The 2012 Mid-Continent Paleobotanical Colloquium is produced under the joint sponsorship of the Department of Geology and Geophysics at Yale, The Peabody Museum of Natural History, The Yale School of Forestry & Environmental Studies, and The Yale Institute of Biospheric Studies. Following the recent successful pattern for these meetings, we plan for registration and an opening reception in the afternoon and evening of Friday, May 11th, with a full day of papers and poster presentations on Saturday, May 12th.

Our annual banquet and awards dinner will be held on Saturday evening. Other attractions will include The Peabody Museum’s fossil exhibits; new Cretaceous Garden; behind the scenes tours of the Peabody’s recently constructed state-of-the-art collections facility; the Marsh Botanical Garden; and the quaint ambience of a post-industrial New England town; not to mention the chance to get together and share some of the latest paleobotanical research with colleagues in a relaxed and informal setting.

Our field trip will take place on Sunday, May 13th in the beautiful Connecticut countryside looking at a lava flow that overwhelmed a stand of conifers in the earliest Jurassic, dinosaur trackways and other exhibits at Dinosaur State Park. We will also have two stops in South Britain, CT to see a large specimen of petrified wood in a local historical museum, and the site of “Connecticut’s Petrified Forest”, which constitutes the second-oldest documented paleobotanical locality in the United States (Hickey et al., 2011).
SCHEDULE OF EVENTS

Friday, May 11th

2:00 – 5:00 pm  Registration
Kline Geology Laboratory Foyer - 210 Whitney Avenue, New Haven, CT

Tours of Marsh Botanical Garden, the Cretaceous Garden, and the
Paleobotany Division of Yale Peabody Museum
Leaving from the Kline Geology Laboratory Foyer

4:00 pm  Marsh Botanical Garden Tour led by Eric Larson
Marsh Botanical Gardens - 227 Mansfield Street, New Haven, CT

5:30 – 5:45 pm  Meet to depart for Reception
Peabody Museum Parking Lot

6:00 – 9:00 pm  Reception (light buffet)
Home of Dr. Leo Hickey - 82 Blake Rd, Hamden, CT

Saturday, May 12th

8:00 – 8:30 am  Breakfast
Kline Geology Laboratory

8:30 - 10:05 am  Presentations
Kline Geology Laboratory

10:05 – 10:30 am  Coffee Break and Viewing of Posters
Kline Geology Laboratory

10:30 -12:30 pm  Presentations
Kline Geology Laboratory

12:30 - 1:30 pm  Lunch
Kline Geology Laboratory

1:30-2:45 pm  Presentations
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Kline Geology Laboratory

2:45-3:15 pm  Coffee Break and Viewing of Posters  
Kline Geology Laboratory

3:15-4:30 pm  Presentations  
Kline Geology Laboratory

4:30-5:30 pm  Tours of the Peabody Museum  
Meet at Peabody Museum Entrance - Herbarium, Invertebrate Paleontology, and Vertebrate Paleontology

5:45-6:30 pm  Reception and Silent Auction  
Kroon Hall, Yale School of Forestry & Environmental Studies - 195 Prospect Street, New Haven, CT

6:30-8:00 pm  Dinner and Awards  
Kroon Hall, Yale School of Forestry & Environmental Studies

8:00-8:45 pm  Keynote Address by Patricia Gensel  
Delving into the Devonian: New insights into the records of early land plants  
Kroon Hall, Yale School of Forestry & Environmental Studies

Sunday, May 13th

8:00 am – 2:30 pm  Optional field trip to the Triassic and Jurassic of Connecticut, including Connecticut’s Petrified Forest (includes a box lunch)  
Meet at Kline Geology Laboratory Foyer - 210 Whitney Avenue, New Haven, CT
KEYNOTE

Patricia Gensel, Ph.D.
University of North Carolina
Delving into the Devonian: New insights into the records of early land plants

Pat Gensel’s research emphasizes the study of fossil plants of Devonian age, with the goals of contributing data about their morphology, structure, evolutionary relationships, and overall patterns of evolutionary change. She also conducts research on plants of Lower Carboniferous age, with the intent of better understanding whole plants, phyletic lines, and evolutionary change in the time immediately following the Devonian. Research on plants of Late Cretaceous age from North Carolina is also underway, particularly on conifers and angiosperm wood; collections of leaves and flowers await study — this is a period of time of radiation of early angiosperm groups and this region has been little studied for over 50 years.

Dr. Gensel is interested in plant morphology, pteridology, and palynology, especially aspects of in situ Devonian spores, stratigraphic applications, and the use of pollen or spores in systematic and phylogenetic analyses in modern and fossil plants.
SCHEDULE OF PRESENTATIONS

Saturday, May 12th

Oral Session 1

Chair: Leo J. Hickey

8:30 am Introductory Remarks

8:35 am Arden R. Bashforth - National Museum of Natural History, Smithsonian Institution
Paleoecology of Early Pennsylvanian vegetation on a seasonally dry landscape

8:50 am Brian A. Atkinson, Gar W. Rothwell, and Ruth A. Stockey - Ohio University; Oregon State University
Permineralized vegetative shoots and seed cones from the Lower Cretaceous of Vancouver Island, British Columbia: A new genus of conifers, Cupressaceae s.l.

9:05 am Shusheng Hu, Harald Schneider, Leo J. Hickey - Division of Paleobotany, Peabody Museum, Yale University; Botanical Institute of Beijing, Chinese Academy of Science; Department of Geology and Geophysics, Yale University
A new Turonian fern sporangium from Linden Clay Pit, New Jersey

9:20 am Peter Crane - Yale University
Renewed and Resurgent: The Cultural History of Ginkgo

9:35 am Steven Manchester - University of Florida
Morphology, anatomy and possible rutaceous affinity of Porosia fruits from the Late Cretaceous and Paleocene of eastern Asia and western North America

9:50 am Scott L. Wing - National Museum of Natural History, Smithsonian Institution
Flora of the Paleocene-Eocene Thermal Maximum in Wyoming
Oral Session 2

Chair: Scott L. Wing

10:30 am  L. Calvillo-Canadell, S.R.S. Cevallos Ferriz - Instituto de Geologia, Ciudad Universitaria, Mexico, D.F.
Inga (Leguminosae: Mimosoideae) and Bursera (Burseraceae) leaves from the Middle Eocene La Carroza Formation

10:45 am  Sarah E. Allen - Florida Museum of Natural History, University of Florida
New inflorescences from the Eocene Bridger Formation, southwestern Wyoming

11:00 am  Deborah Woodcock, Herbert Meyer, Isabel Prado Velasco, Pedro Navaro Colque, Diana Pajuelo Aparicio - Clark University; Florissant Fossil Beds National Monument; Museo de Historia Natural, Peru; INGEMMET, Peru
Paleoecology of the Piedra Chamana Fossils (late middle Eocene, Peru)

11:15 am  Luis A. Flores-Rocha, S.R.S. Cevallos-Ferriz, L. Calvillo-Canadell - Privada de Chimalistac 42 A-103, Colonia Oxtopulco Delegación Coyoacan, México D.F.; Ciudad Universitaria, Coyoacan, Mexico Instituto de Geologia, UNAM
Diverse assemblage of Leguminosae woods from the Neogene of Mexico

11:30 am  Debra Stults, Brian Axsmith - University of South Alabama
Late Miocene fruits and seeds from southern Alabama

11:45 am  Gongle Shi, Haomin Li, Frédéric M.B. Jacques - Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences; Key Laboratory of Tropical Forest Ecology
Dipterocarpaceae fruits from the middle Miocene of Southeast China

12:00 pm  Camilla Crifò - Miami University, Ohio
Leaf vein density, a trait to assess forest structure in the fossil record

12:15 pm  W. A. Green - Harvard University
Leaf Rank Repeatability and Areole size Measurement
Oral Session 3

Chair: Andrew Leslie

1:30 pm  Ashley DuVal - Yale University
Collections of Japanese Woods with Plant Portraits

1:45 pm  Dana Royer - Wesleyan University
Leaf physiognomy as a paleothermometer: progress and challenges

2:00 pm  Casee Lemons, Daniel Peppe - Baylor University
Are fern leaf economics coherent enough to use as a proxy for fossil interpretations?

