

Oikos

**OIK-06451**

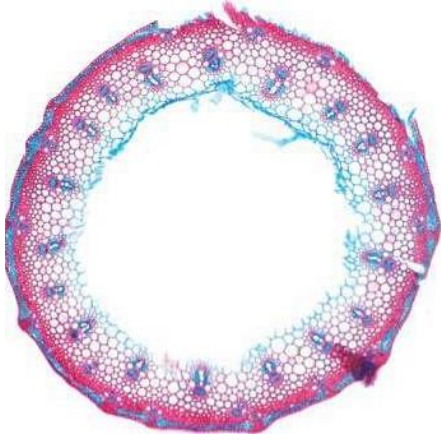
Dolezal, J., Klimes, A., Dvorsky, M., Riha, P., Klimesova, J. and Schweingruber, F. 2019. Disentangling evolutionary, environmental and morphological drivers of plant anatomical adaptations to drought and cold in Himalayan graminoids. – Oikos doi: [10.1111/oik.06451](https://doi.org/10.1111/oik.06451)

Appendix 1

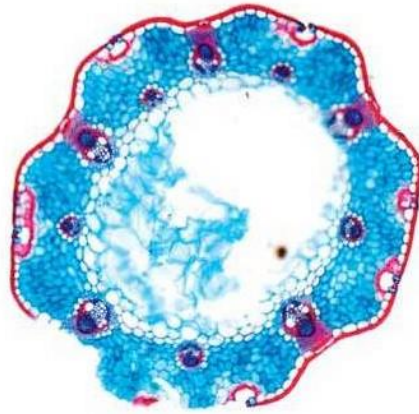
## **Figure A1. Definition of stem features**

Characteristic features on stem cross-section of primarily of Cyperaceae and Poaceae. These are defined by the outline of the stem (culm), the structure of the epidermis, the arrangement of vascular bundles, the form and size of chlorenchyma (assimilatory tissue), the peripheral sclerenchymatic belt, the sclerenchymatic girders, the sclerenchymatic sheath around vascular bundles and cavities (intercellulars) in the parenchymatic tissues and vessel size and the presence of cavities in the protophloem of vascular bundles. The following features are principally based on Metcalfe, C. R. 1960 *Anatomy of the Monocotyledons I. Gramineae*. Oxford Clarendon Press; and Metcalfe, C. R. 1971. *Anatomy of the Monocotyledons V Cyperaceae*. Oxford Clarendon Press.

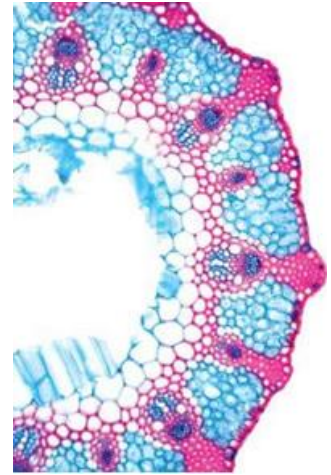
# Outline of culms



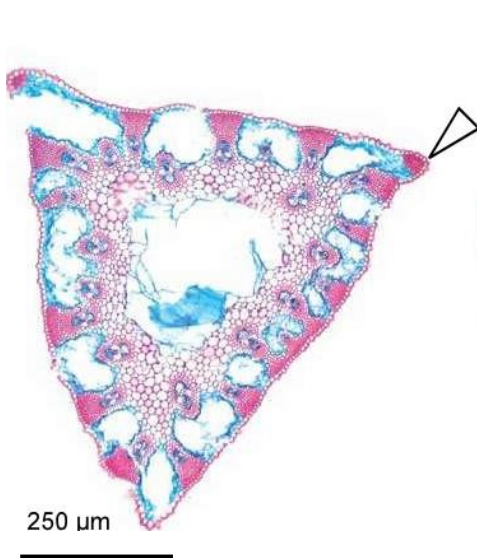
**Outline circular smooth.** *Koeleria macrantha*, Poacea.



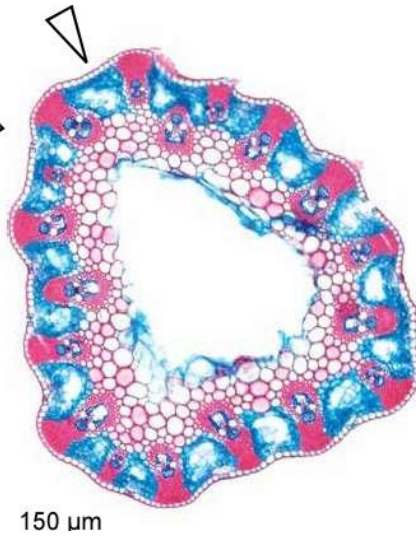
**Outline circular wavy.** *Trichophorum cespitosum*, Cyperaceae.



