

# The 3<sup>rd</sup> Deep Time Meeting Summary

(August 8, 2002, Madison, Wisconsin)

## Overview

## Reports and Discussions

## Presentations

## Goals for the next 6 months

### Overview

The meeting started with a brief introduction of the Deep Time project to new participants. The total number of Deep Time participants since the project started in August 2001 is 68. Thirty-seven participants representing 20 institutions attended the 3<sup>rd</sup> meeting ([Appendix 1](#)). Much of this meeting dealt with methods/problems of integrating fossils into a phylogenetic tree of extant taxa. A symposium was proposed by Pat Herendeen and Peter Crane and approved by ASPT for Botany 2003 at Mobile, Alabama dealing with Deep Time issues (dating, integrating fossils). Another possible symposium for the following year at the Society of Systematic Biologists' Evolution meeting was also discussed. The Deep Time website is growing and there are lots of useful information available there, still with much more to come. "Fossil Focus Groups" were finalized. Deep Time will work with Hallie Sims (who is representing the Paleobiology Database) to consider folding our Deep Time database into their existing database. There was considerable discussion on the database structure. Deep Time participants will meet with the Paleobiology Database group this fall to discuss incorporating our database into the PBDB. Five research groups (see presentation section) presented the results of their efforts to integrate fossil and modern taxa into a single phylogenetic tree. At present, there are at least 8 active research groups sponsored or assisted by Deep Time: Basal Angiosperms; Chloranthaceae; Hamamelidaceae; Juglandaceae; Betulaceae; Fagales; Ericales; Legumes; Palms. Deep Time goals for the next 6 months were set up during the meeting.

### Reports and Discussions

**Student Travel and Training Awards:** Pam Soltis reported that a total of 19 student travel grants (\$500 each) have been awarded during the past year, enabling students to travel to Deep Time related meetings/workshops. Three student training awards (\$2000 each) were awarded to support extended research in labs of other Deep Time participants.

**Symposium Proposal:** Pat Herendeen reported that the symposium proposal he and Peter Crane submitted on dating divergences and integrating fossils was approved by ASPT and is scheduled for the BSA meeting at Mobile, Alabama, in July 2003. We will

try for another somewhat similar symposium at the Evolution meeting of the Society of Systematic Biologists in 2004.

**Website Update:** New updates of the Deep Time website were reported by Hongshan Wang, including new additions of the most recent phylogenetic trees of angiosperms, such as those from Soltis et al. (2000) and Zanis et al. (2002), dating divergences section, links and site map sections. Two more major additions will be the examples of “integrating fossils” section and a functional database (see below) section. We will first put some published examples on the site and then add Deep Time participants’ research results. It was suggested that a “recent paper references” section and a “work shop” area with studies in progress be added to the website.

**Fossil Priority List:** It was suggested that we not assign priorities to the list of key fossils. Instead, priority is determined by individual researchers, and different people or working groups may assign their own priorities to their groups of fossils. To avoid future unnecessary controversy of this issue, “Areas of Focus” was suggested to replace the fossil priority list, such as Hamamelidaceae, Chloranthaceae, Juglandaceae and other Fagales working groups or “areas of focus”. It was proposed that we needed to focus on compiling information on a fossil list (see below).

**Deep Time Fossil Database:** After Hongshan’s report about the database development, discussion about funding opportunities of the database, discussion of the requirements and specification of the database, and Hallie’s demo of the Paleobiology Database website, it was proposed that the Deep Time fossil database be folded into the Paleobiology Database, with two major features added, i.e., archiving fossil images and morphological characters (morphological character list, character states, and/or original descriptions of fossils). It was suggested that there would be about 100 fossils that we can put into the database per year. There will a Paleobiology Database Project meeting scheduled in Washington, D.C. on September 13-15. It was suggested that we send several Deep Time participants to attend this meeting to see the possibilities of adding new specifications and requirements to the existing database. Hallie suggested that it is possible to set up a Deep Time working group as one of the several groups in the PBDB project. Two major aspects, which the Paleobiology Database project does not have, but now are scheduled in their ongoing project, are the additions of images and morphological characters to the database. The Deep Time Fossil Database should focus on locality, horizon, images and characters, and should minimize data entry. Linking to online supplementary data such as morphological data matrices, etc. should be available. Proper figure captions should be with the images to give proper credits to contributors. Copyright issues were also addressed.

