

# Geometric Morphometrics

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**Michelle Chrupa**

- Purpose of Morphometrics
- What is Morphometrics
- Types of Geometric Morphometrics
- Examples of multivariate ordination analysis
- Packages for MO
- Exercise

Where are  
we going?

# Purpose of Morphometrics

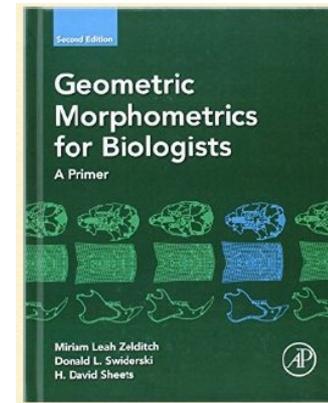
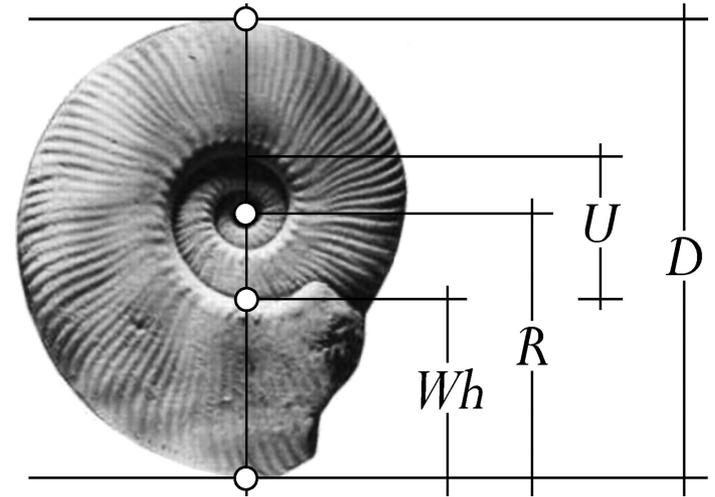
Useful in analyzing their fossil record, the impact of mutations on shape, developmental changes in form, covariances between ecological factors and shape, as well for estimating quantitative-genetic parameters of shape.

Morphometrics can be used to quantify a trait of evolutionary significance, and by detecting changes in the shape, deduce something of their ontogeny, function or evolutionary relationships.

A major objective of morphometrics is to statistically test hypotheses about the factors that affect shape

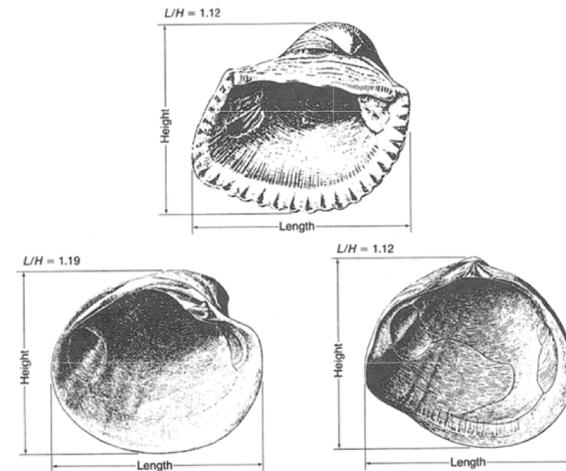
# What Is Morphometrics?

- Quantitative analysis of form, a concept that encompasses size and shape.
- 
- Analyses performed on live organisms, museum specimens and fossils
- 
- The impact of mutations on shape, developmental changes in form, covariance between ecological factors and shape, as well for estimating quantitative-genetic parameters of shape.

