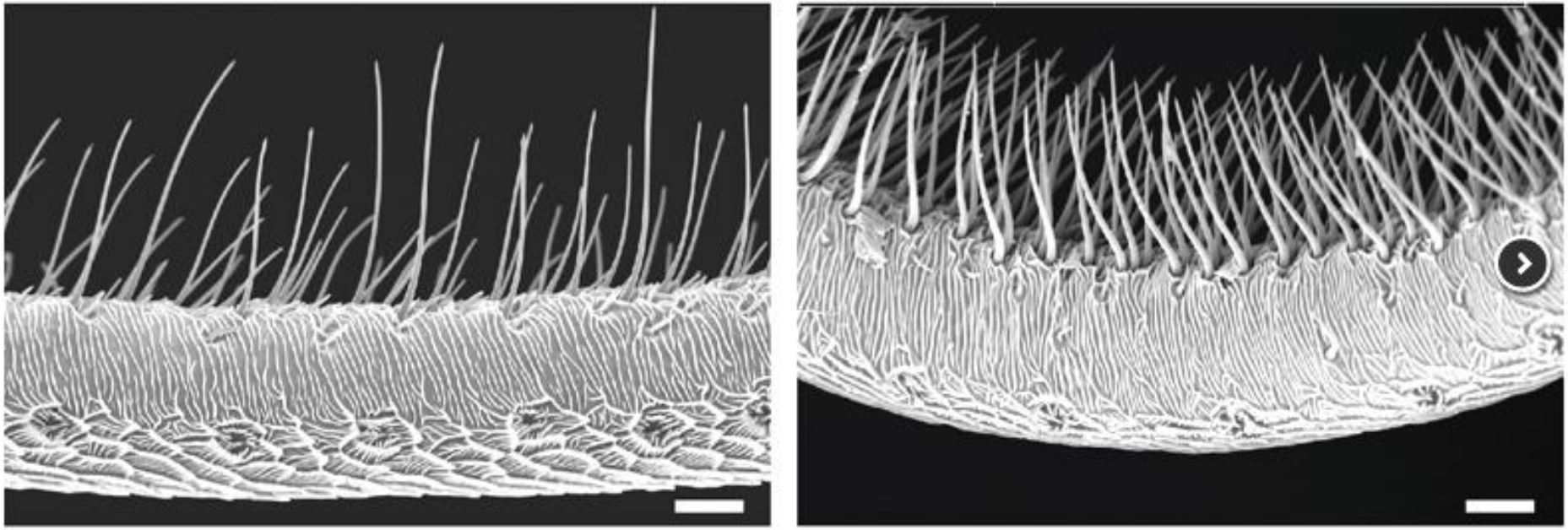
Silkworm *(Bombyx mori)*

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Family	Bombycidae
Genus	Bombyx

Bombyx mori (left) and Bombyx mandarina (right) females. The domesticated moth has lost its camouflage colouration as well as its ability to fly.

Bombyx mandarina x Bombyx mori



In the domesticated species the number of sensilla is considerably reduced (left) in comparison to its closely related wild ancestor (right).

Hemimetabolous (INCOMPLETE METAMORPHOSIS)
= **Egg » Nymph » Adult** (3 stages)

They have no pupa, and because their wings develop in small buds on the outside of their bodies we know they are hemimetabolous. Some good common examples are Damsel , Dragon flies, Mayflies, Stoneflies, Cockroaches, Grasshoppers, Crickets, Stick Insects and True Bugs (Shield bugs, Squash bugs, Stink bugs etc.)

Holometabolous (COMPLETE METAMORPHOSIS)
= **Egg » Larva » Pupa » Adult** (4 stages)

Do have a pupa and their wings develop inside their bodies and are therefore not seen at all until the adult insect emerges.Some well known examples are True Flies (Diptera) and their maggots, Butterflies (Lepidoptera) and their caterpillars, Dobsonflies (Neuroptera)and their hellgrammites and Beetles (Coleoptera) and their grubs.

shedding of the old skin is called 'moulting' or 'ecdysis' and all arthropods have do it not just insects, the skin that is left behind is called an 'exuviae'.

The time spent between hatching from the egg and the 1st moult of the skin is called the **'1st instar'** and the time between the 1st moult and the 2nd moult is called the **2nd 'instar' etc.**

You may often read that a particular species of insect has 4 instars, which means that it moults its skin 4 times before it reaches the adult or pupal stage of its life.

Generation time

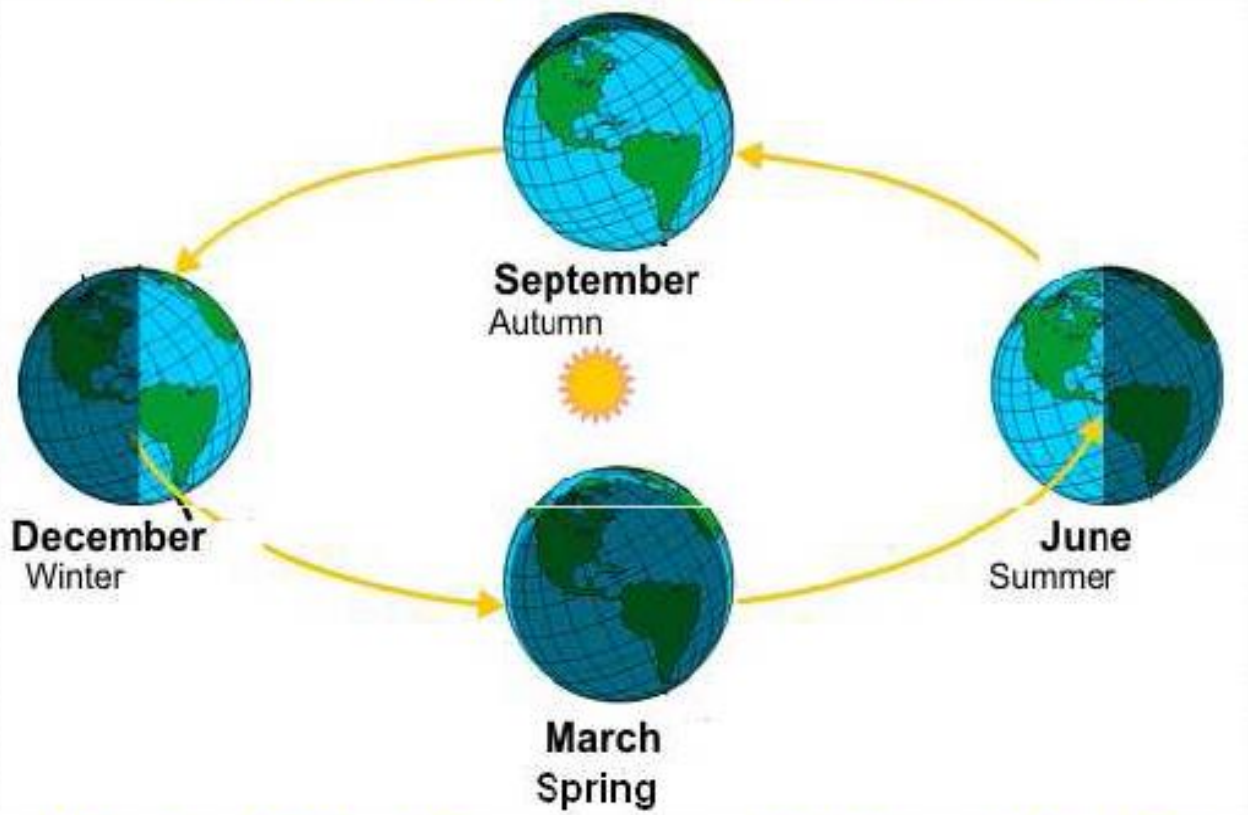
A second way we can describe insect life cycles depends on how long it takes between the egg being laid and the adult insect which started out life as that egg laying some more eggs of her own. This is called generation time, it can range from a little as two weeks in some Drosophila (Fruit flies) to 17 years in some periodical Cicadas and even longer in some dry-wood boring beetles.

The most common lifecyles are, ones which take one year to complete, which we call 'Univoltine', and those where there are two generations per year, which we call 'Bivoltine'. If it takes the insect two years to complete just one generation we call it 'Hemivoltine', and if, like the Drosophila or Aphids, an insect has many generations in one year we call it 'Multivoltine'.

Metamorphosis

When the caterpillar has eaten enough it turns into a pupa, more about this later on because it is different for different groups of Lepidoptera. To do this it stops eating and finds somewhere safe, here it becomes very still (pupa never eat and seldomly move at all) it then moults its skin the same as it does when it is growing only instead of another larval skin it secretes a pupal skin, (inside its old larval skin) that is much thicker and stronger. Generally this pupa then breaks out of the old larval skin, though in many moths the pupa remains inside the old larval skin, you can often find the remains of the caterpillar skin around the tail of a Butterfly pupa.

