The webcast will start in a few minutes….

Musculoskeletal modeling of Dragonflies

Outline

- Introduction by the Host
- **Musculoskeletal modeling of Dragonflies**
  - Sina David & Alexander Blanke
- Questions and answers

Sina David
Phd student
German Sport University Cologne
Institute of Biomechanics and Orthopaedics
(Presenter)

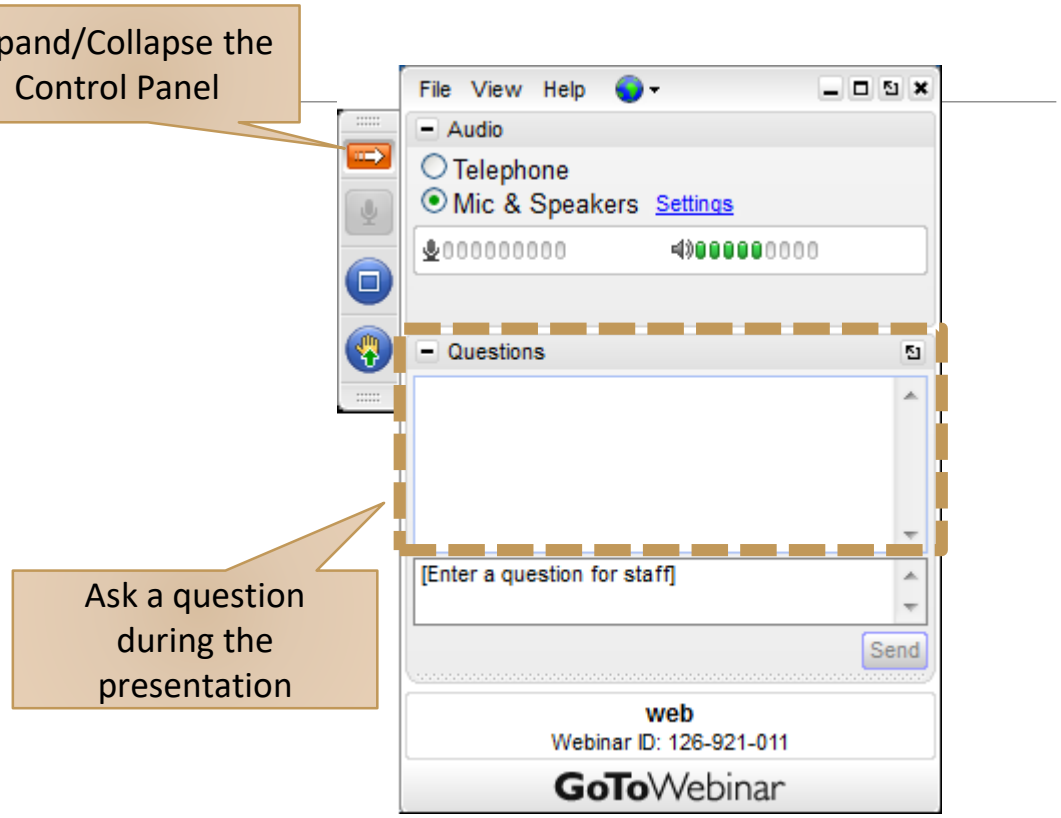
Arne Kiis
AnyBody Technology
(Host)

Control Panel

The Control Panel appears on the right side of your screen.

Submit questions and comments via the Questions panel.

Questions will be addressed at the end of the presentation.
If your question is not addressed we will do so by email.



AnyBody Modeling System

Musculoskeletal analysis

AnyBody Managed Model Repository

Wide range of simulation options

- Motion capture
- Ground reaction force prediction
- Imaging → Patient-specific model
- Man-machine interactions

Rasmussen et. al. (2011), ORS Annual Meeting

Resources

Publication list
http://www.anybodytech.com/index.php?id=publications

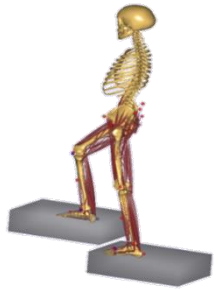
Youtube Channel
https://www.youtube.com/user/anybodytech

Tutorials
http://www.anybodytech.com/fileadmin/AnyBody/Docs/Tutorials/_template/FrontPage/FrontPage.html

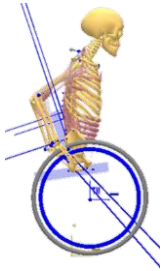
Email
sales@anybodytech.com

From the Publication list

* David, S., Funken, J., Potthast, W. & Blanke, A. (2016), "**Musculoskeletal modeling of the dragonfly mandible system as an aid to understanding the role of single muscles in an evolutionary context**", Journal of Experimental Biology, vol. 219, pp. 1041-1049. [DOI]
* NEW!!! David, S., Funken, J., Potthast, W. & Blanke, A. (2016), "**Musculoskeletal modelling under an evolutionary perspective: deciphering the role of single muscle regions in closely related insects**", Journal of the Royal Society Interface, vol. 13 (123). [DOI]



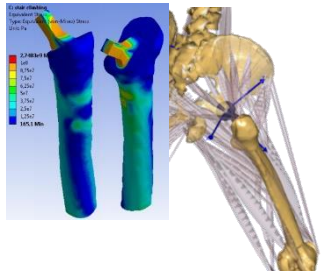
Movement Analysis



Product Design Optimization

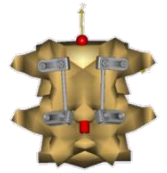
ANYBODY Modeling System

Ergonomic Analysis



Load Cases for Finite Element Analysis

Surgical Planning and Outcome Evaluation

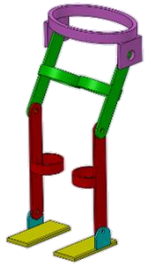


AnyBody Modelling System

Motion and Forces

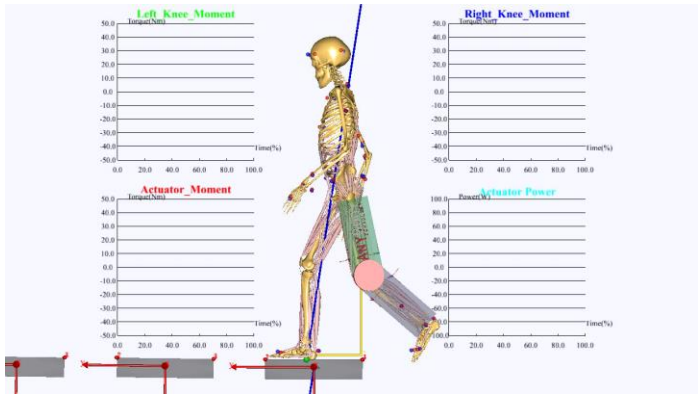
Body model

Environment model



Inverse dynamics
Muscle recruitment

Simulation



Internal body loads

- Muscle forces
- Joint forces

Design Optimization

Post Processing (e.g. FE tools)

Musculoskeletal modeling of Dragonflies

Sina David
PhD Student
German Sport University Cologne,
Institute of Biomechanics and Orthopaedics

Dr. Alexander Blanke,
Research Fellow,
University of Hull,
Department of Mechanical Engineering

Upcoming Webcasts:

- **Feb 09, 2017:** Development of a biomechanical model of the wrist joint for patient-specific model guided surgical therapy planning
  - Jörg Eschweiler, PhD.
    Head of the group "Biomechanical Modelling and Simulation" of the Chair of Medical Engineering at the Helmholtz-Institute Aachen, RWTH Aachen University

Events:

- PhD Course: Predictive Musculoskeletal Modelling
  - At Aalborg University, Denmark
  - 27th to 31st of March 2017
  - Registration is open: goo.gl/yVrHqS

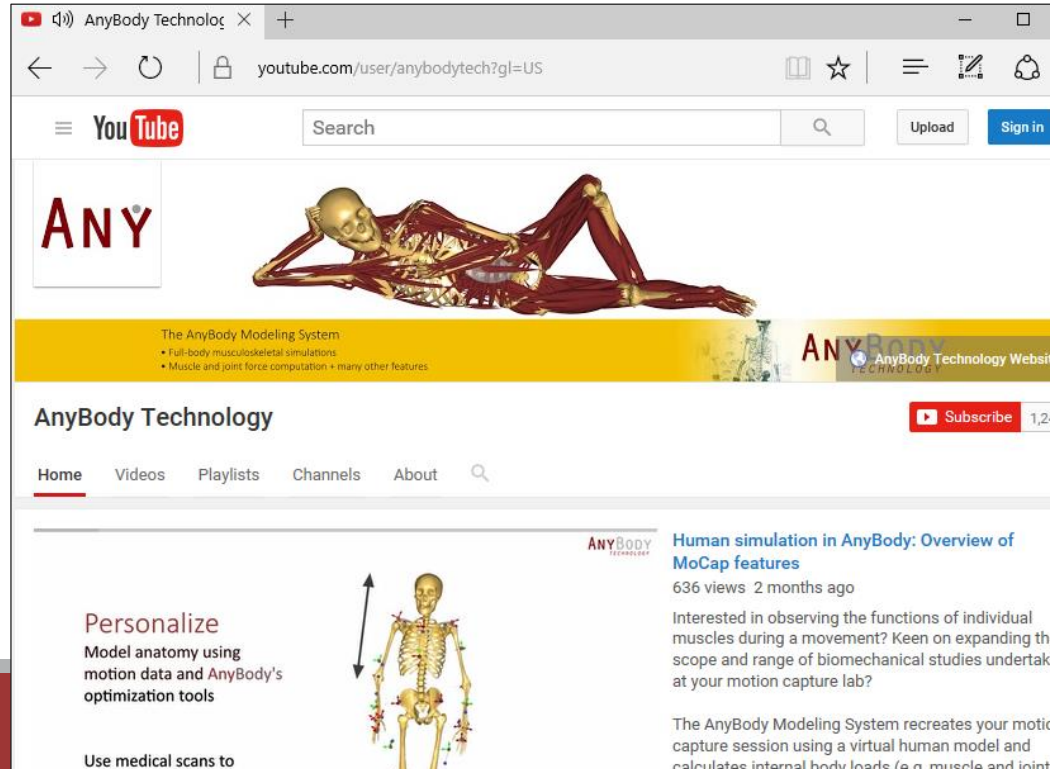
www.anybodytech.com

- Events, dates, publication list, ...

