

## Lec. 4

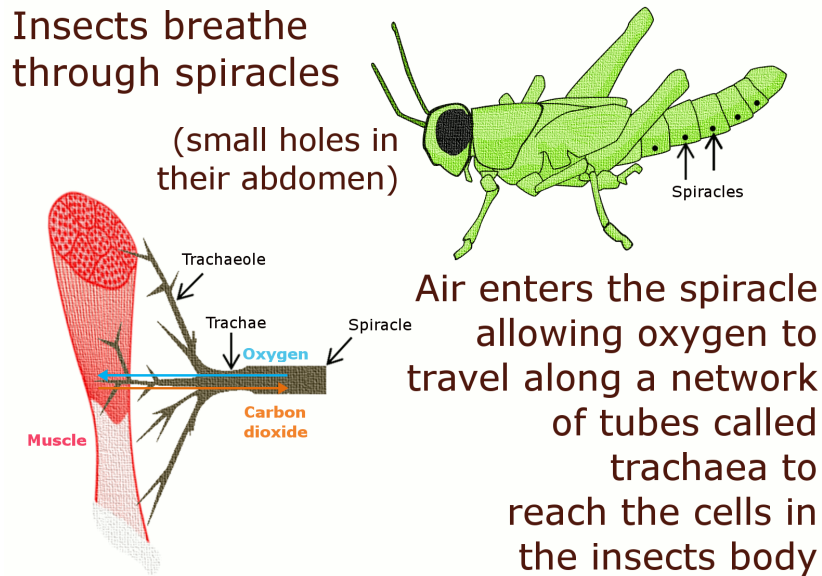
### Respiratory system (Ventilation system)

Insects do not have lungs. They obtain oxygen and dispel carbon dioxide through a series of tubes called tracheae. The tracheae are attached to openings on the body called spiracles. The muscular valves of the spiracles closed most of the time, open only to allow the up take of oxygen and the escape of carbon dioxide. The number and placement of spiracles varies, and smaller insects may not have any.

The tracheae are stiffened by spiral thickenings or threadlike ridges called taenidia, the taenidia keep the tracheae distended, thus allowing free passage of air. The tracheae branch repeatedly, becoming reduced and ending in fine thin-walled tracheoles less than one micron in diameter. The tracheoles insinuate themselves between cells. All insects are aerobic organisms they must obtain oxygen ( $O_2$ ) from their environment to survive.



Fig. 1 The general structure of the trachea



**Fig.2 Gaseous exchange of a grasshopper, showing spiracles in the abdomen.**

### **Number and distribution of spiracles**

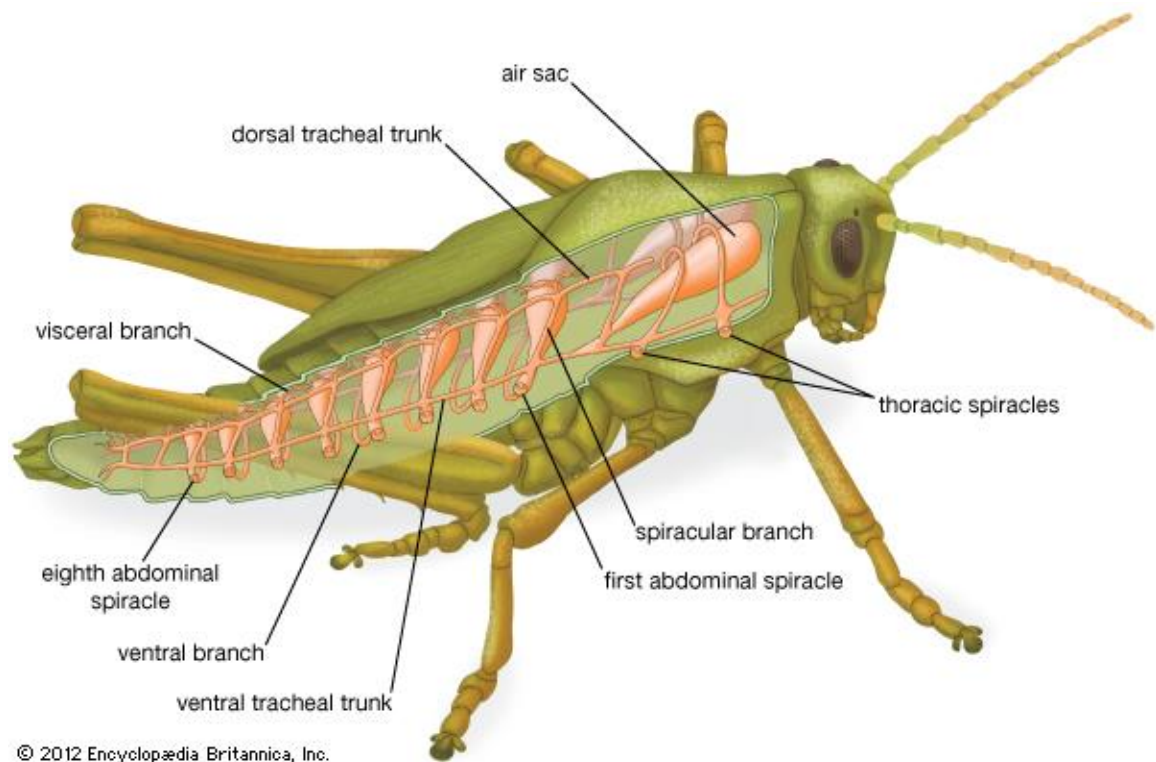
- The largest number of spiracles found in insects is ten pairs, two thoracic and eight abdominal.
- In numerous insects, the first spiracle is on the prothorax, but is mesothoracic in origin.
  - Spiracles never present on head.
  - The respiratory system can be classified based on the number and distribution of the functional spiracles.

