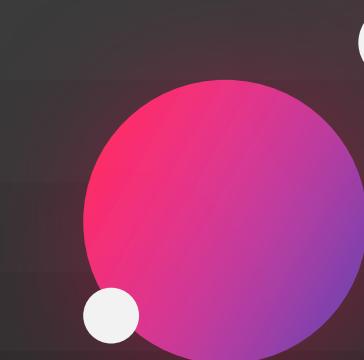
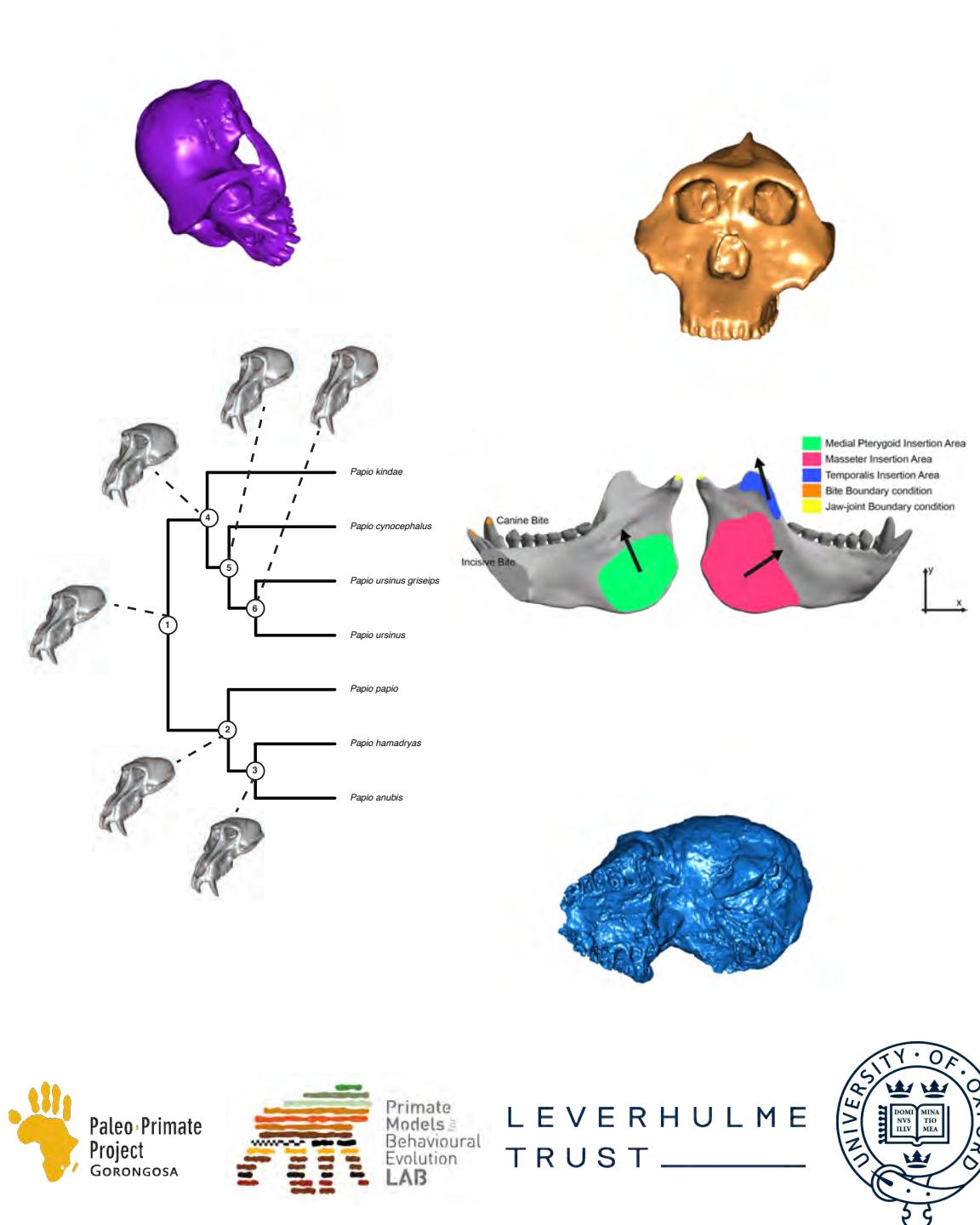


# XIII Jornada Chilena de Anatomía 2020



## Paleoantropología virtual

Dr. Thomas A. PüscheL



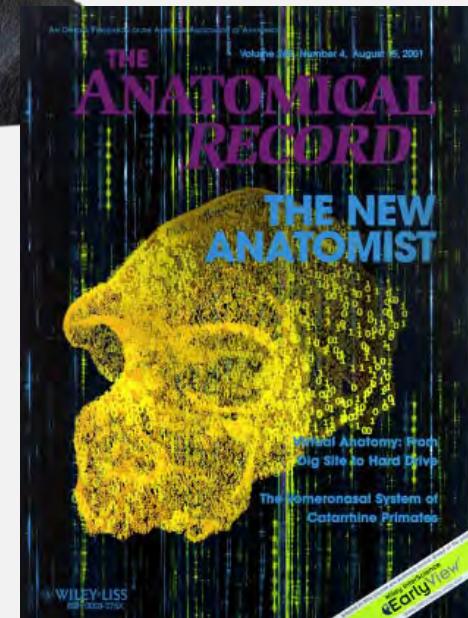
# El Plan para hoy

1. Breve contexto evolutivo



<https://www.visibleapeproject.com/>

2. Definiciones básicas



3. Descripción de las técnicas utilizadas

4. Un par de ejemplos

# Primate order

Lemuroidea



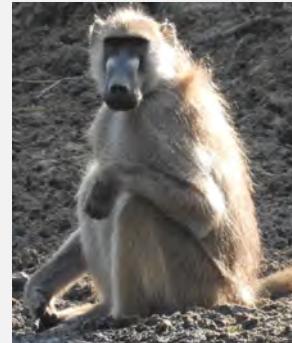
Lorisoidea



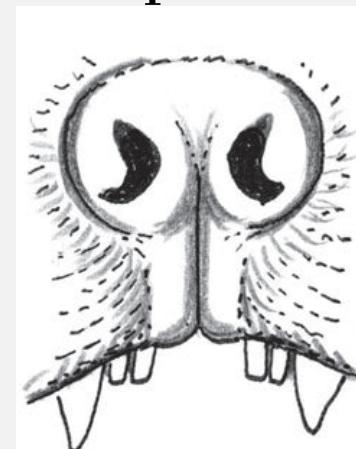
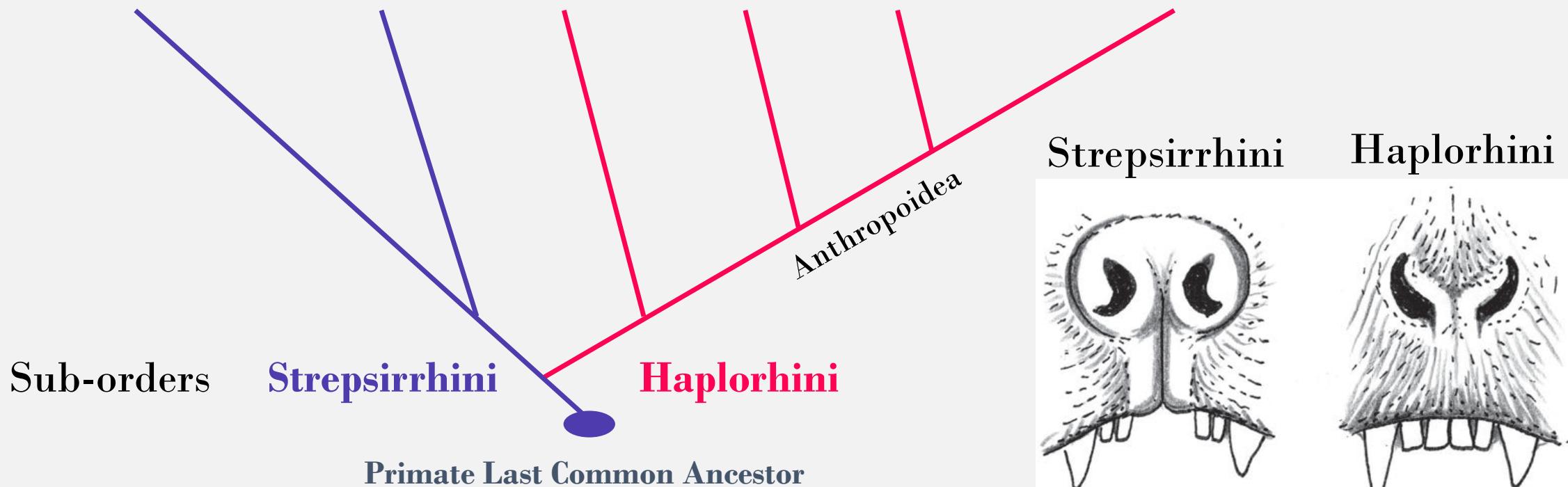
Tarsioidea



Ceboidea Cercopithecoidea



Hominoidea





\**Hylobatidae*

*Pongo*

*Gorilla*

*Pan*

*Homo*

Asian apes

~8 Ma

~6-7 Ma

Lesser apes

Great apes

~14 Ma

\**Hylobatidae:*  
*Sympalangus*  
*Bunopithecus*  
*Hylobates*  
*Hoolock*  
*Nomascus*

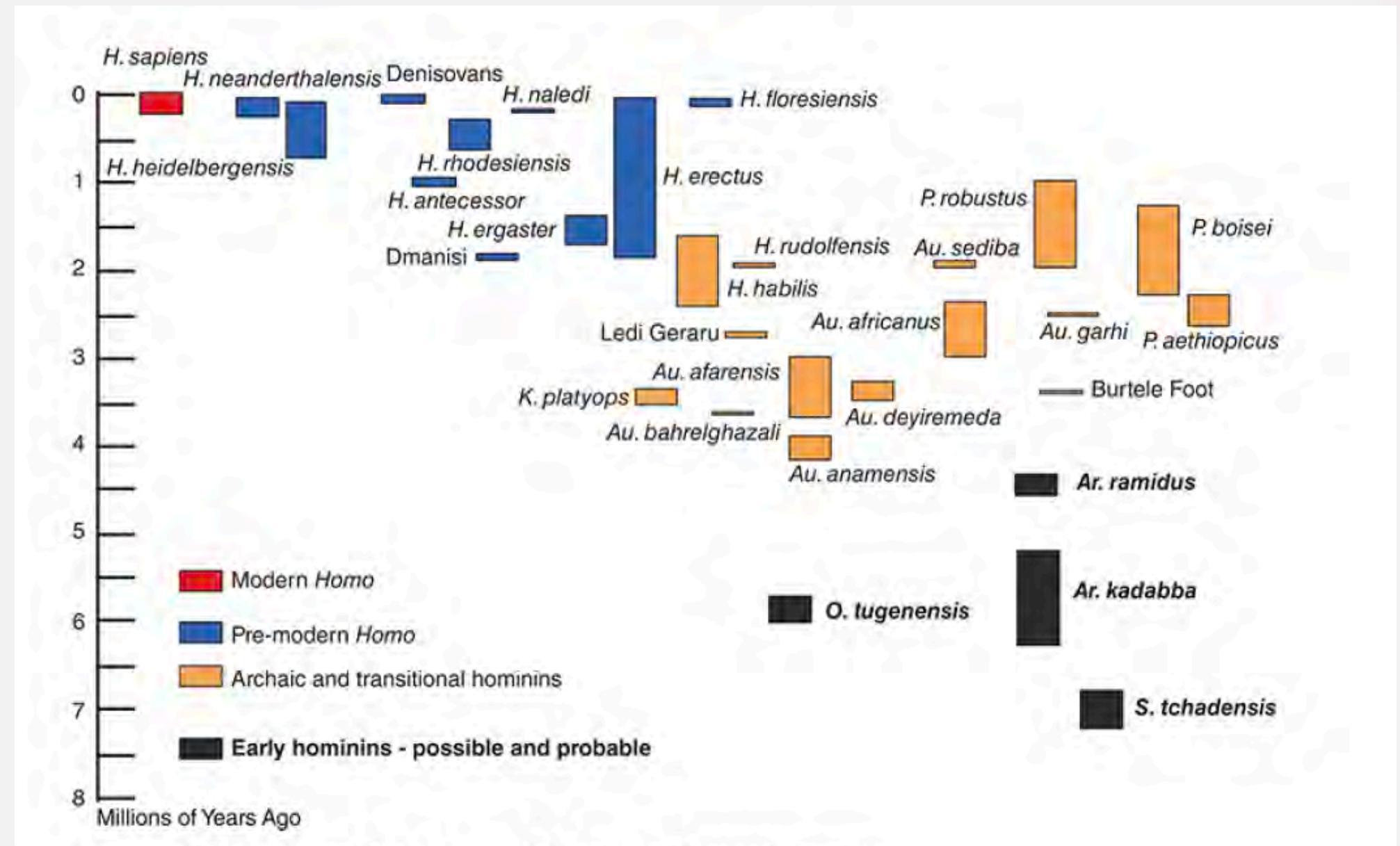
## Homoidea Superfamily Apes



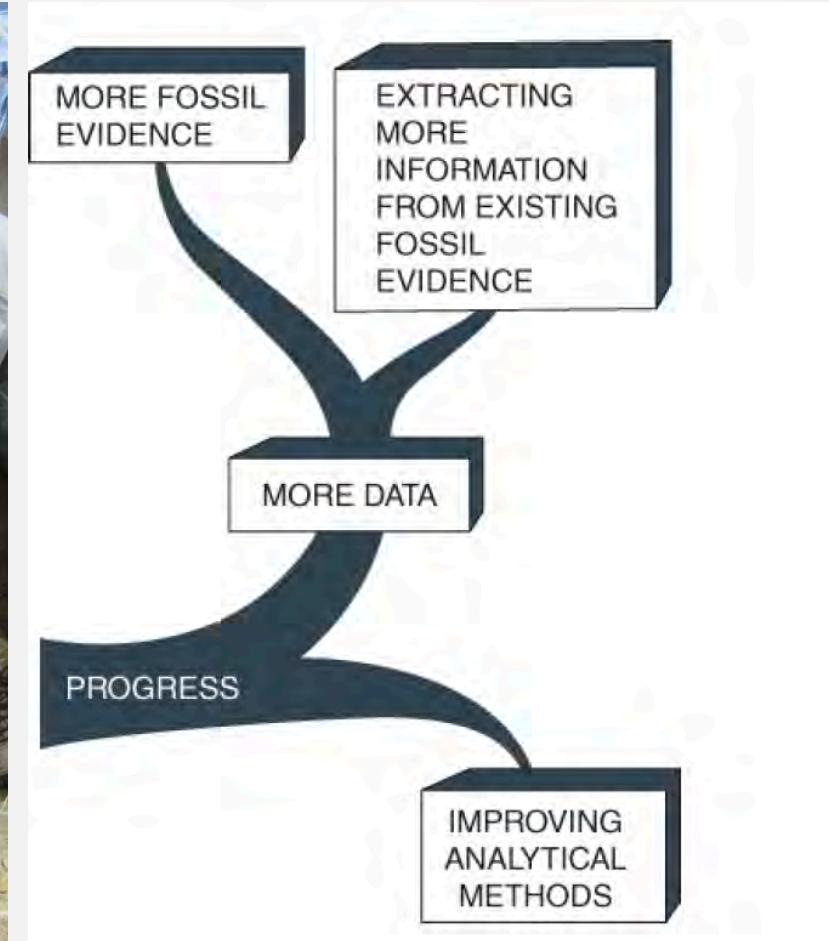
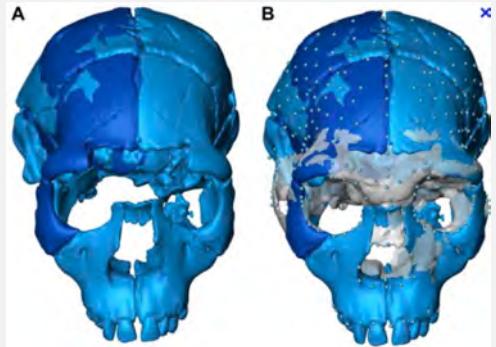


