External morphology- the integument and internal morphology

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(Slides modified from Deb Smith at the University of Kansas, USA)

Before we get started…

For pronunciation of technical words:
http://www.naturalreaders.com/index.html

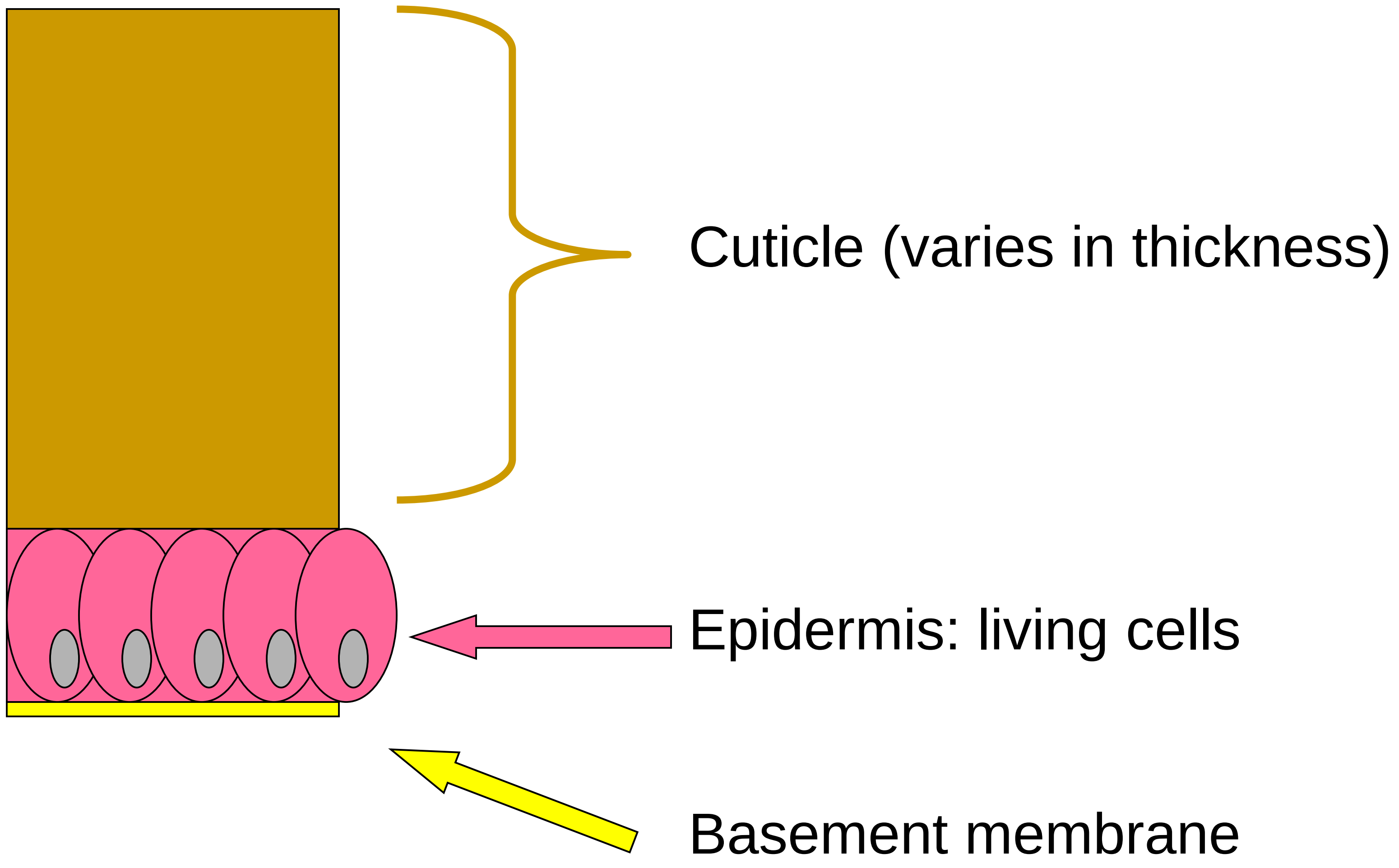
學術名詞中英對照:
http://terms.naer.edu.tw

We will have a quiz NEXT time (4/7)

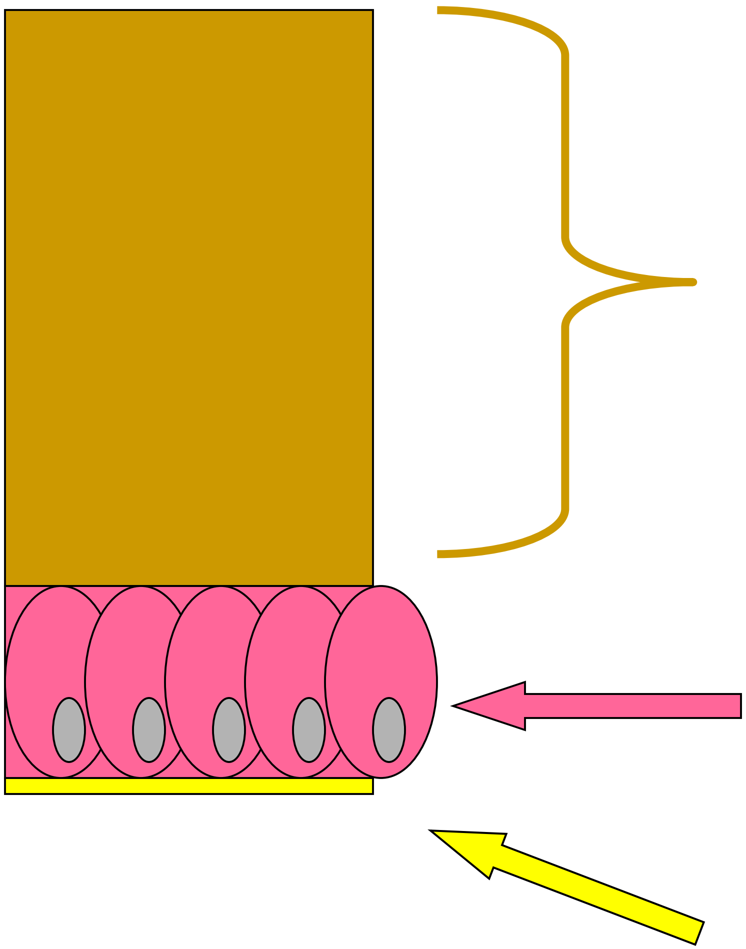
Integument is *complex*

- Composed of many layers
  - Hard “shell”
  - Living cells
  - Secreted layers
- Perforated by pores
- Sites for muscle attachments (remember insects don’t have bones!)

Three basic components



Three basic components



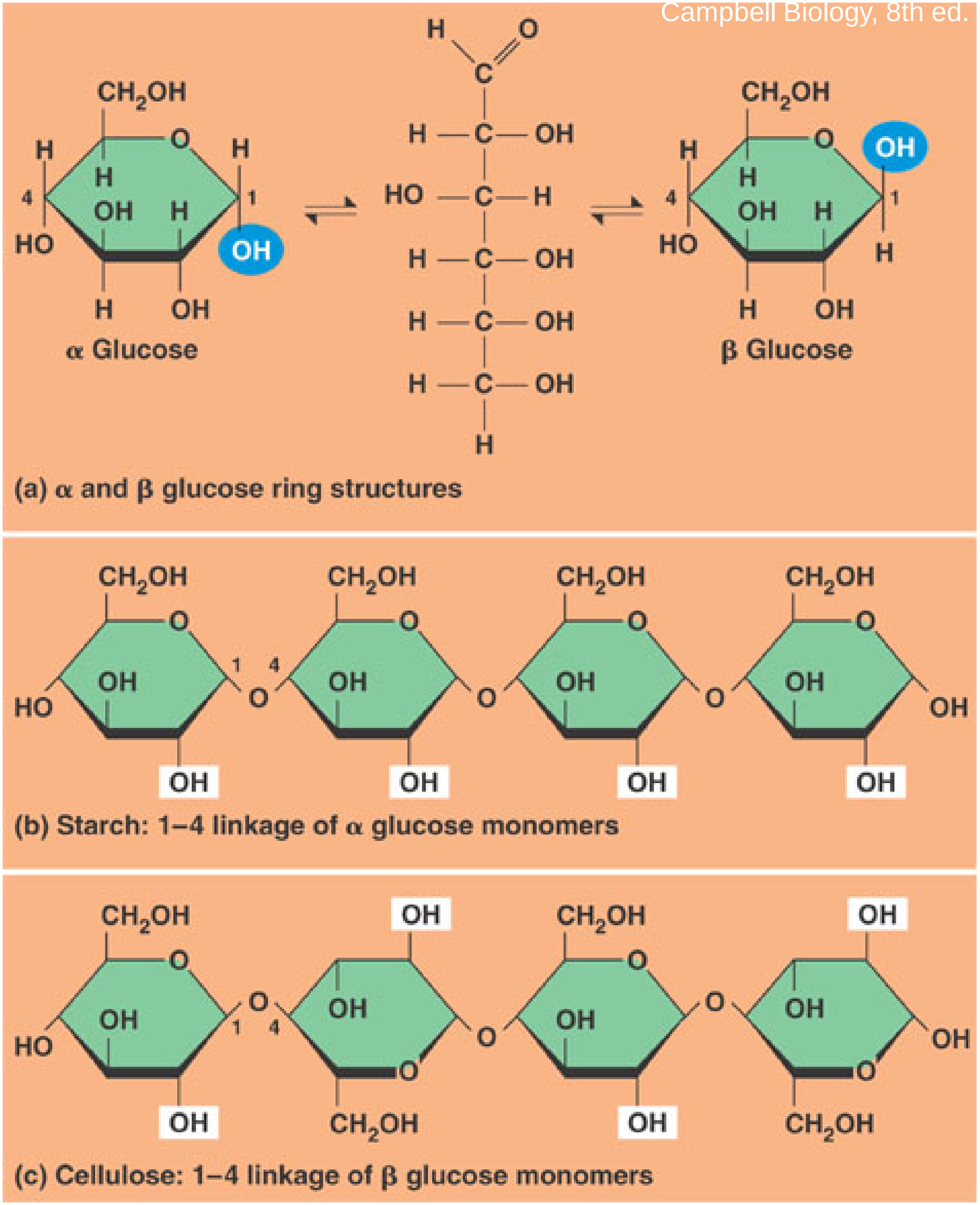
Secreted mainly
by epidermis; contains
CHITIN

Epidermis (living cells)

Secreted by blood cells and
others..

