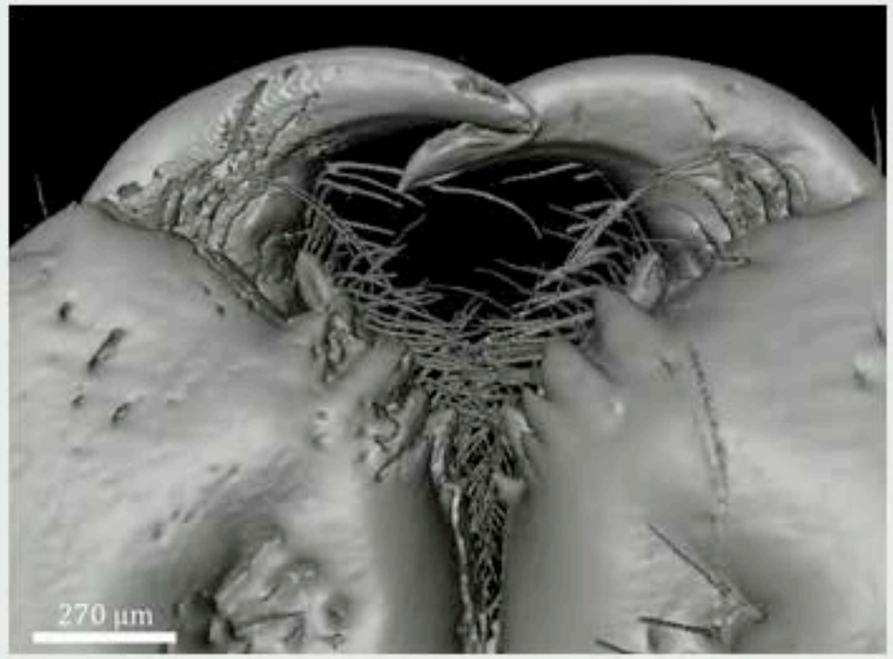
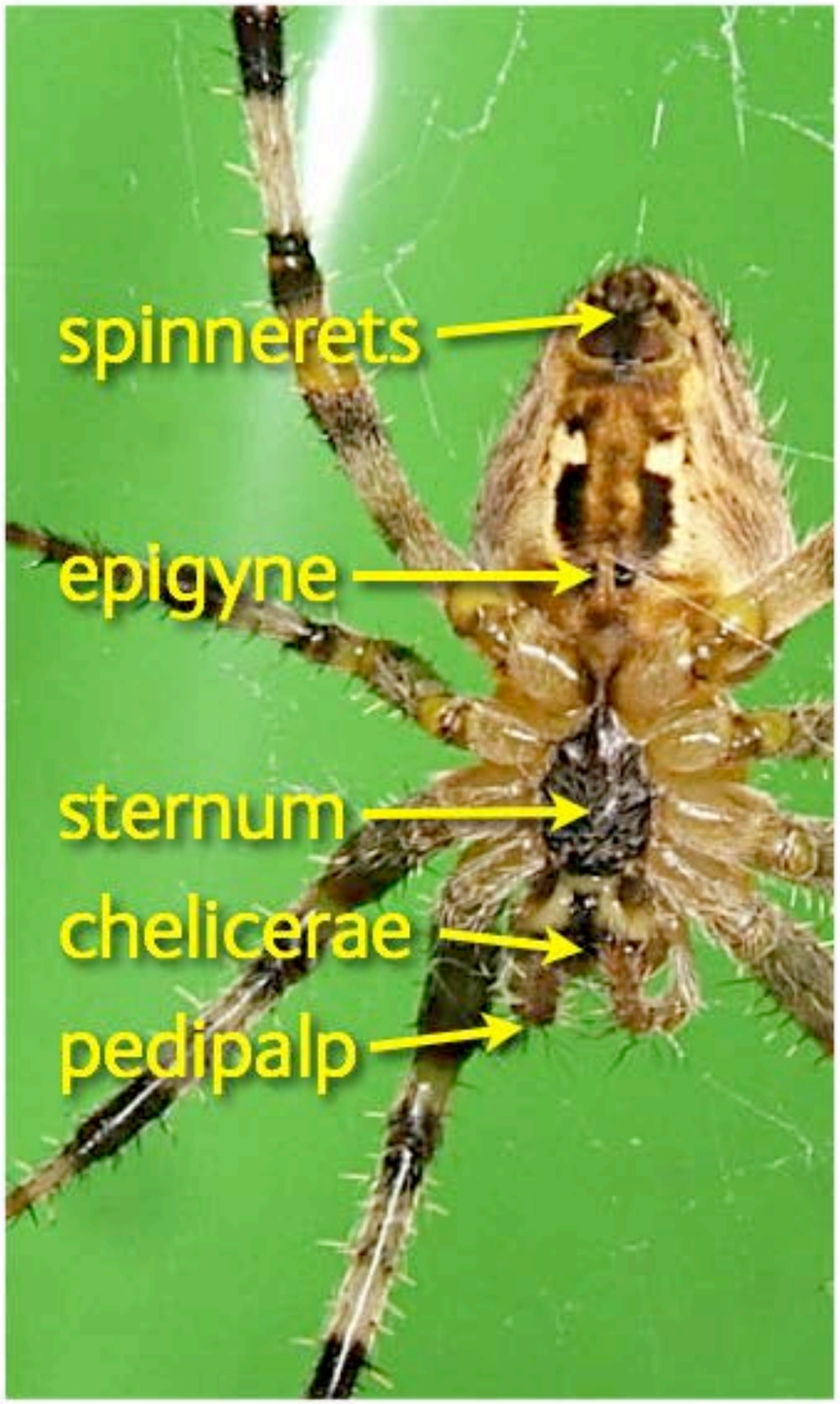
Imaging Techniques in the study of Fossil Spiders



Paul A. Selden

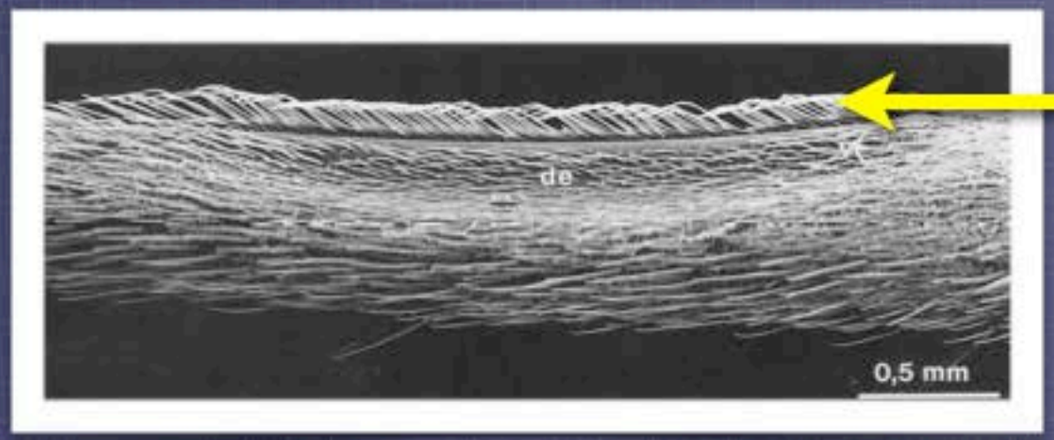
Paleontological Institute, University of Kansas

Characters in Modern Spiders

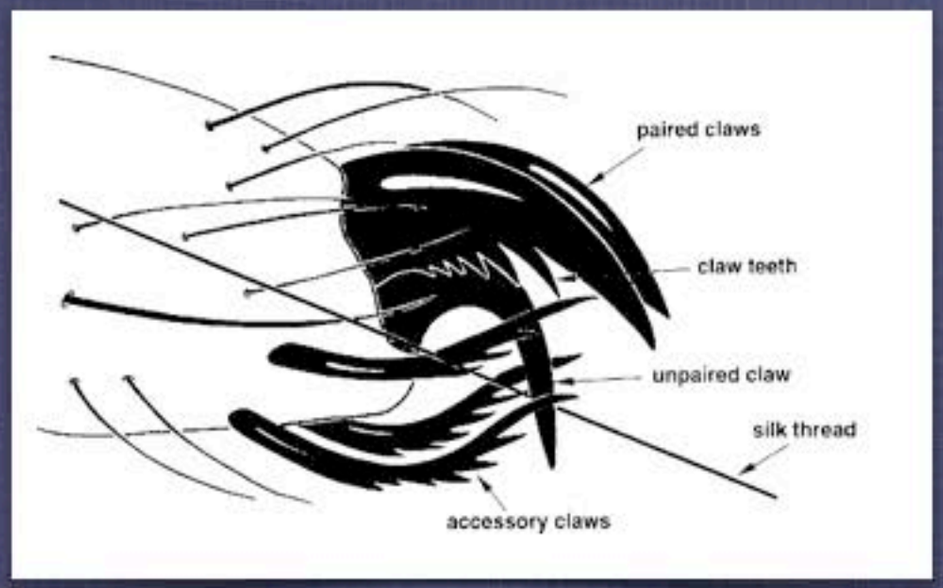


- LEFT: anatomy of a female spider
- BELOW: male spiders have no epigyne and their pedipalps are modified for sperm transfer

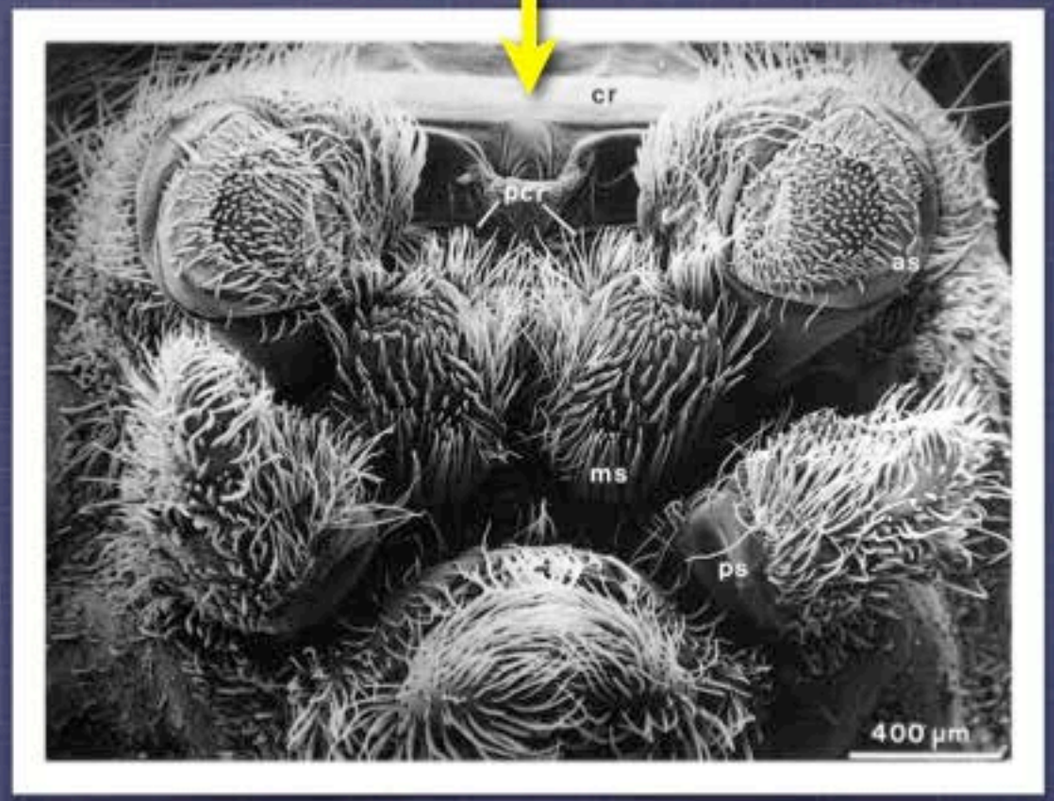
Characters in Modern Spiders



calamistrum of curved bristles on the fourth leg in some spiders; these spiders also possess a **cribellum**—a plate with tiny spigots in front of the spinnerets

