

# BIG4: Biosystematics, informatics and genomics of the big 4 insect groups- training tomorrow's researchers and entrepreneurs

Kick-Off Meeting  
14-18 September 2015  
Copenhagen, Denmark



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 642241

# Morphology is dead – long live morphology!

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*BIG 4 Kick-off meeting*  
*Copenhagen, 14th - 18th September 2015*



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# Morphology is dead – long live morphology! Integrating MorphoEvoDevo into molecular EvoDevo and phylogenomics

Andreas Wanninger\*

Department

Zoologischer Anzeiger 256 (2015) 96–103



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Zoologischer Anzeiger

journal homepage: [www.elsevier.com/locate/jcz](http://www.elsevier.com/locate/jcz)

## Zoologischer Anzeiger

Review

### Morphology should not be forgotten in the era of genomics—a phylogenetic perspective

Gonzalo Giribet\*

Museum of Comparative Zoology, Department of Organismic



**Entomological Science**

Entomological Science (2014) 17, 1–24

doi:10.1111/ens.12053

REVIEW ARTICLE

### Insect morphology in the age of phylogenomics: innovative techniques and its future role in systematics

Frank FRIEDRICH<sup>1</sup>, Yoko MATSUMURA<sup>2</sup>, Hans POHL<sup>2</sup>, Ming BAI<sup>2,3</sup>, Thomas HÖRNSCHEMEYER<sup>4</sup> and Rolf G. BEUTEL<sup>2</sup>

The word "morphology" is from the ancient Greek *μορφή*, *morphé*, meaning "form", and *λόγος*, *lógos*, meaning "word, study, research".



Aristotle (384–322 BCE).

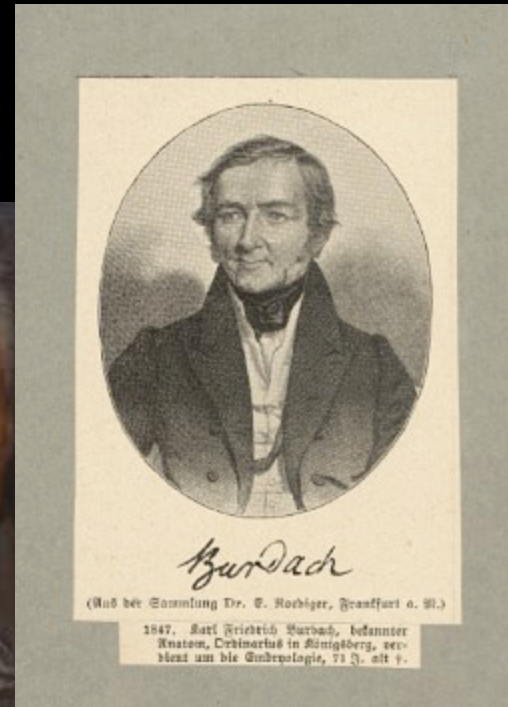
*De Partibus Animalicum.*

The earliest scientific  
entomological information

“Morphologie“

Johann Wolfgang von Goethe in 1779

Karl Friedrich Burdach in 1800





**17<sup>th</sup>  
century**

- *Historia Insectorum Generalis* by Jan Swammerdam

**18<sup>th</sup>  
century**

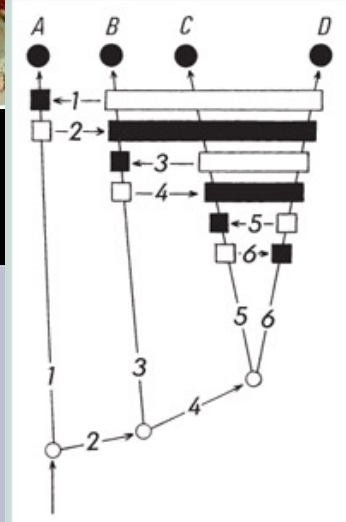
- August Johann Rösel von Rosenhof
- Johann Christian Fabricius
- Pierre Latreille

**19<sup>th</sup>  
century**

- Carl Hermann Conrad Burmeister
- Charles Janet

**20<sup>th</sup>  
century**

- Louis Félix Henneguy
- Berlese
- Augustus Daniel Imms
- Herrmann Weber
- Jean Chaudonneret
- Niels Peder Kristensen
- Willy Hennig



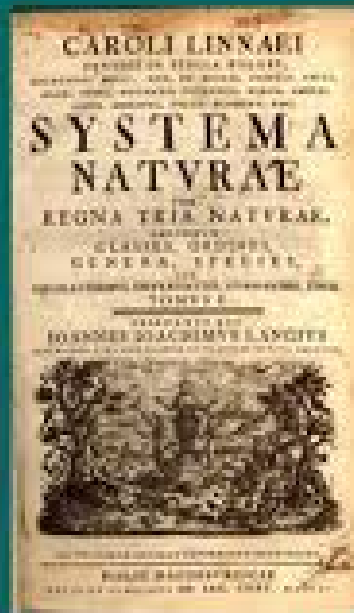
Willi Hennig's 1966 "scheme of argumentation of phylogenetic systematics," which helped set the stage for the development of modern methods of phylogenetic inference. Black rectangles on the branches represent evolutionarily derived character states that provide evidence of shared ancestry.

University of Illinois Press





Linnaeus  
borussicus



General

Classes  
Orders  
Genera  
Species

Particular

*Systema Naturae*, 1735

The Linnaean system has progressed to a system of modern biological classification based on the evolutionary relationships between organisms, both living and extinct.



