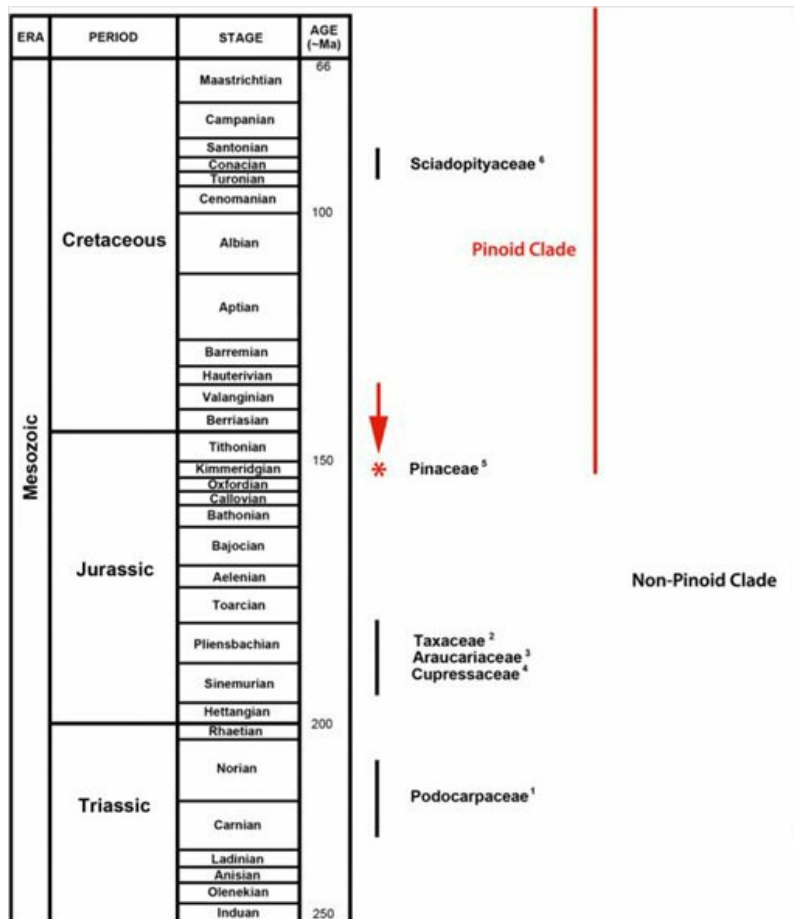


## The origin of modern conifer families

Recent palaeobotanical research including researchers at the University of Birmingham has provided new insights into the early evolution of conifers and the origin of modern conifer families. This research has been supported by NERC (Award NE/E004369/1) to [Jason Hilton \(/staff/profiles/gees/hilton-jason.aspx\)](#) and Richard Bateman.

The fossil record shows that conifers originated in Europe and North America during the Middle Pennsylvanian approximately 310 million years ago, subsequently diversifying and radiating across the global landscape. In the Palaeozoic several groups of conifers are recognisable with the modern conifer families evolving subsequently during the late Palaeozoic and Mesozoic (Figure 1).

The underlying evolutionary history of conifers remains obscure as do the evolutionary relationships between different conifer groups. Molecular systematics have proven extremely useful in determining the relationships of living species but have been less successful in determining the relationships between conifer families in deep time that can only come from information contained in the fossil record.



[View full size table \(/images/College-LES-only/GES/Geology/Cladeagesforconifers.jpg\)](#)

Figure 1. Minimum clade ages for conifers based on oldest well-documented fossil occurrences of crown group families and the two extant clades (From Rothwell et al., 2012).

### Pinaceae and *Pinus*

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Research has identified the oldest representative of the family Pinaceae from the Jurassic of Scotland (Figure 2), as well as the oldest species of the living conifer *Pinus* from the Early Cretaceous of Yorkshire, England (Figure 3). This specimen was unusual as it laid undiscovered in the Lapworth Geological Museum at the University of Birmingham after being collected during an undergraduate field course. The location of the cone was unknown so colleagues at Sheffield University and British Geological Survey helped date the rock using micropalaeontological techniques, confirming it came from the Speeton Clay on the Yorkshire coast (Ryberg et al., 2012).

This research considered the traditional methods used to distinguish *Pinus* based on the characters of ovulate cones and developed a cladistic framework for subsequent studies.

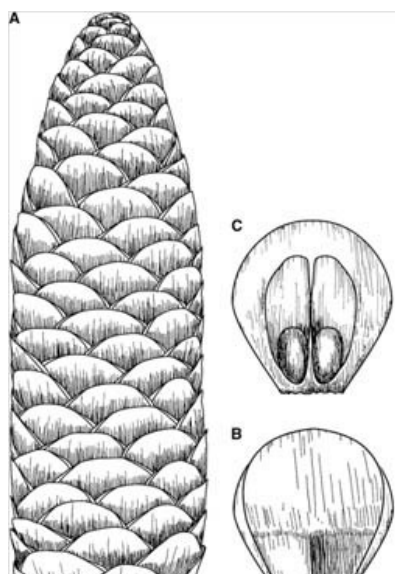
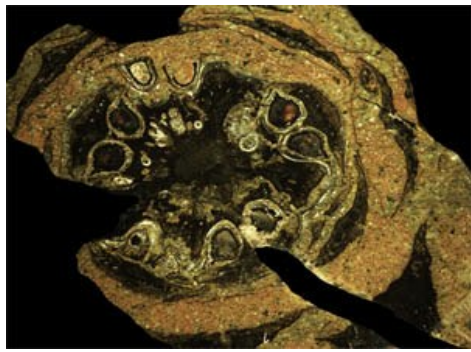


Figure 2. Reconstruction of the Jurassic conifer *Eathiestrobus* from Scotland (Rothwell et al., 2012). *Eathiestrobus* is a basal member of the family Pinaceae and shows that the family was distinct from other conifers prior to the end of the Jurassic period.

