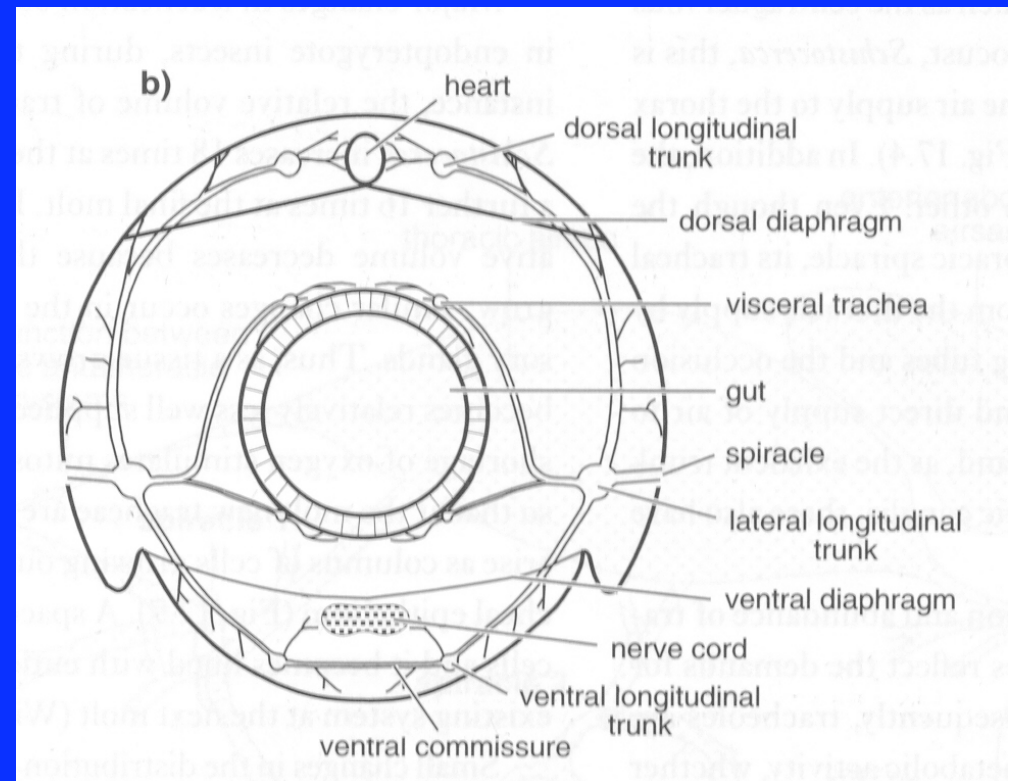


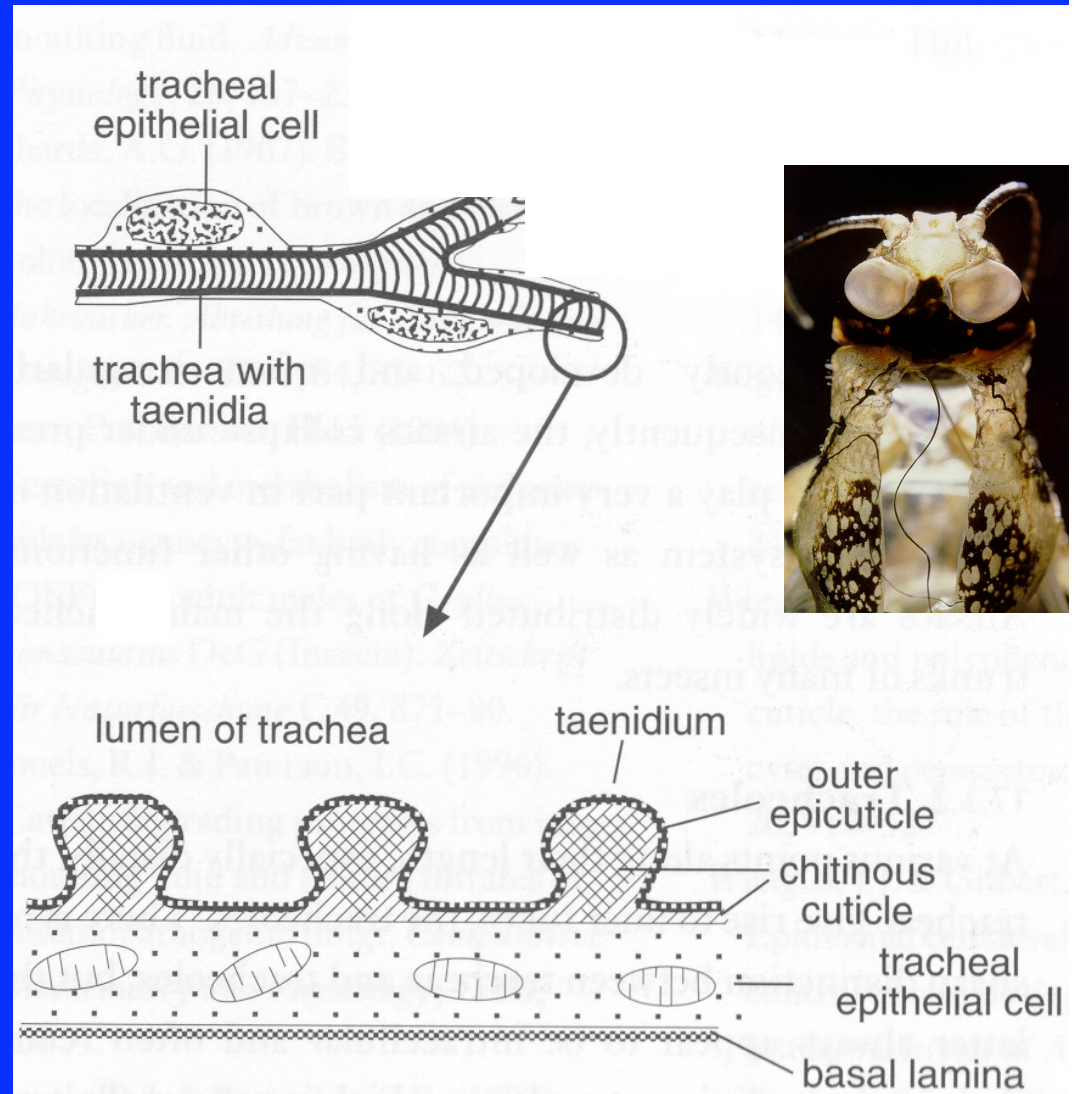
# General Organization

- Longitudinal trunks:
  - lateral
  - dorsal, ventral
- Cross wise tracheae:
  - dorsal, ventral
  - visceral