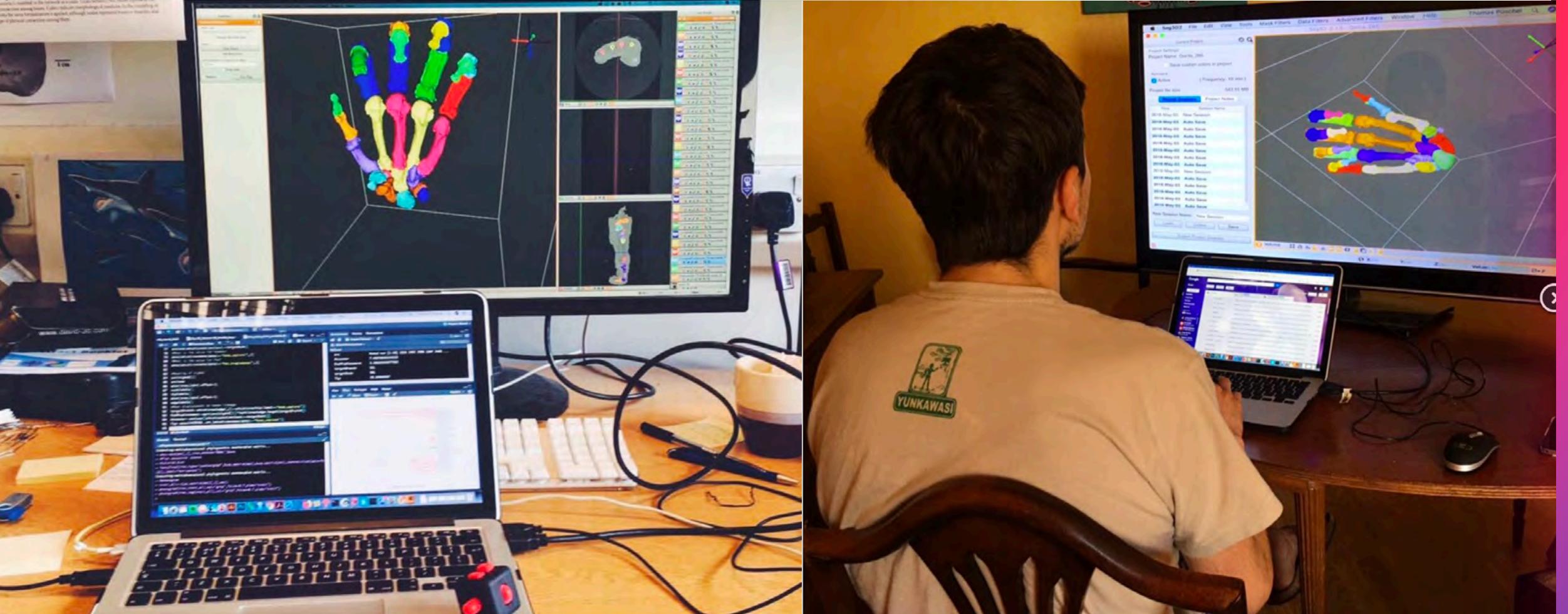
Es la rama de la **antropología biológica** y de la **paleobiología** que se ocupa del estudio de la evolución humana y su registro fósil, en otras palabras de los homíninos antiguos. A veces, también puede ser conocida como **paleontología humana**.

# Paleoantropología



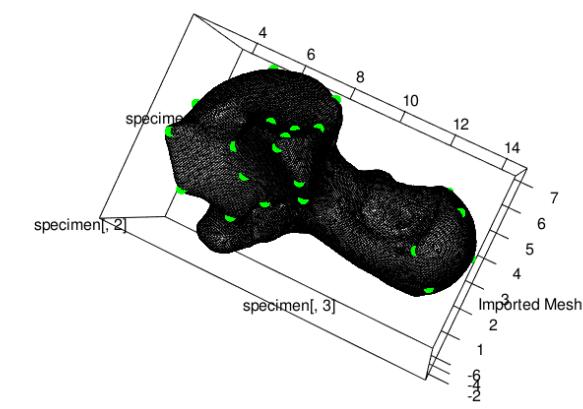
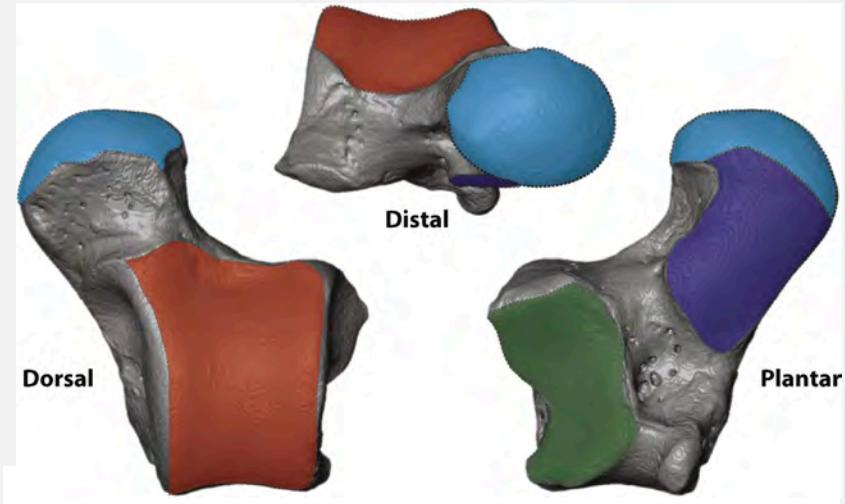
# ¿Cómo avanza la paleontología humana y de primates?

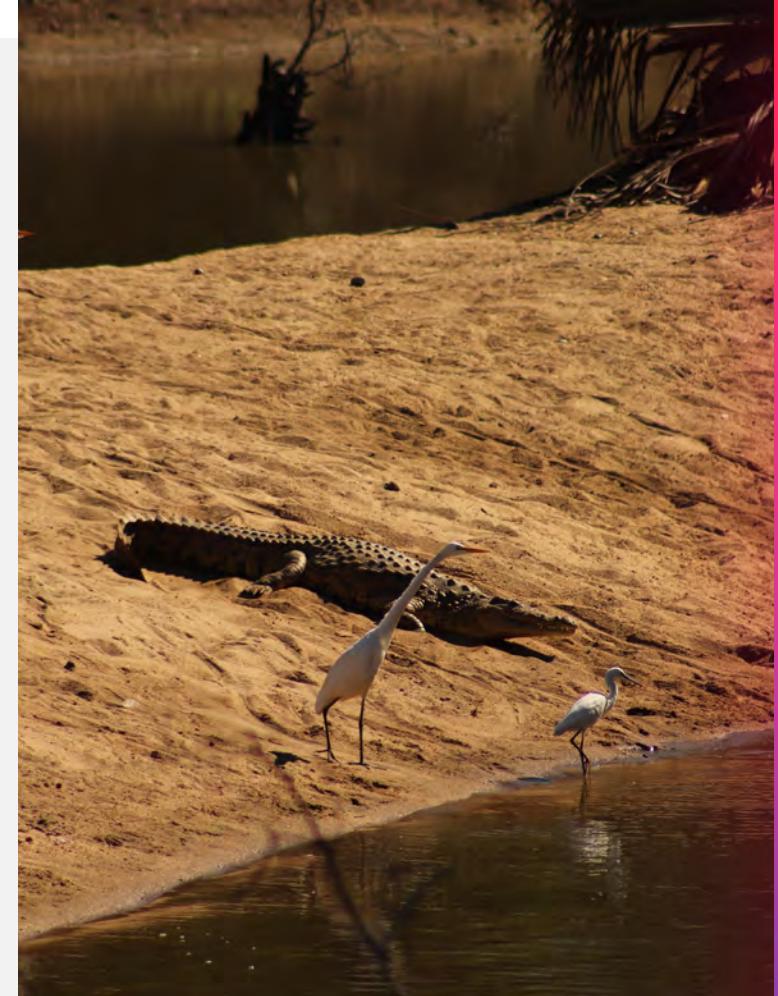




# Mejorando métodos analíticos

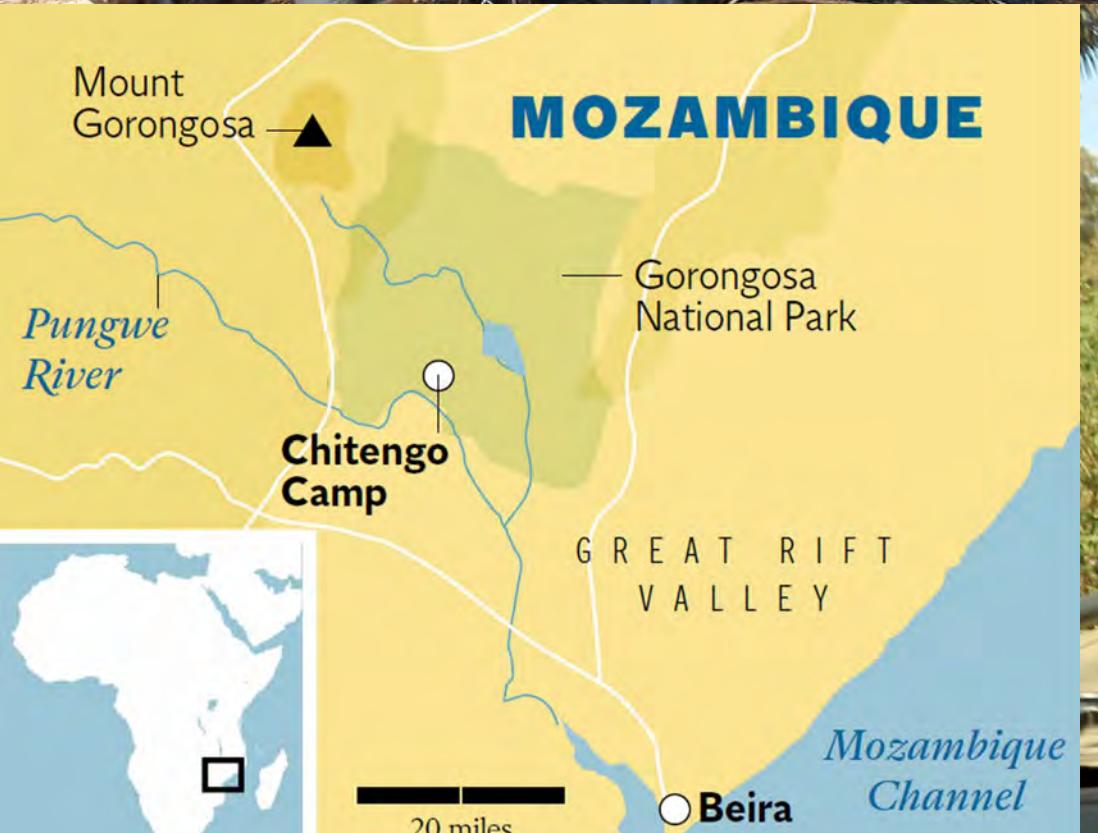
# Extrayendo más información de los fósiles



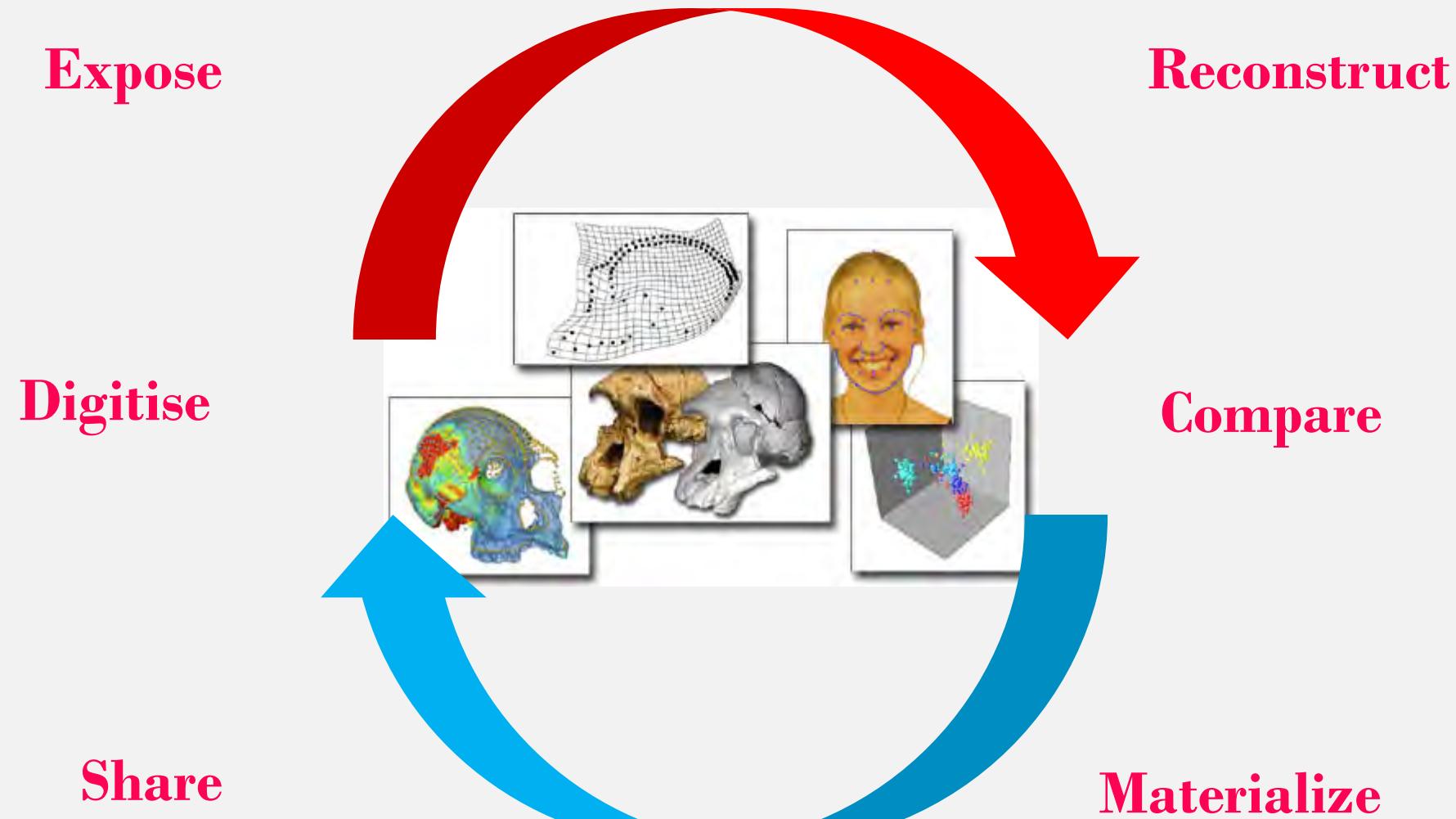


Hace un poco más de un año atrás...





