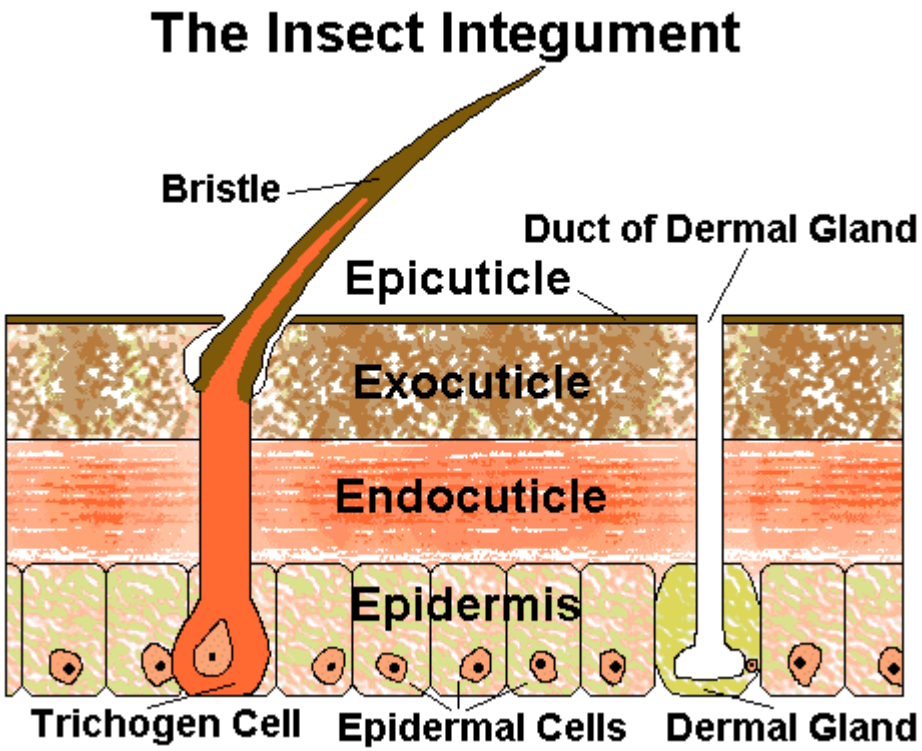
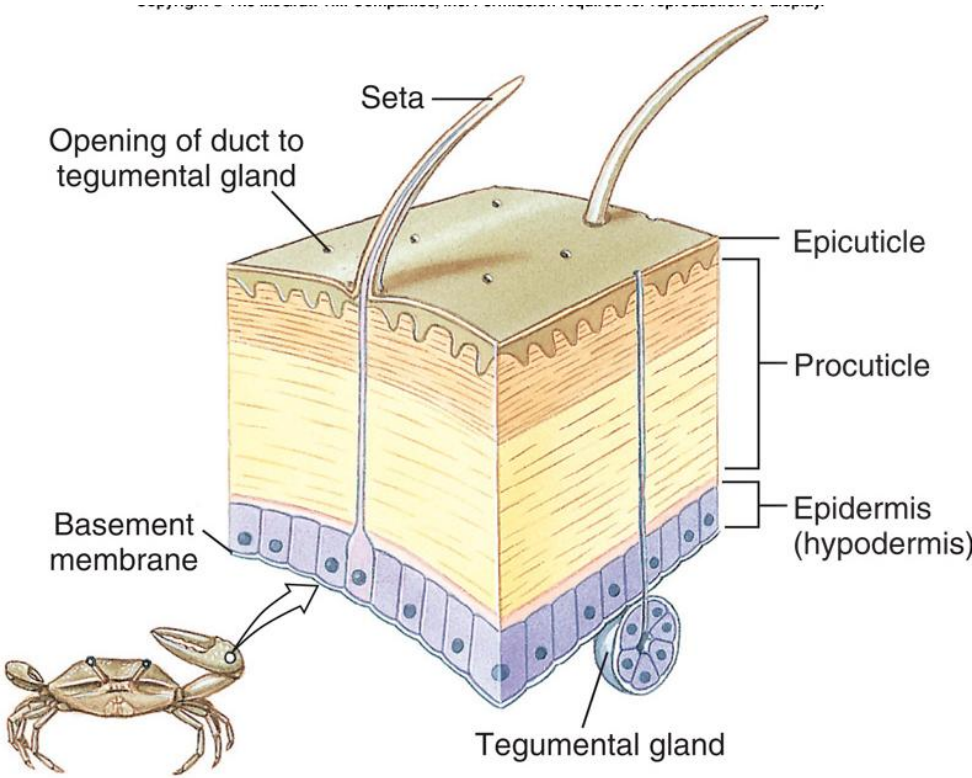
Insect integument

