Chapter 2
Classification of Ascidians

The mysterious morphological structure of ascidians was taken into account for classification by various researchers. Herdman (1882) has given a classification of tunicate based upon the external features in relation to gemmation and formation of colonies. Originally the suborders are designated as the orders Aplousobranchia, Phlebobranchia and Stolidobranchia (Lahille 1886) based upon the complexity of the branchial sac. Subsequently, Perrier (1898) devised the orders Enterogona and Pleurogona based upon the position of the gonads and other morphological considerations. Garstang (1896) put forward a scheme of classification based on anatomical and embryological characters and included, to a certain extent, Lahille’s system of classification. Garstang (1928) and Huus (1937) combined the classification of Lahille and Perrier incorporating Lahille’s Aplousobranchia and Phlebobranchia as suborders of the Enterogona with the Pleurogona containing only the suborder Stolidobranchia (Berril 1950). Storer and Usinger (1965) classified the sub phylum Urochodata and divided it into three classes namely Asciidiacea, Larvacea and Thaliacea. In most modern treatments the class is divided into the orders Enterogona and Pleurogona with the sub orders Aplousobranchia and Phlebobranchia in the Enterogona and a single suborder, the Stolidobranchia in the Pleurogona (Abbott et al. 1997; Kott 1985). In recent classification (Kott 2003), tunicata comprises into four classes. They are:

Class I—Asciidiacea
The class Asciidiacea includes sedentary ascidians. There is a free-swimming larval period in the life history of an ascidian. Individuals are simple/solitary or compound/colonial in nature. Both siphons (branchial and atrial) are pointed upward in direction. Atriopore is dorsal in nature. Pharynx is perforated with numerous gill-slits opens into the atrium. Dorsal lamina may or may not found in the endostylar region. Adult has no tail and notochord. Sexual reproduction occurs. Eg. *Herdmania momus*, *Phallusia arabica* and *Didemnum psammathodes*. 

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Class II—Larvacea (Appendicularia)
This group is also known as appendicularia due to the presence of appendage (tail) used for propulsion. Larvacea includes small, transparent, planktonic group of tunicate with temporary test. Larvaceans are solitary in nature. These animals live in a gelatinous casing or “houses” and retain their larval tail throughout their lives. This tail drives a gentle current of water through the house, propelling the organism in the water. Pharynx has only two gill slits, opens to the outside of the body as there is no atrium. They are hermaphrodites except Oikopleura dioica. This group retains neoteny. Eg. Oikopleura vanhoeffeni.

Class III—Thaliacea
Members of the class Thaliacea never attach to objects, but lives as planktonic drifters. Thaliaceans are strange gelatinous animals that use their siphons to jet-propel themselves gently through the water. Mouth and atripore are on opposite ends providing propel for locomotion. Transparent test may or may not well develop. Life history includes alternation of generation. They occur from the ocean surface down to around 1500 m. Eg. Pyrosoma atlanticum, Salpa and Doliolum sp.

Class IV—Sorberacea
The Sorberacea is a class of benthic ascidian that has a dorsal nerve cord in the adult stage; in contrast to the sea squirt. They are carnivorous in habit. There is no perforated branchial sac. They are carnivorous in habit. Example: Sorbera sp., Gasterascidia sp., Oligotrema sp., and Hexadactylus sp.

2.1 Class: Ascidacea
Most recently, the search of ascidians have increasingly and become the target for many research activities, particularly on the members of class Ascidacea for its double mode of traits in their life history and distinguished from other classes by its sessile habits. So far, more than 3000 species of ascidians are recorded from all over the world. Among the four classes, more number of families and species are recorded from the Class Ascidacea. The individuals of the class Ascidacea comes under two orders. They are Enterogona and Pleurogona.

Order 1: Enterogona
Members of this order comprise both simple and colonial ascidians. The body of the simple form is undivided, whereas in colonial forms the body divides into thorax and abdomen. Tentacles are simple. Unpaired gonads are situated on one side or behind the intestinal loop. Neural gland is present ventral to neural ganglion. Oviduct and sperm duct follow the rectum and open through anus. Larvae are having cerebral eye and otolith.