# Turbo-taxonomy

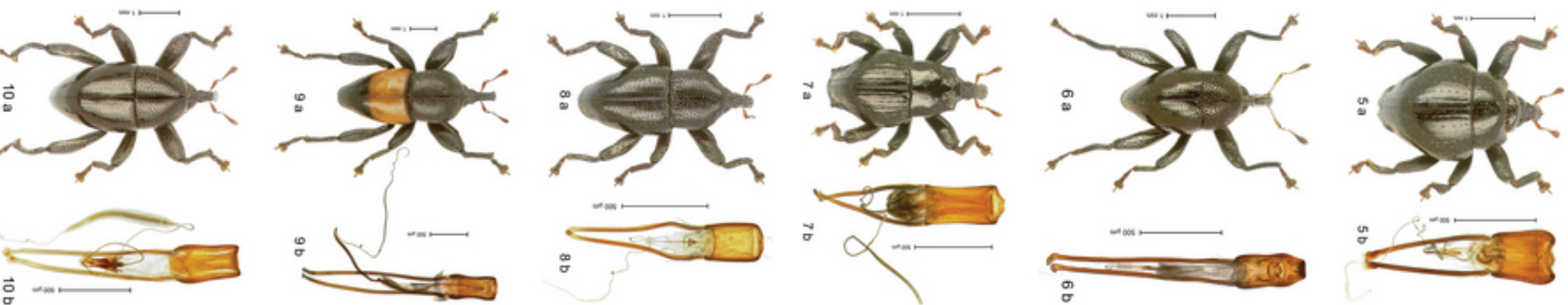


## TAXONOMY ON THE FAST TRACK!

Holotype: diagnosis+ high resolution digital images+ DNA barcode

e.g. Reidel et al. 2013

One hundred and one new species of *Trigonopterus* weevils from New Guinea





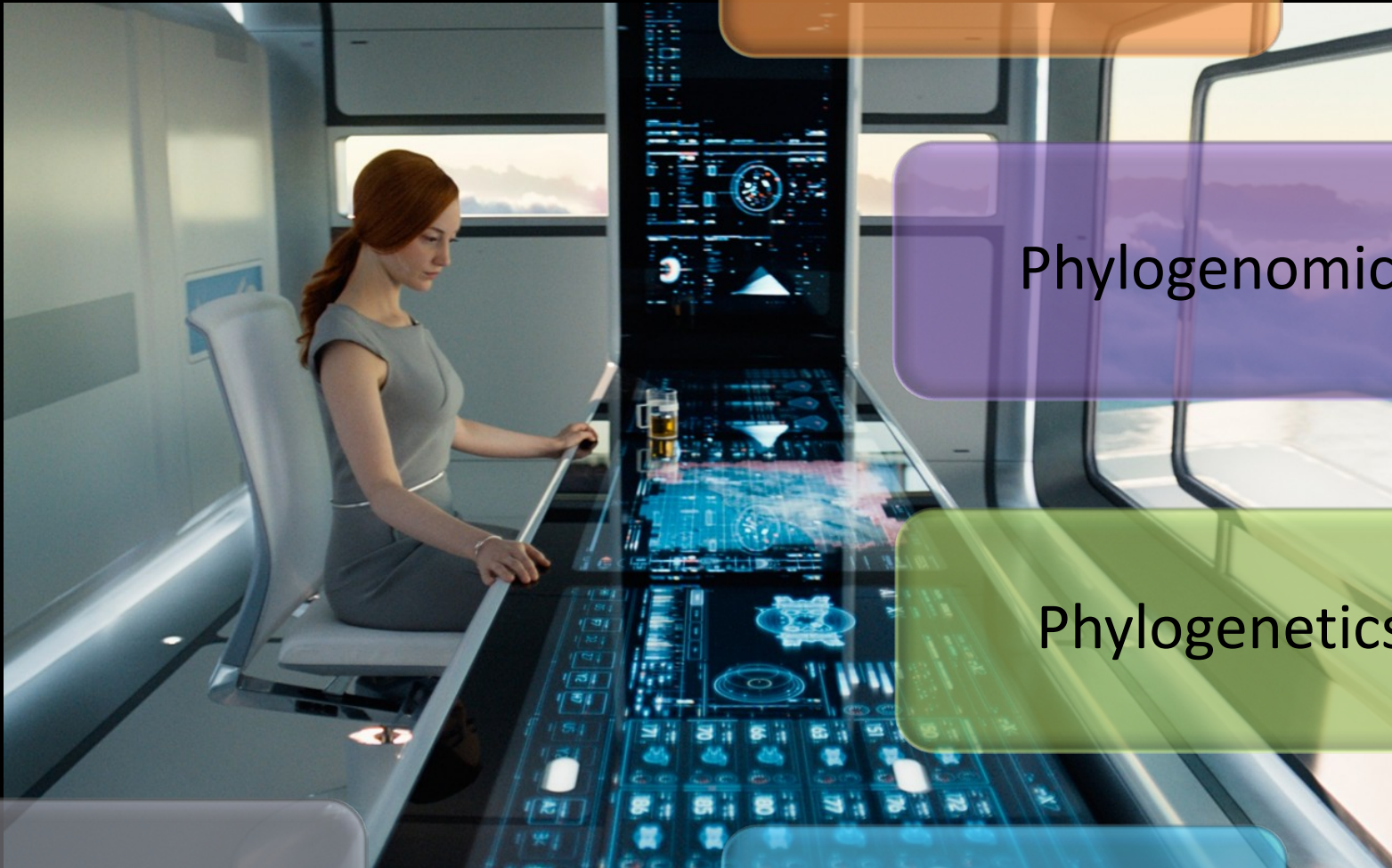
Cyber taxonomy

Phylogenomics

Phylogenetics

Palaeontology

Morphological  
information



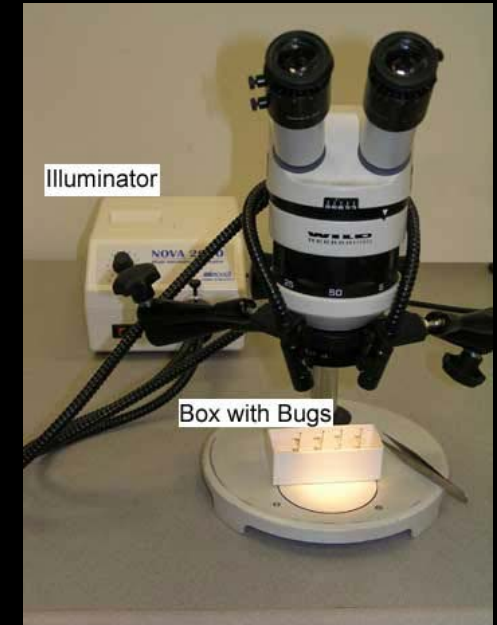
# Techniques in insect morphology



Fixation by pinning and drying



Fixation in ethanol



Illuminator

Box with Bugs



Insect seen through the microscope

dissection



# Digital photography

Visionary Digital's BK Plus Lab with  
a Canon EOS 7D

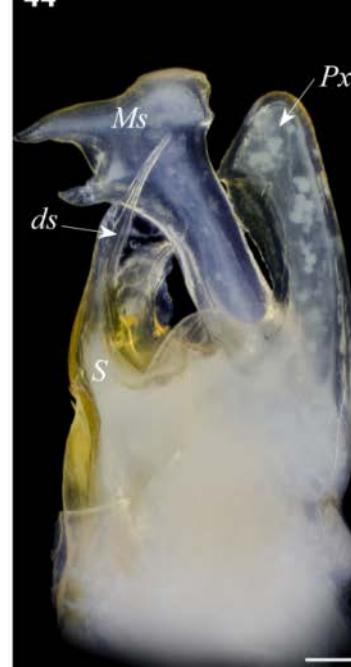


*Ommatoiulus chambiensis* Akkari & Enghoff 2013

43



44



45



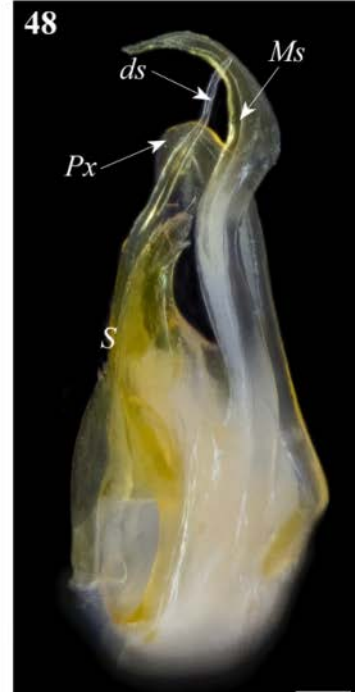
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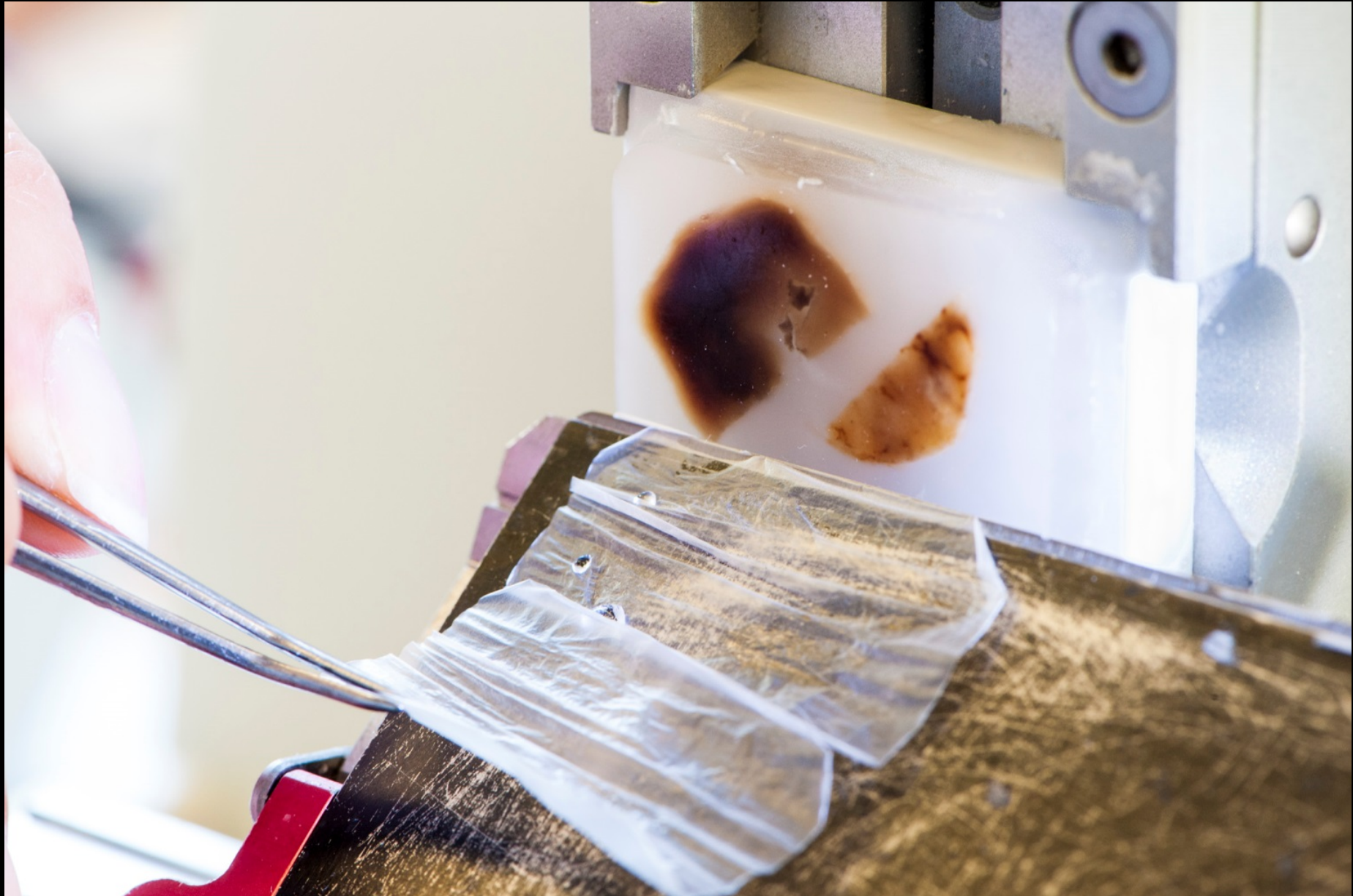
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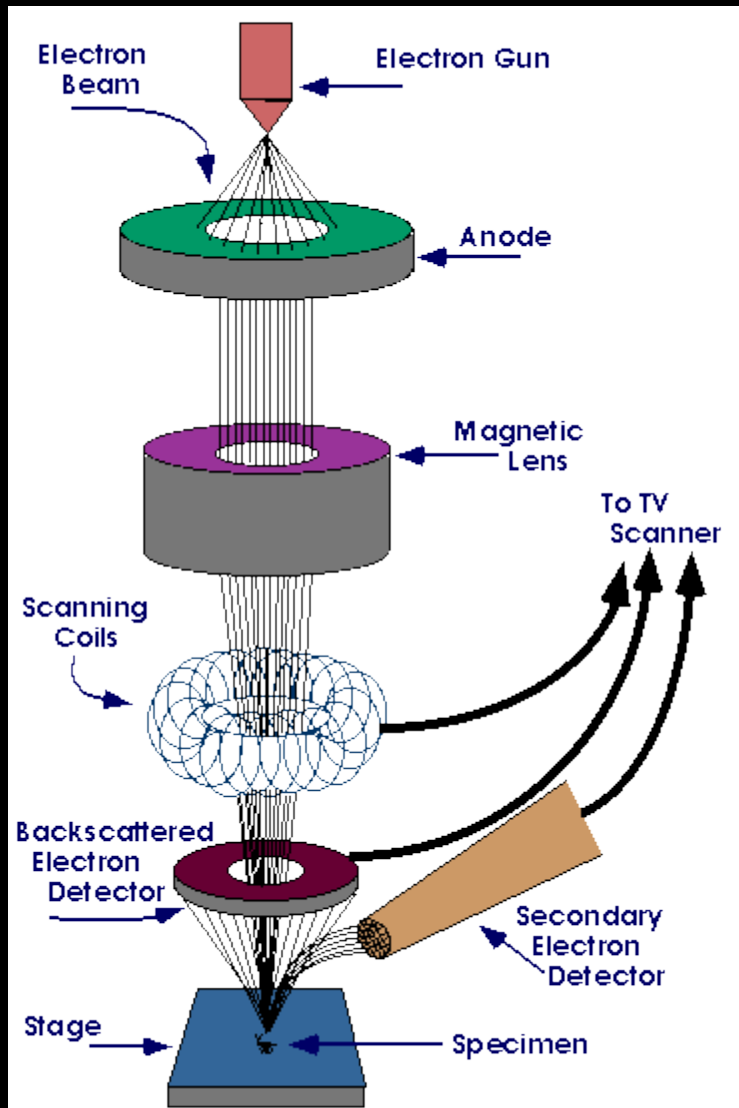