Difference between insects and other arthropods integument





Movie before lecture

- https://www.youtube.com/watch?v=fZkNlvKdK3g

- https://www.youtube.com/watch?v=BXpwhUCDzc8

What is integument

- The **integument** is the protective outer covering of the body
- It is the outer layer of the insect, comprising the
  - epidermis
  - cuticle
  - Basement membrane

Epidermis

- It is the outer cell layer of the insect. It is **one cell thick**, but the cell densities and cell depth changes during development.
- This specialized regions are known as plasma membrane plaques and they are the sites of **secretion of the outer epicuticle and of chitin fibers.**
- the epidermal cells form **pore canal of the cuticle**

Epidermis

- All epidermal cells are glandular in the sense.
- They **secret cuticle and the enzyme** concerned in its production and its digestion at the time of molting.
- Some epidermal cells have additional specialized **glandular functions**.
- Trichogen, tormogen cells, dermal gland cells

Basal lamina/Basement membrane

- The epidermal cells stand on a basal lamina or basement membrane.
  - The primary components of it are
    - fibrous protein,
    - collagen,
    - glycoprotein and
    - glycosaminoglycans.
  - The basal lamina acts as a **molecular sieve**.
  - It forms a **sheet** where muscles are attached.
  - It may be produced by the epidermal cells, but plasmatocytes also contribute to it.

Basic structure of cuticle

- It is differentiated into two main regions:

1- Inner region **Pocuticle**, characterized by the presence of chitin and forming the block of the cuticle. (200 micrometer)

2- Outer thin **epicuticel**, which don't contain chitin.(1-4 micrometer)

