

Life Cycle of *Bombyx mori*

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SILKWORM

- ▶ Larva or caterpillar or imago of the domestic silkmoth

Bombyx mori (Latin: "silkworm of the mulberry tree")

- ▶ It is an economically important insect (**primary producer of silk**)
- ▶ Preferred food ➡ white mulberry leaves, other mulberry species and osage orange
- ▶ Wild silkmths are different from their domestic cousins:
 - ❖ **as they have not been selectively bred**
 - ❖ **they are not as commercially viable in the production of silk**

Introduction

- *Bombyx mori* is the closest relative of *Bombyx mandarina*, the wild silk moth from which it has been domesticated.
- *Bombyx mandarina*, which has a range from **northern India to northern China, Korea, Japan**, and the far eastern regions of **Russia**. The domestic silk moth derives from Chinese rather than Japanese or Korean stock.
- Silk moths were unlikely to have been domestically bred before the **Neolithic Age**. Before then, the tools to manufacture quantities of silk thread had not been developed.
- The *B. mori* and the wild *B. mandarina* can still breed and sometimes produce hybrids.

Introduction

- Domestic silk moths are **closely dependent on humans for reproduction, due to selective breeding.**
- Domestic silk moths are very different from most members in the genus *Bombyx*:
 1. They have lost the ability to fly.
 2. Their color pigments have also been lost.



Wild silk moth [Bombyx mandarina](#)

Domestication

- The domestic species, compared to the wild species, has **increased cocoon size, body size, growth rate, and efficiency of its digestion**.
- It has **gained tolerance to human presence and handling**, and also to **living in crowded conditions**.
- The domestic silk moths **cannot fly**, so the **males need human assistance in finding a mate**, and it **lacks fear of potential predators**.
- The **native color pigments have also been lost**, so the domestic silk moths are leucistic, since camouflage is not useful when they only live in captivity.
- These changes have made the domesticated strains entirely dependent upon humans for survival. The **eggs are kept in incubators** to aid in their hatching.

Genome

- The **full genome** of the domestic silk moth was published in **2008** by the International Silkworm Genome Consortium. **Draft sequences** were published in **2004**.
- The genome of the domestic silk moth is mid-range with a genome size around **432 megabase pairs**.
- **High genetic variability** has been found in **domestic lines of silk moths**, though this is less than that among wild silk moths (about 83 percent of wild genetic variation).
- This suggests a **single event of domestication**, and that it **happened over a short period of time**, with a large number of wild silkworms having been collected for domestication.
- Major questions, however, remain unanswered, according to Jun Wang, co-author of a related study published in 2008, who stated: "Whether this event was in a single location or in a short period of time in several locations cannot be deciphered from the data", and research also has yet to identify the area in China where domestication arose.

Cuisine

- Silk moth pupae are [eaten](#) in some cultures.
- In [Assam](#), they are boiled for extracting silk and the boiled pupae are eaten directly with salt or fried with chili pepper or herbs as a snack or dish.
- In [Korea](#), they are boiled and seasoned to make a popular snack food known as [beondegi](#).
- In [China](#), street vendors sell roasted silk moth pupae.
- In [Japan](#), silkworms are usually served as a [tsukudani](#), i.e., boiled in a sweet-sour sauce made with [soy sauce](#) and sugar.
- In [Vietnam](#), this is known as *con nhộng*.
- In [Thailand](#), roasted silkworm is often sold at open markets. They are also sold as packaged snacks.
- Silkworms have also been proposed for cultivation by astronauts as [space food](#) on long-term missions.