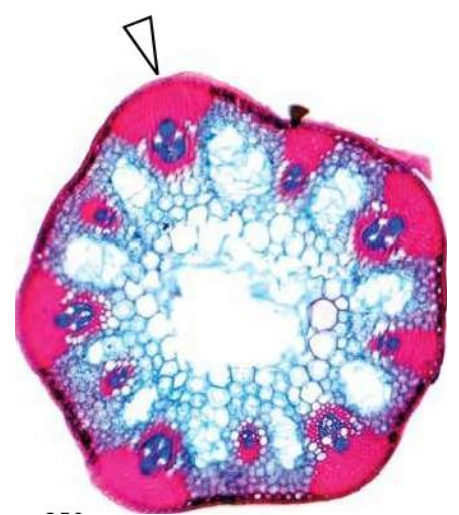
**Outline circular with ribs.** *Sesleria caerulea*, Poacea.



**Outline triangular acute.** *Carex nivalis*, Cyperaceae.

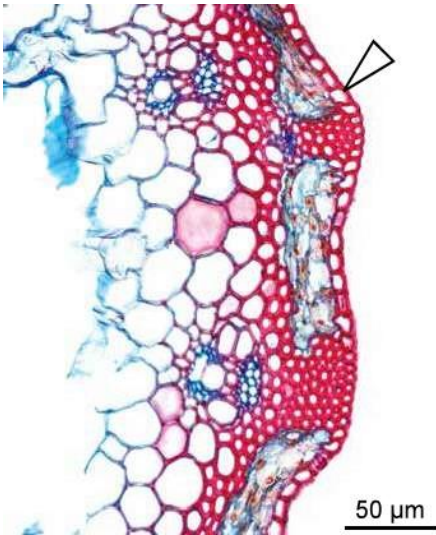


**Outline triangular obtuse.** *Carex haematostoma*, Cyperaceae.

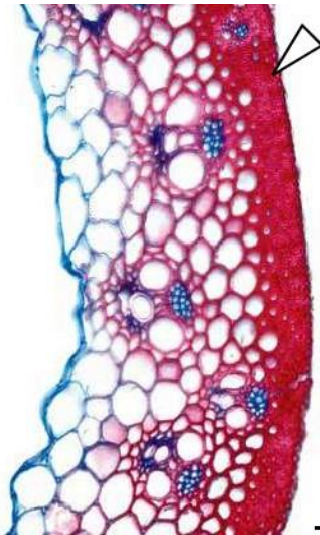


**Outline polygonal obtuse.** *Carex pulicaris*, Cyperaceae.

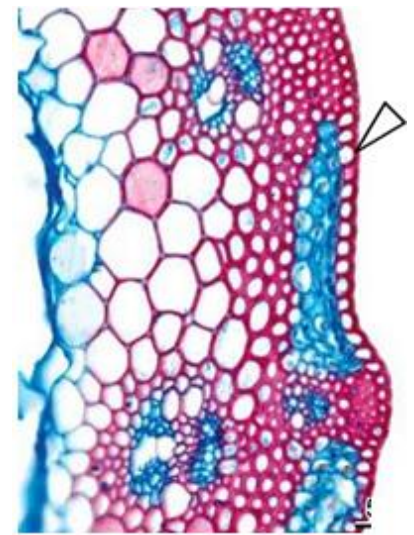
## Epidermis cell walls



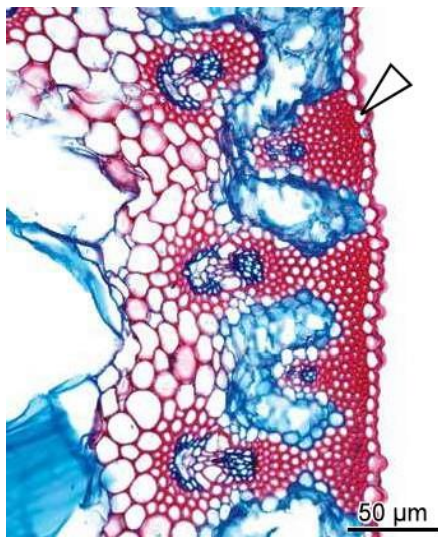
Epidermis smooth, cells thin- to thick-walled.  
*Alopecurus arundinaceus*, Poaceae.