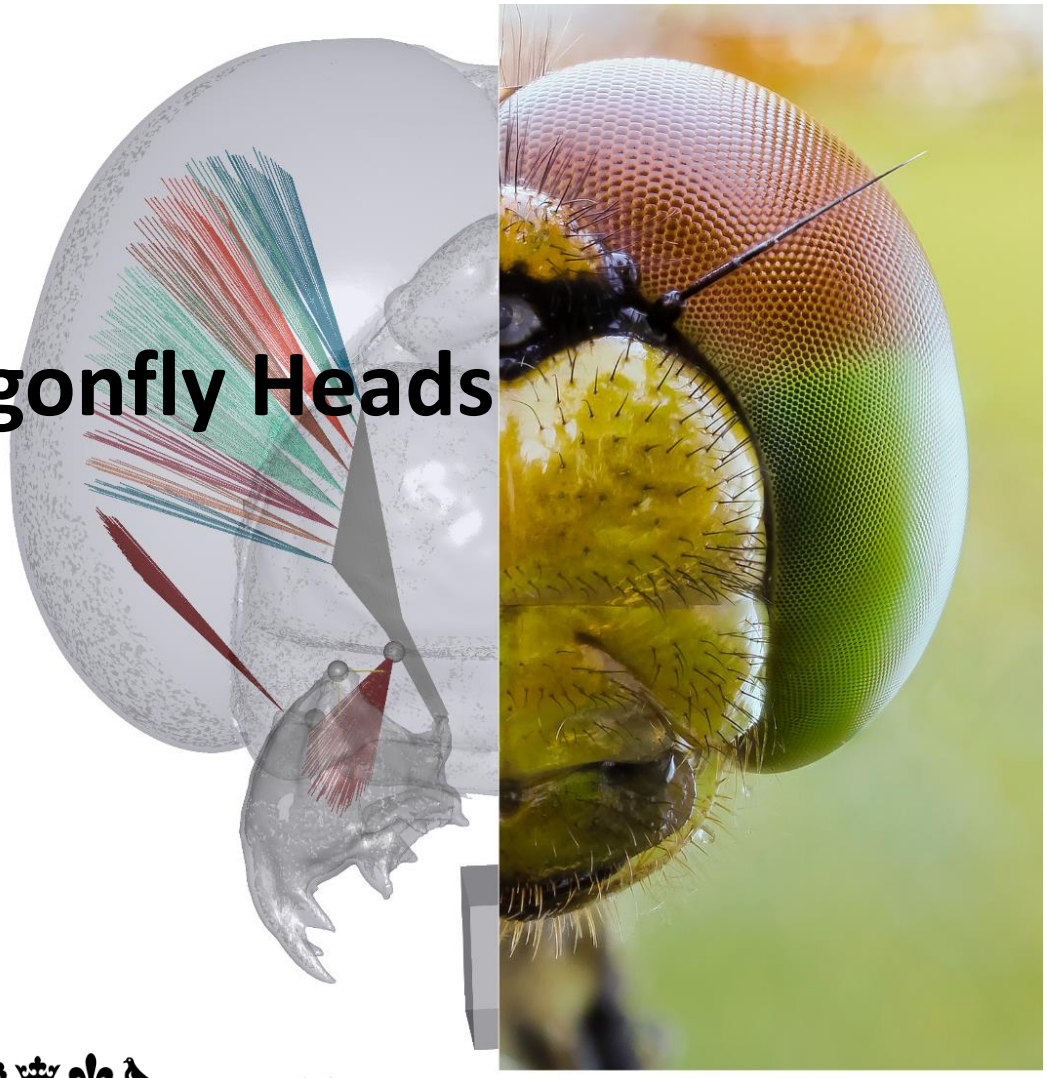
www.anyscript.org

- Wiki, Forum

Check previous webcasts on: http://youtube.com/anybodytech



Musculoskeletal Modeling of Dragonfly Heads



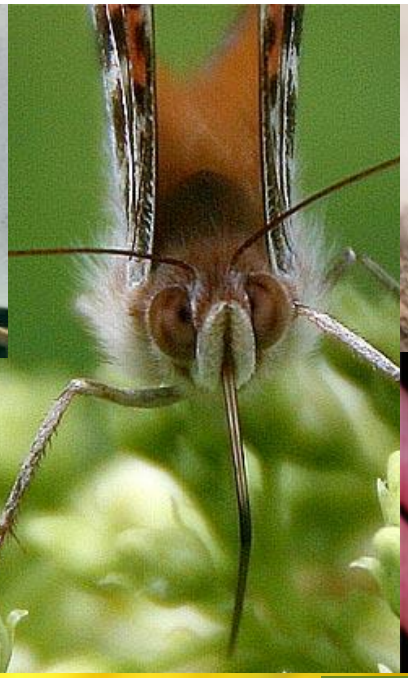
Sina David
& Alexander Blanke

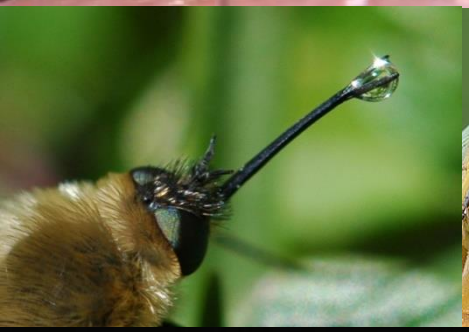
Deutsche Sporthochschule Köln
German Sport University Cologne