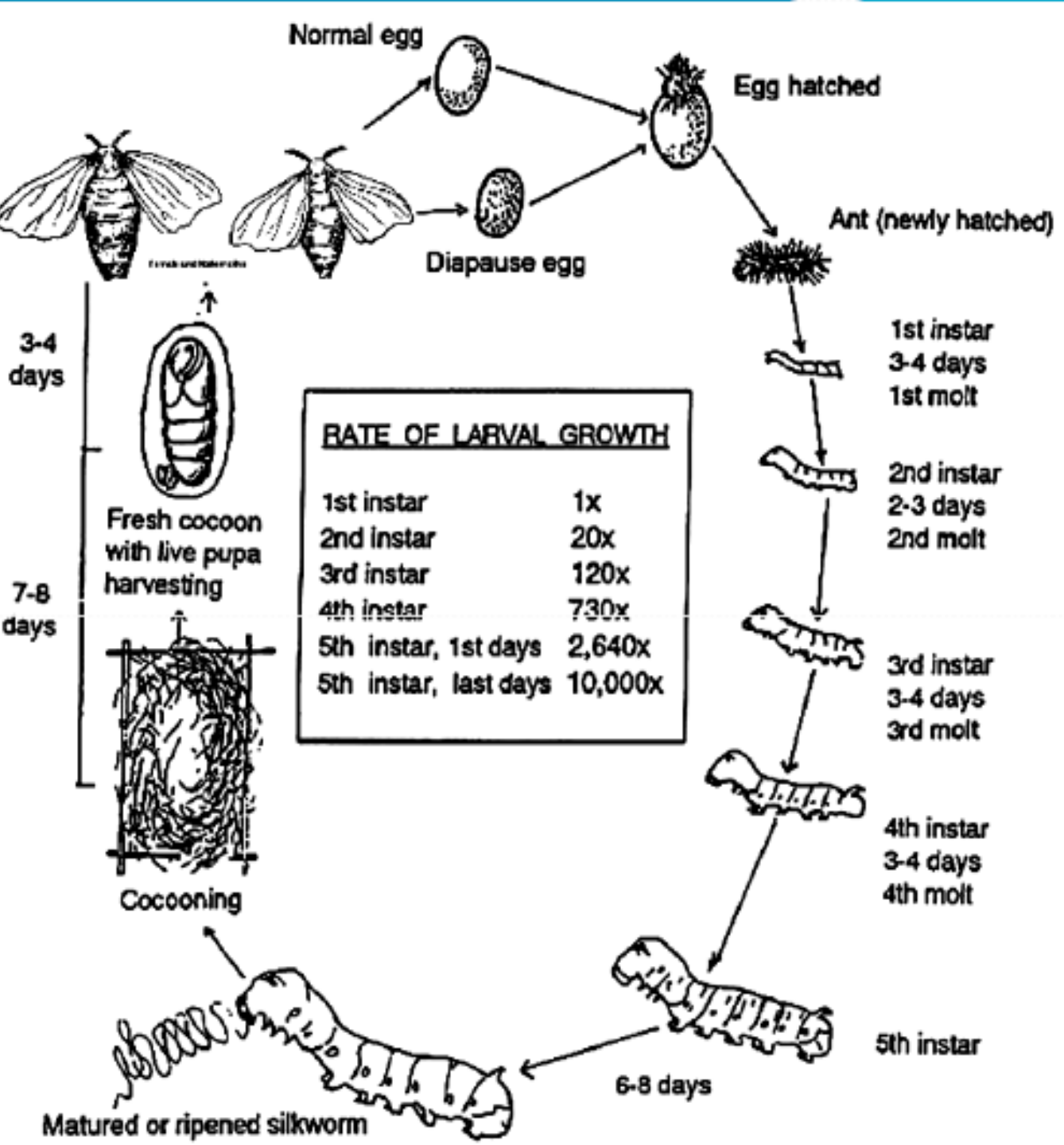
SEASONS OF TEMPERATE ZONE



Natural Uni and Bivoltines are available only in this zone

Univoltines completes their life cycle during spring season (Only ONE)

Bivoltines complete their first life cycle during spring and second life cycle during early summer



MV: Egg-9-12
Larva- 20-24
Pupa- 10-12
Moth- 3-6

BV: Egg-11-14
Larva- 24-28
Pupa- 12-15
Moth- 6-10

Uni - 1 gen/yr
Bi – 2 gen/yr
Mv – 6-8 gen/yr

Larval Stage
Moulting
Mature Worm
Spinning of the cocoon


Bombyx Mori
Female
Exposing its
Scent Glands
(Sacculi
Laterales)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Female silkworm moth emitting pheromone

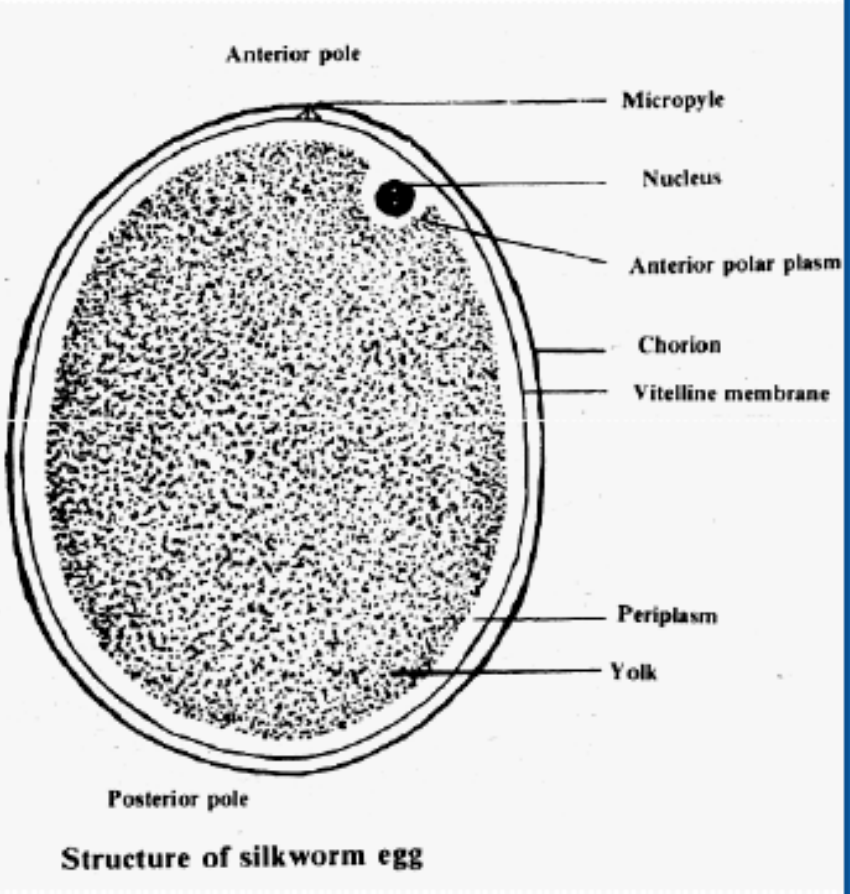
Silkworm *(Bombyx mori)*

Silkworm moth laying eggs

Close up of silkworm moth laying eggs

0.9-1.2 mm

One Laying



Structure of silkworm egg

1-1.3 mm

0.55-0.6mg
Ovaoid/ Spherical
Flat at ventral side
Micropyle
Respiratory channels

Silkworm *(Bombyx mori)*

Silkworm moth larvae hatching

Silkworm larvae hatching

Silkworms At Different Ages

Newly hatched larvae

Enlarged

Second Instar larvae

Third Instar Larvae

Fifth instar Larvae

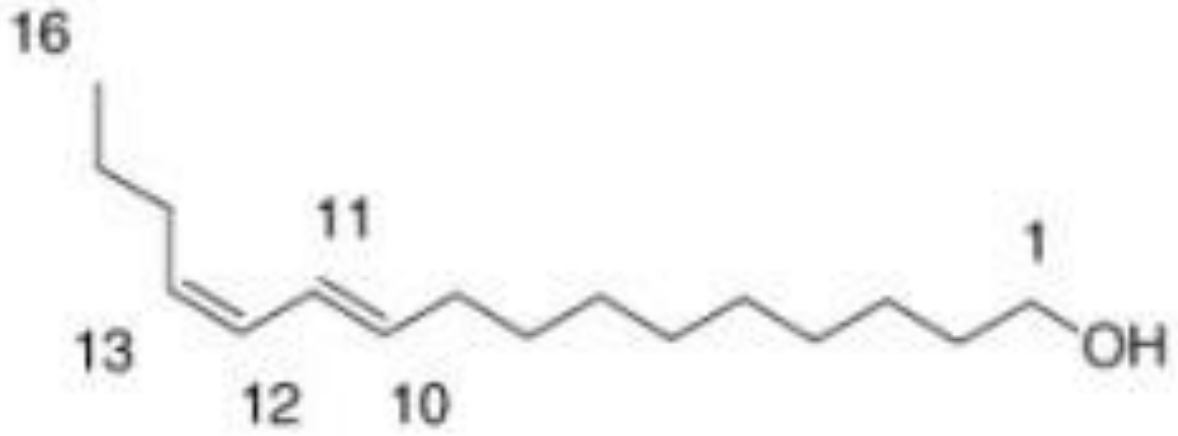
Bombykol
The sex pheromone of the silk moth

Why is it important?

Well, it was the first insect pheromone to be identified nearly 50 years ago, in 1959, by **Adolf Friedrich Johann Butenandt** (1903–1995). He won a Nobel Prize for Chemistry in 1939 at the age of 36, for his work on sex hormones; after that, he turned his attention to insect attractants, successively at the Kaiser–Wilhelm Institute of Biochemistry at Berlin–Dahlem; the University of Tübingen (1945–56), and the University of Munich (1

He was the first person to determine the structure of a pheromone, but the first real indications of the existence of insect pheromones were obtained by Jean-Henri Casimir Fabre (1823-1915), *doyen* of French entomologists.

Insects use volatile organic molecules to communicate messages with remarkable sensitivity and specificity. In one of the most studied systems, female silkworm moths (*Bombyx mori*) attract male mates with the pheromone bombykol, a volatile 16-carbon alcohol. In the male moth's antennae, a pheromone-binding protein conveys bombykol to a membrane-bound receptor on a nerve cell.



Chemistry & Biology

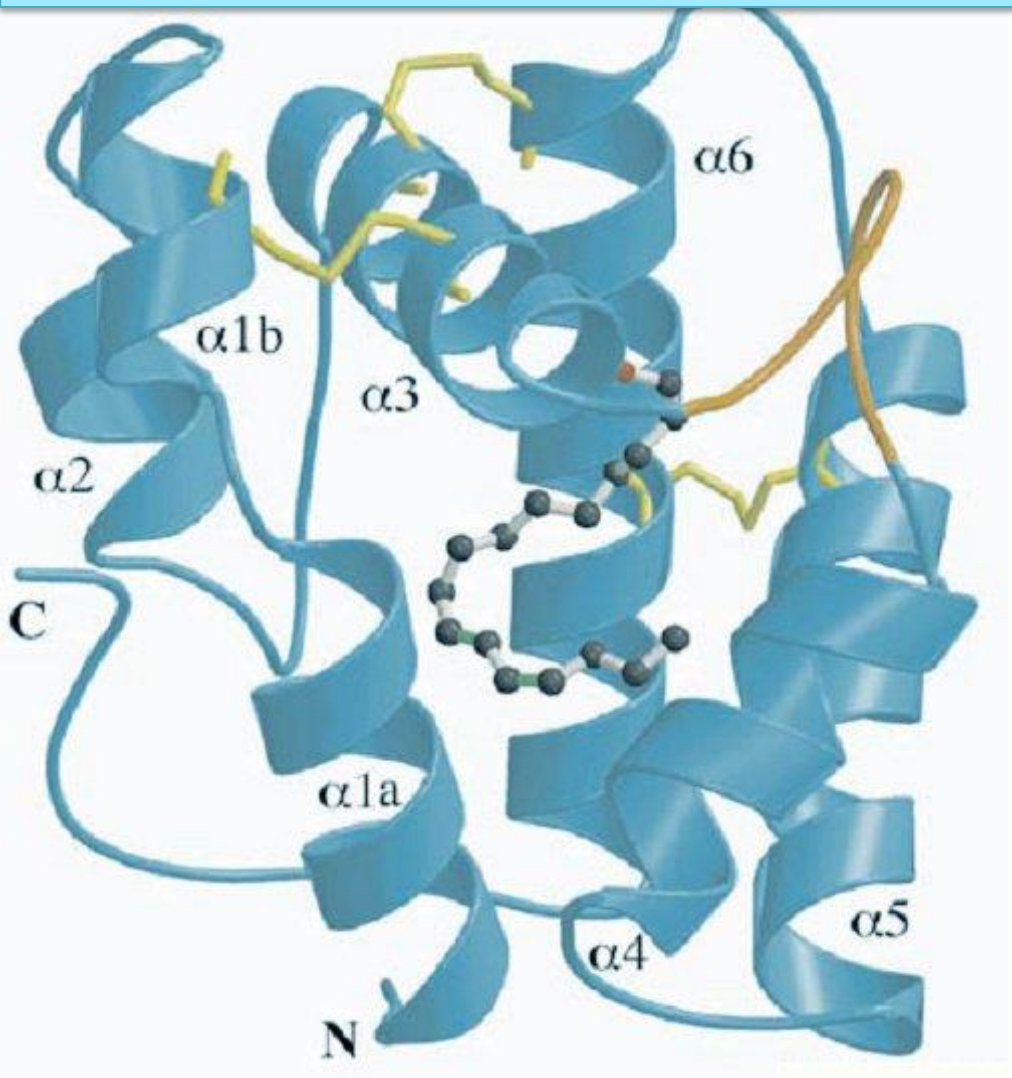
And detecting the pheromone?