# Virtual Palaeoanthropology workflow



# Digitalizar

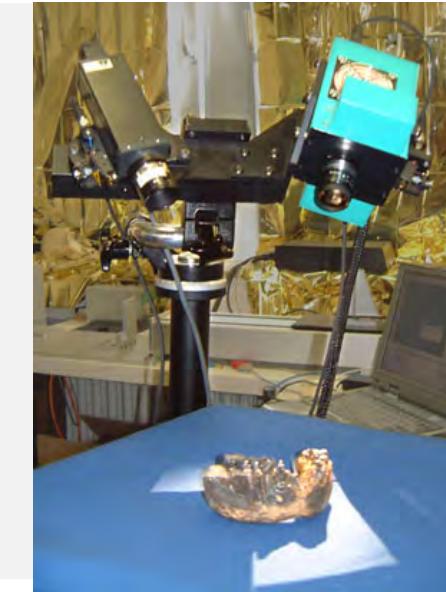
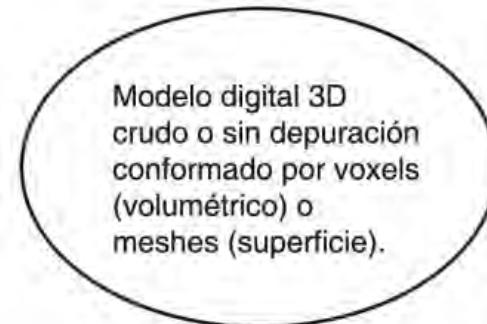
Input



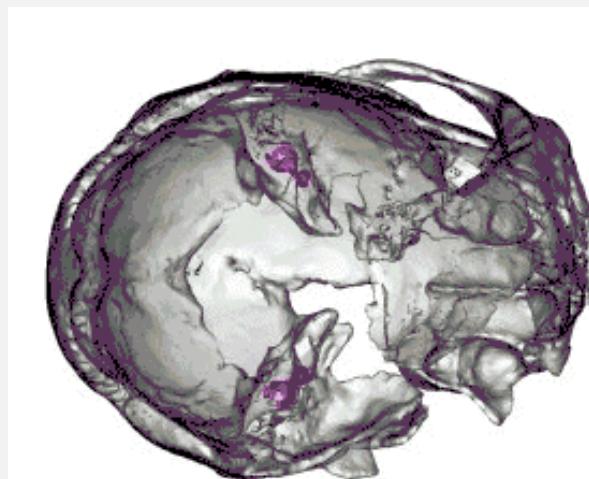
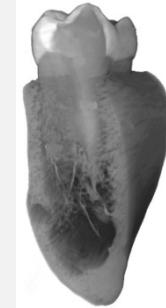
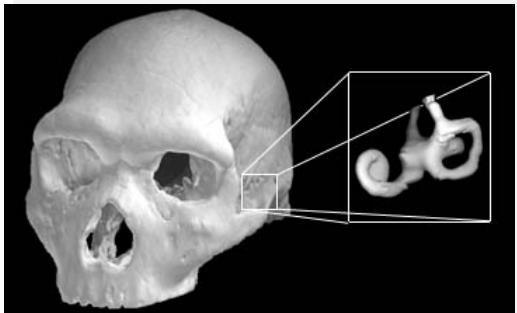
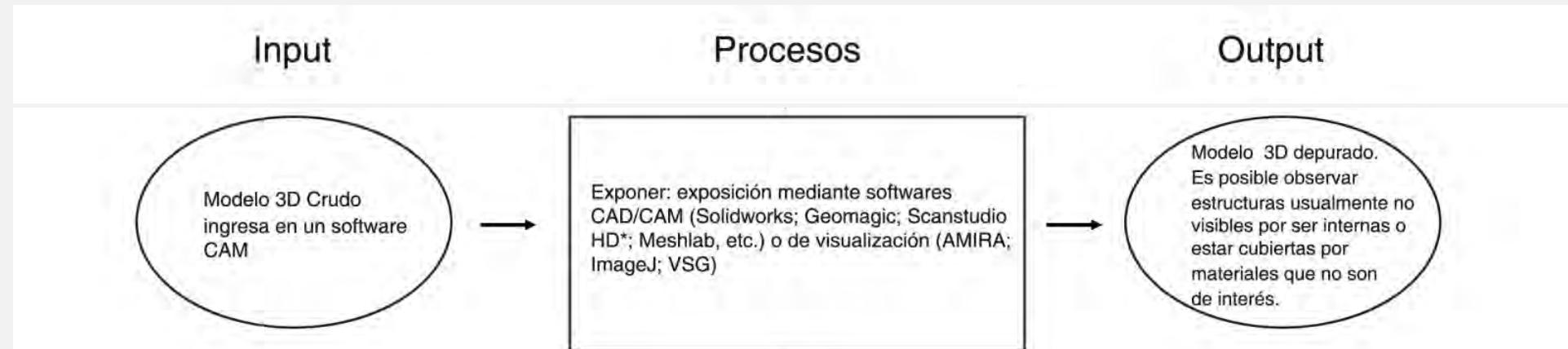
Procesos

Digitalizar: digitalización mediante escáneres:  
a) Volumétrico: CT-scans, IRM, PET, etc. B)  
Superficie: Laser\*, luz estructurada,  
fotogrametría, etc.

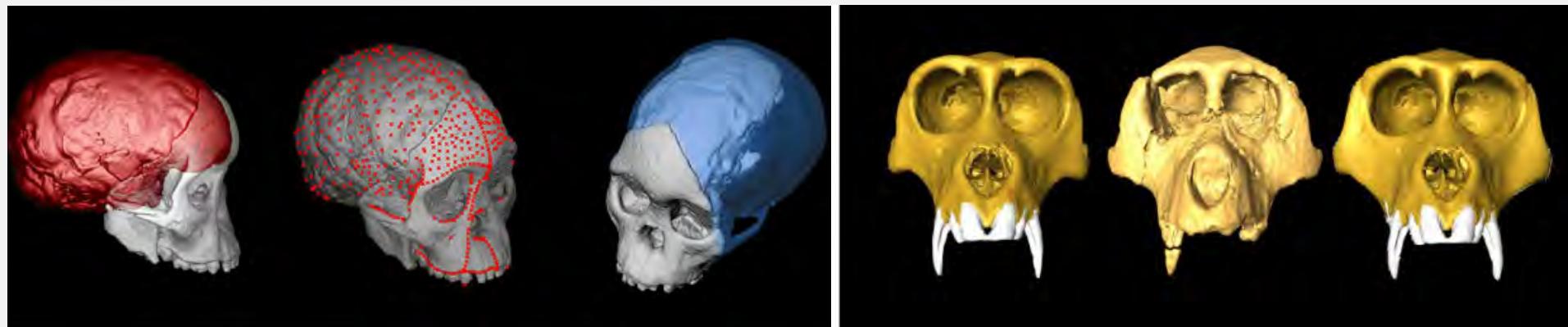
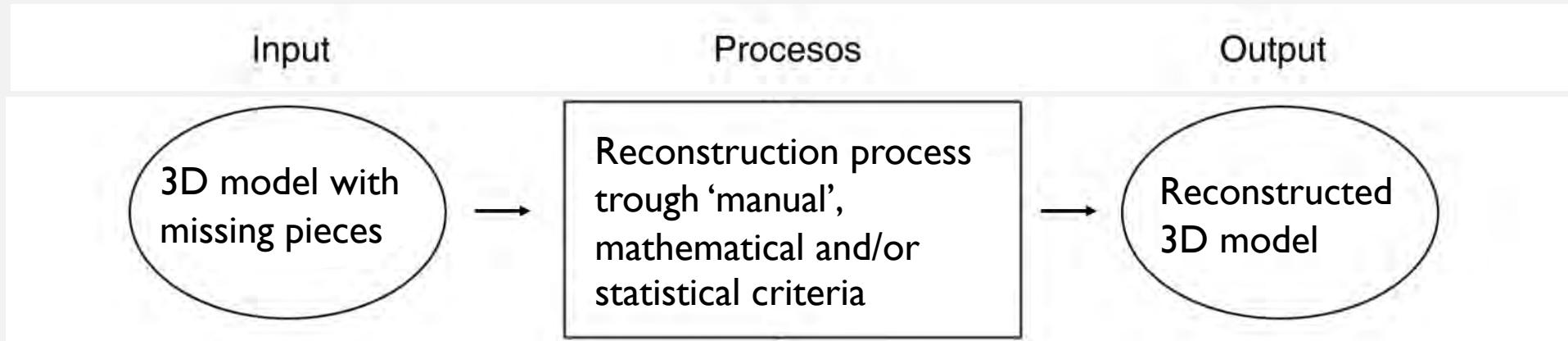
Output



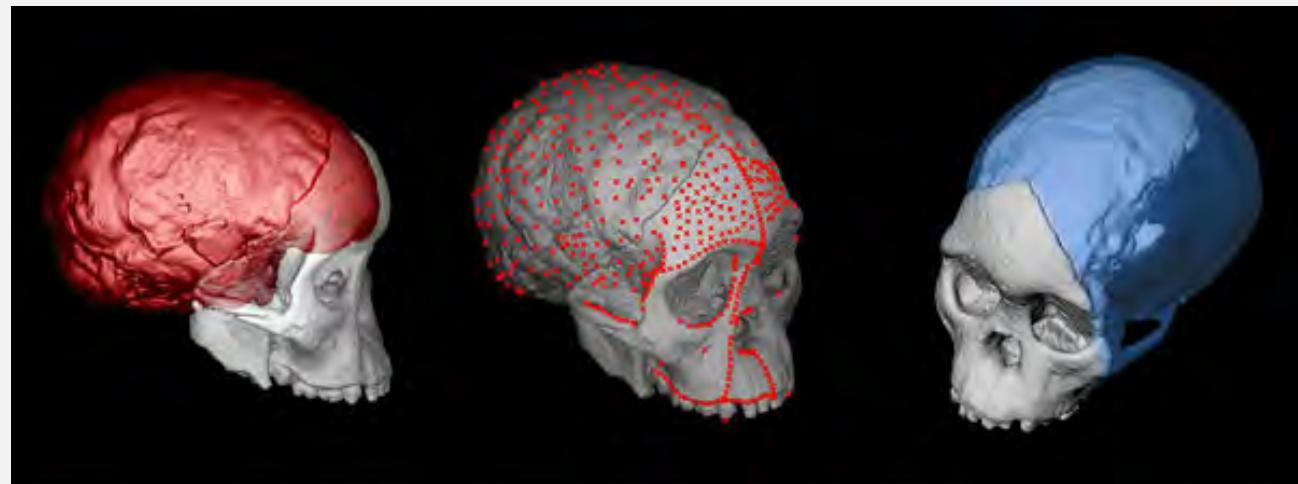
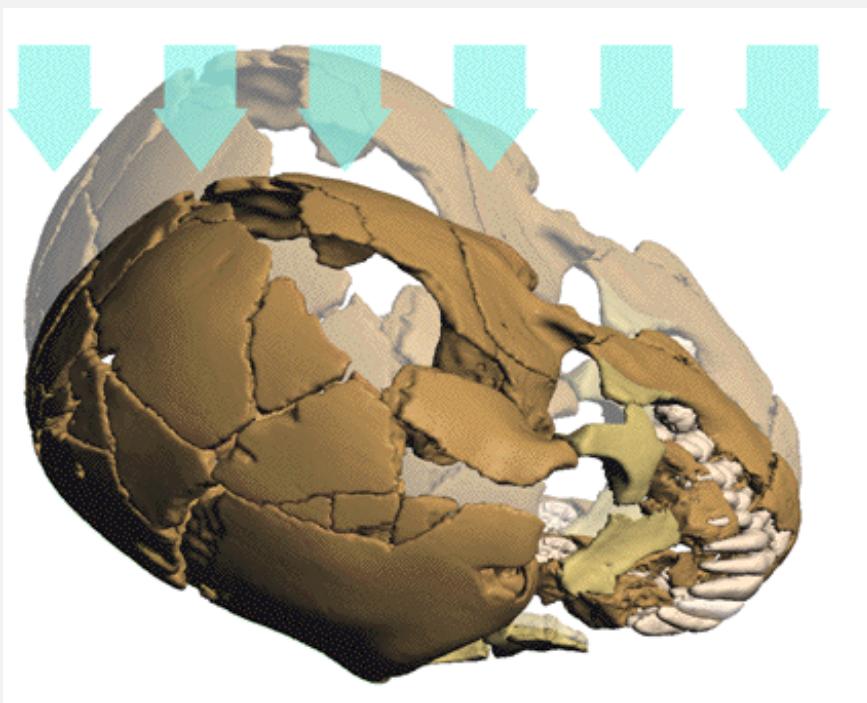
# Exponer



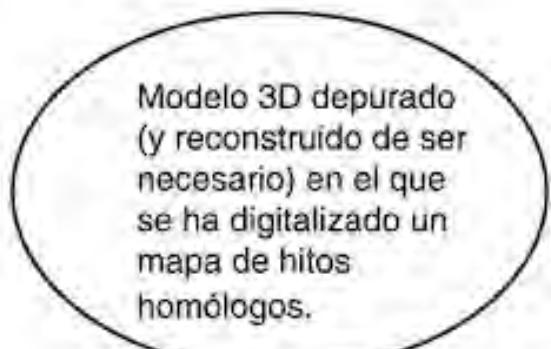
# Reconstruir



# Reconstruir



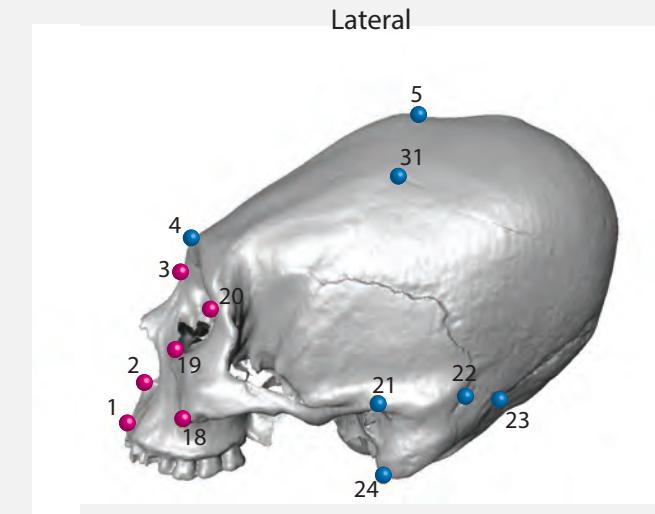
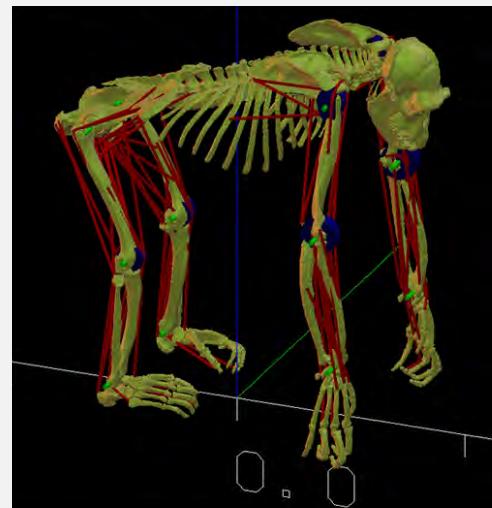
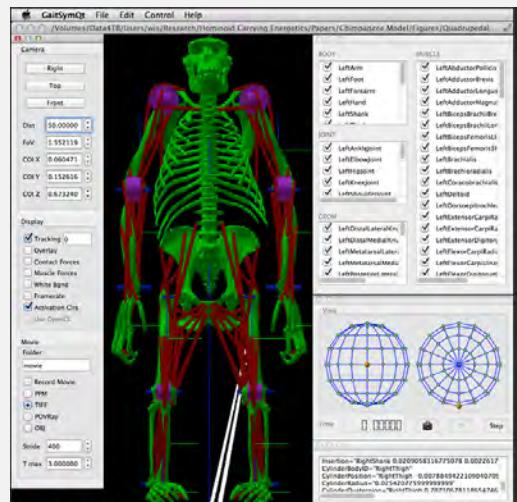
# Comparar



Comparar: análisis comparativo mediante:  
a) Morfometría Lineal (distancia interhitos)  
b) Morfometría Geométrica\* (análisis de Procrusteo y modelos lineales generalizados)  
c) Otros análisis: Biomécanicos (Análisis de elementos Finitos; Dinámicas de multicuerpos), Filogenéticos (Parsimonia, Máxima Verosimilitud, Bayesiano), Taxonómico, etc.

