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A general guide to the metazoan zooplankton groups of the Southern Ocean

David O'Sullivan and Graham Hosie

ANTARCTIC DIVISION
DEPARTMENT OF SCIENCE

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This issue is one of a number of guides dealing with Antarctic marine fauna and flora that will appear in the ANARE Research Note series. These guides are designed to help workers gain a rapid appreciation of a particular group of organisms, especially for identification purposes, by bringing together information that is widely scattered in the literature. The guides are not meant to be exhaustive literature surveys, although every effort has been made to include all the important references.

Species found south of the Subtropical Convergence will be dealt with in detail. Those occurring in more northerly waters but likely to be encountered on Antarctic voyages are included in identification keys.

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A GENERAL GUIDE TO THE METAZOAN ZOOPLANKTON GROUPS OF THE SOUTHERN OCEAN

by

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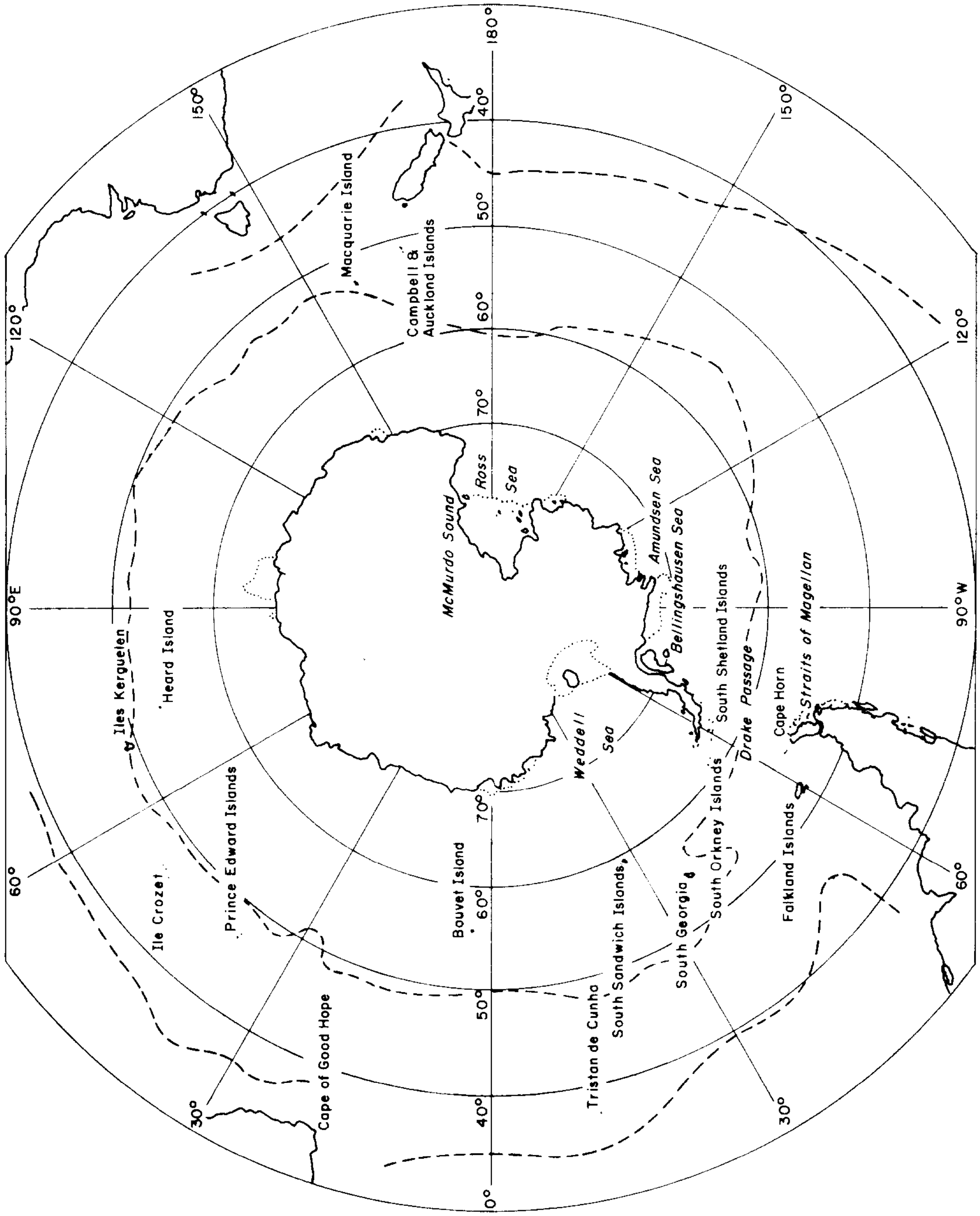
ABSTRACT

The characteristics of a number of zooplankton groups are given together with illustrations, keys and comments on the examination and preservation of the animals. The information provided is intended to enable a novice to sort zooplankton into their first order groups.



Map showing places mentioned in the text.

1. INTRODUCTION

A number of guides to various taxonomic groups of Southern Ocean zooplankton has been published in the ANARE Research Notes series. These guides provide detailed information for the identification of planktonic animals to the species level. People not familiar with plankton systematics often have difficulty in determining to which group a particular organism belongs, so this general guide has been prepared so that even novices can sort specimens into major taxonomic categories. The more detailed guides can then be used to determine the species.

The characteristics of a number of zooplankton groups are detailed, and illustrations of typical animals are given to aid in their identification. General advice on the examination and preservation of each group is also offered.

Only adult, macroscopic, holoplanktonic, metazoan animals are dealt with here as it is beyond the scope of this guide to include the microplankton (such as the single celled protozoa) or to include the pelagic larval stages of benthic and planktonic animals. Only groups found in the Southern Ocean are considered in detail, although some found in adjacent waters (i.e. south of 30° South) are included.

Each phylum is considered separately. In some cases characters are also provided for class and order subdivisions. Where necessary a key has been given to aid in the identification of the subdivision to which the organism belongs. The information provided, though generalised and simplified, should enable all but the most aberrant or rare animals to be categorised.

Many of the textbooks on invertebrate zoology differ in the system of classification used. In this guide the system followed is that given in The Synopsis and Classification of Living Organisms, (S. Parker, Ed.), McGraw Hill, New York, 1982, which contains some excellent summaries of zooplankton systematics. This classification system may differ slightly from those used in the other guides in the ANARE Research Notes series.

2. PHYLUM CNIDARIA

Most cnidarians are marine, though some freshwater species have been recorded. This group of animals was often united with the Ctenophora to form the Coelenterata. However, cnidarians differ from ctenophores by possessing nematocysts, or cnidae (stinging cells), which can be used for defence or in the capture of prey.

Cnidarians exhibit 2 body forms and these alternate in many of their life cycles. One, the erect, cylindrical polyp, is typically attached to a firm substrate at its aboral end, while the other form, the medusa, is typically pelagic and discoid. Only the medusoid phases are given in this guide.

There are four classes: Anthozoa, Hydrozoa, Cubozoa and Scyphozoa. The Anthozoa (false corals, sea fans, sea pens, true corals and anemones) are benthic animals, but the Cubozoa, Hydrozoa and Scyphozoa all are represented in the zooplankton by the medusoid phase (commonly called jellyfish).

The medusa is largely composed of gelatinous connective tissue (mesogloea). The body is bell or umbrella-shaped. The mouth is located in the centre of the concave undersurface, hanging at the end of the manubrium, which protrudes from the undersurface. The manubrium often bears oral tentacles. Tentacles may also hang from the bell margin.

Medusae exhibit primary radial symmetry. This is emphasised by the radial development of the gastrovascular cavities which consist of a circular canal (lying toward the periphery of the medusa and encircling the entire disc) and a number of radial canals (which pass from the central stomach toward the periphery of the disc). In the Hydrozoa the margin of the medusa bell projects inward to form a shelf known as the velum.

2.1 KEY TO CLASSES, ORDERS AND SUBORDERS

1a)	Margin of bell projects inwards to form a shelf (velum)	2
b)	No velum present (Scyphozoa)	9
2a)	Bell square in transverse section, with a tentacle or group of tentacles, at each corner (Cubozoa)	Cubomedusae
b)	Bell round, with tentacles spread around margin (Hydrozoa)	3
3a)	Individual medusae (Hydroida and Trachylina)	4
b)	Highly complex colonial forms, usually with many different types of tentacles and zooids	8
4a)	Margin of bell divided into intertentacular lappets, tentacles spring from umbrella some distance above margin	Narcomedusae
b)	Margin not thus, tentacles are usually marginal or nearly so	5

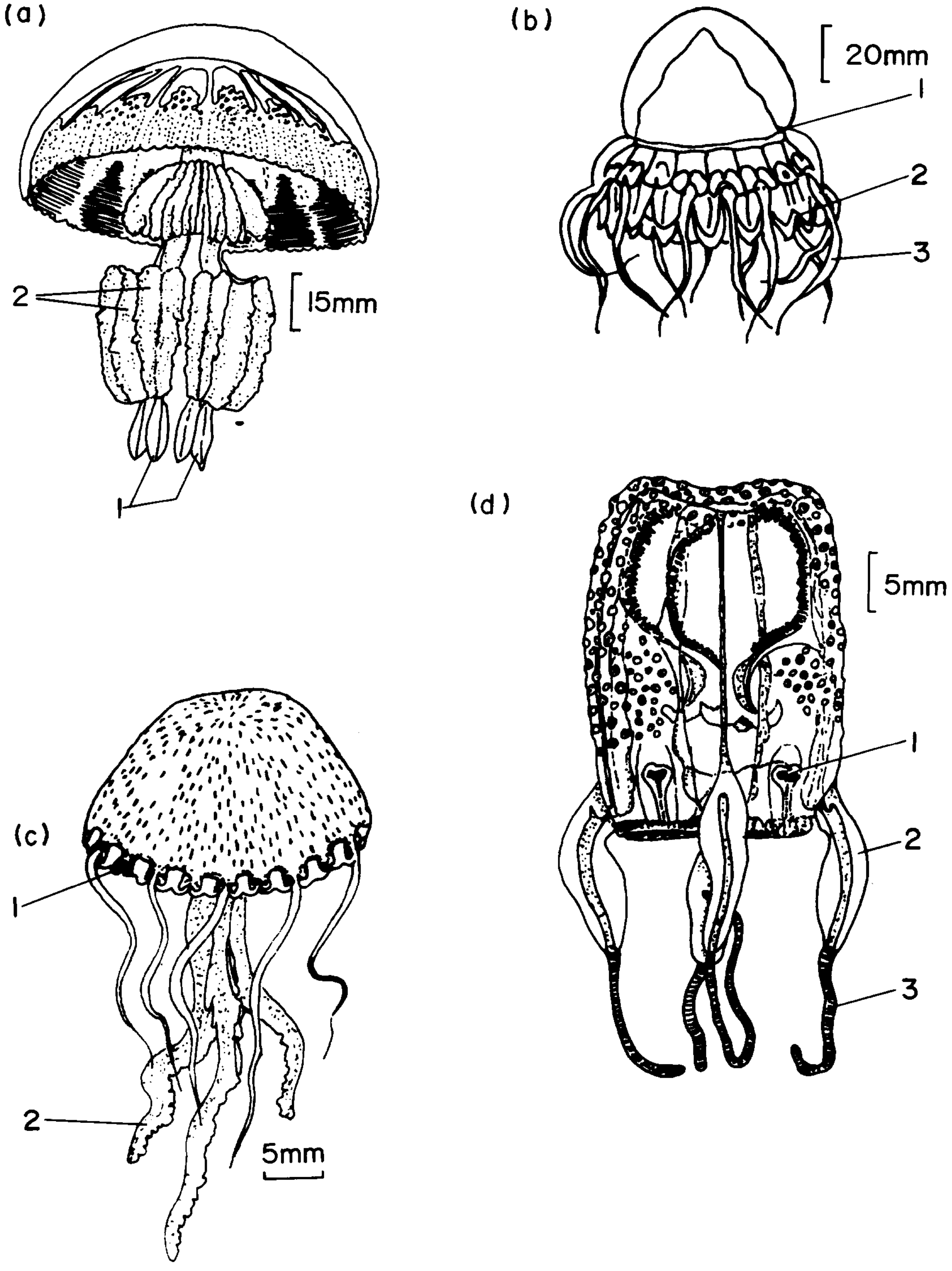
5a)	Gonads borne on stomach only, tentacles on bell are few in number and short	Anthomedusae
b)	Gonads borne on other areas	6
6a)	Gonads borne on radial canals only, usually with 2 rings of tentacles, one at bell margin and one slightly above	Limnomedusae
b)	Gonads borne on radial canals only, or on both stomach and radial canals, only one ring of tentacles	7
7a)	Numerous marginal tentacles	Leptomedusae
b)	Generally few tentacles, some may be placed a little above bell margin	Trachymedusae
8a)	Colony joined by a central stem, large apical balloon-like float, or cone-like with only a few tentacles	Siphonophora
b)	Colony not joined by a central stem, float flattened and saucer-like	Chondrophora
9a)	Numerous mouths with long oral arms, no marginal tentacles	Rhizostomeae
b)	With a single mouth, marginal tentacles present	11
10a)	Medusae with a deep groove or constriction around bell	Coronatae
b)	Without a groove or constriction	Semaeostomeae

Figure 1. The Cnidaria. Representatives of each of the pelagic orders and their diagnostic characters.

Scyphomedusae (a) Rhizostomeae. Pseudorhiza aurosa. (1) mouths, (2) oral arms. (b) Cornatae. Periphylla periphylla. (1) coronal furrow, (2) pedalia, (3) marginal tentacle. (c) Semaeostomeae. Pelagia noctiluca. (1) marginal lappet, (2) lips.

Cubomedusae (d) Cubomedusae. Tamoya haplonema. (1) sense organ, (2) pedalia, (3) marginal tentacle.