Bombykol molecules diffuse through open pores in the hairs on the moth's antennae and reach a receptor protein in the membrane. This produces an electrical change leading to a nerve impulse being sent to the brain.

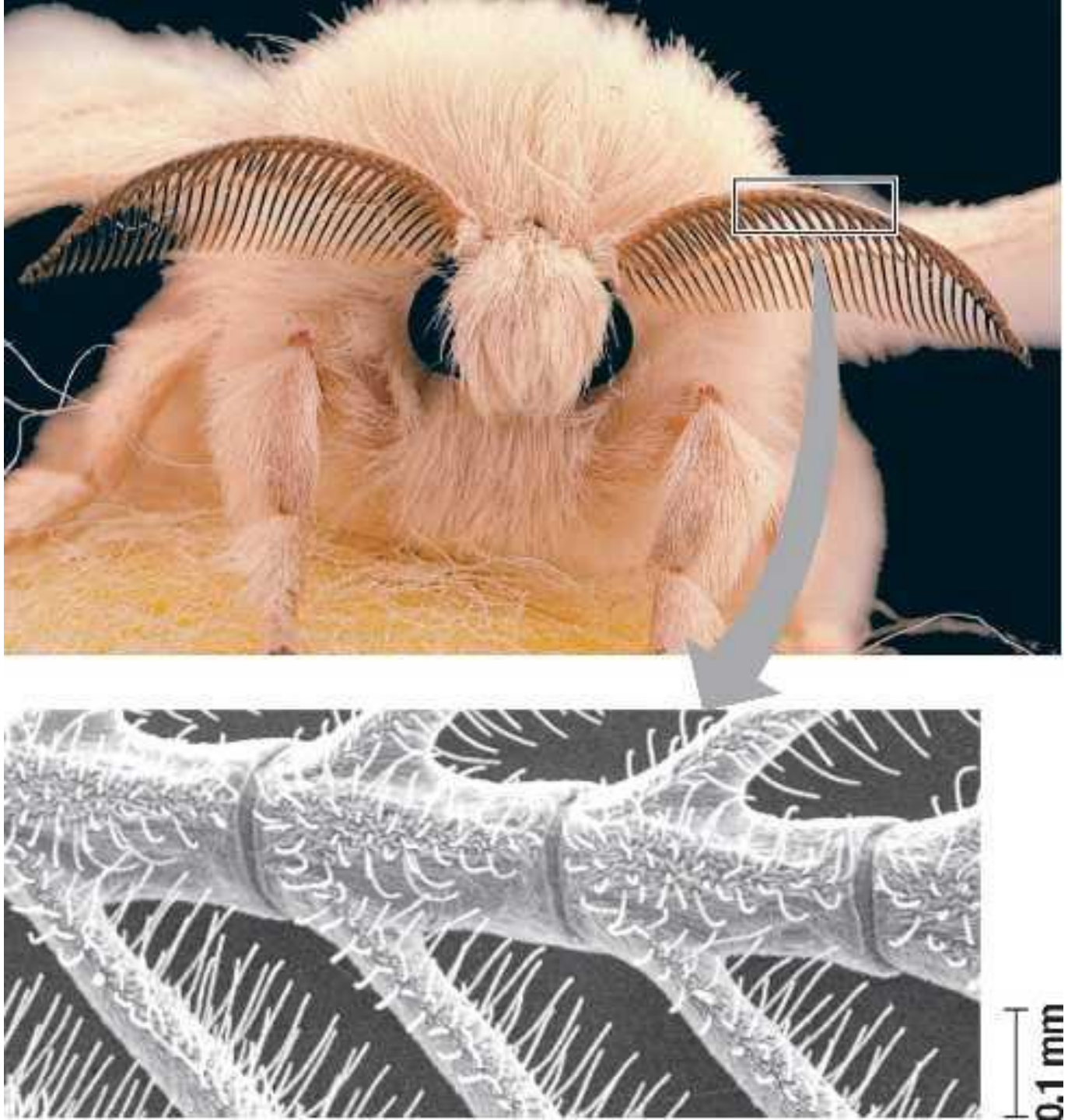
How sensitive is the male to the pheromone?

It's reckoned that it can detect female moths over 10 km away, sensing bombykol at a concentration as low as 1 molecule per 10^{17} air molecules. It detects individual molecules but it is thought that a moth has to detect around 200-300 bombykol molecules in a second to produce a behavioural response.

overall structure of the *B. mori* PBP. Disulfide bridges are shown in yellow, and the loop covering the binding pocket (see text) is in orange. Bombykol is shown in a ball–and–stick representation with double bonds in green.
Reproduced with permission of Professors Jon Clardy and Walter S. Leal from: B.H.Sandler, L.Nikonova, W.S.Leal and J.Clardy, *Chem. Biol.*, **7**, (2000) 143



Pheromone binding protein (PBP) binds the bombykol in a pocket and transports it to the receptor.


0.1 mm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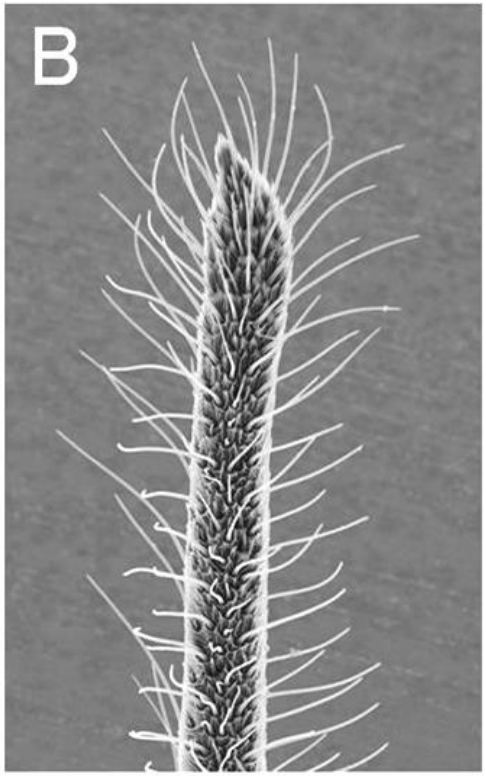
A


B

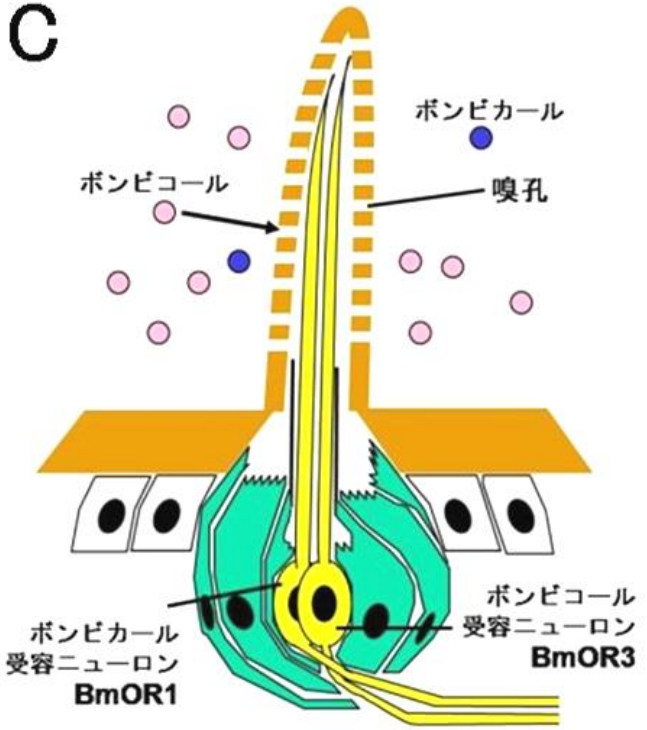

C
ボンビカール
ボンビコール
嗅孔
ボンビコール
受容ニューロン
BmOR3
ボンビカール
受容ニューロン
BmOR1

PLATE I.

FIG. 1.

Bombyx mori, or mulberry feeding silkworm (Male).

FIG. 2.

Bombyx mori (Female).


