Tempskya

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Tempskya sp.
Cretaceous
Chippy Creek, Idaho

Introduction

Tempskyaceae are an extinct family of Mesozoic ferns represented by the single genus *Tempskya* (Tidwell, 2002, p. 153). *Tempskya* occurs as the silicified false trunk of a Cretaceous aged tree fern. *Tempskya* is referred to as a false trunk because internally it is composed of numerous small branching stems and petioles embedded in a mat of adventitious roots (Brown, 1936, p. 48). The ropelike mass of the false trunk is often club-shaped, straight or conical when found intact. The mass of intertwined roots gives the exterior a rope or cable-like appearance, see Figures 1 and 2. The flattened conical shape of the *Tempskya* specimen in Figure 1 is referred to as a "Cardinal's Cap" by collectors and may represent the apex of a false trunk.

Figure 1: *Tempskya* "Cardinal's Cap" or Apex of False Trunk.
Dakota Sandstone Formation, Cretaceous. Utah.

Figure 2: *Tempskya* Exterior Showing Cable-Like Appearance. Utah

Twelve species of Cretaceous aged *Tempskya* have been reported from North America, eight or possibly ten from Europe, one from Japan, one from Argentina, and one from Australia (Tidwell & Wright, 2003, pp 141-143; Clifford & Dettmann, 2005, p. 71). *Tempskya* species are defined primarily by differences in the arrangement and makeup of tissues within the stems of the false trunks. The purpose of this paper is to help collectors explore the general anatomy of the *Tempskya* false trunk in transverse section.

Anatomy

False trunks of some *Tempskya* species reach diameters of 30 centimeters and lengths of 3 meters (Tidwell, 1998, p. 190). Thus, evidence suggests that *Tempskya* was a short to medium height tree fern (Andrews, 1943, p. 136; Andrews & Kerns, 1947, p. 155). Internally, the trunks are composed of stems, petioles and roots. Figure 3 represents a *Tempskya* false trunk cut in the transverse plane. The stems making up the false trunk appear as circular or lobe-shaped structures measuring roughly 1 cm in diameter. The roots are mostly circular and measure around 1 mm in diameter. Figure 4 gives us a closer look at the stems, leaf traces or petioles and roots.