Hydromedusae (e) Anthomedusae. Podocoryne tenuis. (1) stomach, (2) gonad, (3) radial canal. (f) Leptomedusae. Phialella falklandica. (1) gonad, (2) radial canal, (3) marginal tentacles. (g) Limnomedusae. Gossea brachymera. (1) gonad, (2) radial canal, (3) tentacle rings. (h) Narcomedusae. Pegantha martagon. (1) marginal tentacle, (2) intertentacular lappet. (i) Trachymedusae. Haliscera racovitzae. (1) gonad, (2) radial canal, (3) marginal tentacle. (j) Siphonophora. Dimophyes arctica. (1) nectophore. (k) Siphonophora. Physalia physalis. (1) float, (2) zooids, (3) tentacles. (l) Siphonophora. Marrus antarcticus (bract). (m) Chondrophora. Velella velella. (1) float, (2) gonozooids and dactylozooids.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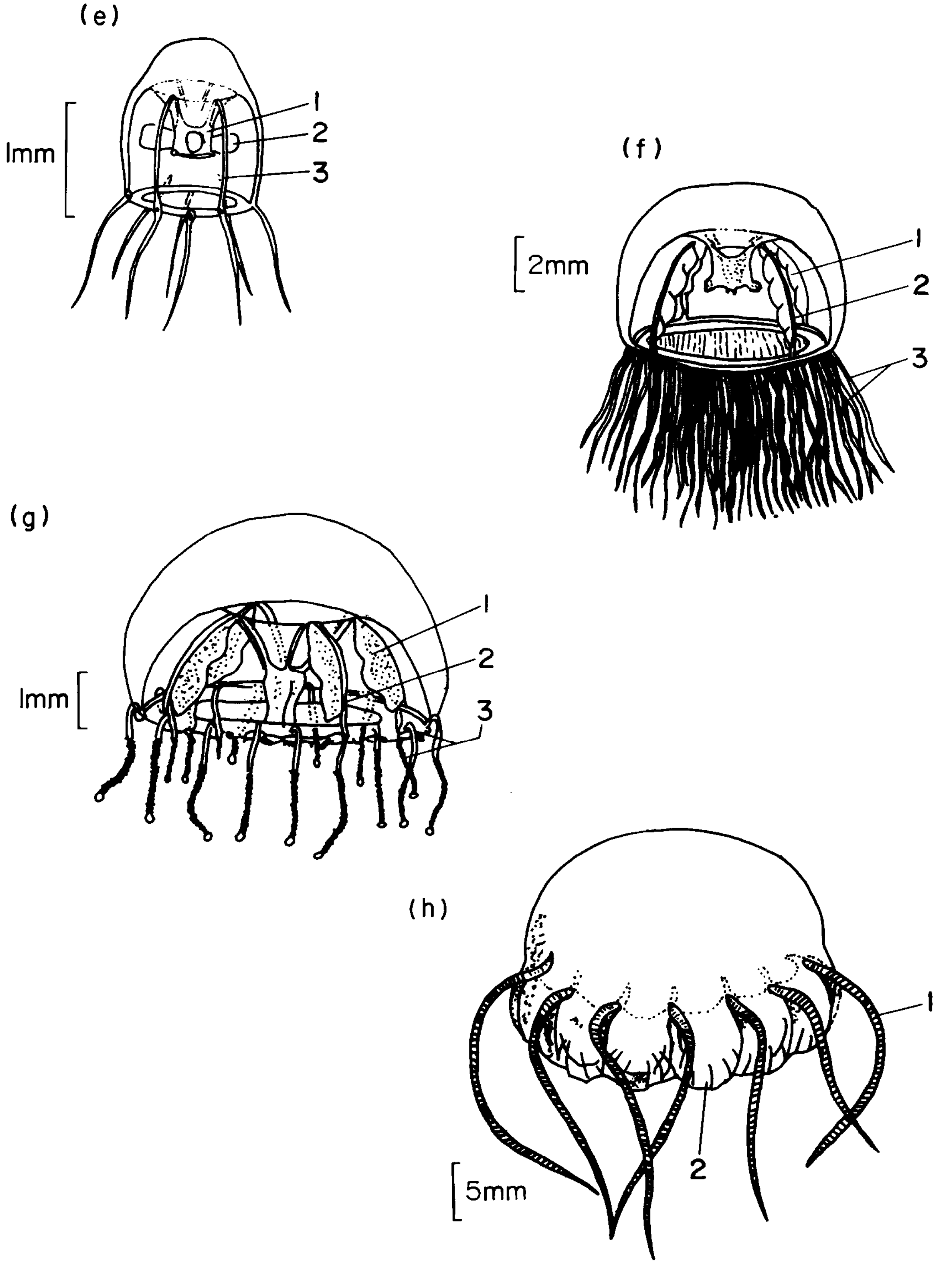
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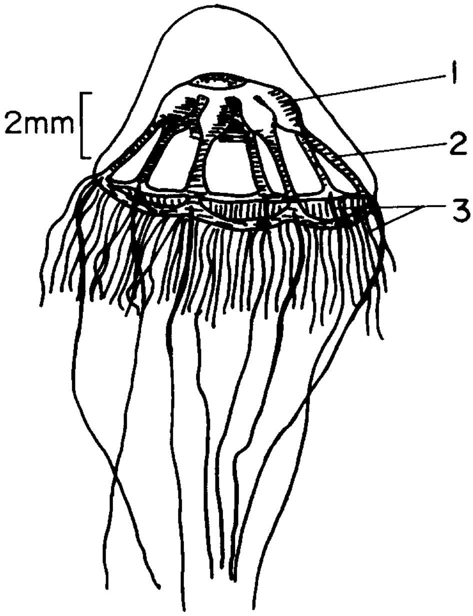

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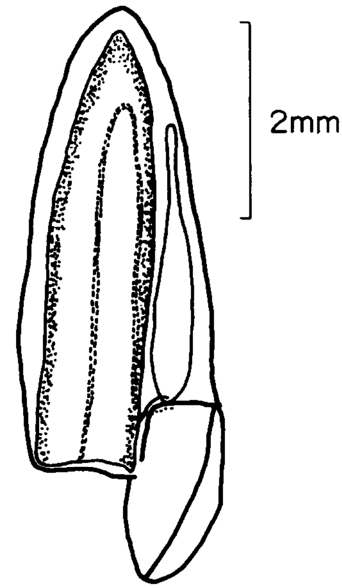

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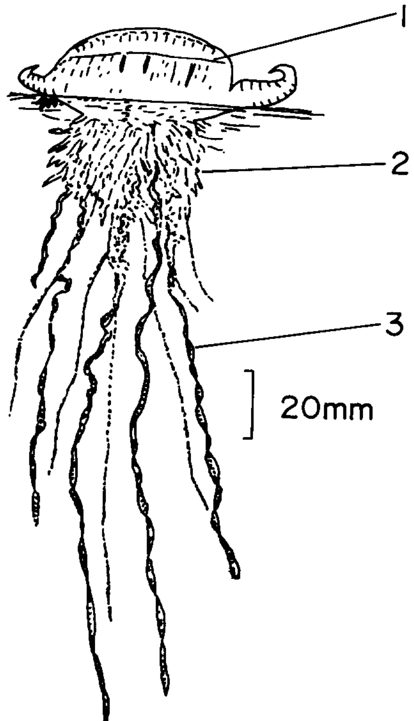

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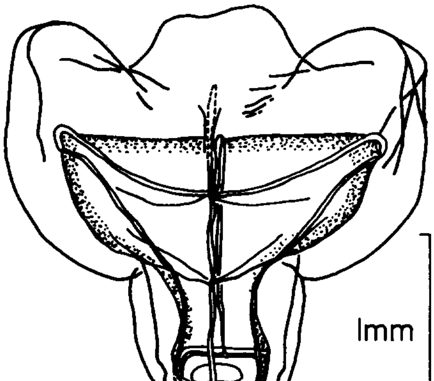

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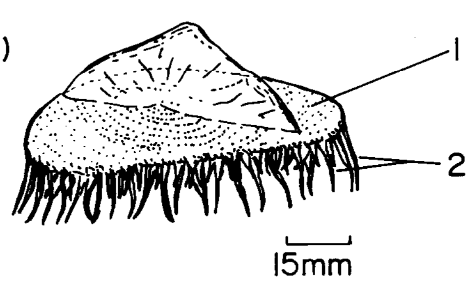

2.2 CLASS SCYPHOZOA-SCYPHOMEDUSAE

This class is exclusively marine with the medusoid stage dominating the life cycle. The majority of scyphozoan medusae have a bell diameter ranging from 20 to 400 mm; sometimes species are even larger. The medusa have a firm gelatinous flat or domed bell. They can be free swimming, demersal or attached. The margin of the bell is usually scalloped into lappets, and bears reduced and generally hollow tentacles or rhopalia (sense organs), or both, in the niches between the lappets, usually in multiples of four. Four radial canals lead from the stomach to a ring canal. No velum is present. Gonads are borne on septa or on the floor of the gastric pockets of the stomach. Colouration is often striking; the gonads and other internal structures, which may be deep orange, pink, red or other colours, are visible through the colourless or more delicately tinted bell.

There are 4 orders of which the Stauromedusae is benthic.

Order Rhizostomeae

The bell is domed or discoidal (Figure 1a), with a margin cleft into 8 more lappets with 8 or 16 rhopalia between each. Marginal tentacles are absent. A central mouth has been replaced by numerous long and branched arms with many mouths. Some species are found in waters adjacent to the Southern Ocean.

Order Coronatae

The bell is more or less domed with a deep groove or constriction (coronal furrow) around the bell umbrella (Figure 1b). Many are up to 1 m in diameter and deep red or purple in colour. The margin of the bell is scalloped and divided into lappets between which lie a solid tentacle or a sense organ (rhopalium). There is a single mouth opening and no oral arms. This group is mostly bathypelagic and contains the monogeneric family Tetraplatidae which was once considered an order (Pteromedusae). A number of species have been reported from the Southern Ocean.

Order Semaeostomeae

The bell is like a flattened bowl or saucer-shaped with a marginal cleft in lappets (Figure 1c). Rhopalia (generally 8 or 16) arise from some or all of the niches between the lappets. Hollow tentacles arise from the subumbrella. The single mouth opening has 4 broad, gelatinous lobed oral arms with frilled edges. There is no coronal furrow. Some species are found in waters adjacent to the Southern Ocean.

2.3 CLASS CUBOZOA - CUBOMEDUSAE

This class consists of a single order (Cubomedusae) which was formerly placed in the class Scyphozoa. The bell is square in transverse section and usually has a tentacle, or a group of tentacles, at each corner of the umbrella (Figure 1d). Opening of the bell cavity is partly closed by an annular diaphram (velarium) similar to the velum of the Hydromedusae. Most species in this class are tropical although some have been reported from waters adjacent to the Southern Ocean.

2.4 CLASS HYDROZOA - HYDROMEDUSAE

In this class there is an alternation of life cycle between attached hydroid and pelagic medusoid generations although the hydroid generation is usually dominant. The medusae are generally small and possess a velum. There are no oral tentacles or rhopalia. There are some freshwater members. There are 7 orders of which the Hydroida, Trachylina, Siphonophora and Chondrophora have pelagic members, all of which are usually small (less than 20 mm in diameter).

Order Hydroida

Medusa are solitary and are usually small and saucer-like or domed. The margin is not scalloped.

Suborder Anthomedusae

Predominantly marine, the medusae are usually bell or bud-shaped (Figure 1e). Gonads are usually borne on stomach or manubrium. The tentacles around the bell are short and few in number. Many Southern Ocean species.

Suborder Leptomedusae

These exclusively marine medusae are flattened with numerous marginal tentacles (Figure 1f). Gonads are borne in connection with radial canals. Many Southern Ocean species.

Suborder Limnomedusae

Predominantly freshwater, the medusae have hollow tentacles, which are usually in 2 rings, one at the bell margin and one slightly above (Figure 1g). Gonads are borne on the stomach wall or radial canals. Some Southern Ocean species.

Order Trachylina

In this order the medusoid phase is usually dominant. Medusae range from 20 to about 300 mm in diameter, with a circular margin or scalloped into lappets. Tentacles usually insert above the bell margin and are equal in number to or are more numerous than the radial canals. Radial canals, usually 4, 6 or 8 in number, may lead to a ring canal. There are 3 suborders of which the Langiomedusae are found only in the tropics.

Suborder Narcomedusae

The general appearance of these medusae is a solid bell, but variations toward elongation or flattening of the bell may occur. The margin of the bell may be scalloped and there are no radial canals. Solid tentacles arise above bell margin (Figure 1h). Sometimes secondary tentacles may be inserted on margin itself. Gonads lie on stomach walls. Some Southern Ocean species.

Suborder Trachymedusae

No polypoid stage in life cycle. The bell margin is not cleft into lappets (Figure 1i). The marginal tentacles can be solid or both solid and hollow. Gonads are borne on 4, 6 or 8 radial canals. The mouth is located at the end of a cylindrical or quadrangular manubrium. Some Southern Ocean species.

Order Siphonophora

Exclusively marine order of swimming or floating colonies consisting of different types of zooids: gastrozooids (feeding zooids), dactylozooids (sensory buds) and gonophores (reproductive zooids). The colonies bud from a stem (or coenosarc) whose gastrovascular canal is continuous with the canals of all the zooids of the colony. A medusoid zooid can take the form of an apical float. Gastrozooids are responsible for feeding and each bears a single feeding tentacle which has lateral contractile branches that bear terminal nematocysts. Dactylozooids resemble the gastrozooid but lack nematocysts and a mouth. Gonophores bear the gonads and can occur singly, or in clusters. Often a colony is broken up while in the net resulting in numerous pieces of bilobed "bract". Some species or forms have a cone-like appearance with only 1 or 2 tentacles - these are called nectophores. There are 3 suborders.

Suborder Calycophorae

These lack an apical gas-filled float and consist of 1 or more nectophores of varied shapes with a tubular stem that buds zooids in groups called cormidia (Figure 1j). Each cormidium consists of a gastrozooid with a tentacle and one or more gonophores of one sex. The cormidia may break loose and live independently, in which case they are called eudoxids. Numerous Southern Ocean species.

Suborder Cystonectae

Swimming bells and bracts are lacking. A large aboral float has a budding zone on one side of its base (Figure 1k). The groups of zooids (cormida) and tentacles hang down together below the float. Usually tropical although some forms have been found in the Southern Ocean.

Suborder Physonectae

The apical gas filled float typically has a budding zone on either side of the base. The cormidium consists of one or more dactylozooids each with an unbranched tentacle, one gastrozooid with a branched tentacle, one or more bracts (Figure 1l) and clusters of gonophores. Numerous Southern Ocean forms. Often these animals are broken up during collection and only a large number of individual bracts are found in the net.

Order Chondrophora

These polymorphic colonies lack an elongate stem. The zooids are attached to a round or oval chitinous, many chambered central blue float that is united with the coenosarc (Figure 1m). Gonozooids and dactylozooids hang from the float. This group was formerly considered a member of the Siphonophora. Some forms have been found in waters adjacent to the Southern Ocean.

2.5 COLLECTION AND PRESERVATION

The free swimming medusae are best collected in nets towed at low speeds (0.5 to 1 knot). Netting is more successful at night when the medusae tend to be abundant at the surface, and the large pelagic forms such as Schyphozoa and Siphonophora can be taken with dip nets or with a bucket. It is important to quickly separate the medusae from the rest of the catch to avoid mechanical damage of the specimens.

Fixation can be carried out by letting the animals swim in a suitably large jar, adding, while stirring gently, 10 vol. % of stock solution (Appendix I) or 40% formaldehyde. Specimens can be moved from one container to another with little damage using a spoon or glass pipette. No advantage will be gained by narcotising before fixation. If performed correctly this procedure will kill the animals without distortion of the umbrella, and with the tentacles moderately extended.

For storage, the diluted stock solution can be used. Formaldehyde buffered with borax or hexamine should be avoided. It is recommended to use glass containers for storage of fixatives prior to use. If glass jars are used for fixation and storage of specimens, a build up of debris on the bodies of the medusa will be prevented.

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3. PHYLUM CTENOPHORA

Pelagic and benthic marine organisms with gelatinous bodies and biradial symmetry. The basic body plan is closely akin to that of the Cnidaria, but is more advanced. There is no alternation of generation in the life cycle and ctenophores are never colonial.

All ctenophores have 8 rows of fused ciliary plates (combs or ctenes) at some stage of their life cycle. These are a characteristic of the ctenophores and the structures from which the name of the phylum is derived. The ctenophore body shape ranges from spherical to ribbon-like. Paired tentacles are present in most forms and have sticky cells or colloblasts which are used to capture prey.

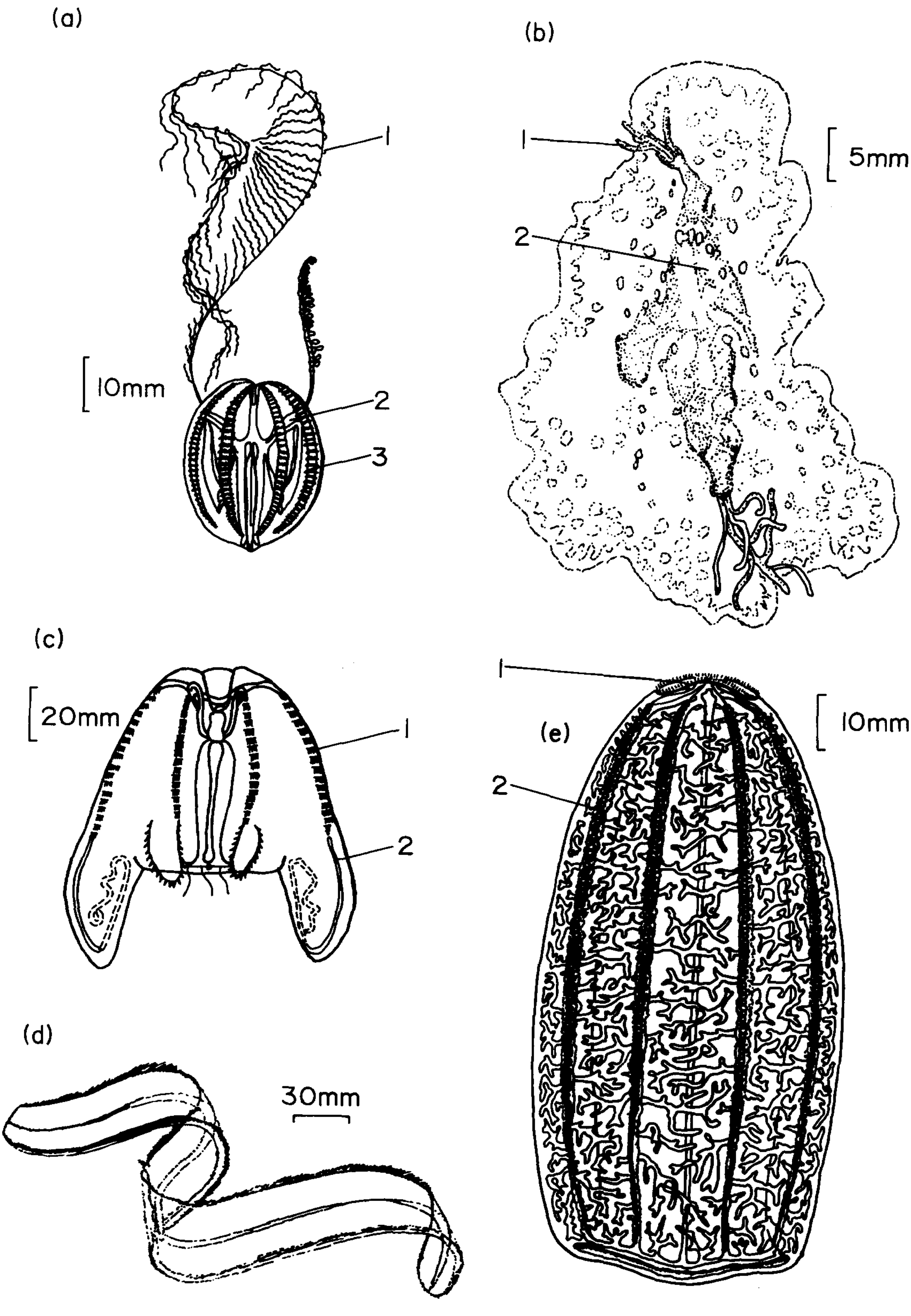
The gut consists of a mouth, pharynx (stomodaeum), the infundibulum (gut or stomach), the infundibular canal, anal canals and anal pores, with peripherally arranged gastrovascular canals. The mouth defines the oral pole, while the statocyst (sense organ) and anal pores define the aboral plane. The stomadaeum is flattened, defining the stomodaeal (also pharyngeal plane). At right angles to this plane, the tentacular plane passes through the tentacle bulbs.

