue on in paleobotany, or would like a good reference book, consider buying:
	+ *Paleobotany, 2nd Edition: The Biology and Evolution of Fossil Plants* by Taylor, Taylor, and Krings (Elsevier, 2009). Sadly, there do not appear to be hard copies available any more, but you can get an eBook either from Elsevier or a kindle version from Amazon for $102.75.
	+ *Paleobotany and the Evolution of Plants, 2nd Edition* by Stewart and Rothwell (Cambridge University Press, 1993). Although over 20 years old, still very useful for information on fossil plant anatomy.
	+ *The Evolution of Plants* 2013 edition by Willis and McElwain
* One major web resource is will be Berkeley’s Virtual Paleobotany Laboratory (http://www.ucmp.berkeley.edu/IB181/VPL/Dir.html), which has well-written, succinct, and well-illustrated summaries of many topics we will cover.
* You should also have a **good 10x hand lens** and an **unruled drawing book**. Please bring both to every lab and fieldtrip.

**Course Requirements/Assignments:** Your course grade will be based on the following components: a midterm exam, a final exam, laboratory activities, and performance in weekly discussions. Additionally, graduate students will be required to write a term paper.

*Exams:* Thanks to wireless internet, iPhones, and other modern technology, memorization isn’t as important as it used to be. Instead, what is important is the ability to find the information you need to solve a problem, critically evaluate it, and draw informed conclusions. To aid you in developing these skills, we will have two take-home essay exams. I will hand out the exam, you will have one week to produce a rough draft (worth 10% of your final course grade). I will grade and provide suggestions for improvement, and then you will revise and hand in your final draft (10% of final course grade) by the date listed on the schedule.

*Lab Activities:* The structure of lab will vary from week to week. Some weeks will have exercises to complete (e.g. supermarket phylogeny exercise and paleoclimate reconstruction). Others will focus on fossil specimens, and you will be expected to make notes and drawings on each specimen in your laboratory notebook. Notes and activities from the field trips should also be completed in your laboratory notebook.

*Discussion performance:*

* Discussion board posts: You are required to complete each Thursday’s readings and post three questions on WyoCourses by 5PM the preceding Wednesday. I will assess your questions on a scale from 1 to 5, based on your ability to pick out the main ideas, critically analyze the authors’ conclusions, apply concepts from previous weeks, and pose questions that we can spend a good chunk of class time discussing.
* Leadership: Each week, one student will be in charge of making sure the entire class gets as much as possible out of the readings. There are two parts to this. First, you should put together a handout of no more than two pages summarizing the major points and figures from the week’s readings. Second, you are responsible for leading the discussion and trying to prevent those awkward silences that we all hate. To help facilitate a lively discussion, I strongly recommend reading through the questions your classmates posted on WyoCourses and preparing a short introduction (<15 minutes; Powerpoint optional).
* Participation: I will assess your contributions to our discussions periodically throughout the semester using a rubric. You can miss one discussion (in addition to any university-approved absences) without it impacting your grade.

*Graduate Student Paper:* After consultation with me, graduate students will choose a topic on which to write a roughly 10-page (double-spaced) term paper on some aspect of paleobotany. I am leaving this broad because I’d like you to choose something that is relevant to your own research and that you will be able to paste paragraphs from into future grant proposals or even your thesis.

**Grading Standards:**

*Undergraduates* *Graduates*

Take-home mid-term exam: Take-home mid-term exam:

 Rough draft: 10% Rough draft: 10%

 Final copy: 10% Final copy: 10%

Take-home final-term exam: Take-home final exam:

 Rough draft: 10% Rough draft: 10%

 Final copy: 10% Final copy: 10%

Discussion section performance: Discussion section performance:

 Discussion board posts: 5% Discussion board posts: 5%

 Leadership: 15% Leadership: 10%

 Participation: 20% Participation: 10%

Lab Activities: 20% Lab Activities: 15%

 Paper: 20%

Final course grades will be assigned according to the following scale:

A: 90-100% B: 80-89.99% C: 70-79.99% D: 60 – 69.99% F: <60%

*Late Assignment Policy:* A 10% penalty will be assessed for each day the assignment is late.

**Disability Statement:** If you have a physical, learning, sensory or psychological disability and require accommodations, please let me know as soon as possible. You will need to register with, and provide documentation of your disability to University Disability Support Services (UDSS) in SEO, room 330 Knight Hall.