2:15 pm  Andrew Simpson - National Museum of Natural History, Smithsonian Institution
Testing the validity of phylogenetic comparative approaches using state speciation and extinction (SSE) models against paleontological reality

2:30 pm  Richard Barclay, Peter Wilf, Terry Lott and David Dilcher - National Museum of Natural History, Smithsonian Institution; Pennsylvania State University; Florida Museum of Natural History, University of Florida; Indiana University
The Cuticle Database: An online visual library for the study of plant cuticle characters

Oral Session 4

Chair: Shusheng Hu

3:15 pm  A. B. Leslie, J.M. Beaulieu, H. S. Rai, P.R. Crane, M.J. Donoghue, S. Mathews - Yale University; Utah State University; Harvard University
Hemisphere-scale Differences in Conifer Evolutionary Dynamics

3:30 pm  Jeremy M. Beaulieu, Michael J. Donoghue - Yale University
Understanding biases in molecular dating analyses: lessons from campanulid angiosperms

3:45 pm  James E. Mickle, Maria Rosaria Barone Lumaga - North Carolina State University; Università di Napoli
An interactive virtual museum of paleobotany based on the Museum of Paleobotany and Ethnobotany at the Botanical Gardens, University of Naples, Italy
4:00 pm  Leo J. Hickey, Shusheng Hu - Yale University
Compendium Index of North American Paleobotany

4:15 pm  Nathan A. Jud and Leo J. Hickey - Smithsonian Institution and Yale University
Primitive angiosperms from the Dutch Gap locality (Aptian, Potomac Group) show suites of eudicot and monocot leaf architectural features

POSTERS

10:05 – 10:30 am
Regan E. Dunn, Caroline A. E. Strömberg, Thien-Y Le, and Aidan C. Loeser
Department of Biology, University of Washington
Seeing the Forest through the Trees: Reconstructing Vegetation Structure from the Cellular Level

M. Madeleine Ray, Gar W. Rothwell
Ohio University, Oregon State University
Anatomically Preserved Cycadophyte Foliage from the Lower Cretaceous of Vancouver Island

Daniel P. Maxbauer and Dana L. Royer
Wesleyan University
A middle Eocene (~45 Ma) atmospheric CO₂ reconstruction from fossil Metasequoia, Axel Heiberg Island (Nunavut, Canada)

Sandra Schachat, Conrad C. Labandeira, Jessie Gordon, Dan Chaney, Stephanie Levi, William A. DiMichele, Maya S. Halthore, Jorge Alvarez
National Museum of Natural History, Smithsonian Institution; University of Maryland; University of Maryland; University of Puerto Rico
Plant–insect associations from the Early Permian (Kungurian) Colwell Creek Pond site of north-central Texas
Paleoecology of Early Pennsylvanian vegetation on a seasonally dry landscape

Arden R. Bashforth

Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, DC, 20560

Almost all reconstructions positing the composition and distribution of Pennsylvanian vegetation involve tropical wetland ecosystems, particularly peat-forming habitats (now coal) and associated damp to waterlogged clastic substrates. Floral assemblages preserved in such settings, where burial and long-term preservation was enhanced, represent communities that thrived during climatic intervals characterized by minimal seasonal dryness. In contrast, strata between coal-bearing intervals are typified by well-developed (calcic and vertic) paleosols, incised paleovalleys, and redbeds that can contain the remains of tropical vegetation adapted to more seasonal rainfall conditions. These dryland floras, inferred to have grown on moisture-deficient soils characterized by rapid oxidation, are only fortuitously preserved and hence are not as well known as wetland floras.

To improve knowledge of the paleoecology of dryland vegetation, plant remains were studied from the Lower Pennsylvanian (upper Bashkirian) Tynemouth Creek Formation of New Brunswick, which accumulated on a fluvial megafan adjacent to an elevated margin in the Maritimes Basin of Atlantic Canada. The redbed-dominated succession exhibits many features that are consistent with deposition under strongly seasonal rainfall, including evidence for degraded interfluves mantled by vertic paleosols, episodic discharge in shallow fixed-channels that cut into indurated floodplains, and shallow pools and waterholes scattered within drainage systems maintained by intermittent flow. By integrating sedimentologic and taphonomic observations with quantitative analysis of 41 megafloral assemblages collected in facies context, this research provides insight into how plant communities were distributed across a seasonally dry Early Pennsylvanian landscape.

Gigantic cordaitalean trees were the overwhelmingly dominant component of the ecosystem, and inhabited channel margins and well-drained interfluves. Medullosalean pteridosperms also occupied channel margins, but may have been centered on somewhat wetter parts of the landscape, particularly along the periphery of shallow ponds that developed in floodplain hollows and rimming waterholes that remained in fluvial drainages during the dry season. Dense stands
of calamitean sphenopsids were most abundant alongside fixed-channels, where they were buried by vertically aggrading splay and sheetflood deposits during monsoonal flooding. Lycopsids and ferns were exceedingly rare and occupied the wettest habitats. Several taxa traditionally characterized as ‘upland’ plants, including *Megalopteris*, *Pseudadiantites*, and *Palaeopteridium*, were a rare but relatively diverse component of the ecosystem. The presence of these unusual plants in the same fossiliferous beds as cordaitaleans and pteridosperms suggests that they were not washed in from distinct ‘extrabasinal’ communities, but rather lived together with other clades on basinal lowlands.

Permineralized vegetative shoots and seed cones from the Lower Cretaceous of Vancouver Island, British Columbia: A new genus of conifers, *Cupressaceae s.l.*

Brian A. Atkinson¹, Gar W. Rothwell¹,², and Ruth A. Stockey²

¹Ohio University, Department Of Environmental & Plant Biology, Athens, OH, 45701, USA; ²Oregon State University, Department Botany and Plant Pathology, 2082 Cordley Hall, Corvallis, OR, 97331, USA

A new genus of permineralized Cupressaceae is described based on vegetative shoots and seed cones from the Lower Cretaceous of British Columbia. These include five seed cone specimens and four vegetative shoots. The attachment of one cone to a vegetative shoot documents that all of the specimens represent the same species. The vegetative remains are similar to living and extinct species of *Cunninghamia* in having helically-arranged, needle-like leaves. Seed cones are cylindrical, 1.3 to 1.5 cm long, and 0.4 cm in diameter, with helically-arranged, bract/scale complexes. The ovuliferous scale is highly fused to the bract, except for three free apical lobes. There are three inverted seeds borne on the adaxial side of the bract/scale complex, each associated with an apical lobe. Seed cones display a novel combination of characters, but are similar in many respects to species of *Cunninghamia*, *Cunninghamiostrobus*, and *Hughmillerites*. This indicates that this new taxon has affinities with the basal Cupressaceae s.l. The novel combination of characters that delimit this plant consists of: 1) needle-like leaves, 2) bract/scale fusion except for the tip, 3) three seeds per bract/scale complex, 4) no interseminal ridge, 5) three free apical lobes of the ovuliferous scale, 6) no vertical division of the bract/scale trace, 7) one resin canal at the origin of the bract/scale complex, 8) continuous resin canal system, 9) one resin canal diverging with the bract trace, 10) resin canals branching in bract, and 11) no resin canals in the bract/scale complex at the level of the seed body adaxial to the vascular strand.
A new Turonian fern sporangium from Linden Clay Pit, New Jersey

