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Secrets in a seed: Clues into the evolution of the first flowers

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Approximately 120-130 million years ago, one of the most significant events in the history of the Earth occurred: the first flowering plants, or angiosperms, arose. In the late 1800s, Darwin referred to their development as an "abominable mystery." To this day, scientists are still challenged by this "mystery" of how angiosperms originated, rapidly diversified, and rose to dominance.

Studies of key features of angiosperm evolution, such as the evolution of the flower and development of the endosperm, have contributed to our current understanding of relationships among the early families of flowering plants. Examining the development of seeds and embryos among early angiosperms may help to improve our understanding of how flowering plants evolved from the nonflowering gymnosperms.

A recent study by Dr. Paula Rudall and colleagues published in the September issue of the *AJB* explores a piece of this mystery: the microscopic anatomy of seed development in Trithuria, a genus in the plant family *Hydatellaceae*, thought to be one of the earliest families of angiosperms—the so-called "basal angiosperms."

Rudall and colleagues' observations of the development of the embryo and endosperm (tissue that surrounds the embryo and provides nutrition) in Trithuria suggest that double fertilization occurs. Double fertilization is a unique feature of flowering plants where one sperm nucleus unites with the egg, producing the embryo, while another sperm nucleus unites with a separate nucleus from the female, producing the endosperm. The endosperm is divided into two regions—the micropylar and chalazal regions.

In Trithuria, the cells of the micropylar region divide many times to form the multi-celled endosperm. However, the chalazal region forms a single-celled haustorium, a structure that absorbs nutrients and ultimately degenerates to form an empty space in the seed. This situation is broadly similar to that of some waterlilies and some monocots but differs from that of many other early-diverging angiosperms such as Amborella, in which the endosperm is formed from the chalazal region.

One of the current hypotheses is that the endosperm originated as a monstrous proembryo that fails to develop into a plant. Rudall and colleagues' observations support this theory.

"Comparative studies of early endosperm development in extant 'basal' angiosperms (including Trithuria) tend to support this theory," Rudall said, "because there are similarities in early development of embryo and endosperm. In both cases, the first cell division produces two distinct domains that differ in their subsequent development." In the embryo, divisions of the chalazal cell produce most of the embryo. The micropylar cell develops into a stalk that attaches the embryo to the seed coat. In the endosperm of Trithuria, the chalazal haustorium may regulate early endosperm development of the micropylar region, in addition to facilitating transfer of nutrients from the perisperm, maternally derived nutritive tissue, to the embryo.

Rudall and colleagues' findings shed some light on the possible role of the endosperm in early angiosperms. "The endosperm of Trithuria, though limited in size and storage capacity, is relatively persistent," Rudall stated. "Coupled with the well-developed perisperm that occurs in Trithuria, this could indicate that the ancestral role of endosperm was to transfer nutrients from the perisperm to the embryo, rather than as a storage tissue."

More information: The full article is available for no charge for 30 days following the date of this summary at www.amjbot.org/cgi/content/full/96/9/1581 .
See also the January 2009 issue of the *American Journal of Botany* at www.amjbot.org/content/vol96/issue1.

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