中山大學生物資優班
昆蟲學

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節肢動物 生物多樣性簡介
OVERVIEW OF Arthropod DIVERSITY

Insects are arthropods

界 Kingdom
門 Phylum
綱 Class
目 Order
科 Family
屬 Genus
種 Species

Major groups within the Arthropoda

Pycnogonida
(海蜘蛛)

Chelicerates
(螯肢類)

Hexapods
(六足類)

ancestor

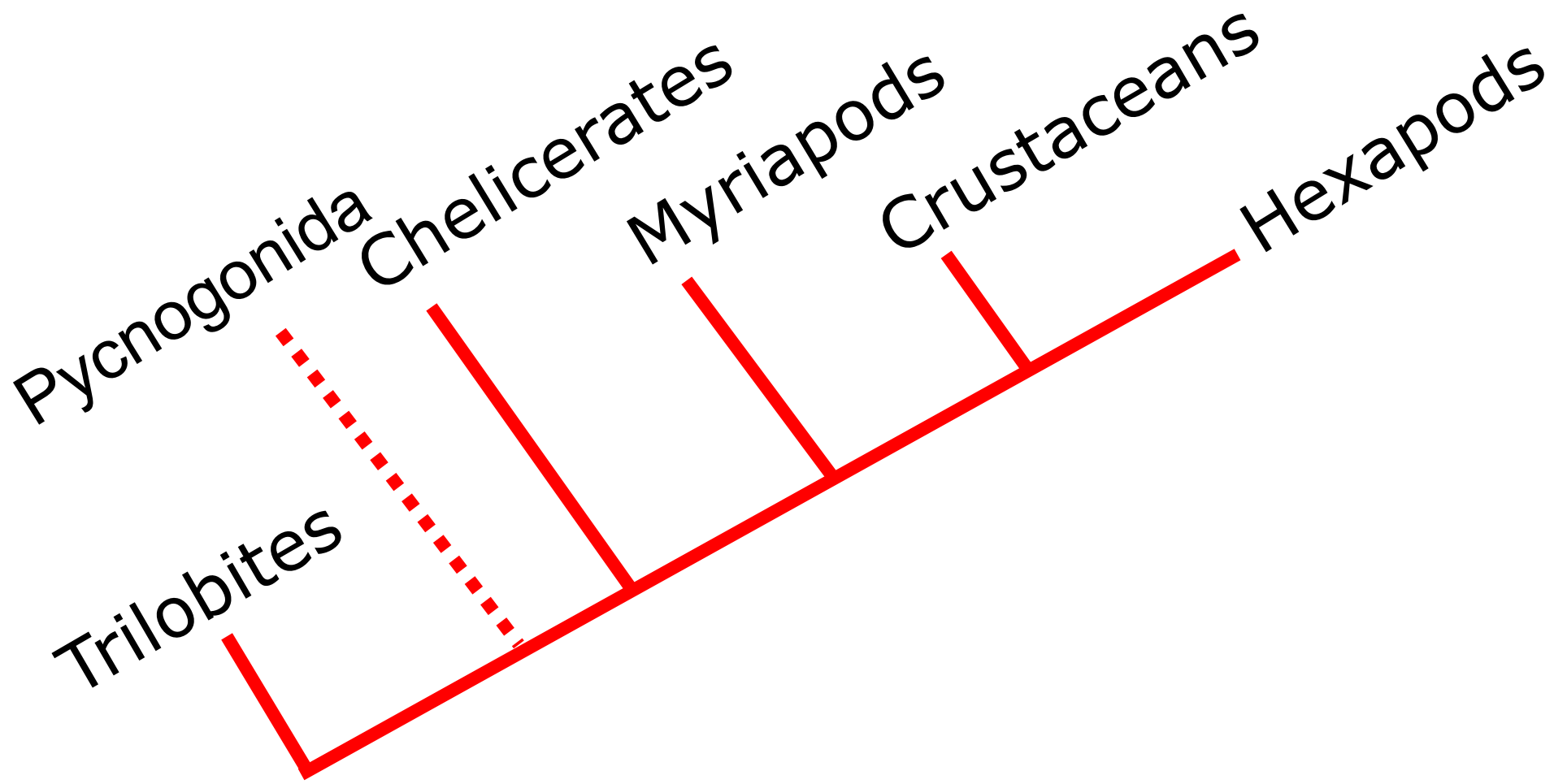
Crustaceans
(甲殻類)

Myriapods
(多足類)

Trilobites
(三葉蟲)

Extinct

節肢動物可能的演化關係



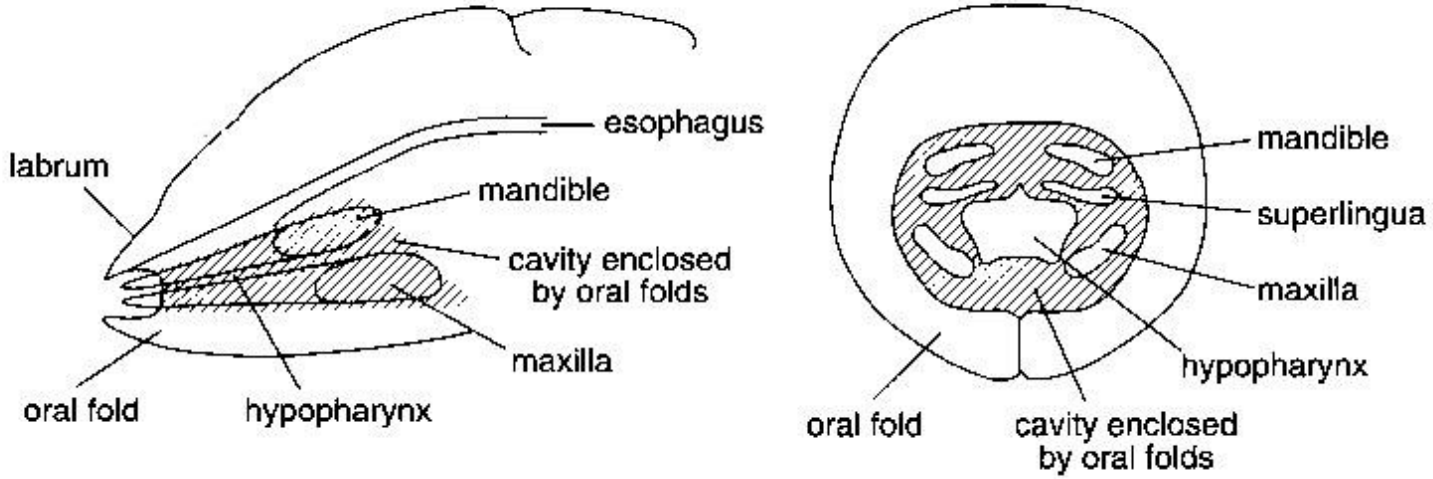
HEXAPODA
(都是六隻腳的動物，但並不是都是昆蟲)

ENTOGNATHS
(內口類)

ECTOGNATHS
(外口類)

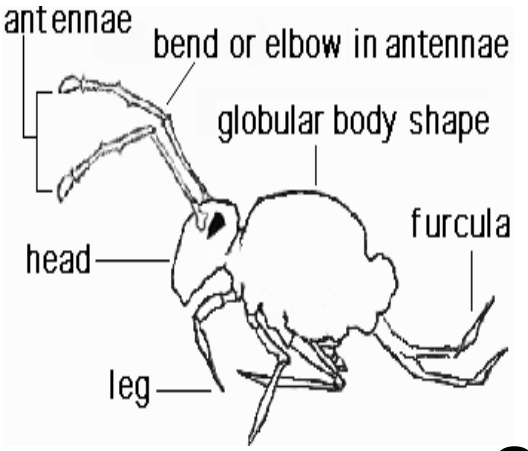
Entognaths(內口類) and Ectognaths(外口類)
(稱「類」而不稱「綱」-演化觀念之適用)

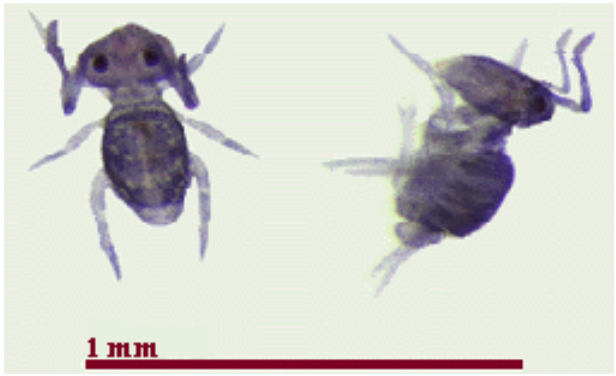
- Entognaths (內口類): Mouthparts "pulled up" into head capsule



THE ENTOGNATHS
Orders Protura, Collembola, Diplura

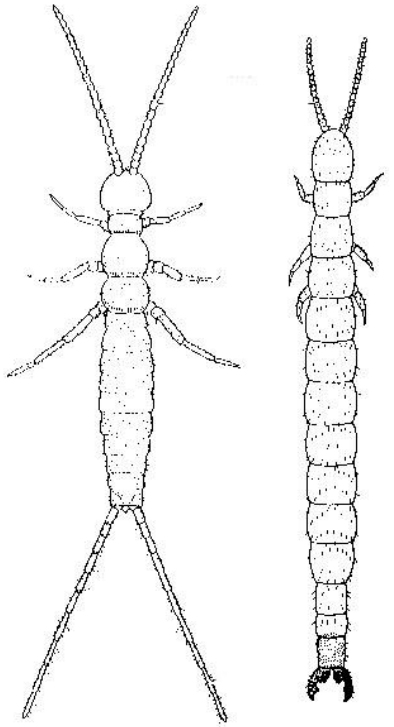
- 小型生物、住在落葉及表土層中





Collembola

Protura

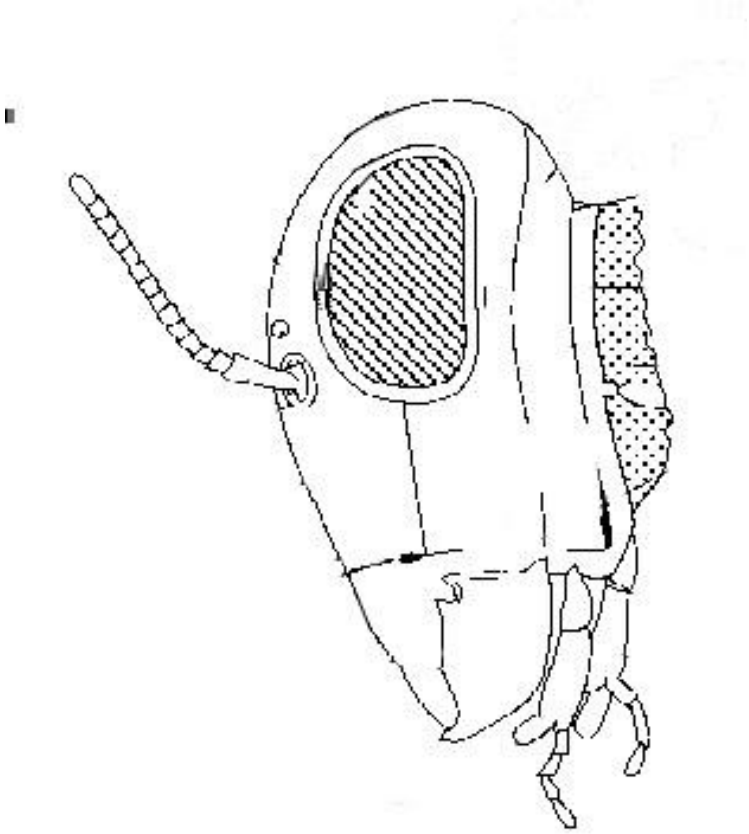


Diplura

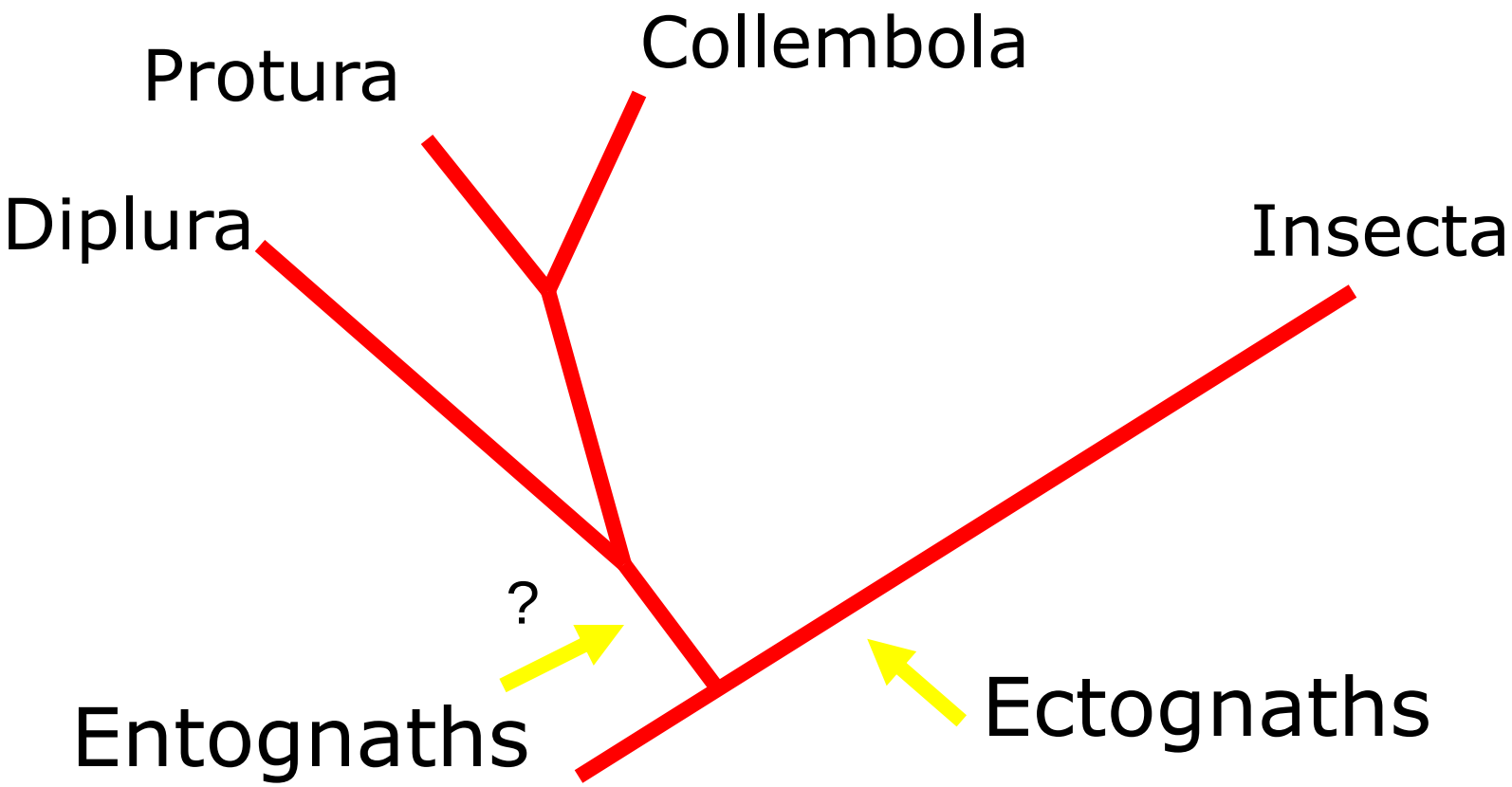
Entognaths(內口類) and Ectognaths(外口類)

六足類的早期分化

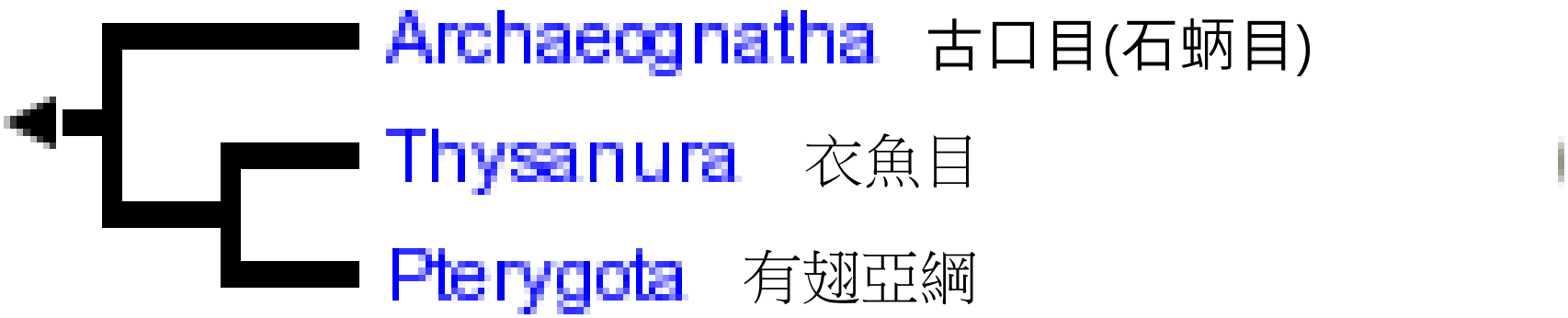
- Ectognathous hexapods: Mouthparts not covered by head capsule(口器外露)



六足類的演化樹

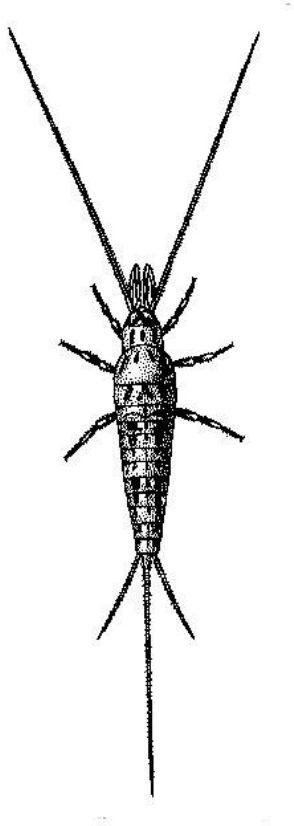

Protura
Collembola
Diplura
Insecta
?
Entognaths
Ectognaths

外口類=昆蟲綱
Ectognaths: CLASS INSECTA

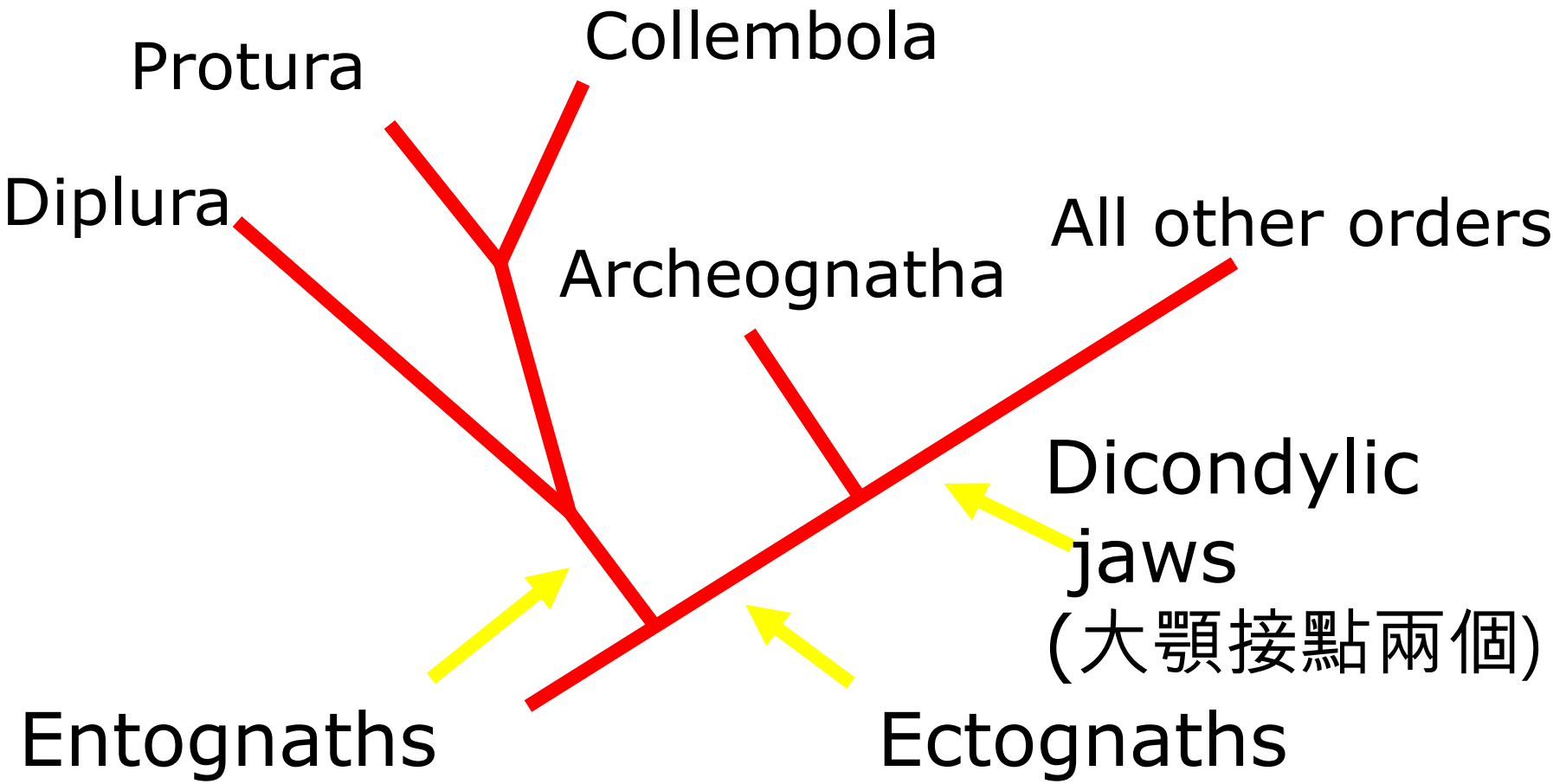


Order Achaeognatha (古口目) and Order Thysanura (衣魚目) sometimes referred to as the apterygotes (有翅亞“類”) — primitively wingless.
Pterygota are the winged insects

