Podcast Interview: Jennifer Mandel

PNAS: Welcome to Science Sessions. I'm Paul Gabrielsen. The sunflower family, formally known as Asteraceae, is the largest family of flowering plants on Earth, with more than 30,000 species successfully established on all continents. The family displays extraordinary diversity, yet the evolutionary origins of this globally important family are difficult to unravel. Jennifer Mandel of the University of Memphis took on that challenge. In a recent PNAS study, Mandel and her colleagues used genetic techniques to narrow down the origin of Asteraceae to Cretaceous-era South America. Later, the family underwent extensive diversification, likely aided by a changing climate. Mandel introduces us to the eclectic Asteraceae family.

Mandel: The species are vines, they're trees, they're shrubs, they're herbs, they can really take any kind of form. Like dandelions are weeds, and others like Echinacea, which you may have heard of, are used as medicinals. Many members of the family are economically important like artichokes, lettuce, chrysanthemums. Another unique species is the strawflower from Australia. It has bright yellow bracts, which, bracts are specialized leaves, and the bracts look like petals on a flower. They retain this bright color even when you dry them, so sometimes they get the name everlasting daisy. One of the scientific names for the family is Compositae, in addition to Asteraceae, and that refers to the composite nature of the head. So, individual flowers in the head are closely aggregated into these tight clusters that botanists call a head or capitulum. So, the structures that people often call petals on a sunflower are actually individual flowers. So, that's kind of neat.

PNAS: Few fossils of Asteraceae exist, and the family has a history of rampant genome duplication, Mandel says, which makes tracing genetic origins complicated. Previous evolutionary histories were based on physical forms, or morphology. But genetic work in the 1980s upended that tree, finding that some lineages likely originated earlier and some later than previously thought.

Mandel: Now with new sequencing technologies and building upon the earlier molecular work that began in the 1980s, along with more recently discovered fossils, including a pollen grain that was from Antarctica that was dated to about 72 million years, which is in the Cretaceous, then this work has sort of culminated in showing that the family likely originated before the mass extinction event, in southern South America. Compared to the previous work, our dataset is pretty huge - 1,000 genes, a million base pairs, 250 taxa. Our work is built upon the many before us who studied the family, both in terms of morphology and taxonomy. The effort in terms of the sampling and the collection of the plant material is really monumental. The sampling is global and we're really indebted to the people who have collected from Patagonia or the Tibetan Plateau for the project.

PNAS: I asked Mandel what the earliest Asteraceae may have looked like.

Mandel: I don't think we really know, it's hard to say. The oldest described lineage, the Barnadesieae, which has these pairs of spines running along the stem, and is a lineage

that itself is really diverse. There's a large time gap, we think, from when the origin of the family in the late Cretaceous until the Barnadesieae evolved. And there aren't fossilized flower heads from that time. Mostly everything we have in terms of fossils are pollen. So it's hard to reconstruct a species from that.

PNAS: After their initial rise in the Cretaceous, the Asteraceae exploded in diversity in the middle Eocene epoch. Mandel explains the role climate may have played in that explosion.

Mandel: For sure the most successful diversification in the family occurred during the middle Eocene probably out of Africa when the Earth was experiencing dramatic climate changes. The climate was cooling since the middle Eocene, had been cooling, and probably habitats were opening up, fewer forests, more open lands, more grasslands. These are habitats in which Asteraceae is so common. So, they'd be something like a right place, right time during the middle Eocene.

One night I was talking to my six-year-old and I said – "Why are sunflowers so successful, why are they everywhere?" And he said "Because they can grow, Mommy." It was a really simple answer, but I actually thought there was a lot of meaning in that. They do grow in just about every environment you can imagine, they have all types of growth forms. Some are weedy and some of them are rare. But I really think that it has something to do with a combination of factors. Polyploidy and genome duplication are really rampant in the family. That can provide novel genetic material for species to evolve. Dispersal is really important for species to be ecologically successful. Think about the white parachute of the dandelion that you used to blow, or maybe still do. The most successful diversification happened when the earth was beginning to cool and habitats were changing and the types of environments in which sunflowers are most successful were opening up. and probably increasing across the globe.

PNAS: Mandel points out that this work only establishes a backbone of evolutionary development of the family, with much more refinement of the family's history yet to come.

Mandel: Some of the more subsequent diversifications and migrations that occurred in more recent times, we haven't sampled those. Those are left as open questions for future studies. For example, the North American sunflowers, we know that there were major diversifications. Those are future work to dive deeper into those questions of subsequent migrations and diversifications.

PNAS: Thank you for listening to PNAS Science Sessions. We would love to hear your thoughts about this show. Get in touch with us at PNAS on Facebook, Twitter, PNAS.org, or with the hashtag #sciencesessions. If you liked this episode, please consider leaving us a review on iTunes. Your review helps us spread the word, and we really appreciate it. Also, don't forget to subscribe to Science Sessions on iTunes.