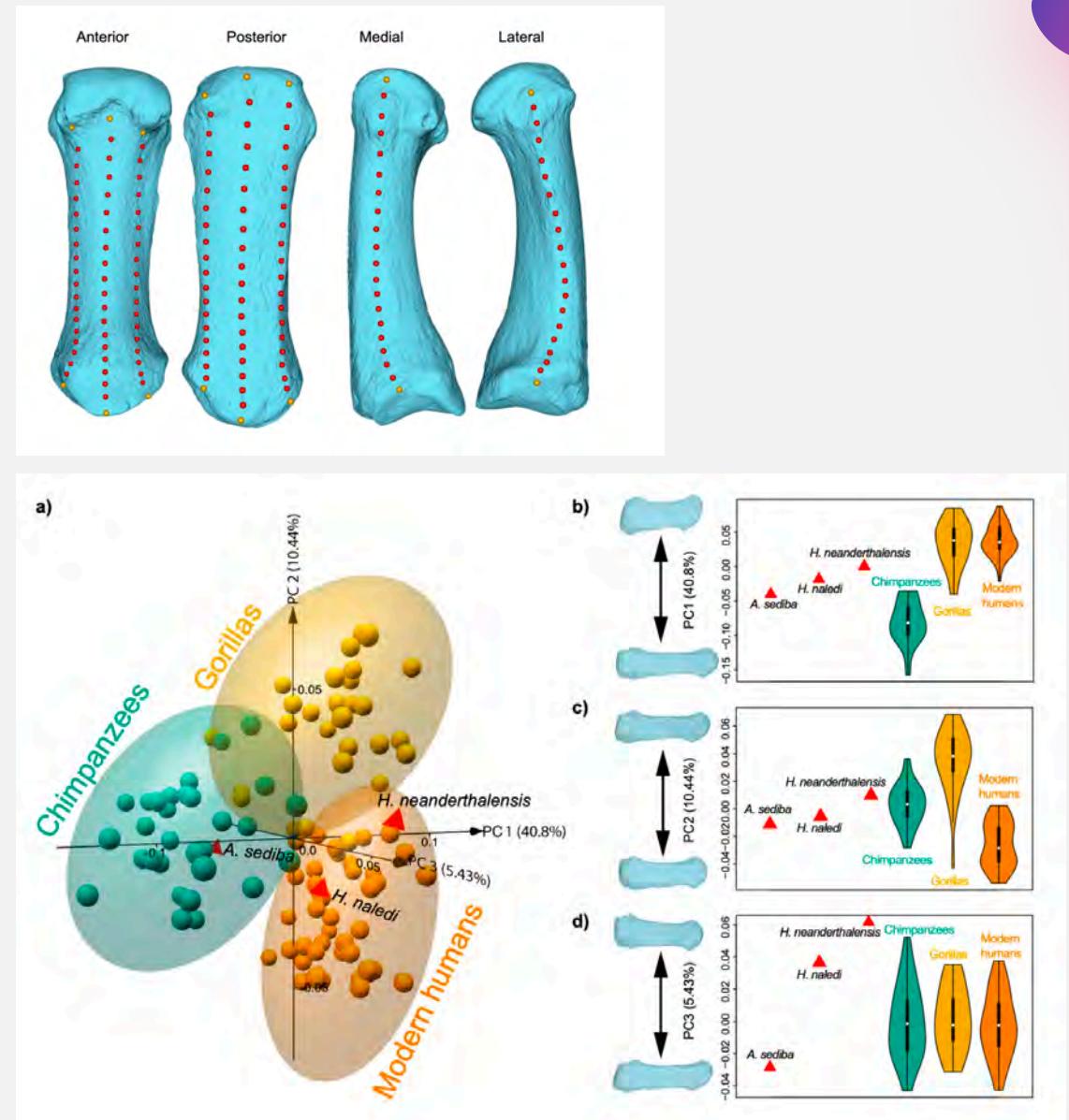


Resultados de los análisis y bases de datos



# Shape

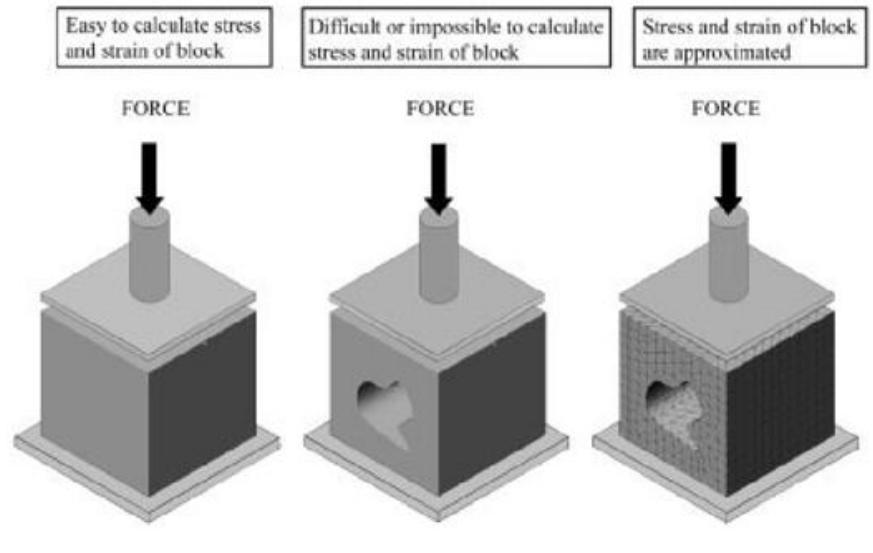
- **Geometric morphometrics (GM)** comprise a set of techniques for the analysis of form (i.e. shape and size) that utilise as primary data Cartesian coordinates rather than linear distances, angles, ratios or other measurements.
- GM has become the standard tool to quantify morphology in organismal biology.



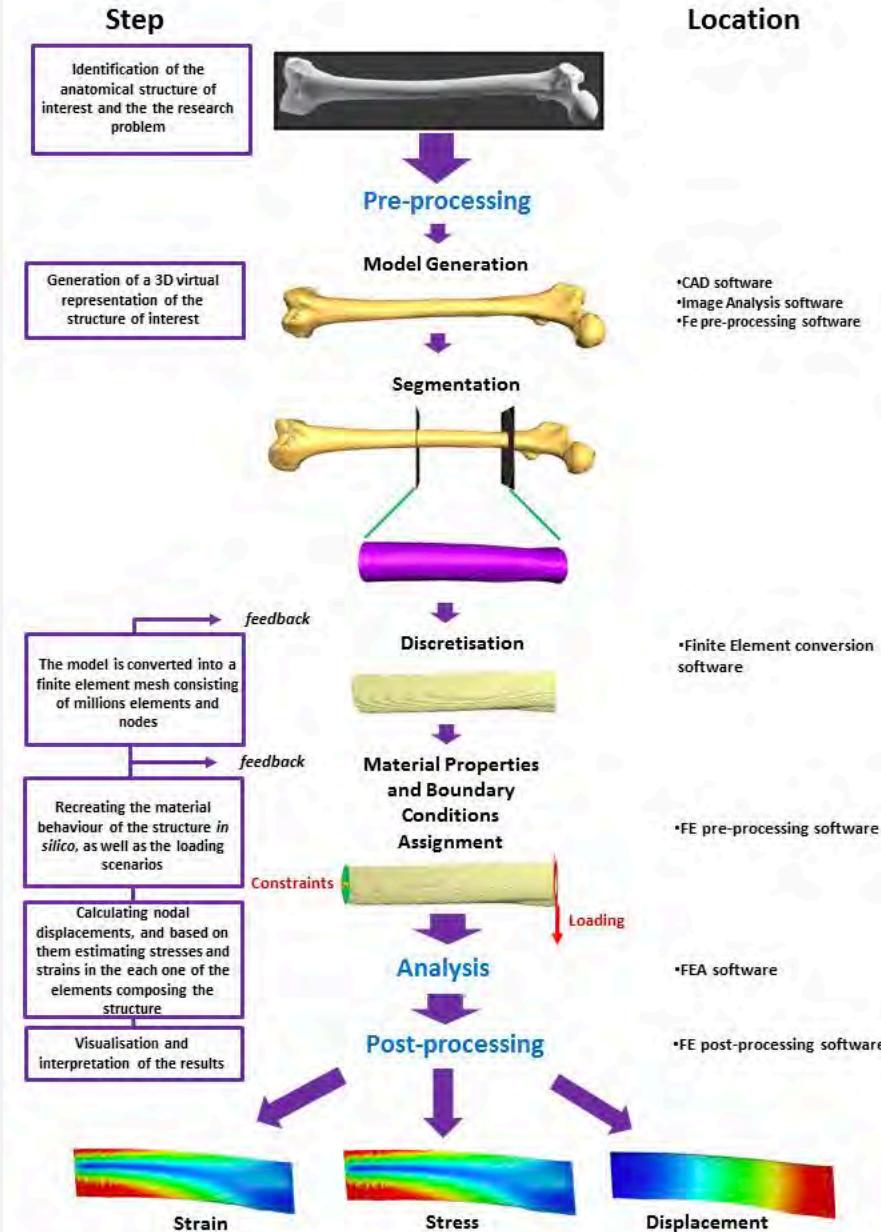
Morley, J., Bucchi, A., Lorenzo, C., and Püschel, T. A. (2020). Characterizing the body morphology of the first metacarpal in the Homininae using 3D geometric morphometrics. *bioRxiv*, 2020.04.30.070326. doi:[10.1101/2020.04.30.070326](https://doi.org/10.1101/2020.04.30.070326).

# Finite Element Analysis

**Finite Element Analysis (FEA)** is a general modelling technique that can be used for structural, thermal, fluid, and acoustic analyses, amongst others.



Richmond, B. G., Wright, B. W., Grosse, I., Dechow, P. C., Ross, C. F., Spencer, M. A., et al. (2005). Finite element analysis in functional morphology. *The Anatomical Record Part A: Discoveries in Molecular, Cellular, and Evolutionary Biology* 283A, 259–274.  
doi:[10.1002/ar.a.20169](https://doi.org/10.1002/ar.a.20169).

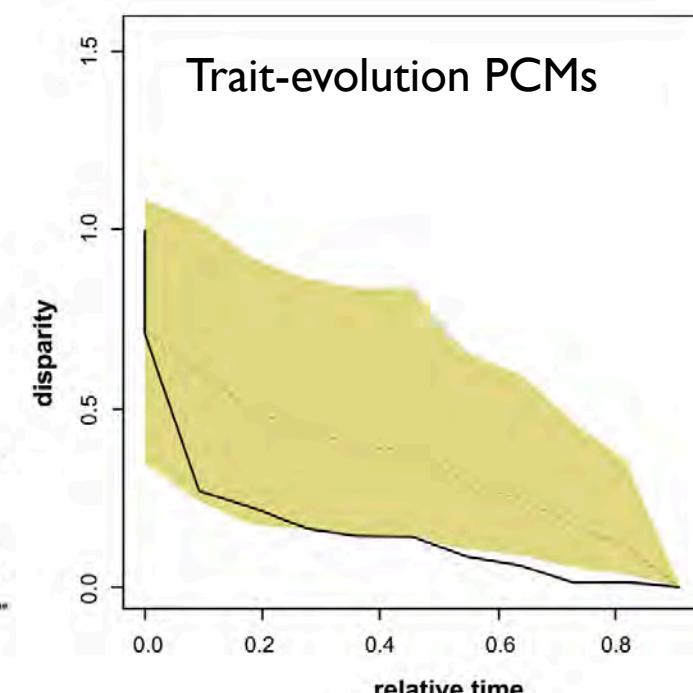
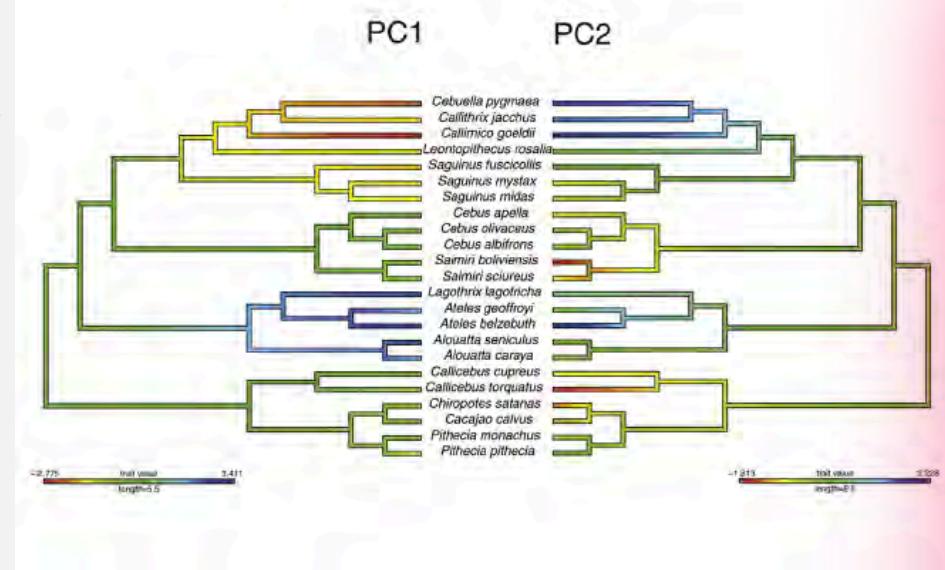
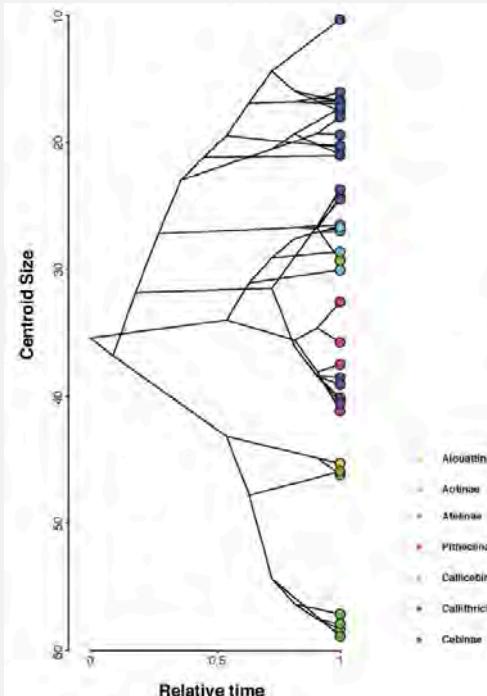


Püschel, T. A. (2012). Biomechanical modelling of Human Femora: a comparison between Agriculturalists and Hunter-Gatherers using FEA, GMM and Beam Theory.

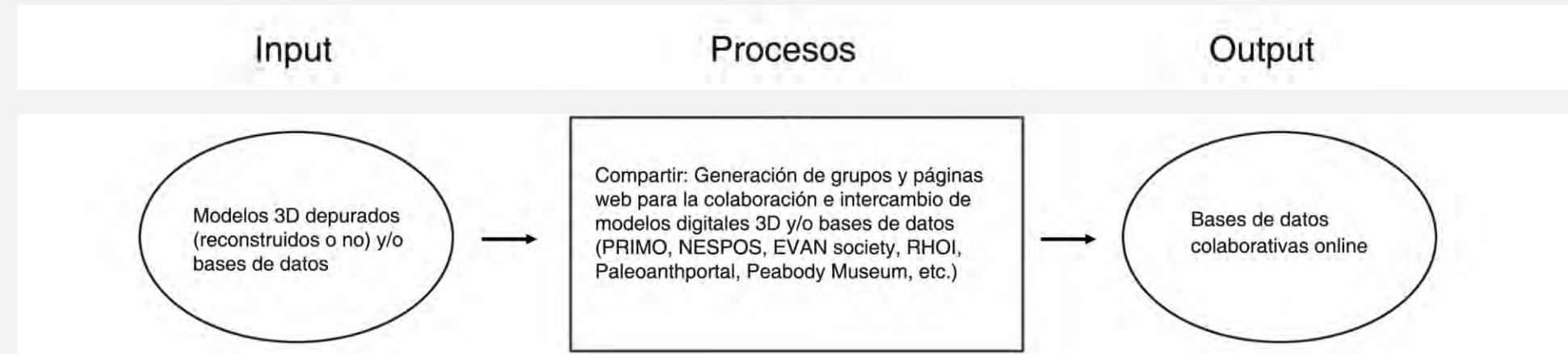
# Phylogenetic comparative methods (PCMs)

- Modern phylogenetic comparative methods (PCMs) area series of statistical procedures applied to analyse phylogenetic trees, and frequently, their association with trait/phenotypic data.
- Currently there are two main sub-families of methods within the PCMs, which can be broadly classified as those focused on **trait evolution** and those used to investigate **lineage diversification**.

Püschel, T. A., Gladman, J. T., Bobe, R. & Sellers, W. I. The evolution of the platyrhine talus: A comparative analysis of the phenetic affinities of the Miocene platyrhines with their modern relatives. *Journal of Human Evolution* 111, 179–201 (2017).