Cuisine

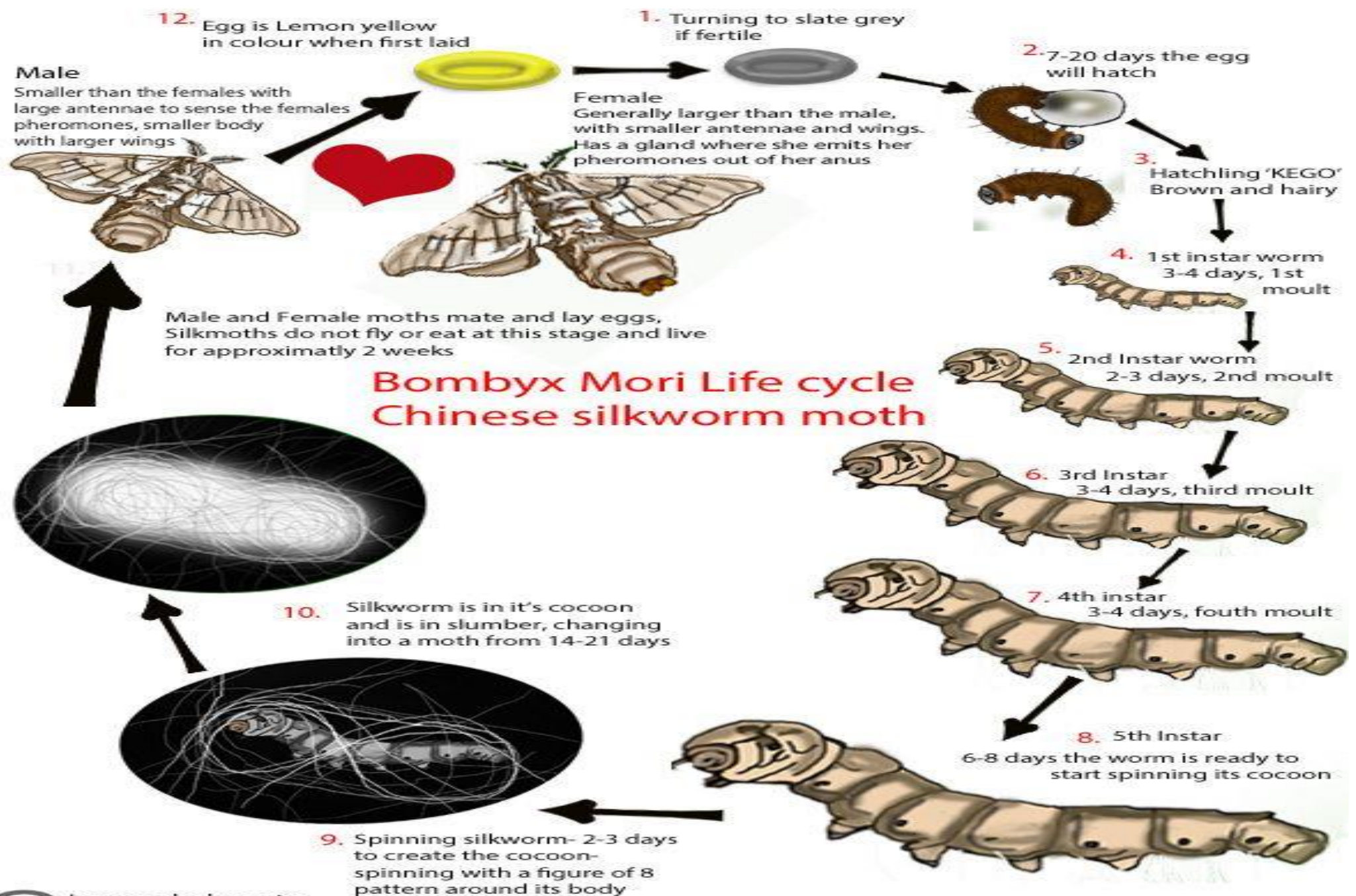


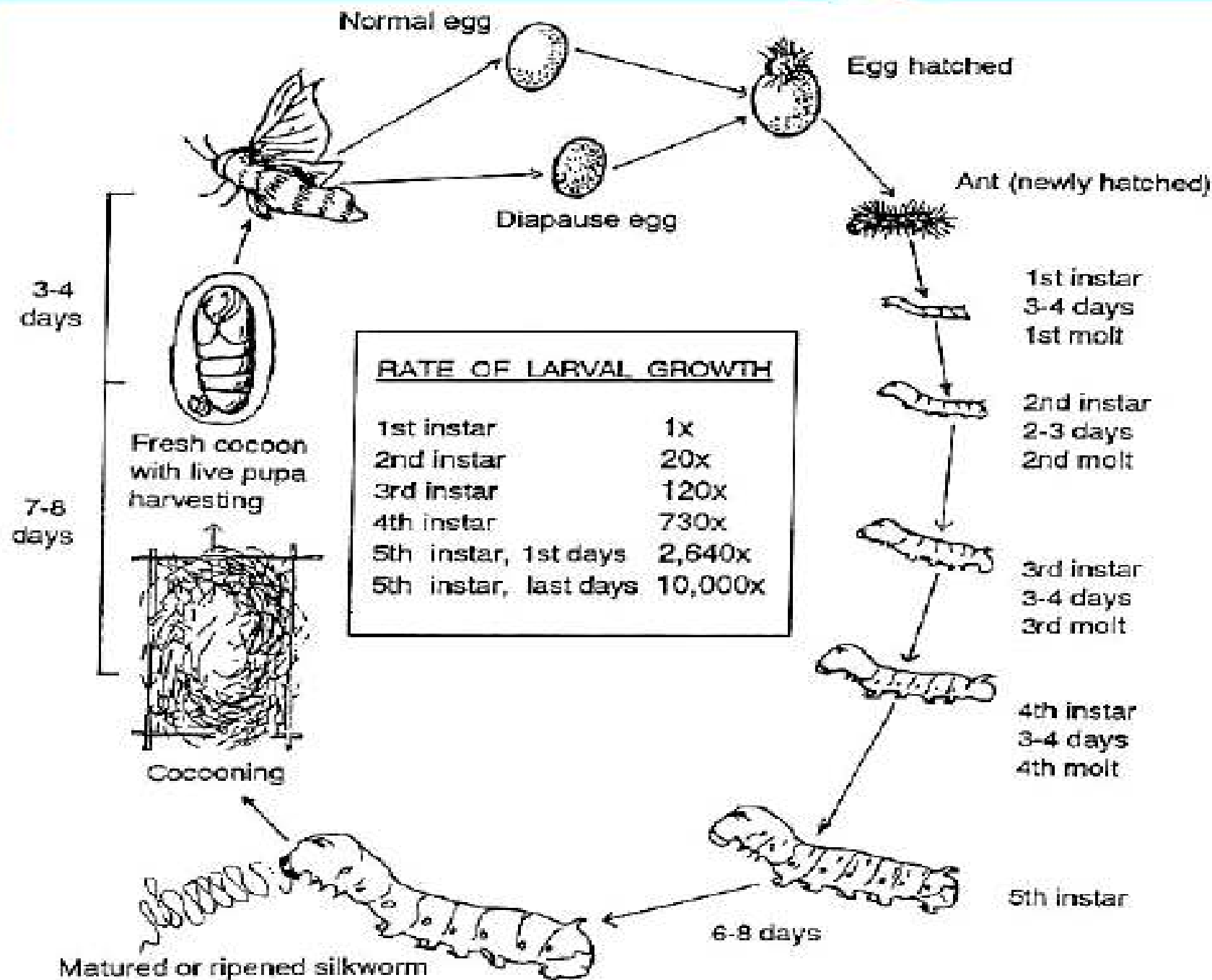
Silkworm pupae dishes



Packaged silkworm snacks from Thailand

- Silkworm moths go through four stages of development – egg, larva, pupa and adult – as do the majority of insects.. Mulberry Silkworms are the caterpillars or larvae of silkworm moths and feed on the leaves of mulberry trees (*Morus*).





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 (Family-Bombicidae, Order-Lepidoptera)

4 stages: egg, larva, pupa , adult

- Eggs are of 2 types:



The diapause (or hibernating) type of eggs :laid by the silk moth inhabiting in temperate regions

The non-diapause (or non-hibernating) eggs :silk moths inhabiting in sub-tropical regions like India



- The female moths lay 200-300 pale-yellow eggs over a couple of days and usually die within 2 weeks. Fertile eggs then turn to brown or purple in a week or so.

new laid silkworm eggs

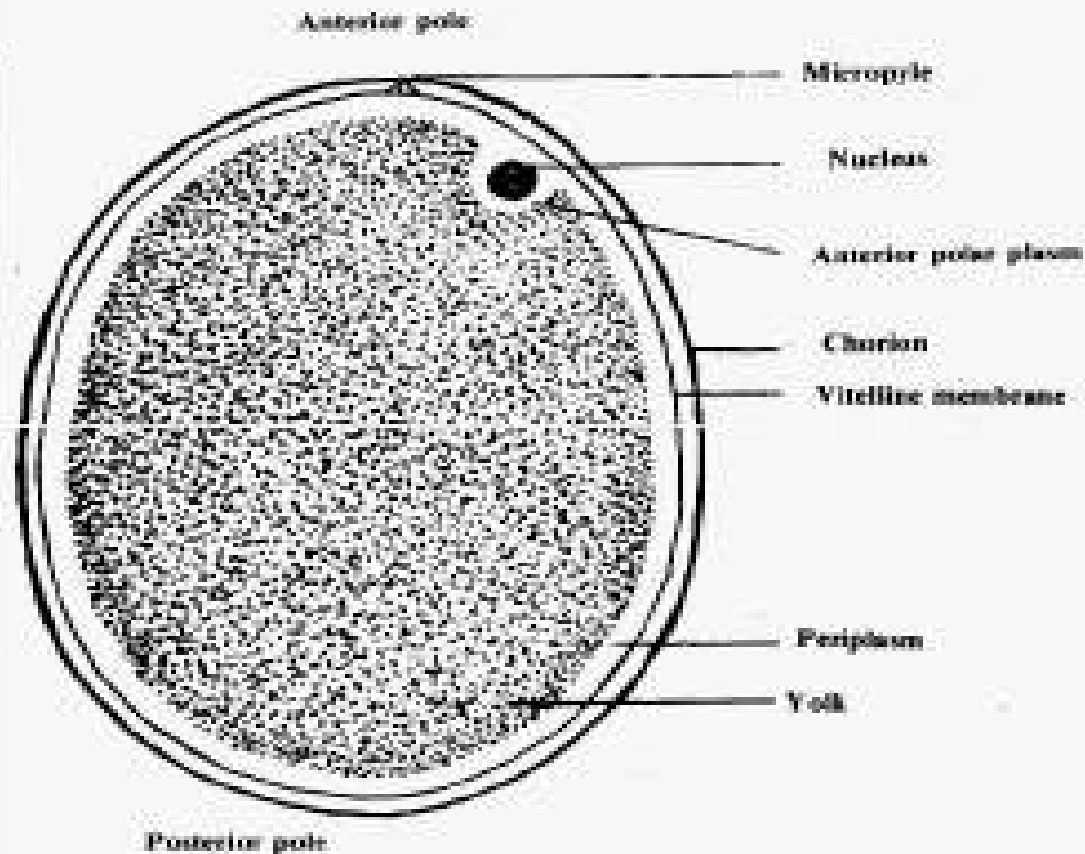


fertile silkworm eggs



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

- The eggs hatch in 10-14 days to produce a very small blackish first instar larva, less than 2mm or $\frac{1}{8}$ inch in length



Figure 2. Silkworm Eggs and Hatching

White eggs are empty shells from which larvae have already hatched. Hollowed eggs that are dark inside contain larvae about to hatch. Larvae bite open the eggshells from within to come out. The openings in white empty shells have been bitten open by larvae.