The phylum is divided into 7 orders, of which the Ganeshida and Thalassocalycida are only known from tropical and sub-tropical waters and are not considered here.

3.1 KEY TO ORDERS

1a)	No tentacles or tentacle bulbs present, body strongly flattened in the tentacular plane, rounded at aboral end	Beroida
b)	Tentacle and tentacle bulbs present	2
2a)	Body oval or rounded, long branched tentacles	Cydippida
b)	Body not oval, compressed in certain places	3
3a)	Body compressed in oral-aboral axis, tentacles in sheaths	Platyctenida
b)	Body compressed in tentacular plane	4
4a)	Two large oral lobes on either side of mouth	Lobata
b)	No oral lobes present, body long and ribbon-like	Cestida

Figure 2. The Ctenophora. Representatives of each of the pelagic orders and their diagnostic characters. (a) Cydippida. Pleurobranchia pileus. (1) tentacle, (2) tentacle sheath, (3) comb row. (b) Platyctenida. Coeloplana willeyi. (1) tentacle, (2) tentacle sheath. (c) Lobata. Bolinopsis infundibulum. (1) comb row, (2) oral lobes. (d) Cestida. Cestum veneris. (e) Beroida. Beroe cucumis. (1) aboral end, (2) comb row.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Order Cydippida

These pelagic ctenophores have well developed comb rows (Figure 2a). The paired tentacles are retractile into tentacle sheaths. The general body shape is globular or ovoid, though some forms are greatly flattened in the stomodaeal plane. The tentacles can be long and branched in some forms. Some common Southern Ocean species.

Order Platyctenida

Order of planktonic, creeping or sessile ctenophores which are often greatly compressed in the oral-aboral axis (Figure 2b). Comb rows are generally absent in adults. The tentacle apparatus is similar to that in Cydippida with tentacle sheaths, but the tentacular canals are bifid. Although sessile members of this order are found in the Southern Ocean, the planktonic family Ctenoplanidae is only found in tropical waters.

Order Lobata

Pelagic ctenophores in which the body is compressed in the tentacular plane and is expanded on each side of the mouth forming a pair of oral lobes (Figure 2c). Tentacle sheaths are lost and tentacles are reduced, surrounding the mouth and extending onto the oral lobes. Some species are found in waters adjacent to the Southern Ocean.

Order Cestida

These pelagic animals are extremely compressed in the tentacular plane and greatly elongated in the stomadaeal plane, having a ribbon-like appearance (Figure 2d). Tentacles and tentacle bulbs are present. Common in waters adjacent to the Southern Ocean.

Order Beroida

In this pelagic order the tentacles and tentacle sheaths are absent (Figure 2e). The body is strongly flattened in the tentacular plane, and the aboral end is rounded or extended into 2 prominent keels. Comb rows are well developed and extend from one half to most of the body height. Species of this order are very common in the Southern Ocean.

3.2 COLLECTION AND PRESERVATION

Planktonic ctenophores can be taken by a tow net or dip net. As with the cnidarians, it is an advantage to collect them at night.

Ctenophores are very fragile and are difficult to preserve without disintegration. Formalin solutions should not be used. Early methods used solutions of osmic and chromic acid but these caused discolouration and disintegration of the specimens.

For fixation either of the following solutions can be used:
(a) tri-chloroacetic acid, 1 g; seawater, 99 mL; or
(b) p-toluene sulphuric acid, 1 g; seawater, 99 mL.

Fix for 30 minutes. The specimens will change slightly from transparency to translucency. It is best to pour the specimens into a jar of fixative. The use of spoons, pipettes or bolting cloth is recommended for moving the animals between containers.

To preserve ctenophores transfer from acid/seawater solution to 1 mL stock solution (Appendix I) and 99 mL of seawater. Keep in this fluid for 5 to 7 days then transfer to 5 mL stock solution and 95 mL seawater for storage. Never store with crustacea as the sharp spines of the crustaceans will cut the ctenophores, leading to disintegration. Storage temperatures should be between 5° and 20°C. Avoid knocking or shaking the jars as this may cause damage.

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4. PHYLUM NEMERTINEA

Commonly known as ribbon worms, nemertineans can be found in marine, freshwater and terrestrial environments. The pelagic nemerteans when alive are often brightly coloured with shades of brown, red, orange, green and yellow. They can grow up to 60 mm long, but most species are less than 20 mm in length.

The flattened and elongate body is unsegmented with no distinct head (Figure 3), although the anterior end may bear side lobes. There are no other appendages. A long and muscular proboscis can be everted from the mouth to capture prey.

The pelagic species are usually found at depths of 500 to 2000 m or more. They float freely due to the extensive gelatinous parenchyma which gives them a low specific gravity.

The phylum consists of 2 classes, Anopla and Enopla. All the pelagic members are from the Enoplan order Hoplonemertea. Eleven species have been reported from the Southern Ocean.

4.1 PRESERVATION

Crystals of chloral hydrate, urethane, chloretone or menthol can be added to containers of seawater with the nemerteans in them to narcotise the animals. This will prevent the tendency to shed the proboscis or even disintegrate when preserved. Pelagic nemerteans should not be preserved in formalin as this may lead to dissolution of some structures. They can be fixed in 30-50% alcohol and stored in 70-90% alcohol.

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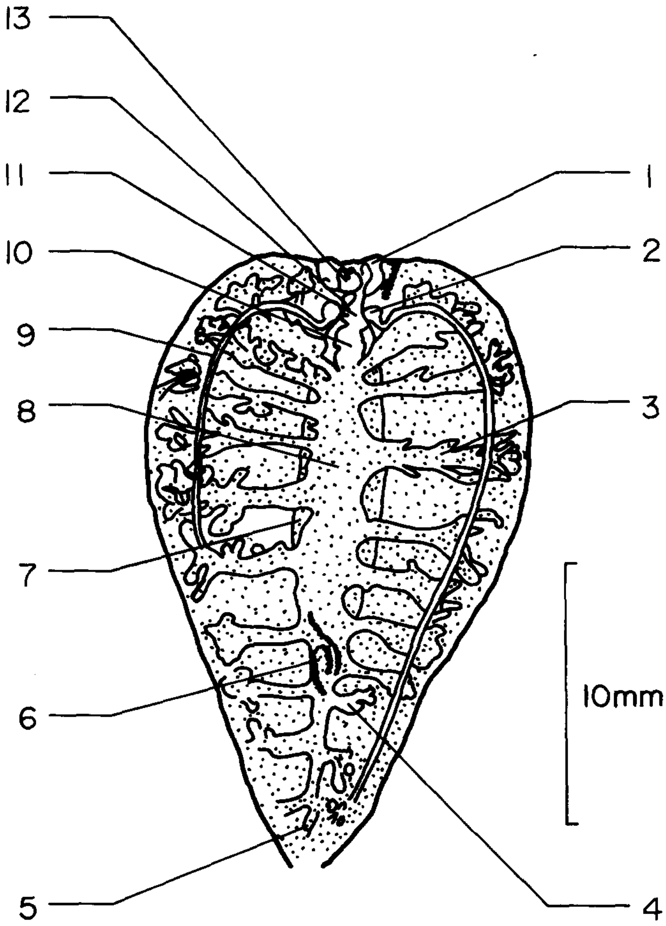

Figure 3. The Nemertinea. A nemertean Obnemertes ramosa showing the major structures: (1) cuticular fold, (2) brain, (3) lateral diverticula, (4) lateral diverticula, (5) rectum, (6) posterior part of proboscis, (7) proboscis sheath, (8) mid gut, (9) lateral nerve chord, (10) caecum, (11) stomach, (12) funnel of proboscis, (13) mouth.

5. PHYLUM MOLLUSCA - CLASS GASTROPODA

Representatives of 2 classes of mollusca can be found in the plankton. The familiar squids and other members of the class Cephalopoda although often caught in plankton nets are free-swimming and will not be dealt with here.

The class Gastropoda is characterised by a single univalve shell which may be reduced or completely lost in some groups. The 2 subclasses, Prosobranchia and Opisthobranchia, both have pelagic members. In these animals the foot is usually enlarged and modified for swimming.

5.1 KEY TO ORDERS

1a)	No shell is present, body is rough and rubbery, 2 small fins	Gymnosomata
b)	Shell present, body delicate	2
2a)	One large leaf-like fin	Mesogastropoda (Heteropoda)
b)	Two flattened fins	Thecosomata

5.2 SUBCLASS PROSOBRANCHIA

Order Mesogastropoda - Superfamily Heteropoda

If present the shell may be well-developed and snail-like or reduced and smaller than the animal. The foot is modified for swimming and consists of a single laterally compressed leaf-like fin (Figure 4a). The remainder of the sole is usually modified into a sucker. Up to 150 mm in length, the heteropods are mainly epiplanktonic in the upper layers of the ocean to a depth of a few hundred metres. They are usually present in the tropics and warm temperate waters, although some species have been reported from the Southern Ocean.

5.3 SUBCLASS OPISTHOBRANCHIA

Order Thecosomata

Commonly known as pteropods, thecosomes usually have a calcareous shell (2 families are shell-less) which may be coiled, tubular or globular. The foot is enlarged laterally into 2 fins (Figure 4b). Generally small, less than 25 mm in length, these cosmopolitan animals feed on microplankton which are swept to the mouth by cilia. The delicate shells are often broken or lost during capture, however thecosomes can be recognised from gymnosomes because they have 2 large fins and a very thin walled, fragile looking body. The gymnosomes have 2 small fins and a very tough, rubbery body.

Order Gymnosomata

The shell is absent, the body is spindle-shaped to ovate, more or less rounded in section (Figure 4c) and small to medium size, usually less than 40 mm in length. The fins consist of lateral lobes which are distinct from the foot. The gymnosomes are carnivorous and can be found in the epi-, meso- and bathypelagic layers.

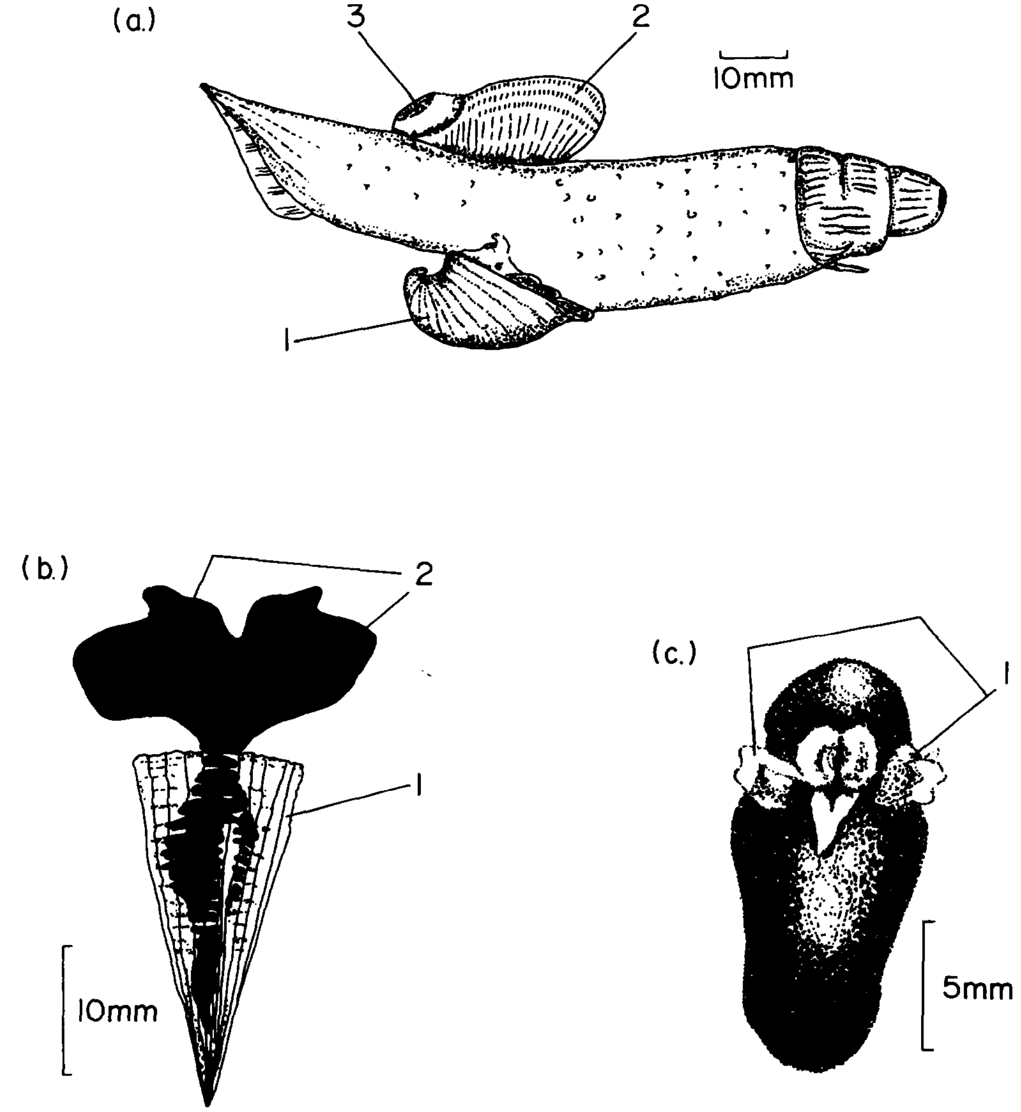

Figure 4. The Mollusca: Gastropoda. Representatives of each of the pelagic orders and their diagnostic characters. (a) Heteropoda. (1) shell, (2) fin, (3) sucker. (b) Thecosomata. (1) shell, (2) fins. (c) Gymnosomata. Spongiobranchea intermedia. (1) fins.

5.4 COLLECTION AND PRESERVATION

Pelagic molluscs are usually collected in plankton nets. The shells are very fragile and the animals should if possible, be removed from the net by hand. The smaller species can be taken up with a pipette and the larger ones picked up by the wings or other soft parts using tweezers. The shelled forms (most thecosomes and the heteropods) and shell-less forms (all gymnosomes and 2 families of thecosomes) can be treated differently because the latter group does not present any problems involving decalicification.

Shelled forms can be relaxed by gradually adding one of the following solutions into a tank containing live specimens:

(a) 7% solution of magnesium chloride;
(b) 1% solution of acetone-chloroform;
(c) a solution of part glycerine, 2 parts 70% alcohol and 2 parts seawater;
(d) MS222 or urethane in seawater.

For the shell-less forms a 0.1% solution of chloral-hydrate can be used.

The amount of fixative used should always be more than 3 times by volume that of the specimens to be fixed. For systematic studies where preservation of the shell is important the following are recommended:

(a) 70% acid free alcohol;
(b) 4% formaldehyde in seawater.

Shelled forms should be preserved in 70% acid free alcohol. Naked forms are best preserved in 3-4% formaldehyde. With shelled forms it is often wise to remove the animal from the shell, so that the body can be preserved in formaldehyde and the shell can be stored dry.

