RESPIRATORY ORGANS OF MOLLUSCA

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Molluscs are familiar to man from prehistoric times as the food and for ornamental shell. Molluscs are the unsegmented animals with the soft body and covered with the hard calcareous shell as the exoskeleton. They are mostly aquatic and possess radula and Organ of Bojanus. This shell is secreted by a thin sheet of tissue called as a mantle, which encloses the internal organs. They are distributed in all possible environments and exhibit many adaptive features. As a consequence of living in the diverse environmental conditions, their respiratory organs are modified accordingly as described below:

A. Skin and Mantle

Specialised respiratory structures are lacking in some Scaphopoda. Respiration is carried by the internal surface of the mantle, particularly the antero-ventral side in *Dentalium, Antalis*. In nudibranchs (Gastropoda) the entire dorsum of the body acts as the site of gas exchange. Integumentary gas exchange occurs in parasitic *Entoconcha, Conia, Limpontia* sp. etc.

The outer covering of the body (skin) and mantle usually act as accessory respiratory organs.

In most of the members of Aeolididae the dorsal surface of the body is provided with papillae. The papillae are variable in size and communicate with the heart by veins. The respiration is known as pallial respiration. Most of the Nudibranchia, *Entoconcha, Unio* etc. respire through skin. In some forms (e.g., *Neomenia, Chaetoderma, Aplysia, Dentalium*, etc.), the mantle is used for respiration.

B. Ctenidium

Aquatic molluscs respire through ctenidia. These are the comb-like outgrowths of the mantle and are located within the mantle cavity.

Structure

1. Ctenidia are paired, symmetrical, ciliated and two rows of flattened gill filaments, arranged one on either side of a long, flattened axis, traversed by afferent and efferent vessels through which haemolymph flows.

2. Narrow spaces are left between the gill filaments to permit free water flow between them but close enough so that cilia on adjacent filaments may operate together in generating water current.

3. Haemolymph circulates through the gill filaments.

4. Skeletal rods support the gill filaments.

5. Cilia generate inhalant water current drawing water below the ctenidia and exhalant current expelling water out from above them.

Number of Gills:

In Polyplacophora the number of gills varies from 6-80 pairs. In Monoplacophora the gills vary 3-6 pairs. In primitive gastropods, either two bipectinate (e.g., *Pleurotomaria, Haliotis*) gills or single bipectinate gill (e.g., *Patella, Trochus, Nerita*) are present.

In Mesogastropods (e.g., *Viviparus, Pila, Lambis, Cypraea*) or Neogastropods (e.g., *Murex, Xancus, Conus*), the single monopectinate gill is present. In Bivalves, pair of plate likes gills and in Cephalopods, 4 gills in *Nautilus* or 2 gills in Coleoidea (e.g., *Sepia, Loligo, Octopus*) are present.

On the basis of topography, the ctenidia can be divided into following categories

1. Holobranchiate type
2. Merobranchiate type
3. Plicate type
4. Monopectinate type
5. Bipectinate type:
    a. Unequal
    b. Equal
6. Feathered type

1. Holobranchiate type:

This type of arrangement of ctenidia is found in Polyplacophora. In this form the ctenidia extend all over the body. The number of ctenidia varies from 14-70 pairs and in some cases the number may be about 80 pairs as in Acanthopleura.

In *Patella* (Gastropoda) a circlet of gill lamellae extends completely around the margin of the mantle. It resembles that of *Chiton* superficially which made Cuvier to include *Patella* and *Chiton* under one class Cyclobranchia.

But the true nature of ctenidia differs greatly. In *Chiton* the ctenidia are present along the margin of the body excepting the head and anus, but in *Patella* the ctenidia are extended throughout the body.

2. Merobranchiate type:

When the ctenidia remain restricted to a particular area of the body, it is called the merobranchiate type. The merobranchiate type of ctenidia can be subdivided into the following types depending on the arrangement of leaflets.

