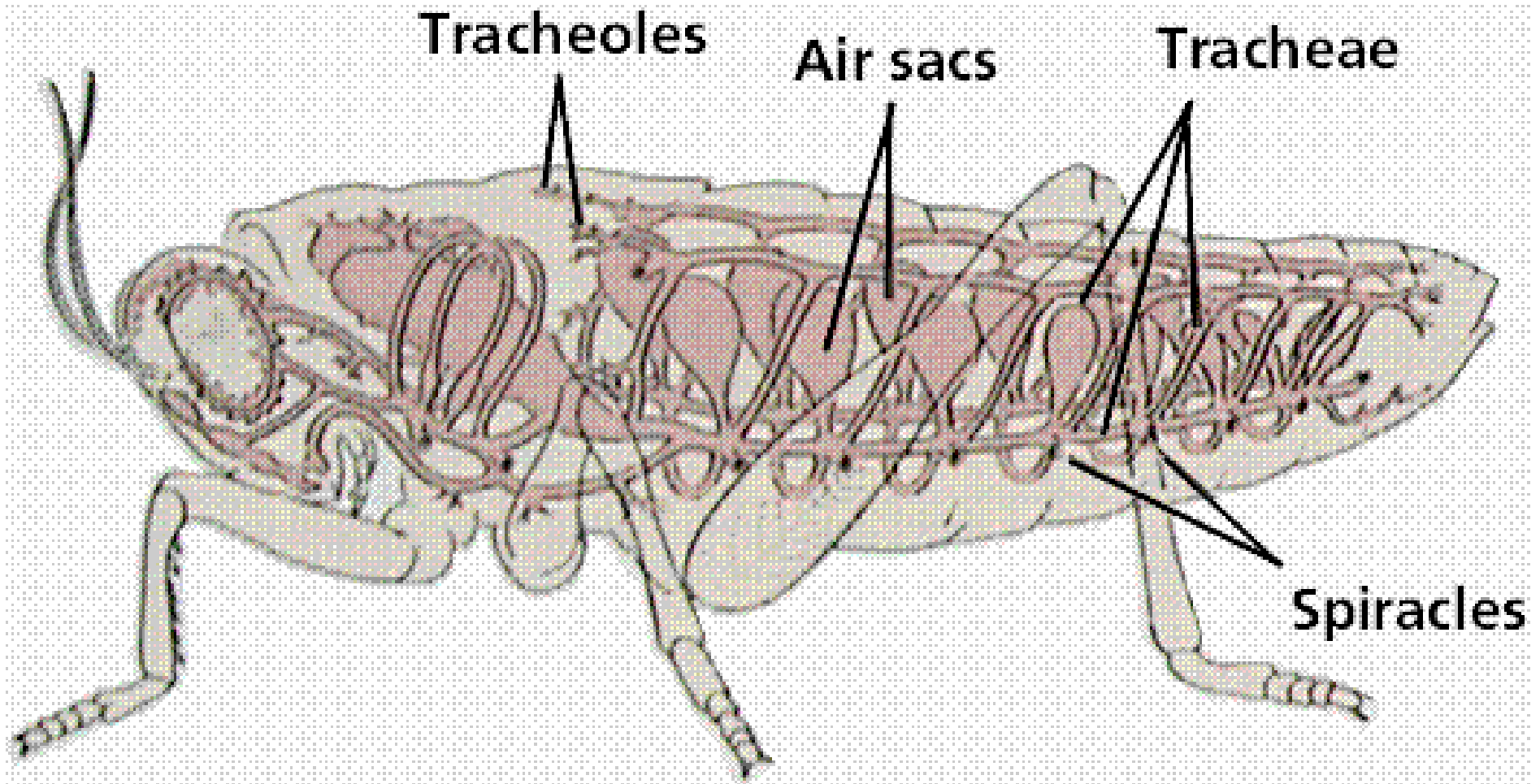
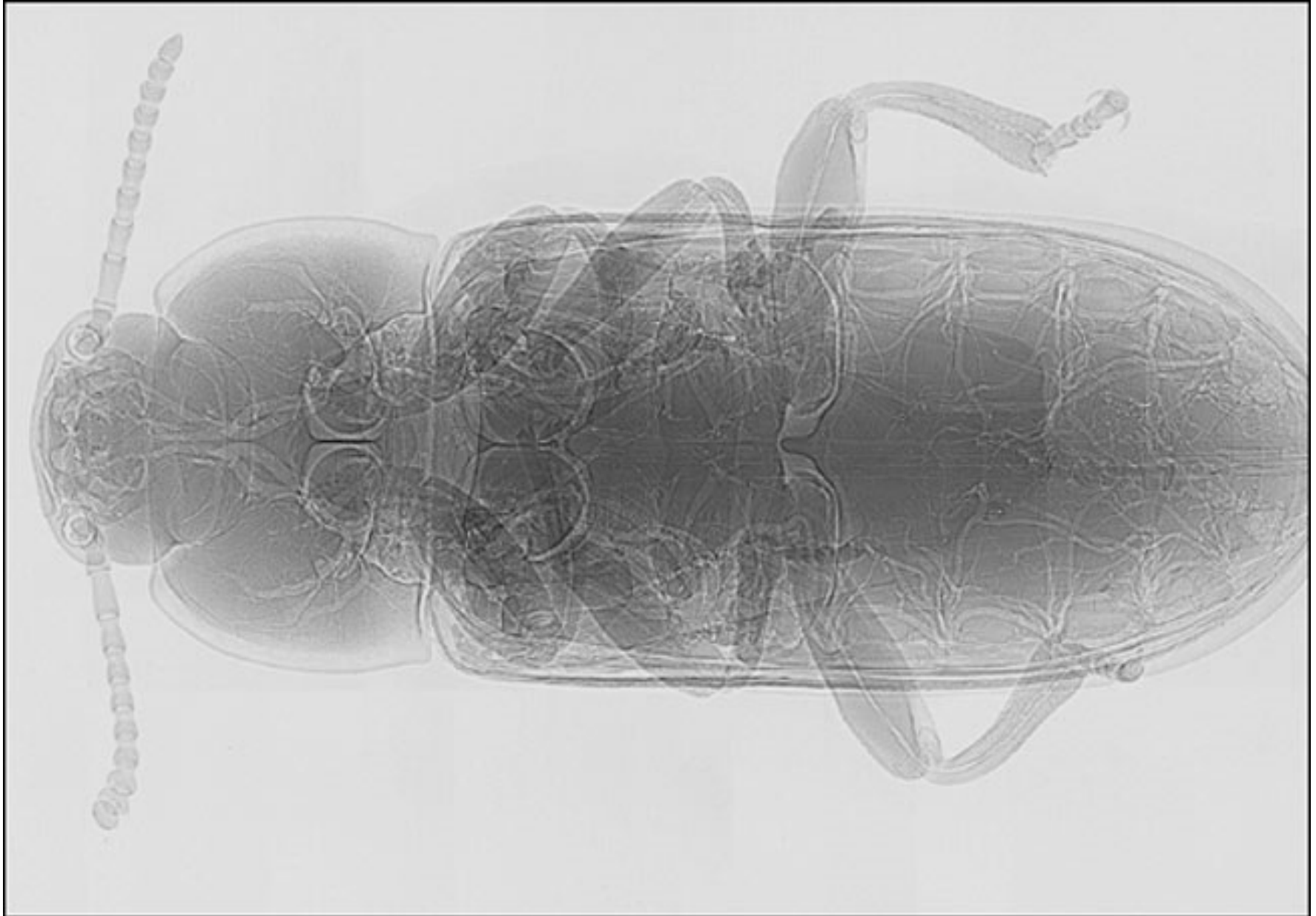