University of Hull

Insects show a remarkable mouthpart diversity



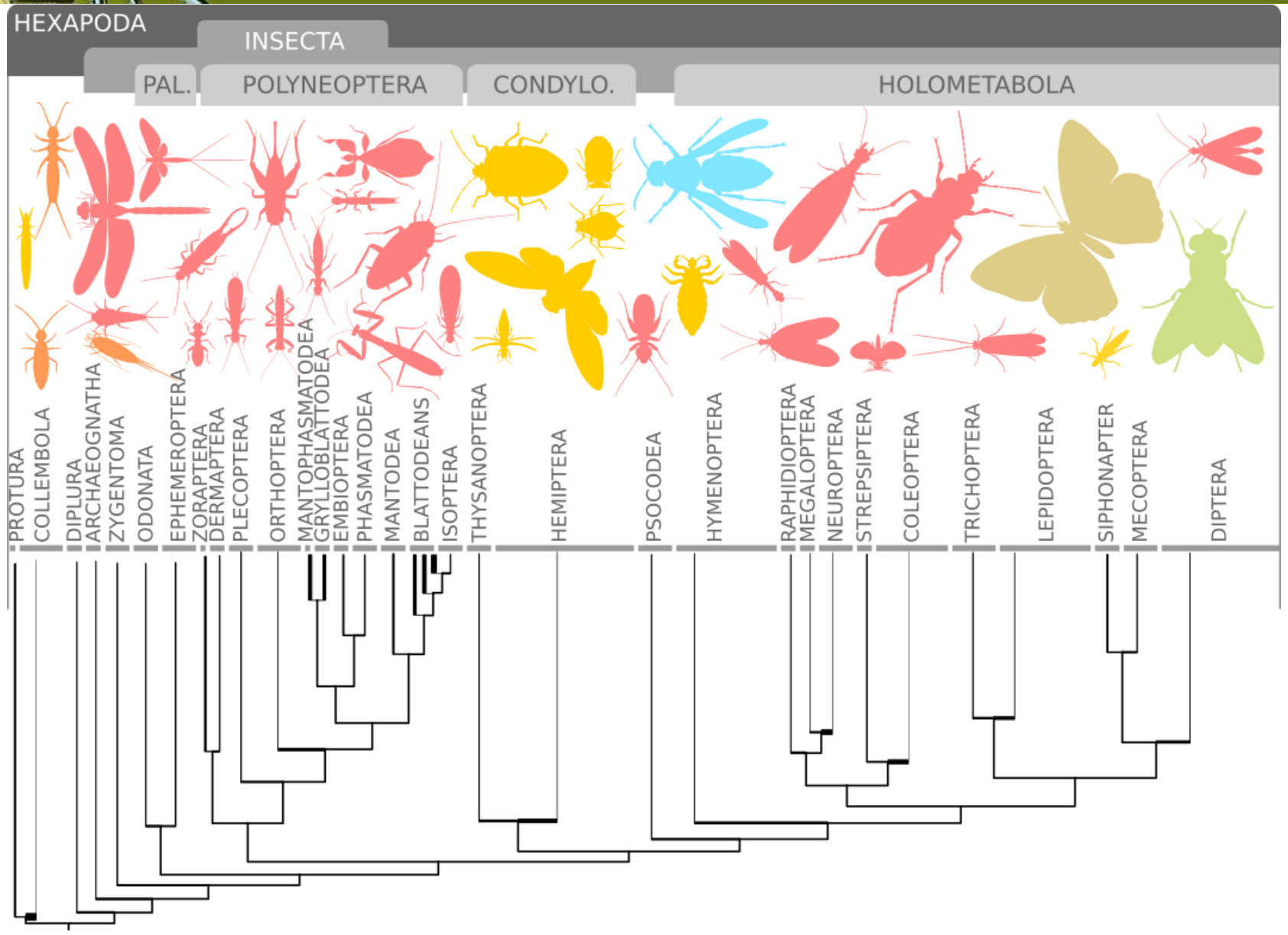




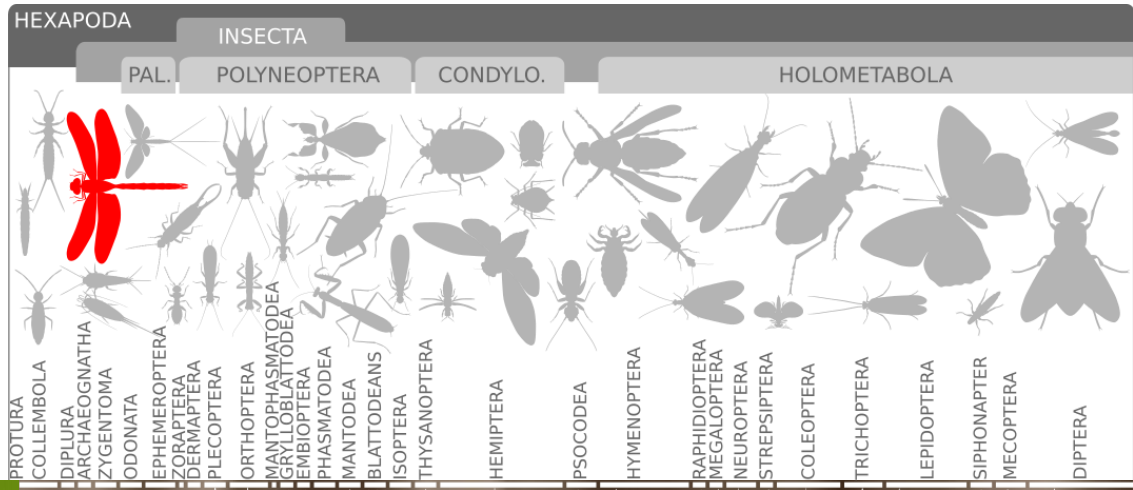


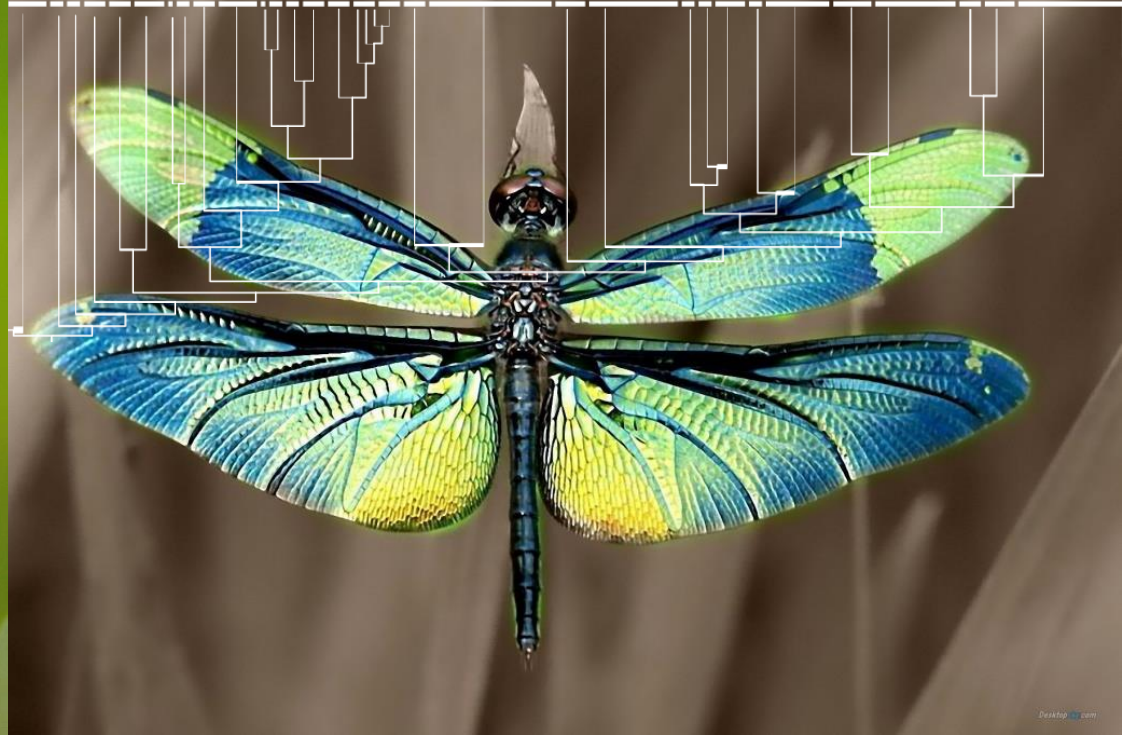


Several mouthpart types evolved multiple times independently

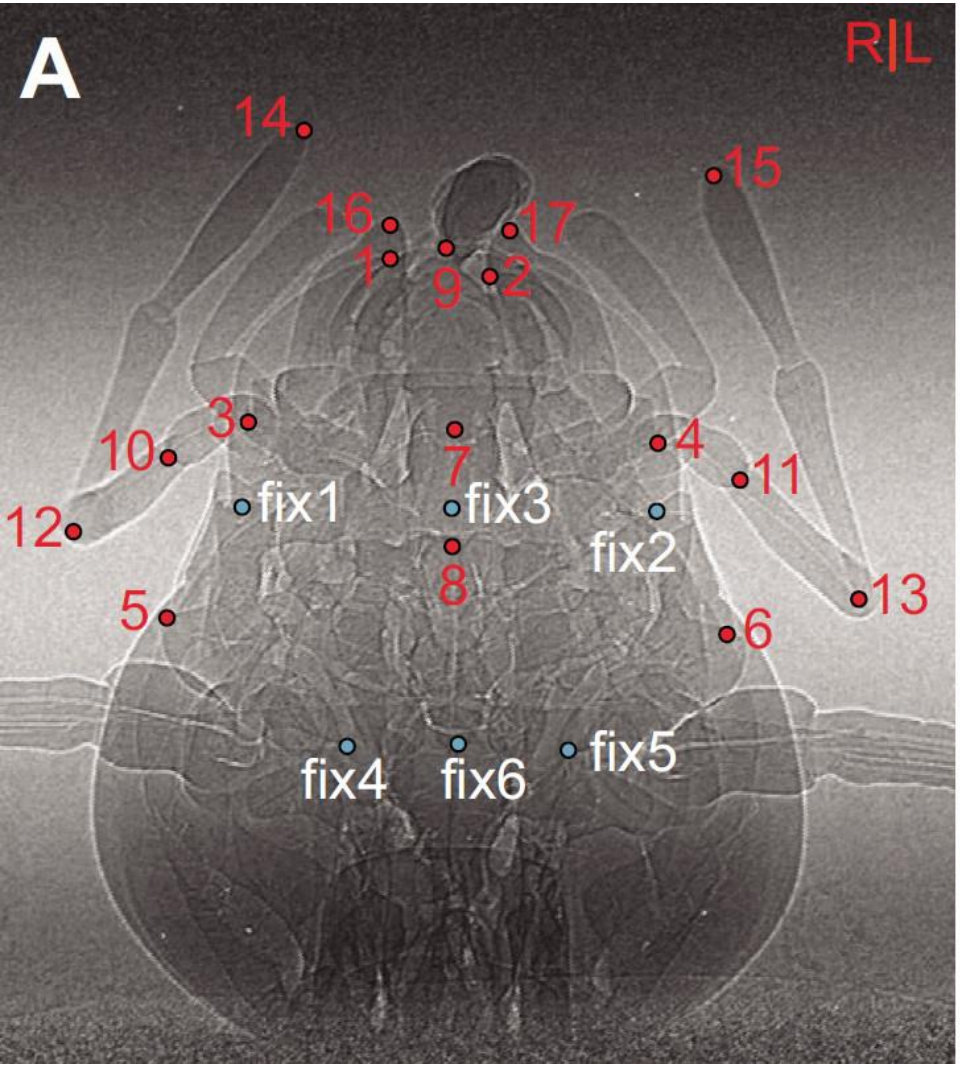


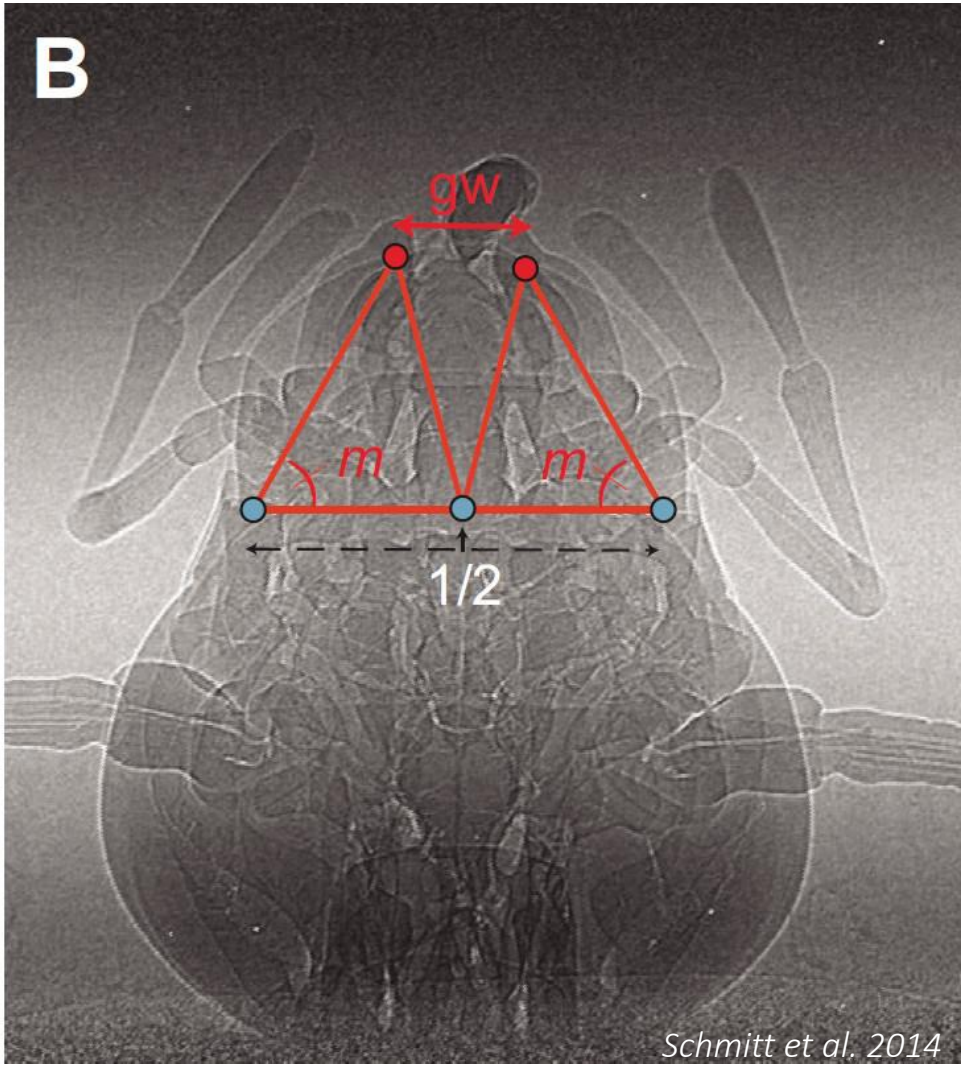
Why are dragonflies important ?