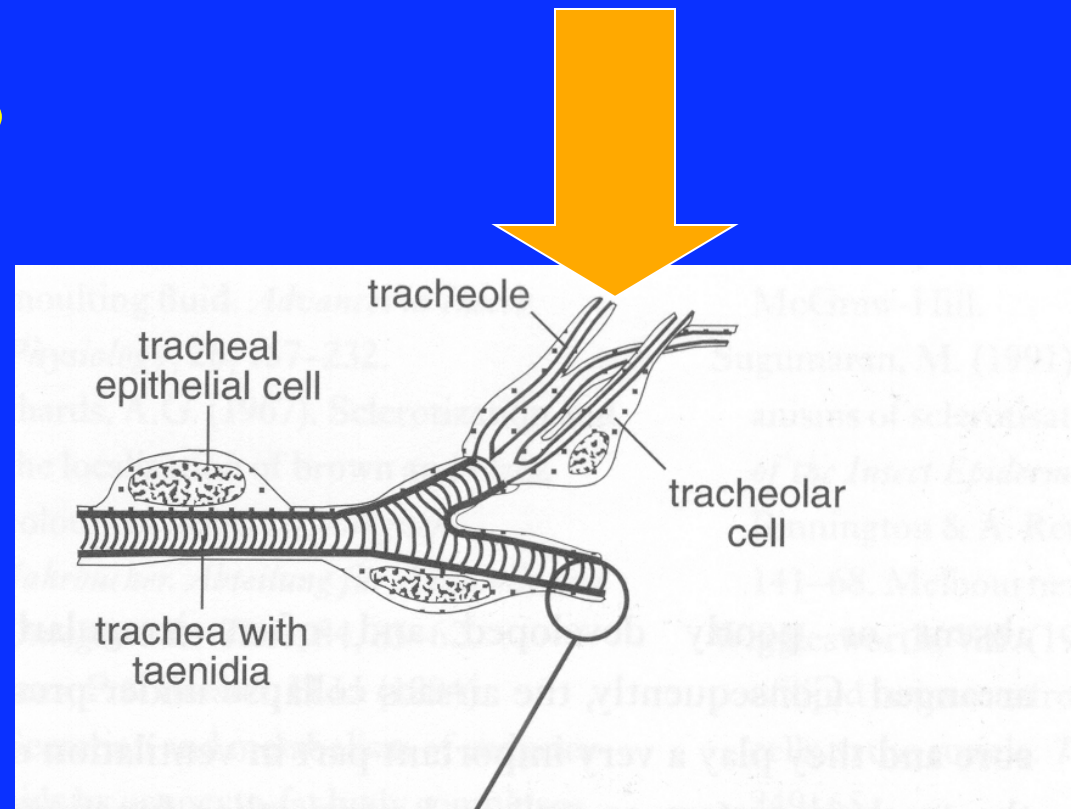
# tracheal epithelial cells

- cuticle shed at molt
- taenidia for strength



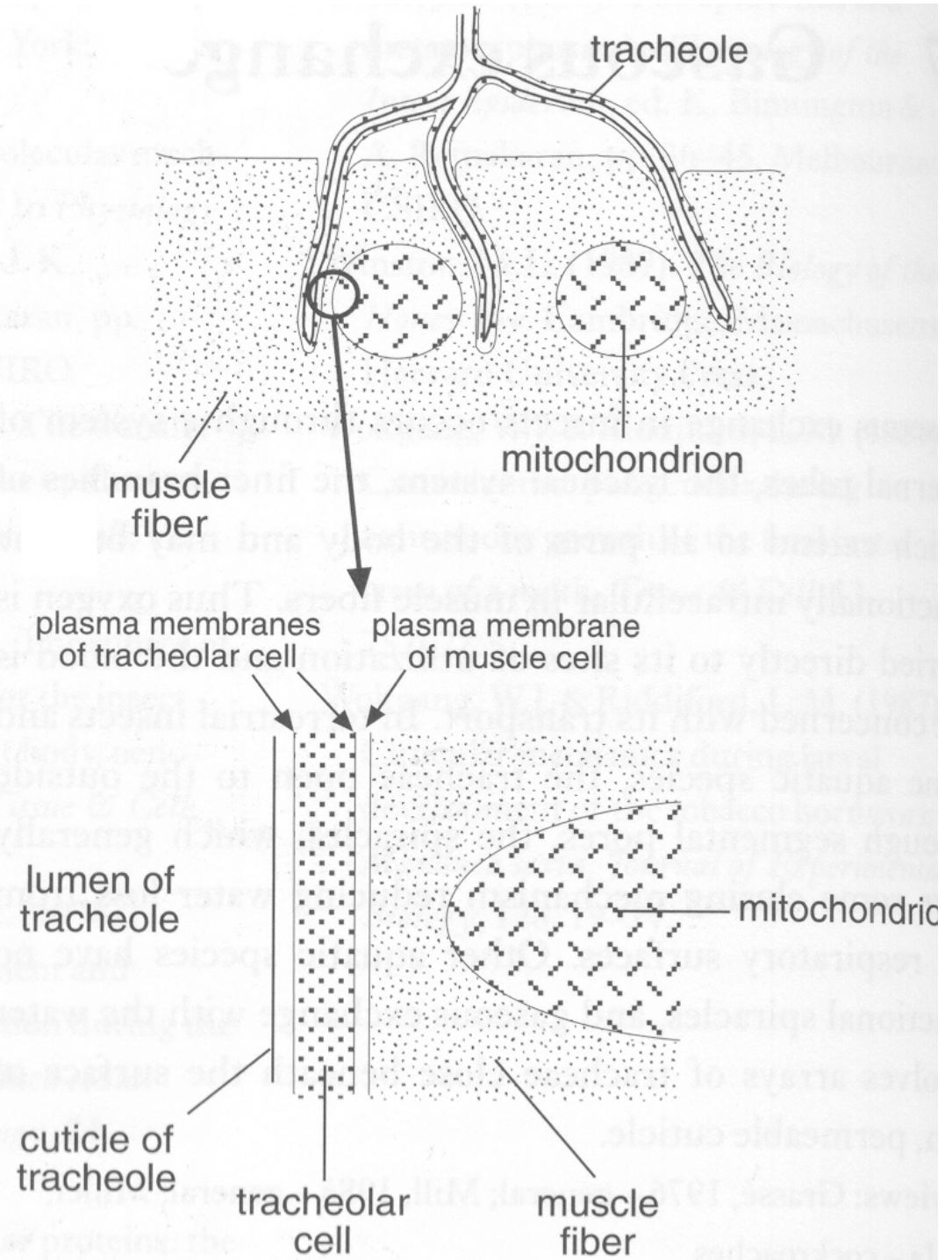
# tracheoles and tracheole cells

- tracheoles keep cuticle at molt
- intracellular



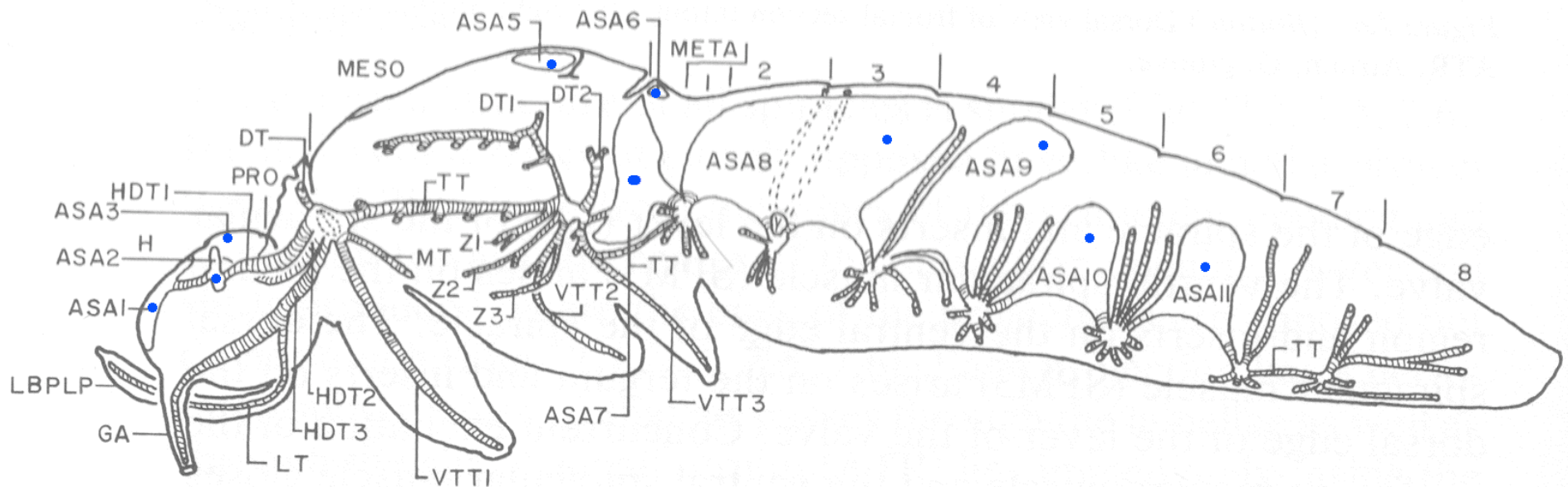
# tracheoles

- in active tissue, tracheoles reach near mitochondria
- atmosphere oxygen diffuses into tissue
- CO<sub>2</sub> released from tissue into tracheole

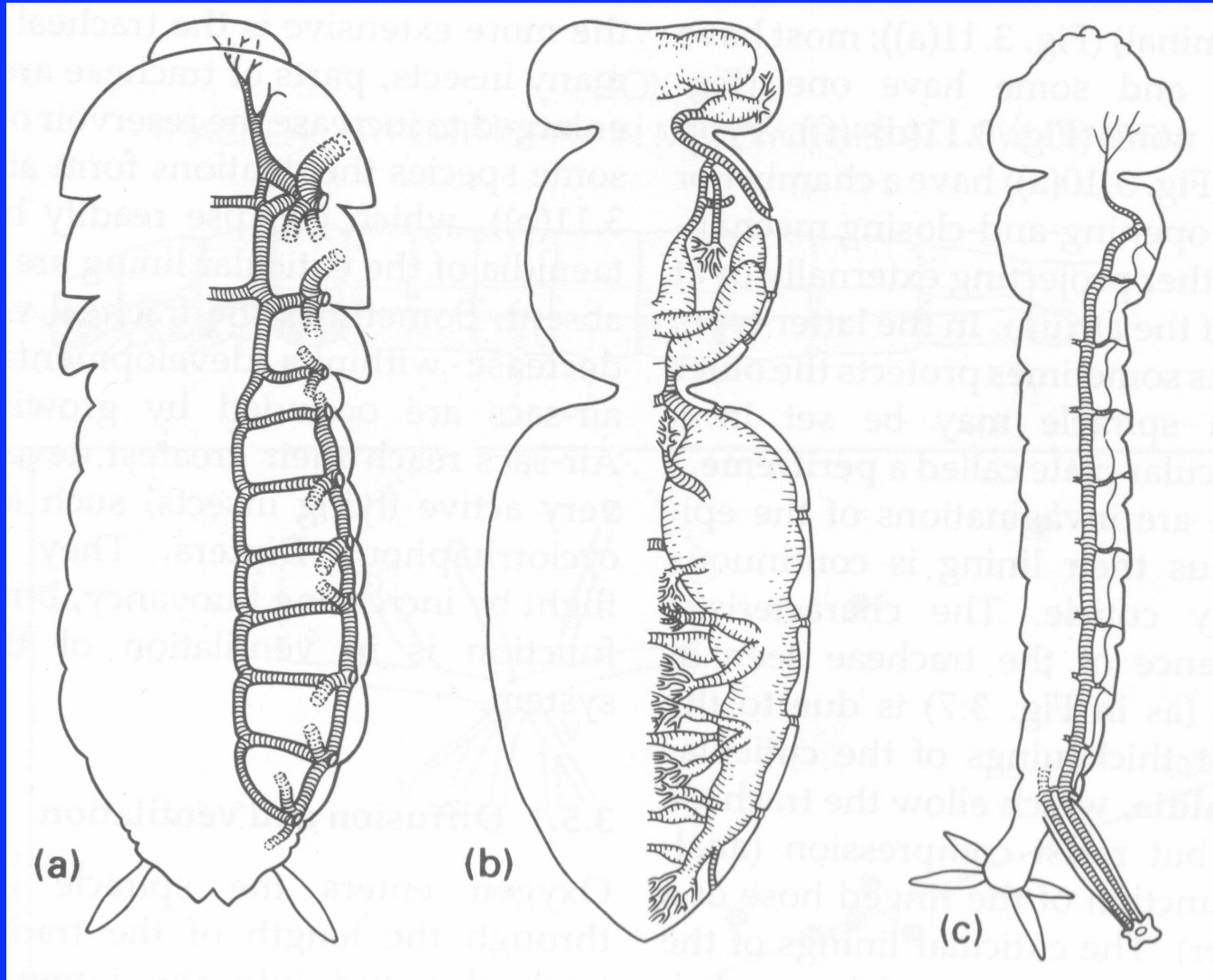


# Systems with air sacs

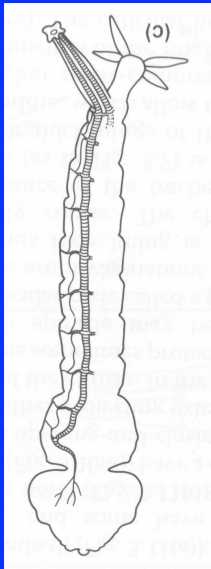
- taenidia reduced or absent
- collapse under pressure
- important in ventilation – forced air movements
- NOT lungs



