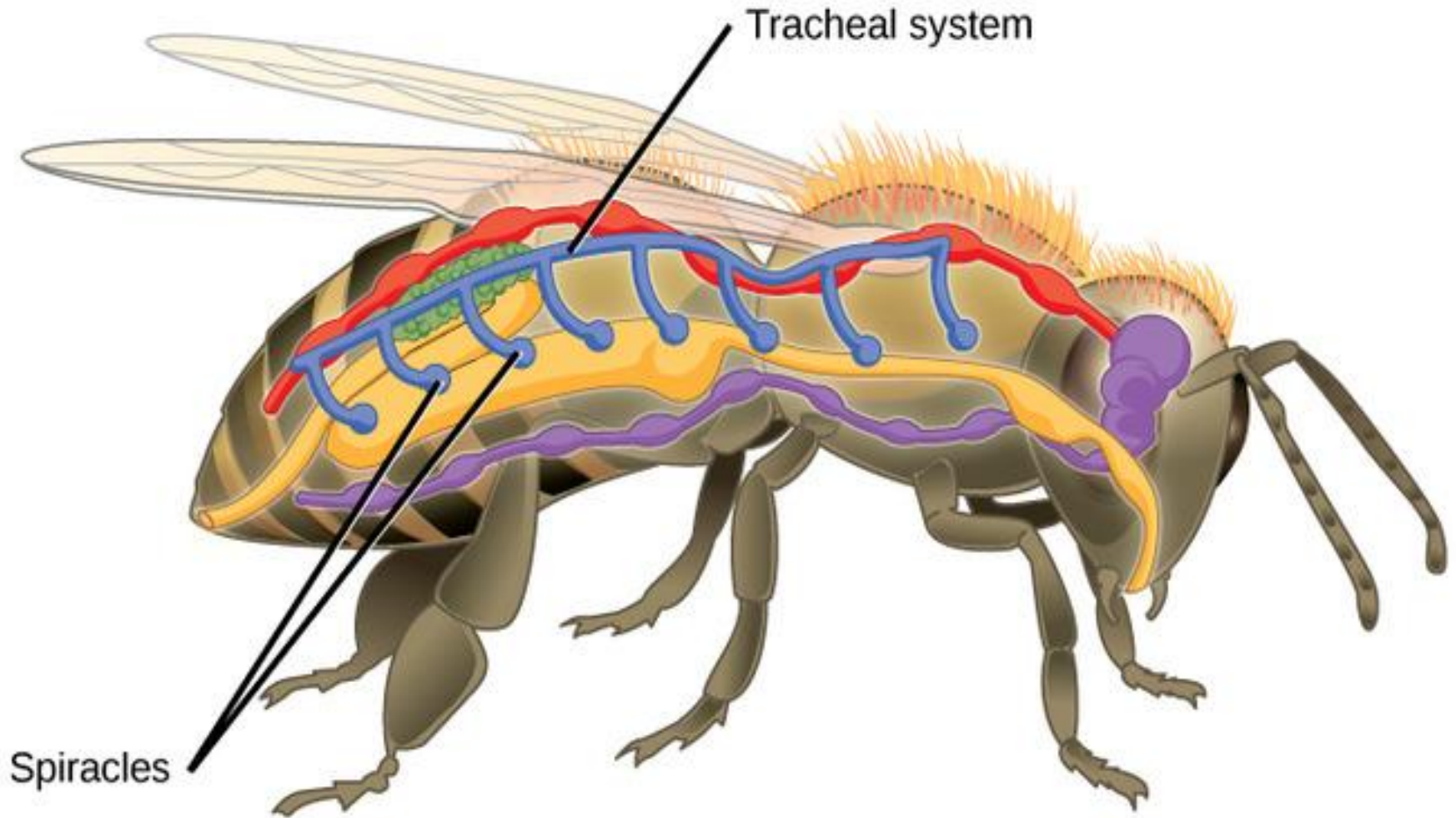


# Insect Respiratory System

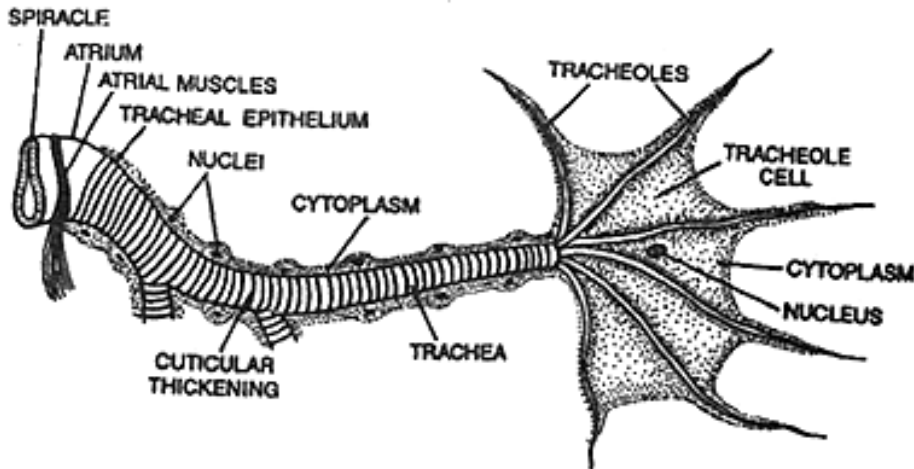


# Tracheal system

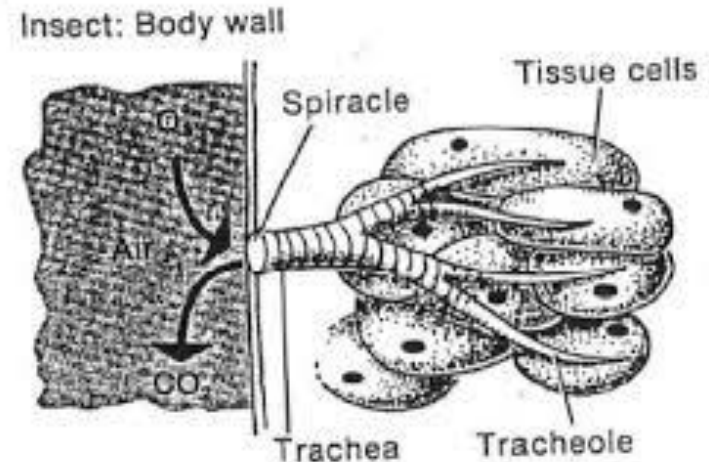
- In insects, exchange of gases takes place through tubular structures, called **trachea**
- distributed throughout the body collectively forming **tracheal system**
- open outside on the body wall through small openings called **spiracles**
- Spiracles occur on the **pleural surfaces** of the body, one on either side of each segment
- trachea are divided in to very fine branches known as **tracheoles**
- They **supply oxygen** to the body tissues
- Trachea are fine elastic tubular structures and **ectodermal** in origin
- consist of cuticle, epidermis, basement membrane
- but arranged in **reverse manner**,

i.e. **basement membrane forms the outermost** coat of trachea

The **inner cuticular lining forms the intima** inside



Spiracle tracheae and tracheoles



- **'Taenidia' - cuticular lining** appear as a spiral thickening throughout the length trachea
- give **support** to the trachea without being collapsed when there is no air
- It consists of chitin, resilin in protein-chitin matrix.
- ramify into very fine branches known as **'tracheoles'** about 0.1 – 1  $\mu\text{m}$  in diameter
- formed in to cells called **'tracheoblast' or tracheolar end cell**
- derived from epidermal cells, lining the trachea
- form a network over the visceral organs including the alimentary canal,
- become **intracellular** and **supply oxygen** directly to **the tissues**

The tracheal system is of 2 types

1. with **functional** spiracles is called the **open** tracheal system
2. with **non-functional** spiracles is called **closed** tracheal system

