TOPIC:

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NAAC ACCREDITED GRADE—'A'

- TOPIC : METAMORPHOSIS IN LEPIDOPTERAN INSECTS
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- NAME OF THE DEPARTMENT: DEPARTMENT OF ZOOLOGY.

Metamorphosis in Lepidopterans

Metamorphosis

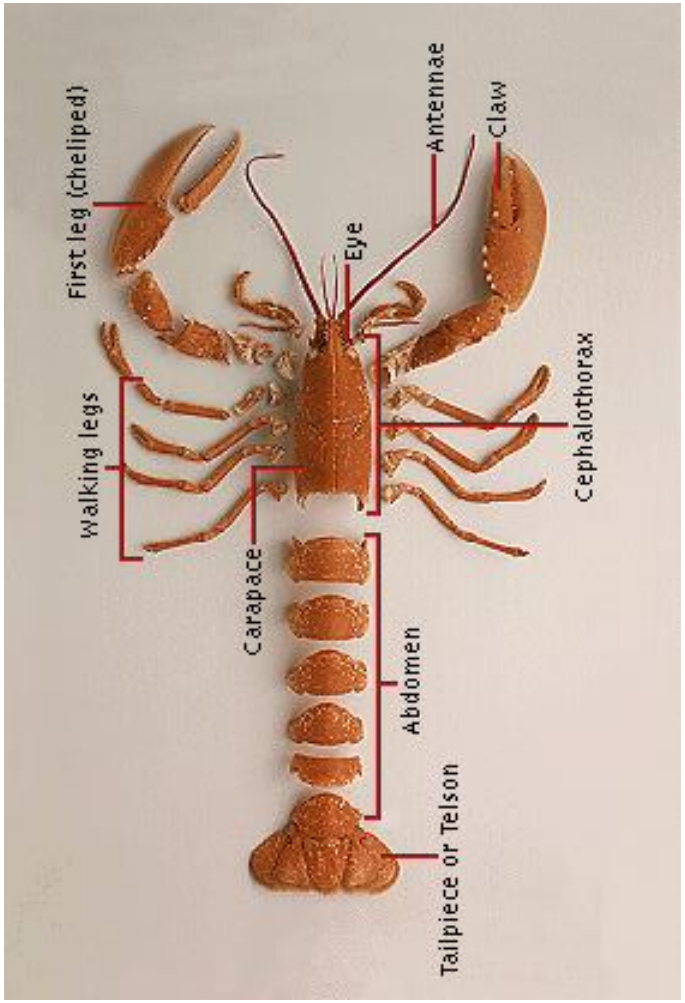
- The term metamorphosis is derived from the Greek words, **meta:** change, and **morphe**: form, designating change in form.
- Metamorphosis is the process of transformation of an **immature larval individual** into **sexually mature reproducing adult**. The transformed adult is completely different from larvae in form, structure and habit. It is the way insects grow and mature. Their lives are divided into separate stages for resting, growing and reproducing.
- **Simply it can be said as the overall change in shape and body form during development of an insect/animal.**

Metamorphosis in insects

- As the insect's body is covered by exoskeleton which is a rigid framework, the growth of the insect becomes difficult.

Metamorphosis in insects

- In order for the insect to grow, it must shed its exoskeleton through the process of moulting and re-grow a new one.
- Shedding of the exoskeleton is called **ECDYSIS** and the cast-off is called an **EXUVIAE**.



Metamorphosis in insects

- Moulting is one of the processes of growth during the development of insect by metamorphosis.

Metamorphosis in insects

- The basic stages of development in insects involve
  - **egg,**
  - **juvenile and**
  - **adult,**
- Though in some cases other stages may as well be present.
- These multiple stages of development is called INSTAR and the final adult stage attained is called IMAGO.
-

Types of metamorphosis

- Although all insects moult and change body shape through their life, some undergo minor changes while most undergo extreme changes in structure and function.
- Based on the degree of changes and stages involved, four types of metamorphoses are recognized:

- No-metamorphosis, or Ametabolous
- Gradual metamorphosis or Paurometabolous
- Incomplete metamorphosis or Hemimetabolous
- Complete metamorphosis or Holometabolous

Ametabolous

- Insects develop without metamorphosis and they just grow by a series of successive moults.
- Juvenile-

✓The young one of the insect called juvenile.

✓Young looks identical to adult except in body proportions and sexual structures.

✓Food and habits of the young and the adults are similar.

- Adult-

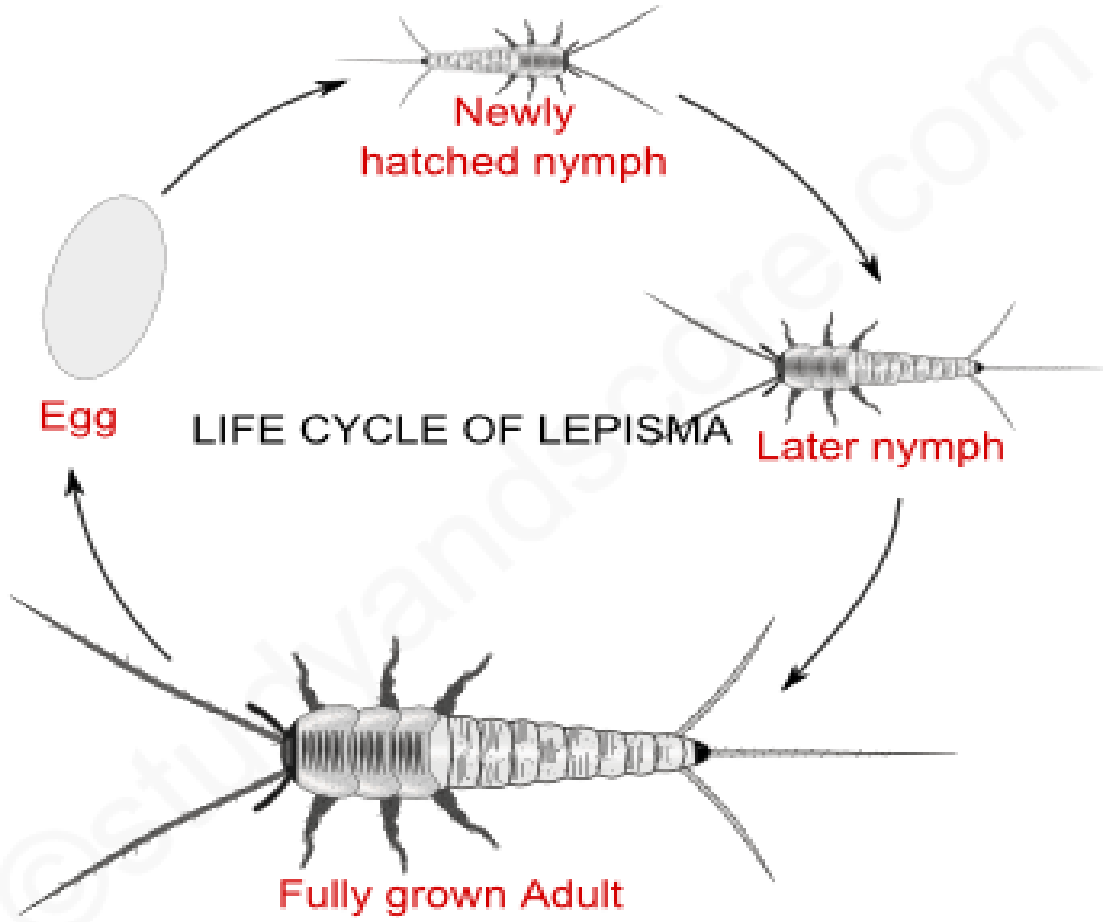
✓Adults are bigger in size as compared to juveniles and possess fully developed reproductive organs.