- Order Archeognatha (古口目“ancient jaws”)
- Only 1 mandibular condyle (大顎接點一個)

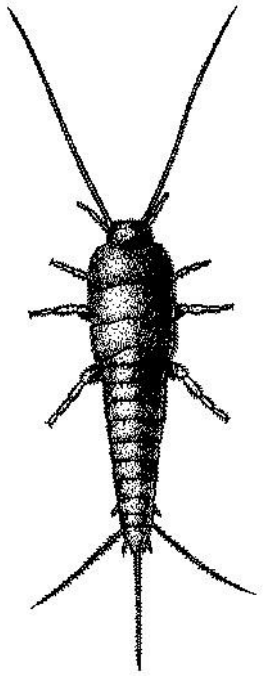


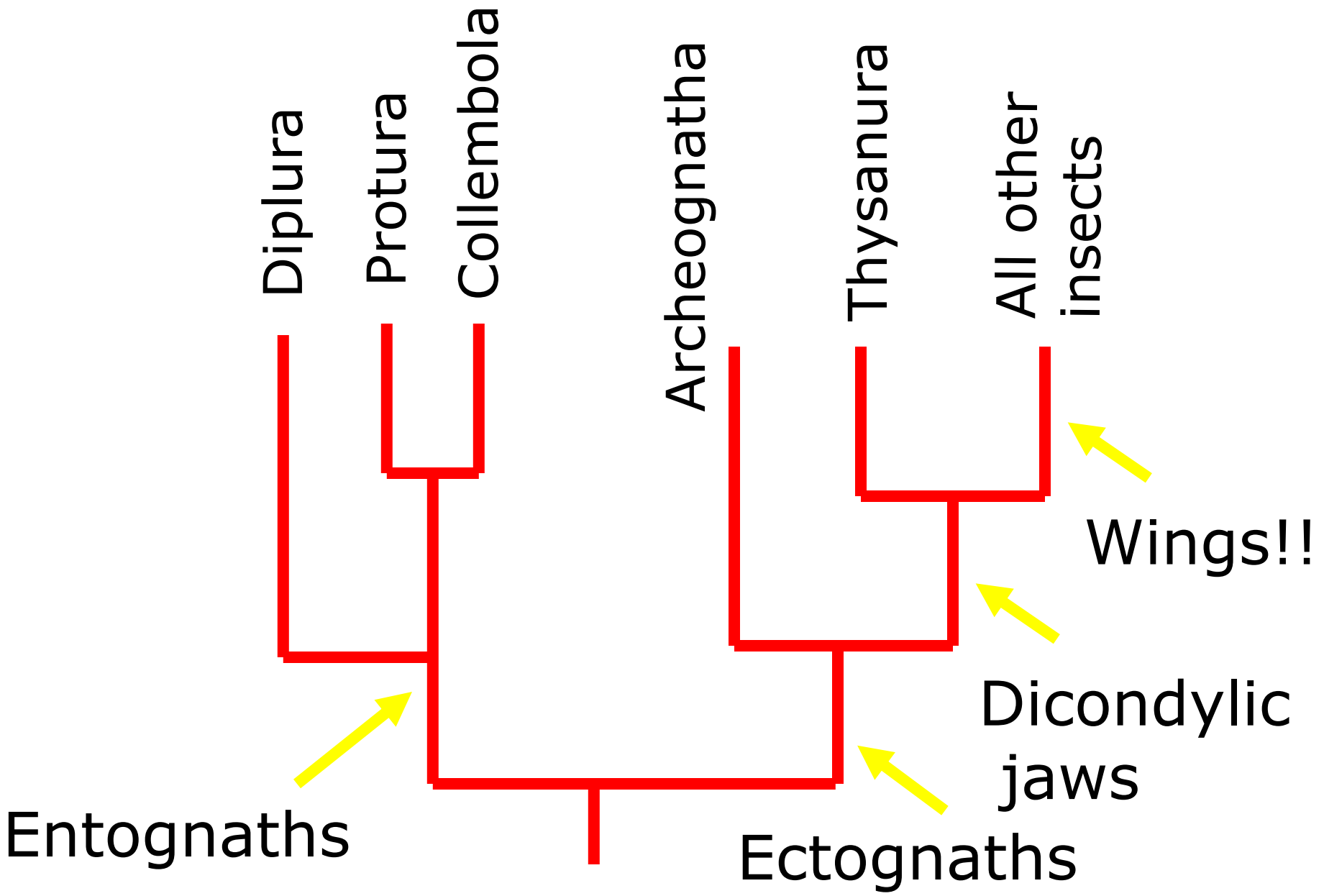
Tree of Hexapod Groups



Order Thysanura (衣魚目、銀魚目)
Silverfish and firebrats

- New invention:
  dicondylic jaws (大顎接點兩個、見模型)




Diplura
Protura
Collembola
Archeognatha
Thysanura
All other insects
Wings!!
Dicondylic jaws
Entognaths
Ectognaths

Pterygotes—winged insects

Ephemeroptera (蜉蝣目) and Odonata (蜻蜓目) sometimes called the Paleoptera (古生翅群 Old wings)

Orders Ephemeroptera (蜉蝣目) and Odonata (蜻蛉目)

Neopteran Insects (新翅群)

- Most of the insect orders
- Special wing-folding mechanism
- Can fold wings flat over back (可以將翅折與腹部平行)

Dictyoperan orders

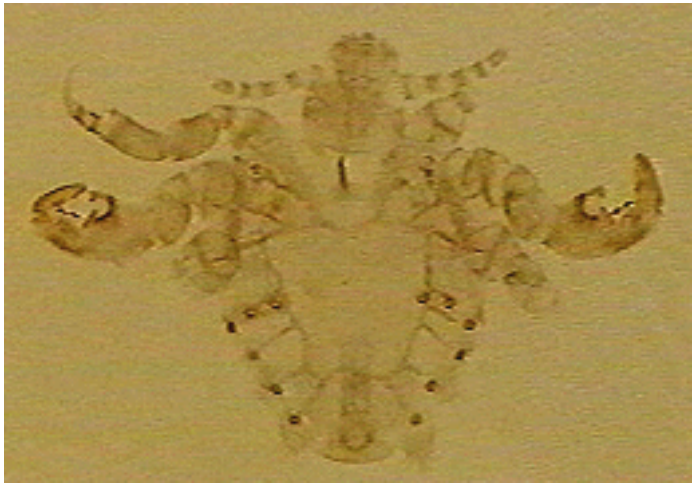
- Blattodea(蜚蠊目)
- Blatteria-Roaches
- Isoptera-Termites
- Mantodea-Mantises

Order Orthoptera:Two big groups:

- Ensifera: “long horned”
- Crickets, katydids and weta

- Caelifera: “Short-horned”
- grasshoppers, locusts and their relatives

Hemipteroid Orders

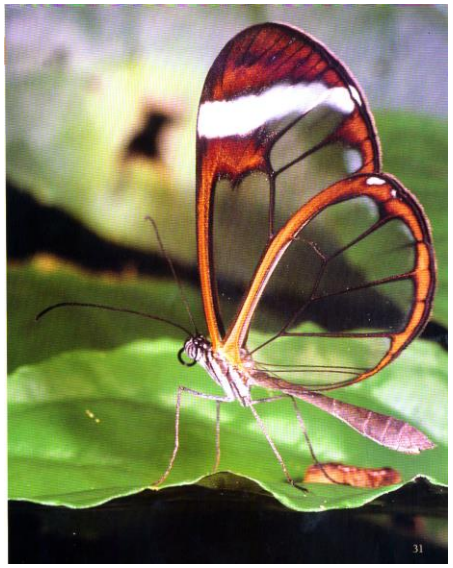


Crab louse-Phthiraptera

A thrips
Thysanoptera

Hemiptera/
Homoptera

Lacewing-Neuroptera



Butterfly-
Lepidoptera

Flea-Siphonaptera

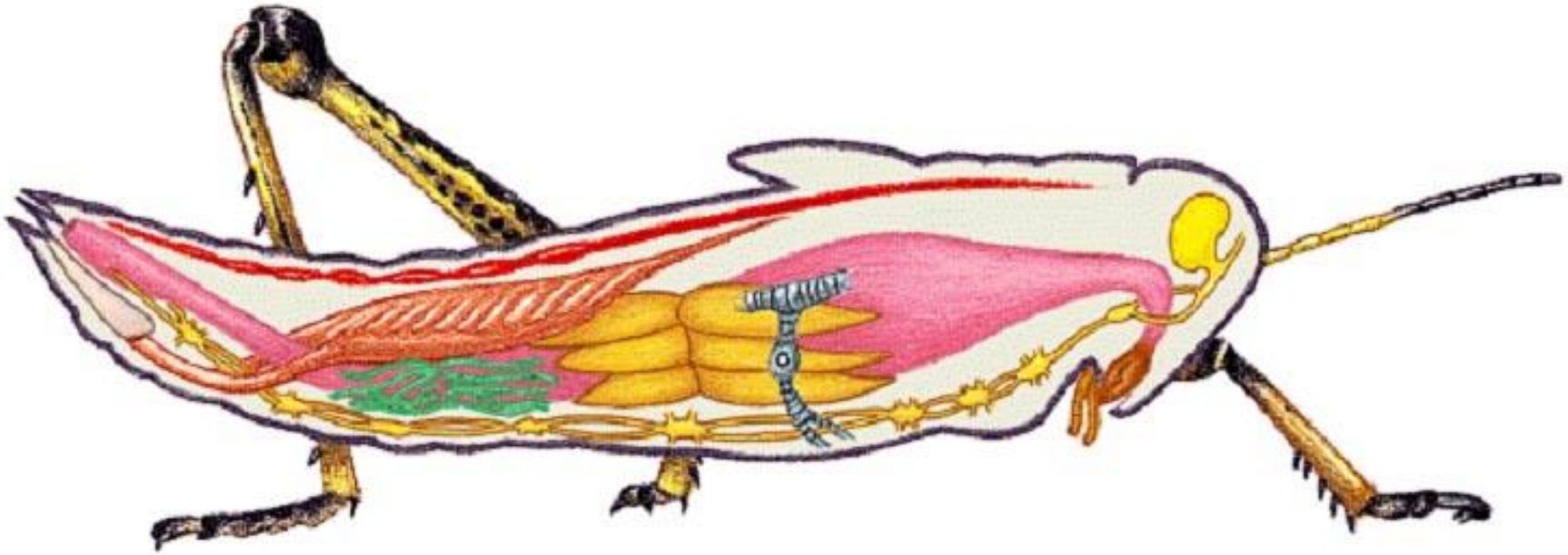
Beetle-Coleoptera

Bee-Hymenoptera

Mosquito-Diptera

Phylum Arthropoda:
the jointed-foot animals

- Many basic features shared with other animal phyla
- SEGMENTED BODY (身體分節)
- DORSAL HEART (心位於背部)
- PAIRED VENTRAL NERVE CORDS (成對的神經索位於腹部)



Phylum Arthropoda

- COMPOUND EYES (複眼)
- many small units, OMMATIDIA (複眼單元)
- OMMATIDIUM has lens, visual pigments

Phylum Arthropoda
unique characters

- Coelom greatly reduced (體腔退化)
- Instead, open circulatory system (半開放體循環)

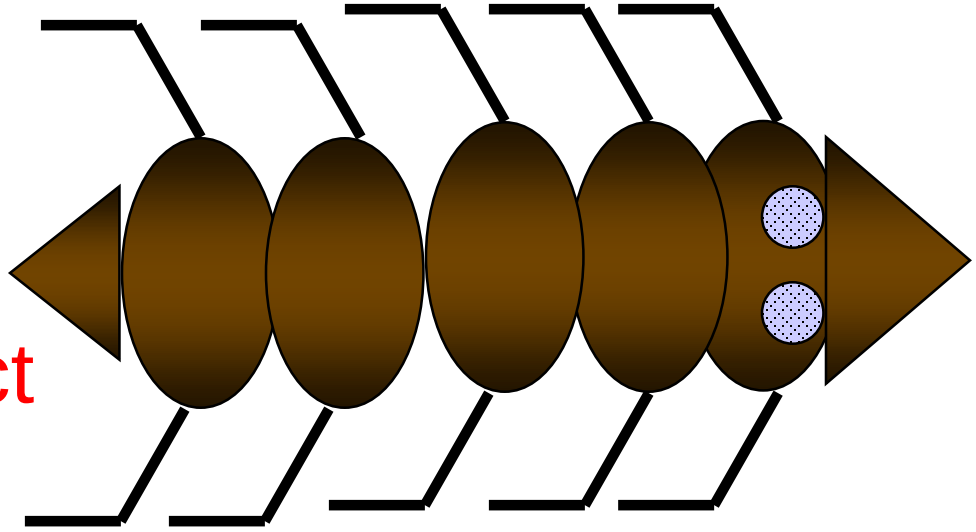
Phylum Arthropoda
unique characters

- Hard, jointed exoskeleton (硬的外骨骼)
  - Cuticle= protein and CHITIN, a polysaccharide
  - Sclerotization of cuticle:

  tanning of protein to form hard plates
- Jointed, segmented appendages on each body segment (外骨骼及附肢分節)

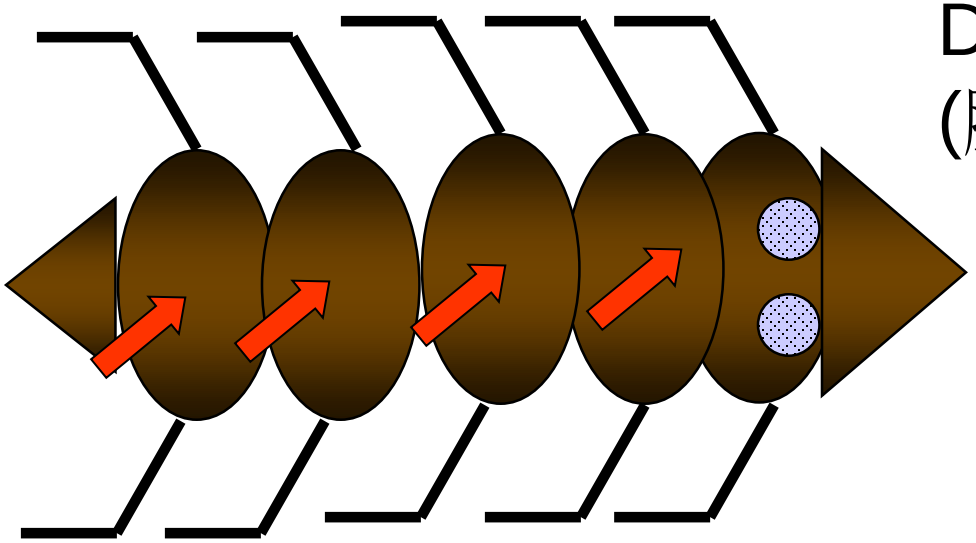
Segmented body plan, Jointed exoskeleton

Anterior to mouth:
non-segmental acron
or prostomium



Just posterior to anus:
non-segmental tail,
or telson or periproct

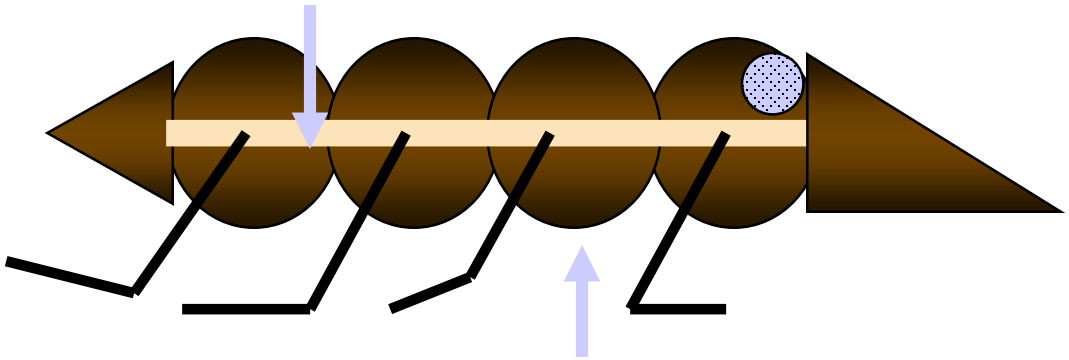
Paired, jointed limbs on each body segment



DORSAL VIEW
(腹面)

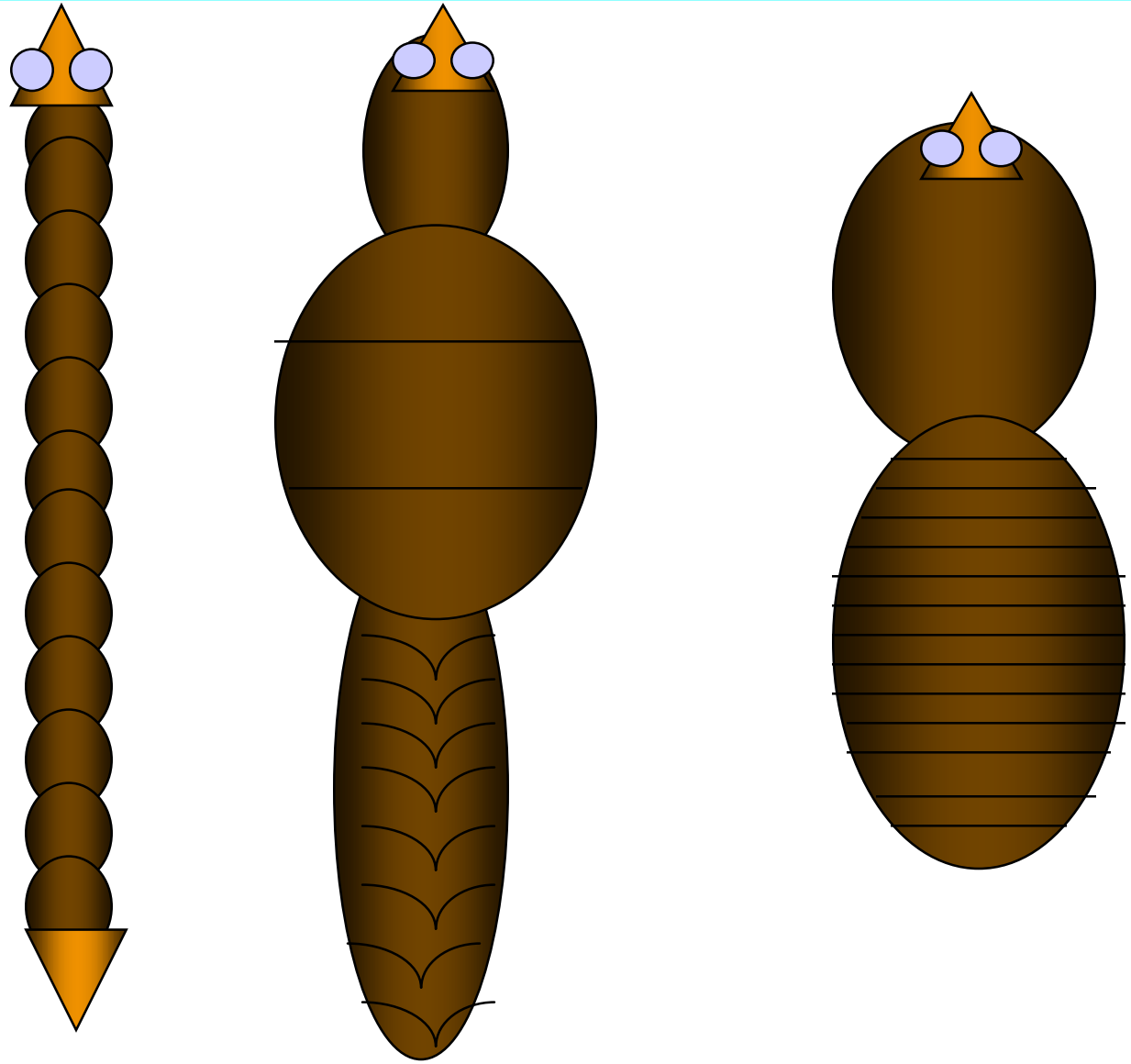
Tergites(背片): hard dorsal plates

Soft, thin pleural membrane

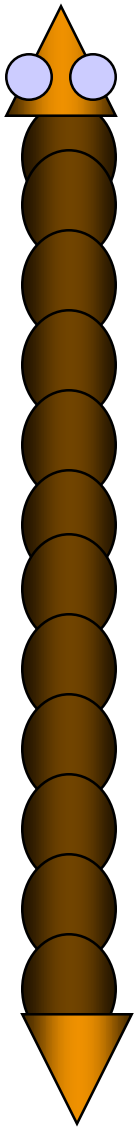


hard ventral plates: sternites(腹片)

Tagmosis (分節特化):
Fusion, specialization of body segments



Modification of limbs



Head or head region

limbs → mouthparts, antennae.