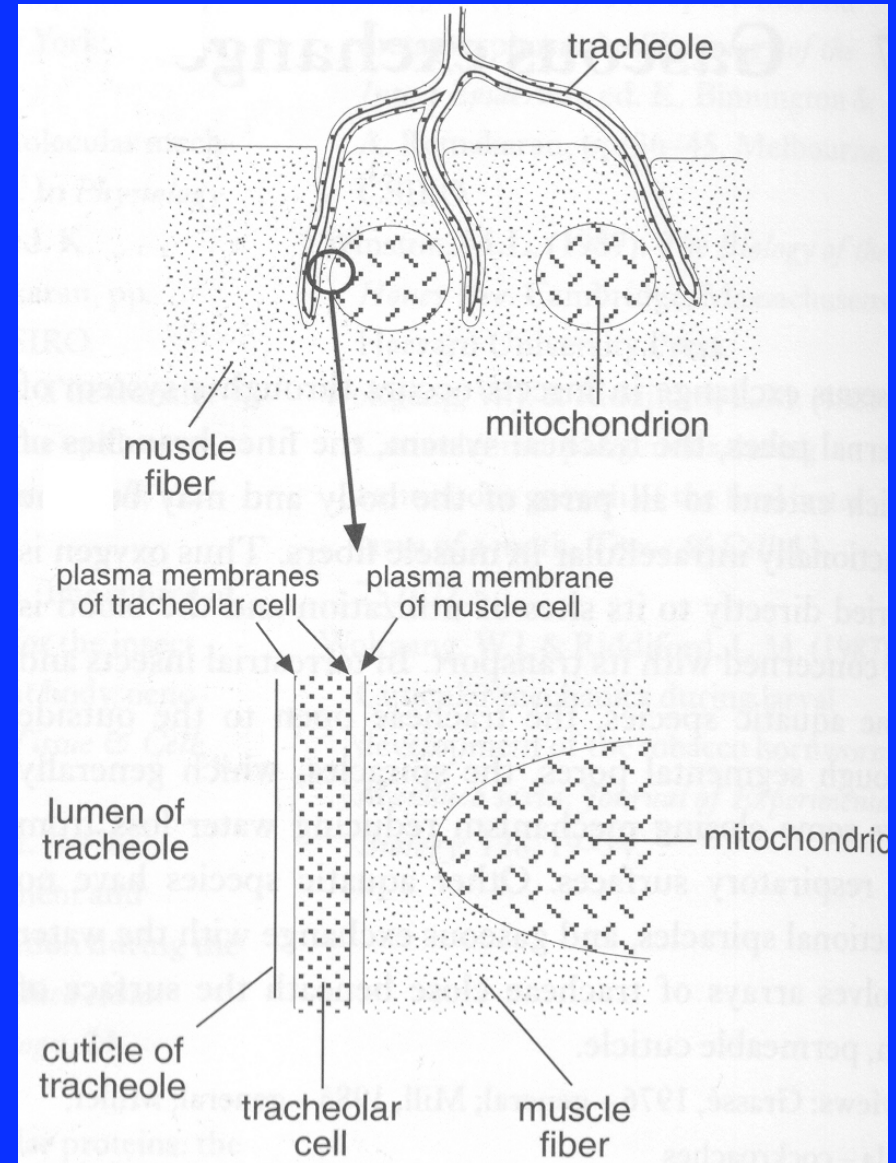
# open (to the air) respiratory systems



# Diffusion of oxygen

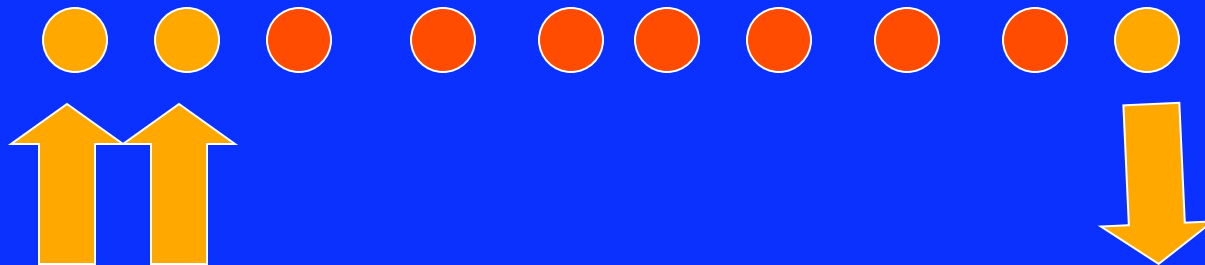
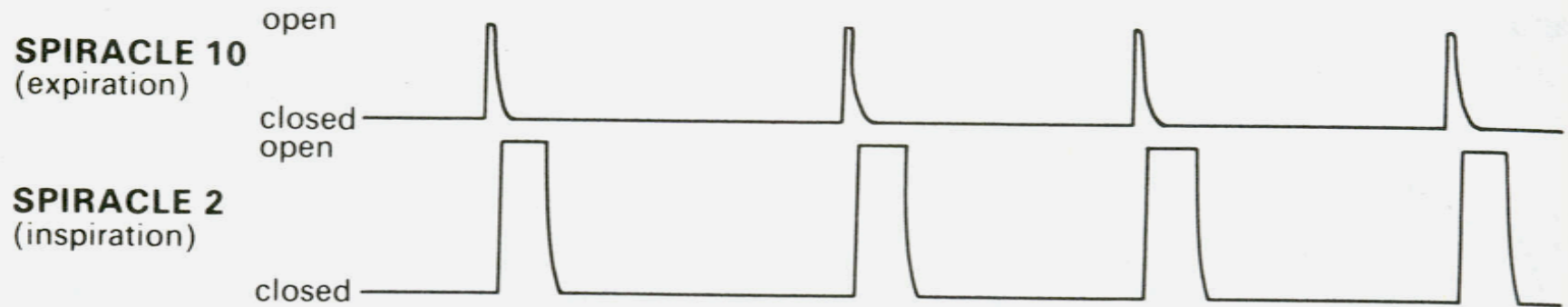


- faster from spiracle to tracheole
- than from tracheole to mitochondria



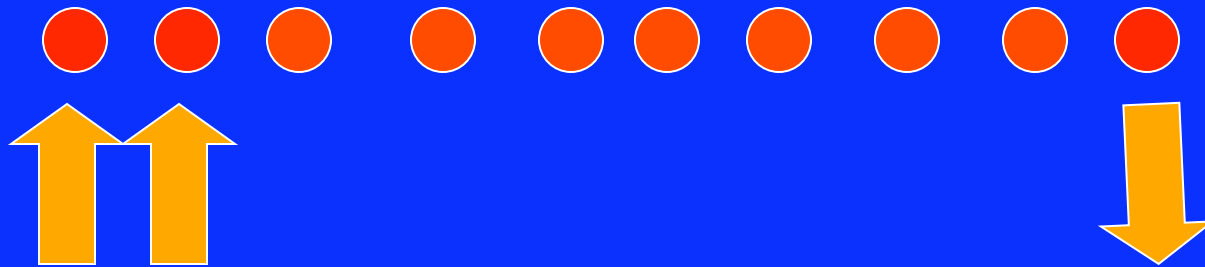
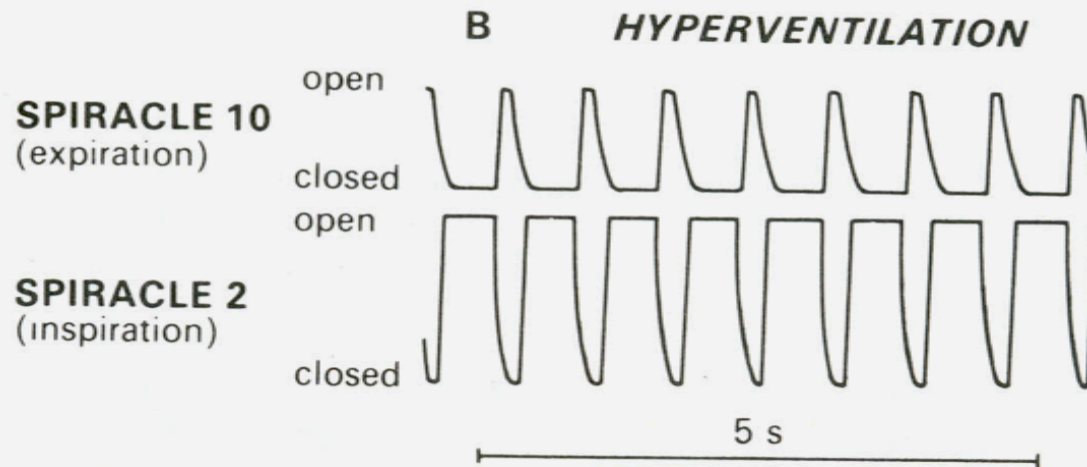
# resting ventilation, example

