General Entomology **College of Education**
Lecture: 12 by Dr. Banaz S. Abdulla
Respiratory system:

Respiration. Includes chemical and physical processes. The chemical phase of respiration is the oxidation accompaniment of metabolism the body tissues, which results in the formation of carbon dioxide and water. Physical respiration has to do with the transportation of oxygen to the tissues and the removal of carbon dioxide. The entire series of physical and chemical processes accomplishing oxidation and the removal of carbon dioxide.

In insects, exchange of gases takes place through tubular structures, called **trachea.** They are distributed throughout the body collectively forming tracheal system. These trachea open outside on the body wall through small openings called spiracles. **Spiracles** occur on the pleural surfaces of the body, one on either side of each segment. The trachea is divided in to very fine branches known as **tracheoles.** They supply **oxygen** to the body tissues. The tracheal system with functional spiracles is called the **open tracheal system** and with non-functional spiracles is called **closed tracheal system**.

Trachea are fine elastic tubular structures which are **ectodermal** in origin. They consist of cuticle, epidermis, basement membrane as in case of general body wall but arranged in reverse manner, i.e. basement membrane forms the outermost coat of trachea, the inner cuticular lining forms the i**ntima** inside. Trachea is **circular** or **elliptical** in their cross section (Fig. 1). The cuticular lining (intima) appear as a spiral thickening throughout the length of the tube of trachea. These spiral thickenings are known as **'taenidia'** (Fig.1) which give support to the trachea without being **collapsed** when there is no air. It consists of **chitin**, **resilin** in protein-chitin matrix. The trachea divided into very fine branches known as **'tracheoles'** which are about 0.1 – 1 μm in diameter (Fig. 2). These tracheoles are formed in to cells called **'tracheoblast'** or which are derived from epidermal cells, lining the trachea. Tracheoles form a network over the visceral organs including the alimentary canal as well as the gonads (ovaries, testis) and penetrate in to the tissues of the organs and become **intracellular** and supply **oxygen** directly to the tissues.

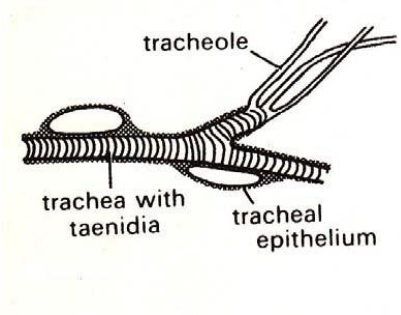


Fig. 1 Structure of trachea.

