ABSTRACTS

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Index of Presenters

Organizing committee: Ashley Hamersma, Indah Huegele, MacKenzie Smith, Julian Correa, Terry Lott, Honshang Wang, Steve Manchester

Cover artwork: Ashley Hamersma

Friday Noon Pre-Conference Oral Abstract

The Evo-Devo of Multicellularity

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The multiple origins of multicellularity had far-reaching consequences ranging from the appearance of phenotypically complex life-forms to their effects on Earth's aquatic and terrestrial ecosystems. Yet, many important questions remain. For example, do all lineages and clades share an ancestral developmental predisposition for multicellularity emerging from genomic and biophysical motifs shared from a last common ancestor, or are the multiple origins of multicellularity truly independent evolutionary events? In this seminar, I highlight recent developments and pitfalls in understanding the evolution of multicellularity with an emphasis on plants (here defined broadly to include the polyphyletic algae) and also draw upon insights from animals and their holozoan relatives, fungi, and amoebozoans. Based on this review, I conclude that the evolution of multicellularity requires three phases (origination by disparate cell–cell attachment modalities, followed by integration by lineage-specific physiological mechanisms, and autonomization by natural selection) that have been achieved differently in divergent lineages. The convergence toward multicellularity is just one example of non-canonical explication. Others include the evolution of photosynthesis, mitosis, and meiosis. This explication should give pause to uncritical conclusions regarding molecular originations of major evolutionary transitions.

Saturday Morning Oral Abstracts

Investigating Mazon Creek fossil plants using computed tomography and microphotography

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More than 20,000 siderite concretions from Mazon Creek are housed in the paleobotanical collections of the Field Museum. A large proportion contain fossil plants of Middle

Pennsylvanian age that often have excellent three-dimensional morphology and sometimes anatomical detail. Approximately eighty plant taxa have been recognized from the Mazon Creek Lagerstätte but few have been studied in detail and in some cases the systematic affinities of these fossils need reevaluation. The three-dimensional (3D) preservation of Mazon Creek plants makes them ideal candidates for study using x-ray micro-computed tomography (CT) and here we apply these techniques to more accurately reconstruct the morphology of specimens of *Tetraphyllostrobus* and *Crossotheca*. The mineralogical composition of the fossil plant preservation was studied using elemental maps and Raman spectroscopy. In-situ spores were studied with differential interference contrast, Airyscan confocal super-resolution microscopy, and scanning electron microscopy. Our analyses show that CT can provide excellent detail on the three-dimensional structure of Mazon Creek plant fossils, with the nature of associated mineralization sometimes enhancing and sometimes obscuring critical information. Results provide guidance for selecting and prioritizing fossil plant specimens preserved in siderite concretions for future research.

Estimates of the late Early Cretaceous atmospheric CO_2 based on stomatal and isotopic analysis of Pseudotorellia from Mongolia

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The Aptian-Albian (121.4-100.5 Ma) is a known greenhouse period, with global temperatures 10-15°C warmer than pre-industrial conditions. Given this warmth, it is surprising that the most reliable CO_2 estimates from this time max out at about 1500 ppm. To address this discrepancy, we applied a well-vetted paleo-CO_2 proxy (Franks leaf-gas exchange model) to two ginkgoalean species of *Pseudotorellia* Florin from the Tevshiin Govi Formation (119.7-100.5 Ma) in central Mongolia. Our estimated CO_2 concentration using *P. resinosa* is 3375 ppm (1920-6436 at 95% confidence). Estimates of *P. palustris* are lower but overlapping (1878 ppm; 1321-3827 at 95% confidence). The primary reason for the high yet variable CO_2 from *P. resinosa* is its very low stomatal density (mean 13.4 mm^{-2}); when stomatal densities are this low, small variations propagate to large changes in estimated CO_2. Despite the variability within and between species, we can exclude CO_2 concentrations below 1300 ppm at high confidence. Overall, a CO_2 concentration >1300 ppm (and potentially much higher) during a greenhouse time keeping in line with our current understanding of climate sensitivity.