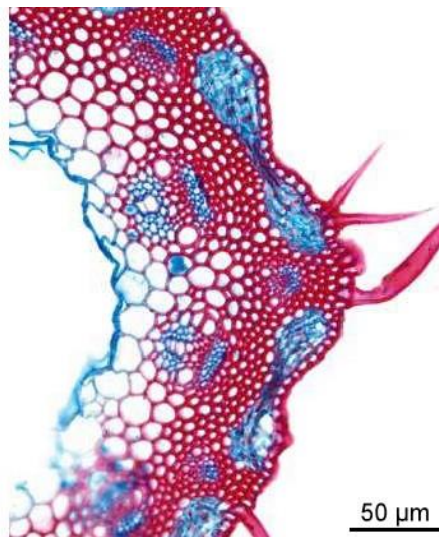
Epidermis smooth, cells thick-walled.  
*Muhlenbergia huegelii*, Poaceae.



Epidermis smooth, cells thin-walled inside,  
thicker-walled outside. *Hierochloa laxa*,  
Poaceae.



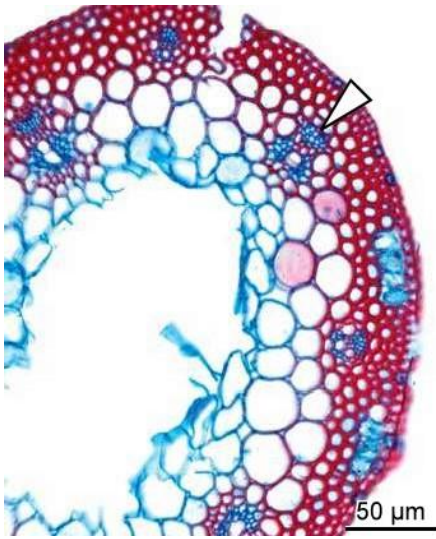
Epidermis bulbiform (papillose).  
*Carex nivalis*, Cyperaceae.



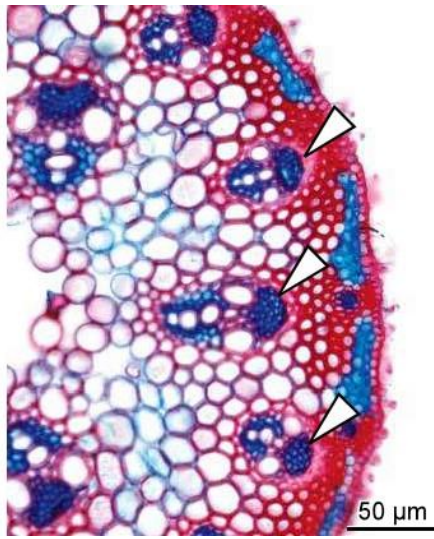
Epidermis with hairs.  
*Trisetum spicatum*, Poaceae.



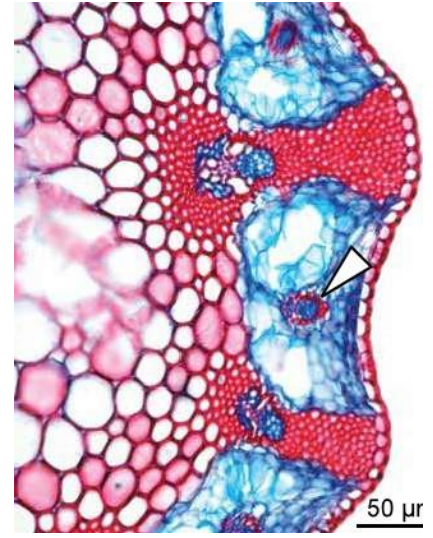
## Arrangement of vascular bundles



Vascular bundles arranged in one circular row.  
*Puccinellia ladakhensis*, Poaceae.