Figure 3: *Tempskya*. Lower Cretaceous, Wyoming. Specimen 24.5 cm x 17 cm

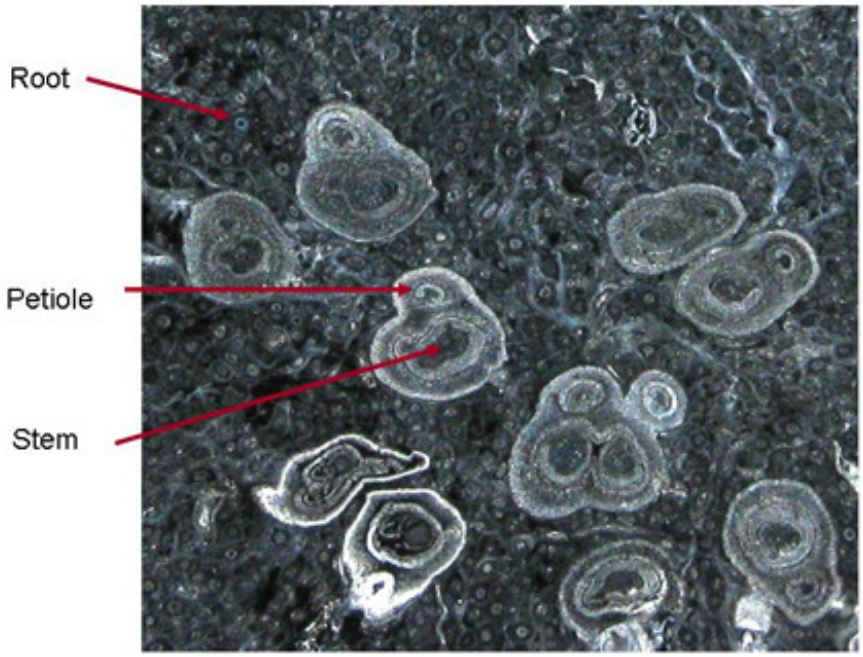

Figure 4: *Tempskya*. Close-up Showing Stems, Leaf Traces or Petioles and Roots

Serial transverse sections of varying sized false trunks have been used to determine the supposed mode of growth for *Tempskya* as well as examination of *in situ* specimens, those found in growth position (Seward, 1924, pp. 489-491; Andrews & Kern, 1947, pp. 134-138; Tidwell & Hebbert, 1992, p. 528). The base of *in situ* trunks exhibit three to

nine lobes each containing a stem. Thus, several stems initiated the growth of the tree fern and branched dichotomously in a uniform profuse manner throughout life, producing both the apical and lateral growth of the false trunk. Roots, emerging from the sides of stems, branched profusely filling in voids, tying the mass of stems together forming the false trunk. Roots, greatly outnumbering the stems provided the structural support for the false trunk. Stems produced leaf traces or petioles frequently. Petioles of leaves, small in size, are close to their point of origin on stems indicating small leaves that persisted for only a short time. The false trunks of *Tempskya* tapered from base to apex. Unlike other tree ferns *Tempskya* was not crowned with large leaves; rather, leaves at the apex were small in size. The false trunk also bore small leaves for a considerable distance downward from the apex (Andrews & Kern, 1947, p. 129).

Roots growing down ruptured stems and petioles. Upper portions of stems continued to be nourished by emerging adventitious roots. Consequently, transverse sections near the base of the false trunk have few stems and many roots while transverse sections towards the apex of the false trunk have many stems embedded among the roots, see Figures 5 and 6.

Figure 5: *Tempskya*. Lower Cretaceous. Greenhorn Mountain, Oregon. Specimen 12 cm. Image courtesy of Frank Daniels

The specimen pictured in Figure 5 exhibits many stems embedded among numerous roots and most likely represents a transverse section higher up on the false trunk (Daniels, 2009, p. 153). The specimen pictured in Figure 6 has very few stems embedded among the adventitious roots, which indicates it came from the base of the trunk. In general, there is an increase in the number of stems from base to apex on the false trunks of most *Tempskya* species. *T. minor* from Utah seems to be different from other *Tempskya* species in that specimens possess very few stems throughout the length of the false trunk (Tidwell & Hebbert, p. 525).

Figure 6: *Tempskya*. Lower Cretaceous. Greenhorn Mountain, Oregon. Specimen 12 cm.

You can explore and learn the general anatomy of the stems and roots with a loupe or dissecting microscope. A 10x loupe can be used to differentiate stems, petioles and roots; however, a 20x loupe or dissecting microscope with 30x or 40x allows one to study the tissues that make up these organs. Most of the roots and stems of *Tempskya* grow in parallel indicating an upright structure. The stems are larger than the roots. Depending on the species, stems may have a diameter of 2.5 mm to 1.5 cm. Roots are generally

1 mm in diameter or less. Roots are often circular in transverse section while stems are circular or lobed. The circular stem pictured in Figure 7 is viewed at 30x.

