

CHAPTER 16

THE PLANKTON: DRIFTERS OF THE OPEN OCEAN

Objectives

1. To learn about the many different marine organisms that are classified as plankton.
2. To understand the classification schemes for plankton.
3. To see how plankton can be sampled from the oceans.
4. To consider ways in which plankton can have a particularly large impact on their environment.

Key Concepts

Major Concept (I) *Plankton include all those organisms that have very little or no mobility of their own. They float and drift with the ocean currents.*

Related or supporting concepts:

- Many plankton have a limited ability to move vertically toward or away from the sea surface.
- In general, plankton have very little ability to move horizontally. They cannot move against ocean currents but are carried along by them.
- Most plankton are microscopic in size and live in communities of very large numbers of organisms.
- Some plankton are very large, including seaweed and jellyfish. Jellyfish can have trailing tentacles that are as much as 15 m (50 ft) long.
- The planktonic community is extremely diverse and consists of both phytoplankton (plants or plant-like organisms), and zooplankton (animals).
- Phytoplankton are the primary producers in the oceans, producing oxygen as a byproduct of photosynthesis.

Major Concept (II) *The plankton can be classified into distinct groups in a number of different ways, including groups according to size.*

Related or supporting concepts:

- Plankton occur in many different sizes from microscopic to organisms tens of feet in length, such as seaweed and jellyfish.
- Plankton less than 0.0012 mm in diameter are called picoplankton. These include bacteria and very small phytoplankton cells. Picoplankton can only be collected using special filtering systems.
- Plankton between 0.002 and 0.02 mm in diameter are called nanoplankton.
- Plankton between 0.02 and 0.2 mm in diameter are called microplankton or net plankton since they can be captured with fine nets dragged through the water. These include both phytoplankton and zooplankton.
- Plankton between 0.2 and 2.0 mm in diameter are called macroplankton.

Major Concept (III) *Phytoplankton are primarily single-celled plants known as algae. They are autotrophic, or self-feeding organisms creating food by photosynthesis.*

Related or supporting concepts:

- Most phytoplankton are single-celled organisms.
- Species of microscopic phytoplankton live both as single cells and as long chains or filaments of independent cells, with no division of labor between them, attached to one another.
- There is only one large multicellular planktonic alga, a seaweed called *Sargassum*. *Sargassum* is found

- drifting in large masses in the North Atlantic Sargasso Sea where it provides a habitat for a very diverse population of marine organisms.
- There are a wide variety of phytoplankton including abundant groups such as the diatoms, dinoflagellates, coccolithophorids and the less abundant silicoflagellates, cryptomonads, chrysoomonads, green algae, and cyanobacteria.
 - The diatoms and dinoflagellates are the most abundant and important phytoplankton.
 - Diatoms have a number of important traits, such as:
 - a. they inhabit nutrient-rich water in temperate to polar regions,
 - b. they are colored with a yellow-brown pigment called fucoxanthin that hides the green hue of chlorophyll,
 - c. they may be either round or elongate,
 - d. those that are round have radial symmetry (they are shaped like pill boxes) and are called centric diatoms,
 - e. those that are elongate have bilateral symmetry and are called pennate diatoms,
 - f. centric diatoms float easily because of their small size and ability to store oil droplets and remain in cold surface waters drifting with the currents,
 - g. pennate diatoms sink more readily and are often found attached to floating objects or on the shallow sea floor (many of them are benthic),
 - h. diatoms are surrounded by a cell wall, or skeleton, called a frustule that is hard, transparent, and impregnated with silica,
 - i. the weight of the frustule is counteracted by the low density of the body tissue, the production of oil droplets that increase its buoyancy, and the formation of spines or ornate appendages on some frustules to increase frictional resistance with the water, and
 - j. there are small holes or pores in the frustule to allow contact between the organism and the seawater.
 - Examples of diatoms are shown in figures 16.1 and 16.2 in your text.
 - Diatoms reproduce both by cell division and by a sexual cycle that produces an auxospore that grows in size and forms a new frustule. Cell division of diatoms can occur every 12 to 24 hours under ideal conditions and produce rapid increases in population size called blooms.
 - Accumulations of diatoms on the sea floor can create diatomaceous or silica-rich sediment that is mined for a variety of purposes and can trap petroleum products beneath the oceans.
 - Dinoflagellates differ from diatoms in a number of important ways. This group includes organisms having properties of both plants and animals but it is usually classified in the phytoplankton category (fig. 16.5). Among their many distinguishing characteristics, they:
 - a. have two whip like appendages called flagella that give them very limited mobility,
 - b. are able to migrate vertically in response to changes in sunlight,
 - c. are able to photosynthesize like a plant and feed by ingesting organic material like an animal, so they are both autotrophic and heterotrophic (heterotrophic organisms feed on other organisms or on organic material),
 - d. sometimes glow with bioluminescence,
 - e. do not add to the sediment on the sea floor because their cell walls and tissues decay completely, and
 - f. can reproduce even more rapidly than diatoms, thus creating blooms.
 - Coccolithophorids are plants that are related to diatoms but have a different skeletal chemistry and share similarities with dinoflagellates. Some of their characteristics include:
 - a. tissues are protected by a number of overlapping plates composed of calcium carbonate that are called coccoliths,
 - b. these coccoliths dissolve readily in cold, high-pressure environments such as the deep sea, consequently they contribute to the sediment in shallow waters less than 4000 m (13,200 ft) deep,
 - c. they reproduce primarily by simple cell division although some species have a form of sexual reproduction, and
 - d. like dinoflagellates, they have two flagella that give them limited mobility.
 - During the late summer-early fall of 1997, a massive bloom of coccolithophorids colored the water blue over most of the continental shelf of the eastern Bering Sea (fig. 16.6). The discoloration of the