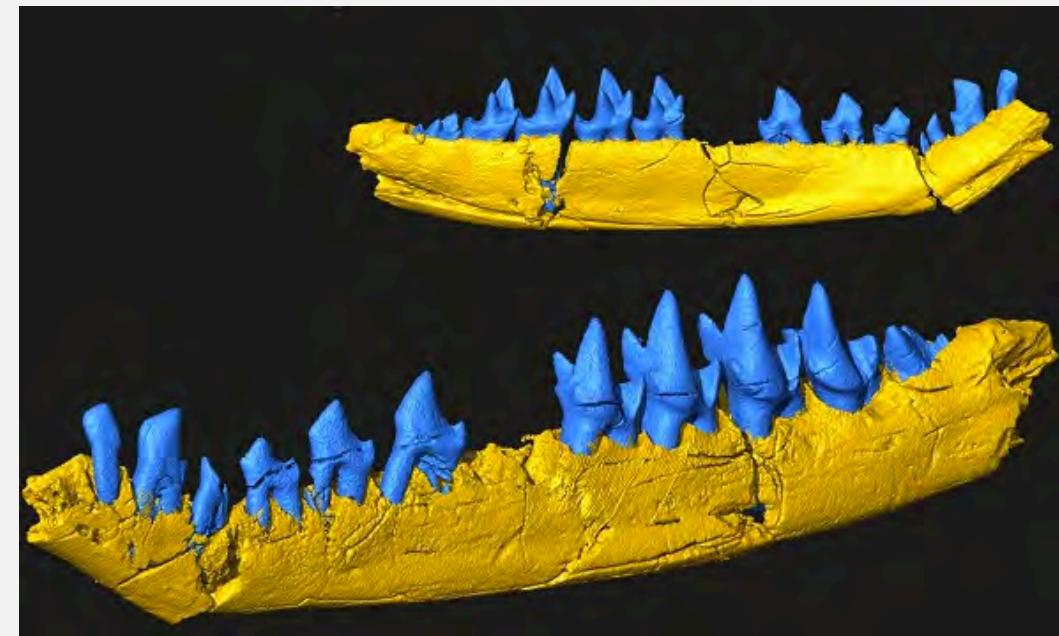
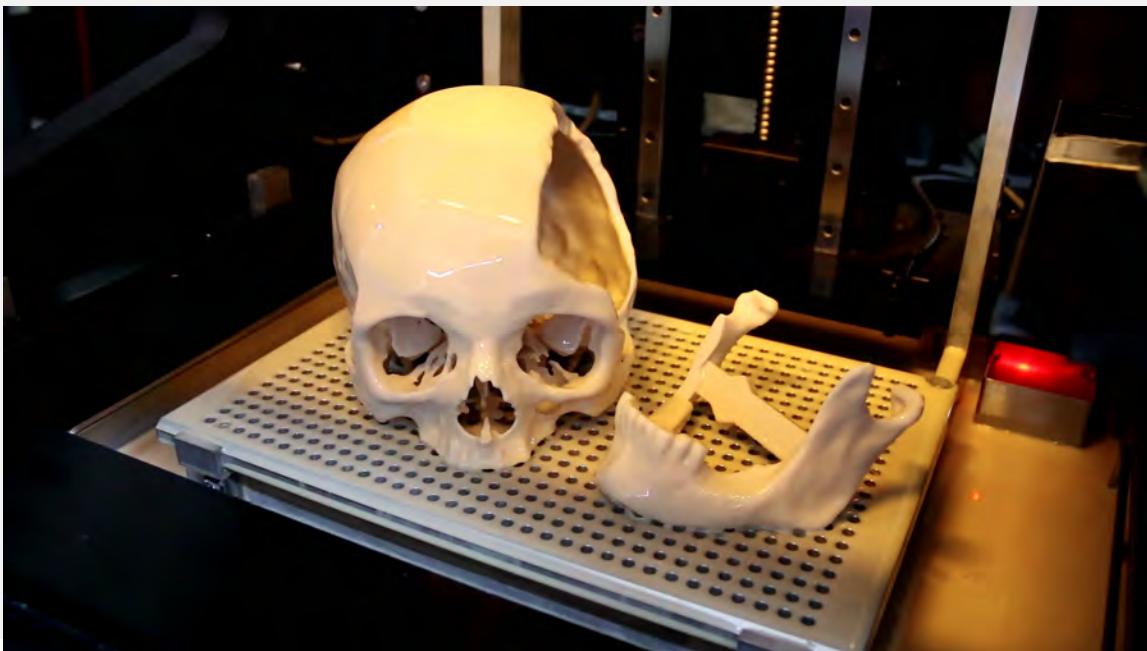
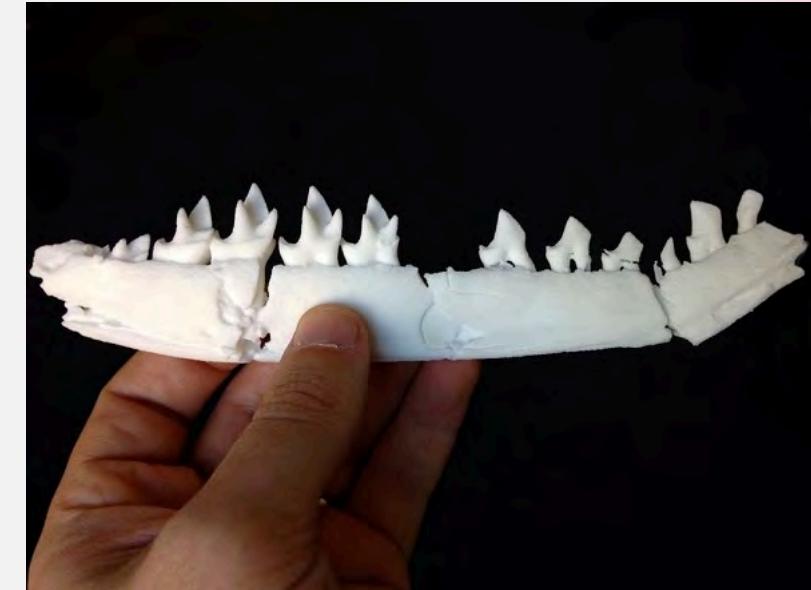
# Compartir



**Sketchfab**

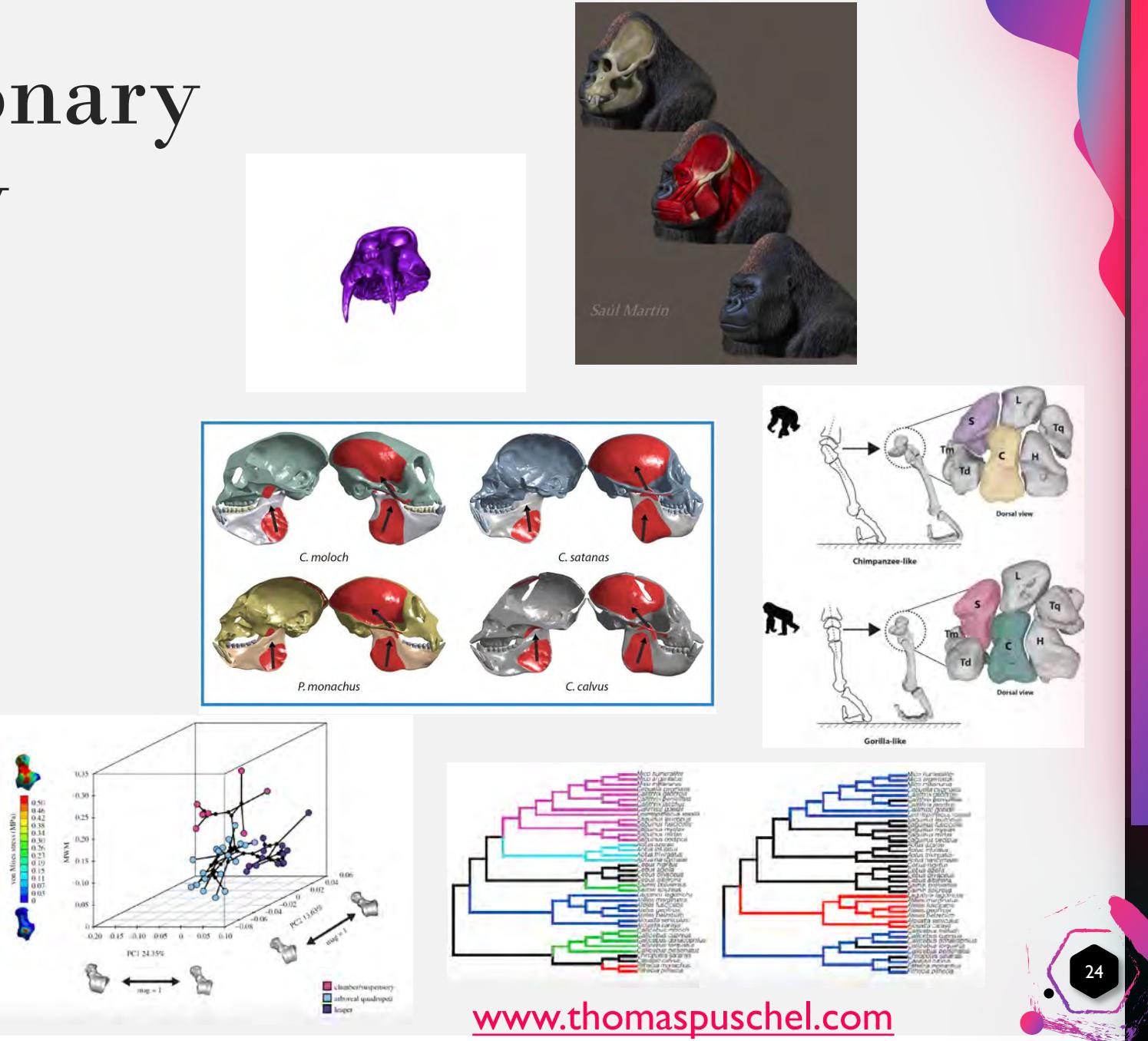


# Materizar



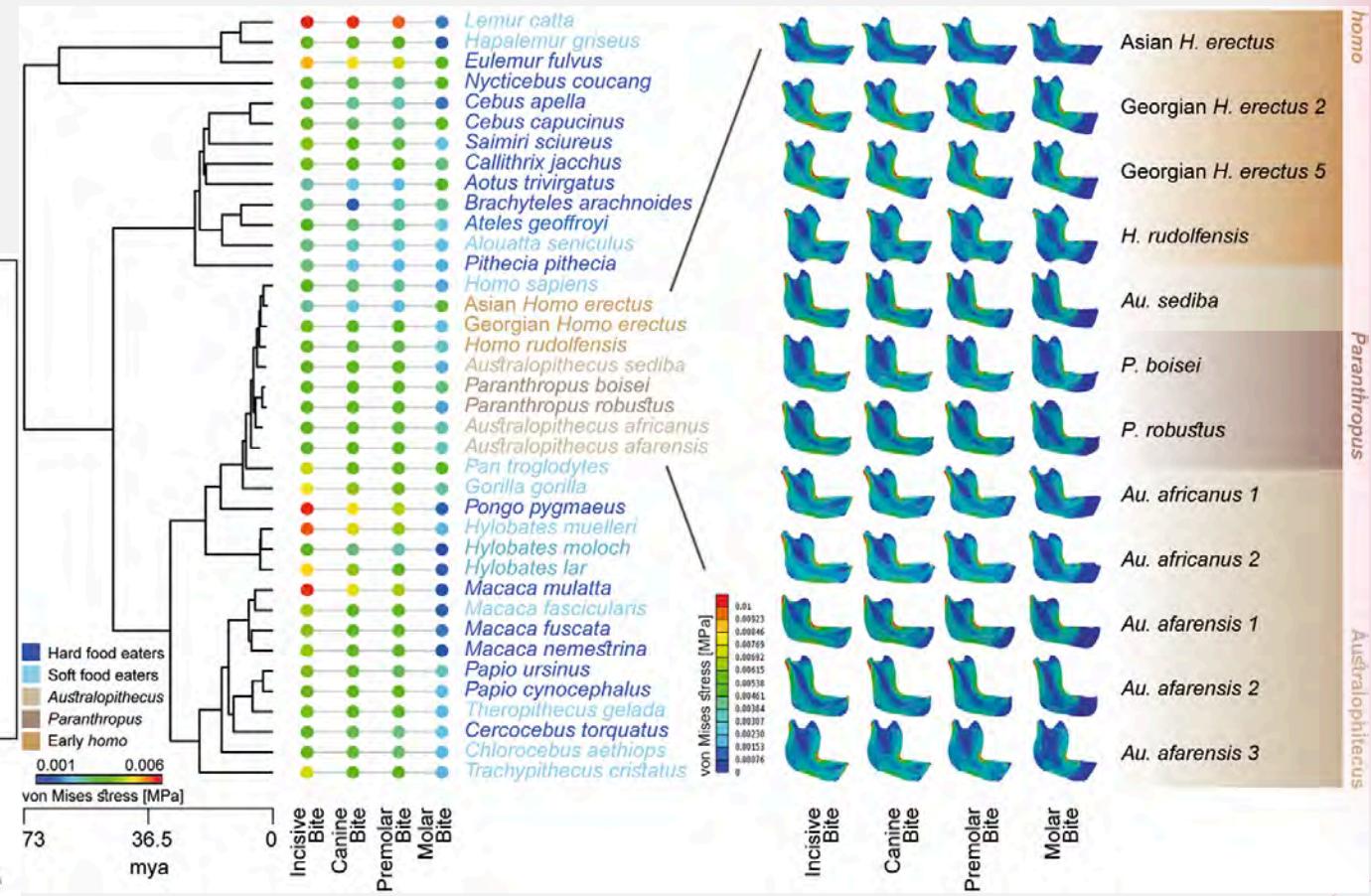
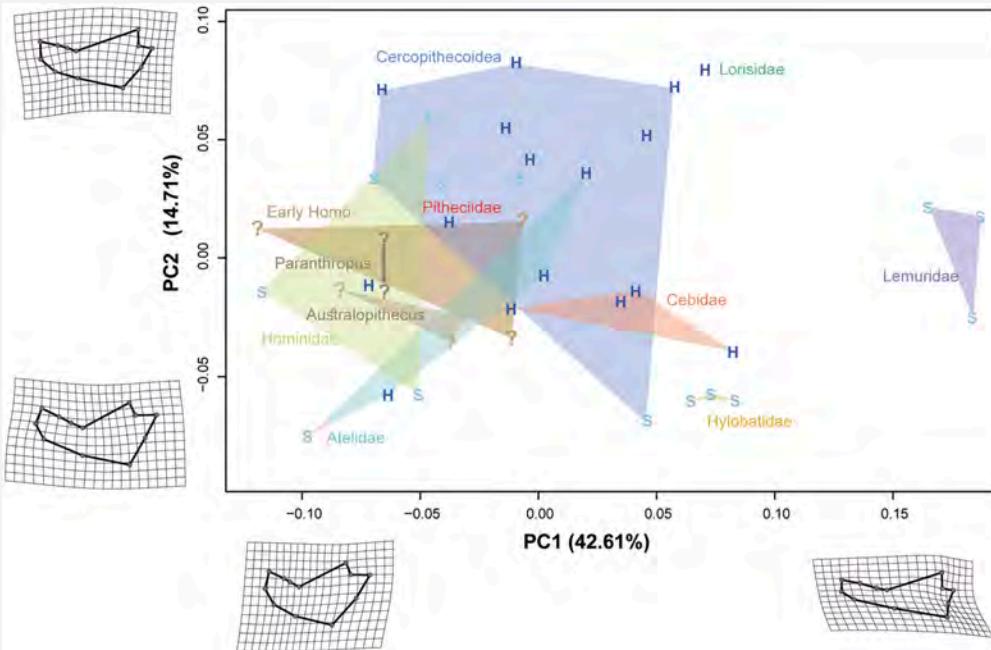
# Primate evolutionary morphology

- Anatomy
- Functional morphology/biomechanics
- Phylogenetic comparative methods



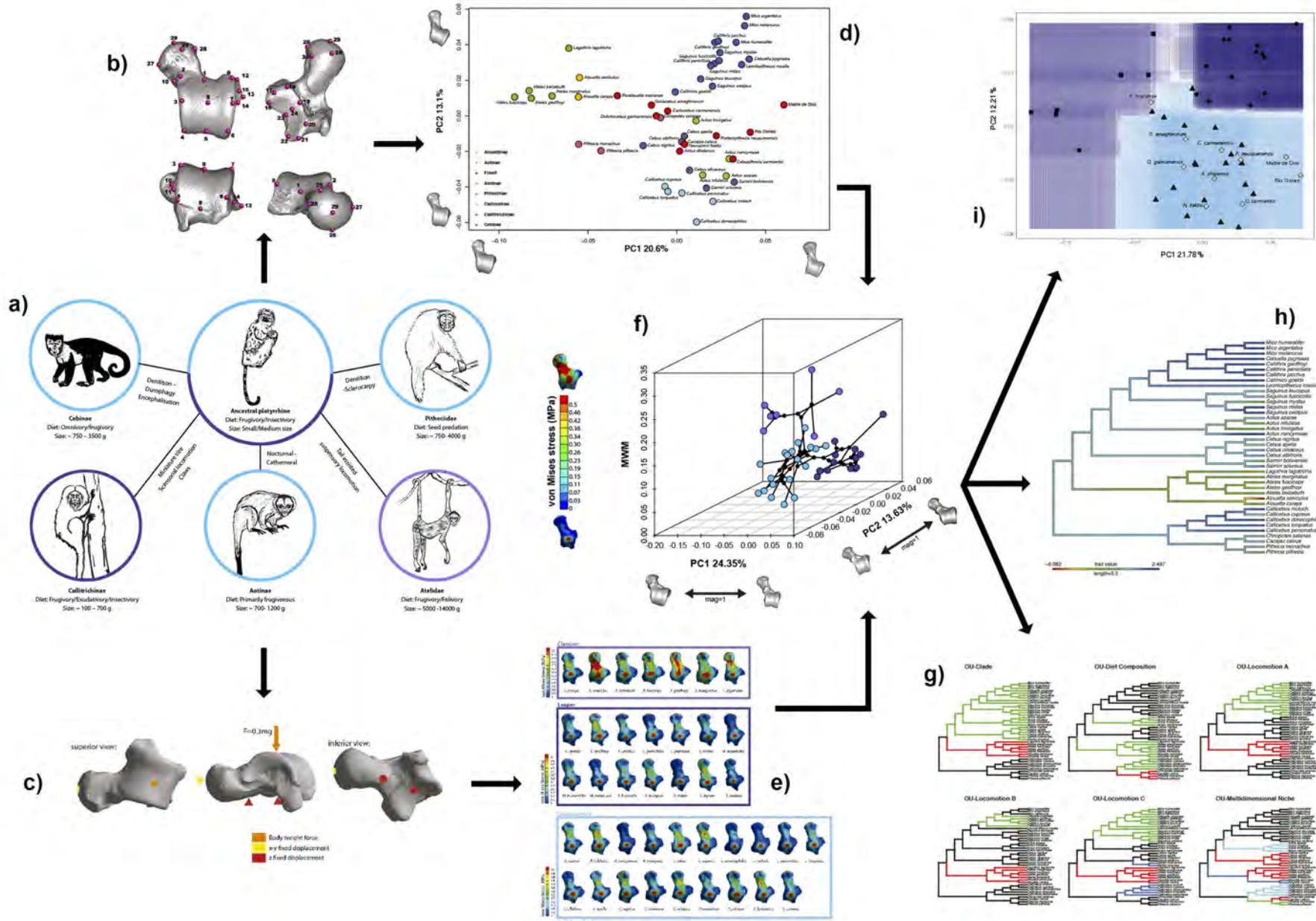
# Approaches combining FEA and GM

GM and FEA combined by analysing their results using multivariate statistical tools



