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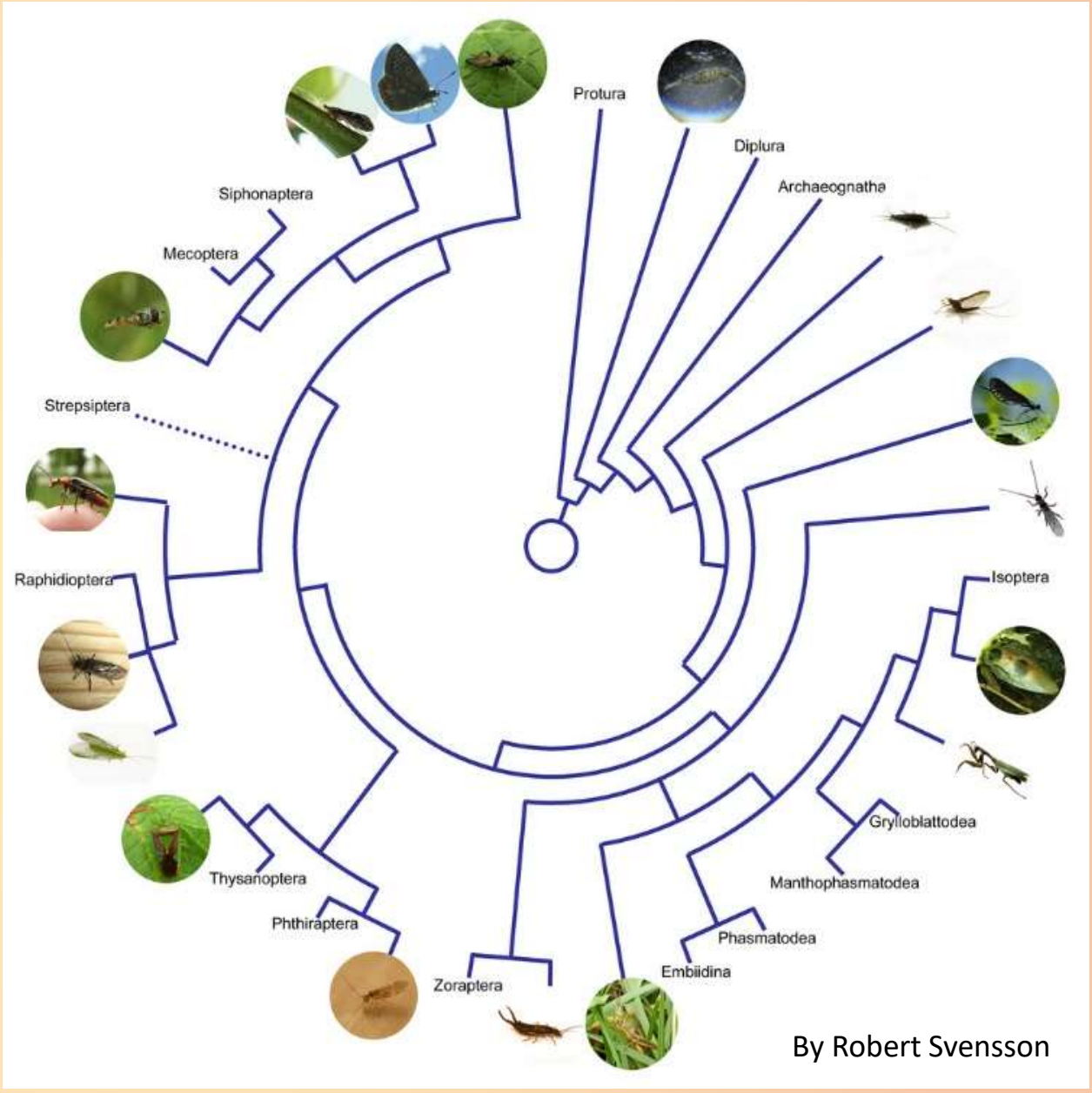
Stephen Hall. 2017. NC Botanical Garden Entomology Course. North Carolina Biodiversity Project.

INSECT RADIATION

THE ORDERS OF INSECTS



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29 ORDERS ARE CURRENTLY RECOGNIZED*

- **Archaeognatha** Bristletails
- **Zygentoma** Silverfish
- **Ephemeroptera** Mayflies
- **Odonata** Dragonflies, Damselflies
- **Dermaptera** Earwigs
- **Notoptera** Ice Crawlers, African Rock Crawlers
- **Plecoptera** Stoneflies
- **Embiodea** Web-spinners
- **Zoraptera** Zorapterans
- **Phasmatodea** Stick- and Leaf-insects
- **Orthoptera** Grasshoppers, Katydids, and Crickets
- **Mantodea** Praying Mantises
- **Blattaria** Cockroaches
- **Isoptera** Termites
- **Psocoptera** Booklice
- **Phtiraptera** Lice
- **Thysanoptera** Thrips
- **Hemiptera** True bugs, Aphids, Cicadas, Hoppers
- **Coleoptera** Beetles
- **Raphidioptera** Snakeflies
- **Megaloptera** Dobsonflies, Alderflies, Fishflies
- **Neuroptera** Lacewings, Antlions, Owlflies, Mantispids
- **Hymenoptera** Wasps, Ants, Bees
- **Mecoptera** Scorpionflies
- **Siphonaptera** Fleas
- **Strepsiptera** Twisted-wings
- **Diptera** Flies
- **Trichoptera** Caddisflies
- **Lepidoptera** Moths and Butterflies

Orders in **black** occur in the Chapel Hill area

* Names follow Footit and Adler (eds) 2009. Insect Biodiversity. Wiley-Blackwell

“APTERYGOTA”

- **Primitively wingless**
  - **Composed of two orders:**
    - ***Archaeognatha (Bristletails)***
    - ***Zygentoma (Silverfish)***
- **All other orders belong to the Pterygota, the Winged Insects**

MONOCONDYLIA

- Newer classification separates the Archaeognatha from all other insects, based on its simple jaw mechanism
- All other insects are now placed in the Dicondylia

ARCHAEOGNATHA
(BRISTLETAILS)

- **Are ectognathic**

ARCHAEOGNATHA
(BRISTLETAILS)

- **Are ectognathic but have several features similar to primitive Hexapods:**
  - **Terminal filament**
  - **Cerci**
  - **Stylii**
  - **Eversible vesicles**
  - **Indirect fertilization**

ARCHAEOGNATHA
(BRISTLETAILS)

- Probably evolved in the Silurian (~ 440 MYA) . The earliest fossils are only about 390 MY old
- Found on all continents
- 504 living species in 4 families

ARCHAEOGNATHA
(BRISTLETAILS)

- This group has now survived four major extinction events and is currently working on its fifth
- One of the most successful organisms of all time!

ZYGENTOMA
(SILVERFISH)

- Possess several of the same primitive features found in the Archaeognatha
- But also possess a dicondylic jaw attachment and other features that relate them more closely to the flying insects
- Now grouped with flying insects under Dicondylia
- Based on a fossil of a dicondylic jaw, this group probably originated in the Devonian; all fossil silverfish, however, are much more recent

Sebastian Stabinger, Wikipedia

PTERYGOTA

- **Are characterized by their possession of wings, which probably had just a single origin**
  - **Sometimes lost secondarily, as in fleas and lice**
- **Also distinguished by their evolution of metamorphosis**
  - **All Pterygotes undergo either incomplete or complete metamorphosis**

PTERYGOTA

- **Divided into two major groups:**
  - **The “Palaeoptera” = Ancient Wings**
    - ***Possess non-folding wings***
  - **The Neoptera = New Wings**
    - ***Possess wings that can be folded flat over the abdomen***

“PALAEOPTERA”

- **The Palaeoptera consist of two modern orders:**
  - **Ephemeroptera**
  - **Odonata**
- **Both are very different from one another**
  - **They may not be any more closely related to one another than they are to the Neoptera**

EPHEMEROPTERA
(MAYFLIES)

- **Oldest flying insects in the fossil record**
  - **probably evolved in the early Carboniferous (~360 MYA) although the oldest fossil are from the Permian or possibly the late Carboniferous**

***Hexagenia* sp.**
Haw River State Park
23 July 2014

EPHEMEROPTERA
(MAYFLIES)

- The only group of flying insects that retains the median caudal filament (nymphs only)
- Most species are associated with highly oxygenated, flowing water (some lake species also)
  - One of the groups of insects (EPT) that the state uses in monitoring water quality

Isonychia sp.
Johnson Mill Preserve
12 June 2017

EPHEMEROPTERA
(MAYFLIES)

- Have a unique two-stage metamorphosis
- Adults do not feed and generally live only a few hours or days

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Belong to the superorder Odonatoptera that originated in the late Devonian or early Carboniferous**
  - **Included the Griffinflies, the largest insects that ever lived**
    - ***Meganeura permiensis* had a wingspan of ~ 28 inches**


Alexandre Albore, Wikipedia

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- Only the lineage that gave rise to the modern Odonates survived the Permian Extinction
- Consists of two main Suborders that first appeared in the Triassic:
  - Epiprocta

Celithemis elisa
Weymouth Woods
18 May, 2013

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- Only the lineage that gave rise to the modern Odonates survived the Permian Extinction
- Consists of two main Suborders that first appeared in the Triassic:
  - Epiprocta
  - Zygoptera

Argia bipunctulata
Weymouth Woods
18 May, 2013

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- Only the lineage that gave rise to the modern Odonates survived the Permian Extinction
- Consists of two main Suborders that first appeared in the Triassic
  - Both possess unique mating structures and behavior

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Epiprocta: Dragonflies**
  - Hold their wings out flat
  - Have aquatic nymphs, terrestrial adults
  - Completely predatory as both nymphs and adults

Erythemis simplicicollis
Upper Roanoke River Game Land
13 July 2012

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Epiprocta: Dragonflies**
  - **7 families occur in our area, including 134 species**
  - **These are among our showiest of insects**
    - ***Many field guides are currently available***
    - ***A website exists specifically for North Carolina records***

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(DRAGONFLIES AND DAMSELFLIES)

- **Epiprocta: Dragonflies**
  - **7 families occur in our area, including 134 species**
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    - ***A website exists specifically for North Carolina records***

Epiaeschna heros
Pollock's Ferry
25 May 2012

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Epiprocta: Dragonflies**
  - **7 families occur in our area, including 134 species**
  - **These are among our showiest of insects**
    - ***Many field guides are currently available***
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Cordulegaster obliqua
Black Ankle Bog
21 May 2010

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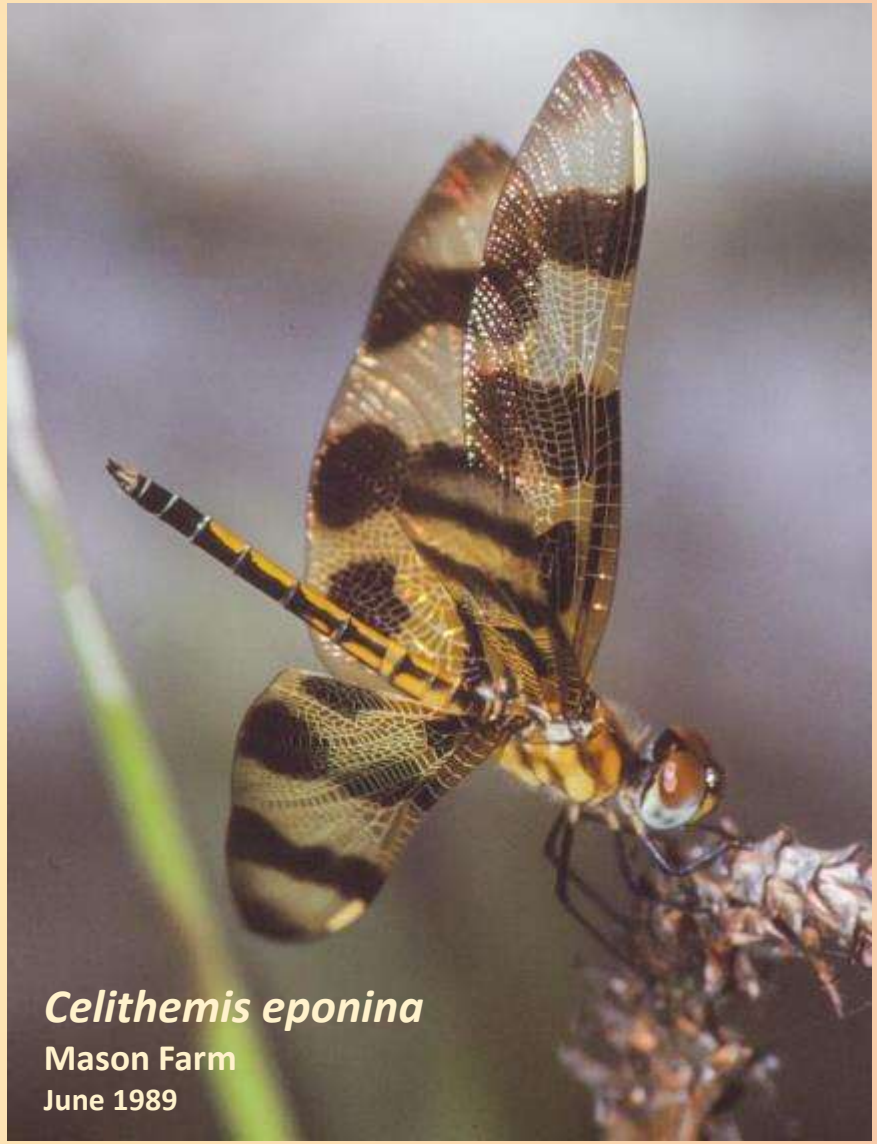
(DRAGONFLIES AND DAMSELFLIES)