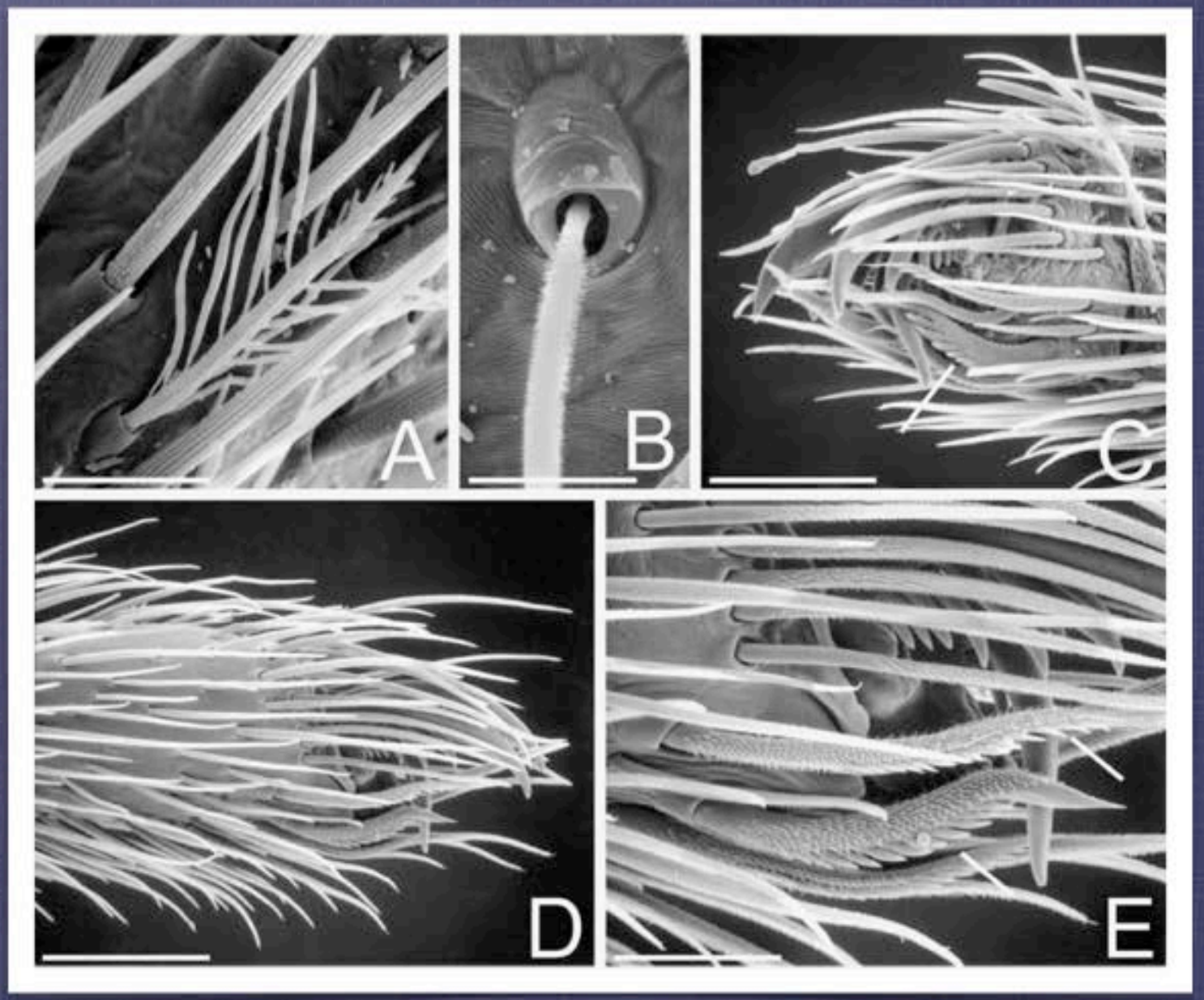


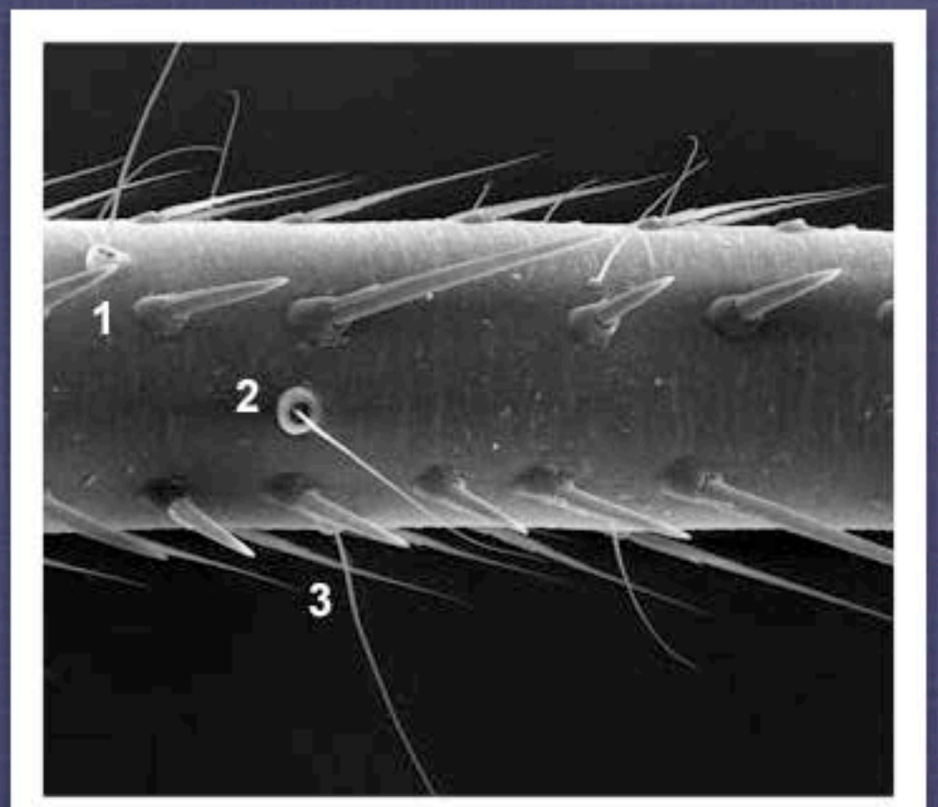
tarsal claws of web-weaving spider



Characters in Modern Spiders

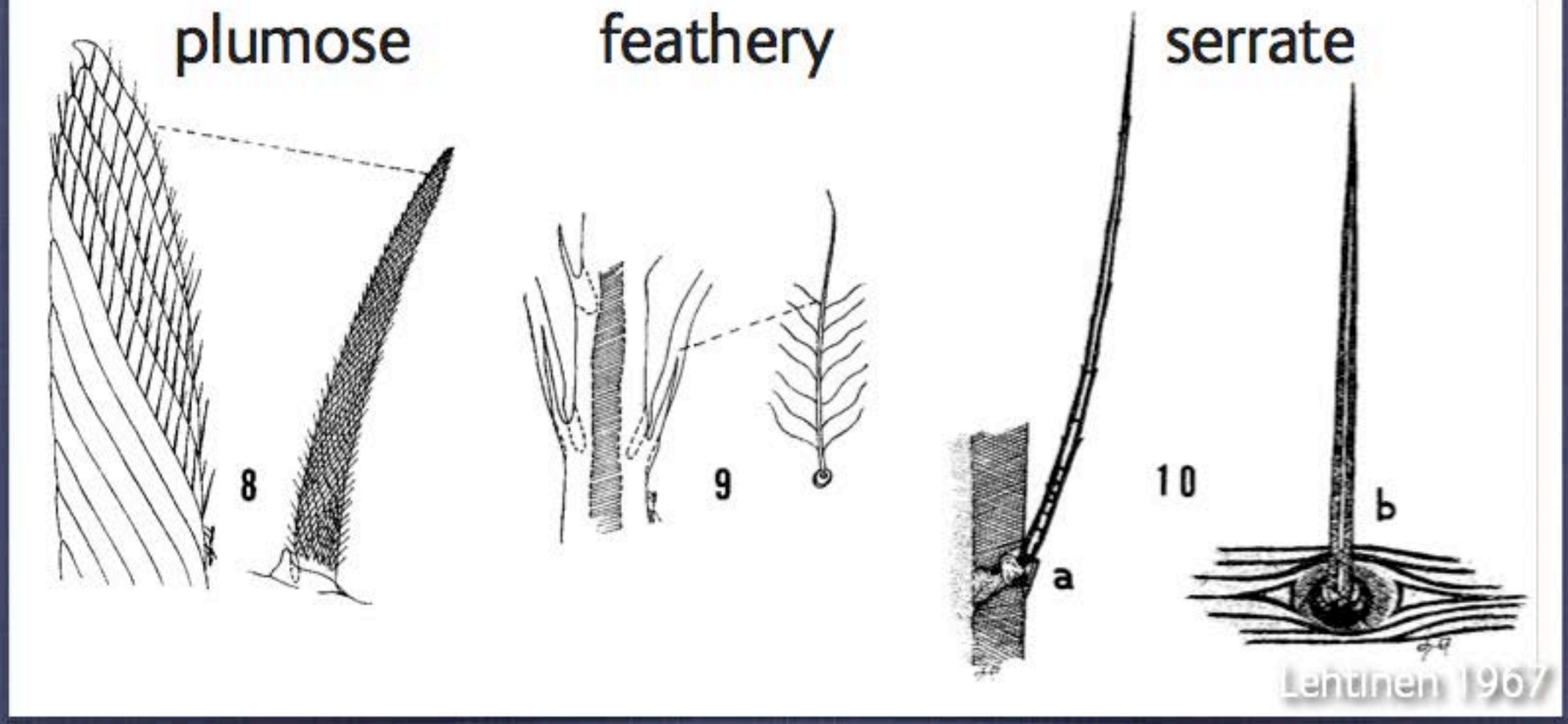
- A: plumose and feathery setae
- B: trichobothria base
- C–E: tarsal claws and accessory claws





- LEFT: macrosetae, taste hairs and trichobothria (1–3)

Setal Ultrastructure



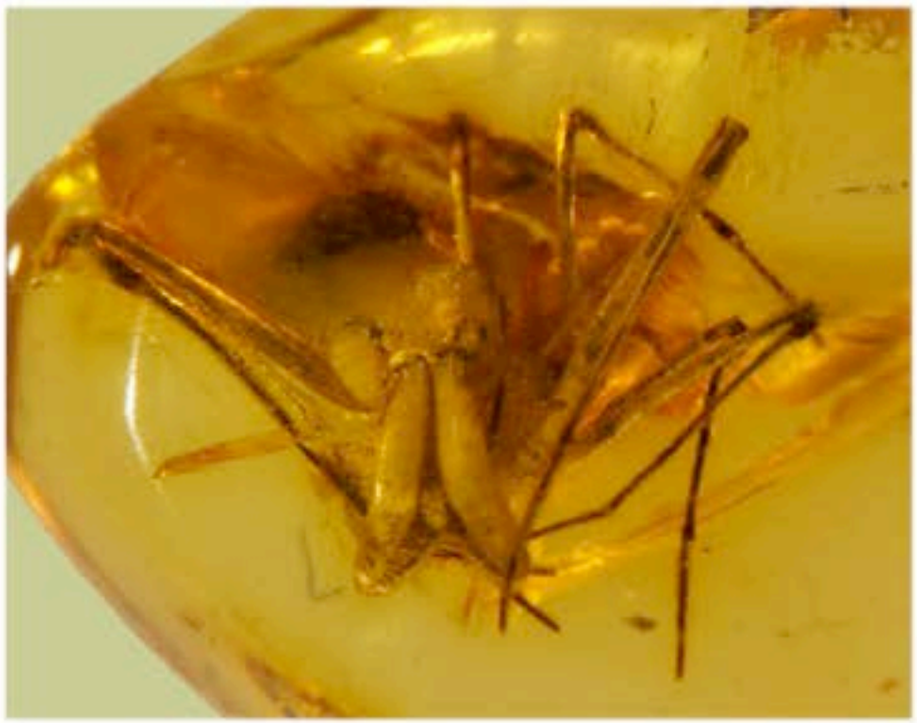
EXAMPLES

plumose	feathery	serrate
Uloboridae	Uloboridae	Nephilidae
Deinopidae	Deinopidae	Araneidae
Megadictyna	*Thaida*	Tetragnathidae
Filistatidae		
Hypochilidae		
Austrochilidae		

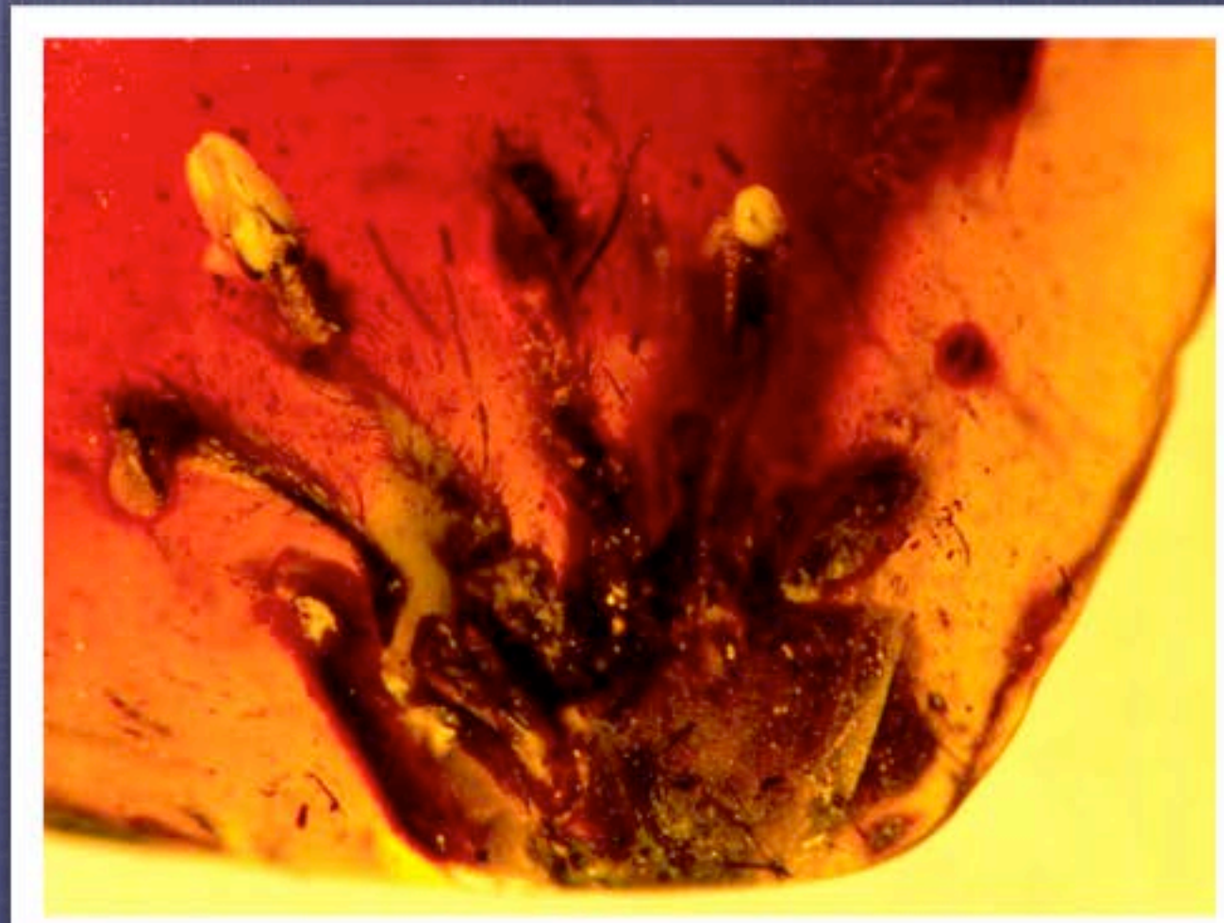
Paleoarachnological Research

- The fossil record
  - preservation in amber
  - rock matrix preservation
- Research techniques
  - use of modern techniques to extract the most information
- Interpretation
  - knowledge of arachnology
  - cladistic methods

Fossil Record



- Preservation in amber is generally good



- but features can be obscured, e.g. by other inclusions, or missing

Fossil Record

- Rock-matrix preservation can be very poor
- But the mere presence of a spider suggests exceptional circumstances of preservation
- Spiders are indicators of Fossil-Lagerstätten
- LEFT: spider in Miocene diatomite of New Zealand

Fossil Record

- Rock-matrix preservation can sometimes be extremely good
- LEFT: male palps on a Jurassic spider from Daohugou, China

Modern palp

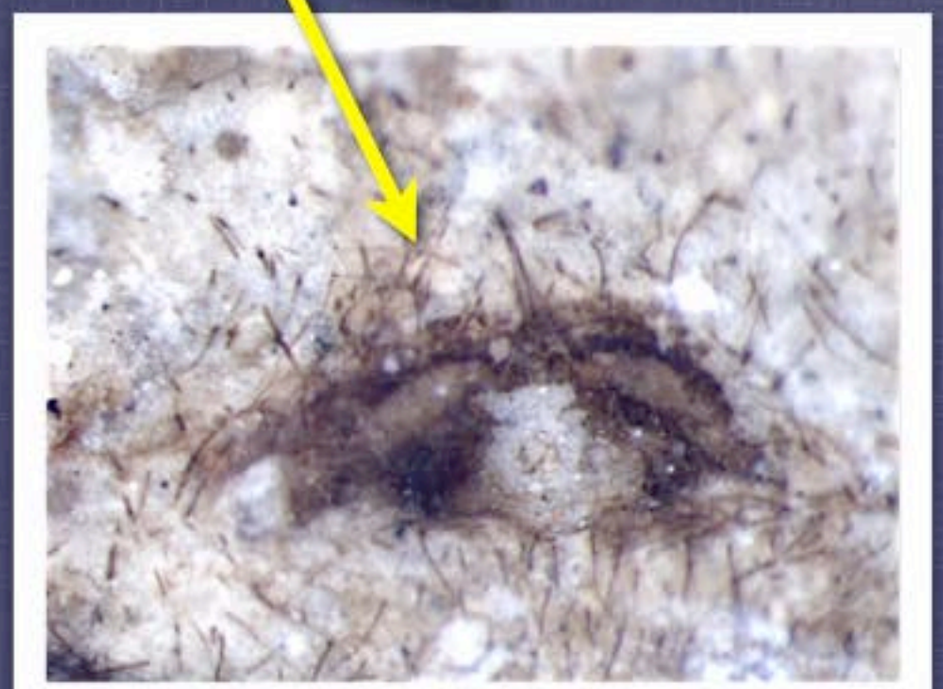
Fossil Record

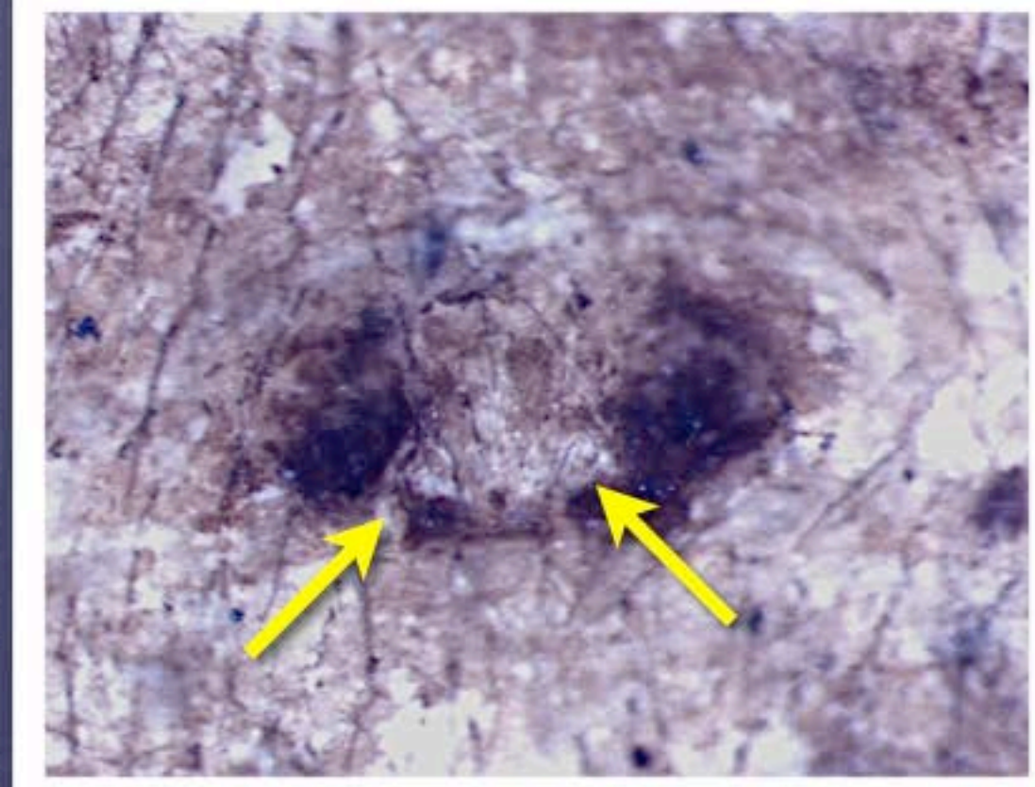
under alcohol

- Rock-matrix preservation can sometimes be extremely good
- LEFT: male palps on a Jurassic spider from Daohugou, China

