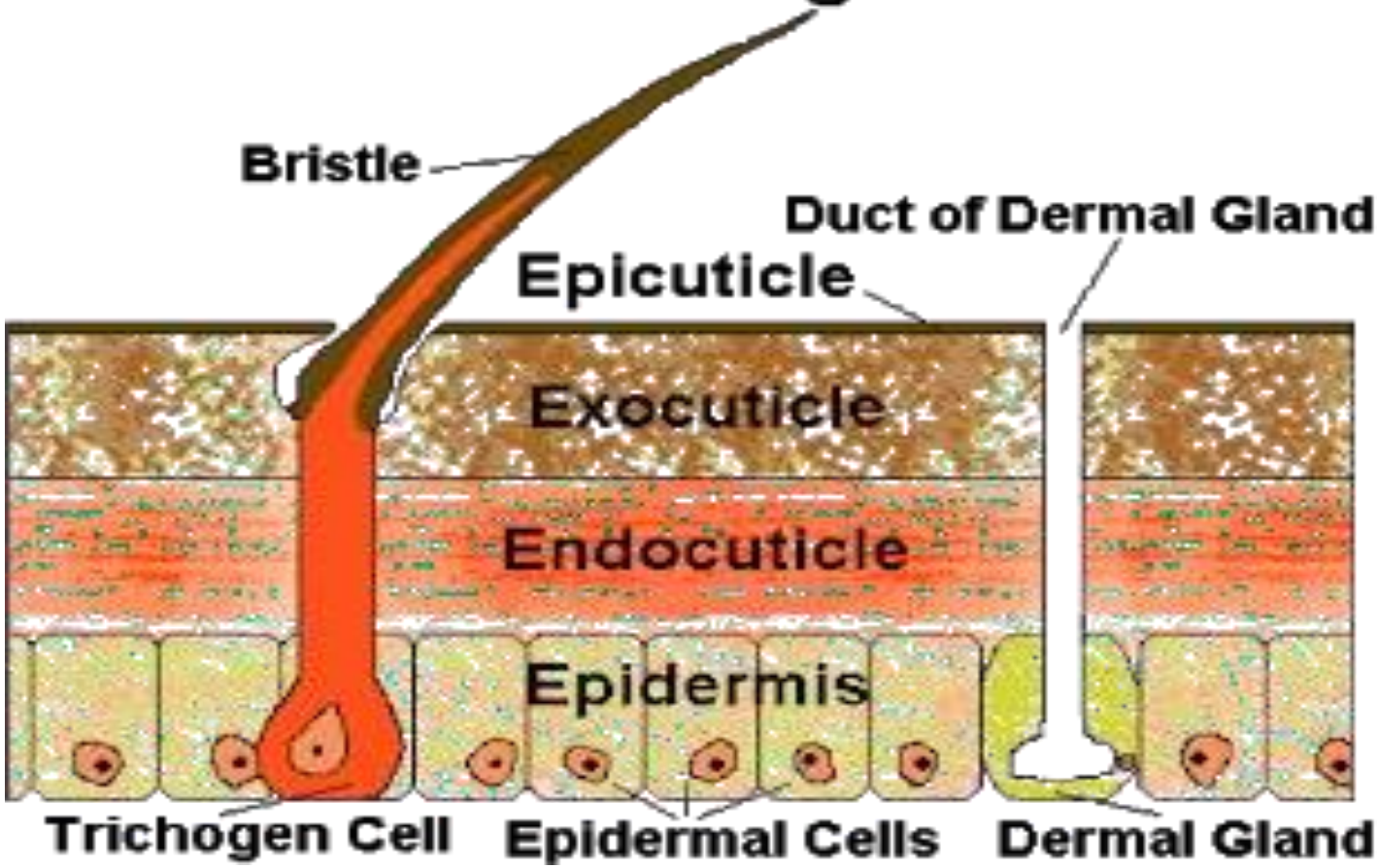
# STRUCTURE AND FUNCTIONS OF INSECT CUTICLE AND MOLTING

**Department of entomology**
**CSA University Kanpur**
**B.Sc. Horti. (IIIrd SEM)**

# STRUCTURE OF INSECT CUTICLE

- The insect exoskeleton is usually called a cuticle.
- The cuticle is the characteristic feature of arthropods and is to a large extent responsible for the success of insects as terrestrial animals.
- The body wall or integument is the outer layer of insect and bends inwards at various points to form supporting ridges or braces.