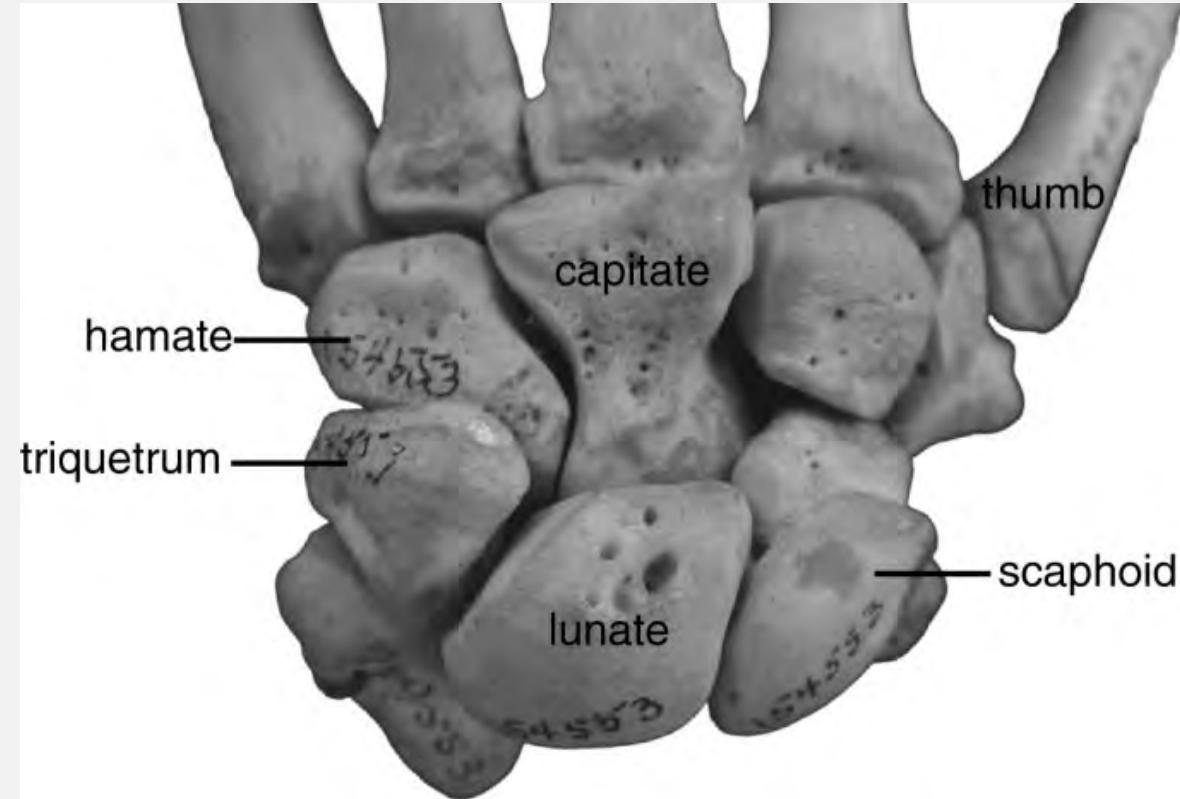
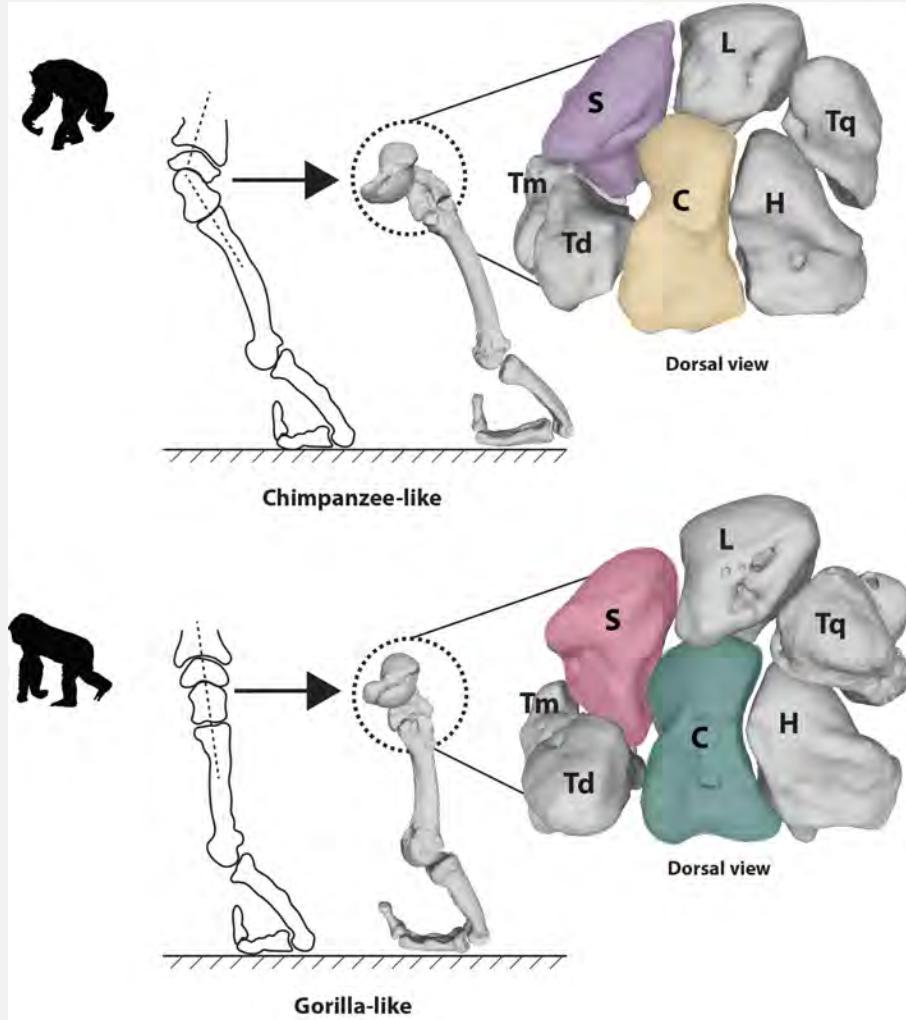
Marcé-Nogué, J., Püschel, T. A., Daasch, A., and Kaiser, T. M. (2020). Broad-scale morpho-functional traits of the mandible suggest no hard food adaptation in the hominin lineage. *Sci Rep* 10, 1–11. doi:[10.1038/s41598-020-63739-5](https://doi.org/10.1038/s41598-020-63739-5).

# A possible workflow



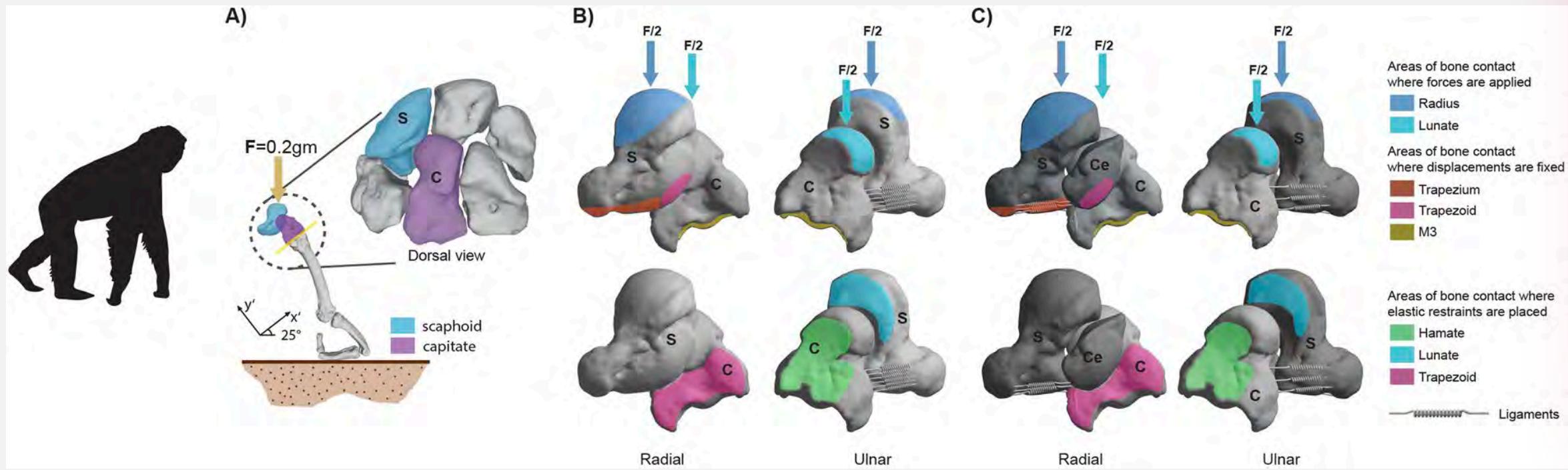
Püschel, T. A. (2017). Morpho-functional analyses of the primate skeleton: applying 3D geometric morphometrics, finite element analysis and phylogenetic comparative methods to assess ecomorphological questions in extant and extinct anthropoids.

# Example: The scaphoid-centrale fusion

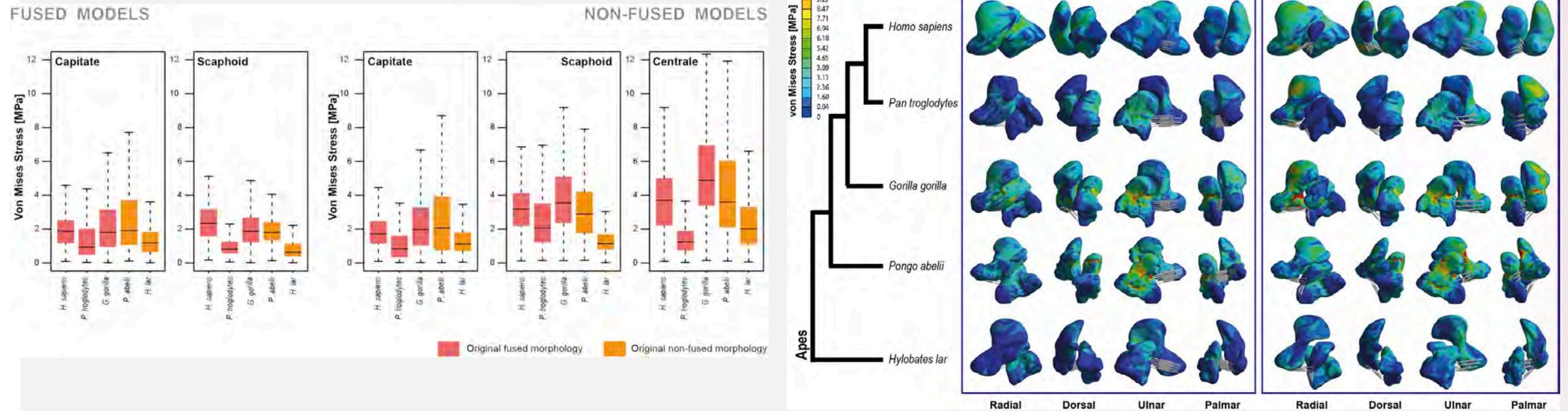


Püschel, T. A., Marcé-Nogué, J., Chamberlain, A. T., Yoxall, A., & Sellers, W. I. (2020). The biomechanical importance of the scaphoid-centrale fusion during simulated knuckle-walking and its implications for human locomotor evolution. *Scientific Reports*, 10(1), 1–7. <https://doi.org/10.1038/s41598-020-60590-6>

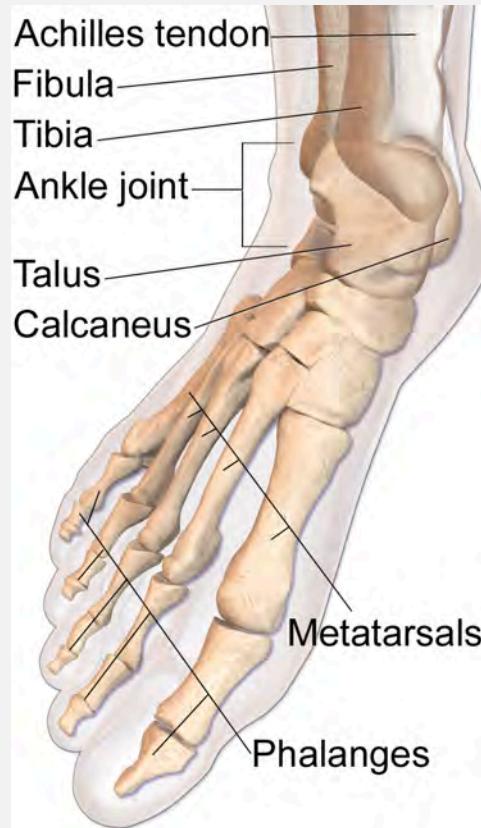
# Biomechanical simulation



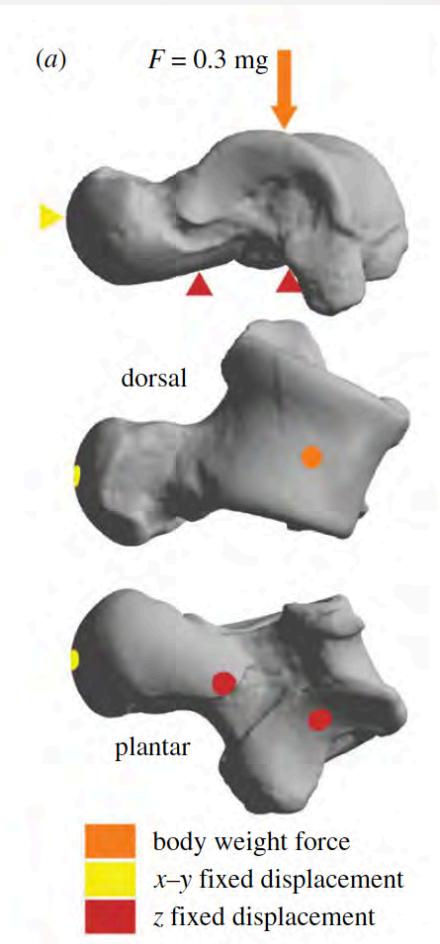
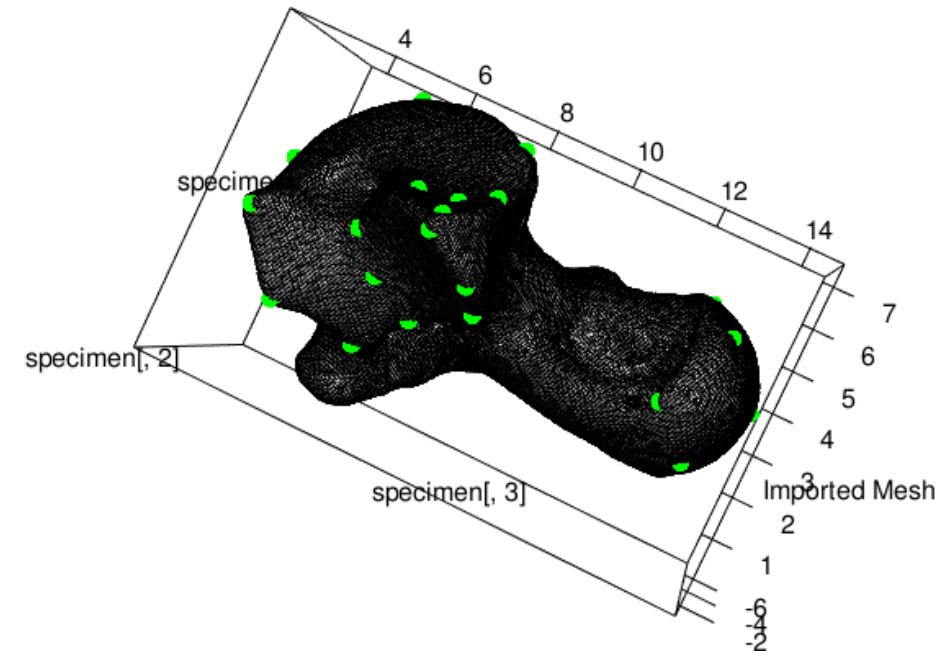
# Biomechanical results