For storage the volume of preservative should be at least twice that of the specimens. Shelled forms can be stored in 70% acid free alcohol or 4% sea water formaldehyde buffered to pH 8. Dry shells can be stored in a glass tube, stoppered with cottonwool plugs wrapped in thin rice or silk paper to keep the specimens from being entangled in cotton fibres.

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6. PHYLUM ANNELIDA - CLASS POLYCHAETA

The phylum Annelida comprises the segmented worms, the body being divided into cylindrical rings or segments with serially arranged organs. The largest class, Polychaeta, contains the marine species. The name refers to the many bristles (or setae) borne on the segments of the body. The class contains 25 orders of which the Phyllodocida contains the pelagic forms.

Order Phyllodocida

Species in this order have a body which consists of similar segments (Figure 5). They can reach up to 230 mm in length, but most species are less than 50 mm. The prostomium (or head) is distinct, usually with at least one pair of antennae, and often with ventral palps and eyes. Each segment of the body bears a well-developed pair of lateral appendages called parapodia. These usually bear setae which can be simple or compound (jointed), and a dorsal and ventral cirrus which is usually leaf-like. Between the cirri is another extension of the parapodia called the setigerous lobe.

The order contains 27 families of which 6 (Alciopidae, Lopadorhynchinae, Iospilidae, Pontodoridae, Tomopteridae and Tychloscolecidae) have holoplanktonic representatives in the Southern Ocean. Eighteen species have been reported from these waters.

In the shallow waters of the neritic zone, members of other polychaete families can be found in the plankton. These are either larval stages or swarming mature stages of benthic species, and will not be considered here.

6.1 KEY TO FAMILIES

1a) Eyes enormous, occupying most of head .... Alciopidae
b) Eyes normal, rudimentary or absent 2

2a) Parapodia of body segments lack setae but have membraneous pinnules .... Tomopteridae
b) Parapodia of body segments have setae, membraneous pinnules absent 3

3a) Setigerous lobe small and setae always simple and acicular, large foliaceous dorsal and ventral cirri .... Typhloscolecidae
b) Setigerous lobe well developed and setae always compound 4

4a) Setigerous lobe produced as a slender thread among the setae .... Pontodoridae
b) Setigerous lobe not produced as a slender thread 5

5a) Antennae absent, body cylindrical .... Iospilidae
b) Four antennae, body usually flattened .... Lopadorhynchinae

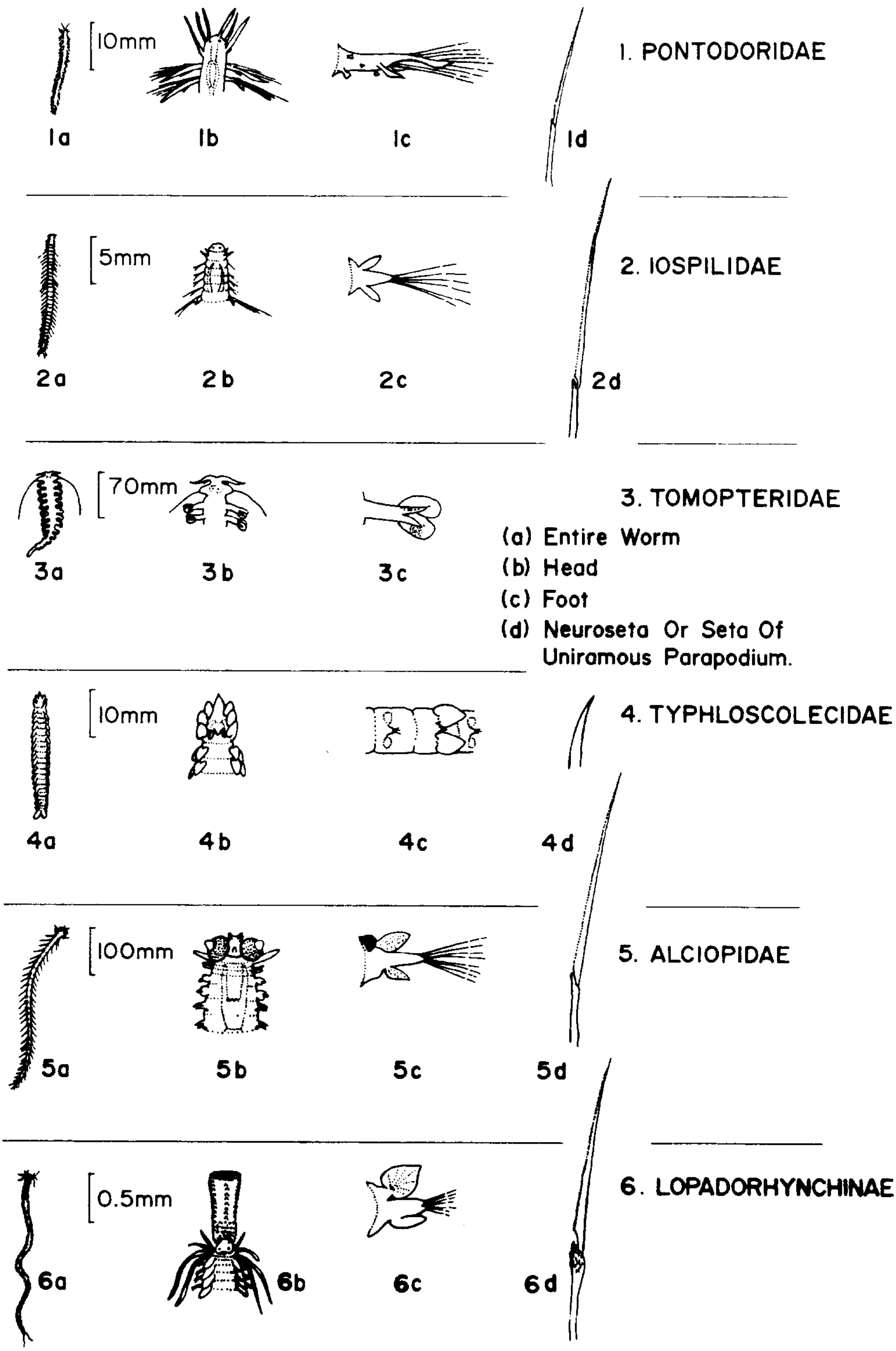

Figure 5. The Annelida: Polychaeta. Illustrations of the family characters of pelagic polychaetes.

6.2 PRESERVATION

Narcotisation of pelagic polychaetes is not usually necessary but 70% alcohol or isotonic magnesium salt solution could be used so that the worms can be preserved in a flat state. For killing and fixation good results are usually obtained by slowly adding buffered formaldehyde to the sample whilst it is being gently stirred, until a concentration of about 8% is reached. Alcohol (70%) can also be used.

Polychaetes can be stored in either 2% formaldehyde (neutralised) or 70 to 80% alcohol, the latter being generally preferred. When specimens are transferred from formaldehyde to alcohol, at least one change of alcohol is required to ensure that the alcohol content is maintained.

6.3 REFERENCES AND FURTHER READING

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7. PHYLUM ARTHROPODA - CLASS CRUSTACEA

The Arthropoda is the largest phylum with an estimated 1 to 2 million species. Arthropods are typically metameric (segmented), as are the Polychaeta with which they share a common ancestry. Each metamere bears a single pair of appendages, which are stiff, tubular and jointed, hence the phylum name (Arthro-poda, jointed-feet). Fusion of segments and loss of appendages may occur. The notable feature of this group is the chitinous exoskeleton which covers the entire body and is periodically shed to allow growth. There are numerous classes of arthropods, however, the primarily aquatic Crustacea is the only class of importance in terms of marine zooplankton.

The crustaceans are an extremely difficult taxa to define, principally due to their great diversity in morphology and development. At some stage in their lives, however, they bear 2 pairs of antennae, which are tenniform and sensory, and a pair of mouthparts called mandibles. The antennules (first antennae) and the antennae (second antennae) are situated pre-orally and together are the distinguishing characteristic of this taxa. No other arthropod group has more than 1 pair of antennae. The mandibles are sited post-orally along with 2 pairs of accessory feeding appendages, the maxillules (first maxillae) and maxillae (second maxillae). All crustacean appendages are typically biramous, with expodite (outer branch) and endopodite (inner branch) arising from the basal segment, the protopodite (Figure 6). In some Crustacea a carapace may be present. This is a posterior fold of the head extending over the thorax and may be fused with a few anterior or all of the thoracic segments. Eight subclasses of Crustacea are recognised, Cephalocarida, Mystacarida, Branchiura, Cirripedia, Branchiopoda, Ostracoda, Copepoda and Malacostraca. Each class is represented in the plankton, at least at the larval stage, however, only the latter 4 classes have adult representatives in the Southern Ocean zooplankton.

7.1 KEY TO MAJOR TAXONOMIC GROUPS

1a) Body and appendages enclosed in a bivalve carapace 2
b) Body and appendages are not enclosed in a bivalve carapace 3

2a) All of body (head, thorax, abdomen) completely enclosed in bivalve carapace, valves hinged dorsally, 2 or less pairs of trunk appendages ..... Ostracoda
b) Only thorax and abdomen enclosed by carapace, no dorsal hinge, 4-6 trunk appendages (Branchiopoda: Diplostraca) Cladocera

3a) Carapace not present 4
b) Carapace present 6

4a) Body not compressed, cylindrical, with notable demarcation between thorax and abdomen, thoracic appendages biramous, no abdominal appendages, caudal rami present, simple naupliar eye ..... Copepoda
b) Body compressed laterally or dorsoventrally, no clear demarcation dorsally between thorax and abdomen, thoracic appendages uniramous, telson and uropods present instead of caudal rami, compound eyes 5

5a) Body compressed dorsoventrally, first antenna uniramous, usually shorter than second antenna, gills abdominal, 1 pair of uropods (Malacostraca) .... Isopoda

b) Body usually laterally compressed, first antenna biramous, usually longer than second antenna, gills thoracic, 3 pairs of uropods (Malacostraca) .... Amphipoda

6a) Carapace fused with no more than the first 4 thoracic segments, marsupium (brood pouch) present in females, protopodite of second antenna with 3 segments, mandibles bear <u>lacinia</u> <u>mobilis</u> (movable accesory incisor) (Malacostraca) .... Mysidacea

b) Carapace fused to all thoracic segments, no marsupium, protopodite of antenna with no more than 2 segments, no <u>lacinia</u> <u>mobilis</u> on adult mandibles 7

7a) Carapace encloses gills forming branchial chamber, usually more than one type of gill (podobranchiae, arthrobranchiae, pleurobranchiae) 3 pairs of maxillipeds (Malacostraca) .... Decapoda

b) Carapace does not cover gills, no maxillipeds, podobranchiae only (Malacostraca) .... Euphausiacea

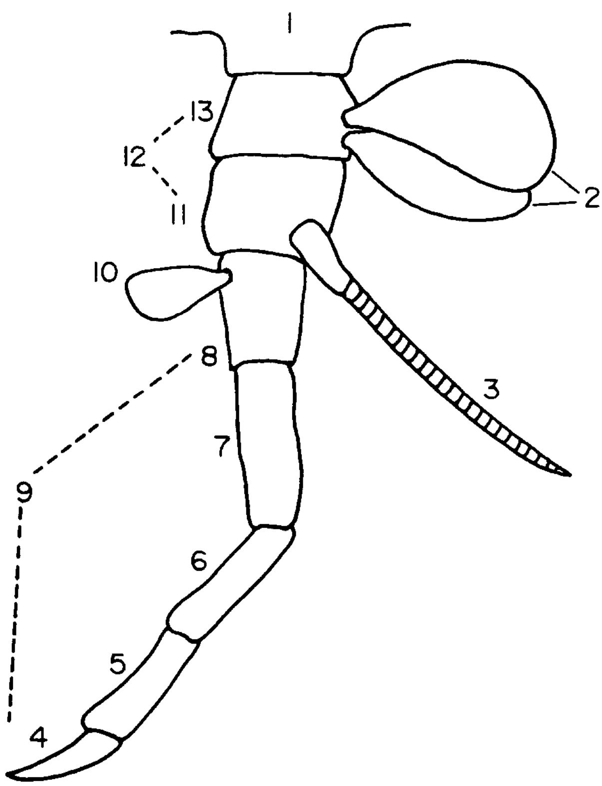


Figure 6. Generalised crustacean appendage showing basic structures: (1) body, (2) epipodites, (3) exopodite, (4) dactylus, (5) propodus, (6) carpus, (7) merus, (8) ischium, (9) endopodite, (10) endite, (11) basis (basipodite), (12) protopodite, (13) coxa (coxopodite).

7.2 SUBCLASS OSTRACODA

The body of these Crustacea is completely enclosed in a clam-like, bivalved carapace which is hinged dorsally by a strip of noncalcified cuticle. The carapace may be circular, elliptical, reniform or subrectangular in shape, with the valves generally smooth and thin in pelagic forms, compared to the robust, ornate shells of many benthic species. Closure of the valves is controlled by a transverse adductor muscle. The trunk is reduced and unsegmented with 2 or less trunk appendages, resulting in only 5 to 7 paired appendages for the whole body. This is fewer in number than for any other adult crustacean. The reduced abdomen terminates in a pair of caudal rami. Both the first and second antennae are well developed, extending beyond the edge of the carapace and are the principal swimming appendages. There are 4 Ostracoda orders, the Platycopa, Podocopa, Myodocopa and Cladocopa, of which the latter 2 orders contain all marine planktonic species. Although some Podocopa are capable of swimming they are most likely not planktonic, while the Platycopa is composed entirely of benthic species. Ostracods, mainly the Myodocopa, are a notable component of the Southern Ocean zooplankton. They are usually only a few millimetres and often transparent. Bathypelagic specimens may exceed 15 mm in size and are orange-brown in colour.

Order Myodocopa

The carapace bears an anterior antennal notch (Figure 7a), which permits the extension of the antennae when the valves are closed. The first antenna has 8 segments, though some may be fused. The second antenna is biramous with a large basal segment. Two pairs of trunk appendages are present.

Order Cladocopa

This order differs markedly from the Myodocopa, by lacking both an antennal notch and trunk appendages. The first antennae has 4 segments and the second is biramous.

7.3 SUBCLASS BRANCHIOPODA

In this group the body (thorax and abdomen) appendages are typically leaf-like, lobed and densely setose (bristled). The flattened epipodite attached to the protopodite functions as a gill, hence the name Branchiopoda (gill-feet). The Branchiopoda is primarily a freshwater group, although marine representatives exist in the suborder Cladocera.

Order Diplostraca - Suborder Cladocera

The carapace is folded to give a bivalve appearance, when in fact the carapace is actually univalved. There is neither a dorsal hinge or an adductor muscle. The carapace is fused with 2 or more thoracic segments and encloses the trunk, the 4 to 6 body appendages, but not the head (Figure 7b). The carapace often terminates posteriorly in an apical spine. There is a single compound eye. The first antenna is uniramous, while the second antenna is biramous and used for swimming. Cladocerans are only a few millimetres long with little pigmentation except for the black compound eye. They occur infrequently in the Southern Ocean.

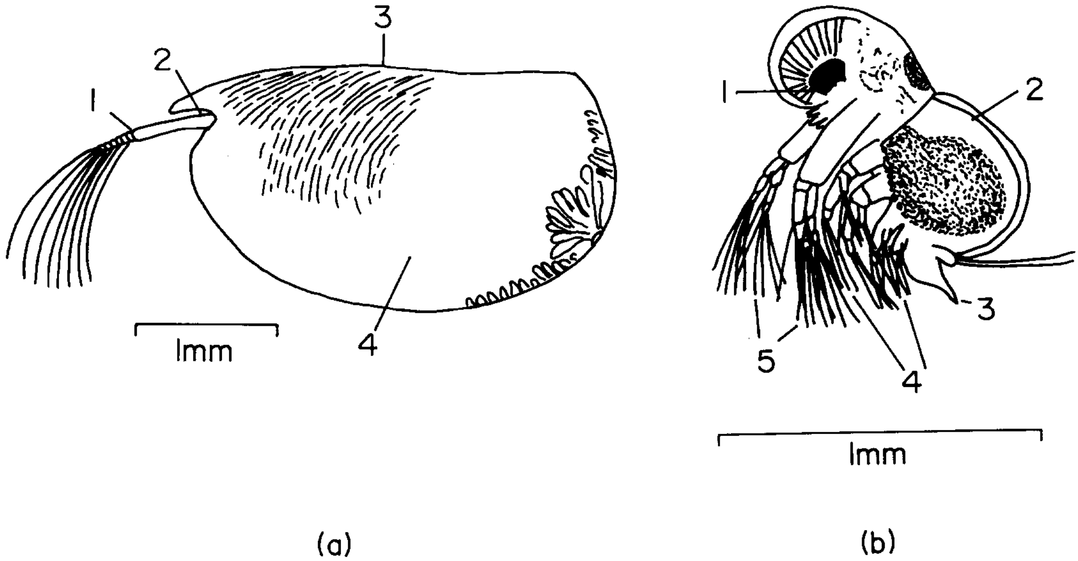


Figure 7. Ostracoda and Branchiopoda. (a) Antarctic Myodocopa ostracod Conchoecia innominata. (1) second antenna, (2) antennal notch, (3) dorsal hinge, (4) carapace. (b) Podon polyphemoides, a common marine Cladocera branchiopod. (1) compound eye, (2) carapace, (3) posterior apical spine, (4) trunk appendages, (5) second antenna.