Ametabolous

- Very few insect species (apterygotes) are ametamorphic

Examples	Orders
Silverfish	Collembola
Springtail	Collembola
Chewing lice	Mallophaga
Sucking lice	Anoplura

Ametabolous



Paurometabolous

- Insects are known to exhibit gradual development, the juveniles resemble an adult with some exceptions
- Nymph-

✓They are smaller than adults,

✓Wings are either absent or reduced

✓Lacks external genital appendages and are sexually immature.

- Adult-

✓Adults are winged,

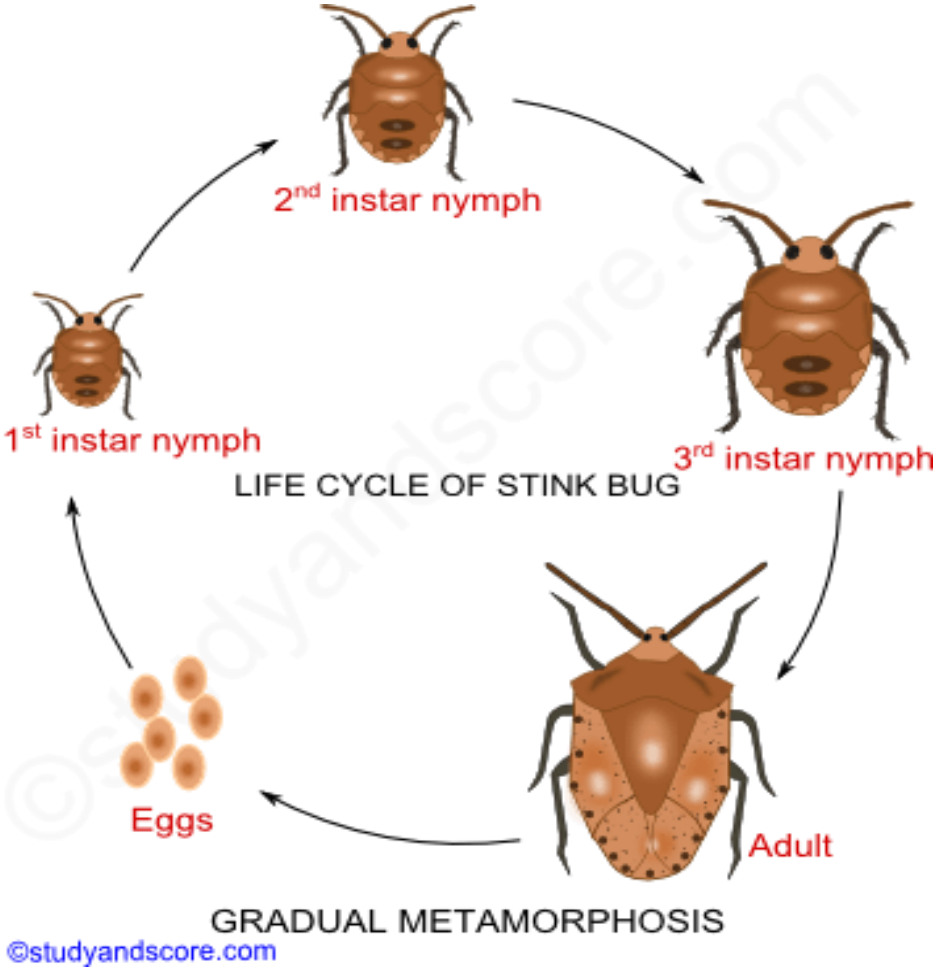
✓Sexually mature and live in the same habitat and feed on the same foods as nymphs so they possess similar mouthparts.

The young nymphs undergo several nymphal stages through successive moulting to transform into adult.