What's chitin?

- A polysaccharide
- Similar to cellulose
  - (polymer of a simple sugar, glucose)
- Polymer of modified simple sugar: acetylglucosamine
- Second most abundant polysaccharide in nature (cellulose is first)

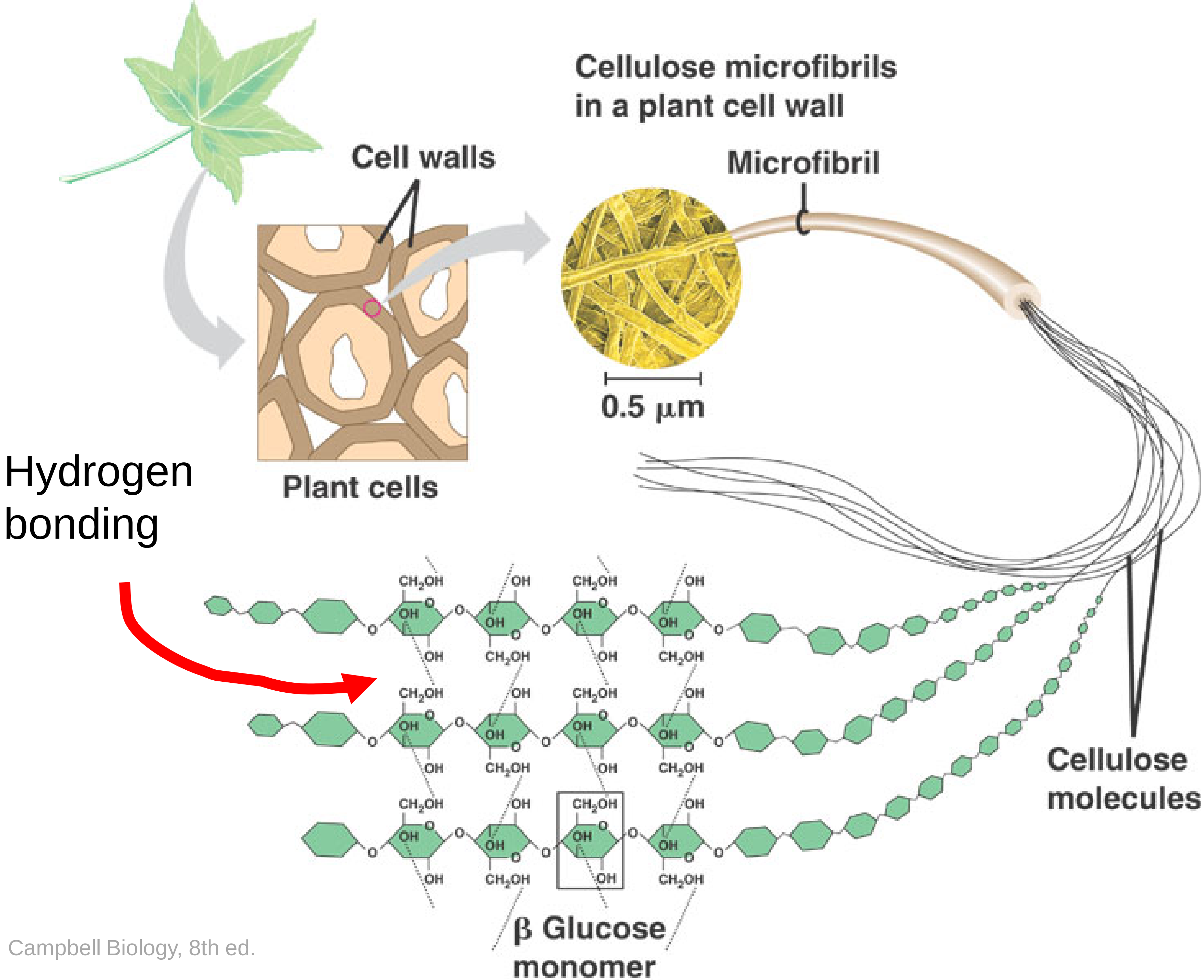


Type of linkage:

Digestible starch

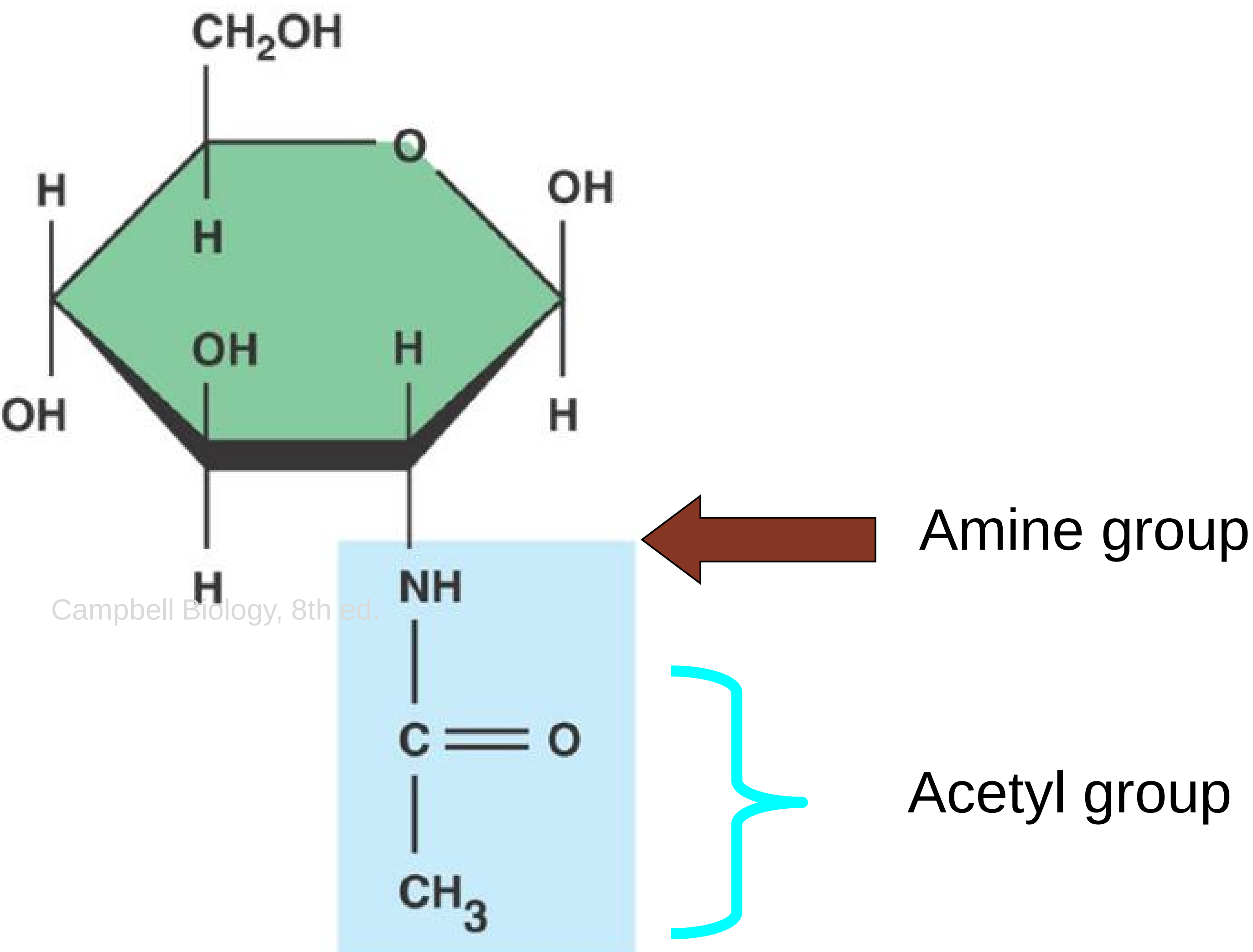
vs.

Indigestible cellulose



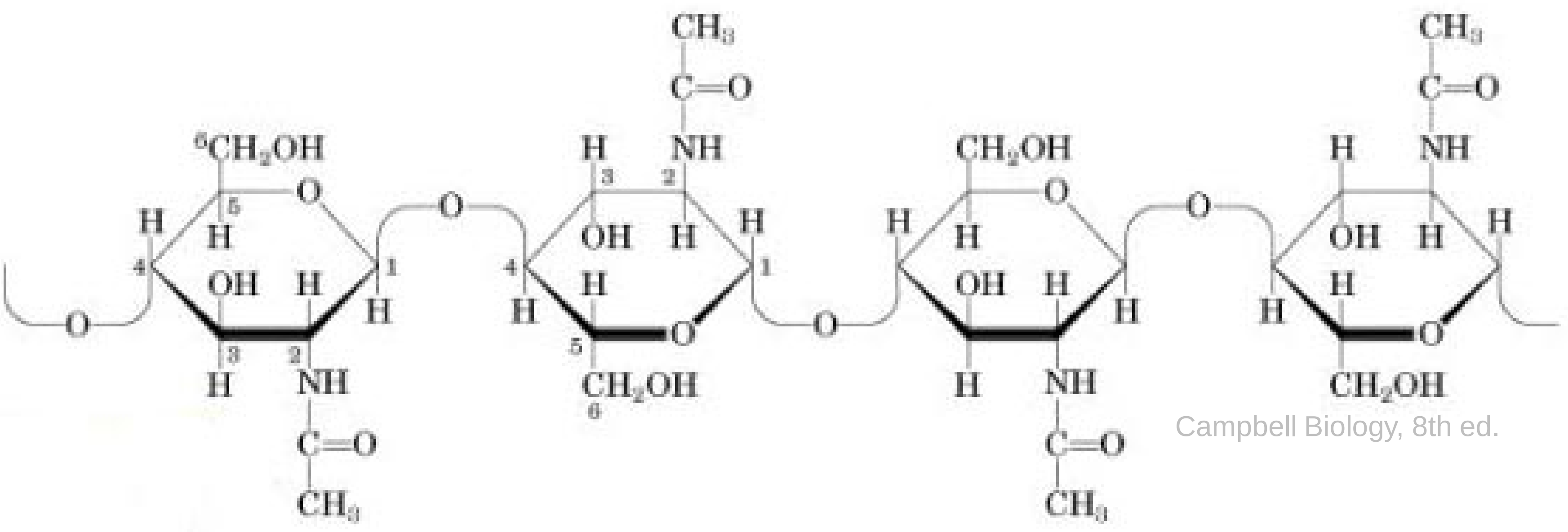
Campbell Biology, 8th ed.