It was proposed by Pat that a fossil list ([Appendix 2](#)) be put on the Deep Time website as a gateway to data. All the text in blue font in the sample table should be linked to relevant information currently available. For example, when a user clicks on the locality [Åsen](#), the user should be directed to a page with all the fossils from this locality listed (in a specific format). When a user clicks on [Platanaceae](#) in the table, it should link to a page with all fossil members of this family listed. When a species name of a fossil taxon is clicked, a page ([Appendix 3](#)) should come out with the following

information such as an image (more images if available), locality and age information, brief description (detailed original description also available on further click), phylogenetic position, comments, etc. As to fossil dates, each fossil has its own data, and we need to get the detailed information together from the literature. Age of a specific locality or fossil should be easy to understand and not prone to misinterpretation. Maximum and minimum age range are preferred to absolute age.

It was suggested that Deep Time sponsor an educational workshop during the next meeting, which is scheduled during a weekend in February, 2003, in Gainesville, Florida. The next Gainesville meeting would designate one day to an educational workshop emphasizing methods of phylogenetic analysis, integrating fossils into molecular phylogenetic analysis, molecular dating, etc. The workshop is free.

### **Presentations**

***Archaeofructus***: David Dilcher presented the results of integrating an Early Cretaceous fossil, *Archaeofructus* (consisting of two species), from northeast China with extant angiosperm based on morphological and molecular data. The use of “age range” in terms of absolute age was discussed. Character selection, importance of taxon sampling, importance of placing morphological characters on the tree (what morphological characters place a taxon where), character interpretation, and persisting lineages of stem taxa after the origin of the angiosperms were also discussed. When a fossil is below all angiosperms like the placement of *Archaeofructaceae*, there is an extra burden of proof. Extra care and work are needed.

***Juglandaceae***: Steve Manchester presented the research results of integrating fossil and extant taxa in the *Juglandaceae*. This is an ongoing project with Paul Manos, Pam Soltis and Doug Soltis supported by a Deep Time student training grant awarded to Ruiqi Li, a graduate student from the Beijing Botanical Institute of China. Discussion topics after the presentation include: Since the best five fossil species were picked for the integration, what happens when one uses morphological characters alone and when fossils are added one at a time? What happens when “bad” fossils are included in the analysis? It still may be useful to add less well-known taxa. Issues of outgroup selection were discussed. Bootstrapping was used to assess conflict in the placement of the fossils; this approach appears to be novel among such fossil analyses. Implications for repeated evolution of animal-dispersed fruits were also discussed. The Importance of different types of characters was pointed out because one suite of characters (fruit, for example) might be highly homoplasious. There are no “toxic interactions”: fossils do not cause the tree to collapse. Low bootstrap values are common when there are few characters, and this is typical of morphological analyses, even of modern taxa.

***Chloranthaceae***: James A. Doyle presented results of his work with Helena Eklund and Patrick S. Herendeen on integrating fossils with extant *Chloranthaceae*. *Chloranthaceae* are a small “magnoliid” family of four very distinct genera with extremely reduced flowers, but fossil dispersed pollen, leaves, and reproductive structures indicate they were one of the first abundant angiosperm groups. Eklund, Doyle, and Herendeen have compiled a morphological cladistic data set of 131 characters