# Histology and TEM





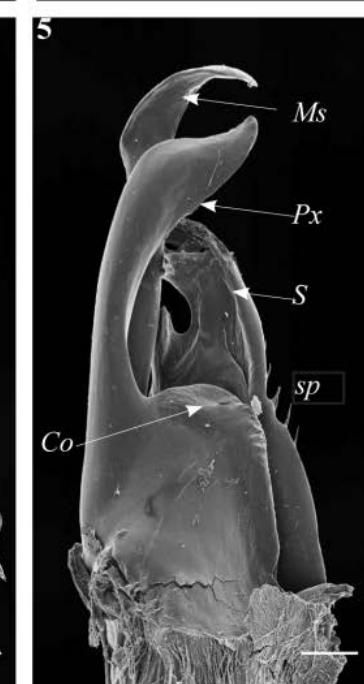
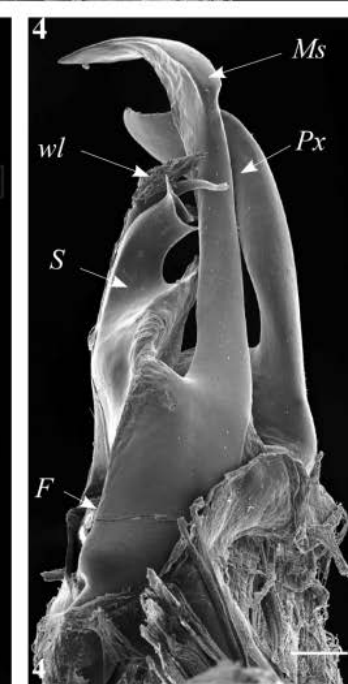
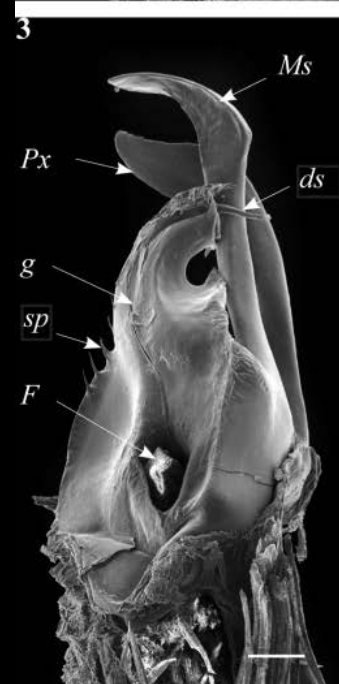
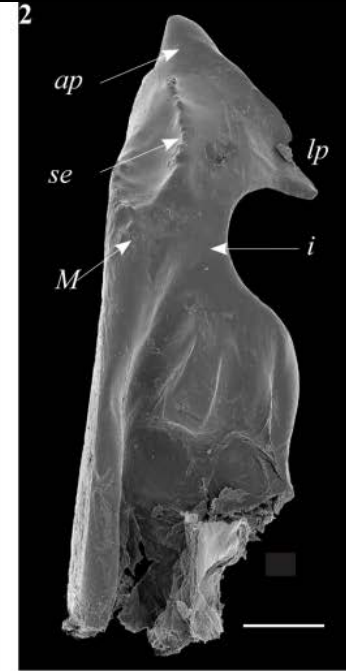
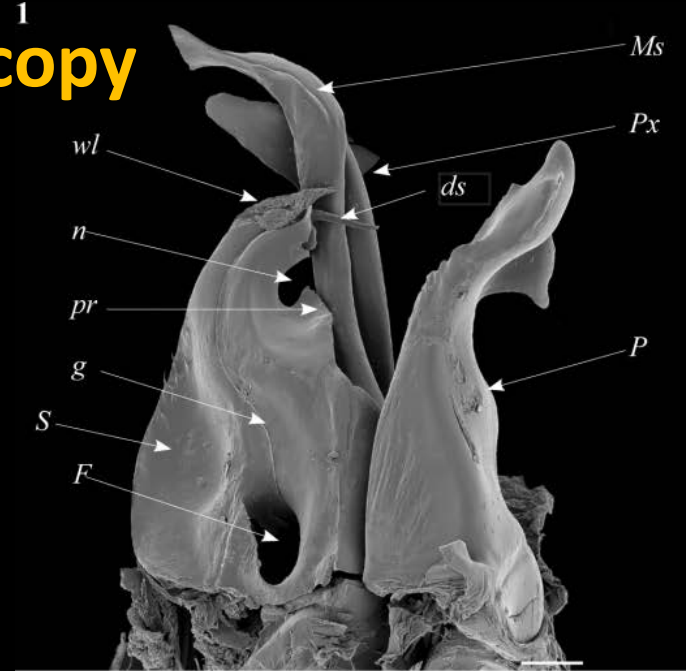
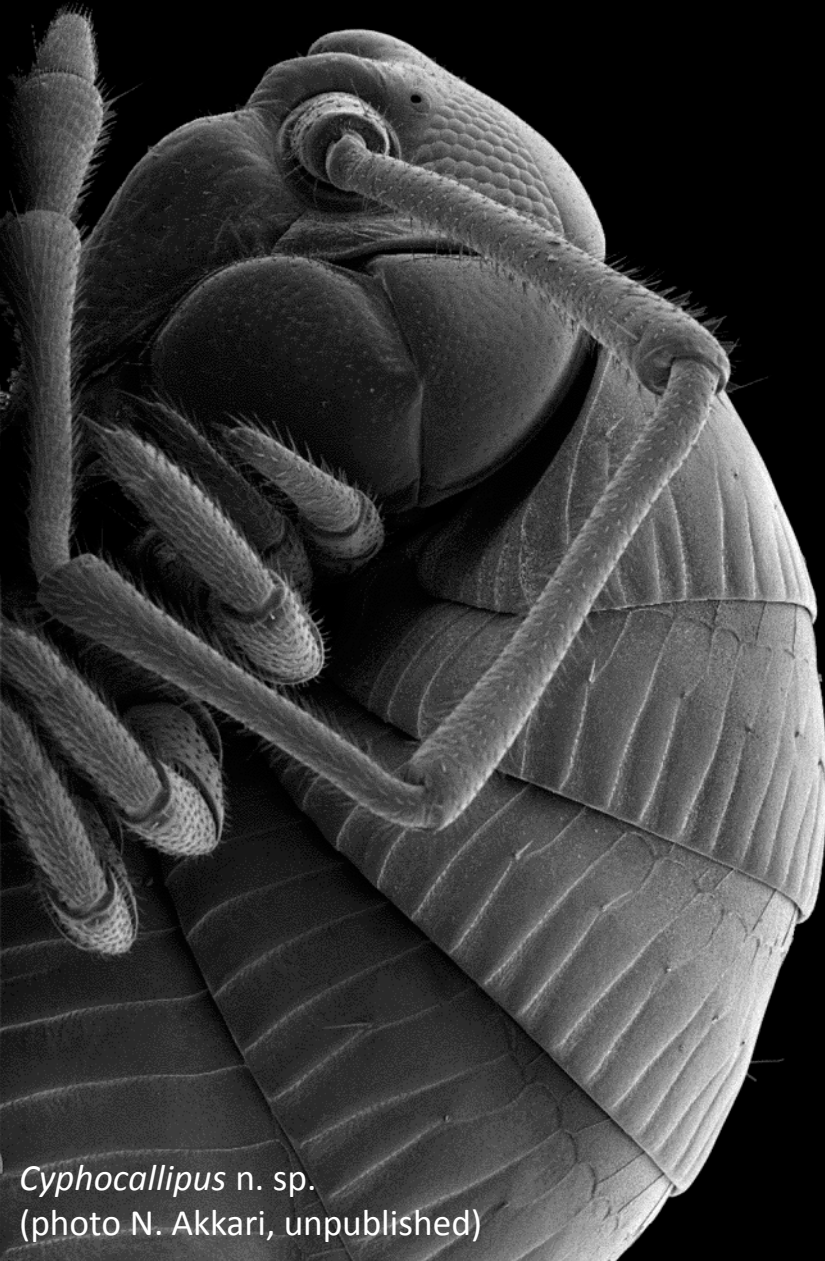
# Scanning electron microscopy



The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron-sample reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample