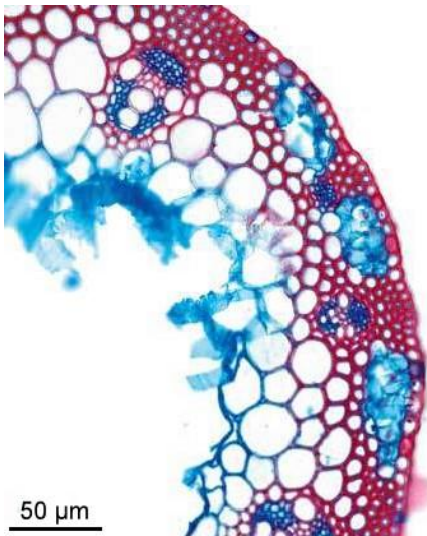


Vascular bundles arranged in two to three circular rows.  
*Stipa caucasica*, Poaceae.

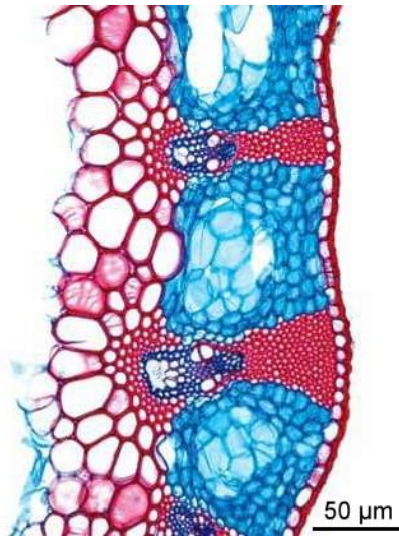


Vascular bundles arranged in peripheral bundles within the chlorenchyma.  
*Kobresia nitens*, Cyperaceae.

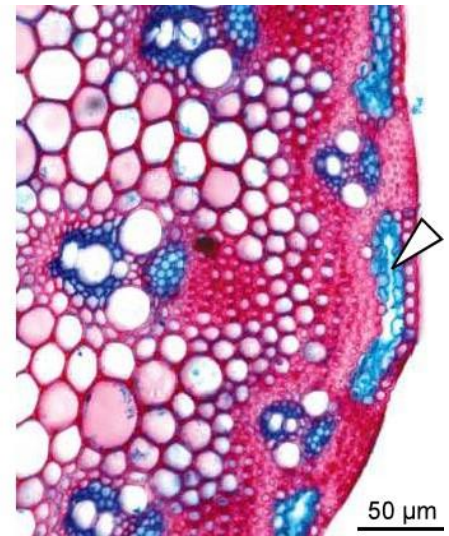
## Form of chlorenchyma



Chlorenchyma round to oval, often slightly irregular.  
*Puccinellia thomsonii*, Poaceae.



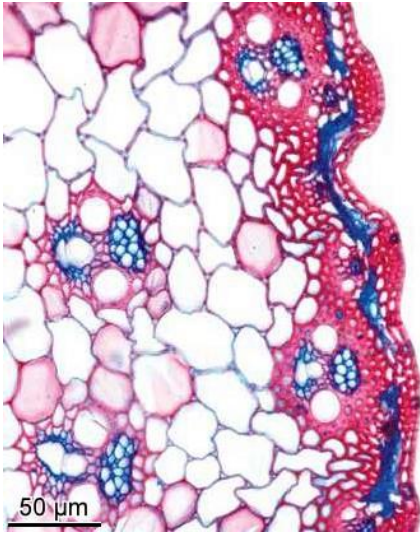
Chlorenchyma square to rectangular.  
*Carex montis-everesti*, Cyperaceae.



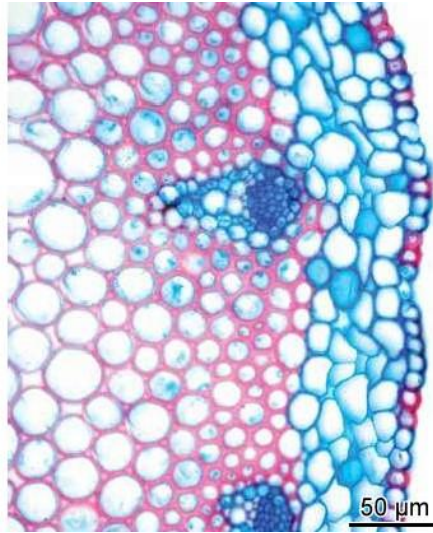
Chlorenchyma tangentially enlarged.  
*Bromus pectinatus*, Poaceae.