A6
A7


A6
A7
A8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Bombyx mori *male*
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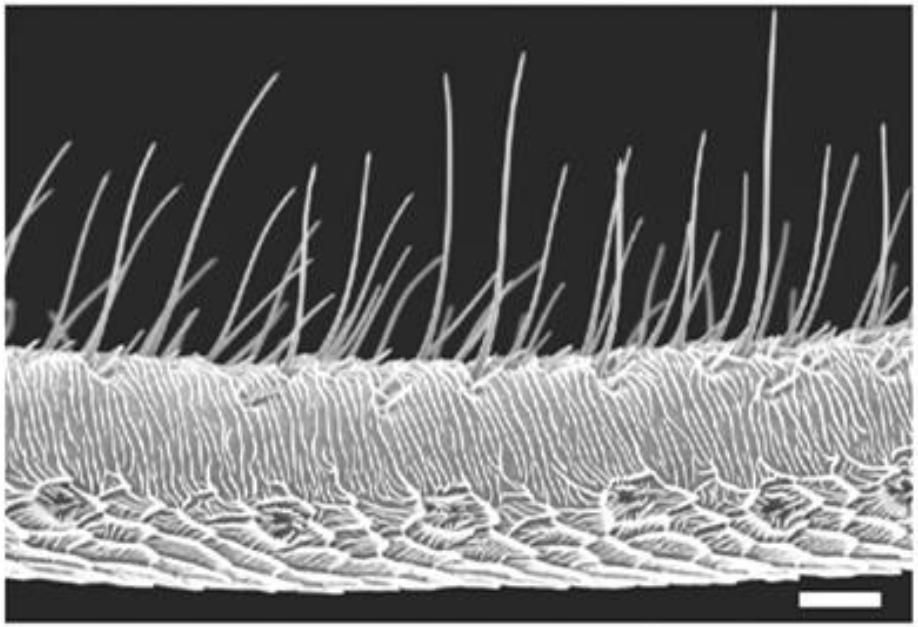
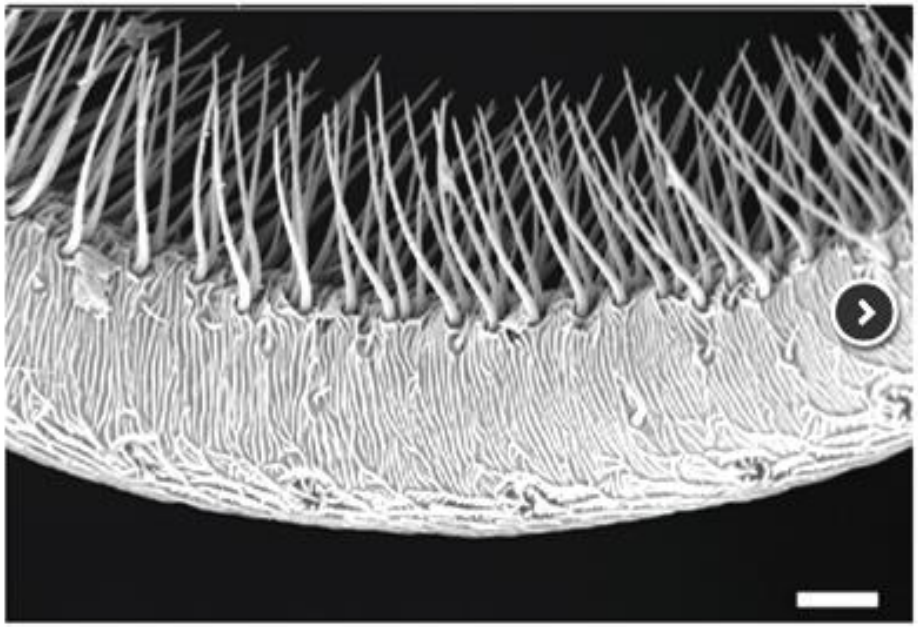
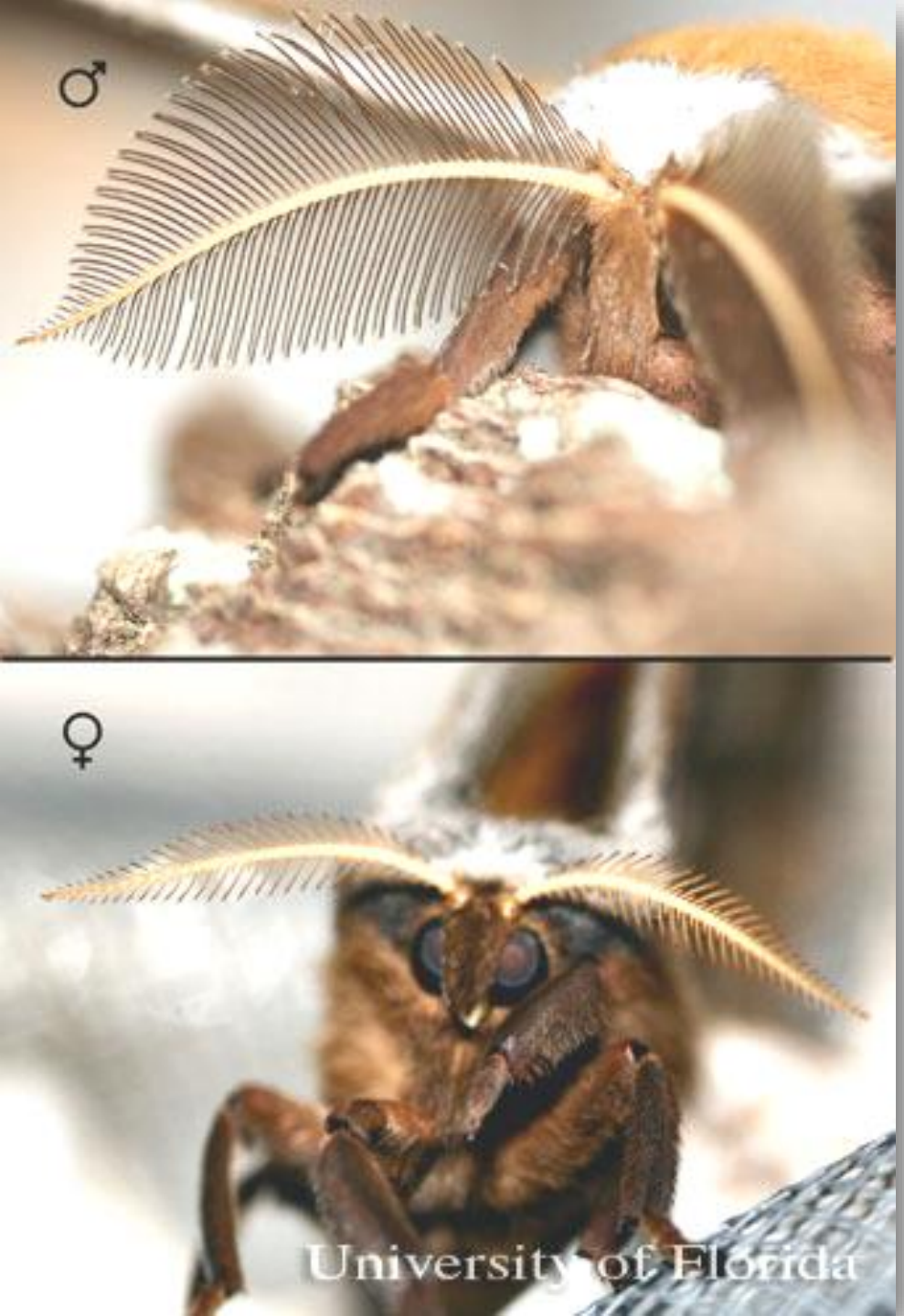


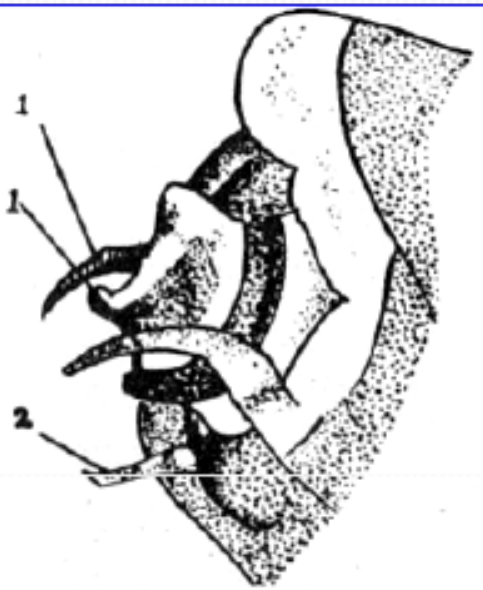




Polyphemus antennae are quadripectinate (comb-like on four sides) with those of males being larger than those of females.

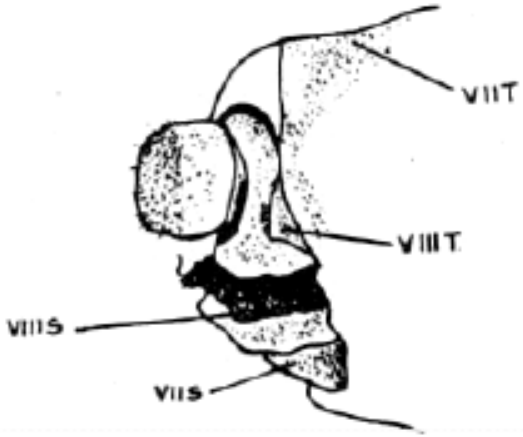
Male and female polyphemus moth, *Antheraea polyphemus* (Cramer) antennae.

Sexing at Moth stage



1) CIASPERS (HARPES or HOOKS)
2) AEDEAGUS

Abdominal end of male moth

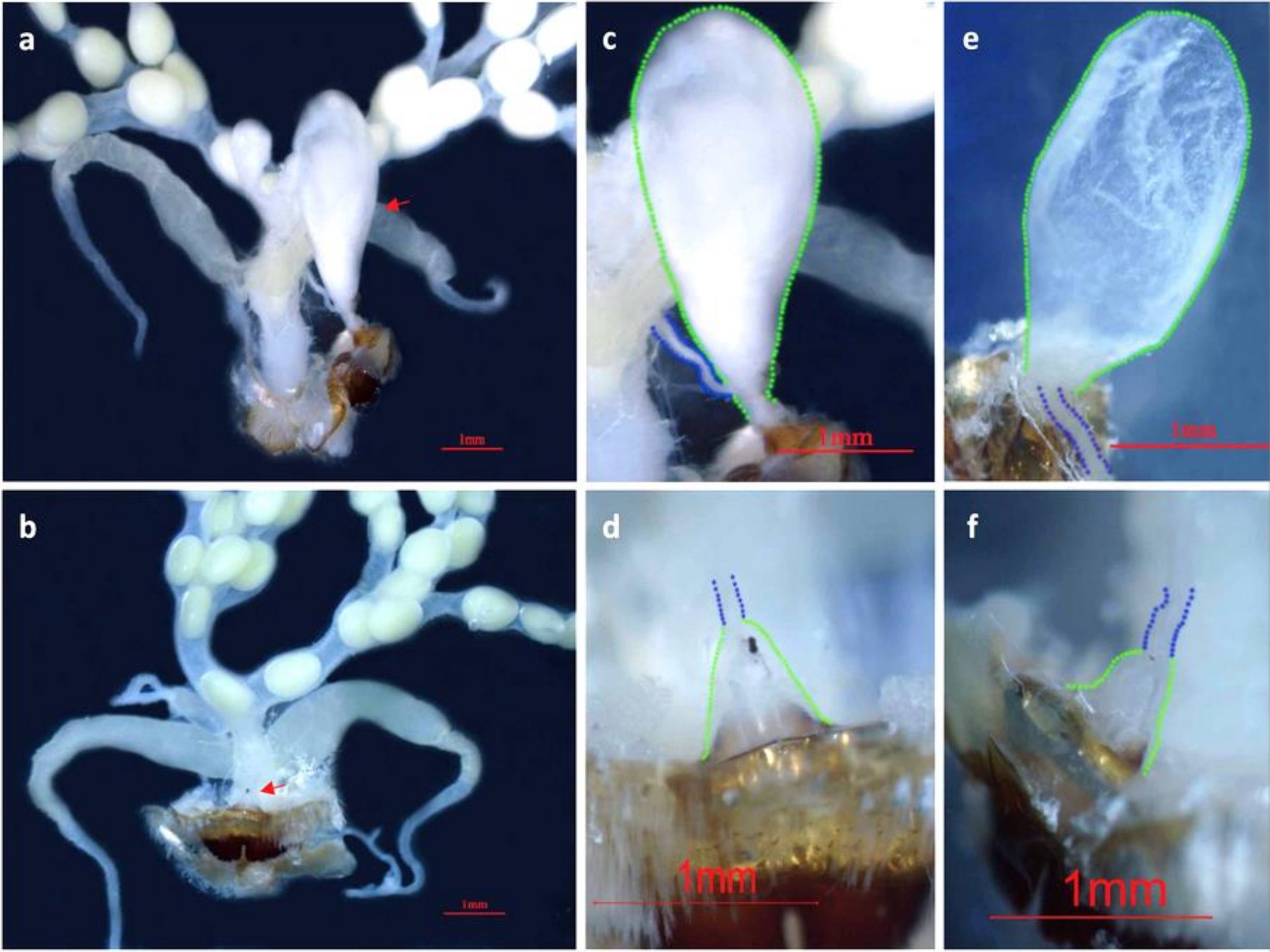


(lateral view)