- **Epiprocta: Dragonflies**
  - **7 families occur in our area, including 134 species**
  - **These are among our showiest of insects**
    - ***Many field guides are currently available***
    - ***A website exists specifically for North Carolina records***



ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Zygoptera: Damselflies**
  - **Hold their wings together (more or less) above their abdomens**

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Zygoptera: Damselflies**
  - **Hold their wings together (more or less) above their abdomens**
  - **Like dragonflies, they have aquatic nymphs and terrestrial adults**

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Zygoptera: Damselflies**
  - Hold their wings together (more or less) above their abdomens
  - Like dragonflies, they have aquatic nymphs and terrestrial adults
  - They are also completely predatory in both stages

Argyia moesta
Tar River
21 June 2013

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Zygoptera: Damselflies**
  - Three families occur in our area, including 53 species
  - Covered by the same field guides and websites as for the Dragonflies

Hetaerina Americana
Uwharrie River
14 June 2011

ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Zygoptera: Damselflies**
  - **Three families occur in our area, including 53 species**
  - **Covered by the same field guides and websites as for the Dragonflies**

Archilestes grandis
Roberdo Bog
23 June 2011

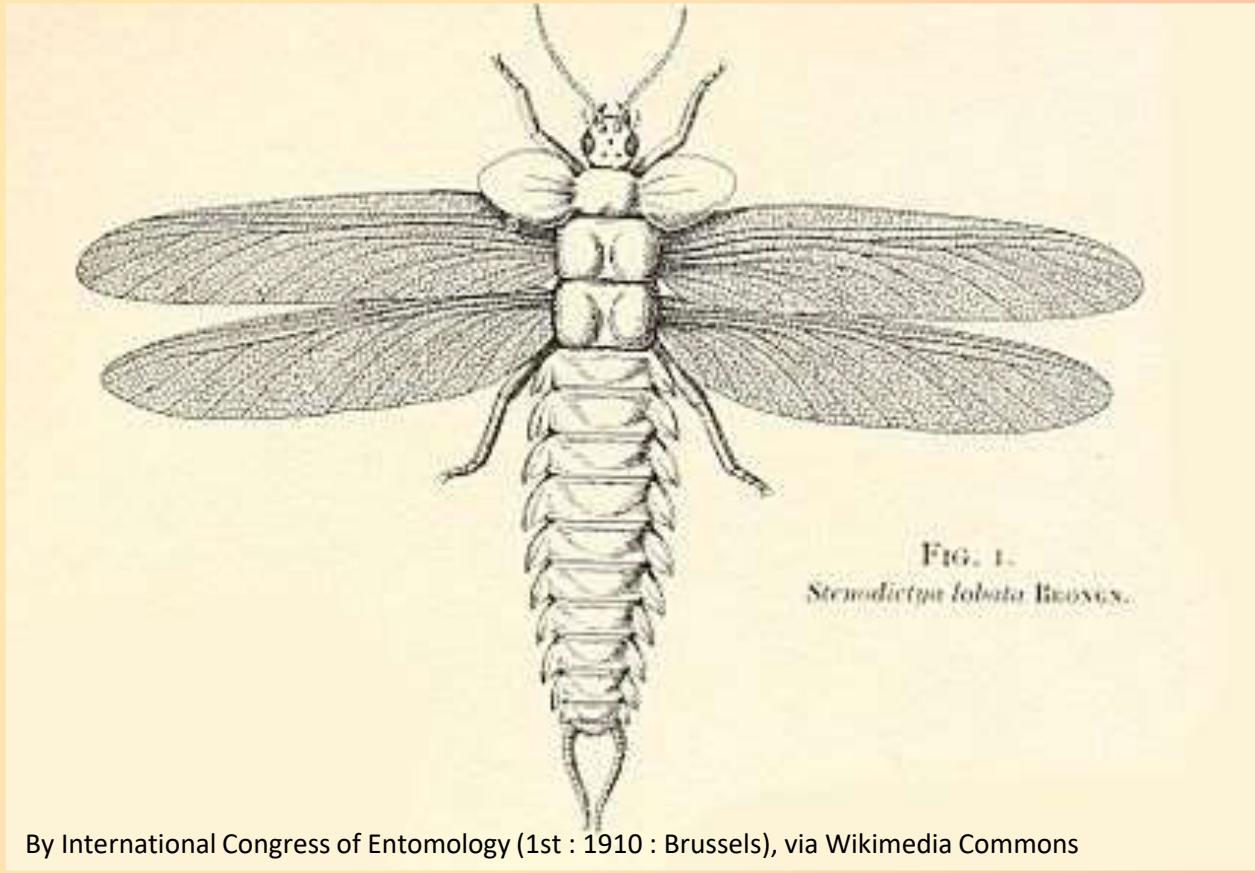
ODONATA
(DRAGONFLIES AND DAMSELFLIES)

- **Zygoptera: Damselflies**
  - Three families occur in our area, including 53 species
  - Covered by the same field guides and websites as for the Dragonflies

Ischnura hastata
Duke Forest
29 June 2016

“PALAEOPTERA”

- **Palaeodictyopterida**
  - Were the dominant group of insects in the Palaeozoic
  - Possessed many gigantic species, some with wingspans of over 20”
  - Were completely wiped out at the end of the Permian, the only super-order of insects to become extinct

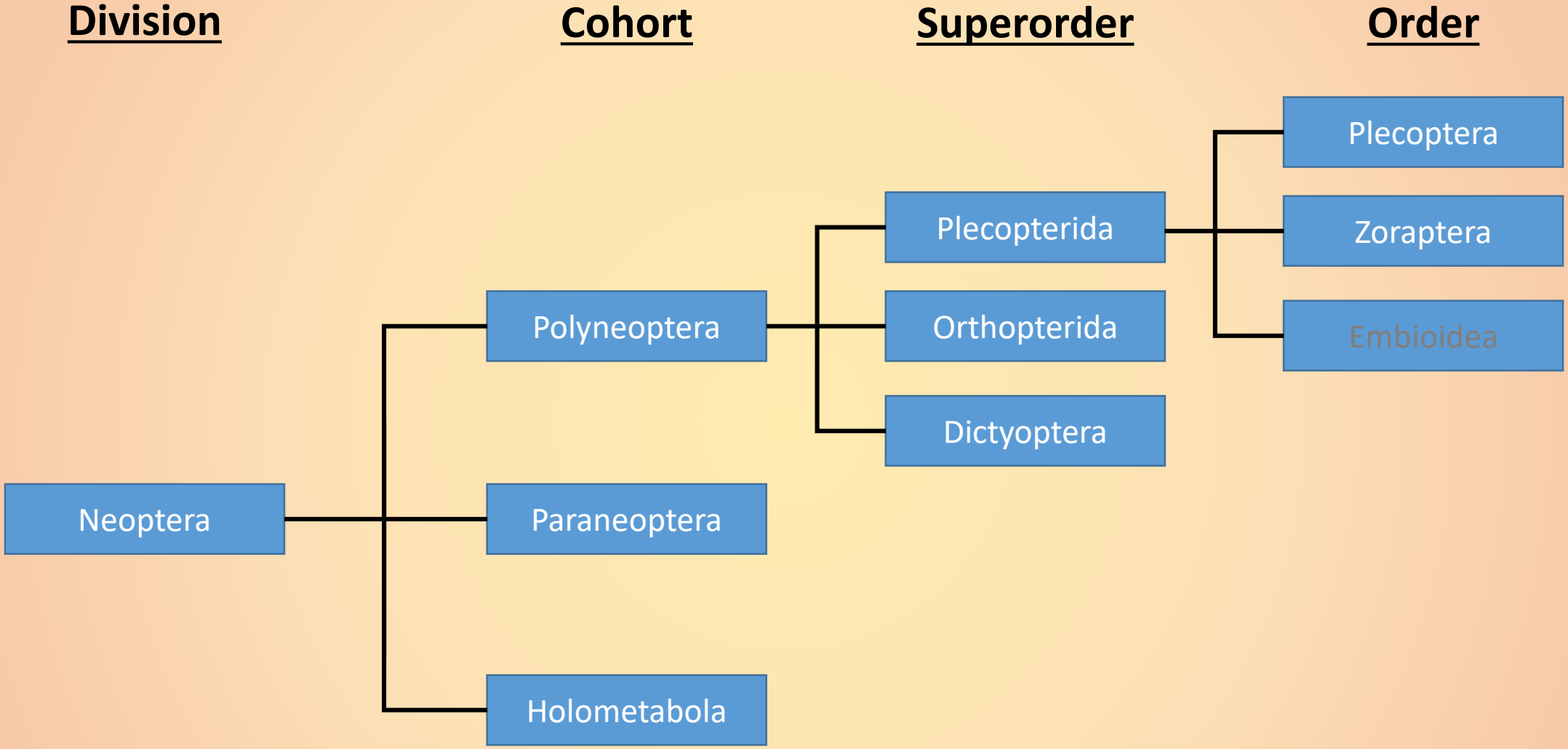


By International Congress of Entomology (1st : 1910 : Brussels), via Wikimedia Commons

NEOPTERA

- In contrast to the Palaeoptera, these species can fold their wings flat over their abdomens
- The first fossil representatives are from the Carboniferous
- They now comprise the vast majority of insect species

Plecoptera sp.
Stone Mountain State Park
16 May 2015


Division
Cohort
Superorder
Order
Neoptera
Polyneoptera
Paraneoptera
Holometabola
Plecopterida
Orthopterida
Dictyoptera
Plecoptera
Zoraptera
Embioidea

PLECOPTERA
(STONEFLIES)

- **Earliest fossils are from the Permian, ~ 285 MYA**
- **Possess chewing mouthparts, prognathous head, and relatively unmodified appendages**

***Pteronarcys* sp.**
Pilot Mountain
17 May 2017

PLECOPTERA
(STONEFLIES)

- **Nymphs are aquatic**
- **Possess a pair of cerci but not the central filament found in Mayflies; gills are located ventrally**
- **Nymphs feed mainly on plants or detritus**
- **Used as indicators of good water quality**

PLECOPTERA
(STONEFLIES)

- **Nine families occur in North Carolina, including 144 species (Beatty, 2011)**