Other limbs →

walking, swimming, (運動)

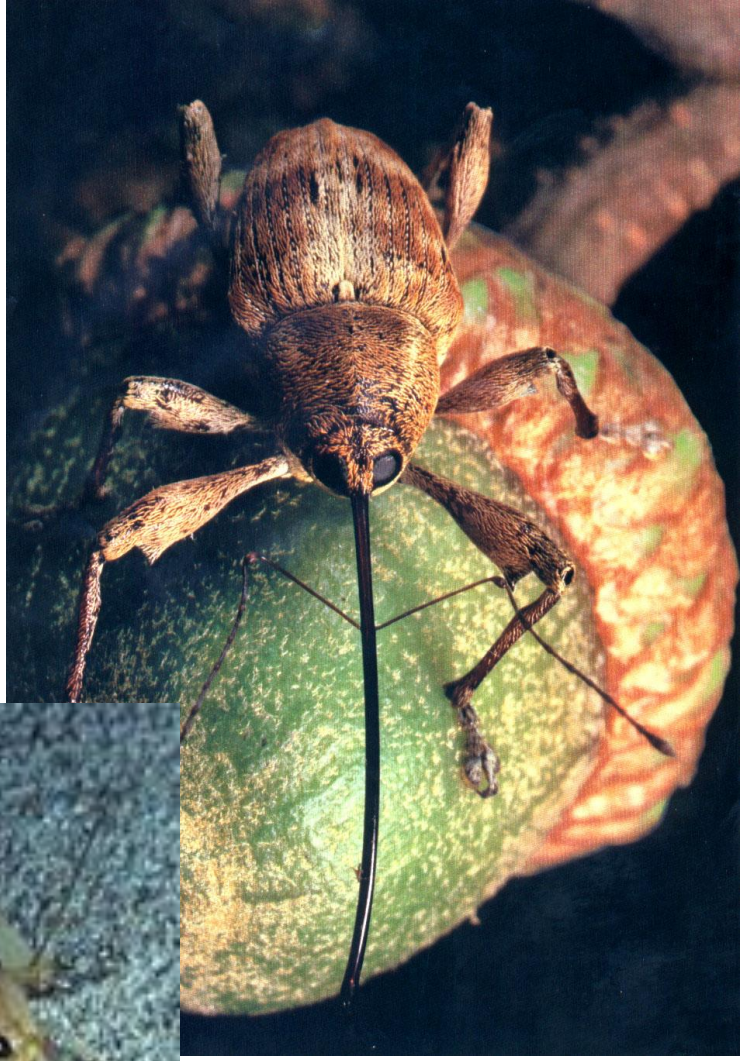
sperm transfer,

holding eggs, (生殖)

Limbs may be lost

Insects: 3 body regions or tagmata

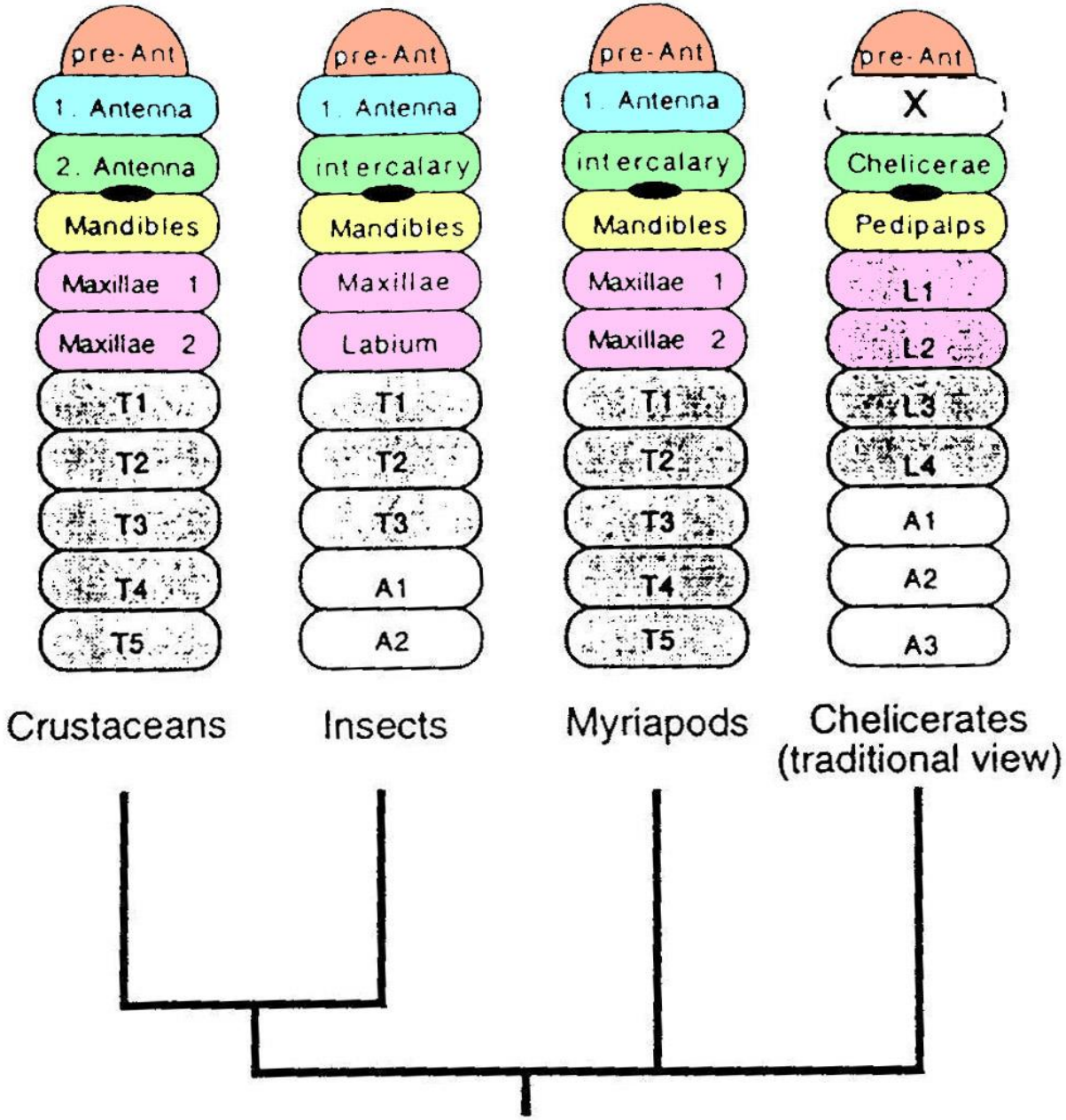
- Abdomen(腹), thorax(胸), head (頭)

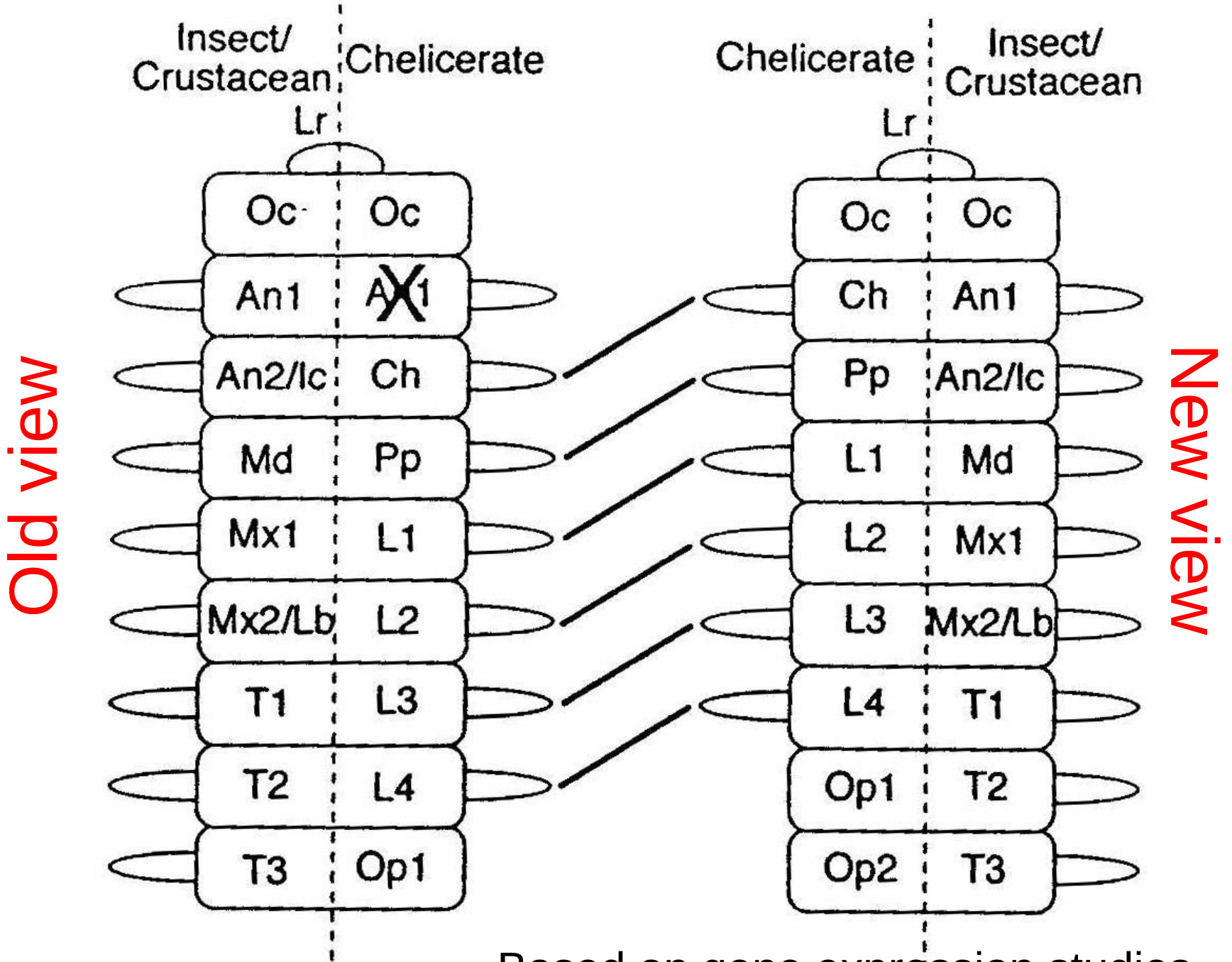


Segmentation (分節)– how do we know(如何知道分幾節)?

- Count appendages (計算附肢)
  - Each pair of appendages (or things derived from the appendages) indicates a segment
- Count pairs of nerve ganglia (計算神經節)
  - (one pair per segment)
- Examine limb buds in embryos (由胚胎)
- (分子生物學的方法) Use labeled antibodies or other method to determine where gene for “front edge of a segment” is turned on in developing embryo

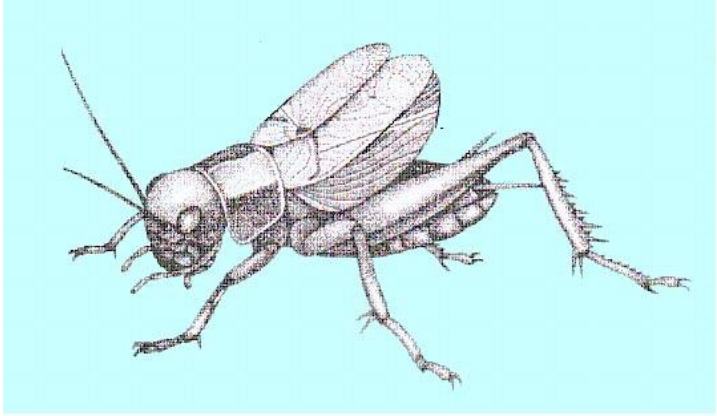
“Traditional” view



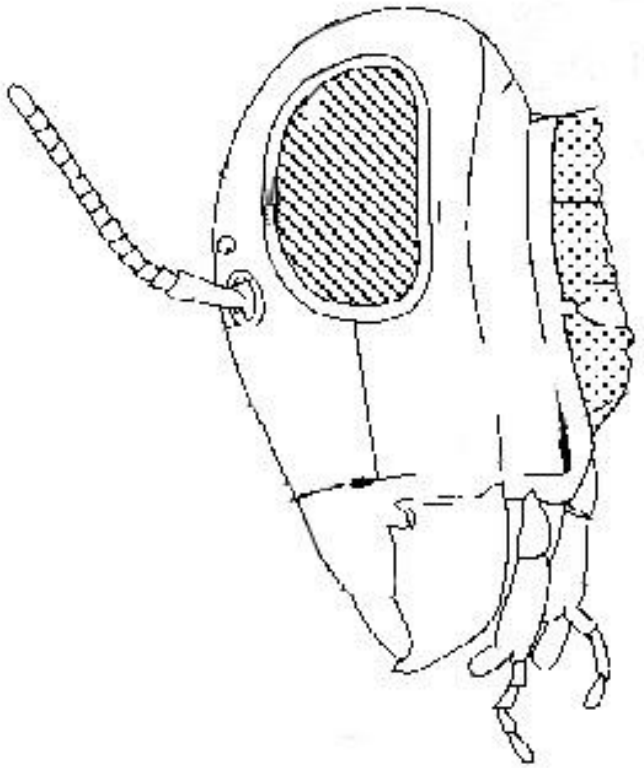


Based on gene expression studies

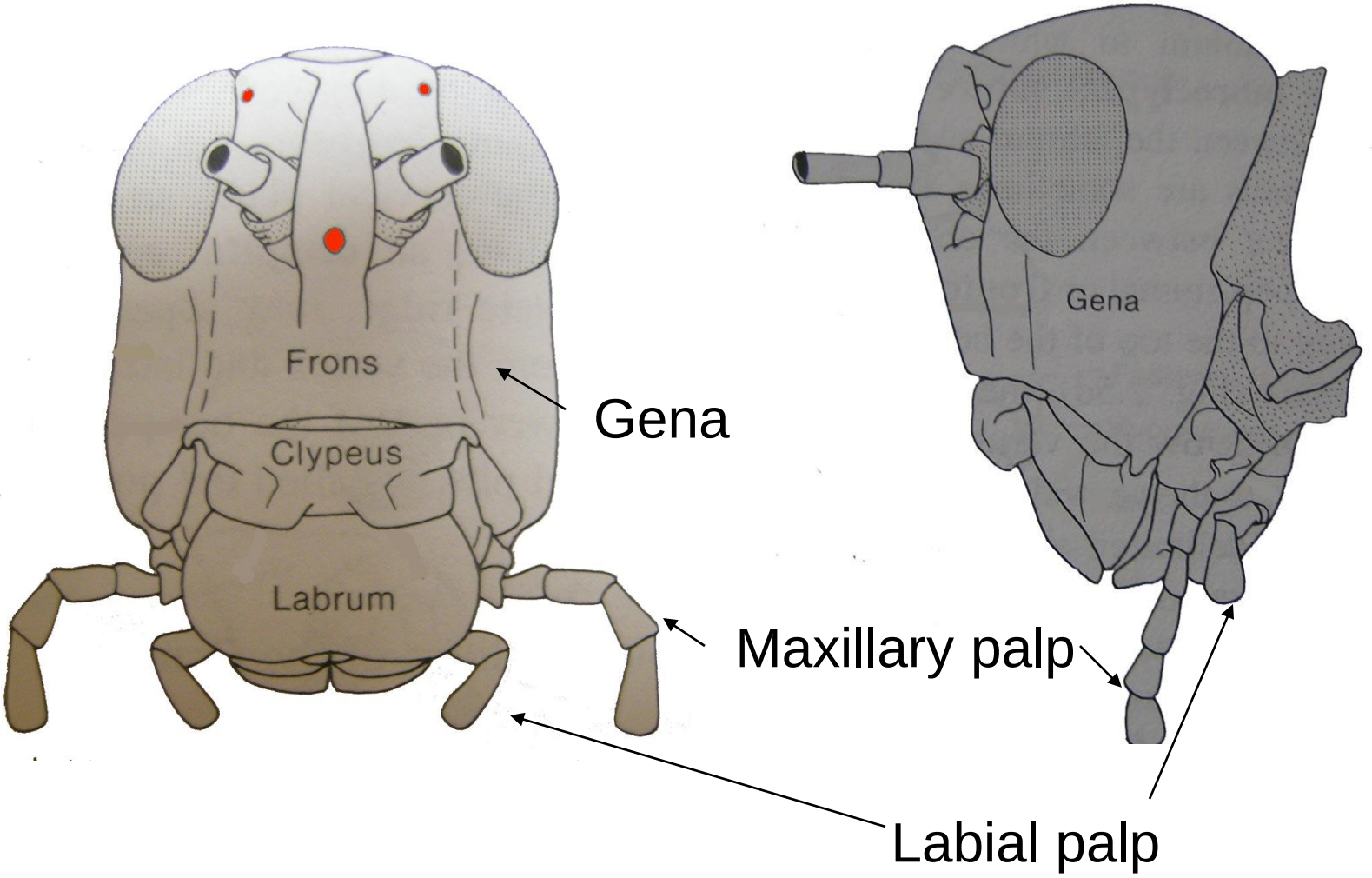
Basic insect head



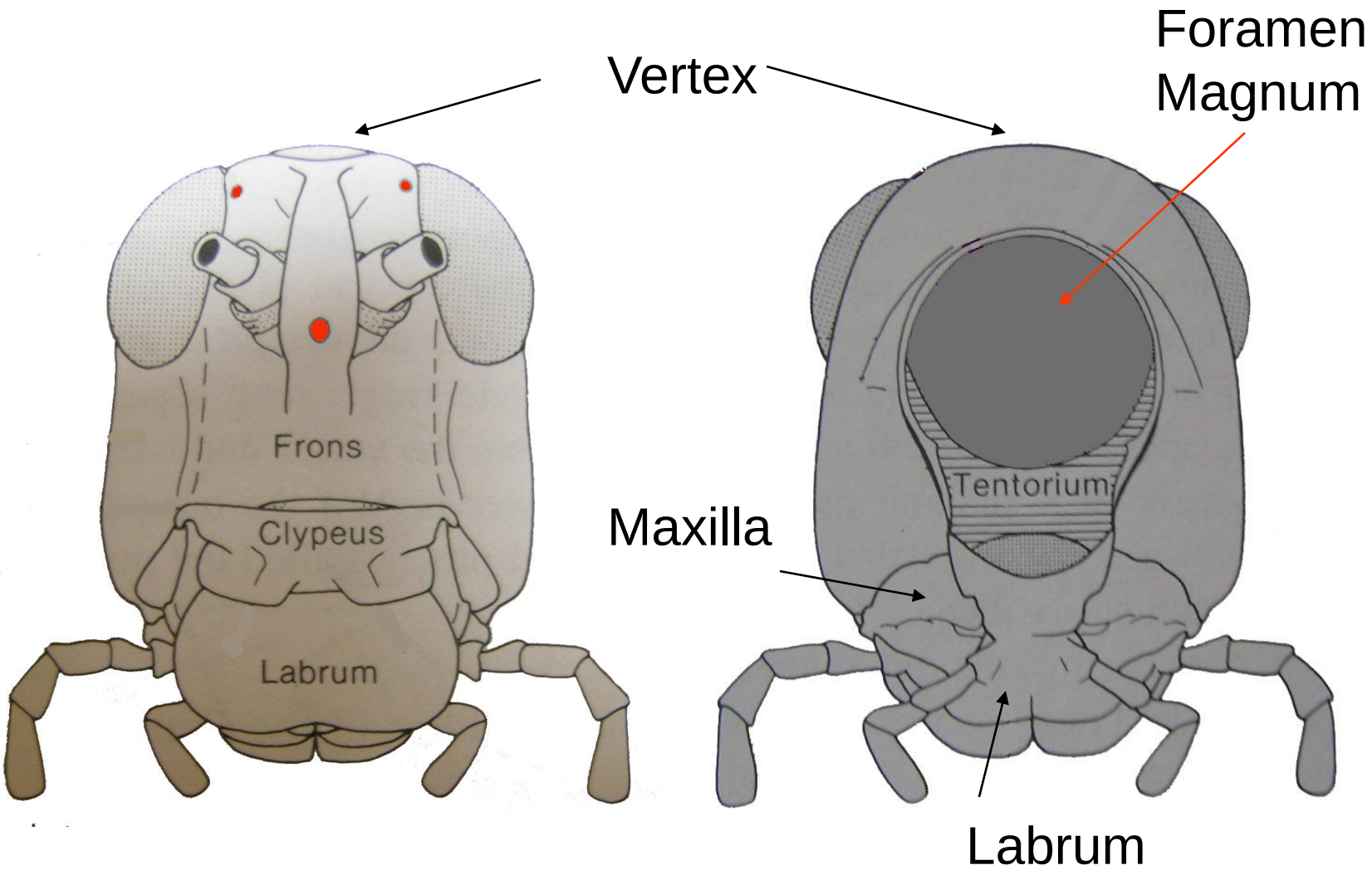
- Head capsule
- 1 pair compound eyes(複眼)
- 3 simple eyes-ocelli (單眼)
- 1 pair antennae (觸角)
- 3 pair mouthparts (口器)
  - Mandibles(大顎)
  - Maxillae(小顎)
  - Labium (唇)