Paurometabolous

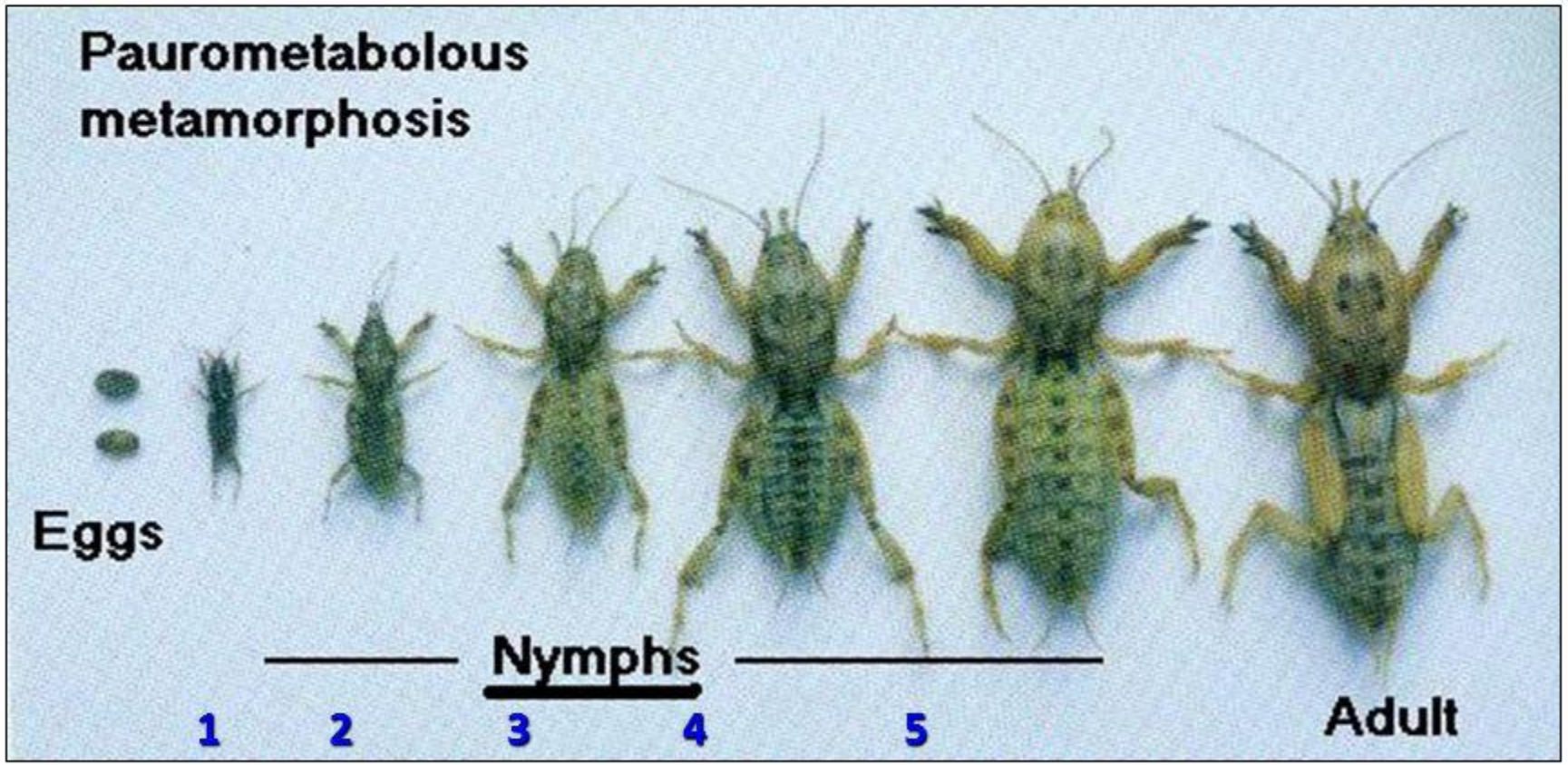
Examples	Orders
Grasshoppers	Orthoptera
Termites	Isoptera
Booklice	Corrodentia
Thrips	Thysanoptera
True bugs	Hemiptera
Aphids	Homoptera
Earwigs	Dermaptera

Paurometabolous



Insect Metamorphosis

Paurametabolous – gradual metamorphosis



instars

Hemimetabolous

- Juvenile look quite different from the adult .
- Nymph-

➢ They have wing pads that gradually increase in size and become functional in the adult stage only after the final moult.

➢ The juveniles are largely referred to as nymphs or naiads.

➢ These nymphs are sexually immature and are aquatic in habitat and thus possess gills for breathing.

- Adult-

➢ They occupy separate ecological niche (aerial) from the nymphs and hence do not compete for resources.

➢ Adults have different mouthparts from that of the nymph.

- Just before moulting into the adult stage, the aquatic or subterranean juvenile crawls out of the pond, stream, or ground into a twig or stem and a winged adult emerges from its skin.

Examples	Orders
Mayflies	Ephemeroptera
Dragonflies	Odonata
Stone-flies	Plecoptera

