Subject: Fundamental of Entomology
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STRUCTURE AND FUNCTION OF INSECT CUTICLE

Body wall or Integument of insect

The outer most layer of insect covering of the whole insect body. It forms a composite structure which forms the skeleton of the insect body and ectodermal in origin. It provides area for muscle attachment; protection from desiccation, physical /mechanical injuries and shape, strength to the body and its appendages.

Body wall of insect consists of 3 layers

1. Cuticle
2. Epidermis (or) hypodermis
3. Basement membrane

1. Cuticle:

It is outermost thick layer of integument secreted by epidermis. It is divided in to two layer

A) **Epicuticle**

B) **Procuticle**

A. Epicuticle: It is a thin outermost layer varying in thickness from 1-4μ. Chitin is absent in epicuticle. epicuticle consists of the following 4 layers.

1. **Cement layer** :

It is secreted by dermal glands and is composed of lipoprotein. It protects the body from external damage. It is give the size and shape of insect body.

2. **Wax layer:**

It is prominent layer , 0.25μ in thickness, consisting of long chain hydrocarbons, esters of fatty acids and alcohols. It is water proof layer preventing water loss from the body

3. **Polyphenol layer:**

It is a non-static layer containing various types of phenols which are mainly used in the formation of the proteins. It is resistant to acids and organic solvents.

4. **Cuticulin layer:**

It is an amber coloured thin layer over the surface of the epidermis which is strengthened by outer polyphenol layer.

B. Procuticle:

It is differentiated in to **exo** and **endocuticle** after sclerotization process.

1. **Exocuticle**

It is darkly pigmented, hard and sclerotized. It offers rigidity to the cuticle and consists mainly chitin and a hard protein called **sclerotin**.

2. **Endocuticle**

It is soft, light coloured and unsclerotized. It contains more chitin but lacks hard protein sclerotin.

Pore canals: These are numerous fine vertical channels traversing both exo and endocuticle measuring **< 1µ (0.1 – 0.15µ)** in diameter. They run perpendicularly from epicuticle through out the length of the cuticle. They are useful in transportation of cuticular material and enzymes to the outer pro and epicuticle parts.