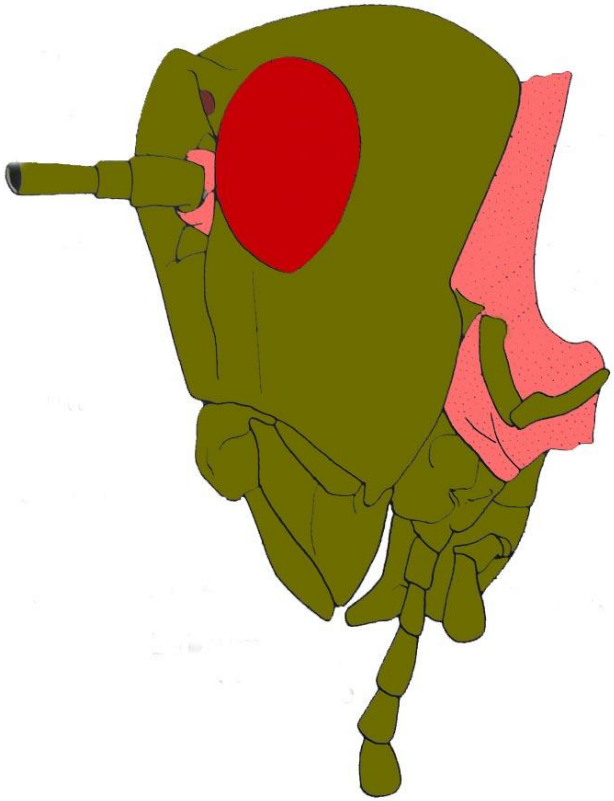
Parts of the head

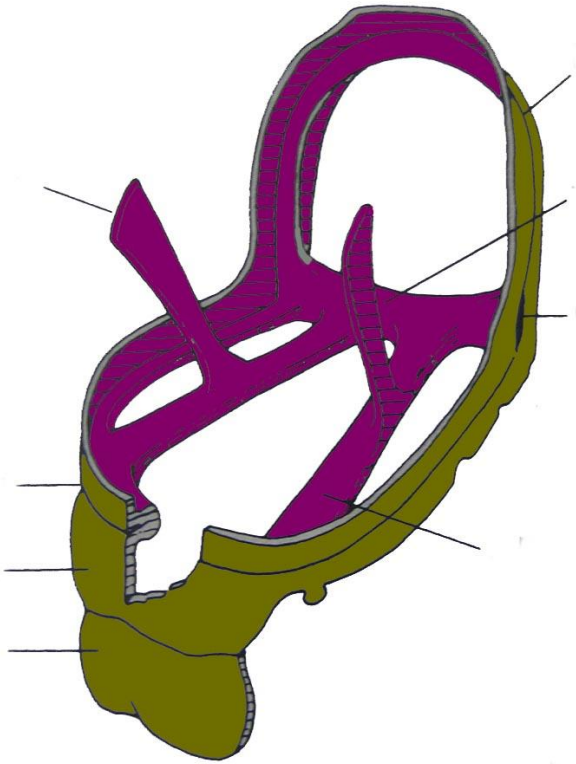


Parts of the head



Internal bracing in insect head

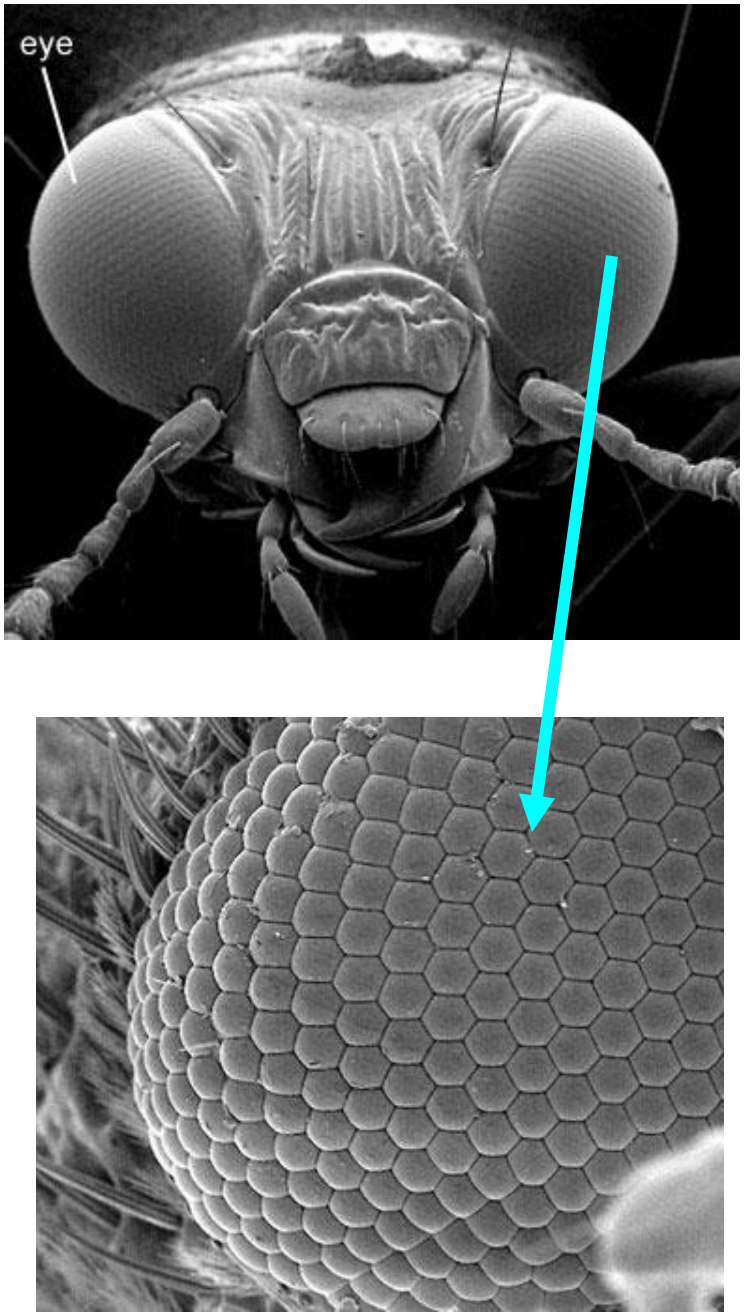




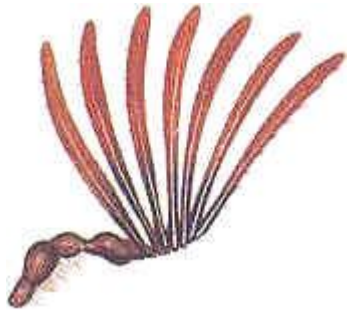
Tentorium

Eyes

- Compound eyes
- Up to 3 simple eyes or ocelli
- More on eyes later



Eyes of praying mantis

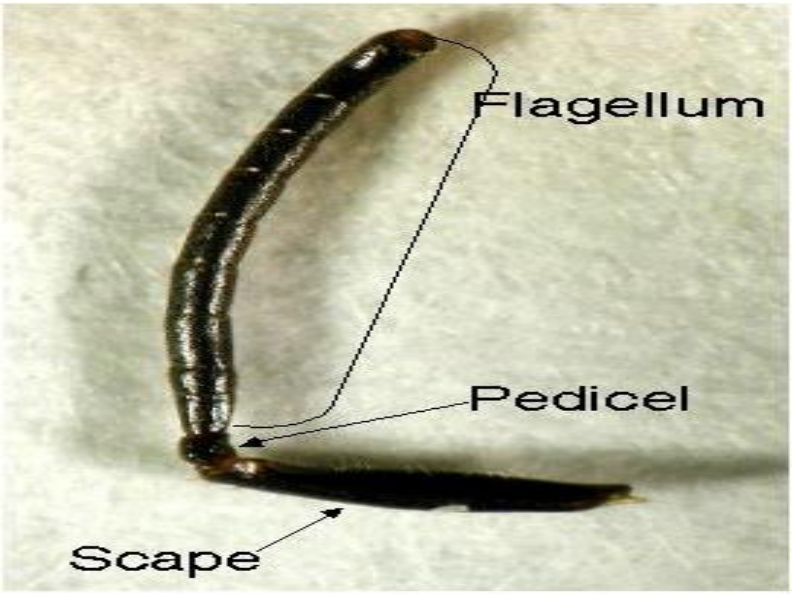



Antennae

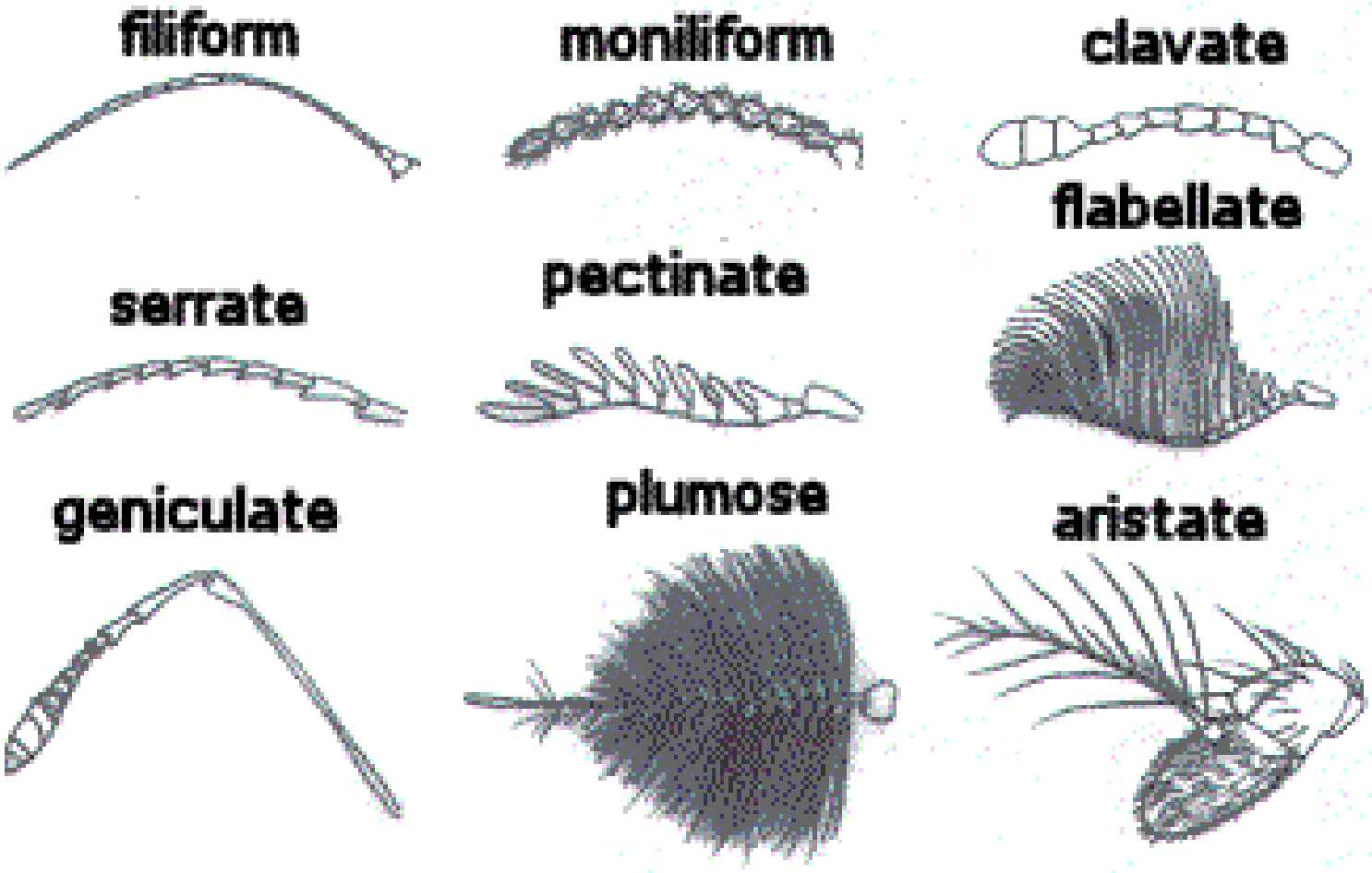
- Sensory
  - Chemoreception(化學接受器)
  - Touch(觸覺接受器)
- Parts
  - Scape (基)
  - Pedicel (軸)
  - Flagellum (with many small flagellomeres)(羽)

Antennae

- Honey bee
- (*Apis mellifera*)

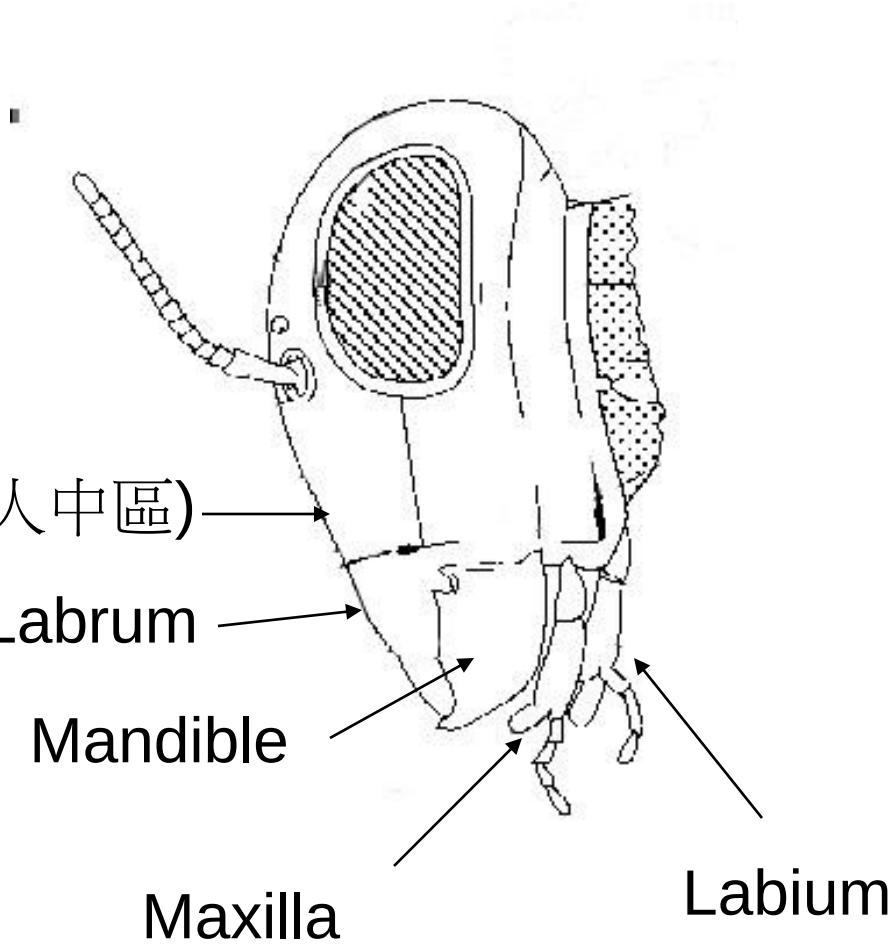


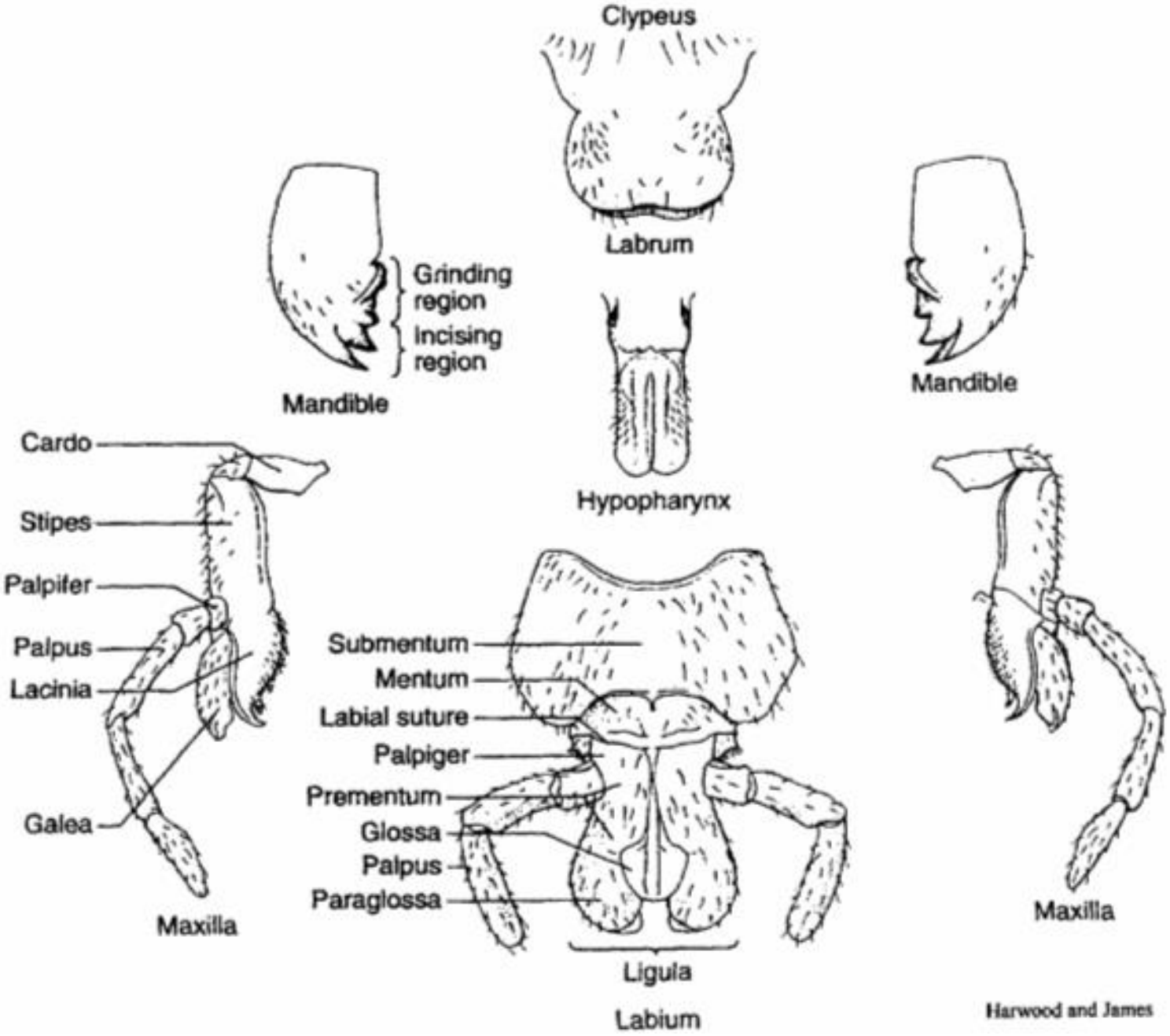
Many modifications



Mouthparts

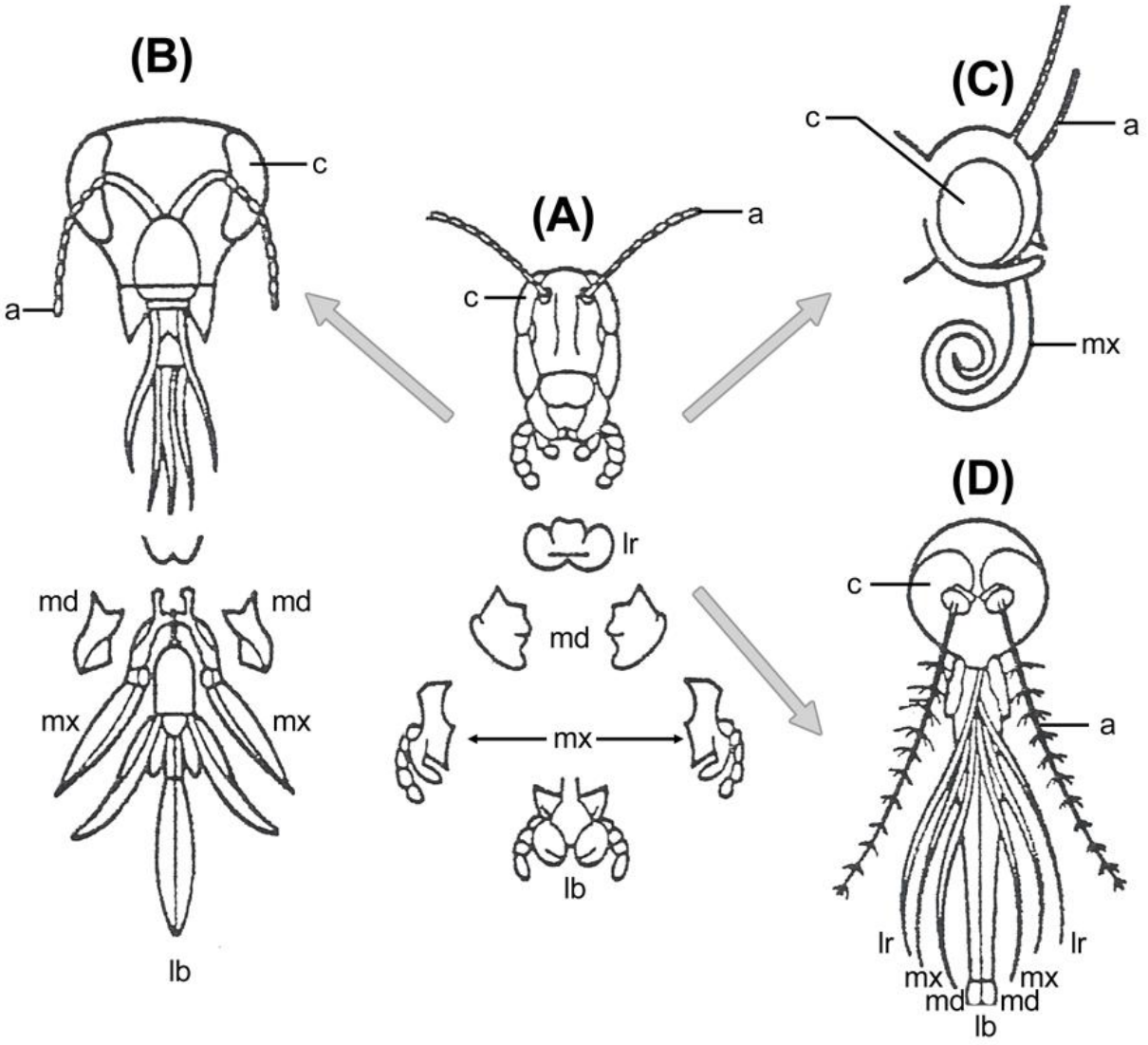
- Labrum
  - “upper lip”
  - May or may not be derived from limbs
- Mandible (2)
- Maxilla (2)
- Labium
  - formed of fused left and right limbs