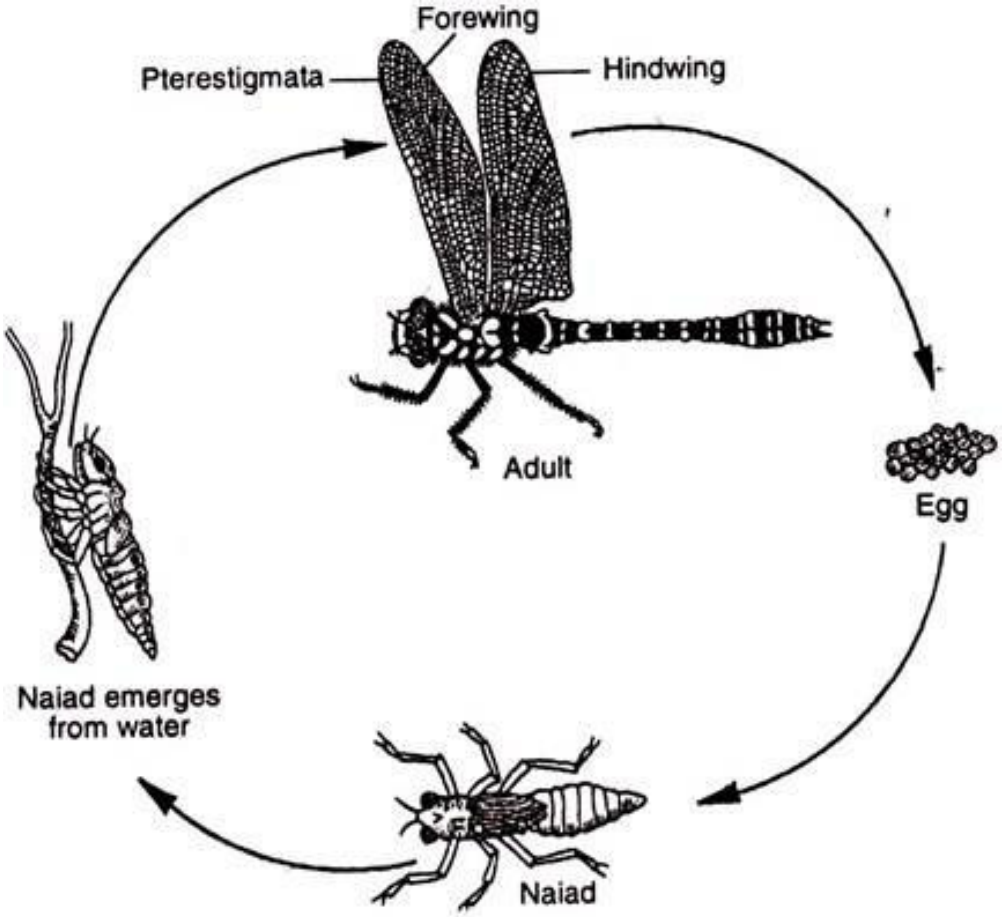
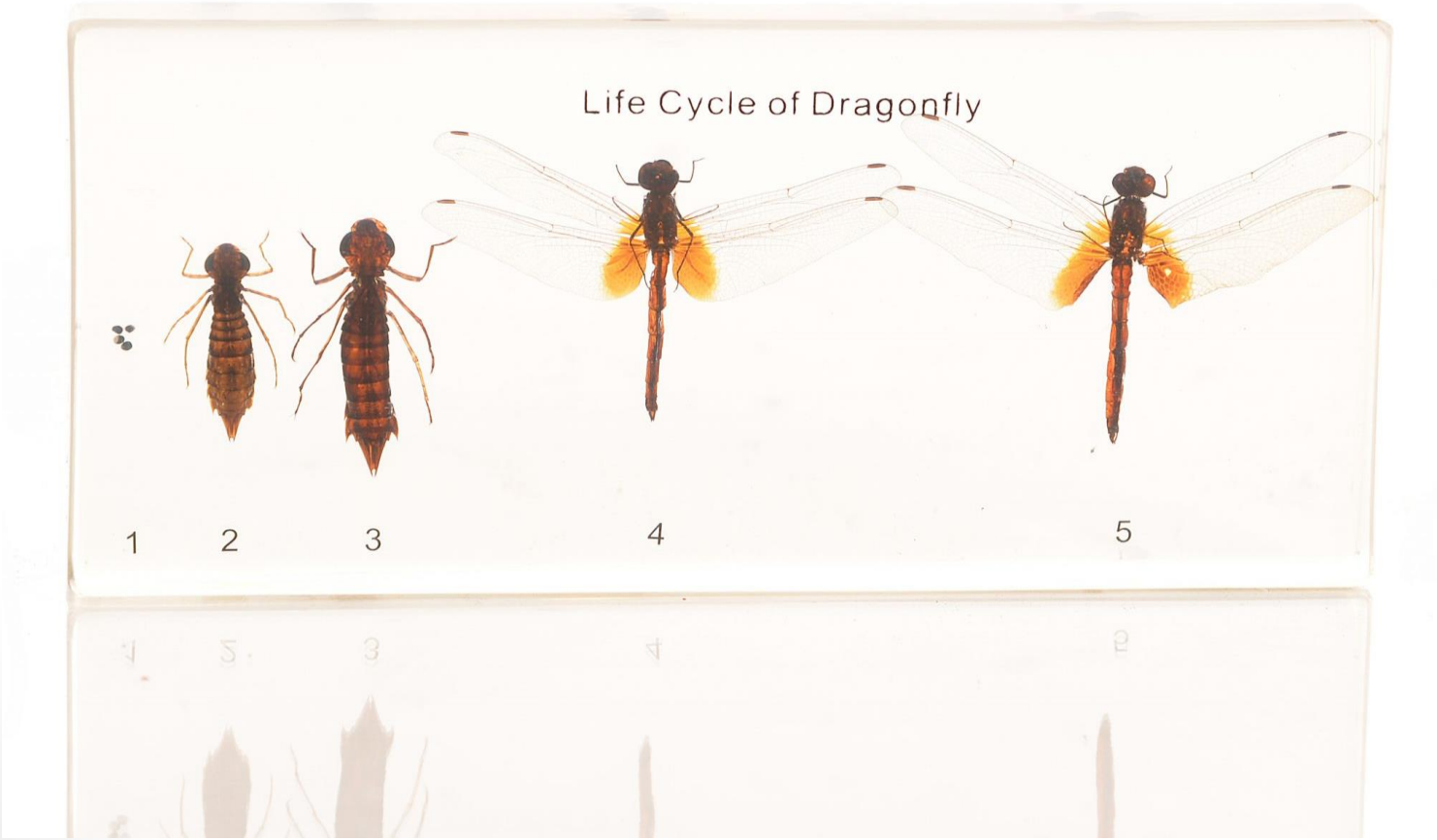


Fig. 18.136: Hemimetabolous metamorphosis in dragon fly.

Dragonfly



Mayfly

Holometabolous

- It is a complete type of metamorphosis in which the insects pass through four stages of life:

✓egg

✓ larva

✓pupa and

✓adult.