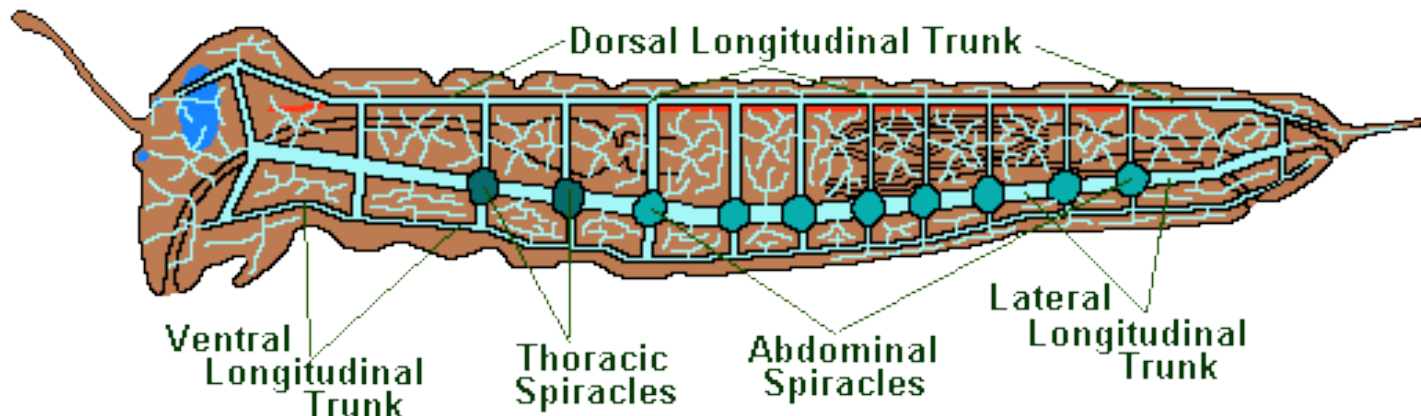
## Differences between trachea and tracheoles:

	Trachea	Tracheoles
1	These are large tubes running from spiracles	Fine tubes arising <b>distally</b> from trachea
2	Taenidia <b>present</b>	<b>Absent</b>
3	Intima layer is <b>shed</b> during moulting	Intima layer is <b>retained, unchanged</b> during moulting
4	Never become intracellular	Intracellular
5	The intima layer consist of protein – chitin matrix <b>with resilin</b>	Chitin – protein matrix present, <b>resilin absent</b>

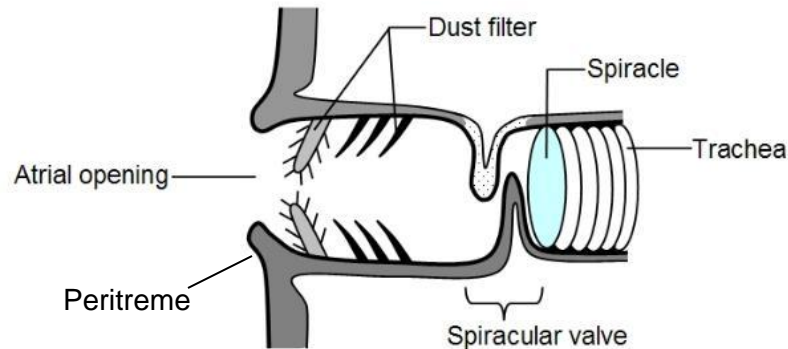
## Tracheal trunks

- Trachea coming from spiracles join with neighbouring ones form '**longitudinal trunks**'
- Trachea combine with others 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, 2 lateral trunks** and **ventral trunk**
- The dorsal trunk supply oxygen to **proximal part of the body as well as to heart**
- the ventral supplies to the **central nervous system**
- The two lateral longitudinal trunks spreads tracheoles to **gut, legs, gonads and wings**
- The head do not contain spiracles
- air is supplied through the **first pair of spiracles** by two main branches of dorsal trunk
- One branch supply O<sub>2</sub> to **eyes, antenna, brain**
- Other branch to **mouthparts and muscles of the head**