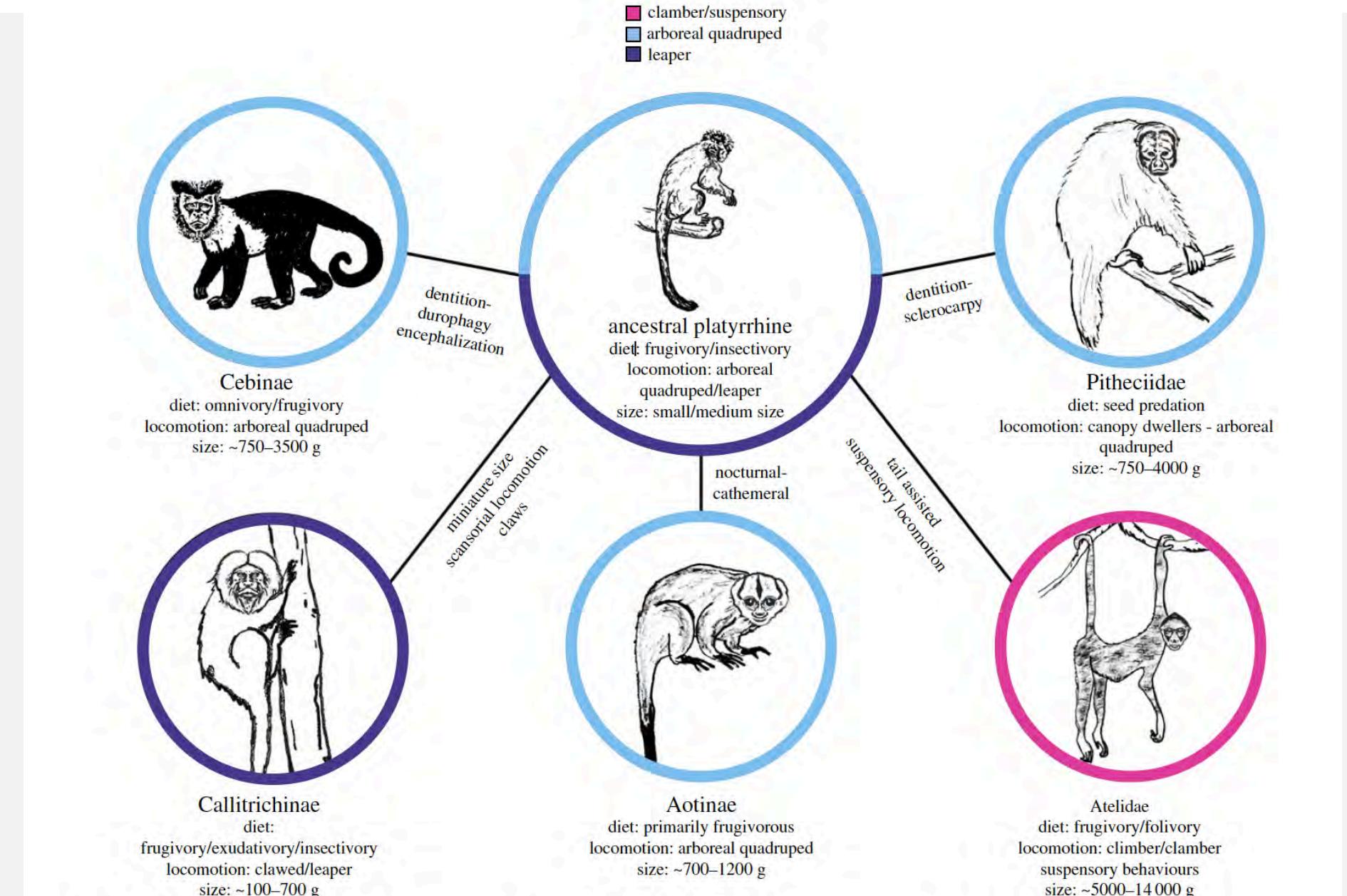
# Example: the platyrhine talus



Lower Leg and Foot

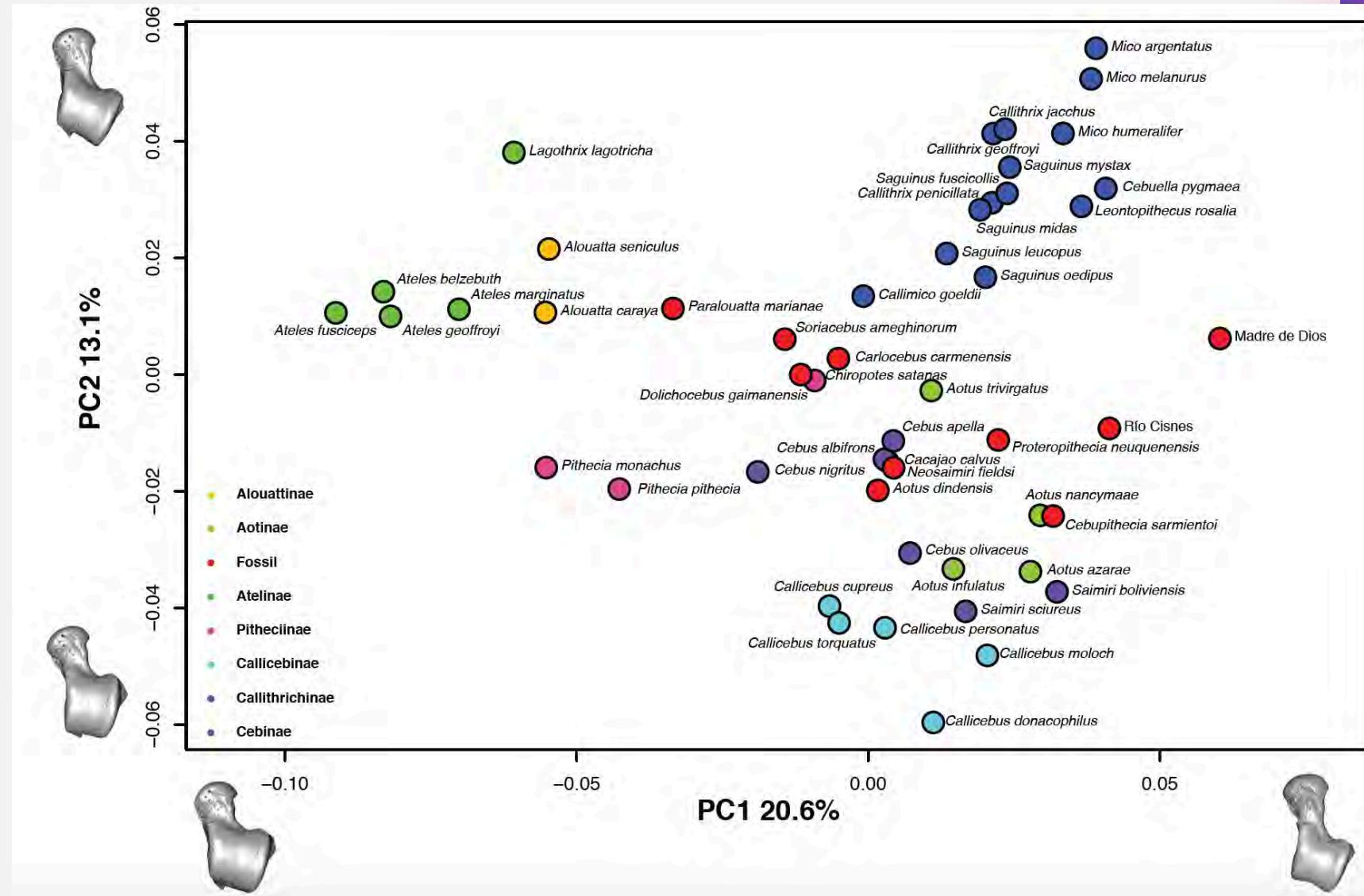


Püschel, T. A., Marcé-Nogué, J., Gladman, J. T., Bobe, R. & Sellers, W. I. Inferring locomotor behaviours in Miocene New World monkeys using finite element analysis, geometric morphometrics and machine-learning classification techniques applied to talar morphology. *Journal of The Royal Society Interface* **15**, 20180520 (2018).



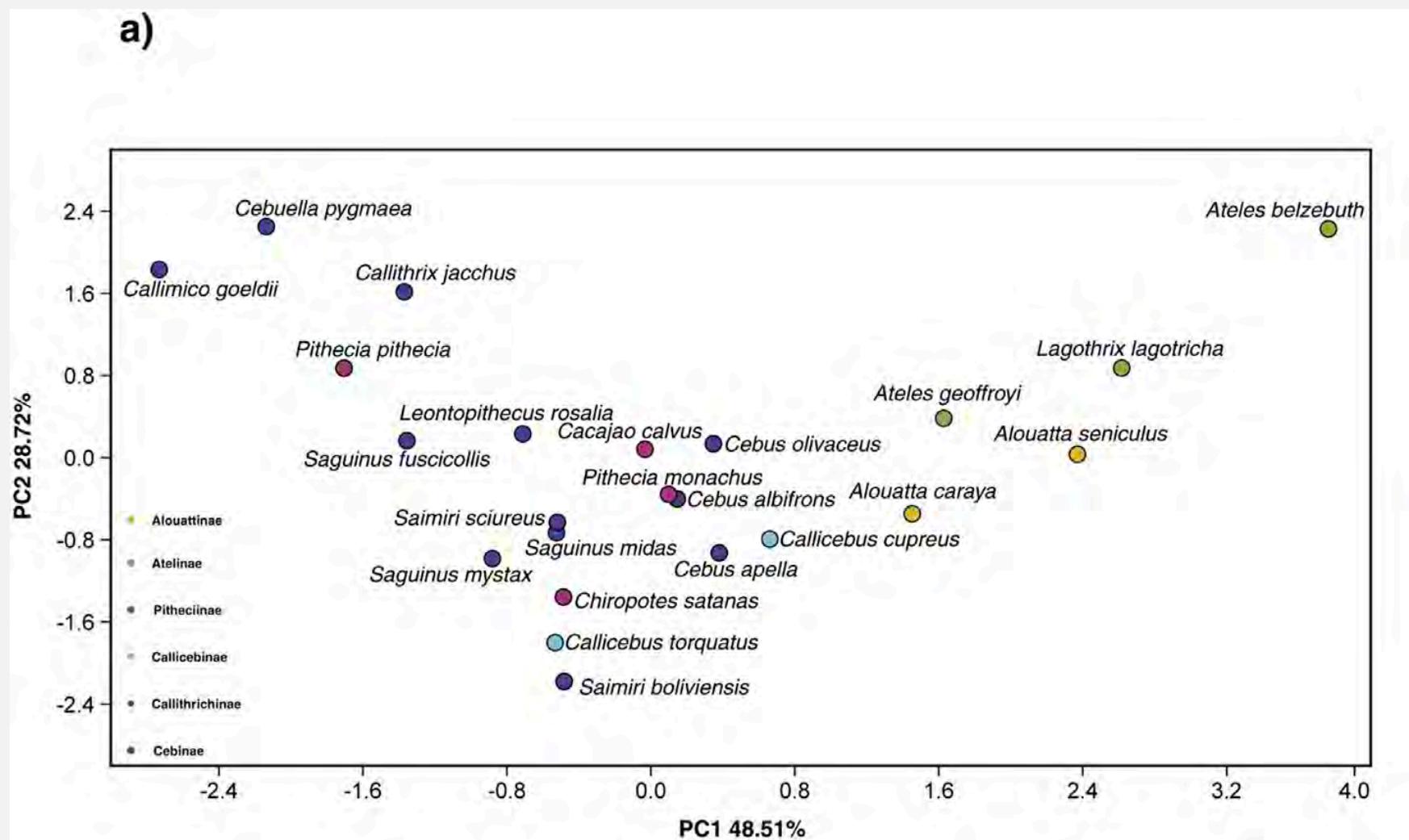
Püschel, T. A., Marcé-Nogué, J., Gladman, J. T., Bobe, R. & Sellers, W. I. Inferring locomotor behaviours in Miocene New World monkeys using finite element analysis, geometric morphometrics and machine-learning classification techniques applied to talar morphology. *Journal of The Royal Society Interface* **15**, 20180520 (2018).

# PCA: Shape



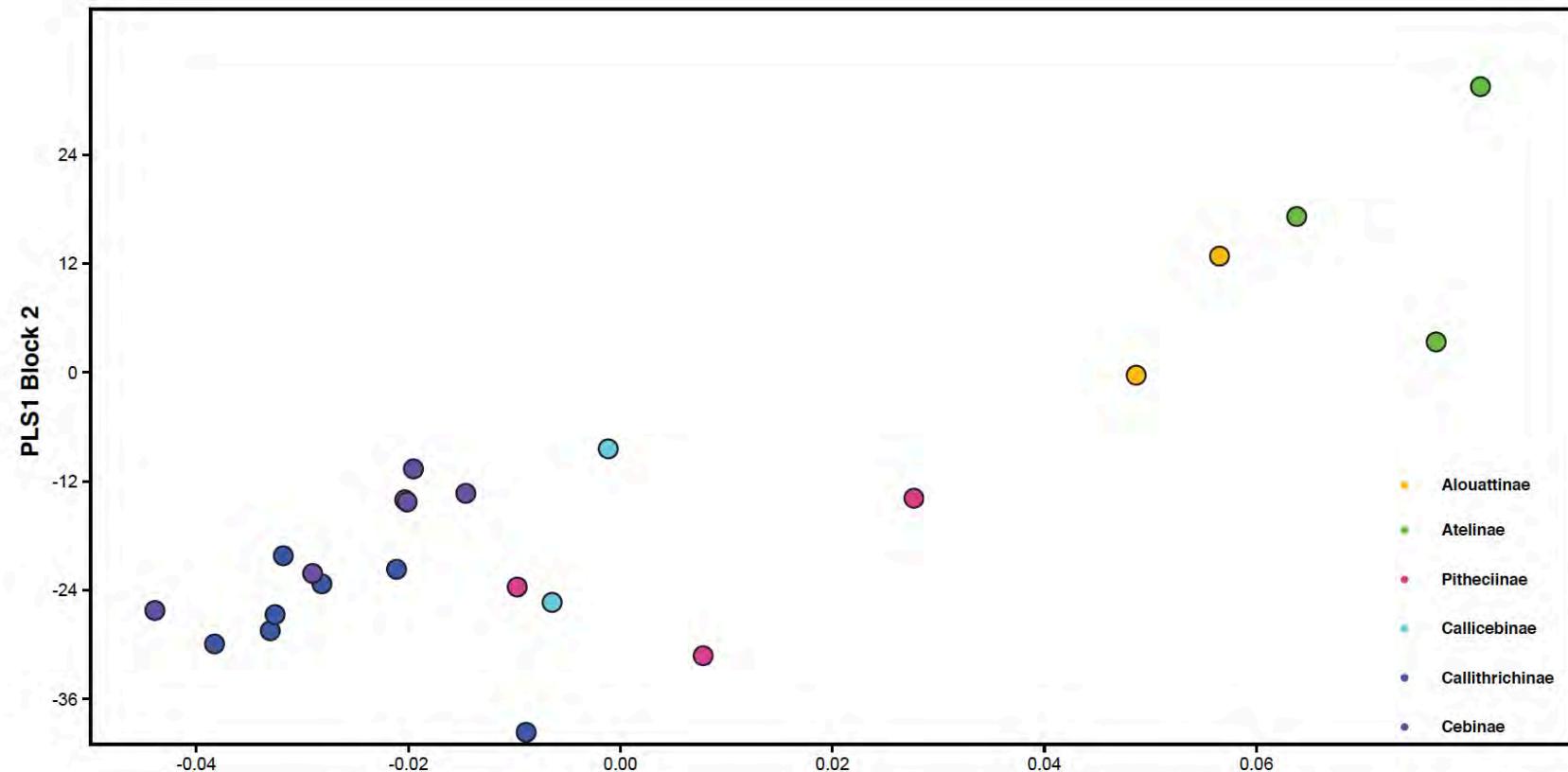
Püschel, T. A., Gladman, J. T., Bobe, R. & Sellers, W. I. The evolution of the platyrhine talus: A comparative analysis of the phenetic affinities of the Miocene platyrhines with their modern relatives. *Journal of Human Evolution* **111**, 179–201 (2017).

