Insects Rule, Mammals Drool: The insects

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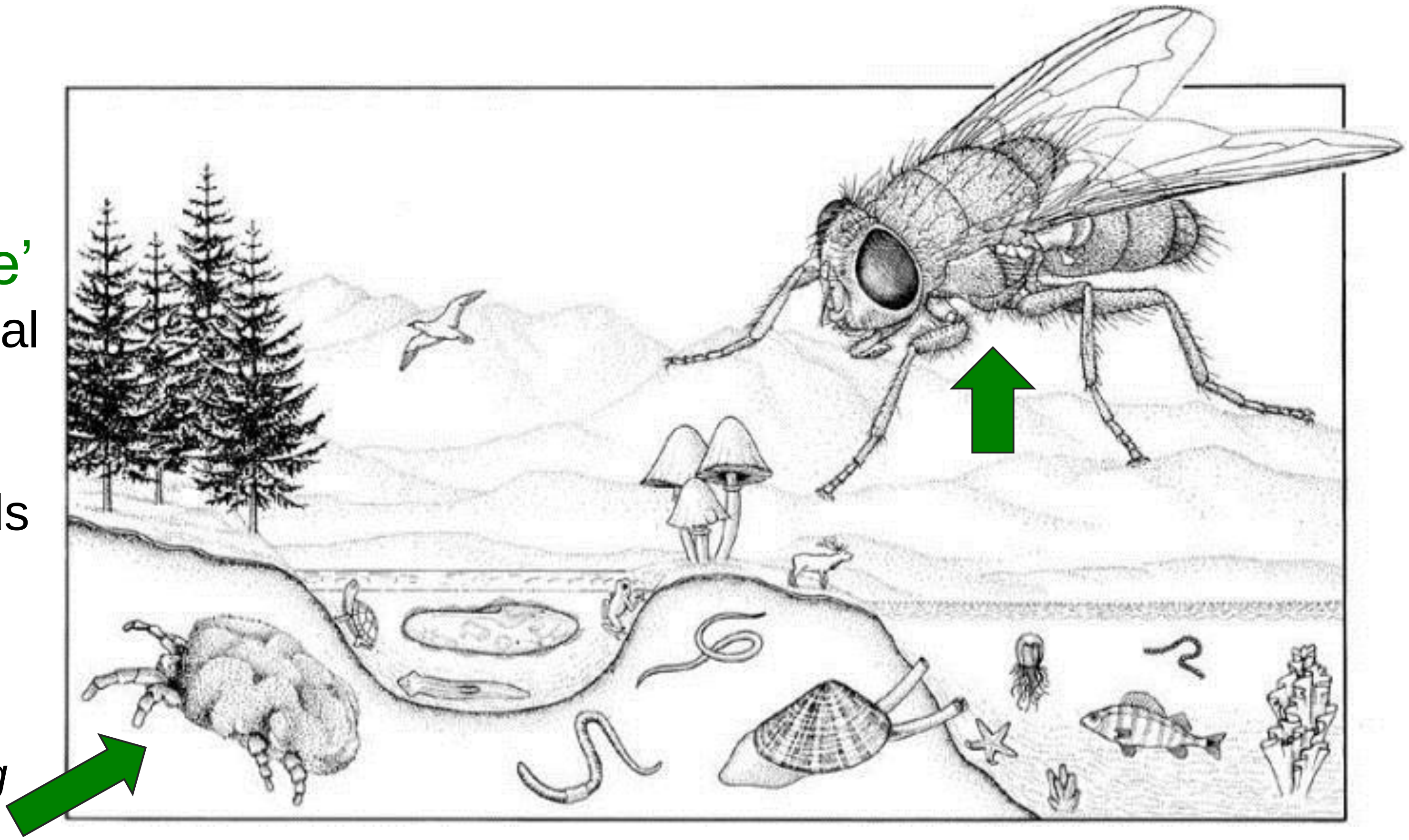
Insects are incredibly important to life on earth

- Nutrient cycling of plants, wood, manure, carrion
- Pollination & seed movement
- Biological control via predation & parasitism
- Base of many food chains
- Pests of food, fiber, activity + disease transmission

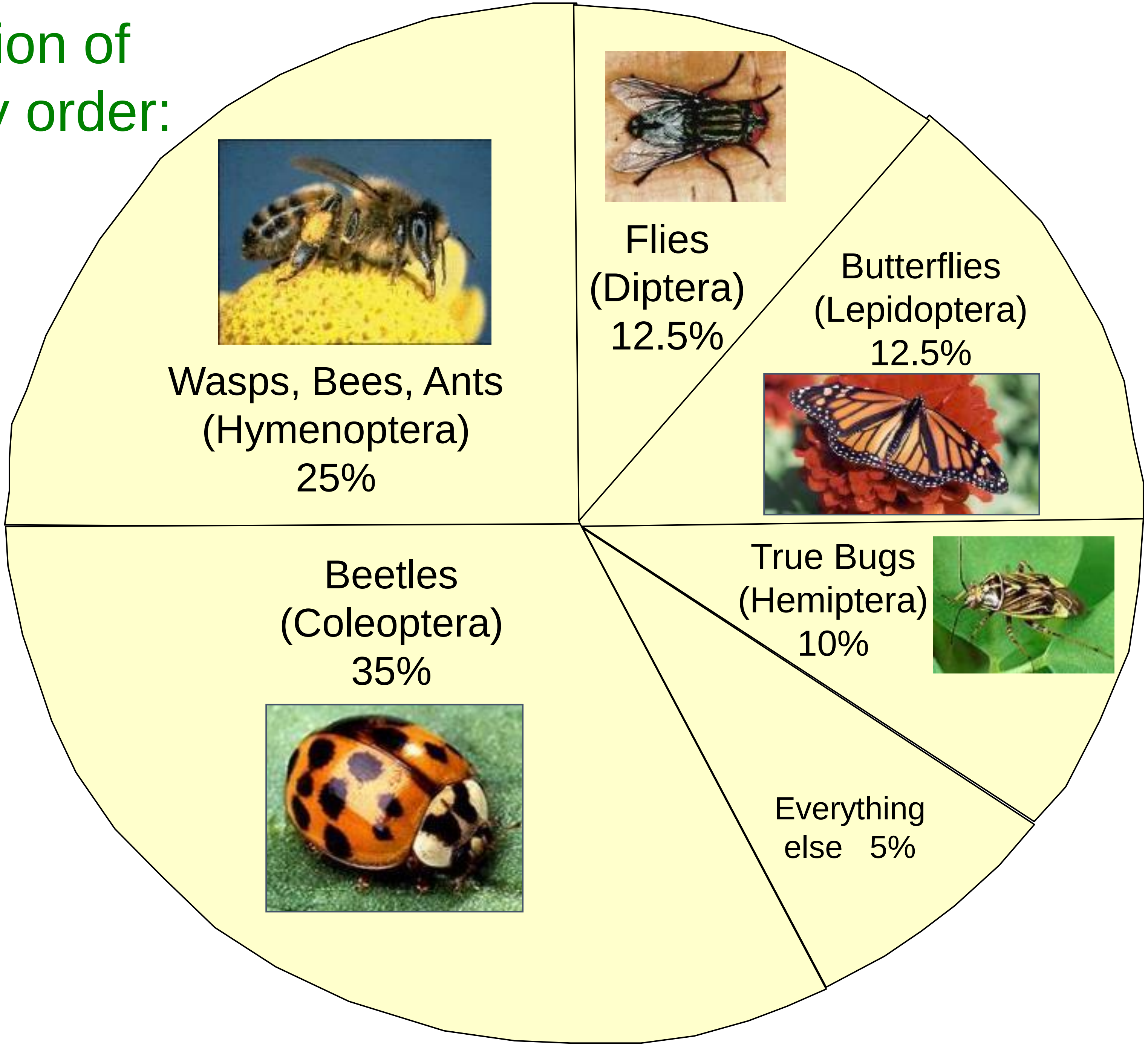
'Speciescape'

80% of all animal species are arthropods. Most arthropods are insects.



the remaining arthropods

Distribution of species by order:

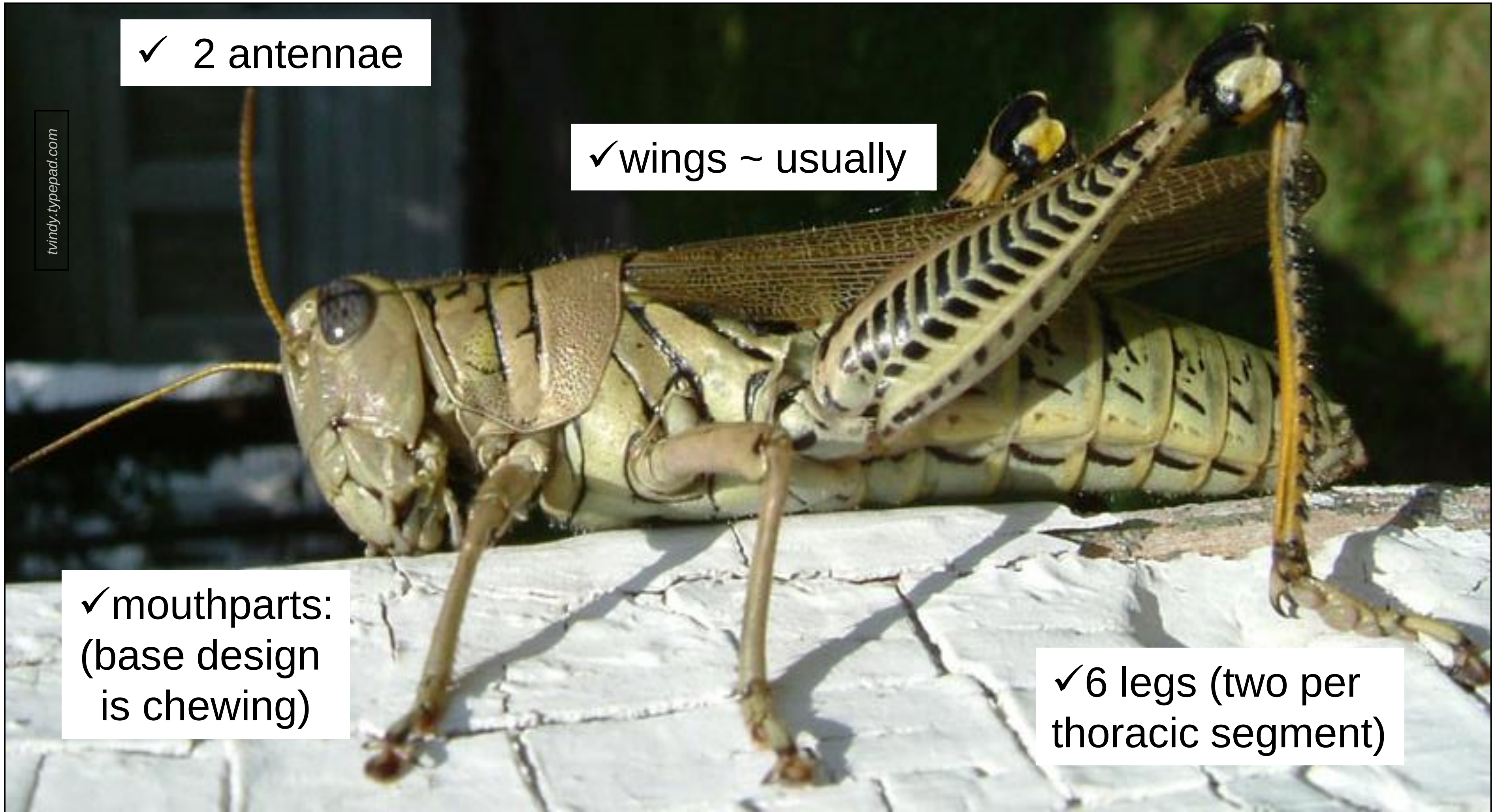


Much of the good and bad about insects comes down to **morphology** (the structure & function of body parts)

What makes an insect an insect?

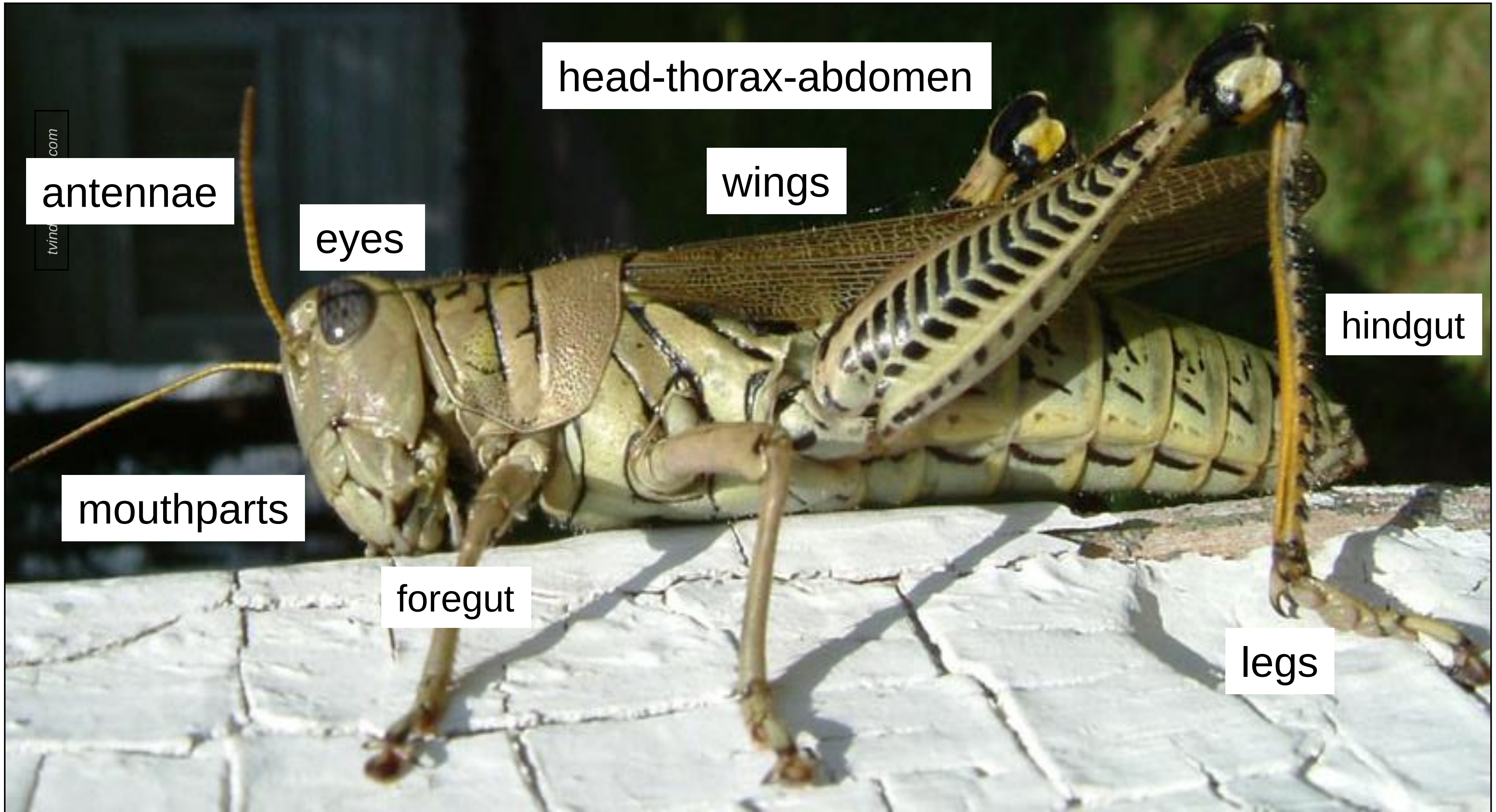
✓ Segmented body with paired jointed appendages
✓ three body regions