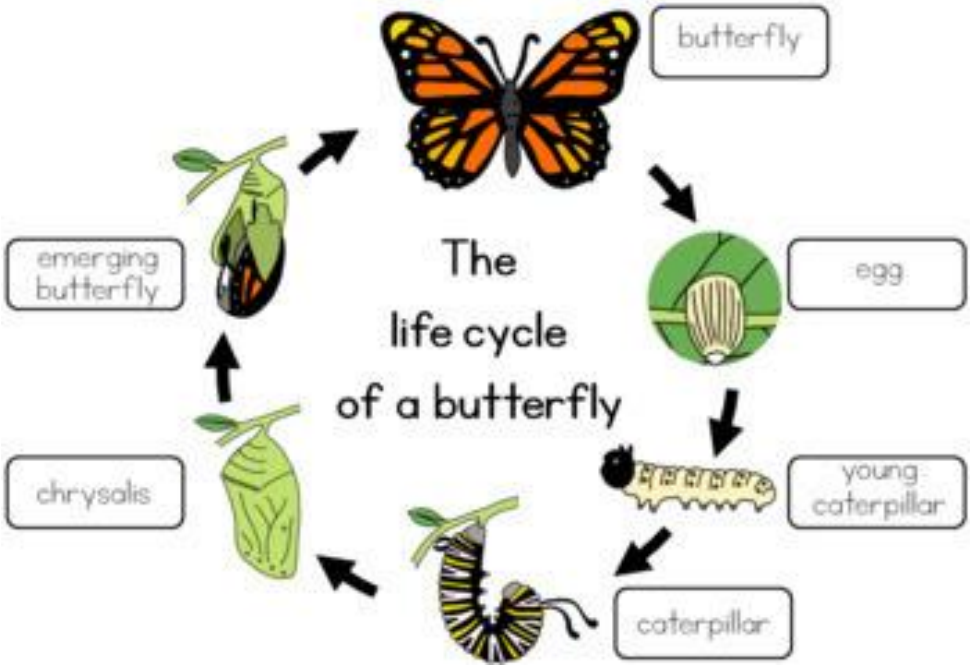
- Larva- Immediately after hatching from egg,
- active and voracious feeder
- immature, wriggling stage called larva emerges.
- Larva undergoes several moults, each stage being called as instar.
- Larva is differently referred in some insect orders like maggots (flies), caterpillar (butterflies and moths) and grubs (beetles).
-

Holometabolous

- Pupa-
- After several moults larva transform into a resting, non-feeding and inactive stage called pupa.
- Pupa is sometimes also referred as chrysalis and is more commonly used for butterflies and moths.
- Pupa is encased in a firm case or cocoon for the protection of developing pupa.
- Inside the pupa, larva undergoes drastic changes in which larval organs are hydrolysed and adult structures develop from clusters of embryonic reserve cells called imaginal discs.
-

Holometabolous

- Adult-
- completely different from the larvae in form, structure, feeding habit and habitat.
- Larval forms lack wing pad. Their food is different from the adults and the two often have different kind of mouthparts.



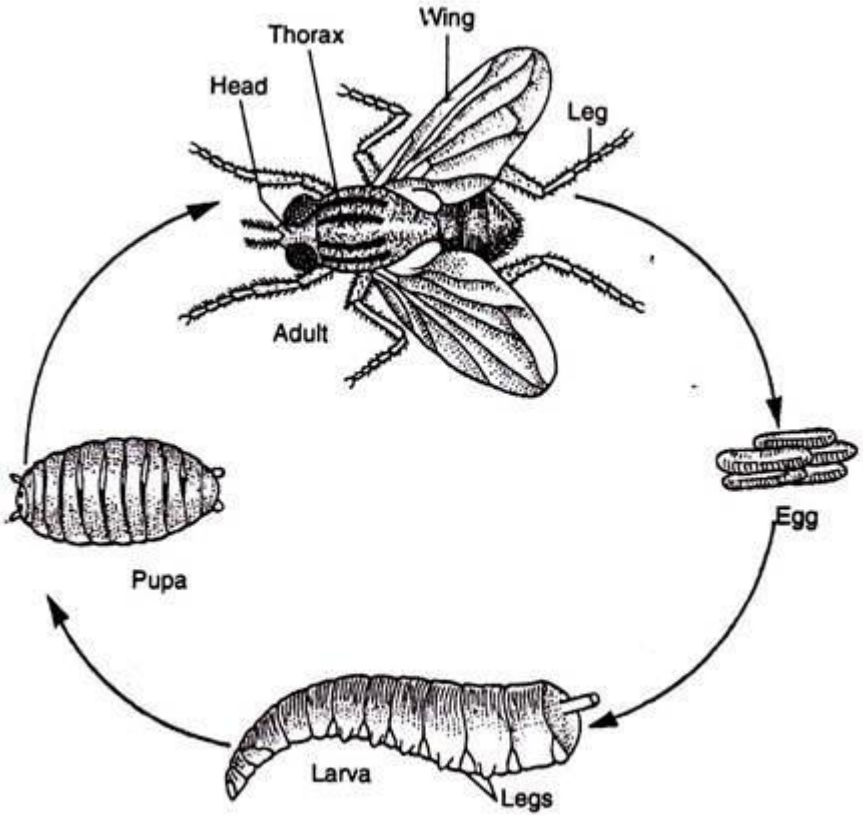


Fig. 18.137: Illustration of holometabolous development in fly.