## A NORMAL VENTILATION



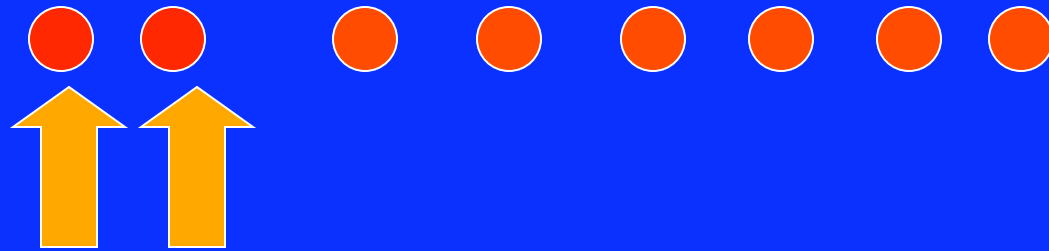


# hyperventilation - time 'all closed' is reduced - continuous

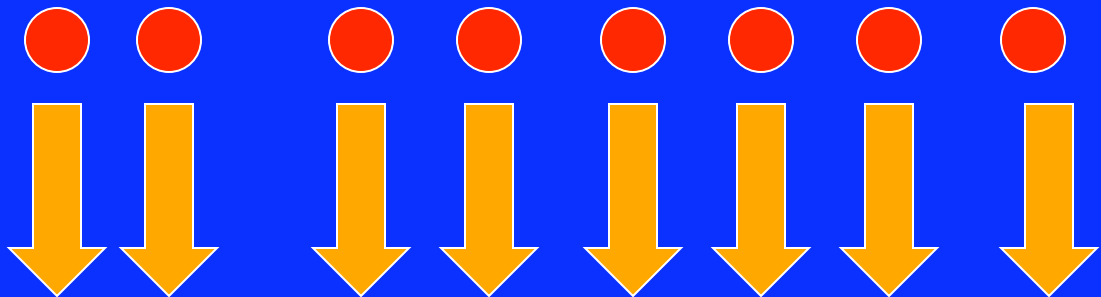


in flight, all spiracles are used

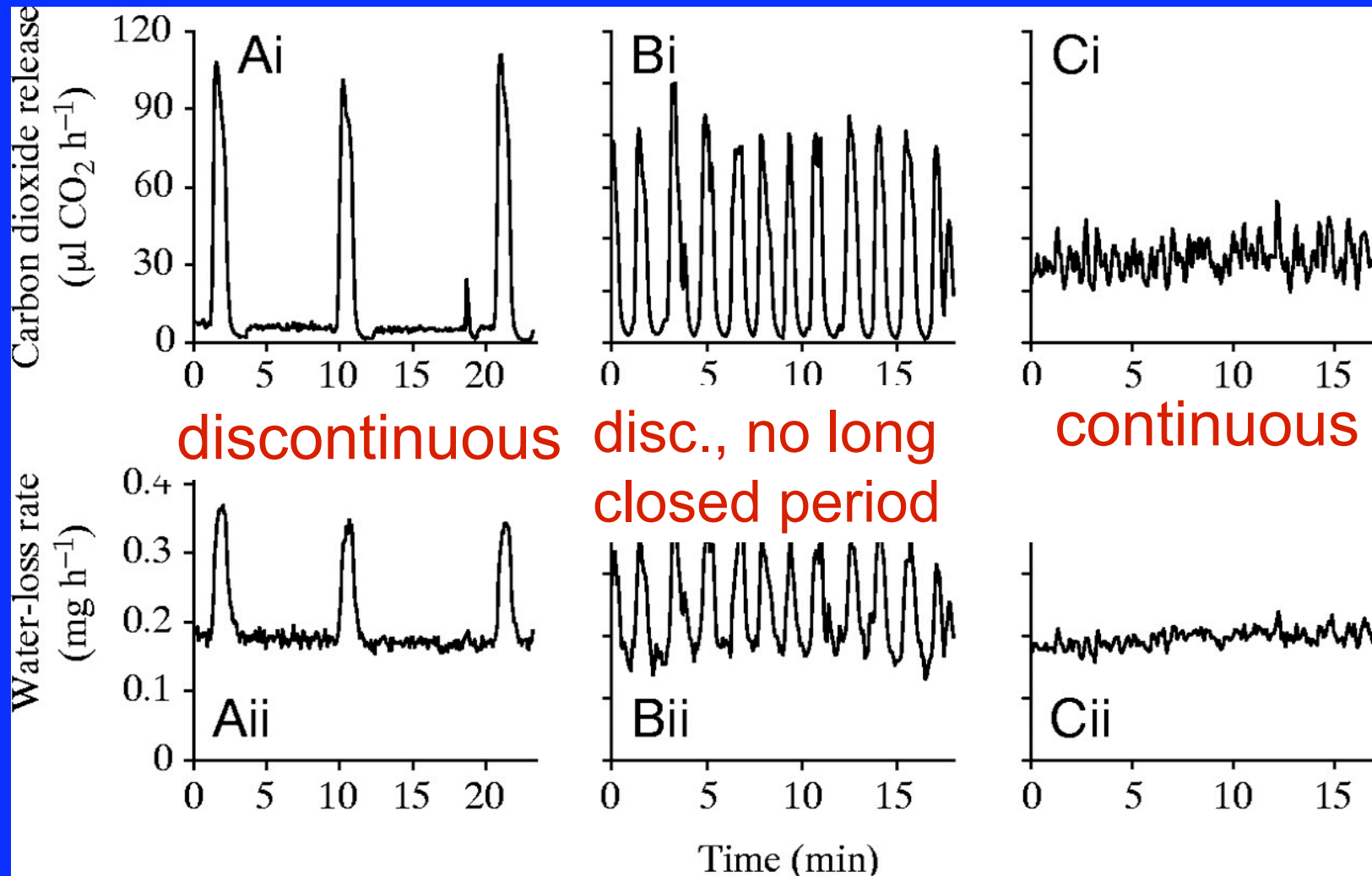
inspiration



expiration



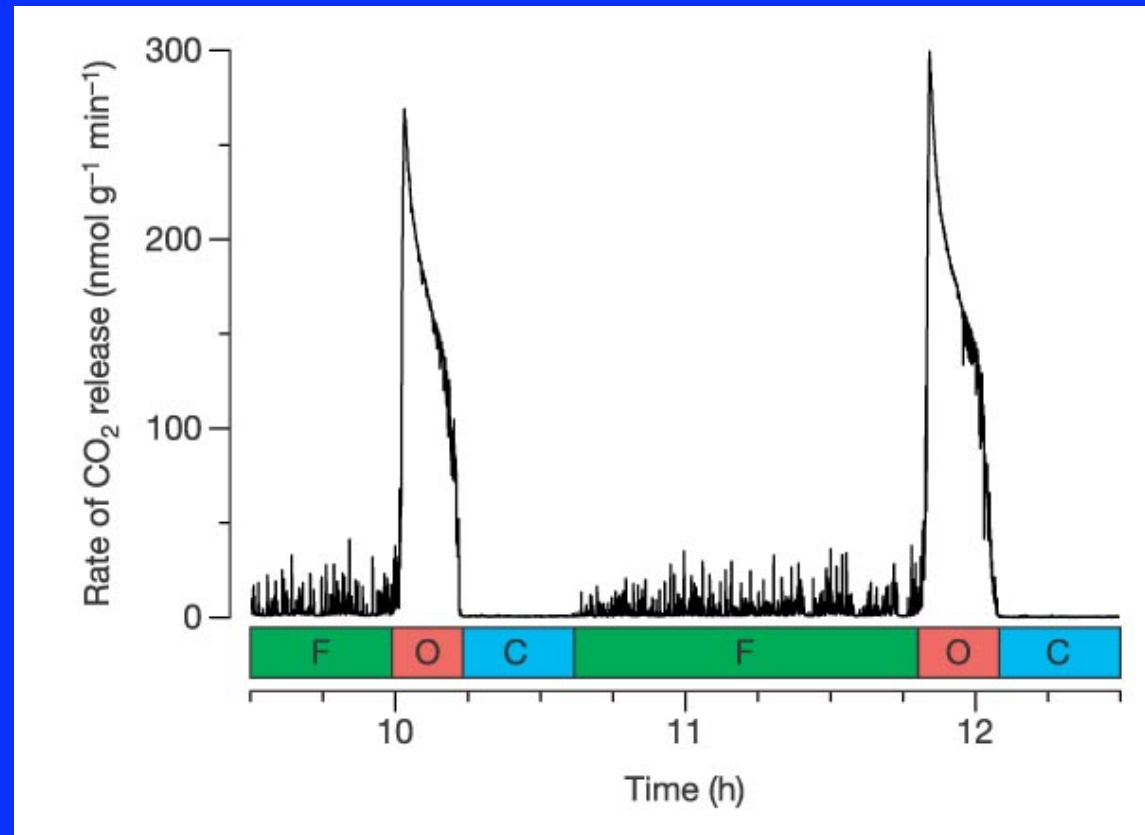
# Three general patterns of respiration in insects