Fossil Record

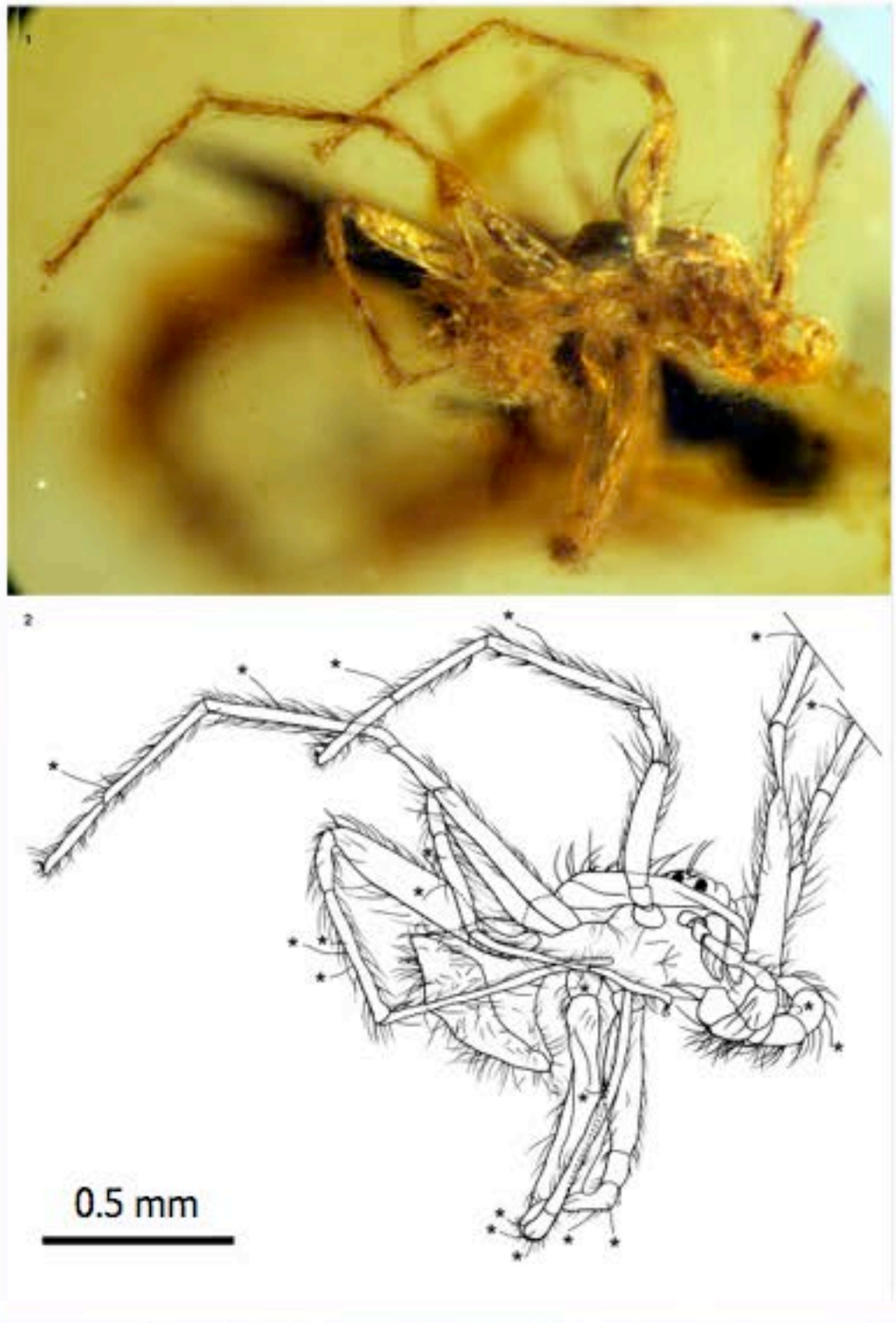
- Female theridiosomatid from Cretaceous of Russia
- epigyne shows internal ducts (BELOW)





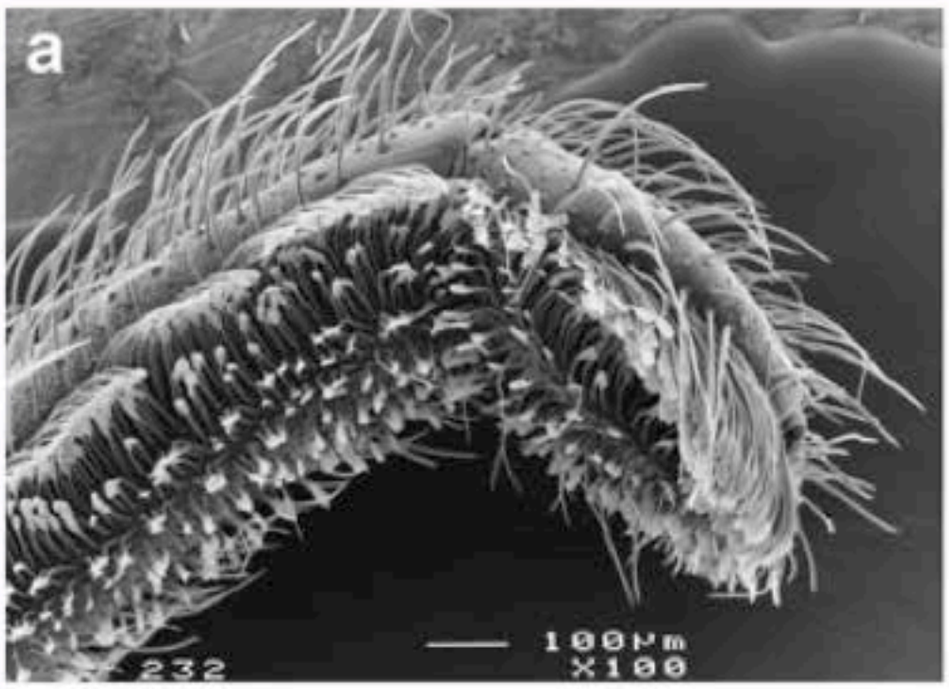
Amber Spiders

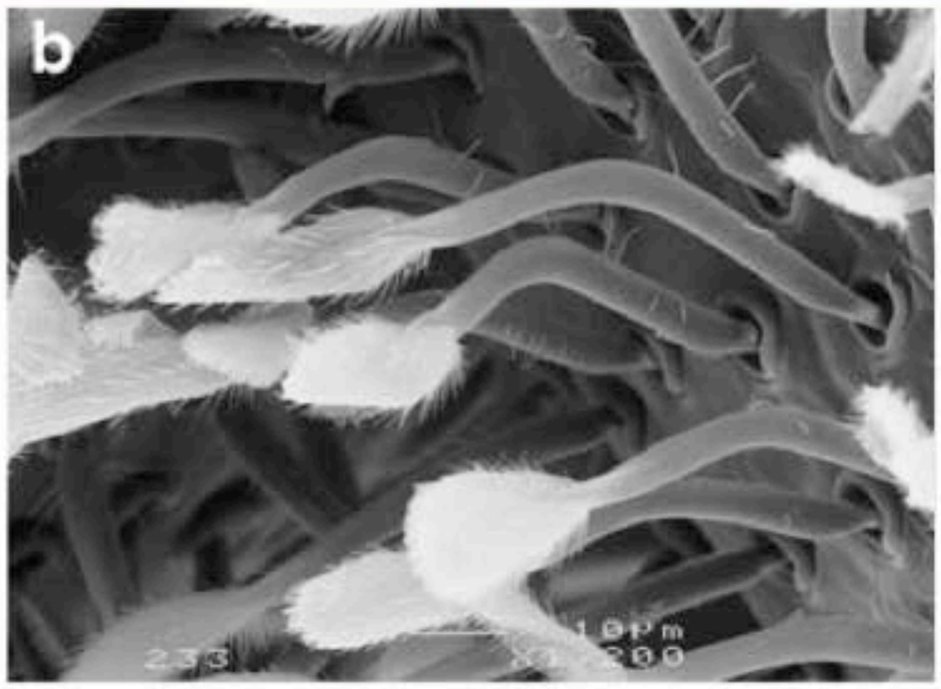
- Light microscopy is commonly sufficient to get fine details from amber spiders
- Cretaceous amber spiders showing trichobothria



Amber Spiders

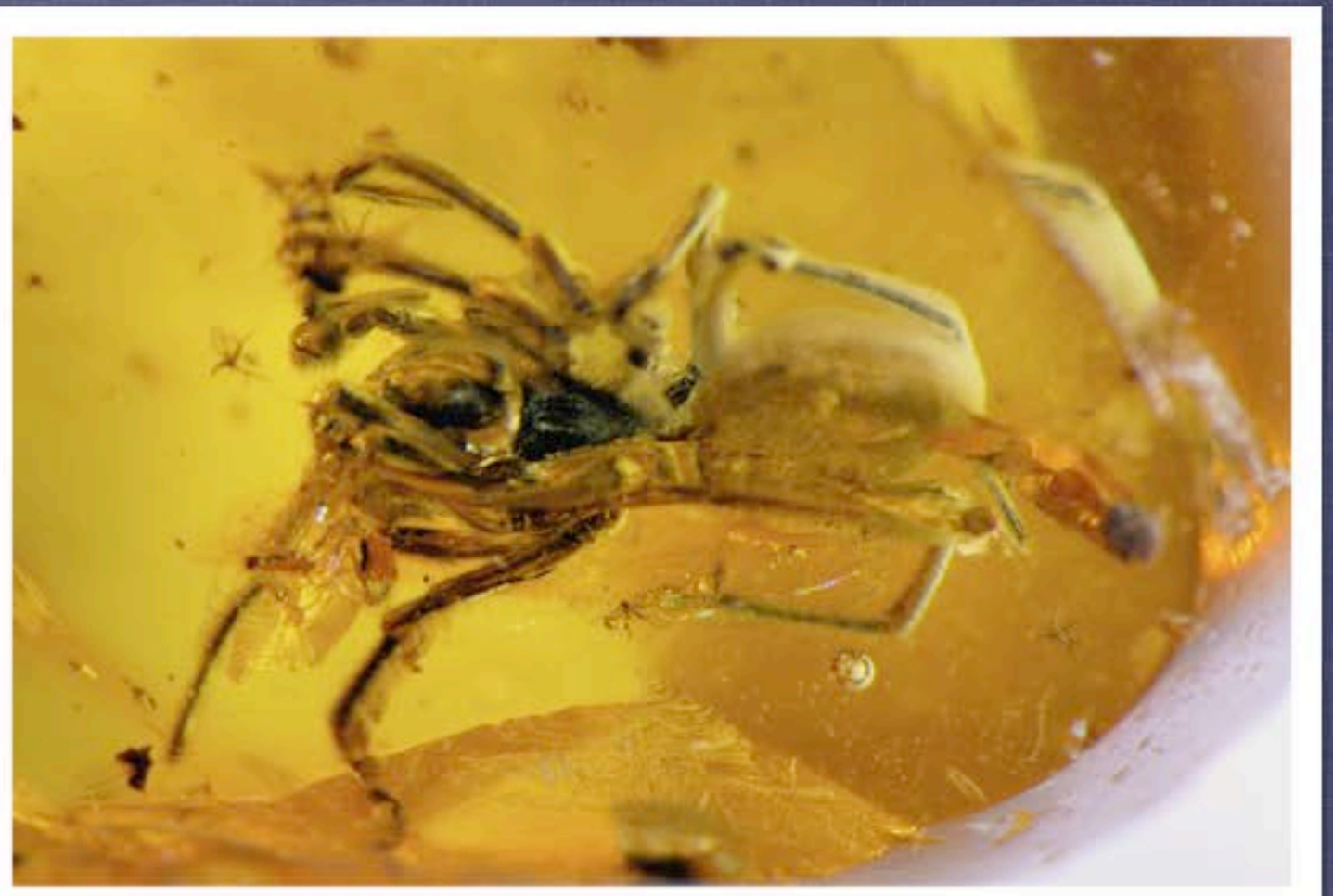
- Spatulate hairs typical of palpimanoids
- RIGHT: Cretaceous amber palpimanoid
- BELOW: modern *Palpimanus*