Insect mouthpart studies to date





Schmitt et al. 2014

- Why is it so difficult to study insect mouthpart kinematics and muscles?

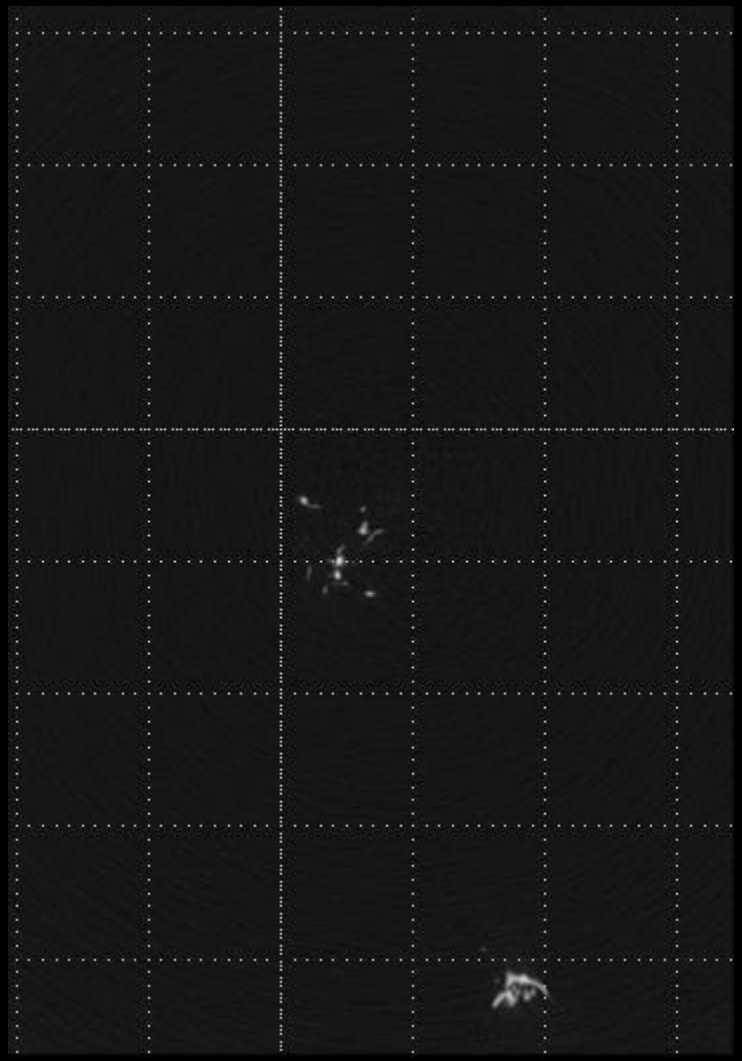
A baby Tasmanian devil – cute!

An adult emerald damselfly

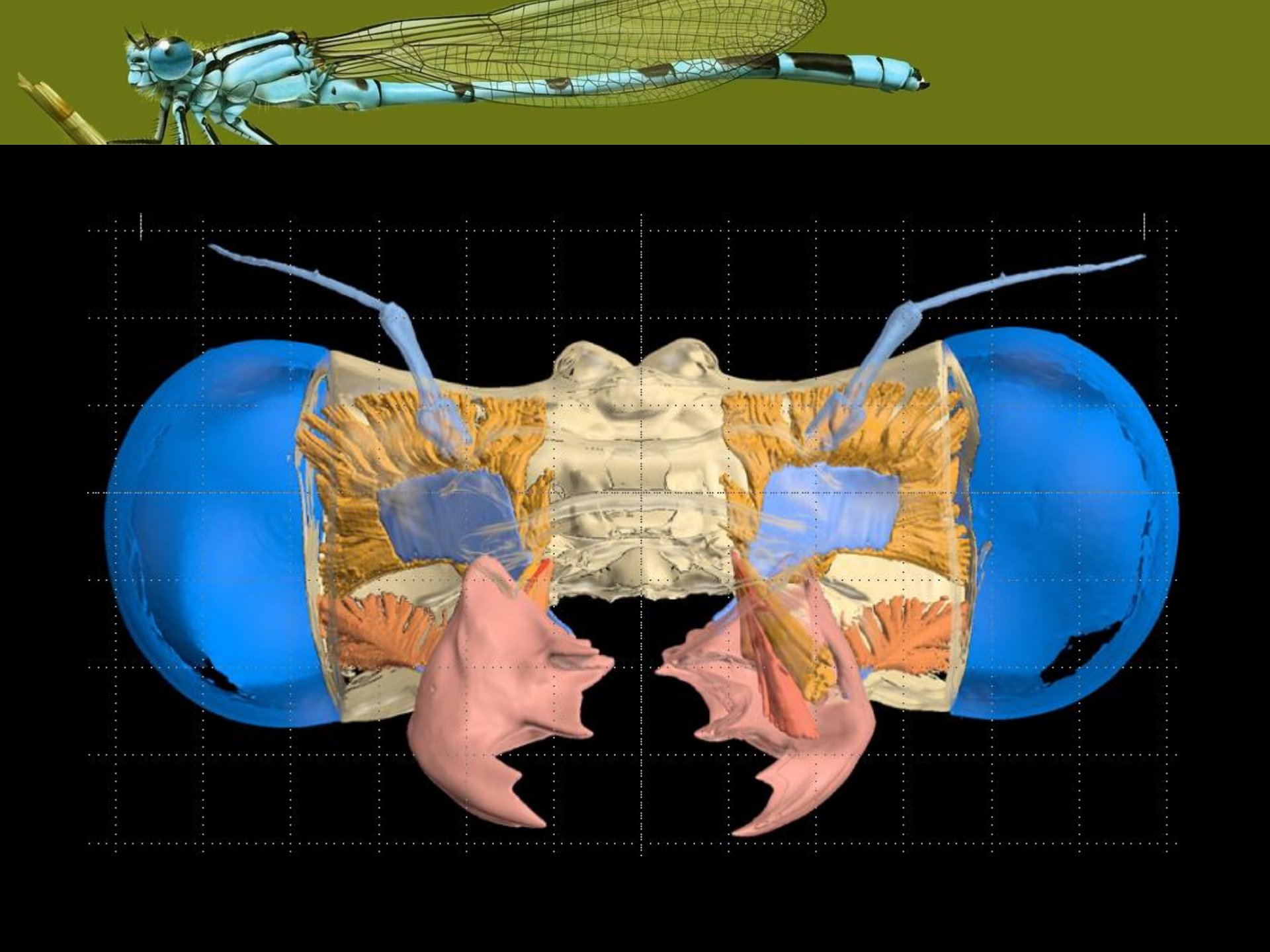
microCT helps to generate detailed virtual anatomies

Desktop microCT's

microCT to obtain accurate virtual anatomies

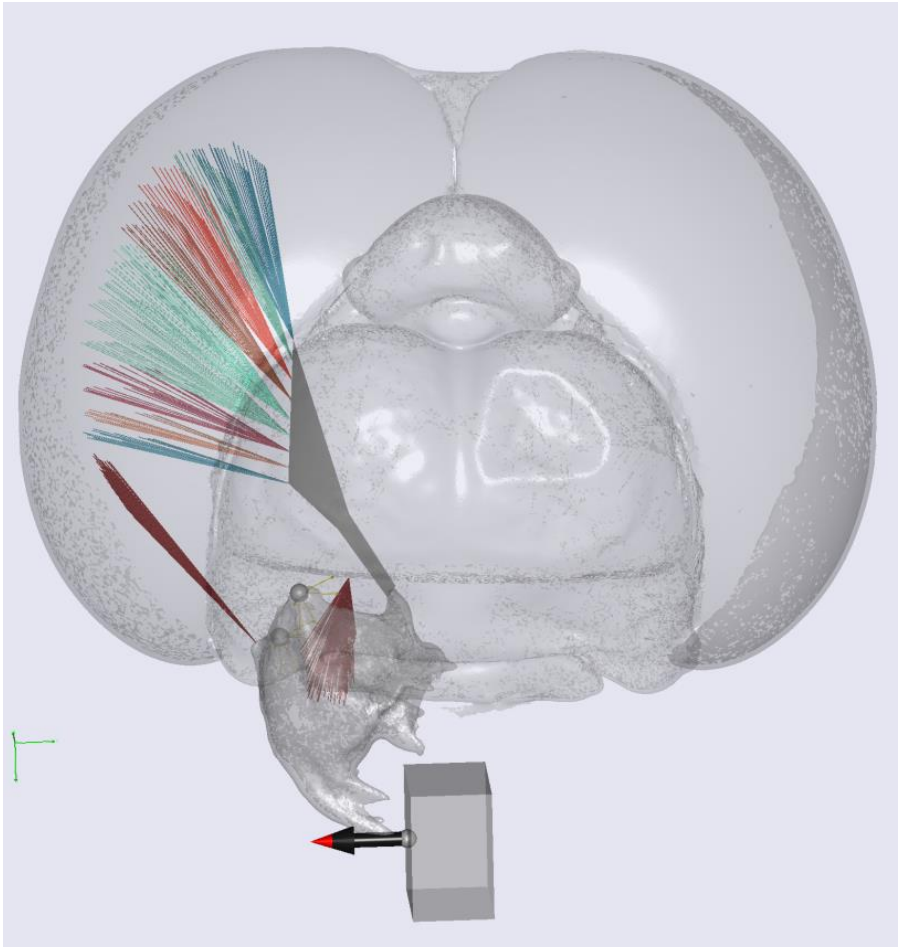


Lestes virens *thorax*
(Small Emerald Damselfly)