- The body wall of insect is composed of three principal layers: the cuticle, epidermis and basement membrane.

# The Insect Integument

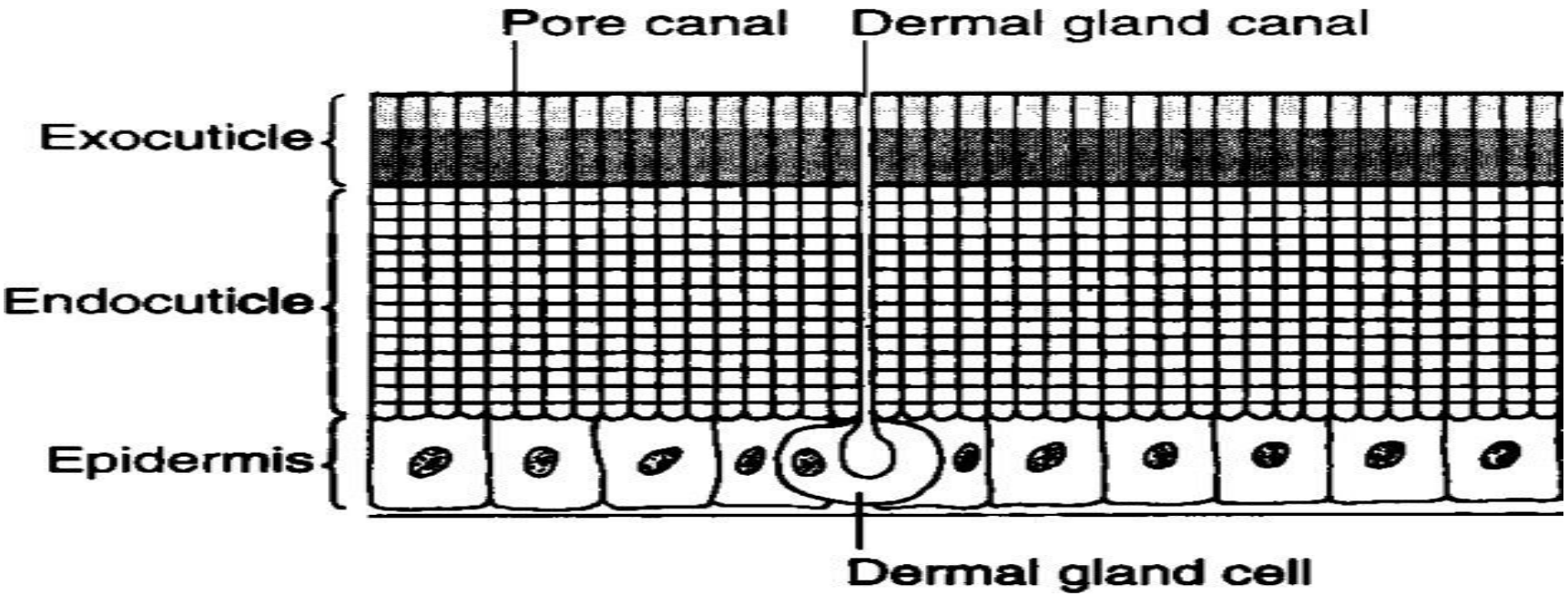


# AN INSECT MOLTING ITS EXOSKELETON

# FUNCTIONS OF THE INSECT EXOSKELETON

- Being a physical structure.
- Protection from physical harm.
- A place of attachment for muscles.
- Serves as an interface between the insect and the environment.
- Serves as the site of sensory input.
- Helps to maintain water balance (the wax layer).
- Helps to prevent the entry of harmful microbes and chemicals.
- Helps to maintain an ionic balance.