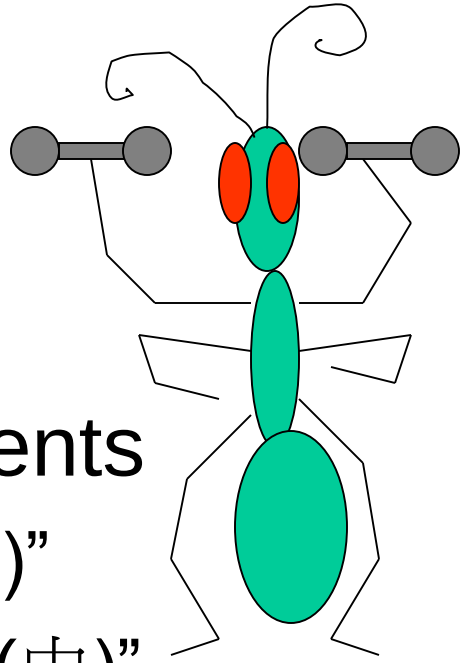


Harwood and James

Modified Mouthparts



Insect thorax



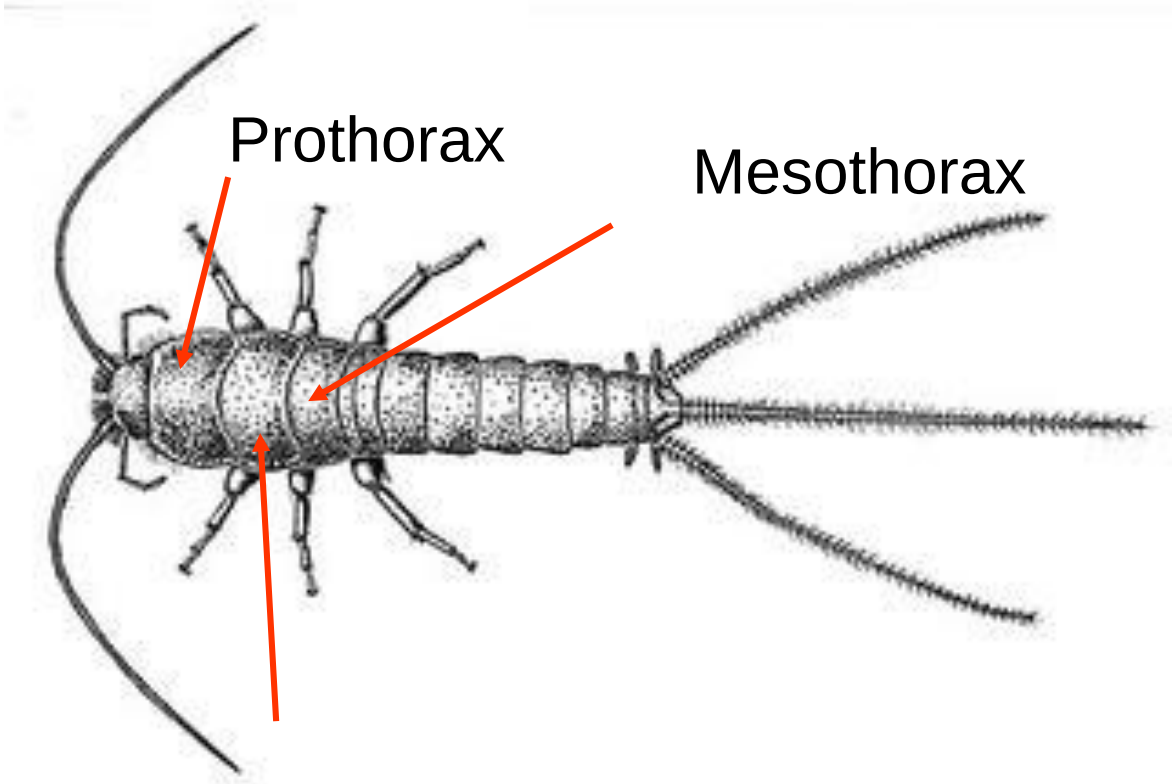
- Formed from three body segments
  - 1st referred to with prefix “pro (前)”
  - 2nd “meso (中)”
  - 3rd “meta (後)”
- Three pairs of walking legs
- In winged (pterygote) insects, 2 pairs of wings

Apterygotes: Archeognatha & Thysanura

Legs similar

Thoracic segments clearly visible

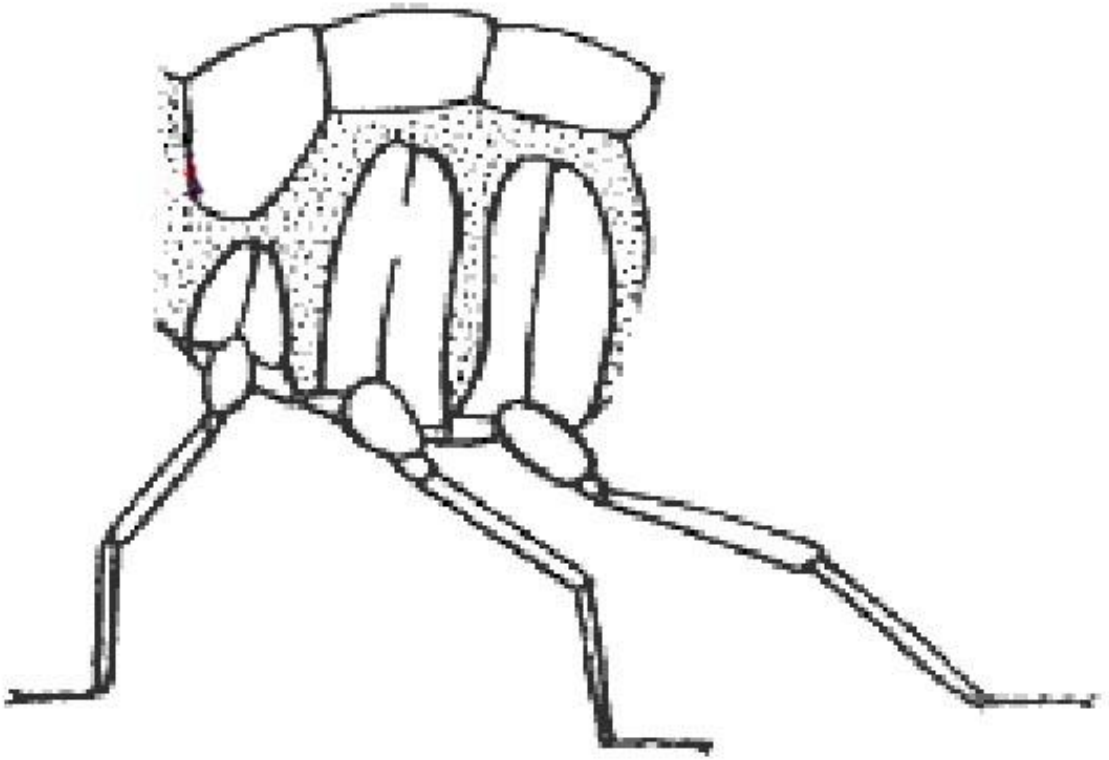
Three segments clearly visible



Thoracic segments often fused or modified

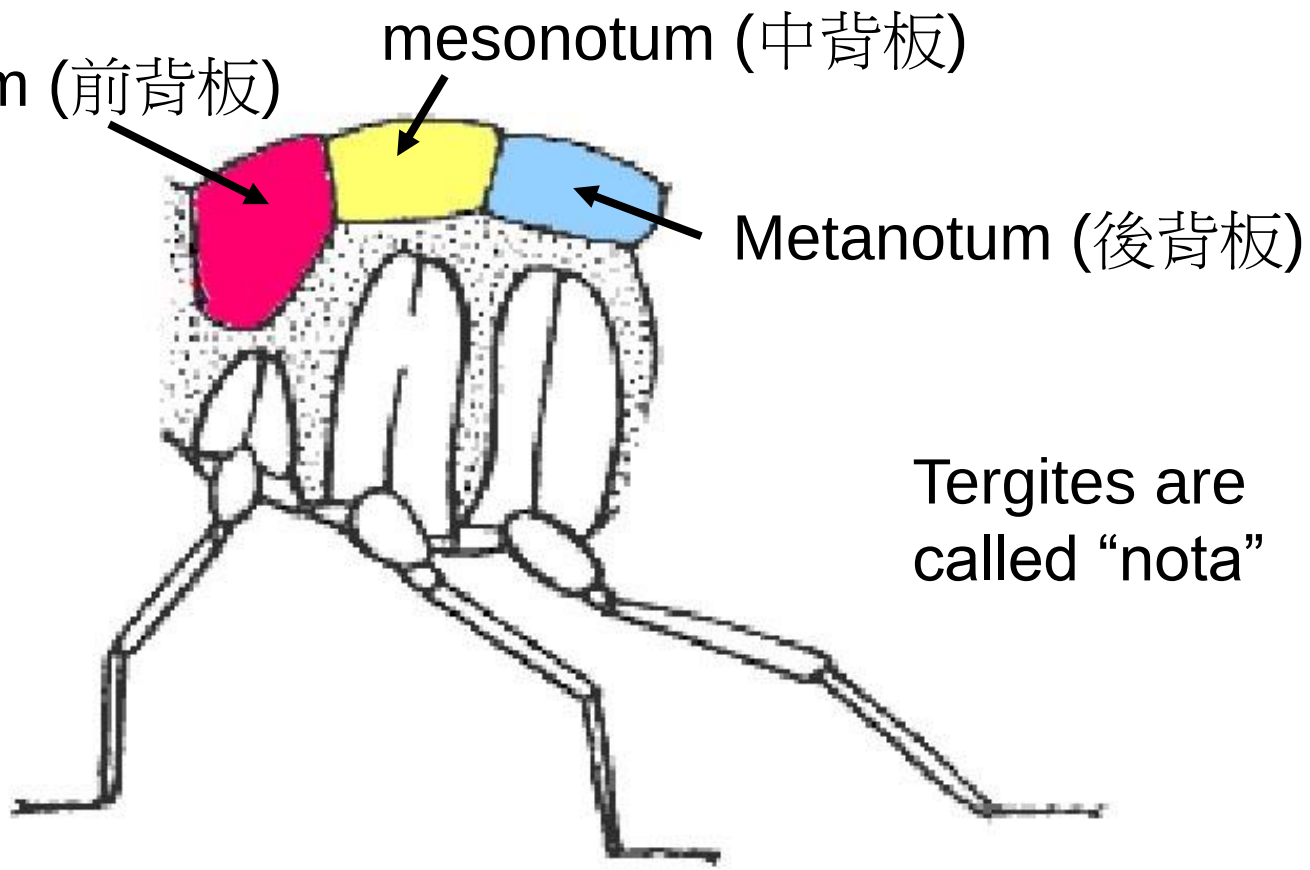
Larva of a trichopteran

Basic thoracic sclerites



Larva of a trichopteran

Basic thoracic sclerites

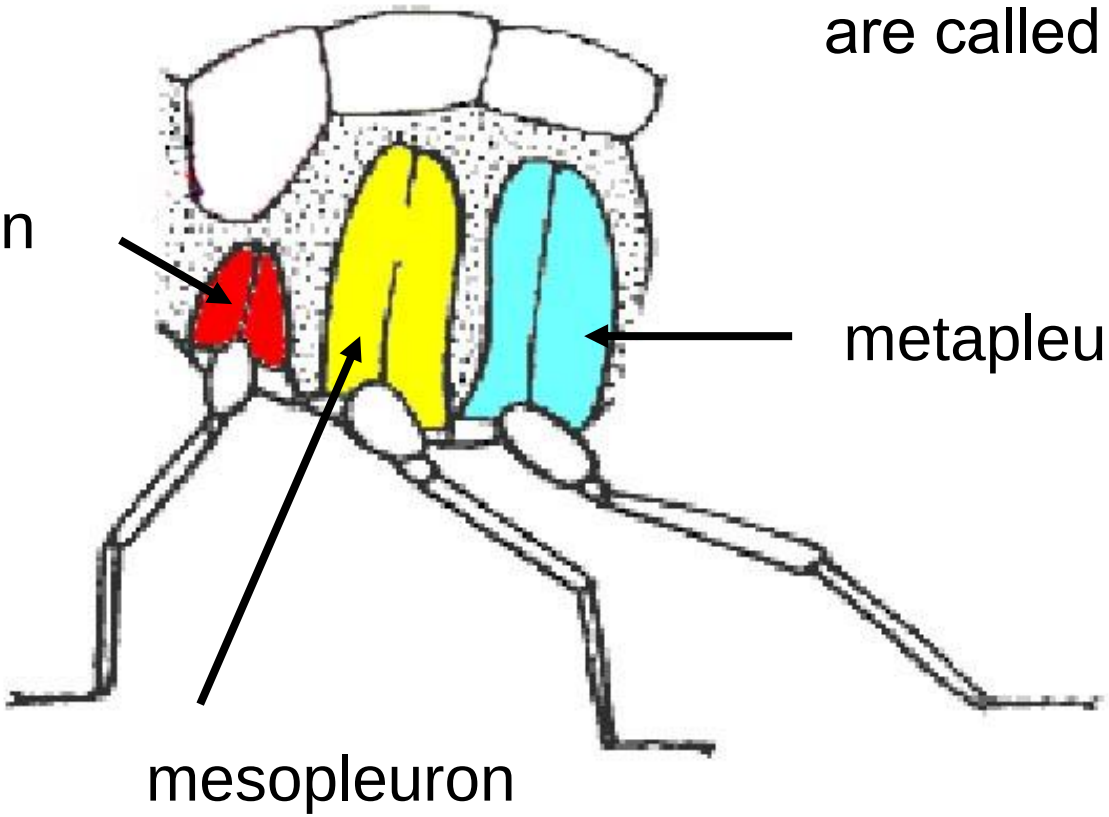


Tergites are called “nota”

Larva of a trichopteran

Basic thoracic sclerites

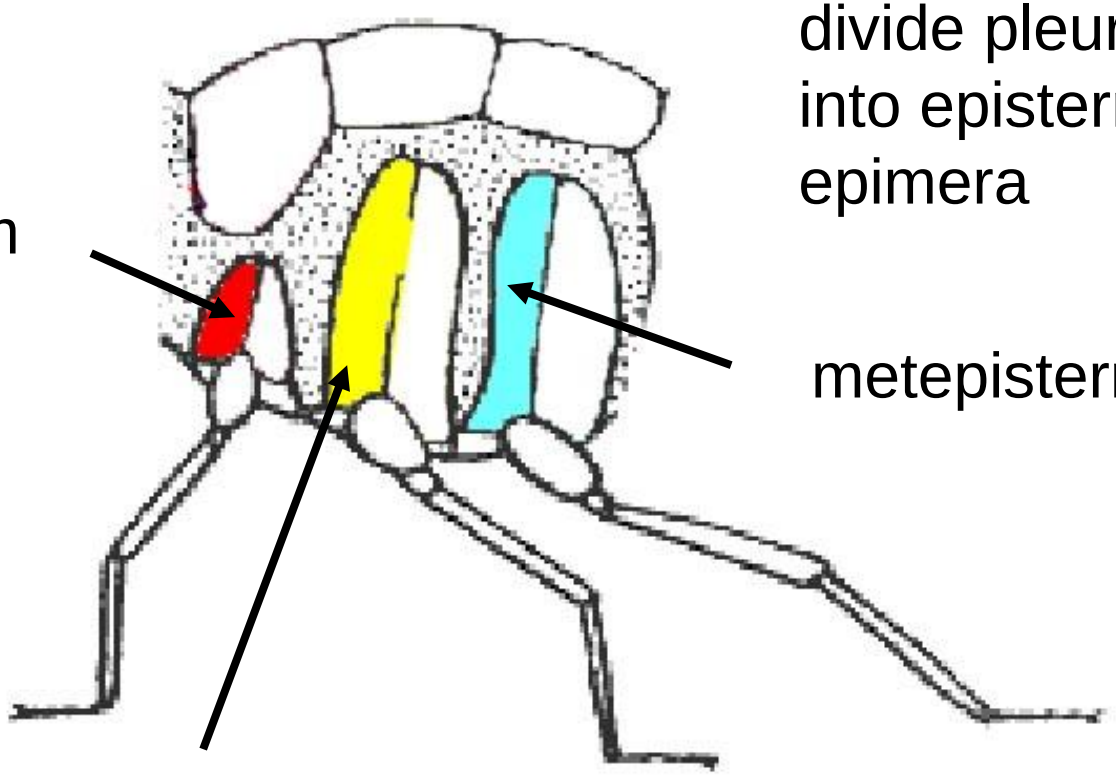
Lateral sclerites are called “pleura”