✓ exoskeleton.....thus growth by molting



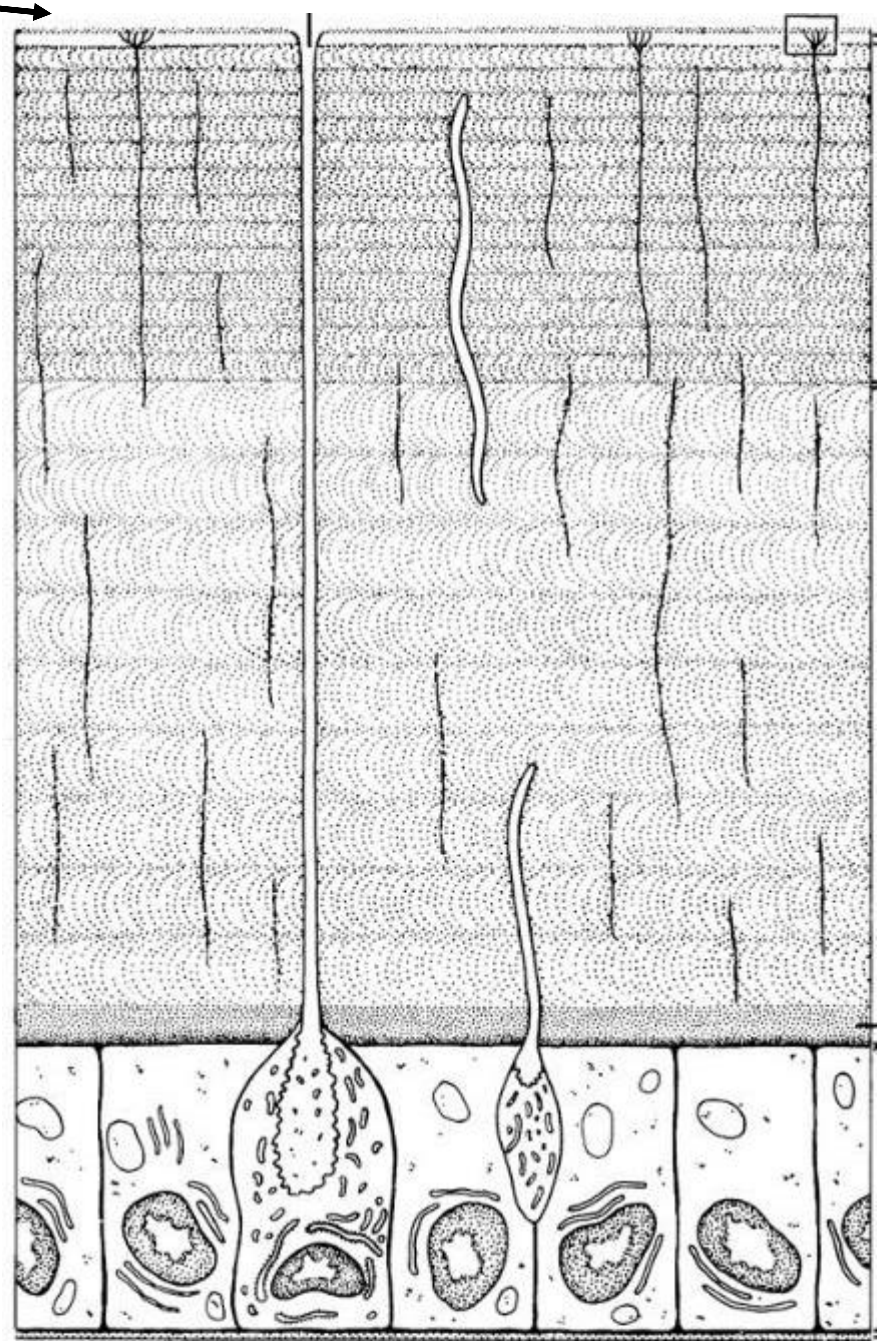
The Exoskeleton (cuticle) key to the success of arthropods & their colonization of land

- Provides shape to the body
- Barrier to the environment
- Muscle attachment points
- Coloration
- Sensing
- Reduces water loss



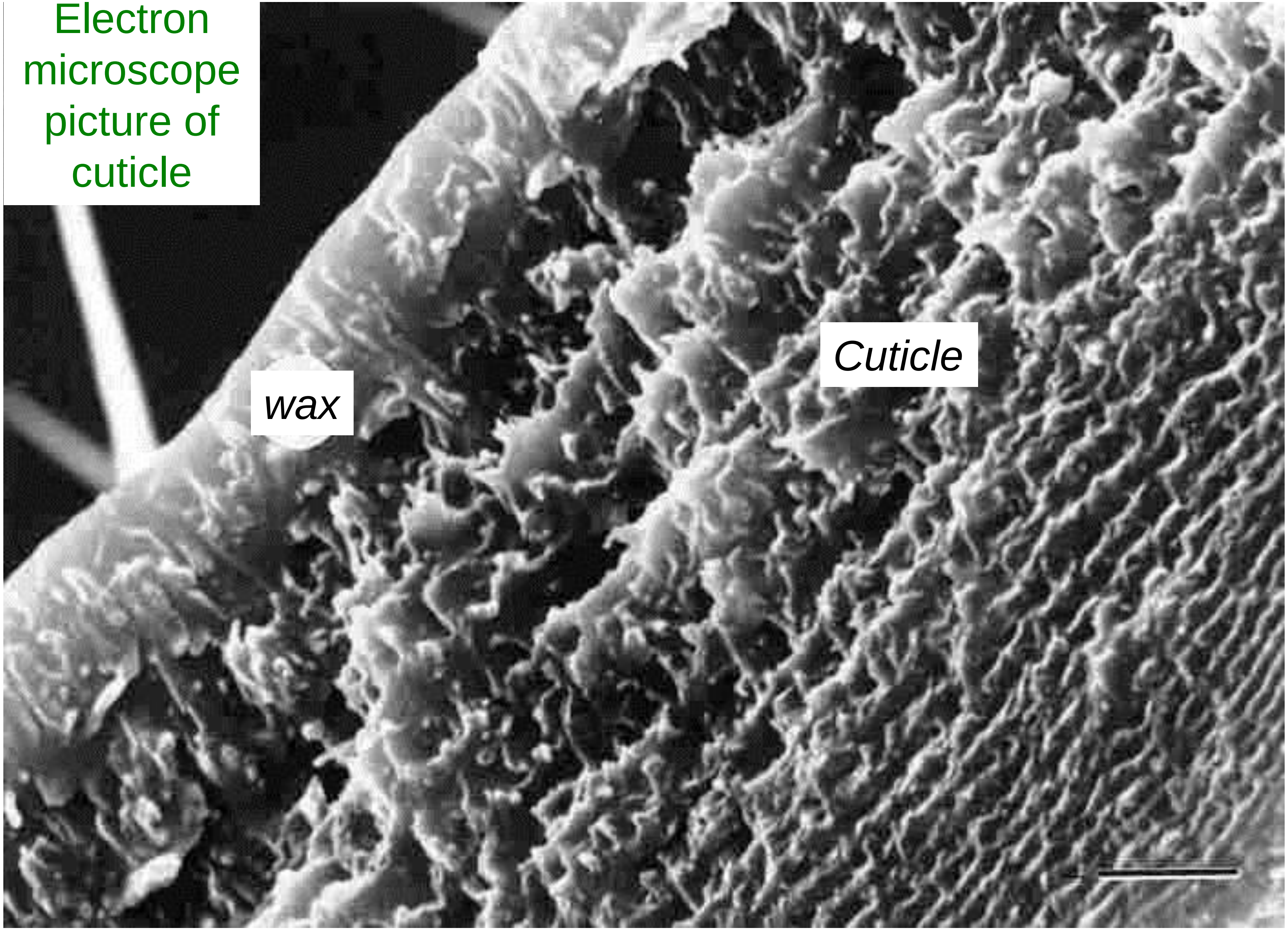
thin surface layer, waxy

Cuticle
- thick layer, supports the body
- contains the protein chitin
- it may sclerotize



Epidermis
- living cells that make the cuticle
- secretes wax onto the surface

Electron microscope picture of cuticle



Waxy layer

- makes insects shiny
- prevents dehydration

other cuticle functions

- sculpturing to reflect light
- hairs to deter predation
- warning colors & camouflage

Sclerotization

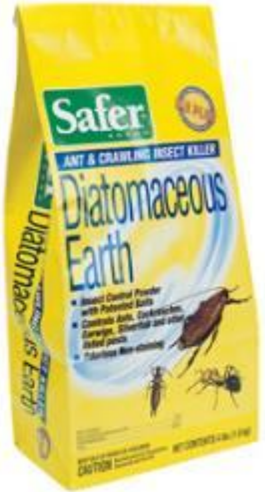
- Protein chains cross-link
- Exocuticle darkens, strengthens
- Process is irreversible
- Makes insects ‘crunch’

Sclerites

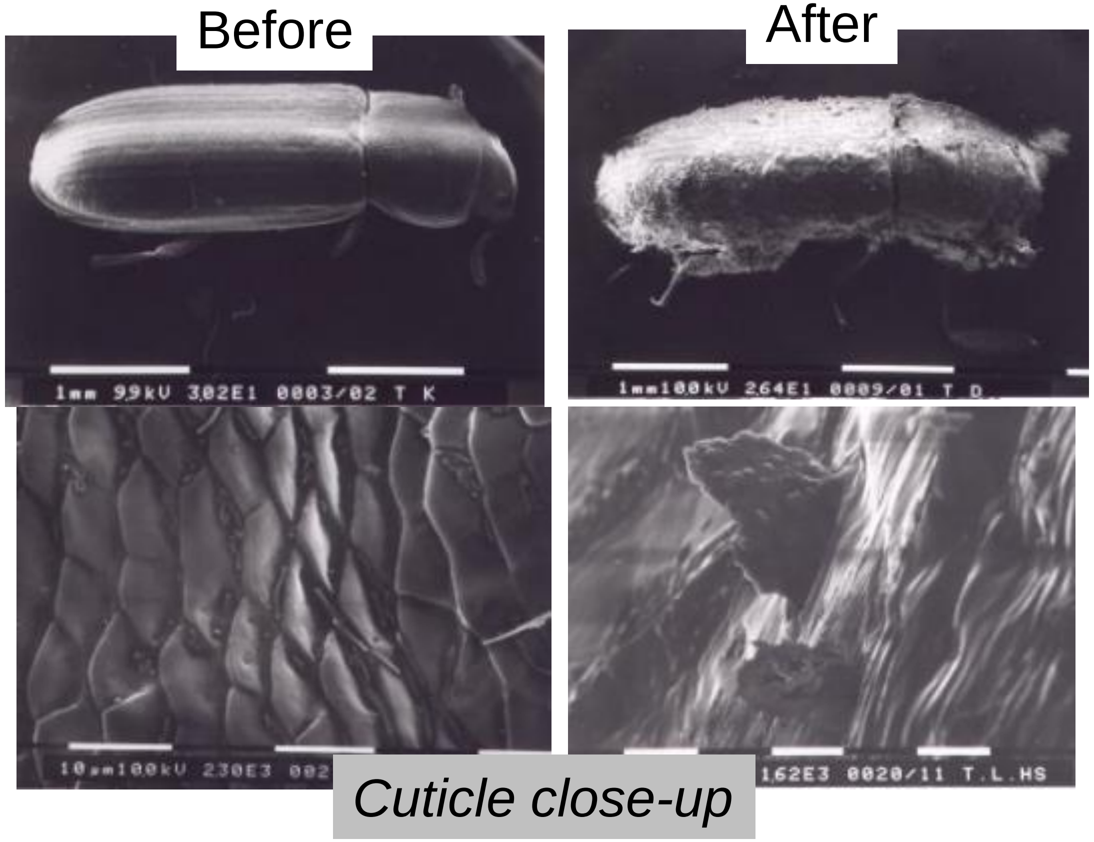
Sclerotized plates on the body wall, surrounded by elastic membranes that don't harden (think armor plating)

Sclerites give insects flexibility & allow the body to expand

How does this relate to pest management?



