INSECT INTEGUMENT

(Source: A TEXT BOOK OF ENTOMOLOGY by HERBERT H. ROSS, *Chapman & Hall Limited, London*)

The body wall or integument is the surface layer of ectoderm which surrounds the body and appendages. It is a complex organ containing many kinds of external hairs and sense receptors and internal processes of many types for attachment of muscles.

The body wall has three primary functions: (1) the protection of the organism from outside forces, such as evaporation (insects' most important enemy), inimical organisms, and disease; (2) the reception of external stimuli through specialized sensory hairs, processes, or areas; and (3) acting as the agent of the locomotor system, since the motivating muscles of the legs, wings, and movable sclerites are attached to the exoskeleton. In addition, the integument cannot stretch and in immature insects must be shed regularly to allow growth. These functions are accomplished by a surprisingly simple cellular structure.

STRUCTURE OF INTEGUMENT. The body wall consists primarily of a layer of cells, the *epidermis,* and an outside covering, the *cuticle,* which lies on top of and is secreted by the epidermis. Formation of cuticle is the chief function of the epidermis. The cuticle forms a mechanical protective layer whose properties contain the key to much insect physiology.

EPIDERMIS. The cells comprising most of the epidermis are simple in type, with large nuclei, united by an indistinct basement membrane. Certain cells of this layer, however, are highly specialized and produce hairs and other surface structures of peculiar types.

CUTICLE. The cuticle is made up of a relatively thick inner layer, the *procuticle,* and a very thin outside *epicuticle.*

The epicuticle is usually only a micron thick but seems to be the layer which gives the entire cuticle its property of impermeability. The epicuticle may be composed of several layers. The inner layer is composed chiefly of *cuticulin* (possibly a lipoprotein), and the outer layers usually contain waxes and other organic substances.

The procuticle is composed of *chitin,* proteins and other compounds. Chitin, the distinctive component of the procuticle, is susceptible to some acids but is resistant to alkalis. The procuticle may be differentiated into a more or less definite outer layer, the *exocuticle,* and an inner layer, the *endocuticle.* The exocuticle is often impregnated with cuticulin and color substances such as carotin and melanin. These substances strengthen and color the soft chitin and give the impregnated areas hardness and much greater impermeability. Such strengthened areas are called "sclerotized" and may contain as little as 20 per cent chitin. Soft areas, which may consist of as much as 80 per cent chitin, are called "membranous".

The procuticle has the form of a fairly elastic jelly, traversed by extremely fine openings or pore canals. The pore canals run from the epidermal cells to or into the epicuticle but not completely through it. They are believed to be filled with cytoplasmic filaments, which, if it is true, would endow the cuticle with a certain amount of sensitivity. In very thick, hard cuticle, as on the elytra of beetles, the cuticle may be laid down as successive series of minute parallel rods, which give the structure additional strength.

SPECIALIZED CELLS. Certain of the epidermal cells have special functions, either the secretion of fluids or the formation of definite structures such as hairs.

DERMAL GLANDS. Single epidermal cells or groups of cells develop into large cells which produce various secretions. These cells are connected to the exterior by a duct running through the cuticle. Secretions of different types are produced by a variety of these dermal glands, including wax (often forming definite external patterns), many types of ill-smelling scent compounds, and irritating skin poisons.

Certain of the dermal glands (formerly thought to produce molting fluid) are believed to secrete the outer waxy covering of the epicuticle.

SETAE. Most of the flexible hairs or bristles of insects are formed by epidermal cells called *trichogen cells.* At the time of the actual formation of the hair, the trichogen cell is large and nucleated and has a duct which passes through the cuticle to the surface. From this point the products of the cell build up the hair. Closely associated with the trichogen cell is a *tormogen cell,* which forms a socket (usually flexible) around the base of the hair. A hair or bristle of this histological origin is called a *seta;(pl., setae).* The parent cells may degenerate after the seta is formed.

Specialized setae originate in the same manner. These include scales, poison hairs, and sensory setae.

COLOR. The great majority of insect colors are located in the epidermis or its vestiture. Insect colors are of two types: pigments and structural colors.

Pigments such as carotin and melanin are deposited in the exocuticle and produce different colors by selective action on different wavelengths of light. These pigments are responsible for practically all nonmetallic insect colors and a few metallic ones.

Structural colors are produced by extremely delicate and minute vanes which break up light into various wavelengths by reflection and interference. These vanes may be produced by the epicuticle, as is the case with many beetles, especially those with metallic colors. The most common example of this occurs in the moths and butterflies. In these the wings are covered with scales (modified setae), and the scales bear ribs running the length of the scale. Studies with the electron microscope have shown that each rib is composed of several parallel extremely thin fenestrate vanes. Studies on the tropical *Morpho* butterflies indicate that ribs of more simple structure produce nonmetallic colors and those ribs of great complexity produce the dazzling iridescent colors for which these butterflies are famous.

MOLTING. Although in immature insects the cellular epidermal layer of the body wall can grow and expand, the cuticle does not grow or stretch. To allow increase in body size, therefore, an insect must produce periodically a larger new cuticle and shed the old. This phenomenon of shedding the old "skin" is termed *molting* or *ecdysis*. It is one of the most important physiological processes of insects. The actual act of molting is preceded by the formation of the new cuticle under the old. The following steps in this process have been observed.