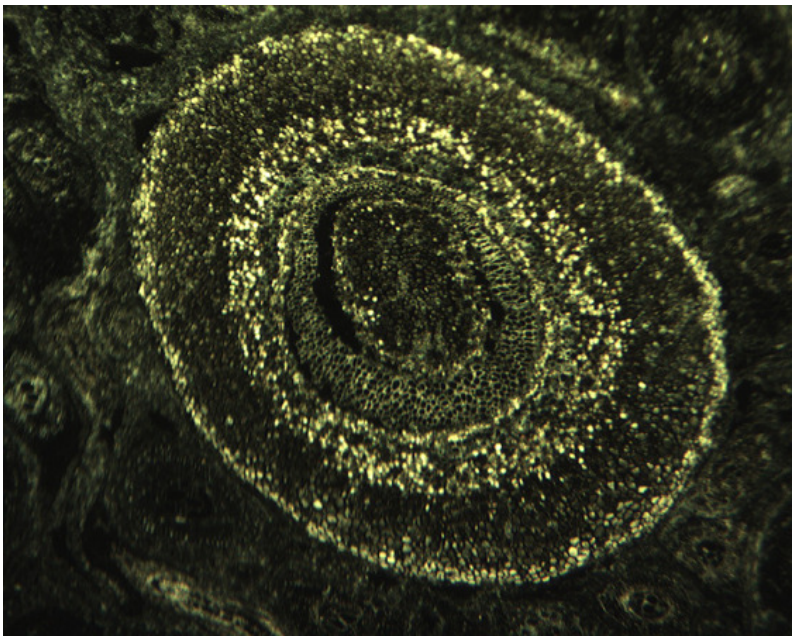

Figure 7: *Tempskya* Circular Stem at 30x. Stem measures 4 mm in diameter

Bulges or lobes on stems represent the formation of leaf traces or petioles. In Figure 8 an outgrowth of the stem represents the early stages of leaf trace formation. Tissue from the stem will form the new leaf trace. Figure 9 shows a leaf trace that has formed. The water conducting tissue (xylem) of the leaf trace or petiole forms a characteristic horseshoe or c-shape when viewed in cross-section. In many species the stem forms a second petiole, see Figure 10. In Figure 10 we can see that the c-shaped xylem in the petiole was derived from a portion of the ring-shaped xylem in the stem. Once the leaf trace has formed the stem's xylem will once again form a ring-shape. Many of the petioles are formed oriented to the outside of the stem. In many false trunks that are found complete it has been observed that stem branching is numerous, and that the trunk is radially symmetrical with respect to the departure of leaf traces (Andrews & Kern, 1947, p. 126). Some specimens exhibit dorsiventral symmetry with respect to leaf traces. Some have suggested that such specimens represent false trunks that grew horizontal along the ground before growing upright, while others believe these specimens are just partial false

trunks that were in fact radial in symmetry when complete (Tidwell & Hebbert, 1992, p. 524).

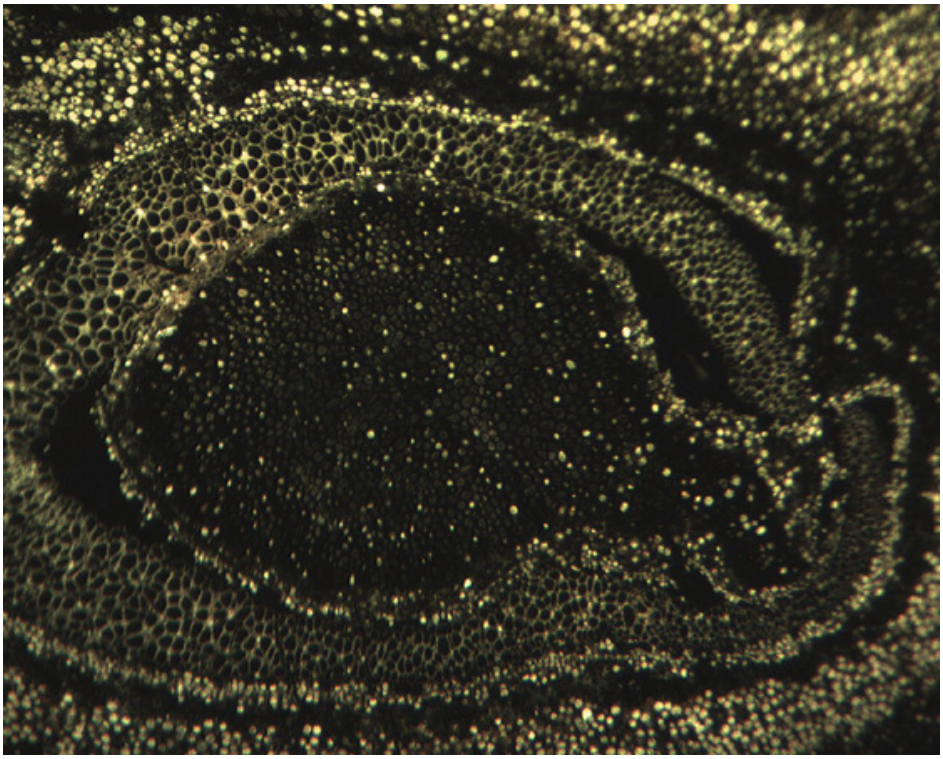

Figure 8: *Tempskya* Stem Forming Leaf Trace at 40x Stem measures 5 mm.