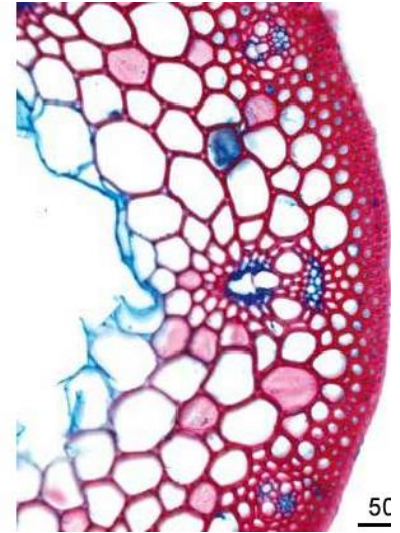
## Form of chlorenchyma



**Chlorenchyma a 1-2-seriate line.** *Pennisetum flaccidum*, Poaceae.

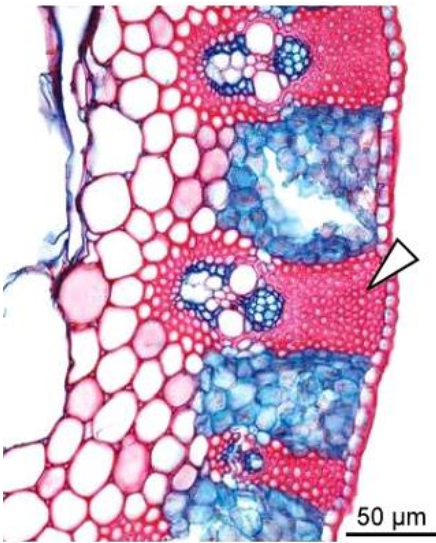


**Chlorenchyma in a continuous belt.** *Allium* sp., Amaryllidaceae.

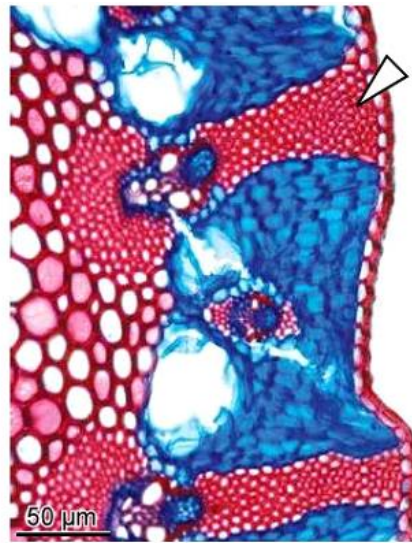


**Chlorenchyma absent.** *Vulpia myuros*, Poaceae.

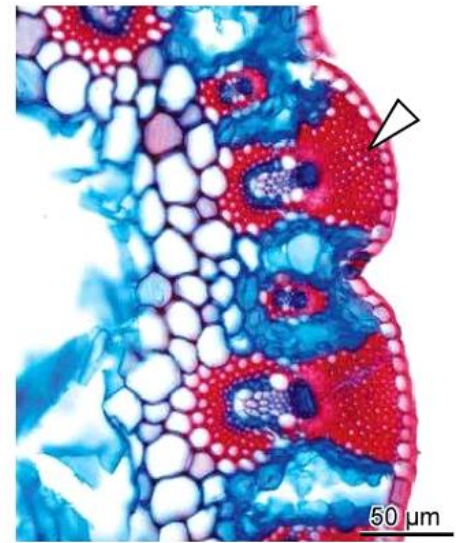
## Sclerenchymatic girders



**Girders squared.** *Carex plectobasis*, Cyperaceae.



**Girders radially rectangular.** *Kobresia robusta*, Cyperaceae.

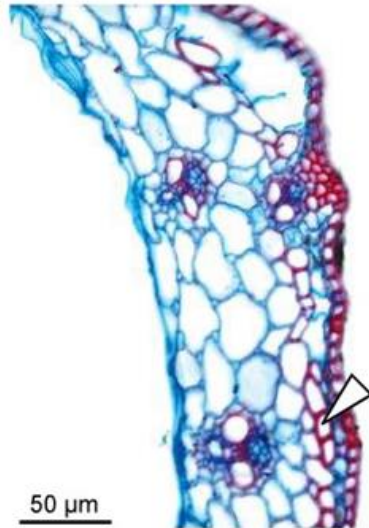


**Girders conical.** *Carex karoii*, Cyperaceae.

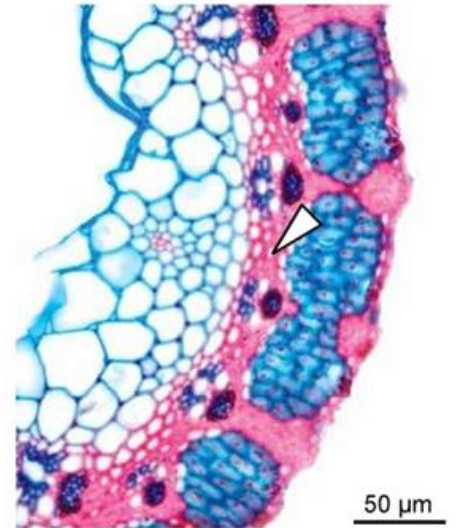