**Attendance/Participation Policy:** University sponsored absences are cleared through the Office of Student Life.

**Academic Honesty:** The University of Wyoming is built upon a strong foundation of integrity, respect and trust. All members of the university community have a responsibility to be honest and the right to expect honesty from others. As stated in UW Regulation 6-802, any form of academic dishonesty is unacceptable to our community and will not be tolerated. Teachers and students should report suspected violations of standards of academic honesty to the instructor, department head, or dean. Other University regulations can be found at: <http://www.uwyo.edu/generalcounsel/new-regulatory-structure/index.html>)

**Course Schedule:**

Week Lecture, discussion, and lab topics

1 **Jan 26** Lecture: Introduction, fossil plant preservation

Lab: Modes of fossil plant preservation

Discussion: *What sorts of research questions can paleobotanists answer?*

2 **Feb 2** Lecture: Earliest plant life (KD p. 7-19)

 Lab: Supermarket phylogeny exercise

 Discussion: *Shaping the planet’s atmosphere*

3 **Feb 9** Lecture: The transition to land (KD p. 19-23)

Lab: Early vascular plants

 Discussion: *Emerging terrestrial ecosystems*

4 **Feb 16** Lecture: A frozen ecosystem – The Early Devonian Rhynie Chert (KD p. 23-29)

 Discussion: *Key Evolutionary Innovations (leaves, size, seeds)*

 **February 19th: Day trip to DMNS**

5 **Feb 23** Lecture: The first appearance of forests (KD Ch. 2-3)

Lab: Williams Conservatory activity

Discussion: *The effect of terrestrial plants on global elemental cycles*

6 **Mar 1** Lecture: Fossil fuel: The rise of the Carboniferous coal swamp (KD Ch.4)

Lab: Coal ball peels

Discussion: *How ecologically similar were the Carboniferous coal*

 *swamps to modern rainforests?*

7 **Mar 8** Lecture: The Permian rise of gymnosperms

Lab: Seed plants

Discussion: *Molecular clocks vs. the plant fossil record*

8 **Mar 22** Lecture: The Permo-Triassic turnover

Lab: None. Work on midterm exam.

 Discussion: *Do plants dance to a different beat?*

9 **Mar 29** Lecture: Mesozoic ecosystems (KD Ch. 6)

Lab: “Dinosaurs in parking lots” at the UW Geological Museum

Discussion: *Did angiosperms coevolve with dinosaurs?*

10 **Apr 5** Lecture: The rise and radiation of flowering plants (KD Ch. 8)

Lab: Angiosperms

Discussion: *Darwin’s abominable mystery: The origin & expansion of*

*angiosperms*

11 **Apr 12** Discussion: *The K-T (Cretaceous-Paleogene) biotic crisis and its*

*aftermath*

Lab: Plant-insect interactions in the fossil record

 Lecture: Early Cenozoic greenhouse floras

12 **Apr 19** Lecture: Plants as paleoclimatic and paleoecological indicators

(KD Ch. 5)

Lab: Paleoclimate reconstruction

Discussion: *How did polar forests work? (we might have*

*them again soon)*

13  **Apr 26** Lecture: The rise of grasslands in the Oligocene/Miocene

Lab: None. Prepare for possible field trip and work on final exam

 Discussion: *What triggered C4 evolution?*

14 **May 3** Lecture: Ice ages and beyond: Quaternary climatic fluctuations

and plant migration patterns

Lab:Quaternary pollen lab

 Discussion: *Novel climates and no-analog communities in*

*the Quaternary*

**IMPORTANT DUE DATES:**

**MIDTERM EXAM: Mar 3: Exam handed out in class**

 **Mar 10: Rough draft due in class**

 **Mar 22: Rough draft returned with comments**

 **Mar 25: Final draft due @ 5PM**

**FINAL EXAM: Apr 21: Exam handed out**

 **Apr 28: Rough draft due**

 **May 5: Rough draft returned with comments**

 **May 11: Final draft due @ 5PM**

**GRADUATE STUDENT PAPER: due April 11.** I am willing to read one rough draft and give you comments within one week, if you would like.

**The instructor may make changes to the syllabus as the course proceeds. If necessary, these changes will be announced in class. Substantive changes made to the syllabus shall be communicated in writing to the students.**

**Discussion Topics and Readings**

\*Required Readings

\*/2 required reading for half the class

**Week 1 – What sorts of research questions can paleobotanists answer?**

\*Emerald Planet, Chapter 1.

\*Wing SL and DiMichele, 1992. Ecological characterization of fossil plants. In: Behrensmeyer et al. (eds). *Terrestrial ecosystems through time*, pp. 139-180.