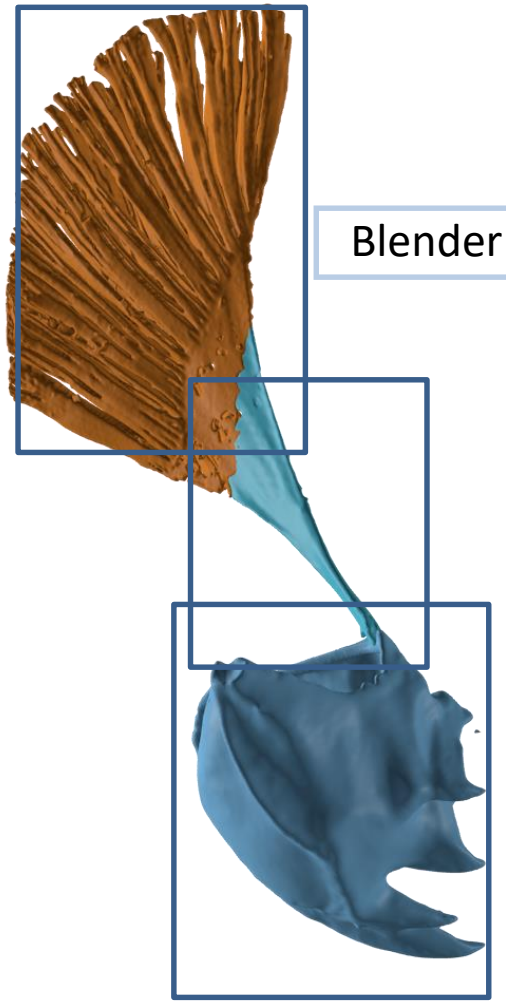


Model Setup

- 3 Rigid Segments
- 1 Tendon
- 5 Muscles (554 fibers)
- 2 Spherical joints

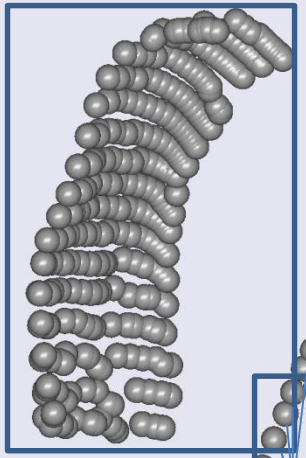


Model Setup

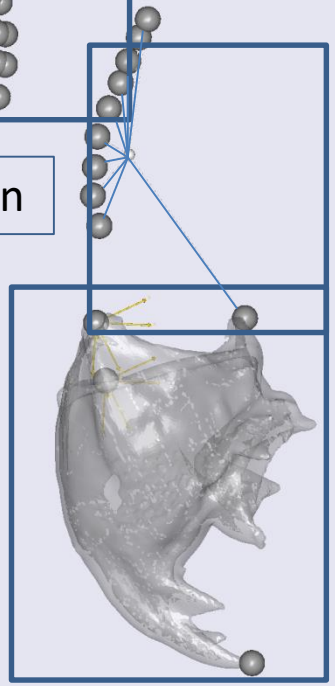


Blender coordinates and surfaces

Muscle insertions

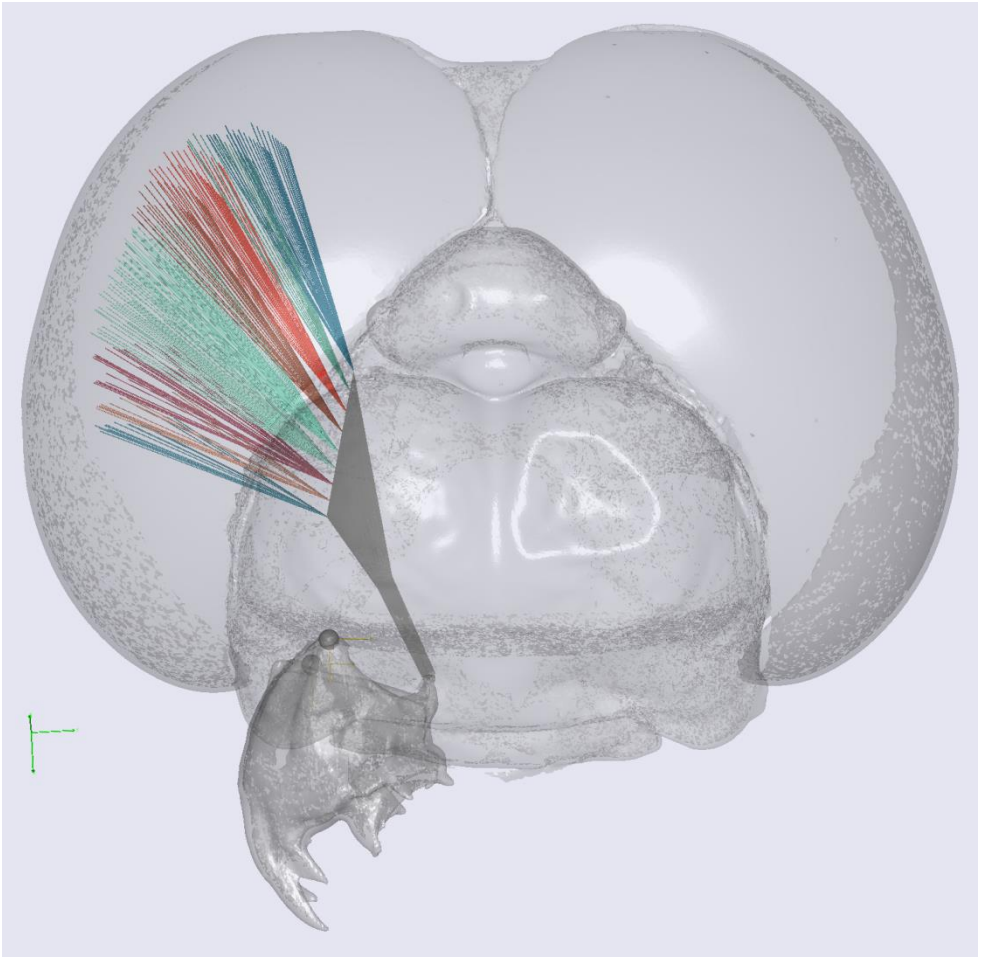


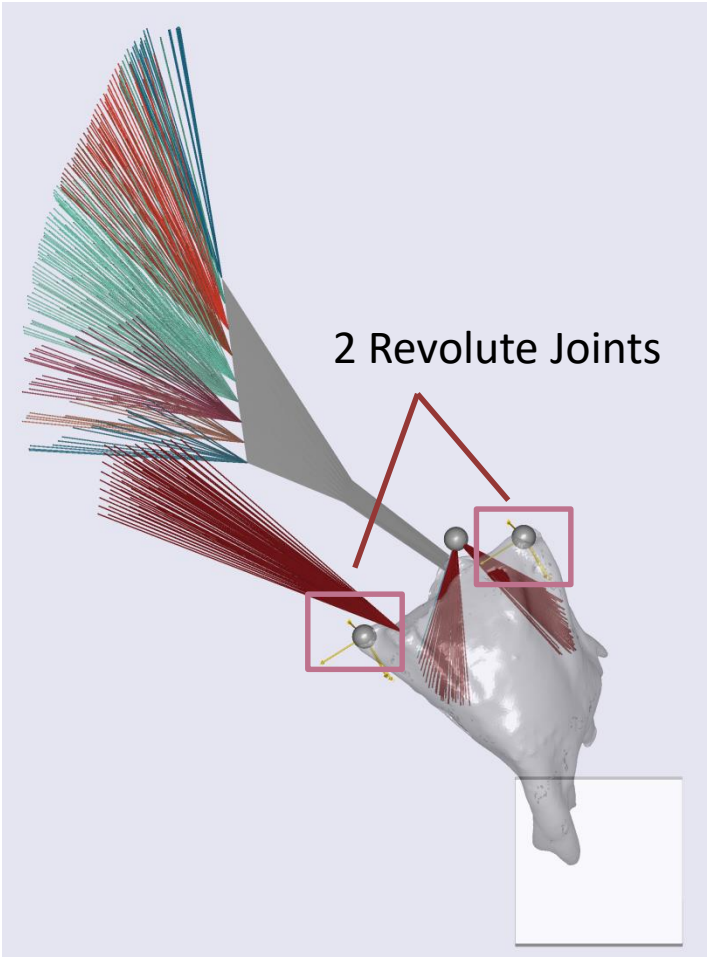
Tendon



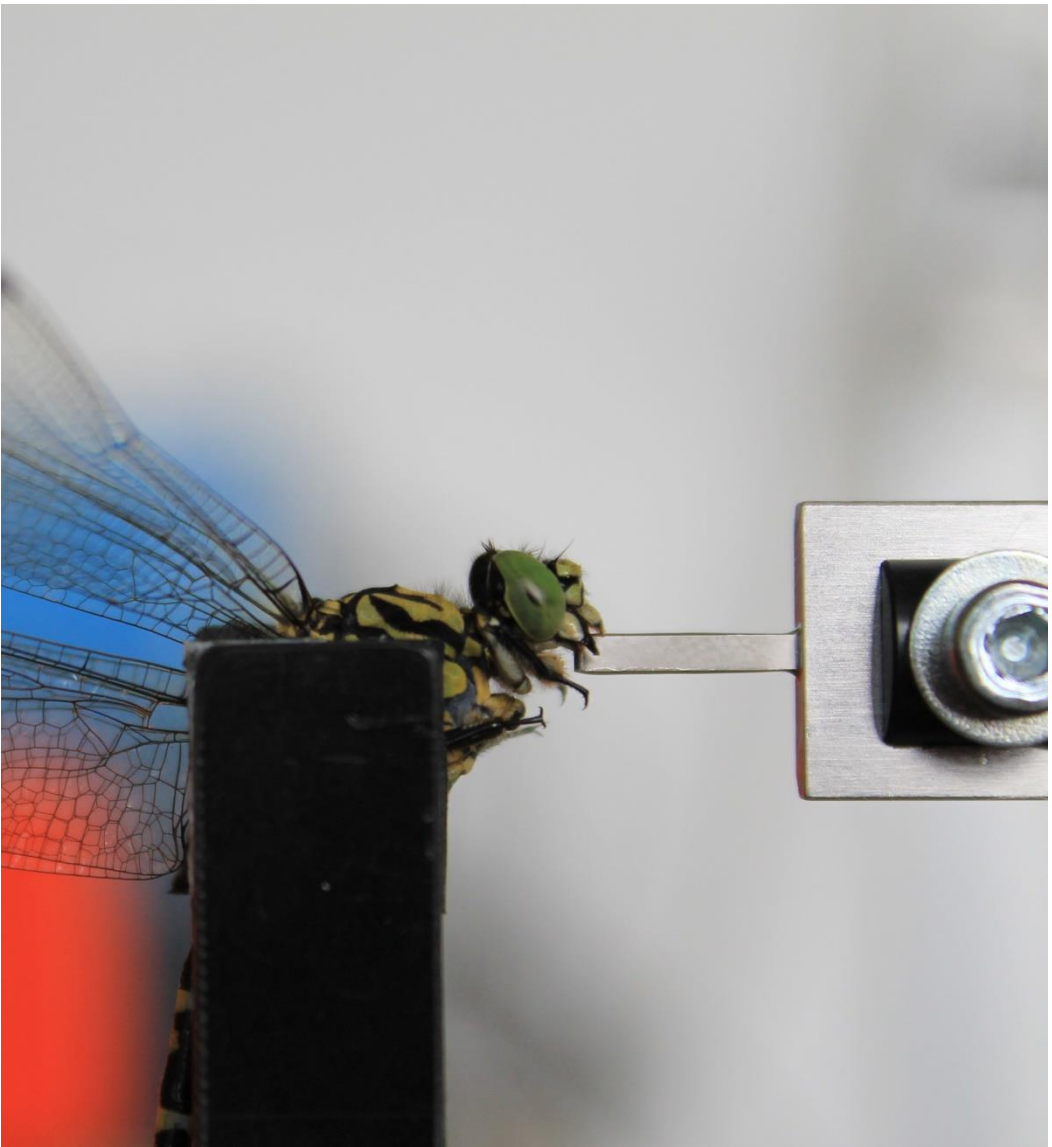
Endoskeletton

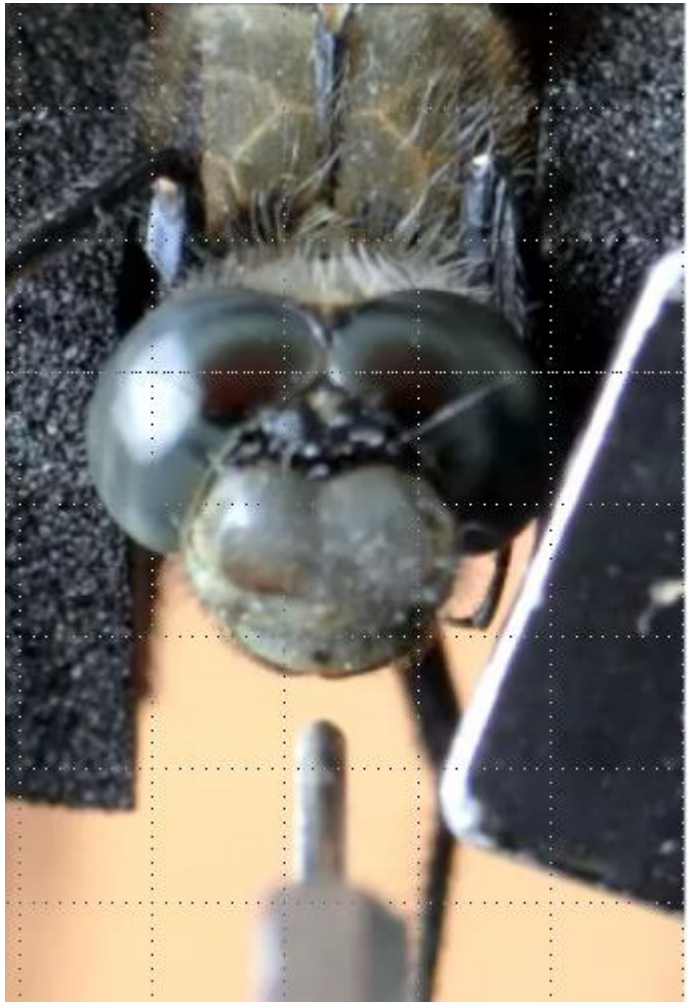
Model Setup





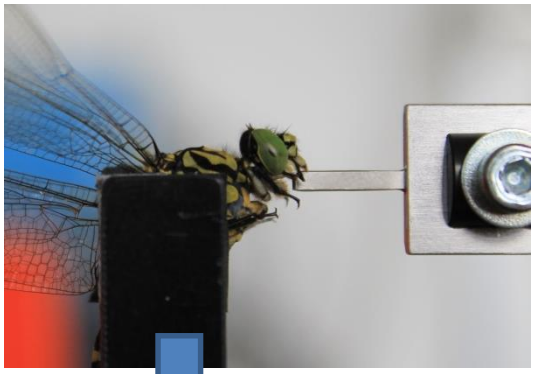
Bite Force Measurement

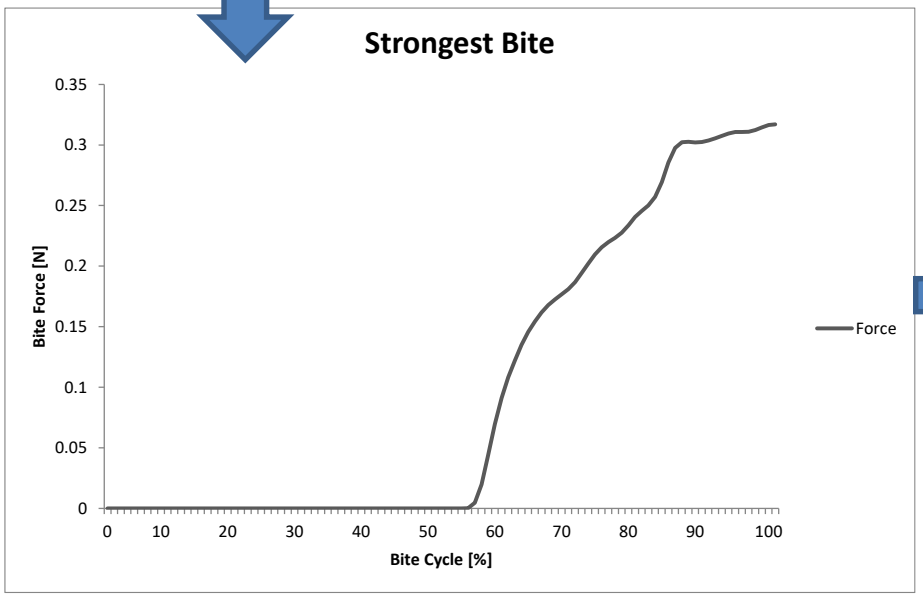