# The Insect Gas Exchange System



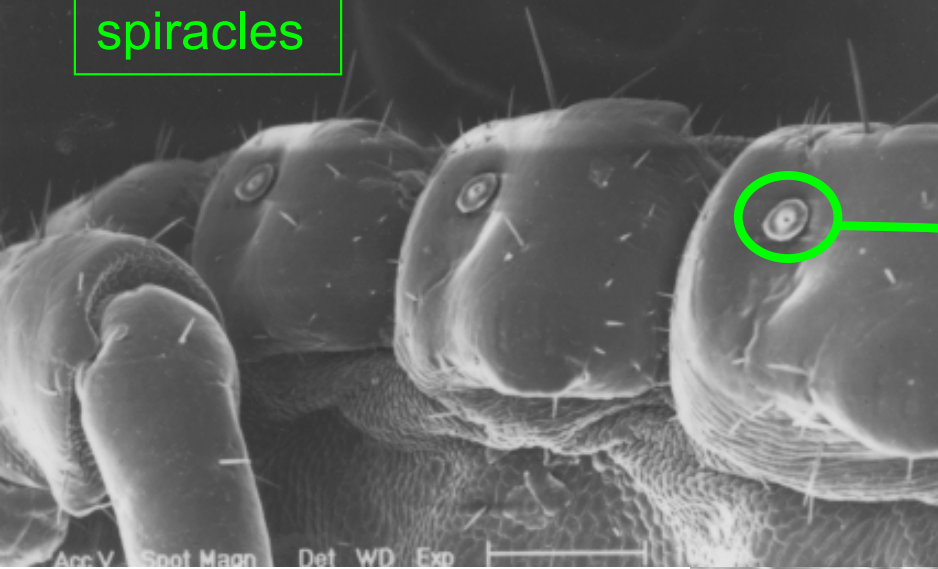
An X-ray of the yellow mealworm beetle - revealing the system of white tubes or tracheae running through its body



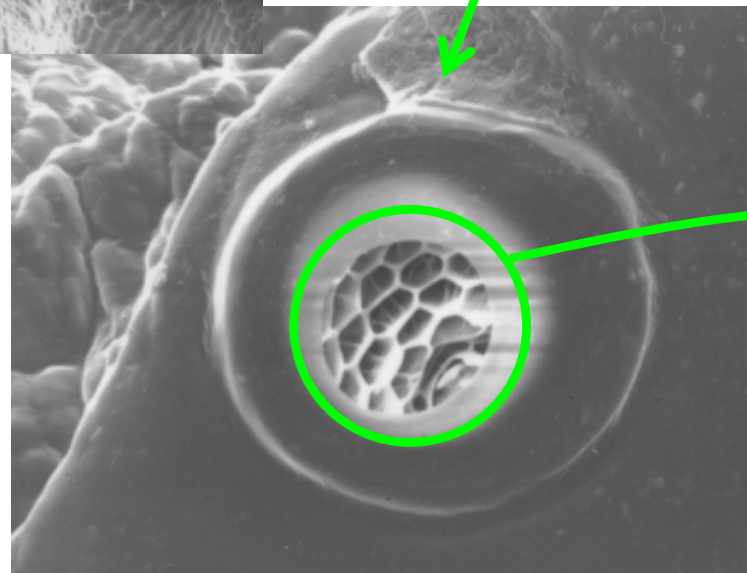
# The Insect Gas Exchange System

- An insect has spiracles (openings) lined with chitin on the sides of its body.
- The chitin give shape to the openings.
- The spiracles can open and close by small muscles.
- These muscles contract to shut flap like valves and relax to open the valves – allows control of the flow of air as well as slow down the loss of water.