- Some insecticides target the cuticle



- Some insecticides <u>move through</u> the cuticle (contact poisons)

- The cuticle can be a <u>barrier</u> to other insecticides (stomach poisons) or interfere with control (wax)

Limitations of having an exoskeleton

- ✓ Limits size
- ✓ Limits movement
- ✓ Limits food, egg storage
- ✓ Limits growth

How does an insect get out of its exoskeleton?

In most animals, the offspring & adults look similar...

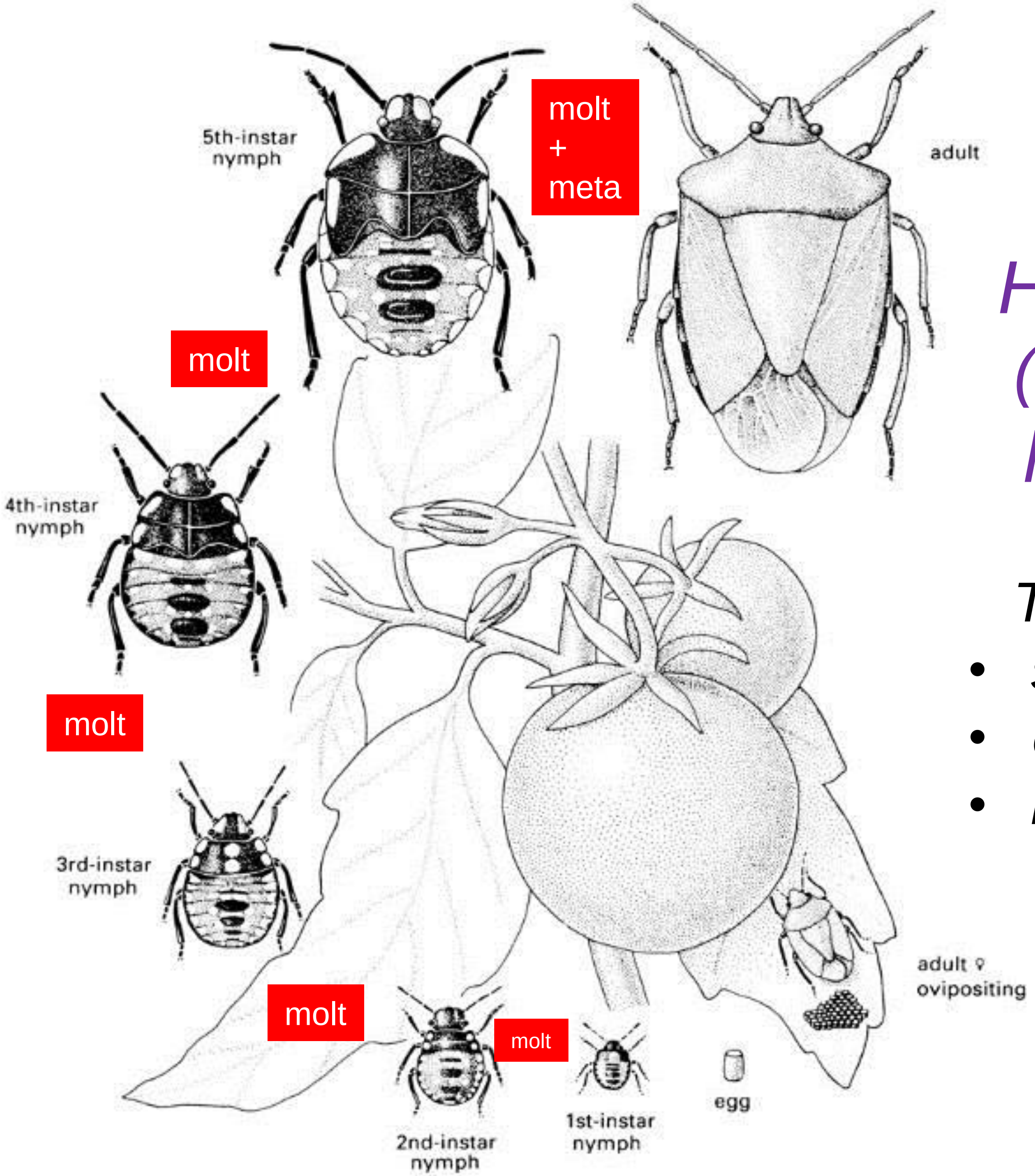
....but insects undergo substantial changes involving two processes:

Molting
GROWTH

shedding the cuticle

Metamorphosis:
CHANGE

significant change in body from young to adult (gaining reproductive maturity & wings)



Hemimetabolous (simple or gradual) Metamorphosis

The young (nymphs):

- *smaller*
- *can't reproduce*
- *lack wings*

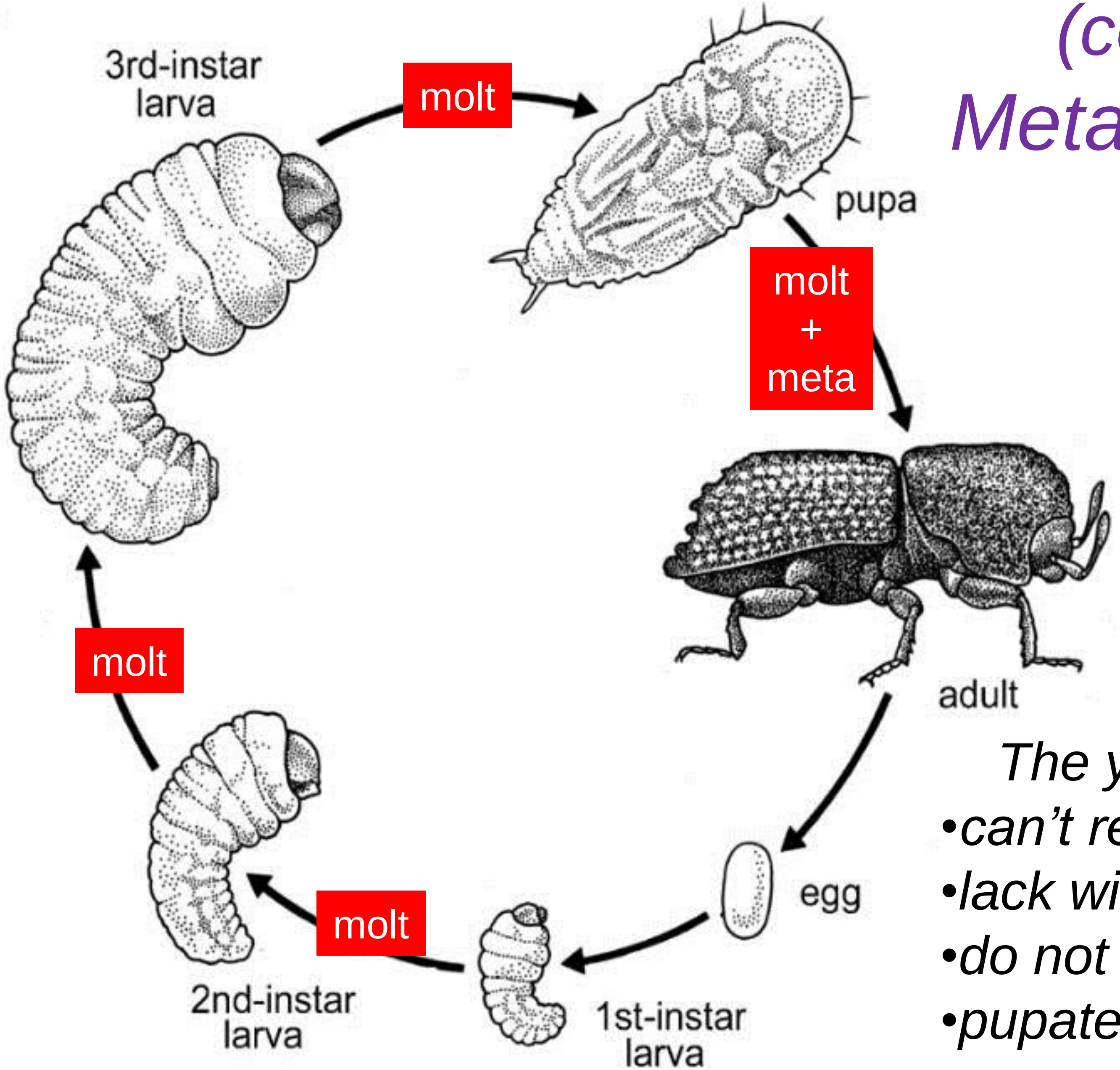
<u>hemimetabolous groups include:</u>

crickets
grasshoppers
earwigs
roaches
termites
mantids
walkingsticks
dragonflies
true bugs
lice

Boxelder bug

Green stink bug

Holometabolous (complete) Metamorphosis



The young (larvae):

- *can't reproduce*
- *lack wings*
- *do not resemble adult*
- *pupate*

holometabolous groups include:

beetles
flies
butterflies & moths
wasps, bees, & ants


Emerald ash borer


Honey bee

Japanese beetle

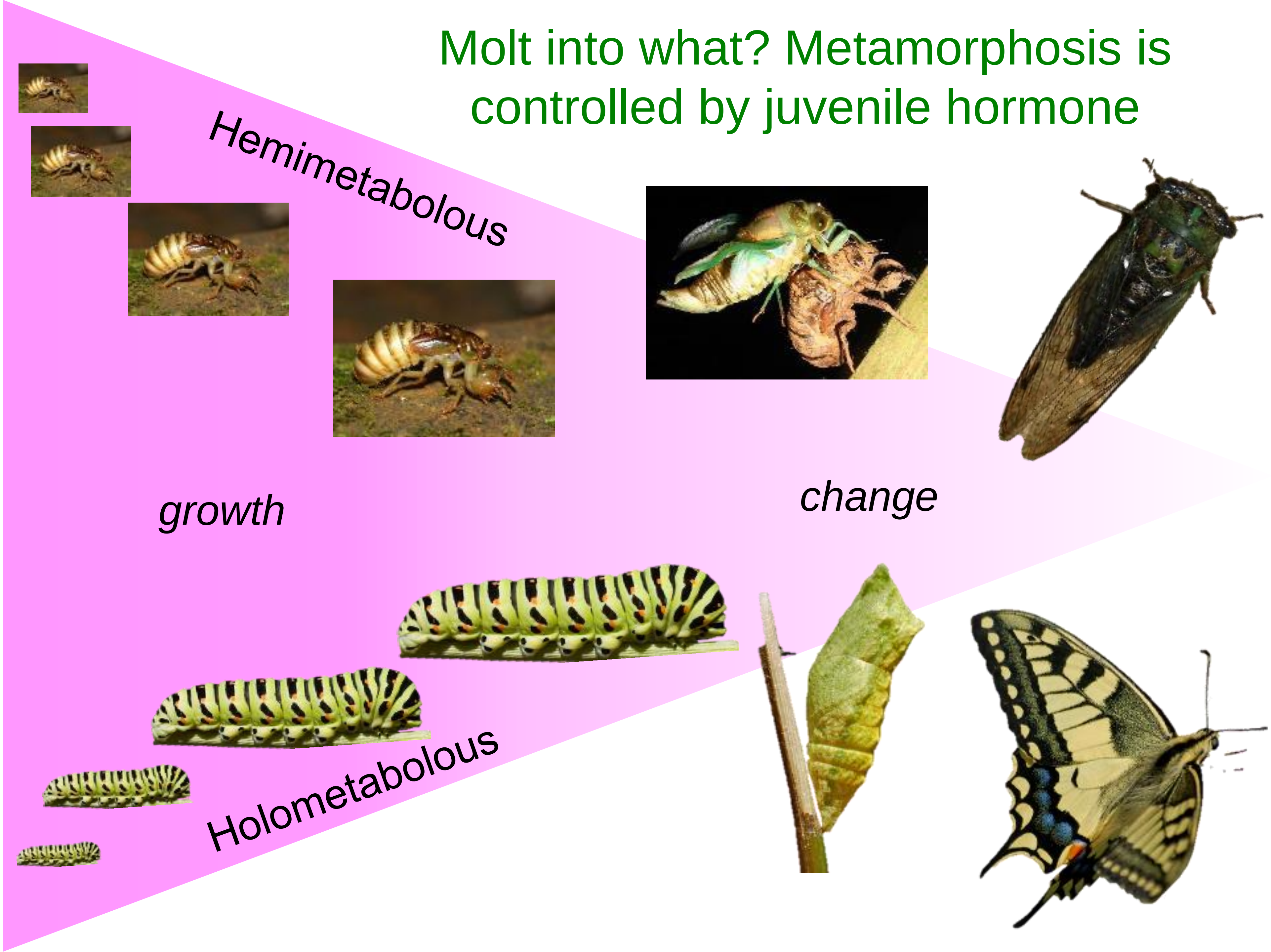
How does an insect molt?

* a hormone (ecdysone) signals the insect to molt
* the old cuticle loosens & pulls away
* a new cuticle is made underneath it
* enzymes digest away & recycle most of the
  old cuticle (making it very thin)
* the old cuticle splits along the dorsal line




The new cuticle is soft, but eventually hardens after the insect pumps itself up.
(in this example, the molt was also for metamorphosis)

Molt into what? Metamorphosis is controlled by juvenile hormone



How does this relate to pest management?