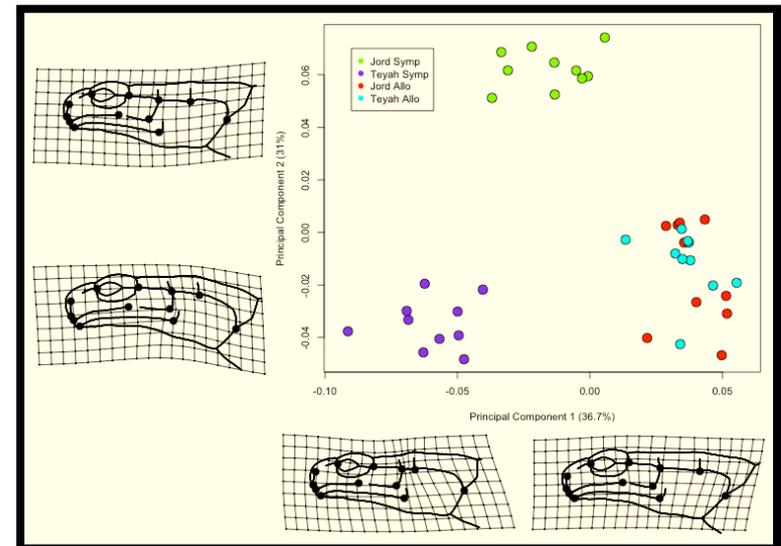


# What Is Morphometrics?

- Can be used to quantify a trait of evolutionary significance, and by detecting changes in the shape, deduce something of their ontogeny, function or evolutionary relationships.
- Statistically test hypotheses about the factors that affect shape.



Principal component analysis  
Principal coordinate analysis  
Factor analysis  
Discriminant analysis  
Canonical variate analysis  
Multivariate analysis of variance



# Why is Morphometrics?

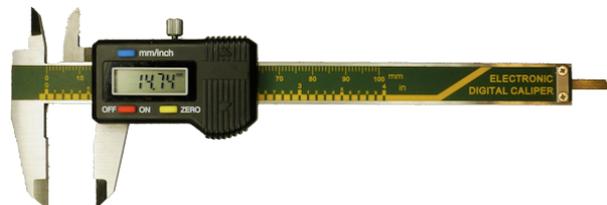
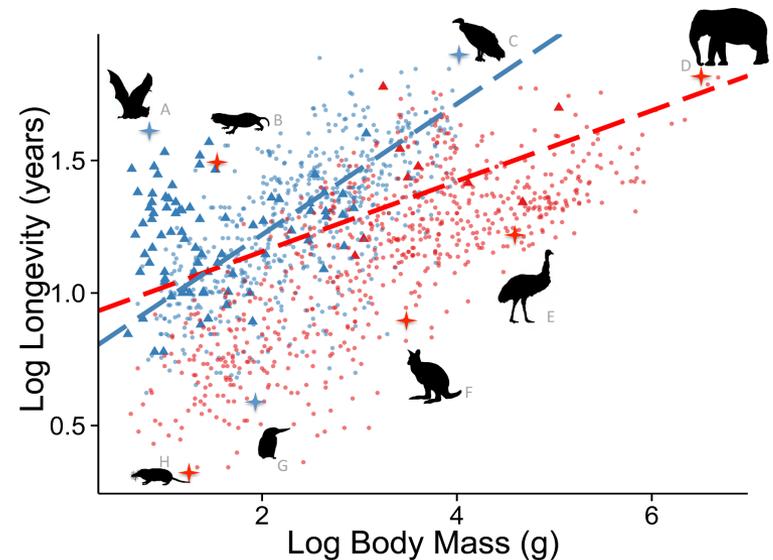
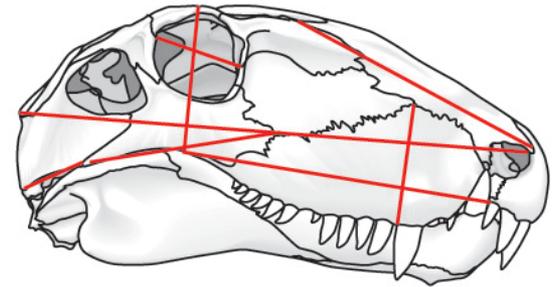
1. Are two specimens different? How are they different?
2. Are two (or more) samples different? How are they different?
3. With what factors are the differences correlated?
4. Do the differences correspond to a particular model or hypothesis?
5. How have the differences evolved?