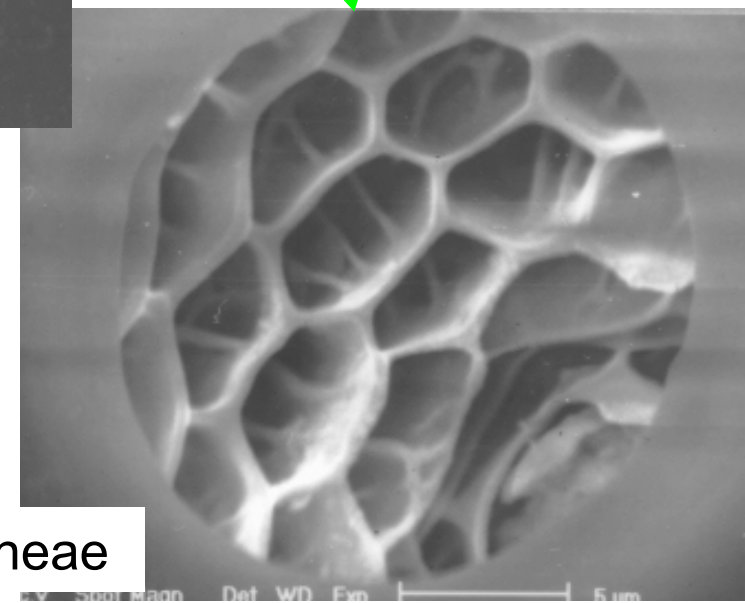
spiracles



Zoom

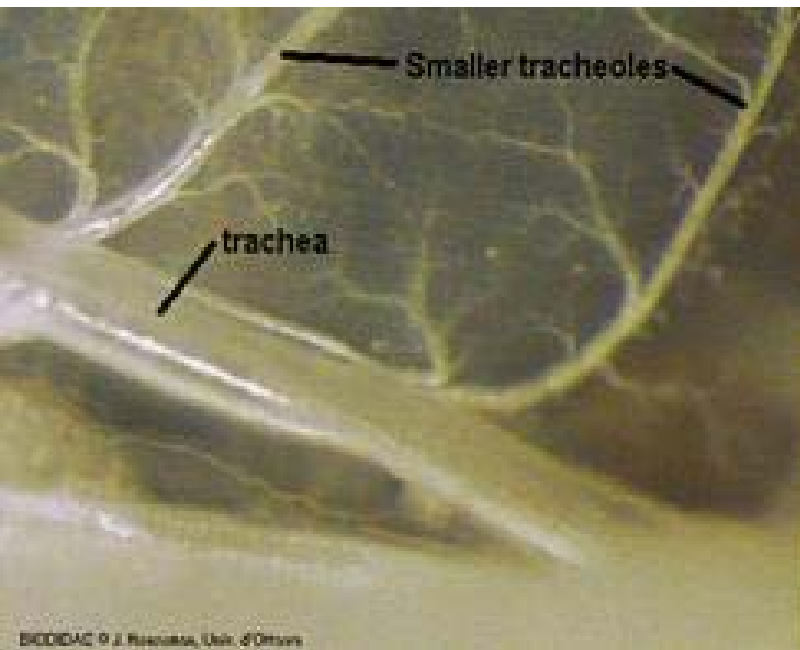
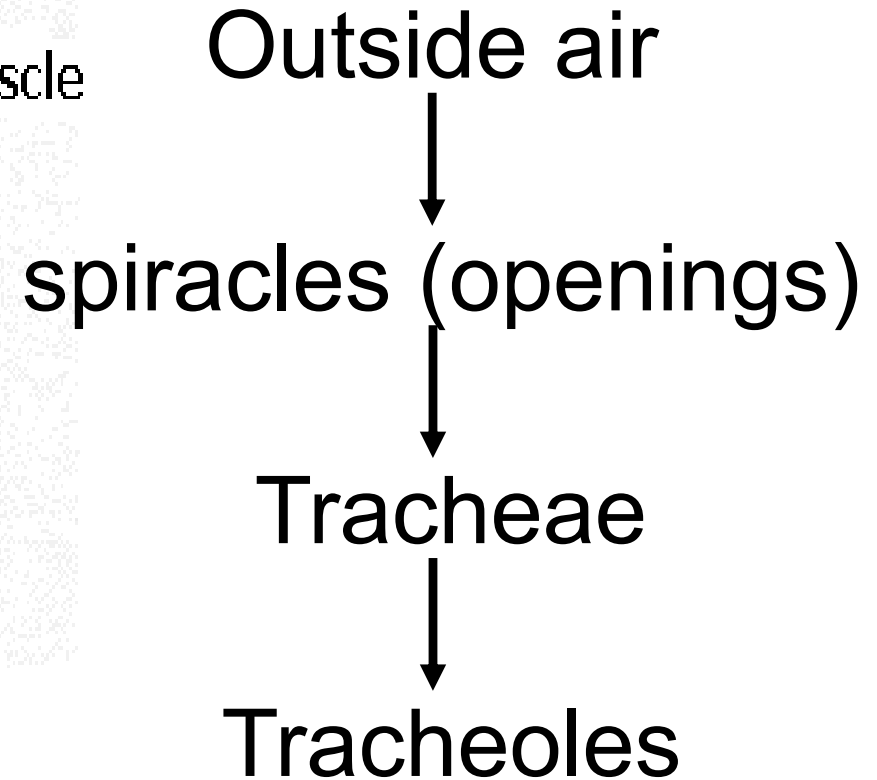
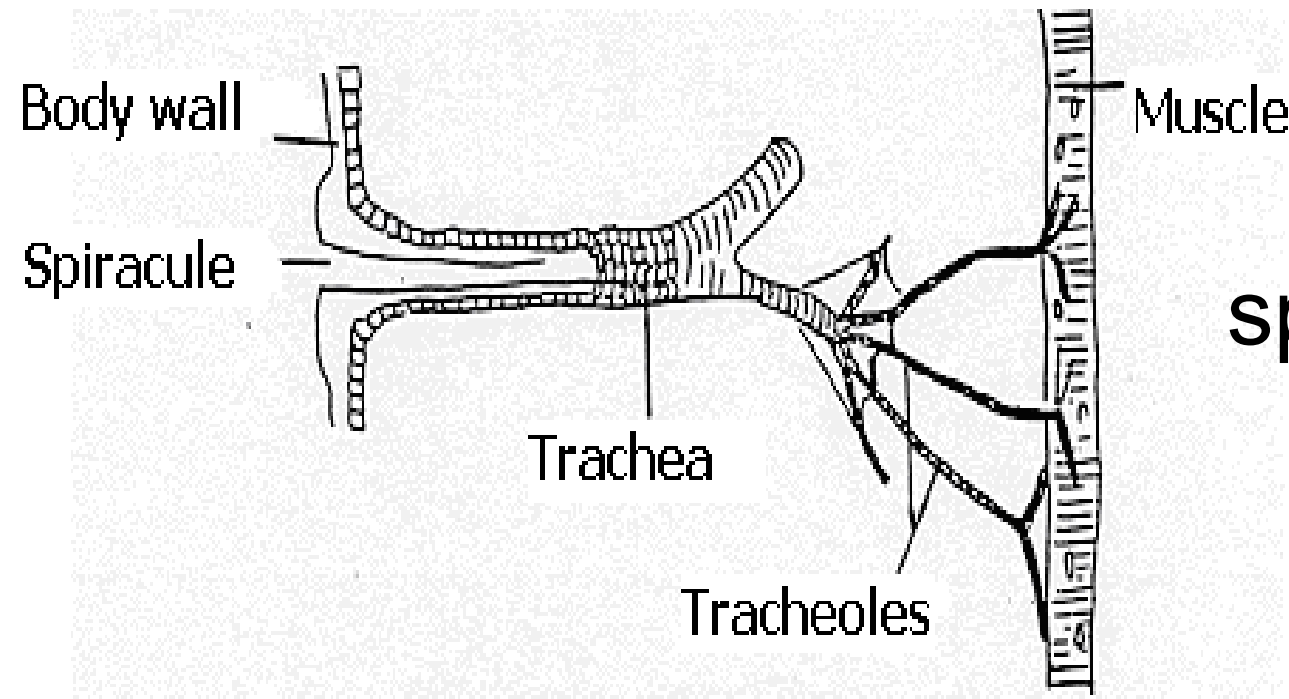


Zoom

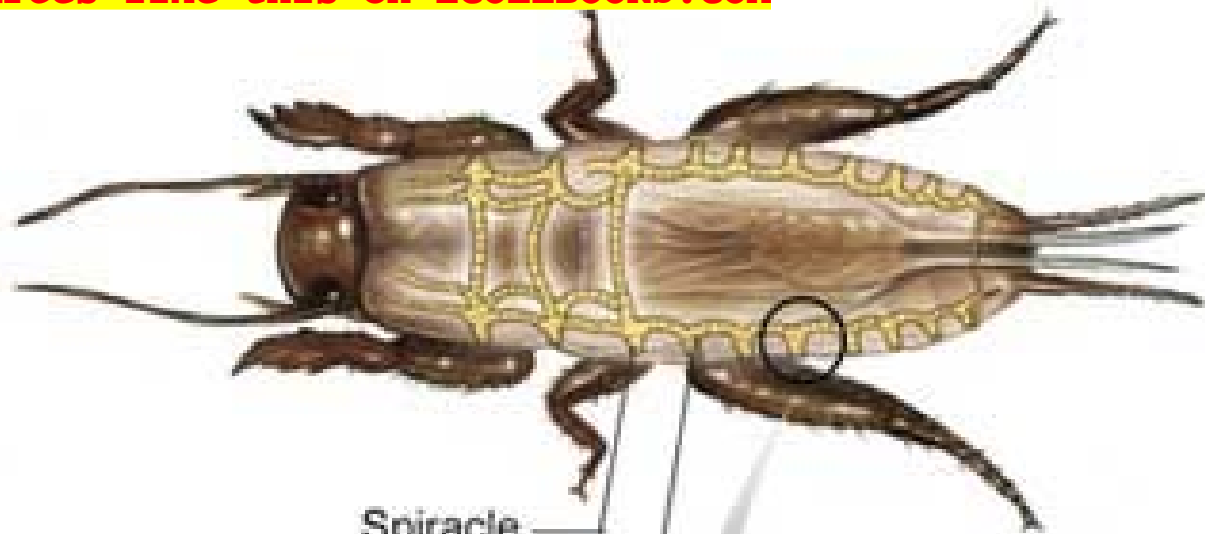


The spiracles open into a system of tubes called tracheae

# Tracheal System



Trachea walls are reinforced with **Taenidia** (thickening of the chitin) – allows insects to flex and stretch without developing kinks that might restrict air flow.