VII T & VIII T-7 & 8 Abdominal tergite

VII & VIII S — 7 & 8 Abdominal sternites

Abdominal end of female moth


a
1mm
c
1mm
e
1mm
b
1mm
d
1mm
f
1mm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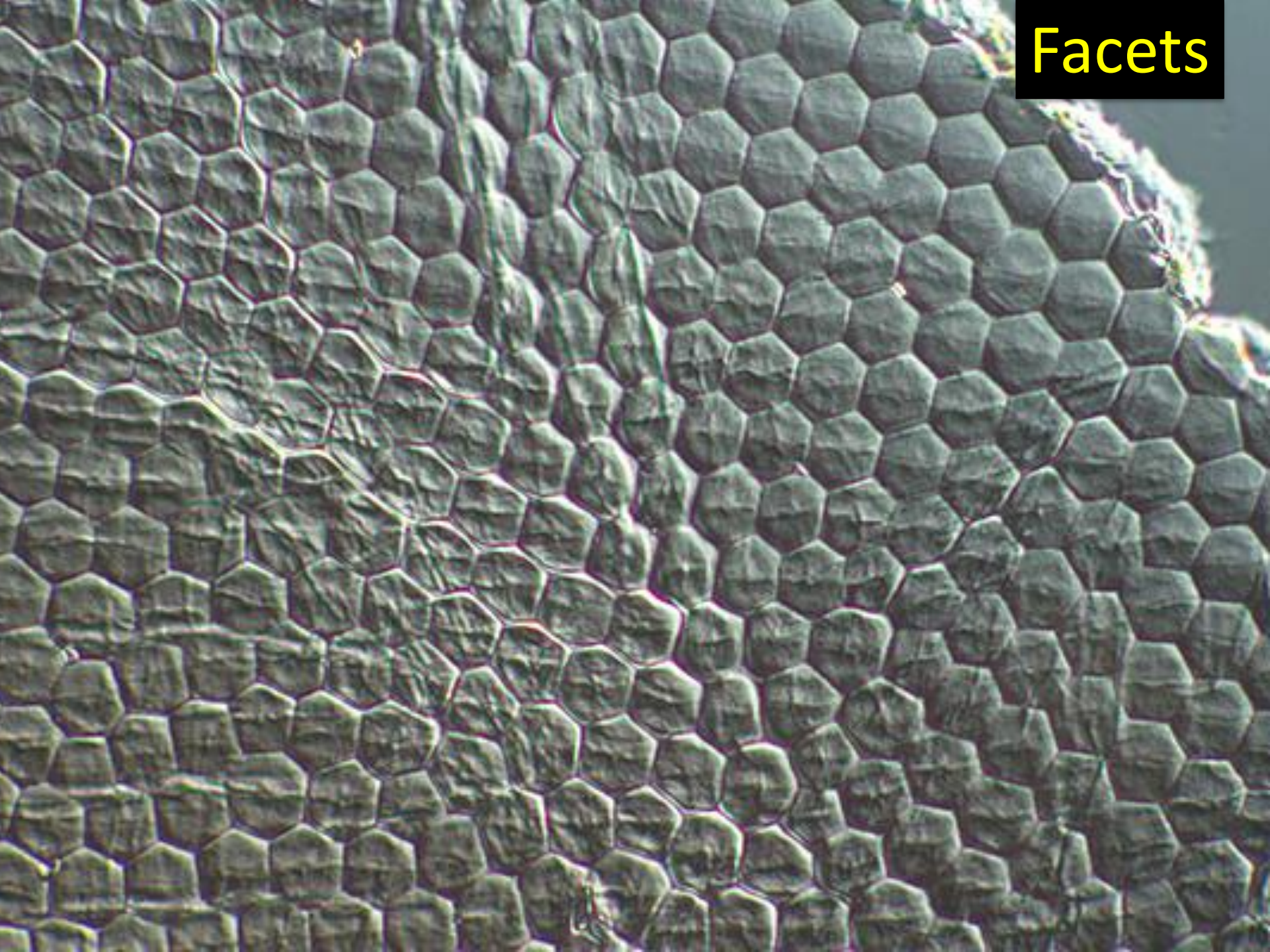
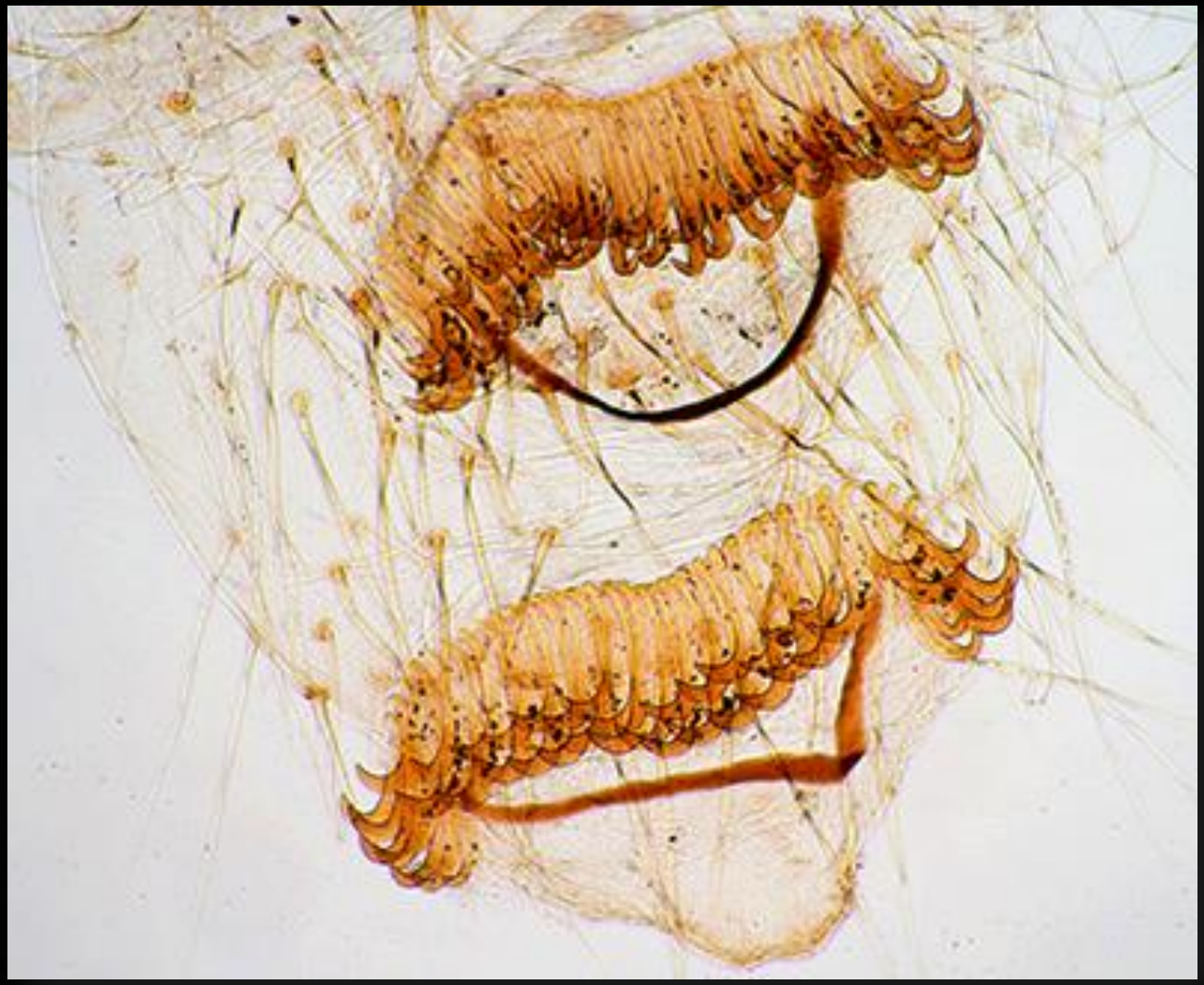

Facets

There are three pairs of thoracic legs, five pairs of abdominal legs 'prolegs' and tracheal structures leading to nine pairs of spiracles are clearly seen.