- At ideal temperatures (25° to 30°C), the larva grows to 3 inches (75mm) in length in 25-30 days and Rennie and Westwood calculate that it increases 9,000 times in weight during that time. To accommodate this enormous increase in size, it sheds its skin four times and therefore goes through 5 larval stages or instars before it is ready to pupate.

3rd instar silkworm larva



4th instar silkworm larva



5th instar feeding on mulberry



All Five Larval Stages of Silkworm

Newly hatched larvae



Enlarged



Second Instar larvae



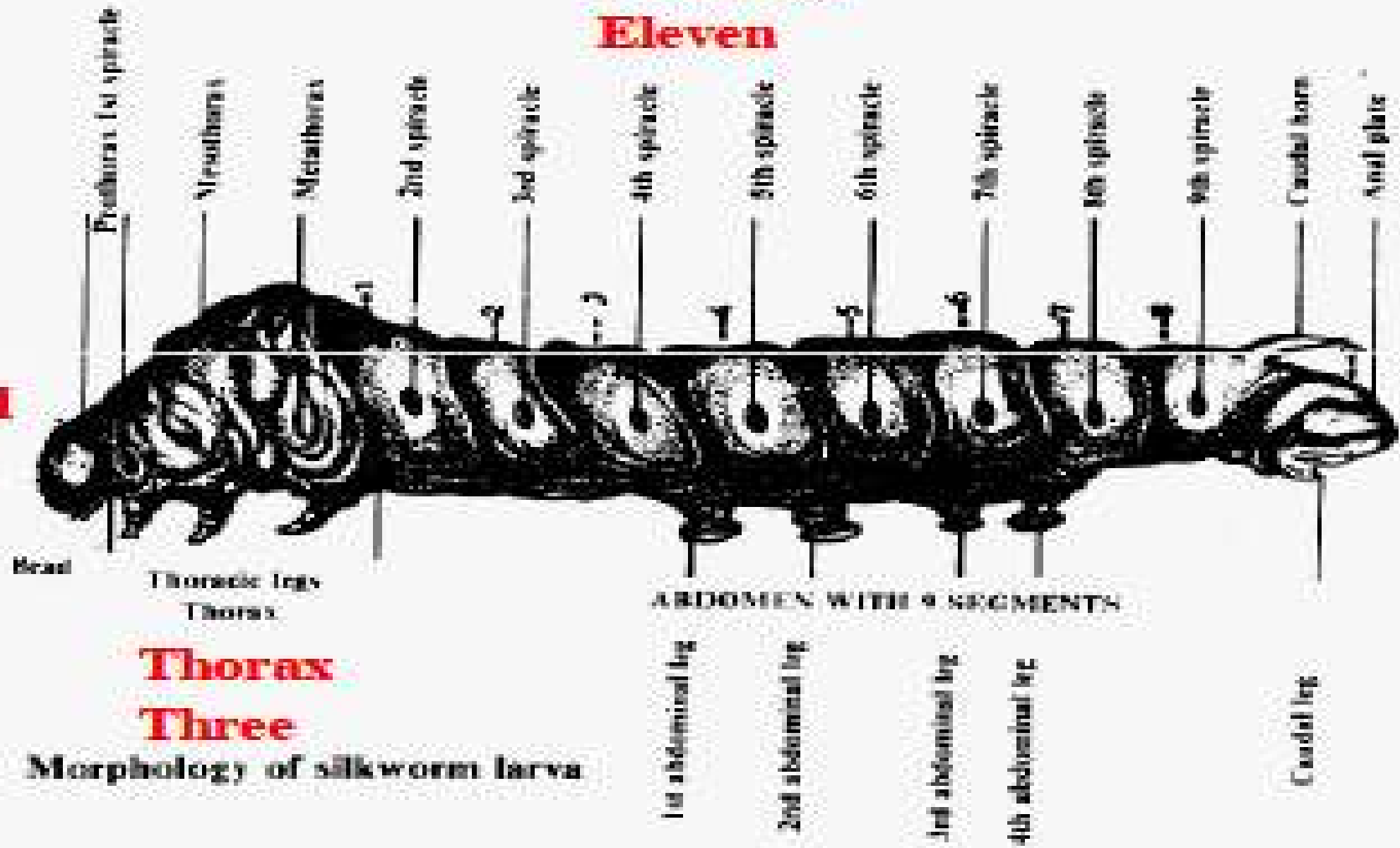
Third Instar Larvae

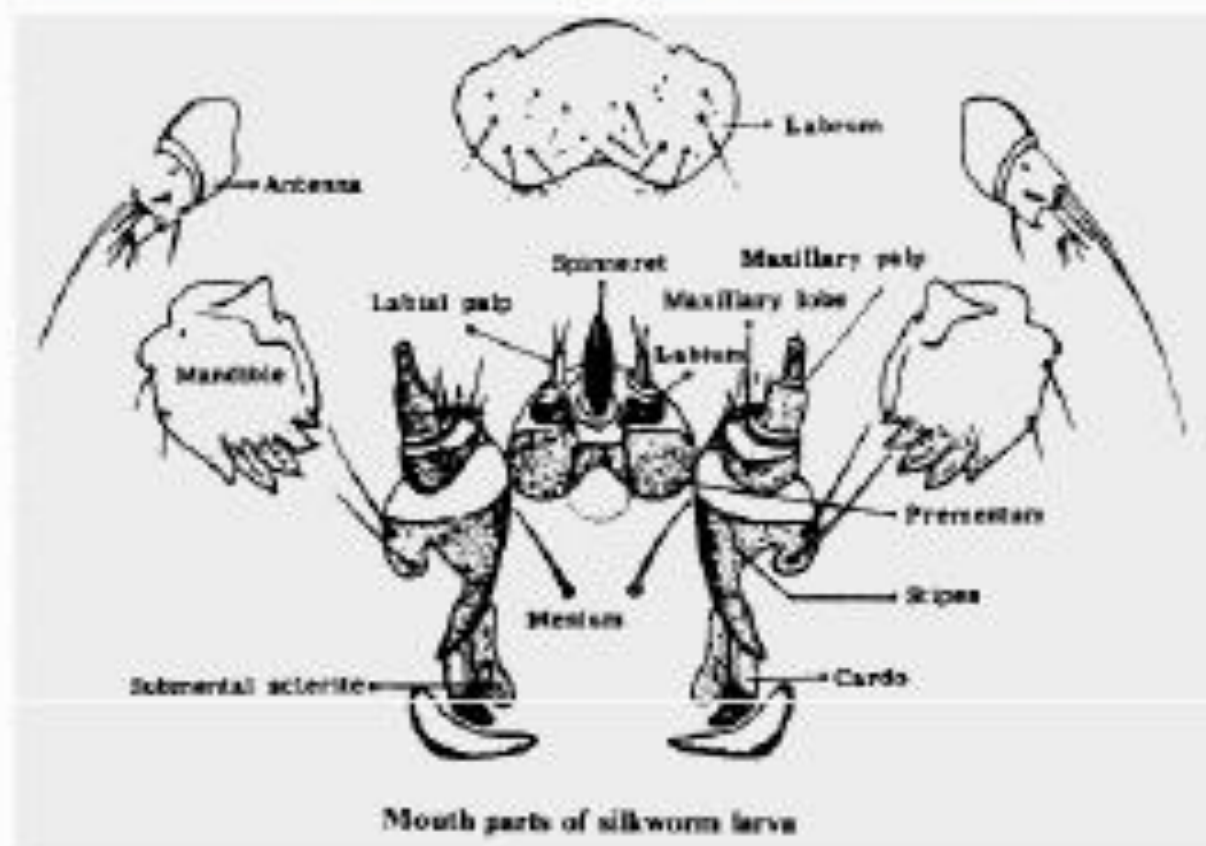


Fifth instar Larvae

Abdomen Eleven

Head Six





Coloured scanning electron micrograph (SEM)
of the head of a silkworm moth caterpillar
(Bombyx mori).