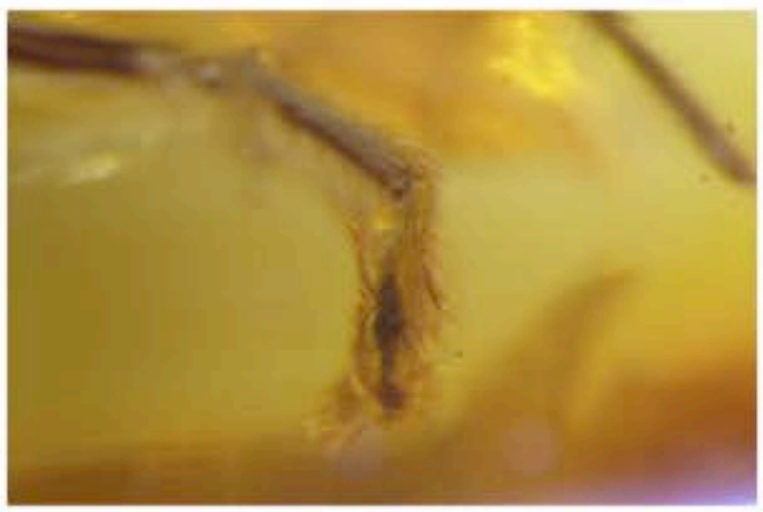




Amber Spiders

- Z-stacks now get over the problem of narrow depths of field





BEFORE

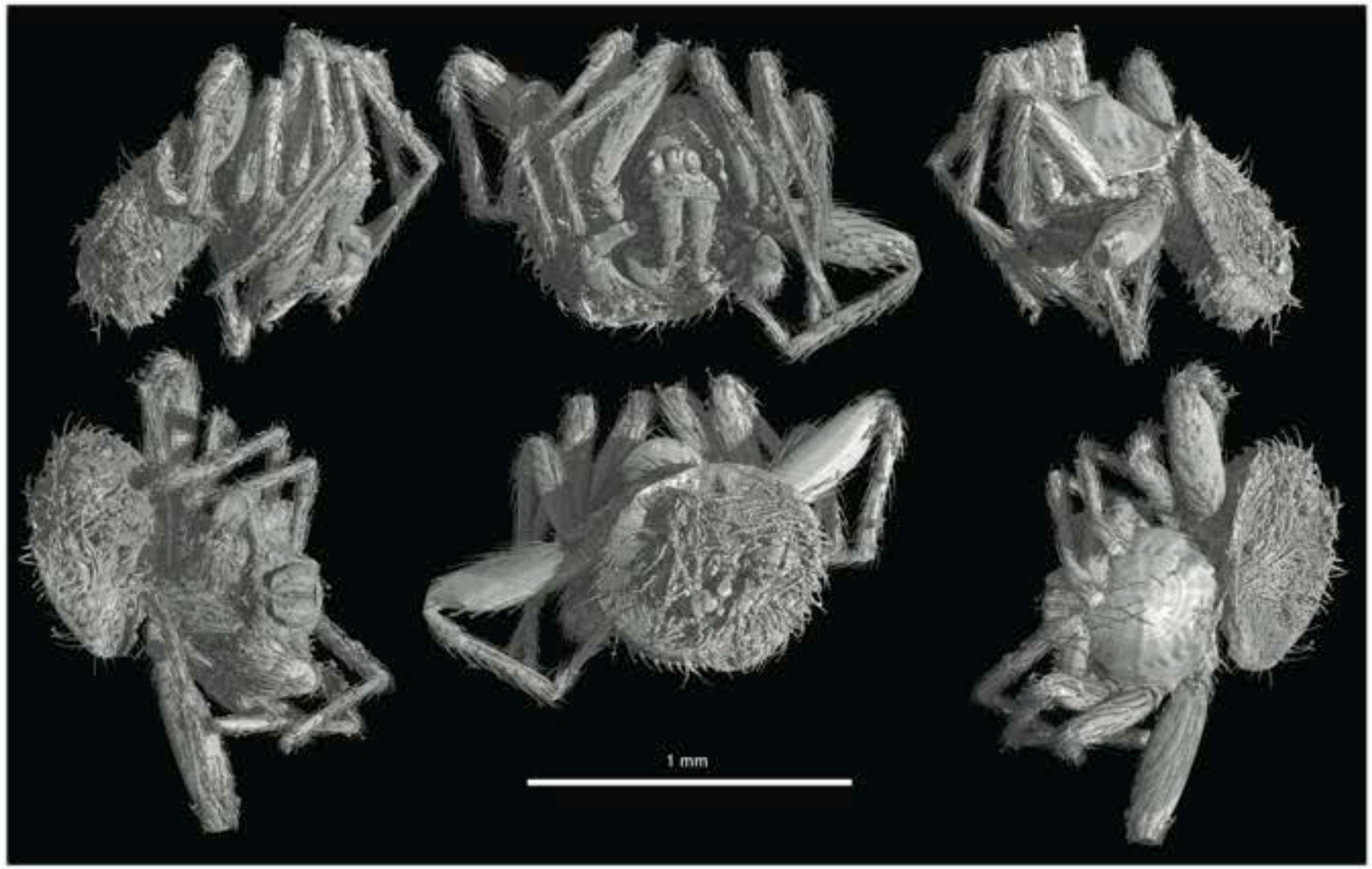
Amber Spiders

- Z-stacks now get over the problem of narrow depths of field

AFTER

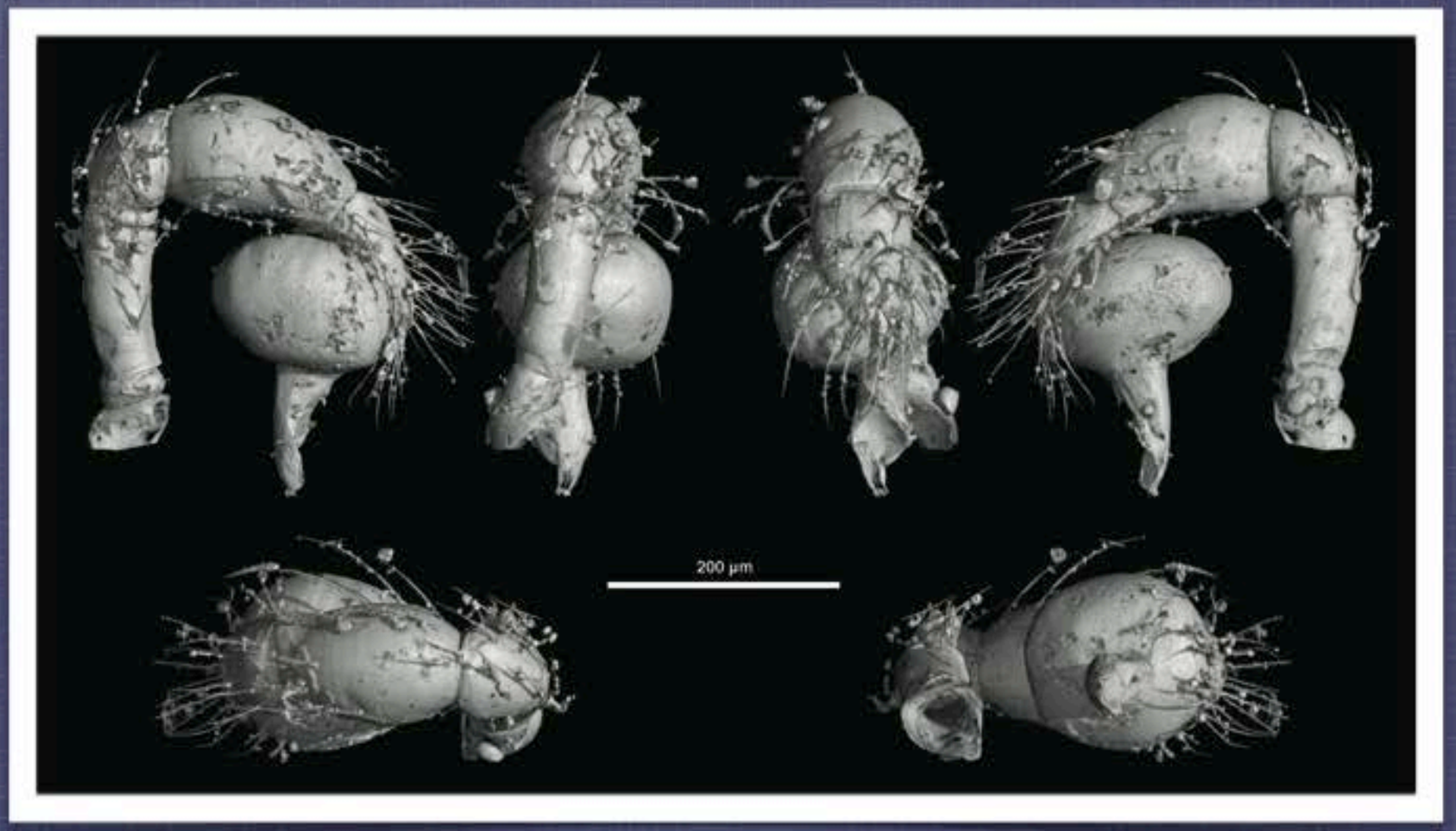
Amber Spiders

- Amber may be opaque, or morphology obscured, so x-ray CT scanning can help: Cretaceous amber *Orchestina*