A new look at '*Laurus*' *macrocarpa* Lesquereux from the mid-Cretaceous (Cenomanian) Dakota Formation

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1. Oak Spring Garden Foundation 2. Florida Museum of Natural History

The classic mid-Cretaceous 'Dakota Sandstone flora' consists mainly of impressions of angiosperm leaves in a relatively coarse yellow-ochre sandstone matrix. However, it also contains a few reproductive structures, including the angiosperm flowers/fruits *Lesqueria* and *Dakotanthus*. Specimens described previously as fruits of *Laurus macrocarpa* Lesquereux and *Laurocarpum tetragonale* MacNeal from Nebraska, Kansas and Texas are preserved as molds and casts that lack cellular details, but light microscopy and micro-CT scanning reveals structural features indicating that *L. macrocarpa* and *L. tetragonale* are not angiosperm fruits, but a chlamydospermous seed with a four-valved outer envelope, most likely produced by plants closely related to extant Gnetales. These fossils provide the first macrofossil evidence of probable Gnetales in the angiosperm-dominated Dakota Formation and a new search image for future investigations of the fossil record of Gnetales and related plants.

Filling in the gaps: Evaluating a Miocene flora near Anchor Point, Kenai Lowland, Alaska

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In 2016, Steve Friend contacted the University of Alaska Museum of the North about plant, animal and trace fossils found at the Anchor River State Recreation Area, Kenai Lowland, Alaska. These fossils are of presumed mid-late Miocene age. Three floristic stages (the Seldovian, Homerian and Clamgulchian), also from the Kenai Lowland, are well known from studies by Jack Wolfe and others, documenting climatic and floristic transitions from the Middle Miocene through the Early Pliocene. Wood, charcoal fragments and possibly leaf cuticles are present in the Anchor Point matrix and will be prepared for microscopy. The matrix will also be processed for palynomorph study. Identified plant fossils include: miscellaneous conifer foliage and cones, including those of *Metasequoia*, *Taxodium*, *Glyptostrobus*, and *Picea*; *Betula* and *Alnus* leaves, inflorescences and infructescences; pollen catkins assignable to Juglandaceae; leaves potentially assignable to *Alangium*, *Ilex*, *Quercus* and *Ribes*; and trochodendraceous fruits and leaves. Trochodendraceae, *Glyptostrobus* and *Metasequoia* are known from several Miocene sites in the Pacific Northwest, Japan and Kamchatka, but today are restricted to Asia in distribution. Other taxa are biogeographical disjuncts between Asia and North America. Initial findings suggest the Anchor Point assemblage may be transitional to the Seldovian and Homerian floristic stages.

Stories from Republic: What Eocene plants can tell us

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The early Eocene fossil localities in and around the old mining town of Republic in northeastern Washington host a rich biota of plants, insects, occasional invertebrates and at least one bird. The Republic flora, along with other related lacustrine floras of the Okanogan Highlands that extend up into British Columbia have provided leaves, flowers, fruits and seeds of many early representatives of today's important temperate plants including members of Rosaceae, Sapindaceae, Betulaceae, Ulmaceae, Platanaceae and Anacardiaceae among others and a rich record of conifers. In this presentation I will discuss several of our recent studies from Republic that both contribute to plant systematics but also focus on evidence of the evolutionary mechanisms that were apparently in place already in the latest early Eocene. These include evidence of dormancy, possible hybridization, plant defense against herbivorous mammals, as well as ferns and waterlilies with similar morphologies and plant habits as we see in these groups today.

Late Cretaceous Normapolles plants from the Czech Republic

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The Normapolles complex is a group of eudicot angiosperms known from various Late Cretaceous and Paleogene localities in the Northern Hemisphere. All representatives share a distinctive type of pollen grain, which is characterized by three complex apertures that are either porate or colporate, and have a short polar axis. Normapolles flowers and fruits associated with Normapolles pollen are rarer, and so far, have been described only from the Late Cretaceous. All Normapolles taxa are thought to belong to the order Fagales, and they are characterized by small, mostly epigynous flowers with a simple, undifferentiated perianth, and dry, indehiscent fruits with a single seed. So far, six genera of Normapolles plants (*Budvaricarpus*, *Calathiocarpus*, *Caryanthus*, *Dahlgrenianthus*, *Slavicekia* and *Zlivifructus*) are known from the Czech Republic. A seventh genus, *Walbeckia*, is currently under revision – it appears to be another Normapolles genus, but it has not yet been submitted for review. Specimens assigned to Normapolles plants are reported mostly from the Klikov Formation of late Turonian–Santonian age consist of three lithological types that occur in irregular cyclic sequences and is the basal stratigraphic unit of the South Bohemian Basins. The Klikov Formation comprises continental sediments, mostly alluvial and rarely lacustrine.