Basic thoracic sclerites

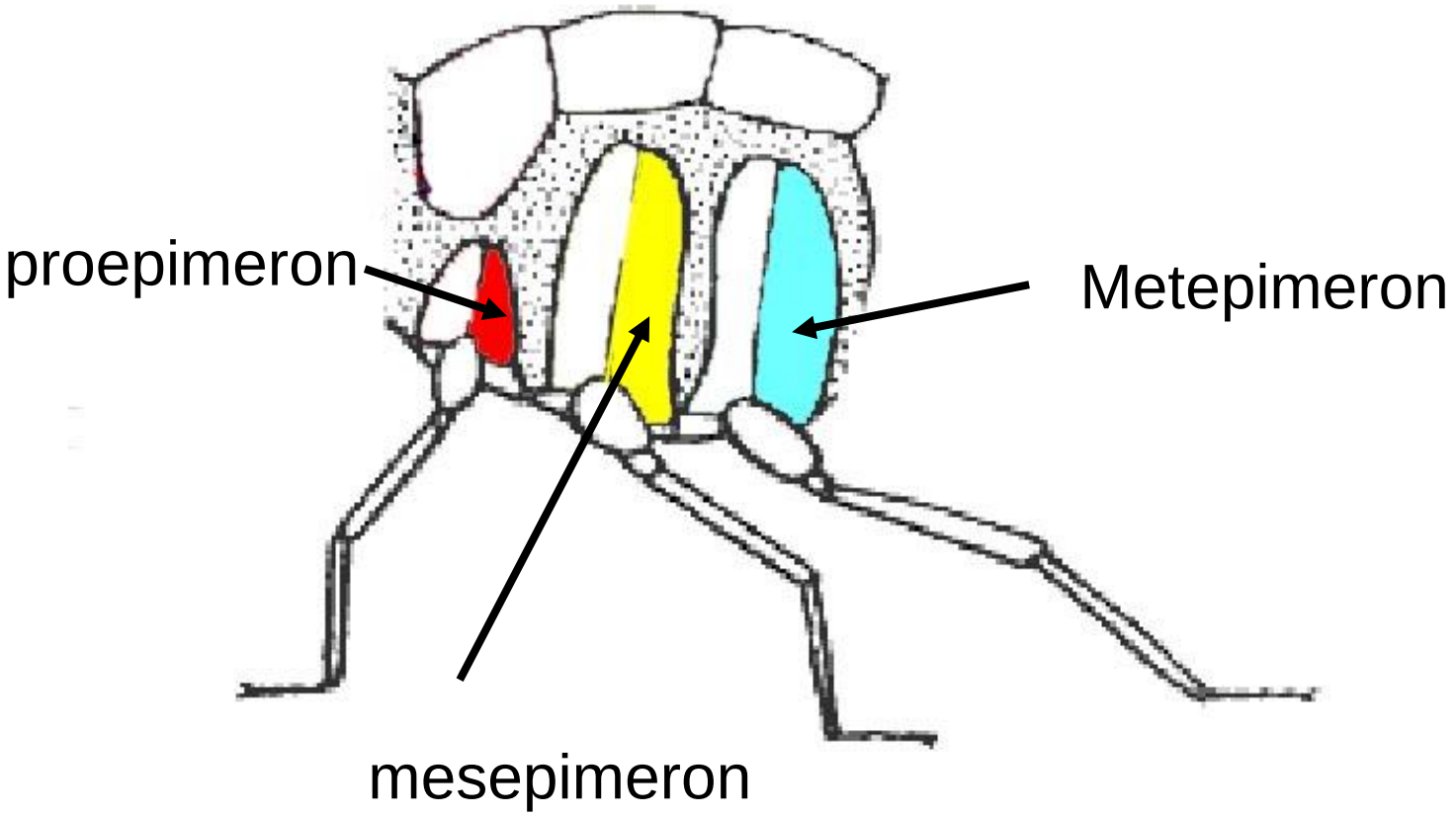
Larva of a trichopteran

Pleural sutures divide pleurons into episterna and epimera



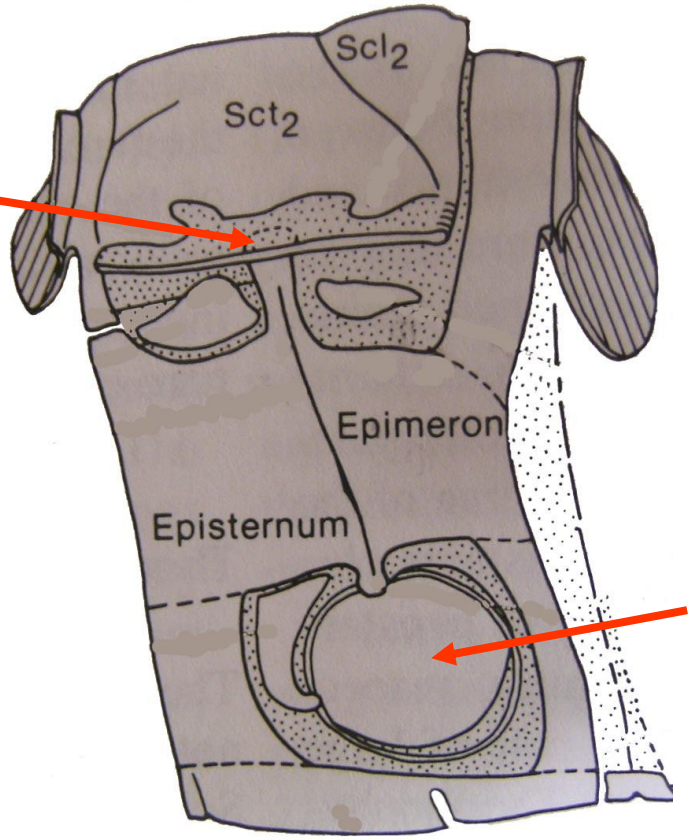
Larva of a trichopteran

Basic thoracic sclerites

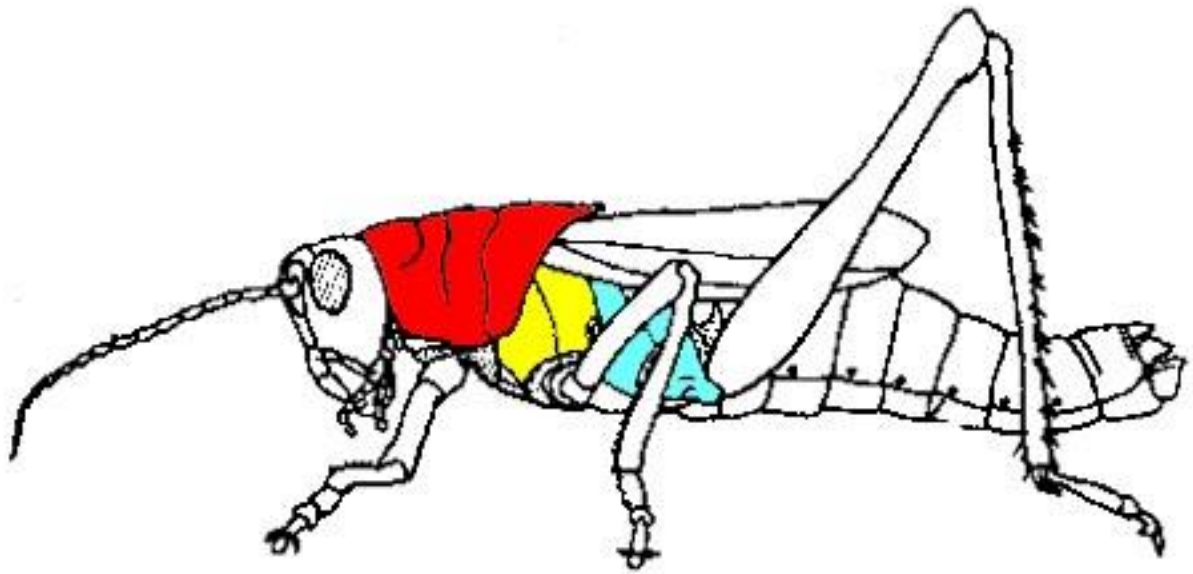


A more realistic mesothoracic segment

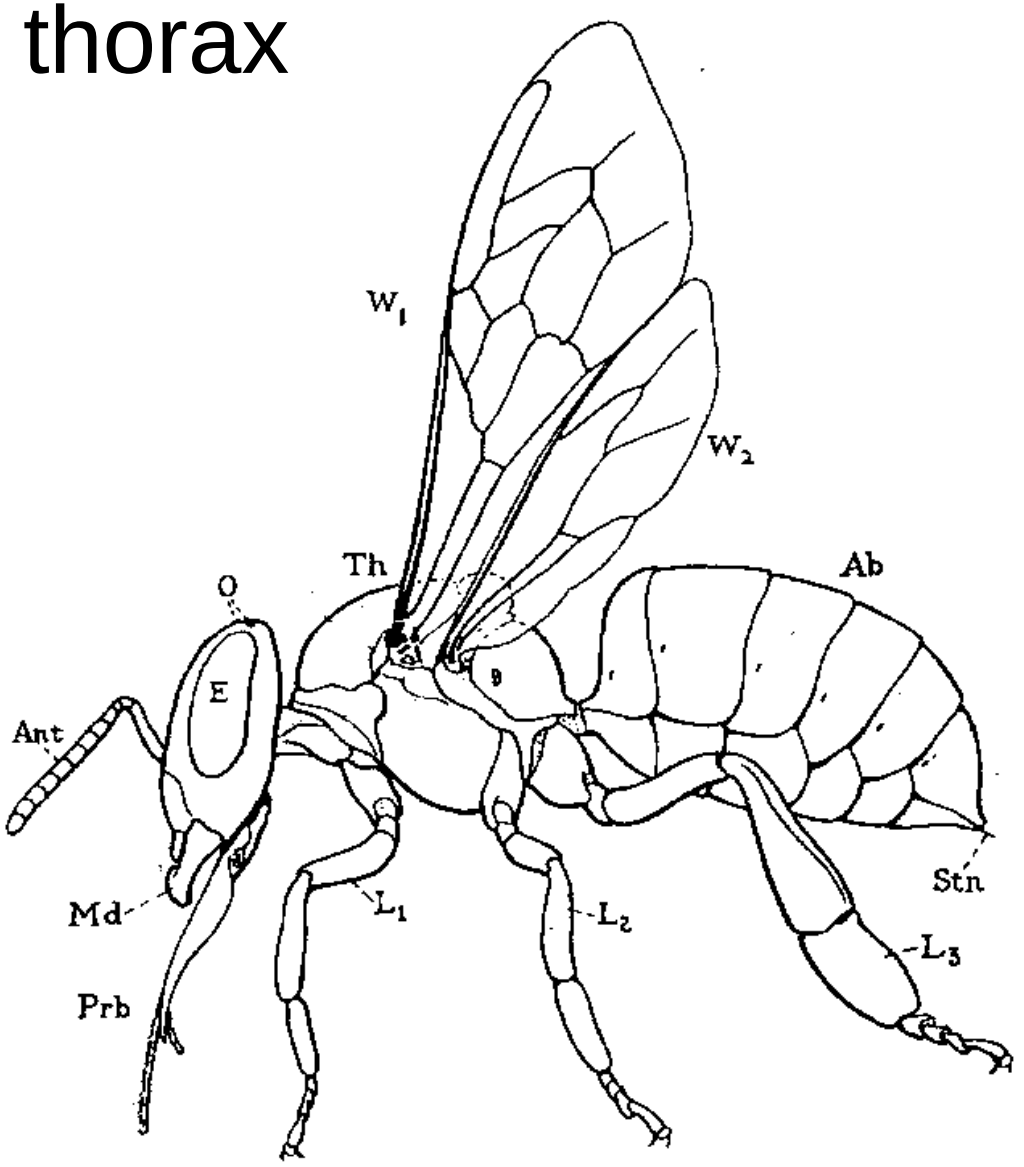
Wing articulates here



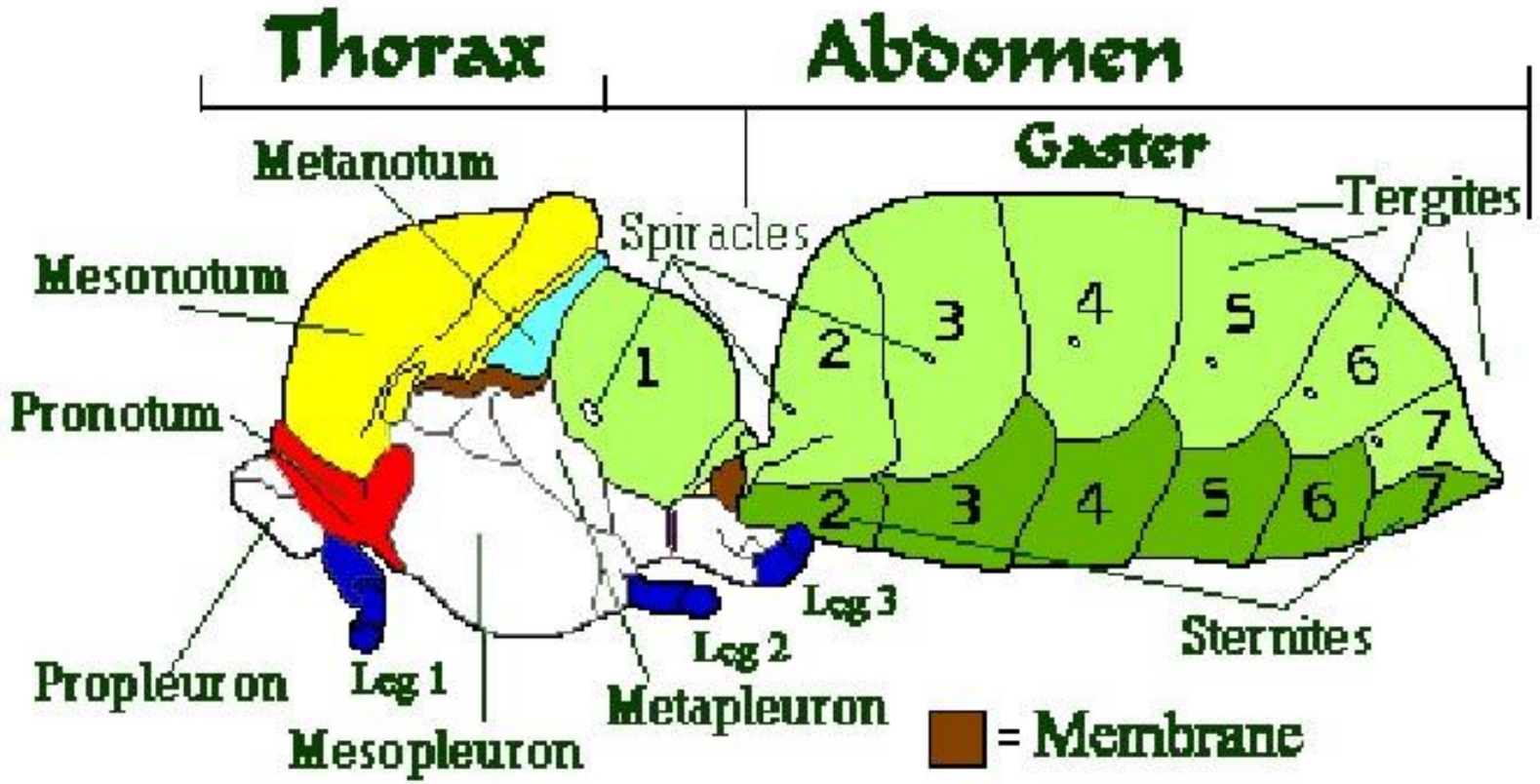
Leg attaches here



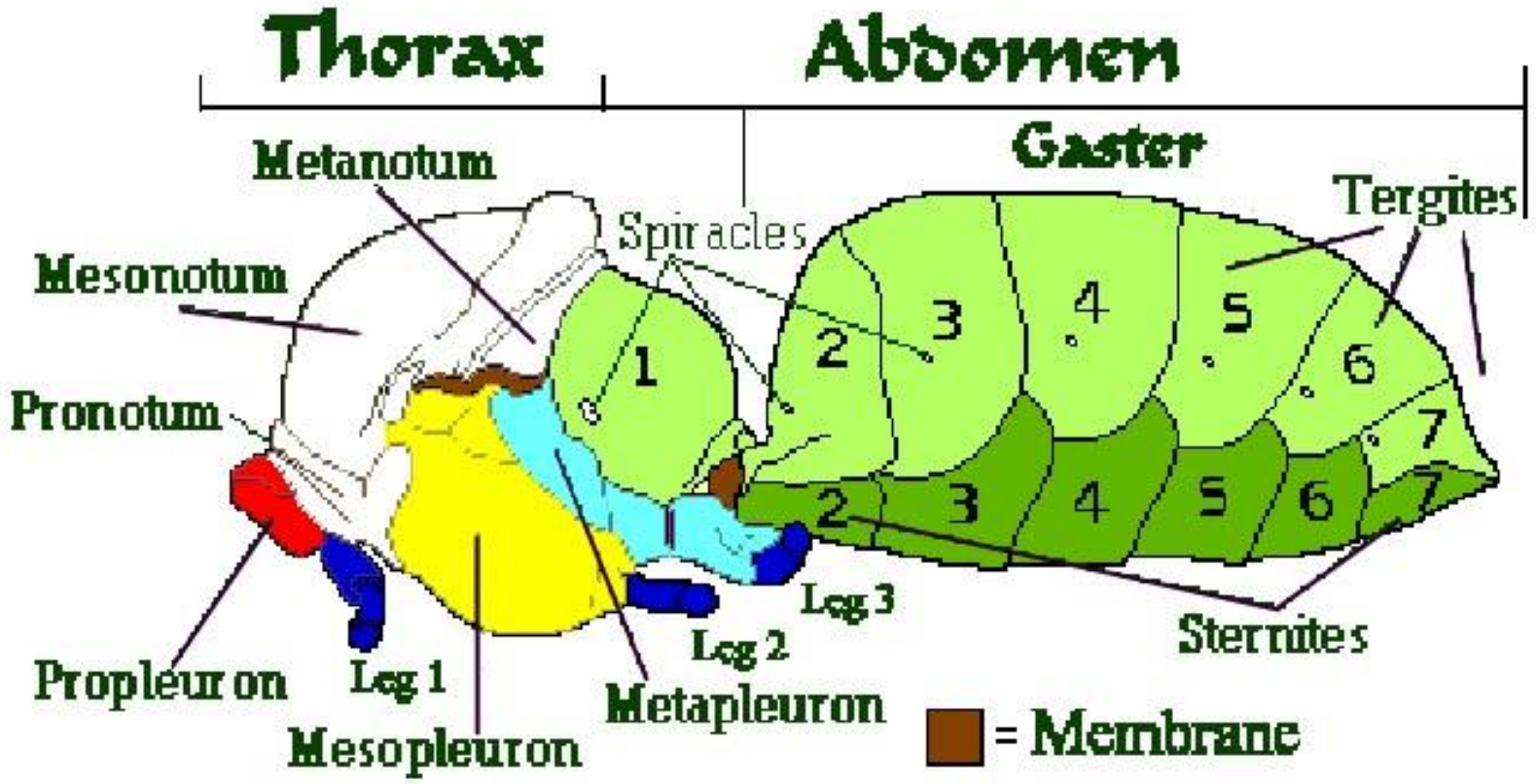
Honey bee thorax



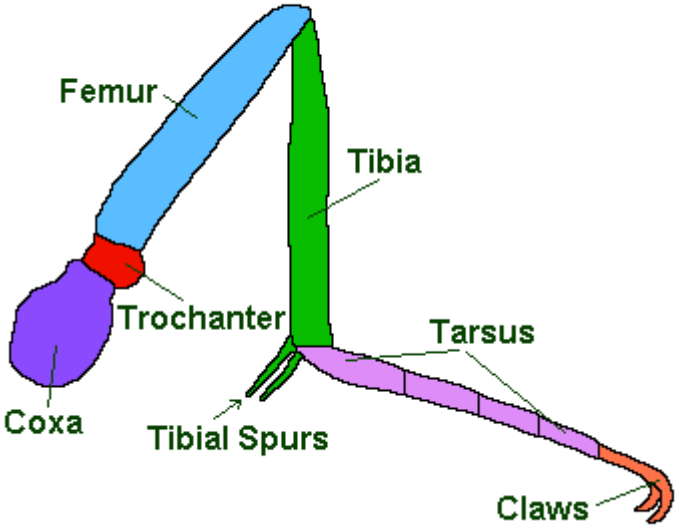
Thorax highly modified in a bee

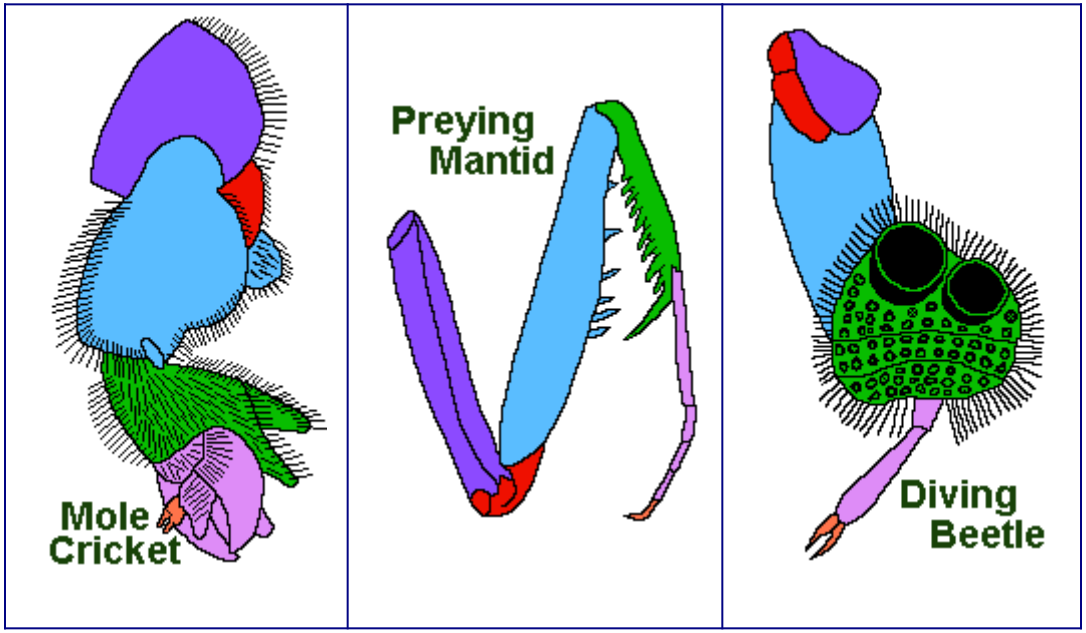


Thorax highly modified in a bee



The Insect Leg





What about wings?

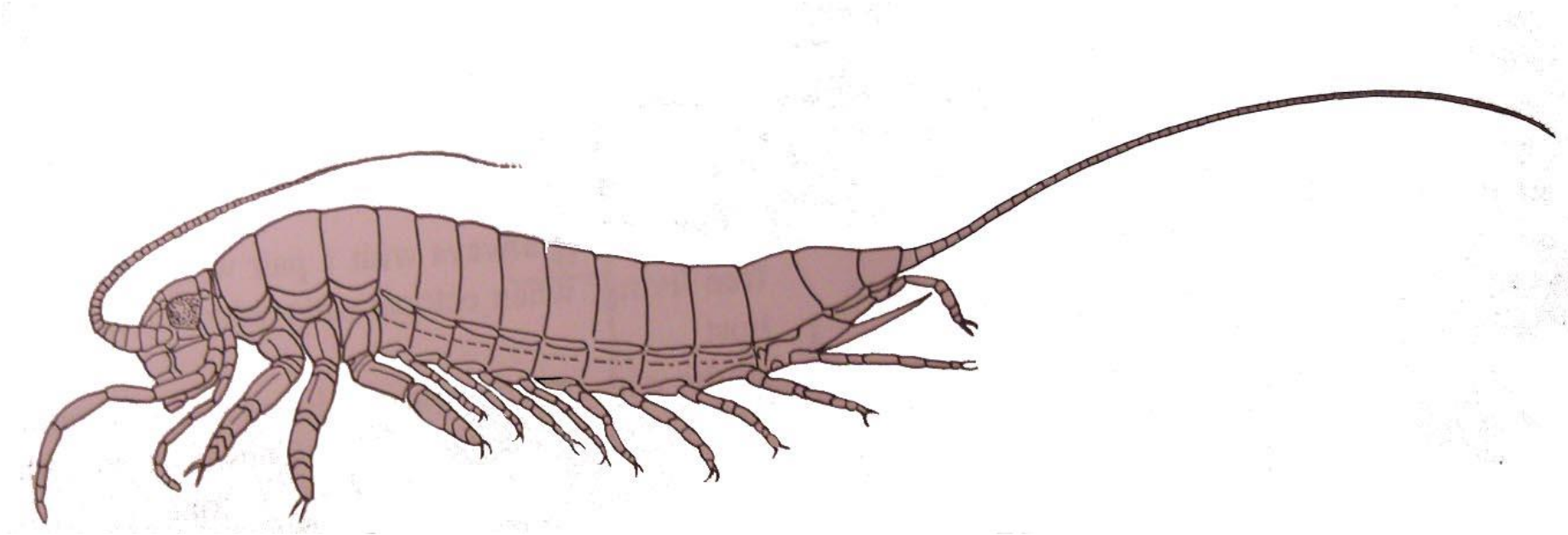
- Two pair
- On 1st and 2nd thoracic segments
- Diptera (flies) have only anterior pair
- Second pair replaced by halteres

External morphology- Abdomen

Abdominal segmentation

- Usually easy to observe
- 11 segments
- 9-10 easy to observe
- Specialized for digestion, fat storage, reproduction

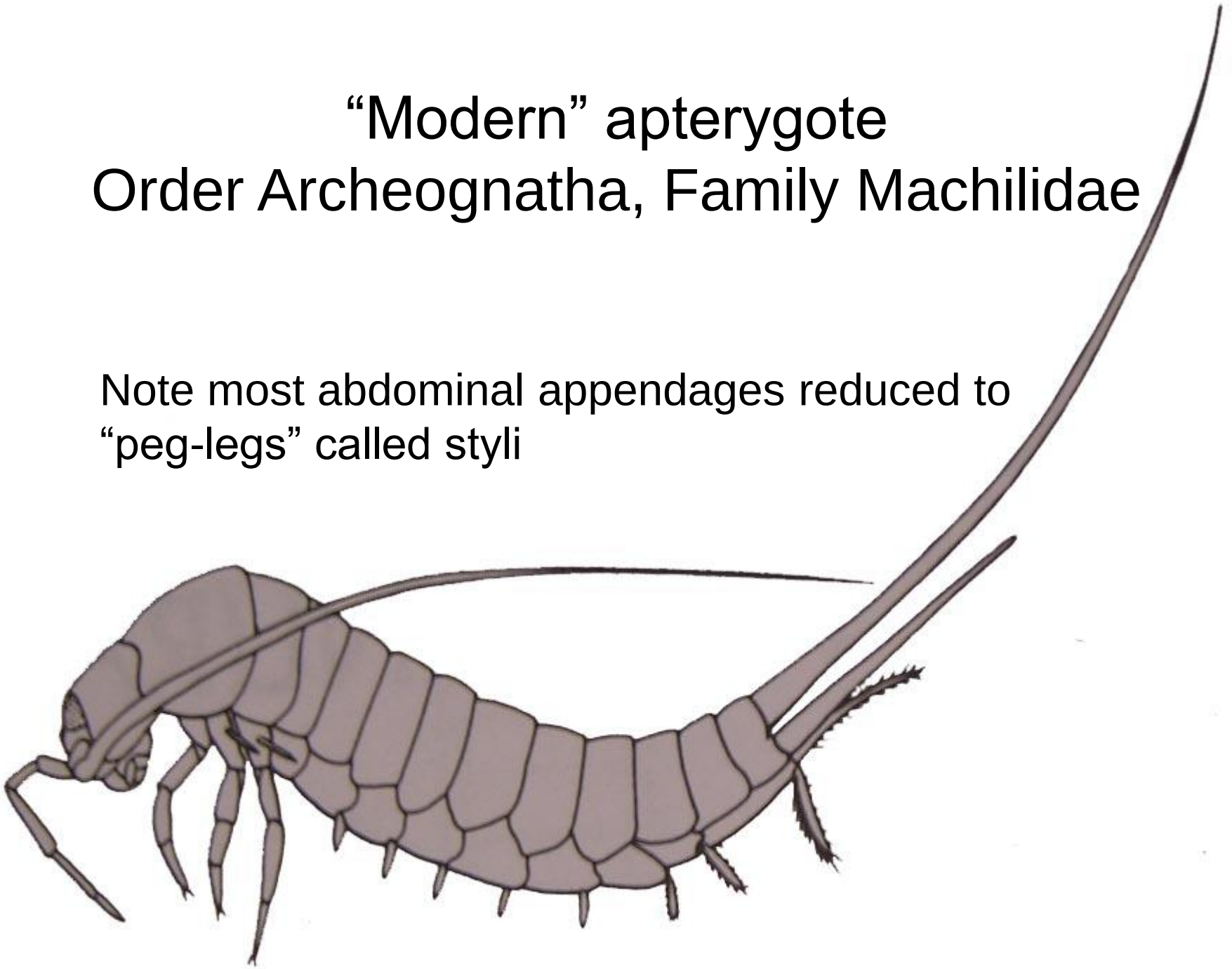
Dasyleptus- extinct apterygote from Carboniferous period