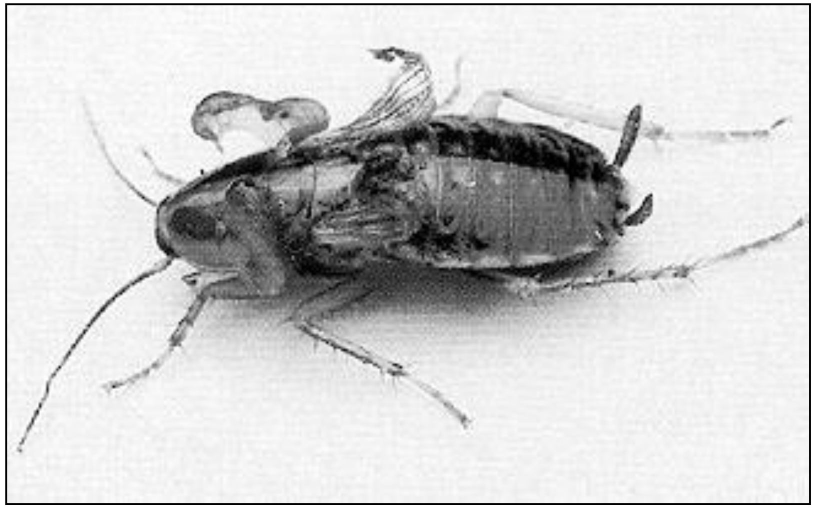
Many new biopesticides mess up molting or metamorphosis

Insect Growth Regulators (IGRs) mimic/block hormones

- prevent shedding of cuticle
- cause sterile adults

- mess up production of the exoskeleton

- force an insect to change too early, or stay in a stage too long



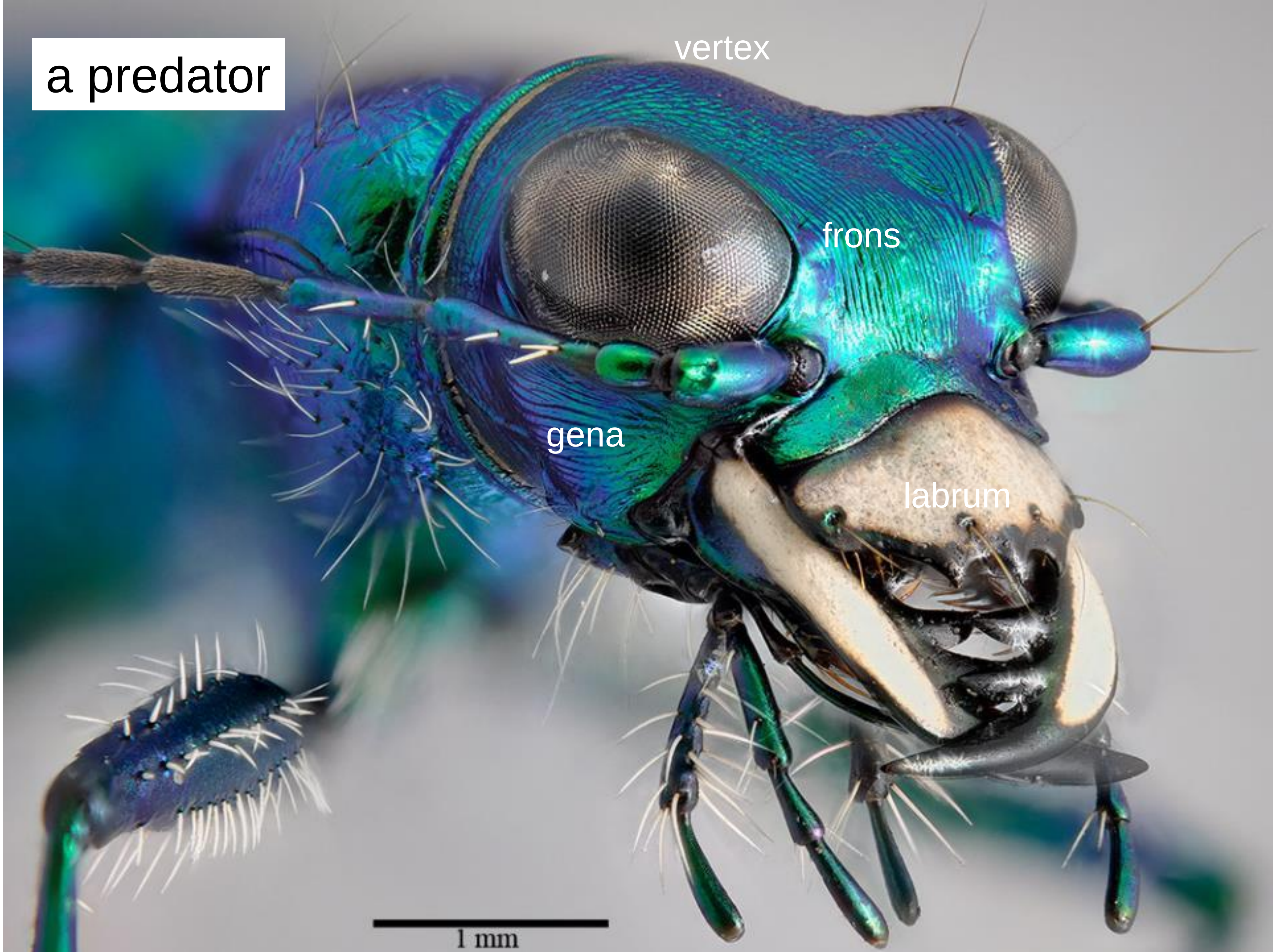
Basic body parts of insects

…from front to back

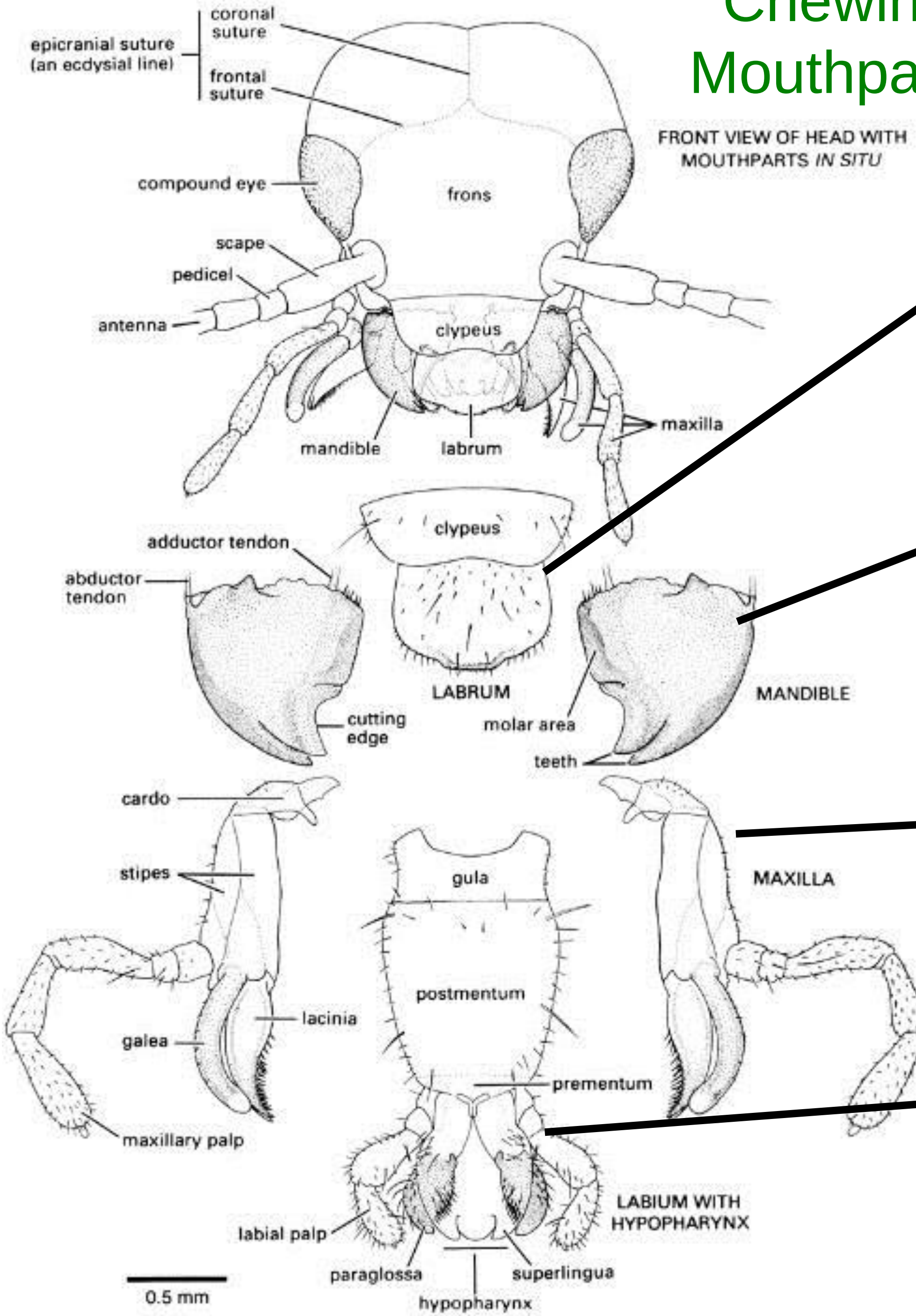
The Head

eating
sensing

a plant
feeder
with basic
downward-
facing
chewing
mouthparts


a predator
vertex
frons
gena
labrum
1 mm

Chewing Mouthparts



<u>Labrum</u>

- upper lip
- keeps food in

<u>Mandibles</u>

- extremely hard
- cut, crush food
- defense

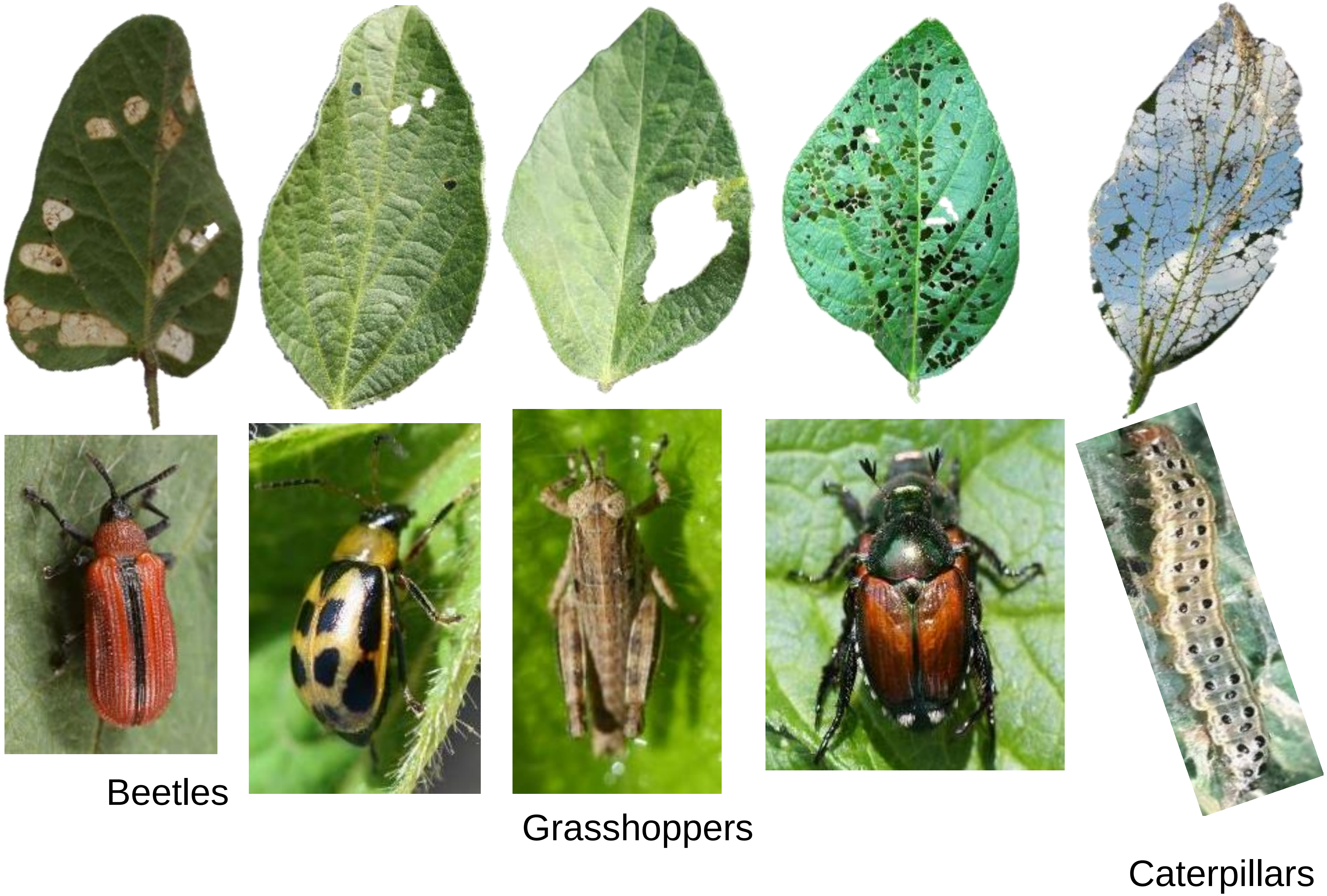
<u>Maxillae</u>

- assists w/ chewing
- sensory
- chemoreception

<u>Labium</u>

- lower lip
- sensory

Biodidac.bio.uottawa.ca



Types of defoliation

caterpillars
(Lepidoptera)