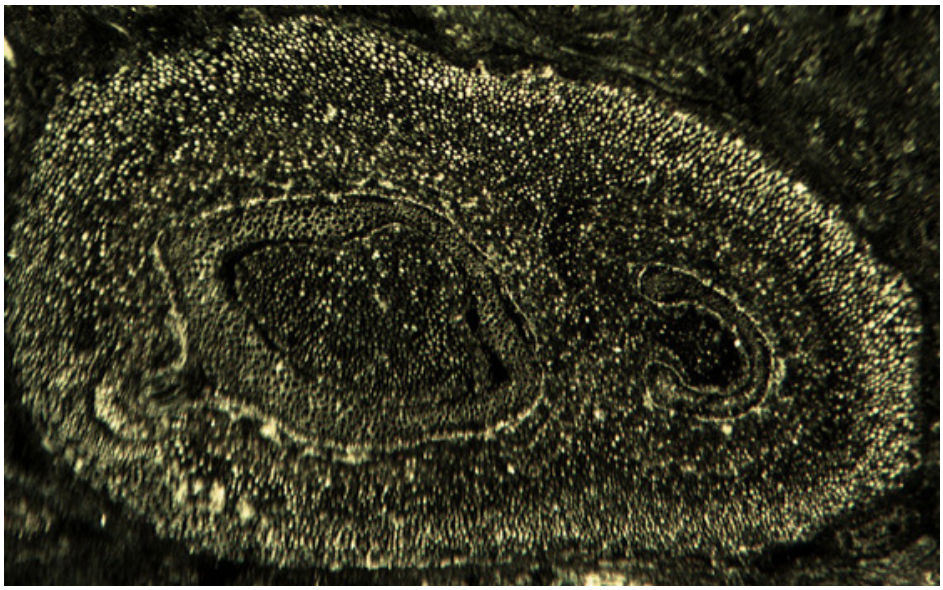

Figure 9: *Tempskya* Stem and Newly formed Petiole at 20x. Stem & petiole 6mm.

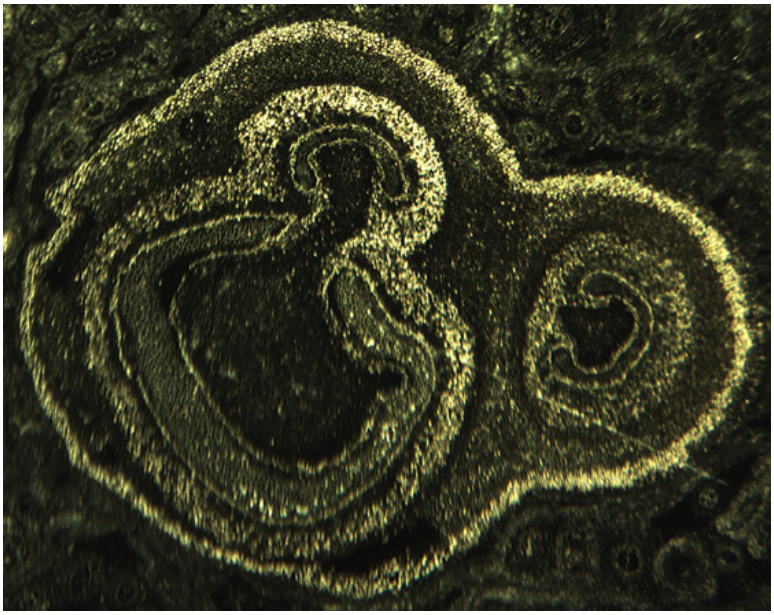

Figure 10: *Tempskya* Stem Forming Second Petiole.