# Traditional Morphometrics

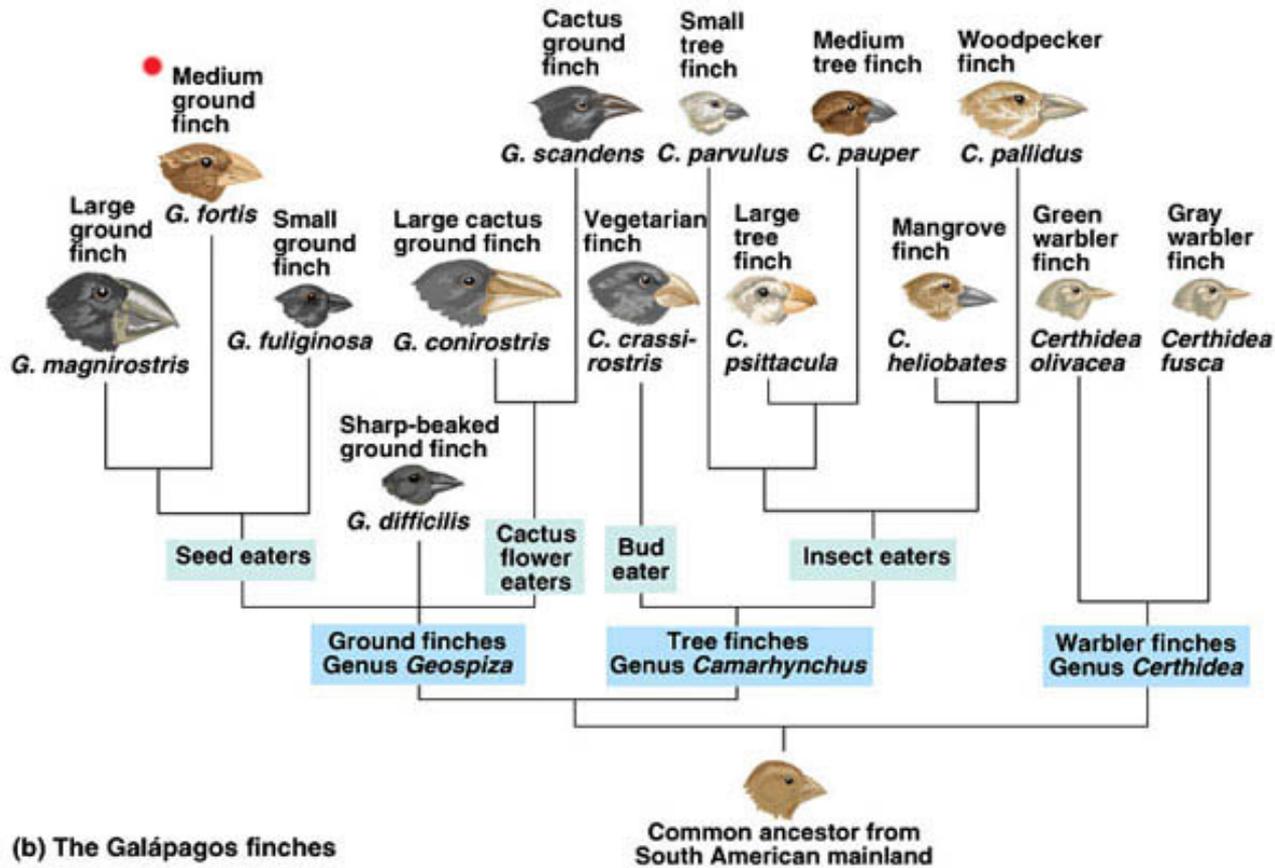
Statistical techniques available for morphometric analysis which have been widely applied in the past 20 or 30 years