N-acetylglucosamine: the monomer making up chitin



The structure of the chitin monomer

Chitin



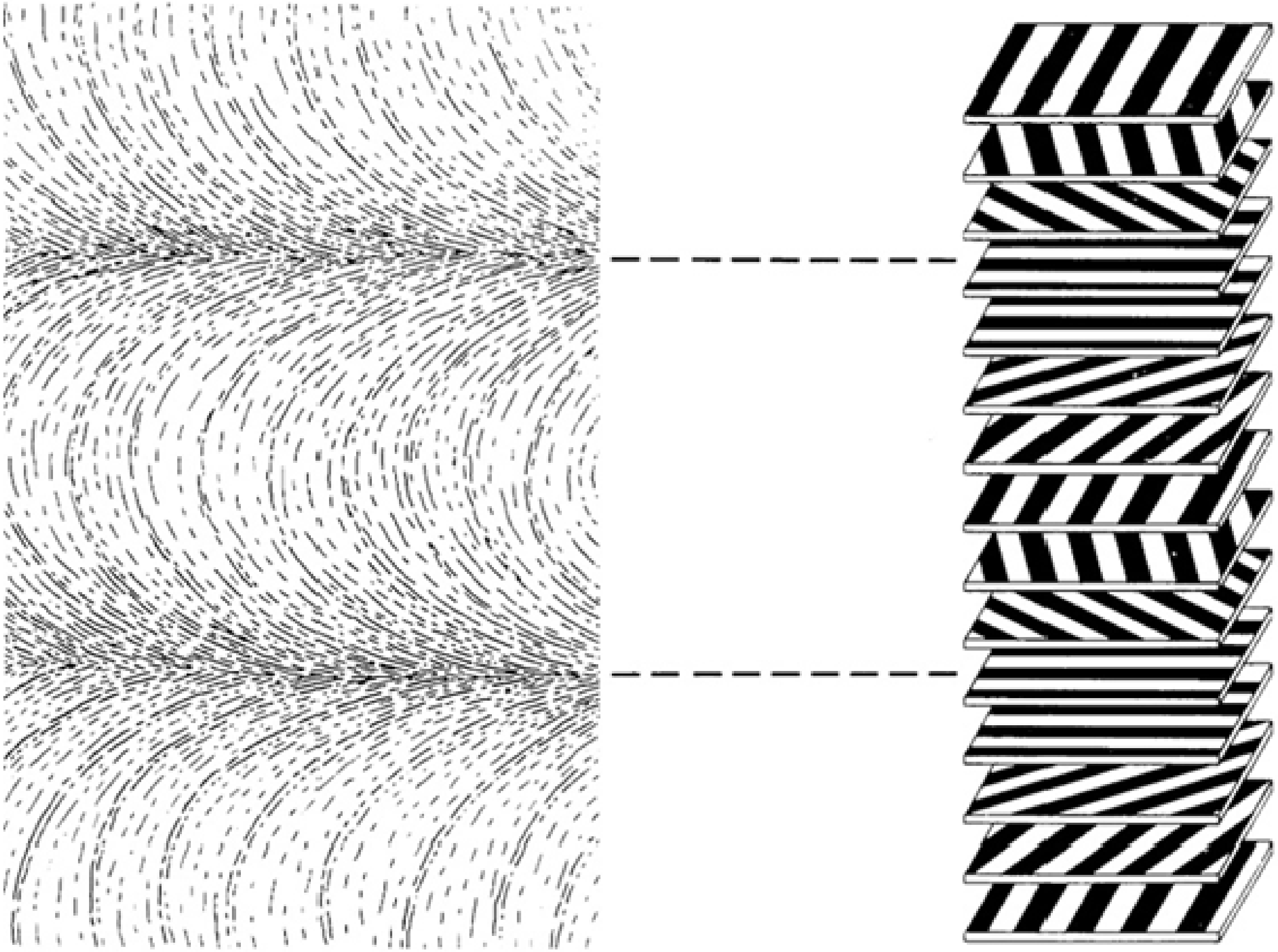
Campbell Biology, 8th ed.

Hydrogen bond cross-links between strands

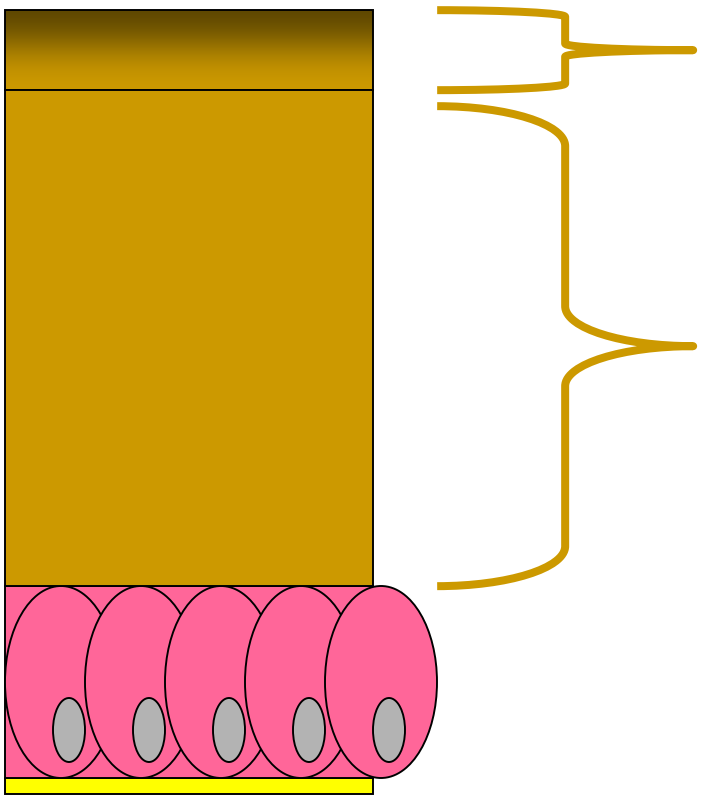
Chitin fibers secreted in layers

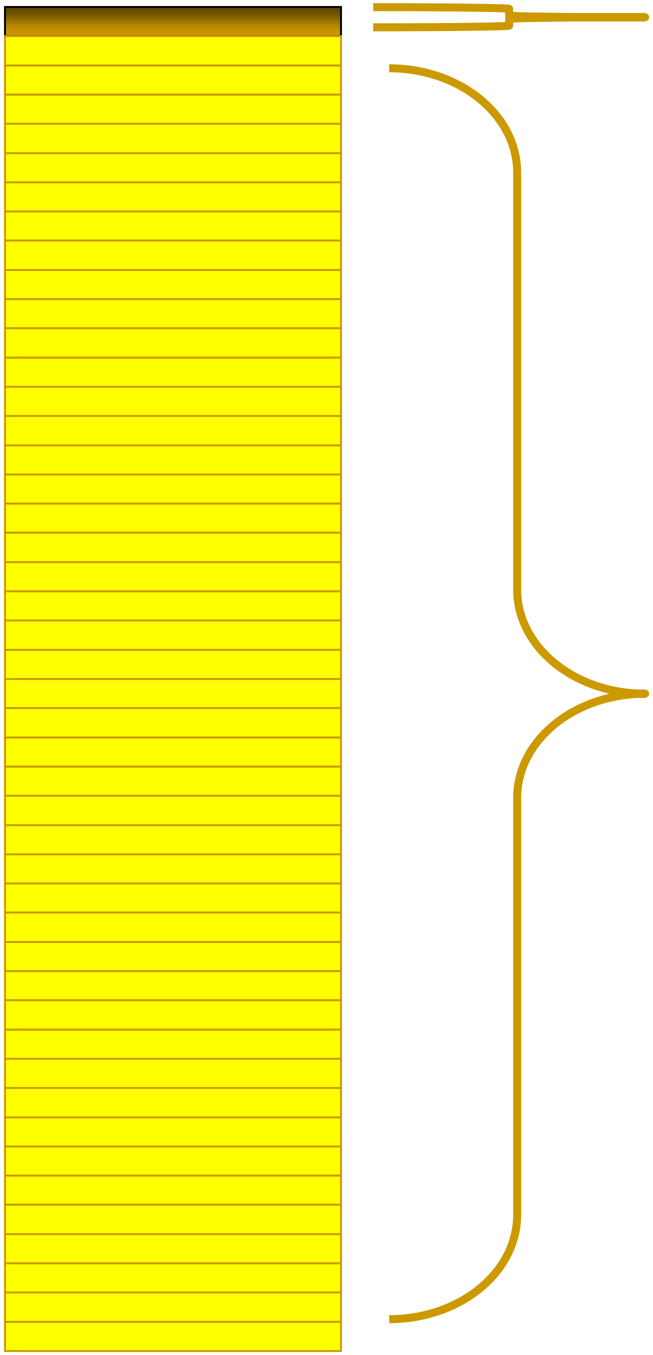
- Chitin fibers embedded in protein matrix
- Orientation of chitin fibers changes
- Like plywood: layers oriented in different directions increases strength