Spiracle

Tracheal tube

Epithelial cell

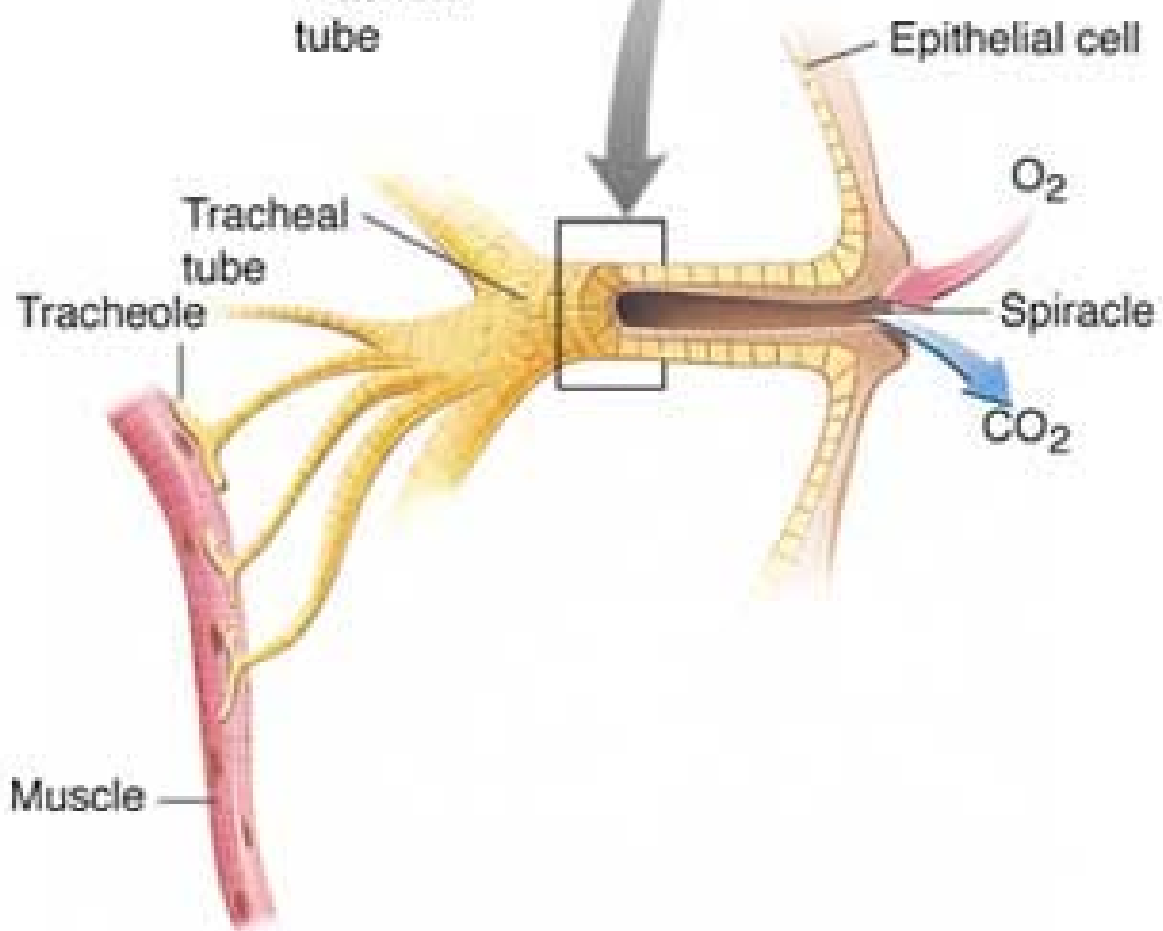
Tracheal tube  
Tracheole

O<sub>2</sub>

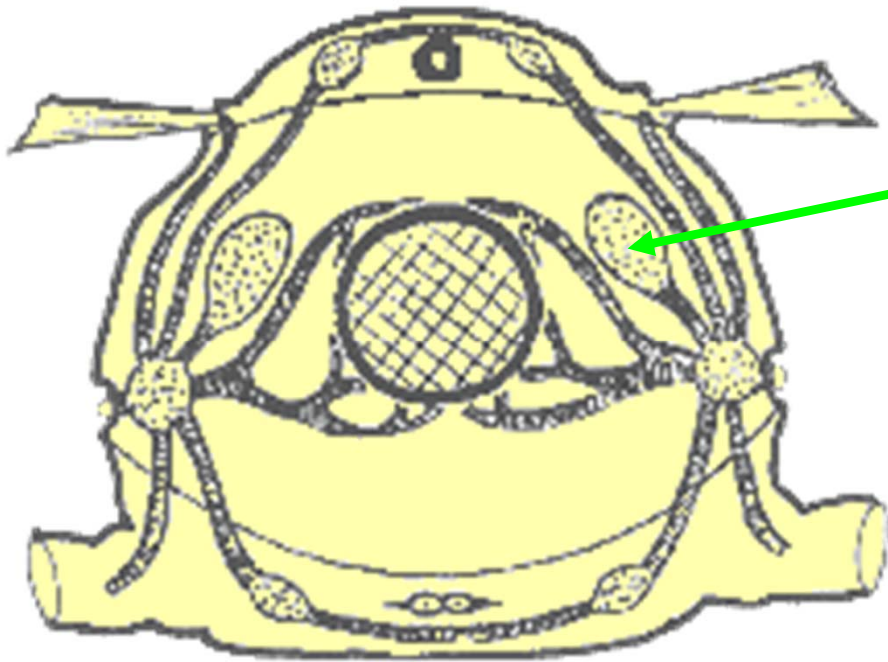
Spiracle

CO<sub>2</sub>

Muscle

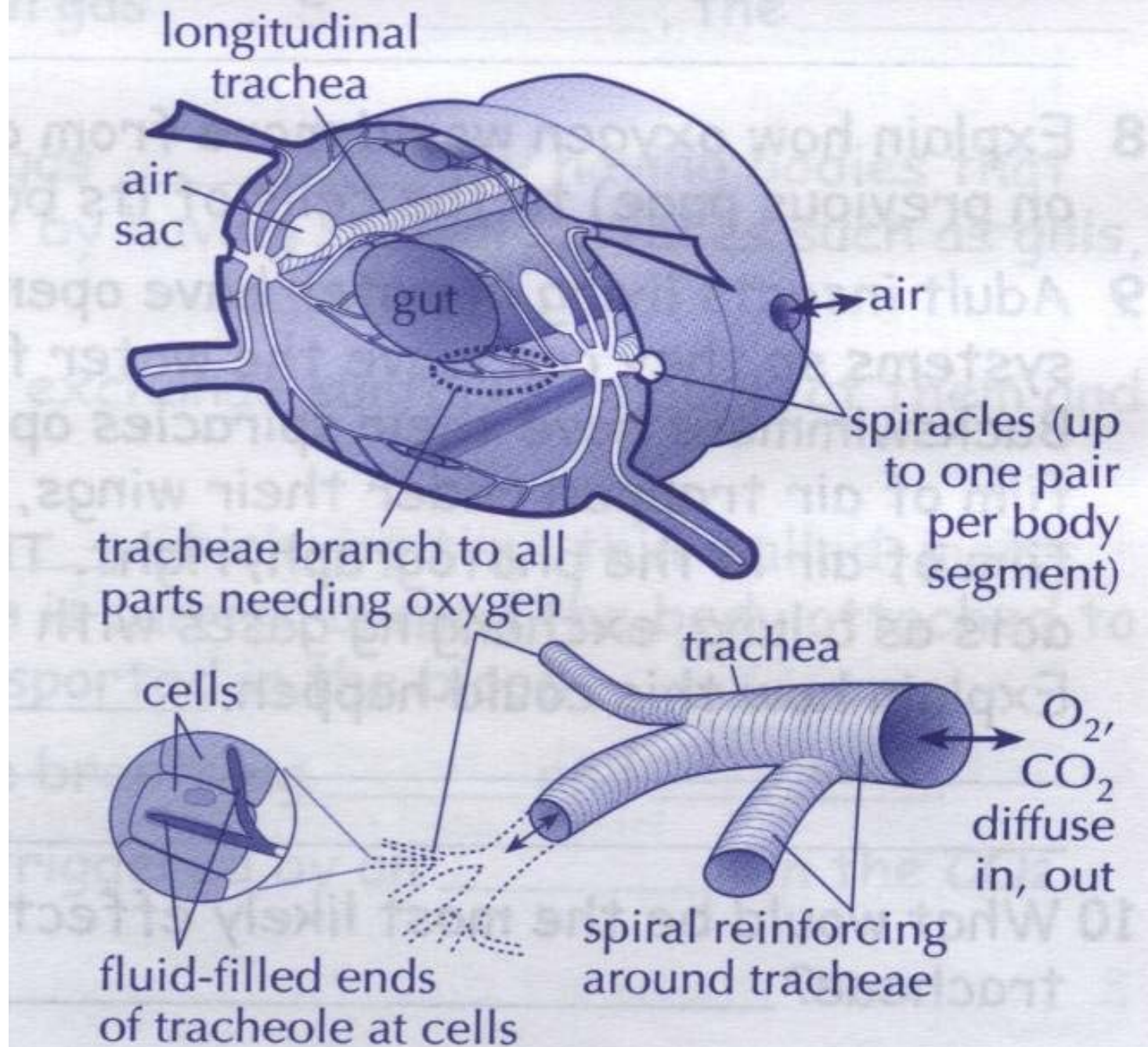


# Storage of Air – adaptation for dry habitat



- Collapsible air sacs present in areas without taenidia
- In dry terrestrial environments, this temporary air supply allows insects to conserve water by closing its spiracles during very dry periods use the stored air in the sacs.