Shusheng Hu¹, Harald Schneider², Leo J. Hickey¹, ³

¹Division of Paleobotany, Peabody Museum, Yale University, New Haven, CT 06511; ²Botanical Institute of Beijing, Chinese Academy of Science; ³Department of Geology and Geophysics, Yale University, New Haven, CT 06520

Charcoalified plant mesofossils have been recovered from Turonian carbonaceous clay samples collected from the Linden Clay Pit, New Jersey. In addition to angiosperm flowers, fruits and seeds, three fern sporangia were discovered. These are elongate and elliptical and average 2.3mm long and 0.9mm wide, with a 425μm long remnant of the stalk. The sporangium wall is 9μm thick except for an area where the wall is up to 29μm thick that may have functioned as annulus. Each sporangium contains up to 5000 spores. These are average 56 μm in diameter, with a raised trilete mark and scabrate sculpturing. In TEM section the spore wall has a very thin perine and a compact, uniform exine, with several cavities around the aperture. A detailed comparison of this material with extant lycophytes and members of the filicalian-sphenopsid clade excluded the homosporous lycophytes and the Marattiaceae based on the lack of stalked sporangia in those clades. Although sporangia of Equisetaceae and Psilotaceae have thick walls and contain a large number of spores per sporangium, spores of Equisetaceae differ by lacking trilete aperture and possessing elaters, while those of the Psilotaceae are aggregated into synangia. Stalked fossil sporangia and a large spore output fit Ophioglossaceae very well, but spore wall structure does not support this affinity. Sporangia of some members of Osmundaceae also have thick walls and large spore output. But spores of Osmundaceae have echinae that bear tubercles and a foliated exospore. Interestingly, although the wall structure of the Linden fossil spores is similar to that of Dicranopteris linearis of the Gleicheniaceae and some primitive members of that family have large sporangia and a high spore output, the morphology of their sporangia does not otherwise match that of the fossil sporangia. Therefore, the botanical affinity of the Linden sporangia is unknown.

Renewed and Resurgent: The Cultural History of Ginkgo

Peter Crane

Yale School of Forestry and Environmental Studies

The long fossil record of Ginkgo in the face of massive and pervasive environmental change provides clear evidence of extraordinary resilience in this ancient and unique lineage of plants.
However, at the end of the Cenozoic Ginkgo almost became extinct and it grows today in most parts of the world only because it has been planted there by people. The cultural history of Ginkgo cultivation in China appears to be relatively shallow compared to that of many other useful plants: most likely it extends back not more than about a thousand years. From China Ginkgo spread to Korea, and was most likely introduced into Japan in the fourteenth century. Engelbert Kaempfer was the first western botanist to describe Ginkgo during his visit to Japan in the 1690s and Ginkgo was first cultivated in Europe around fifty years later in mid-eighteenth century. Those introductions may have been from both China and Japan. Trees from this early phase of Ginkgo introduction still survive in Belgium, the Netherlands, and the U.K. By the 1760s the nurseryman James Gordon was growing Ginkgo in his nursery at Mile End, London. Gordon was the source of the specimen described by Linnaeus in 1771, the old Ginkgo that still grows at Kew, and very probably the first Ginkgo trees to be grown in North America, which were planted by William Hamilton and William Bartram in Philadelphia. Today, in addition to being grown for its nuts and for the supposed medicinal properties of its leaves, Ginkgo is planted most commonly in cities and is now one of the world’s most common street trees.

Morphology, anatomy and possible rutaceous affinity of Porosia fruits from the Late Cretaceous and Paleocene of eastern Asia and western North America

Steven R. Manchester

Florida Museum of Natural History, University of Florida

Fruits of Porosia verrucosa (Lesquereux) Hickey are known from many localities in the Paleocene of North America and eastern Asia. In North America, the fruits are known from a few sites of late Cretaceous (Campanian to Maastrichtian) age in Wyoming and Alberta, more than 50 localities in the Paleocene of Wyoming, Montana, North Dakota and Alberta, and at a few sites of early Eocene or Paleocene age in Oregon (Pilot Rock vicinity), and Washington (Chuckanut flora). In Asia, they are known from Maastrichtian of Koryak highlands of northern eastern Russia and from the Paleocene of the Zaisan Basin of Kazakhstan, and of the Amur Region. Porosia fruits have not been recovered from Europe and Greenland and the Amer-Asian distribution suggests dispersal across Beringia. The botanical affinities of these distinctive reniform structures have remained uncertain due to limitations in our understanding of its morphology and anatomy, but the discovery of seeds within them indicates that they are fruits, rather than float leaves as once speculated. Usually they are preserved as molds, casts, or impressions, but a few sites yield well preserved cuticles and a few have permineralized specimens. Combined information from specimens preserved in these different modes, allows us to understand their structure in good detail, and provide clues to botanical affinities. Complete pedicellate specimens from both Asian and North American localities indicate that the fruits were commonly borne in pairs with their ventral margins partially coalesced; hence they appear to be schizocarpic. Styles and stamens have not been observed but a whorl of scars on the peduncle below the fruit indicates the position of a
hypogynous perianth. Each fruitlet or mericarp is elliptical to reniform in face view, and lenticular in cross section. Sections of permineralized fruits indicate one locule in each mericarp, containing a single seed. Fully developed mericarps range from 0.8 to 2.0 cm in length, 0.6 to 1.6 cm in width, and are 1.3-2.2 mm thick, but frequently only one of the pair develops fully and the other remains small, only a few mm in length and width. The most striking feature of these fruits is the prominent closely spaced, anticlinally oriented tubules in the fruit wall. This gives a speckled appearance to the fruits; the tubules usually stand in relief as tiny sediment-filled protuberances all over the surface of each fruit. In permineralized specimens they are seen to be spaces without cellular tissue that readily filled with silica. I interpret these to represent oil cavities of the kind commonly found in Rutaceae. Together with other features suggestive of sapindalean affinities, like the superior ovary, unilocular mericarps, apparently axile placentation, the presence of regularly spaced, large oil cavities in the fruit wall lead to the new suggestion that these fruits represent the Rutaceae.

Flora of the Paleocene-Eocene Thermal Maximum in Wyoming

Scott L. Wing

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Late Paleocene and early Eocene floras from the northern Rocky Mountain region characteristically contain a mix of lineages that are today largely temperate (e.g., Betulaceae, Platanaceae, Cornales, Juglandaceae and taxodioid Cupressaceae) and those that are more subtropical-tropical (e.g., Arecaceae, Myrtaceae, Icacinaceae, and Lauraceae). Over the last 7 years I have collected 15 sites preserving plants from the particularly warm period of ~200,000 years at the beginning of the Eocene known as the Paleocene-Eocene Thermal Maximum (PETM). Plants belonging to the "temperate" families listed above are absent from these sites. Instead, the collections are dominated in diversity and abundance by Fabaceae and other families that tend to have more tropical to subtropical distributions today, such as Gyrocarpaceae. Some of the PETM taxa have been described previously from the Green River Fm., but others appear to be new. I will summarize what is currently known of the systematic affinities of the PETM flora, highlighting the fossils that are best understood.
**Inga** (Leguminosae: Mimosoideae) and **Bursera** (Burseraceae) leaves from the Middle Eocene La Carroza Formation

L. Calvillo-Canadell, S.R.S. Cevallos Ferriz

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Though the dry tropical flora in Low Latitude North America seems to be a relatively recent development of the tropical vegetation, some of its members seem to have a large history, as suggested by the Middle Eocene La Carroza Formation flora, in North Eastern Mexico. Presence of leaflets with narrow elliptic-oblong, asymmetric lamina, cuneate-convex base; serrate margin except in proximal zone. First order venation pinnate, well developed mid-vein, secondary veins eucamptodromous. Weak interior secondary veins present, third-order venation random reticulate. Fourth order venation dichotomous and areoles well-developed conform with the **Bursera** (Burseraceae) leaf type. A fragmented compound leaf with four pairs of elliptic-oblong leaflets, acute apex, asymmetrical convex base, first order venation pinnate, secondary veins brochidodromous, pulvinate petiole, nectary interpetiolar and winged rachis is compared with the leaves of members of **Inga** (Leguminosae:Mimosoideae). **Bursera** is today an important genus restricted to dry tropical flora, while **Inga** has a wider tropical distribution, perhaps suggesting that these fossils formed part of a rain forest that was being selected as climatic condition changed in Central and Southern Mexico, as suggested by their presence in the Oligocene Coatzingo Formation, where dry tropical or chaparral vegetation has been described, and confirmed by its extant distribution.