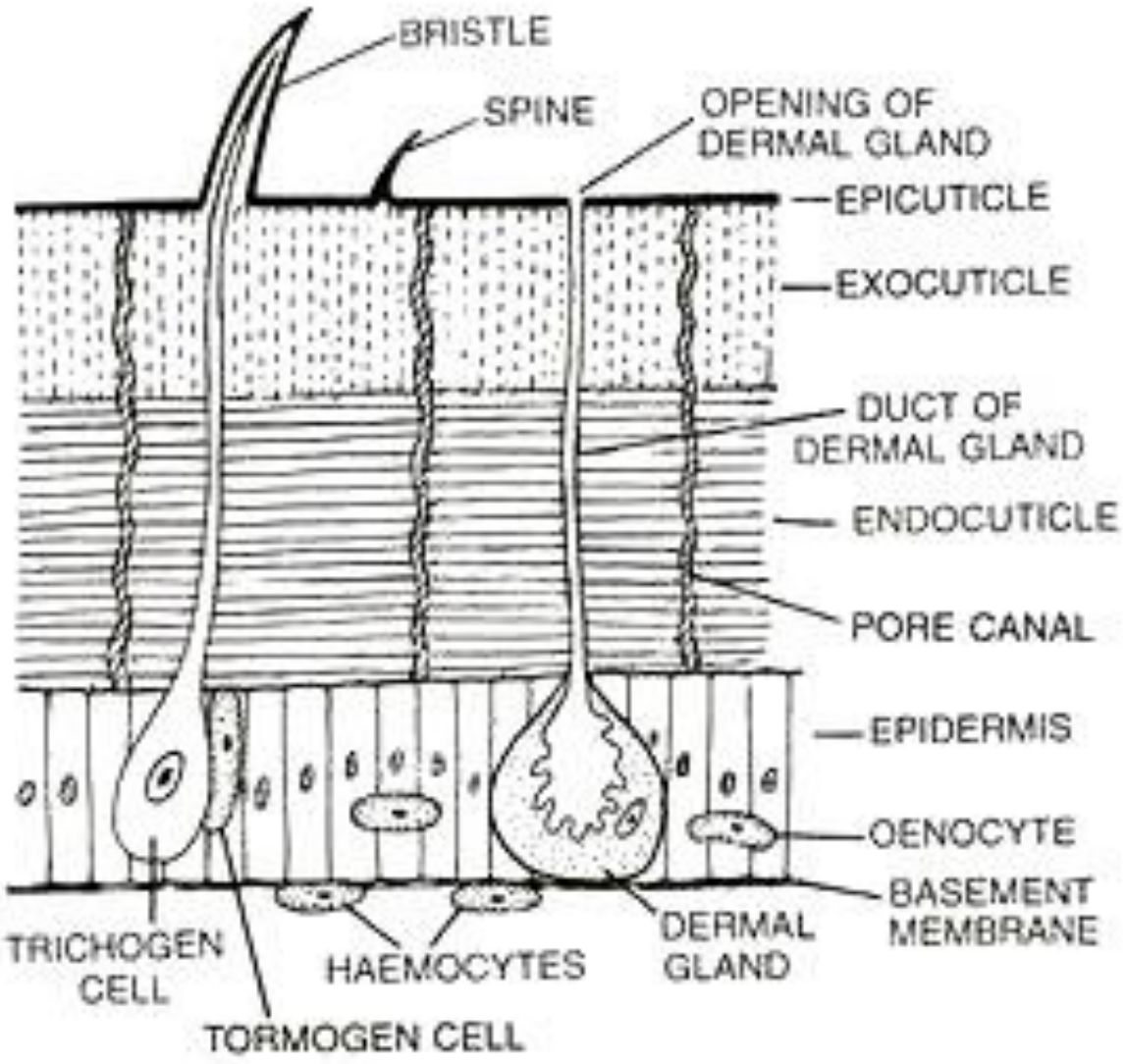

Fig. 7A.20. T.S. Body wall of Cockroach.

Two major components of insect cuticle are **Chitin** and **Proteins**

i). Chitin : It is a **nitrogenous polysaccharide.** $(C_8H_{13}O_6N)_x$. It accounts for 25-60 per cent of the dry weight of the cuticle. It is named by Odier in 1834.It consists of high molecular weight polymer of anhydro-**N-acetyl glucosamine** residues joined by **β-glycosidic linkages**. It is embedded with proteins in the procuticle to form glycoproteins. It is insoluble in water, alcohol, organic solvents, dilute acids and concentrated alkalies, but **soluble** only in **concentrated mineral acids** and **sodium hypochlorite**.

ii). Proteins: Cuticle has 3 types of proteins

(a) Arthropodin: It is soft water soluble protein present in endocuticle. The conversion of arthopodin in to sclerotin is known as **sclerotization or tanning.**

(b) **Sclerotin:** It is also called **tanned protein** which is **amber** coloured and present only in exocuticle.

(c) **Resilin :** It is a rubber like elastic protein which is **colourless** and present in joints such as wing hinge ligaments, leg joints, clypeolabral joints or suture and tergosternal joints

2. Epidermis or Epidermal Cell

It is an unicellular layer formed from polygonal cells which modifies in to cuboidal or columnar during the process of moulting. These cells consists of well developed nucleus and other cytoplasmic contents. Adjacent epidermal cells are held together by means of certain cytoplasmic processes**.**

All the epidermal cells are glandular and secrete cuticle and the enzymes involved in production and digestion of old cuticle during moulting. The epidermal cells get differentiated in to following types based on the function they perform and may modify in to

a) **Dermal glands** producing cement layer

b) **Trichogen cell** producing hair like seta or trichome.

c) **Moulting glands** secreting moulting fluid which digests the old cuticle

d) **Peristigmatic glands** around the spiracles in case of Dipteran larvae

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3. **Basement membrane**:

It is the basal part of the body wall formed from degenerated epidermal cells and appear as non-living amorphous (shapeless) granular layer of integument. It is about 0.5μ in thickness and consists of fibrous **protein, glycosaminoglycans** which are polymers of disaccharides. The basement membrane forms a continuous sheet beneath the epidermis, where muscles are attached and become continuous with **sarcolemma** of the muscles.