# Scanning electron microscopy

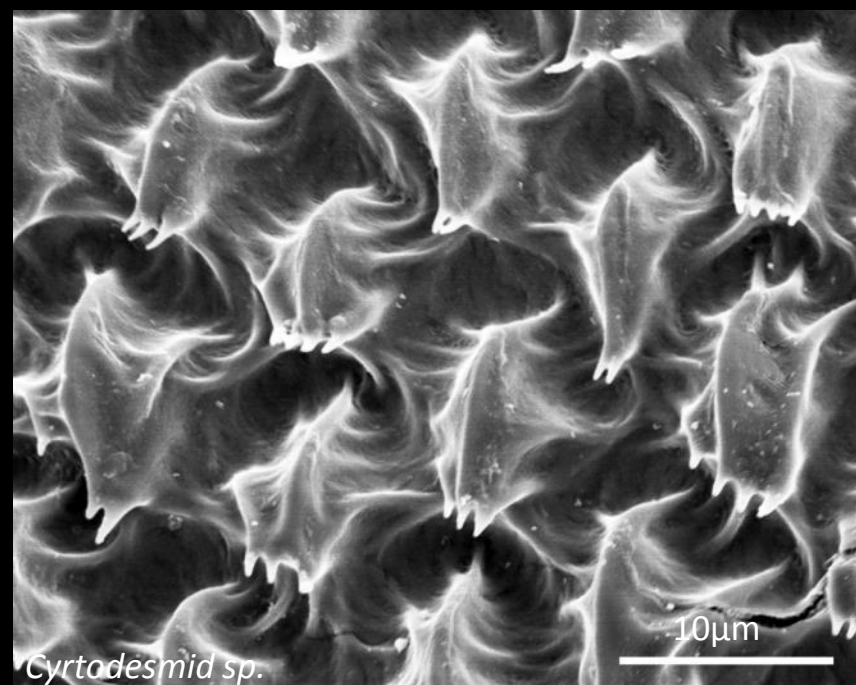
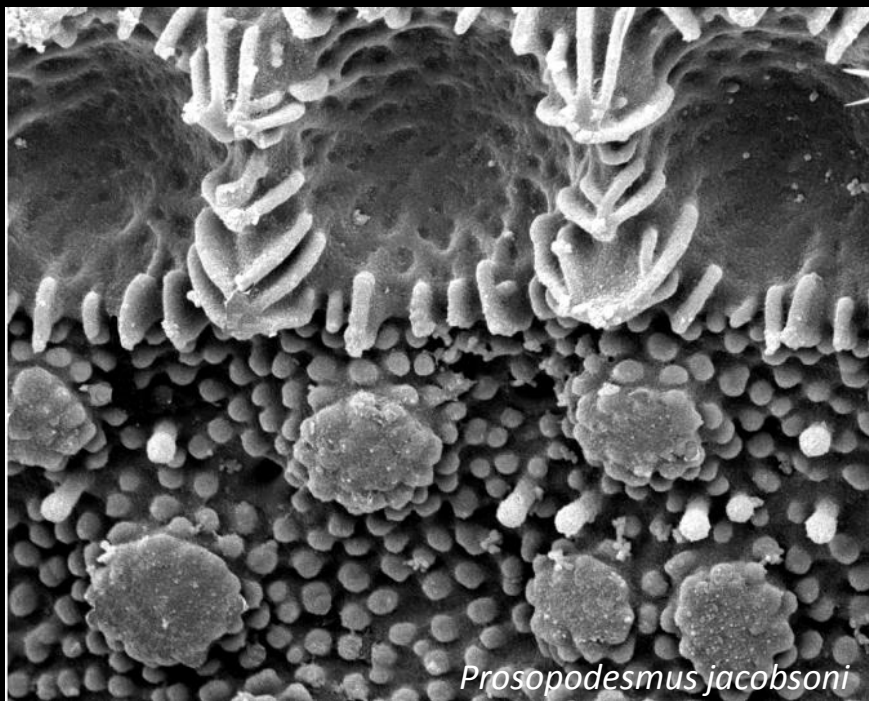
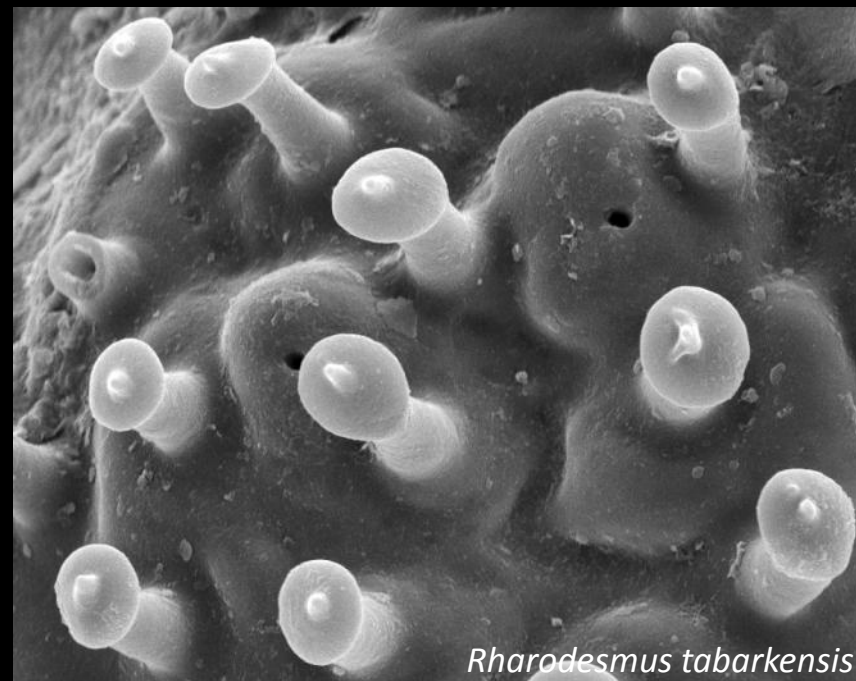
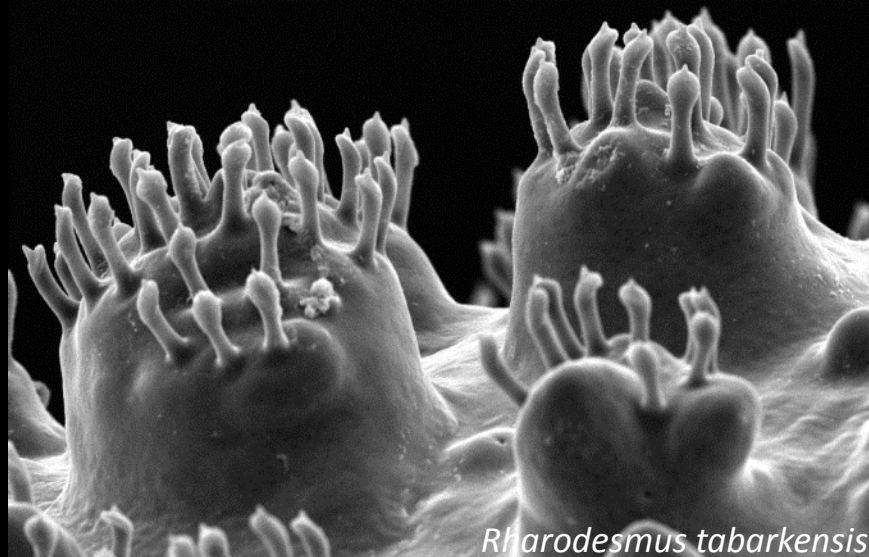
JEOL JSM-6335F



*Cyphocallipus n. sp.*  
(photo N. Akkari, unpublished)

*Ommatoiulus chambiensis* Akkari & Enghoff 2013  
Akkari et al. 2013. ZooKeys 328: 5–45.





## STATIC VIEWS

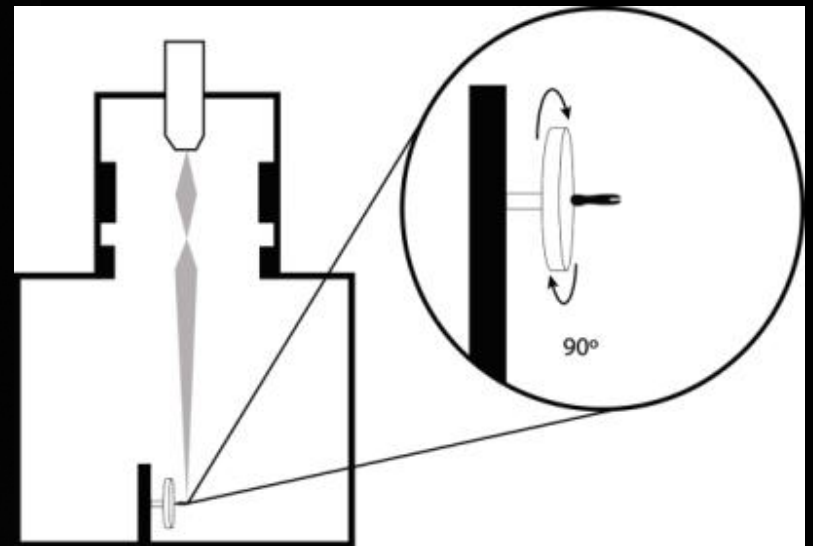
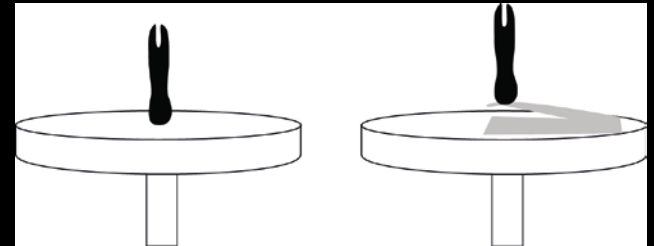
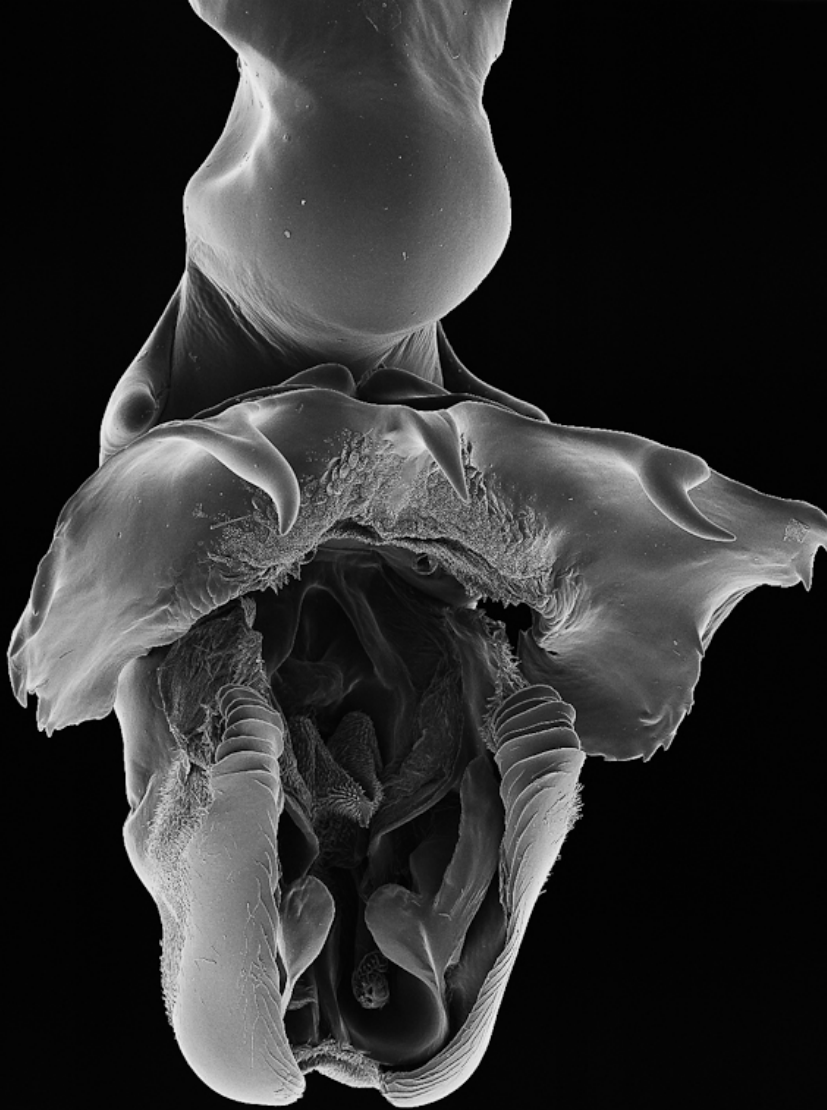