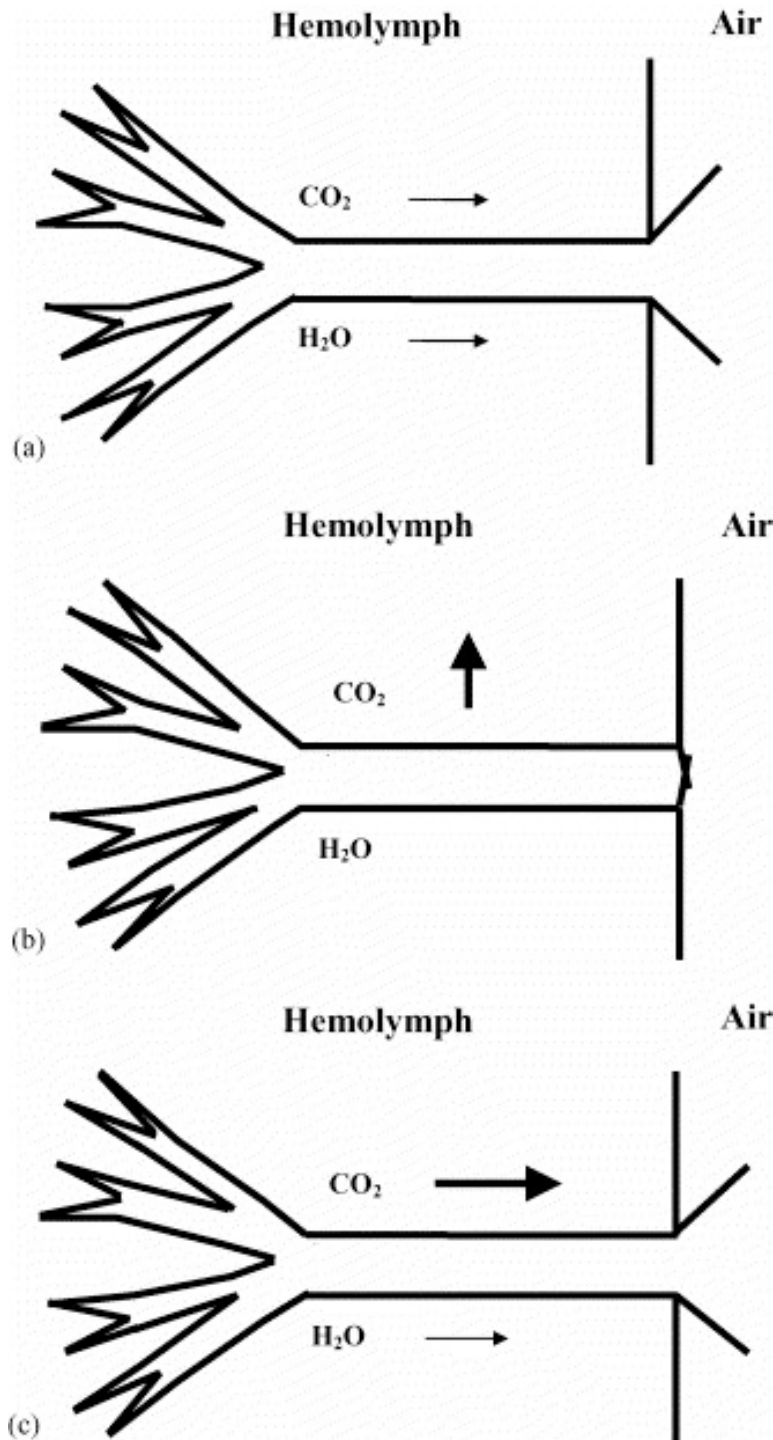


Recordings of CO<sub>2</sub> release (Ai-Ci) and water loss

# 3 spiracle phases

- Closed
- Flutter
- Fully open

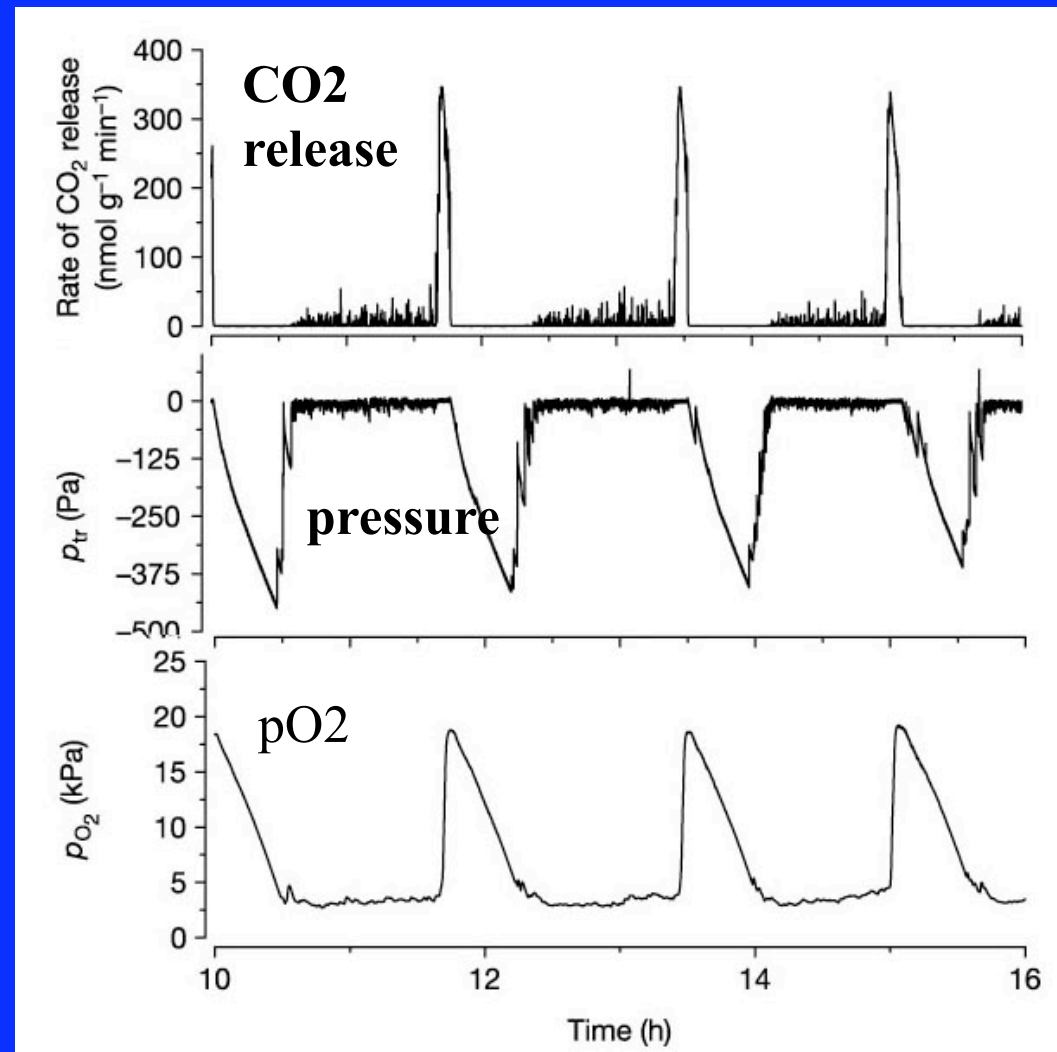




- end of open phase – gradient favors diffusion out of  $\text{CO}_2$ ,  $\text{H}_2\text{O}$
- spiracle closed,  $\text{CO}_2$  build up, no change in  $\text{H}_2\text{O}$
- spiracle opens – gradient for  $\text{CO}_2$  flow out high,  $\text{H}_2\text{O}$  always the same

# Start with Closed Phase

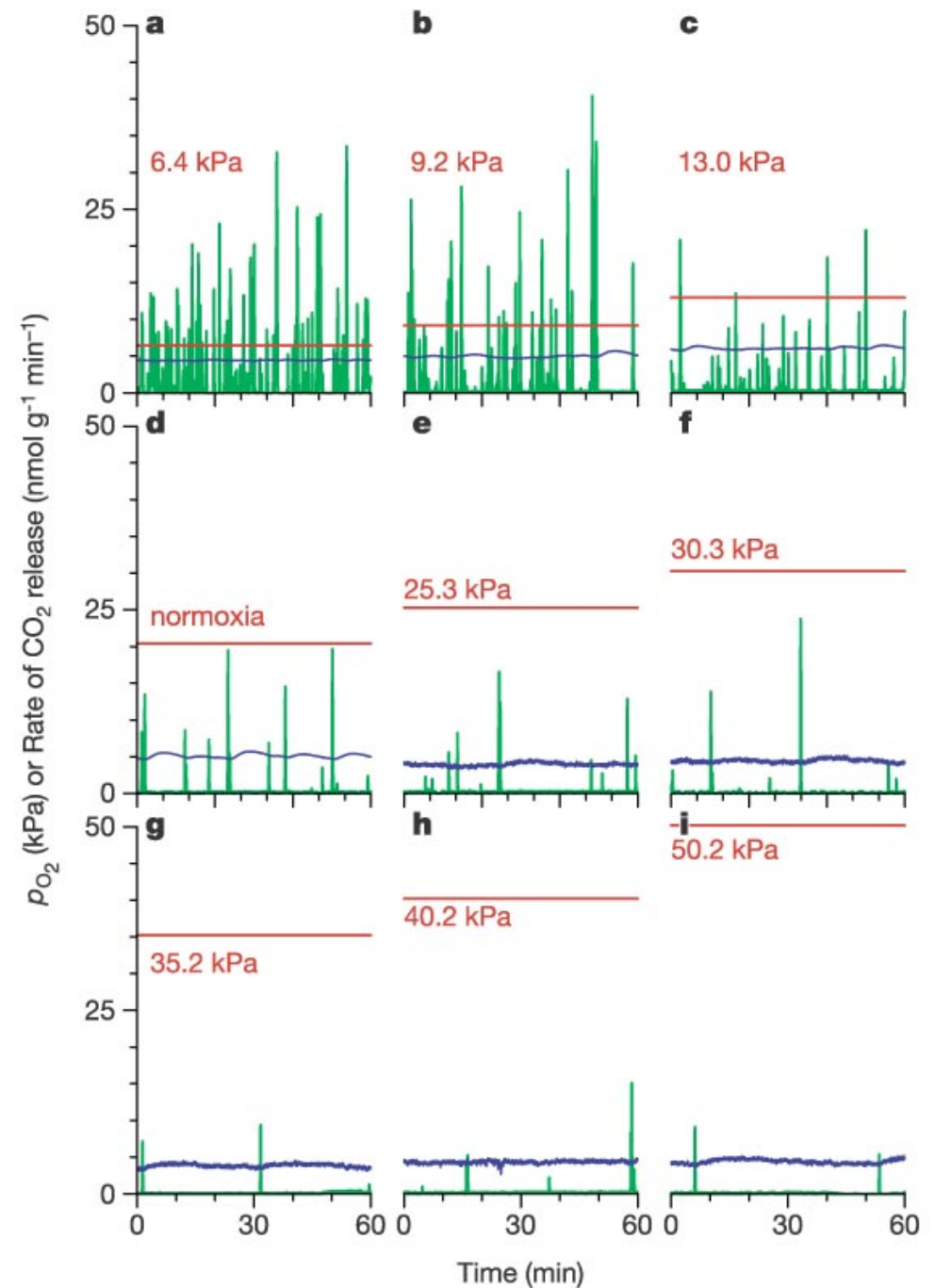
- pO<sub>2</sub> falls
- Pressure falls
- Flutter begins
- Pressure equalizes
- Build up of CO<sub>2</sub> triggers spiracle to open
- O<sub>2</sub> triggers closure



# Manipulate oxygen levels

- Red line is oxygen level in atmosphere
- Green lines are CO<sub>2</sub> release
- Blue line is the O<sub>2</sub> level inside tracheae

