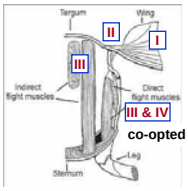
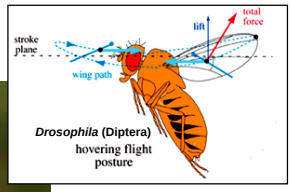
I. A surface, with support
II. Some sort of articulation mechanism
III. Muscles to power the surface
IV. Mechanisms to generate lift
- Passive mechanisms
  - Tilt
  - Twist
  - Camber
- Active mechanisms



co-opted from leg base

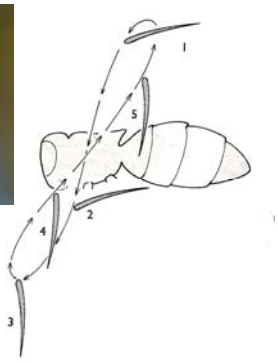
Complex wing motion

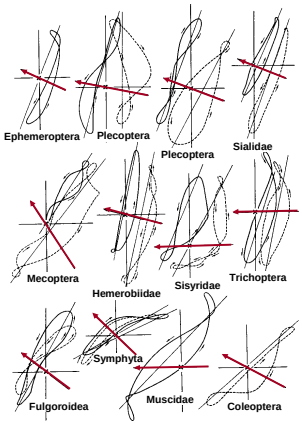
Odonata: Anisoptera



Muscidae (Diptera): red = top surface, blue = bottom surface

Tracing the path of wing motion in Hymenoptera

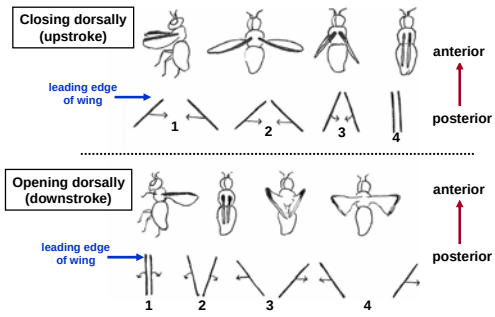




= path of fore wing

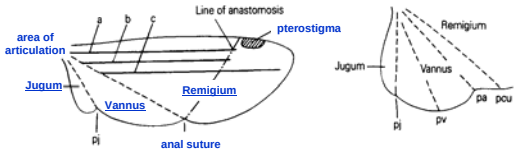
= path of hind wing

Clap & fling (also clap & peel, etc.)

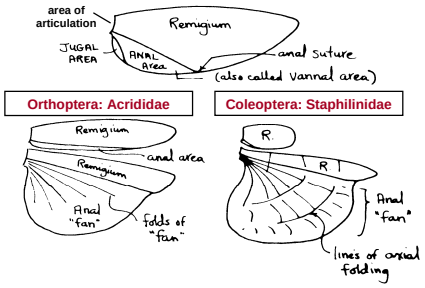


Major wing regions: Remigium, Vannus/clavus, and Jugum

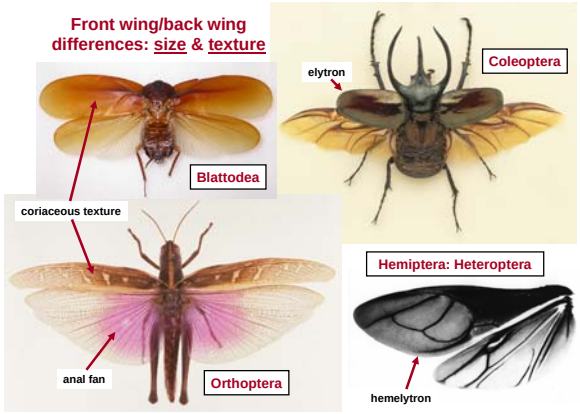
a = axis of rotation (torsion)
b = axis of mass
c = axis of aerodynamic pressure