- water was due to light reflecting off the calcareous coccoliths and was easily recorded by the satellite sensor SeaWiFs (sea-viewing wide-field-of-view sensor).
- Silicoflagellates have two flagella and produce skeletons from silicon dioxide but they are not abundant in the marine environment.
 - Silicoflagellates are found in the Arctic, Antarctic, and the open-ocean.

Major Concept (IV) *Planktonic animals are called zooplankton. These animals have three main life-styles; as herbivores or grazers (plant eaters), as carnivores (flesh eaters), or as omnivores (feeding on both animals and plants in the plankton). Most zooplankton are quite mobile over short distances but are still considered to be drifting organisms.*

Related or supporting concepts:

- Zooplankton are very diverse with representatives from nearly every animal phylum.
- Zooplankton exhibit a variety of strategies for survival in a world where reproduction rates are high and life spans are short. For example, in warm waters with abundant nutrients many species can produce three to five generations in a year. In cold waters with a short growing season for phytoplankton only one generation may be produced.
- The spatial distribution of organisms is controlled by large scale properties and mass movements of the water. High densities of organisms occur along water mass boundaries in areas of surface convergence, they can also accumulate at density boundaries. In a similar manner eddies and surface currents can disperse large populations.
- Concentrations of zooplankton along density boundaries beneath the surface can create a deep scattering layer (DSL) that will reflect sound energy from depth recorders and give the impression of a false bottom, or abnormally shallow water depth.
- Independent movement on the part of zooplankton is primarily in a vertical direction and usually occurs in a diurnal pattern. They will ascend at night to feed on phytoplankton near the surface and descend during the day to return to darker waters for protection from predators. The range in vertical migration is from 10–500 m (33–1650 ft).
- There are many different types of zooplankton but we will discuss a representative sample of eight major groups including small crustaceans, arrowworms, protozoans, mollusks, comb jellies, tunicates or salps, jellyfish, and larval forms of many marine organisms.
- Probably the most well-known and common group of zooplankton are the crustaceans (shrimp-like animals), most notably the copepods and euphausiids (see fig. 16.7).
 - a. These groups are basically herbivorous and can consume more than half their body weight daily.
 - b. Copepods and euphausiids dominate the Antarctic but are found all over the world oceans.
 - c. There are more copepods than any other kind of zooplankton in the oceans.
 - d. Copepods are the link between the primary producers (phytoplankton) and first-level carnivorous consumers.
 - e. Euphausiids are larger than copepods, move more slowly, and live longer.
 - f. Both euphausiids and copepods reproduce more slowly than phytoplankton, doubling their populations only three to four times a year.
 - g. A well-known group of euphausiids, called krill, occur in enormous numbers in the Antarctic.
 - h. Krill are the main food source for baleen whales, including the blue, right, gray, humpback, sei, and the finback whales.
 - i. There are about 85 different species of krill. The Antarctic is dominated by the species *Euphausia superba* (see fig. 16.8).
 - j. Antarctic krill are found over an enormous area roughly four times the size of the United States.
 - k. During the summer the Antarctic krill live near the surface and in the winter they are thought to live beneath the ice or perhaps dive to the sea floor.
 - l. It is estimated that the krill biomass may be from 135 million to 1.35 billion metric tons.
 - m. Because of the tremendous food potential of krill and other crustaceans, there is a great deal of

