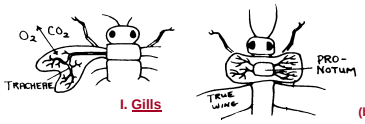
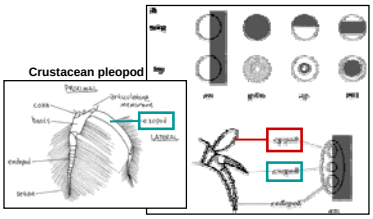
Origin of insect wings: Gills (I), Spiracular Flaps (II), & Fins (III)



I. Gills

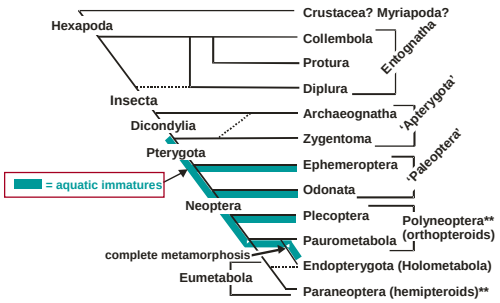
II. Spiracular flaps (better location than gills)



Gills in Ephemeroptera naiads

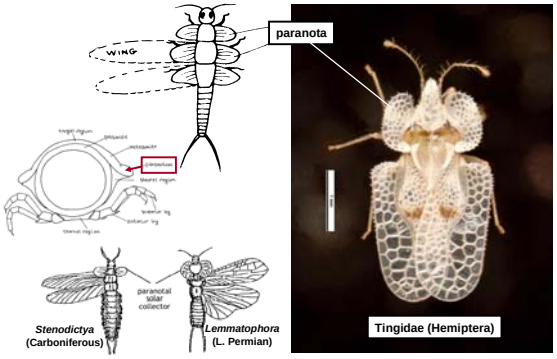
III. Fins (terrestrial origin, with 2ndary return to water)

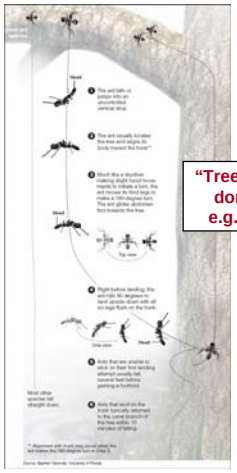
Phylogenetic distribution of wings vs. aquatic immatures: support for gills as wing precursors?



(** 'Exopterygota')

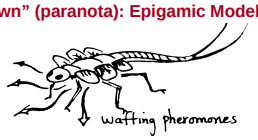
Origin of insect wings: IV. from Paranota



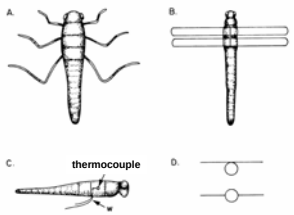


"Trees Down" (actually, you don't even need wings: e.g. ants [Hymenoptera])

"Trees Down" (paranota): Epigamic Model (Brown)



"Trees Down" (paranota): "Thermoregulatory" Model (Kingsolver)



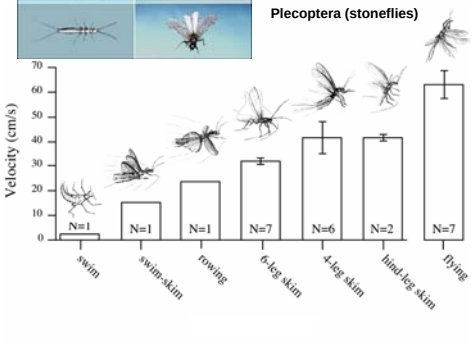
"Ground Up" (gills or paranota): "Floating" & "Jumping" Models (Wigglesworth and others)

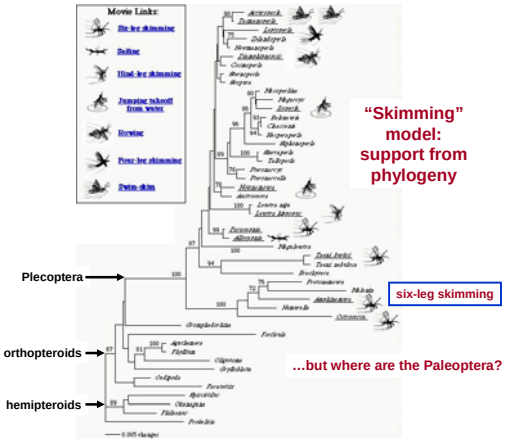
Floaters: Thysanoptera (thrips)

Jumpers: Orthoptera

Ground Up (gills): "Skimming" Model (Marden & Kramer)

Plecoptera (stoneflies)