## Peripheral belt of sclerenchyma



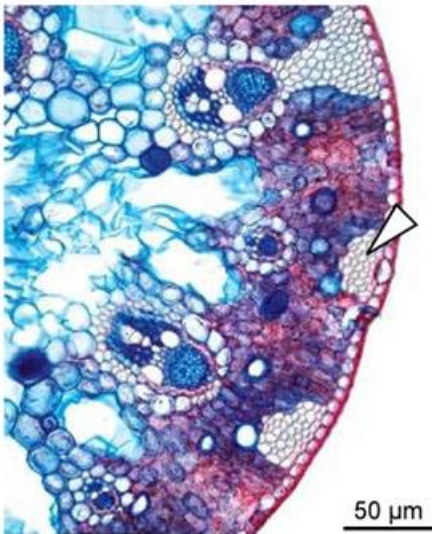
**Peripheral sclerenchyma belt.**  
 > 3-seriate, *Stipa mongholica*,  
 Poaceae.



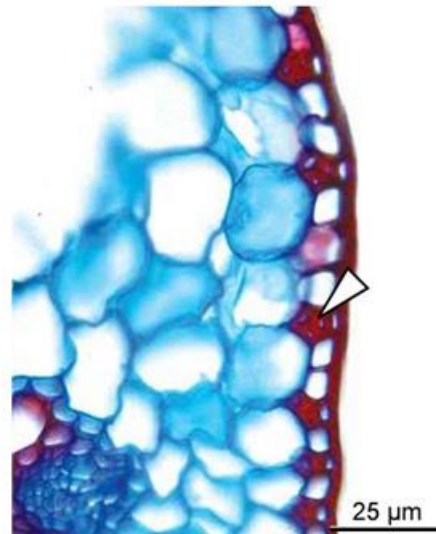
**Peripheral sclerenchyma belt.**  
 1-3-seriate, *Agrostis aequalis*,  
 Poaceae.



**Peripheral sclerenchyma belt  
 inside chlorenchyma.** Smooth or  
 wavy. *Poa sterilis*, Poaceae.



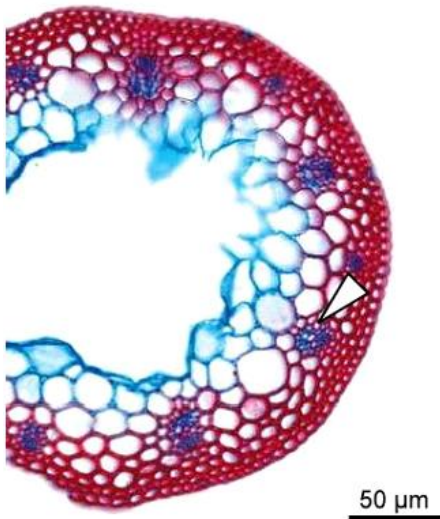
**Isolated peripheral sclerenchymatic  
 groups.** *Blysmus compressus*,  
 Cyperaceae.



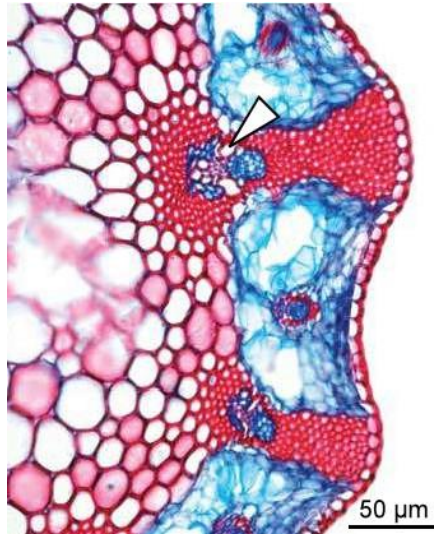
**Isolated peripheral sclerenchymatic  
 groups.** *Eleocharis uniglumis*,  
 Cyperaceae.