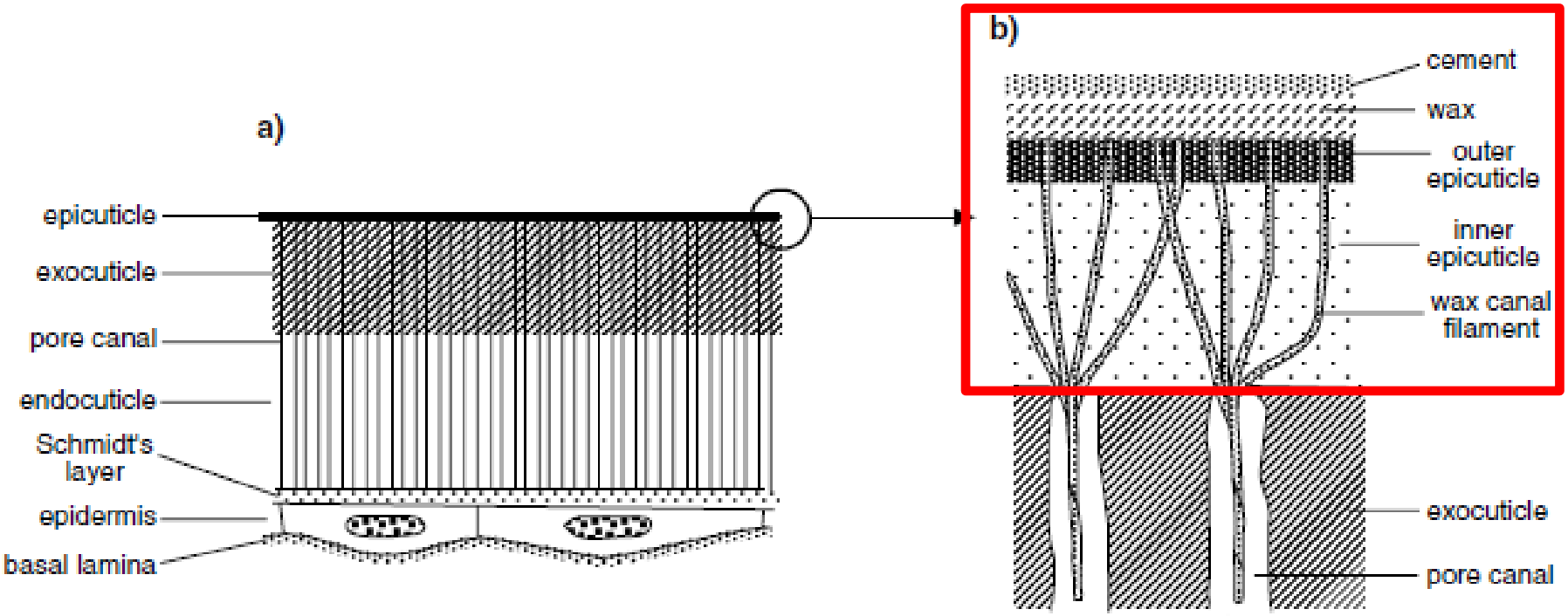


Fig. 16.2. Basic structure of the integument: (a) section through mature integument; (b) section through the epicuticle at greater magnification.

Epicuticle

Made up of several layers

1. Inner epicuticle
2. Outer epicuticle
3. Wax
4. Cement

1. **Inner epicuticle**
    1. Thickest layer **of 0.5 to 2micron**
    2. Immediately outside the procuticle
    3. Chemically complex and consists of **tanned lipoprotein**
    4. It contains phenolic substances and phenoloxidase (perform tanning)
2. **Outer epicuticle** (also called **cuticulin** due to its material)
    1. Thin layer of **15nm**
    2. It has highly **polymerized lipid and protein**
    3. First-formed layer at each molt and protect procuticle from molting enzymes.
    4. **inextensible**

3- Wax layer

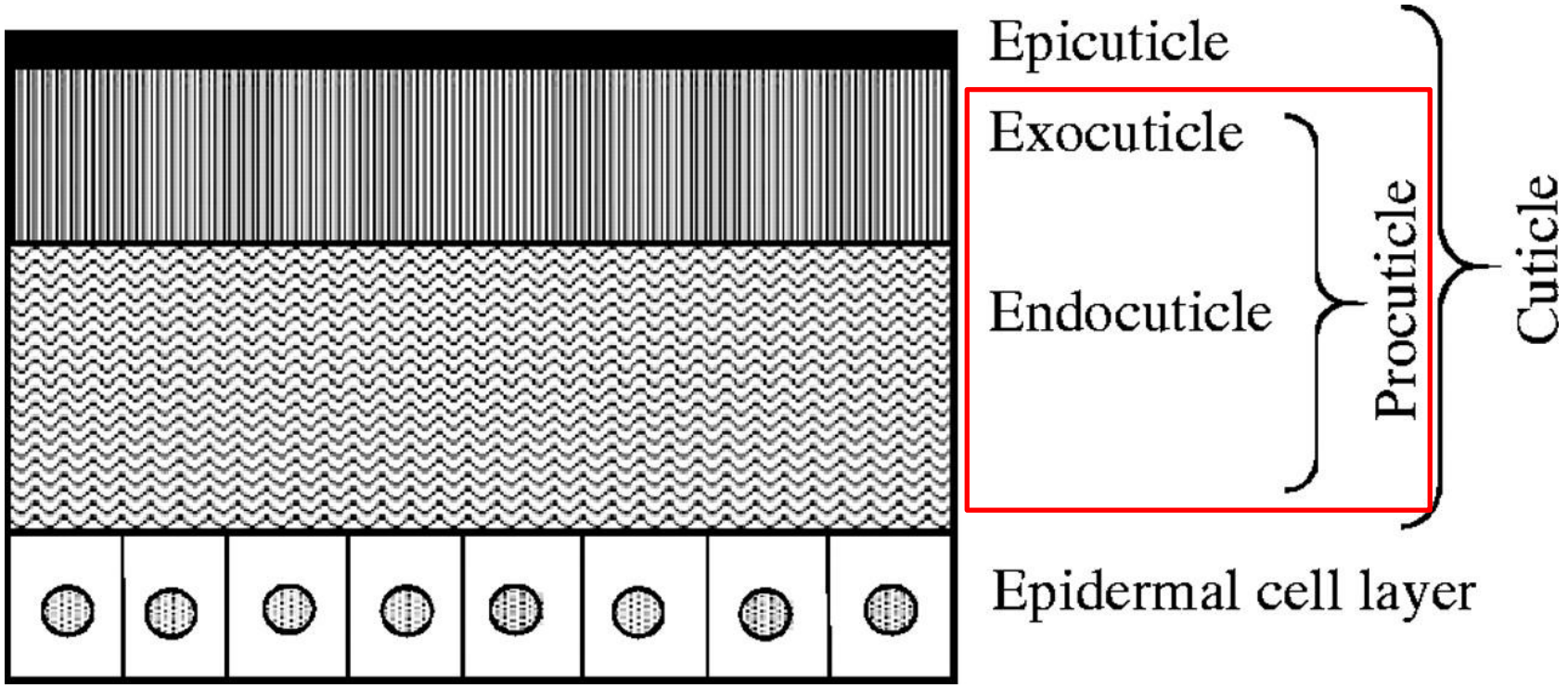
1. Present outside of **epicuticle**
2. Variable thickness
3. Water proofing the cuticle
4. Synthesized by **oenocytes**
5. Contain different compounds
   - hydrocarbons with odd number of carbon atoms,
   - 90% wax,
   - aliphatic alcohols with even number of carbon atoms (12 to 34),
   - fatty acids
6. Honey bees produce wax. Wax is secreted by epidermal cells on the ventral surface of abdominal segments 4 to 7.