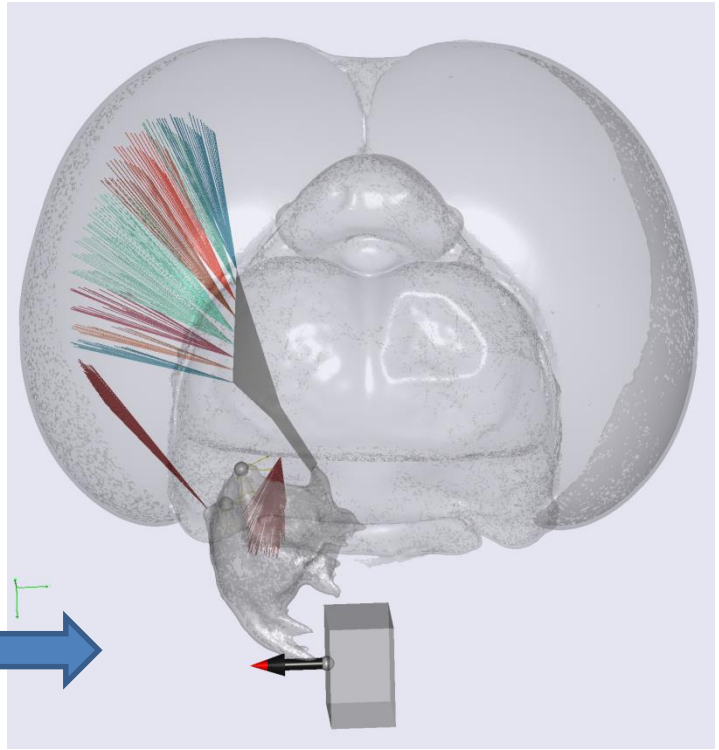


David et al 2016

Attaching Force







Muscle Model

- AnyMuscleModel – assuming constant strength of the muscle

Pro: Initial force is only input parameter
Con: Ignores cross bridge binding

- AnyMuscleModel2E – Three element model

Pro: Very detailed/ Physiological
Con: Lots of input parameters

- AnyMuscleModel2ELin – Bilinear model

Pro: Very detailed/ Physiological
Con: Lots of input parameters

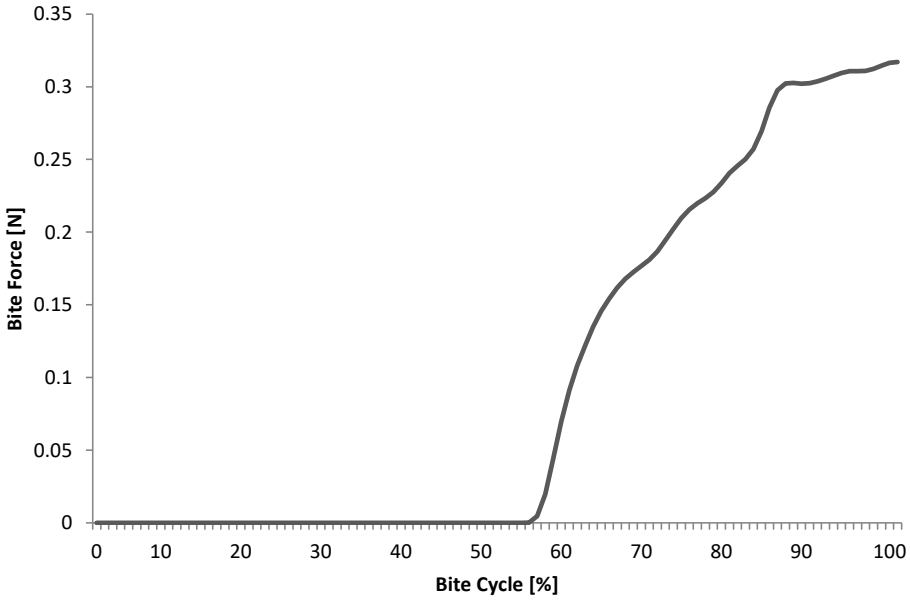
Muscle Model

Muscle Model

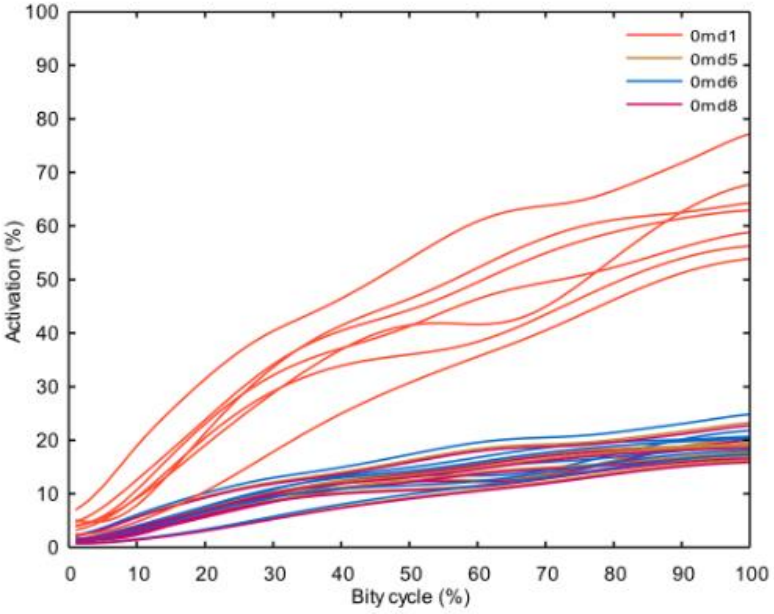
- Initial is unknown

  When does muscle activation reach 80% level?