# PARTS OF THE EXOSKELETON




**Note :-**

*There are different parts that make up the exoskeleton, as can be seen in the Insect Integument picture above. Basically, the exoskeleton is comprised of a living layer, called the epidermis, and a non-living layer, called the cuticle, and those parts of there very own structures as well.*

- The epicuticle, which is the very top part of the exoskeleton. it is the outermost layer of the exoskeleton, it is very thin, but consists of many different layers.

- There are usually 4 layers within the epicuticle, but the details of the layers vary among the different insect groups, and this it is not always the case. Then there is the chitinous cuticle, which is comprised of the exocuticle and endocuticle, these parts are very thick, and chitinous (meaning tough, protective, and semi-transparent).

- These parts of the exoskeleton serve a structural function, they help the exoskeleton keep its form, these two parts taken together are usually referred to as the cuticle.

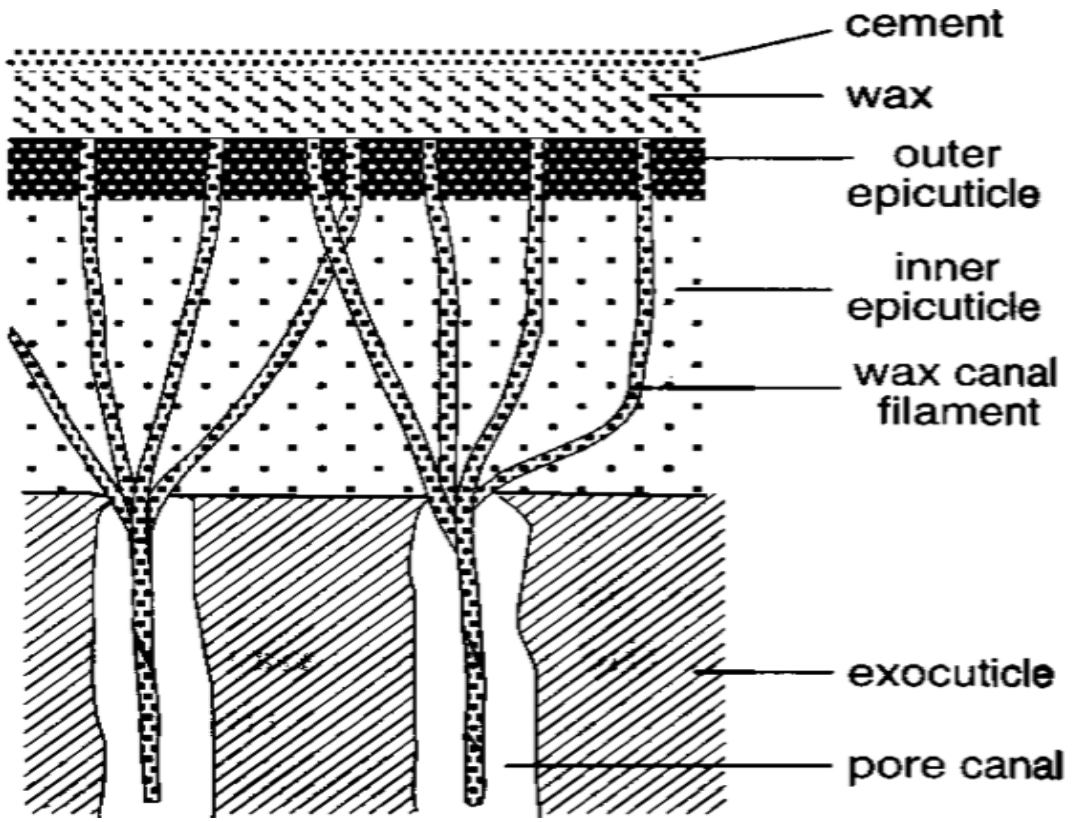
- Cuticle is composed of both chitin and protein, 20-50% being chitin, and the rest being protein. Lastly there is the living portion of the exoskeleton, which is the epidermis and the basement membrane (basal lamina).