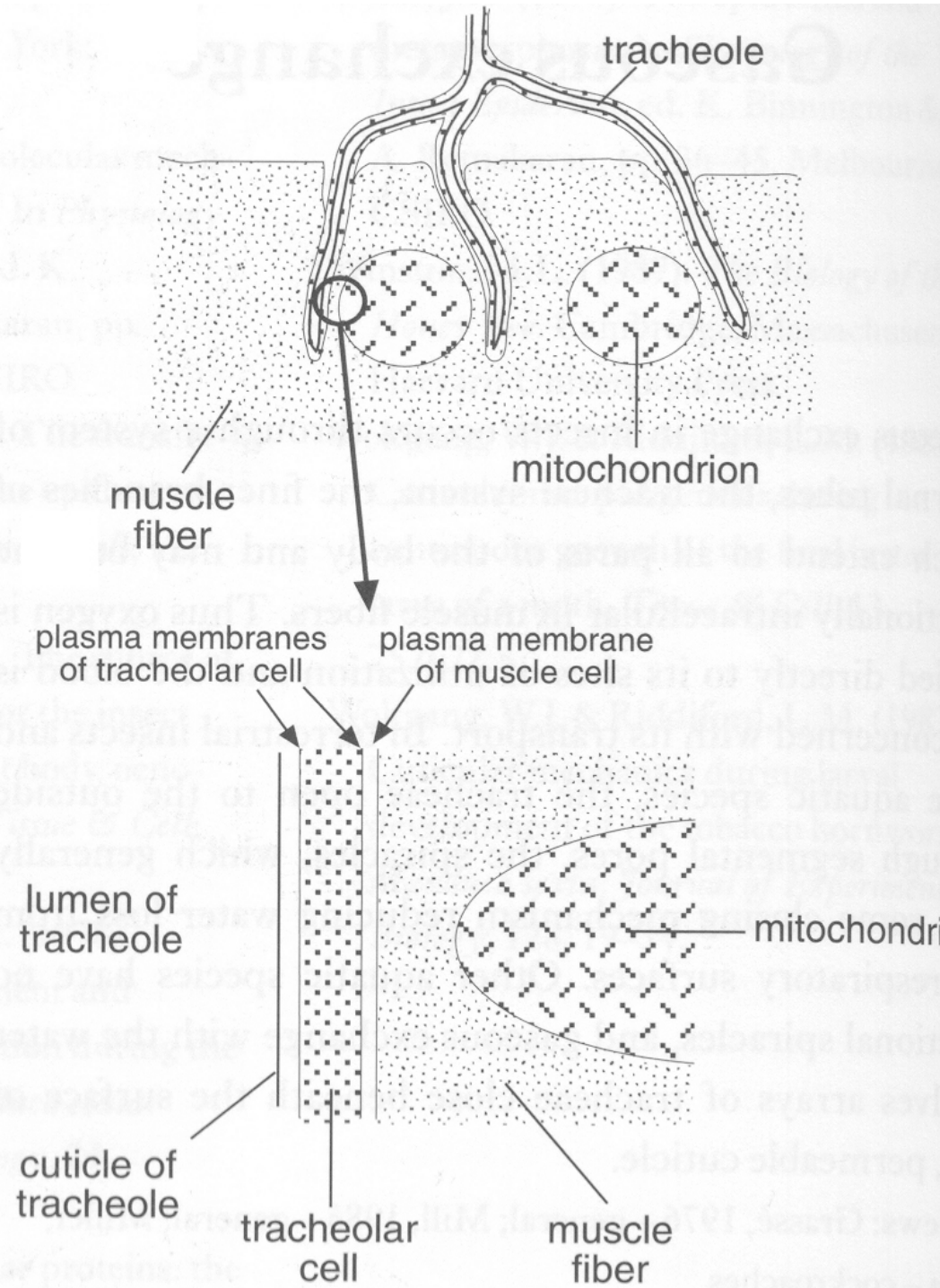
2005 Nature 433:516



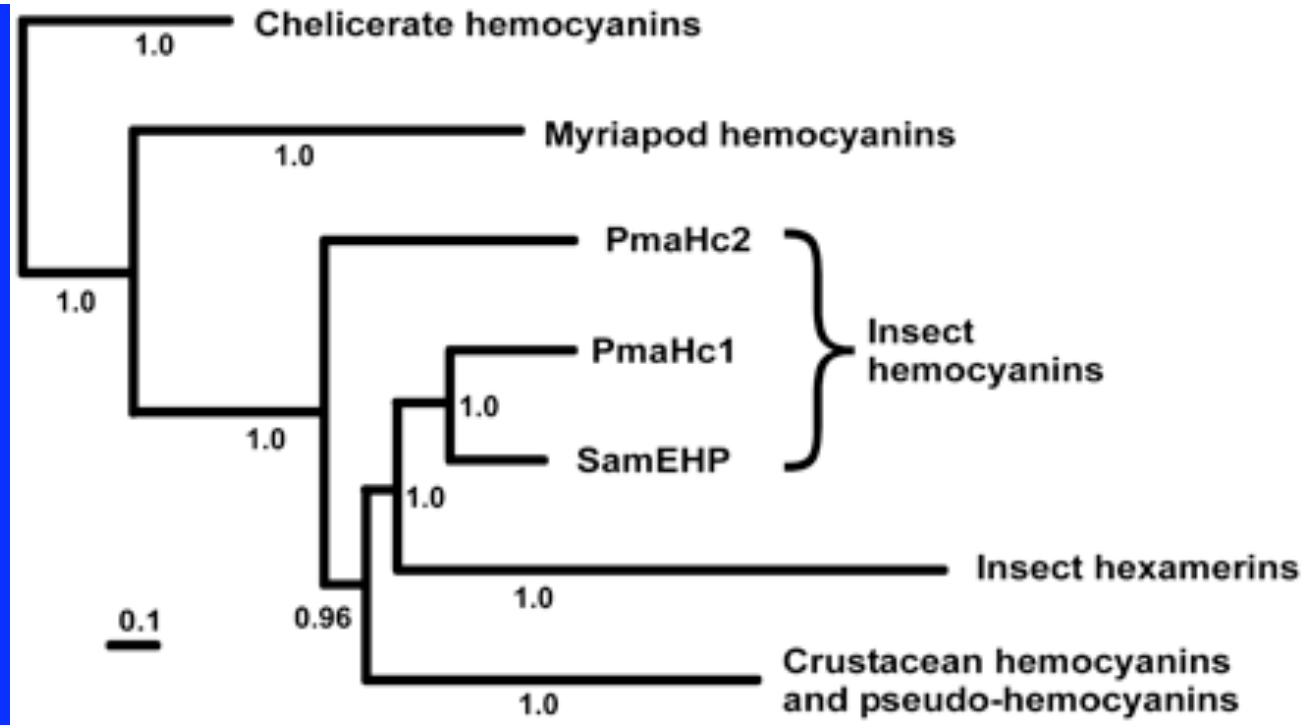
# Diffusion of oxygen

## oxygen

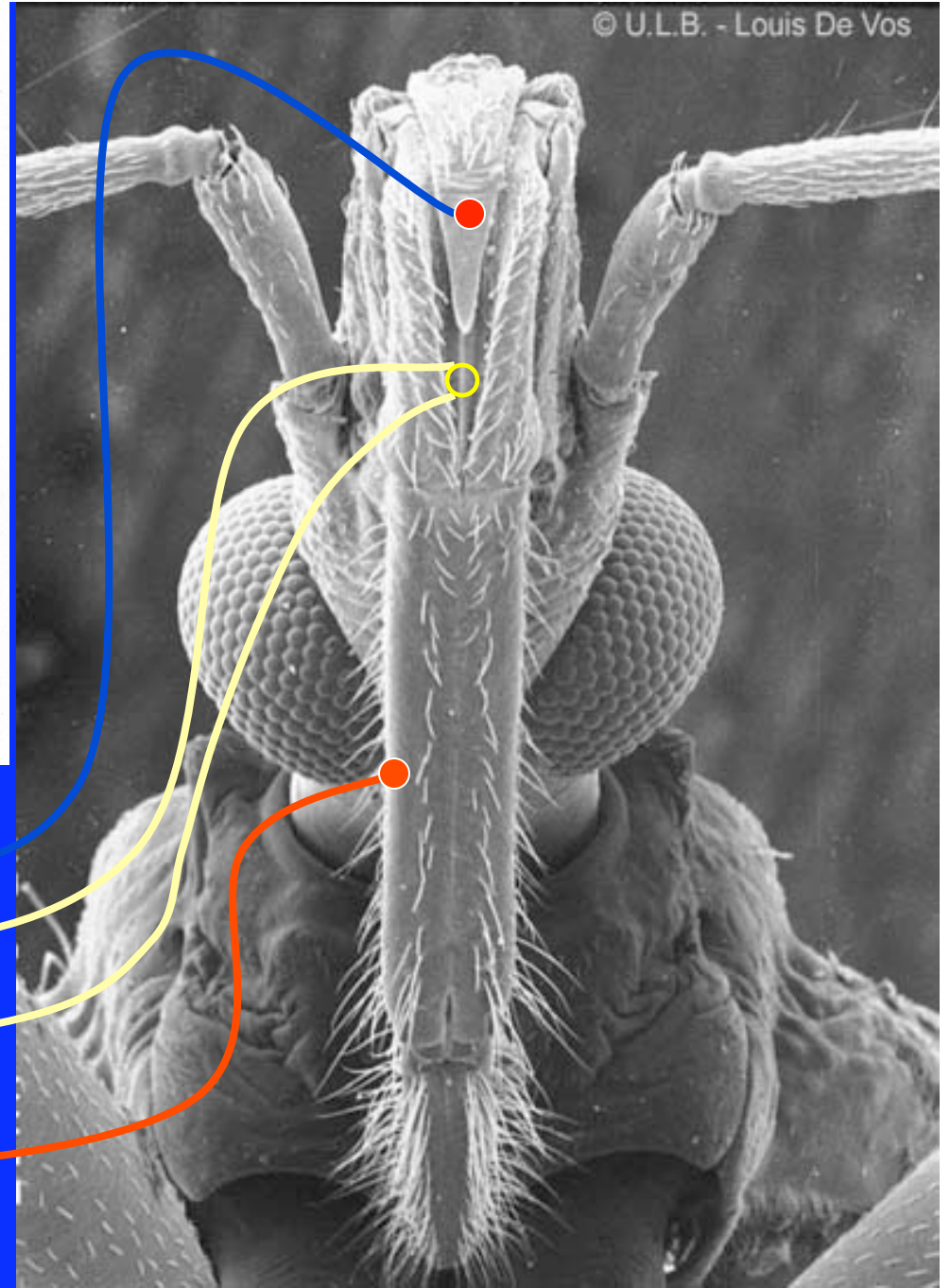
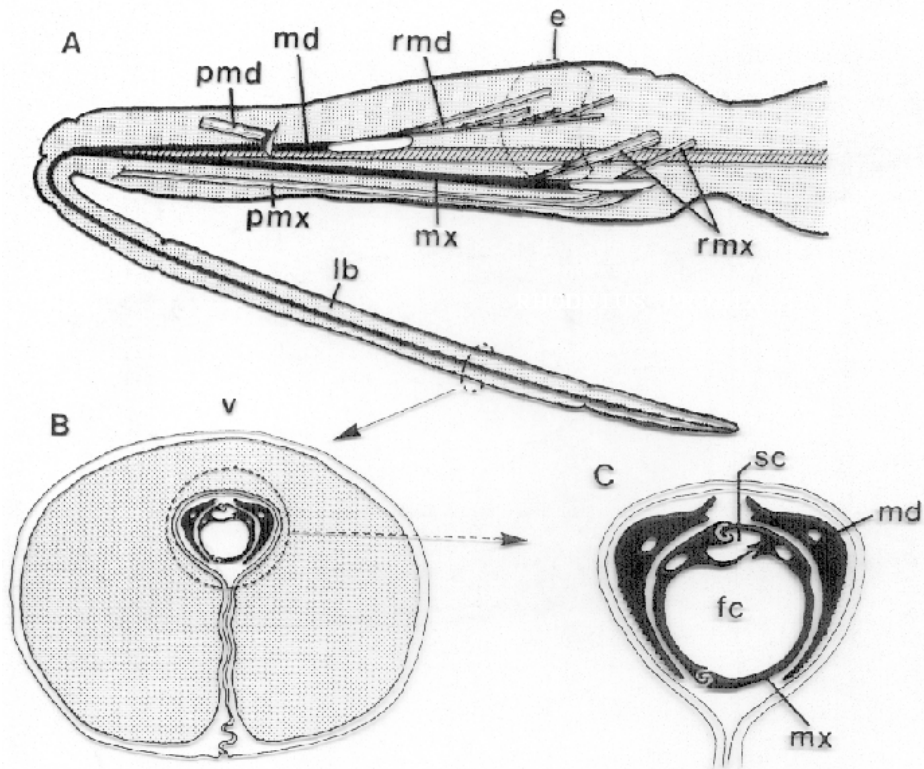
remember that diffusion of oxygen through tissue between the tracheole and mitochondria is slow