Order Enterogona consists of two suborders:

Suborder 1: Aplousobranchiata Lahille, 1886
(=Haplobanchia Garstang, 1895, and = Krikobranchia Seeliger 1906).
It comprises only colonial ascidians. Zooïds are elongated and divided into distinct thorax and abdomen. Post abdomen may or may not be present. Branchial sac has no folds and inner longitudinal vessels, simple, transverse, ciliated ridge is present. Gut loop is present in abdomen. Gonads are present in the abdomen or post abdomen.

There are three families included in Aplousobranchiata.

**Family 1: Clavelinidae Forbes and Hanley, 1848**
It includes colonial forms with most of them are social ascidians. Zooïds are more or less free or embedded in matrix. Body is divided into thorax and abdomen. Gill slits ranged from three to many. Atrial siphon opens to extensive directly or into a common cloaca. True post abdomen is absent. Gonads are situated within the loop of intestine. This family comprises three subfamilies.

**Subfamily 1: Polycitorinae**
Zooïds open to exterior independently with atrial siphon. Both atrial and branchial siphon are 6 lobed. Asexual reproduction is common and occurs by budding of abdominal constriction

Genera: *Polycitor, Eudistoma, Archidistoma, Tetrazoma, Cystodytes* and *Sigillina*.

**Subfamily 2: Clavelininae**
Solitary and colonial forms. The siphons are smooth bordered and opens to the exterior directly. Internal longitudinal branchial vessels are absent.

Genera: *Clavelina, Podoclavelina, Pycnoclavelina, Archiascidia, Oxycorynia*.

**Subfamily 3: Holozoinae**
Zooïds are arranged in systems. Branchial siphon has six lobed, whereas atrial siphons are the modified atrial languets. Brood pouch with embryos present at thoracic level. Buds are produced at end of the abdomen.

Genera: *Distaplia, Sycozoa, (Corella), Holozoa*.

**Family 2: Polyclinidae Milne-Edwards, 1842 (=Synoicidae Hartmeyer, 1908)**
It includes only colonial ascidians, usually massive and gelatinous. Zooïds are large with seven or more rows of stigmata. Branchial aperture is lobed, whereas atrial aperture is not lobed. Atrial siphon opens into common cloaca. Body of the zoïd is divided into thorax, abdomen, posterior abdomen. Gonads and heart are present in post abdomen. Budding is by post abdominal constrictions. The family Polyclinidae includes two subfamilies.

**Subfamily 1: Polyclininae**
Polyclinids with atrial apertures forming common cloaca, branchial siphon six or eight lobed.

(a) Branchial siphon six lobed, stomach smooth-walled.

Genera: *Polyclinum, Aplidiopsis, Sydneioides*.

(b) Branchial siphon six lobed, stomach with ridges.

Genera: *Apidium, Amaroeucium, Synoicum*.
(c) Branchial siphon eight lobed, stomach with ridges.
   Genera: *Sydnyum*, *Morchellium*.

(d) Aberrant genus. *Pharyngodictyon*.

**Subfamily 2: Euherdmaniae**
Polyclinid with free atrial siphons. Epicardia separate.
   Genus: *Euherdmania*.

**Family 3: Didemnidae Giard, 1872**
Exclusively colonial forms. Colonies are encrusted and the zooids are very short divided into thorax and abdomen. Atrial siphons are modified to form atrial lip. Calcareous spicules are present in the test. Gonads are present dorsal or posterior. Budding is complex involving epicardia.

**Suborder 2: Phlebobranchiata Lahille, 1885**
(=Dictyobranchia Seeliger, 1906).
   Both solitary and colonial forms. Body is not divided into thorax and abdomen in Diazonidae. Branchial sac is with internal longitudinal vessels or in the form of bifurcating branchial papillae, but never with folded. Gonads are present in gut loop or at the side of branchial sac. Phlebobranchiata includes seven families.

**Family 1: Cionidae Lahille, 1887**
Solitary in habit. The digestive tube is horizontal and posterior to thorax. Branchial sac is large contains many rows of stigmata. Inner longitudinal vessels with secondary papillae. Heart is V-shaped situated between stomach and base of endostyle. Gonads are present in gut loop, both oviduct and spermduct open near the anus. Generally oviparous.
   Genus: *Ciona*.

**Family 2: Diazonidae Garstang, 1891**
Both solitary and colonial forms. Each zooid has separate atrial and branchial siphons. Body is divided into a thorax and an abdomen, gut loop is vertical enclosing gonads. The branchial sac with numerous rows of stigmata, inner longitudinal vessels are present with primary papillae. Secondary papillae are absent. Gonad is in gut-loop with ducts opening near the anus.
   Genera: *Diazona*, *Tylobranchion*, *Rhopalea*.