Bennington JB, DiMichele WA, Badgley C, Bambach RK, Barrett PM, Behrensmeyer AK, Bobe R, Burnham RJ, Daeschler EB, Van Dam J, Eronen JT, Erwin DH, Finnegan S, Holland SM, Hunt G, Jablonki D, Jackson ST, Jacobs BF, Kidwell SM, Koch PL, Kowaleski MJ, Labandeira CC, Looy CV, Lyons SK, Novack-Gottshall PM, Potts R, Roopnarine PD, Strömberg CAE, Sues H-D, Wagner PJ, Wilf, P and Wing SL, 2009. Paleontological Powers of Ten: issues of scale in paleoecology. *Palaios* 24: 1-4.

**Week 2 – Shaping the planet’s atmosphere**

\*Knoll AH, 2003. The geological consequences of evolution. Geobiology 1: 3-14.

\*Catling DC, Glein CR, Zahnle KJ, McKay CP, 2005. Why O2 is required by complex life on habitable planets and the concept of planetary “Oxygenation Time.” *Astrobiology* 5: 415-438.

Kump LR, 2008. The rise of atmospheric oxygen. Nature 451: 277-278.

Knoll AH, 2003. *Life on a Young Planet: The First Three Billion Years of Evolution on Earth*, Chapter 6. Princeton University Press.

**Week 3 – Emerging terrestrial ecosystems**

\*Kenrick P and Crane PR, 1997. The origin and early evolution of plants on land. *Nature* 389: 33-39.

- Please have this read by class time on February 2.

Gensel PG, 2008. The earliest land plants. *Annual Reviews of Ecology, Evolution, and Systematics* 39: 459-477.

 - Supplemental reading for February 2 lecture.

\*Labandeira CC, 2007. The origin of herbivory on land: The initial pattern of live tissue consumption by arthropods, *Insect Science*, 14: 259-274.

\*Shear and Selden 2002 – Rustling in the undergrowth: animals in early terrestrial ecosystems

**Week 4 - Key Evolutionary Innovations (leaves, size, seeds)**

**\***Beerling DJ, 2007. Leaves, genes, and greenhouse gasses. In: *The Emerald Planet: How Plants Changed Earth's History*. Oxford University Press, pp 8-34.

\*Donoghue MJ, 2005. Key innovations, convergence, and success: macroevolutionary lessons from plant phylogeny. *Paleobiology*, 31: 77-93.

**Week 5 – The effect of terrestrial plants on global elemental cycles**

\*Beerling DJ and Berner RA, 2005. Feedbacks and the coevolution of plants and atmospheric CO2. *PNAS* 102: 1302-1305.

\*Algeo TJ, Scheckler SE and Maynard JB, 2001. The effect of the rise of land plants on atmospheric CO2 during the Paleozoic. In: Gensel PG and Edwards D. *Plants Invade the Land: Evolutionary and Environmental Perspectives*. Columbia University Press, New York, pp. 213-236.

**Week 6 – How ecologically similar were the Carboniferous coal swamps to modern rainforests?**

\*Falcon-Lang HJ, DiMichele WA, Elrick SD, Nelson WJ, 2009. Going underground: in search of Carboniferous coal forests. *Geology Today* 25: 181-184.

\*Boyce CK, Brodribb TJ, Field TS, Zwieniecki MA, 2009. Angiosperm leaf vein evolution was physiologically and environmentally transformative. *Proceedings of the Royal Society B* 276: 1771-1776.

\*/2DiMichele WA, Falcon-Lang HJ, Nelson WJ, Elrick SD, Ames PR, 2007. Ecological gradients within a Pennsylvanian mire forest. *Geology* 35: 415-418.

\*/2Gastaldo RA, Stevanovic-Walls IM, Ware WN, Greb SF, 2004. Community heterogeneity of Early Pennsylvanian peat mires. *Geology* 32: 693-696.

**Week 7 – Molecular Clocks vs. The Plant Fossil Record**

DiMichele WA, Davis, JI, Olmstead RG, 1989. Origins of heterospory and the seed habit: the role of heterochrony. Taxon 38: 1-11.

* Supplemental reading for lecture on March 8.

\*Magallon S, Hilu KW, Quandt D, 2013. Land plant evolutionary timeline: Gene effects are secondary to fossil constraints in relaxed clock estimation of age and substitution rates. *American Journal of Botany* 100: 556-573.

\*Wilf P and Escapa IH, 2014. Green Web or megabiased clock? Plant fossils from Gondwanan Patagonia speak on evolutionary radiations. *New Phytologist* 207: 283-290.