from all parts of the plant, 38 living species of Chloranthaceae, 10 outgroups, and six fossil reproductive structures with *in situ* pollen scored for characters preserved in the fossils. They have analyzed this data set with and without fossils and obtained generic relationships consistent with higher-level molecular analyses. Addition of fossils had only minor effects on the arrangement of extant species, but most of the fossils had several equally parsimonious positions in the tree. Their results indicate that Barremian-Aptian female flowers with *Asteropollis* pollen are basal members or outgroups of the basal genus *Hedyosmum*, and three species of Late Cretaceous trilobed androecia are outgroups to or nested within *Chloranthus*. However, Cenomanian *Couperites* fruits with *Clavatipollenites* pollen, which has been compared with pollen of extant *Ascarina* but is plesiomorphic for the family, may represent either an extinct line nested within Chloranthaceae or an extinct sister taxon. They hope to combine this morphological data set with molecular sequences being amassed by Hongzhi Kong (Beijing), Susanne Renner (University of Missouri St. Louis), and Lennart Andersson (Gothenburg), with the help of Taylor Field (Berkeley), who is studying the ecophysiology of Chloranthaceae and other “basal” angiosperms, to obtain a better estimate of relationships within the genera and the position of the fossils, and to relate the results to early floral evolution, molecular estimates of divergence times, paleoecology, and biogeographic history. It was suggested that this is a good example for the web site!

**Hamamelidaceae:** Susana Magallón presented a phylogenetic study of Hamamelidaceae, other members of the Saxifragalean clade and early diverging eudicots, including three fossil flowers. Some of the major points discussed included: (1) The selection of characters used for phylogenetic analysis, particularly regarding the effect of including many characters that are absent in the fossils. This study indicates that the presence of a few critical characters in the fossils (i.e., synapomorphies of particular clades) overrides the effect of many missing characters; (2) The effect of adding fossils into a topology. In this study, adding fossils to the analysis did not alter the phylogenetic relationships found when only living taxa were included. Also, the fossils were not resolved as early diverging lineages, rather, they were placed as sister taxa to living species; (3) Evaluation of support for clades based on bootstrap analysis. Most of the recovered clades were supported by low bootstrap values, although a few were supported by >95% bootstrap percentages. The necessity to use a different measure of clade support for analyses based on morphological data became evident; and (4) the congruence between molecular and morphological results at different levels in the phylogeny was discussed. Whereas the relationships among major clades according to the morphological study are in severe conflict with well-supported molecular results, the use of morphological data to address relationships within particular clades appears very promising.

**Betulaceae:** Felix Forest presented a phylogenetic analysis of the Betulaceae including at least one species of each subgeneric division (26 taxa) of the six genera. He estimated divergence times within the family using one of the six most parsimonious trees and six calibration points from the fossil record of Betulaceae. The calibration was performed using both the stem lineage and crown group nodes. The resulting estimates were compared to the fossil estimates and used collectively to determine the most appropriate position for the fossils. Using methods developed by Marshall, the

confidence interval of the stratigraphic range of *Alnus* was assessed. The results of these confidence interval evaluations were compared to the molecular estimates. The importance of the use of maximum and minimum ages was discussed following the presentation.

### **Goals for the next 6 months**

New sections such as “integrating fossils” and “recent paper references” sections will be added to the Deep Time website; A functional database (or a prototype) should be available before the next Deep Time meeting; First papers from our group dealing with these issues are in preparation and some are expected to be submitted soon; Sponsor an educational workshop during the 4<sup>th</sup> Deep Time meeting in Gainesville, Florida, in 2003.