Did not pay close attention to the shape or geometry

Considers size and mass



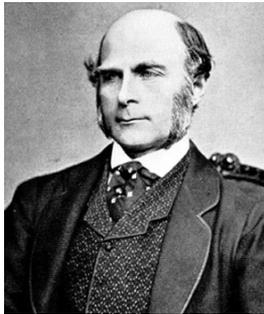
# Traditional Morphometrics



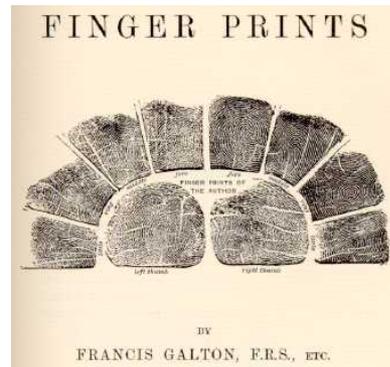
(b) The Galápagos finches

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# Geometric Morphometrics



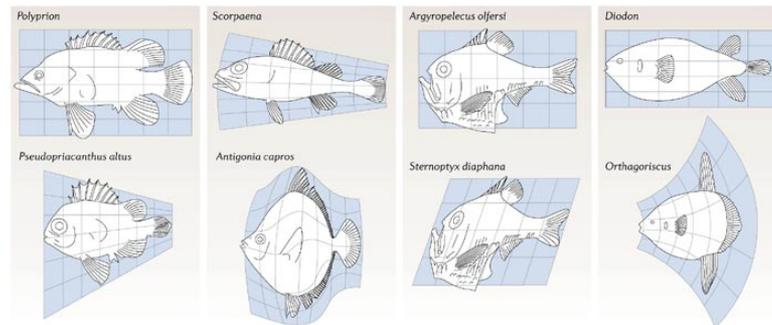
Sir Francis Galton 1822 - 1911



Biometric approach to genetics:  
regression & correlation



D'Arcy Thompson 1860 - 1948



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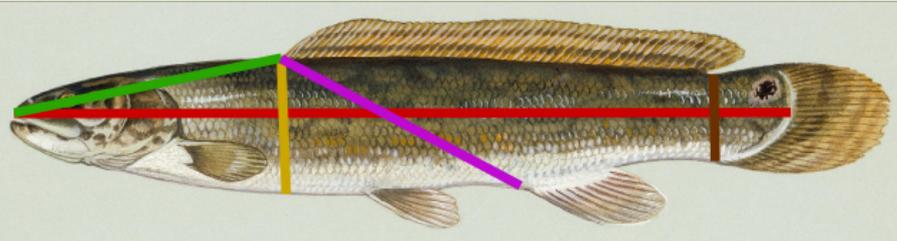
*On Growth and Form*, 1917

# What Is Geometric Morphometrics?

The shape we want to study

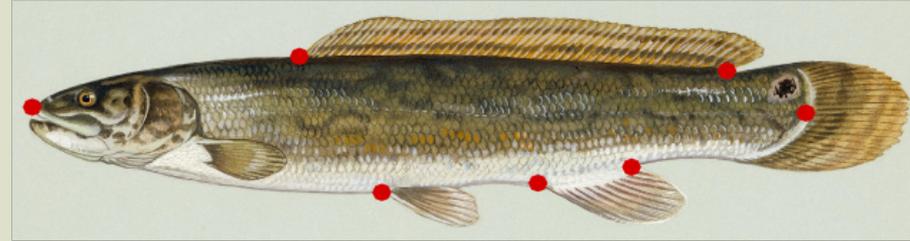


What we obtain with traditional morphometrics



The geometry is lost!

What we obtain with geometric morphometrics

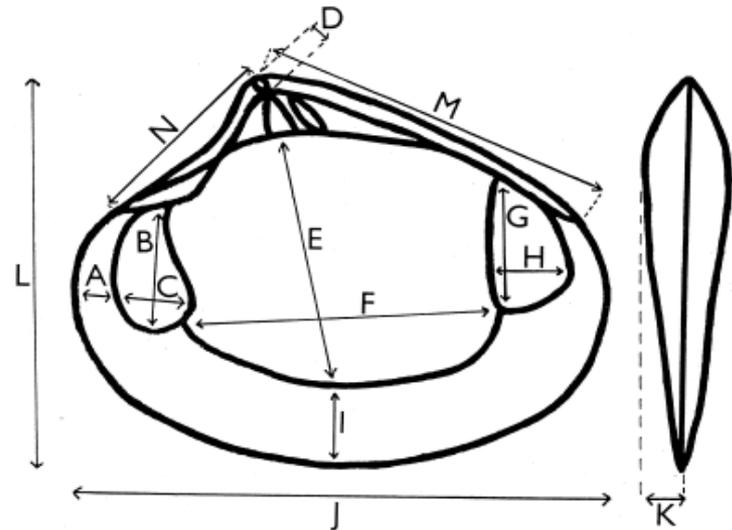
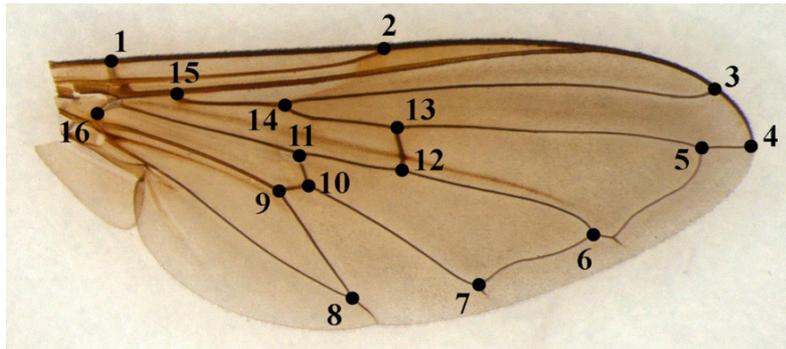