7.4 SUBCLASS COPEPODA

The body of a copepod is short and cylindrical and there are usually 9 free trunk segments. There is no carapace. The head is either rounded or bears a rostrum and is fused to the first, and sometimes the second, thoracic segments. The thorax (metasome) is tapered and consists of 6 segments with 6 pairs of natatory appendages. The first pair is modified as maxillipeds for feeding and is uniramous, while the remaining 5 pairs are natatory and typically biramous, although the last pair may also be uniramous. The abdomen (urosome) is narrower than the prosome (head and thorax) and lacks appendages except for a pair of caudal rami. The first antenna is long, conspicuous and uniramous. There are no compound eyes, but a median naupliar eye is typical.

The order Calanoida is the dominant group in the marine zooplankton. They occur in vast numbers in all oceans and as herbivores form the major link between the phytoplankton and the carnivores. The Calanoida are possibly rivalled only by the Euphausiacea in terms of major trophic importance in Southern Ocean food chains. The order Cyclopoida has a number of Antarctic representatives and a few planktonic species of the primarily benthic Harpacticoida have been recorded from subantarctic waters. The remaining 4 orders of Copepoda are primarily parasitic or commensal.

Order Calanoida

Some degree of fusion of the thoracic segments often occurs, resulting in variations of 3 to 5 metasomal segments. The first segment fuses often with the head and sometimes the fourth segment with the fifth. The number of urosome segments varies between 2 and 5, of which the first always bears the genital opening. The principal point of trunk (prosome-urosome) articulation is between the last (sixth) thoracic and the first abdominal (genital) segment, that is the fifth and sixth postcephalic segments (Figure 8a). The first antenna is long with 25 segments, though fusion may reduce the number to 18, and generally reaches near to or beyond the end of the thorax. The second antenna is biramous. The fifth pair of swimming feet are situated on the last metasomal segment and are generally not reduced. Ovigerous females carry a single median egg sac. Antarctic calanoids vary in size between approximately 1 and 13 mm, many of which have some red or orange pigmentation. The baythypelagic copepod Bathycalanus bradyi is commonly larger than 10 mm and is bright red.

Order Cyclopoida

The prosome-urosome articulation is located between the fourth and fifth postcephalic segments, i.e. the fifth and sixth thoracic segments. The prosome is generally more ovoid compared to that of the Calanoida (Figure 8b). The first antenna is shorter than the length of the prosome and consists of 6 to 17 segments. The first antenna in males are modifed for grasping the females.

The second antenna is uniramous. The last metasomal segment bears the fourth pair of swimming feet. The fifth pair are much reduced and attached to the first urosomal segment. Ovigerous females carry 2 lateral egg sacs. Cyclopoids are approximately 1 to 2 mm in size.

Order Harpacticoida

The prosome-urosome articulation occurs between the fourth and fifth postcephalic segments. However, the articulation is not obvious dorsally, since the urosome is almost as wide as the metasome (Figure 8c). The body is generally linear in shape. The first antenna is short, comprising 4 to 10 segments, and in the males they are usually swollen, hook-like and used for grasping. The second antenna is biramous. The fifth pair of thoracic legs are generally morphologically dissimilar from the other 4 pairs. They are particularly common close inshore but are likely to be uncommon in oceanic plankton samples. Maximum size is about 2 mm.

7.5 SUBCLASS MALACOSTRACA

The subclass Malacostraca constitute the largest group of Crustacea and exhibit considerable diversity in size and shape. However all malacostracans refer to a common set of anatomical features known as the caridoid facies. The 'ideal' malacostracan has a set number of body segments; 20 somites, comprising 6 head, 8 thoracic and 6 abdominal segments. The female reproductive opening is on the sixth thoracic somite and the male opening is on the eighth. The carapace encloses the thorax at the sides. The compound eyes are stalked, while the median eye is vestigal in adults. The second antenna has a scale-like exopodite, which is used for keeping the animal level in the water. There are 8 pairs of thoracic appendages, each with a 5 jointed, cylindrical endopodite,

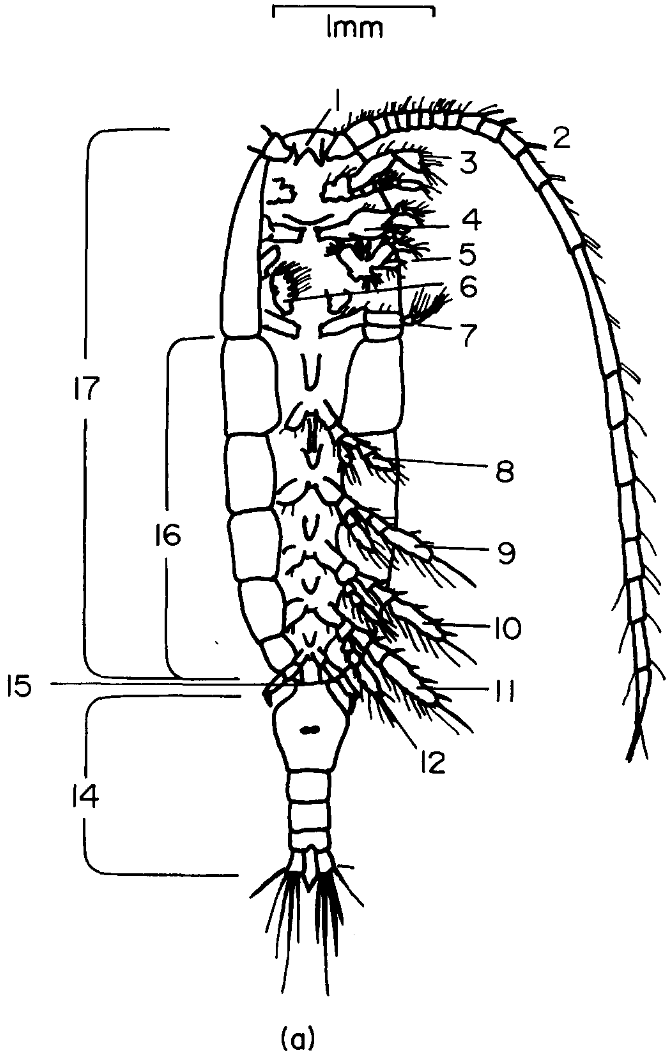
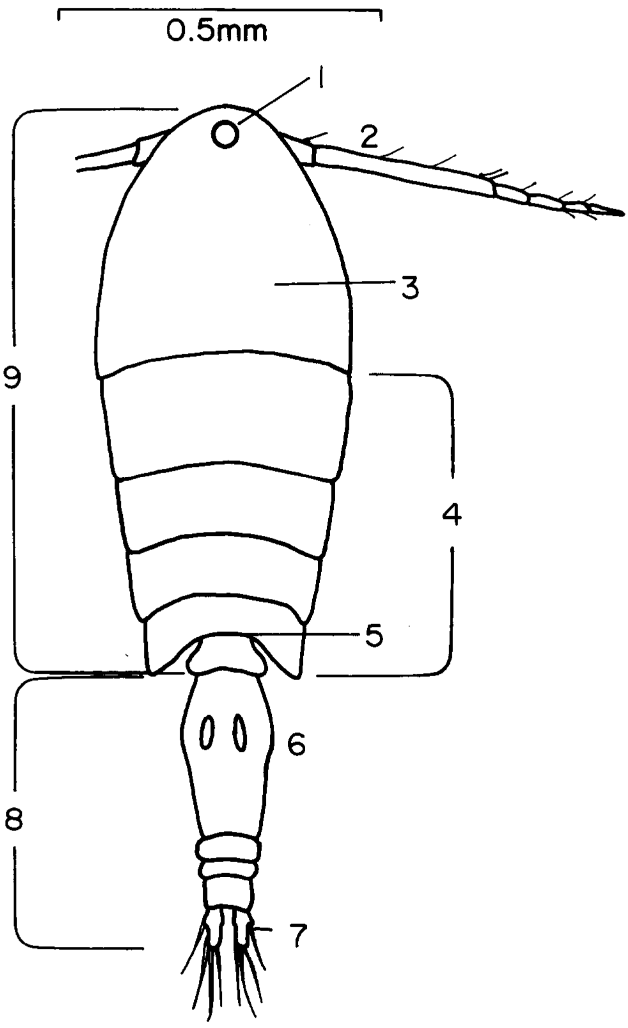
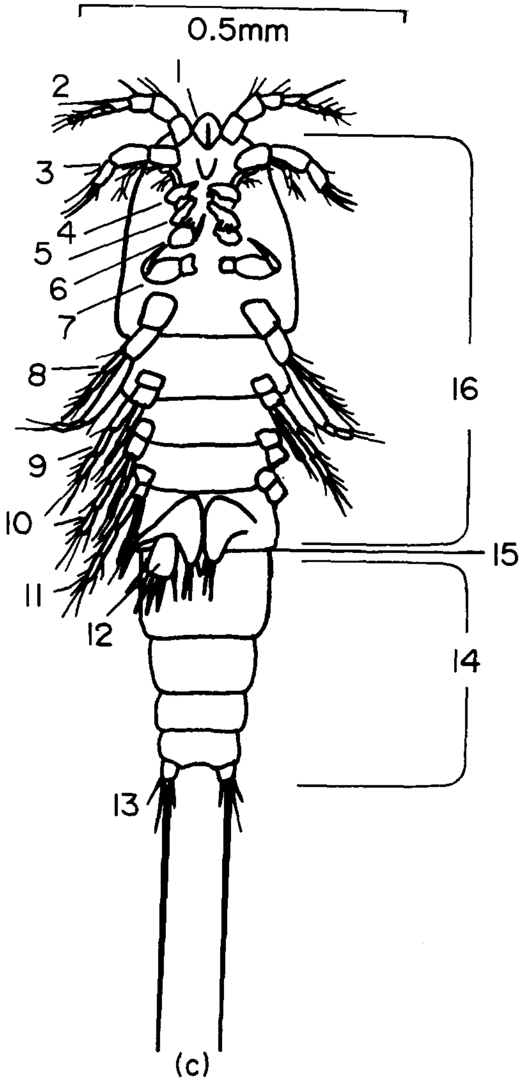


Figure 8. The Copepoda. (a) Generalised calanoid, ventral view. (1) rostrum, (2) first antenna, (3) second antenna, (4) mandible, (5) first maxilla, (6) second maxilla, (7) maxilliped, (8-12) swimming legs 1 to 5 (pereiopods), (13) caudal ramus, (14) urosome, (15) principal point of articulation, (16) metasome (thorax), (17) prosome, (18) genital segment (abdominal 1 and 2).



(b)

(b) Generalised cyclopoid, dorsal view. (1) naupliar eye, (2) first antennae, (3) cephalosome (head and first thoracic segment), (4) metasome (thorax), (5) principal point of articulations, (6) genital segment (abdominal 1 and 2), (7) caudal ramus, (8) urosome, (9) prosome.



(c) Generalised harpacticoid, ventral view. (1) rostrum, (2) first antenna, (3) second antenna, (4) mandible, (5) first maxilla, (6) second maxilla, (7) maxilliped, (8-12) swimming legs 1 to 5 (pereiopods), (13) caudal ramus, (14) urosome, (15) principal point of articultion, (16) prosome.

a natatory exopodite and respiratory epipodites. The abdominal appendages are also biramous. The first 5 pairs, the pleopods, are paddle-like, setose and natatory. The last pair, the uropods, are broad, turned back and along with the telson form a tail fan, which is used for rapid backward swimming. Caudal rami are lacking. The mandible bears a uniramous palp and the masticating surface is divided into a cutting pars incisiva and a grinding pars molaris. The first maxilla has 2 endites (extensions of the endopodite) and the second maxilla has 4. The caridoid facies are primarily suited to a pelagic mode of life and are best exhibited in the small, pelagic, shrimp-like (caridoid) species belonging to the Mysidacea, Euphausiacea and Natantia, which possibly resemble the hypothesised pelagic filter-feeding ancestral malacostracan. Many of the features have been lost within the various taxonomic groups due mainly to the transition from a pelagic to a benthic lifestyle, but the one feature that remains constant in all species is the number of somites.

The Malacostraca are a taxonomically complex group, with a large number of superorders, orders and suborders.

Superorder Peracarida

The carapace of Peracarida, when present, is fused only to some anterior (usually 4) thoracic segments. At least the last 4 thoracic segments are free. The first thoracic segment and sometimes the second and third are fused to the head. The protopodite of the second antenna has 3 segments. The eyes may be either stalked or sessile. The mandible bears a lacinia mobilis, a movable accessory incisor. A notable character of this group is the presence of ventral marsupium or brood pouch on females, formed from lamellar processes (oostegites) of the coxae of the thoracic limbs.

Order Mysidacea

The carapace extends posteriorly over most or all of the thorax, but is fused with no more than the first 4 thoracic segments. A rostrum extends anteriorly. The compound eyes are stalked. The first antenna is biramous and the second bears a scale-like exopodite. The thoracic legs usually have natatory exopodites, except sometimes the first, second and eighth pairs. The first pair of thoracic appendages and sometimes also the second, are modified as maxillipeds. The pleopods may be reduced in both sexes or modified in males. Statocysts are characteristically present in the uropod endopodite of many species (Figure 9). There are 2 suborders, the Lophogastrida and Mysida, both of which are common in Antarctic waters especially inshore. Antarctic mysids range in size between approximately 10 and 40 mm.

Suborder Lophogastrida

Mysids with gills on some thoracic legs. The pleopods are well developed and unmodified in either sex. Statocysts are not present on the uropods. The marsupium is composed of 7 pairs of oostegites.

Suborder Mysida

There are no gills. The pleopods are reduced, often rudimentary, in females, while those of males are variable. Statocysts are usually present in the uropod endopodites. The marsupium comprises less than 7 pairs of oostegites.

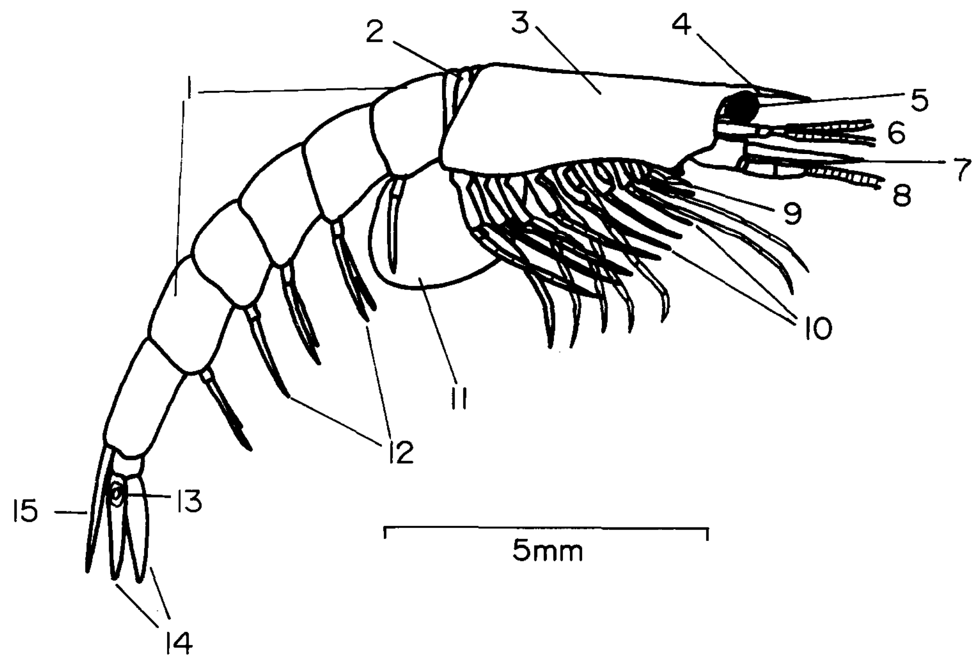


Figure 9. Mysidacea. Generalised form showing major characteristics of the order. (1) abdominal segments, (2) free thoracic segments, (3) carapace, (4) rostrum, (5) compound eye, (6) first antenna, (7) antennal scale (A2 exopodite), (8) second antenna, (9) maxilliped, (10) natatory thoracic exopodites, (11) marsupium (brood pouch), (12) pleopods, (13) statocyst, (14) uropods, (15) telson.