Holometabolous

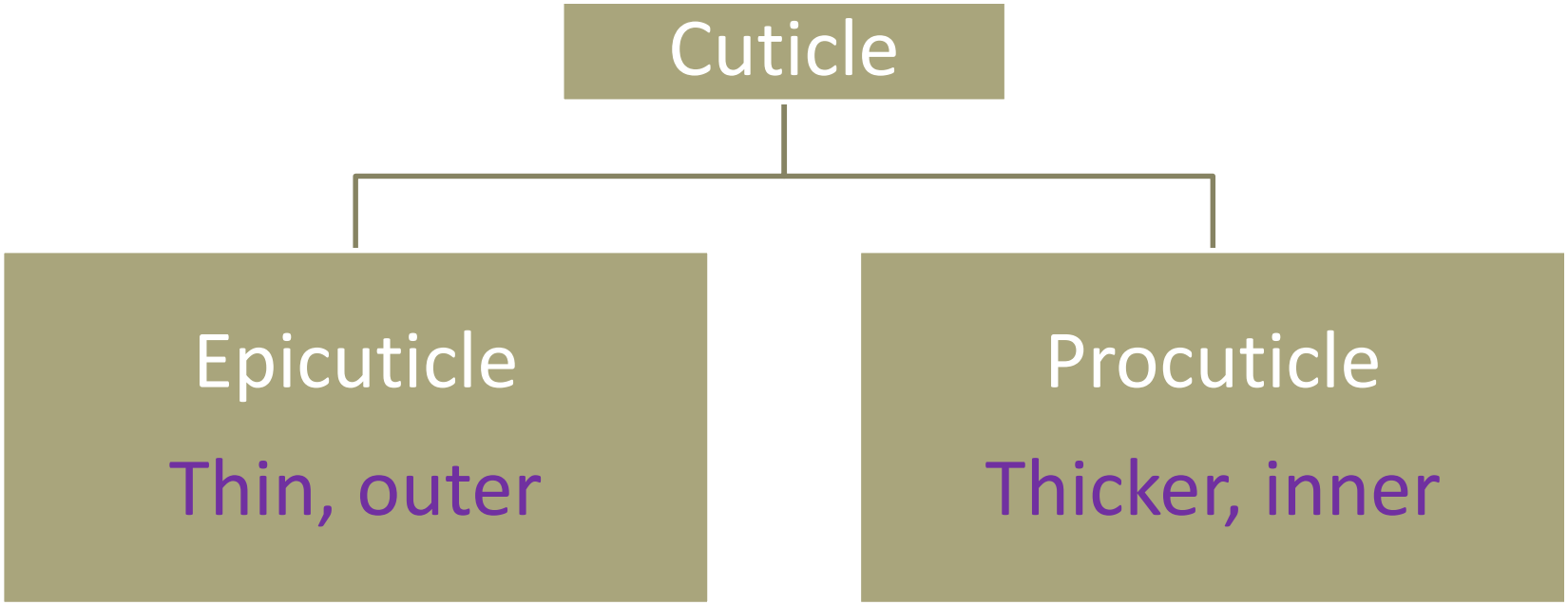
Examples	Orders
Lacewings	Neuroptera
Beetles	Coleoptera
Scorpion-flies	Mecoptera
Coddid-flies	Trichoptera
Moths, Butterflies	Lepidoptera
Flies	Diptera
Fleas	Siphonoptera
Wasps, bees	Hymenoptera

Structure of Exoskeleton

- The distinguishing features of arthropods is chitinous exoskeleton/Cuticle.
- It is an outer non cellular, complex layer comprising of three sub layers.
- **Secreted by: Underlying epidermis.**
- Often referred to as hypodermis and is made up of simple cuboidal epithelium.

Cuticle

- Made up of 2 layers:



Epicuticle

- Outer most layer which is very thin.
- Multilayerd

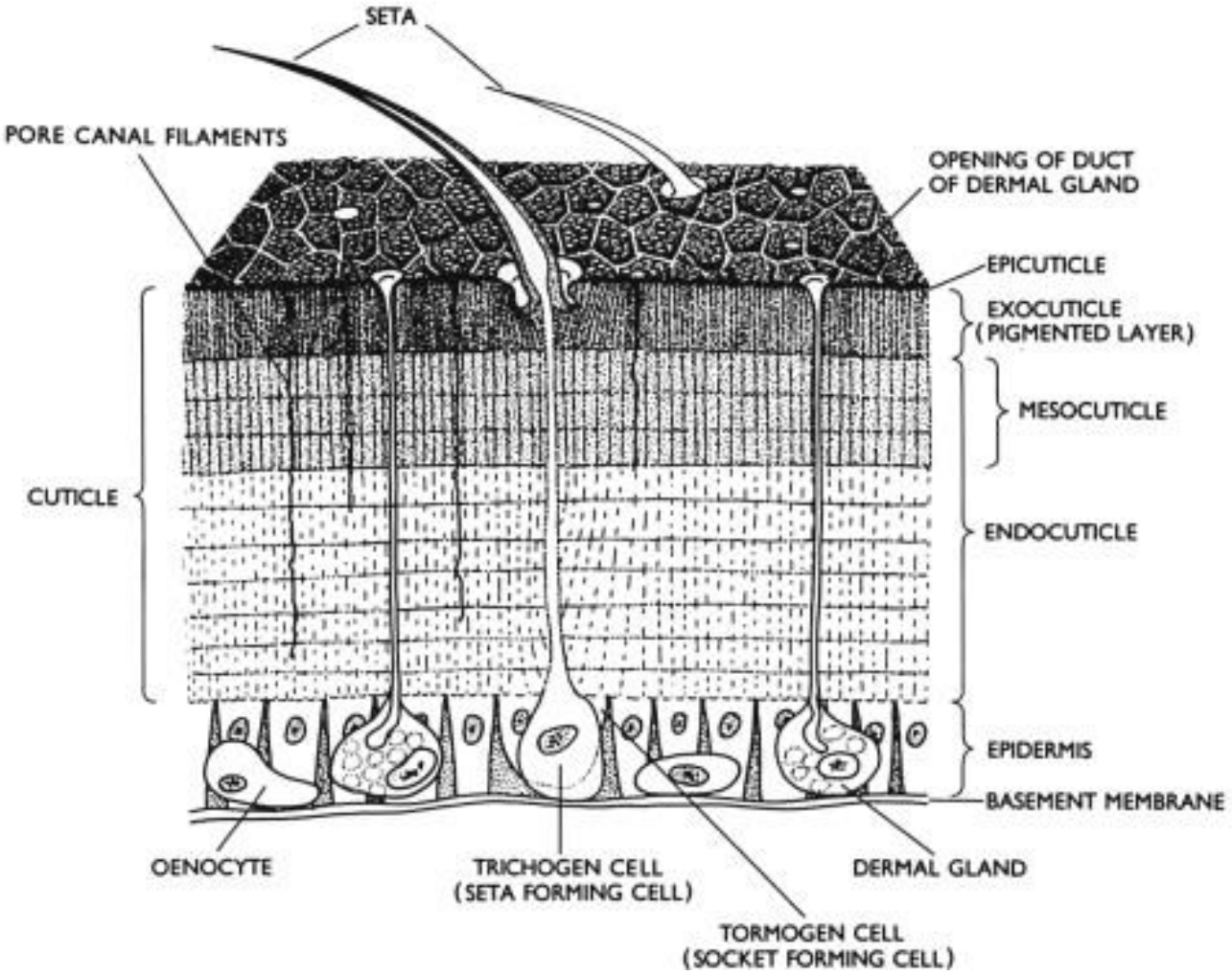
1. Outer or external epicuticle: protective lipoprotein layer also called CEMENT LAYER.
2. Inner epicuticle : Waxy layer in insects.