- Wax is used by honey bees to protect themselves against water loss through the integument and in the construction of combs. The major fractions of the cuticular wax were analyzed by gas-liquid chromatography and were shown to be qualitatively similar to those of comb wax (Blomquist et al. 1980). However, the composition of the cuticular wax of the honey bee is quantitatively different from that of the comb wax.

- The major component of the cuticular lipids is hydrocarbon, which comprises **58% of this wax**.
- In contrast, hydrocarbon comprises **only 13-17% of the comb wax, and monoester is the largest component** (Tulloch 1971). Comb wax is produced by four pairs of glands within the abdomen while cuticular wax is likely produced by epidermal cells of the integument

4- Cement layer

1. Very thin layer outside most of the wax
2. Consisting of **mucopolysaccharide** associated with lipids
3. Protect underlying wax
4. Not produced by all insects (e.g., honey bee)
5. It is secreted by gland cell.

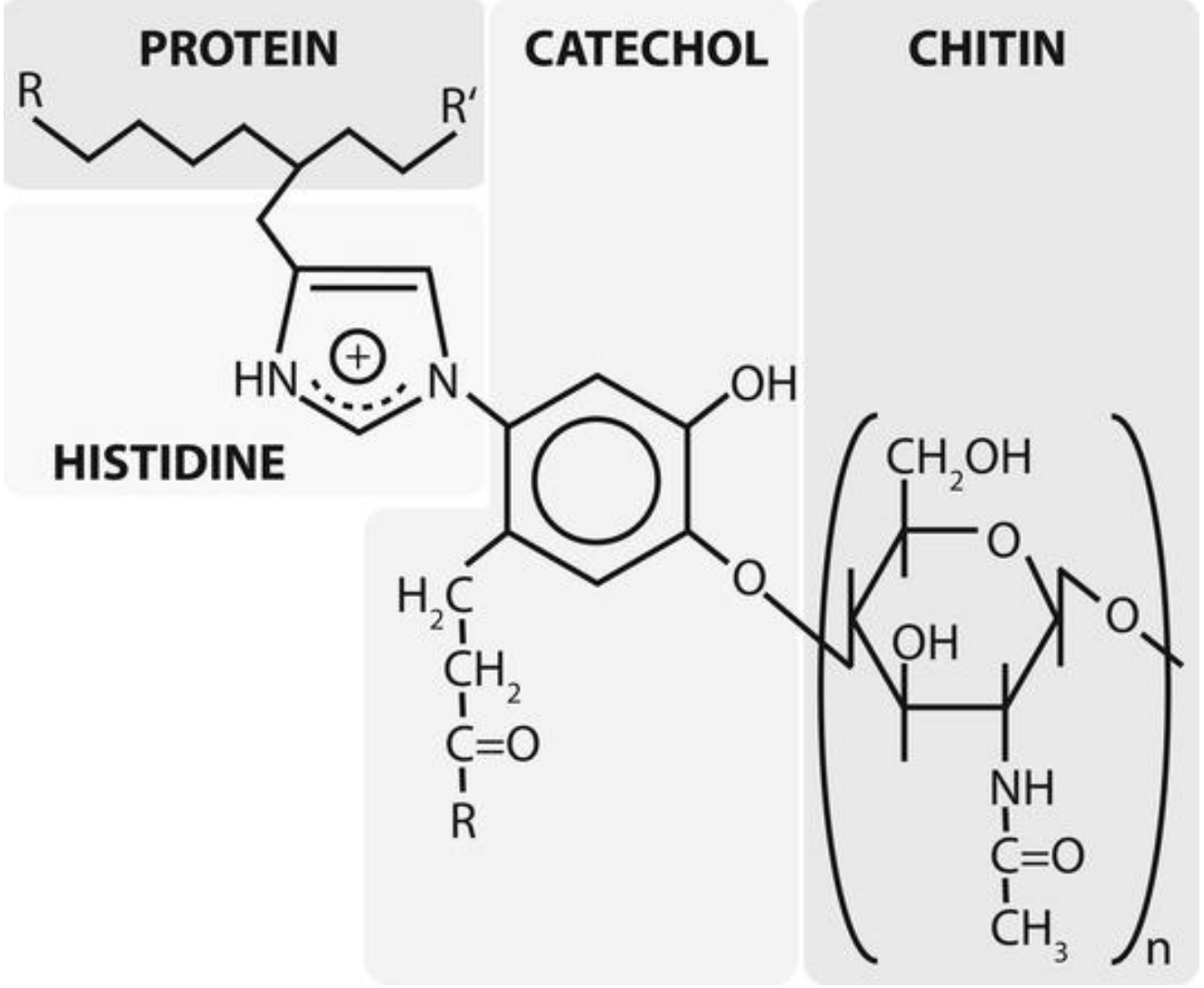

Epicuticle
Exocuticle
Endocuticle
Procuticle
Cuticle
Epidermal cell layer

Procuticle

- Chitin commonly comprising 20-50% of insect dry weight.
- Cuticle bound to protein.
- the outer part become hard and rigid to form **exocuticle**,
- the inner undifferentiated part is called **endocuticle**.
- Between of the two there maybe a region of hardened, but not fully darkened cuticle (which contain stain) is called **mesocuticle**.

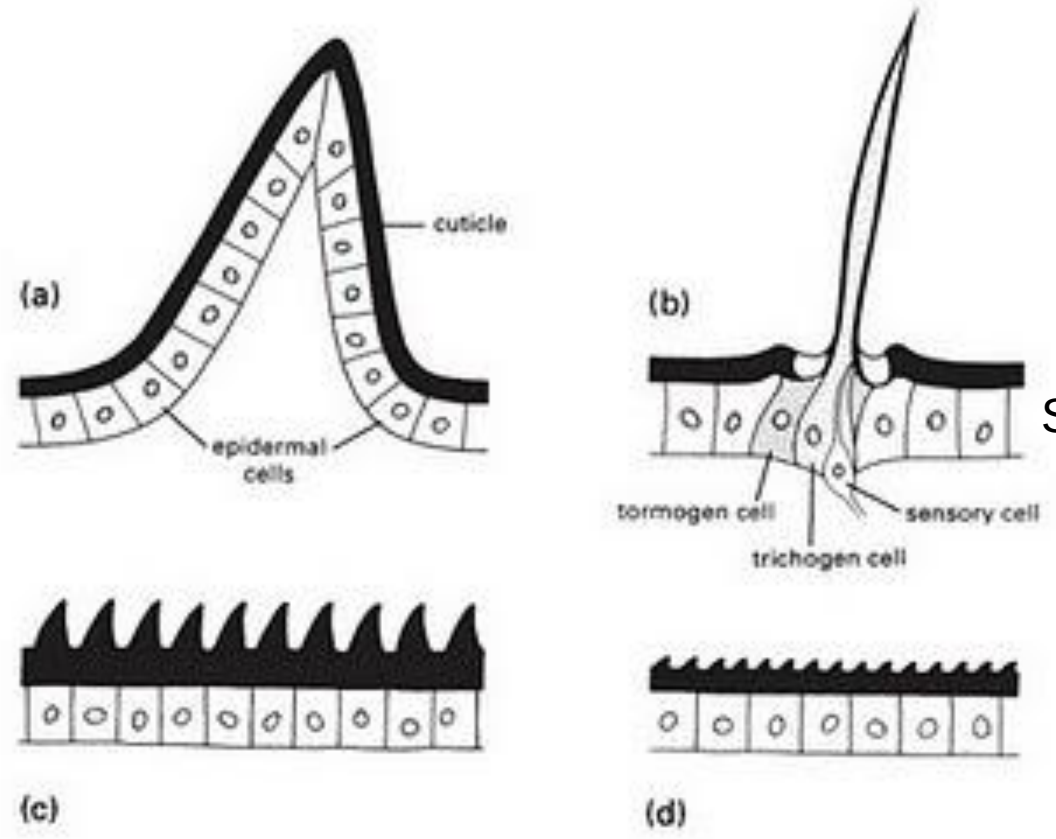
What is Chitin?