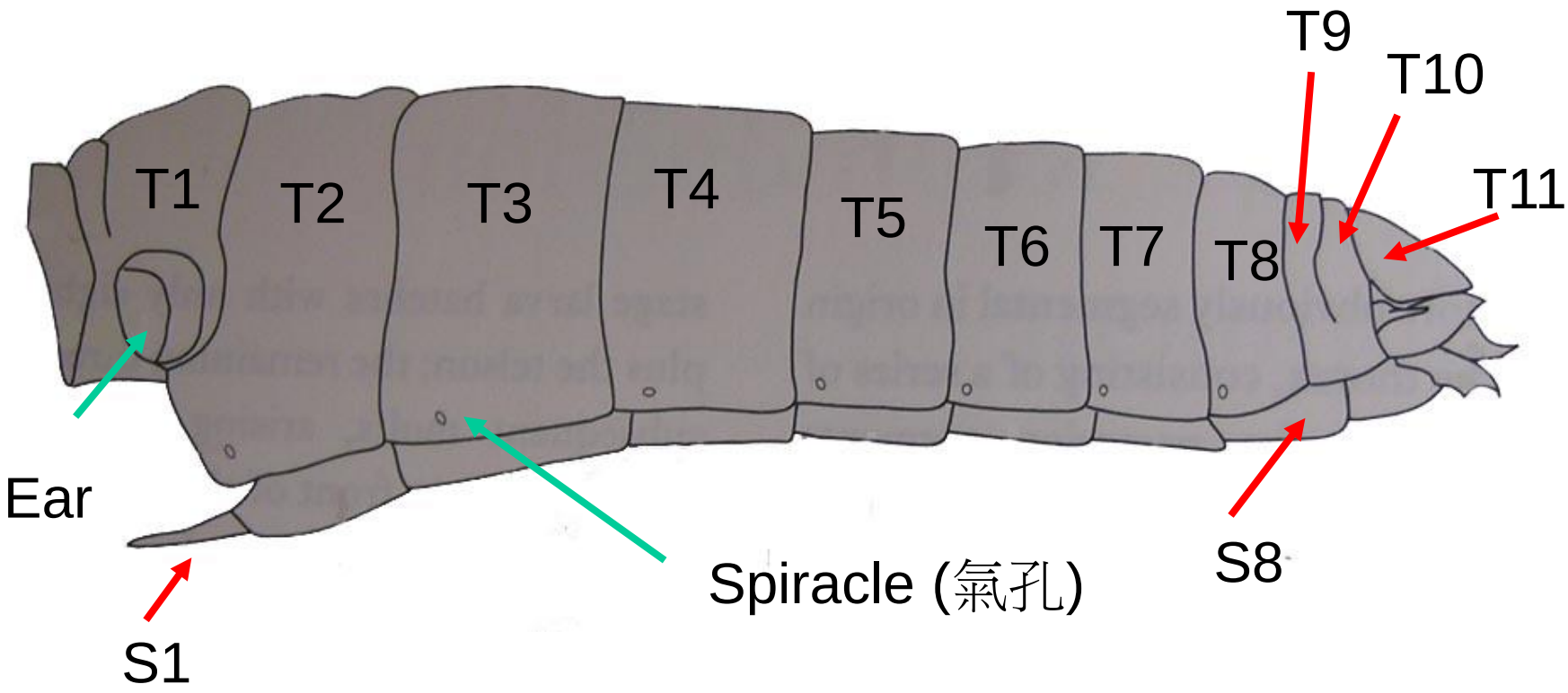
Note appendages on abdominal segments!

“Modern” apterygote
Order Archeognatha, Family Machilidae

Note most abdominal appendages reduced to “peg-legs” called styli



Modern *Nomadacris* (Orthoptera)



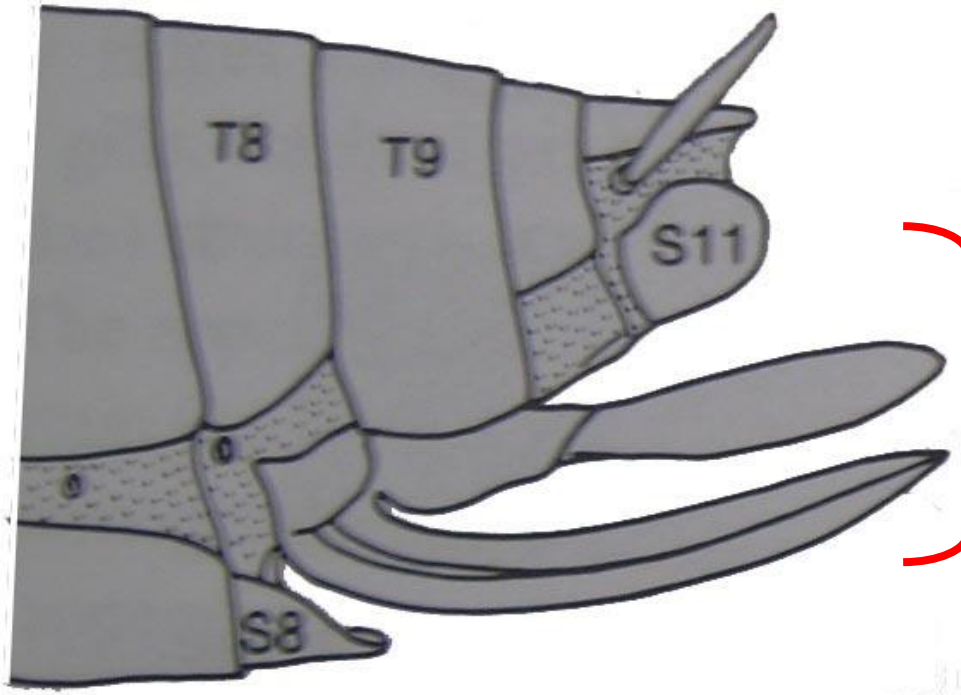
T = tergite, S = sternite

Ear = Tympanum

Where did all the abdominal appendages go?

- Most lost without a trace
- Genitalia (生殖器)
  - 8th & 9th segments of females
  - 9th of males
- Cerci (one cercus) (觸毛)
  - 11th segment

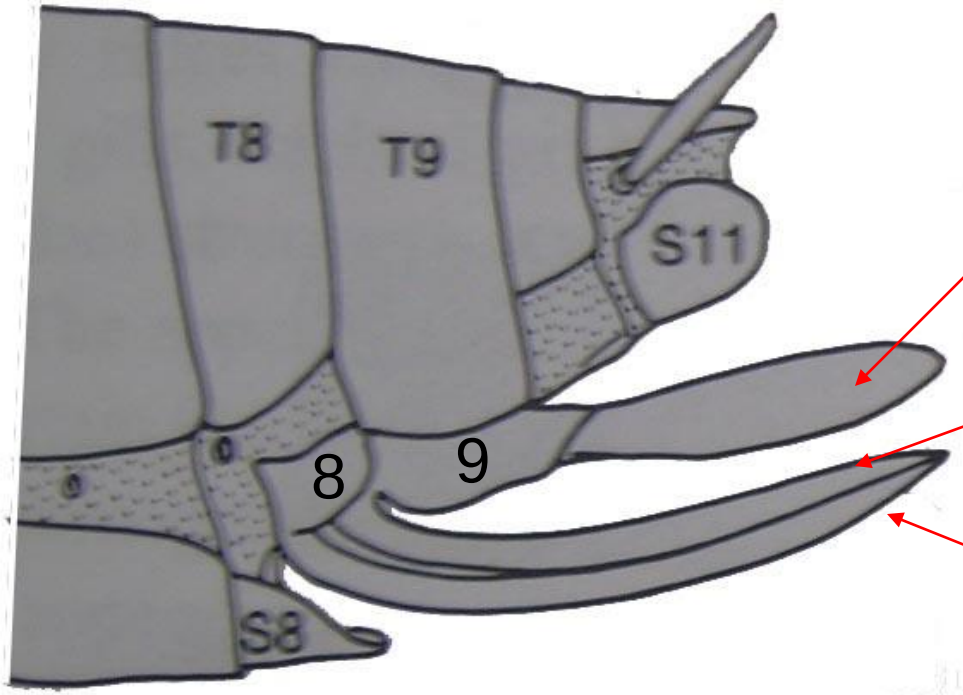
Generalized female genitalia



Ovipositor (產卵器)

Genital opening on 8th segment

Generalized female genitalia



3rd valvula

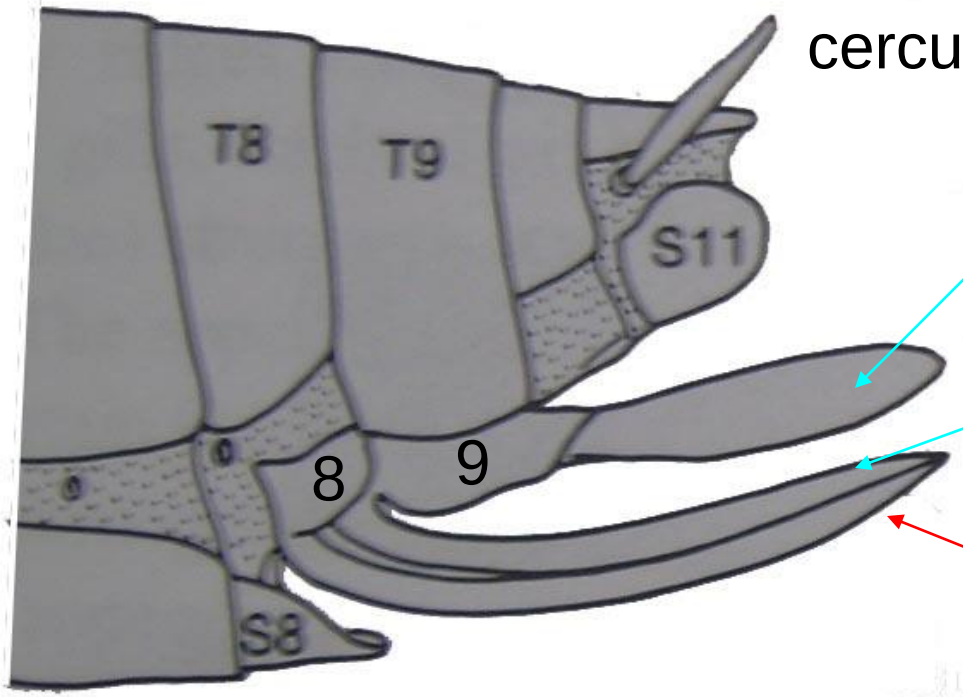
2nd valvula

1st valvula

1st and 2nd valvulae may form a tube for egg-laying

3rd valvulae may form protective sheath

Generalized female genitalia

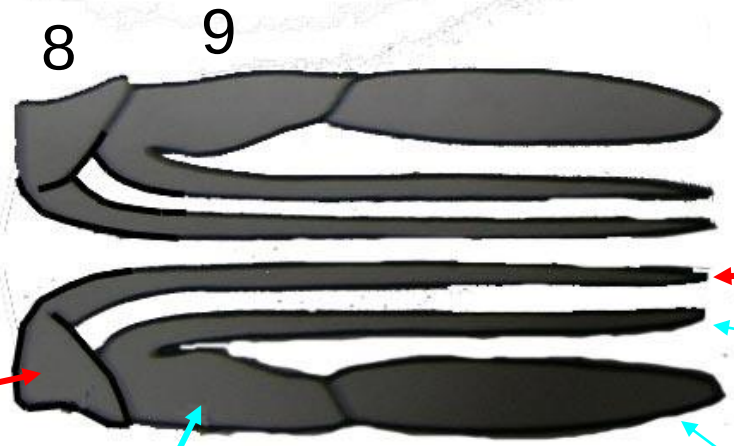


cercus

3rd valvula

2nd valvula

1st valvula



1st valvifer

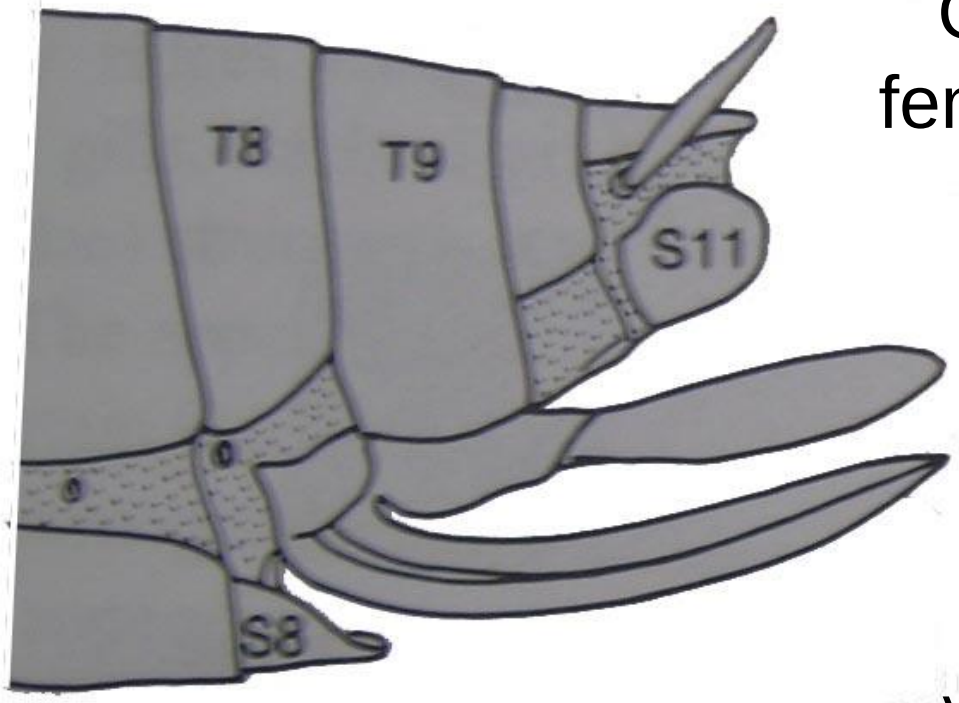
2nd valvifer

1st valvula

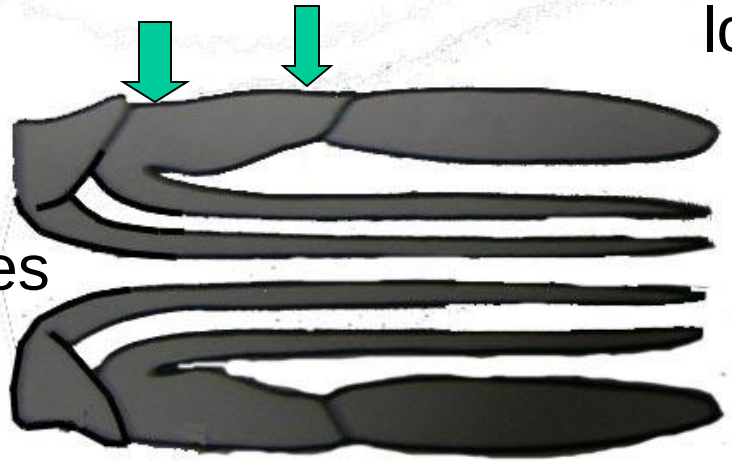
2nd valvula

3rd valvula

Generalized female genitalia

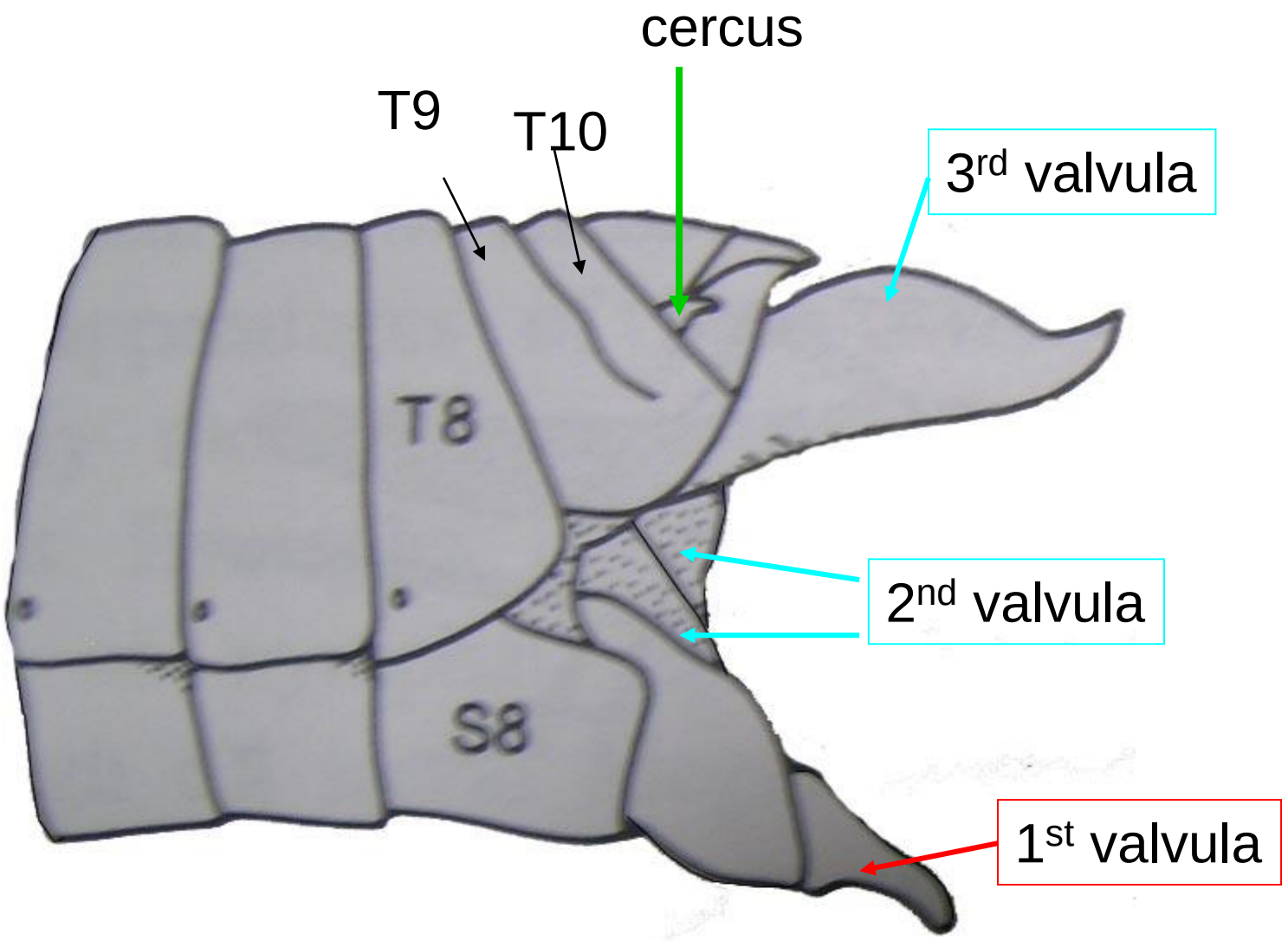


Valvulae =
lobes on coxae



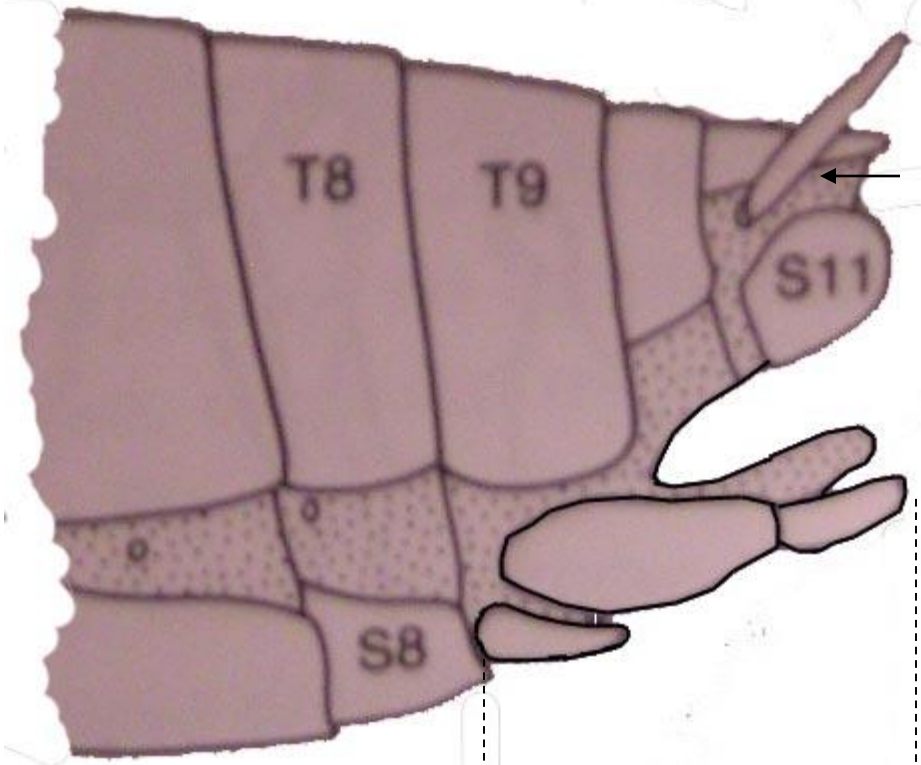
Valvifers = coxae of
Modified appendages

Female of *Romalea microptera* (Orthoptera)