- This part of the exoskeleton secretes the cuticle, which ages and rises closer and closer to the top (going through the endocuticle and exocuticle) until it is part of the epicuticle, or the outer, hardened "shell" of the insect.

- The molting of the shell happens when new cuticle pushes the old cuticle out of the way.
- The epidermis has one cell layer, and includes specialized cells, such as gland cells and sensory cells.

- The basement membrane (Basal lamina) underlies the epidermis (hence the name), serves as a molecular sieve, which means that the basal lamina has control over what materials are absorbed by the epidermis, and therefore, what materials go into the creation of the cuticle.

# The Epicuticle




*Lets talk a little bit more about the layers that make up the epicuticle*

# There are four major layers of the epicuticle.

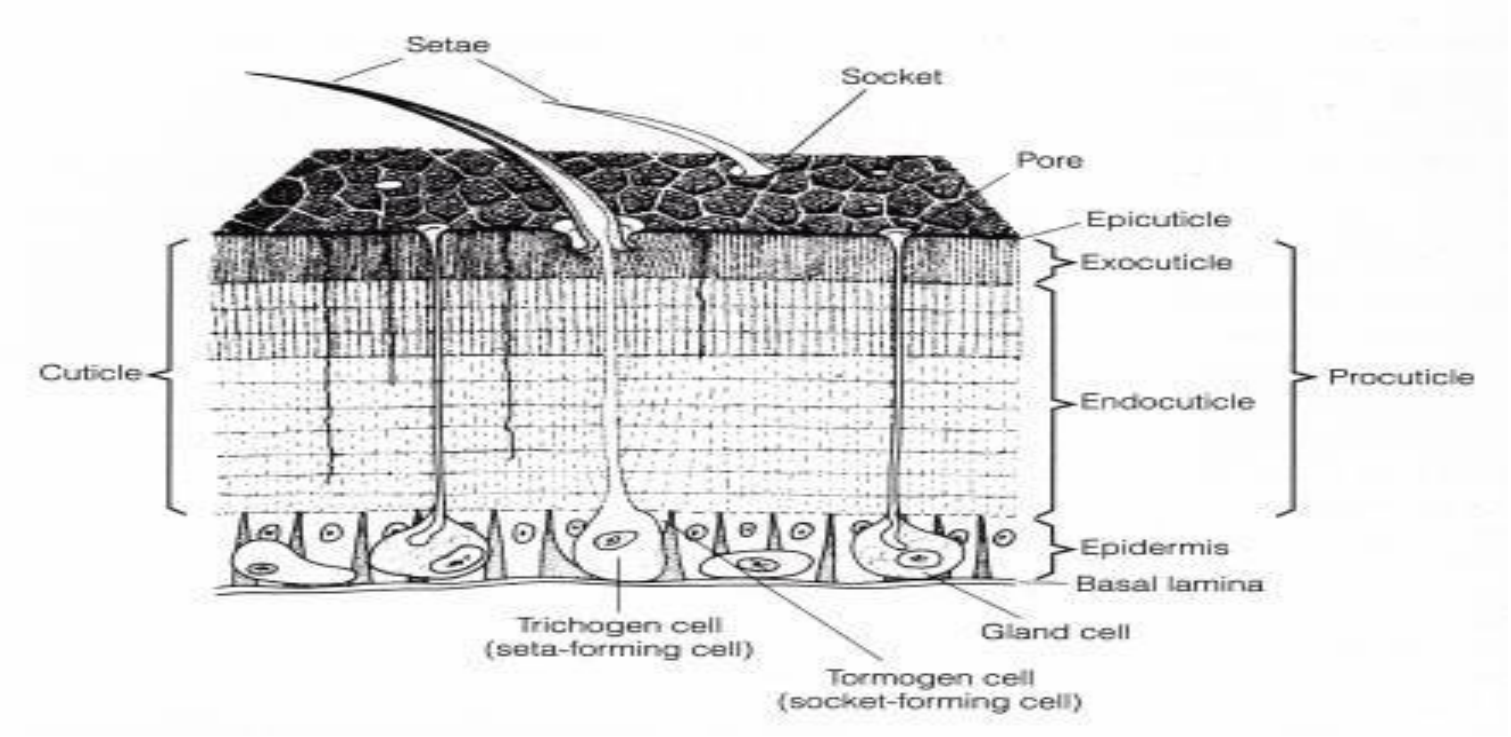
- Cement layer-serves to protect the wax layer.