Orientation of chitin fibers



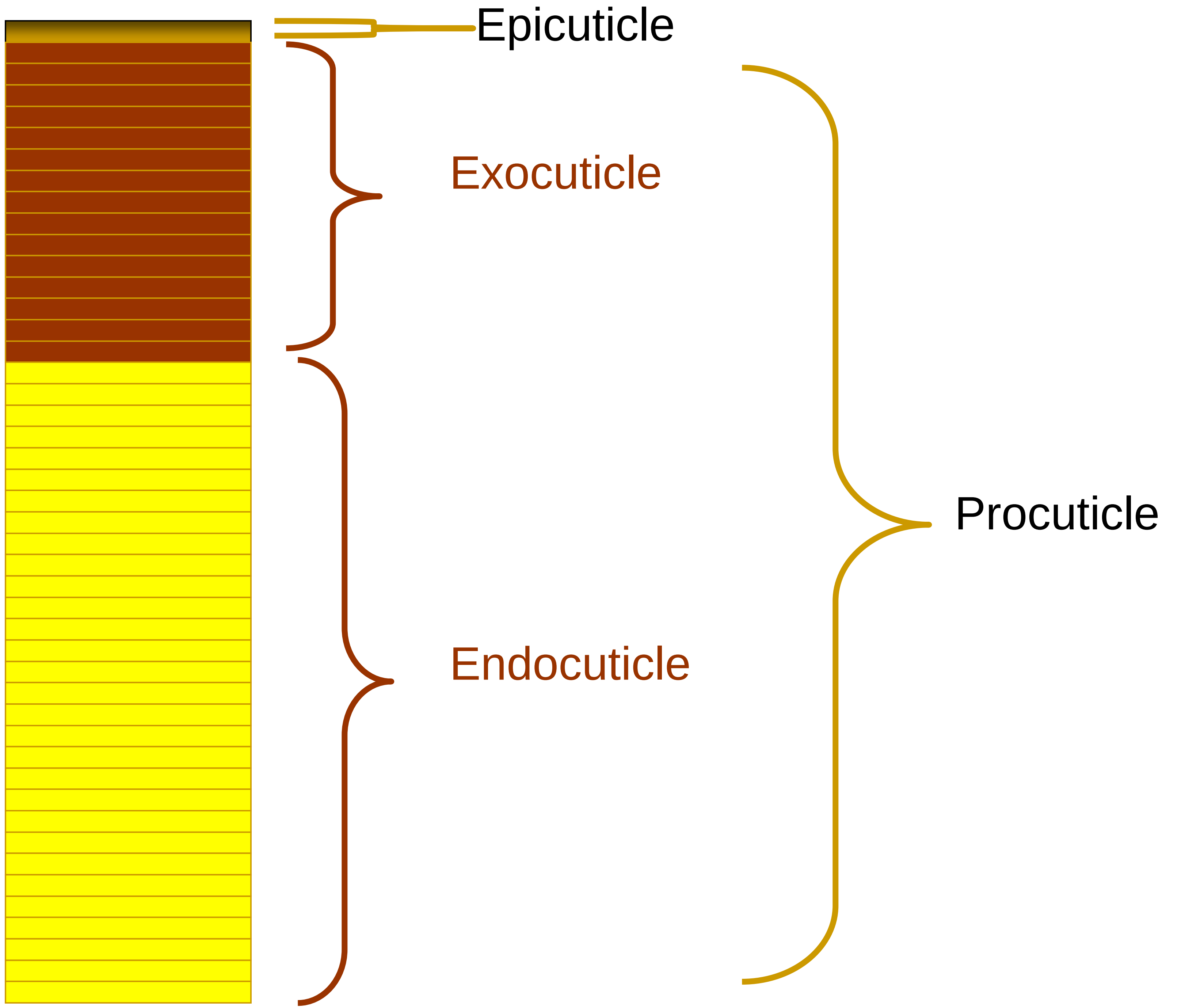
Fine structure of cuticle





Epicuticle: 1- 4 micrometers

Procuticle: up to 200 micrometers

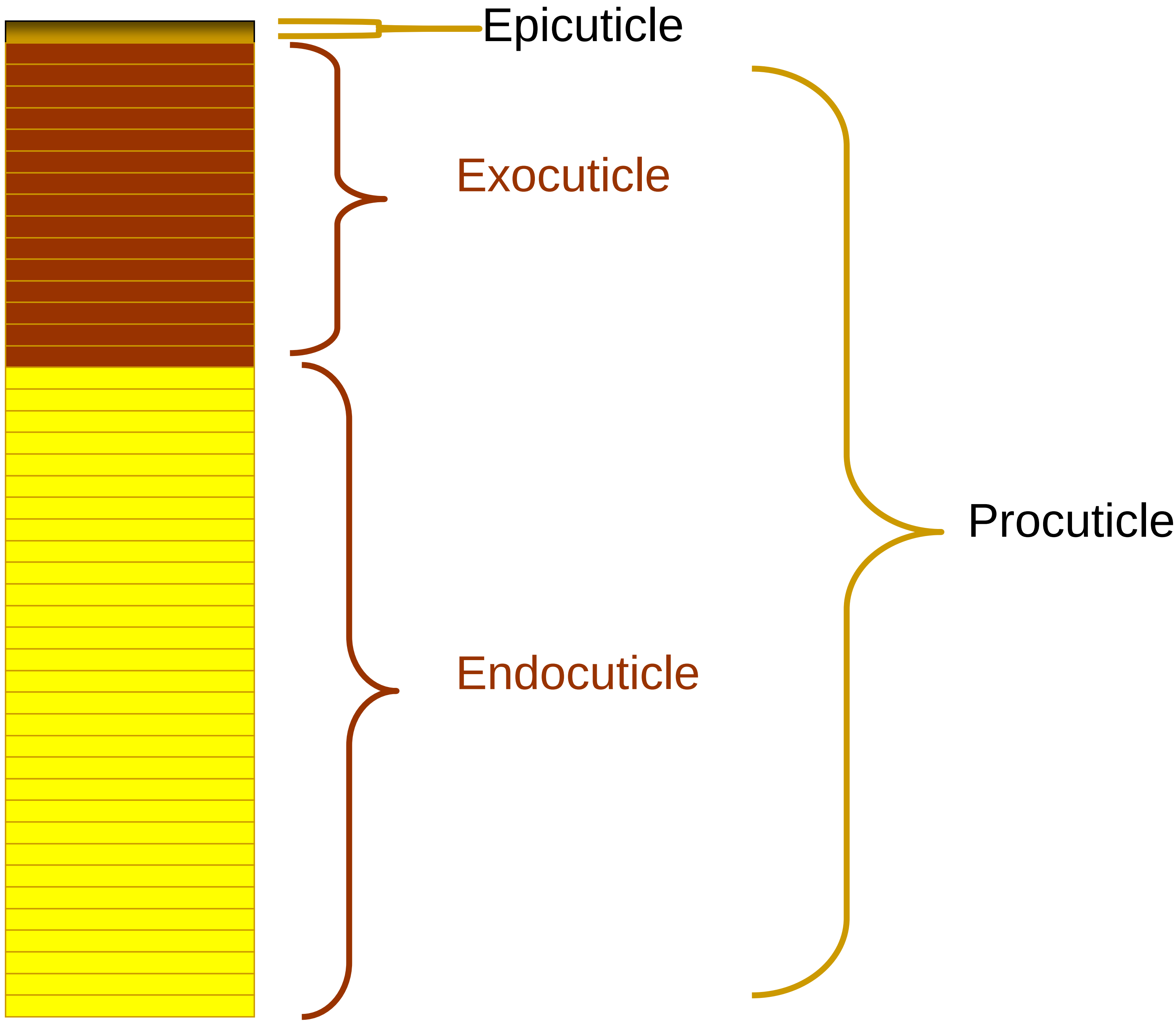

Epicuticle
Exocuticle
Procuticle
Endocuticle

Tanning or sclerotization

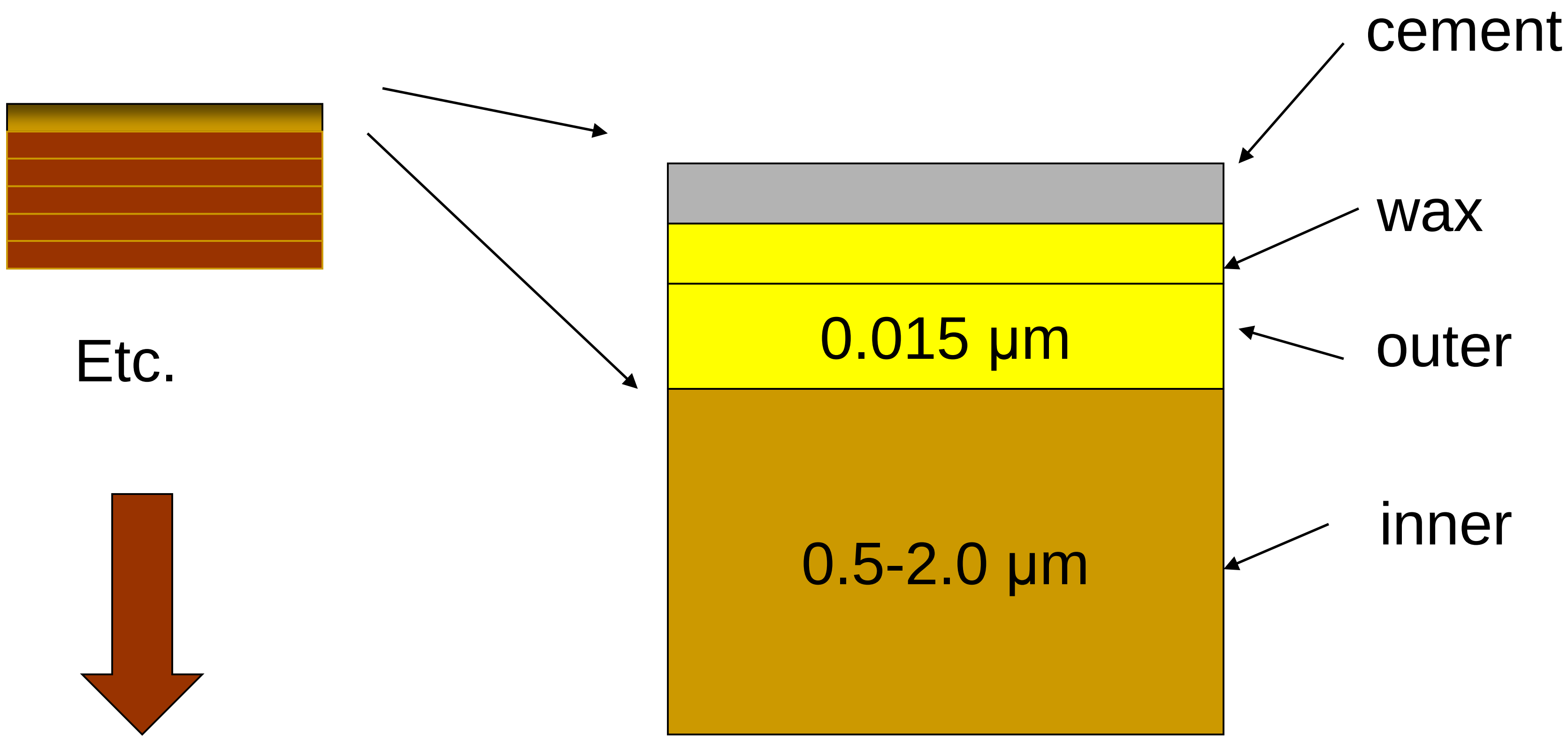
- In exocuticle
- Protein-protein cross linkages
- More cross-linkage, exocuticle is stiffer, more rigid
- Thin flexible membrane at joints not sclerotized