**New inflorescences from the Eocene Bridger Formation, southwestern Wyoming**

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The fluvial Bridger Formation of southwestern Wyoming is well known for its vertebrate fauna but also contains well preserved paleobotanical remains including wood, leaves, fruits, seeds, flowers, and pollen. While fossil leaves (including **Lygodium** and **Populus**) are more abundant in both the Bridger flora, and the adjacent lacustrine Green River Formation, the associated reproductive structures provide important new clues as to the systematic affinities of the plants.
growing in this region approximately 50 Ma. We recognize at least seven types of flowering structures from a well-collected exposure along the Blue Rim escarpment site (UF 15761) in Sweetwater County, Wyoming. Only one of these, Landeenia, has been published previously. The remaining six flower structures are currently under investigation and include: 1. Specimens with three tepals and six stamens ranging from 6.6 to 9 mm in diameter. In situ pollen from specimens of the same morphotype from the Barrel Springs locality of the Green River Formation may provide additional characters to assist in taxonomic identification. 2. A specimen ca. 10 mm in diameter with five tepals. 3. Another five-tepaled flower ca. 7 mm in diameter preserving a rounded central structure that is large in comparison to the size of the petals. 4. A morphotype with up to eight tepals and numerous stamens (~40-90, possibly in fascicles) and a prominent gland or nectary like structure at the base of each tepal. Observations suggest the corolla and androecium are fused and this composite structure detached from the gynoecium before being deposited. These transversely compressed specimens have been tentatively matched to laterally compressed specimens in which only three or four of the tepals are visible, some with fruiting bodies. It is hypothesized that this variety of structures represents different developmental stages of the same species. 5. A spicate inflorescence with flowers preserved in multiple orientations (possibly spiral) that range from 1 to 1.5 mm in width. 6. A globose to ellipsoidal inflorescence that varies from ~1.7 to 4.2 cm in diameter often with protruding stamens. These structures are composed of oval subunits which are frequently striated. A detached subunit from one of these inflorescences preserves 2-3 stamens. Epifluorescence microscopy has confirmed the presence of pollen in both the stamens of the large globose inflorescences and the eight-tepaled flowers. Various other reproductive structures (including fruits and pollen) preserved at Blue Rim are still in need of review; with luck more specimens of these morphotypes or others will be uncovered during the upcoming field season and can be linked to the approximately 42 dicotyledonous leaf morphotypes found at the same site.

Paleoecology of the Piedra Chamana Fossils (late middle Eocene, Peru)

Deborah W. Woodcock¹, Herbert W. Meyer², Isabel Prado Velasco³, Pedro Navaro Colque⁴, Diana Pajuelo Aparicio⁴

¹Clark University; ²Florissant Fossil Beds National Monument; ³Museo de Historia Natural, Lima Peru; ⁴INGEMMET, Lima Peru

The Piedra Chamana Fossil Forest in northern Peru, which is associated with volcanic rocks of the Huambos Formation (39 Ma), includes a large amount of fossil wood occurring across an 8-km-long area. In one part of the site, woods are weathering out of a volcanic mullflow (lahar) deposit and in growth position in an underlying ashfall that also contains fossil leaves. The fossils appear to represent 1) lowland tropical forest with a diversity of monocots and dicots, 2) a back-mangrove or seasonally flooded association with the mangrove genus Avicennia and other taxa.
including palms, and 3) low diversity coastal/strand vegetation with *Avicennia*. Presence of *Avicennia* among both woods and leaves and morphological/anatomical analyses of the leaves and woods are consistent with dry conditions along the shore of the ocean embayment that extended into the continental interior during this period. Estimated specific gravity of the woods averages .50-.55, lower than the average for wet tropical forest, but the range of values (.33-.77) approaches that of lowland tropical forests generally. The fossils document uplift of ~2600 m since the late middle Eocene and include a type of ecosystem (coastal mangrove) that is rarely preserved in the rock record.

**Diverse assemblage of Leguminosae woods from the Neogene of Mexico**

Luis A. Flores-Rocha¹, S.R.S. Cevallos-Ferriz², L. Calvillo-Canadell²

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Woods collected in the towns of Las Guacamayas, Chiapas (Miocene), Panotla, Tlaxcala (Miocene), and Culiacan, Sinaloa (Pleistocene) are similar to that of Leguminosae. The fossil woods studied have in common the presence of storied structures (vessel elements, axial parenchyma, rays), vessel-ray pits smaller than intervessel pits, aliform, banded, confluent and/or vasicentric axial parenchyma, etc.; all these characters are shared with extant legume woods; however, they also have characteristics that makes them differ from each other, and other legume species, such as the size of intervessel and vessel-ray pits, diameter of vessel elements, number of pores per mm² and rays/mm, presence of homogeneous rays only the presence or heterogeneous as well, ring-porosity (rare in the group) and diagonal arrangement of pores, presence of vascular tracheids and some others. However, the combination of these characters is not enough to rule out that some of the samples could represent individuals of the same species, or alternatively may represent different developmental stages of the same species, yet their detailed discussion suggests that some are species of the same genus, but most are species of distinct genera. The anatomical study suggests that taxonomically the fossil material represents the subfamilies Caesalpinioideae with the genera *Caesalpinia*, *Haematoxylon*, *Gleditsia* and *Gymnocladus*; Papilionoideae with *Dalbergia*, *Swartzia*, *Sophora*, *Milletia/Lonchocarpus* and *Holocalyx*; and Mimosoideae with *Mimosa* and *Xylica*. These new records confirm the important presence of Leguminosae in Mexico during the Cenozoic, particularly during the Neogene (Miocene and Pleistocene), and highlight the presence of some taxa that grow naturally in South America today.
Late Miocene fruits and seeds from southern Alabama

Debra Stults, Brian Axsmith

Department of Biology, University of South Alabama

Study has just been initiated on two comparable sites in southern Alabama in which significant numbers of paleocarpological remnants have been recently recovered. Although plant fossils had been realized at one of these sites forty years ago, no serious specimen collection attempts had occurred until now. The first site is called Mauvilla, located near the village of Mauvilla along an area of the Chickasaw Creek in the central portion of Mobile County in southern Alabama. The second site is separated from the first by a couple of miles and occurs along Williams Creek, also in Mobile County. Original geological study of the Mauvilla site was undertaken due to the presence of vertebrate fossils and, at the time, was presumed to be part of the Mid-Piacenzian Citronelle Formation. However, subsequent determination that one of the vertebrate fossils was the late Miocene three-toed horse, *Protohippus gidleyi* Hulbert, established a 9.0-6.5 Ma age for the site. Currently both sites are regarded as being portions of the Ecor Rouge sand, a unit typified as a Late Miocene fluvial deposit. Most of the plant fossils recovered are mesofossils and microfossils, although there are some compression fossils of *Chaemocyparis*, *Taxodium*, and *Trapa*. Paleocarpological analysis is very preliminary at this point, but there appears to be greater than 30 different taxa represented by seeds, fruits, and reproductive parts. Identifications thus far recognize gymnosperms as represented by *Chaemocyparis* and *Taxodium*. Interestingly, no *Pinus* mesofossils have yet been found. Early angiosperms identifications include *Carya*, multiple *Quercus* species, multiple *Nyssa* species, *Cyrrilla*, *Carex*, *Scirpus*, *Trapa*, *Vitis*, and probable other vitaceous species. Palynological analysis of these Ecor Rouge sites is occurring concurrently. This new study of plant fossils within the northern Gulf of Mexico Coastal Plain will be a major addition to the understanding of how the plant community in this region may have changed. It will be incorporated into a timeline that is being developed in this laboratory from plant fossils of southern Alabama that currently includes specimens of the Late Cretaceous, Late Miocene, Mid-Pliocene, and Pleistocene.