- international interest in exploiting them for human consumption. Krill are a basic link in the marine food web for not only whales, but seals, seabirds, squid, and many fish.
- n. The first krill harvests were in the 1960s. The largest harvest, 529,000 metric tons, was taken by Japan, Korea, Poland, and Chile during the Antarctic summer of 1980–81. During the next 15 years the harvest declined. In 1998 81,000 metric tons were harvested, in 1999 the harvest increased to 103,000 metric tons, and 104,000 metric tons in 2000.
 - o. The high iodine content of krill meat prevents marketing for human consumption.
 - p. Krill are used as livestock and poultry feed in eastern Europe and as fish feed in Japan.
- Another species of zooplankton are the arrowworms or chaetognaths (pronounced like: key-toe-naths). These are large (2–3 cm) (1 in) carnivores that feed on other members of the zooplankton. They are important enough to mention because some species of arrowworms occur in specific water masses and can be used as biological tracers or indicators.
 - The most important protozoans are foraminiferans and radiolarians because they construct shells or tests. Foraminiferans such as globigerina create calcium carbonate tests (that make up carbonate oozes in many parts of the oceans), while radiolarians construct their tests from silica (that are a primary component of deep siliceous oozes at low latitudes).
 - a. Both foraminiferans and radiolarians live in relatively warm water.
 - b. The calcareous foraminifera tests dissolve easily at low temperatures and high pressures. They are generally preserved in the sediment at depths less than 4000 m (13,200 ft).
 - c. The siliceous radiolarian tests are resistant to dissolution and are generally found at depths greater than 4000 m (13,200 ft).
 - Tintinnids, often called bell animals, are tiny protozoans that propel themselves through coastal and open-ocean waters by very fine hair-like structures called cilia that ceaselessly beat the water (see fig. 16.9).
 - An interesting group of planktonic mollusks are the pteropods (see fig. 16.10).
 - a. Pteropods are related to snails and slugs.
 - b. They may or may not have a calcareous shell depending on the species.
 - c. They all have a foot-like structure that is modified into a transparent, undulating “wing.”
 - d. Some species are herbivores while others are carnivores.
 - In the water column there are many organisms that are translucent or transparent. A very important group with this characteristic is the comb jellies or ctenophores (pronounced like: teen-o-fours) (see fig. 16.11).
 - a. They are bioluminescent.
 - b. They propel themselves slowly with eight rows of beating cilia.
 - c. Some have trailing tentacles like jellyfish.
 - d. All ctenophores are carnivores, feeding on other zooplankton.
 - Another transparent group of zooplankton is the tunicates, which are distantly related to vertebrates (organisms with backbones). There are pelagic tunicates known as salps that can be found in dense patches covering large areas of the sea surface.
 - Another very common group of translucent and transparent zooplankton are the Coelenterates or Cnidaria (the c is silent). We know these organisms as the jellyfish. Most of these are carnivorous. Jellyfish occur in both solitary and colonial forms. Colonial forms include the Portuguese man-of-war, *Physalia*, which can sting, and the small by-the-wind-sailor, *Velella*, which does not.
 - Most of the animals we have talked about spend their entire lives as zooplankton, and as such are called holoplankton. However, there are many organisms that spend only portions of their life cycles as plankton; these are called meroplankton. The meroplankton include egg, larval, and juvenile stages of many marine organisms. This early period of time spent as plankton enables the wide dispersal of many organisms throughout the seas.

Major Concept (V) *Another important group of plankton are the bacteria.*

Related or supporting concepts:

- Bacteria are the smallest living organisms.
- They are single cells without membrane-bound nuclei.

- Bacteria are the most numerous organisms in the ocean. It is estimated that there are 1×10^{29} bacterial cells in the oceans at any given time, roughly one-third in the upper ocean and the remaining two-thirds in deep water.
- In some marine environments bacteria can produce 1×10^{30} generations annually.
- Autotrophic marine bacteria include:
 - a. photosynthesizing cyanobacteria that are most abundant in intertidal and estuarine environments and can produce massive blooms in tropical and subtropical latitudes, and
 - b. the bacteria that populate hydrothermal vents on the deep-sea floor.
- Heterotrophic bacteria exist on nearly every available exposed surface in the oceans and play a critical role in the decay and breakdown of organic matter.
- They also absorb dissolved organics and transform it into particulate matter. Particles in the water column have attached bacterial populations and are an excellent food source for small zooplankton.
- Bacterial activity (i.e., rates) of decomposition of marine detritus and decaying organic material appears to decrease with both temperature and depth in the water column. It is minimal at depths below 2000 m (6600 ft). However, bacterial activity in deep-sea sediments is much more active than had been previously thought.
- New studies indicate that roughly half of the organic matter created by oceanic primary productivity is processed by bacteria, viruses, and single-celled protozoans in a system called the “microbial loop.”