Epicuticle: thin, but crucial

- 1-4 micrometers
- contains many layers


Epicuticle
Exocuticle
Endocuticle
Procuticle

Layers of epicuticle



Layers of epicuticle

- Secreted by epidermis
  - Remember the epidermis?
  - Living cells
- Cement layer: mucopolysaccharide
  - Protects
- Wax: hydrocarbons
  - Waterproofs
  - Distinctive odors
  - Blooms, fluffs
- Outer layer: polymerized lipids
- Inner: tanned lipoproteins

Last of all...muscle attachments

- Most muscles attach to inner surface of exoskeleton.
- But the exoskeleton is shed several times.
- ???

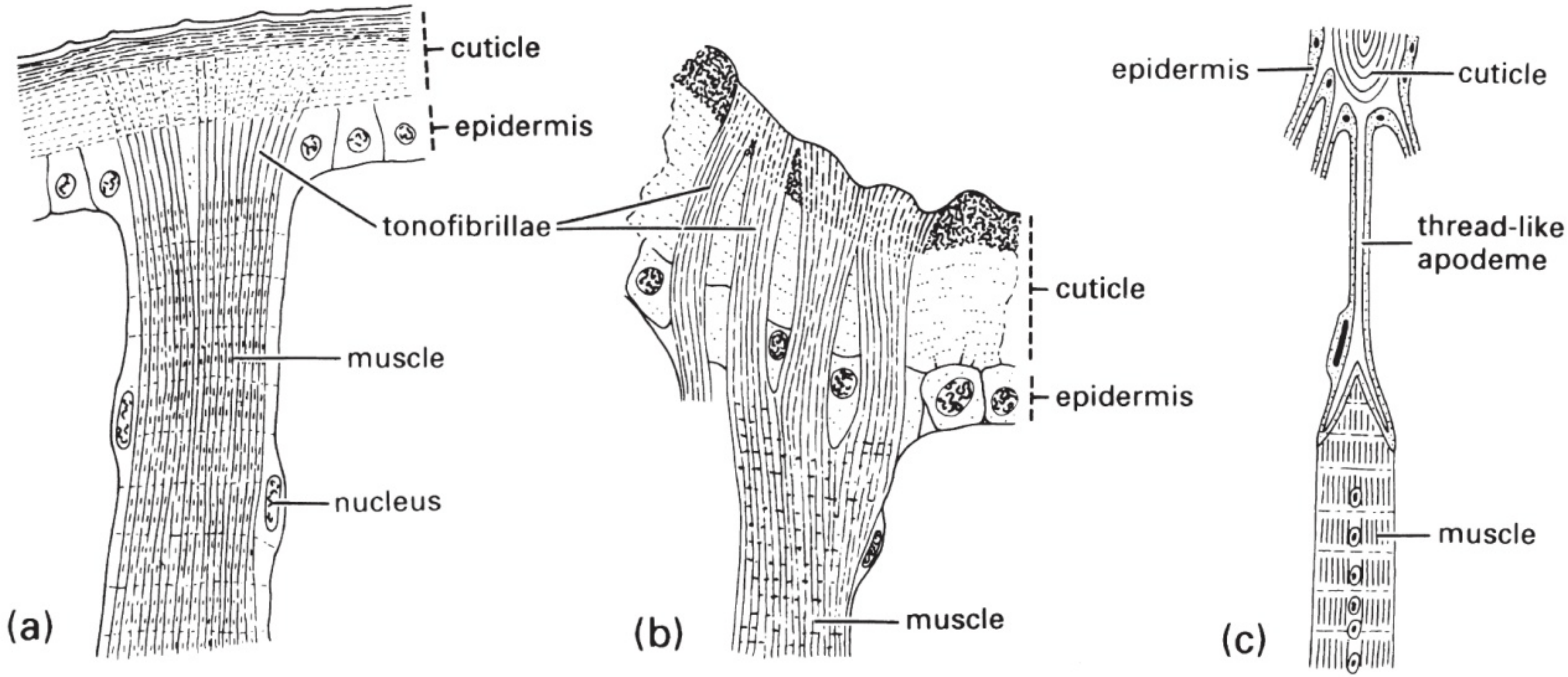
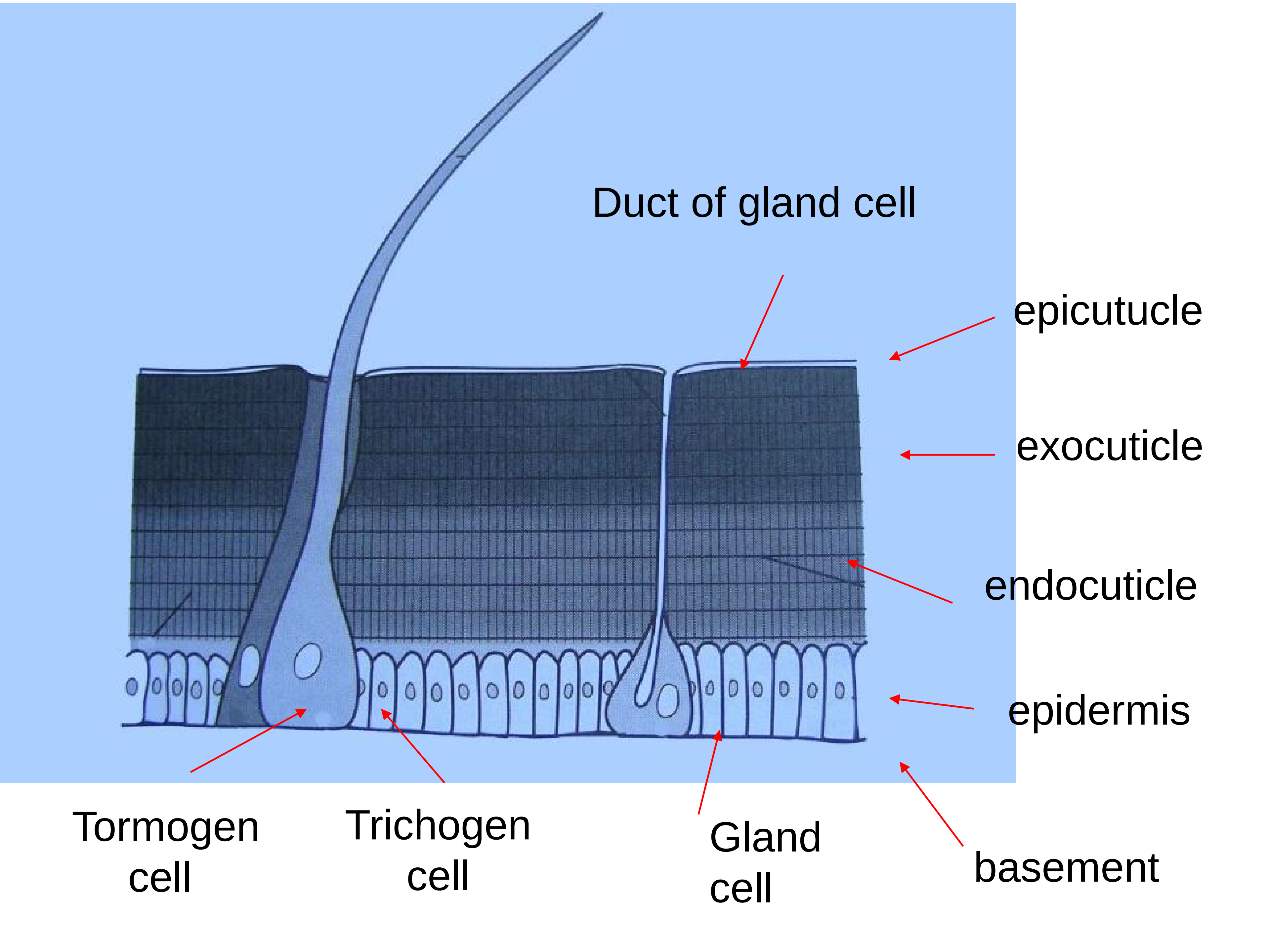
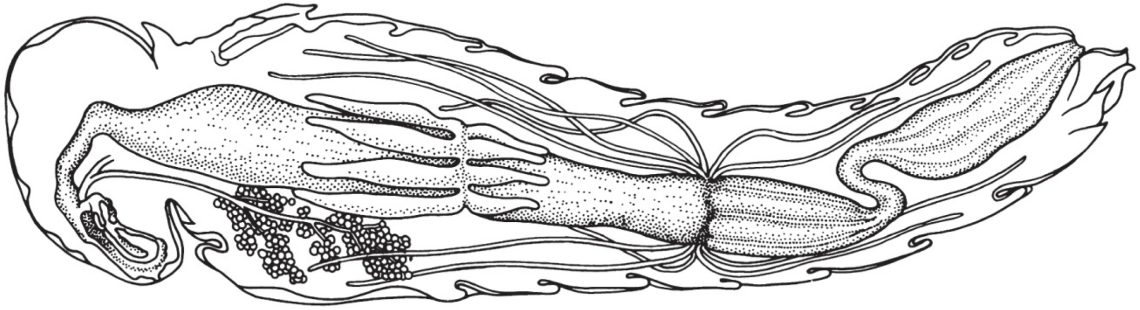


Fig. 3.2 Muscle attachments to body wall: (a) tonofibrillae traversing the epidermis from the muscle to the cuticle (b) a muscle attachment in an adult beetle of *Chrysobothrus femorata* (Coleoptera: Buprestidae) (c) a multicellular apodeme with a muscle attached to one of its thread-like, cuticular "tendons" or apophyses. (After Snodgrass 1935.)