**Family 3: Perophoridae Giard, 1872**
Exclusively colonial and individuals are separate from one another. Gut loop is lower and at the side of branchial sac. The branchial sac with longitudinal vessel is in the form of bifurcating primary papillae. Secondary papillae are absent. The heart is long up to the base of endostyle along the dorsal side. Epicardia are absent. Gonad is in gut-loop; sperm duct opens near the anus. Whereas oviduct is very short and opens into brood pouch chamber in matrix cavity.
   Genera: *Perophora*, *Ecteinascidia*. 
Family 4: Corellidae Lahille, 1887 (= Rhodosomatidae Hartmeyer, 1908)
Exclusively solitary. Gut loop is partly below, partly at the right side of the branchial sac. The branchial sac has inner longitudinal vessels and without secondary papillae. Epicardia are present. Gonads in gut-loop and both ducts open near the anus.
Genera: Corella, Rhodosoma, Chelyosoma, and some imperfectly known abyssal genera.

Family 5: Ascididae Herdman, 1880
Exclusively solitary forms. The gut-loop is entirely on the left side of the branchial sac. The branchial sac has inner longitudinal vessels, with or without secondary papillae. The epicardia are represented by numerous renal vesicles. Gonads are in gut loop and both ducts open near the anus.
Genera: Ascidia, Asciidiella, Phallusia.

Family 6 and 7: Hypobythiidae Sluiter, 1895, and Agnesiidae Huntsman, 1912
Contain respectively one and two highly specialized deep-water genera probably related to Ascididae.

Order 2: Pleurogona
Both simple and colony forming ascidians. The body is never divided into the thorax and abdomen. Gonads are in the lateral mantle wall on both sides. The neural gland is usually dorsal, sometimes lateral to ganglion. Tentacles may be simple or compound. Buds are produced from the mantle wall.

Suborder 1: Stolidobranchiata Lahille, 1886. (= Ptychobranchia Seeliger, 1906)
Solitary or colony forming pleurogonid ascidians. Branchial sac with inner longitudinal vessels or bars, usually with longitudinal folds. This suborder comprises three families.

Family 1: Styelidae Sluiter, 1895
Both solitary and colony forming ascidians. Siphons are smooth edged or fringed with four lobes. Tentacles are simple. Branchial sac is always 4 folds on each sides. Stigmata straight. Dorsal lamina has smooth-edged. Stomach is wide ridges and pyloric caecum.

Subfamily 1: Styeliinae
Solitary styelids: Both siphons have four-lobed. Usually four folds on each side of the branchial sac. Gonads are on one or both sides, usually multiple.
Genera: Pelonia, Styela, Katatropa, Polycarpa, Cnemidocarpa.
Genera on one side only.
Genera: Dendrodoa, Podostyela.

Subfamily 2: Botryllinae
Colony forming styelids; colonies are either compact or with zooids more or less free. Buds are produced from the mantle wall. Gonads are very variable. Tadpole larvae are with peculiar sensory “photolith”.

2.1 Class: Asciidiacea
(a) Branchial sac with folds and numerous inner longitudinal vessels or bars. 
   Genera: *Polyandrocarpa, Eusynstyela, Gynandrocarpa, Stolonica, Distomus*.

(b) Branchial sac without folds, but with residual longitudinal vessels or bars. 
   Genera: *Botryllus, Botrylloides, Symplegma, Metandrocarpa, Kukenthalia, Dictyostyela, Chorizocarpa, Polyzoa*.

**Family 2: Pyuridae Hartmeyer, 1909**
Exclusively solitary ascidians. Both siphons are four lobed. Tentacles are branched. Branchial sac is above with four folds on each sides. Many internal longitudinal vessels are present. Stigmata are straight. The stomach is narrow and smooth. 
   Genera: *Pyura, Boltenia, Microcosmus, Tethyum, Culeolus*.

**Family 3: Molgulidae Lacaze-Duthiers, 1877**
Exclusively simple ascidians with both siphons are six lobed. Tentacles are branched. The branchial sac has 6 or 7 branchial folds with numerous longitudinal vessels. Stigmata are curved and arranged in spirals. The renal organ is a large closed sac lying on left side. 
   Genera: *Molgula, Eugyra*. 