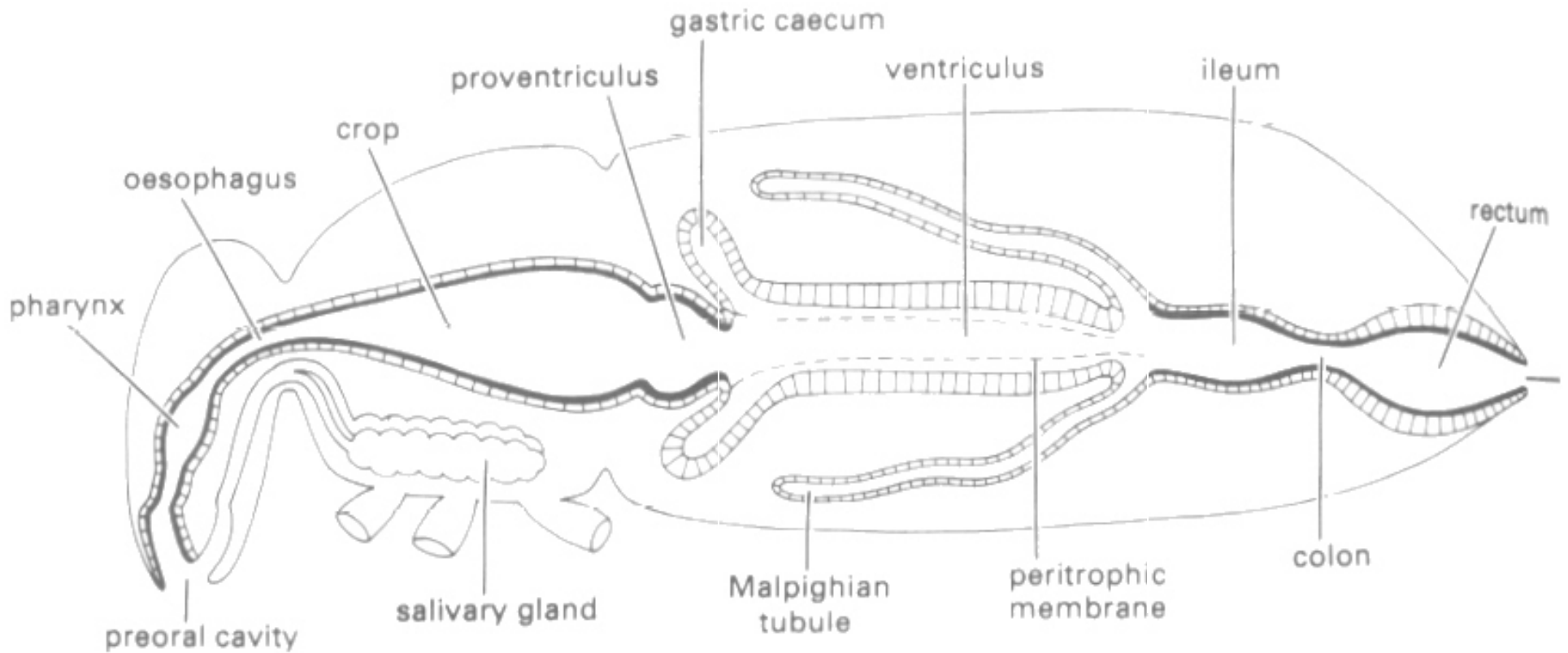
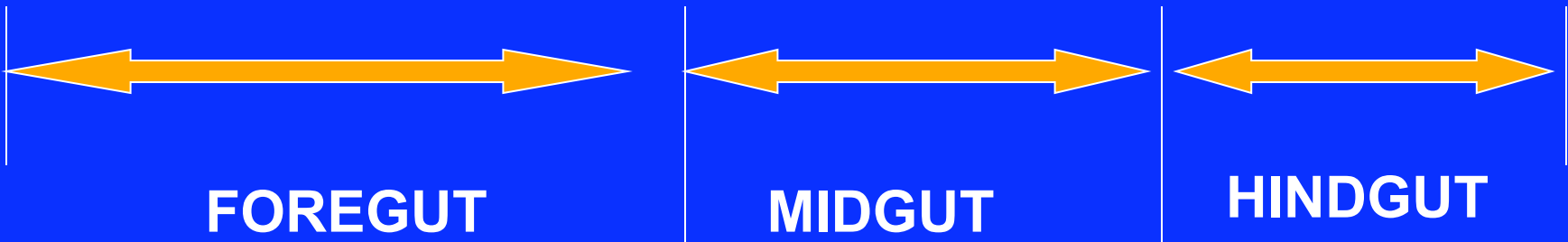


- relationship of INSECT HEMOCYANINS to other arthropod hemocyanins
- higher insects have lost them
- (have a new function!)

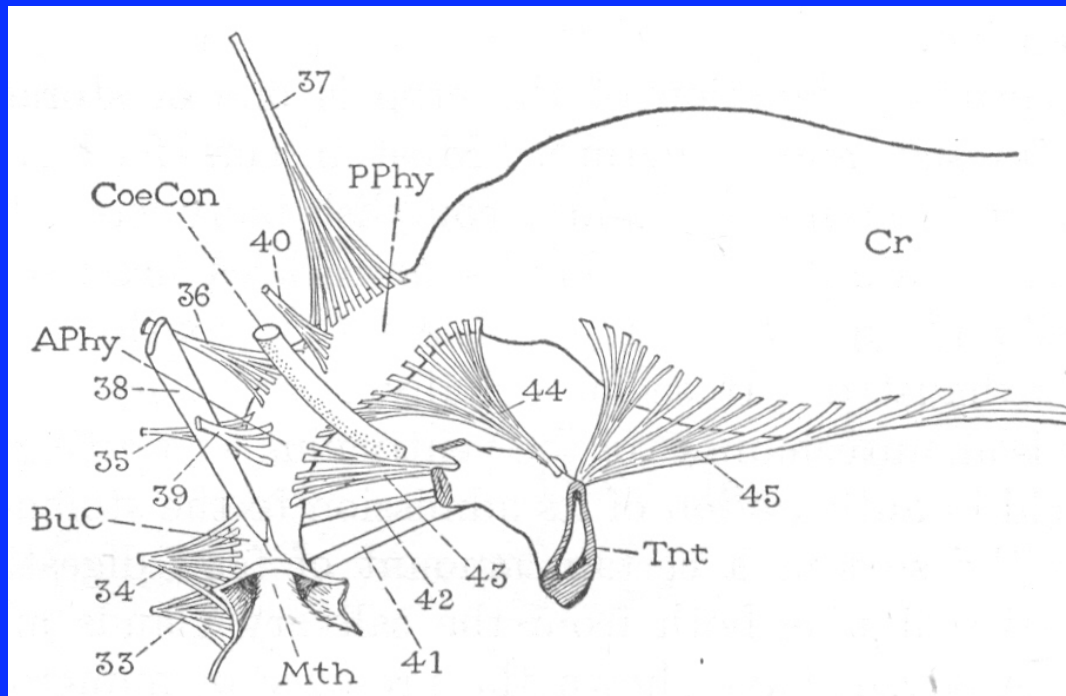


- labrum
- mandibles
- maxillae
- labium

# Your basic gut

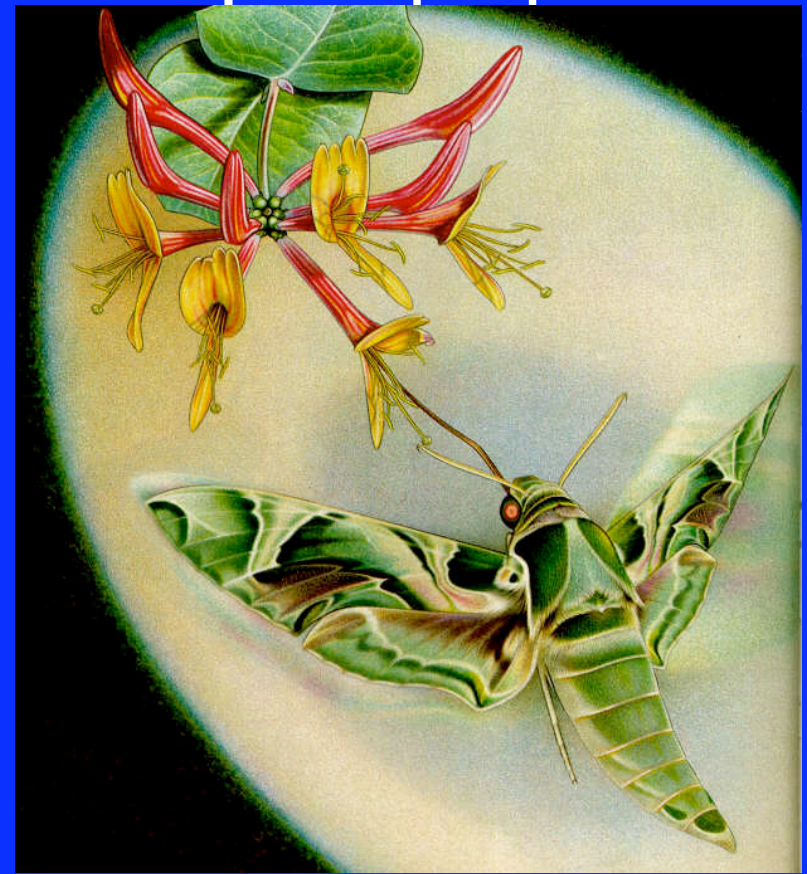
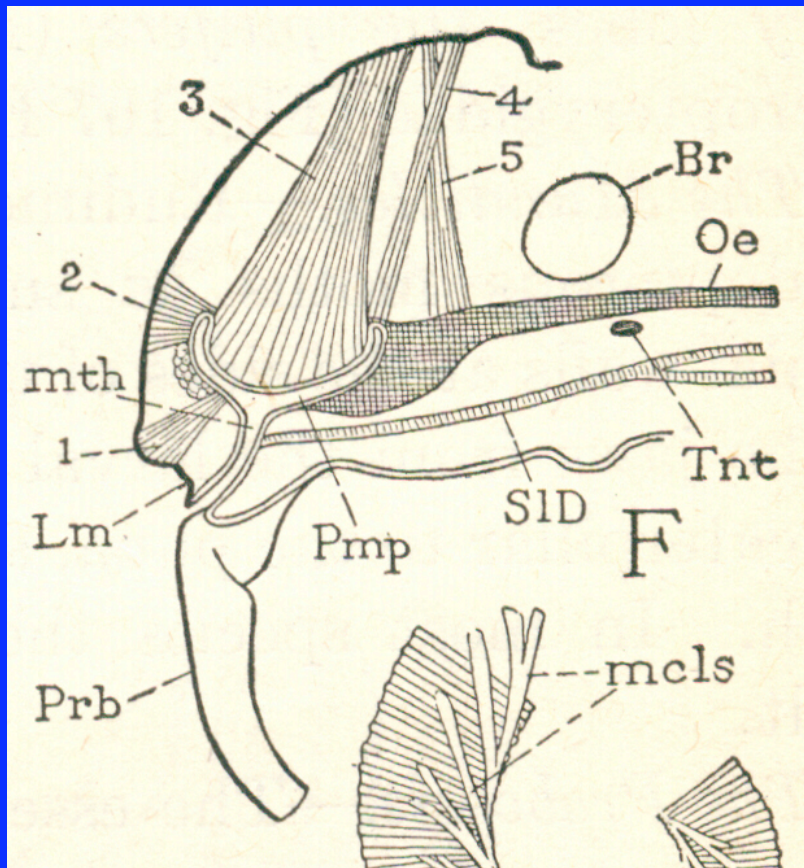