- Chitin is a polysaccharide made up largely of **N-acetylglucosamine** residues.
- The sugar residues are linked by **1-4 β linkage**,
- Adjacent chitin chains are held together by hydrogen bonds to form microfibrils.



Chemical structure of poly-N-acetyl-d-Glucosamine (chitin) linked to proteins in insect cuticles through catecholamines and histidine moieties (modified after Schaefer et al. 1987)

Cuticular appendages and processes



Seta (Macrotrichia)

Microtrichia

Fig. 2 The four basic types of cuticular protuberances: (a) a multicellular spine; (b) a seta, or trichoid sensillum; (c) acanthae; and (d) microtrichia.

<table>
<tr><th colspan="2">Cuticular Appendages are</th><th>Cuticular processes are</th></tr>
<tr><td colspan="2">Outgrowths</td><td>Outgrowths</td></tr>
<tr><td colspan="2">Connected with cuticle with membranous joints.</td><td>Connected with cuticle rigidly. No membranous joints.</td></tr>
<tr><td colspan="2">They arise from epidermis cells.</td><td>Don’t arise from epidermis</td></tr>
<tr><td>Unicellular appendages</td><td>Multicellular appendages</td><td rowspan="3">Cuticular processes are either:
1. Microtrichia
2. Spines</td></tr>
<tr><td>Involves a single epidermal cell</td><td>Involves more than one epidermal cells</td></tr>
<tr><td>Setae (Macrotrichia)</td><td>Multicellular appendages are either:
A) Spines B) Spur</td></tr>
</table>

Cuticular Appendages are		Cuticular processes are
Known as hairs	**Spines:** Immoveable appendages, present on tibia.	**Microtrichia**: fixed hairs, hair like structure present on wings of Mecoptera and Diptera
Arise from a cup like pit which is known as **alveolus**	**Spur:** Moveable appendages, present at the end of tibia.	
Alveolus: Cavity at the base of setae	……	**Spines:** Thorn like structure, harder than microtrichia
Setae is a hollow structure and develop from **trichogen cells**	……	
Cuticular membrane is produced by **tormogen cells**	……	……
Imp. in systematics particularly [thysanura, diptera, lepidoptera, diplura(larvae)]	……	……
Arrangement of setae is known as **chaetotaxy**		

Function of Exoskeleton

- Inhibits water loss from body
- Prevents damage by chemicals and injury
- Protects against infection
- Provide shape and structure
- Muscles attachement for locomotion
- Innerlining of trachea, foregut and hindgut

Cuticular extensions

- Insects are well endowed with cuticular extensions, varying from fine and hair-like to robust and spine-like. Four basic types of protuberance , all with sclerotized cuticle, can be recognized on morphological, functional, and developmental grounds:
-

  1. Spines are multicellular with undifferentiated epidermal cells.

  2. Setae, also called hairs, macrotrichia, or trichoid sensilla, are multicellular with specialized cells;

- 3. Acanthae are unicellular in origin.

  4. microtrichia are subcellular, with several to many extensions per cell

Cuticular extensions Con…

Setae sense much of the insect's tactile environment. Large setae may be called bristles or chaetae, with the most modified being scales, the flattened setae found on butterflies and moths (Lepidoptera) and sporadically elsewhere. Three separate cells form each seta, one for hair formation (trichogen cell), one for socket formation (tormogen cell), and one sensory cell (Fig. 4.1).