- Wax layer-serves as water-proofing for the insect.

- Outer epicuticle-serves as a place for muscle attachment, and as protection for the se cuticle against enzymes and may also contribute to the surface pattern.

- Inner epicuticle-May serve as an enzyme reservoir.

# Chitinous Cuticle




**Note :-**

The layers of the chitinous cuticle are derived from the procuticle. Insect cuticle is initially laid down as one material, called the procuticle, and subsequently becomes differentiated into exocuticle and endocuticle, and the differentiation is derived from whether or not, and how the layers are tanned and stabilized. All of these layers are comprised of chitin and protein.

## THE EXOCUTICLE

The exocuticle is tanned (sclerotized, darkened), and it functions for all the physical, hard properties. It is responsible for:-

- Hardness and color
- Muscle attachment
- Rigidity
- Physical protection

## THE ENDOCUTICLE

The endocuticle is usually not tanned (sclerotized, darkened), and its main function is to serve as the flexibility to the exocuticle's rigidity. Otherwise, the insect would be completely hardened and would not be able to move. The endocuticle is usually clear, or colorless, and membranous.

## THE MESOCUTICLE

There is a layer between the exocuticle and endocuticle, called the mesocuticle. not much is known about this layer, and its importance.

## COMPOSITION OF CUTICLE

**I. CHITIN:** It is the main constituent of cuticle, which is Nitrogenous polysaccharide and polymer of N-acetyl glucosamine. It is water insoluble but soluble in dilute acids, alkalies and organic solvents.

**II. ARTHROPODIN:** An untanned cuticular protein, which is water soluble.

**III. SCLEROTIN:** Tanned cuticular protein, which is water insoluble.

**IV. RESILIN:** An elastic cuticular protein responsible for the flexibility of sclerites, e.g., wing articulatory sclerites.

## ENDOSKELETON

Cuticular in growth of body wall providing space for muscle attachment is known as endoskeleton. There are two types

**I. APODEME:** Hollow invagination of body wall.

**II.APOPHYSIS:** Solid invagination of body wall.

## CUTICULAR APPENDAGES

**NON-CELLULAR:** Non-cellular appendages have no epidermal association, but rigidly attached. e.g. minute hairs and thorns.

**CELLULAR:** Cellular appendages have eipdermal association.

### UNICELLULAR

**a. Clothing hairs, plumose hairs**. e.g. Honey bee. Bristles. e.g. flies.

**b. Scales** - flattened out growth of body wall e.g. Moths and butterflies

**c. Glandular seta**. et. caterpillar

**d. Sensory setae** - associated with sensory neuron or neurons

**e.Seta** - hair like out growth (Epidermal cell generating seta is known as **Trichogen**, while the socket forming cell housing trichogen is known as **Tormogen.**

Study of arrangement of seta is known as **Chaetotaxy**).