## A diagram showing the general arrangement of tracheae and spiracles in open tracheal systems





# Respiratory tubes in a mayfly larva

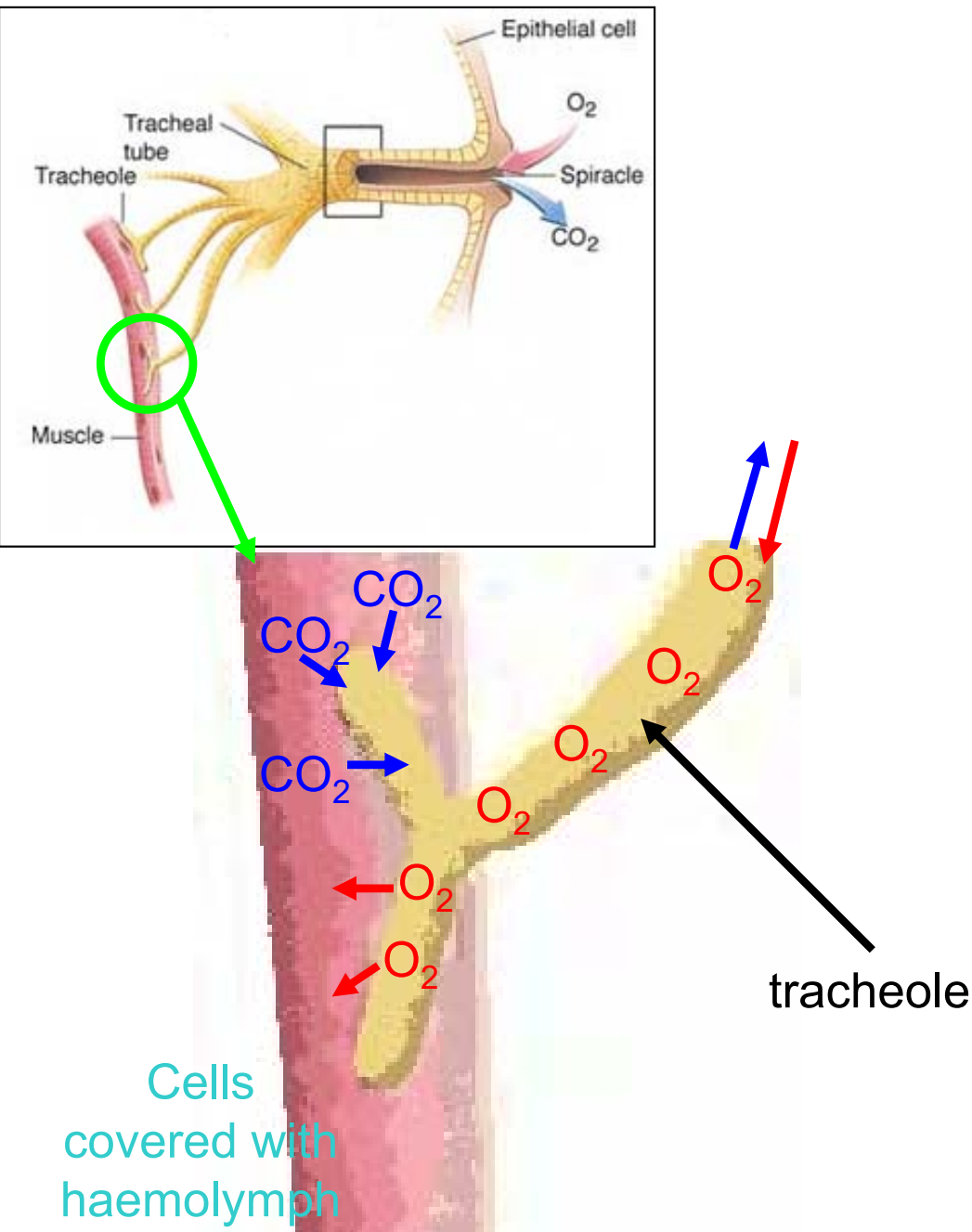


# Tracheoles



- Trachea lead to smaller tracheoles.
- The ends of each tracheole finishes in a group of body cells.
- The ends are lined with a thin moist surface (membranes) where the exchange of gases can take place.
- The thin membranes are surrounded by watery **haemolymph**.
- The body cells are bathed in the haemolymph.