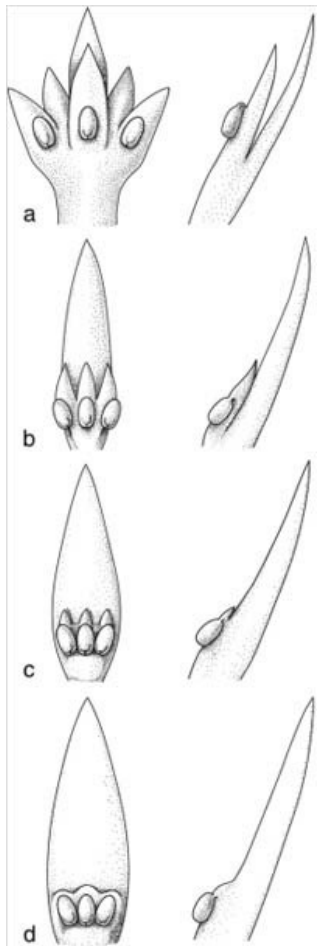


**Figure 3.** Transverse section through the cone of *Pinus yorkshirensis* from the Cretaceous of Yorkshire, England (Ryberg et al., 2012).

This is the oldest known species of the genus *Pinus* and was found in the collections of the Lapworth Geological Museum at the University of Birmingham.

## Cupressaceae

This research has also documented Jurassic aged species of the family Cupressaceae (Rothwell et al., 2011) that provide important insights into the evolution of bracts and scales in ovulate cones (Figure 4). Additional cones are currently under investigation and the project is now developing methods of analysing conifer evolution based on evidence contained in their ovulate cones.



**Figure 4.** Proposed transformational series of bract/ovuliferous dwarf shoot (=ovuliferous scale) morphologies in the evolution of Cupressaceae from Palaeozoic voltzalean conifers (from Rothwell et al., 2011).

- a. Morphology equivalent to the voltzalean genera, *Voltzia*, *Voltziopsis*, *Aethophyllum*, and *Telemachus*.
- b. Morphology equivalent to the genus *Cycadocarpidium*.
- c. Morphology equivalent to *Hughmillerites* and *Elatides*.
- d. Morphology equivalent to *Austrohamia* and *Taiwania*.

Previous research has studied pollen cones of extinct Cheirolepidiacean conifers and provided the first detailed anatomy of cones produced by this group (Rothwell et al., 2007). Research on conifers also includes work on developmental abnormalities in living and fossil conifer cones (Rudall et al., 2011) and the spatial divergence of male and female reproductive organs in gymnosperms (Bateman et al., 2011). Additional specimens are currently being investigated, and the search is on for further Mesozoic anatomically preserved conifers.

## Publications

Bateman, R. M., **Hilton, J.** and Rudall, P. J. **2011.** Spatial separation and development divergences of male and female reproductive units in gymnosperms, and their relevance to the origin of the angiosperms. Pages 8–48 in: L. Wantorp and L. Ronse DeCraene (eds) *Flowers and the tree of life*. Systematics Association.

Rothwell, G. W. Mapes, G., **Hilton, J.** and Hollingworth N. T. **2007.** Anatomy of cheirolepidiacean pollen cones; *Classostrobus crossii* sp. nov. *International Journal of Coal Geology* 69: 55–57.

Rothwell, G. W., Mapes, G., Stockey, R. A. and **Hilton, J.** **2012**. The seed cone *Eathiestrobus* gen. nov.: fossil evidence for a Jurassic origin of Pinaceae. *American Journal of Botany* 99: 708–720.

Rothwell, G. W., Stockey, R. A., Mapes, G. and **Hilton, J.** **2011**. Structure and relationships of the Jurassic conifer seed cone *Hughmillerites judii* gen. et sp. nov.: implications for the early evolution of cupressaceae. *Review of Palaeobotany and Palynology* 164: 45–59.

Rudall, P.J., **Hilton, J.**, Vergara-Silva, F., and Bateman, R. M. **2011**. Recurrent abnormalities of conifer cones and the evolutionary origins of flower like structures. *Trends in Plant Sciences* 16: 151–159.

Ryberg, P. E., Stockey, R. A., **Hilton, J.**, Mapes, G., Riding, J. B. and Rothwell, G.W. **2012**. Reconsidering relationships among stem and crown group Pinaceae: oldest record of the genus *Pinus* from the Early Cretaceous of Yorkshire, UK. *International Journal of Plant Sciences* 173: 917–932.

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