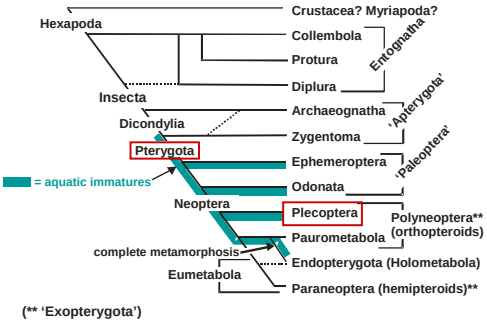




"Skimming" model: support from phylogeny

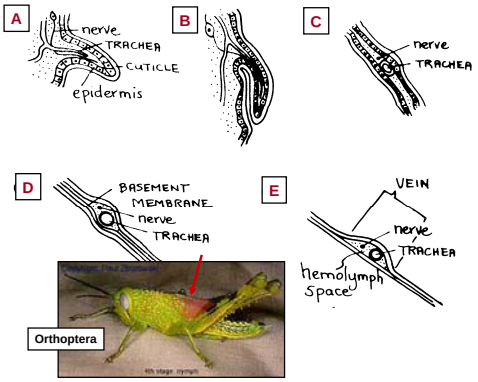
...but where are the Paleoptera?

Possible problem for the "skimming" model

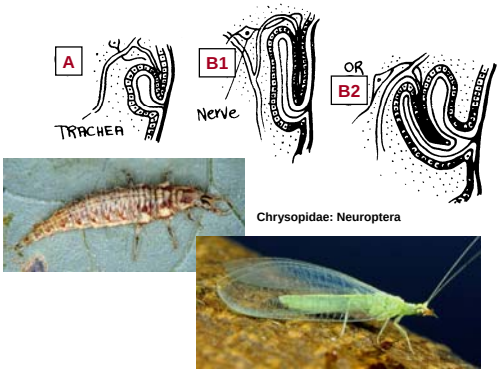


(** 'Exopterygota')

Ontogeny of the exopterygote wing

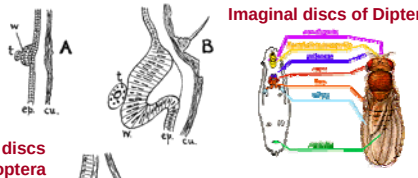


Ontogeny of the endopterygote wing

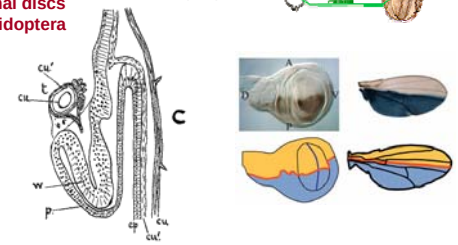


Chrysopidae: Neuroptera

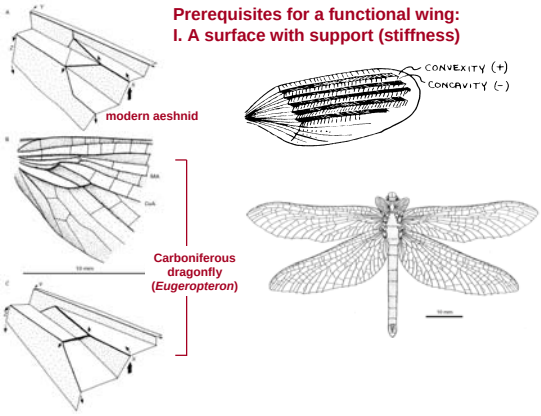
Imaginal discs of Diptera



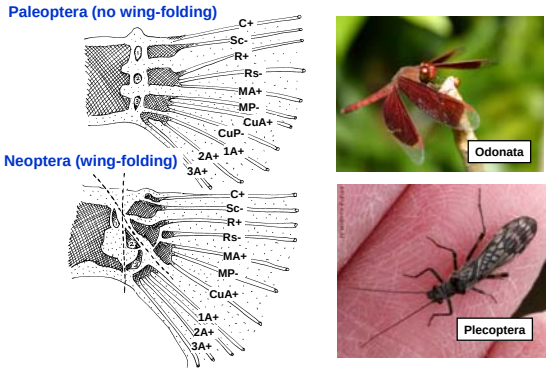
Imaginal discs of Lepidoptera



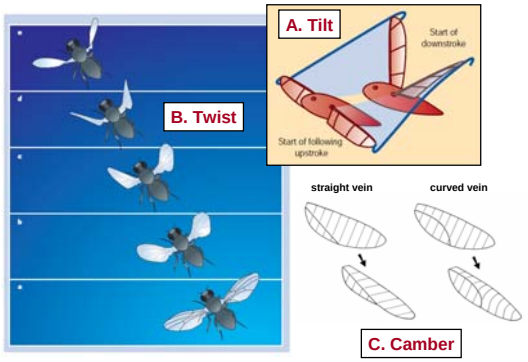
Prerequisites for a functional wing:
I. A surface with support (stiffness)



II. Some sort of articulation with the body



IV. Passive mechanisms for generating lift



Camber – an example from *Schistocerca* (Orthoptera)