- When the silkworm larva is fully grown and ready to pupate, it stops feeding, looks for suitable location and starts to spin a hammock of silk in which to form the cocoon. The hammock is a loose, irregular protective network of silk in which the cocoon will be suspended

silkworm larva spinning hammock



- Once the hammock is complete, the larva settles to produce an even, regular, lozenge-shaped and closely-knit cocoon of silk. The cocoon is much denser and is formed from one length of a fine, strong, lustrous silk thread that is the source of commercial silk and that may be up to 1 kilometer in length.

cocoon suspended in hammock



- When the cocoon is complete, the larva starts to shrink in length, develops a hard skin and turns into a pupa, inside which the adult moth develops and metamorphoses (changes from larva to adult). Metamorphosis takes about two to three weeks and the silkworm moths then emerge from their cocoons.



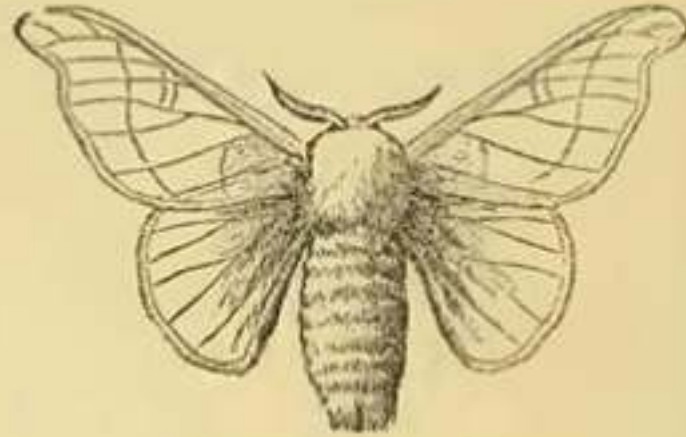
PLATE 1.

FIG. 1.



Bombyx mori, or mulberry feeding silkworm (Male).

FIG. 2.



Bombyx mori (Female).

- Males are **more active and flap their wings rapidly** to attract the females.
- Within 24 hours of mating, the male moth dies, while the female lays abundant eggs, after which it dies as well.
- There on, a new silkworm life cycle begins.

- Male and female moths are **flightless** and **lack functional mouth parts** which are **mostly sucking type**.
- They are **creamish white**, with short and plumose antennae.
- The female has a **larger abdomen** whereas the male has a **much larger pair of antennae**.



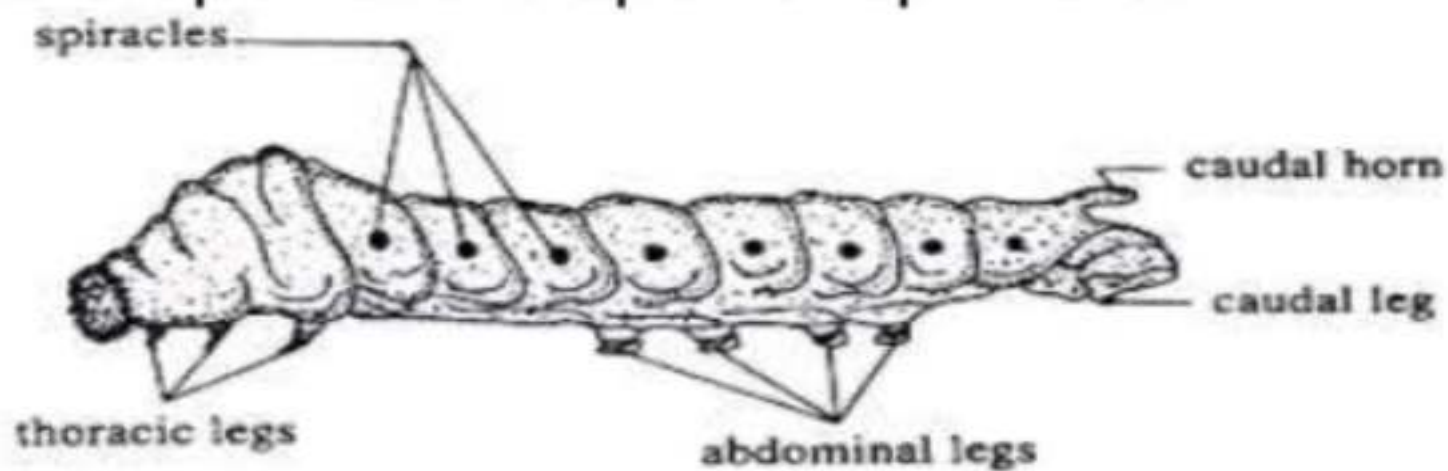
LIFE CYCLE OF THE MULBERRY SILKWORM

Stage	Period (days)	Characters
Egg	9-12	Yellowish-white, semi round, 1mg wt
Larvae	25-30	Last instar larva is greenish, cylindrical caterpillar, 3-3.5 inches long, bears 3 pairs of thoracic legs, 5 pairs of prolegs, last pair modified to clasps, spiracles- 1 thoracic and 8 abdominal. Each larva feeds on 90gm of leaves during its larval period (voracious feeders)
I Instar	3-4	
II Instar	2-3	
III Instar	3-4	
IV instar	5-6	
V Instar	7-8	
Prepupa	4-7	Non feeding stage, cocoon spinning within 2-4 days
Pupa	10-12	
Adult	2-3	Robust creamy white moth, bipectinate antenna, non feeder, poor flier. Each female lays 400-600 eggs, secretes alkaline solution to dissolve the cocoon (fibers)