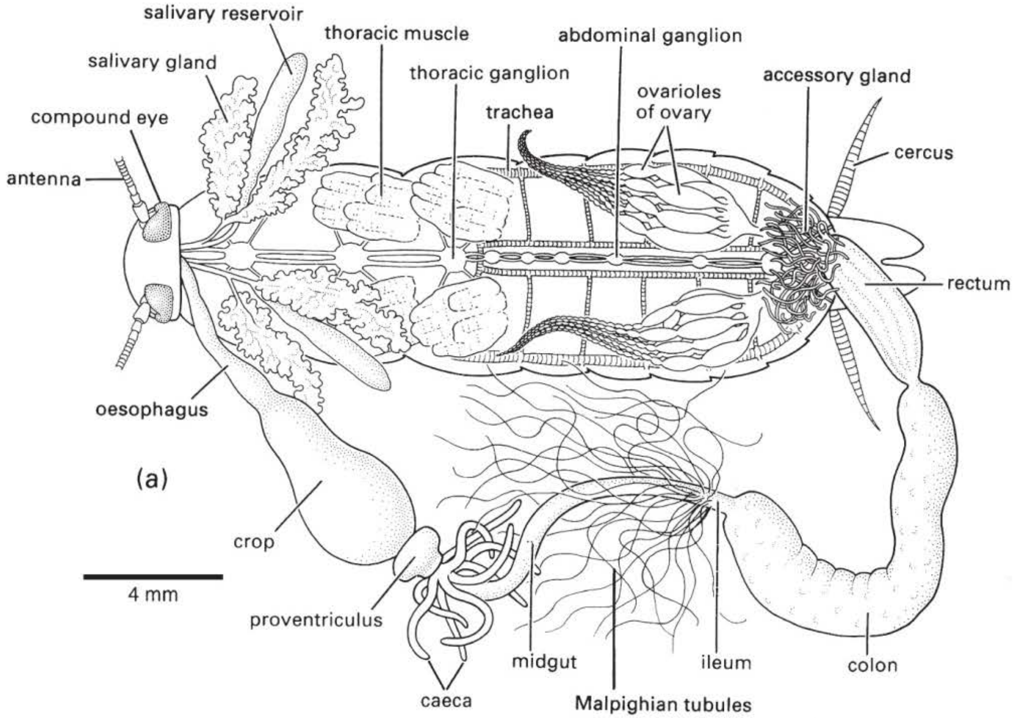


Duct of gland cell
epicutucle
exocuticle
endocuticle
epidermis
basement
Tormogen cell
Trichogen cell
Gland cell

Internal Morphology



Internal structures of a locust. (After Uvarov 1966.)



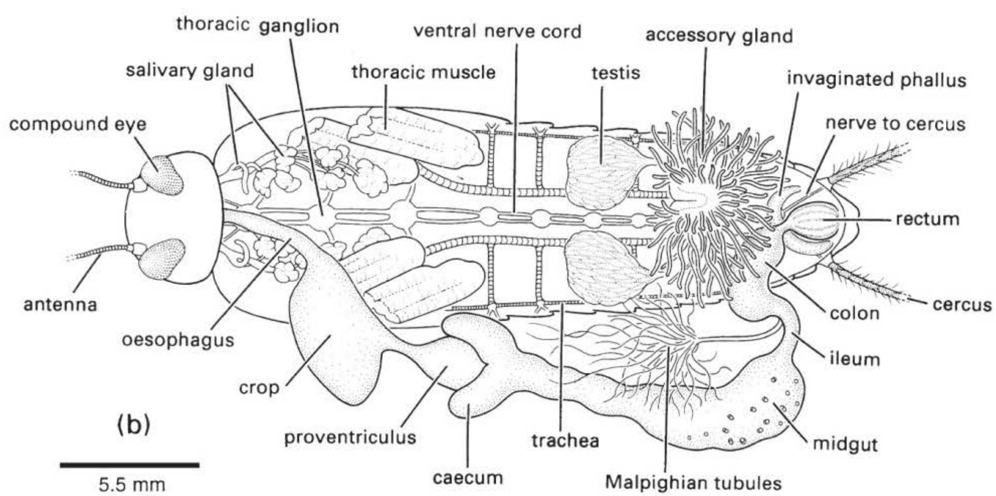


Fig. 3.1 Dissections of: (a) a female American cockroach, *Periplaneta americana* (Blattodea: Blattidae): and (b) a male black field cricket, *Teleogryllus commodus* (Orthoptera: Gryllidae). The fat body and most of the tracheae have been removed; most details of the nervous system are not shown.

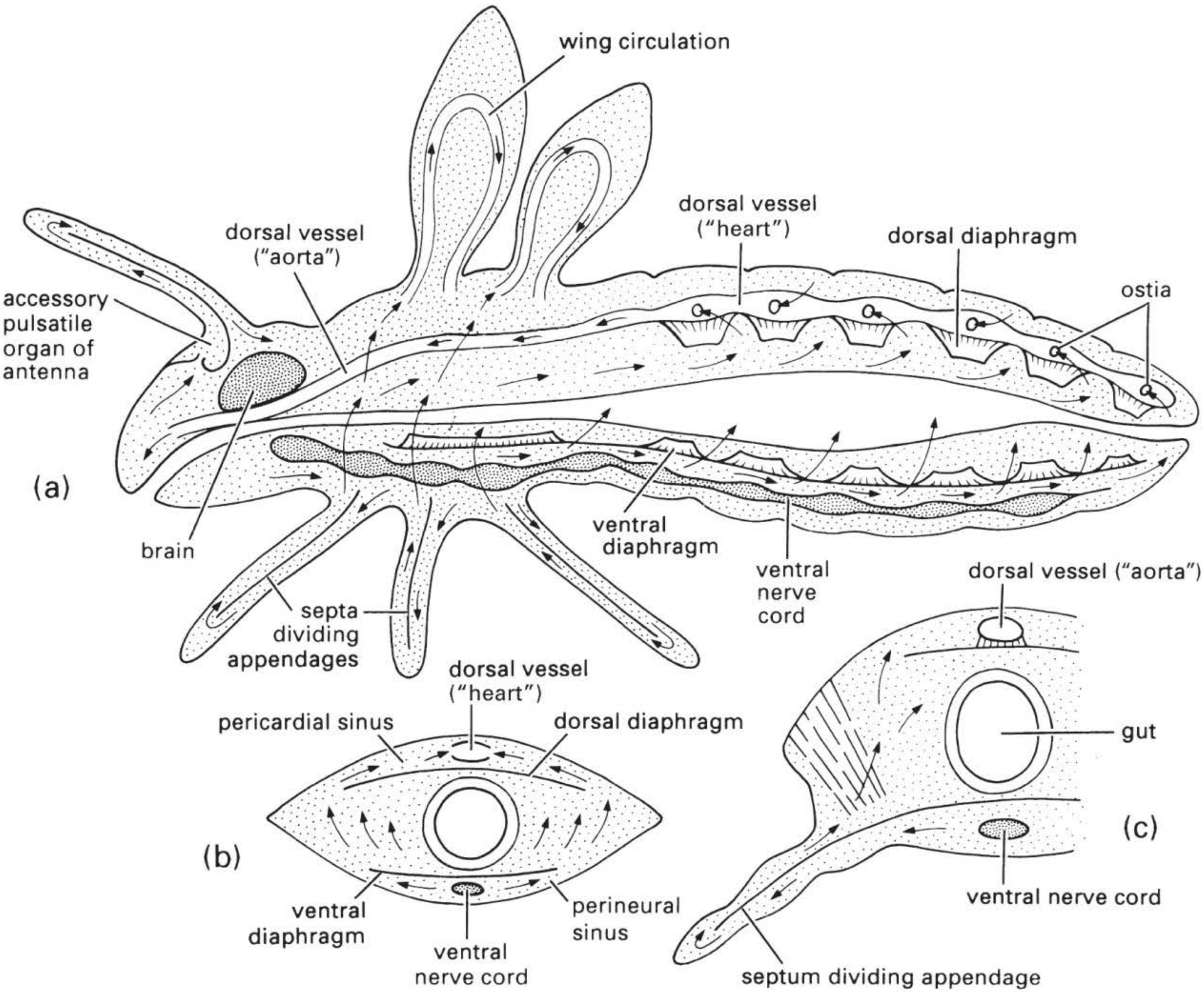


Fig. 3.9 Schematic diagram of awell-developed circulatory system: (a) longitudinal section through body; (b) transverse section of the abdomen; (c) transverse section of the thorax. Arrows indicate directions of haemolymph flow. (After Wigglesworth 1972.)