Depending on the arrangement of leaflets the gills have been subdivided into four types:

(a) Plicate type:

This type of gill comprises in simple flat transversely folded projecting integumentary laminae. In *Neomenia* a tuft of filaments arises from the cloacal wall.

(b) Monopectinate type:

This type of ctenidia consists of flattened gill filaments arranged in only single side of the ctenidial axis as observed in *Pila, Triton*.

(c) Bipectinate type:

This type of ctenidium has flattened gill filaments arranged in two rows.

They may be of two types:

(a) Unequal:

When both of them are present, but right one is smaller as observed in *Fissurella, Haliotis*.

(b) Equal:

When both gill filaments present in two rows are of same sizes. This is the characteristic of the Bivalves. Amongst Bivalves they become variously modified. *Nucula* possesses short flat leaflets. In some forms long filamentous leaflets are present.

These filaments may be free as in *Arca* or may be joined by ciliary connectives as in *Mytilus*. In *Unio* the ciliary junctions are replaced by membrane. In *Poromya* the ctenidium becomes degenerated and is represented as a transverse partition.

(d) Feathered type:

This type of ctenidium is characteristic of the Cephalopods. Detailed structure is described in the biology of *Sepia*.

Ctenidia in different groups of molluscs:

1. Monoplacophora

The pallial groove contains five to six pairs of unipectinate gills. Example: *Neopalina*.

2. Polyplacophora

Bipectinate ctenidia located in the mantle groove

(a) Number of ctenidia varies from 14 in *Lepidopleura* to 80 in *Acanthopleura*.

(b) Gill rows may be holobranchiate with two exceptions bearing merobranchial type. Examples: *Chiton, Chiton*.

3. Aplachophora:

The gills are reduced to a paired, feather-shaped structure situated near the cloacal cavity, one on each side. The gills are merobranchiate. Example: *Chaetoderma*.

4. Gastropoda:

The gills vary widely in number and position in this group:

A. Prosobranchia:

Ctenidia lie in front of the heart.

a. Diatocardia:

The arrangement is most primitive. The gills are two, long, feathered, on each side and lie symmetrically to the middle line. Example: *Fissurella*.

b. Monotocardia:

The arrangement of the gills is remarkably uniform. A single gill, feathered on one side and united to the mantle along its whole length. Example: *Triton*.

B. Opisthobranches:

The gills are partially enclosed in the mantle cavity (Tectibranchiata). The true ctenidium, when present, is little developed and located on the right side of the body. Example: *Aplysia*.

5. Bivalvia:

The gills are bipectinate, equal on either side, usually very large, having assumed food collecting function in most species in addition to gas exchange.

A. Protobranchiata:

Gills are smallest and lie behind the foot at the back of the mantle cavity. In *Nucula* the gill filaments are triangular.

B. Filibranchiata:

Each gill separately forms a 'W' in section-.with long, narrow limbs. The gill axis lies at the middle angle of the W. Examples: *Area, Mytilus, Anomia*.

C. Pseudolamellibranchiata:

The reflected dorsal tips of the gill filaments have coalesced laterally with the mantle and medially with the base of the foot. The gill has a greater cohesion than that in the fili-branchs. The gills are more complex, with the surface plicate or thrown into folds and grooves. Examples: *Ostreidae, Pectinidae, Pleriacea*.

D. Eulamellibranchiata:

The adjacent filaments of gills are united by vascular cross connections, leaving narrow openings, the Ostia between them. The two lamellae of each demi-branch are attached back to back in the same way. Examples: *Cardiacea, Myacea*.

E. Septibranchiata:

The ctenidia do not exist as such, being converted into a horizontal muscular septum running from the base of the foot to the mantle, and extending right back to the siphons. Example: *Poromya*.

6. Cephalopoda:

The gills are large, paired, bipectinate and one suspended on either side of the rectum by their afferent edges, not by efferent, as in gastropods, and the water current is driven from afferent to efferent side.

A. The gill filaments are firm and fleshy, non-ciliated, and thrown into primary and secondary folds to increase respiratory surface. In Nautilus, the gills are two pairs.