***Perlesta?* sp.**
Pilot Mountain
17 May 2017

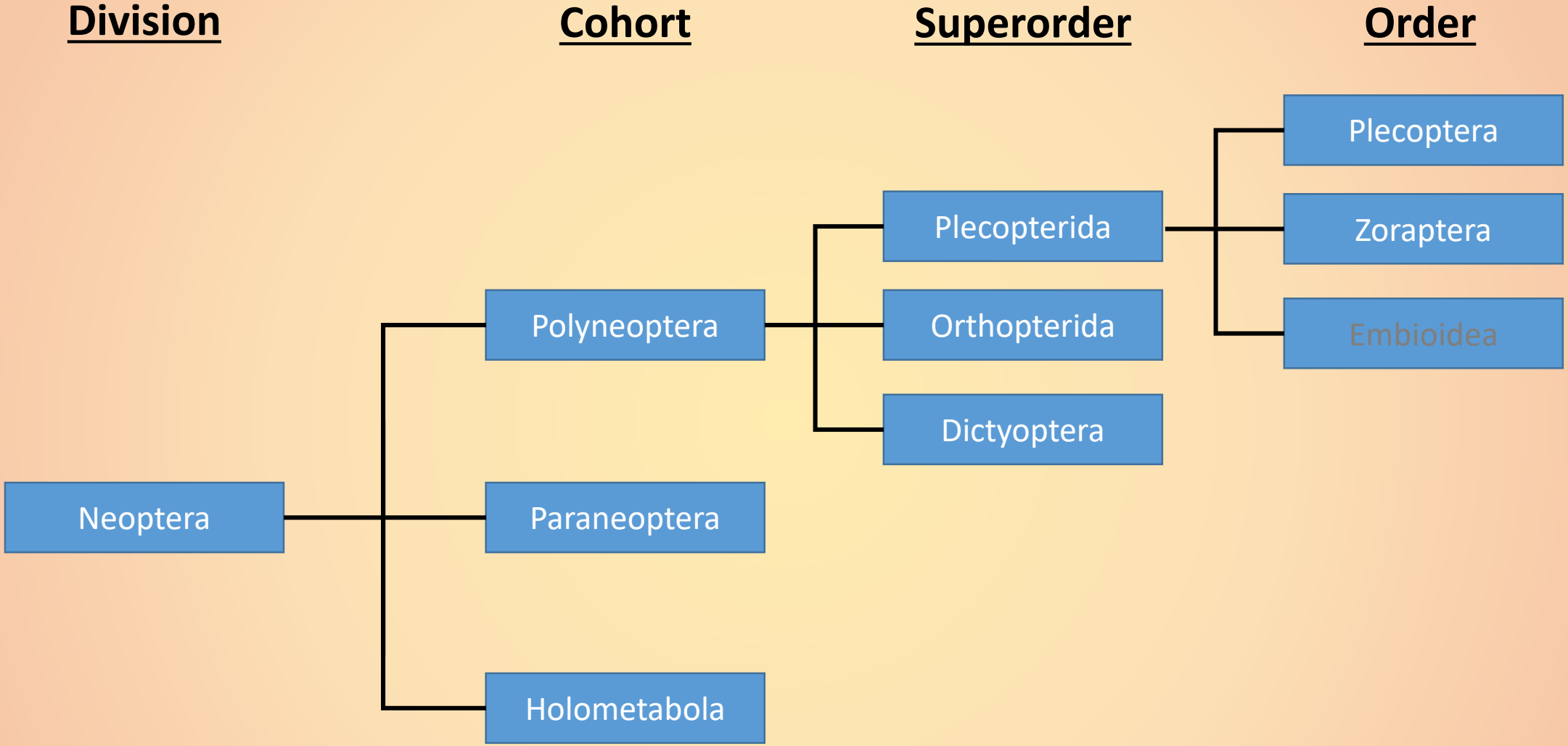
ZORAPTERA
(ZORAPTERANS)

- **Represented by a single family with only a single genus**
  - **39 species have been described**
- **Two adult forms:**
  - **Wingless and eyeless**
  - **Winged and with eyes**


David Maddison, via Tree of Life Project

ZORAPTERA
(ZORAPTERANS)

- **Live in colonies under bark of fallen trees; also found in sawdust piles**
- **Feed on mites and other small invertebrates; also on fungi**
- **About 3 mm in length; very fast!**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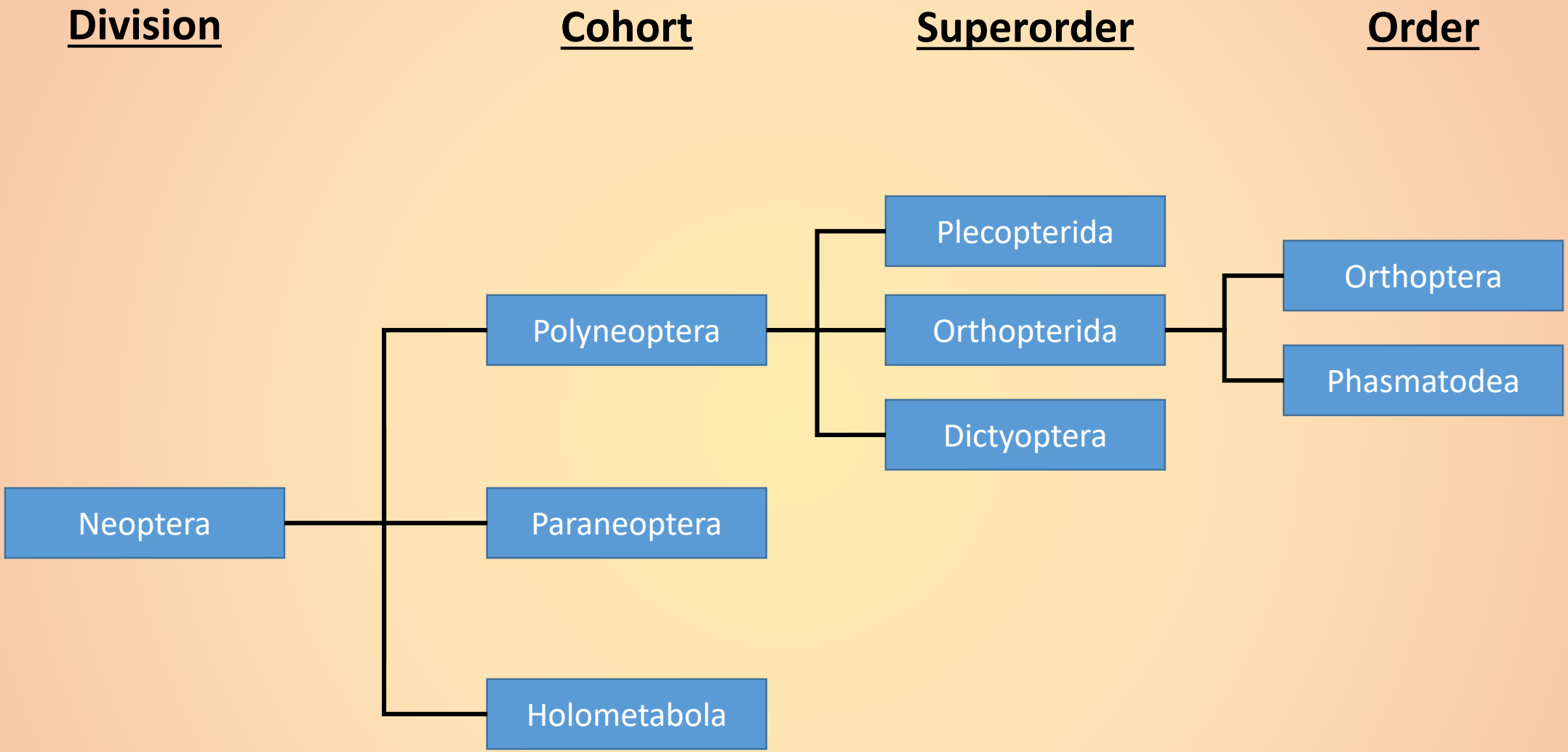
Plecopterida
Orthopterida
Dictyoptera
Plecoptera
Zoraptera
Embioidea


Division
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Polyneoptera
Paraneoptera
Holometabola
Plecopterida
Orthopterida
Dictyoptera
Orthoptera
Phasmatodea

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Originated in the Carboniferous**
- **Charcterized by:**
  - **hind legs greatly modified for jumping**
  - **forewings that are usually tough and leathery**
  - **chewing mouthparts**
  - **many species can stridulate or crepitate, i.e., produce sounds with their wings or legs**

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Two suborders:**
  - **the Ensifera**
    - ***Females have "sword" - like ovipositors***
    - ***Have long, filamentous antennae***

Conocephalus fasciatus
Mason Farm
9 October 2014

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Two suborders:**
  - **the Caelifera**
    - ***Females have short, stout ovipositors***
    - ***Have short antennae***

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Ensifera:**
  - **Crickets**
    - ***Originated in the Permian***
    - ***Ovipositors are generally needle-like***

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Ensifera:**
  - **Crickets**
    - ***Originated in the Permian***
    - ***Ovipositors are generally needle-like***
    - ***Males stridulate***

Oecanthus sp.
Chapel Hill
19 October 2016

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Ensifera:**
  - **Crickets**
    - ***Originated in the Permian***
    - ***Ovipositors are generally needle-like***
    - ***Males stridulate; both sexes possess ears on their fore-tibiae***

Neoxabea bipunctata
Warrensville
25 September 2014

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Ensifera:**
  - **Katydids**
    - ***Ovipositors are usually flattened; used for depositing eggs in plant leaves and stems***
    - ***Males stridulate***

Scudderia sp.
Person County
25 September 2013

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Ensifera:**
  - **Katydids**
    - ***Ovipositors are usually flattened; used for depositing eggs in plant leaves and stems***
    - ***Males stridulate***
    - ***Most are herbivores but at least a few groups are carnivorous or scavenging***

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Ensifera:**
  - **Gryllacridoids (Camel Crickets)**
    - ***Wingless and songless***

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Caelifera:**
  - Grasshoppers
    - *Are all herbivorous*
    - *Include several important crop pests*

ORTHOPTERA

(KATYDIDS, CRICKETS, AND GRASSHOPPERS)

- **Caelifera:**
  - Grasshoppers
    - *Are all herbivorous*
    - *Include several important crop pests*
    - *The majority are associated with natural habitats*

PHASMATODEA
(STICK- AND LEAF-INSECTS)

- Originated in the Carboniferous
- Are divided into two main groups
  - Stick Insects
  - Leaf Insects

PHASMATODEA
(STICK- AND LEAF-INSECTS)

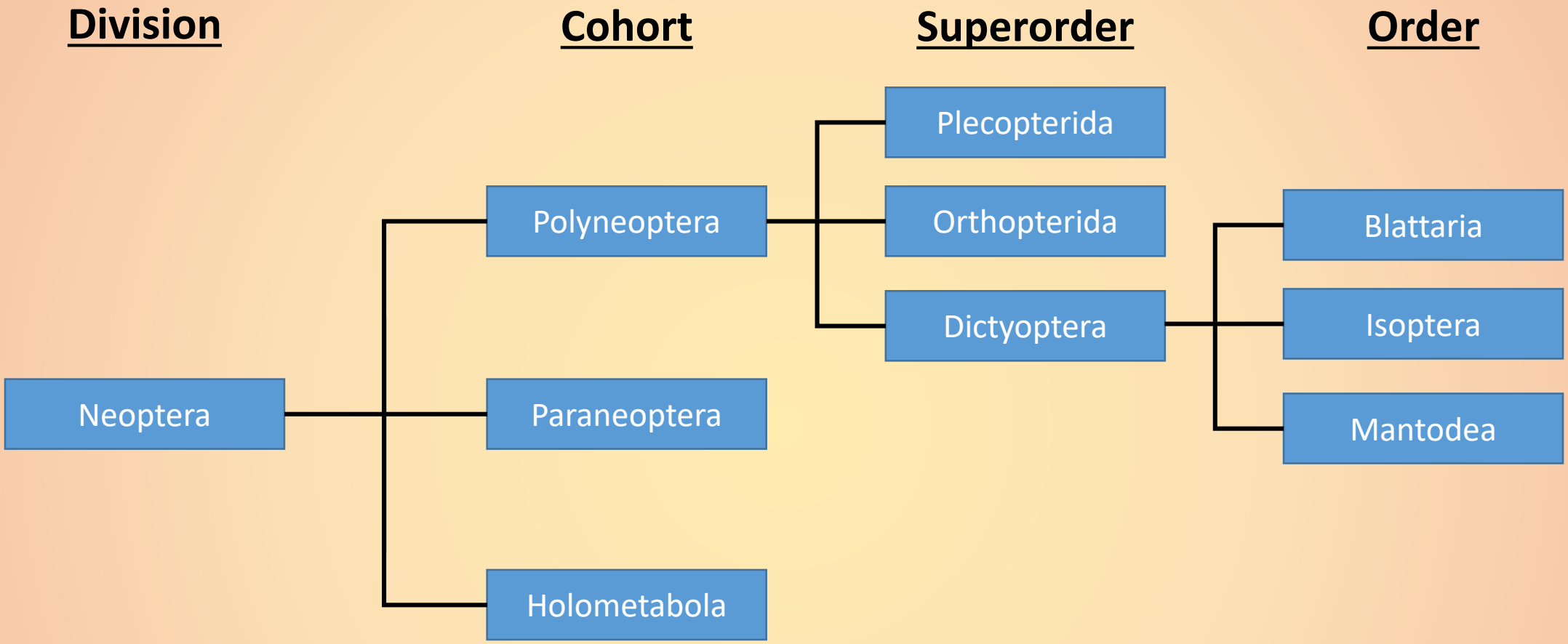
- **Walking Sticks**
  - Are stick-like appearance
  - Have chewing mouthparts

PHASMATODEA
(STICK- AND LEAF-INSECTS)

- **Walking Sticks**
  - Are stick-like appearance
  - Have chewing mouthparts
  - Are all herbivorous

PHASMATODEA
(STICK- AND LEAF-INSECTS)

- **Walking Sticks**
  - **Have specialized defensive glands on the thorax**
    - ***Some species can spray phenolic compounds that cause temporary blindness***


Division
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Polyneoptera
Paraneoptera
Holometabola
Plecopterida
Orthopterida
Dictyoptera
Blattaria
Isoptera
Mantodea

BLATTARIA
(ROACHES)