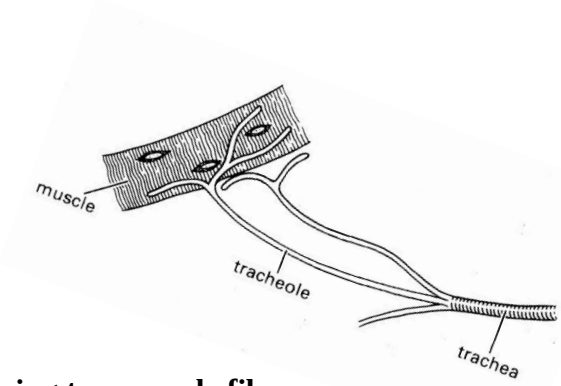
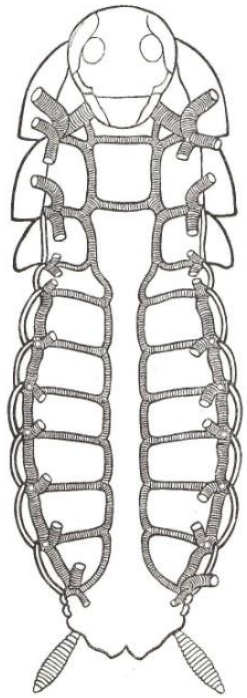
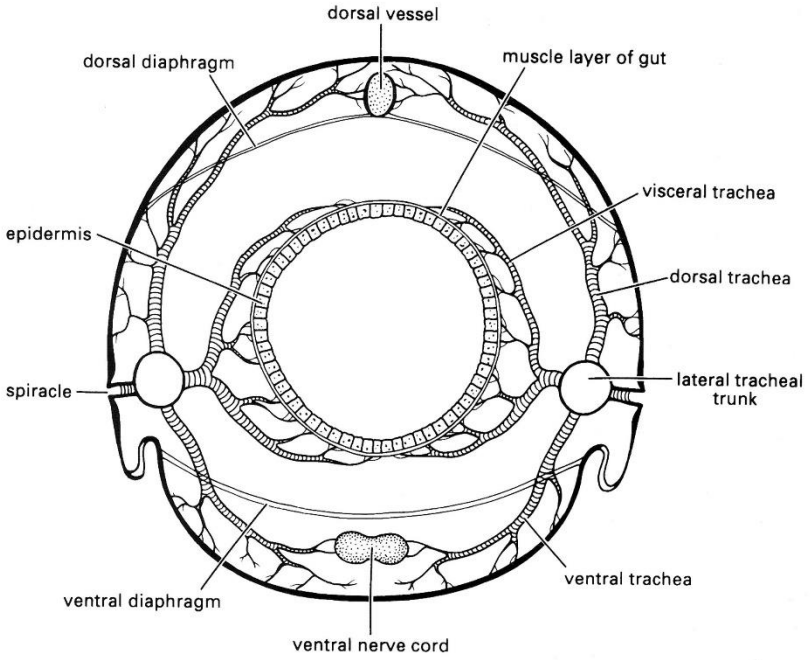


Fig. 2 Tracheoles running to a muscle fiber.

Tracheal trunks

The trachea coming from spiracles throughout the body join with those of neighbouring spiracles forming **'longitudinal trunks'**. Likewise, these trachea by combining with those coming from dorsal, lateral and ventral sides of the body fuse to form **transverse commissures** and **longitudinal connectives** all these in total form into **dorsal trunk**, **lateral trunks** which are **two** in number and **one ventral trunk** (Fig. 3). The dorsal trunk **supply oxygen** to proximal part of the body as well as to heart whereas the ventral supplies to the central nervous system. The two lateral longitudinal trunks spread tracheoles to alimentary canal, legs, gonads and wings. As the head do not contain spiracles, **air** is supplied through the first pair spiracles by means of two main branches of the dorsal longitudinal trunk, where one branch supply O2 to eyes, antenna, brain; other branch to mouthparts and muscles of the head.

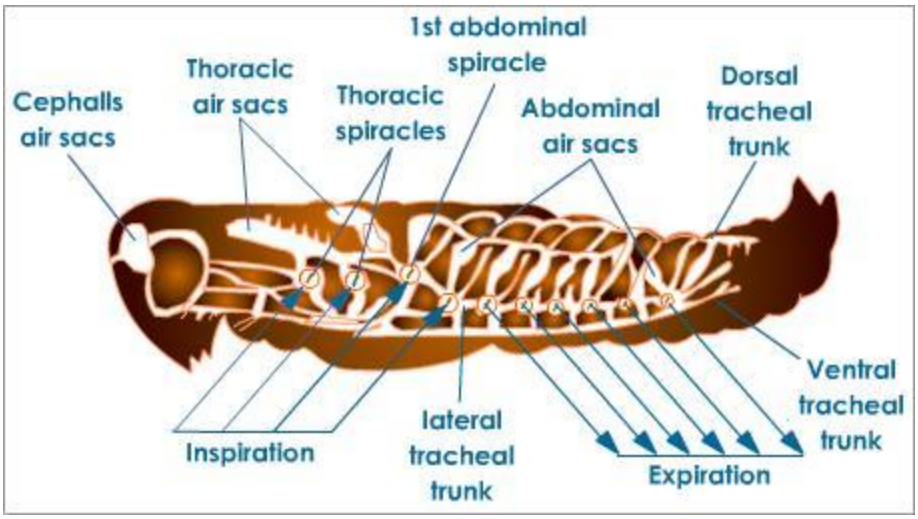




(A) **(B)**

Fig.3 (A) Dorsal tracheal system of abdomen of locust; and (B) diagrammatic transverse section through abdomen of a hypothetical insect to illustrate main tracheal branches.