Biogeographic implications of Cenozoic European hickory nuts of *Carya ventricosa* and *C. hauffei*

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The eastern Asian—eastern North American biogeographic disjunction has received much attention with interests in its origins and timing. *Carya* is one of the classic genera exhibiting this pattern. Although absent from Europe today, the genus has a rich fossil record there. We studied, by micro-CT scanning, the nuts of the extant species of hickories (*Carya*) and walnuts (*Juglans*) in comparison with those of the fossil European species *Carya ventricosa* and *C. hauffei*. Although these fossils were at one time placed in *Juglans*, the peripheral of the main vascular bundles in the primary septum is a diagnostic feature for *Carya*. *C. ventricosa* is morphologically closest to East Asian *C. poilanei,* although not identical. *C. hauffei* differs from extant *Carya* species by its rough nutshell exterior resembling some *Juglans*, but has diagnostic features of *Carya*, with similarities both to the Asian *C. cathayensis* complex and the North American *C. aquatica* group. We conclude that *C. ventricosa* has its closest relationships to eastern Asia indicating likely eastward migration via the southern Turgai route prior to the extinction in Europe. The affinities of *C. hauffei*, still under investigation, might reflect former ties with North America via the North Atlantic land bridge.

Poster Abstracts

Further identification of disarticulate prickles of *Rosa* and *Rubus* using geometric morphometrics

Mikayla Agbamuche[1], Ashley Hamersma[1] and Steven R. Manchester[1]
1 Florida Museum of Natural History

Roses, known for their beauty and economic value, have been culturally important for millenia and part of vegetation worldwide for much longer. Based on research from the last decade, the crown age of Rosaceae is estimated to be between 101.6- 95.09 Ma and fossil occurrences indicate the genus was present in North America by the early Eocene (55.8-48.6 Ma). Today, more than 100 species of wild rose thrive across the incredibly diverse temperate regions of the Northern Hemisphere. One of the most distinguishing features of the genus *Rosa* are its prickles which can contain helpful morphological information to consider when identifying fossils. Often, fossil prickles are recovered as disarticulate individuals. They may be assigned to Rosa based on overall morphology and presence of other reproductive or vegetative fossils indicative of *Rosa* like the 'rosehip' accessory fruits and compound leaves. Other rosaceous genera bear prickles as well, and of these, *Rubus* is often found in similar habitats to *Rosa*. However, fossil prickles are

rarely assigned to *Rubus*. Here we address with observational study, ontological discussion, and landmark-based morphometrics the differences between the prickles of *Rubus* and *Rosa* and applications to fossil determinations in aiding studies of Rosaceae diversity and evolution.

Oligocene palm fruits of west coastal Peru

Ashley Hamersma[1], Steven R. Manchester[1] and Fabiany Herrera[2]
1 Florida Museum of Natural History; 2 Field Museum

Palms are one of the most diverse and dominant plant groups in the tropical and subtropical areas of South America today but their macrofossil record in the region is relatively limited. The Belen paleobotanical flora of western Peru was introduced by Berry and is important as one of the most diverse fruit and seed floras from South America. Dating with diatom assemblages to the early Oligocene, this assemblage provides insight to vegetation of northwestern Peru prior to the full uplift of Andes and establishment of the Humboldt current. This flora dates to prior to the close of the Central American Seaway and the Great American Interchange, providing vegetational insights into the flora and climate in the area prior to these paleobiogeographic events. Berry recognized three palms in his investigation of the Belen flora. Two are based on a single specimen and remain questionable because they lack diagnostic pores and other characters, but the specimens assigned to *Palmocarpon bravoi* show distinctive features confirming their identity as palms. Here, we revisit *P. bravoi* as based on original collections and supplemented by new specimens collected in 2010, concluding that the original taxon concept includes what we now consider to be two separate species.