Major Concept (VI) *Microbiologists have found that the oceans are also populated with large numbers of viruses.*

Related or supporting concepts:

- Viruses are non-cellular particles consisting of genetic material surrounded by a protein coat.
- They are remarkably successful parasites that infect plant, animal, and bacterial cells.
- Viruses can only reproduce inside of a host cell in an infected organism.
- Most marine viruses are free in the water but some are associated with bacteria.
- Viral infection may be a significant mechanism for mortality in marine bacteria. It is estimated that 32% of heterotrophic bacteria and 15% of cyanobacteria contain mature virus particles.
- The addition of viral particles to laboratory samples of seawater has been shown to reduce primary productivity by as much as 78%. This suggests that viral infection of marine phytoplankton may restrict or terminate phytoplankton blooms in the ocean.

Major Concept (VII) *Plankton can be categorized in four kingdoms and their phyla and classes as outlined in section 16.4 in your text.*

Major Concept (VIII) *The abundance, spatial, and temporal distribution of plants and animals that make up the plankton are critical parameters required by marine biologists for understanding oceanic ecosystems. To acquire this information we must sample the plankton throughout the marine environment.*

Related or supporting concepts:

- Traditional sampling is done with fine-meshed nets that can be dragged through the water column at different depths for varying periods of time (see fig. 16.19). The nets can be towed behind a ship at a constant depth as it moves through the water or they can be towed vertically upwards from a given depth with the ship at a stationary point.
- Critical parameters involved in obtaining a good sample with a net include:
 - a. matching the mesh size with the size of the organisms you wish to capture,
 - b. calculating the volume of water that has been sampled and the flow rate through the net,
 - c. towing at depths where the organisms are specifically concentrated, and

- d. towing at speeds where the animals do not escape, yet they are not warned away by the wake effects at the opening of the net. NOTE: Even so, these nets are avoided by some organisms, and destroy many of the fragile ones.
- Modern nets have flow meters, and electronic devices that open the net at a specific depth, close it, and sequentially open additional nets.
- Plankton can be sampled by using water bottles or submersible pumps. Bottles can be lowered to the desired depth and then closed via messenger or electronic signal. Pumps can also be lowered to a specific depth where they will pump water directly back to the ship. In any case, the water must then be filtered to remove the plankton.
- Acoustic and photographic/video methods are now being used to document the population size (surface area and volumes) of organisms and their specific behavior in the water column.

Major Concept (IX) *As a society we worry about man-made pollutants in our environment, however, we have not yet fully appreciated the variety of naturally occurring toxins that occur in marine organisms and can have a large impact on great numbers of people.*

Related or supporting concepts:

- The number of harmful algal blooms (HAB) reported in coastal waters has increased dramatically in the last few decades.
- It is estimated that HABs have a \$40 million impact annually on the U.S. economy.
- Toxic blooms of single-celled organisms that discolor the water are often called red tides but HAB is the preferred term because they are not related to the tides and they are not always red.
- HABs are most frequently produced by a certain species of dinoflagellates.
- HABs may or may not be poisonous to other marine organisms.
- Adverse responses to marine toxins include paralytic shellfish poisoning (PSP), neurotoxic shellfish poisoning (NSP), diarrhetic shellfish poisoning (DSP), and amnesiac shellfish poisoning (ASP) also known as domoic acid poisoning (DAP). These can be contracted by humans who consume clams, mussels, and oysters that have ingested toxic dinoflagellates.
- In North American waters several dinoflagellates produce red tides; *Gonyaulax*, *Alexandrium*, and *Gymnodinium* are toxic, but *Noctiluca* is not.
- The dinoflagellates themselves are generally nonpoisonous to shellfish, but the toxins they produce are concentrated in shellfish tissues and are harmful to humans who may eat the shellfish.
- Some HABs can produce massive fish kills and can also kill shrimp and crab.
- *Alexandrium* form cysts in a stage of their life cycle that can lie on the bottom in a dormant state. When conditions are right these cysts can suddenly become active and create a bloom.
- A severe 1972 HAB spread from Maine to Massachusetts and has reappeared every year since.
- Dinoflagellates that inhabit the Gulf of Mexico can be carried into the Atlantic by the Florida Current and transported along the east coast of the United States by the Gulf Stream.
- Red tides seem to be stimulated by the addition of nitrates and phosphates to coastal waters from sewage and agricultural runoff.
- The toxins themselves vary tremendously. A single species may produce several different toxins that can all have varying adverse effects on humans ranging from mild discomfort to death. Many toxins are unaffected by heat so thorough cooking will not neutralize the poison!
- Even when the red tide discoloration of the water has passed, the shellfish will retain the toxin in their tissues for long periods of time. Eventually they will flush the toxins from their systems but it is generally a very slow process. The resulting financial loss for the shellfish industry can amount to millions of dollars while waiting for them to be edible again.
- Not all red tides are lethal, however. Some are the result of pigmentation in dense populations of planktonic algae.
- The dinoflagellate *Pfiesteria piscicida* is a particularly harmful organism that:
 - a. was first identified in North Carolina in 1993,
 - b. has caused major fish kills in the estuaries and coastal waters of the mid-Atlantic and southeastern United States,
 - c. can undergo at least 24 transformations to different forms that stun and poison fish, and