lacewings & related insects

Hymenoptera: wasps, bees, ants

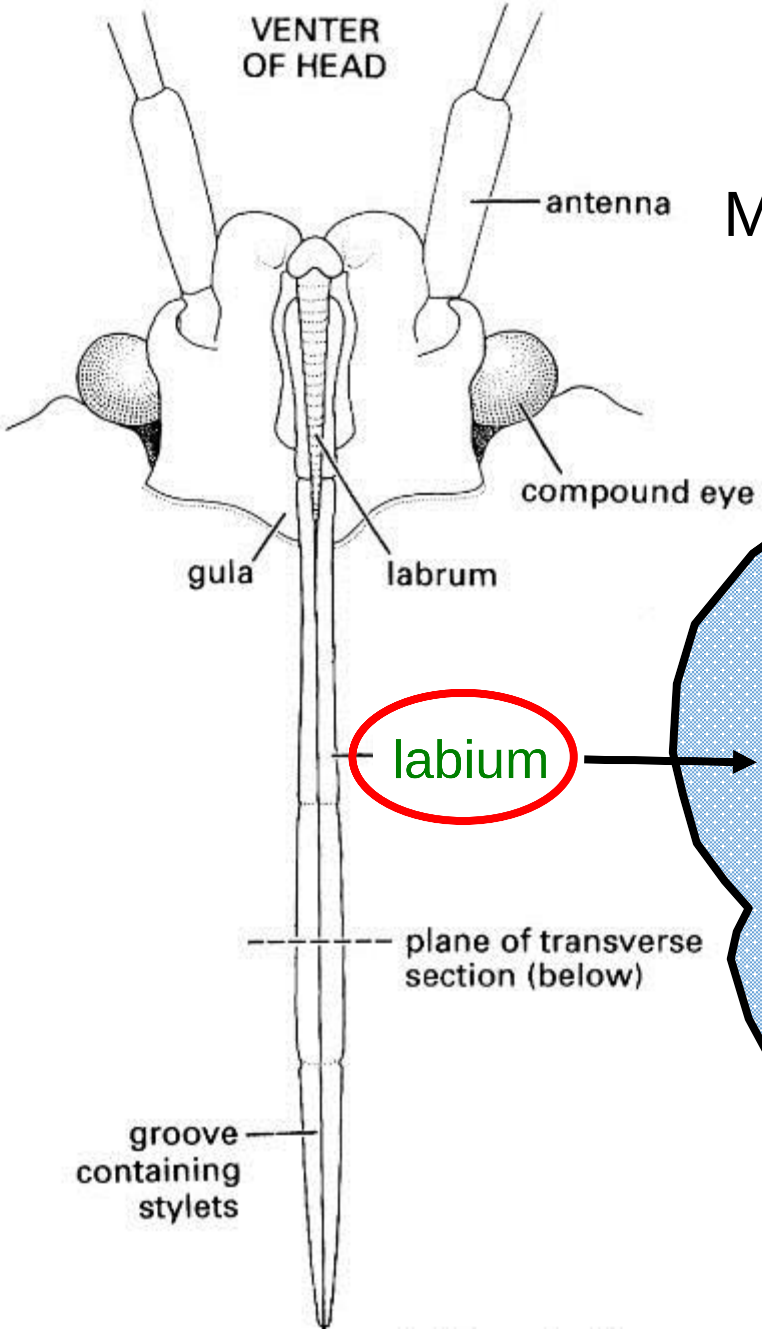
All beetles - Coleoptera

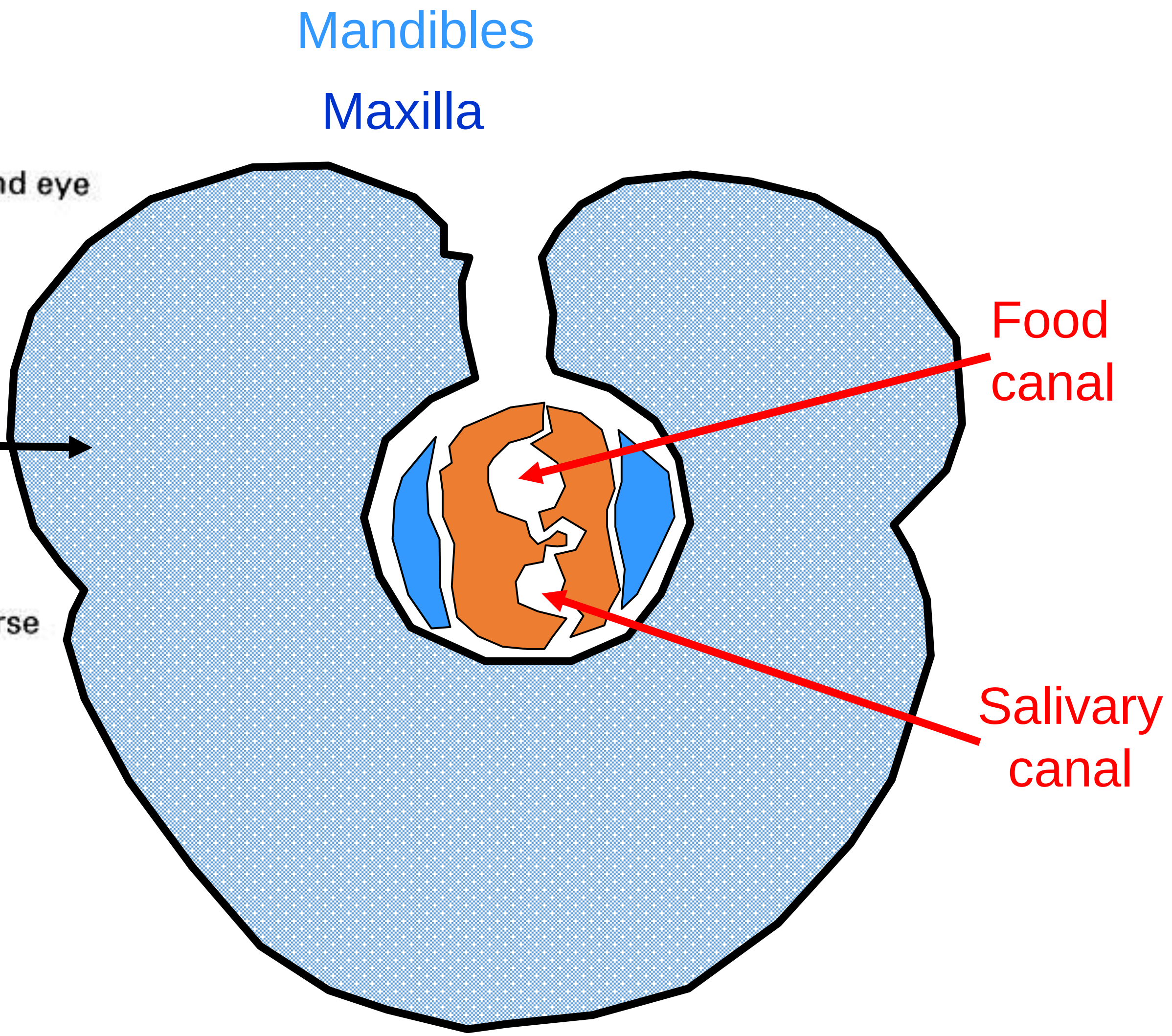

Don’t be fooled!

Order Hemiptera

Piercing-sucking mouthparts

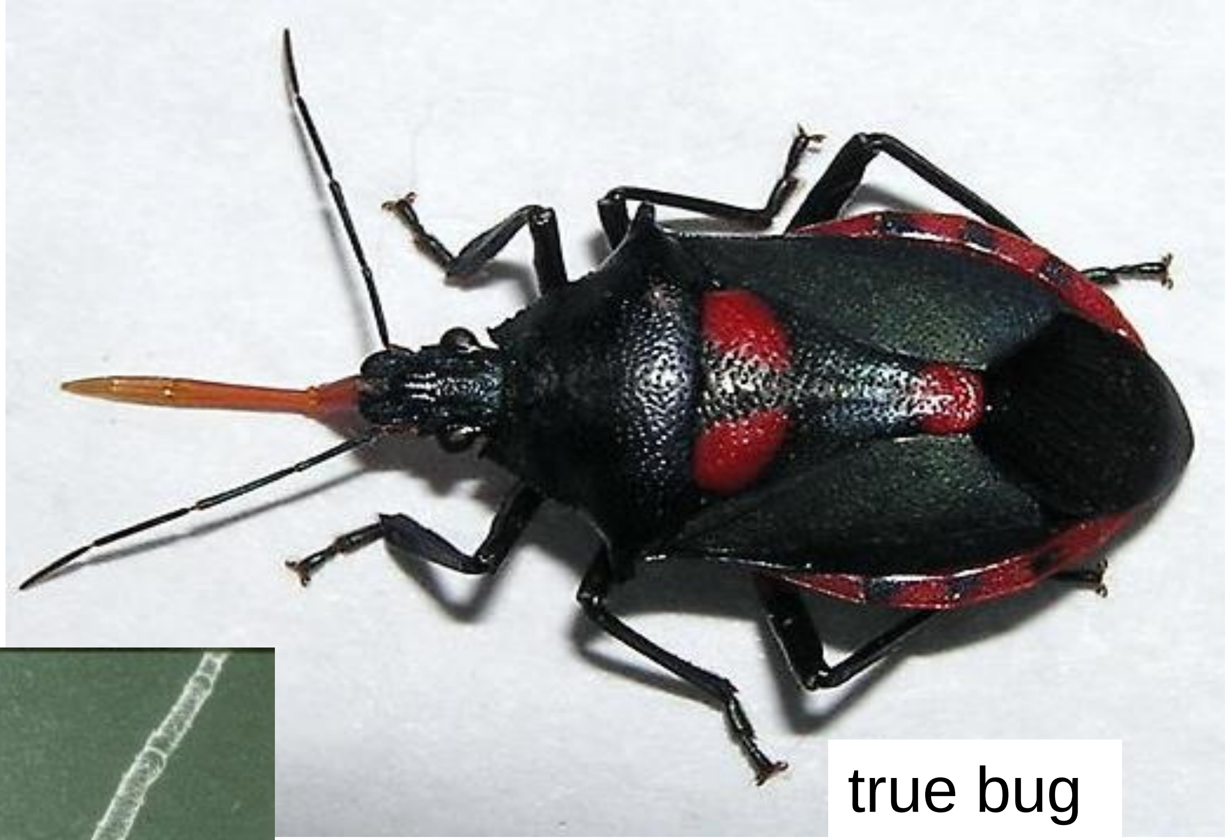
Modified to pierce plant or animal tissue





Labium

Covers stylet.
Protective
Segmented



true bug

EM picture
of an aphid

Sucking insects

true bugs

aphids

leaf & plant hoppers, cicadas

thrips

whiteflies

Symptoms of piercing-sucking

Physical damage to plant surface

- punctures
- catfacing

Symptoms of piercing-sucking

- removal of plant sap
  (water stress)
- stunting, twisting, yellowing, browning of leaf tissue

Symptoms of piercing-sucking

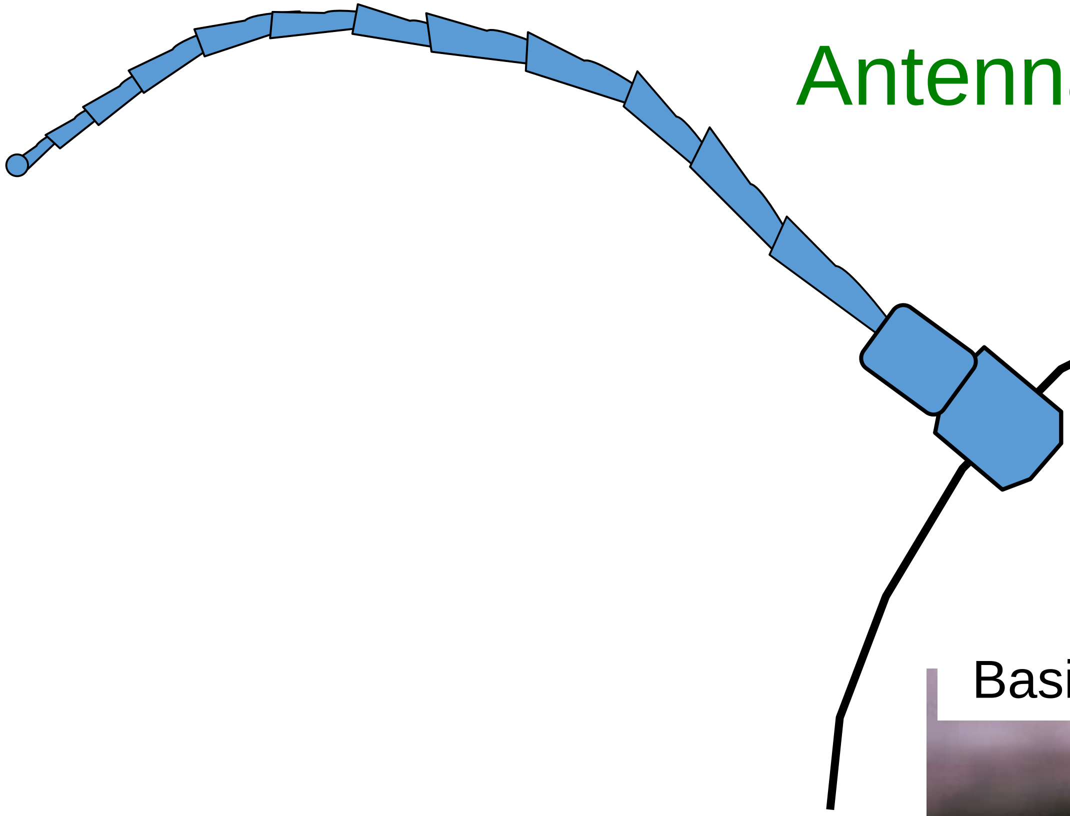
- Removal of plant sap/ stress
- stunting, twisting yellowing
- Hopperburn (leafhoppers)

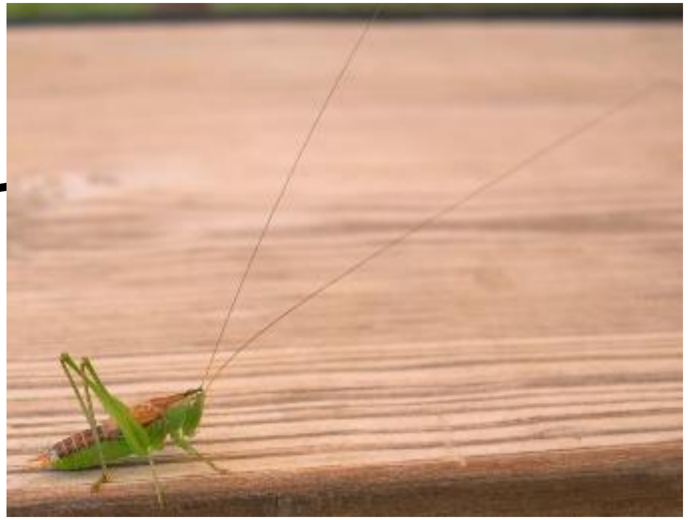
Symptoms of piercing-sucking

- Transmission of plant viruses (esp. aphids)