## INTERACTIVE

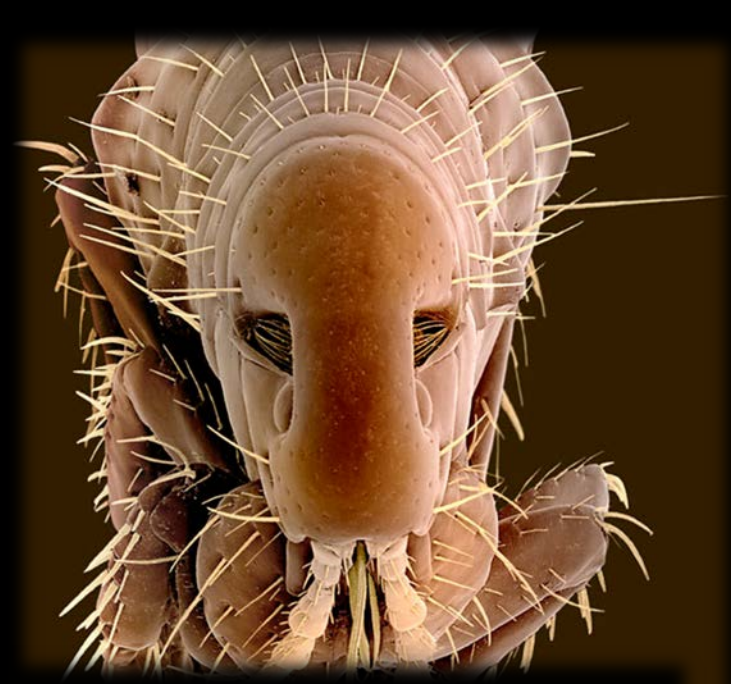


**Akkari N**, Cheung DK-B, Enghoff H, Stoev P.  
**2013. ZooKeys 328: 5–45.**

Cheung DK-B, Brunke AJ, **Akkari N**, Souza  
CM, Pape T. **2013. ZooKeys 328: 47–57.**

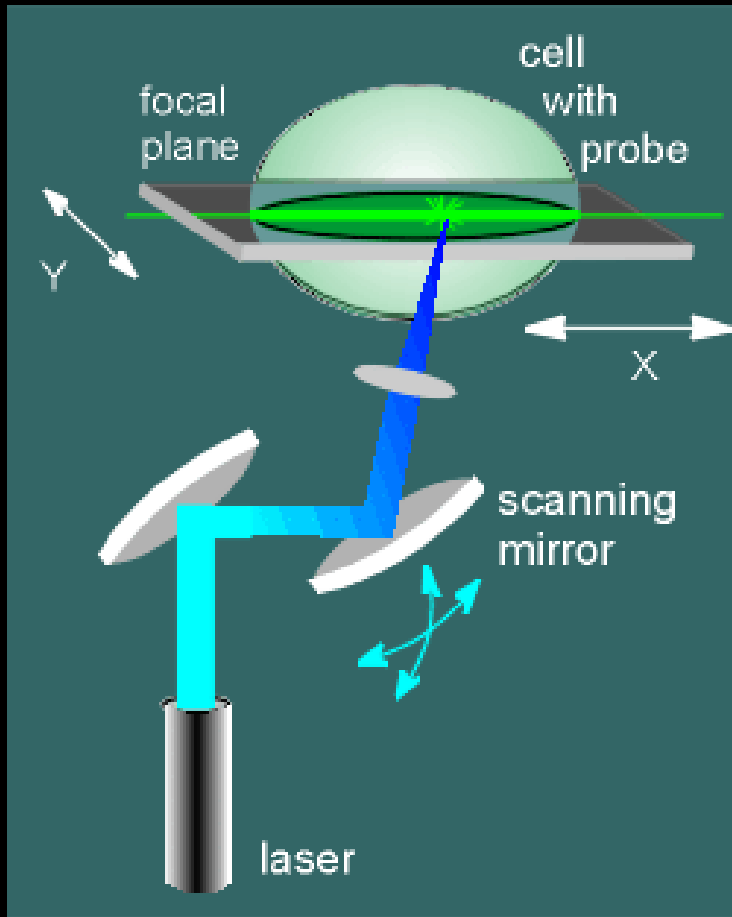






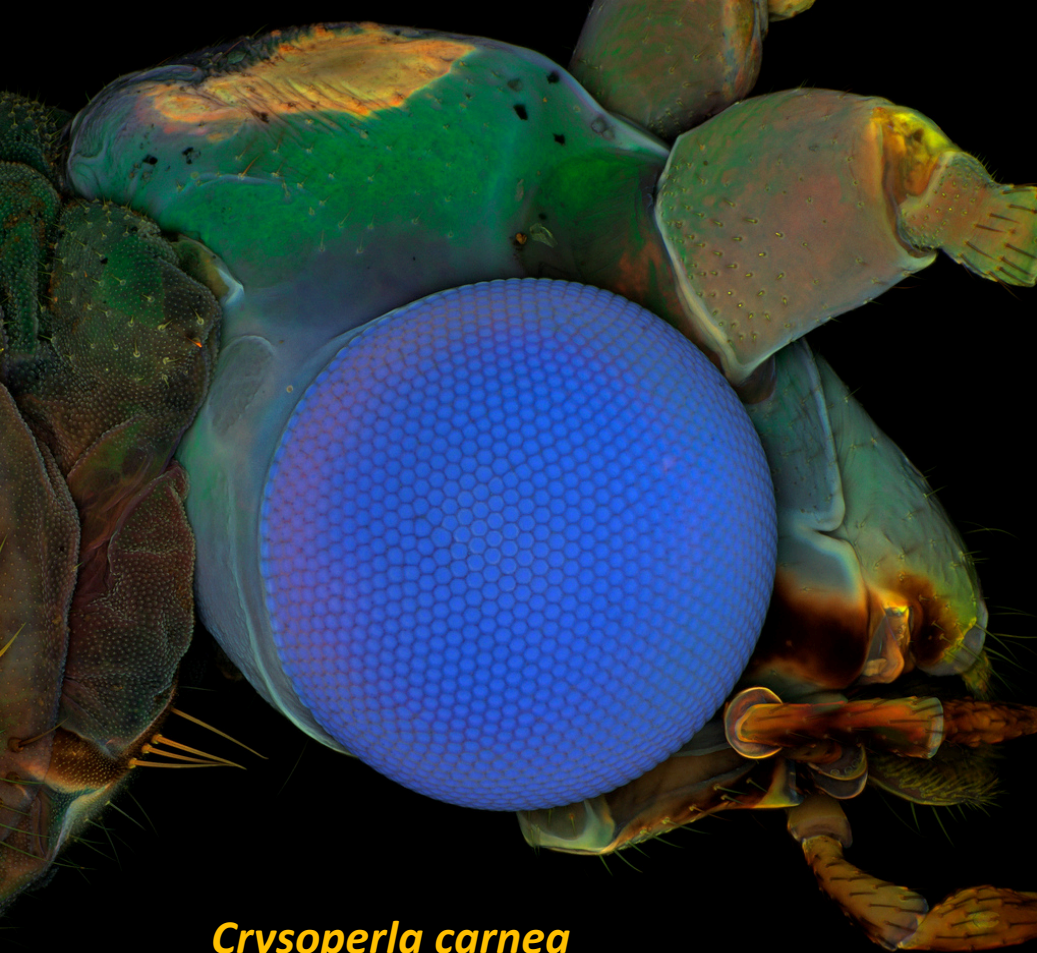
by Steve Gschmeissner

# Confocal laser scanning microscopy



Confocal laser scanning microscopy (CLSM or LSCM) is a technique for **obtaining high-resolution optical images with depth selectivity**. The key feature of is its ability to acquire in-focus images from **selected depths**, a process known as optical sectioning.