Amber Spiders

- Amber may be opaque, or morphology obscured, so x-ray CT scanning can help



Cretaceous amber *Orchestina* palp

Modern *Orchestina* palp

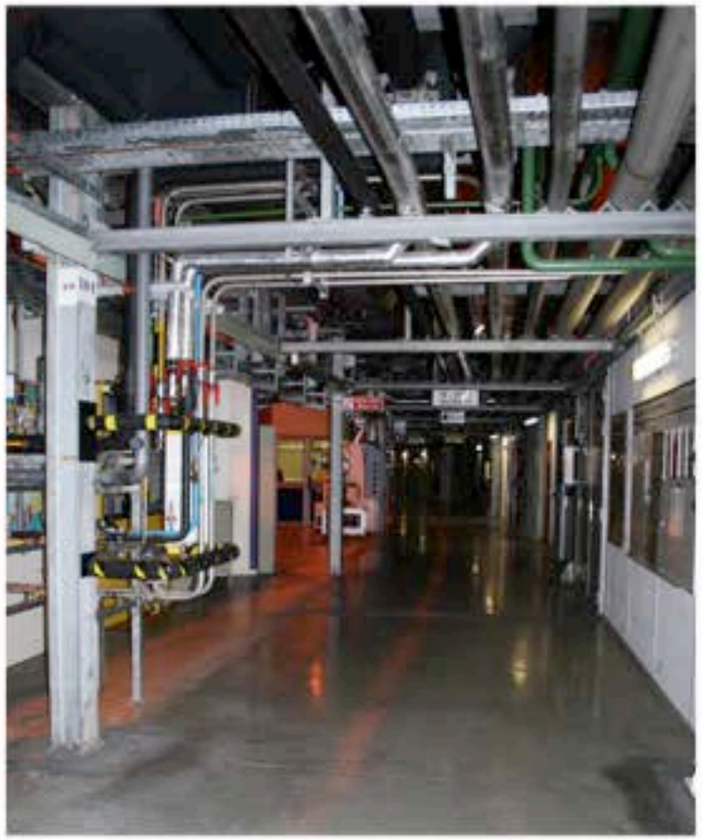
Amber Spiders

- Internal structures can be seen too

French Cretaceous amber micropholcommatid

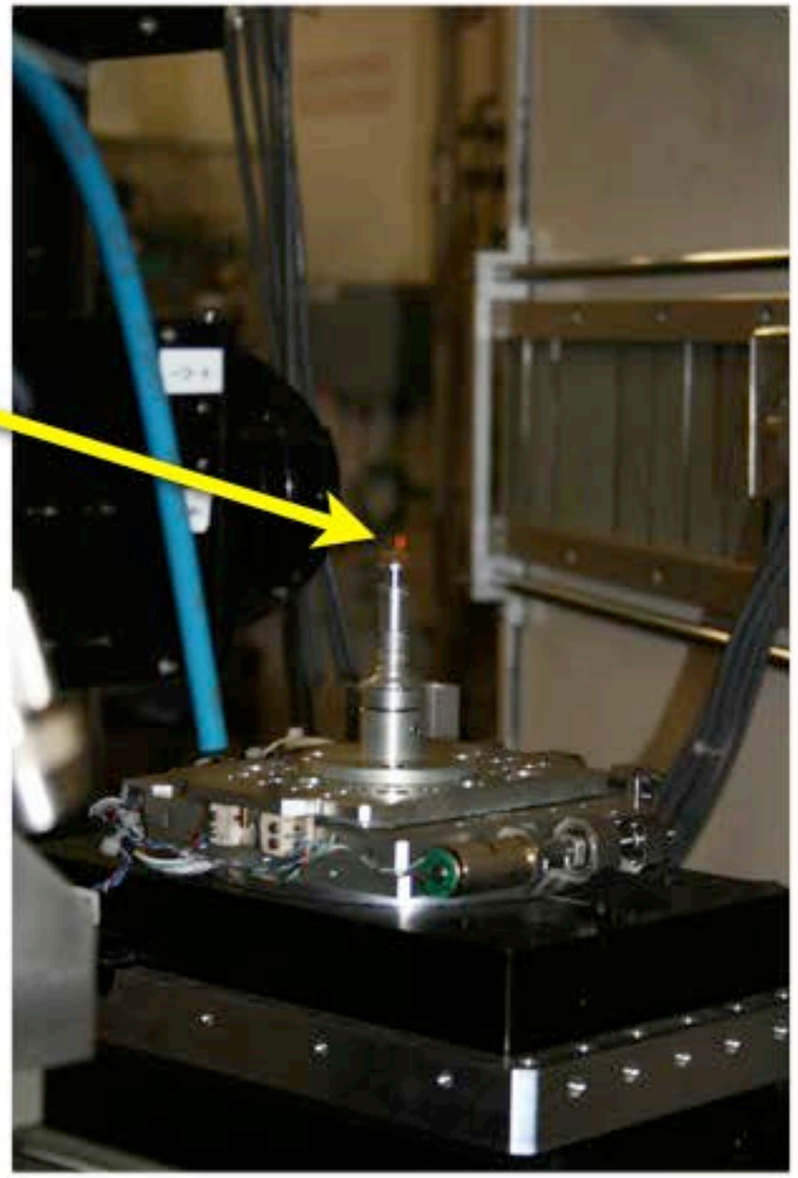
Amber Spiders

- Higher resolution can be obtained using synchrotron radiation



European Synchrotron Facility,
Grenoble, France

amber
specimen



Amber Spiders

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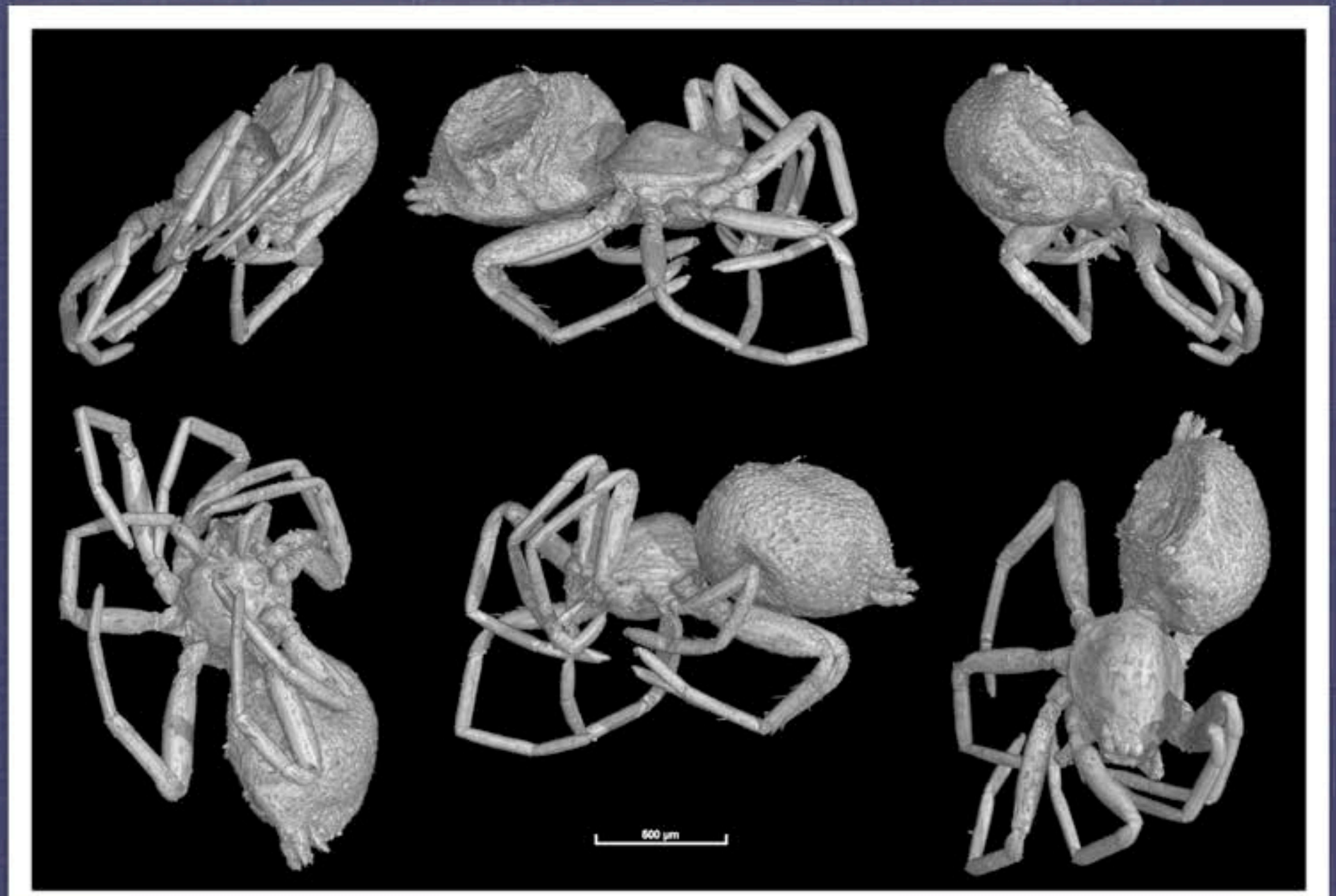
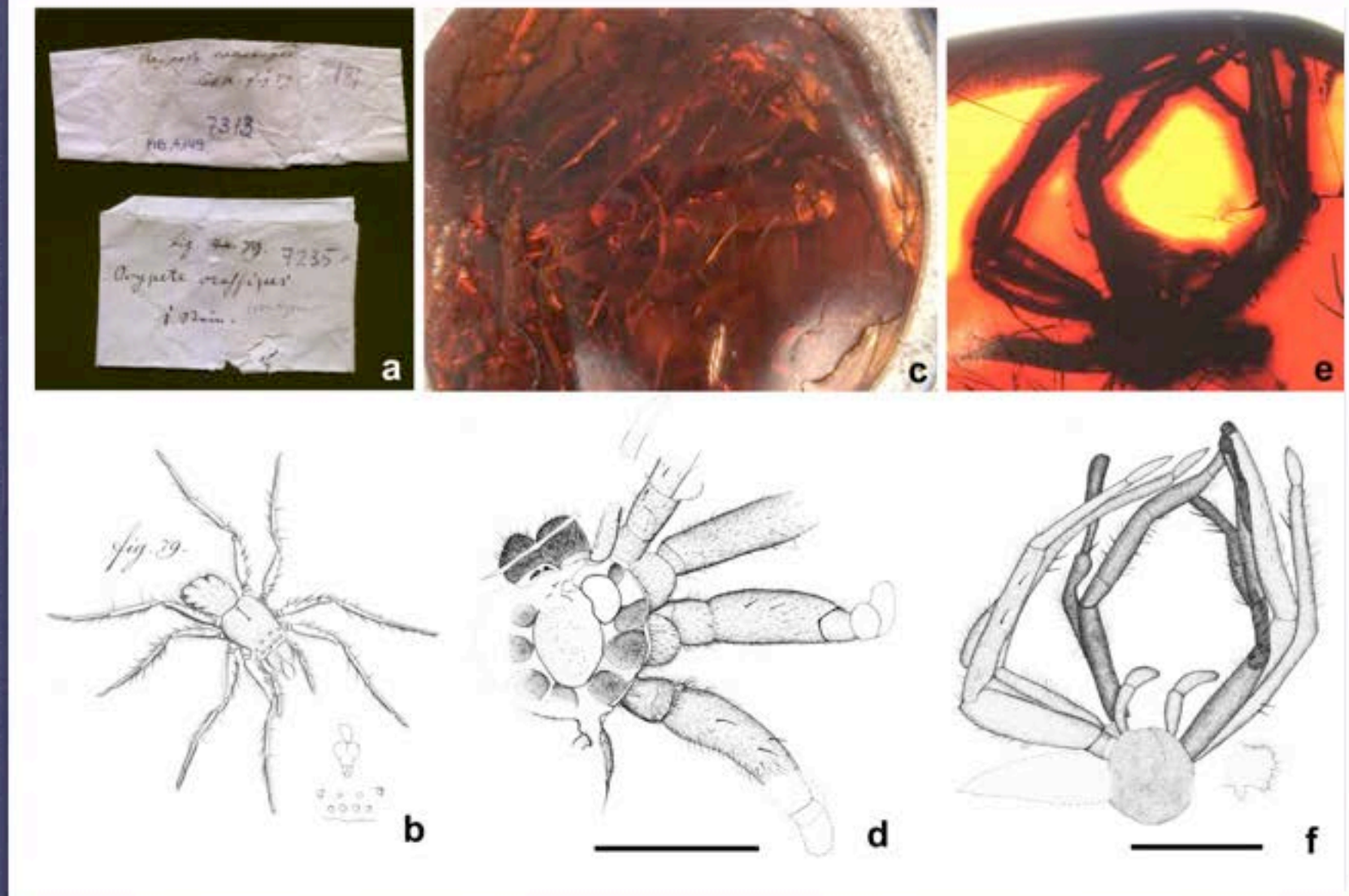


Amber Spiders

- 3D print of CT-scanned amber spider, Cretaceous of Spain

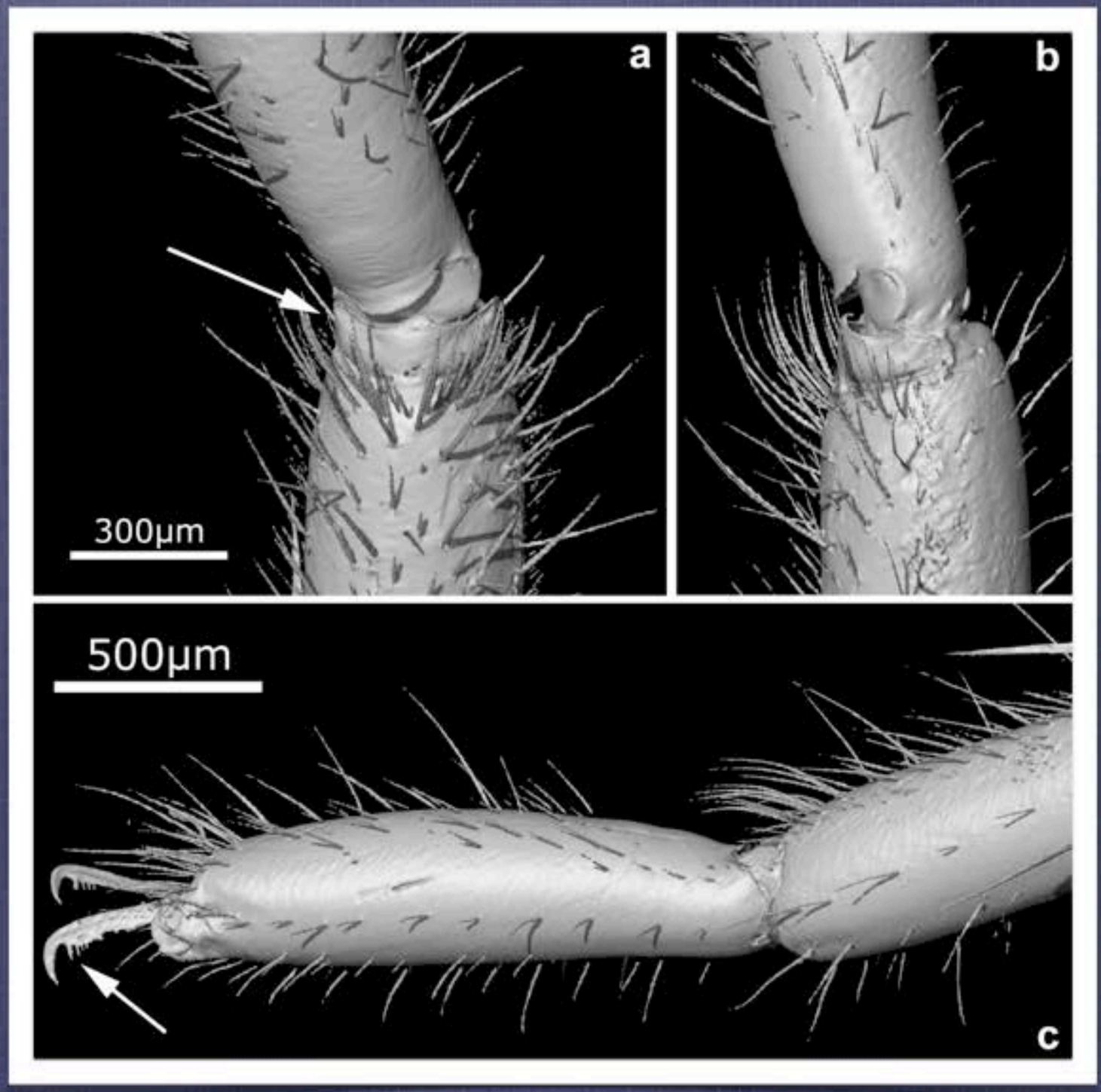
Amber Spiders

- Resolution can be enhanced using phase contrast
- Koch & Berendt (1854) specimen from Baltic amber



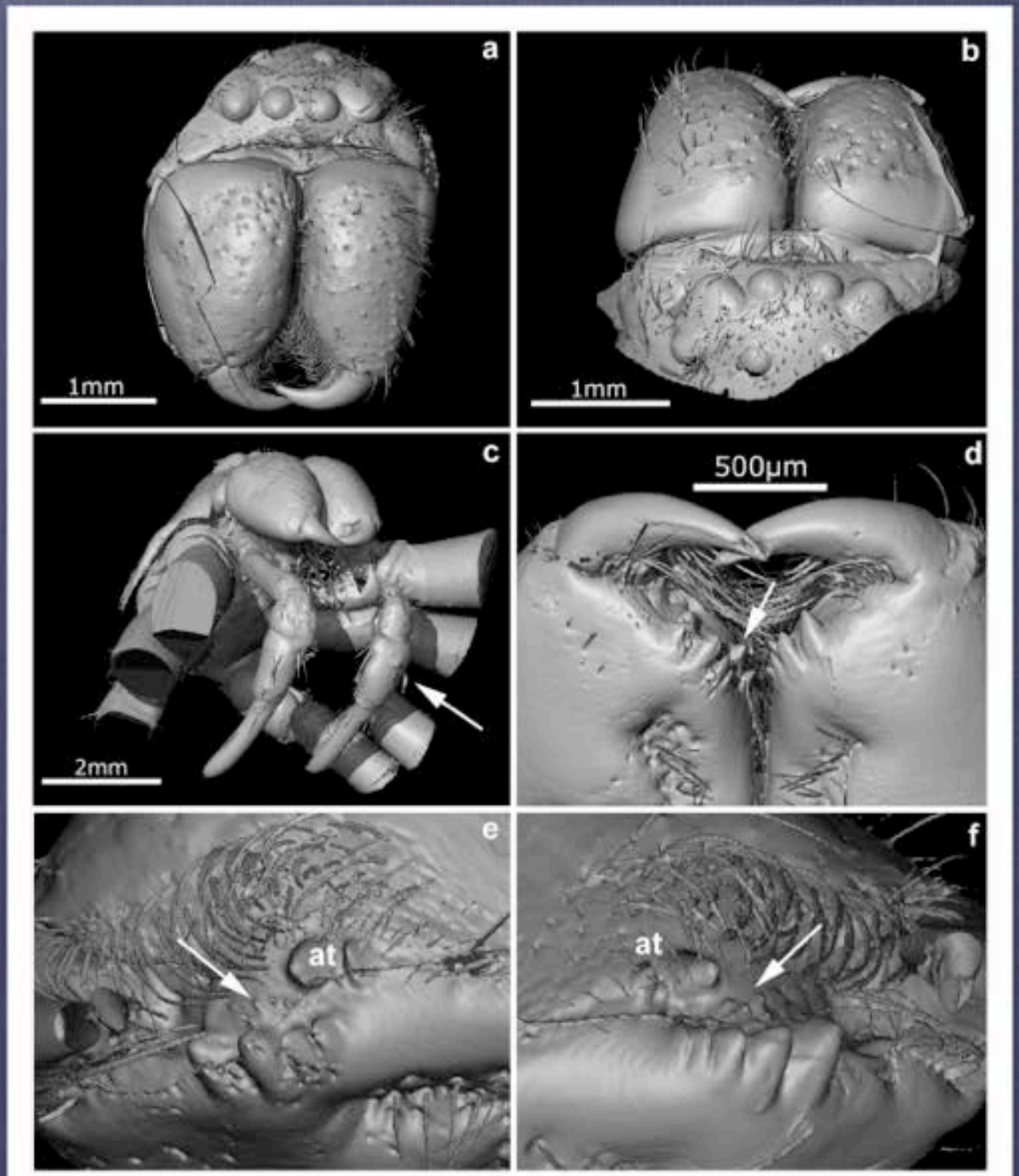
Amber Spiders

- Details of leg joints and tarsal claws place this specimen in Sparassidae: Eusparassinae



Amber Spiders

- Details of cheliceral dentition and male palp structures place it in the modern genus *Eusparassus*



Matrix Spiders

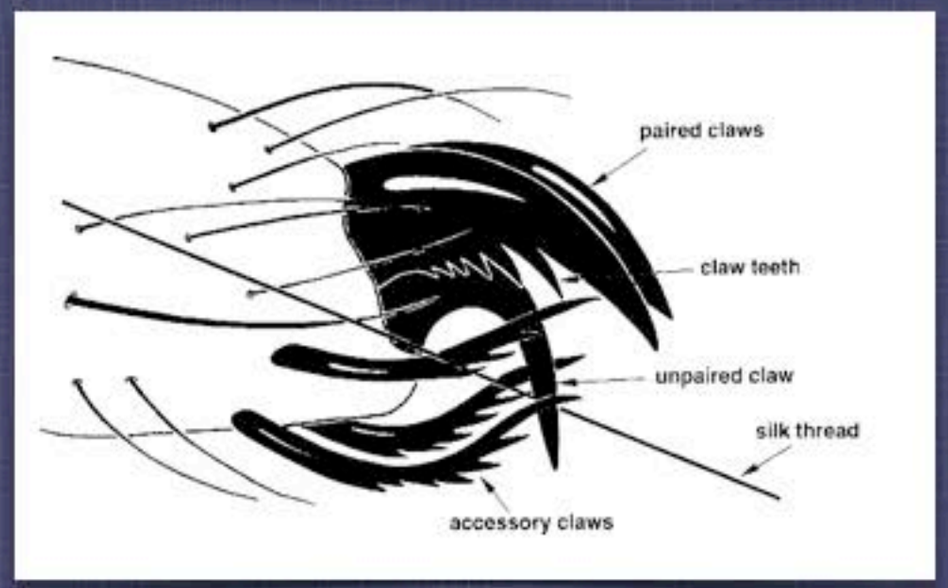
- At first impression, spiders in rock appear to preserve less detail than amber spiders
- Alcohol can enhance definition

Dry

Alcohol

Matrix Spiders

- Fine details such as tarsal claws seen using oil-immersion reflected-light microscopy
- This work done in 1980s; nowadays we can use z-stacks to expand depth of field