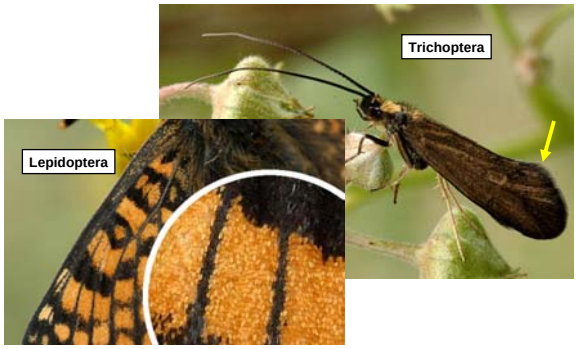
Changes in the proportions of remigium vs. vannus

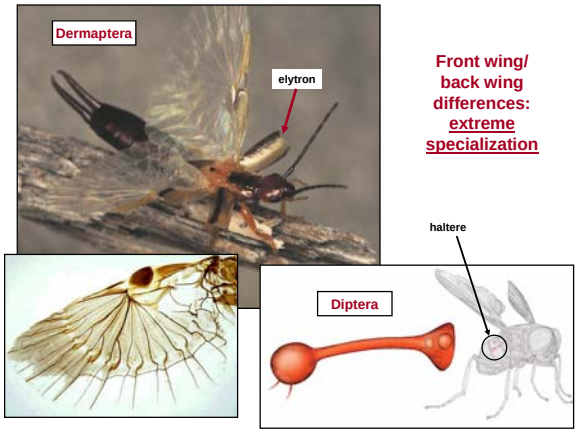


Front wing/back wing differences: size & texture

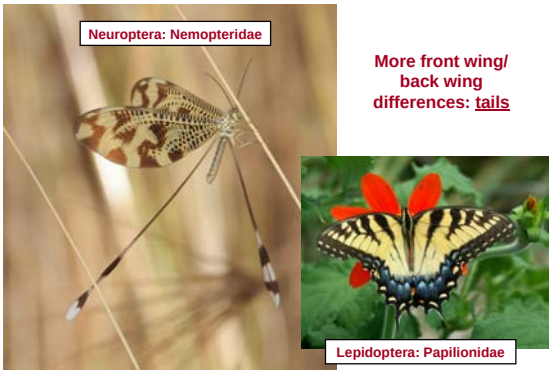


Other textural changes: hairs (setae) and scales



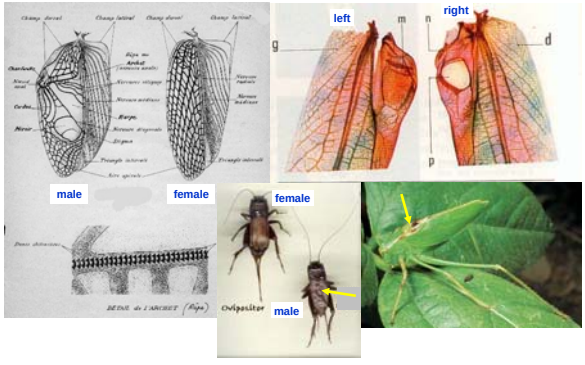


Front wing/ back wing differences: extreme specialization

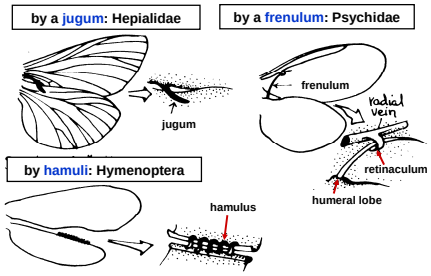


More front wing/ back wing differences: tails

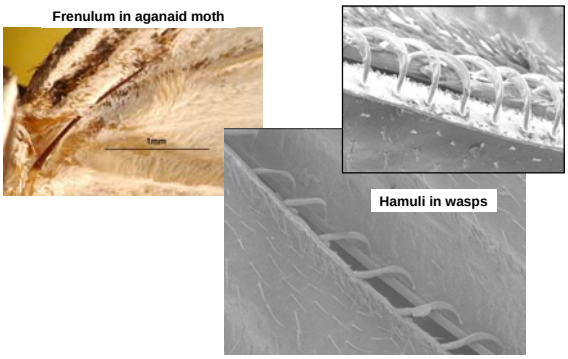
Front/back, left/right, & sex differences: strigils