Order Isopoda

The body of isopods is dorsoventrally flattened (Figure 10a). The head is shield-shaped and fused with the first, sometimes the second, thoracic segments. There is no carapace. The abdomen is usually the same width as the thorax, thus the 2 sections may not be clearly demarcated dorsally. The compound eyes are sessile (not stalked). The first antenna is uniramous and usually shorter than the second antenna, which is also uniramous. The first pair of thoracic appendages are modified as maxillipeds and the remaining 7 pairs, the pereiopods are usually similar. All thoracic appendages are uniramous, i.e. the exopodites are absent. The pleopods are typically biramous, natatory and have lamellar rami that function as gills. The isopods therefore differ markedly from the rest of the malacostracans, by having abdominal instead of thoracic gills. The uropods do not usually form a tail fan. Eight suborders exist within the Isopoda, composed primarily of benthic species with some parasitic. The Asellota is the only suborder with truly planktonic species, the presence of which in Antarctic waters is yet to be confirmed. Isopods are occasionally taken in inshore waters around Antarctica and are most likely benthic forms that have ventured into the water column or they are ectoparasites. Those taken in plankton nets are usually only a few millimetres in size but specimens can attain 70 mm in size.

Order Amphipoda

The body is typically slender and laterally compressed, though in some Hyperiidea the body may be globose. The head is fused to the first thoracic segment and there is no carapace. The abdomen is usually distinctly demarcated from the thorax. The compound eyes are sessile. The first antenna is biramous and usually longer than the second antenna which lacks an exopodite. All the thoracic appendages are uniramous. The first pair are maxillipeds and are fused basally with each other. The next 7 pairs, the pereiopods, differ considerably in organisation. The first 4 pairs are directed forwards with the dactyl segments directed back, while the last 3 pairs of pereiopods are directed backwards and the dactyli forward. The first and second pereiopods are typically modified as subchelate, prehensile gnathopods. The abdomen comprises 2 sections of 3 segments each. The anterior pleosome is large and bears 3 pairs of biramous, natatory, multiarticulate pleopods. The posterior urosome is smaller with 3 pairs of biramous uropods that do not form a tail fan. Two of the 4 amphipod suborders have marine pelagic members in the Antarctic, the Gammaridea and Hyperiidea.

Suborder Gammaridea

The first and second antennae are usually well developed and long (Figure 10b). The thoracic appendages have well developed and usually overlapping coxal plates. A palp is present on the maxilliped. The last two abdominal segments are free. Planktonic gammarids occur only occassionally in Southern Ocean zooplankton. Gammarids are approximately 5 to 20 mm in size and may be orange-brown in colour.

Suborder Hyperiidea

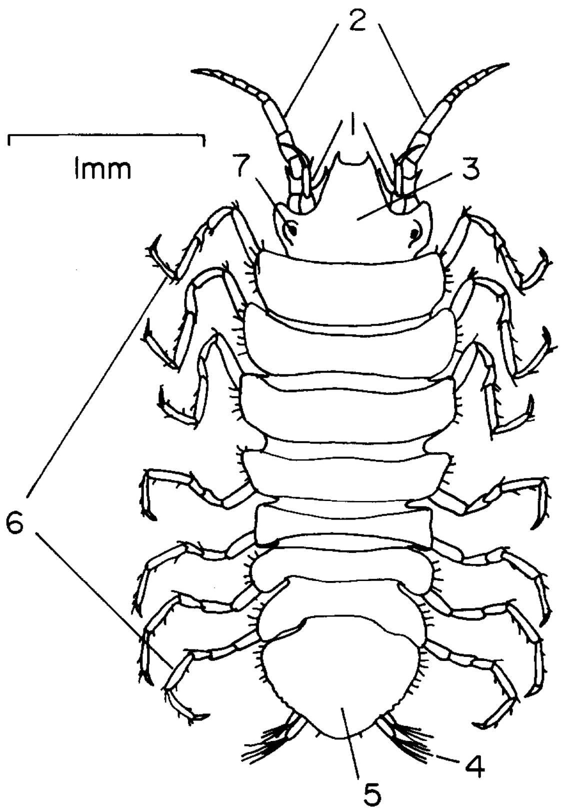
The maxillipeds lack palps. The coxae of the thoracic legs are often small or fused with the body. Both pairs of antennae are positioned on either the anterior or ventral surface of the head. The last 2 abdominal segments are fused. The most notable feature of this group is the very large compound eyes that cover the greater part of the head (Figure 10c). Hyperiids occur in all oceans and are entirely marine and planktonic. They are generally about the same size and colour as gammarids, though specimens larger than 30 mm are quite common.

Superorder Eucarida

All Eucarida possess a carapace which is fused dorsally to all thoracic somites. The protopodite of the second antenna is composed of 2 segments. The compound eyes are stalked. A *lacinia mobilis* is not present on adult mandibles and there is no marsupium as in the Peracarida. There are only 2 orders of Eucarida, the Euphausiacea and Decapoda, both of which are represented in Antarctic waters.

Order Euphausiacea

The carapace covers the sides of the thorax but does not enclose the tubular gills (Figure 11). The gills consist of a single series called podobranchiae, which are attached to the coxopodite of the thoracic limbs. The eyes are compound, well developed and stalked. All thoracic legs are biramous. The endopods form a setose feeding basket and the exopods ventillate the gills. The eighth pair and sometimes the seventh are rudimentary and the adults lack

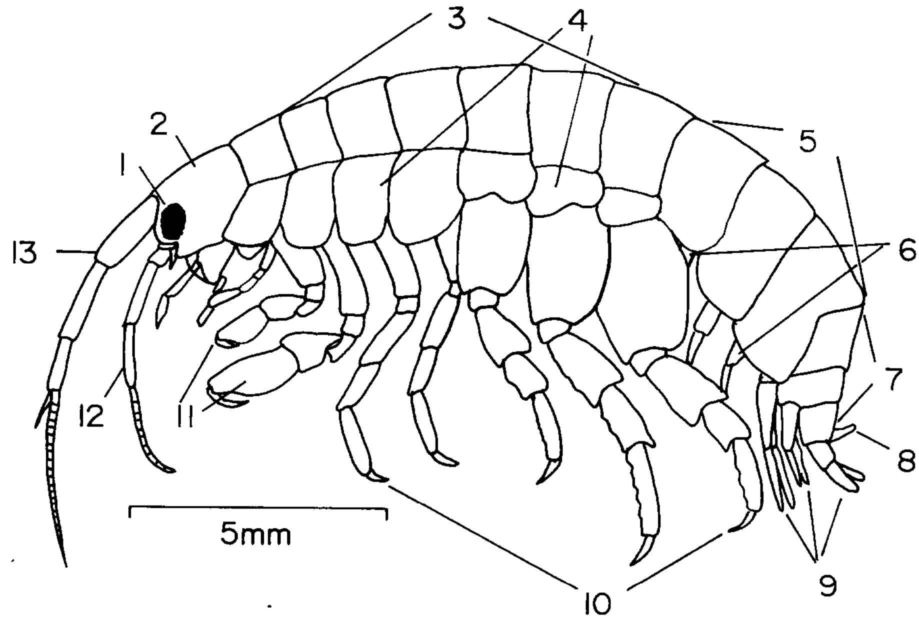


(a)

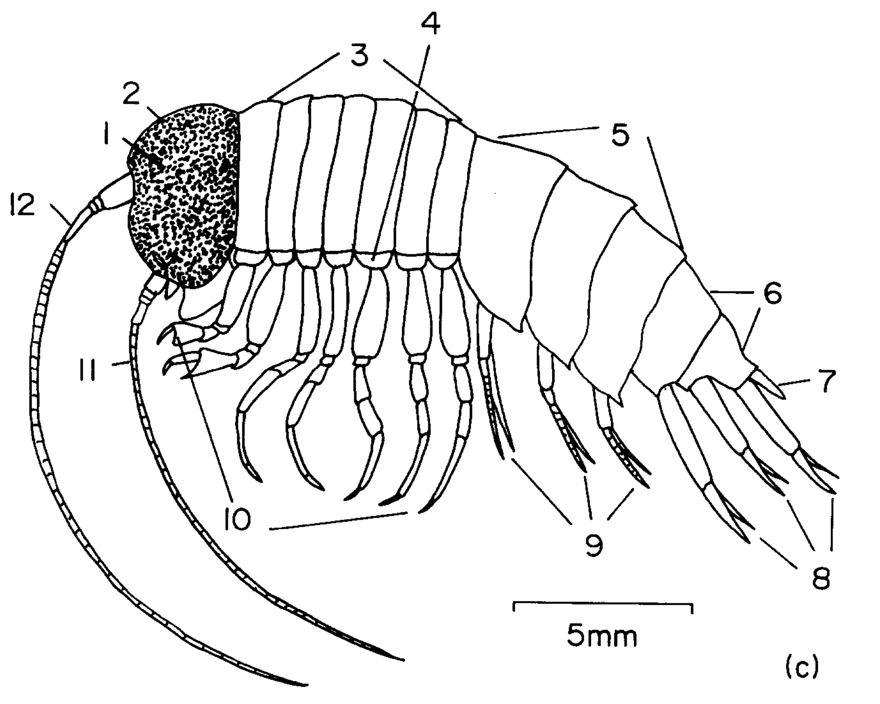
Figure 10. Isopoda and Amphipoda. (a) Antarctic isopod Austrofilius furcatus. (1) first antenna, (2) second antenna, (3) head, (4) uropod, (5) telson, (6) pereiopods, (7) compound eye.

(b) Generalised gammarid amphipod. (1) compound eye, (2) head, (3) thorax, (4) coxae (coxal plates), (5) pleosome, (6) pleopods, (7) urosome, (8) telson, (9) uropod, (10) pereiopods, (11) gnathopods, (12) second antenna), (13) first antenna.

(c) Generalised hyperiid amphipod based on Hyperia. (1) compound eye, (2) head, (3) thorax, (4) coxae (coxal plates), (5) pleosome, (6) urosome, (7) telson, (8) uropods, (9) pleopods, (10) pereiopods, (11) second antenna, (12) first antenna.



(b)



(c)

maxillipeds. The 5 pairs of setose pleopods are used for swimming. The telson bears a pair of movable spines that are believed to be a vestigial caudal furca. There are no statocysts. Light emitting organs, photophores, are present in each eyestalk, at the base of each of the second and seventh thoracic appendages and between the bases of the first 4 pairs of pleopods.

The euphausiids, commonly known as krill, are marine, pelagic and occur in large numbers in all oceans. In Antarctic waters, euphausiids, particularly Euphausia superba, form dense aggregations or swarms and are important in the diet of many higher organisms including seabirds, seals and whales. E. superba can reach a maximum size of 60 mm, while other euphausiids range in size between 15 and 35 mm. They are transparent usually with some orange-red pigmentation. Individuals that have been feeding on phytoplankton often have a conspicuous bright green hepatopancreas (digestive gland) visible through the carapace.

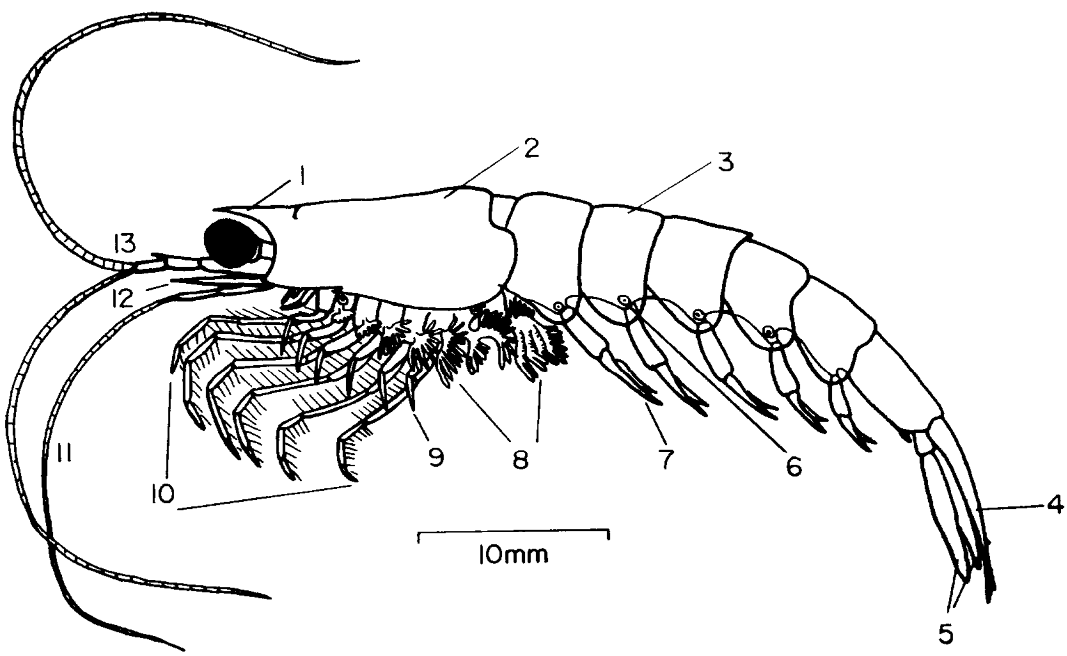


Figure 11. Euphausiacea. Generalised form showing major characteristics of the order. (1) rostrum, (2) carapace, (3) abdominal segment, (4) telson, (5) uropod, (6) photophore, (7) pleopod, (8) gills (podobranchiae), (9) thoracic exopodites, (10) feeding basket (thoracic endopods), (11) second antenna, (12) antennal scale (A2 expodite), (13) first antenna.

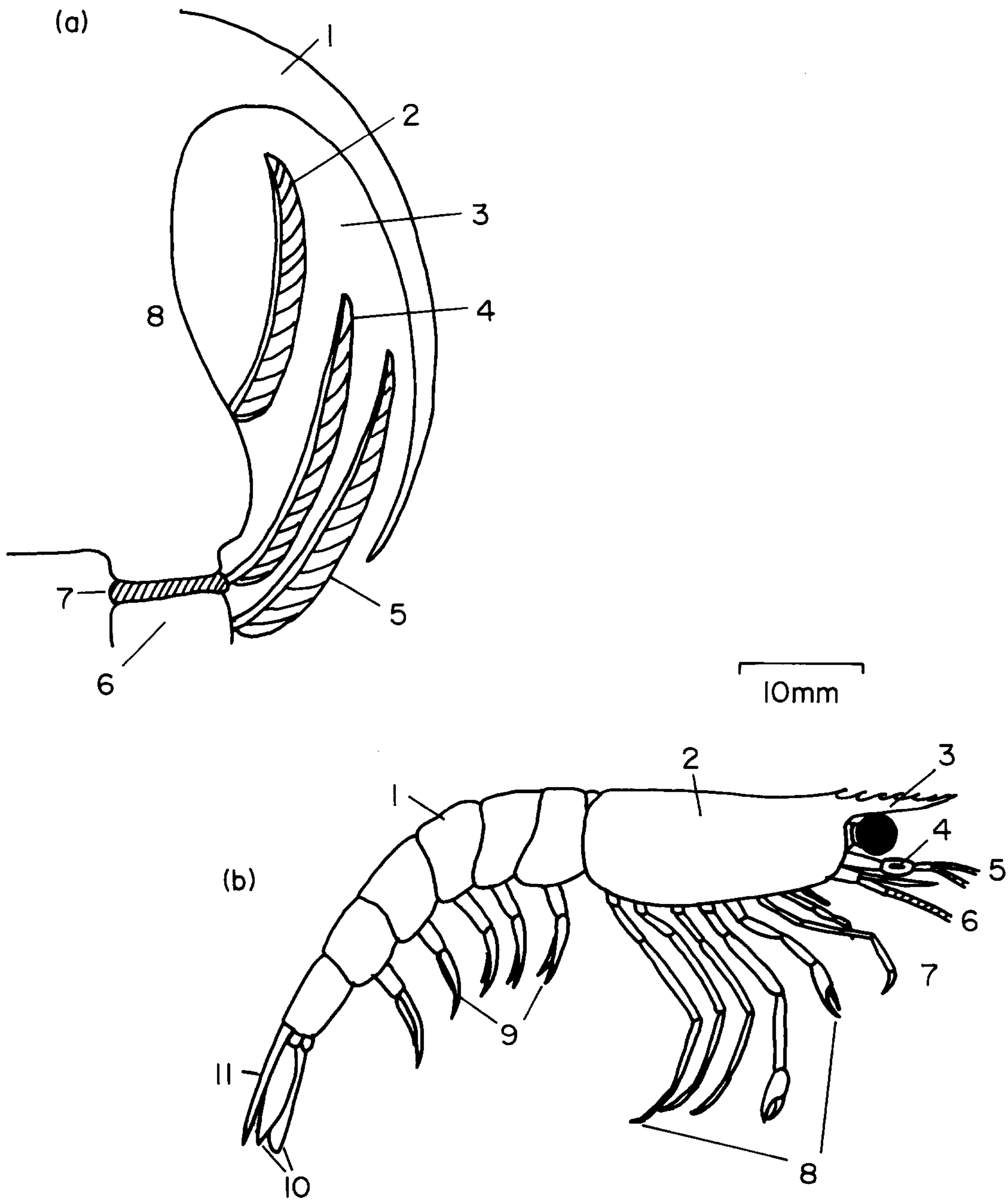


Figure 12. Decapoda. (a) Branchial chamber depicting the three types of gills. (1) carapace, (2) pleurobranch gill, (3) branchial (gill) chamber, (4) arthrobranch gill, (5) podobranch gill, (6) coxopodite, (7) joint membrane, (8) thorax.