Characterization of a flower of fossil genus *Sahnianthus* by micro-CT and considerations of placement in Lythraceae

Chandana Karumanchi[1], Ashley Hamersma[1] and Steven R. Manchester[1]
1 Florida Museum of Natural History

The Deccan intertrappean beds of India are sedimentary beds deposited between volcanic events from the Late Cretaceous (Maastrichtian) to Paleocene (Danian) as the Indian subcontinent drifted northward over a mantle plume or hotspot in the present-day location of Réunion Island. The cherts of the locality produce abundant morphologically and anatomically preserved fossil woods as well as plant reproductive material including fruits, seeds, and flowers. Paleobotanical study of this locality is important in order to provide high-resolution insight into the rapid climatic and biotic change brought on by repeated and extensive volcanism. The fossil genus *Sahnianthus* has been recorded from the area and is represented in the University of Florida collections. It has been hypothesized to belong to the family Lythraceae and here we use new techniques to confirm that placement. Specimens have been studied with micro-computed tomography scanning (micro-CT) and digital reconstruction in order to develop a more accurate idea of their morphology and anatomically characterized through study of thin sections with light

microscopy. This contributes to the understanding of overall paleoclimatic and paleogeographic change in the area, as well as confirm the affinity of reproductive material to the family Lythraceae, expanding its known fossil record and geographic extent.

A new species of winged-rachis leaf from the Eocene of western North America

Diamond Kinard[1] and Steven R. Manchester[1]
1 Florida Museum of Natural History

A distinctive new angiosperm fossil leaf species is described from Eocene lake bed sediments of the Clarno Formation in eastern Oregon. The leaves consist of a serrated terminal leaflet on a long petiole or rachis that bears one or more diamond-shaped laminar wings. Although lateral leaflets have not been observed, the laminar wings are similar to those surveyed in winged rachises of pinnately compound leaves found in various angiosperm families of Eudicots including Juglandaceae, Burseraceae, and Rutaceae.

Fruits of *Sabia* from the Miocene of western North America

Gabriel Latchaw[1] and Steven R. Manchester[1]
1 Florida Museum of Natural History

We consider a newly recognized species of fruit that has been recovered as a rare fossil in middle Miocene floras of eastern Oregon and Idaho. Based on their distinctive endocarp morphology, as revealed by reflected light and micro-CT scanning, in comparison with similar extant fruits we conclude that they represent the Asian genus *Sabia* of the protealean family, Sabiaceae. Although this genus was previously recorded from the Eocene of western North America, these fossils indicate that it survived as late as the Miocene.

Paullinieae (Sapindaceae) as a possible model for adaptive radiation in lianas

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Paullinieae (Sapindaceae) are a diverse group of neotropical lianas in a family that otherwise consists of mostly trees and shrubs. Although Paullinieae constitutes a small percentage of the family's genera, they account for a quarter of the species diversity. This project seeks to understand the evolution of the group by exploring its phenotypic diversity, correlations between phenotype and environment, and the diversification rate to clarify if its evolutionary history is best explained by adaptive radiation. To quantify phenotypic variation at the genus level, I used images from the Smithsonian Botany Collection to measure fruit and seed data, such as wing width and length, seed width and length for 50 species of *Serjania*. To test for a correlation between fruit and seed traits in *Serjania* and climate variables such as mean annual precipitation and mean annual temperature, I used phylogenetic least squares regression (PLSR). Finally, I created a fossil-calibrated phylogenetic tree using the programs Beauti and BEAST to estimate