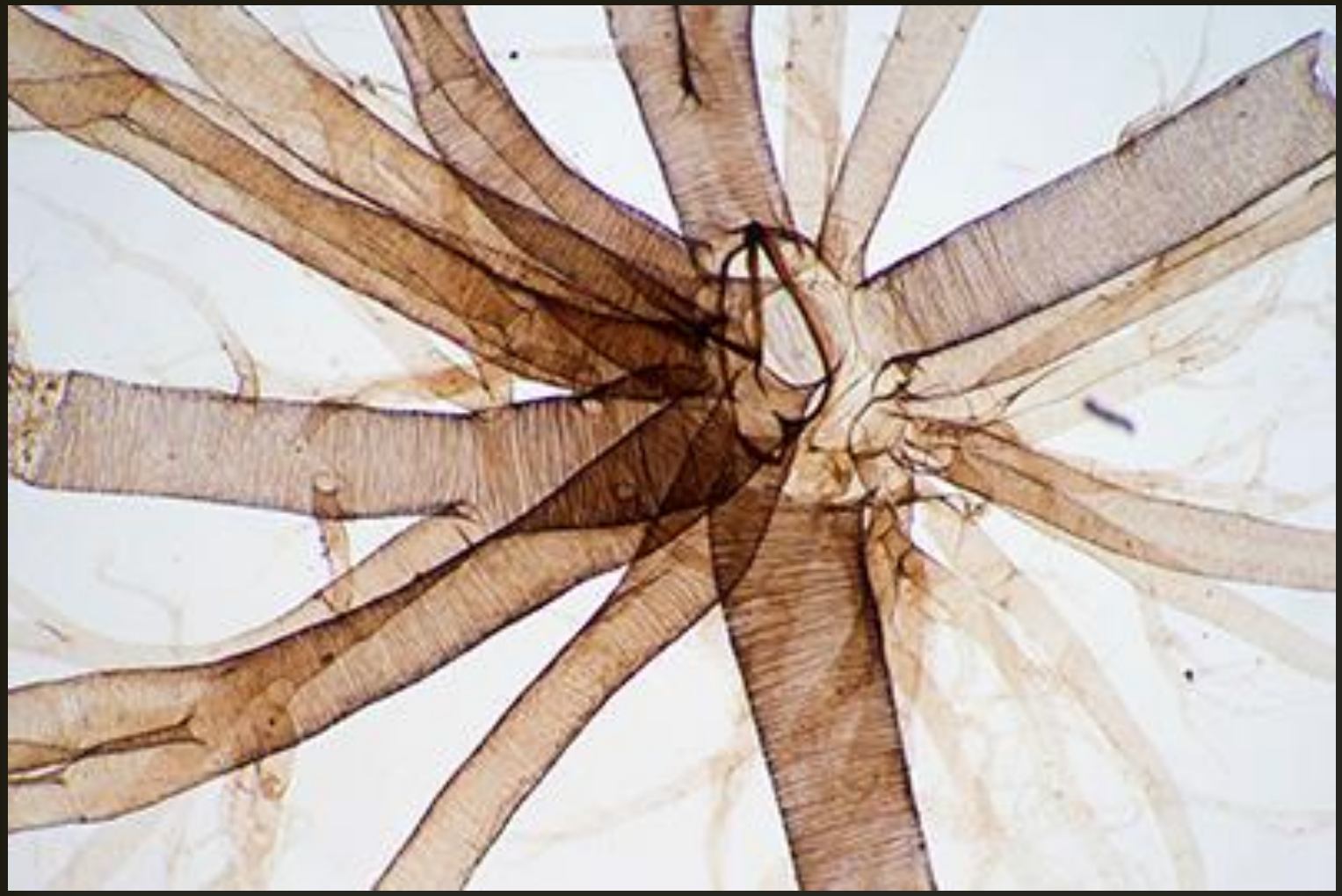
One of the three pairs of thoracic legs of the larva.



One of the five pairs of fleshy abdominal legs or prolegs, lost in the adult.

A female silk moth *Bombyx mori* double claws on the legs are seen

A pair of spiracles and part of the complex tracheal network.

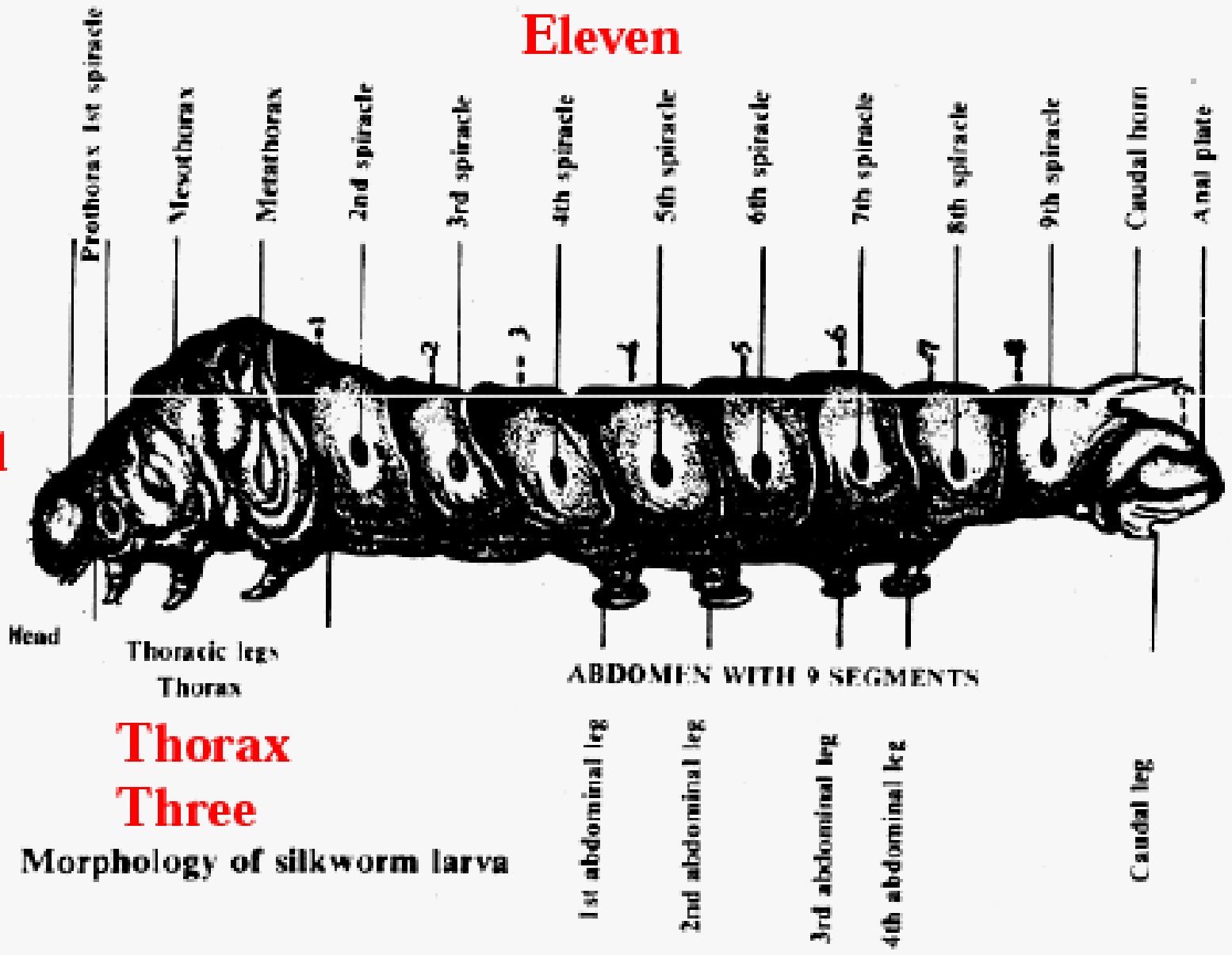


A neat arrangement of part of the trachea on the second papered slide. The spiral thickening of the tubes can be seen.

False colour SEM image of the head of a silkworm larva which beautifully shows the mandibles, lateral ocelli, spinneret and the thoracic legs.