- **Modern roaches date only from the Jurassic**
  - **They represent the a lineage of Paleozoic "Roachoids", that mostly vanished at the end of the Permian**
  - **The ancient Roachoids had long ovipositors, whereas modern Dictyoptera produce egg cases**

BLATTARIA
(ROACHES)

- **Have chewing mouthparts and are highly polyphagous**
- **Most of the species we see in our houses are actually introduced**

BLATTARIA
(ROACHES)

- **Have chewing mouthparts and are highly polyphagous**
- **Most of the species we see in our houses are actually introduced**
- **Our native species live in the forest and other natural habitats**

Cariblatta lutea
Chapel Hill
27 May 2017

BLATTARIA
(ROACHES)

- **Have chewing mouthparts and are highly polyphagous**
- **Most of the species we see in our houses are actually introduced**
- **Our native species live in the forest and other natural habitats**

Parcoblatta sp.
Chapel Hill
27 May 2017

BLATTARIA
(ROACHES)

- **The Cryptocercidae are found only in the mountains of North Carolina, the Pacific Northwest, and east Asia**
  - **Similar pattern is seen in many relict plant and animal species**

***Cryptocercus punctulatus* complex**
Vade Mecum, Paul Scharf, photographer
21-July-2016

ISOPTERA
(TERMITES)

- **Evolved from roaches**
  - **Similar to Cryptocercus, with similar symbiotic protozoans and bacteria, and similar parental care**
  - **Now considered by some to be just a subgroup within the Blattaria**

ISOPTERA
(TERMITES)

- **All species are highly social**
  - **Multiple generations live together**

ISOPTERA
(TERMITES)

- **All species are highly social**
  - **Show strong division of labor with sterile castes**

MANTODEA
(MANTIDS)

- **Are highly predatory**
  - **Characterized by their raptorial forelegs and chewing mouthparts**

MANTODEA
(MANTIDS)

- **Only two species are native to North Carolina**

MANTODEA
(MANTIDS)

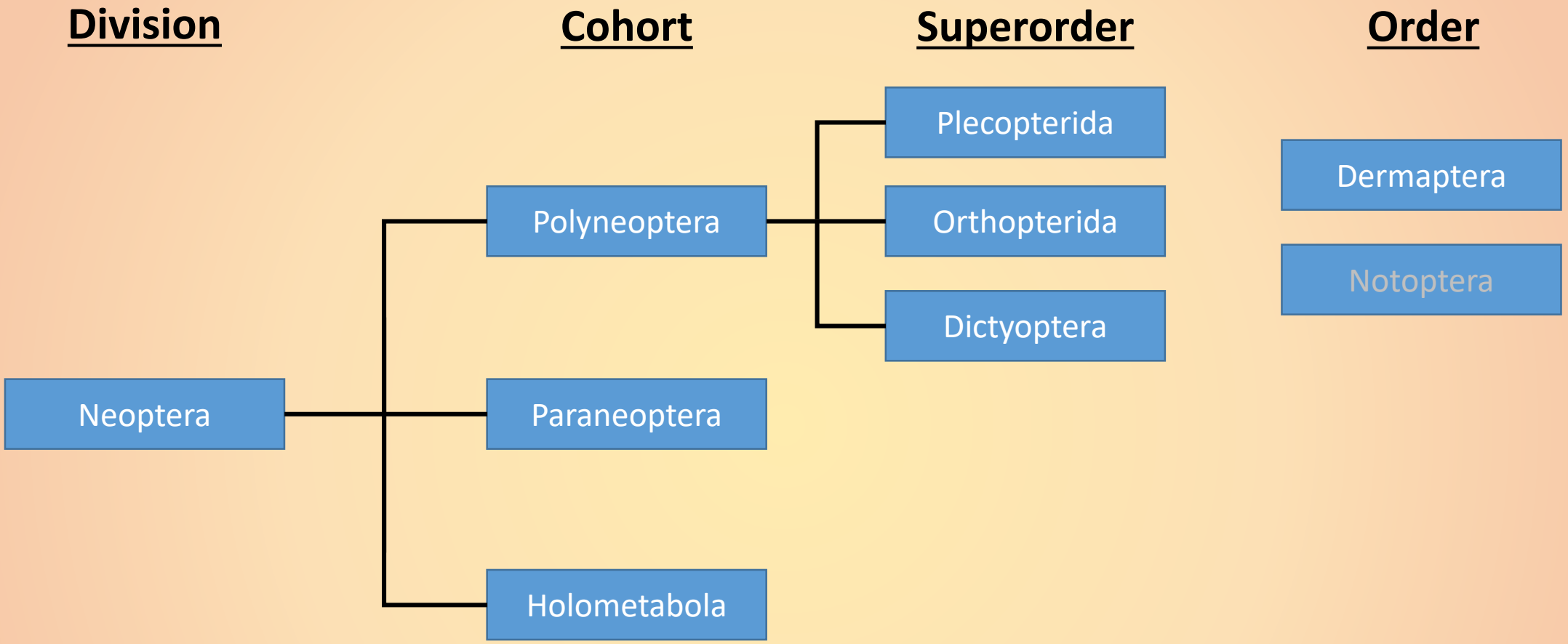
- **Only two species are native to North Carolina**

MANTODEA
(MANTIDS)

- **The species most often seen are exotic**
  - Chinese Mantis

MANTODEA
(MANTIDS)

- **The species most often seen are exotic**
  - European Mantis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Holometabola
Plecopterida
Orthopterida
Dictyoptera
Dermaptera
Notoptera

DERMAPTERA
(EARWIGS)

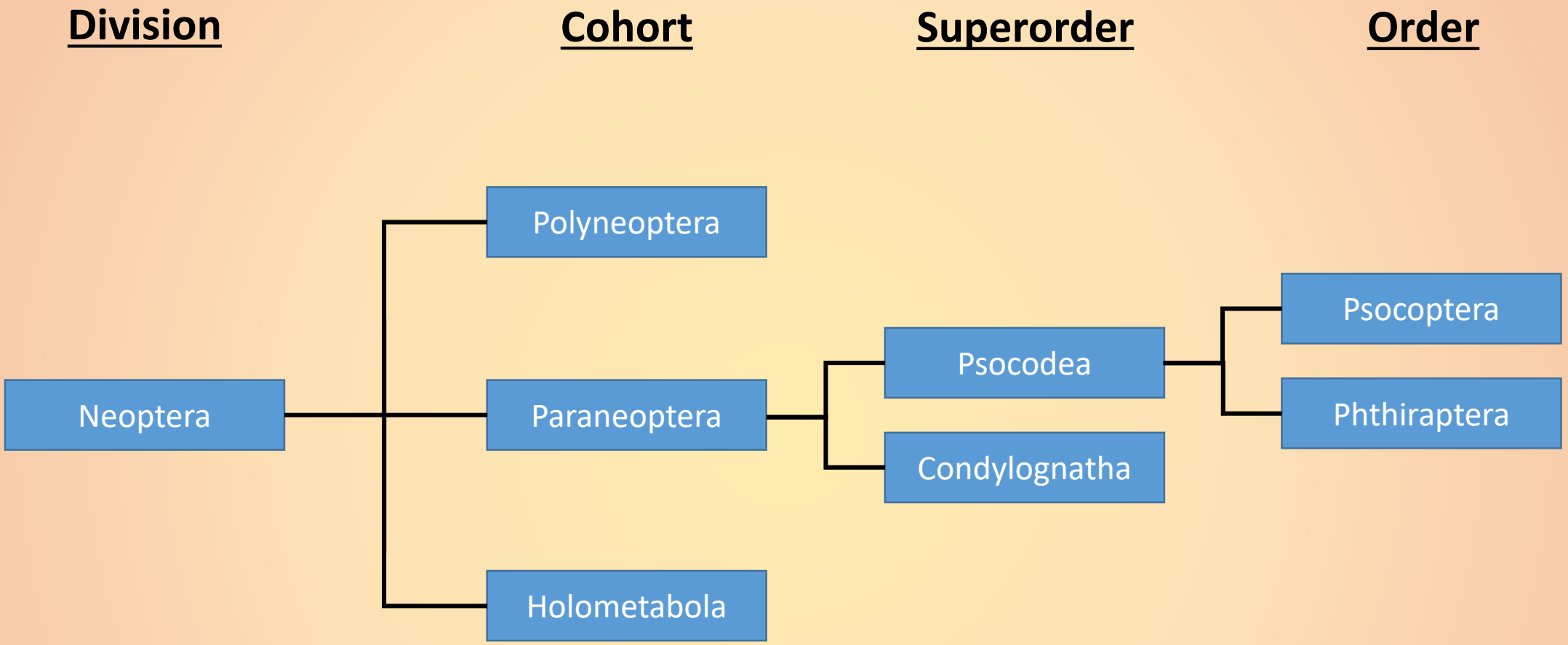
- **Fossils date from the Triassic, with possible origins in the Permian**

DERMAPTERA
(EARWIGS)

- **Possess forceps at the end of the abdomen (also seen in a few other groups)**
- **Forewings are short and leathery; hindwings are fan-shaped**
- **Nocturnal and omnivorous**

DERMAPTERA
(EARWIGS)

- **Six species are native to North Carolina**
- **Several introduced species also occur here**
  - **E.g. the European Earwig, *Forficula auricularia***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Holometabola
Psocodea
Condylognatha
Psocoptera
Phthiraptera

PSOCOPTERA
(BOOK AND BARK LICE)

- Are small species with bulging eyes and foreheads
- Both winged and wingless forms exist
- Wings are held roof-like over the abdomen

PSOCOPTERA
(BOOK AND BARK LICE)

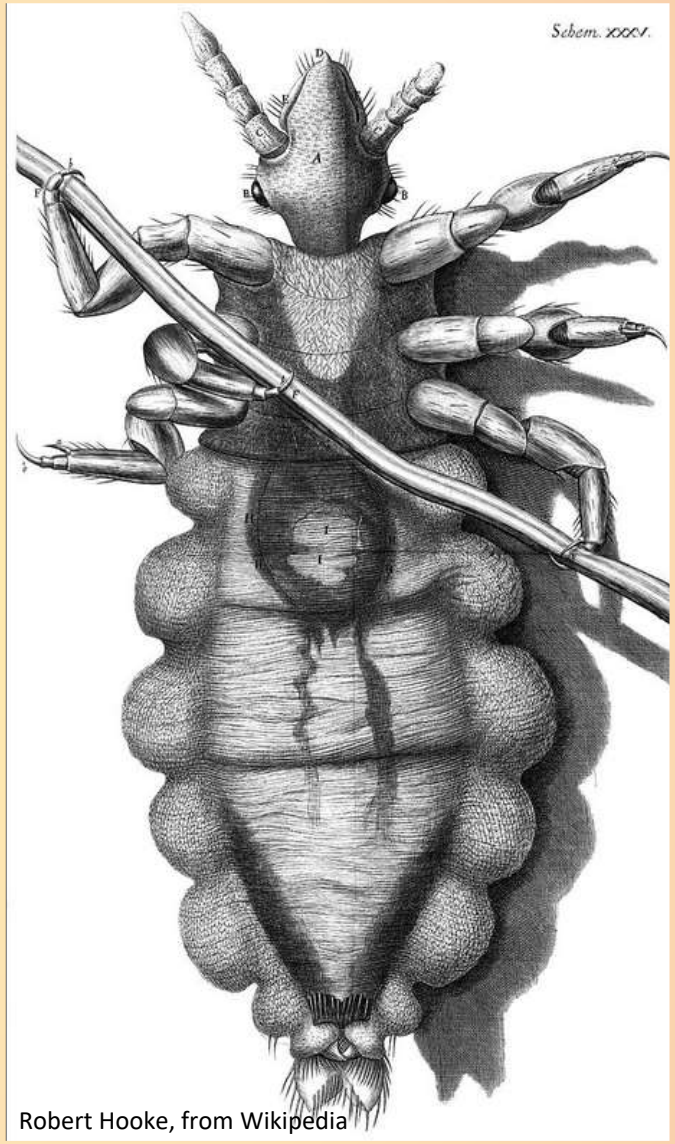
- **Have pick-like mouthparts**
  - **Barklice feed on bark algae, fungi, and other small organic materials**
    - ***They do not do any harm to the plants they are found on***
  - **Booklice feed on similar materials but also glue and other book bindings**

PSOCOPTERA
(BOOK AND BARK LICE)

- **Barklice are often gregarious, forming multi-generational groups**

PHTHIRAPTERA
(TRUE LICE)