# grasshopper pharynx-crop

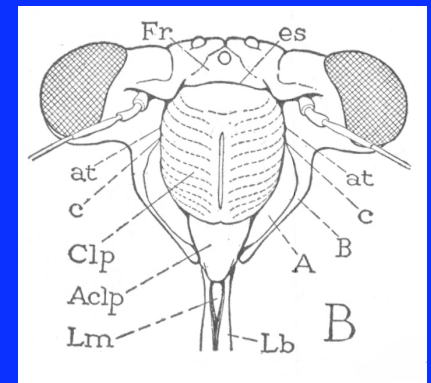
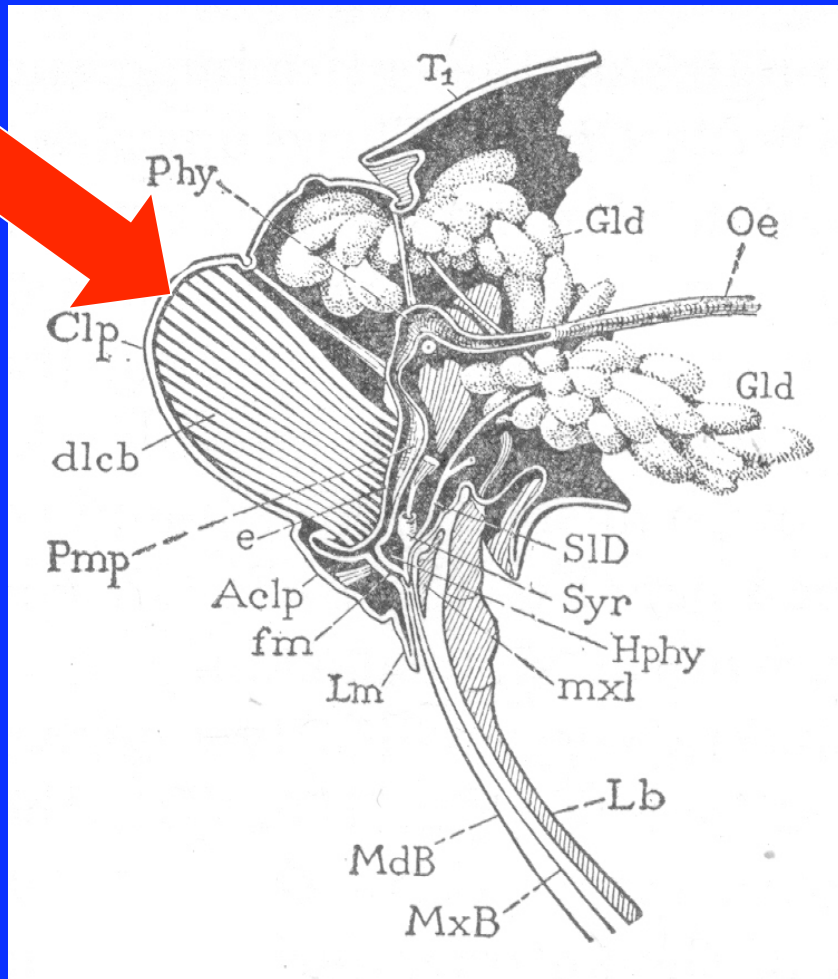


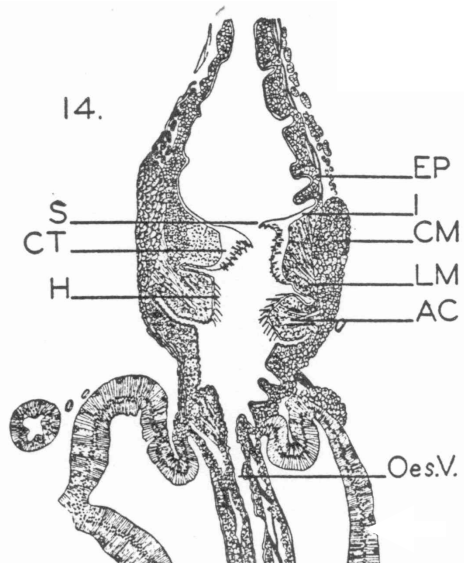
- pharynx especially has muscles
- muscles give the ability to PUMP

# pharyngeal pump - Lepidoptera



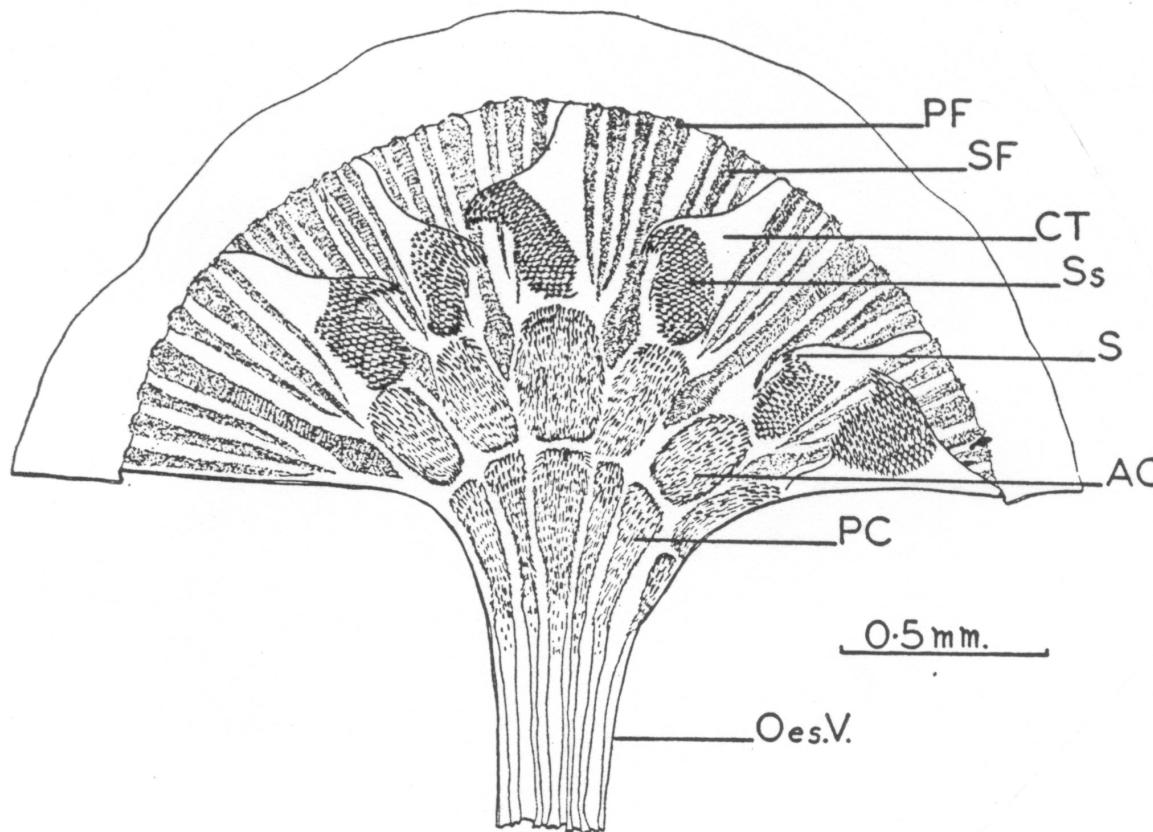
# pharyngeal pump - plant fluid feeds





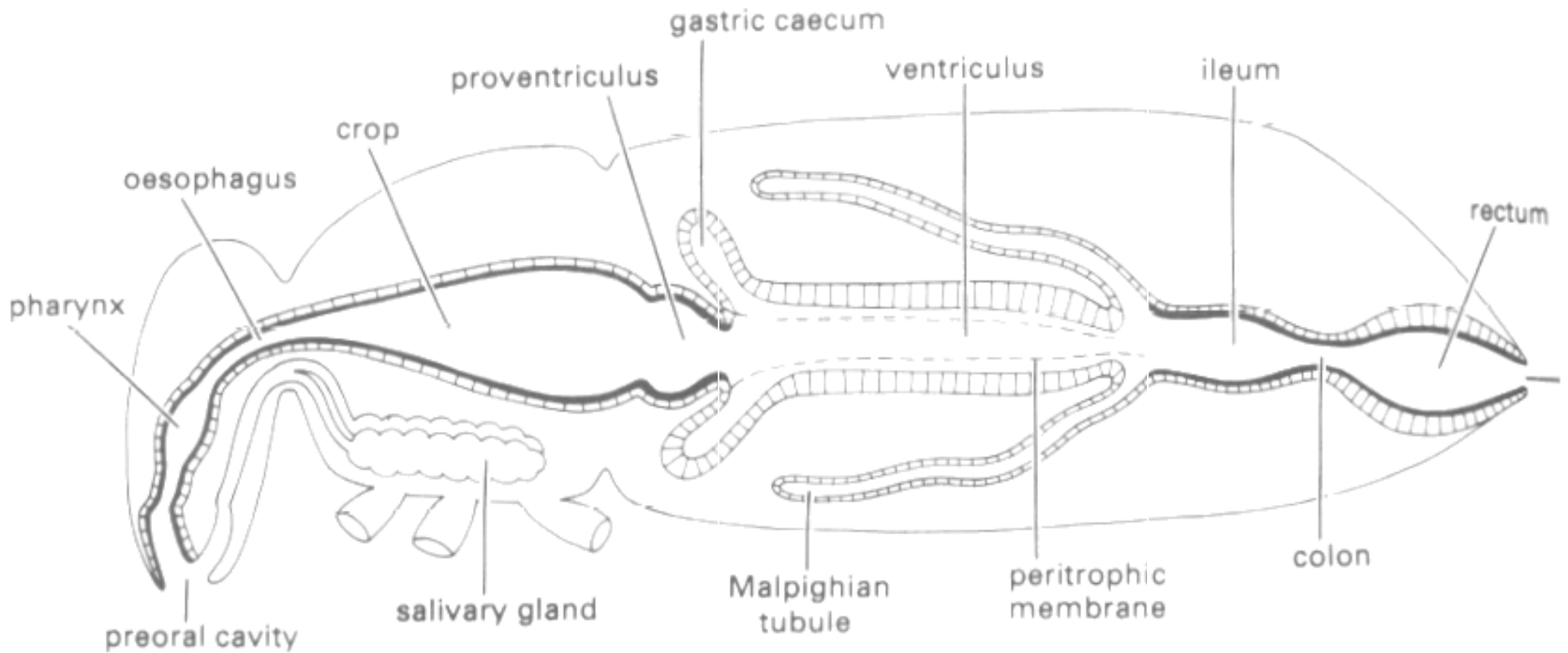
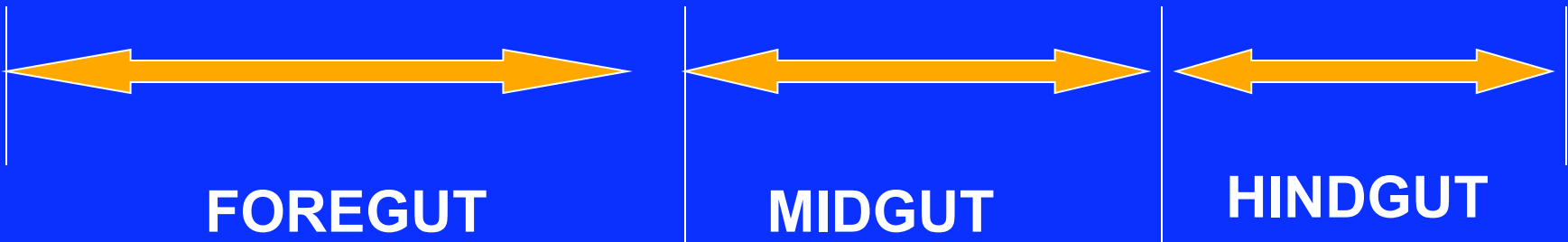
midgut

# proventricular spines



- orthopteroid insects
- push and tear food
- good species specific characters

# Your basic gut





# Midgut - general features

- = ventriculus
- NOT lined with cuticle
- gastric caeca
- secretes enzymes
- absorbs nutrients
- secretes peritrophic envelope