The geometry is retained

# Types of Geometric Morphometrics – 2D

Landmark analysis - discrete anatomical loci that are arguably homologous in all individuals in the analysis (i.e. they can be regarded as the "same" point in each specimens in the study)

They are quantified as Cartesian coordinates (x,y[,z])

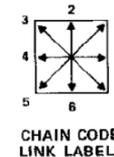
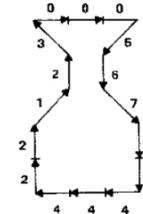
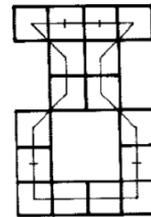
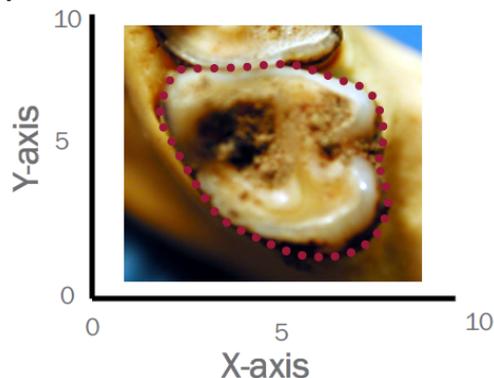


# Types of Geometric Morphometrics

Outline analysis - coefficients of mathematical functions are fitted to points sampled along the outline

They are quantified as Cartesian coordinates  $(x,y[,z])$ , often converted to angles

Older techniques such as the fit to a polynomial curve and Principal components quantitative analysis have been superseded by the two main modern approaches: eigenshape analysis and elliptical fourier analysis (EFA)



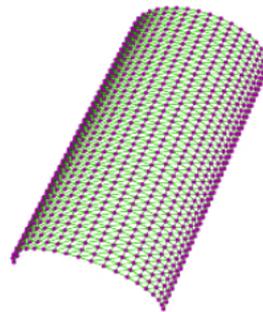
# Types of Geometric Morphometrics

Surfaces - Surfaces are the 3D surface of an object

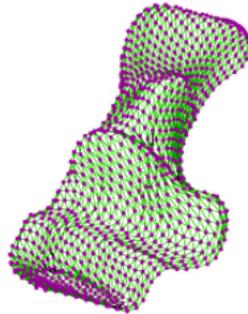
They are quantified as Cartesian coordinates (x,y,z)



A.



B.



C.



D.

Polly, P. D. 2008. Adaptive Zones and the Pinniped Ankle: A 3D Quantitative Analysis of Carnivoran Tarsal Evolution. Pp. 165-194 in (E. Sergis and M. Dagosto, Eds.) Mammalian Evolutionary Morphology: A Tribute to Frederick S. Szalay. Springer: Dordrecht, The Netherlands.

# What is a Landmark?

- Landmark – any point described with cartesian coordinates (x, y, z) used to represent the shape of a structure.
- Landmark (2) – any point that can be placed on a biologically or geometrically homologous point on the structure.
- Semi-landmark – a point that is placed arbitrarily using an algorithm, often by defining endpoints at biologically homologous points and placing a specified number of semilandmarks between them.