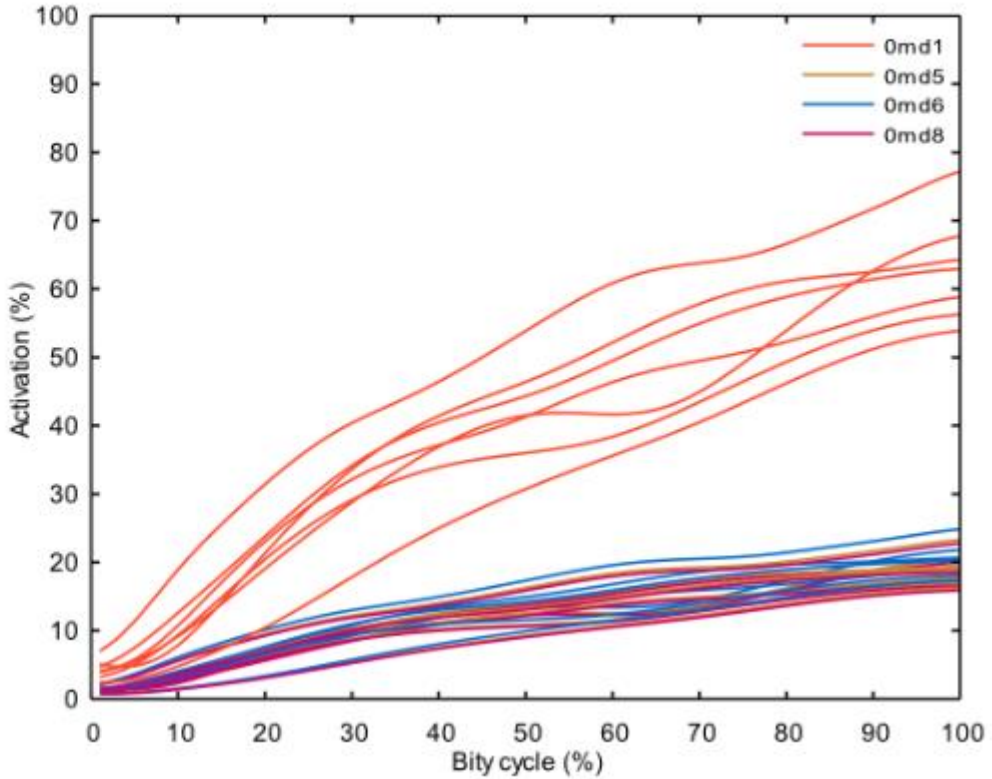
Strongest bite



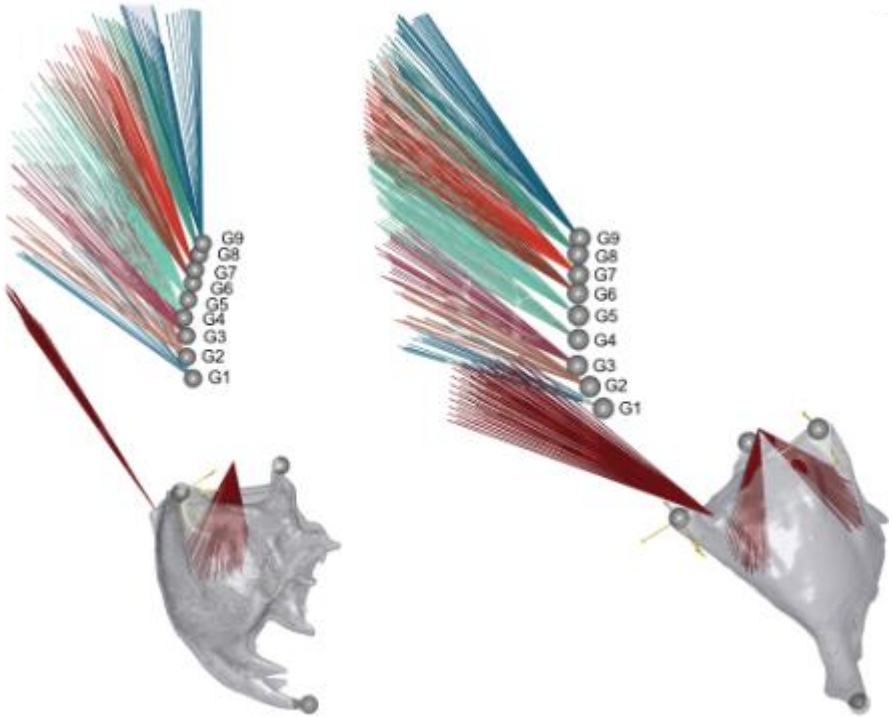
Muscle Activation

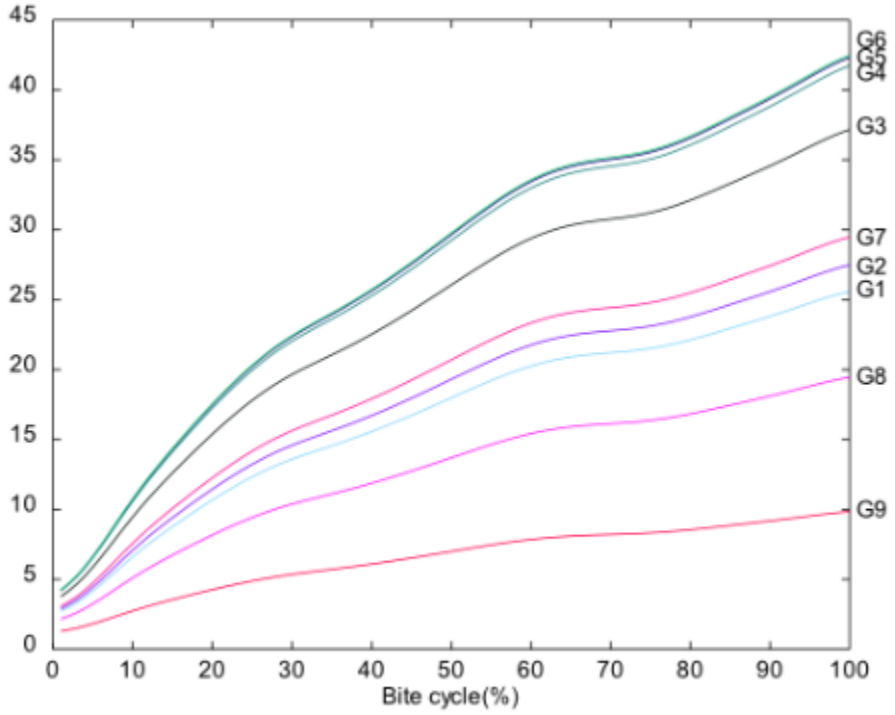


Results

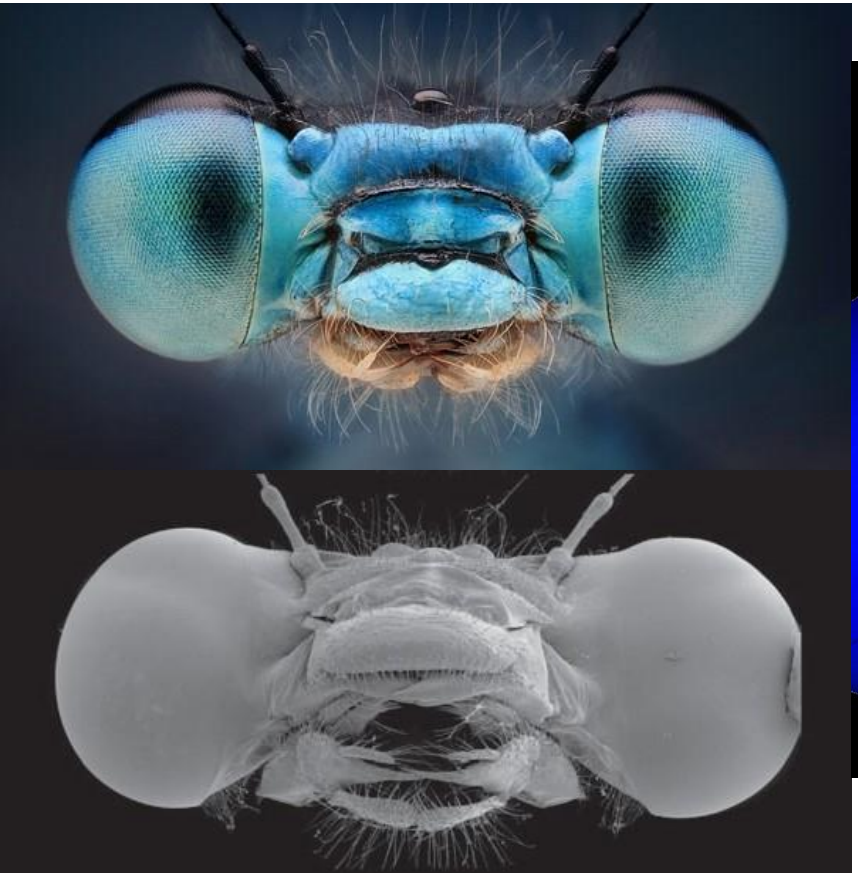

0md1
0md5
0md6
0md8
Activation (%)
Bity cycle (%)
0
10
20
30
40
50
60
70
80
90
100

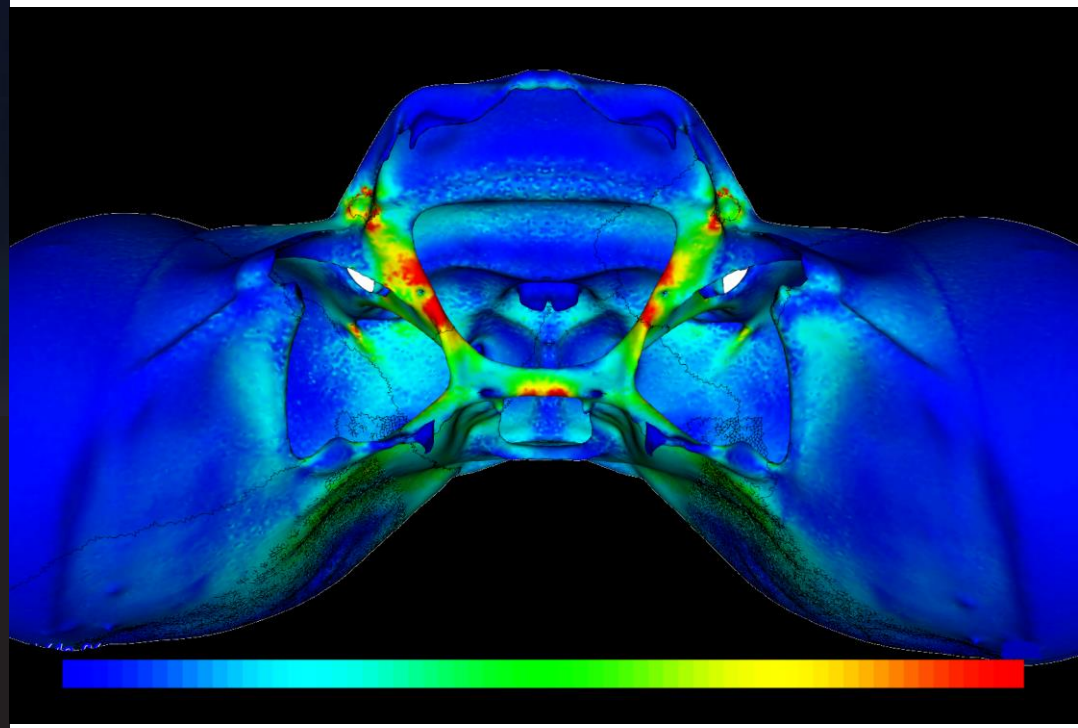
Results


G9