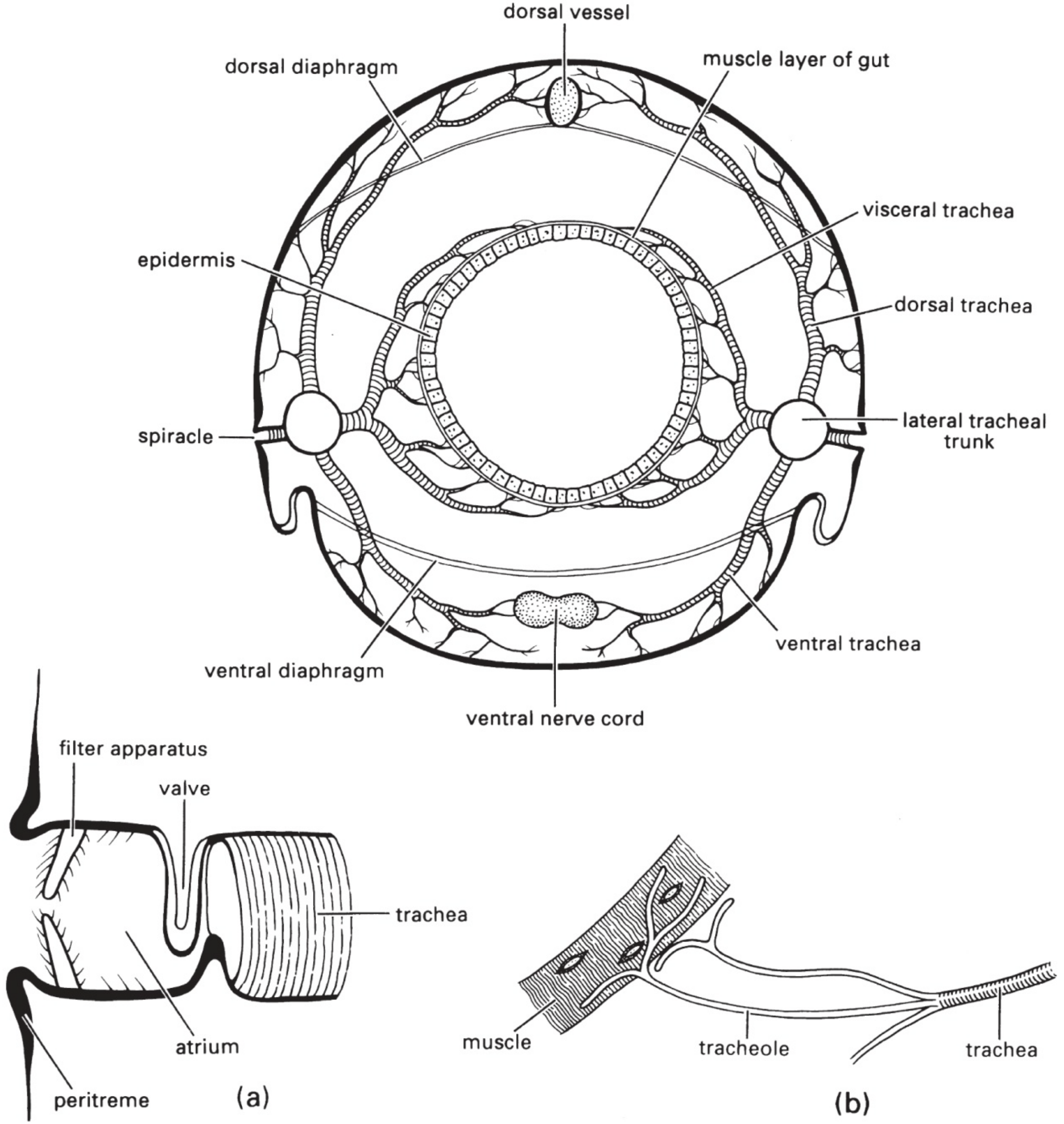


Fig. 3.10 Schematic diagram of a generalized tracheal system seen in a transverse section of the body at the level of a pair of abdominal spiracles. Enlargements show: (a) an atriate spiracle with closing valve at inner end of atrium; (b) tracheoles running to a muscle fibre. (After Snodgrass 1935.)

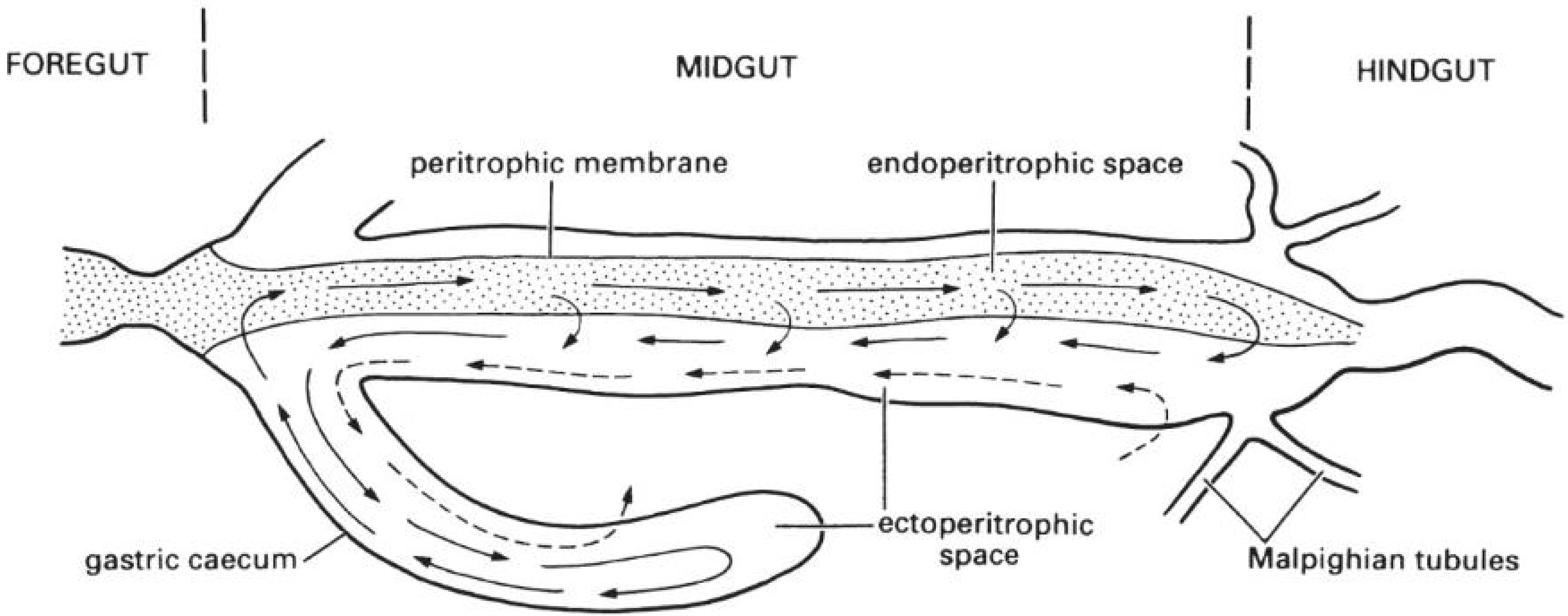


Fig. 3.16 Generalized scheme of the endo–ectoperitrophic circulation of digestive enzymes in the midgut. (After Terra & Ferreira 1981.)