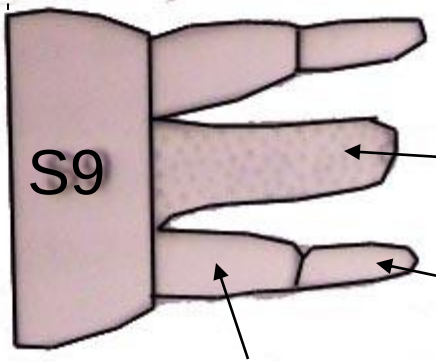
Genitalia of most insects highly modified from basic plan

Generalized male genitalia



anus

Paramere =
Gonostylus+gonocoxite

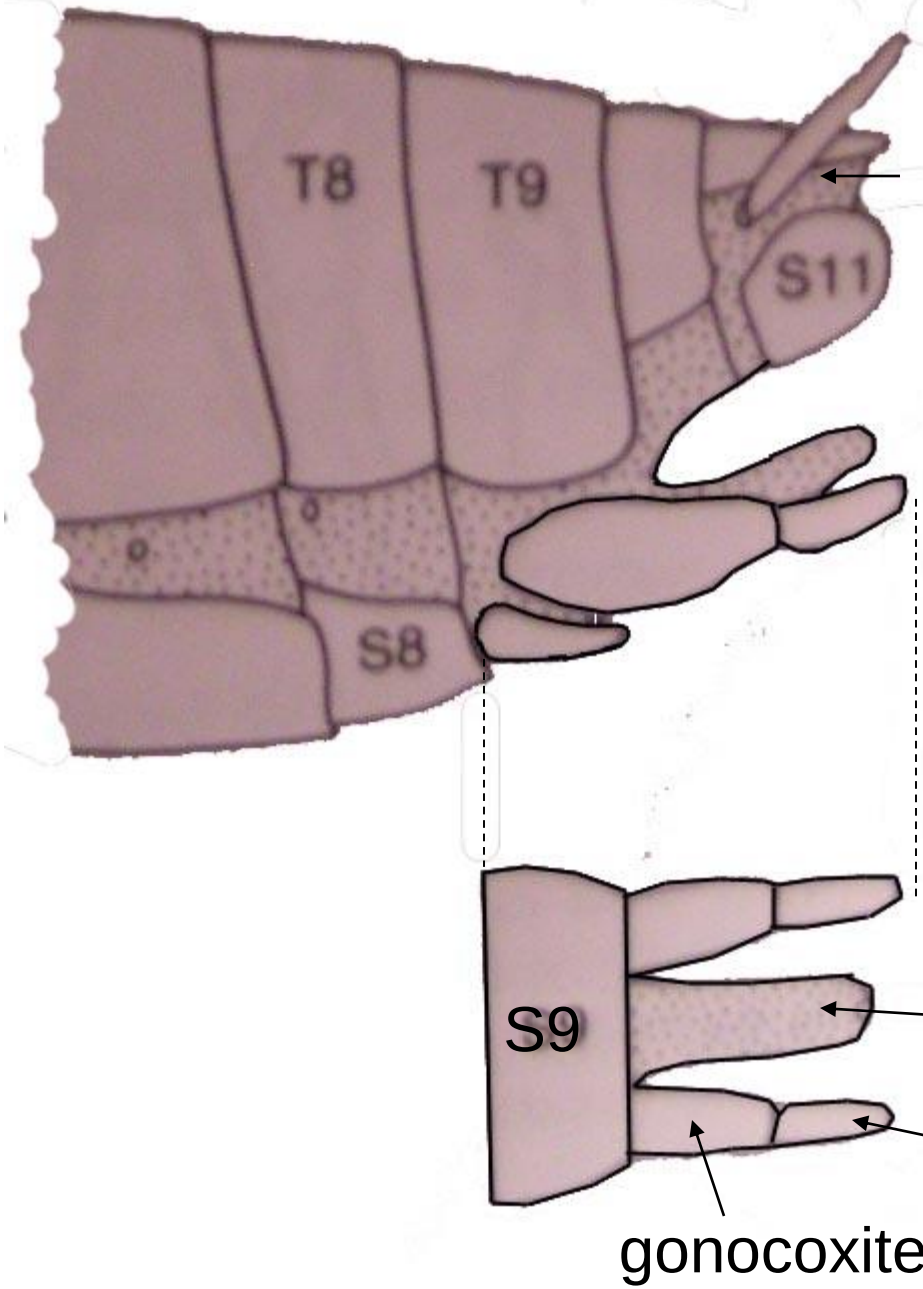


Aedeagus (= penis)

gonostylus

gonocoxite

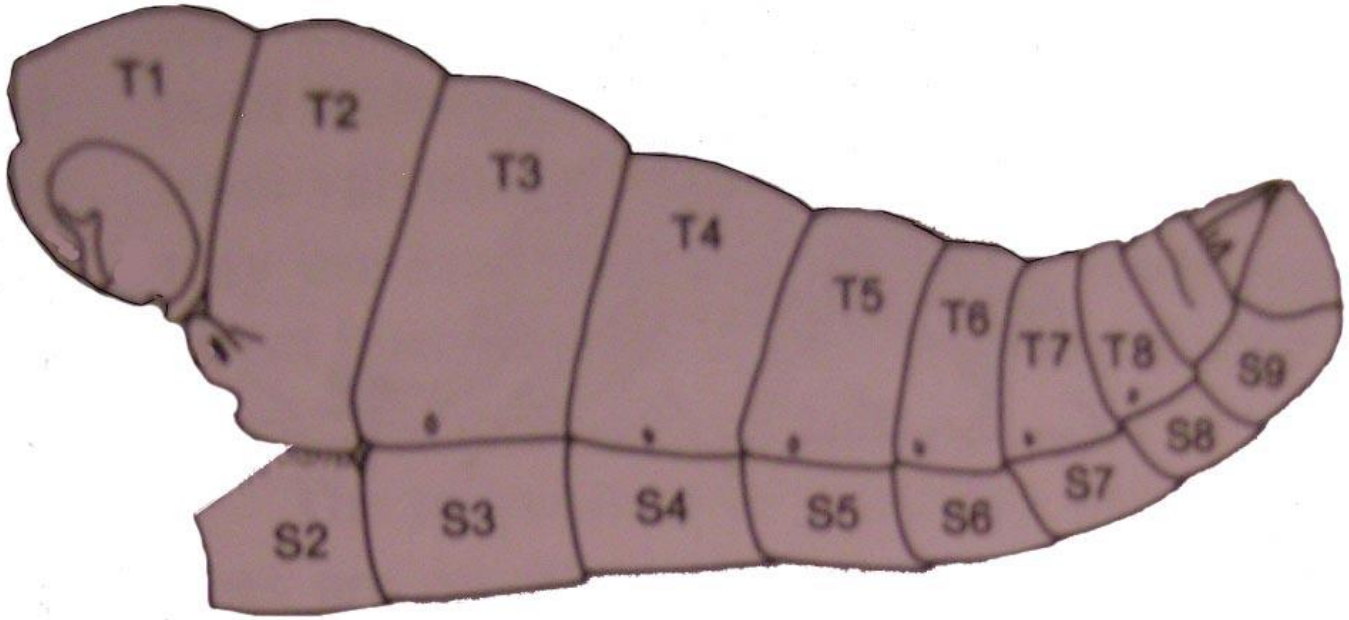
Generalized male genitalia



Gonostylus+gonocoxite (or paramere) = modified leg

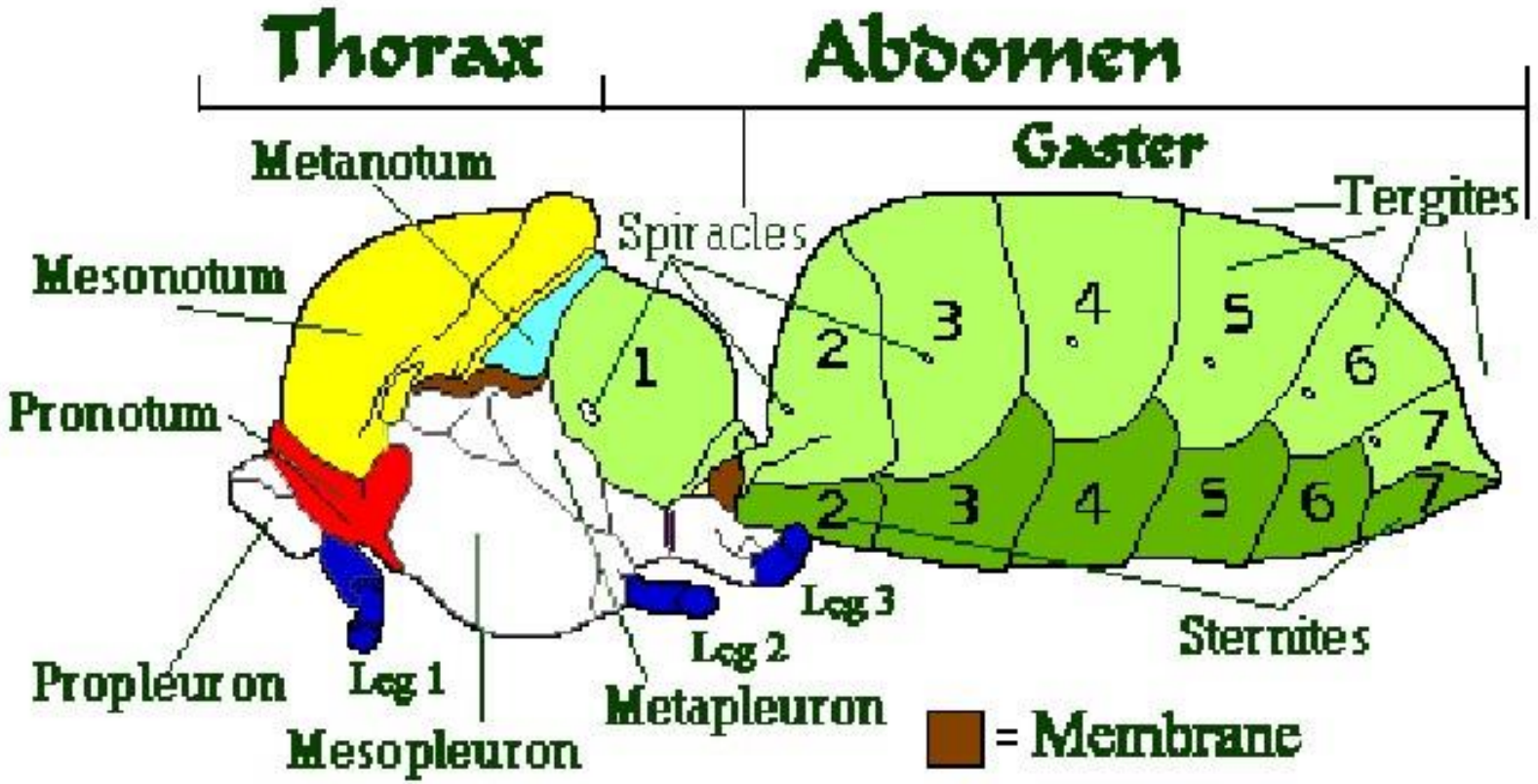
Aedeagus = fused lobes from coxae of 9th appendages

Male of *Romalea microptera* (Orthoptera)



Not much to see from the outside

Abdomen highly modified in a bee



昆蟲綱分目檢索表

1a 原生無翅；腹部第 6 節前常有附肢.....2
1b 有翅或次生無翅；腹部第 6 節前無附肢.....6
2a 無觸角；腹部 12 節.....原尾目 Protura
2b 有觸角；腹部最多 11 節 3
3a 腹部 6 節或更少，無尾毛，第 l 節有腹管，第 3 節有握器，第 4 或第 5 節有彈器.....彈尾目 Collembola
3b 10 節或 11 節，有尾毛，附肢為刺突或泡….....4
4a 腹端只有 l 對尾毛或尾鋏，無中尾絲；無複眼.....雙尾目 Diplura
4b 腹端有 l 對尾毛及 1 條中尾絲；有複眼….....5
5a 胸部較粗，背側拱起.....石蛃目 Microcoryphia
5b 胸部較扁，背側不隆起.....衣魚目 Zygentoma
6a 口器有成對的大顎，或口器退化.....7
6b 口器無大.....29
7a 有尾毛；頭不延伸成喙狀.....8
7b 無尾毛；少數有尾毛則頭延伸成喙狀.....20
8a 觸角剛毛狀；翅豎在背上或平展而不能折疊.....9
8b 觸角絲狀，念珠狀或劍狀等；翅可以向後折疊，或無翅 10
9a 尾毛細長而多節，有時還有中尾絲；後翅很小，無翅痣.....蜉蝣目 Ephemeroptera
9b 尾毛粗短不分節，無中尾絲；前後翅相似或後翅更寬，有翅痣……蜻蜓目 Odonata
10a 後足為跳躍足，或前足為開掘足.....直翅目 Orthoptera
10b 後足非跳躍足，前足也非開掘足.....11
11a 跗節 4～5 節.....12
11b 跗節最多 3 節 17
12a 前口式.....13
12b 下口式.....14
13a 前後翅均為膜翅，或無翅；觸角念珠狀.....等翅目 Isoptera
13b 無翅；觸角線狀.....蛩蠊目 Grylloblattodea
14a 前胸比中胸短小，體細長如枝或寬扁似葉.....竹節蟲目 Phasmida
14b 前胸比中胸長或寬大.....15
15a 前足為捕捉足，中足和後足為步行足.....螳螂目 Mantodea
15b 前足、中足和後足均為步行.....16
16a 體外形兼似螳螂和竹節蟲；全部無翅；無單眼；尾毛短且不分節…….....
…….....螳蟲脩目 Mantophasmatodea

16b 體平扁；部分無翅；有單眼；尾毛短，分節.....蜚蠊目 Blattodea
17a 跗節 2 節，尾毛不分節；觸角 9 節.....缺翅目 Zoraptera
17b 跗節 3 節.....18
18a 前足基跗節膨大，具絲腺；前翅與後翅相似〈雄〉，或無翅〈雌〉.....
.....紡足目 Embioptera
18b 前足基跗節正常，不能紡絲；有翅種類的後翅比前翅寬大.....19
19a 尾毛堅硬呈鋏狀；前翅短小，革質，後翅膜質如摺扇.....革翅目 Dermaptera
19b 尾毛不呈鋏狀；前翅狹長，後翅臀區擴大，均為膜質 .....積翅目 Plecoptera
20a 跗節最多 3 節，有爪；翅膜質.....21
20b 跗節 4～5 節；如 3 節以下則無爪，或前翅角質.....22
21a 跗節 2～3 節；觸角細長而多節；有翅或無翅.....齧蟲目 Psocoptera
21b 跗節 l～2 節；觸角短小，最多 5 節；無翅；外寄生於鳥獸類 .....
.....食毛目 Mallophaga
22a 前翅為棒翅，後翅很大；雌蟲無翅，無足，內寄生於昆蟲體內.....
.....撚翅目 Strepsiptera
22b 前翅不為棒翅.....23
23a 前翅角質，和身體一樣堅硬如.....鞘翅目 Coleoptera
23b 前翅和後翅均為膜質，或無翅.....24
24a 腹部第 1 節常併入胸部；或後翅前緣有 1 列小鉤；或無翅.....
.....膜翅目 Hymenoptera
24b 腹部第 1 節不併入胸部；後翅無小鉤列.....25
25a 頭部向下延伸呈喙狀；有短小的尾毛.....長翅目 Mecoptera
25b 頭部不延伸成喙狀.....26
26a 前胸很小；足脛節上有很大的中距和端距；翅為毛翅.....毛翅目 Trichoptera
26b 前胸發達；足脛節上無中距，端距較小或呈爪狀；翅為膜翅.....27
27a 後翅臀區發達，可以折疊.....廣翅目 Megaloptera
27b 後翅臀區很小，不能折疊.....28
28a 頭基部不延長；前胸如延長，則前足為捕捉足；雌蟲常無產卵器.....
.....脈翅目 Neuroptera
28b 頭基部和前胸均向前延長；前足不特化；雌蟲有針狀產卵器.....
.....蛇蛉目 Raphidiodea
29a 口器為虹吸式；翅為鱗翅.....鱗翅目 Lepidoptera
29b 口器非虹吸式；翅上無鱗片.....30
30a 跗節 5 節.....31
30b 跗節最多 3 節，或足退化，甚至無足.....32
31a 體不側扁；前翅膜質，後翅為棒翅；少數無翅.....雙翅目 Diptera
31b 體側扁；無翅.....蚤目 Siphonaptera
32a 無翅；口器位於頭的前端；足為攀懸足；外寄生於哺乳類動物.....

.....蝨目 Anoplura
32b 有翅；口器位於頭的下面；足不適於攀緣…….....33
33a 翅為纓翅；口器常不對稱；足端有泡.....纓翅目 Thysanoptera
33b 翅為非纓翅；口器對稱；足端無泡…….....34
34a 前翅為半鞘翅；喙明顯出自頭部.....半翅目 Hemiptera
34b 前翅全部革質或膜質；喙明顯出自胸部，或喙很退化，或無喙.....
…….....同翅目 Homoptera

Lab 2
External Morphology

頭部 (The Head)

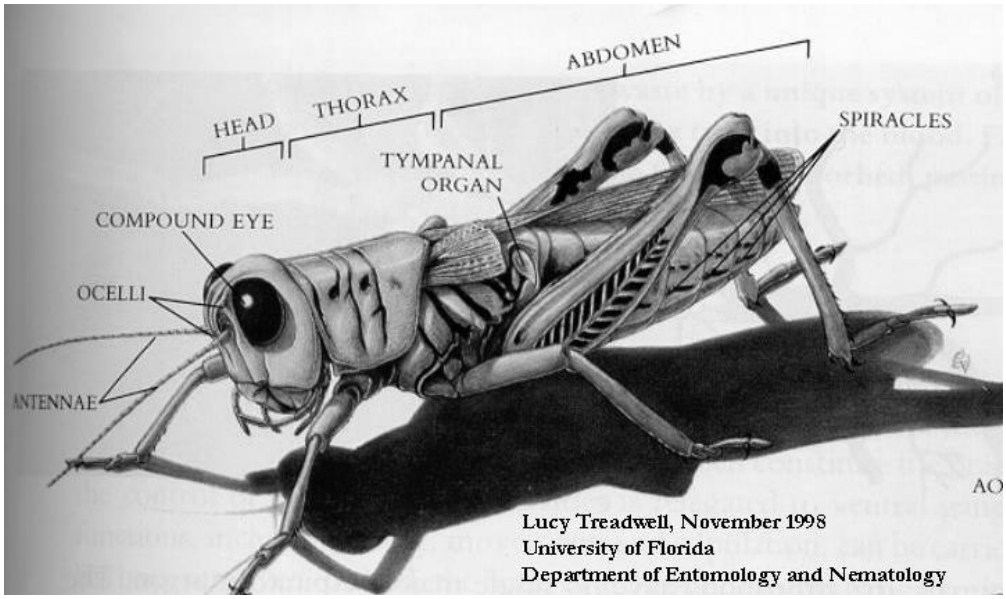
- 複眼 compound eyes ─由許多小眼組成的眼睛，位於頭部兩側，為主視覺器官。
- 單眼 ocelli ─ 位於頭部上方兩個複眼之間的眼睛，三個或兩個，主飛行平衡與　光線調節。
- 大顎 mandible ─ 位於口器外側，用於切、磨食物與防禦。
- 小顎 maxilla ─ 位於大顎後方，協助大顎處理食物，上有感覺毛可試食物味道
- 上唇 labrum ─ 位於口器上方，左右大顎之間，保護取食器官
- 下唇 labium ─ 位於小顎後方，內含許多重要的取食器官。
- 觸角 antenna ─ 位於頭部上方左右對稱，形式多樣，是重要的感覺器官。
- 口器 mouthparts ─ 昆蟲諸多攝食器官的總稱，依食性不同而有多種形式。

胸部 (The Thorax)

- 胸背板 nota ─ 包覆胸部，保護內部器官的外骨骼。
- 楯片 scutum ─ 位於中胸部位，覆蓋於中胸之上的硬片 。
- 前腳 fore legs ─昆蟲的前步足，左右對稱，有些種類特化為捕食腳。
- 中腳 mid legs ─昆蟲的中步足，左右對稱。
- 後腳 hind legs ─昆蟲的後步足，左右對稱，有些種類具有游泳划水功能。
- 基節 coax ─ 腳部與胸部接合的節，為第一足節。
- 轉節 trochanter ─ 位於基節與腿節之間的第二足節。
- 腿節 femur ─昆蟲的第三足節，通常會較粗大。
- 脛節 tibia ─昆蟲的第四足節，通常會較細長，有些種類有棘刺。
- 跗節 tarsus ─昆蟲的第五足節，又分成若干小節以利攀附。
- 爪　claw ─ 在昆蟲足部的最末端，用以抓住攀附物。
- 翅　wings ─ 有翅昆蟲的飛行器官，有膜質、革質及半膜半革質等形式。
- 翅痣 pterostigma ─翅膀近前緣處的一枚有色素的小斑點。
- 翅基 base ─ 翅膀與胸部交接之處。
- 中室 discal ─翅膀基部到中間部位，由翅脈圈圍起來的一塊區域。

腹部 (The Abdomen)

- 外生殖器 external genitalia ─昆蟲的外部生殖器官，可直接觀察的部分。
- 產卵器 ovipositor ─ 雌蟲的產卵器官，位於腹部尾端。
- 產卵管 common oviduct ─ 雌蟲用以排出卵的管狀器官，有針狀或刀狀的形狀。
- 生殖孔 gonopore ─ 生殖管開口，在沒特化的情況下，雌蟲為輸卵管開口，雄蟲為射精管開口。
- 陽莖 penis ─ 雄蟲的交配器官，用以排放精子。
- 陰道 vagina ─ 雌蟲的交配器官，為陽莖伸入排放精子之管道。
- 輸卵管 oviducts ─ 雌蟲的卵子輸送管道。
- 受精囊 spermatheca ─ 雌蟲用來儲放雄蟲精子的囊狀器官。
- 氣孔 spiracles ─昆蟲的呼吸孔。



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