the age of the group and the sister clade. To compare diversification rates, I used the method-of-moments estimator to compare Paullinieae with its sister clade. Although there is variation in seed size and wing proportions, the PLSR revealed no significant relationship between seed size and mean annual precipitation (MAP) or mean annual temperature (MAT), but there was a significant relationship between wing length and MAP. The estimated age of the crown group is ~30.5 Ma using the fossil *Ampelorhiza* to calibrate the node representing the most recent common ancestor of *Serjania*, *Paullinia*, and *Cardiospermum*. Preliminary results of the diversification rate analysis indicate that Paullinieae does have an elevated net diversification rate and higher morphological variation compared to its sister group under a variety of possible speciation and extinction rate scenarios. The tribe is very diverse, but so far we have not identified a clear relationship between adaptive phenotypic variation and environmental variables across the tribe that we would expect for adaptive radiations. Future research could explore other aspects of the family's phenotypic variation, such as floral morphology and pollinator relationships.

Palynomorph analysis of the P-40 locality of the Lake Clarkia Fossil Beds

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1 University of Idaho

16 million years ago, ancient Lake Clarkia formed when the Columbia River Flood Basalts dammed the St. Maries River near Clarkia, Idaho. The world-famous Clarkia Fossil Beds contain exceptionally preserved fish, plants, and palynomorph fossils that record the high temperatures of the Mid-Miocene Climatic Optimum. While the P-33 and P-37 localities of Lake Clarkia have been extensively studied, little has been done with the P-40 locality due to poor access to the site. Here, we have documented changes in diversity and species richness through a section that is 10 cm thick, representing roughly 11 years of deposition at the P-40 locality near Clarkia, Idaho. Preliminary results show depositional changes within 1 cm intervals, with significant changes in the number and distribution of pollen grains, particularly with bisaccate grains (*Pinus*, *Picea*, and *Cathaya*) and *Betula*. Season change is also indicated by increases in the size and frequency of diatoms that record diatom blooms.

Fossil leaves of *Pterospermum* (Malvaceae) from the Early Miocene of Jungu, Yunnan Province with their paleoecological and phytogeographical implications

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Pterospermum (Malvaceae) is mainly distributed in the tropical regions of Asia and only has a few fossil records in India. This study reported fossil leaves of *Pterospermum* from the Lower Miocene Sanhaogou Formation in the Jinggu Basin, Yunnan Province, China. Three types of

Pterospermum were recognized based on detailed morphological comparisons with both fossil and living species. *P. shuangxingii*, a recently described species, is characterized by an obovate leaf shape, untoothed margin, trilobed leaf apex and cordate and asymmetrical leaf base, which resembles the living species *P. grandiflorum* from Southeast Asia. *P.* cf. *yunnanense* is represented by an unlobed leaf with a relatively small size, and *P.* sp. has two simple teeth at the apex. The discovery of *Pterospermum* from the Jinggu Basin indicates an early Miocene diversification of this genus in SW China. Together with latest molecular phylogenetics and fossil record, we propose that *Pterospermum* may have originated in India during the Early Eocene and dispersed to Southeast Asia during the Neogene. Besides, this study observed similar insect damage patterns on both fossil and modern *Pterospermun* leaves, with some probably caused by weevils (Brachyceridae: *Desmidophorus*). It suggests that the modern plant-insect interaction in this genus could date back to the early Miocene.

Saturday Afternoon Oral Abstracts

Warmer Temperature Estimate for the Eocene Clarno Nut Beds of Oregon

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1 Florida Museum of Natural History

The Nut Beds of the Clarno Formation of central Oregon (Lutetian Eocene, ca. 44 Ma) are of scientific and public interest due to its diverse carpoflora (173 species) that is the basis for the Clarno Unit of John Day Fossil Beds National Monument. Previous climate estimates using leaves or wood from the same site range from 9.2-18.8ºC for mean annual temperature (MAT) and 195-295 cm for growing season precipitation (GSP). New calibration data and an additional 45 morphotypes to the previously used 74 morphotypes warrant a rerun of the Climate Leaf Analysis Multivariate Program. We find a MAT of 20ºC and a GSP of 201 cm. The likely driver of the increase in temperature from previous estimates is the increase in proportion of entire margined morphotypes. Precision could be improved with more complete specimens as the completeness score was only 55%. Nonetheless, this study shows the importance of reevaluating sites when more specimens are found.