Cuticular extensions Con…

- There is no such cellular differentiation in multicellular spines, unicellular acanthae, and subcellular microtrichia. The functions of these types of protuberances are diverse and sometimes debatable, but their sensory function appears limited. The production of pattern, including color, may be significant for some of the microscopic projections. Spines are immovable, but if they are articulated, then they are called spurs. Both spines and spurs may bear unicellular or subcellular processes

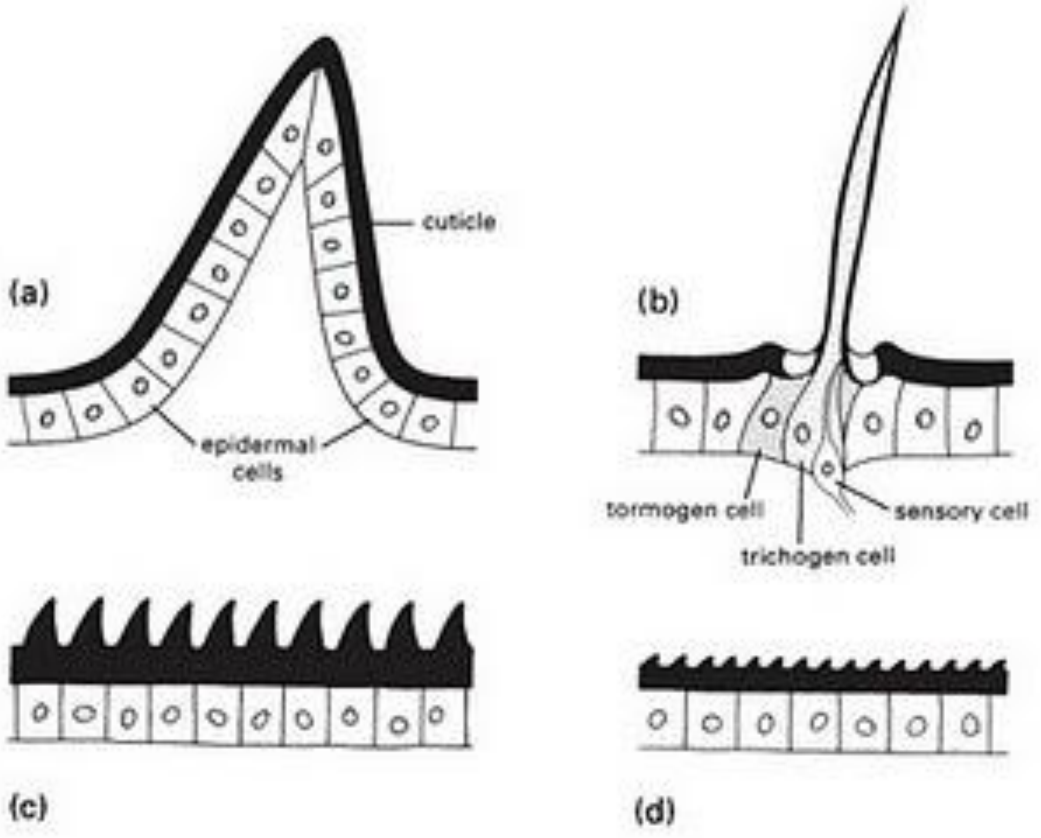


Fig. 2 The four basic types of cuticular protuberances: (a) a multicellular spine; (b) a seta, or trichoid sensillum; (c) acanthae; and (d) microtrichia.

Movie before lecture

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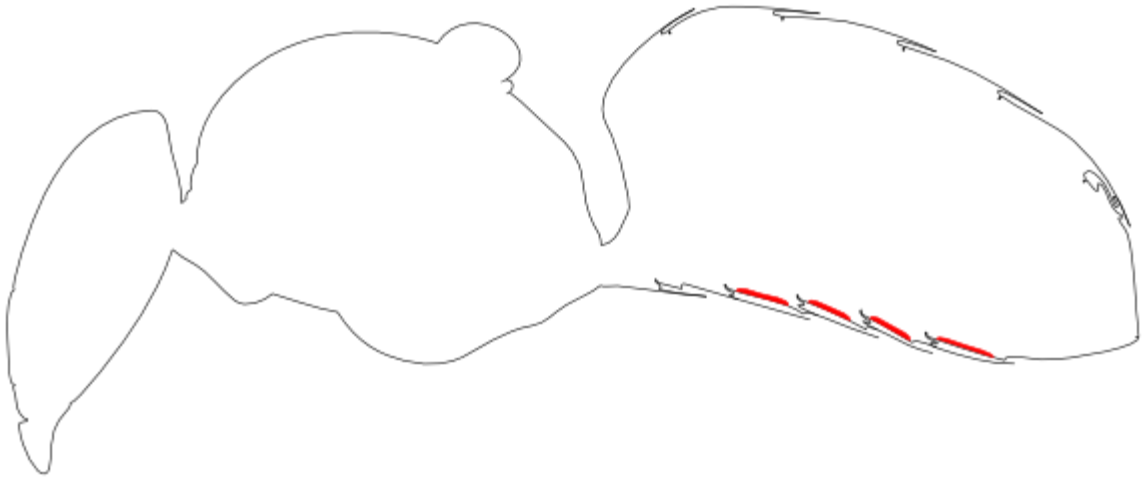
Wax gland (4 to 7 sternites)