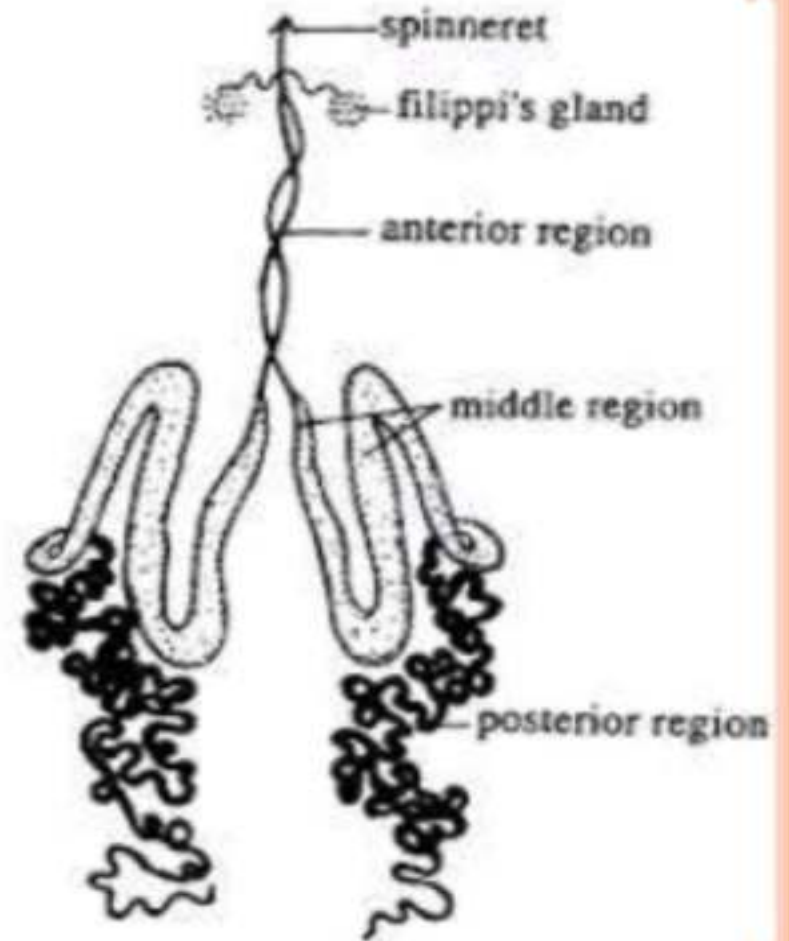
Silk



- **Fifth Larva** makes quick round movements of its head at the rate of 65 movements per minute while spinning its cocoon.
- Larval stage consist of pair of **silk glands**, which are greatly developed, about **4 times the body length** and folded enormously in **hind gut**
- Silk glands=**labial glands**
- Silk glands=**homologous to salivary glands**
- Anteriorly, each gland opens into salivary duct. Both ducts unite and open at the apex of spinneret



- Silk gland composed of single layer of secretory cells bearing branched nuclei, internally lined by cuticle and externally by peritoneal membrane
- Silk gland has 3 parts: anterior silk gland (250 cells), middle silk gland (300 secretory cells) and posterior silk gland (500 cells)
- Anterior part- no secretory function
- Middle part- secrete sericin
- Posterior part- secrete fibroin and p25



Silk secretion



60-70% fibroin

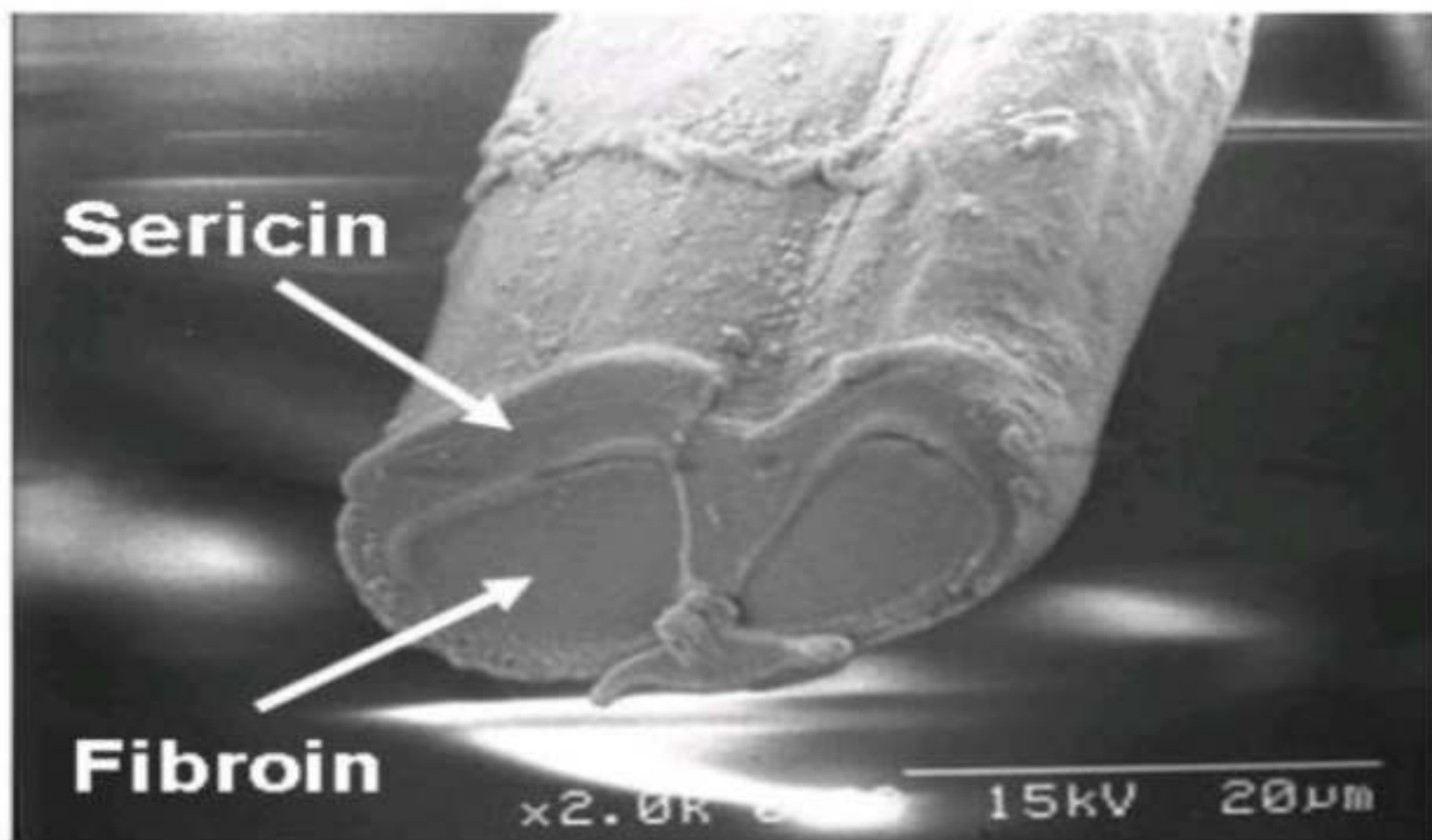
- tough, elastic and insoluble
- Make the core of the filaments in the form of brins

20-25% sericin

- gelatinous (gummy), hot water soluble protein
- Holds the brins together

- The weight in gm of 900 m long silk filament is called a "**Denier**".
- The size of a normal cocoon is 1.8 to 3 deniers.
- A single cocoon weight is 1.8 to 2 gm and its shell (without enclosed pupa) is only 0.45 gm.
- About 2500 cocoons yield 0.45 kg of silk.





Cross-sectional image of a cocoon

Peace silk/Ahimsa Silk

- Commercial silk is made by **boiling the intact cocoons** and unwinding the single silk strand onto reels.
- Only a **few moths are allowed to emerge** to continue the population of silkworms.
- The rest are killed by being boiled in their cocoons.
- “**Peace silk**”, also known as “**vegetarian silk**” is raised and processed differently.
- The **moths are allowed to emerge from their cocoons** to live out their full life cycle.
- The **silk is degummed and spun like other fiber**, instead of being reeled.