The Idaho specimen pictured in Figure 11 possesses stems that measure 3 mm and roots that measure 1 mm or less in diameter. A second leaf trace is in the process of forming. Roots surround the stem and leaf traces. Using a loupe or dissecting microscope one can learn to identify tissues that make up the stems, petioles and roots of the false trunk.

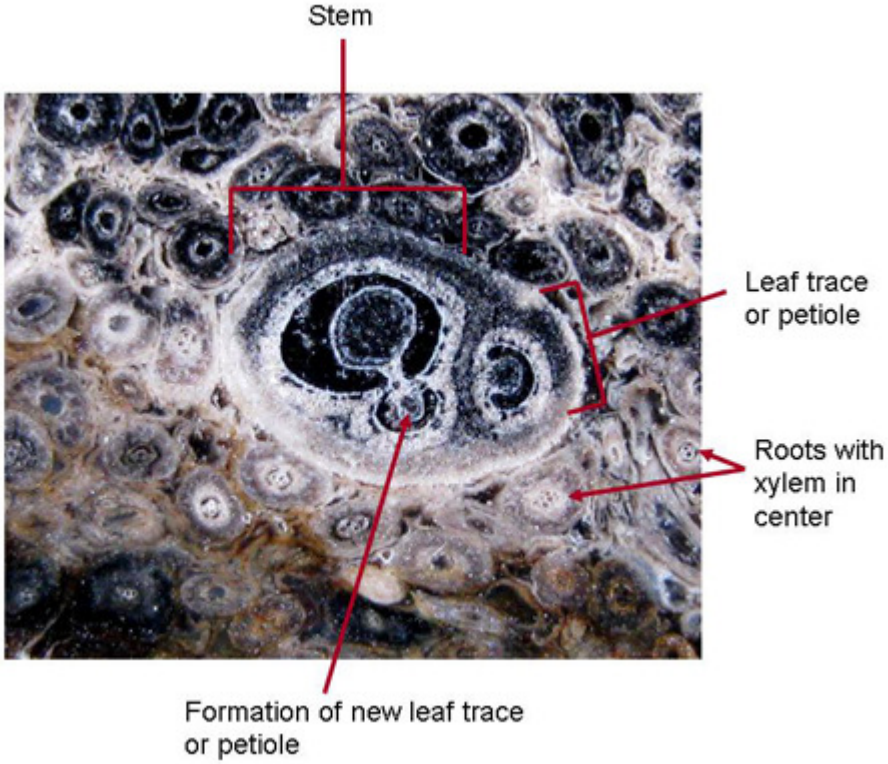

Figure 11: *Tempskya* Stem, Leaf Traces & Roots. Idaho Specimen

Tempskya stems consist of a pith centered in a ring of xylem tissue (water conducting tissue) surrounded inside and out by phloem (food conducting tissue). Cortex tissue surrounds the pith, xylem and phloem. The stem pictured in Figure 12 measures 6 mm in diameter, while the roots measure 1 mm or less. Two leaf traces have formed and the xylem in the stem is once again forming a ring-shape. The characteristic c-shaped xylem strands of the leaf traces or petioles are clearly visible in this Wyoming specimen.