Some bugs
are beneficial
predators

Antennae



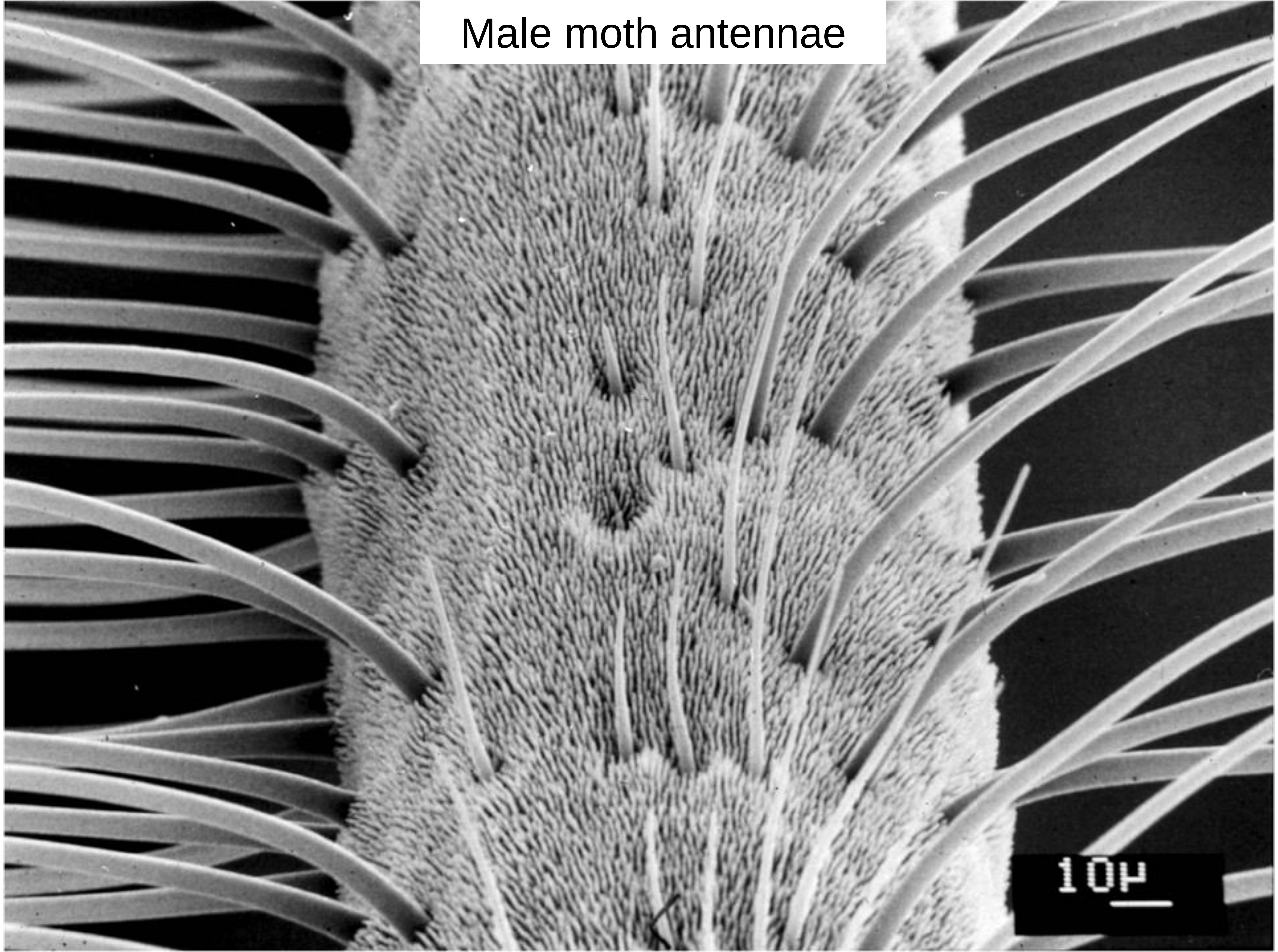


Basic filiform thread-like antenna

- mobile, segmented
- sensory hairs, cones, or pits along the length

- senses touch, temp., air position, speed, and chemicals

Male moth antennae

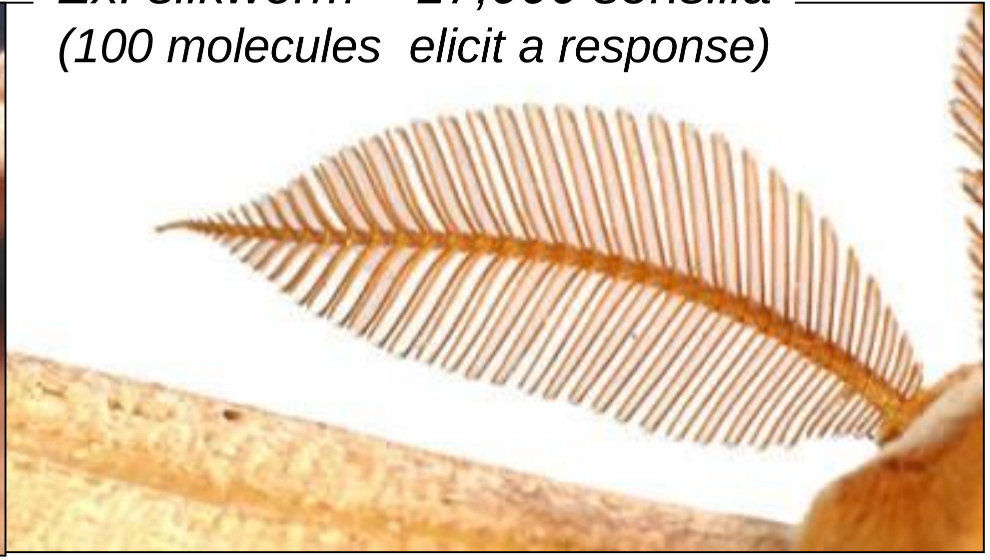


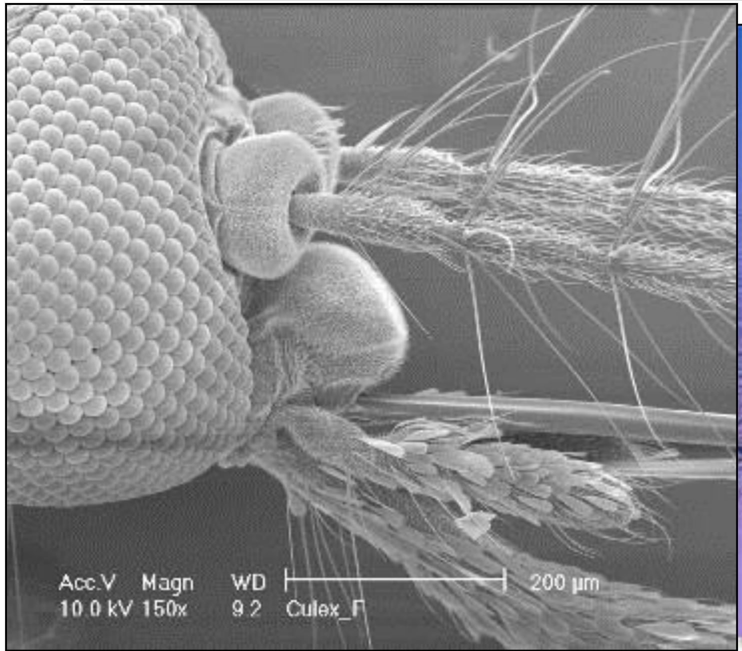
Insect chemoreception may be VERY sensitive

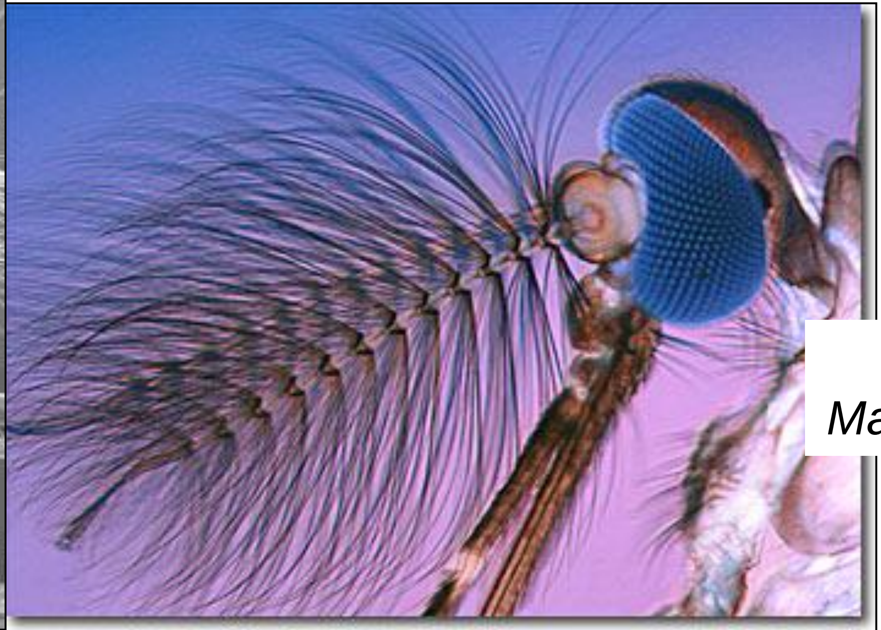
- modified antennae have increased are flow & surface area

Ex: silkworm = 17,000 sensilla

(100 molecules elicit a response)



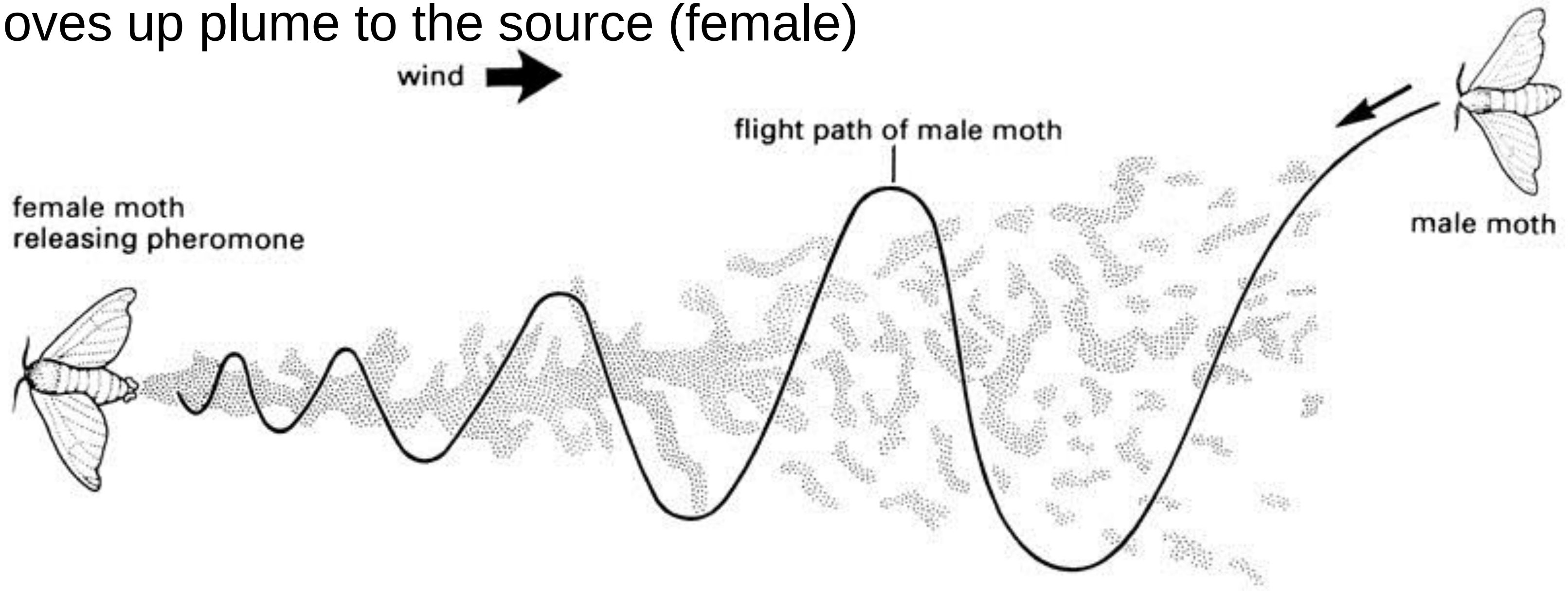




Example:
Male mosquito

Insects live in a chemical world – excel at chemical detection

Sex pheromone: Male senses pheromone
Moves up plume to the source (female)