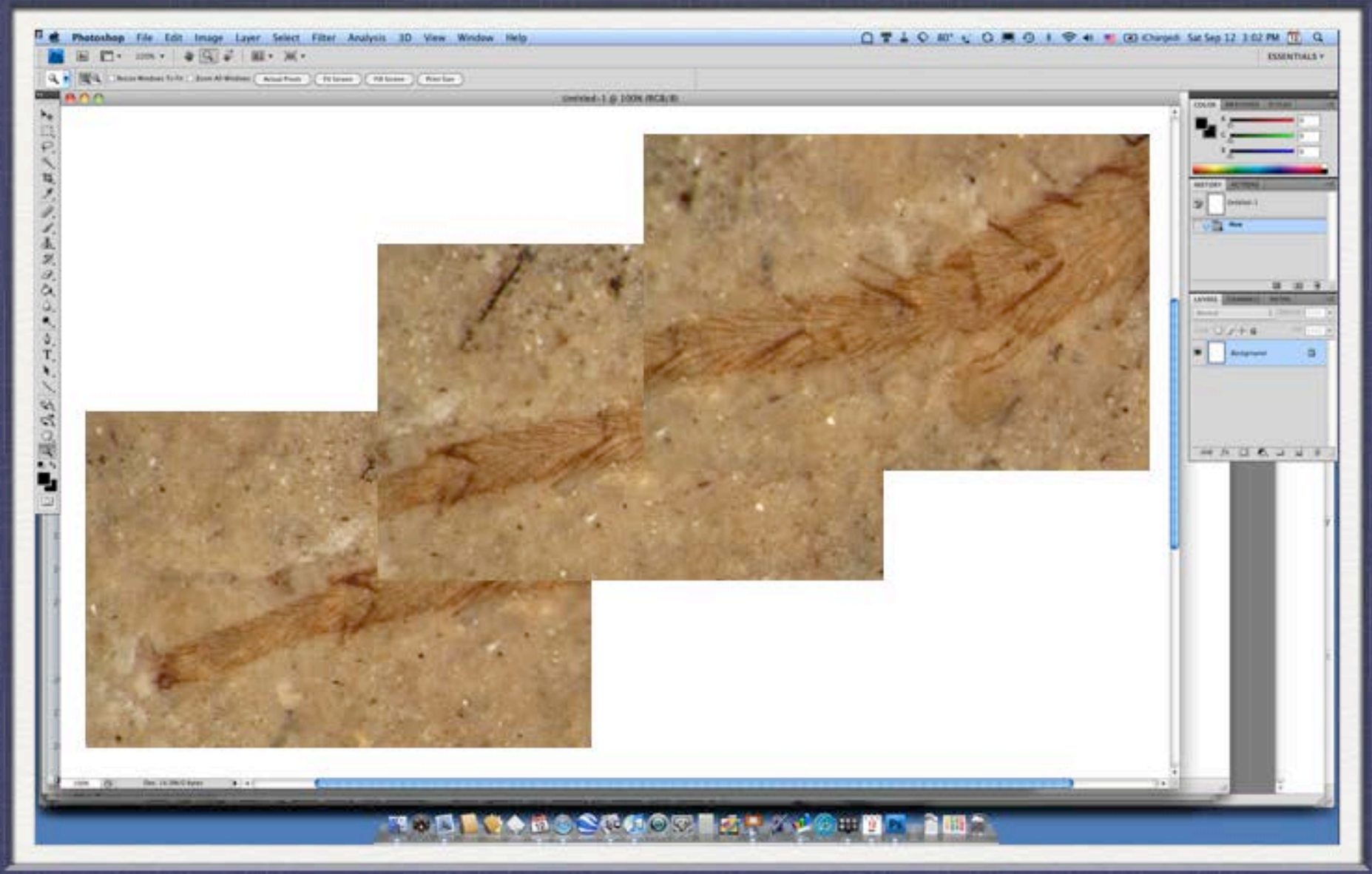


Matrix Spiders

- High-resolution DSLR and digital image manipulation can extract very fine details from matrix-preserved spiders

Matrix Spiders

- Many images taken at high magnification can be merged into a single, high-resolution image with good depth of field



Matrix Spiders

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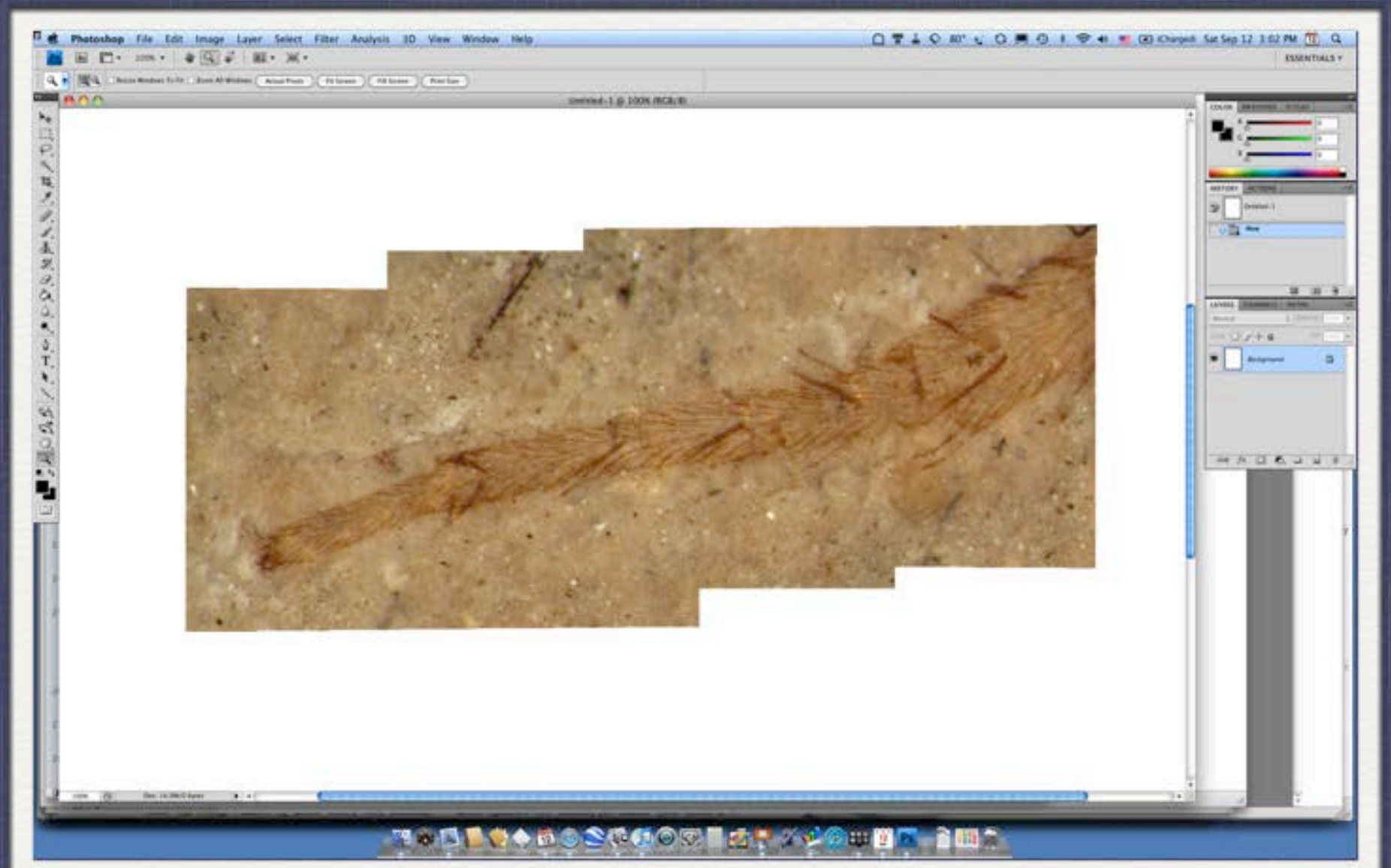
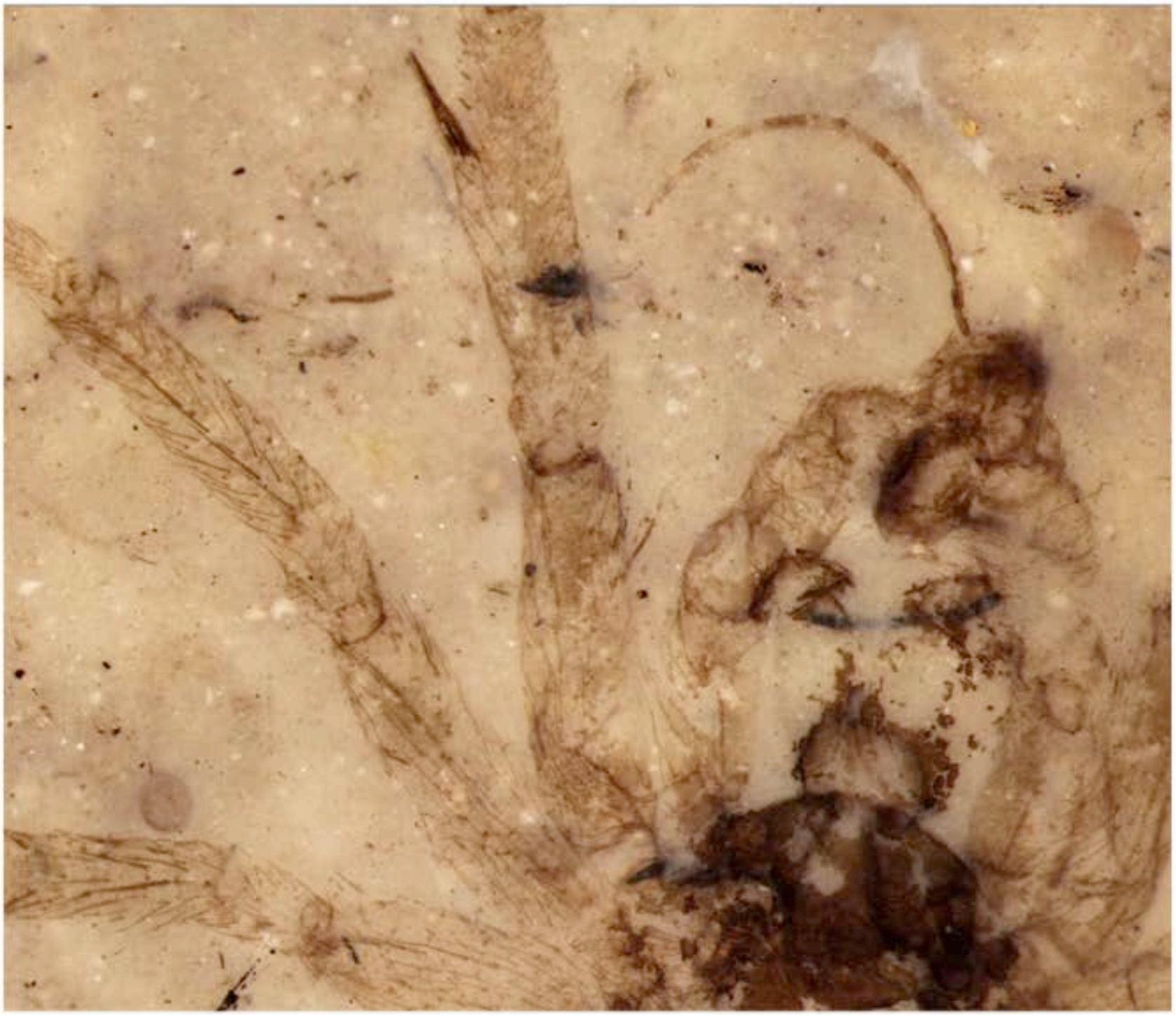


Matrix Spiders

- Whole specimen at high resolution
- Can zoom in and see detail
- Jurassic plectreurid from China

Matrix Spiders



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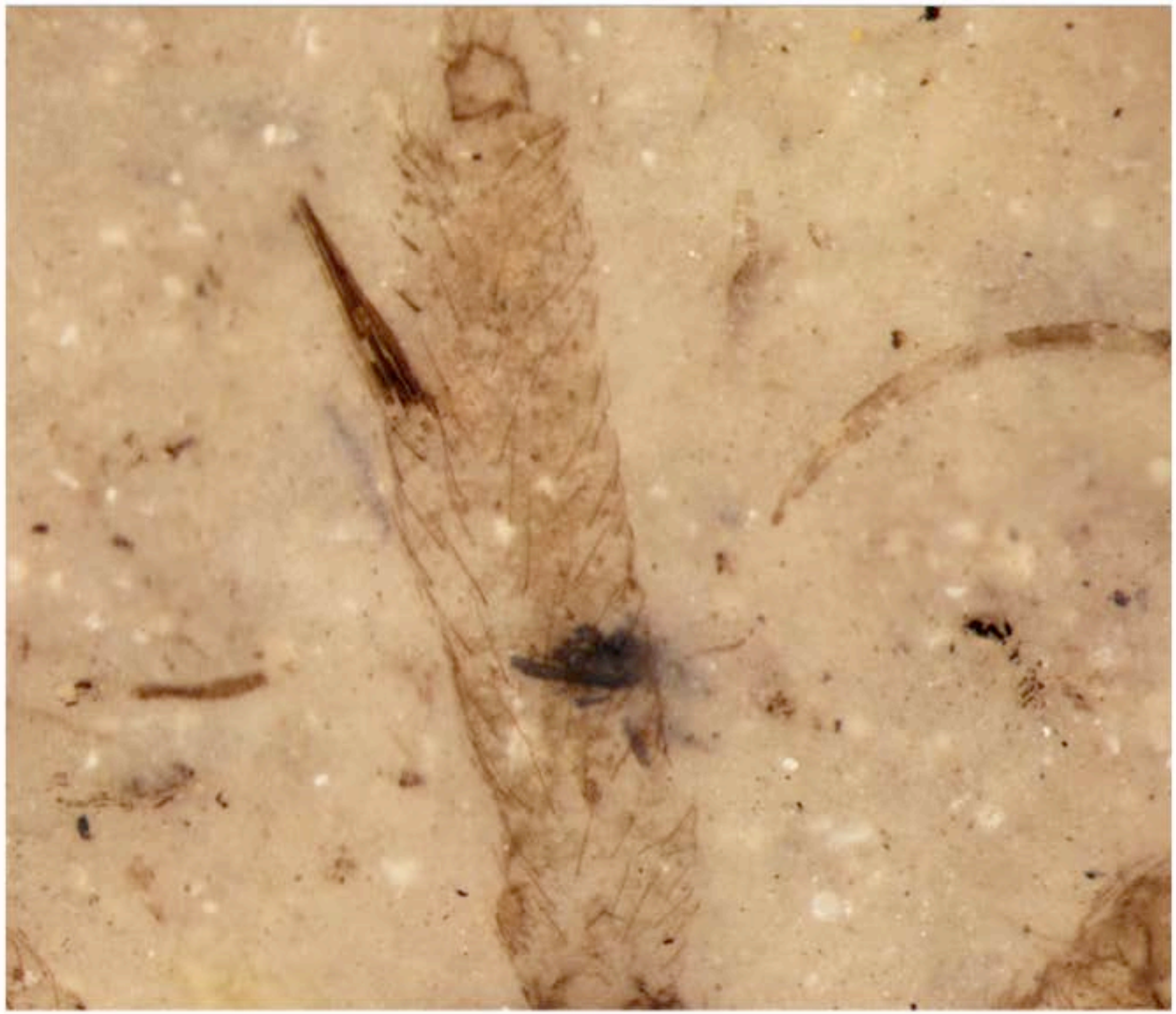
Matrix Spiders



- Whole specimen at high resolution
- Can zoom in and see detail
- Jurassic plectreurid from China

Matrix Spiders

- Whole specimen at high resolution
- Can zoom in and see detail
- Jurassic plectreurid from China

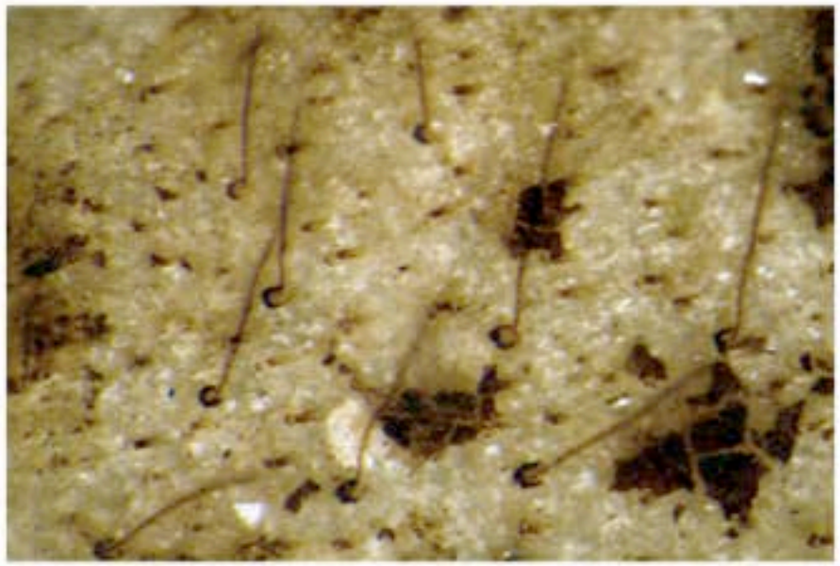
Matrix Spiders

- Helical end of embolus discovered by merging photos of part and counterpart

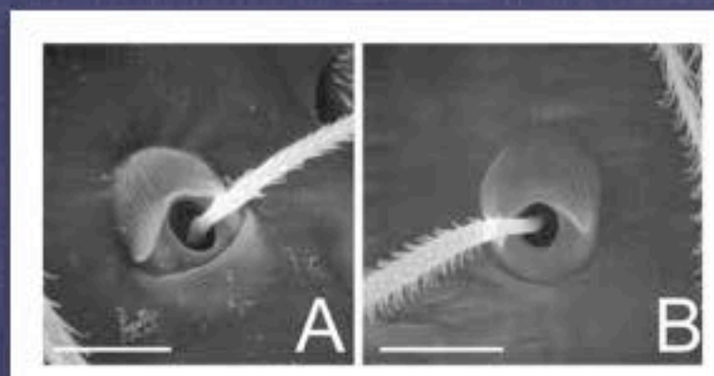
One of *Nature* magazine's
Images of the Year 2010