Dipterocarpaceae fruits from the middle Miocene of Southeast China

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The Dipterocarpaceae is a tree family dominant in Asian tropical rain forest, many of its species being of great economic value. The fossil records of this family are mostly represented by wood and leaves, the reliability of them is, however, often questionable. The fruits of Dipterocarpaceae, characterized by their persistent enlarged calyx lobes, the fruit wings, are easily identifiable but very rarely represented in the fossils. In a previous report, we described a fruit wing of *Dipterocarpus* from the Miocene Fotan Group in the Zhangpu County, Fujian Province, Southeast China. This *Dipterocarpus* fruit wing was collected by a palynologist in the 1980s during her field work for palynological sampling. In order to get more materials of this fossil species, we carried out field work two times in the same site in the past year and fortunately discovered some well-preserved winged fruits, isolated fruit wings, and abundant leaf impressions and compressions.

All new discovered plant fossils were collected from the middle part of the Fotan Group. This Group is composed of about three layers of basaltic rocks, in between every two of them with sedimentary deposits such as arenaceous conglomerate rocks, sandstone and mudstone interbedded with lignite and diatomite. The palynostratigraphic study of the sedimentary layers indicated a Miocene, and most probably middle-late Miocene age. The Ar$^{40}$/Ar$^{39}$ age of the basaltic rocks in Zhangpu under the fossil yielding sedimentary layer is 14.8±0.6 Ma, corresponding to the Langhian stage (middle Miocene).

Among the newfound fossil fruits, four species with Dipterocarpaceae affinity have been distinguished including the previously reported *Dipterocarpus zhengae* H.M. Li & G.L. Shi. The new materials of *D. zhengae* include a nearly complete winged fruit with the nut and two enlarged calyx lobes, and a compression of a single fruit wing with cuticle preserved. The new discovery would improve our knowledge of this fossil species. The other three new discovered dipterocarps species are referred to the genus *Shorea* on the basis of the preliminary comparisons with herbaria of this family. They are represented by completely preserved winged fruits as well as isolated preserved fruit wings. All of these fruits have three persistent enlarged calyx lobes with 9-12 longitudinal veins nearly parallel arranged, which only happens in the genera *Shorea* and *Parashorea* among the family Dipterocarpaceae. The morphological characters of the enlarged calyx lobes indicate they most probably belong to the genus *Shorea* rather than *Parashorea*. The three *Shorea* species are different from each other in the size of the nuts, as well as the size and vein number of the fruit wings. Fossil leaves found together with the winged fruits have been distinguished to more than 50 morphotypes. The recognized families include Lauraceae, Fabaceae, Fagaceae, Moraceae, Hamamelidaceae, Clusiaceae, and probably Dipterocarpaceae as well. We believe this flora might represent an ancient rain forest in the middle Miocene of Southeast China.
Leaf vein density, a trait to assess forest structure in the fossil record

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Background and Aims: An emblematic ecosystem in the modern Neotropics is the multistratified forest, composed of various species having very distinct demands of resources and conditions. Its origin is still debated and little is known about when and how its modern structure developed. Our aims are to explore the variation of vein density ($D_v$) through the forest, to test if this trait can be used to evaluate the position of a plant within an ecosystem, and to infer from the fossil record the structure of ancient forests. Vein density is a leaf trait that can be preserved in the fossil record and which correlates with maximum conductance to water vapor; its increase during the Cretaceous is thought to have allowed an improvement in transpirational capabilities through angiosperms’ evolution.

Methods: 245 trees belonging to 83 tropical species with different ecological strategies were selected from Parque Nacional Metropolitano semi-deciduous dry forest and Parque Nacional San Lorenzo evergreen humid rainforest in Panama. Three leaves per individual coming from one to three individuals per species were analyzed. Leaves were stored in a refrigerator and then were treated. A 2cm$^2$ fragment was cut from each leaf and cleared in NaOH for 10 to 30 days. Leaves were then stained using a Safranin-Ethanol solution. Stained leaves were photographed with a digital camera mounted on a stereoscope at a magnification of 20x. Three photos per leaf were analyzed with ImageJ; vein density ($D_v$=L/A) was calculated as the total vein length (L) per unit leaf area (A). The leaf area measured is usually around 10mm$^2$. $D_v$ variation between species from different forest strata (canopy vs. understorey), with different light requirements (sun-demanding vs. shade-tolerant species), and phylogenetic position (basal vs. derived angiosperms) was analyzed.

Results: Vein density is significantly higher for canopy than for understorey trees. Light-demanding species have higher average $D_v$ than shade-tolerant species, and in both types, vein density follows a horizontal gradient. No significant phylogenetic signal for $D_v$ was found, but derived angiosperms show generally higher values and a wider range of vein density.

Conclusion: Vein density distribution through the forest reflects its stratification and the coexistence of different ecological strategies among trees; this trend shows that the placement of a tree within the forest (strata) is a central driver of leaf eco-physiological adaptations. The next step of this project will be to compare $D_v$ distribution between tropical forest and a temperate forest in the U.S. in order to verify if this trait can be used to distinguish between these two very different environments. If a dissimilar distribution will be observed, then vein density could be considered a reliable environmental proxy and used to distinguish tropical and temperate forests.
in the fossil record. After that, and before applying this method to the fossil record, it is also necessary to study $D_v$ in the forest's leaf litter, which is what is primarily reflected in any fossil flora.

Leaf Rank Repeatability and Areole size Measurement

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Leaf rank is a semi-quantitative scoring method for assessing the degree of organization in the vein network of a dicot leaf. Different aspects of leaf vein networks have been associated with leaf hydraulics, structural support, and macroevolution, as well as used as taxonomically informative characters and biostratigraphic markers. Full quantitative description of these vein networks remains in the future, but preliminary measurements of 120 cleared leaves show how the procedures of leaf ranking do allow us to capture reliable, consistent information from leaf vein networks quickly. In addition, we have looked at the subjective error associated with the scoring, and can document a relationship between leaf rank and quantitative variables like areole size.
Oral Session 3

Collections of Japanese Woods with Plant Portraits

Ashley DuVal

Yale School of Forestry and Environmental Studies

This work analyzes the origins, historical context and broader significance of five sets of illustrated wood blocks from early Meiji Japan (1878), held in multiple economic botany collections, which include images of Ginkgo and other trees. Each board is constructed from the wood of an economically important tree or palm, painted to depict the botanical details of the species, framed with its bark and cornered with cross sections of its branch. There are 220 stylistically similar boards representing 150 different species held among five collections in Europe, North America and Japan. In each case little was known about their origin, intended purpose and details of their acquisition. Similar components, including four styles of labels, make it possible to relate boards across the different collections to one another. A collective analysis of the sets of wood blocks (xylotheques) is undertaken to determine details relevant to their origin and construction, the circumstances under which they left Japan, and their broader significance. The painted wood blocks demonstrate a unique fusion of western and eastern approaches to art and education and are helpful artifacts for understanding the rapidly changes in scientific philosophy in early Meiji Japan. Greater understanding of their historical context and significance was only possible through analysis and correlation across multiple collections.