Trail-marking Pheromone

Aggregation Pheromone

Pheromones – are used for insect detection & control

Detection –
Especially
invasive
species

Gypsy moth trap
w/ disparlure

Time emergence
or spraying

Codling moth
pheromone
dispenser

Mating disruption

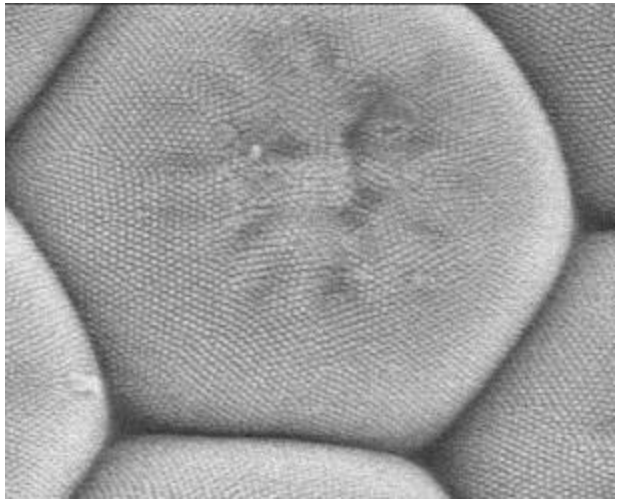
Ocelli

‘simple eyes’
on the head of
many adults & nymphs

Extremely light sensitive
Detect cyclical changes
in day length

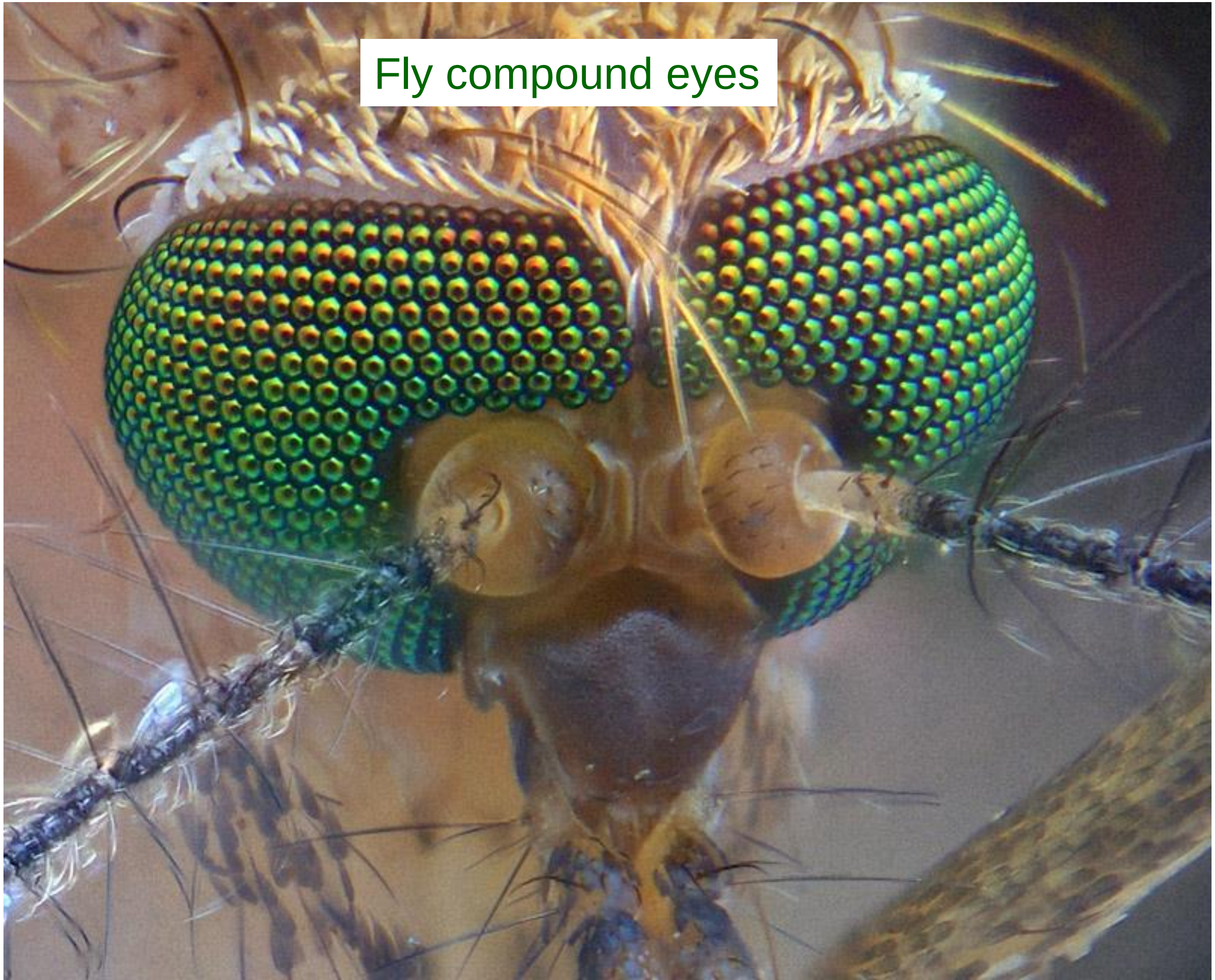
Compound eyes – most adults, nymphs

Compound eye is made up of many individual subunits = an ommatidium

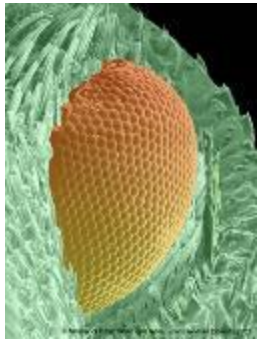


Number varies by insect
- some ants = 1 ....dragonfly = 10,000

Fly compound eyes

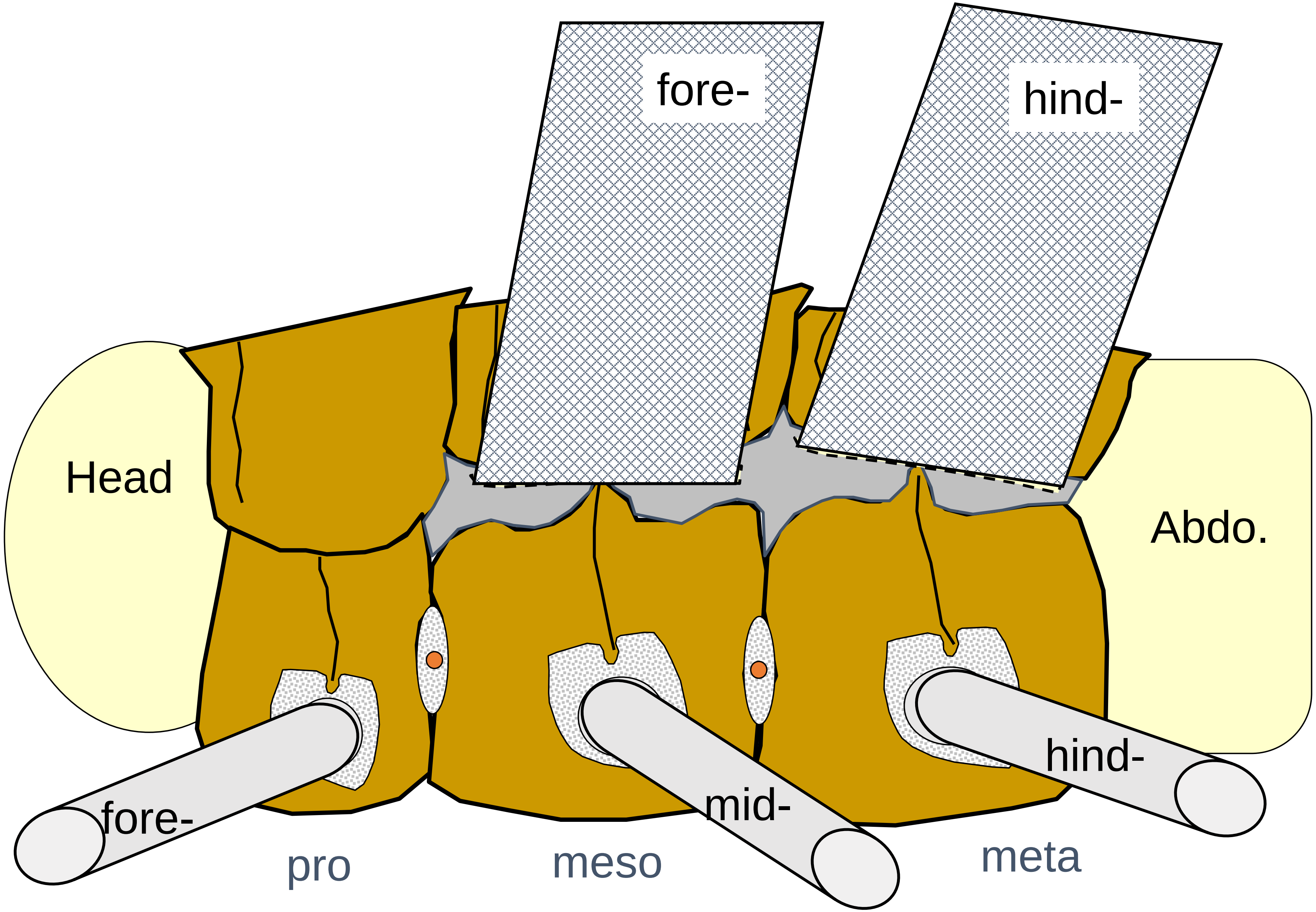


insect eye
vs.
human eye:

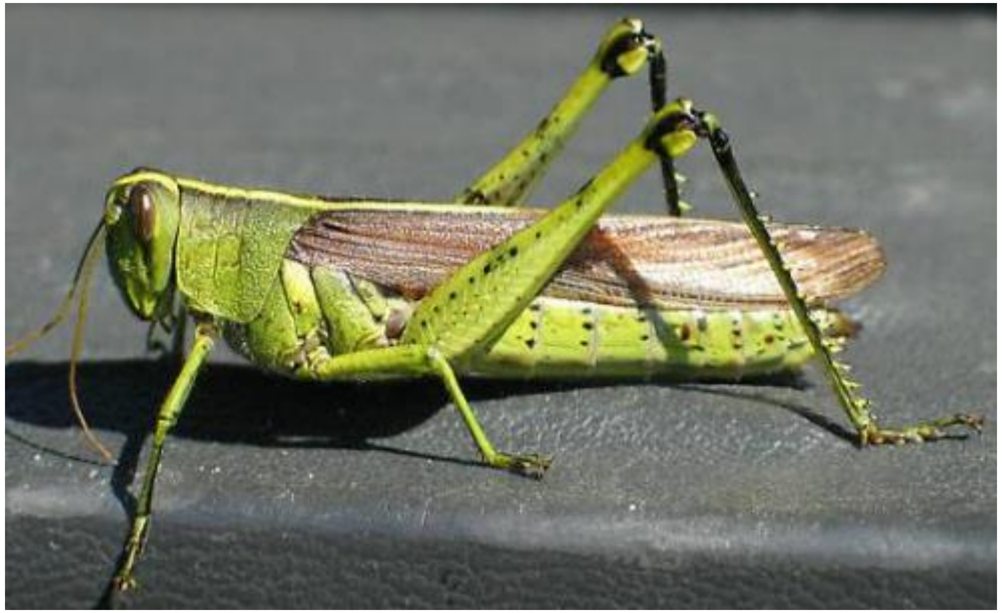


Resolving power	Reduced - (fuzzier image)	+
Detecting pattern, shape, contrast	+	+
Detecting movement	++	+
Binocular Vision	+	+
Color vision	most	+
UV vision	many	-
Detect polarized light	some	-