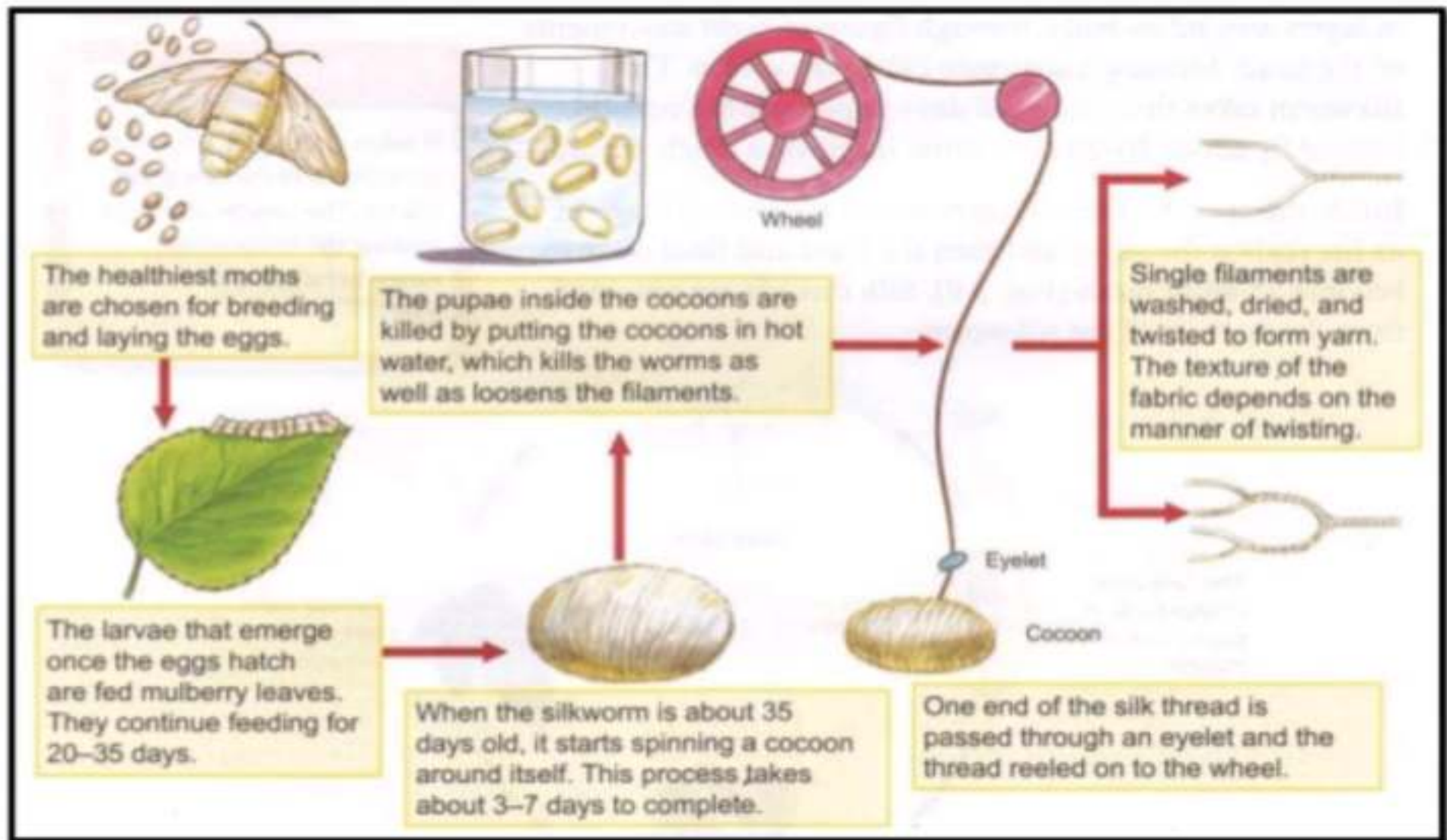
Peace silk/Ahimsa Silk

- The resulting yam is soft, fluffy, and light like a cloud. This is the best silk for warmth and therapeutic use.
- As the process of harvesting the silk from the cocoon kills the larva, sericulture has been criticized by animal welfare and rights activists.
- [Mahatma Gandhi](#) was critical of silk production based on the [Ahimsa](#) philosophy "not to hurt any living thing".
- This led to Gandhi's promotion of cotton spinning machines, an example of which can be seen at the Gandhi Institute.
- He also promoted [Ahimsa silk](#), [wild silk](#) made from the cocoons of wild and semiwild silk moths.

Culture of Bombyx Mori:

1. The moth is made to lay eggs, on a Wotting paper. The eggs are collected and treated with 2% formaldehyde.
2. The larvae hatch out within 10 to 11 days. They are reared in bamboo trays and strict hygiene is maintained. The larva is about 3 mm long and called 1st instar.
3. The larvae are voracious eaters. Chopped, young mulberry leaves are given as food in the beginning, but with advanced age, entire and matured leaves are supplied.
4. The 1st, 2nd, 3rd, 4th and 5th ins tars eat for 3, 2½, 3, 5 and 8 days, respectively.
5. The 5th instar starts spinning silk thread around its body from outside to inside and encloses itself within four days in a cocoon of a continuous silk thread.
6. Before cocoon formation, matured larvae are transferred to special trays known as spinning trays.
7. The cocoon are treated with hot water to kill the pupae within them and processed for getting raw silk.
8. For next crop, healthy cocoons are selected during harvest and kept in well- ventilated cages for emergence of adults.

SERICULTURE



Difference Between Male and Female Silkworms

Moth



Female and Male moths



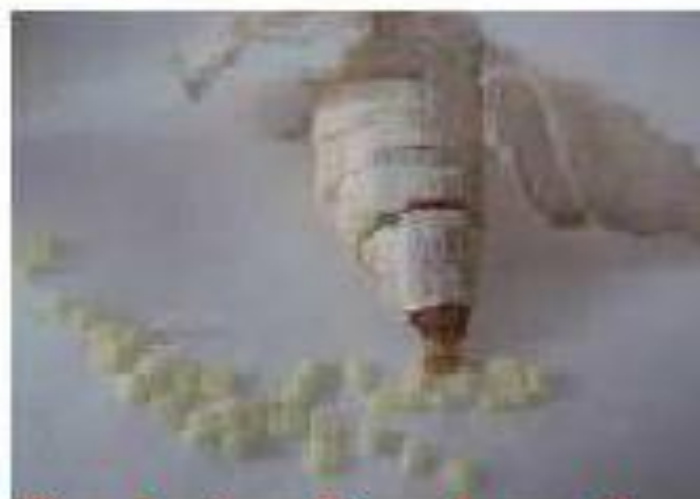
Female and Male moths



Paired Female and Male moths



Female moth



Egg laying Female moths

Male Moth vs Female Moth



Male Moth



Female Moth

Smaller in size

Active

Comparatively bigger antenna.

Abdomen narrow

Posterior end has a pair of hooks called harper or claspers.

Ovipositer absent.

Eight abdominal segments are visible.

Larger in size

Sluggish

Comparatively smaller antenna.

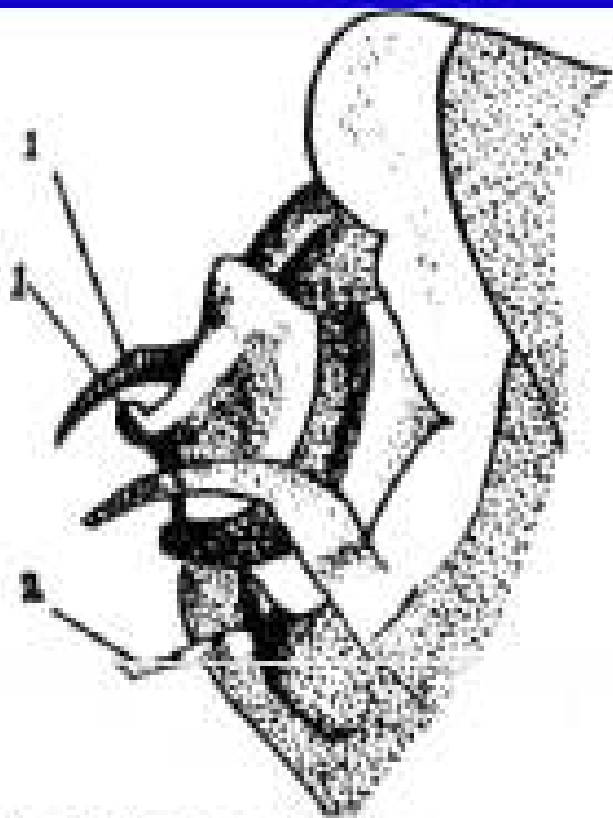
Abdomen bloated

Posterior end had a knob like projection with sensory hairs.