***Crysoperla carnea***

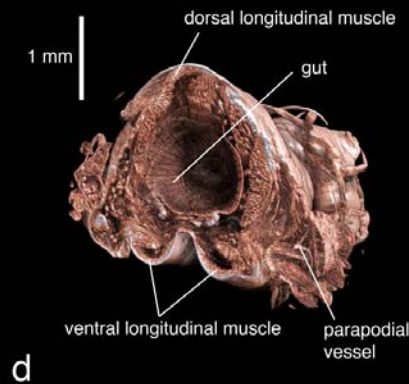
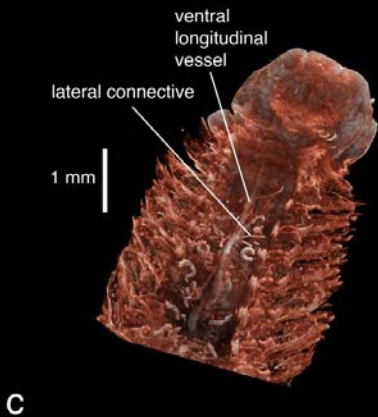
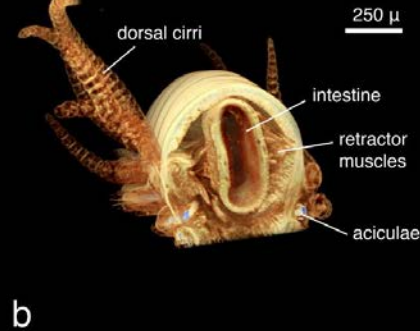
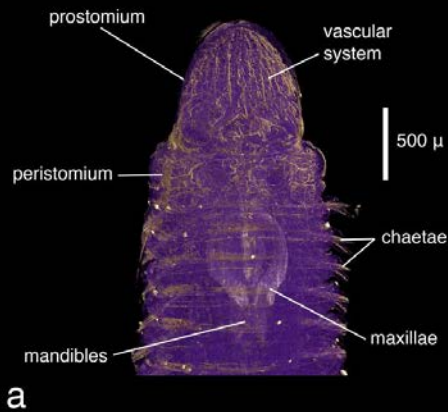
<http://flickrhivemind.net/Tags/microscopy,zeiss/Interesting>



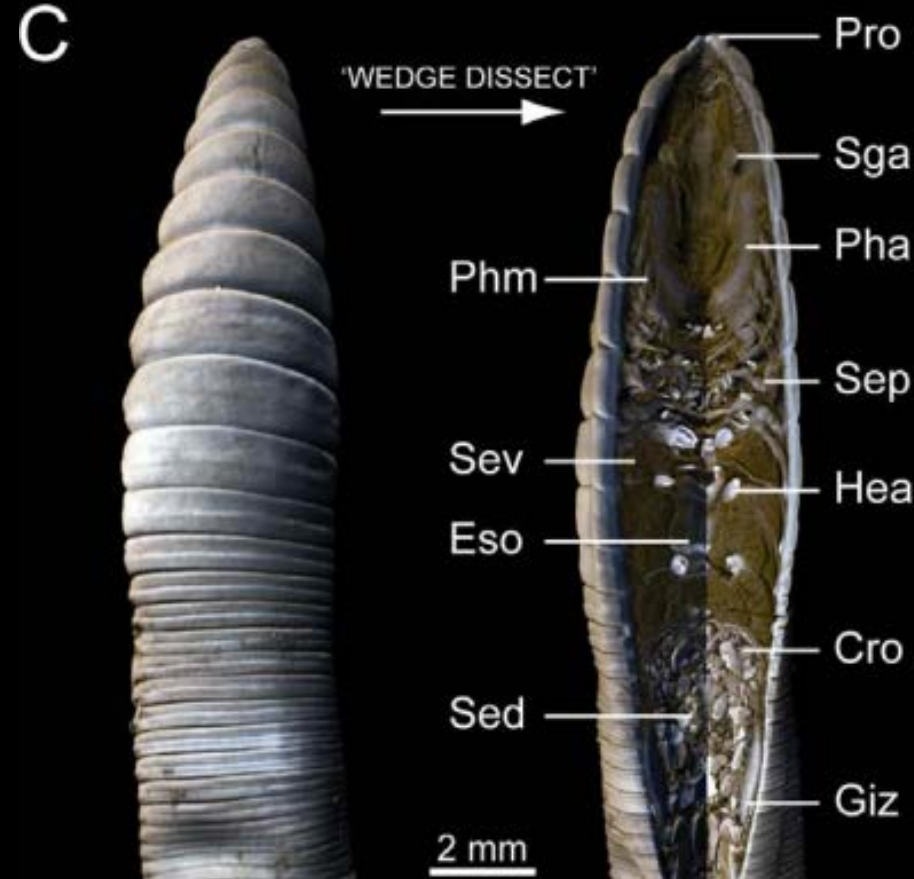
**Oak lace**

Images are acquired point-by-point and reconstructed with a computer, allowing three-dimensional reconstructions of topologically complex objects.

# Can micro-CT become an essential tool for the 21<sup>st</sup> century taxonomist? (Faulwetter et al. 2014)

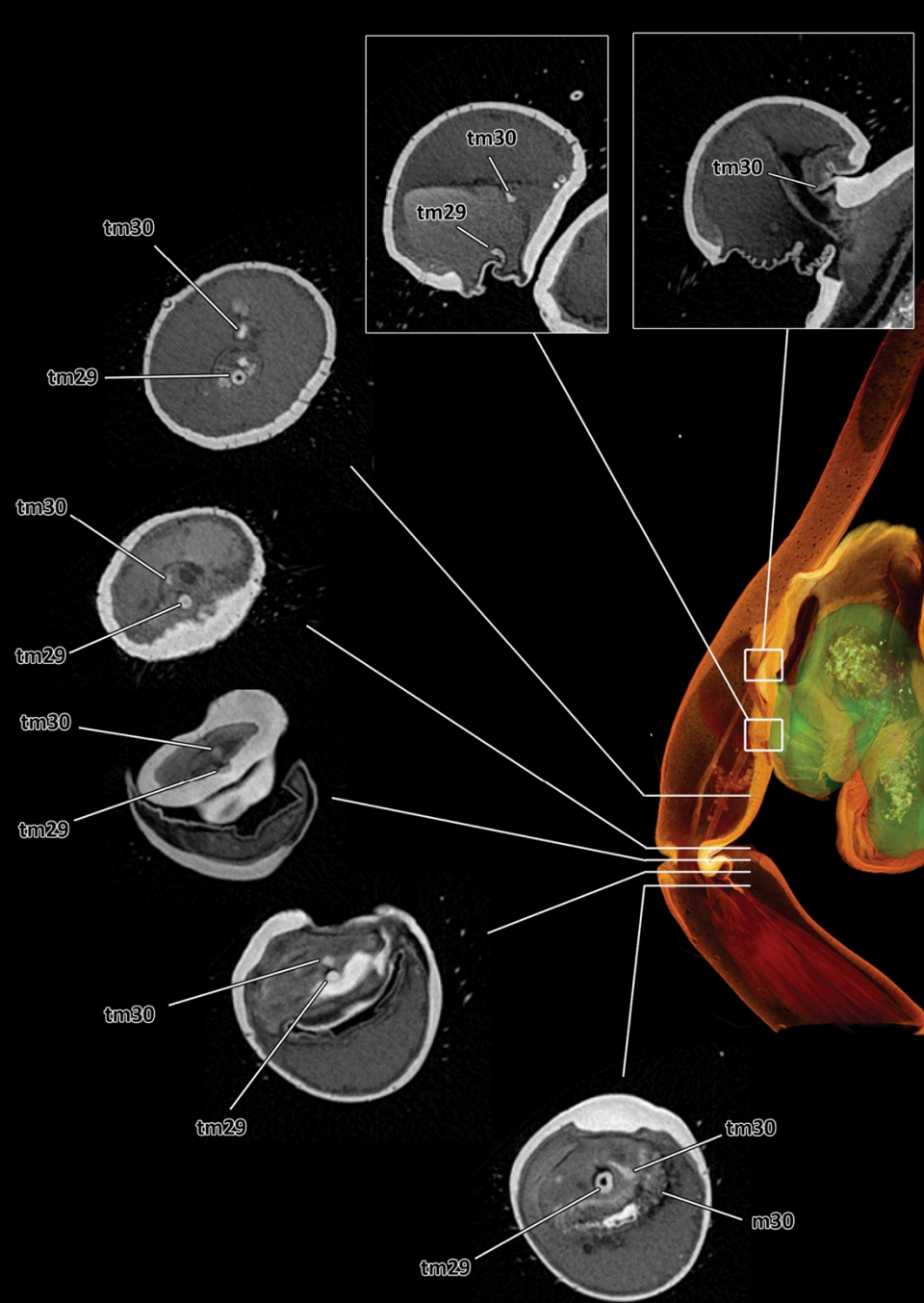
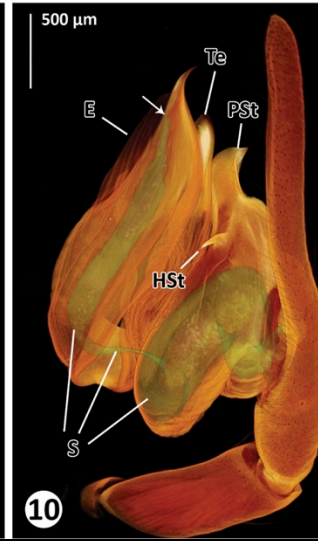
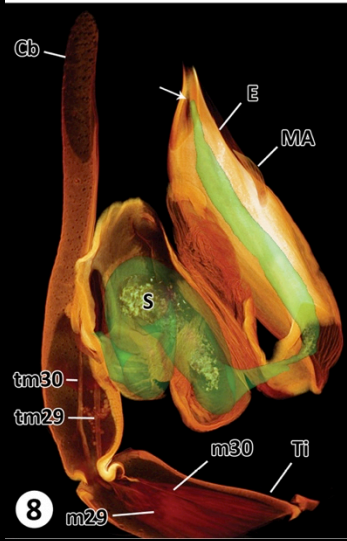
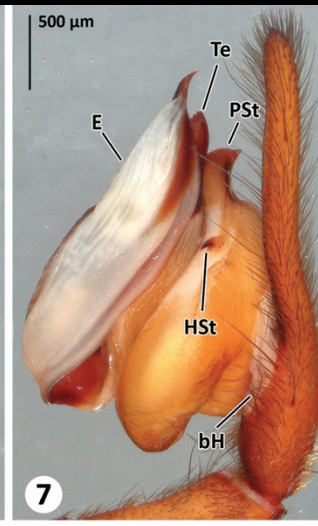
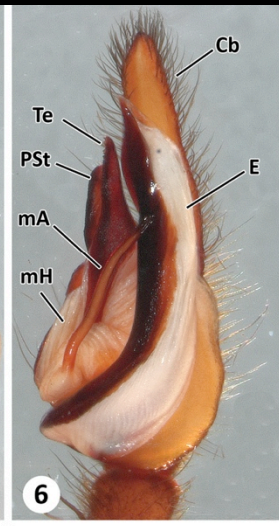
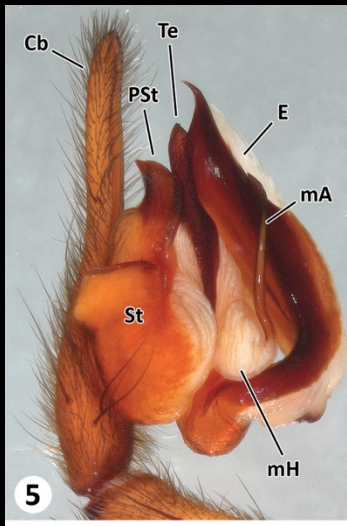