Cuticular/ Integumental modifications

Cuticle/Integument is modified in to external outgrowths or internal invaginations.

A. Cuticular Out growths: They are divided into **cuticular appendages** and **cuticular processes** depending on the presence or absence of membranous articulations.

I. **Cuticular appendages**: These are the outgrowths of the cuticle / integument connected with it by means of a membranous joint . They arise from modified epidermal cells. These are classified in to **setae and spurs.**

(1) **Seta/ Macrotrichia:** Commonly known as hairs and arise from a cup like alveolus or pit. Setae are hollow structures developed as extension of exocuticle and are produced by a single enlarged hypodermal cell called ' **trichogen**' cell. Articular membrane is usually produced by a second hypodermal cell called '**tormogen**' cell. Setae have role of taxonomic importance and vary with species to species.

(2) **Spurs :** Occur on the legs of many insects and differ from setae in being **multicellular** in origin.

II. **Cuticular processes**: They have no membranous articulation. They are of two types

(1). **Microtrichia / fixed hairs / aculei:** These are minute hair like structures found on wings of Mecoptera and certain Diptera.

(2). **Spines :** Outgrowths of the cuticle which are more or less thorn like in form.

Spurs Spines Cuticular appendages Cuticular processes Movable, multicellular structures and thick walled

B. Culticular invagination:

The body wall or cuticle of the body wall invaginate internally and grow in to definite structures which are of two types.

Moulting

The insect cuticle is hard and forms unstretchable exoskeleton and it must be shed from time to time to permit the insects to increase their size during growth period. Before the old cuticle is shed new one has to be formed underneath it ,this process is known as moulting

Moulting is a complex process which involve 3 process

1) **Apolysis** 2. **Ecdysis** 3) **Sclerotization**

1) Apolysis : [Apo = formation ; Lysis = dissolution] The dissolution of old cuticle and formation of new one is known as apolysis.

2) Ecdysis : The stage where the insect has both newly formed epi and procuticle and old exo and epicuticle is known as pharate instar. The ecdysial membrane starts splitting along the line of weakness due to muscular activity of the inner developing insect and also because of swallowing of air & water resulting in the

distention of the gut. The breaking at the ecdysial membrane is also due to the pumping of blood from abdomen to thorax through muscular activity. After the breakage of old cuticles which is known as exuviae, the new instar comes out bringing its head followed by thorax, abdomen and appendages.

3) Sclerotization : After shedding of old cuticle the new cuticle which is soft, milky white coloured becomes dark and hard through the process known as tanning (or) sclerotization. The process of hardening involves the development of cross links between protein chains which is also known as sclerotization. This tanning involves the differentiation of procuticle in to outer hard exocuticle and inner soft endocuticle. Three types of hormones involved in the process of moulting which are as follows

JH : Juvenile Hormone :Produced from corpora allata of brain that helps the insects to be in immature stage.

MH : Moulting hormone: Produced from prothoracic glands of brain that induces the process of moulting

Eclosion Hormone: Released from neurosecretory cells in the brain that help in the process of ecdysis or eclosion.

Functions of Body wall

i. It provides the Structure, size and shape of the insect body.
ii. It provides the Water resistance/ balance of insect.
iii. It Protects the insect organs against physical harm.
iv. Provides the space for muscle attachment.
v. It helps to prevent the entry of harmful microbes and chemicals.
vi. It serves as interface between insect and environment.
vii. It helps to maintain an ionic balance in insect body.
viii. It serves as the site of sensory input.