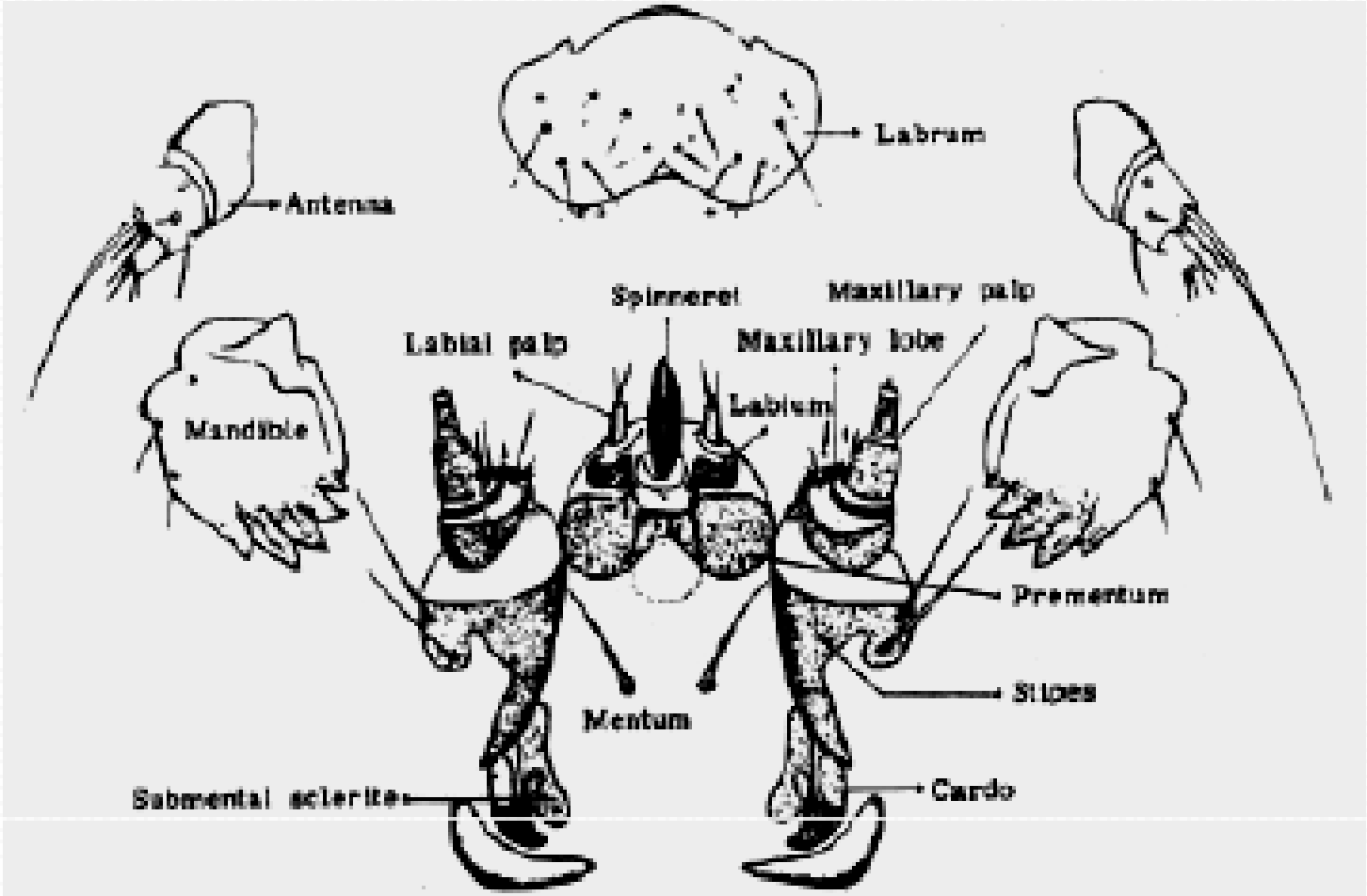
Abdomen
Eleven

Head
Six



Thorax
Three

Morphology of silkworm larva

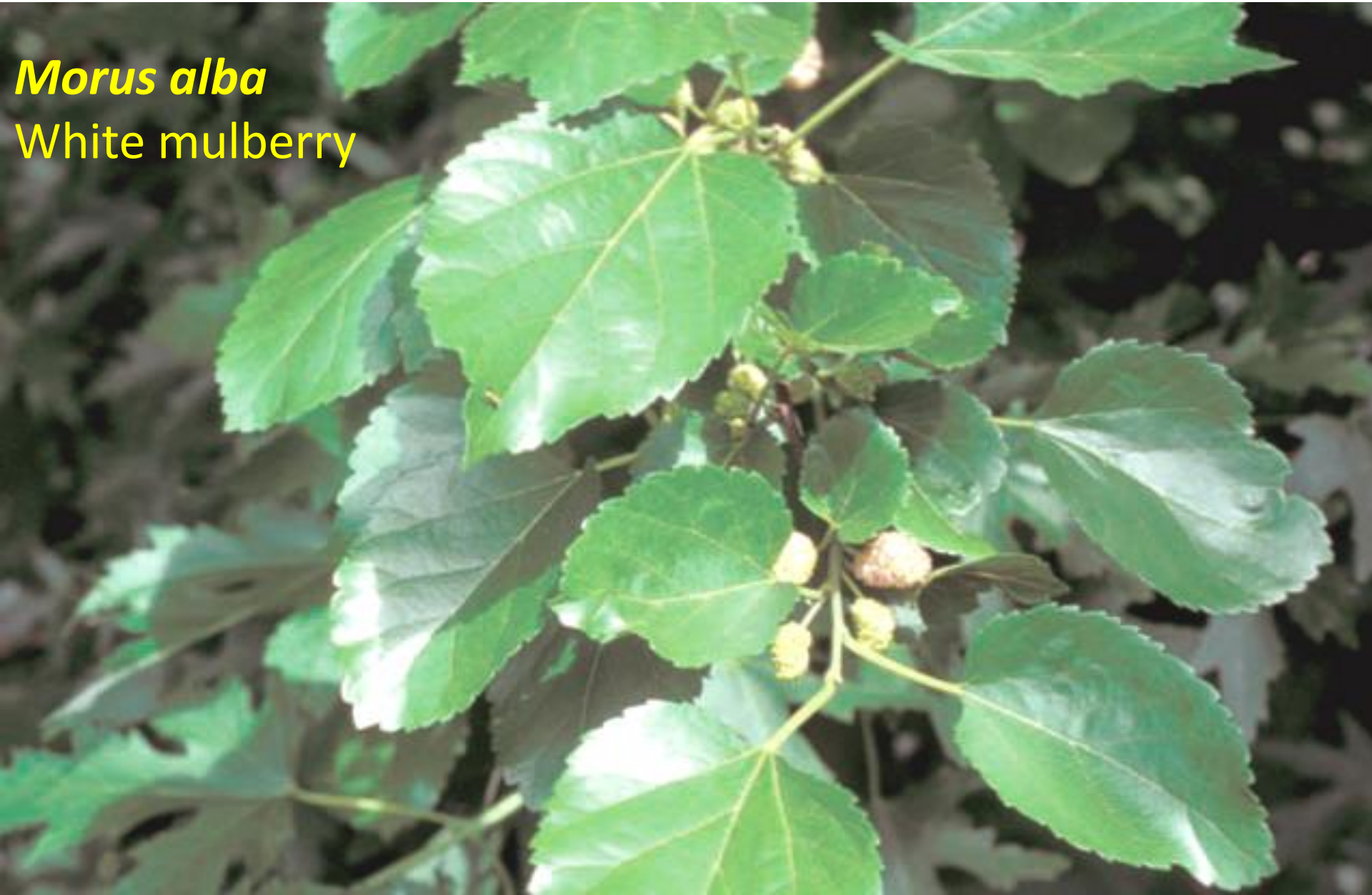


Mouth parts of silkworm larva

Silkworm *(Bombyx mori)*

Silkworm feeding on mulberry leaf

Morus alba leaves and immature fruit.



Introduction

The genus *Morus* contains approximately 16 members, occurring primarily in northern temperate regions with some extending into tropical areas of Africa and the South American Andes. There are 11 species distributed widely in China

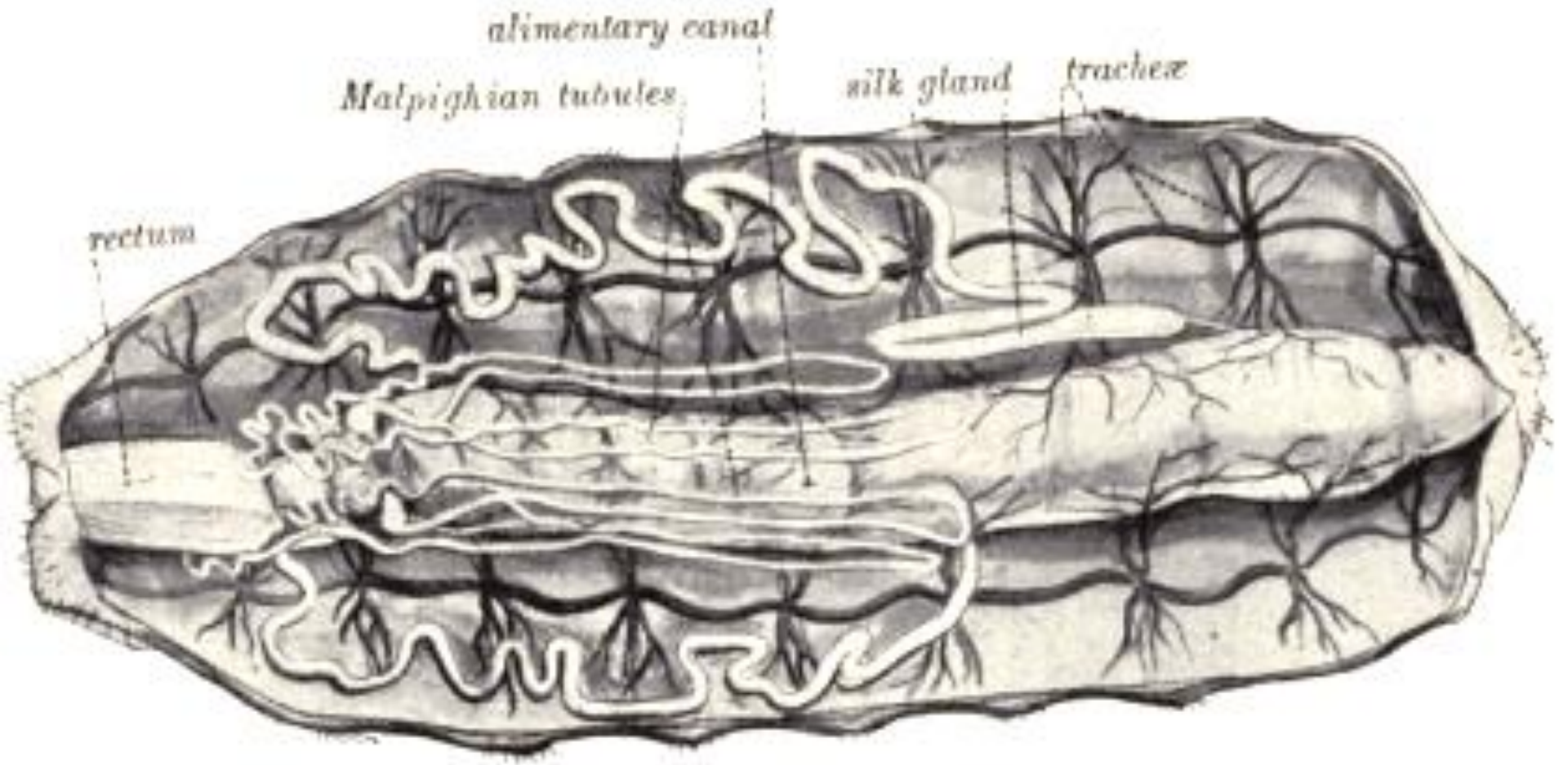
Species of *Morus* in China

Scientific Name	Scientific Name
M. alba L.	*M. nigra* L.
M. australis Poir.	*M. notabilis* Schneid.
M. cathayana Hemsl.	*M. serrata* Roxb.
M. liboensis S. S. Chang	*M. trilobata* (S. S. Chang) Cao
M. macroura Miq.	*M. wittiorum* Hand.-Mazz.
M. mongolica (Bur.) Schneid.	