1. First the old cuticle is loosened to form a small space between it and the epidermal cells. Simultaneously the epidermal cells may multiply.
2. Enzymes are secreted into the space below the cuticle and begin to digest it.
3. The epidermal cells begin to secrete the new cuticle.
4. The epidermal cells apparently continue to absorb the digested old cuticle and use this material in adding to the new cuticle. Up to 85 per cent of the old cuticle may be digested.
5. When the new cuticle is otherwise completed certain enlarged dermal glands discharge their contents over the outside of the new cuticle. This secretion forms the final waxy layer of the epicuticle.
6. When the new cuticle is fully formed, the insect has to break out of the old one. The initial rupture is made along a mesal line of weak cuticle which typically extends along the dorsum of the thorax. This rupture is caused by the pressure of the blood. The insect contracts the abdomen, forcing the blood into the thorax and causing it to bulge until the cuticle breaks along the line of weakness. The insect may swallow air (or water, if aquatic) to aid in this process. The insect then wriggles and squirms free from the old skin. At or before this time, the molting fluid is usually reabsorbed by the body, so that at the time of molting the area between the old and new skins may be dry.
7. For a short period after molting the new cuticle can be stretched, at least in the nonsclerotized (membranous) portions. During this short period, therefore, the insect stretches the cuticle to accommodate expected size increase of the body before the next molt. This is done first by swallowing air or *water* to increase the internal volume and then by increasing the blood pressure in first one region and then another, thus "blowing up" the regions and stretching the integument. When the blood pressure is reduced, the stretched integument *does not shrink again* but contracts into a series of small folds or minute accordionlike pleats. In larvae with no sclerotized body areas, these folds may occur over the entire body. In insects with definite sclerotized plates, the folds occur in the membrane between the sclerites. As the body increases in size with subsequent growth, the integument

increases by a simple expansion of the folds. When this avenue for increase is exhausted, the insect must molt again to allow further size increase. The entire active molting process may take only a few seconds, or it may require an hour or more.

8. After its complete formation, the new skin becomes impermeable to many substances, especially water, and is locally sclerotized and colored to assume its normal condition. In many groups, such as the grasshoppers, this occurs just after the stretching process which follows molting. In other cases, for instance in adult Trichoptera, Lepidoptera, and many Hymenoptera, this occurs before molting while the adult is still incased in the pupal skin. It was thought formerly that hardening and coloring of the skin were a result of its exposure to air after molting, but experiments on partial dissection have shown this not to be true.

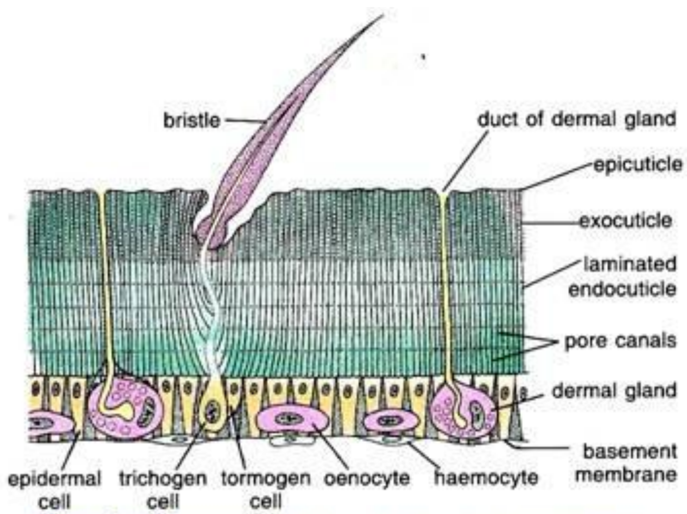
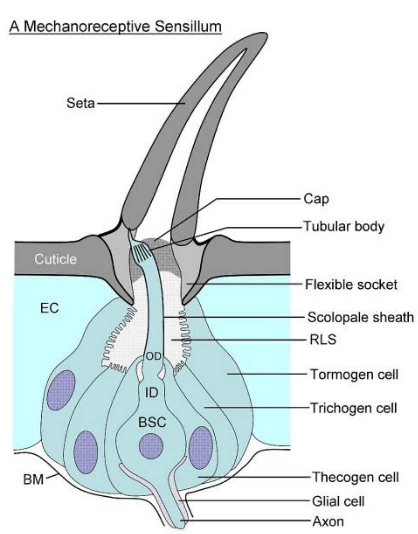
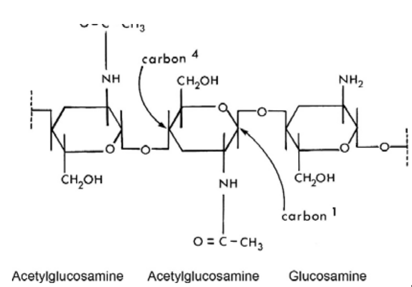


Fig. 73.10. *Periplaneta*. T.S. of body wall representing integument of insects in general.





Chitin Structure