# Passive Diffusion of Gases



- Oxygen from the air in the tracheoles dissolves into the haemolymph fluid on the thin moist membrane surface and diffuses into the cells.
- $O_2$  diffuse from tracheoles into haemolymph from a high concentration of  $O_2$  to a lower concentration of  $O_2$ .
- $CO_2$  produced by cell respiration can diffuse from the cells into haemolymph into tracheoles from a high concentration of  $CO_2$  to a lower concentration of  $CO_2$ .

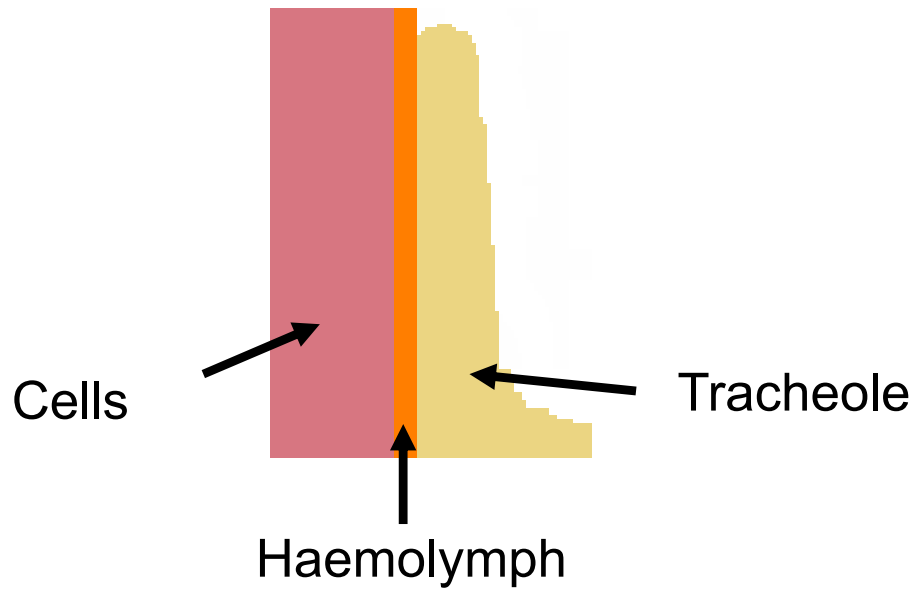
# Increased Surface Area for Gas Exchange



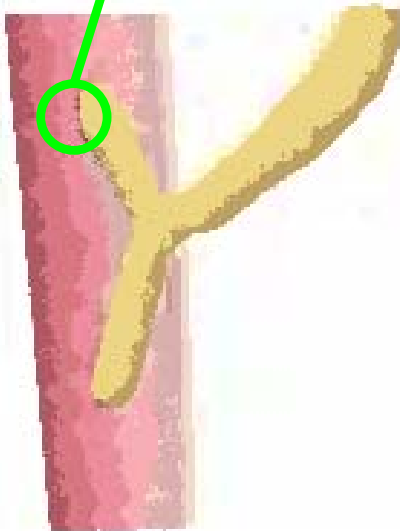
Extensive network of trachea and tracheoles  
↑'s surface area exposed for diffusion of:

- $O_2$  into haemolymph and further to the body cells.
- $CO_2$  out of cells into haemolymph into tracheoles.

# Thin Surface for Gas Exchange



Zoom



Thin surface to endings of tracheoles ↓'s the barrier to diffusion of:

- $O_2$  into haemolymph and further to the body cells.
- $CO_2$  out of cells into the haemolymph into the tracheoles.

# Moist Surface for Gas Exchange

Moist surface at end of the tracheoles is important for:

- $O_2$  to dissolve into the watery substance for diffusion into the haemolymph.
- $CO_2$  to dissolve into the water substance for diffusion out of the haemolymph into the tracheoles

# What Prevents Insects from being the Size we see in the Horror Movies?



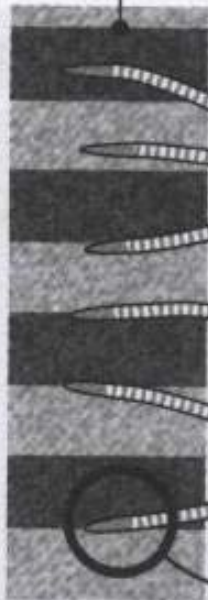
Havoc that could be wrought by a monster longhorn beetle is graphically depicted in drawing.

- Insects rely upon passive diffusion and physical activity for the movement of gases within the tracheal system.
- Diffusion of  $O_2$  and  $CO_2$  through the air in the tracheal tubes is fast enough only for distances less than 1cm for the body surface. This limits the size/radius of the insect's body.
- Larger organisms use a blood circulatory system (blood vessels) to overcome this limitation.

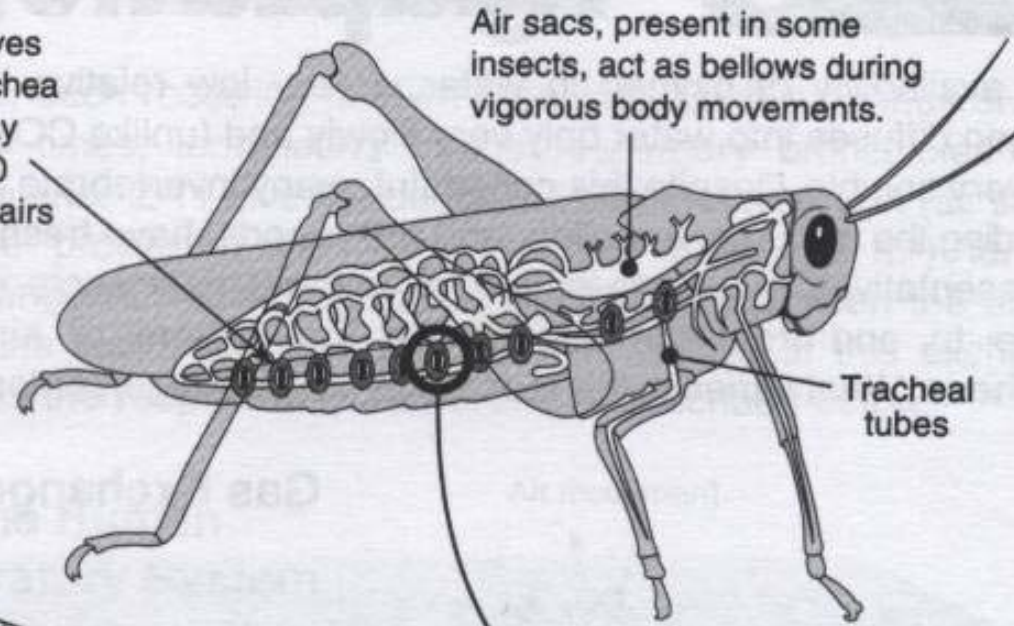
Spiracles are controlled valves that form the exit point of trachea from the body (an insect may have up to a maximum of 20 spiracles; eight abdominal pairs and two thoracic pairs).