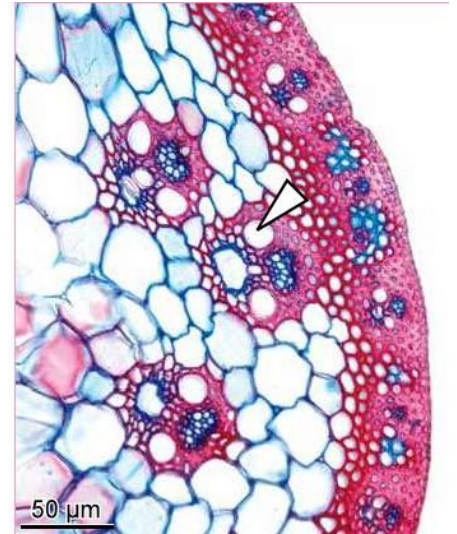
## Vessel size



**Vessel diameter < 20 μm.**  
*Festuca hartmannii*, Poaceae.



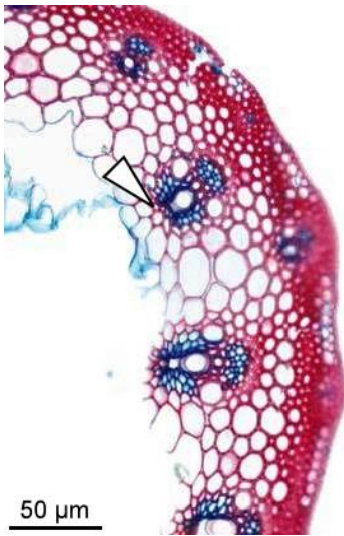
**Vessel diameter 20—50 μm.**  
*Kobresia nitens*, Cyperaceae.



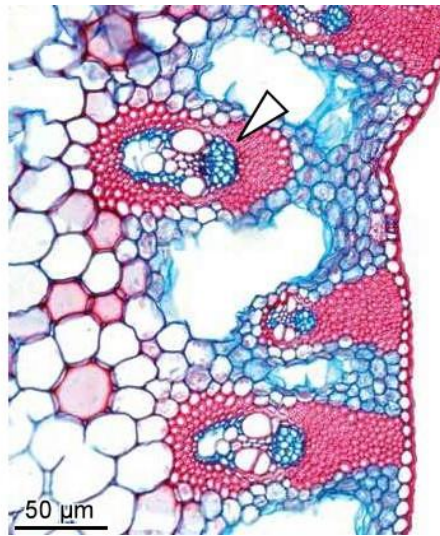
**Vessel diameter 30—50 μm.**  
*Digitaria sanguinalis*, Poaceae.



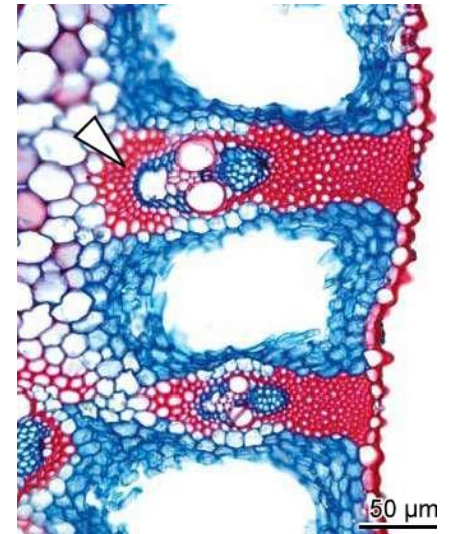
## Sclerenchymatic sheath around vascular bundles



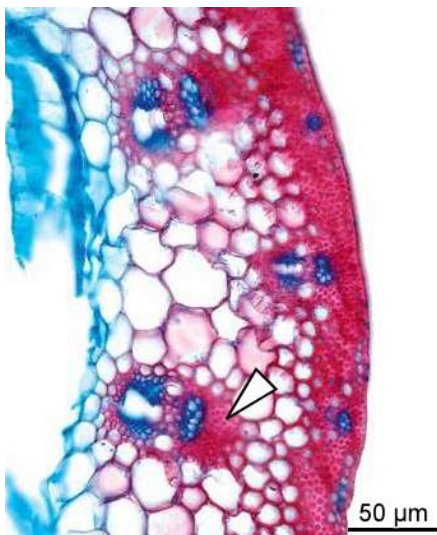
**Sclerenchymatic sheath small**, 1-2 cells around the vascular bundle. *Stipa himalaica*, Poaceae.