(b) Generalised natant decapod. (1) abdominal segment, (2) carapace, (3) rostrum, (4) statocyst, (5) first antenna, (6) second antenna, (7) maxilliped, (8) pereiopods, (9) pleopods, (10) uropod, (11) telson.

Order Decapoda

On each side of the thorax, the carapace extends well down enclosing the gills within a branchial chamber. The large exopodite (scaphognathite) present on the second maxilla generates a respiratory current for this chamber. There is usually more than one series of gills present, of which some are attached to the coxopodites of the thoracic legs (podobranchiae), some to the joint-membranes at the bases of the legs (arthrobranchiae) and others to the sides of the thorax (pleurobranchiae) (Figure 12a). The first 3 pairs of thoracic appendages are modified as maxillipeds, while the remaining 5 pairs (pereiopods) usually function as legs for walking and sometimes swimming, hence the name Decapoda (ten-legs). Exopodites are usually absent from these legs. A statocyst is usually housed in the first antenna peduncle.

The Decapoda is the largest crustacean order, containing more than 8500 species. However the Decapoda, particularly the suborder Reptantia, are poorly represented in the Antarctic. This order has only one Antarctic species, an anomuran crab which is bathybenthic. The remaining 10 recorded Antarctic species belong to the other decapod suborder, the Natantia (shrimps and prawns).

Suborder Natantia

The body tends to be more or less laterally compressed. The carapace extends anteriorly as a prominent compressed rostrum. The scale of the second antenna is large and functions as a rudder in swimming. The pereiopods are slender and any of the first 3 pairs may be chelate. The first abdominal segment is not reduced, as occurs in Reptantia. There are 5 pairs of well developed natatory pleopods (Figure 12b). Antarctic Natantia species can be further divided into the 2 sections (often called infraorders), the Caridea and Penaeidea. The former section is readily distinguished by the pleura of the second abdominal segment which overlaps those of the first. Antarctic Natantia are either bathypelagic or inhabit inshore areas. They are occasionally taken in plankton hauls. Species range in maximum size from 28 to 150 mm and are often bright orange or red.

9.6 COLLECTION AND PRESERVATION

Planktonic crustaceans can be collected using dip nets. Because of the fragility of many species (e.g. thin integument, slender limbs, delicate articulating surfaces, setae and spines), nets should be fitted with a rigid cod end and towed for a minimal length of time. The catch should be gently removed from the net and processed as quickly as possible, since many species may deliberately break off limbs (autonomy) when stressed or dying. Surface hauls and dip netting at night is often advantageous for collecting species that exhibit diurnal vertical migration.

Neutralised formaldehyde, prepared in aqueous solutions of about 2 to 4% is most often used for fixing planktonic crustaceans. A stock solution can be prepared by adding 30-40 g of sodium tetraborate to 1L of 40% formaldehyde, which is then stored for 1 to 2 months to 'age'. The solution should then be filtered to remove precipitates prior to use. Specimens can be fixed in either solutions of 5-10 mL of formaldehyde stock in 95 mL of filtered seawater, or in 5 mL of stock, 0.5 mL propylene phenoxetol and 4.5 mL propylene glycol in 90 mL of filtered seawater. After fixation in the latter solution, specimens can be sorted and stored in a solution of 0.5 mL propylene phenoxetol and 4.5 mL propylene glycol in 95 mL of filtered seawater. The pH of solutions should be between 7.6 and 8.3 and the solution should be replaced if they differ from this range. The ratio of plankton to fixative should be about 1:4 by volume. In species containing high quantities of lipid, as occurs in high latitude species, the ratio should be reduced to 1:9 since the lipids will lower the pH.

Soft, delicate, fragile specimens can be made more rigid and manageable by placing them in an aqueous solution of 70% Ethanol. Transfer of specimens from a formaldehyde-seawater solution to 70% aqueous Ethanol should be made through the following series of solutions preventing distortion and shrinkage of specimens.

1. Three baths of distilled water, 10 minutes each
2. 30% Ethanol (aqueous), 10 minutes
3. 50% Ethanol (aqueous), 1 hour
4. Finally, 70% Ethanol (aqueous).

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8. PHYLUM CHAETOGNATHA

The phylum Chaetognatha is exclusively marine and consists mainly of planktonic species but includes some benthic forms. The group is commonly known as arrow worms. The distinctive body is thin and elongate and divided into 3 parts, head, trunk and tail, by transverse septa (Figure 13). The head bears 1 or 2 rows of sharp spines (or teeth), located frontoventrally anterior to the mouth, and posterior to these spines, a paired group of laterally situated grasping spines or hooks. One or 2 pairs of lateral fins extend from the body and the tail bears a terminal caudal fin. Although some species can reach 100 mm in length, most are less than 30 mm.

The group contains 1 class, the Sagittoidea and 2 orders, the Phragmorphora and Aphragomorpha. Of the 10 genera, Eukrohnia, Krohnitta, Pterosogitta, Sagitta and Heterokrohnia have been reported from the Southern Ocean.

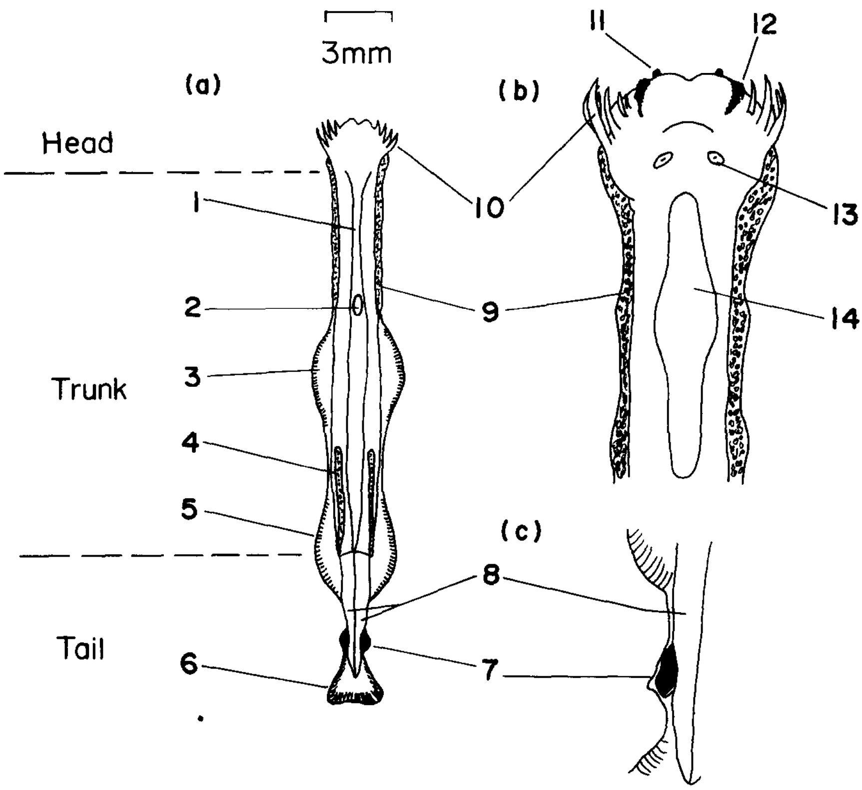

Figure 13. The Chaetognatha. A chaetognath, Sagitta marri, showing the major parts: (a) ventral view of adult, (b) head and anterior part of trunk, dorsal view, (c) shape and position of seminal vesicle, dorsal view. (1) intestine, (2) subenteric ganglion, (3) anterior lateral fin, (4) ovary, (5) posterior lateral fin, (6) tail fin, (7) seminal vesicle, (8) testes, (9) collarette, (10) hooks, (11) anterior teeth, (12) posterior teeth, (13) eyes, (14) corona.

8.1 COLLECTION AND PRESERVATION

Chaetognaths can be collected by means of tow nets at low speed (maximum 0.5 knots) to avoid damage. Specific identification is based on a formula of head armature (number of hooks and teeth), length of body, position and morphology of lateral fins, position and shape of seminal vesicles, and tail length as a percentage of body length. For this reason it is important that chaetognaths do not contract during preservation.

Specimens can be narcotised by placing them in a bowl of clean seawater. Menthol crystals are sprinkled on the surface and the bowl covered. The chaetognaths should be observed periodically and fixed when immobile. Induction time is usually between 1 and 4 hours. An isotonic solution of magnesium chloride ($MgCl_2$) in fresh water diluted in 2 to 3 parts of seawater containing the chaetognaths can also be used for narcotisation.

Alcohol should never be used for fixation since it causes considerable shrinkage of the body. Four to 5% formaldehyde (buffered with calcium carbonate in excess) and seawater up to a maximum of 10% formaldehyde, is a good fixative. Samples can be stored in 2% formaldehyde solution.

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9. PHYLUM CHORDATA - SUBPHYLUM TUNICATA

The Tunicata are Chordata without any coelom, segmentation or bony tissue. The notochord is restricted to the tail which is present only in the larval organisation and the class Appendicularia. The various groups in the Tunicata differ greatly in morphology but all are covered in a test which is largely composed of tunicin related to cellulose.

The Tunicata is represented in the plankton by the classes Thaliacea (containing the orders Pyrosomida, Doliolida and Salpida) and Appendicularia. The free swimming larvae (commonly known as tadpole larvae) of the Class Ascidiacea are also found in the plankton but will not be dealt with here.

9.1 KEY TO CLASSES AND ORDERS

1a)	Animal has no tail or notochord, body generally enveloped in a test	(Thaliacea) 2
b)	Animal with tail attached to ventral side, test forms a gelatinous house which does not attach to animal and can be lost, notochord present	Appendicularia
2a)	Animal a cylinder or tube-like, closed or rounded at one end	Pyrosomida
b)	Body barrel-shaped, open at both ends	3
3a)	Transverse muscle fibres only partially surround test ..	Salpida
b)	Transverse muscle fibres completely surround test	Doliolida

9.2 CLASS THALIACEA

Freeswimming pelagic forms organised into colonies, in the orders Doliolida and Salpida solitary and colonial forms alternate. The group is characterised by the occurrence of branchial and atrial siphons at opposite ends of the animal (anterior and posterior respectively). The exhalent current of water provides a propulsive force to move the organism through the water.

Order Pyrosomida

Monogeneric (Pyrosoma) order forming colonies which are generally less than 100 mm in length. The zooids, embedded in a common test, are arranged around the cylinder so that their branchial siphons open on the exterior surface and the atrial siphons discharge into the hollow cavity of the cylinder. The anterior end of the cylinder is closed (Figure 14a), the posterior end serves as a common cloacal aperture through which the combined water currents of all zooids are discharged as a jet of water propelling the colony forward. Common in the Southern Ocean.

Order Doliolida

The body is barrel-shaped with an anterior inhalent (branchial) and a posterior (exhalent) aperture (Figure 14b). The body (up to 50 mm in length) is surrounded by 8 hoop-like muscles, the posterior and anterior ones acting as sphincters for the siphons. There is an alternation of generation between a

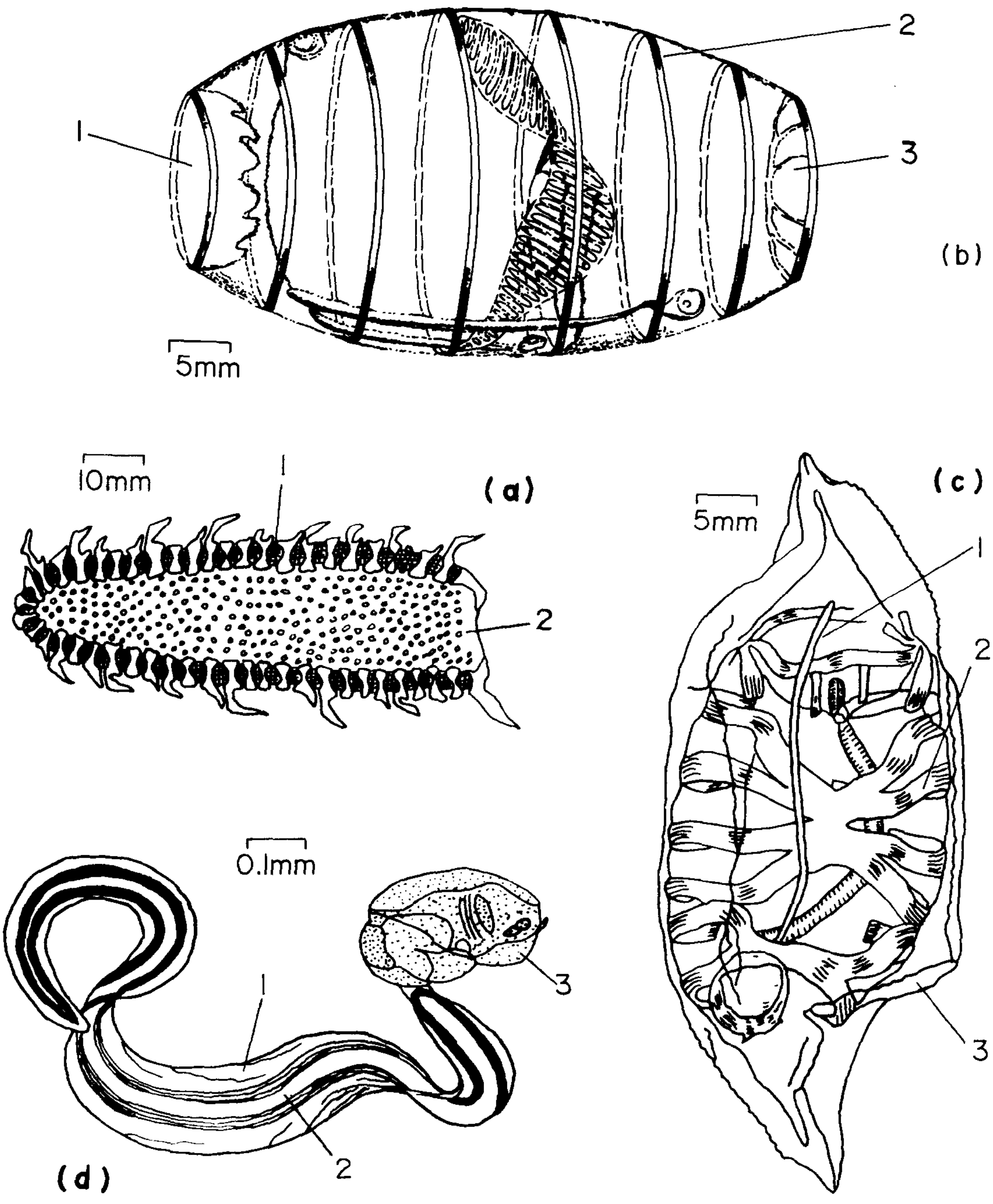

Figure 14. The Chordata: Tunicata. Representatives of each of the pelagic orders and their diagnostic characters. (a) Pyrosomida. Pyrosoma sp. (in section). (1) zooid, (2) posterior end of cavity. (b) Doliolida. Doliolina intermedium. (1) inhalent aperture, (2) muscle band, (3) exhalent aperture. (c) Salpida. Salpa thompsoni. (1) branchial aperture, (2) muscle band, (3) atrial aperture. (d) Appendicularia. Oikopleura parva. (1) tail, (2) notochord, (3) body.

solitary sexually reproducing form and an asexually reproducing colony forming form. Rarely found in the Southern Ocean.