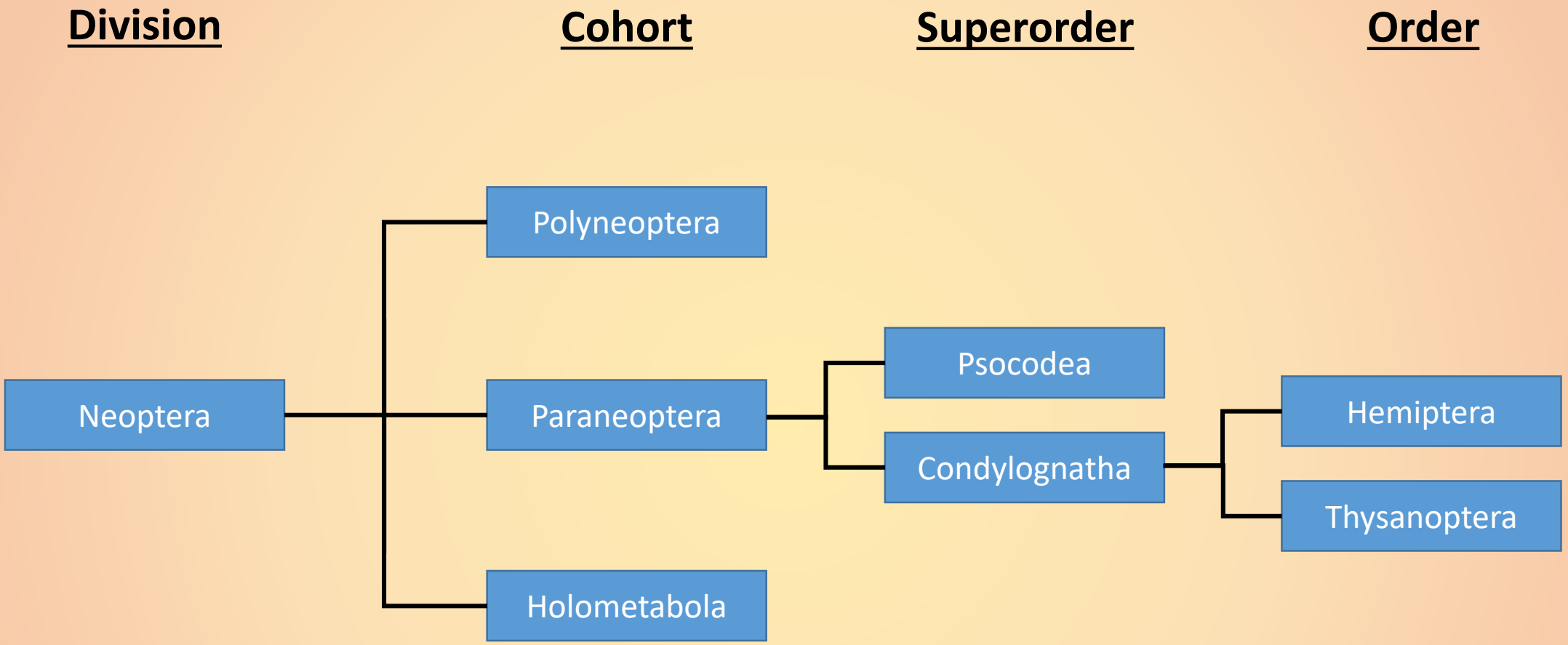
- **Believed to have evolved from the Psocoptera**
  - **Some authorities are include them in the same Order, Psocodea**
- **Mouthparts are chewing or piercing**
- **All species are wingless**



Robert Hooke, from Wikipedia

PHTHIRAPTERA
(TRUE LICE)

- **All are parasitic on vertebrates, with long associations with particular species**
  - **Human lice apparently originated before Homo sapiens left Africa**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Holometabola
Psocodea
Condylognatha
Hemiptera
Thysanoptera

HEMIPTERA
(TRUE BUGS)

- **Originated in the Permian**
- **Characterized by their piercing, beak-like mouthparts and loss of palps**
- **Includes the greatest number of species of non-Holometabolan insects**

HEMIPTERA
(TRUE BUGS)

- **Heteroptera**
  - Forewings are membranous only in the outer third
  - Contain scent glands on their thorax
  - Contains the largest number of species in the Hemiptera

HEMIPTERA
(TRUE BUGS)

- **Heteroptera**
  - **Many of the more primitive members of this group are predatory**
    - ***E.g., Wheel Bug***

HEMIPTERA
(TRUE BUGS)

- **Heteroptera**
  - **Many of the more primitive members of this group are predatory**
    - ***Giant Waterbug***

HEMIPTERA
(TRUE BUGS)

- **Heteroptera**
  - **Bedbugs and Kissing Bugs are external parasites on mammals, including Humans**

By Curtis-Robles et al. via Wikimedia Commons

HEMIPTERA
(TRUE BUGS)

- **Heteroptera**
  - **Other families have become mainly herbivorous, and include some crop pests**
    - ***E.g., the Long-necked Seed Bug, which feeds on strawberry seeds***

Myodocha serripes
Chapel Hill
29 April 2017

HEMIPTERA
(TRUE BUGS)

- **Heteroptera**
  - **The majority, however, seldom stray out of their native habitats**
    - ***e.g., the Milkweed Bug***

HEMIPTERA
(TRUE BUGS)

- **"Homoptera"**
  - **Formerly used for beaked species with membranous fore- and hindwings**
  - **Now divided up into three suborders**

HEMIPTERA
(TRUE BUGS)

- **Suborder Sternorrhyncha**
  - Includes Apids, Adelgids, Scale Insects, White Flies, and Plant Lice (Psyllids)
  - Sap suckers; produce honeydew as a waste product but which is attractive to ants

HEMIPTERA
(TRUE BUGS)

- **Suborder Auchenorrhyncha**
  - Cicadas

HEMIPTERA
(TRUE BUGS)

- **Suborder Auchenorrhyncha**
  - **"Hoppers":**
    - ***Frog Hoppers***
    - ***Plant Hoppers,***
    - ***Tree Hoppers***
    - ***Leaf Hoppers***

THYSANAPTERA
(THRIPS)

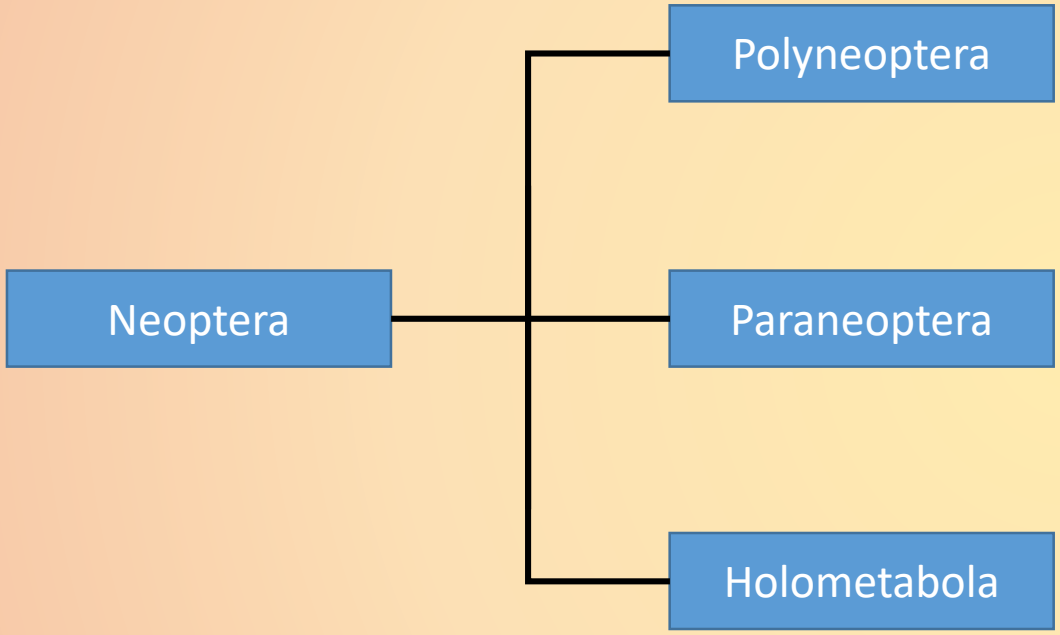
- Oldest fossils are from the Triassic
- Characterized by fringed wings
- Mouthparts are stiletto-like, similar to the Hemiptera
- Most species are herbivores but there are also a few predators and parasites

Alton N. Sparks, Jr., via Wikipedia Creative Commons

THYSANAPTERA
(THRIPS)

- Thrips show the entire range of social behavior, from solitary to eusocial (with specialized castes)

Division **Cohort**

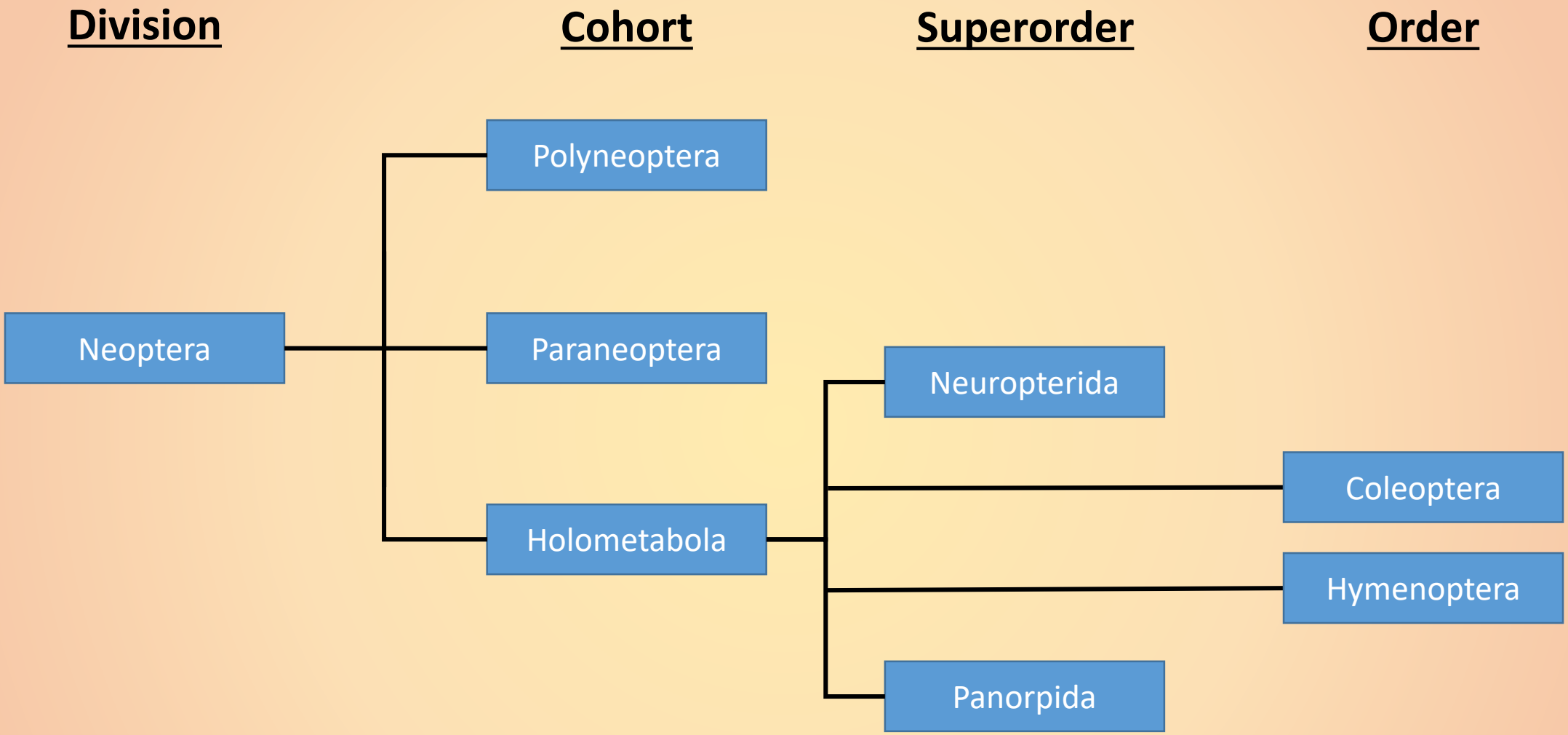


HOLOMETABOLA

- **Characterized by complete metamorphosis**
- **Possess larvae rather than nymphs**
  - **Lack external wing buds**
  - **Reduced sensory structures**
  - **Often sedentary and living inside dense substrates**