## Diagrammatic Representation of the Insect Tracheal System



- Spiracles: openings of the internal tubular trachea
- Except in **Diplura**, 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**
- Consists small ring like sclerite at opening, '**peritreme**' leading to a cavity, '**atrium**'
- The closing and opening of spiracles is accompanied by **atrial valve**
- Lined with fibrous processes and form a felt chamber which reduces water loss



- In some **dipterans, coleopterans, lepidopterans**, spiracles consists of **sieve plate** containing large number of small apertures
- **gas exchange** takes place and prevent entry of water especially in aquatic forms
- In **terrestrial insects**, water loss through spiracles is controlled by the **closing mechanism**
- consists of **one or two valves** or a **constriction** from the trachea or by muscular activity
- Hydrophobic nature of spiracles is also due to the presence of modified epidermal glands known as **peristigmatic glands**
- They secrete a **hydrophobe** material preventing the wetting of these organs

**Classification of tracheal system**-In most of the insects, **10 pairs of spiracles** are present.

based on number and arrangement of functional spiracles

**I. Holopneustic** : 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** : through **body wall** e.g.: Protura, Collembola and endoparasites

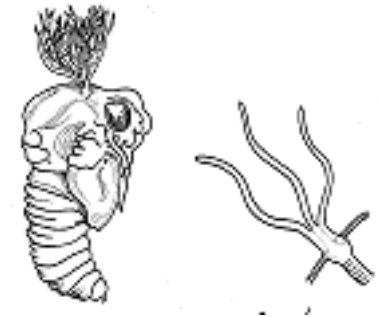
2. **Tracheal gills/ abdominal gills**: e.g.: larva of Trichoptera, nymphs of Ephemeroptera

- **outgrowths of the trachea** in the **form of gills**
- on the **lateral sides of the body**
- **Absorbs dissolved oxygen**
- vary in shape as **lamellate or filamentous**



3. **Spiracular gills**: E.g.: aquatic pupae

- **Peritreme or atrium** is drawn out in to a long filament
- adapted for both **aquatic and aerial** respiration
- enables the insect to live in air, moist places, completely in water



4. **Blood gills**:

- Tubular/digitiform or eversible structures at the anal end 4-6 in larva of Trichoptera
- In **chironomid larva**, **2 pairs** on penultimate segment and **4 shorter anal gills** are present
- Called blood gills as they **contain blood** but some times have trachea
- **absorption of water and inorganic ions** rather than respiration



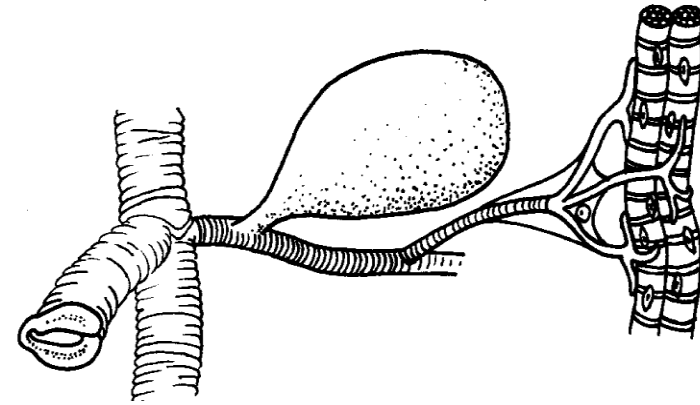
## 5. Rectal gills: e.g.: dragonfly nymphs (naids)

- rectum modifies in to a barrel like chamber
- rectal wall forms basal **thick pads** and distal **gill filaments**
- which are richly supplied with **tracheoles**



## 6. Air sacs: e.g.: winged insects

- **trachea dilated** to form thin walled air sacs
- **do not contain the taenidia**
- seen as glistening sac like structures
- function as **storage structures of air**
- change their volume with respiratory movement



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

- special type of air store in the form of a **thin film**
- held by a system of **hydrofuge** hairs, scales
- **volume remains constant**
- If there is adequate oxygen, the it act as a **physical gill**
- The trachea opens in to **plastron**