Posterior end of the abdomen has a protractile knob like ovipositor

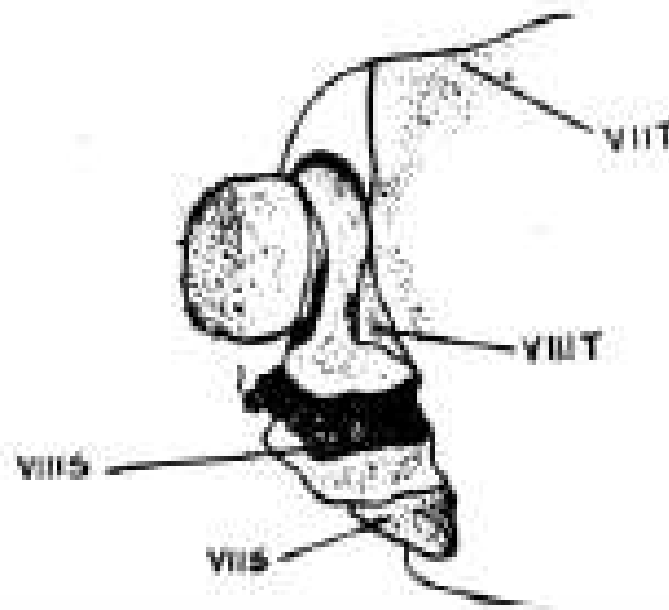
Seven abdominal segments are visible.

Sexing at Moth stage



- 1) CLASPERS (HARPES or HOOKS)
- 2) AEDEAGUS

Abdominal end of male moth



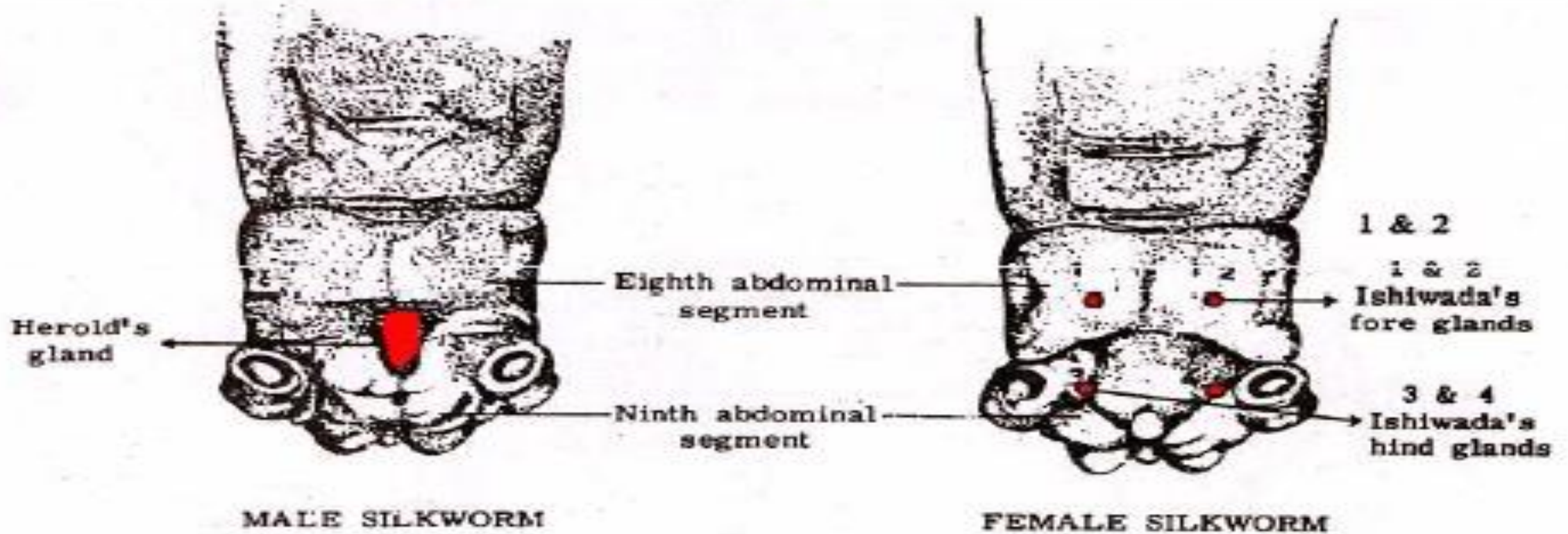
(lateral view)

VII T & VIII T — 7 & 8 Abdominal tergite

VII & VIII S — 7 & 8 Abdominal sternites

Abdominal end of female moth

Sexual Marking at larval stage



- In **females** the raptured larva, one pair of **Ishiwata's fore-gland** and a pair of **Ishiwata's hind glands** are present at the ventral side of 8th and 9th abdominal segments respectively.
- The **male** larva possesses a **single small median white gland — Herold's gland** at ventral side, near the junction of 8th and 9th abdominal segments

Female

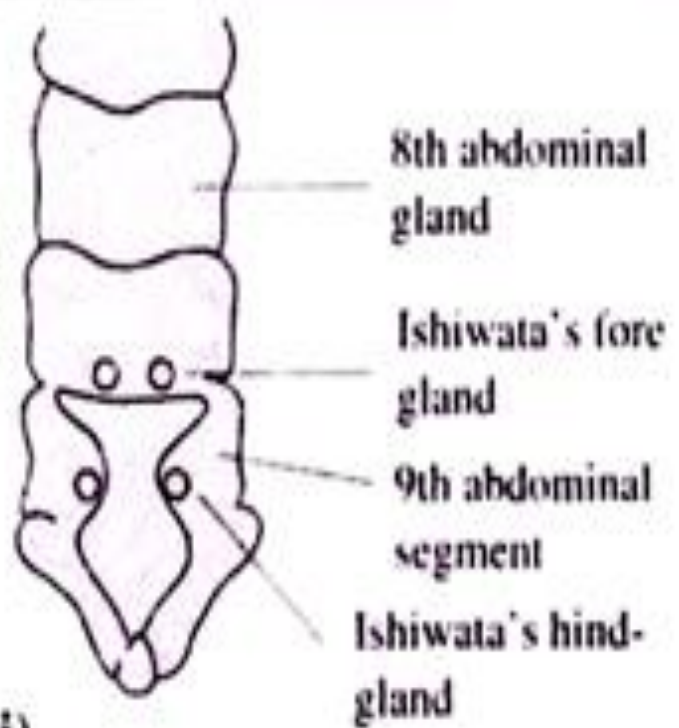


Fig. 3.19c(i)