### MULTICELLULAR e.g.

**Spur** - movable structure

**Spine**- Immovable structure

# Cuticular appendages

## Non-cellular

- no epidermal association
- rigidly attached.
- Eg. minute hairs and thorns

## Cellular

- epidermal association

### unicellular

- Clothing hairs, plumose hairs. e.g. Honey bee
- Bristles. e.g.flies
- Scales - flattened out growth of body wall e.g. Moths and butterflies
- Glandular seta. eg. caterpillar
- Sensory setae - associated with sensory neuron or neurons
- Seta - hair like out growth from epidermis

### multicellular

- Movable e.g. Spur
- Immovable e.g. Spine

# GLANDS

Cuticular glands are either unicellular or multicellular. Following are some of the examples.

**WAX GLAND** - e.g. Honey bee and mealy bug.

**LAC GLAND** - e.g. Lac insects.

**MOULTING GLAND** - secreting moulting fluid.

**ANDROCONIA OR SCENT SCALE** - e.g. moth.

**POISON GLAND** - e.g. slug caterpillar.

**Functions of Body wall**

- Acts as **external armour** and strengthen external organs like jaws and ovipositor
- Protects the organs against physical aberration, injurious chemicals, parasites, predators and pathogen.
- Internally protects the vital organs, foregut, hindgut and trachea.
- Provides space for muscle attachment and gives shape to the body.
- Prevents water loss from the body.
- Cuticular sensory organs helps in sensing the environment.
- Cuticular pigments give colour.

**MOULTING (Ecdysis)**

**Ecdysis** Periodical process of shedding the old cuticle accompanied by the formation of new cuticle is known as moulting or ecdysis. The cuticular parts discarded during moulting is known as **Exuvia**. Moulting occurs many times in an insect during the immatured stages before attaining the adult-hood. The time interval between the two subsequent moulting is called as Stadium and the form assumed by the insect in any stadium is called as **Instar.**

## Steps in moulting

•**Behavioral changes:** Larva stops feeding and become inactive.

•**Changes in epidermis:** In the epidermis cell size, its activity, protein content and enzyme level increases. Cells divide miotically and increases the tension, which results in loosening of cells of cuticle.

•Aolysis: **Detachment of cuticle** from epidermis

•Formation of **Sub cuticular space**

•Secretion of **moulting gel** in the sub cuticular space which is rich with chitinase and protease.

•**New epicuticle formation:** Lipoprotein layer (cuticulin) is laid over the epidermis.

•**Procuticle formation:** Procuticle is formed below the epicuticle.

•**Activation of moulting gel:** Moulting gel is converted into moulting fluid rich in enzymes. This activates endocuticle digestion and absorption.

•**Wax layer formation:** Wax threads of pore canals secrete wax layer.

•**Cement layer formation :** Dermal glands secretes cement layer (Tectocuticle).

**Moulting:**

This involves two steps

•**Rupturing of old cuticle:** Insect increases its body volume through intake of air or water which enhances the blood flow to head and thorax. There by the old cuticle ruptures along prede- termined line of weakness known as **ecdysial-line**

•**Removal of old cuticle:** Peristaltic movement of body and lubricant action of moulting fluid helps in the removal of old cuticle. During each moulting the cuticular coverings discarded are the cuticular of legs, internal linings of foregut and hindgut and trachea.

•**Formation of exocuticle**:

The upper layer of procuticle develops as exocuticle through addition of protein and tanning by phenolic substance.