Matrix Spiders

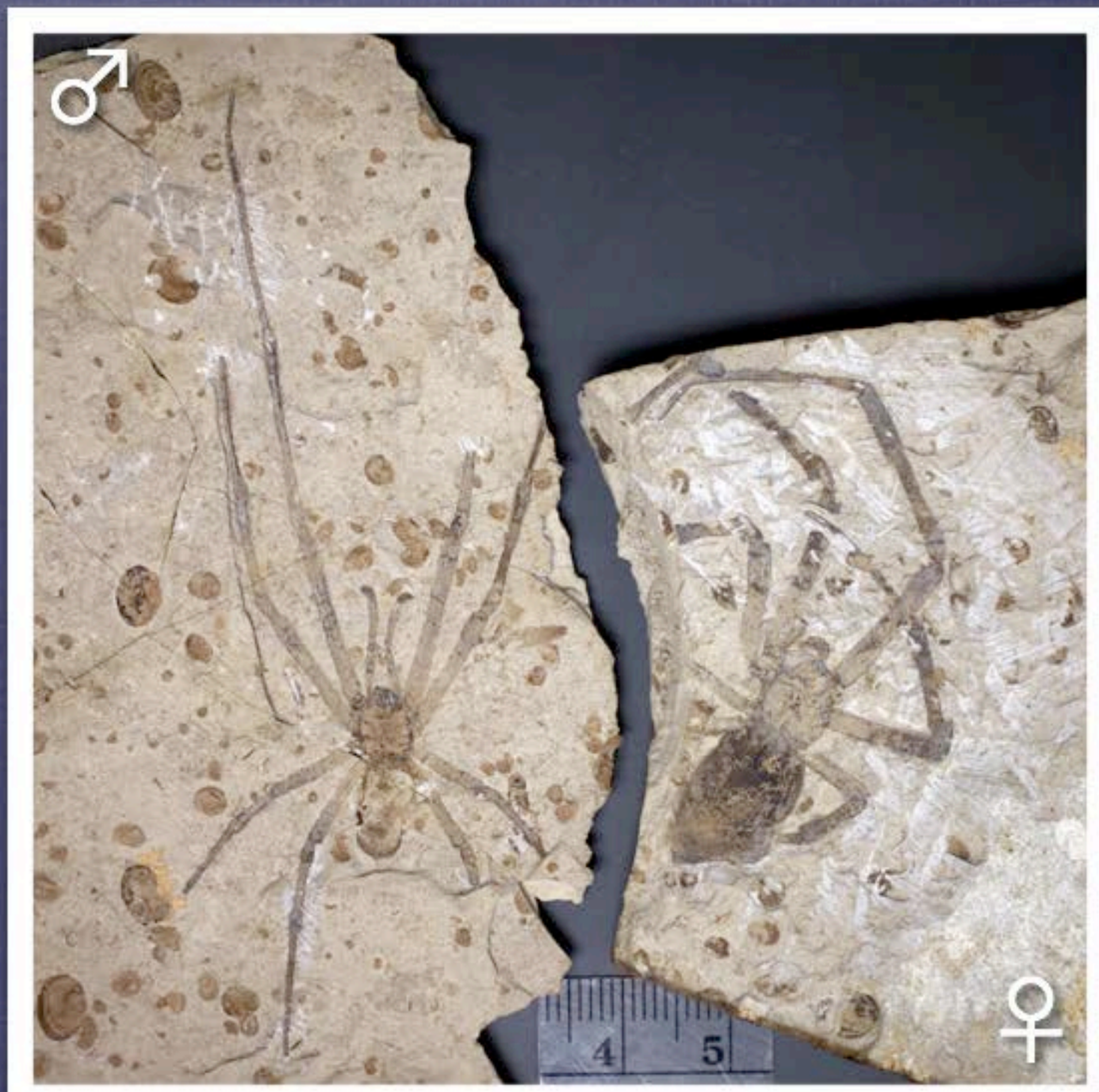
- A giant spider from the Jurassic of China