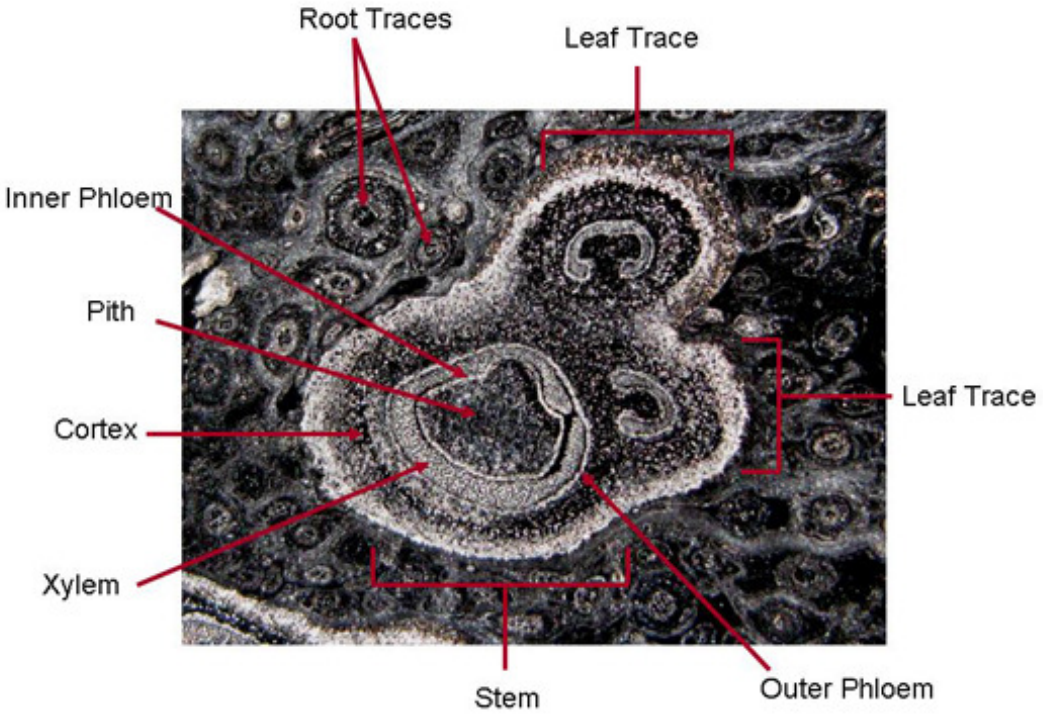

Figure 12: *Tempskya* Stem, Leaf & Root Traces. Wyoming Specimen

In cross section the xylem in *Tempskya* roots forms a cross. Phloem surrounds the primary xylem filling in the remaining area at the center of the root. Cortex tissue surrounds the vascular tissue of the root, see Figure 13. It is the cortex of the roots, which provides most of the structural support for the false trunk. In fact the cable-like structure of the *Tempskya* false trunk was composed mostly of roots. Figure 13 is the same large root trace pointed to in the picture above. As mentioned earlier the transverse sections taken close to the base of the false trunk may be composed entirely of roots. Stems lower in the plant were ruptured by invading roots growing downwards. Disintegrated stems were replaced by roots. Figure 14 shows a root growing through a

stem. The root with the characteristic cross-shaped xylem can be seen below and adjacent to the pith of a stem. The pith of the stem has a somewhat pear shape as it was in the process of forming a leaf trace.