Silkworm *(Bombyx mori)*

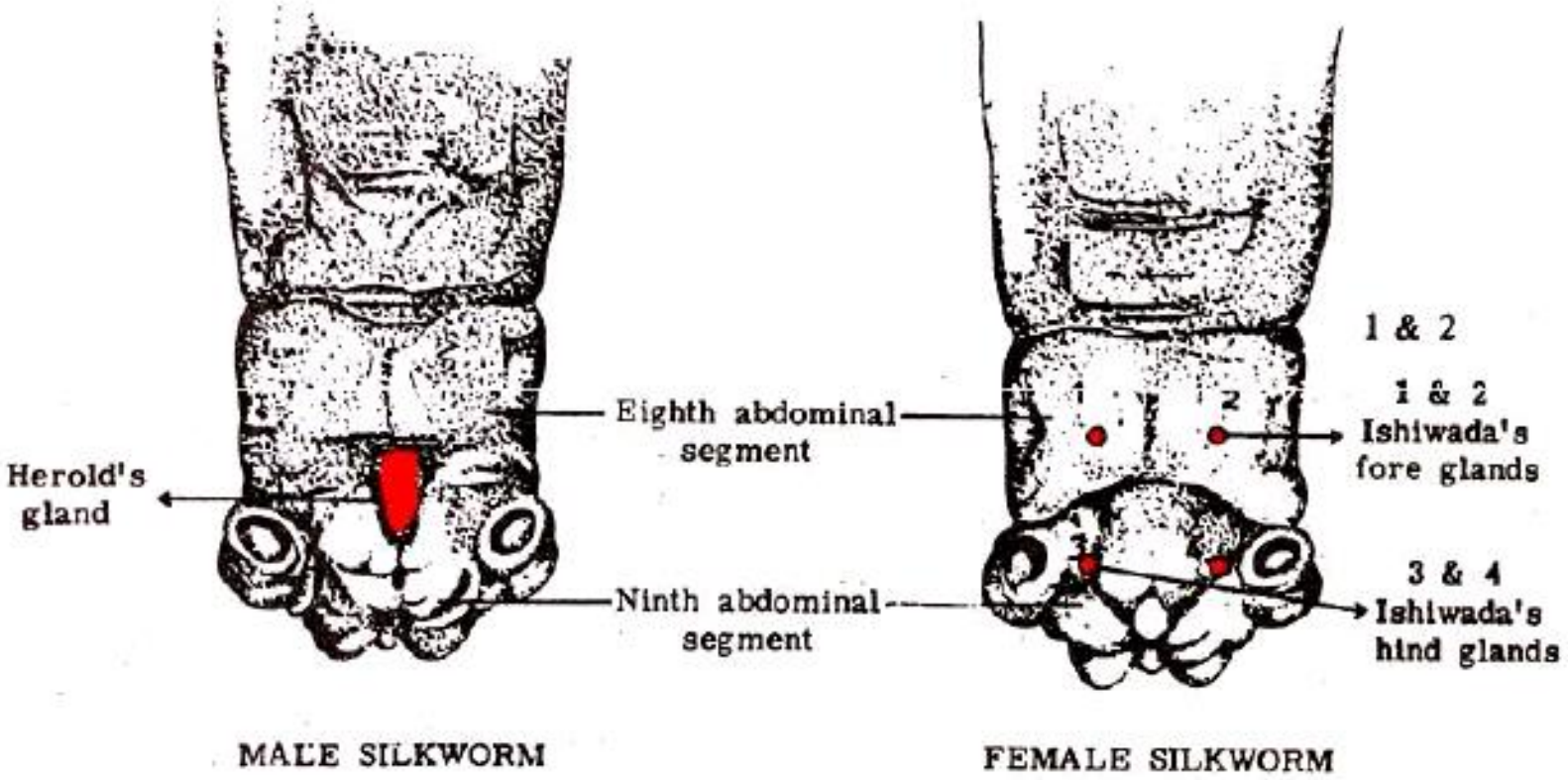
Close up of silkworm feeding

Silkworms feeding on mulberry


alimentary canal
Malpighian tubules
silk gland
tracheæ
rectum

Rearing silkworms on mulberry leaves

Sexual Marking at larval stage (For identification)



Sex separation in silkworm, *Bombyx mori* L refers to isolation of male and female individuals.

Sex discrimination based on sexual markings : Sex separation can be practiced in the normal silkworm strains in the larval, pupal and moth stages based on the imaginal buds for sexual organs (larva and pupa) or morphological and behavioural differences (moth stage).

Larval stage :

•A single imaginal bud “Herold’s gland” is located on the ventral median line between the 8th and 9th abdominal segments of the male

.

•Two pairs of small spots “Ishiwata’s fore and hind glands” are located ventrally, respectively on the 8th and 9th abdominal segments of the female.

Pupa stage :

•Males are smaller in size whereas females are plumpier.
•Males have a small brown, glossy spot just below the 8th abdominal segment.
•In females, there is a division of the segment which is represented by a dark line or ‘X’ marking between 8th and 9th abdominal segments.

Silkworm spinning silk

Silkworm spinning cocoon

Silkworm inside cocoon

Silkworm and cocoon on mulberry leaf


ARKive
www.arkive.org
Silkworm cocoon within leaf
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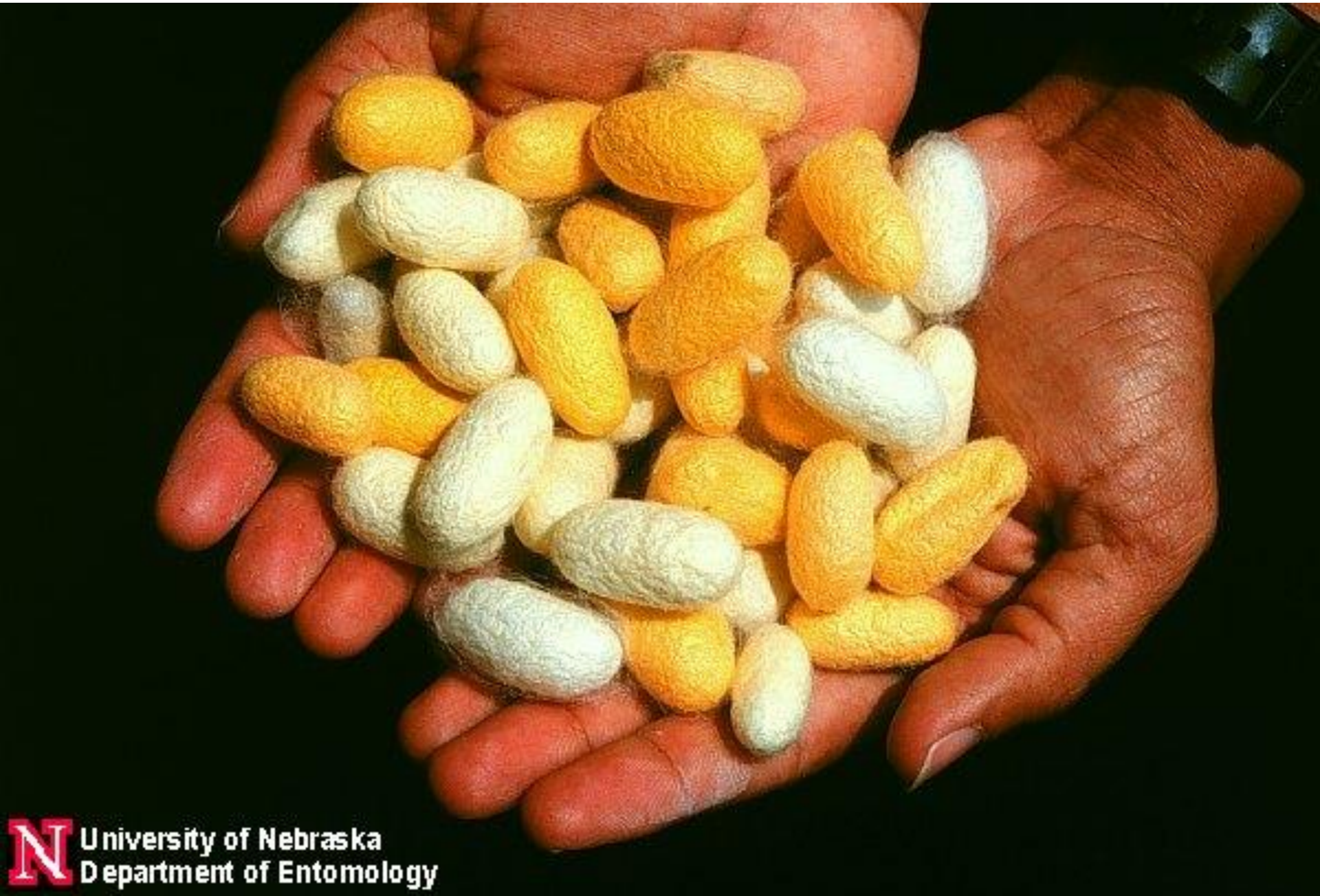
Silkworm cocoons


University of Nebraska
Department of Entomology

Cross section of silkworm in cocoon prior to pupation

Silkworm pupating

Silkworm pupation in advance stages

Final stage of silkworm pupation

Silkworm pupa

Silkworm pupae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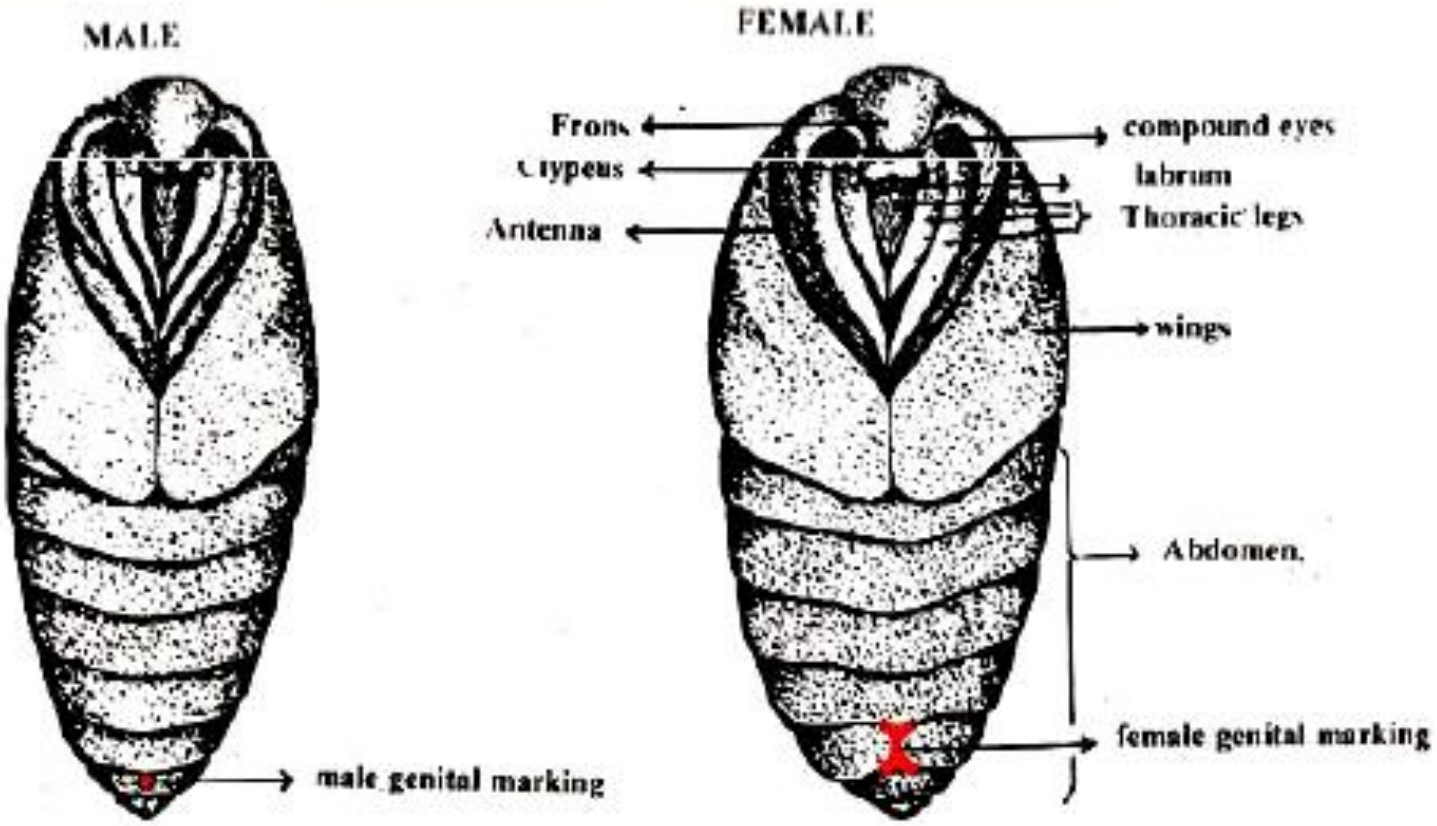

male and female pupa – *Bombyx mori* **Sexual Marking at Pupal stage**

Silkworm Moth Emerging from Cocoon


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Silkworm moths emerging from cocoons
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