- Wax is long chain hydrocarbons and esters of fatty acids and alcohol.
- Prevents water loss
- Protection against bacterial invasion

3. Cuticulin layer: Made up of protein. Well developed in insects.

- 2 layers
- Thin dense outer layer
- Thick less dense inner layer
- Involved in hardening of exoskeleton.

Cuticle


SETA
PORE CANAL FILAMENTS
OPENING OF DUCT OF DERMAL GLAND
EPICUTICLE
EXOCUTICLE (PIGMENTED LAYER)
MESOCUTICLE
CUTICLE
ENDOCUTICLE
EPIDERMIS
BASEMENT MEMBRANE
OENOCYTE
TRICHOGEN CELL (SETA FORMING CELL)
TORMOGEN CELL (SOCKET FORMING CELL)
DERMAL GLAND

Procuticle

- Lies beneath the epicuticle.
- Primarily made up of layers of protein and chitin but no collagen.
- Subdivided into

1. Outer exocuticle :

- Much thicker with the composition of Chitin and sclerotin. This layer is dark in colour and rigid.
- Absent in joints and along the lines where skeleton ruptures during molting.
- Protein molecules are cross bonded to one another by orthoquinone linkages .

Procuticle

- Bonding agent is produced from the polyphenols catalyzed by polyphenol oxidases.
- Sclerotisation begins in the cuticulin layer and then progresses into epicuticle.

2. Inner endocuticle:

- Compared to others it is the inner and thickest layer.
- This layer is made up of Chitin and arthropodin.
- This layer is colourless, soft and flexible.
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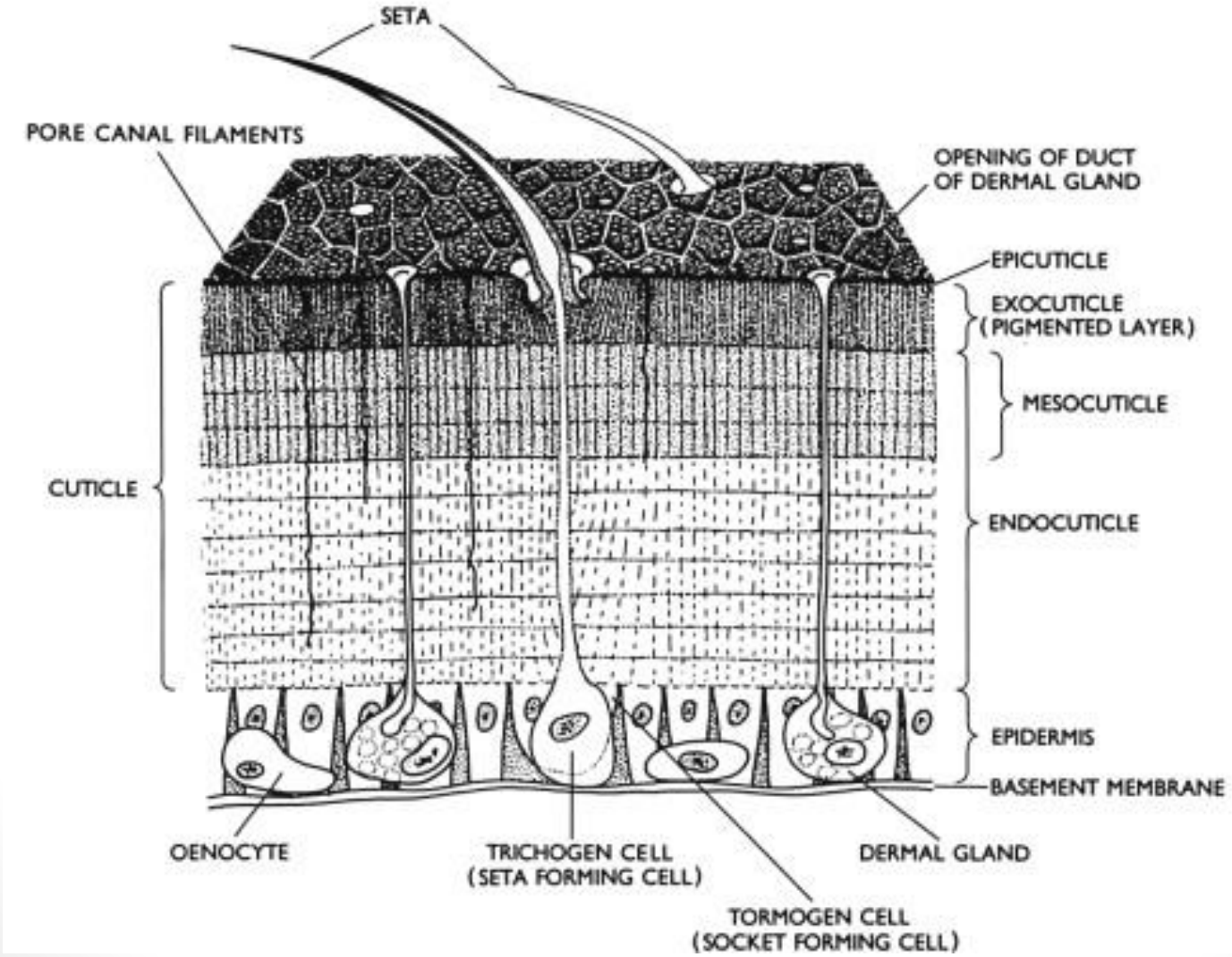
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(SOCKET FORMING CELL)

Molting

- An overall increase in body size takes place in staggered increments associated with the periodic loss of the old exoskeleton and the deposition of a new larger one. The process of shedding the exoskeleton is called molting.

- The process of moulting is important for the growth of larval stages in successive instars which prepares the insect for transition from larva to adult stage.

- During moulting insect undergoes several changes including some major histological changes.