The Flora of the Dennis Formation

Elizabeth Wilson[1] and Nathan Jud[1]
1 William Jewell College

The plant fossil record provides direct evidence of changes in the diversity and distribution of plants through time. However, our knowledge of the plant fossil record is limited by the amount of available data. Therefore, the discovery and description of plant fossils help us better understand the history of earth. The greater Kansas City area is built on bedrock of limestone and shales that were deposited during the late Carboniferous Period (Pennsylvanian). These strata are

the result of climate change during that time. We describe the diversity of plants preserved in the Dennis Formation based on fossils collected from several sites in the Kansas City area. The macrofossil assemblages are dominated by *Cordaites spp.*, "*Neuropteris*" *lindahli*, and *Macroneuropteris scheuchzerii*. Fossil pollen and spores show evidence of additional diversity including ferns and lycophytes. Permineralized wood occurs locally in creeks and is currently under investigation. We compare this flora with floras of similar age around North America and discuss how they help us to test hypotheses about climate and vegetation change during the Pennsylvanian.

Uncovering the reproductive morphology of *Ettingshausenia* (Platanaceae) from the Czech Republic

Indah Huegele[1] and Jiri Kvacek[2]
1 Florida Museum of Natural History; 2 National Museum, Prague

Several different species of *Ettingshausenia*, an extinct genus of Platanaceae, grew in the Bohemian Basin during the mid-Cretaceous. Although the leaf diversity has been well-studied, it was completely clear what reproductive structures were associated with these plants. We studied fossil inflorescences from several localities in the Peruc-Korkany Formation of the Bohemian Cretaceous Basin and analyzed them using micro-computed tomography (microCT) and SEM. We find that large, staminate inflorescences likely are associated with *E. bohemica* (based on their common co-occurrence at localities like Vyšehořovice). These inflorescences have developed, cup-shaped perianth and 4-5 stamens per floret. The abundance of staminate material compared to pistillate material and large size of some staminate capitula is unusual for Platanaceae. These findings provide important insight to the reproduction of mid-Cretaceous sycamores in Central Europe.

Revisiting the Eocene flora from the Claiborne Group in western Kentucky, USA

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During the early Paleogene, the Earth experienced a long-term global temperature increase punctuated by multiple hyperthermal events. The warming resulted in a decreased global latitudinal temperature gradient and a global increase in seasonality and drought. Changes in faunal and floral distribution and composition have been documented in the western part of North America and other regions during this time period and studies have supported the hypothesis that a widespread band of thermophilic plant communities existed and expanded into the mid latitudes, consistent with biota tracking climate change. It is not clear how well these

floras are connected, and how exactly they responded during these rapid and long-term global warming events. Our goal is to gain insight in the composition of Eocene Gulf Coastal Plain USA plant communities during this warm time using various leaf physiognomic traits, proxies, and systematic census of several floras. For this, we visited and collected floras from several localities in the Claiborne group in western Kentucky. We've used cuticular analysis to describe leaf morphotypes and narrow down their botanical affinity. Initial analysis of floras from one collection suggests at least 7 morphotypes indicative of a warm environment and a fairly open canopy structure.

Passion fruit seeds, one from the Oligocene of Mississippi and one from the Pleistocene of Alabama

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We describe two *Passiflora* seeds, one from the Late Oligocene (approximately 25 Ma) in a newly recognized paleobotanical site in southern Mississippi, and one from a previously recognized paleobotanical Pleistocene site (approximately 85–82 ka) in southern Alabama. The Late Oligocene site is the Jones Branch site of the Chickasawhay River and is listed as Late Oligocene based upon indicator mammalian taxa, such as *Agnotocastor* and *Miohippus*. The age of the Pleistocene site is based upon luminescent dating of quartz and feldspar minerals. Upon comparisons of these two fossils seeds with other fossil *Passiflora* seeds (which record is sparse) and abundant modern *Passiflora* seeds, we describe a new species from the Late Oligocene to be named in memory of Brian Axsmith. We also document the first record of the modern species, *Passiflora incarnata*, from the Pleistocene epoch, within a region (south Florida northward to New Jersey and westward to Kansas and Texas) where it currently naturally occurs.

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