

## LECTURE 5.

### **Anatomy: Respiratory system**

#### **Respiratory System**

The insect respiratory system is made up of a series of tubes that originate from **spiracles**

(openings of the exoskeleton that allow for gas exchange) and extend throughout the

body. Internally, the tubes, or **trachea**, appear as thin white lines throughout the

hemocoel and are particularly noticeable surrounding internal organs.

Trachea deliver

oxygen to internal organs and tissues.

Compare the tracheae with the Malpighian tubules. They are often very similar in

appearance. Did you confuse tracheae with Malpighian tubules earlier?

Two ways to distinguish the structures are color and location. Tracheae have a 'shinier'

appearance under the scope and may even appear 'silvery'. As for location, Malpighian

tubules are found at the junction of the midgut and hindgut (although they may extend

outward into the hemocoel), whereas tracheae are positioned throughout the body.

#### **Respiratory system**

Similar to aerobic animals, insects must obtain oxygen from their environment

and eliminate carbon dioxide respired by their cells. This is gas exchange through series

of gas filled tubes providing surface area for gaseous exchange

(Respiration strictly refers

to oxygen-consuming, cellular metabolic processes). Air is supplied directly to the tissue

and haemolymph (blood) is not involved in the respiratory role. Gas exchange occurs by

means of internal air-filled tracheae. These tubes branch and ramify through the body.

The finest branches called tracheole contact all internal organs and tissues

and are

numerous in tissues with high oxygen requirements. Air usually enters the tracheae via

spiracular openings positioned laterally on the body. No insect has more than ten pairs

(two thoracic and eight abdominal).

Based on the number and location of functional spiracles respiratory system is

classified as follows

1. Holopneustic: 10 pairs, 2 in thorax and 8 in abdomen. e.g. grasshopper
2. Hemipneustic: Out of 10 pairs, one or two non-functional
3. Peripneustic: 9 pairs - 1 in thorax 8 in abdomen e.g. Caterpillar
4. Amphipneustic 2 pairs - One anterior, one posterior, e.g. maggot.
5. Propneustic: 1 pair - anterior pair e.g. Puparium
6. Metapneustic: 1 pair - posterior pair e.g. Wiggler
7. Hypopneustic: 10 pairs - 7 functional (1 thorax + 6 abdominal), 3 non functional. e.g.

head louse

8. Apneustic: All spiracles closed, closed tracheal system e.g. naiad of may fly.

### **Organs of respiration**

**Spiracles:** Spiracles have a chamber or **atrium** with a opening and closing mechanism

called **atrial valve**. This regulate air passage and minimise water loss.

Each spiracle is set

in a sclerotized cuticular plate called a **peritreme**. **Tracheae** are invaginations of the

epidermis and thus their lining is continuous with the body cuticle. The ringed

appearance of the tracheae is due to the spiral ridges called **taenidia**. This allow the

tracheae to be flexible but resist compression. The cuticular linings of the tracheae are

shed during moulting.

**Tracheoles** are less than 1  $\mu\text{m}$  in diameter and they end blindly and closely contact the

respiring tissues. Taenidia and waxlayer is absent. Cuticulin layer is

permeable to gases.

It is intracellular in nature, but enclosed only in the cytoplasm of tracheal and cell called

tracheoblast. Gaseous exchange occurs across tracheoles. There are four tracheal trunks

viz., lateral, dorsal, ventral and visceral, helping in the passage of air. In the trachea, thin

walled-collapsible sac like dilations are present, called as airsacs where taenidia is

absent. **Airsacs** acts as oxygen reservoir. Provide buoyancy to flying and aquatic insects.

Provide space for growing organs. Acts as sound resonator and heat insulators.

### **Mechanism of respiration**

Oxygen enters the spiracle and passes through the length of the tracheae to the

tracheoles and into the target cells by a combination of ventilation and diffusion along a

concentration gradient, from high in the external air to low in the tissue.

Where as the net

movement of oxygen molecules in the tracheal system is inward

(Inspiration), the net

movement of CO

2

and water vapour molecules is outward (Expiration).

### **Respiration in aquatic insects:**

**1. Closed tracheal system:** In some aquatic and many endoparasitic larvae spiracles are

absent and the tracheae divide peripherally to form a network. This covers the body

surface, allowing cutaneous gas exchange. e.g. **Gills** : Tracheated thin outgrowth of body

wall.

Lamellate gills - mayfly naiad

Filamentous gills - damselfly naiad

Rectal gills - dragonfly naiad

**2. Open tracheal system:**

- i. **Air store:** Air bubble stored beneath wings acts as physical gill, e.g. water bug.
- ii. **Respiratory siphon** - e.g. Wiggler
- iii. **Caudal breathing tube** -e.g. Water scorpion
- iv. **Plastron** : Closely set hydrofuge hairs of epicuticle hold a thin film of air indefinitely.

## **Sources**

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