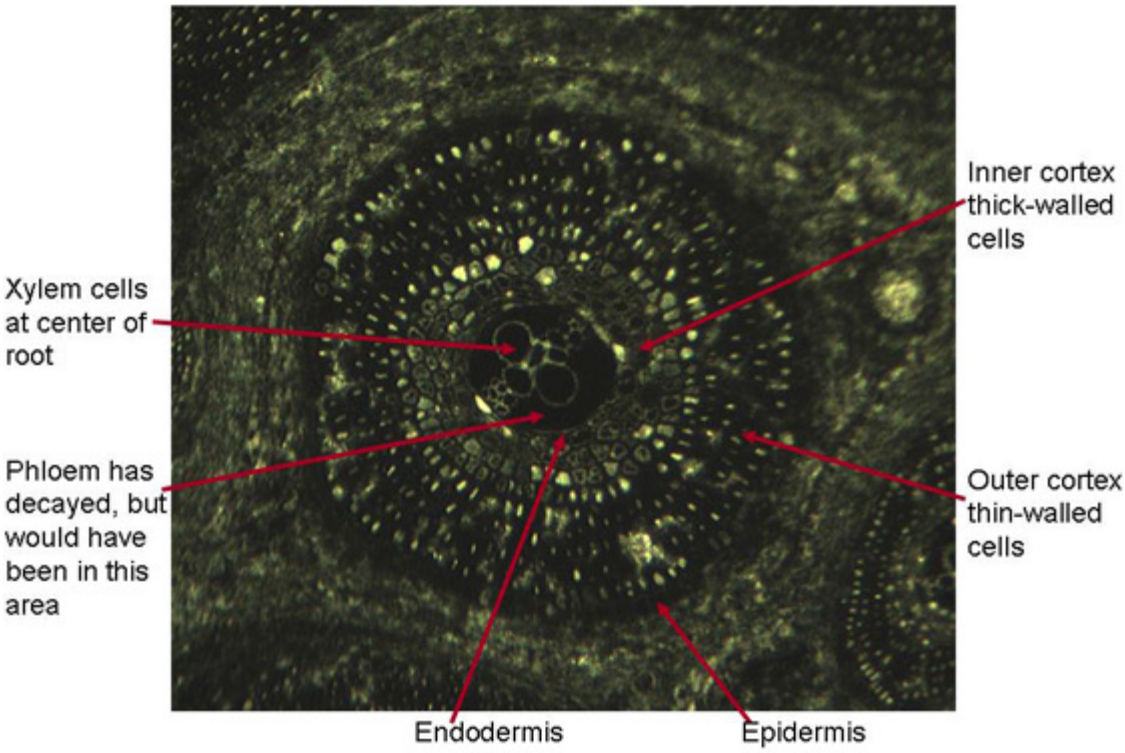

Figure 13: *Tempskya* Root at 40x. Root Measures 1.2 mm in Diameter

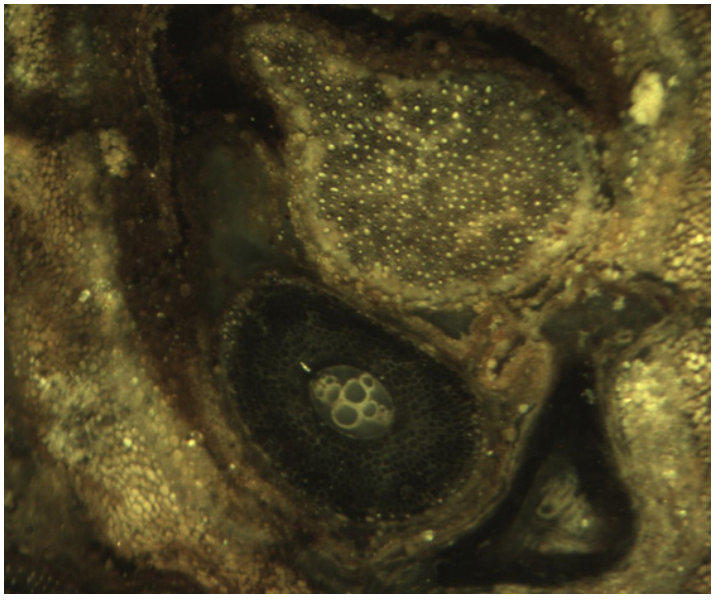

Figure 14: *Tempskya* Root Grows Through Stem. Specimen from Idaho.

Ecology

Galleries filled with fecal pellets in roots, stems and leaves provide evidence of at least three different kinds of insects feeding on various *Tempskya* species (Tidwell & Hebbert, 1992, pp. 521 & 524; Tidwell, 2002, pp. 154-157). Fecal pellets of an unidentified insect can be seen in the roots of an Idaho specimen, see Figure 15.