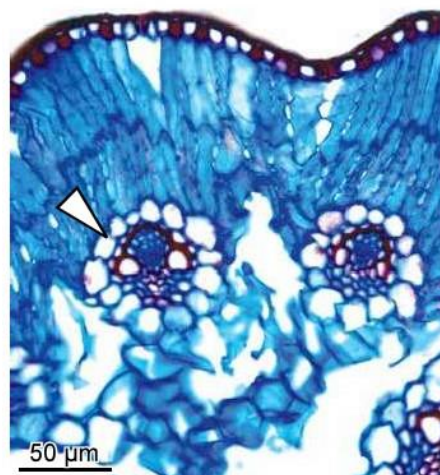
**Sclerenchymatic sheath large**. 3 or more cells around or at least at the distal end of the vascular bundle, *Carex infusata*, Cyperaceae.



**Sclerenchymatic sheath eccentric centripetally**. *Carex moorcroftii*, Cyperaceae.

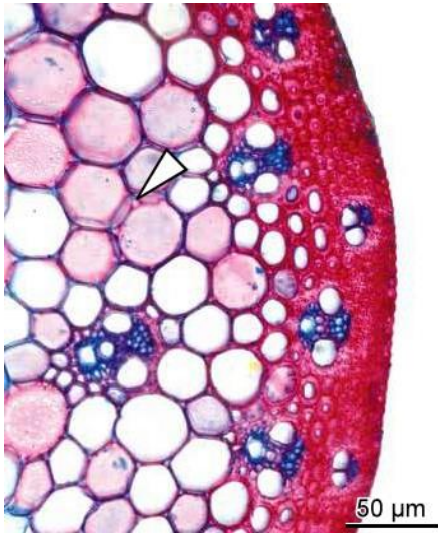


**Sclerenchymatic sheath eccentric centrifugally**. *Stipa brandisii*, Poaceae.

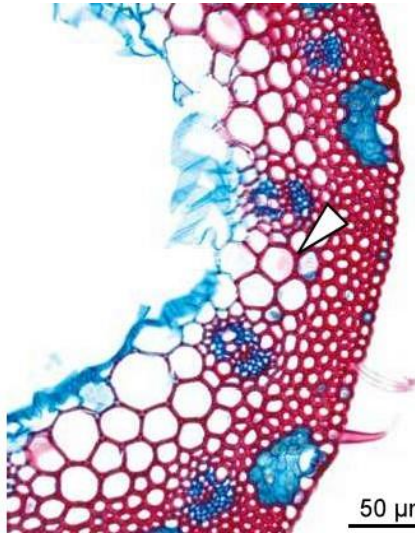


**Sheath around vascular bundle not lignified**. *Eleocharis uniglumis*, Cyperaceae.

## Intercellulars in parenchymatic tissue

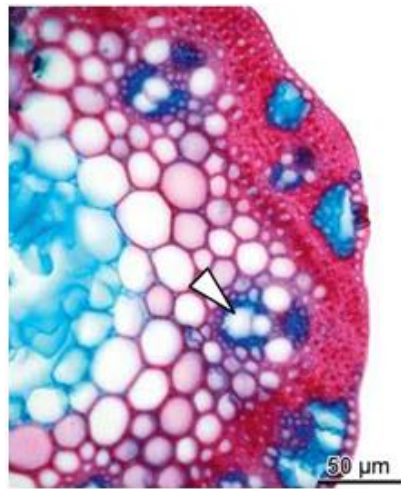


Cavities in parenchymatic zones  
small triangular. *Cymbopogon jwarancusa*,  
Poaceae.



Cavities in parenchymatic zones absent.

## Intercellulars in the protoxylem



With cavities on the protoxylem of vascular bundles.  
*Bromus japonicus*, Poaceae.

## Figure A2. Phylogenetic trees.

Derived tree based on Bayesian inference (see Methods) used to assess phylogenetic inertia in this study. Branch colors correspond to reconstructed states according to asymmetrical 2-parameter Markov k-state model as implemented in Mesquite 2.6 (Maddison and Maddison 2009). **Left:** Sclerenchymatic sheaths around vascular bundles, **Right:** Vessel size.