Landmarks must be present on all specimens

The data must reflect a hypothesis

The data must represent the shape adequately

# Why Use Geometric Morphometrics?

Morphometrics is very important in biology because it allows quantitative descriptions of organisms. Quantitative approach allowed scientists to compare shapes of different organisms much better and they no longer had to rely on word descriptions that usually had the problem of being interpreted differently by each scientist.

- What it cannot do:
  - tell you what “shape” and means
  - tell you if you have two groups in one sample
  - identify clade characteristics

# SOFTWARE

. PAST - PAleontological STatistics

. SHAPE

. MORPHOJ

. R packages

geomorph

Shapes

svd

scatterplot3d

rgl

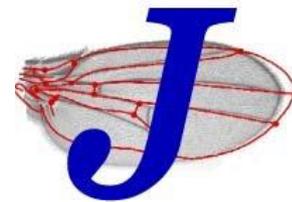
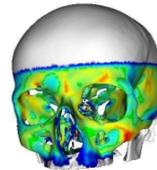
MASS

ape

vegan

***SHAPE*** *Ver. 1.3*

GEOMORPH



# Geomorph

Digitizing landmarks and outlines

Superimposition

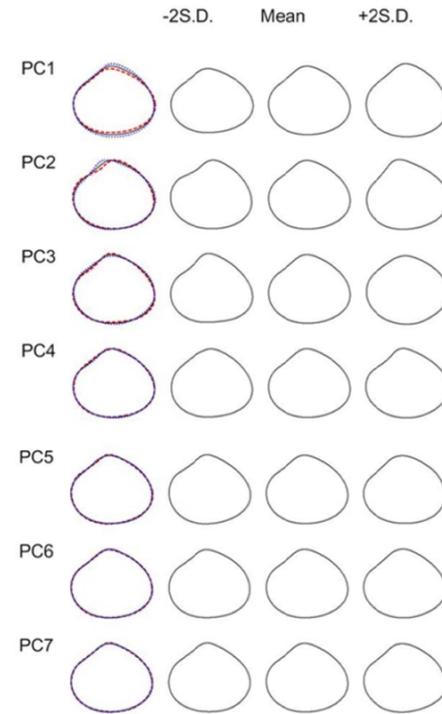
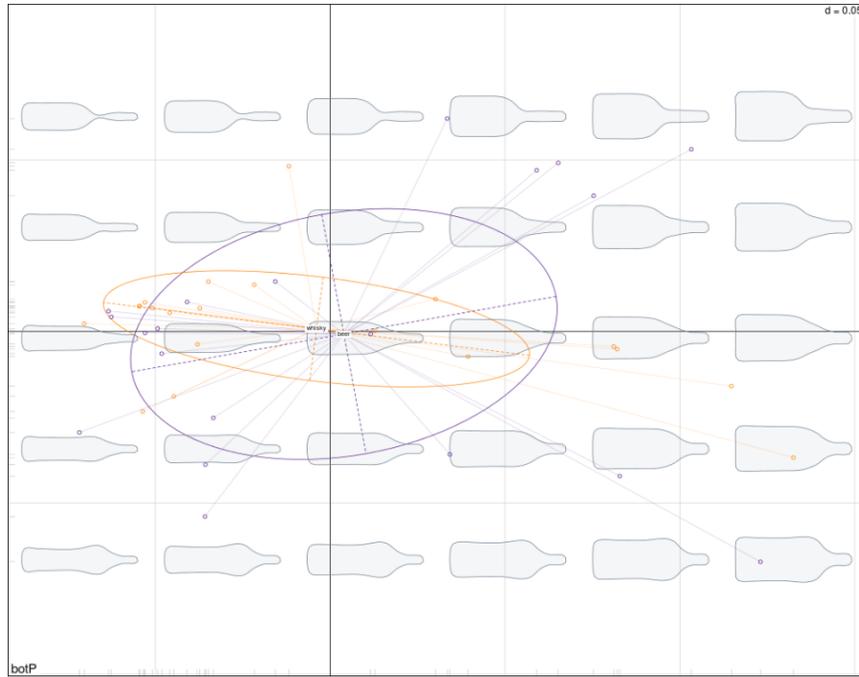
Outline analysis

MANOVA

Principal components analysis of landmarks

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THANK YOU