Male

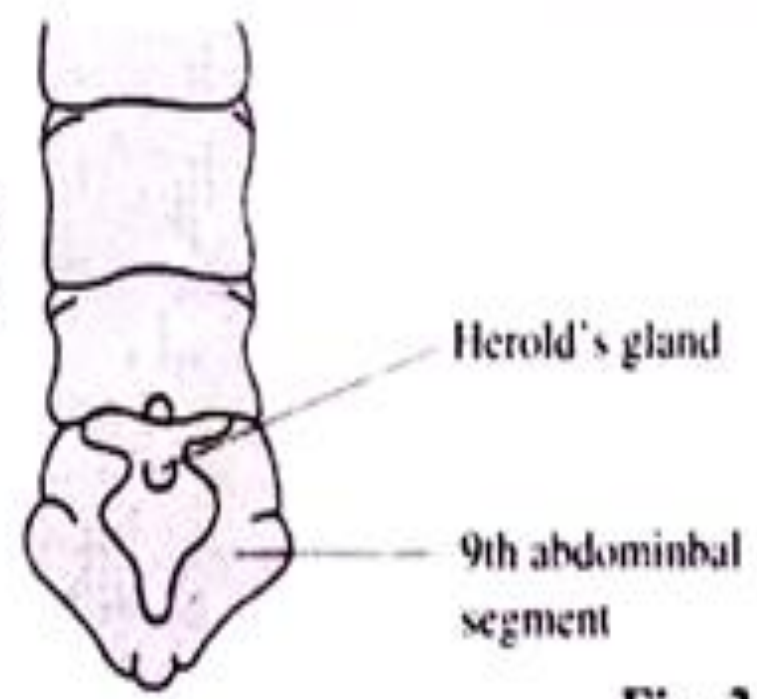
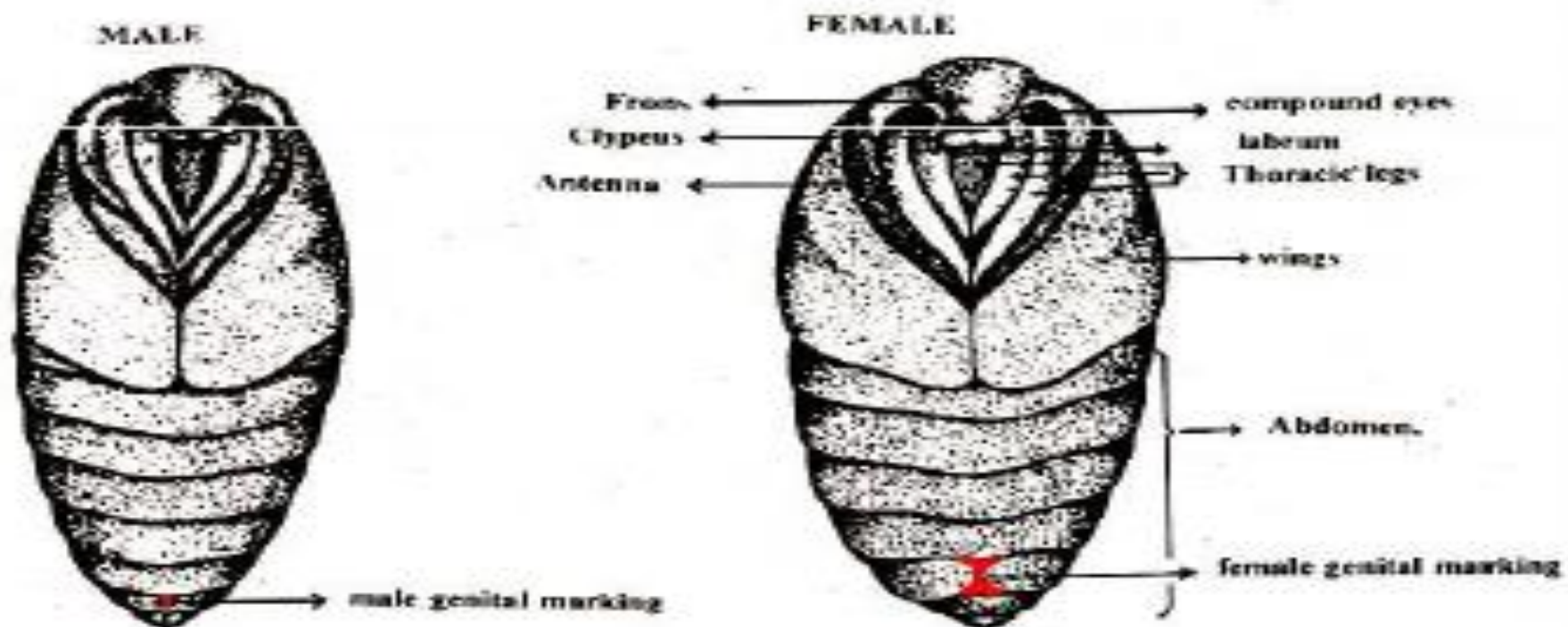


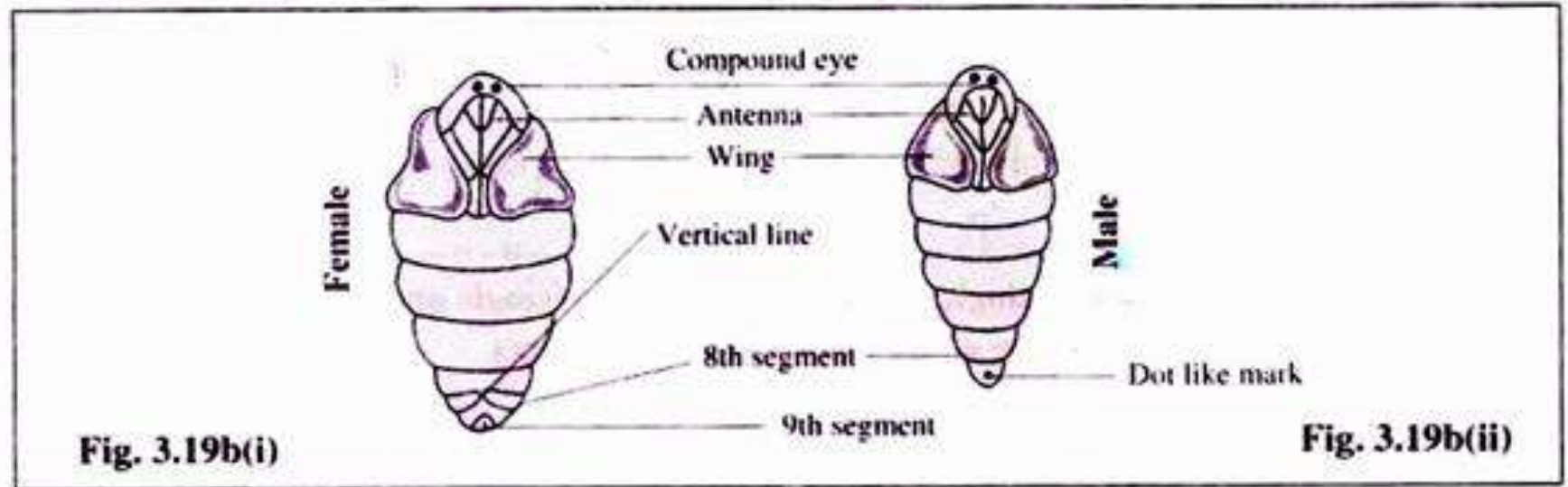
Fig. 3.19c(ii)

PUPA



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

Pupa



FEMALE PUPA

- The body of female is broader than male pupa.
- On the ventral side of 8th abdominal segment, a vertical line is present.
- No spot is present on 9th abdominal segment of female mulberry moth.
- The female cocoon is heavier than the male cocoon.

MALE PUPA

- The body is narrower than the female pupa.
- No vertical line is present on 8th abdominal segment.
- A small spot is present on 9th abdominal segment in male mulberry moth.

SERICULTURE : OPPORTUNITIES

- Sericulture being cottage industry plays an important role in employment generation and poverty alleviation.
- It is one of the most profitable activities in rural sector.
- Availability of indigenous technology at low cost.
- Regular and quick returns.
- Large demand and Popularity of hand woven silks in the west.
- Strong domestic demand coupled with use of silk garments on festive occasions.
- Large production gap to meet the domestic demand.
- Scope for establishing the large production units and organized sector.



Thank you!