# PCA: Locomotor data



Püschel, T. A., Gladman, J. T., Bobe, R. & Sellers, W. I. The evolution of the platyrhine talus: A comparative analysis of the phenetic affinities of the Miocene platyrhines with their modern relatives. *Journal of Human Evolution* 111, 179–201 (2017).

# PLS: shape and locomotor data



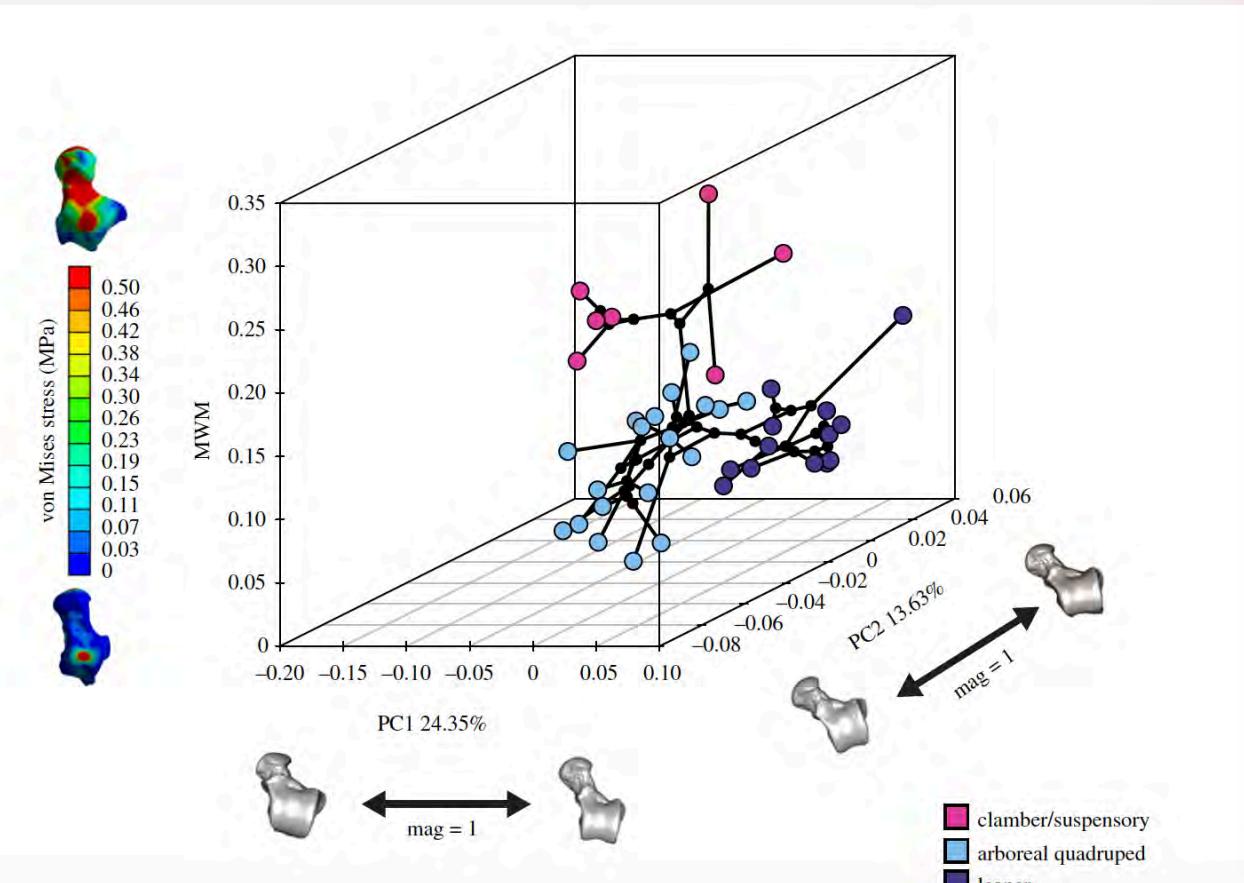
r-PLS: 0.84; p-value:  
0.0022; 10,000  
permutations



PLS1 Block 1



Püschel, T. A., Gladman, J. T., Bobe, R. & Sellers, W. I. The evolution of the platyrhine talus: A comparative analysis of the phenetic affinities of the Miocene platyrhines with their modern relatives. *Journal of Human Evolution* **111**, 179–201 (2017).



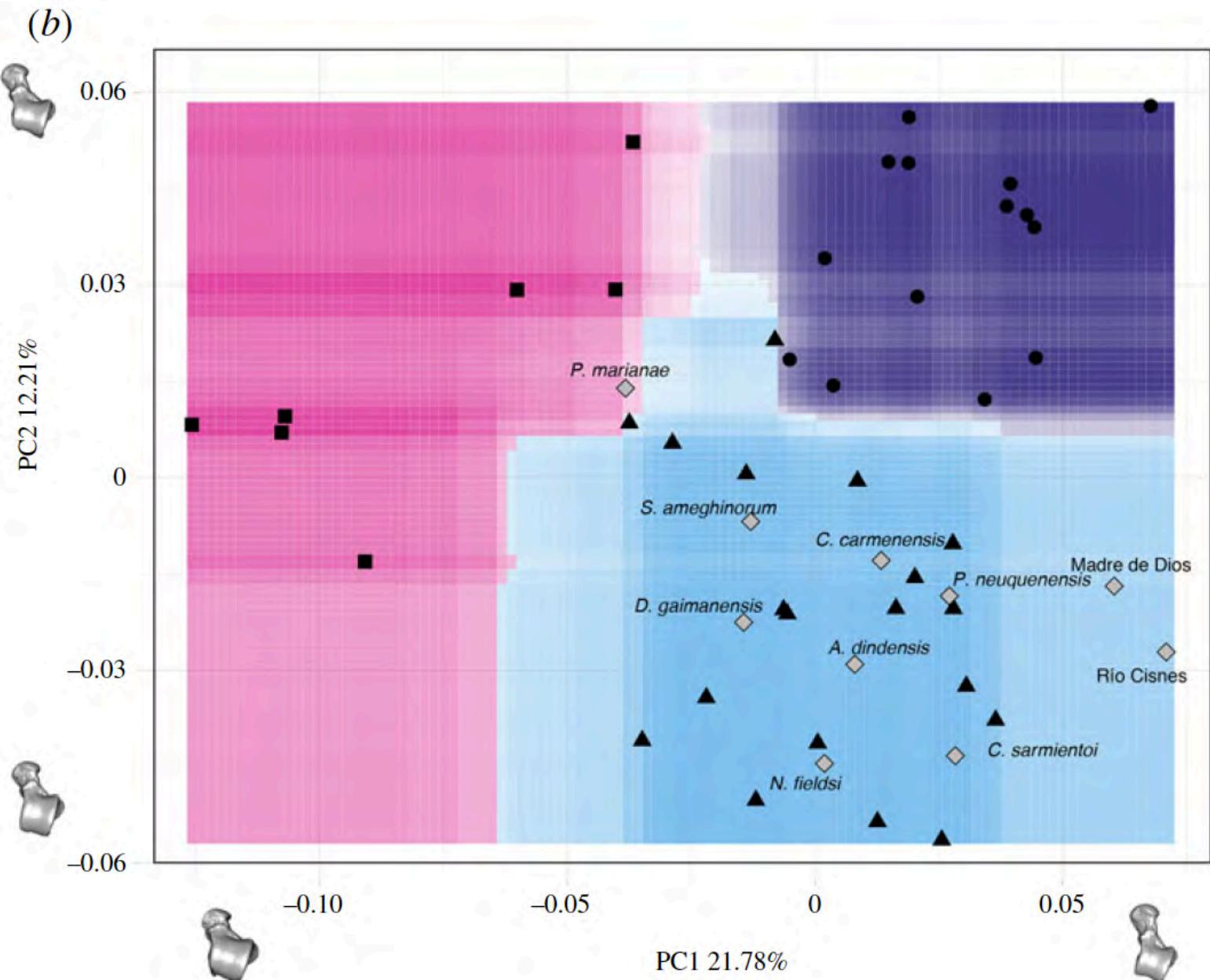
Püschel, T. A., Marcé-Nogué, J., Gladman, J. T., Bobe, R. & Sellers, W. I. Inferring locomotor behaviours in Miocene New World monkeys using finite element analysis, geometric morphometrics and machine-learning classification techniques applied to talar morphology. *Journal of The Royal Society Interface* 15, 20180520 (2018).

(b)

## locomotion

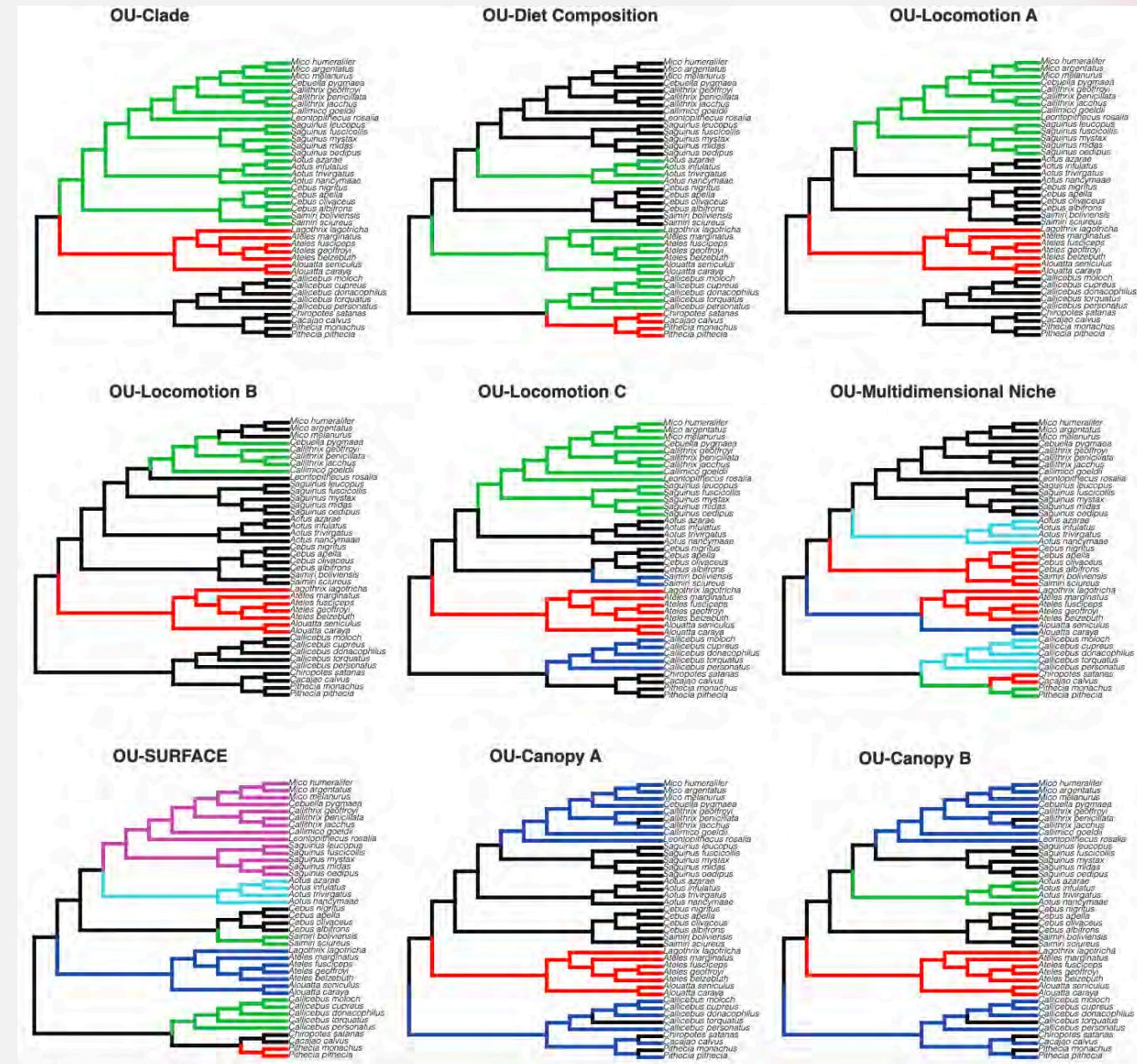
- leaper
- ▲ quadruped
- clamber/suspensory

## fossil



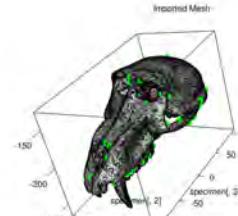
# Evolutionary modelling

Püschel, T. A., Gladman, J. T., Bobe, R. & Sellers, W. I. The evolution of the platyrhine talus: A comparative analysis of the phenetic affinities of the Miocene platyrhines with their modern relatives. *Journal of Human Evolution* 111, 179–201 (2017).

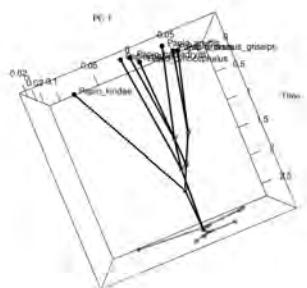


# Conclusiones

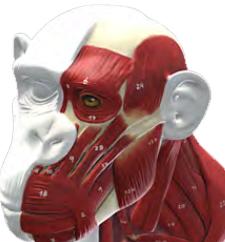
## Anatomy



## Primate evolution



## Palaeoecology

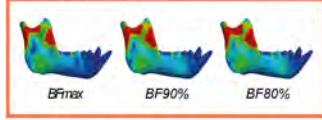


## Morphometrics

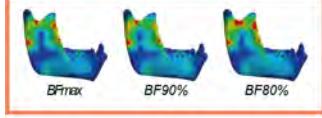


## Palaeobiology

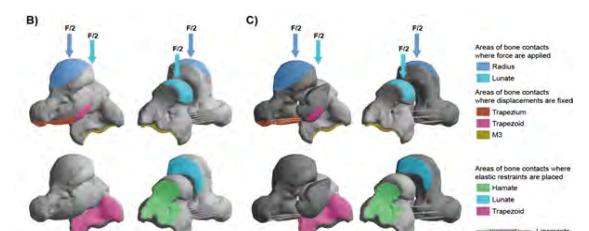
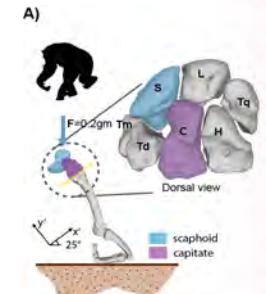
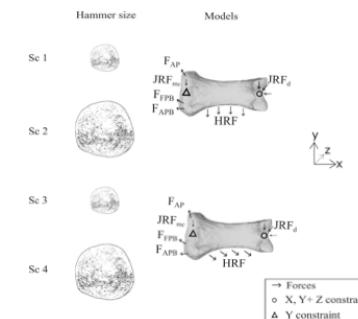
### *Ekembo henseloni*

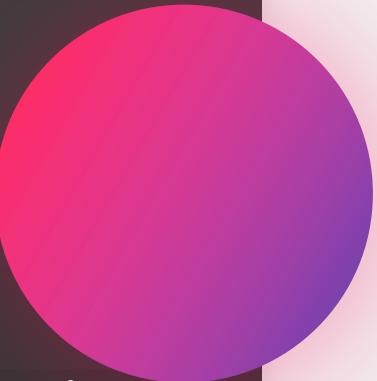


### *Ekembo nyanzae*



## Biomechanics





# Muchas gracias!

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[thomas.puschelroulez@anthro.ox.ac.uk](mailto:thomas.puschelroulez@anthro.ox.ac.uk)



Thomas A. Puschel

Leverhulme Early Career Fellow

Primate Models for Behavioural  
Evolution Lab - Oxford University