HOLOMETABOLA

- **Comprises 85% of all insect species**
  - **The Big Four -- Coleoptera, Diptera, Lepidoptera, and Hymenoptera – by themselves constitute 80% of all described species of insects**
  - **Success is partly due to separation of sedentary, feeding stages from highly mobile, reproductive stages**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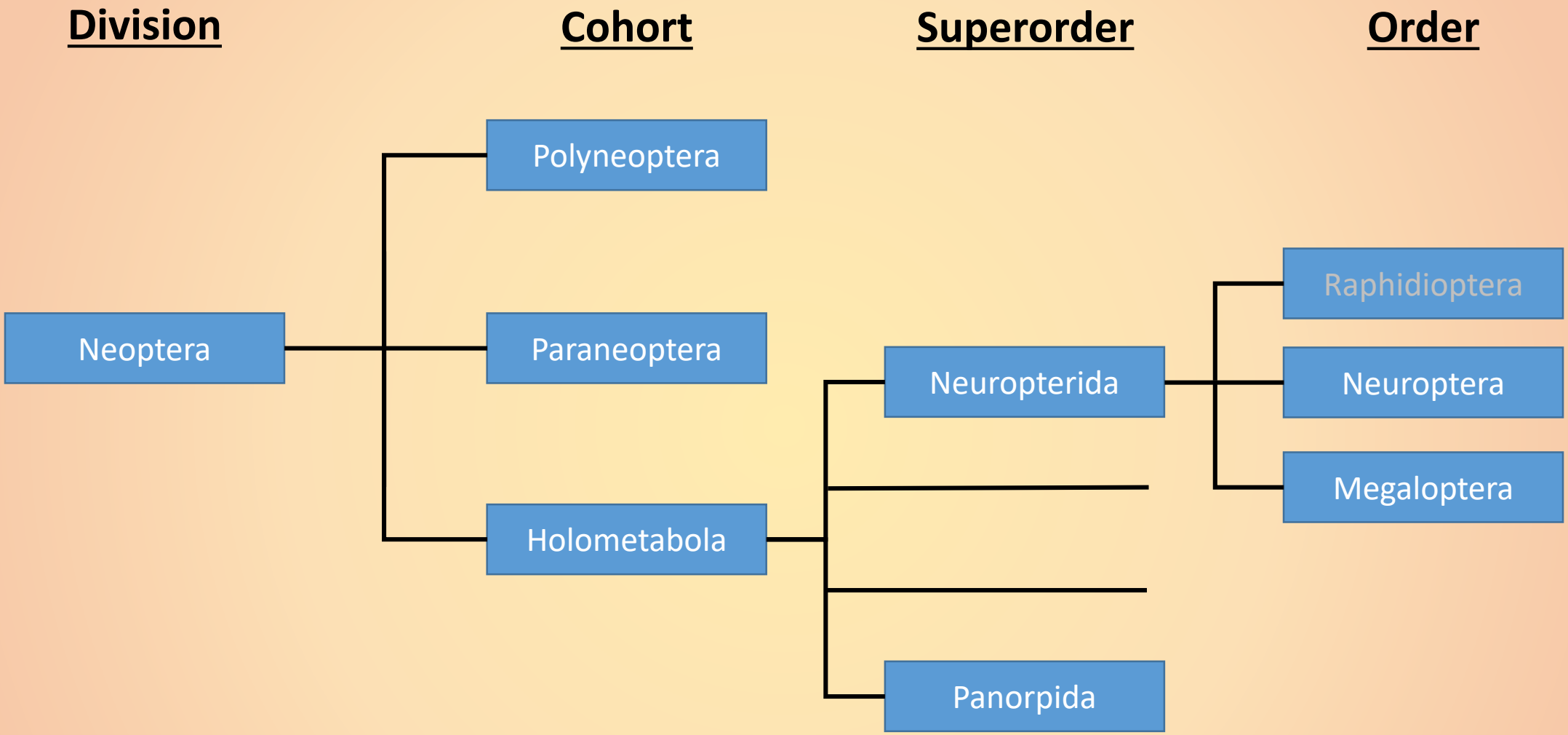
Paraneoptera
Holometabola
Neuropterida
Coleoptera
Hymenoptera
Panorpida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Paraneoptera
Holometabola
Neuropterida
Panorpida
Raphidioptera
Neuroptera
Megaloptera

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

- An archaic group within the Holometabola; fossils exist from the Permian
- Adults have a fine network of veins on their wings and have chewing mouthparts

Ceraeochrysa lineaticornis
Chapel Hill
17 November 2014

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

- **Larvae are characterized by their sickle-shaped mouthparts**

Green Lacewing Larva
NC Botanical Garden
13 June 2017

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

- **Larvae are characterized by their sickle-shaped mouthparts**
  - **completely predaceous on other insects**

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

- **Lacewings are the most commonly encountered members of this group**
  - **Green Lacewings**

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

- **Lacewings are the most commonly encountered members of this group**
  - **Brown Lacewings**

Hemerobius sp.
Chapel Hill
April 29, 2017

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

- **Lacewings are the most commonly encountered members of this group**
  - **Beaded Lacewings**

Lomamyia flavicornis
Chapel Hill
27 September, 2007

NEUROPTERA
(ANTLIONS)

- **Antlions are another common group**
  - **The pits dug by the larvae are far more often noticed than either the larvae or the adults themselves**

NEUROPTERA
(ANTLIONS)

- **Antlions are another common group**
  - **Larvae lie in wait at the bottom, preying on any insect unlucky to fall in**

NEUROPTERA
(ANTLIONS)

- **Antlions are another common group**
  - **Larvae lie in wait at the bottom, preying on any insect unlucky to fall in**

Myrmelion sp.
Chapel Hill
1 May 2017

NEUROPTERA
(ANTLIONS)

- **Adults look like damselflies but hold their wings folded over their abdomens**
  - **antennae are also longer**

NEUROPTERA
(OWLFLIES)

- **Owlflies are closely related to the Antlions, but are less commonly seen**

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

- **Mantisflies have wings and heads similar to Lacewings but have raptorial front legs that are very similar to those of the Mantises**
  - **Larvae are parasitic on the eggs of other insects**

Dicromantispa interrupta
Pilot Mountain State Park
17 May 2017

NEUROPTERA

(LACEWINGS, ANTLIONS, OWLFLIES, MANTISFLIES)

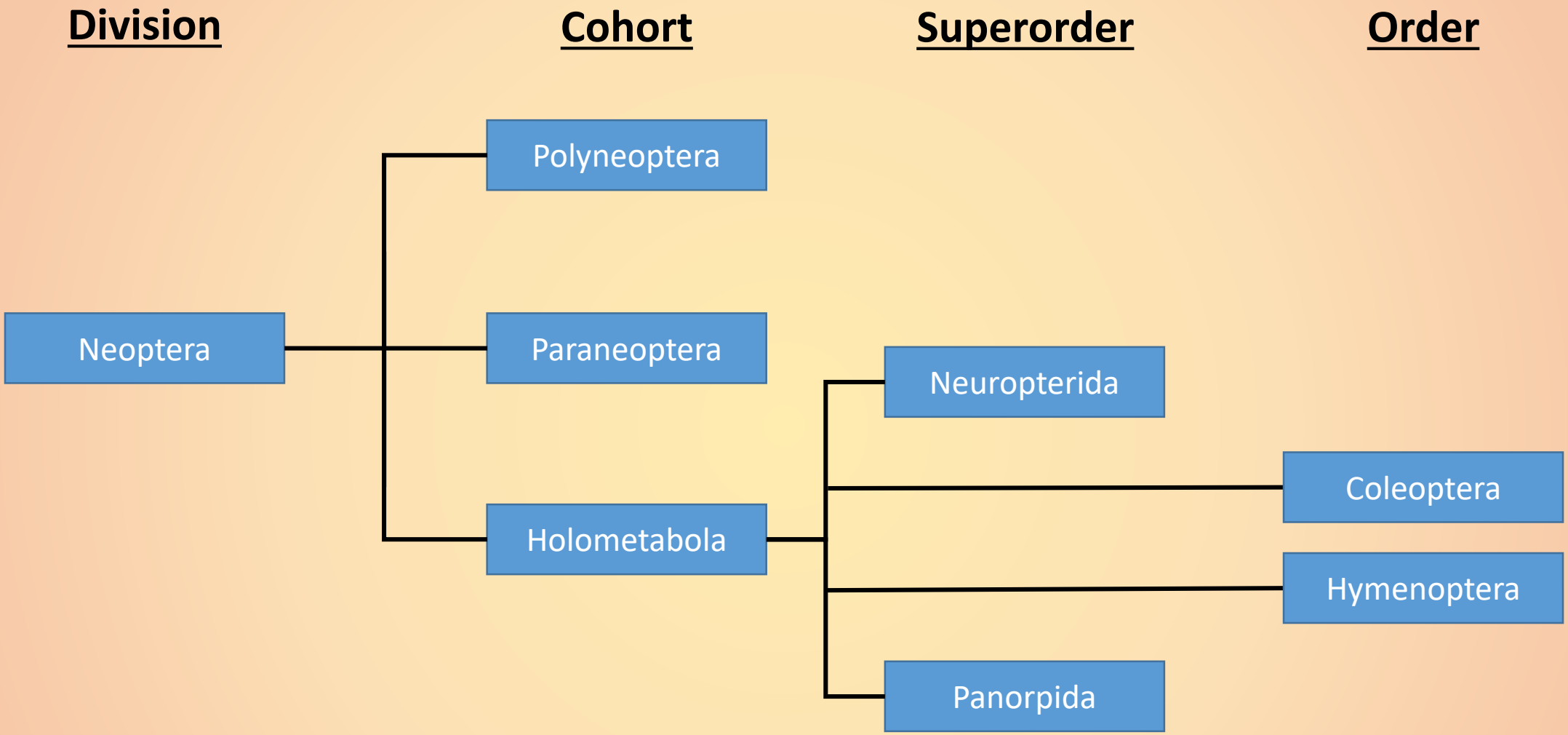
- **Mantisflies have wings and heads similar to Lacewings but have raptorial front legs that are very similar to those of the Mantises**
  - **Larvae of this species feed solely on spider eggs**

Zeugomantispa minuta
Chapel Hill
28 Oct 2014

MEGALOPTERA

(DOBSON FLIES, ALDER FLIES, FISH FLIES)

- **Are generally similar to the Neuroptera but larger**
- **Have aquatic larvae that lack the hollow, sickle-shaped mouthparts**
  - **Male Dobsonflies have tusk-like mouthparts that are used in mating but not for feeding**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Coleoptera
Hymenoptera
Panorpida

COLEOPTERA
(BEETLES)

- **Possess more species than any other group of organisms**
  - **Currently about 400,000 have been described and the global estimate is >1,000,000**

Lucanus capreolus
Haw River State Park
23 July 2014

COLEOPTERA
(BEETLES)

- **Success is partly due to the development of complete metamorphosis**
  - **Beetle larvae are pre-eminent among wood-boring species**

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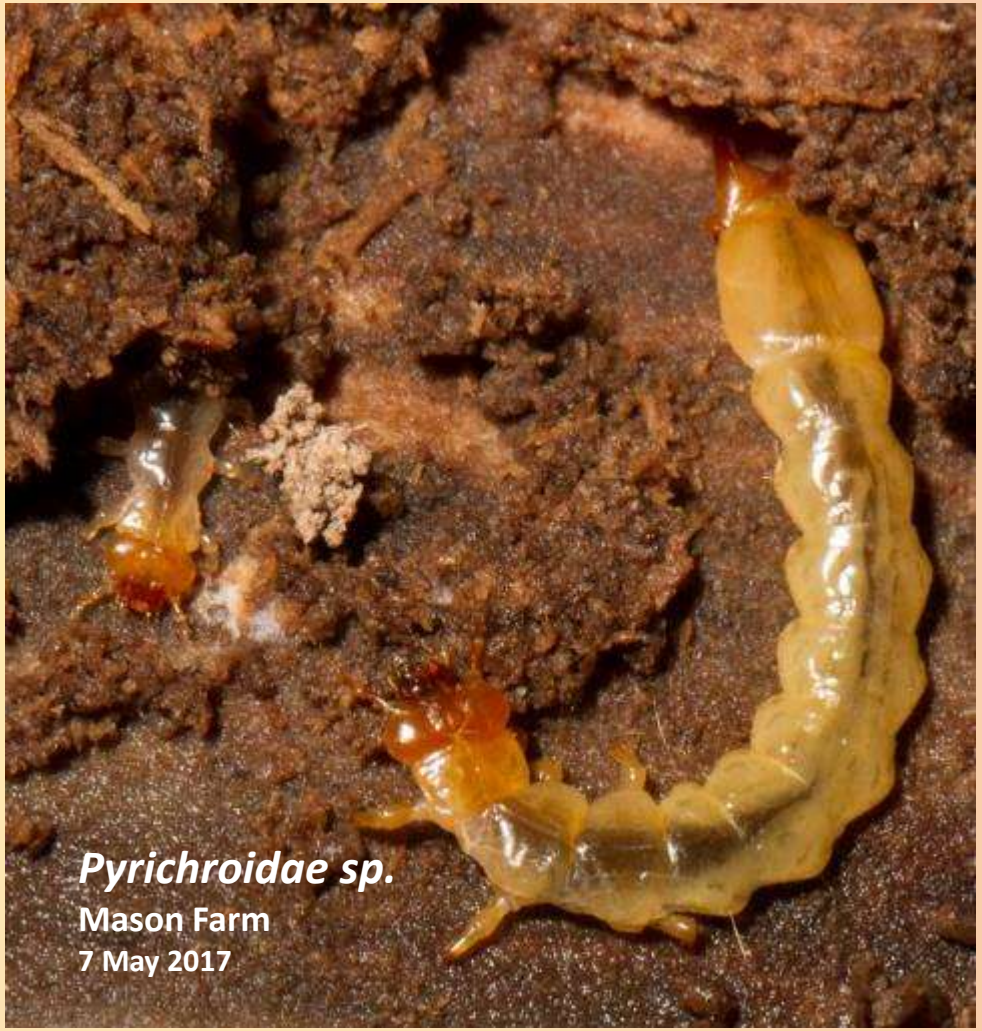