G8
G7
G6
G5
G4
G3
G2
G1
G9
G8
G7
G6
G5
G4
G3
G2
G1

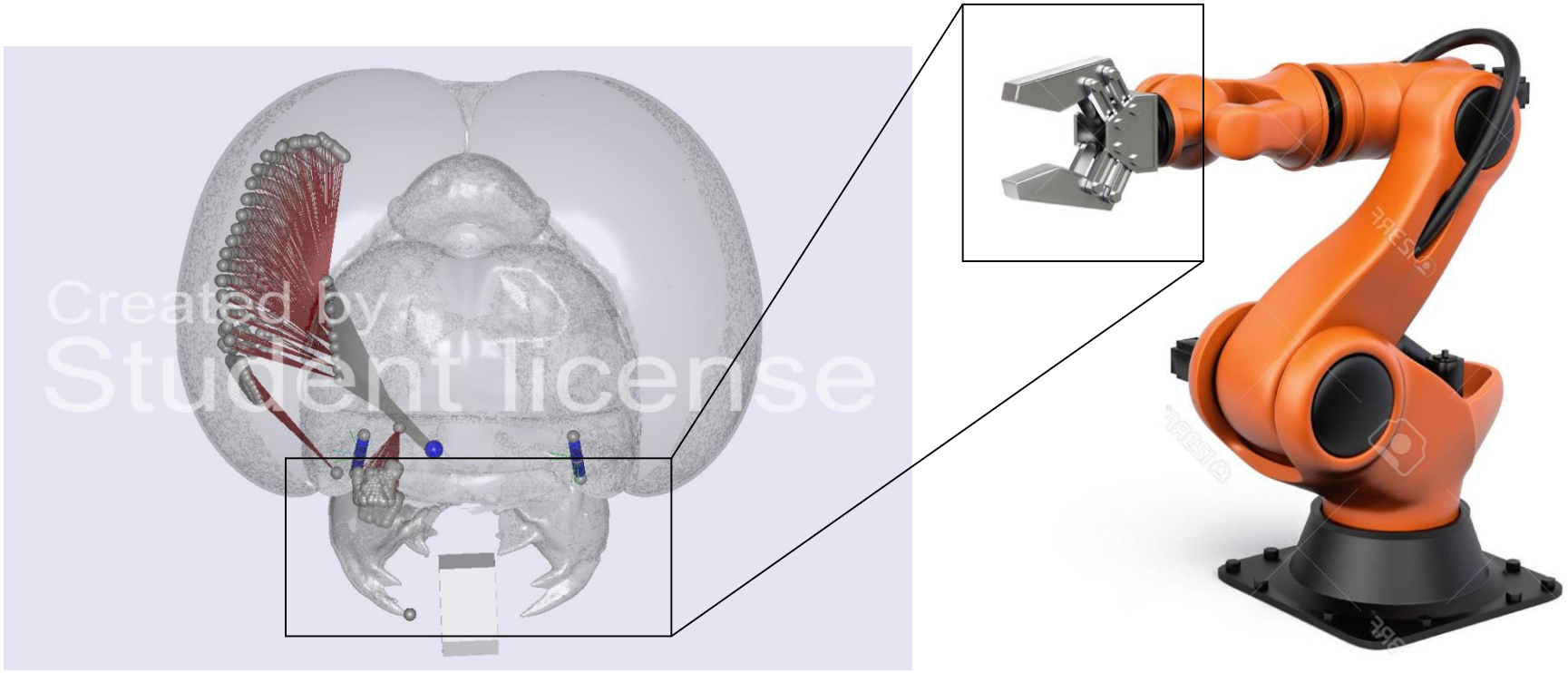

45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Bite cycle(%)
G6
G5
G4
G3
G7
G2
G1
G8
G9

What we can do with MDA results





Apart from evolution…



Material optimised robot design

- Typ. load: ~300% of own weight
- Max. load: ~25% of own weight