The tracheal air sac (fig.4). Thin-walled dilations of the tracheae which by their elasticity increase the efficiency of respiration, particularly in fast flying insects. Taenidia are absent from, or poorly developed in air sacs. The sacs are collapsible, are important in ventilation and also permit internal organs in the body cavity as for example when the ovaries are enlarged by eggs or the gut is engorged with food. Air sacs serve as reservoirs of oxygen and also serve as bellows in distributing air and cooling the body particularly during flight. They also help in decreasing weight in fast-flying species. Air sacs are present in certain members of most of the pterygote orders and reach the greatest development in some the cyclorrhaphous Diptera, in Apidae among Hymenoptera , but they are absent in apterygota and in homometabolous larvae.



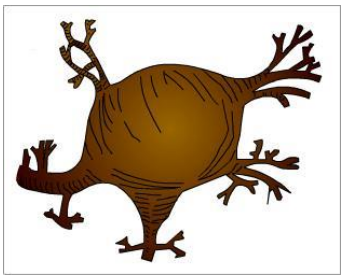


Fig.4 Air Sacs.

Spiracles: They are the **openings** of the internal tubular trachea, except in **Diplura**, in all the orders, spiracles are **absent** in prothorax and distributed in meso, metathorax and abdomen, a total of **10** pairs are present in general, 2 pairs in thorax and 8 pairs in abdomen. Spiracles are situated on **pleural** surface. They consists of a small ring like sclerite at opening called '**peritreme'** leading to a cavity known as **'atrium'** (Fig. 5).

The closing and opening of spiracles is accompanied by **atrial valve** lined with fibrous processes and form so called **felt chamber** which reduces water loss in the absence of closing mechanism.

In some dipterans, coleopterans, lepidopterans, spiracles consists of **sieve plate** containing large number of small apertures through which **gas** exchange takes place. This modification is to **prevent entry of water** especially in **acquatic** forms. In most of the **terrestrial** insects, water loss through spiracles is controlled by the **closing mechanism** which consists of one or two valves or a constriction from the trachea

or by muscular activity. The **hydrophobic** nature of spiracles is also due to the presence of modified epidermal glands known as **peristigmatic glands** which secrete a hydrophobe material preventing the wetting of these organs.

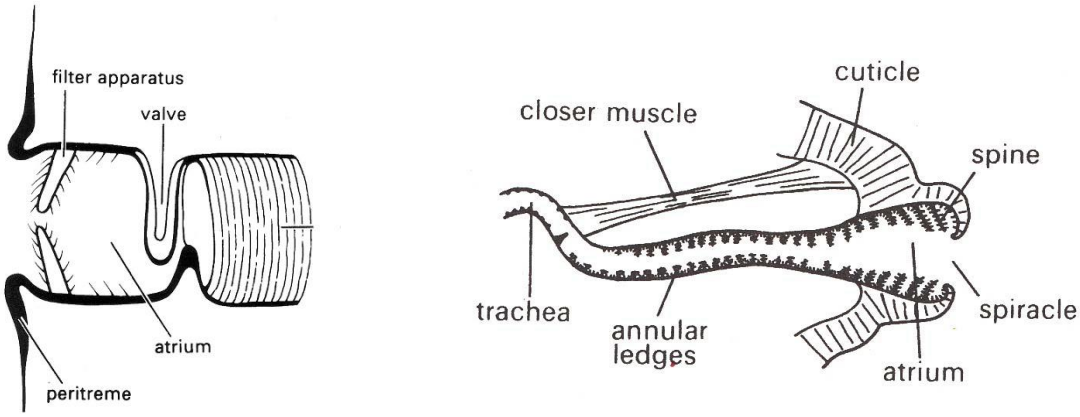


Fig. 4. Structure of spiracle.