COLEOPTERA
(BEETLES)

- **Success is partly due to the development of complete metamorphosis**
  - Many others have subterranean larvae

Cicindela sp.
Mason Farm
16 August 1985

COLEOPTERA
(BEETLES)

- Others are aquatic or free-roaming

COLEOPTERA
(BEETLES)

- **The majority of their success is due to their heavy armor**
  - **Allows them to burrow into wood and underground as adults**

COLEOPTERA
(BEETLES)

- **The majority of their success is due to their heavy armor**
  - **Gives them substantial protection from predators**

COLEOPTERA
(BEETLES)

- **Adults are also highly diverse in form and habitat**

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COLEOPTERA
(BEETLES)

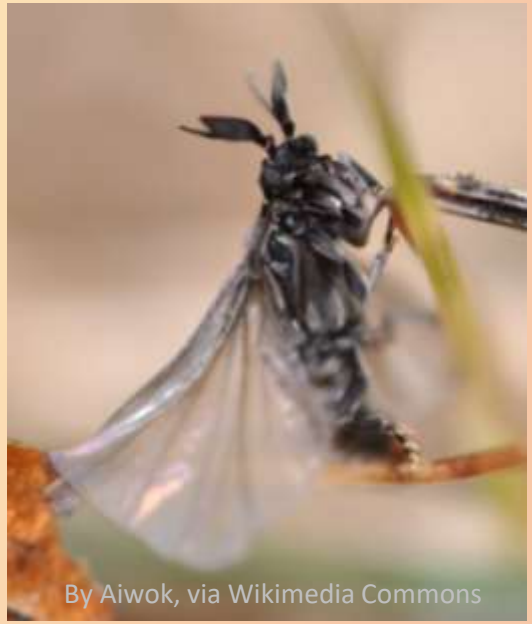
- **Adults are also highly diverse in form and habitat**

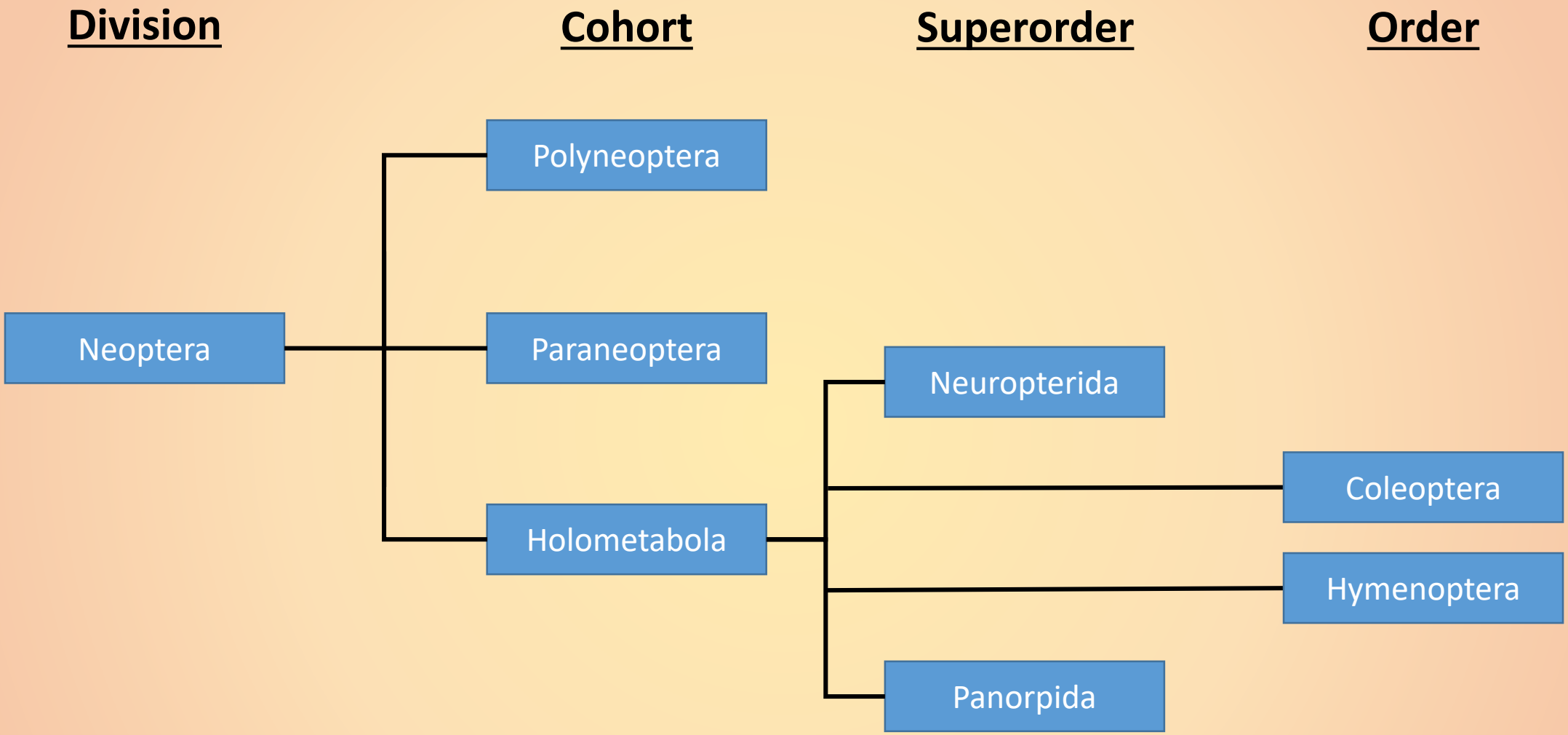
Chrysochus auratus
Duke Forest
13 June 2015

STREPSIPTERA
(TWISTED WINGS)

- **Strepsiptera are tiny parasites on wasps and bees**
  - **Placement within the Holometabola is uncertain**
    - ***Probably linked to the Beetles***


By maxson.erin, via Wikimedia Commons


By Aiwok, via Wikimedia Commons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Hymenoptera
Panorpida

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- Characterized by their prominent ovipositors
- Have a relatively recent origin, first showing up in the Triassic
- Relationship to the other Holometabola is uncertain

Braconidae sp.
Chapel Hill
17 June 2015

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Two main divisions:**
  - **The "Symphyta"**
    - ***Possess closely adjoined thorax and abdomen***
    - ***All but one family are plant feeders***
    - ***Include two main subgroups:***
      - The Horntails
      - The Sawflies

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Apocrita**
  - Possess narrow wasp-waists

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Apocrita**
  - The vast majority are parasitoids
  - Mostly in two superfamilies:
    - *Ichneumonoidea*
    - *Chalcidoidea*

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Apocrita**
  - **Aculeata**
    - ***Stinging Wasps***
      - Ovipositor is used as a weapon; eggs emerge from an opening at the base of the sting
      - Most are predatory, stinging their prey and bringing it back to their nests to feed their larvae
      - Some are solitary

Sphecius speciosus
Fort Fisher Aquarium
15 August 2014

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Apocrita**
  - **Aculeata**
    - ***Stinging Wasps***
      - Ovipositor is used as a weapon; eggs emerge from an opening at the base of the sting
      - Most are predatory, stinging their prey and bringing it back to their nests to feed their larvae
      - Some are solitary
      - Many are eusocial

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Apocrita**
  - **Aculeata**
    - ***Bees***
      - Feed on flower nectar and pollen, both as adults and immatures
      - Most have extensive parental care (some are nest parasites, i.e., cuckoos)

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(WASPS, BEES, AND ANTS)

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    - ***Bees***
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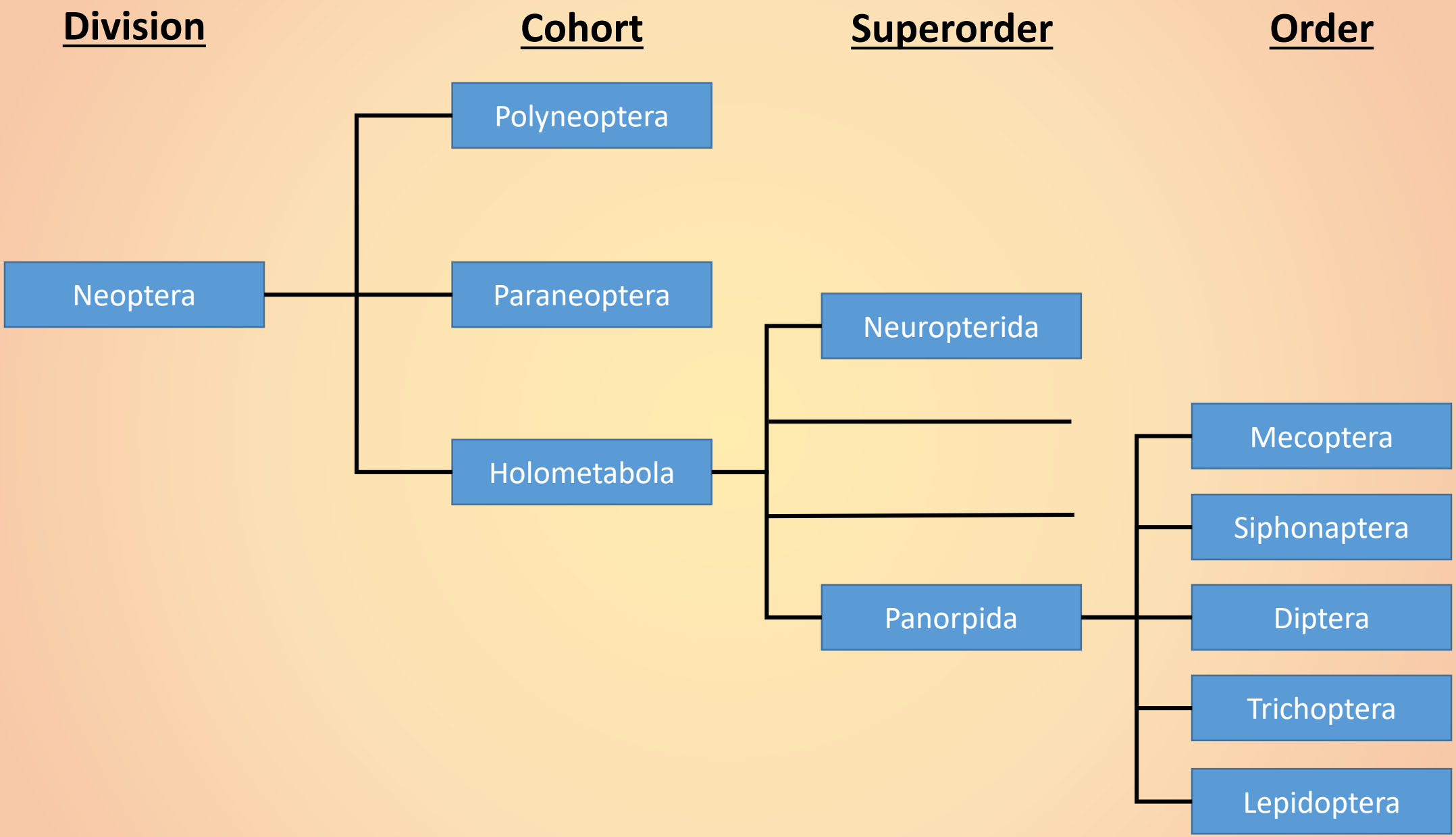
      - Most have extensive parental care (some are nest parasites, i.e., cuckoos)
      - Some are solitary
      - Some are colonial nesters

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Apocrita**
  - **Aculeata**
    - ***Bees***
      - Feed on flower nectar and pollen, both as adults and immatures
      - Most have extensive parental care (some are nest parasites, i.e., cuckoos)
      - Some are solitary
      - Some are eusocial, with division of labor and separate castes

HYMENOPTERA
(WASPS, BEES, AND ANTS)