**Appendix 1. A list of the 3<sup>rd</sup> Deep Time meeting participants.**

<b>Name</b>	<b>Institution</b>
Chuck Bell	Yale University
Maria von Balthazar	University of Zurich, Switzerland
Julie Broughton	University of California, Santa Barbara
Matyas Buzgo	University of Florida
Sarah Corbett	University of Florida
Peter Crane	Royal Botanic Gardens, Kew, UK
David Dilcher	Florida Museum of Natural History
James A. Doyle	University of California, Davis
Peter Endress	University of Zürich, Switzerland
Felix Forest	Royal Botanic Gardens, Kew, UK
Bee Gunn	University of Missouri-St. Louis
Patrick S. Herendeen	The George Washington University
Khidir W. Hilu	Virginia Tech
Sara Hoot	University of Wisconsin, Milwaukee
Kathy Kron	Wake Forest University
Elma Kay	Saint Louis University
Sangtae Kim	University of Florida
Lucia Lohmann	University of Missouri-St.Louis and Missouri Botanical Garden
Susana Magallón-Puebla	Universidad Nacional Autónoma de México
Steven R. Manchester	Florida Museum of Natural History
Paul Manos	Duke University
Merran Matthews	University of Zurich, Switzerland
Ashley B. Morris	University of Florida
Michael Nowak	University of Oklahoma
Darin Penneys	University of Florida
Kristen Porter-Utley	University of Florida
Elizabeth Ann Powell	Wake Forest University
Julissa Roncal	Florida International University
Vincent Savolainen	Royal Botanic Gardens, Kew, UK
Harald Schneider	Duke University
Juerg Schoenenberger	University of Zurich, Switzerland
Katia Silvera	Florida Museum of Natural History
Hallie Sims	National Museum of Natural History
Pam Soltis	Florida Museum of Natural History
Doug Soltis	University of Florida
Hongshan Wang	Florida Museum of Natural History
Xin Wang	University of Florida
Barbara Whitlock	University of Massachusetts

## Appendix 2. A Sample Fossil List

Age		Stratigraphic Horizon / Locality	Systematics		Organs	# of species	Reference
			Order / Family	Genus / Species			
Coniacian-Santonian (89 ±0.5 – 83.5 ±0.5 Ma)*	Coniacian-Santonian	Åsen		<i>Chloranthistemon</i>	Flower	2	Eklund et al. 1997
			Hydrangeaceae or Escalloniaceae	<i>Scandianthus</i>	Flower	2	Friis and Skarby 1982
			Escalloniaceae	<i>Silvianthemum</i>	Flower	1	Friis 1990
			Juglandales or Myricales	<i>Antiquacarya</i>	Flower,	2	Friis 1983
				<i>Manningia</i>	Flower	1	Friis 1983
				<i>Caryanthus</i>	Flower	2	Friis 1983
				Upatoi Creek	Platanaceae	<i>Quadriplatanus</i>	Inflorescence

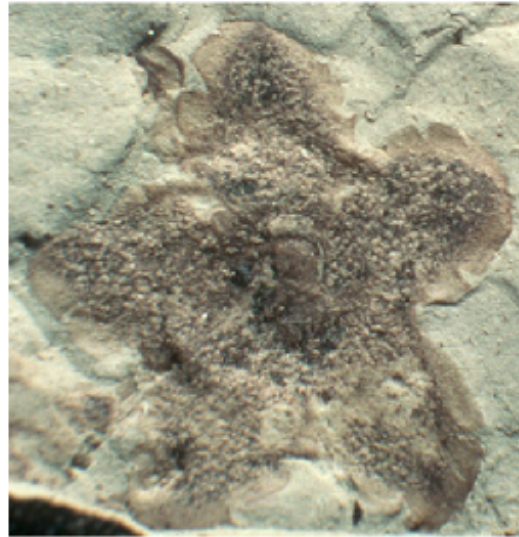
\* Age based on the Geological Time Scale of the International Commission on Stratigraphy (ICS) at <http://www.micropress.org/stratigraphy/tscale.htm>

Appendix 3. A sample page for each taxon.

**Taxon A**

**Reference 1**

**Reference 2**



[Click here for more images](#)

**DIAGNOSIS:** ([Link to detailed original description](#))

**LOCALITY:** [Rose Creek, Nebraska](#) ([Link to other taxa from this locality](#))

**PHYLOGENETIC POSITION:** ([Link to a tree or trees](#))

**AGE:** [Albian Cretaceous](#) ([Link to other localities of the same age](#))

**COMMENTS:** ([Link to Comments on this taxon](#))

**OTHER INFORMATION**