Leaf physiognomy as a paleothermometer: progress and challenges

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Leaf physiognomy (size and shape) in fossils is commonly used to reconstruct terrestrial paleoclimate. One long-standing popular method is leaf-margin analysis, which infers mean annual temperature from the site-mean proportion of species with untoothed leaf margins. In this presentation I will review digital leaf physiognomy, a relatively new multivariate approach for reconstructing climate. Based on the criteria of calibration statistics and comparison with independent climate estimates in fossil case studies, digital leaf physiognomy appears more robust than leaf-margin analysis and other multivariate approaches such as Climate-Leaf Analysis Multivariate Program (CLAMP).
Despite the progress made with digital leaf physiognomy, many challenges remain with most leaf-climate methods. I will highlight the confounding nature of leaf thickness, leafing habit (deciduous vs. evergreen), growth habit (tree, shrub, liana, herb), and phylogenetic history, and propose a path for including these factors in leaf-climate methods. These methods have been applied to fossil assemblages for almost a century and remain one of the most robust and common ways to reconstruct terrestrial paleoclimates. Successful engagement with their current challenges will help to ensure their continued use.

Are fern leaf economics coherent enough to use as a proxy for fossil interpretations?

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Ferns have a long and robust fossil record; however, the habitats and ecophysiological development of ancient ferns are poorly understood. Understanding the ecology of ancient ferns begins with assessing extant ferns. One way of assessing fern ecology is through the analysis of leaf economic spectrum, which is comprised of leaf traits that reflect tradeoffs essential to plant survival. As an example, leaf mass per area (LMA) and leaf life span (LLS) reflect the expenditure of growing new photosynthetic tissue and the duration over which the revenues of photosynthesis are returned, respectively. Species with high LMA have more robust leaves, which in turn allow for longer LLS. Although LMA cannot be measured directly from fossils, recent work has shown that in gymnosperms and angiosperms, there is a strong scaling relationship between leaf area and petiole width, normalized to leaf mass. Thus, by measuring leaf area and petiole width, LMA and LLS can be quantified for fossil gymnosperms and angiosperms.

Given the interrelationship of leaf economic traits and their phylogenetic independence, we hypothesized that: (1) all levels of fern leaf hierarchy will hold the same allometric leaf trait relationships, and (2) previously established biomechanical plant models for gymnosperms and angiosperms can be used as a paleoecological proxy for ferns. However, results show that allometric relationships are not consistent within all levels of fern hierarchy, and a distinctly different biomechanical model explains the relationship between PW and LMA in extant ferns. These results suggest that there is good potential for using biomechanical models for interpreting the life history attributes of fern fossil leaves, though the model is different from those developed for angiosperms and gymnosperms.
Testing the validity of phylogenetic comparative approaches using state speciation and extinction (SSE) models against paleontological reality

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Modern phylogenetic methods rely heavily on molecular data, providing them with a host of more characters than traditional morphological systematics. Using phylogenetic trees and the character states of terminal taxa, it is possible to reconstruct ancestral character states in the absence of a fossil record. State Speciation and Extinction (SSE) models, developed by Madisson et al., take this a step further by enabling estimation of speciation and extinction as a function of character states, as well as the rates and directions of change from one set of character states to another. For example, a particular suite of character states can be represented by many species because it confers high fitness to the individual, thereby resulting in populations shifting toward that set of character states. Alternatively, a combination may be common because once it occurs in a lineage, the species that possesses it has elevated net speciation rates, and thus diversifies in an adaptive radiation. SSE algorithms are capable of distinguishing between these two scenarios under certain simplifying assumptions. However, these simplifying assumptions include lack of environmental change that alters selective regime, lack of secular trends in speciation and extinction rates over time, and other such assumptions known to be violated by fossil data. Nonetheless, it is possible that some SSE models are robust to violations of some of these assumptions, especially in clades whose evolutionary histories are dominated by periods of net speciation, such as most presently diversifying clades. Conifers present an excellent laboratory in which to study the effects of violated assumptions on the use of SSE algorithms, containing both younger, actively diversifying groups such as the Pinaceae, as well as older groups such as the Araucariaceae and Cupressaceae (sans Juniperus) whose peak periods of diversity are past. In addition, models can also be used to create realistic simulations of diversification and decline of hypothetical clades the diversification parameters of which are known. Collection and assembly of data with which to test the validity of SSE algorithms when their assumptions are violated is in progress; current results will be presented at the meeting.

The Cuticle Database: An online visual library for the study of plant cuticle characters

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We announce the release of The Cuticle Database, the first large, unrestricted visual library of leaf cuticle available on the Internet, hosted at the Earth and Environmental Systems Institute at Penn State: http://cuticledb.eesi.psu.edu. The Cuticle Database is a reference tool designed to promote the study of plant cuticle characters, intending to facilitate systematic studies of living and fossil plants and to allow recognition of ecological variation. The Cuticle Database Project has been a collaboration between scientists at Indiana University, the Florida Museum of Natural History, Northwestern University, The Field Museum, and Pennsylvania State University. The project was initiated in 2005 and originally hosted at The Field Museum. Principal funding for major web development and data migration to Penn State was provided by the David and Lucile Packard Foundation, with additional support from the National Science Foundation. The image library of plant cuticle was created by photographing the prepared cuticle slide collection of Dr. David Dilcher. The originally sampled herbarium leaves and the prepared cuticle slides are both archived in the Paleobotany Collection at the Florida Museum of Natural History. This collection of slides was prepared by David Dilcher, his students, and wife Katherine Dilcher at Yale University and Indiana University, using vouchered herbarium specimens. Now in digital form in the Cuticle Database, Dilcher’s collection comprises 1678 individual records spanning 69 plant families, including 476 genera and 1298 separate species. The Cuticle Database will continue to grow, predominantly from future contributions by members of the botanical and paleobotanical scientific communities.

New software was designed and coded by Alex Sokoloff to meet the specific goals of the Cuticle Database Project. The database runs on the open-source Django web framework (v. 1.3), which comes with an object-relational mapper that describes the database layout in Python code. The user interface was designed and implemented by Chris Thurman (christhurman.com), with site graphic design and logos by Jessica Leon-Guerrero (digigirlstudio.com). The content of the Cuticle Database is accessed principally through search. Each page allows family, genus, and species-level searches, or the user can conduct an advanced search on individual metadata fields. Search results provide the user with a scrollable list of records, including a thumbnail image of the lower epidermal surface and a subset of important metadata. Choosing a record from the search results builds a dynamic species record with a medium-resolution image of the upper and lower cuticle surfaces, as well as all available metadata. The highest resolution image available can also be viewed and downloaded.

Care has been taken to verify that the submitted taxonomic name for each record is free of typographical errors and updated to a consistent level. Data were cleaned of errors, and entries in metadata fields were standardized during data migration from The Field Museum to Penn State. The existence of each submitted species name was verified in the taxonomic databases of the Missouri Botanical Garden (www.tropicos.org), the International Plant Names Index (www.ipni.org), and The Plant List (www.theplantlist.org). No attempt was made to rectify synonyms at the species level, as these are not universally accepted, and we leave this to the discretion of the researcher to decide for each individual case. However, designed into the site is a system for updating the genus and family level designations using the ‘Kew Genus + APG Family Lookup’ tool (www.phylodiversity.net/phylomatic/kewlookup.html). On a periodic basis all
records are filtered using this tool; genera are modified to match the list at Kew; families are changed to match the Angiosperm Phylogeny Group. The Kew Lookup tool does not always provide the most current name, which should be vetted by the user, but it is an automated improvement over the historic nomenclature associated with many slides. For transparency and consistency as the name changes over time, the ‘Original Designation’ of the submitted taxonomic name remains unchanged and visible to the user below the most current assignment.