tibial trichobothria



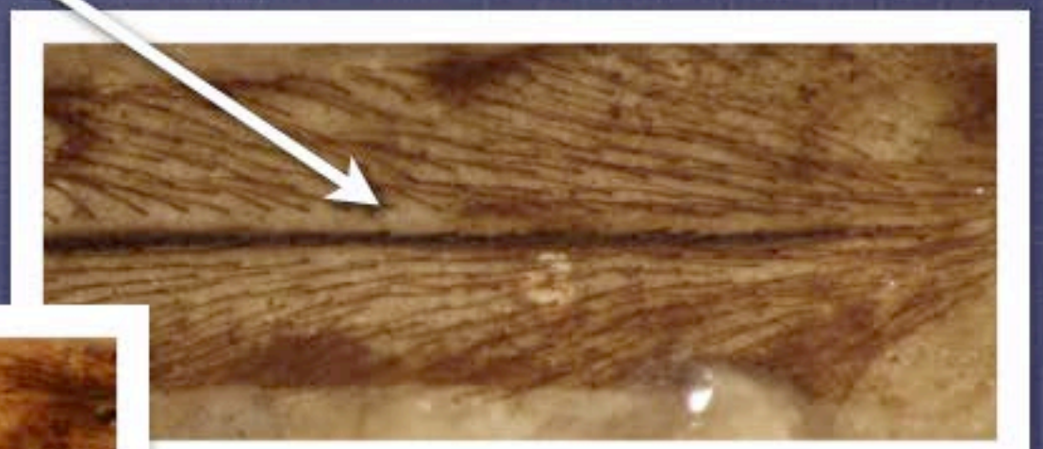
Recent trichobothrial bases



Matrix Spiders

- Male fourth leg

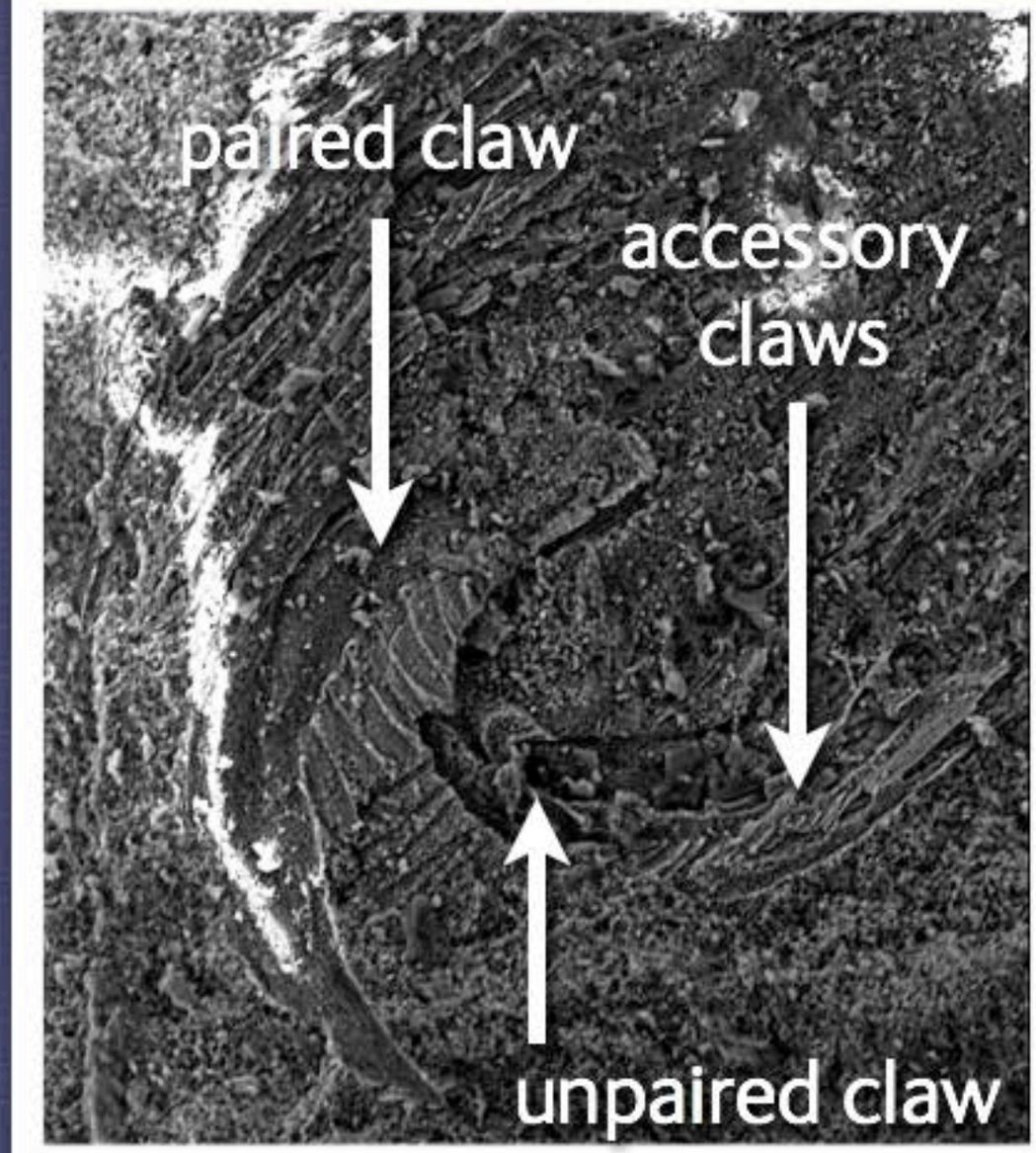
tarsus

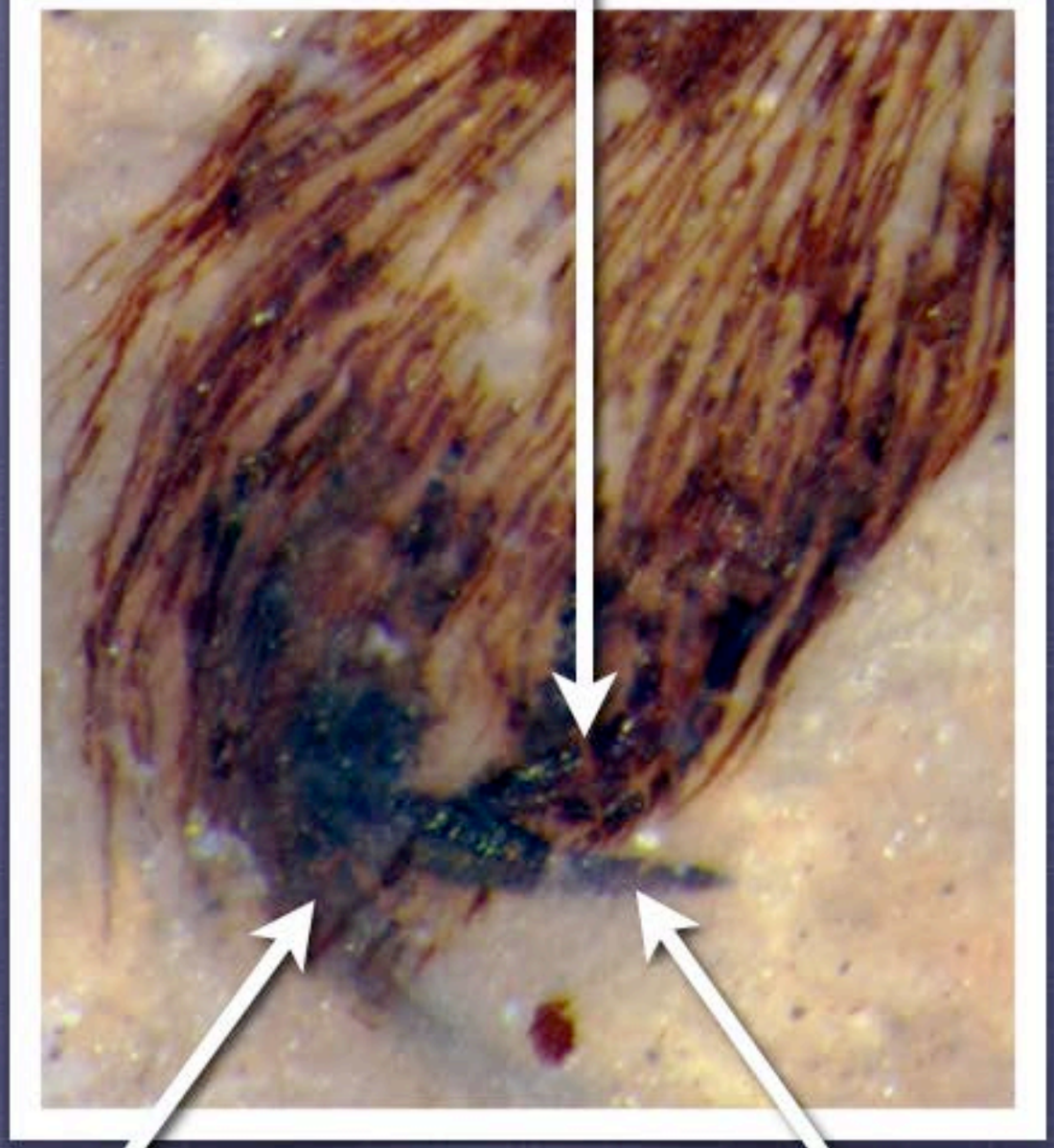


calamistrum

SEM

- Tarsal claws



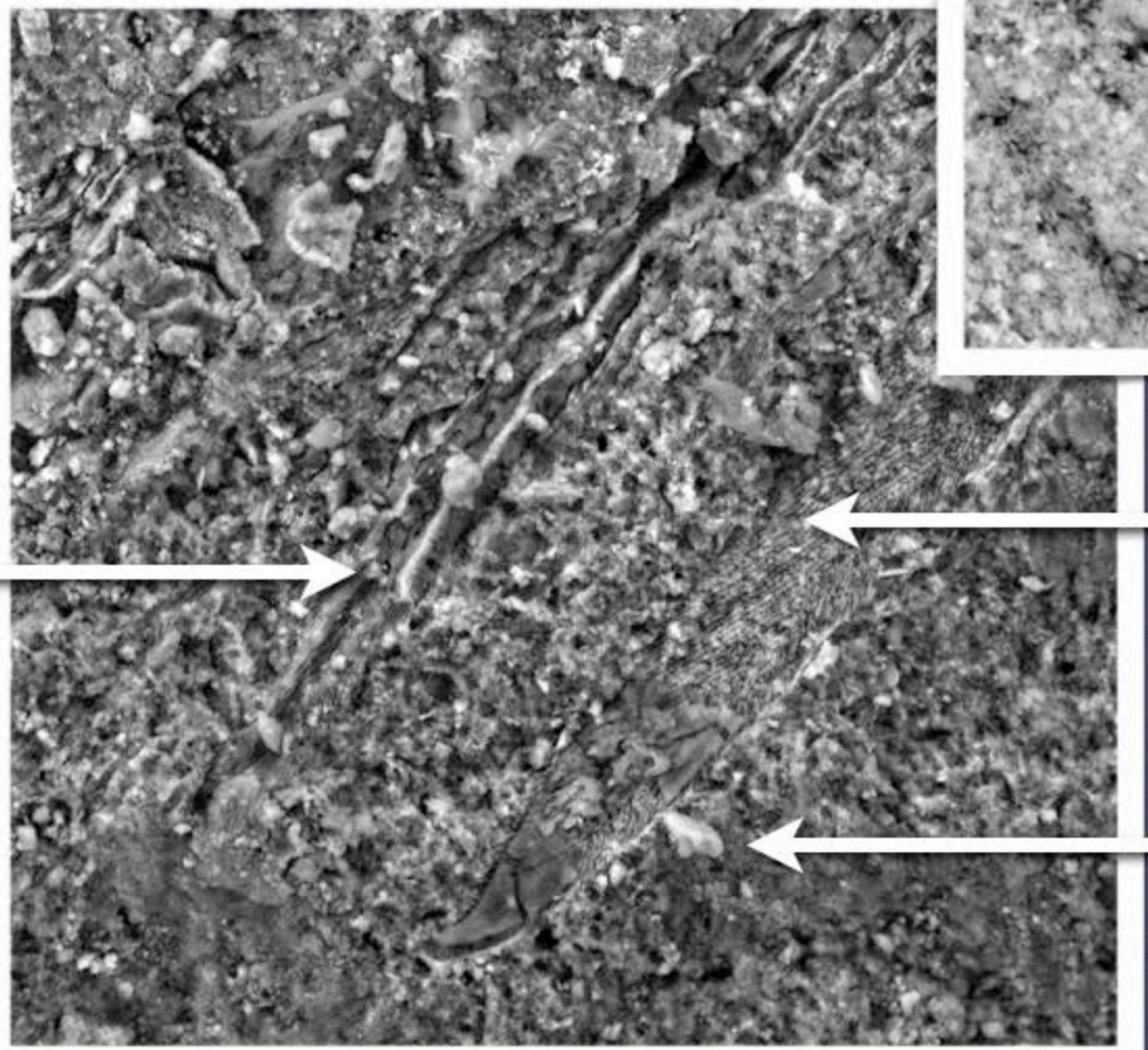


SEM

- Setal ultrastructure

♀

♂



regular setae show outer layer of reticulate microspines (plumose)

plumose structure of macroseta

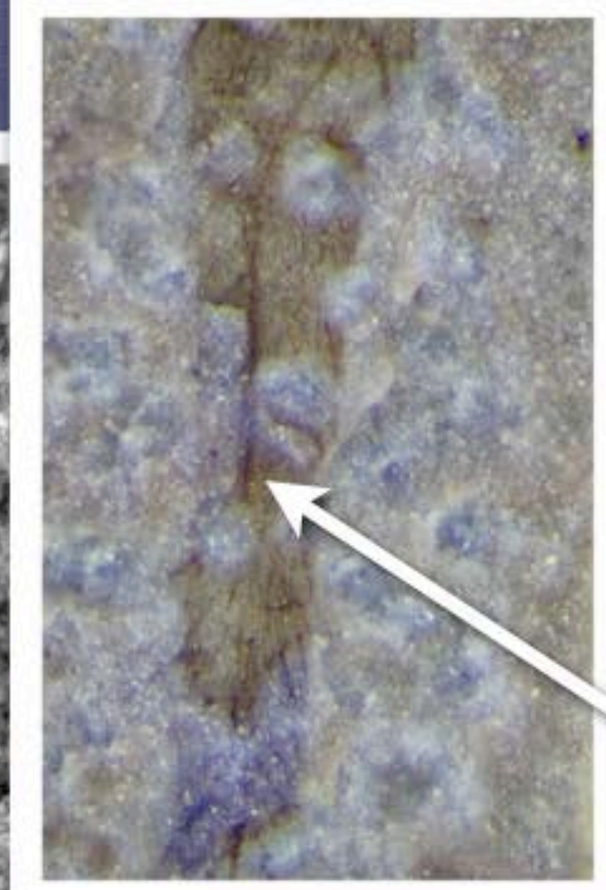
macroseta with curved tip

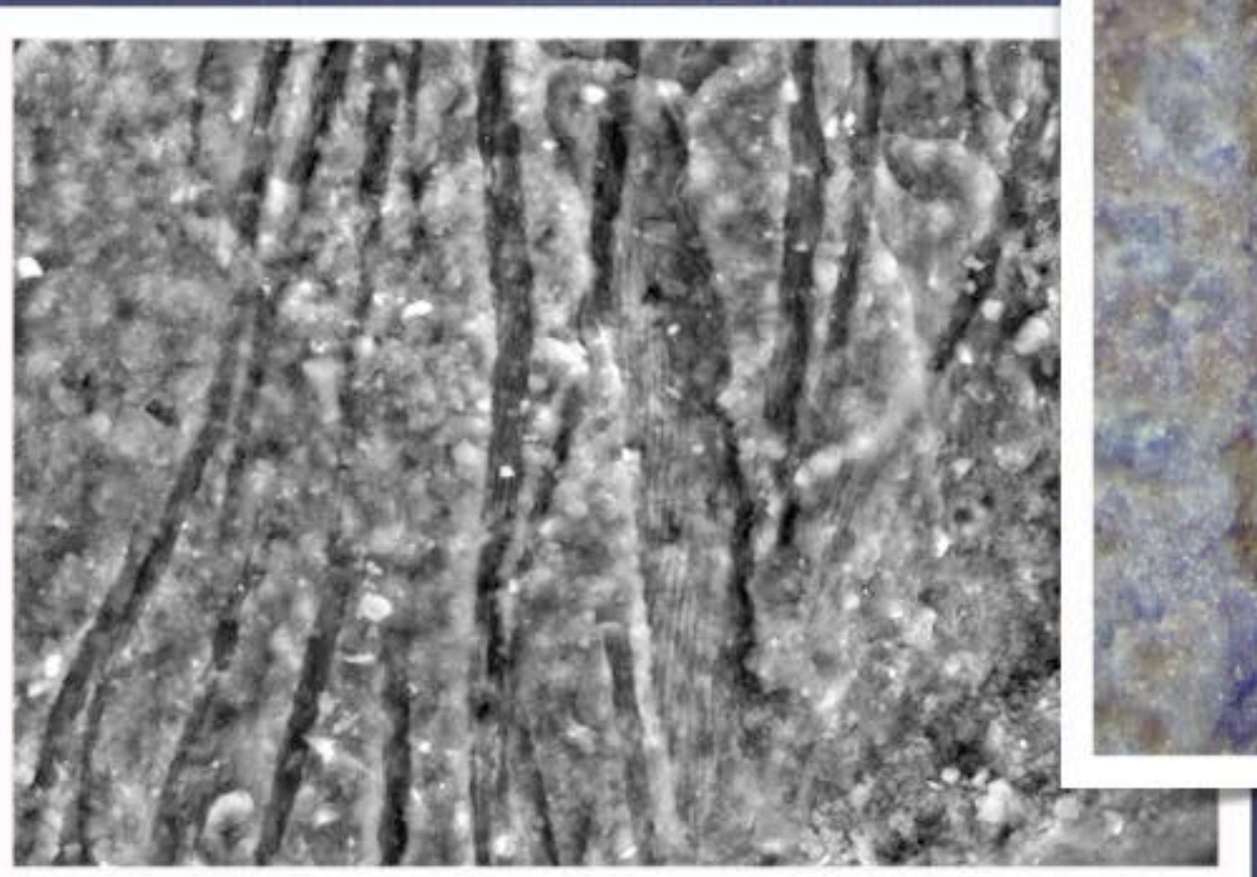
Juraraneus

- Eskov (1984) described *Juraraneus rasnitsyni*, from the Middle Jurassic of Transbaikalia
- First Jurassic spider described

Juraraneus

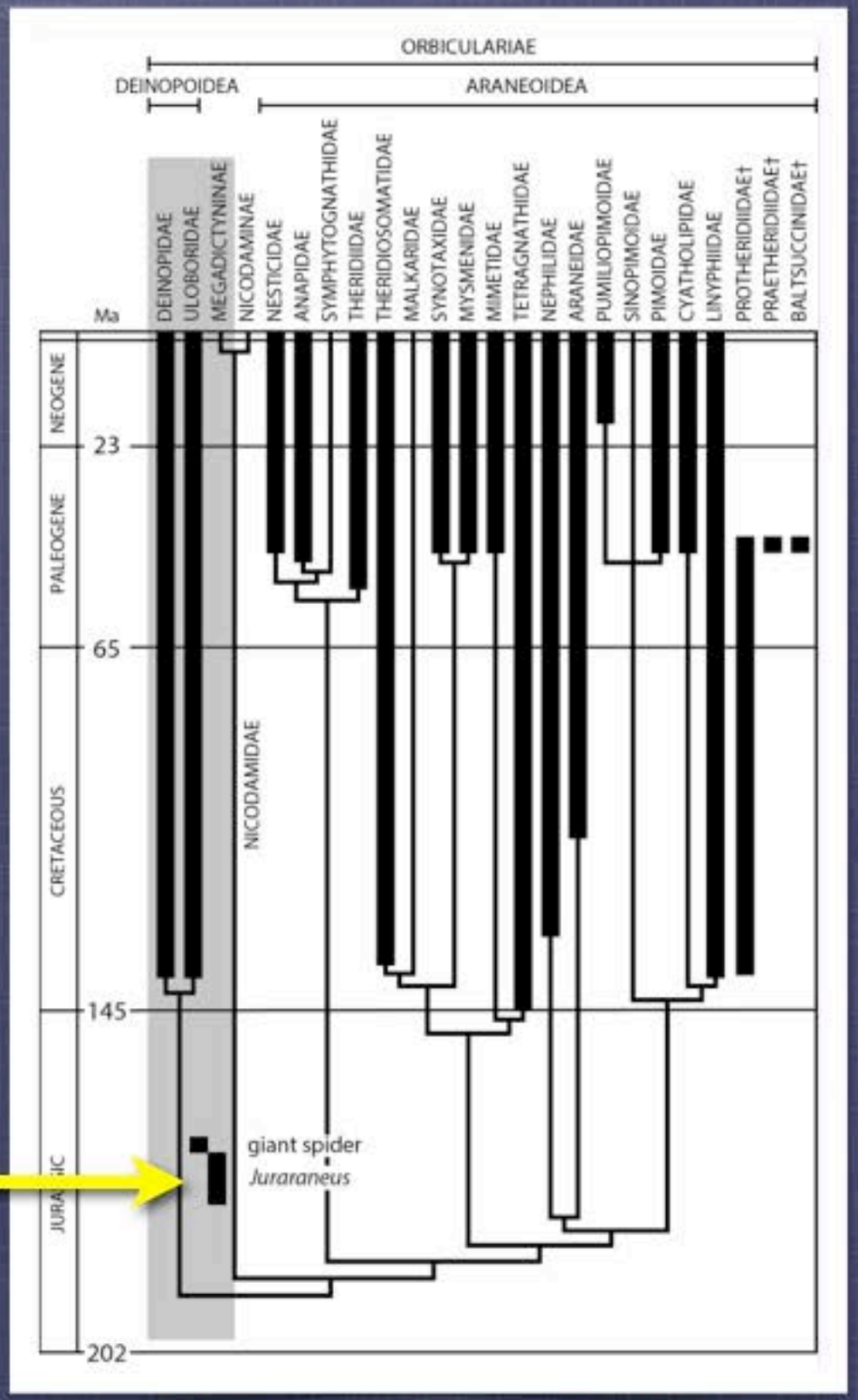
- Restudy of the only specimen showed it to be cribellate
- New SEM work shows plumose setae





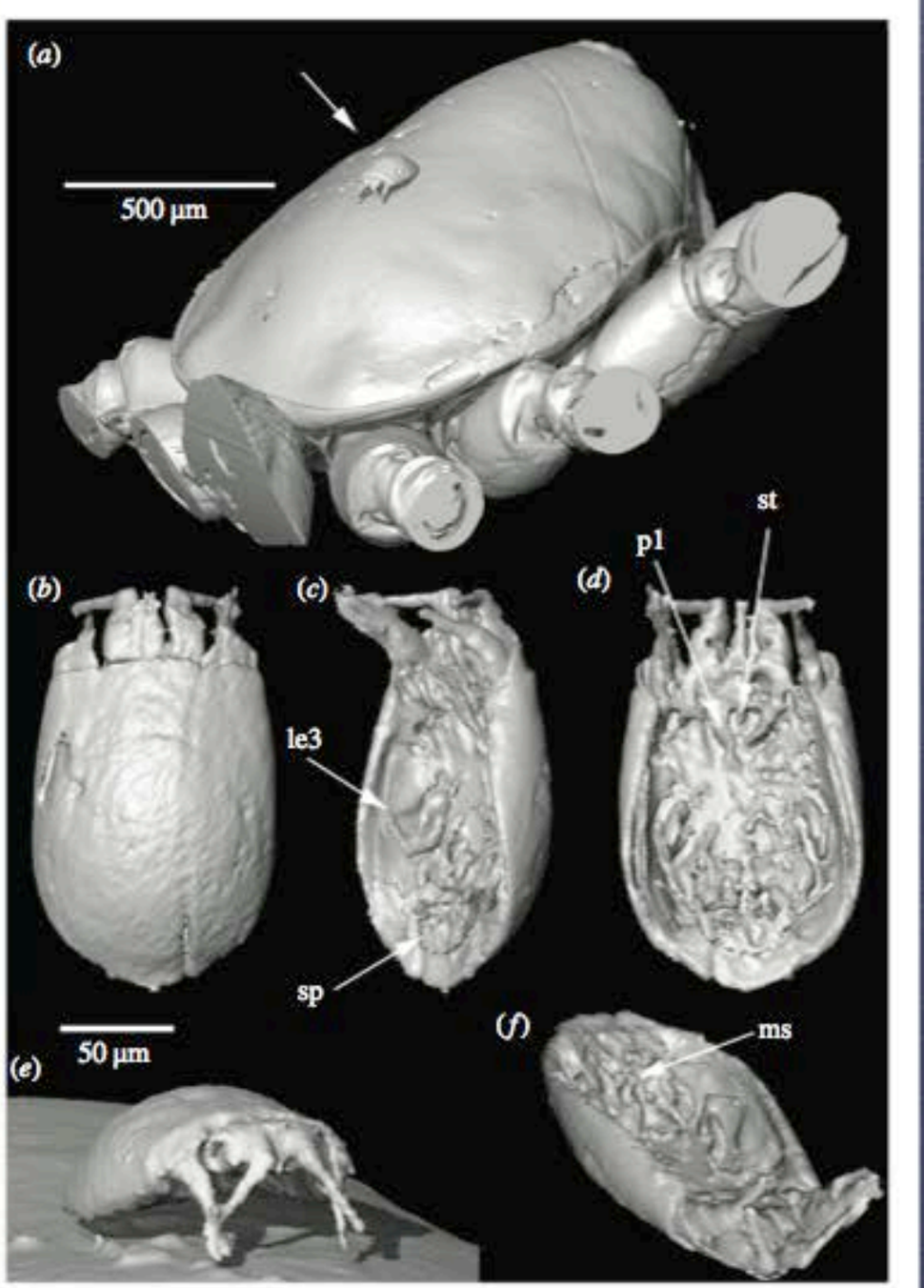
Orbicularian Phylogeny

- SEM had never before been used in the study of fossil spiders
- It has been shown to be very useful in revealing setal ultrastructure, and hence aid phylogenetic studies



These Jurassic spiders lie near the base of the orbweaver clade, among the cribellate orbicularians

The End



THANK YOU!

Paul Selden

www.paulselden.net

phoretic deutonymph of astigmatid mite on spider carapace, Baltic amber