In addition, the most active insects have large thin-walled expansions of the tracheae called **air sacs**, which serve to increase the volume of air displaced during respiratory movements.

**Air sacs** are found as tiny sacs off the larger breathing tubes (tracheae) of insects, as extensions of the lungs in birds, and as end organs in the lungs of certain other vertebrates. They serve to increase respiratory efficiency by providing a large surface area for gas exchange.

## What do air sacs do in insects?

- Act as **air reservoir**
- When filled with air appear **shiny white vesicle**.
- Assist flight by **reducing gravity** of insects
- Sound resonator of tympanic membrane**



**Fig. 3 The respiratory system of grasshopper**

Larger insects may **require active ventilation** of the tracheal system (especially when active or under heat stress). They do this by opening some spiracles and closing others by using abdominal muscles to alternately expand and contract body volume.

### **Tracheae**

The **tracheae are the larger tubes** of the tracheal system, running inward from **the spiracles and usually breaking up into finer branches**,

### **Tracheoles**

The **tracheae give rise to finer tubes, the tracheoles**. There is no

sharp distinction between tracheae and tracheoles, but the tracheoles always appear to be intracellular and often keep their cuticular lining at molting.

### Functions of the respiratory system:

1. Provide the cells and tissues with oxygen.
2. To eliminate carbon dioxide a product of cellular respiration.
3. To work in conjunction with the circulatory system in providing oxygen to the flight muscle system.
4. Prevents the accumulation of toxic oxygen molecules.

### How does respiration take place in insects?

The tracheoles end within the body cells. Gases move by diffusion within the tracheal system. When the insect is less active the ends of the tracheoles contain fluid. It is where the fluid and gas meet (= the fluid/gas interface), that exchange of gases occurs (oxygen is taken up, carbon dioxide is given off).

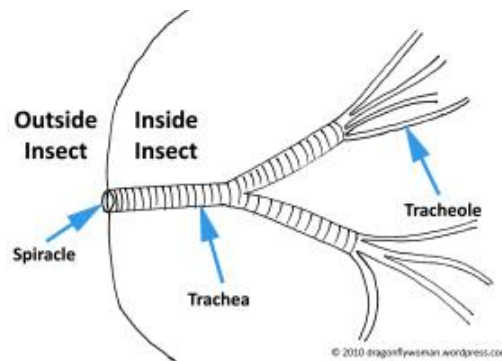
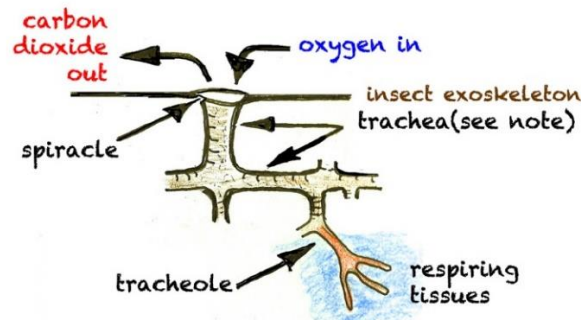


Fig. 4 Gaseous exchange of tracheal system



Because of the high concentration of oxygen in the tracheole diffusion moves it into the tissue. Likewise, the high concentration of carbon dioxide in the tissues moves it outward through the tracheole. Note: the trachea is made of chitin rings. The same tough material that makes up the insect exoskeleton.

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Fig. 5 Gaseous exchange of tracheal system

### Opening and closure of the spiracles

1. When closure muscle contracts the spiracles are closed
2. When closure muscle relaxes, they open.

### What regulates the opening and closing of spiracles?

The opening & closer of spiracles **Under the control of the nervous system.**

### Gas Exchange in Aquatic Insects

Even aquatic insects use a tracheal system for gas exchange.

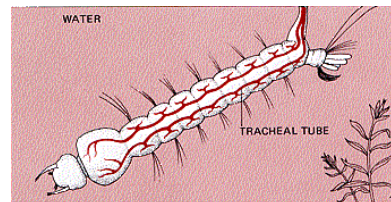
- Some, like mosquito larvae ("wigglers"), get their air by poking a breathing tube — connected to their tracheal system — through the water surface.



- Some insects that can submerge for long periods **carry a bubble** of air with them from which they breathe.



- Still others have **spiracles mounted on the tips of spines**. With these they pierce the leaves of underwater plants and obtain oxygen from the bubbles formed (by **photosynthesis**) within the leaves.



- Even in aquatic insects that **have gills**, after oxygen diffuses from the water into the gills, it then diffuses through a gas-filled tracheal system for transport through the body.