The current release of the Cuticle Database (v. 1.0) is dominated by angiosperms from the Americas, because this was the research focus of David Dilcher’s lab. However, future plans include expanding the database to increase taxonomic and geographic breadth. To enhance the value of the database, we encourage the contribution of well-documented material, especially if these are vouchered herbarium specimens or fully curated fossils. Contributors will be fully acknowledged, and those able to provide well-documented images from more than 50 species will be included as co-authors in the official Cuticle Database citation, although contributions of all sizes are encouraged. We invite you to bring forward your collection of cuticle images to enhance this useful new tool for botanists and paleobotanists!
Hemisphere-scale Differences in Conifer Evolutionary Dynamics

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Northern and Southern Hemispheres differ fundamentally with respect to the distribution of seas and landmasses, which may generate differences in the diversity and diversification patterns of organisms inhabiting them. The evolutionary history of conifers provides an opportunity to explore these dynamics, because the majority of extant conifer species belong to lineages that have been broadly confined to the Northern or Southern Hemisphere through the Cenozoic. Based on a critical review of fossil evidence, we developed an age-calibrated phylogeny sampling more than 80% of living conifers. Most extant conifer species diverged recently during the Neogene within clades that were generally established during the later Mesozoic. However, lineages that diversified mainly in the Southern Hemisphere are significantly older than their counterparts in the Northern Hemisphere, and have a median node age more than twice that of corresponding Northern lineages. Our tree topology and divergence times are also best fit by diversification models where Northern Hemisphere conifer lineages have higher rates of species turnover compared to Southern Hemisphere lineages. These patterns may ultimately result from the greater amount of high-latitude land area in the north, leading to more extreme continental climates and a greater degree of connectivity between landmasses. Both of these features may favor extinction or replacement of older lineages.

Understanding biases in molecular dating analyses: lessons from campanulid angiosperms

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For flowering plants, the ages of clades estimated from molecular phylogenetic analyses have not always corresponded well with the accepted fossil record. In particular, the application of molecular clock methods has tended to yield older dates, in many cases much older than has seemed credible based on the stratigraphic record. As methods have further relaxed the
assumptions of substitution rate inheritance (e.g. uncorrelated relaxed-clocks) and acknowledge the uncertainty in a fossil age by treating fossil calibrations as probabilistic priors, the gap between the stratigraphic record and molecular age estimates seems to only get wider. It may be that these older molecular dates are indeed real and are providing a new understanding of key events in flowering plant evolution. However, it is still unclear how uncorrelated relaxed-clock models perform in the presence of molecular rate shifts between lineages and how the placement of fossil calibrations influences their performance in these situations. Here we study these issues in detail by focusing on the Campanulidae, a large angiosperm clade that has been the subject of a recent molecular phylogenetic analysis. With respect to the dating, the campanulids, and the major lineages within the clade, are inferred to have existed far back into the Cretaceous, possibly too far based on biogeographic analyses. We explore the possibility that these discrepancies reflect potential biases in the divergence time estimates. We use a simulation approach to assess the impact of lineage-specific rate heterogeneity on molecular age estimates. These simulations suggest that in certain situations current methods are unable to cope with extreme differences in molecular rate and older age estimates are often the consequence. We also demonstrate how inferences about biogeographic history might be useful in pinpointing instances where molecular age estimates are potentially misleading.

An interactive virtual museum of paleobotany based on the Museum of Paleobotany and Ethnobotany at the Botanical Gardens, University of Naples, Italy

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The Museum of Paleobotany and Ethnobotany at the Botanical Gardens of the University of Naples (www.ortobotanico.unina.it) functions primarily as a teaching facility. Located in the “Castle” on the grounds of the Garden, the paleobotany section of the museum occupies two rooms that depict the plant fossil record from evolutionary and taxonomic viewpoints. The centerpiece of the museum’s displays is a three-dimensional phylogenetic tree of the plant kingdom that is 2 X 2 m at the base and 2.5 m high. An interactive virtual museum has been developed based on the paleobotanical displays in the museum. The CD of the virtual museum shows a layout of the actual museum. Clicking on the display cases shows the display in that particular case, and explains the subject of the case. When clicked on, cases that display fossils will show the individual fossils with name and data, the phylogenetic tree is accessible, and displays of models showing, for example, the evolution of the seed, leaf and stele are available in the virtual museum. The development of a virtual museum on CD permits wide distribution to audiences within and especially outside the Naples area. Its use in classrooms and other venues increases awareness and interest in paleobotany among both botanists and the general public.

2012 MPC-29 Mid-Continent Paleobotanical Colloquium
The Division of Paleobotany at Yale Peabody Museum is pleased to announce the electronic publication of the *Compendium Index of North American Mesozoic and Cenozoic Type Fossil Plants*. This file is a digitized version of a card-file index of approximately 20,000 images and text of fossil plant species, maintained at Yale Peabody Museum of Natural History. The Compendium Index presently covers fossil floras from North America, including Greenland, starting in the Triassic Period and extending to Pleistocene. In some cases its coverage is extended to higher latitude regions of Eurasia because of the close relationship of the entire circumpolar flora of those times. Each record in the physical Compendium consists of an 8”x10” card onto which the illustrations and description of an individual occurrence of a fossil plant species have been reproduced on the front and reverse side, respectively. Along with the illustration, the front of the card also contains the species name, age, and other locality data, as well as its nomenclatural status and bibliographic information. Each entry thus consists of at least two images—a front and a back—that together make up the primary card.

The taxonomic identification of fossil plant material is an essential first step in determining the evolutionary history of clades as well as for reconstructing past vegetation and paleoenvironment. Yet the identification of fossil plant material is often a painstaking process that may consume months of research time. In order to determine the correct name for a fossil plant, researchers must comb a broad array of publications from highly disparate and often hard to obtain sources that span a period of more than 160 years. Moreover, the large number of misidentifications, synonyms, and misapplied names in the systematic literature require access to high quality pictorial data in addition to descriptions and lists of names and occurrences. Despite recent advances in digitization the scattered nature and lack of systematic finding-aides for this literature often cause investigators to overlook important primary sources.

The Compendium was begun in 1937 by Erling Dorf, of the Department of Geology at Princeton University, and by 1940, covered some 126 references. Dorf’s major innovation involved organizing its cards into a set of numbered morphological categories (e.g., leaf shape, major venation type) that grouped like forms with one another regardless of their purported taxonomic assignments. In 1984 the Compendium was transferred to Peabody Museum, where work on updating the content and reorganizing the classification system. At first, most new references were added using paste-ups of high quality Xerox copies. Today, new cards are made by means of Photoshop and physical copies of new cards are still prepared but these consist entirely of digital
scans of images and text. Work on the Compendium remains an ongoing project of the Division of Paleobotany.

**Primitive angiosperms from the Dutch Gap locality (Aptian, Potomac Group) show suites of eudicot and monocot leaf architectural features**

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Undoubtedly, many Early Cretaceous angiosperm fossils do not correspond to modern genera or families, making them notoriously difficult to identify; however, leaf architectural characters can be viewed in a phylogenetic framework that permits the recognition of major clades in Lower Cretaceous deposits. Using this approach we discuss new leaf fossils from the Potomac Group Dutch Gap locality in Northern Virginia, a multi-story sequence of fluvial sediments. One of these new leaf morphotypes displays a suite of features that permit its recognition as the oldest monocot, while another has a suite of characters that suggests that it is an early eudicot- possibly a member of Ranunculales or a stem eudicot. Both of these morphotypes come from the lowest beds at Dutch Gap and are preserved in light-gray, poorly-sorted mudstone interlaminated with beds of medium-gray, well-sorted claystone. These plants most likely grew together as understory herbs in the distal levee-backswamp transition.