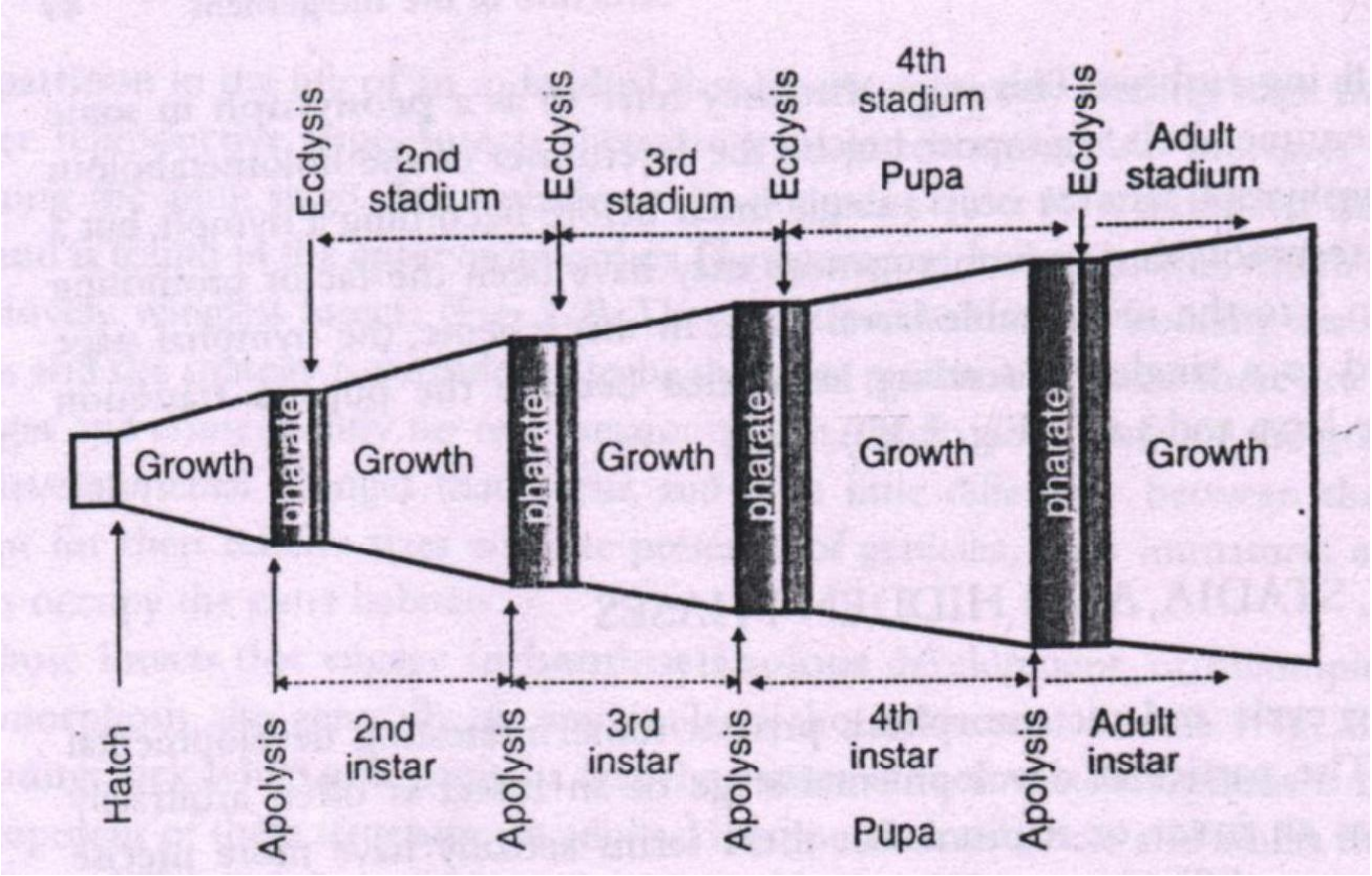
•**Formation of endocuticle:**

The lower layer of procuticle develops as endocuticle through addition of chitin and protein. This layer increases in thickness.

**Control of Moulting:**

It is controlled by endocrine gland like prothoracic gland which secrete moulting hormone. Endocrine glands are activated by prothoracico-tropic hormones produced by neurosecretory cells of brain.

# STAGES OF MOULTING IN INSECT



# Thank You...

**Dr. Omendra Sharma**