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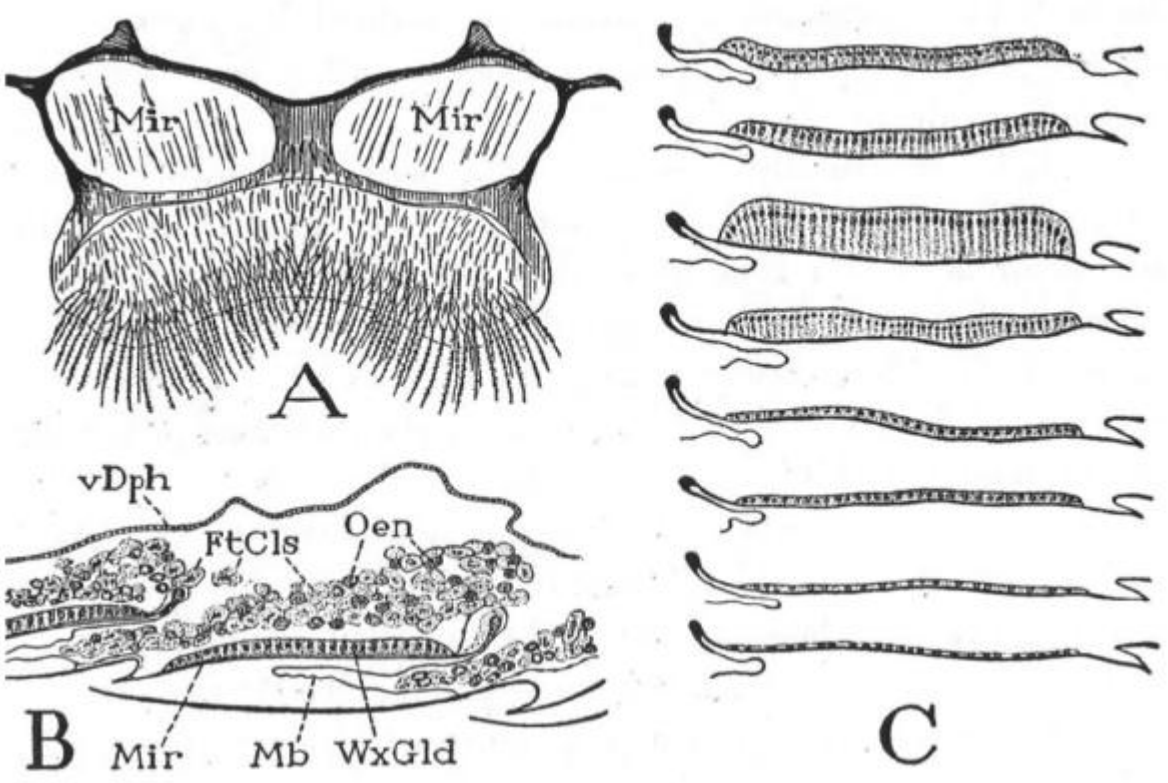

- *Figure 1.- The Wax Glands: A = Sternum of segment VI of worker, ventral, showing polished "mirrors" beneath wax glands, B = lengthwise section through two wax glands with overlying masses of fat cells and oenocytes. C = stages in the development and regression of a wax gland. Mir = mirror, WxGld = wax gland, FtCls = fat cells, Oen = oenocytes, vDph = ventral diaphragm, Mb = intersegmental membrane. (Snodgrass 1956).*