B. The haemolymph flows through each gill is assisted by a pulsatile accessory branchial heart, located at the base of the gill in the course of the afferent ctenidial vessel and placed in an annexe of the pericardium.

C. Pallial contractions drive water between the gill filaments at great pressure.

Adaptive or secondary gills and integument:
The gills develop from aberrant sites:

1. Anal gills:

Delicate leaflets form a rosette around the anus. Example: *Doris*. In *Chactoderma* a pair of symmetrical lateral gills are present on each side of cloaca.

2. Cerata or dorsal appendages:

In many opisthobranches the dorsum bears highly vascular appendages called cerata. They may be simple and club-shaped (*Aeolis*), dendritic (*Dendronotus*) or multi-lobed resembling a bunch of grapes (*Dotochica*).

3. Pleural gills:

In Pleurophyllida lateral rows of branchial leaflets are situated beneath the mantle.

4. Pallial gills:

In certain basommatophore pulmonate secondary external gills develop by the enlargement of the pallial lobe, just outside the pneumostome. They, however, lack cilia. Examples: *Planorbidae, Ancylidae*.

Relationship between heart and gills:

The heart and the gills are intimately related because the main function of the gills is to aerate blood on its way to the heart. The number of gills is directly proportional to the number of the auricles. For example, when the gills are two in number, two auricles are present as encountered in *Octopus* and *Loligo*.

In *Chiton*, two auricles correspond to the two sets of the multiple gills, In *Nautilus,* there are four gills and four auricles. When the gill is unpaired, the heart has one auricle as seen in Opisthobranchs, Mesogastropods, Neogastropods, etc.

Terrestrial Respiration:

Amphibious adaptation and adaptation to terrestrial life have introduced remarkable modification in the respiratory structures of molluscs.

The structures associated with terrestrial respiration are:

1. Nuchal lobe:

The left nuchal lobe is better developed and forms a long respiratory siphon. Example: *Monotocardia*.

2. Pulmonary sac:

In some amphibious prosobranchs *Pila, Ampullarius, Siphonaria*, etc. the pallial cavity is incompletely partitioned by a fleshy fold, the epitaenia, into a right branchial chamber and a left pulmonary chamber. The highly vascularized roof of the pulmonary chamber forms a pulmonary sac, the aerial respiratory structure, with a small aperture opening in the pulmonary chambers.

Air enters the pulmonary chamber through an opening at the tip of the left siphon. Aerial respiration takes place during aestivation and when there occurs a depletion of oxygen concentration in water. The pulmonary epithelium comprises cuboidal or squamous cells bearing short microvilli and many mucous cells.

3. Lung:

In pulmonate, both stylommatophores and basommatophores is present as the respiratory structure and is a true lung of independent origin, not vascularized mantle, which occupies the major part of the roof of the pallial cavity.

In some it extends to the walls and floor. In slugs, Athoracophoridae the lung is nonvascular and its wall gives off a number of delicate branched tubules, named tracheae (Hiscock, 1972), which function as respiratory structures.

The pallial cavity opens to the exterior by a large, oval aperture, the pneumostome, the opening and closure of which are controlled by contraction and relaxation of muscles. Large pulmonary veins with extensive ramification drain oxygenated blood from lung to auricle.

Respiratory organs for terrestrial mode of living:

Terrestrial habit leads to complete loss of gills and a variety of respiratory organs develop to suit the particular environment.

Trachea:

In some Pulmonata, the pulmonary chamber gives off breathing air-tubes, called trachea.

Nuchal lobe:

In Monotocardia (Mesogastropoda) the left nuchal lobe is better developed and forms a long respiratory siphon.

Amphibious forms:

These forms are exemplified by *Pila*. It possesses both ctenidium as well as pulmonary sac. *Siphonaria* is furnished with a lung- cavity and a ctenidium. Both the forms represent a transitional stage between aquatic and terrestrial life.

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