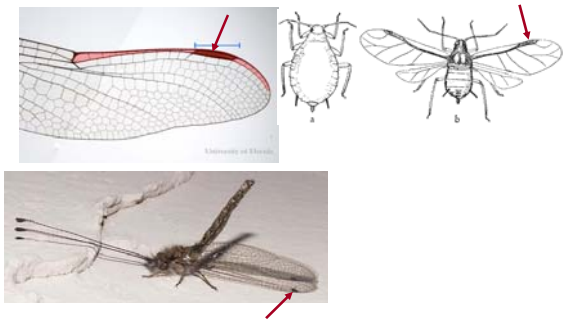
Jugal specializations and wing coupling mechanisms



Wing coupling mechanisms

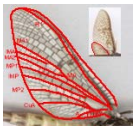


Pterostigmas

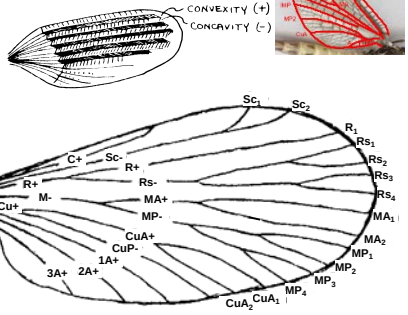


Insect wing venation: the ancestral archedictyon

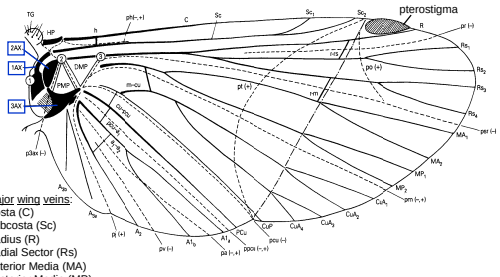
Interpreting wing venation in modern insects



Major wing veins:
Costa (C)
Subcosta (Sc)
Radius (R)
Radial Sector (Rs)
Anterior Media (MA)
Posterior Media (M
Anterior Cubitus (
Posterior Cubitus
Anal (A)

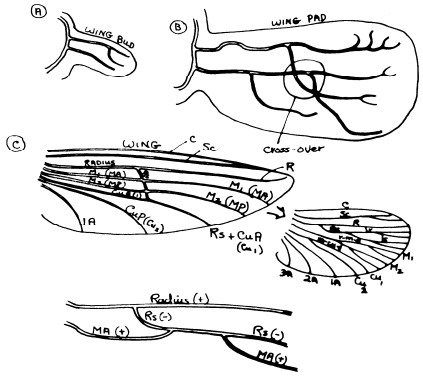


A more detailed view of wing venation



Major wing veins:
Costa (C)
Subcosta (Sc)
Radius (R)
Radial Sector (Rs)
Anterior Media (MA)
Posterior Media (MP)
Anterior Cubitus (CuA)
Posterior Cubitus (CuP)
Anal (A)

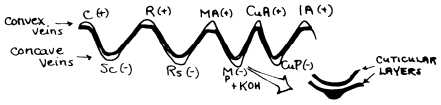
Homologizing wing veins: the pretracheation theory



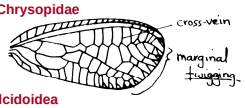
Alternatives to the pretracheation theory

Tracheae grow into pre-existing "lacunae"

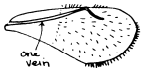
Homologizing wing veins: convexities and concavities



Neuroptera: Chrysopidae

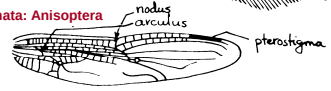


Hymenoptera: Chalcidoidea

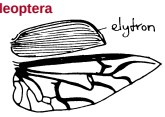


Thysanoptera

Odonata: Anisoptera



Coleoptera



Hemiptera: Heteroptera