Air sacs, present in some insects, act as bellows during vigorous body movements.

Insect muscle fibres



Tracheoles



Tracheal tubes

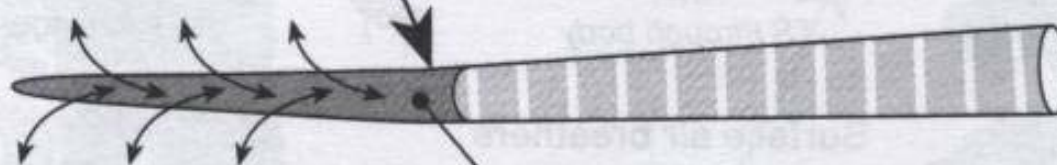


Carbon dioxide

Oxygen

Tracheal tubes

### Detail of tracheole ending

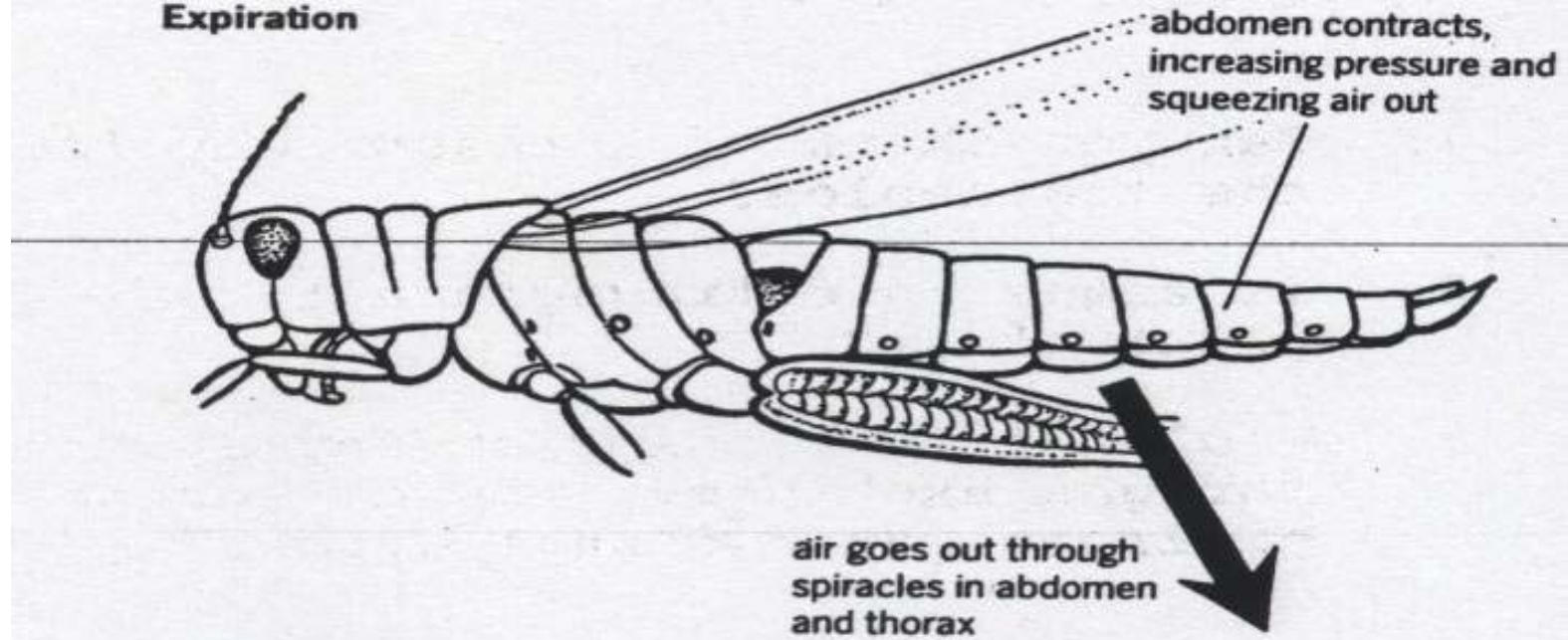


Dissolved oxygen is delivered to muscle fibres by the fluid.

Fluid moves into the tracheoles when muscles are at rest; fluid is drawn into the tissue when muscles are contracting.