Polychaeta  
(Faulwetter et al. 2014)



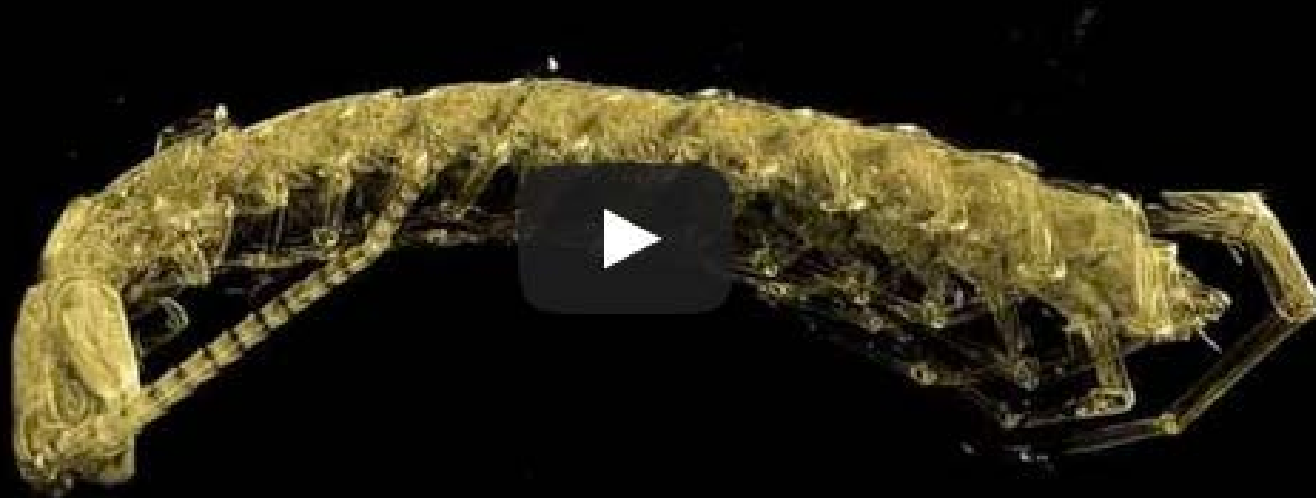
Oligochaeta  
(Fernández et al. 2014)





Araneae  
(Michalik & Ramír. 2013)

3D model of *Eupolybothrus cavernicolus* Komeričk...



0:00 / 1:39



YouTube

CHILOPODA

Stoev et al. (2013)

3D model of  
*Eupolybothrus cavernicolus*



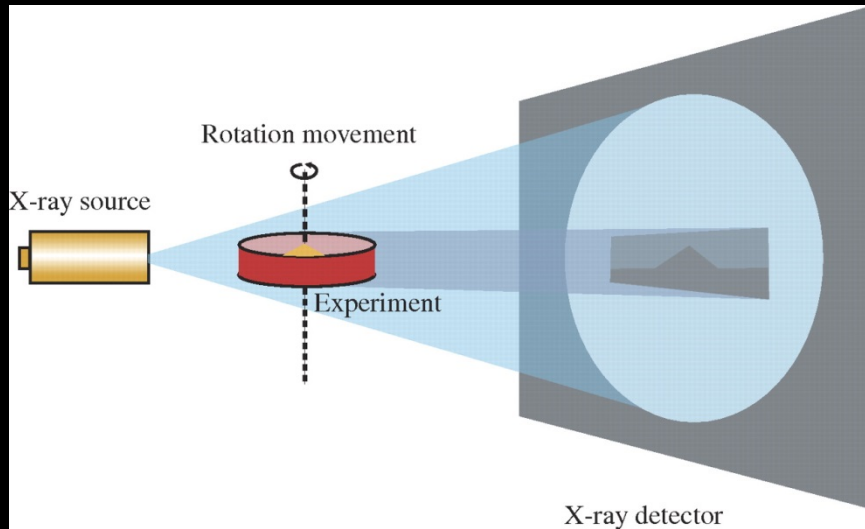
DIPLOPODA  
AKKARI et al. (2015)

*Ommatoiulus avatar* Akkari and Enghoff, 2015  
male holotype



*Ommatoiulus avatar* Akkari and Enghoff, 2015  
Female paratype

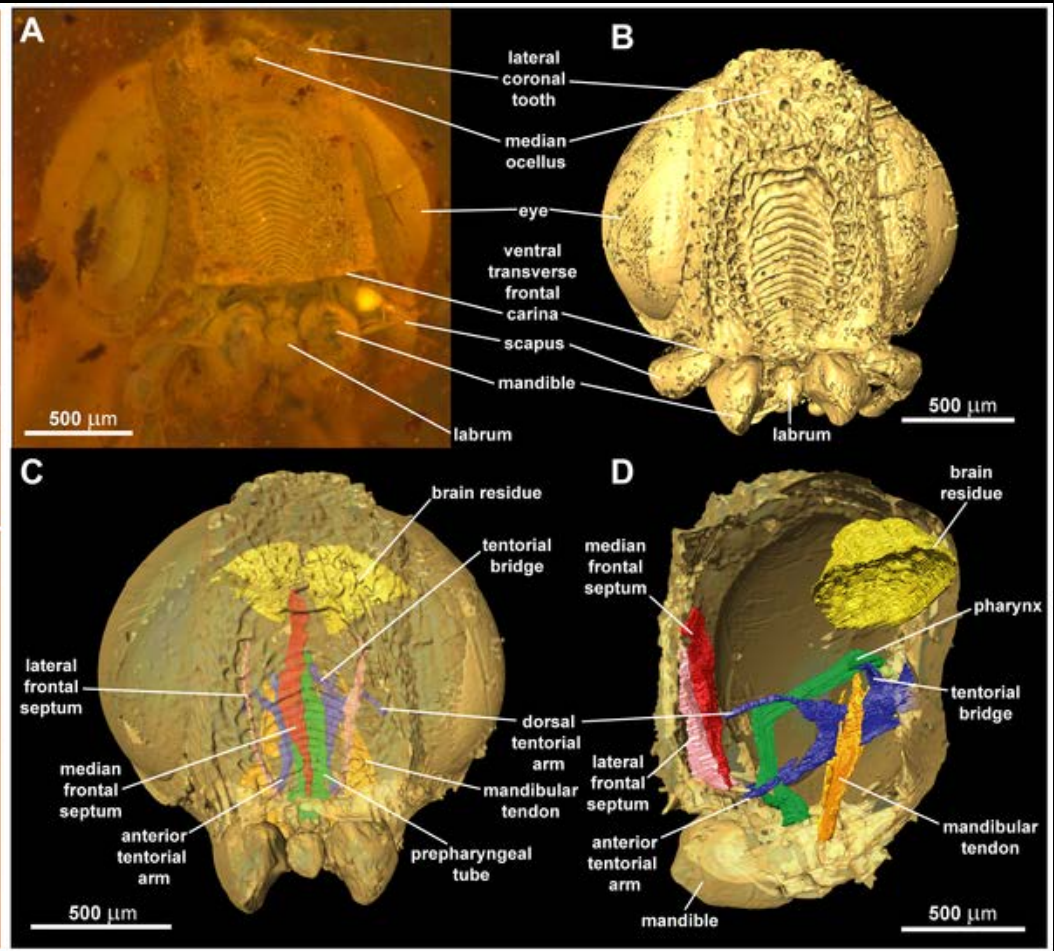
# X-ray microtomography



**X-ray microtomography** uses x-rays to create cross-sections of a physical object that can be used to recreate a virtual model (3D model) without destroying the original object.