Classification of tracheal system based on number and **arrangement of functional spiracles**

In most of the insects, 10 pairs of spiracles are present. Some of the modifications are as follows

I. **Holopneustic** : These are primitive type with 2 pairs of spiracles on thorax and 8 pairs on abdomen . All the spiracles are functional. 1 + 1 + 8. e.g. **dragonflies, grasshoppers and cockroach.**

II. **Hemipneustic** : One or more pairs of spiracles become non-functional. They are

a) **Peripneustic** : Metathoracic spiracle is closed. 1 + 0 + 8. e.g.: **larvae of Lepidoptera, Hymenoptera, Coleoptera.**

b) **Amphipneustic** : Only mesothoracic and last pair of abdominal spiracles are open. 1 + 0 + 1. e.g: larva of **cyclorrhaphan Diptera**.

c) **Propneustic :** Only one pair i.e. mesothoracic spiracles are open, 1 + 0 +0 e.g.: **mosquito pupa.**

d) **Metapneustic :** Only last pair of abdominal spiracles are open. 0 + 0 + 1. e.g.: **mosquito larvae.**

e) **Apneustic:** No functional spiracles. e.g: **mayfly larva, nymph of Odonata**

III. **Hypopneustic :** 1 or 2 pairs of spiracles may completely disappear or absent e.g.: **Siphunculata, Mallophaga**

IV. **Hyperpneustic :** More than 10 pairs of spiracles are present e.g.: ***Japyx* sps. (dipluran**).

Other types of respiration

1. Cutaneous respiration: e.g.: **Protura, Collembola** and **endoparasitic** insects. When the spiracles are absent, respiration occurs through body wall which forms main source for gaseous exchange.

2. Tracheal gills: e.g.: **larva** of **Trichoptera, nymphs** of **Ephemeroptera,** also called as **abdominal gills** which occur as the outgrowths of the trachea in the form of gills distributed on the lateral sides of the body. They are useful for **absorption of dissolved oxygen**. They may vary in shape as **lamellate** or **filamentous.**

3. Spiracular gills : In some **aquatic pupae**, **P**eritreme or atrium of spiracles is drawn out in to a long filament like structure known as **spiracular gills.** These gills are adapted for both **aquatic** and **aerial** respiration, enabling the insect to live in air and moist places or completely in water or at the edges of water structures.

4. Blood gills: These are tubular or digiti form or eversible structures present at the anal end of body ranging from 4-6 in **larva of Trichoptera**. In chironomid larva of Diptera, 2 pairs of blood gills are present on penultimate segment and a group of 4 shorter anal gills are present. These are called **blood gills** as they contain blood but sometimes have trachea. Function of these structures is the **absorption** of **water** and inorganic ions **rather than respiration**.

5. Rectal gills: In dragonfly **nymphs (naids**), the rectum modifies in to a barrel like chamber where the rectal wall forms in to basal thick pads and distal gill filaments which are richly supplied with tracheoles. They help in **respiration**.

6. Air sacs: In many winged insects, the trachea get dilated at some points to form thin walled air sacs which do not contain the taenidia. These can be seen as glistening sac like structures mainly function as storage structures of air which change their volume with respiratory movement.

7. Plastron respiration: e.g.: **aquatic beetles**.

The plastron is a special type of air store in the form of a thin film held by a system of hydrofuge hairs, scales or other cuticular processes whose volume remains constant. If there is adequate oxygen dissolved in water, the plastron can act as a **permanent physical gill.** The trachea opens in to plastron.

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