- **Apocrita**
  - **Aculeata**
    - ***Ants***
      - Evolved from Vespoid wasps
      - All are eusocial
      - Are extremely important ecologically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Neuropterida
Panorpida
Mecoptera
Siphonaptera
Diptera
Trichoptera
Lepidoptera

MECOPTERA
(SCORPIONFLIES)

- **Fossils are known from the Permian**
  - **The group is relatively unspecialized**
    - ***Possess beak-like but chewing mouthparts***
  - **Most are predatory or scavenging, but some feed on pollen or other plant material**

MECOPTERA
(SCORPIONFLIES)

- **Males offer nuptial gifts to females**
  - **Hanging flies use their hindlegs to hold these offerings**

SIPHONAPTERA
(FLEAS)

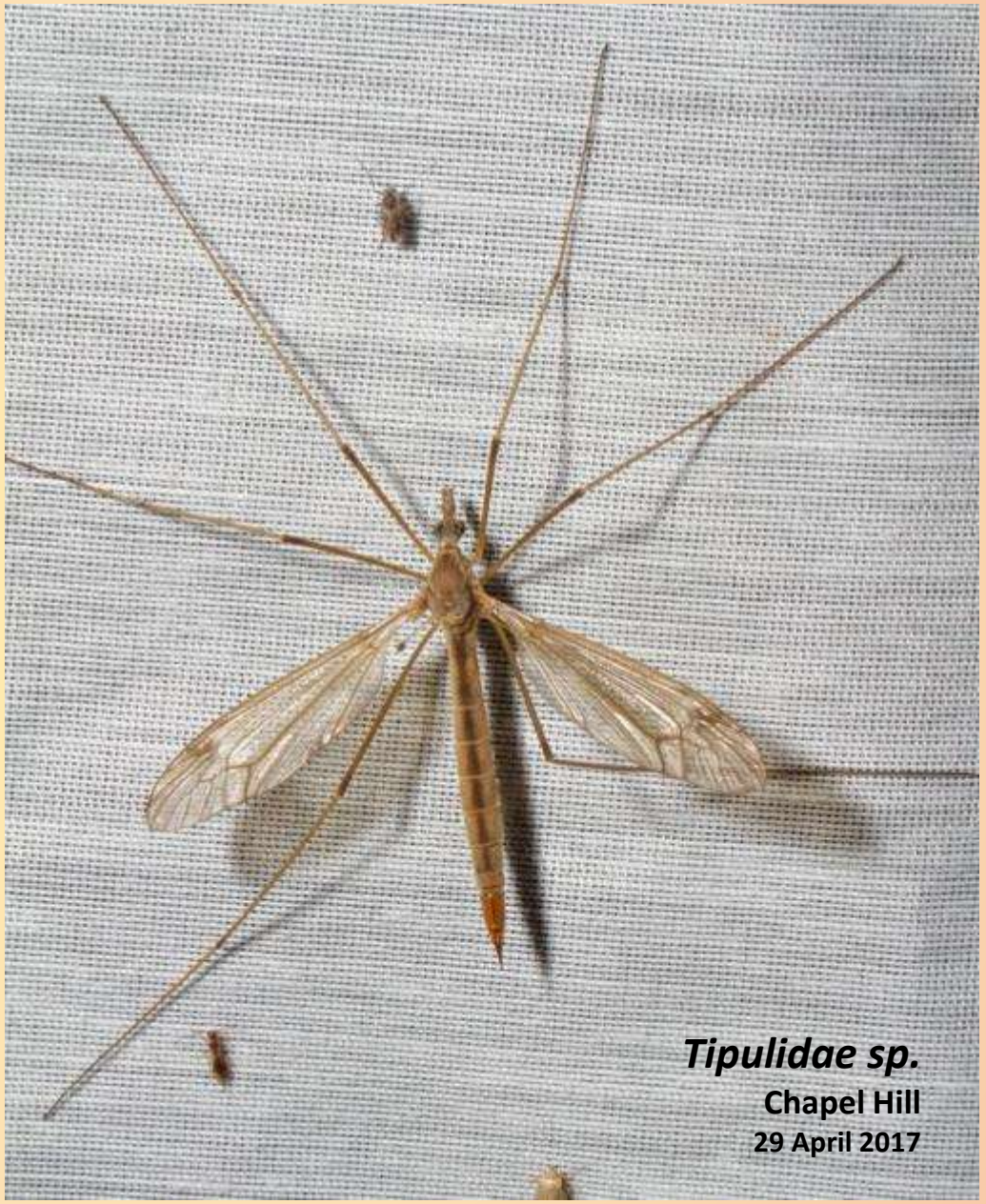
- **All are flightless parasites on vertebrates**
  - **Some are important disease carriers**

SIPHONAPTERA
(FLEAS)

- **Appear to be closely related to a flightless group of Mecopterans, the Snow Scorpionflies**
  - **Are now often included within the Mecoptera**

DIPTERA
(TRUE FLIES)

- **Are also closely allied to the Mecoptera**
  - **Probably a sister group that split off in the Permian**
  - **Craneflies are similar to the Hanging Flies**
    - ***Considered the most primitive group of the flies***



DIPTERA
(TRUE FLIES)

- **Characterized by their possession of just a single pair of wings**

DIPTERA
(TRUE FLIES)

- **Characterized by their possession of just a single pair of wings**
  - **The second pair are reduced to small structures called halteres that are used for balancing during flight**

DIPTERA
(TRUE FLIES)

- **Mouthparts vary enormously**
  - **Diptera are probably the most diverse group of insects in terms of their diets and ecological roles**
  - **Many have parasitic larvae**
    - ***E.g., Tachinid flies***

Tachinidae sp.
Weymouth Woods
8 May 2013

DIPTERA
(TRUE FLIES)

- **Mouthparts vary enormously**
  - **Some are also parasitic on vertebrates as adults**

DIPTERA
(TRUE FLIES)

- **Mouthparts vary enormously**
  - **Several families are predators on other insects**
    - ***E.g., Long-legged Flies***

DIPTERA
(TRUE FLIES)

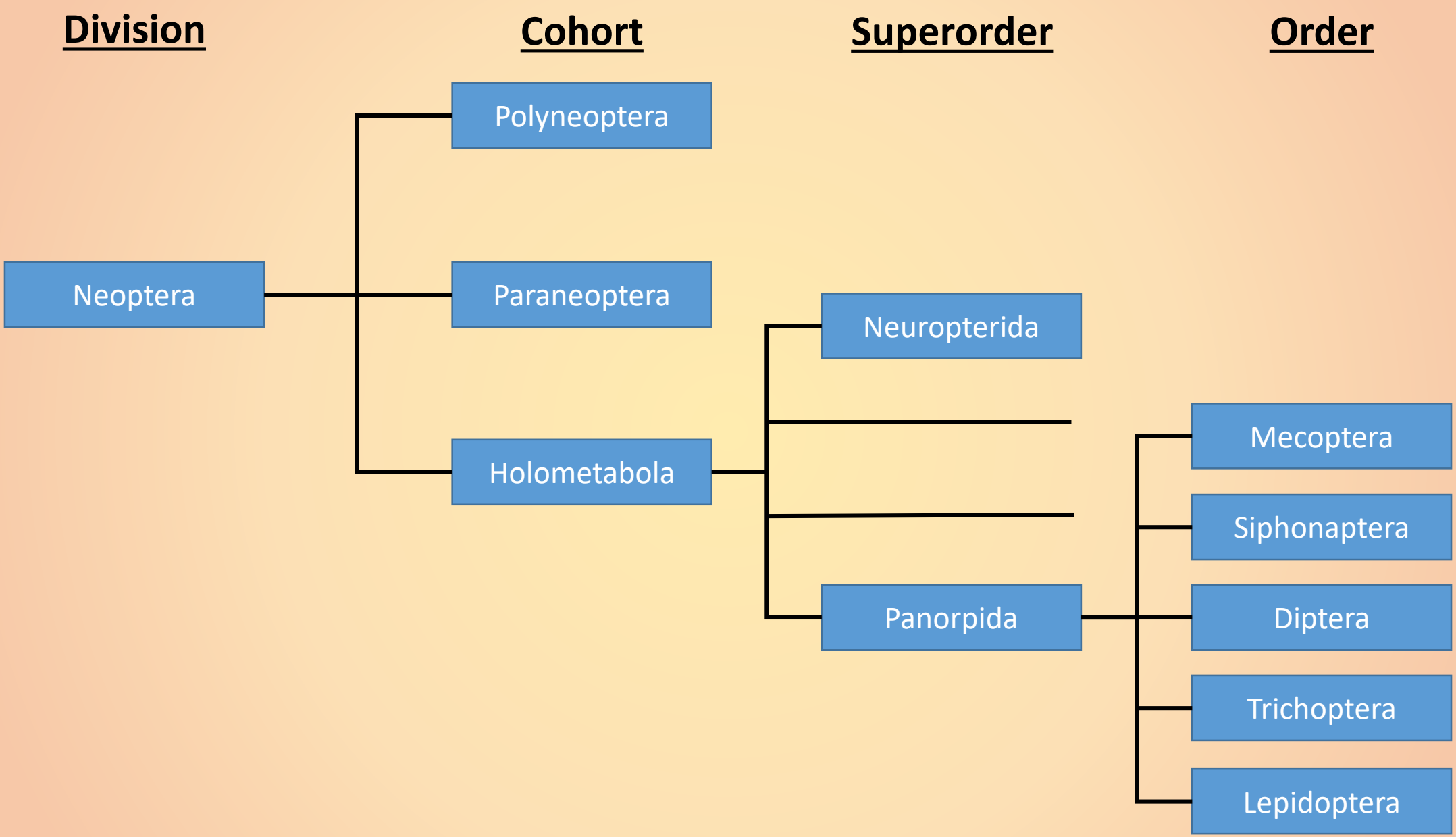
- **Mouthparts vary enormously**
  - **Several families are predators on other insects**
    - ***Robber Flies***

DIPTERA
(TRUE FLIES)

- **Mouthparts vary enormously**
  - **Many are scavengers**
    - ***e.g., Flesh Flies***

DIPTERA
(TRUE FLIES)

- **Mouthparts vary enormously**
  - **Adults of several families feed primarily on nectar or pollen**
    - ***e.g., Flower Flies***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Mecoptera
Siphonaptera
Diptera
Trichoptera
Lepidoptera

TRICHOPTERA
(CADDISFLIES)

- **Are characterized by aquatic larvae, many of which build cases out of plant debris and pebbles**

MyForest, Wikipedia

TRICHOPTERA
(CADDISFLIES)

- **Some build nets instead**
  - **Used to capture small organisms and detritus**

TRICHOPTERA
(CADDISFLIES)

- **Along with the nymphs of Mayflies and Stoneflies, larvae of Caddisflies are used as indicators of high water quality**

TRICHOPTERA
(CADDISFLIES)

- **Adults have relatively weakly developed mouthparts and probably feed on liquids, if at all**
- **They lack the scales found in the Lepidoptera but may have tufts of setae**

Hydropsyche sp.
Chapel Hill
29 April 2017

LEPIDOPTERA
(MOTHS AND BUTTERFLIES)

- **Are probably second only to Beetles in total number of species**
  - **300,000 -500,000 species have been estimated globally**

LEPIDOPTERA
(MOTHS AND BUTTERFLIES)

- **Problably diverged from the Trichoptera in the early Jurassic**
  - **The most primitive Lepidopterans still possess chewing mouthparts, similar to those of the Caddisflies**
    - ***E.g., the Goldcap Moss-eater Moth***

LEPIDOPTERA
(MOTHS AND BUTTERFLIES)

- **All other Lepidoptera have tubular mouthparts for feeding on nectar**
  - **Radiated only after the Flowering Plants evolved in the Cretaceous and Tertiary**

LEPIDOPTERA
(MOTHS AND BUTTERFLIES)

- **In addition to their distinctive mouthparts, Lepidoptera are characterized by the scales that cover their wings**
  - **Modified setae, constructed from chitin**

Papilio glaucus
Duke Forest
17 March 2016

LEPIDOPTERA
(MOTHS AND BUTTERFLIES)

- **Their larvae are called Caterpillars**
  - **They comprise the largest group of plant-eating insects, outnumbering even Beetles!**
  - **Some groups also feed on fungi, lichens, dead leaves**
  - **A few are predatory and one family are parasites on Plant Hoppers**

LEPIDOPTERA
(MOTHS AND BUTTERFLIES)

- **Butterflies are the best known species**
  - **177 species have been recorded in North Carolina**

Atlides halesus
Lake Waccamaw
28 September 2013

LEPIDOPTERA
(MOTHS AND BUTTERFLIES)

- **Moths – which include all other species of Lepidoptera – are far more diverse**
  - **Nearly 3,000 species have been recorded in North Carolina**
- **Many species are equally spectacular as the butterflies, if not as well-known or appreciated!**