Molting

- The instar becomes less active

- Increase in size and number of the epidermal cells by mitosis becoming more and more closely packed.

- Retraction of the epidermis results in cuticular detachment forming a sub- cuticular space. The process is called apolysis.

1. The space beneath the old cuticle is filled with moulting gel which is secreted by the epidermal cells

*[contains inactive chitinase and protease enzymes]

- The first layer of new epicuticle is laid down…….**2.**

- On the completion of formation of epicuticle the moulting gel becomes fluid that contains active enzymes and start hydrolysing/digesting the innermost old endocuticle.

- The epidermal cells begin to deposit the undifferentiated procuticle……**3.**

- Simultaneously the digested endocuticle is reabsorbed

[Exocuticle remains undigested by these active enzymes in the moulting fluid owing to it sclerotization]

- The old cuticular sheath is finally ruptured which occurs along definite lines of weakness (ecdysial lines) in the head capsule and along the median antero- dorsal part of the body.

……**4.**

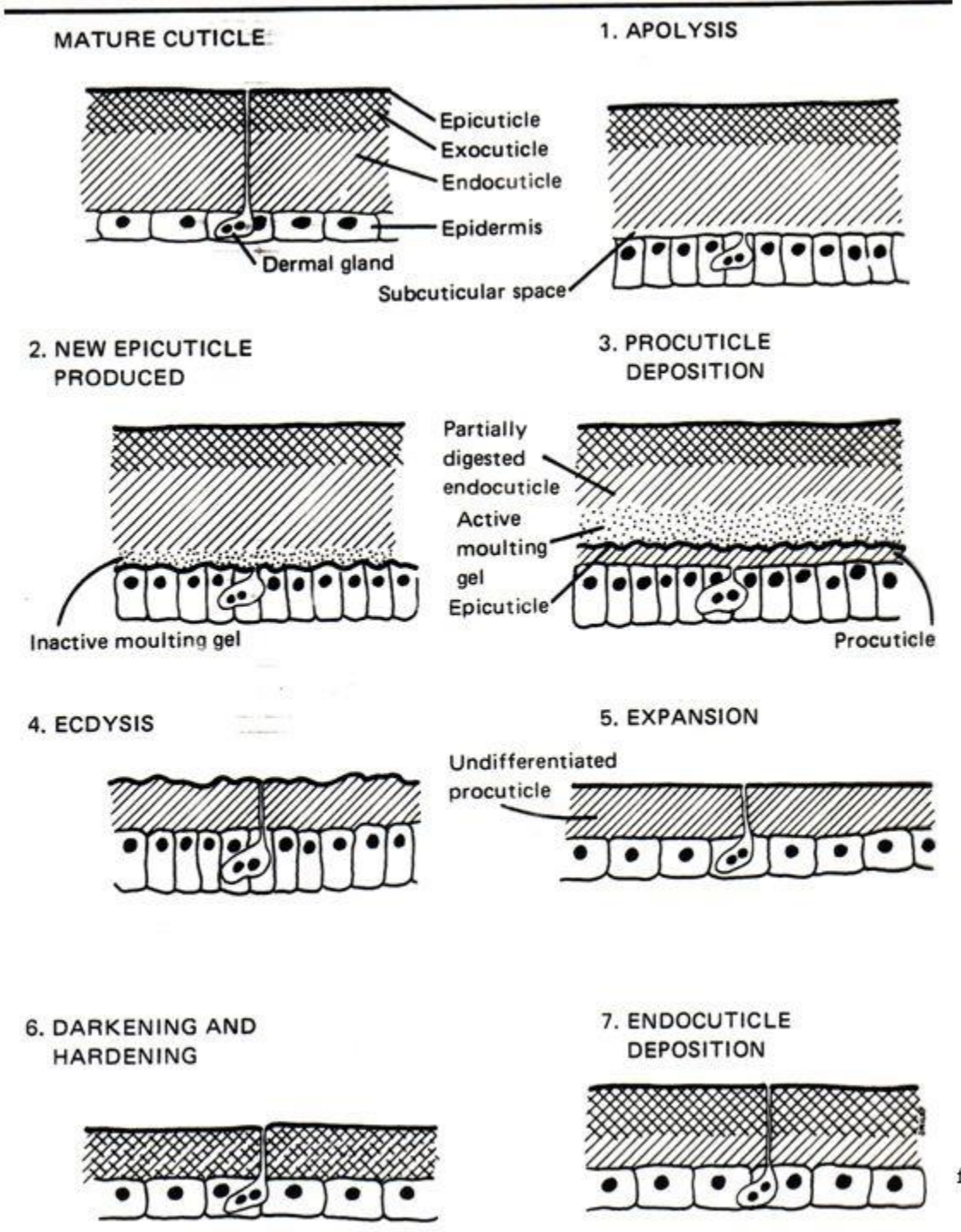
Expansion: The pressure needed to rupture the cuticle is generated by swallowing air or water by muscular contractions resulting in accompanied hemolymph pressure change.

……**5**.

Hardening (sclerotization) and darkening of integument; exocuticle is formed……**6.**

Deposition of endocuticle……**7.**

The seven basic phases of insect molting.



from Evans 1984

Hormonal control

- **What triggers the moult?**

- Brain for successful pupation and
- The concept of critical period during brain hormone secretion.
- The entire process of insect development is largely controlled by three main hormones

Hormone	Secreted by	Chemical nature	Function
Prothoracicotrophic hormone (PTTH)	Neurosensory cells Corpora cardiaca	Ecdysteroids	Stimulates prothoracic glands
Prothoracic gland hormone (PGH)	Prothoracic glands	Ecdysone	triggers moulting
Juvenile hormone (JH)	Corpora allata	Lipids	Regulates morphogenesis and promotes metamorphosis

PTTH

- **What stimulates secretion of PTTH?**

- When the larval or nymph has grown sufficiently big, and have attained a critical weight an interplay of the hormonal titers regulate the metamorphosis.

- Growing and the distended body of the insect sends a sensory signal to the brain resulting in activation of clusters of neurosecretory cells in the brain which in turn triggers the production of PTTH.

Action pathway for JH and Ecdysone