**POSTER ABSTRACTS**

**Seeing the Forest Through the Trees: Reconstructing Vegetation Structure from the Cellular Level**

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In many cases, traditional paleobotanical studies using fossil leaves or pollen lack the ability to accurately reconstruct the structure of ancient vegetation. Vegetative structure determines many important aspects of an environment including productivity, soil moisture and temperature, fire frequency, carbon storage, atmospheric gas concentrations, and faunal habitat and diet. Phytoliths extracted from paleosols represent highly localized fossil plant assemblages and have been used to reconstruct habitats in studies involving grassland evolution. However, the existing method for reconstructing vegetative structure and habitat type (open vs. closed) using phytoliths depends on taxonomic occurrences of presumed open-habitat grass types. This method may lack resolution to reliably reconstruct vegetation when open habitat grass phytoliths are absent, and it depends on the assumption that open-habitat grasses have always been so. Therefore, a taxon-free, morphological approach is needed when considering fossil phytolith assemblages. This study presents a novel proxy for estimating Leaf Area Index (LAI), a measure of openness, from the fossil record. It uses the known relationship between sunlight and epidermal plant cell shape in dicotyledons, whereby leaves growing in shade have more undulated, or wavy cells than sun leaves, and our previous work has indicated that such a relationship exist in grasses as well. Modern soil samples from variable light environments (savanna, shrubland, deciduous tropical forest, flooded savanna and multi-tiered rainforest) were collected from areas in Costa Rica. For each soil sample, LAI was estimated using hemispherical photography. Phytoliths were extracted from the soil samples, epidermal plant cells from all taxa (including those from ferns and angiosperms) were traced, and phytolith undulation was standardized using a Phytolith Undulation Index (PUI). Preliminary results indicate a strong, positive correlation between cell undulation and LAI where undulation increases with increasing LAI. This finding potentially adds a new tool to paleoecological and evolutionary studies where data about habitat structure are desired.

Anatomically Preserved Cycadophyte Foliage from the Lower Cretaceous of Vancouver Island

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Anatomically preserved cycadophyte frond fragments have been discovered in Lower Cretaceous deposits at Apple Bay on the north end of Vancouver Island, British Columbia, Canada. Carbonate concretions contain several isolated “pinnules” and a pinnately dissected frond that produces pinnule bases, all of which were originally hypothesized to represent a frond of the Bennettitales. Pinnule bases extend from the midrib at 90° angles, and pinnule venation is longitudinal with no pinnule mid-vein. By contrast, the isolated pinnule-like frond parts have a distinct midrib. A surface view of one specimen shows parallel margins, the prominent midrib from which veins
diverge at 90° angles, and deep ridges on the abaxial surface. Cross sections of the isolated “pinnules” show a ring of vascular bundles with associated sclerenchyma in the midrib. These specimens reveal that there are at least two plants at the Apple Bay locality that produced cycadophyte foliage. One has a pinnate frond and bears pinnules with no midvein. The other may be a simple leaf with a distinct midrib and haplocheilic stomata. The pinnate frond appears to conform to the Bennettitales, and may correspond to either the *Williamsonia* sp. or the *Foxeoida connatum* seed cones that have been described from the same locality. The other foliage type is of less certain affinities, and could possibly represent the seed fern that produced the uniovulate cupules previously described from Apple Bay as *Doylea tetrahedrasperma*.

A middle Eocene (~45 Ma) atmospheric CO$_2$ reconstruction from fossil *Metasequoia*, Axel Heiberg Island (Nunavut, Canada)

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The Eocene (55–34 Ma) has been well studied by paleoclimatologists largely due to the dramatic climate shift from the early Eocene greenhouse to the onset of Antarctic glaciation at the Eocene-Oligocene boundary. Paleoatmospheric CO$_2$ reconstructions have focused primarily on the early Eocene Climatic Optimum (EECO) (~52 Ma). Relatively less is known about the middle Eocene which represents an important time period between peak warmth and the transition to a global icehouse. The middle Eocene fossil forests of the Buchanan Lake Formation on Axel Heiberg Island in the Canadian High Arctic provide well preserved, yet fragile, remains of the deciduous conifer *Metasequoia*. *Metasequoia* is often used in studies of paleoatmospheric CO$_2$ from stomatal density (SD) and stomatal index (proportion of epidermal cells to stomata, SI) due to the high degree of evolutionary stasis within the genera. Both SD and SI reconstructions are based on species-specific calibration curves, which are laborious to construct and perform poorly at estimating high levels of CO$_2$. More recently, gas-exchange based models which emphasize stomatal conductance, known photosynthetic parameters, and carbon isotope data have been developed which remove dependence on modern calibrations and remain valid at high CO$_2$ levels. In the past, difficulty in isolating *Metasequoia* cuticle from Axel Heiberg precluded reconstructions of paleoatmospheric CO$_2$. We present a new, simplified, method to obtain clear *Metasequoia* cuticle from Axel Heiberg using primarily hydrofluoric acid and epifluorescence microscopy. We test the gas-exchange based approach to reconstructing paleoatmospheric CO$_2$ and present an initial high-resolution CO$_2$ record from Axel Heiberg Island.

Plant–insect associations from the Early Permian (Kungurian) Colwell Creek Pond site of north-central Texas

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A qualitative analysis of insect damage in a Permian flora from Texas shows a far wider variety of damage types than in other deposits previously analyzed in this globally important, iconic section of Upper Pennsylvanian and Permian floras and faunas. This represents the youngest Permian deposit assessed for this type of plant-animal interaction during the Permian in western equatorial Pangaea. Over 1,000 leaves from the Lower Permian (Kungurian) Colwell Creek Pond (CCP) site in Texas reveal low external foliage feeding levels but high incidences of piercing-and-sucking, oviposition, and galling. Galls were overwhelmingly represented on the peltasperm *Auritifolia waggoneri*. Leaves belonging to the form genus *Taeniopteris* suffered a high incidence and wide range of insect damage. The Gigantopteridaceae were represented by only one species, *Evolsonia texana*, which was not particularly heavily herbivorized, in contrast to gigantopterid foliage in older floras from the same region. Incidences of new gall types add significantly to the late Paleozoic gall record and may shed light on the transition from the Paleozoic to Modern Insect Fauna.

Comparisons of the functional feeding groups represented at CCP with other sites from the Lower Permian of Texas indicate that herbivory type and intensity was highly variable in the late Paleozoic. Significantly higher incidences of insect damage than on Upper Permian and Lower Triassic foliage from Gondwana, which is much better sampled than the equatorial region, shed light on changing plant-insect dynamics through the emergence of the Modern Insect Fauna and through the End-Permian Extinction.
Walking directions: Marsh Botanical Gardens Tour

**Departure time:** May 11th, 2-5 pm with a guided tour at 4 pm

**Departure location:** Kline Geology Laboratory - 210 Whitney Avenue, New Haven, CT

**Destination:** Marsh Botanical Gardens - 227 Mansfield Street, New Haven, CT (0.7 miles)

1. Head north on Whitney Ave toward Humphrey St
2. Turn left onto Edwards St
3. Turn right onto Prospect St
4. Turn left onto Hillside Pl
5. Turn right onto Mansfield St
Emergency Transportation (New Haven area)

METRO TAXI (203) 777-7777
QUICK TAXI (203) 777-7778
CITY WIDE TAXI (203) 777-0007

Driving directions: Reception (light buffet) at the home of Dr. Leo Hickey

Departure time: May 11th, 5:45 pm
Departure location: Peabody Museum Parking Lot/210 Whitney Avenue, New Haven, CT
Destination: 82 Blake Rd, Hamden, CT (1.9 miles)
1. Head north on Whitney Ave toward Humphrey St
2. Turn left onto Blake Rd
   Destination will be on the left
Walking directions: Kroon Hall, Yale School of Forestry & Environmental Studies

**Departure location:** Kline Geology Laboratory - 210 Whitney Avenue, New Haven, CT

**Departure time:** May 12th, 5:45 pm

**Destination:** Kroon Hall – 195 Prospect Street, New Haven, CT (0.3 miles)

1. Head south on Whitney Ave toward Sachem St
2. Turn right onto Sachem St
3. Turn right onto Prospect St
4. Destination will be on the right
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