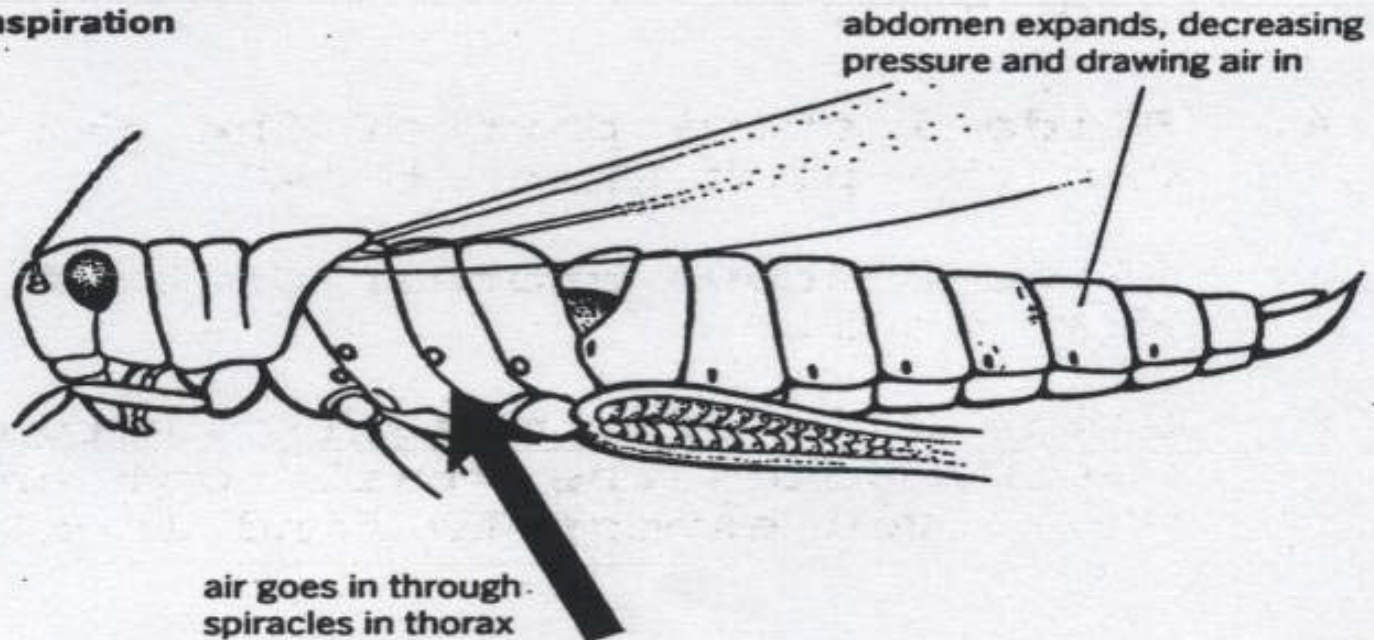


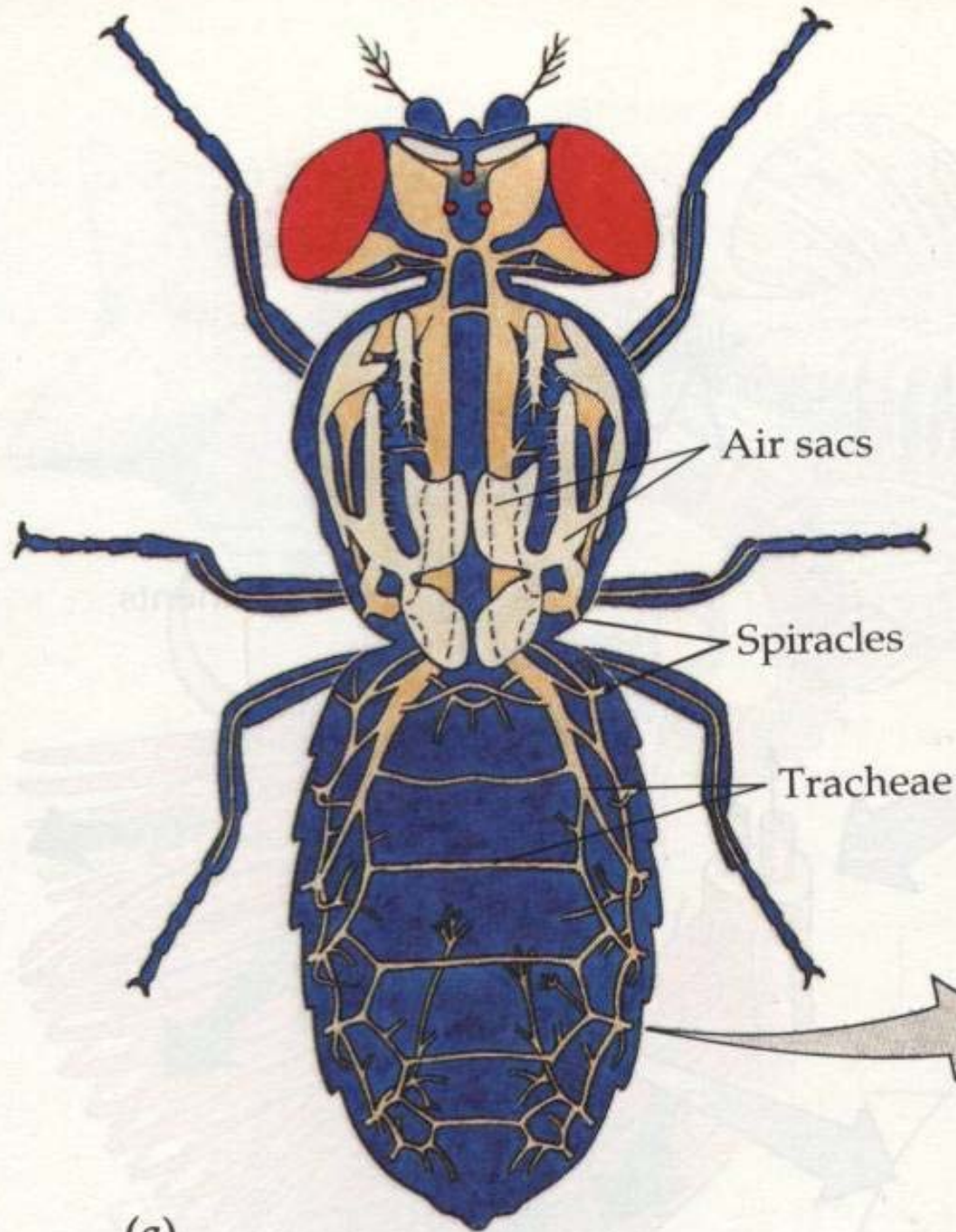
**Expiration**



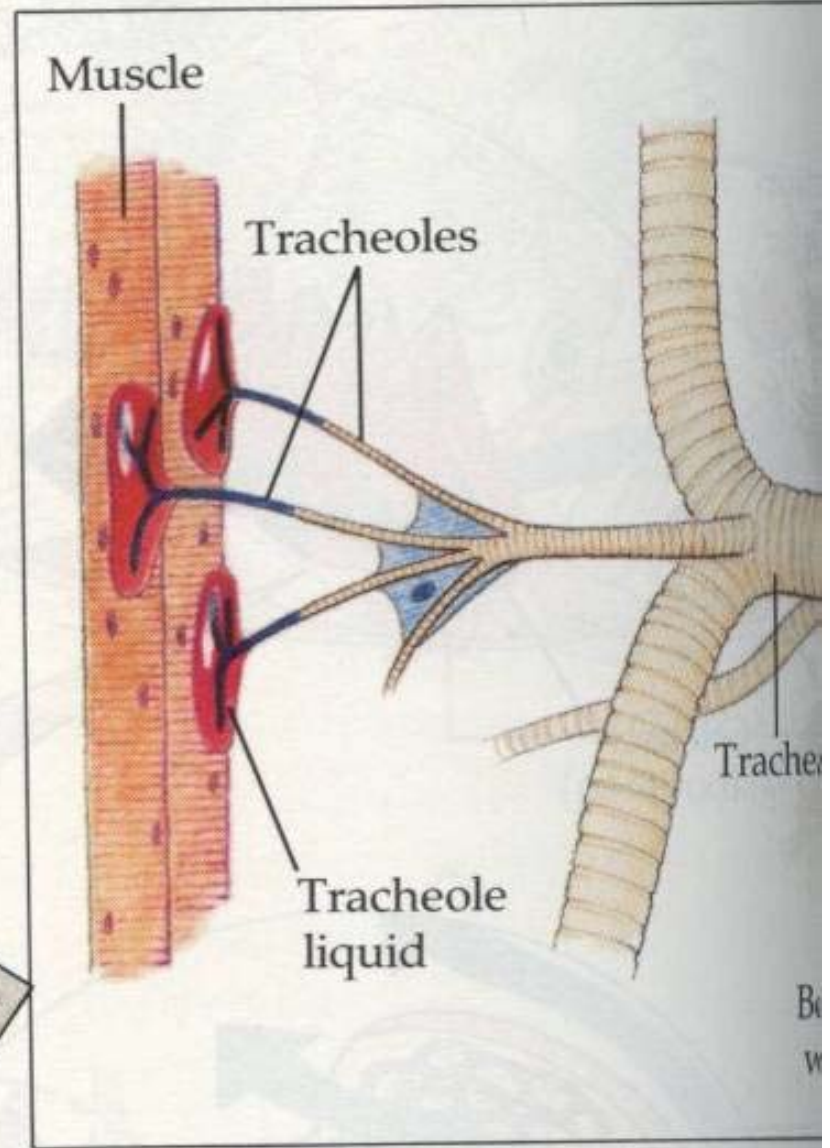
*Breathing movements in a flying locust*

**Inspiration**





(a)



(b)