**Week 8 – Do plants dance to a different beat?**

\*Traverse A, 1988. Plant evolution dances to a different beat. Plant and evolutionary mechanisms compared. Historical Biology 1: 277-356.

\*McElwain JC and Punyasena SW, 2007. Mass extinction events and the plant fossil record. Trends in Ecology and Evolution 22: 548-557.

Cleal CJ and Cascales-Miñana B, 2014. Composition and dynamics of the great Phanerozoic Evolutionary Floras. *Lethaia* 47: 469-484.

**Week 9 - Did angiosperms coevolve with dinosaurs?**

\*Barrett PM and Willis KJ, 2001. Did dinosaurs invent flowers? Dinosaur-angiosperm coevolution revisited. Biological Reviews 76: 411-447.

\*/2Butler RJ, Barret PM, Kenrick P and Penn MG, 2009. Diversity patterns amongst herbivorous dinosaurs and plants during the Cretaceous: implications for hypotheses of dinosaur/angiosperm co-evolution. Journal of the Evolutionary Biology 22: 446-459.

\*/2Butler RJ, Barrett PM, Penn MG, Kenrick P, 2010. Testing coevolutionary hypotheses over geological timescales: interactions between Cretaceous dinosaurs and plants. *Biological Journal of the Linnean Society* 100: 1-15.

**Week 10 - Darwin’s abominable mystery: The origin of angiosperms**

\*Crepet WL and Niklas KJ, 2009. Darwin’s second “abominable mystery” why are there so many angiosperm species? American Journal of Botany 96: 366-381.

\*Feild TS, Brodribb TJ, Iglesias A, Chatelet DS, Baresch A, Upchurch GR, Gomez B, Mohr BAR, Coiffard C, Kvacek J, Jaramillo C, 2011. Fossil evidence for Cretaceous escalation in angiosperm leaf venation. *PNAS* 108: 8363-8366.

\*Berendse F and Scheffer M, 2009. The angiosperm radiation revisited, an ecological explanation for Darwins abominable mystery. Ecology Letters 12: 865-872.

**Week 11 – The K-T (Cretaceous-Paleogene) biotic crisis and its aftermath**

\*Sweet AR, 2001. Plants, a yardstick for measuring the environmental consequences of the Cretaceous-Tertiary boundary event. *Geoscience Canada* 28: 127-138.

\*Wilf P and Johnson KR, 2004. Land plant extinction at the end of the Cretaceous: a quantitative analysis of the North Dakota megafloral record. *Paleobiology* 30: 347-368.

\*/2Wappler T, Currano ED, Wilf P, Rust J, Labandeira CC, 2009. No post-Cretaceous ecosystem depression in European forests? Rich insect-feeding damage on diverse middle Paleocene plants, Menat, France. *Proceedings of the Royal Society B* 276: 4271-4277.

\*/2Wilf P, Labandeira CC, Johnson KR, and Ellis B, 2006. Decoupled plant and insect diversity after the end-Cretaceous extinction. *Science* 313: 1112-1115.

**Week 12 – How did polar forests work (we might have them again soon)?**

\*Williams CJ, LePage BA, Johnson AH, Vann DR, 2009. Structure, biomass, and productivity of a late Paleocene Arctic forest. *Proceedings of the Academy of Natural Sciences of Philadelphia* 158: 107-127.

\*Royer DL, Osborne CP, Beerling DJ, 2003. Carbon loss by deciduous trees in a CO2-rich ancient polar environment. *Natur*e 424: 60-62.

Eberle J, Fricke H, Humphrey J, 2009. Lower-latitude mammals as year-round residents in Eocene Arctic forests. *Geology* 37: 499-502.

 -Supplemental, for those of you interested in the animals in these forests.

**Week 13 – What triggered C4 evolution?**

\*Keeley JE and Rundel PW, 2005. Fire and the Miocene expansion of C4 grasslands. *Ecology Letters* 8: 683-690.

\*Edwards EJ, Osborne CP, Strömberg CAE, Smith SA, and Grasses Consortium, 2010. The Origins of C4 grasslands: integrating evolutionary and ecosystem science. *Science* 328: 587-591.

**Week 14 – Novel climates and no-analog communities in the Quaternary**

\*Williams JW and Jackson ST, 2007. Novel climates, no-analog communities, and ecological surprises: past and future. *Frontiers in Ecology and the Environment* 5: 475-482.

\*Gill JL, Williams JW, Jackson ST, Lininger KB and Robinson GS, 2009. Pleistocene megafaunal collapse, novel plant communities, and enhanced fire regimes in North America. *Science*, 326: 1100-1103.