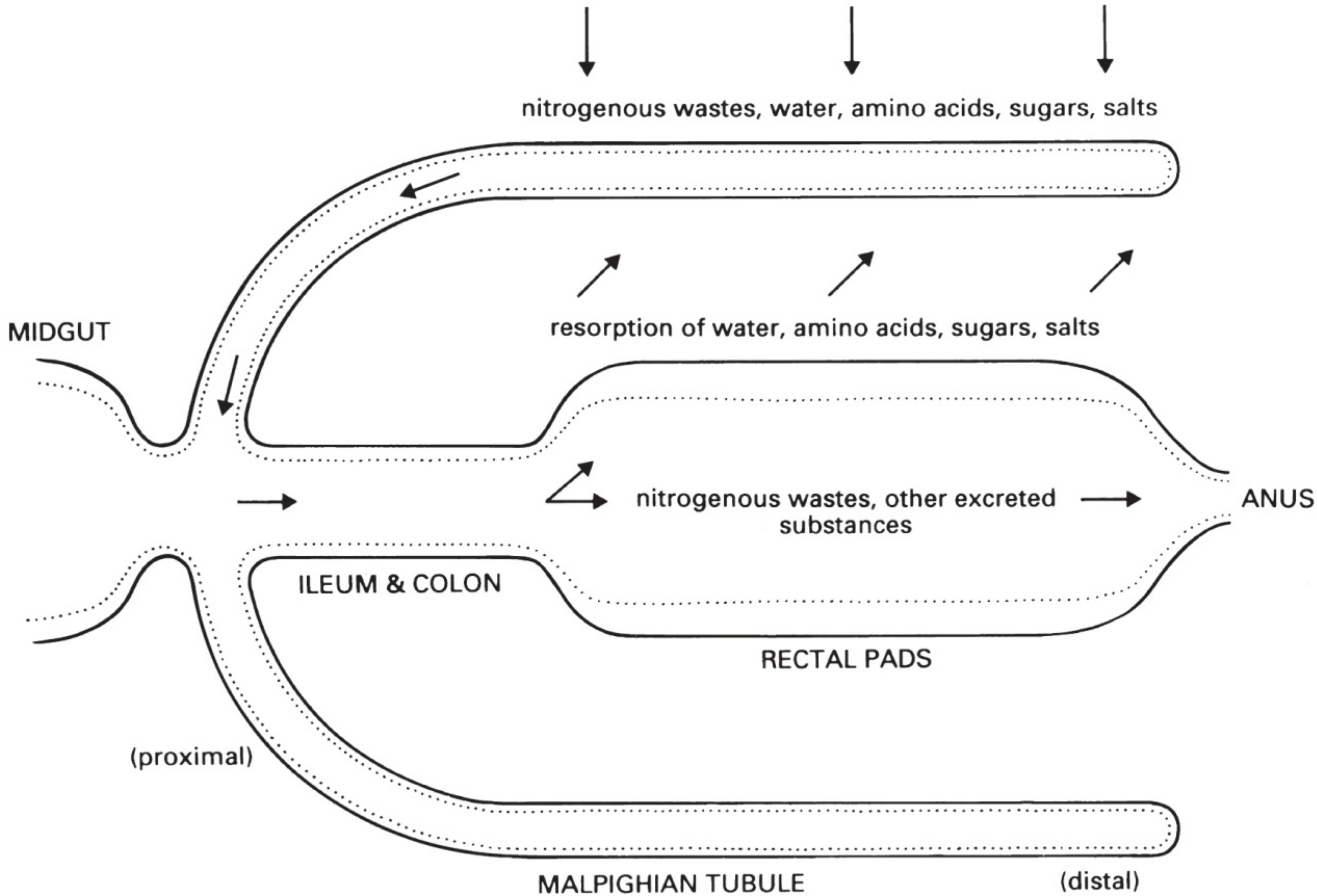
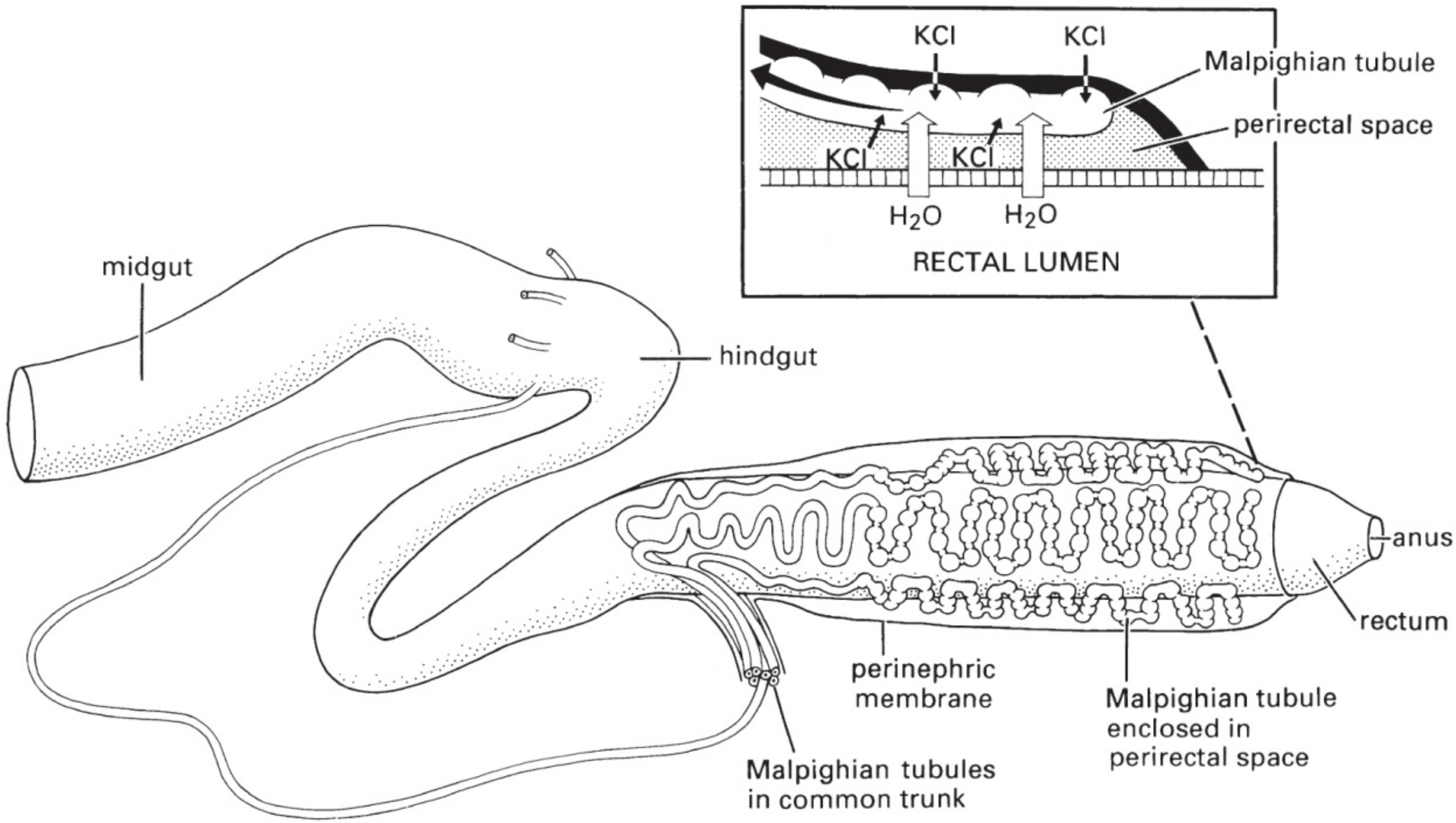


Fig. 3.17 Schematic diagram of a generalized excretory system showing the path of elimination of wastes. (After Daly *et al*. 1978.)



*After Grimstone *et al.* 1968; Bradley 1985.

Box 3.4 Cryptonephric systems*

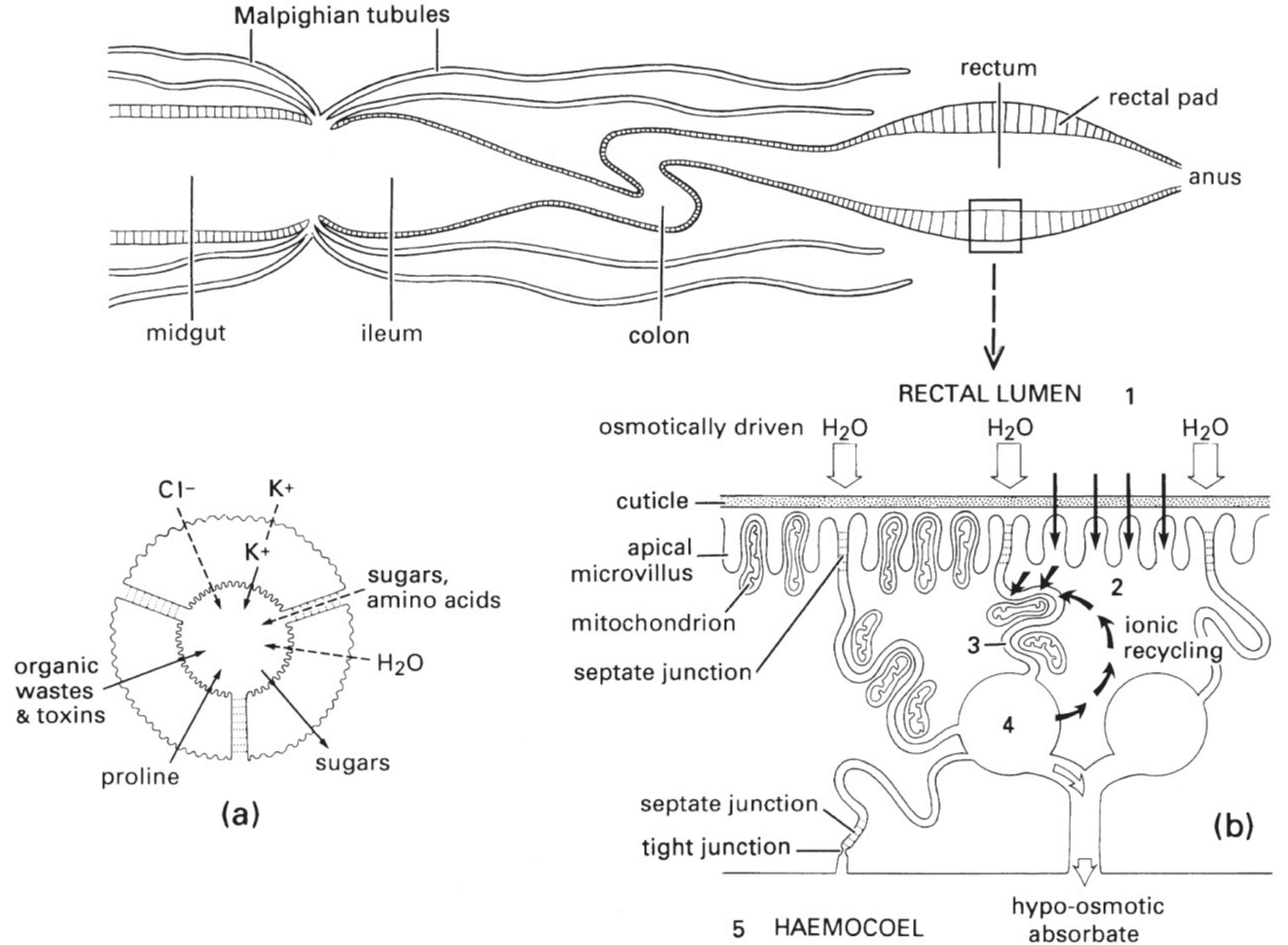


Fig. 3.18 Schematic diagram of the organs in the excretory system of the desert locust, *Schistocerca gregaria* (Orthoptera: Acrididae). Only a few of the > 100 Malpighian tubules are drawn. (a) Transverse section of one Malpighian tubule showing probable transport of ions, water and other substances between the surrounding haemolymph and the tubule lumen; active processes are indicated by solid arrows and passive processes by dashed arrows. (b) Diagram illustrating the movements of solutes and water in the rectal pad cells during fluid resorption from the rectal lumen. Pathways of water movement are represented by open arrows, and solute movements by black arrows. Ions are actively transported from the rectal lumen (compartment 1) to the adjacent cell cytoplasm (compartment 2) and then to the intercellular spaces (compartment 3). Mitochondria are positioned so as to provide the energy for this active ion transport. Fluid in the spaces is hyperosmotic (higher ion concentration) to the rectal lumen and draws water by osmosis from the lumen via the septate junctions between the cells. Water thus moves from compartment 1 to 3 to 4 and finally to 5, the haemolymph in the haemocoel. (After Bradley 1985.)