Order Salpida

In this order solitary asexually reproducing forms alternate with aggregates of sexually reproducing forms. In both forms the zooid is roughly barrel-shaped with an anterior branchial and posterior atrial aperture (Figure 14c). Several sets of muscles partly surround the body. Up to 60 mm in length. Some species very common in the Southern Ocean.

9.3 CLASS APPENDICULARIA

Small (less than 5 mm) solitary free-swimming forms characterised by the retention in the adult of a muscular tail and a notochord (Figure 14d) and by the presence of a complicated external food-collecting envelope, the house. The house is often lost or damaged during collection. Numerous Southern Ocean species.

9.4 PRESERVATION

For thaliaceans, the best fixative is 4% formaldehyde in fresh seawater. Anaesthetisation is unnecessary. Fixed specimens, especially the delicate ones, are best preserved and stored in 70% ethanol (aqueous).

For appendicularians a 2% formaldehyde and seawater solution is a good fixative and can be used to preserve them.

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APPENDIX I

GENERAL NOTES ON PRESERVATION

The methods described in this guide on collection and preservation of each zooplankton group will ensure that the specimens are in the best possible condition for identification to species level. Although this may involve dissection of the specimen and examination under a microscope, most species can be identified using external characters.

Often nets are towed to catch a certain type or group of zooplankton. A slow ship speed needed to catch delicate cnidarians, ctenophores and tunicates may mean that many of the faster swimming crustaceans escape. Towing for crustaceans will result in a bycatch of other groups, but often these are damaged in the net.

Unless detailed microscopical examinations are to be carried out on some groups, most of the catch can be preserved together using a general fixative although the delicate groups should be separated from the crustaceans.

For fixing and preserving mixed marine zooplankton, particularly in bulk, formaldehyde is the best general purpose solution to use. A 4% solution of formaldehyde is made up as follows:

> 40% formaldehyde (as purchased) 10 mL;
> seawater or distilled water, 90 mL.

Plankton are fixed by adding them to a half full jar of 4% formaldehyde solution. More 4% formaldehyde is added until the jar is full. The jar should be sealed to prevent evaporation. To ensure proper preservation the recommended proportion of plankton to fixative is 1:9. The minimum time for fixation is 10 days. This will preserve plankton in good condition for more than 50 years.

When calcareous plankters are to be preserved the formaldehyde solution should be buffered to a pH between 6.5 and 7.5 using borax (2% in excess).

Propylene phenoxetol and propylene glycol have no fixative properties but keep tissues soft and flexible. When they are added to formaldehyde a fixative with reduced hardening properties, suitable both as a fixative and as a preservative for morphological and taxonomic purposes, is produced.

A general preserving solution for most plankters is:

> propylene phenoxetol, 0.5 mL;
> propylene glycol, 4.5 mL;
> 40% formaldehyde (buffered or not), 5 mL;
> seawater or distilled, 90 mL (formaldehyde concentration 2%).

To make a concentrated stock which requires dilution with water to be suitable as a fixative and preservative:

propylene phenoxetol, 50 mL;
propylene glycol, 450 mL;
40% formaldehyde, buffered or not, 500 mL.

This may be diluted as follows (general fixative):

stock solution, 10 mL;
seawater or distilled, 90 mL (formaldehyde concentration 2%).

The pungent nature of 2% or 4% formaldehyde solutions makes open dish sorting of plankton unpleasant. The use of the following sorting solution makes sorting more comfortable:

propylene phenoxetol, 0.125 mL;
propylene glycol, 1.125 mL;
40% formaldehyde, 1.250 mL;
seawater or distilled, 97.5 mL.

A fluid containing no formaldehyde can be used:

propylene phenoxetol, 0.25 mL;
propylene glycol, 2.25 mL;
seawater or distilled 97.5 mL.

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Steedman, H.F. (Editor) (1976). General and applied data on formaldehyde fixation and preservation of marine zooplankton. In: Zooplankton Fixation and Preservation, pp. 103-154, UNESCO Press, Paris.

WARNING: Great care should be exercised when working with formaldehyde.

Formaldehyde vapours are irritating to the eyes, nose and throat and may cause headaches, drowsiness, loss of memory, coughs, sneezing, skin rashes, disturbed sleep, unusual thirst and breathing troubles.

A fume extraction system should be used when solutions are exposed to the air. PVC gloves should be worn to prevent dermatitis which can result from the liquid solution coming into contact with the skin. Splashes in the eyes produce painful irritation and may lead to destruction of tissue. Any liquid on the skin should be immediately washed off with large amounts of water.

Chemical reactions involving formaldehyde and hydrochloric acid or any source of chloride ions, may result in the formation of dis-(chloromethyl)-ether which is CARCINOGENIC.

APPENDIX II

GLOSSARY

Adductor muscle — in the ostracods, bivalved molluscs and other bivalved animals, a muscle whose function is to close a bivalved shell

Anterior — towards the head, in front, opposite to posterior

Arthrobranchiae — in the Decapoda of the Crustacea, gills attached to the joint membranes at the bases of the thoracic legs

Atrial (cloacal) siphon — opening on ventral side of tunicates through which water passes out of the animal (exhalent opening)

Basipodite — the second basal segment of a crustacean appendage. Together with the coxopodite it forms the protopodite

Bathybenthic — belonging to the deep sea bottom habitat

Bathypelagic — belonging to the deep water layers; usually refers to depths beyond 1000 metres

Benthic — belonging to, or living on the sea bottom

Bifid — divided into 2 parts

Biramous — in the Crustacea the condition in which appendages are divided into 2 segmented branches, the exopodite and endopodite. These branches emanate from a basal segment, the basipodite

Biramous parapodium — a foot or parapodium in polychaetes (Annelida) with 2 rami, 1 is the notopodium (dorsal) and 1 is the neuropodium (ventral)

Body cavity — internal cavity of most triploblastic animals (absent in Platyhelminthes, Nemertea) in which many organs are suspended, allowing their mutual displacement, which is especially important for the gut. Primary body cavity is the haemocoel. Secondary body cavity is the coelom

Bract — float zooid from Siphonophora (Cnidaria) colony

Branchial siphon — opening on dorsal side of tunicates where water passes through the animal (inhalent opening)

Carapace — in the Crustacea, a fold of the exoskeleton of the head which extends back over the thorax and may be fused with a few anterior or all of the thoracic segments. The carapace may extend laterally to protect the side of the body

Caridoid facies — literally "shrimp features". The common set of anatomical features of the malacostracan Crustacea

Carpus — in the Crustacea, the third of 5 segments of the endopodite of the thoracic appendage

Caudal — concerning the tail

Caudal rami — literally, tail branches. In lower Crustacea, such as ostracods and copepods, the last abdominal segment is branched into 2, often bearing setae. Sometimes called caudal furca (tail fork)

Chelate — claw-like or pincer-like. In the Crustacea the terminal segment of the appendage acts as the movable jaw of the claw and the prolonged extension of the penultimate segment acts as the other immovable jaw

Chitin — a nitrogenous carbohydrate polymer forming a constituent of the arthropodan exoskeleton; hence chitinous. Chitin is chemically similar to cellulose

Circular canal — part of the gastrovascular cavity. Lies toward the periphery of medusa, encircling the entire disc

Cirrus(i) — elongated projection of body

Cloacal aperature — terminal opening of the body of tunicates

Coelom — main body cavity of many triploblastic animals, in which gut is suspended

Coenosarc — stem from which Siphonophora (Cnidaria) colonies bud. Its gastrovascular cavity is continuous of all the zooids in the colony

Colloblast — sticky or adhesive cells composed of a hemispherical head located on the surface of ctenophoran tentacles

Cormidium — group of gastrozooids and genophores in a Calycophorae (Cnidaria) colony

Coronal furrow — a deep groove or constriction around the bell umbrella of Coronatae (Cnidaria) medusa

Coxal plate — extensions of the coxopodite of Amphipoda. Crustacean appendage forming a lateral shield below the edge of the carapace

Ctene (comb row) — row of fused ciliary plates in Ctenophora. Used for locomotion

Dactylozooid — sensory buds or zooid from Siphonophora (Cnidarian) colony

Dactylus — the last (distal) segment of the endopodite of the crustacean thoracic appendage

Diploblastic — having the body made of 2 cellular layers only (ectoderm and endoderm). This condition is obscured (see Mesogloea) in large jelly-fish

Dorsal — pertaining to, on, or near the back; opposite to the ventral surface

Endite — inward extensions of certain basal segments of the endopodite of the crustacean appendage

Endopodite — the inner branch of a biramous crustacean appendage on the only part of a biramous limb remaining

Epipodite — an outward extending process arising from the base of a crustacean appendage

Exopodite — the outer branch of a biramous crustacean appendage

Exumbrella — convex surface of medusa bell

Gastrovascular cavity — an internal space where digestion occurs. This cavity lies along the polar axis of the animal and opens to the outside at one end to form a mouth

Gastrozooid — feeding or nutritive zooid from Siphonophora (Cnidaria) colony

Germ-layer — main layers of group of cells in embryos which give rise to certain specific tissues. There are 2 in diploblastic animals, endoderm and ectoderm. In triploblastic animals there is in addition the mesoderm

Gnathopod — in the Crustacea, usually Amphipoda, an appendage in the oral region modified to assist with the food

Gonophore — reproductive zooid from Siphonophora (Cnidaria) colony

Holoplankton — organisms that spend their entire life in the water column. Often referred to as permanent plankton

Infundibulum — ctenophoran gut

Ischium — the first (proximal) segment of the endopodite of the crustacean thoracic appendage

Lacinia mobilis — a movable accessory incisor found on the mandibles of certain Crustacea

Lappets — lobes of the bell margin of Schyphozoa (Cnidaria) medusa formed by scalloping

Lateral — pertaining to, or on the side

Mandibles — the paired crushing mouth appendages of Arthropoda

Manubrium — a tube-like extension of the under surface of the medusa stage of cnidarians. It can be lobed or frilled and the mouth opens at its end. May possess nematocysts

Marsupium — in the Peracarida of the Crustacea, brood pounch found on the ventral surface of females, formed from lamellar processes (oostegites) of the coxopodite of the thoracic limbs

Maxillae — 2 pairs of mouthparts of a crustacean located posterior to the mandibles, usually used to handle food

Maxilliped — an appendage in 1, 2 or 3 pairs, located posterior to the maxillae in Crustacea, often used in feeding

Membraneous — thin and flattened like a membrane

Meroplankton — organisms that only spend part of their life-cycle in the water column, e.g. eggs and larvae. Often called temporary plankton

Merus — the second segment of the endopodite of the crustacean thoracic appendages

Mesogloea — layer of jelly-like material between external and internatal cellular layers of the body of a cnidarian. In medusa, this layer is very thick

Metamere — a body segment; hence metamerous; segmented

Metazoa — animals whose bodies consist of many cells, as distinct from Protozoa, which are unicellular

Metasome — in the Copepoda of the Crustacea, the thorax

Natatory — formed or adapted for swimming

Naupliar eye — the simple eye of the nauplius larva (first larval stage) of crustaceans, also found in adult Copepoda

Nematocyst (cnida) — specialised cell, found only in the phylum Cnidaria. Used for anchorage, for defence, and for the capture of prey by medusa

Neritic — pertaining to, or living only in coastal waters (i.e. the shallow water over the continental shelf)

Neuropodium — lower or ventral part of a biramous parapodium in Polychaetes (Annelida)

Notochord — skeletal rod lying lengthwise, between the gut and the nervous system. Occurs in larval tunicates and in adult Appendicularia (Tunicata)

Notopodium — upper or dorsal part of a biramous parapodium in Polychaetes (Annelida)

Oostegites — large plate-like inner extensions of the coxopodite of the thoracic limb in Peracarida Crustacea, which form a brood pouch (marsupium) for developing eggs

Oral-aboral axis — axis of the body running through the line of the mouth and its opposite end, usually the anus or anal pore

Ovigerous — bearing eggs

Palps — paired projections growing out from sides of head

Parapodia — paired paddle-like appendages of Polychaetes (Annelida)

Parenchyma — tissue consisting of living thin-walled cells, often almost as broad as long, and permeated by a system of inter-cellular spaces containing air

Pars incisiva — the cutting portion of the crustacean mandible

Pars molaris — the grinding portion of the crustacean mandible

Pelagic — ocean inhabiting

Pereiopods — the locomotory thoracic limbs of Malacostraca Crustacea, sometimes applied to crustacean thoracic limbs in general

Pharynx (stomodaeum) — part of gut between mouth and stomach

Pinnules — membraneous side branches of the notopodium and neuropodium in the Tomopteridae (Annelida)

Pleopods — the abdominal appendages of a crustacean. Usually used for swimming and in the Malacostraca often called swimmerets

Pleosome — in the Crustacea the abdominal segments that bear the pleopods

Pleurobranchiae — in the Decapoda of the Crustacea, gills that arise from the lateral walls of the thorax

Podobranchiae — in the Euphausiacea and Decapoda of the Crustacea, gills attached to the coxopodites of the thoracic appendage

Posterior — towards the tail, behind, opposite to anterior

Proboscis — anterior part of the alimentary canal derived from the stomodaeum which can be everted to project forwards

Propodus — the fourth (penultimate) segment of the endopodite of the crustacean thoracic limb

Prosome — in the Copepoda of the Crustacea, the head and thorax (metasome)

Prostomium — anterior segment or head of Polychaetes (Annelida)

Protopodite — the basal segment of a crustacean limb, comprising the coxopodite and basipodite

Radial canal — part of the gastrovascular cavity of medusae. Passes from the central stomach toward the periphery of the disc

Radially symmetrical — capable of being halved in either of 2 (or more) planes so that the halves are approximately mirror images

Rhopalia — little, club-shaped sensory structures found on the bell margin of Scyphozoa medusa

Rostrum — in the Crustacea, a prolongation of the anterior portion of the carapace beyond or below the head, usually as a pointed process extending between the eyes in higher crustaceans

Scaphognathite — the extended exopodite of the second maxilla; used for regulating the flow of water through the respiratory chamber

Seminal vesicle — organ which stores sperm

Seta(e) — in Polychaeta and Chaetognatha solid bristle-like structures, used for locomotion, flotation, protection or predation in the case of chaetognaths. In Arthropoda, hollow bristles containing living tissue, which extend from appendages by means of a joint

Setigerous lobe — that projection or part of the notopodium or neuropodium which bear the setae on Polychaetes (Annelida)

Setose — set with bristles (setae); bristly

Somites — a body segment of an articulate animal

Sphincter — ring of muscle in an opening of a hollow organ, able by contraction to narrow or close

Statocyst — a gravity receptive organ found in many invertebrates used to orientate the body in space

Stomodael (also pharyngeal) plane — plane of the body running directly through stomodaeum

Stomodaeum (pharynx) — part of gut between mouth and stomach

Sub-chelate — having an imperfect claw (chela). In a sub-chelate limb of a crustacean, the last segment folds back on the preceding segment in a pincer-like fashion. However, unlike a true chela, the preceding segment does not form a prolonged immovable jaw (see chelate)

Subumbrella — concave or undersurface of medusa bell

Telson — the terminal abdominal segment of Crustacea, notably the Malacostraca, and along with the uropods forms a tail fan

Tenniform — long and slender; whip-like

Tentacular plane — plane of the body running directly through the tentacles

Test — outer wall or mantle of Tunicates

Triplobastic — having the body made up of 3 layers (ectoderm, mesoderm, endoderm), in all Metazoa, except Cnidaria and Ctenophora which are diploblastic. See germ-layer

Trunk — the body, less head and limbs, i.e. thorax and abdomen

Tunicin — a substance related to cellulose making the test of tunicates

Uniramous — in the Arthropoda an unbranched appendage. In crustaceans, either the endopod or usually the exopod is lacking

Univalve — made up of a single piece (valve), e.g. Gastropoda (Mollusca)

Urosome — the abdomen of a crustacean. In the malacostracan Crustacea the term refers to abdominal segments bearing uropods

Uropods — in the malacostracan Crustacea, the last pair of abdominal appendages. These are usually broad and flat and together with the telson form the tail fan. Amphipoda have 3 pairs of uropods

Velarium — annular diaphram which partly closes the opening of bell cavity in Cubomedusae (Cnidaria)

Velum — inward projection of the margin of the bell of hydrozoan (Cnidaria) medusa

Ventral — pertaining to, or or near the front; opposite to dorsal. Strictly on or of the abdomen

Zooid — member of a colony of animals which are joined together

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