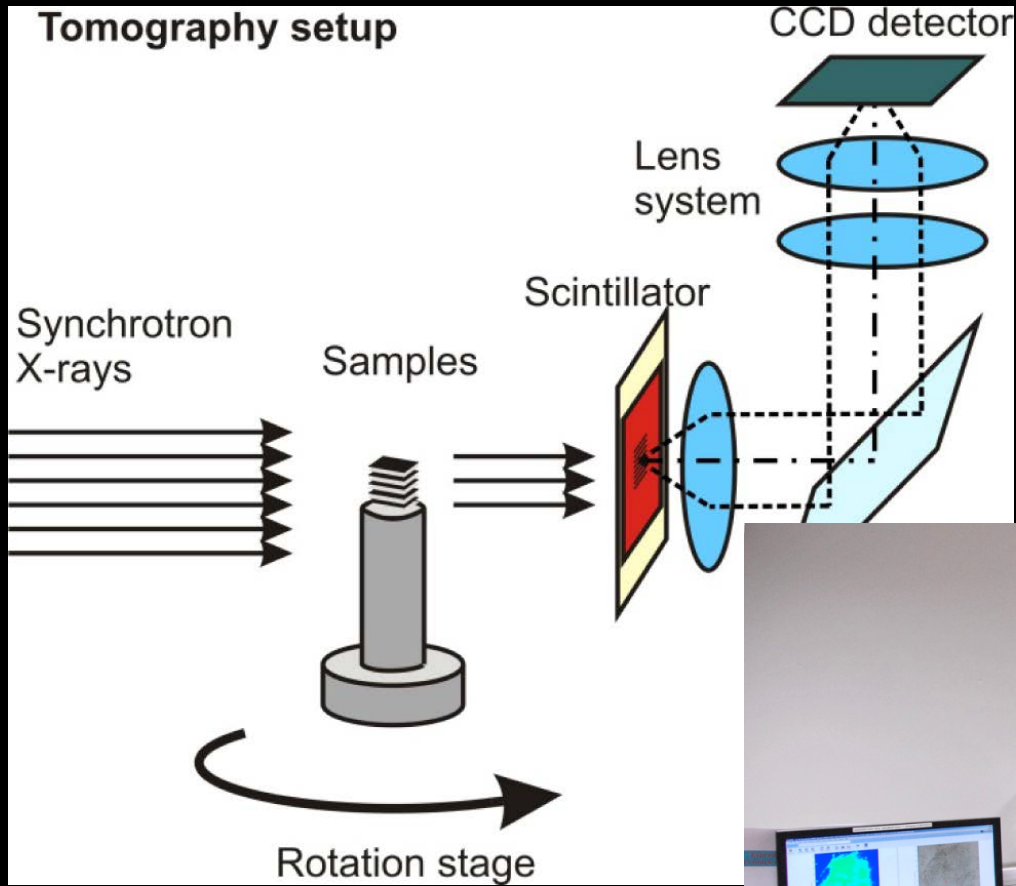






*Baltorussus* Total Makeover: Rejuvenation and Sex Change in an Ancient Parasitoid Wasp Lineage. Lars Vilhelmsen, Dominique Zimmermann. Plos ONE e98412. doi:10.1371/journal.pone.0098412

# Synchrotron X-ray microtomography





# Reconstructing the anatomy of the 42-million-year-old fossil †*Mengea tertiaria* (Insecta, Strepsiptera)



Hans Pohl, Benjamin Wipfler, David Grimaldi, Felix Beckmann & Rolf G. Beutel *Naturwissenschaften* (2010) 97:855–859

# In Vivo Time-Resolved Microtomography

Reveals the Mechanics of the Blowfly Flight Motor

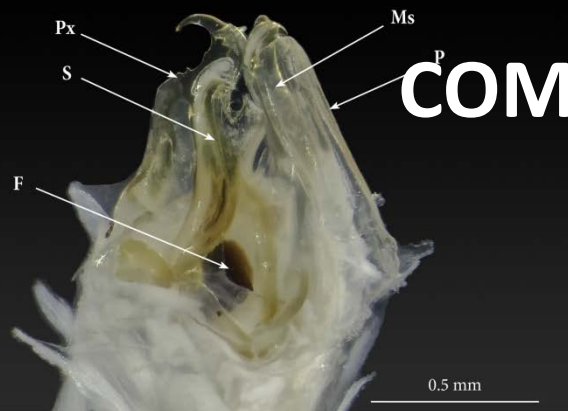


a synchrotron-  
based study  
performing  
micrometre-  
resolution, time-  
resolved  
microtomography  
on the 145 Hz  
wingbeat of  
blowflies

A blowfly's wingbeat is 50 times shorter than a blink of a human eye...

Walker SM, Schwyn DA, Mokso R, Wicklein M, Müller T, Doube M, et al. (2014) In Vivo Time-Resolved Microtomography Reveals the Mechanics of the Blowfly Flight Motor. PLoS Biol 12(3): e1001823. doi:10.1371/journal.pbio.1001823

A

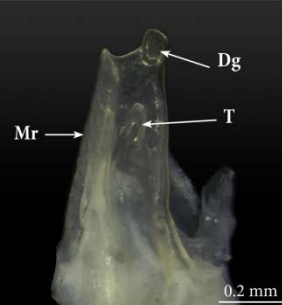


# COMBINING TECHNIQUES

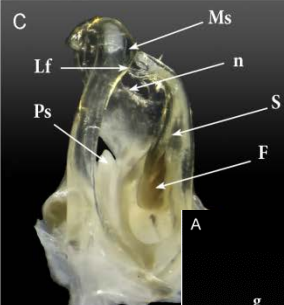
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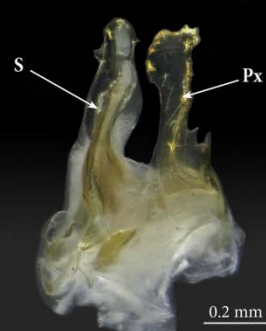
B



C



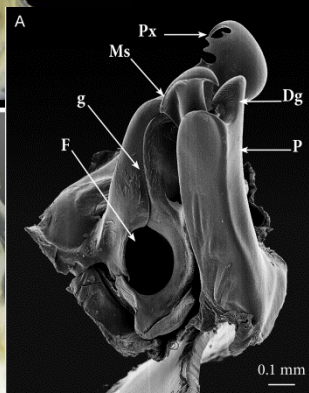
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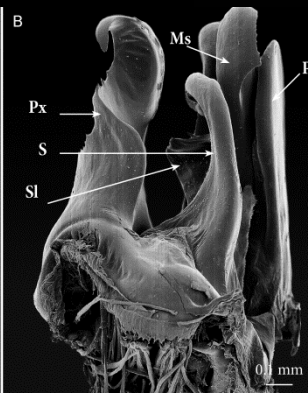
E



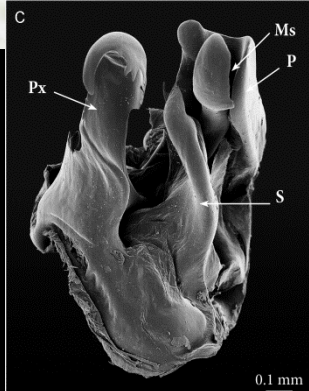
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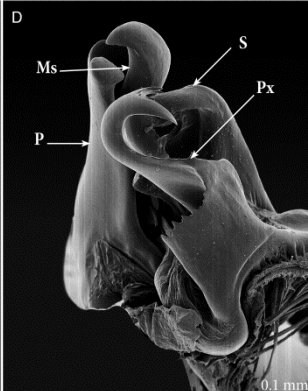
B



C



D



# Morphological data storage

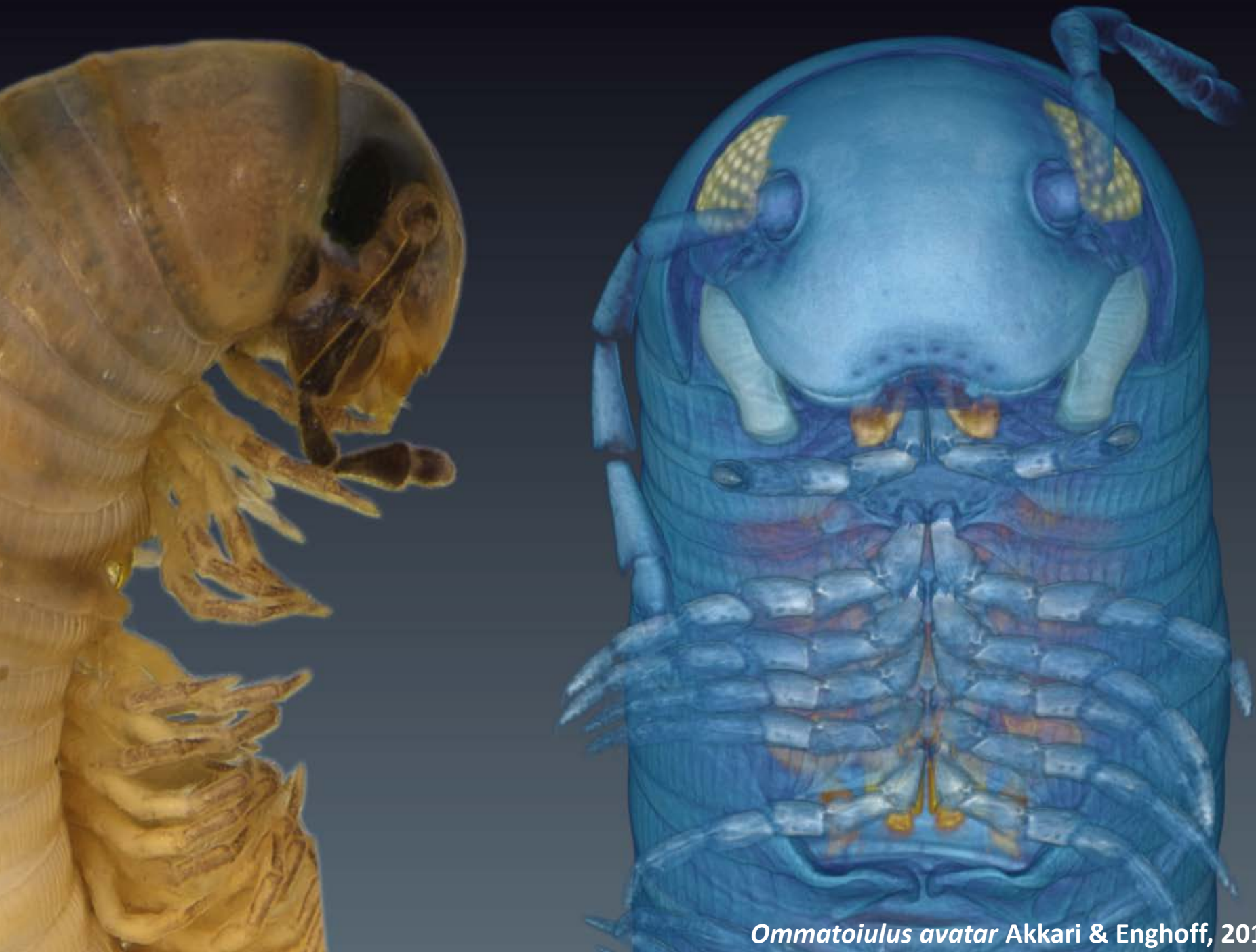


Repositories

Open acces

Sharing – re using





*Ommatoiulus avatar* Akkari & Enghoff, 2015