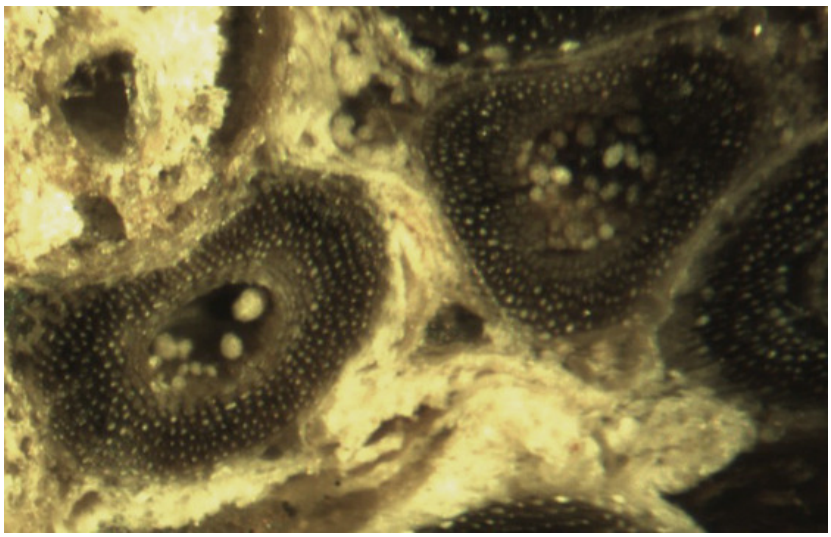

Figure 15: Fecal Pellets in *Tempskya* Roots at 40x.

Hyphae resembling mycorrhizal fungi have been found associated with the roots of some *Tempskya* specimens possibly revealing a symbiotic relationship (Tidwell & Hebbert, 1992, p. 524). Andrews and Kerns (1947) reported that *Tempskya* fossils in Idaho and Wyoming are associated with cycadeoids, conifers, angiosperm dicots, dinosaur bones, and possibly tropical ferns. They picture a tropical habitat for *Tempskya*. Andrews and Kerns also point out that although the leaves of *Tempskya* were small, large numbers were distributed over a considerable portion of the false trunk possibly making it ideal for browsers.

Most *Tempskya* fossils are found reworked in younger gravels or reworked within the formations in which they were preserved. The only *in situ Tempskya* specimens are found in an upright growth position embedded in undisturbed carbonaceous shale southeast of Castle Dale, Utah (Tidwell & Hebbert, 1992, p. 525). The carbonaceous shale suggests *Tempskya* grew in swamps on flood plains, similar to the Mississippi Delta

or the Florida Everglades. *T. judithae* described from Australia is associated with conifers, ferns, and angiosperms. The depositional environment represents the broad alluvial plain of a riverine/lacustrine system. Clifford and Dettmann (2005) postulate a flood plain habitat with mild temperatures and periodically moderate to high precipitation (p. 83).

Conclusion

Isolated spores and several sporangial remains have been found associated with *Tempskya* but none with definite attachment to the plant (Taylor, Taylor & Krings, 2009, p. 459). Transverse sections of leaves have been reported associated with *T. wyomingense* (Tidwell & Hebbert, 1992, p. 521). The restoration of the probable habit of *Tempskya* by Andrews and Kern uses *Anemia* type foliage (Andrews & Kern, 1947, pp. 139 & 140). Interestingly, fronds of *Anemia fremontii* have been collected as compressions in the coalified sediments around the base of *in situ Tempskya* false trunks (Tidwell & Hebbert, p. 516). Discovery of complete *Tempskya* leaf structures and fertile remains attached to the false trunk would be both exciting and scientifically significant.

The false trunk of the tree fern *Tempskya* is intriguing with its intertwined rope or cable-like structure of roots, stems and petioles. The extensive distribution of *Tempskya* in the Northern Hemisphere and its discovery in the Southern Hemisphere provide evidence of its ecological importance. One can imagine the highly evolved herbivorous dinosaurs of the Cretaceous seeking out the foliage growing along the false trunks of *Tempskya*.

The profuse branching of stems and roots as well as the frequent formation of leaf traces, frozen in time by silica, provides dynamic evidence of ancient growth in most *Tempskya* specimens. For collectors, knowledge of *Tempskya* anatomy may provide insight into specimens within their collection. What part of the false trunk does the specimen represent? Is there evidence of insect feeding? Can one identify a stem or root dividing, petioles forming or roots invading stems? Permineralized specimens with excellent cellular preservation can provide a snapshot of ancient plant growth. Imagination fueled by empirical evidence; a true joy of science.

Acknowledgements

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