The Thorax = Movement



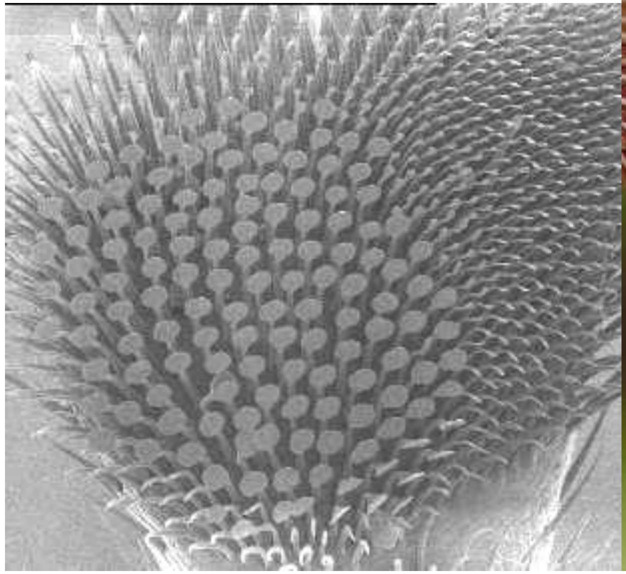
Running legs
Jumping legs

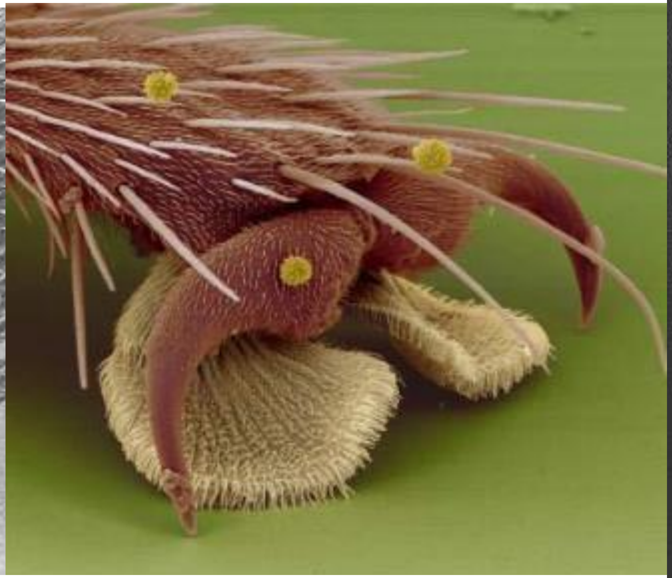


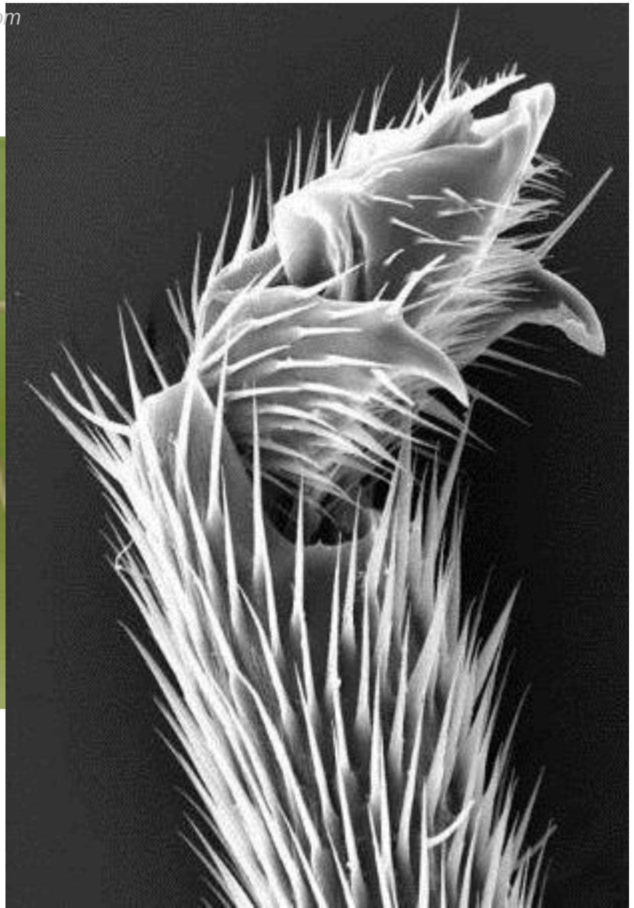
Fossorial legs

Raptorial legs

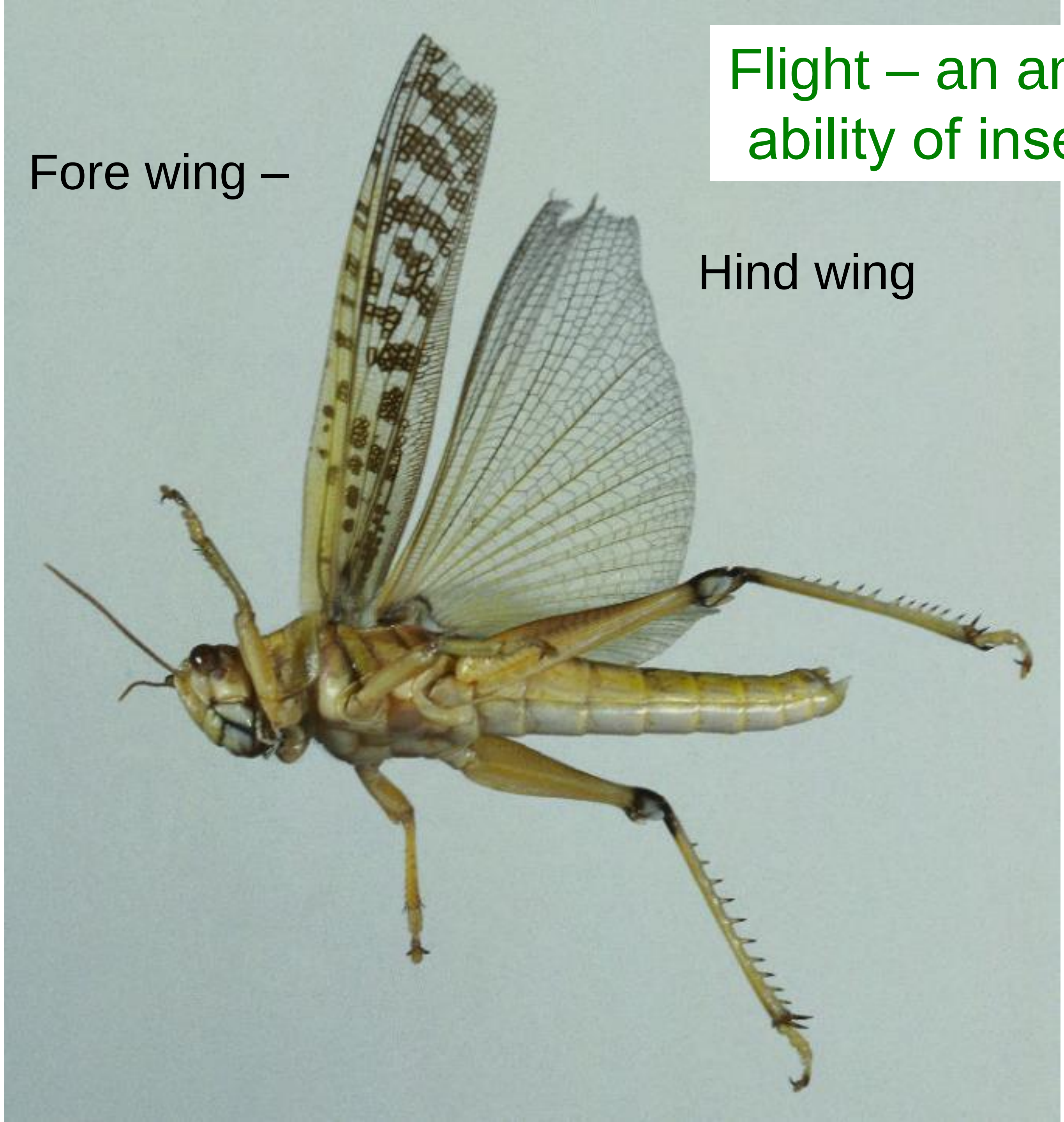
hooks, claws, and pads on the tarsi allow insects to go places that other animals cannot





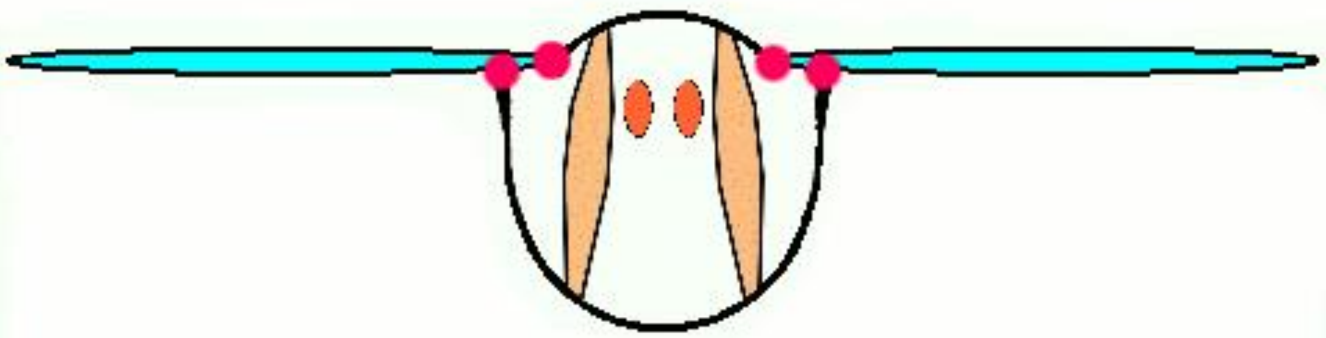


Flight – an amazing ability of insects…



wing fossil
~300 million yrs old

Insects were the only animals to fly for 180 million yrs



Numerous wing types – only ADULTS have wings

Hemelytra forewing of true bugs (Hemiptera)

Elytra forewing of beetles (Coleoptera)

Scale covered wings
of moths, butterflies
(Lepidoptera)

Flies (Diptera)
Only have two wings
HW modified into a
'haltere'

What if wings are missing?

Juvenile insect
(hemimetabolous)
= nymph with wing pads

What if wings are missing?

Wingless adult

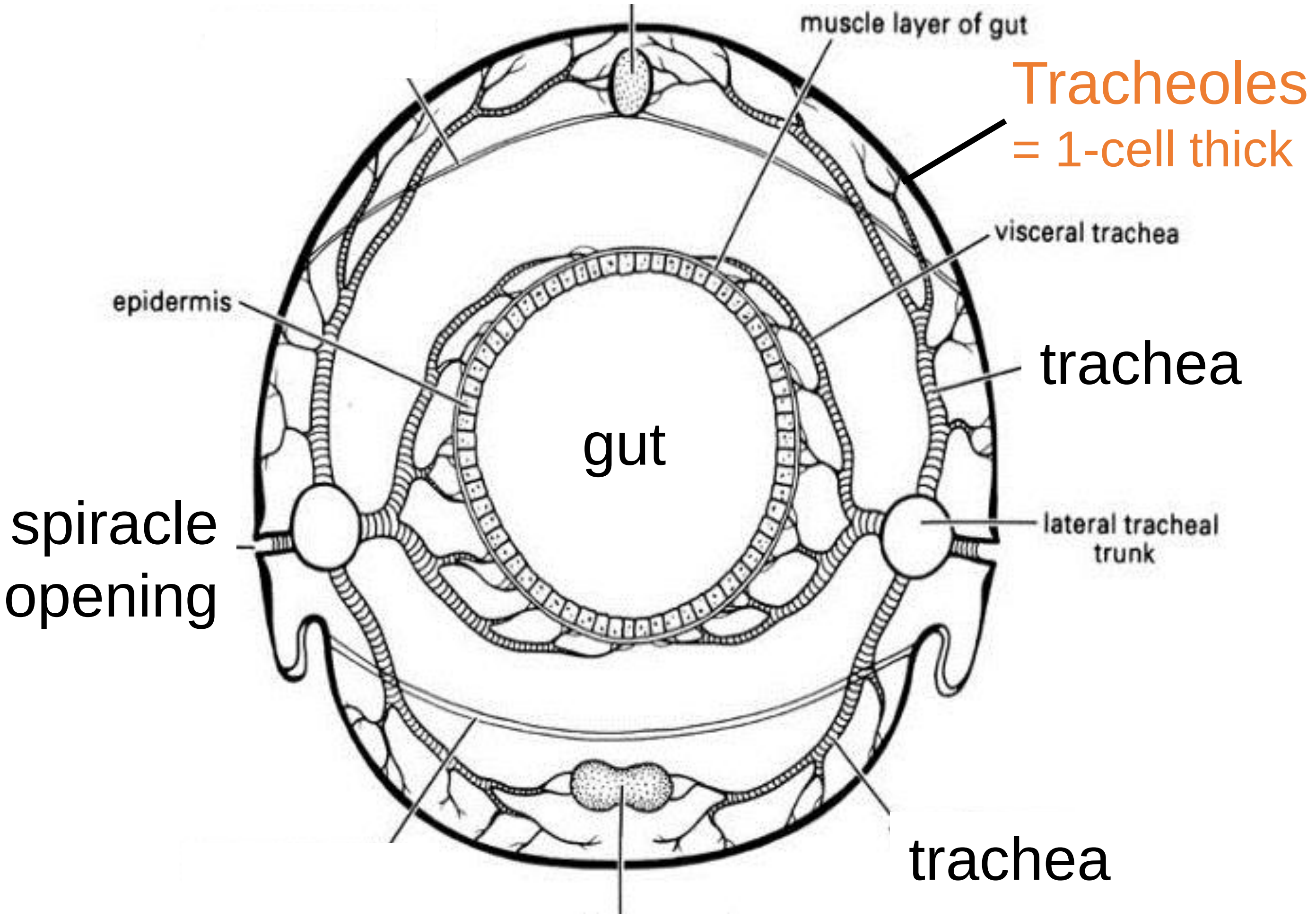
Members of entire orders or families are wingless

In other groups, wingless individuals appear at certain times or in certain castes

Spiracles - openings into the tracheal system
 (delivers oxygen to cells)
- can be closed for long periods

Tracheal System

- tubes (tracheae) branch from opening, getting smaller & smaller
- the smallest tubes = tracheoles, deliver O_2 to individual cells

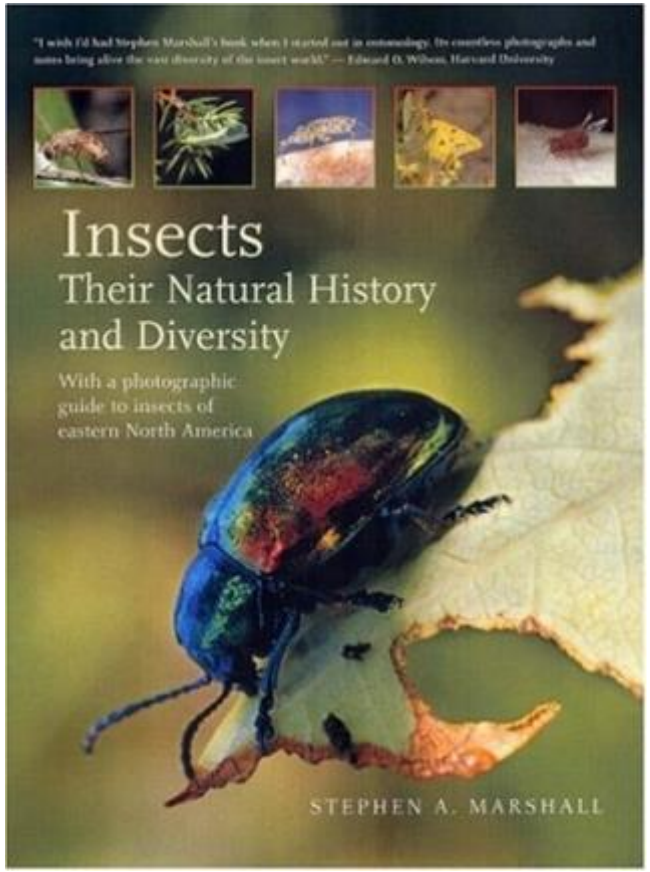


Limitations in moving oxygen partially explain why there are no giant insects (except in movies)

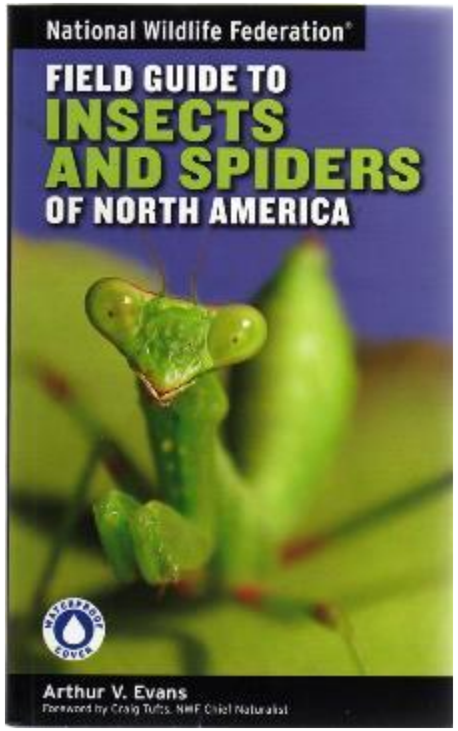
Final thought- just because insects are small...

...that does not make them primitive or simple

Good books, sites for more info



S. Marshall
(shop for reduced cost on Amazon + free shipping. Its heavy)



Evans field guide
(may fall apart)

BugGuide web site
Useful for ID

Sweep nets, traps
Great Lakes IPM
Vestaburg, MI
1-800-235-0285