- d. has been linked to a variety of symptoms in people including sores, severe memory loss, nausea, respiratory distress, and vertigo.
- Toxic diatom blooms can poison shellfish and other organisms with domoic acid. If poisoned shellfish are eaten by humans the domoic acid poisoning (DAP) can produce short-term memory loss, also known as amnesic shellfish poisoning (ASP).
- Another response to marine toxins is caused by the ingestion of fish in tropical regions and is called ciguatera poisoning. There are over 400 species of fish that are affected by the ciguatera toxin. This toxin is thought to be produced by the fish as a result of their ingestion of toxic dinoflagellates.
- There is no known way to prepare affected fish to make it safe to eat and there is no known antidote to the poison.
- Japanese researchers have suggested that this toxicity is progressive in the food chain with herbivorous fish becoming infected first, followed by the omnivorous and carnivorous fish.
- In the United States there may be over 2000 instances of poisoning per year and worldwide between 10,000 and 50,000 people are affected annually.
- Over 10 million dollars are lost annually for the seafood industry in the United States as a result of ciguatera poisoning.
- Finally, there seems to be a global wave of cholera epidemics sweeping coastal areas. *Vibrio cholerae*, the bacteria responsible, may travel in ballast water attached to the surfaces of phytoplankton and zooplankton.
- A cholera epidemic in 1991 along the Peruvian coast lasted 15 months and caused more than half a million people to become ill with 5000 deaths.

Matching Key Terms with Major Concepts

At the end of the chapter in the textbook is a list of key terms. You should be able to match each of these with one of the previously listed major concepts. To test your ability, try to match the following key terms with the number (I–IX) of the appropriate major concept identified in this section:

autotrophic	coccolithophorid	krill
Cnidaria	salp	holoplankton
test	frustule	diatom
picoplankton	ciguatera	meroplankton
ctenophore	phytoplankton	foraminiferan
copepod	herbivore	bacteria
<i>Sargassum</i>	carnivore	nannoplankton
microplankton/net plankton	omnivore	radiolarian
chaetognath	euphausiid	crustacean
heterotrophic	bilateral symmetry	radial symmetry
bloom	zooplankton	filament
auxospore	tintinnids	cilia
cyanobacteria	red tide	

Test Your Recall

Answer the following questions to test your understanding

FILL IN THE BLANK

1. The word _____ is derived from a Greek word which means "to wander."
2. Bacteria and other microscopic plankton are the _____ of the sea.
3. Organisms that spend their entire life cycles as plankton are called _____.

4. _____ organisms are self-feeding as they produce nutrients through photosynthesis.
5. The two-part pillbox cell wall surrounding diatoms is called a _____.
6. When populations of plankton increase rapidly to millions of organisms, the event is termed a _____.
7. A whip like appendage that provides limited mobility to dinoflagellates is called a _____.
8. The animal members of the plankton are called _____.
9. Plankton may accumulate in large populations in areas of rapid density change called _____.
10. Depth sounding equipment can detect masses of organisms forming a _____.
11. The main food for baleen whales is _____.
12. Arrowworms are so specific to certain water masses that they can be used as _____.
13. Many protozoans form shells, or _____, from calcium carbonate or silica.
14. A zooplankton that spends only part of its life in the plankton community is called a _____.
15. _____ play an important role in the decay and breakdown of organic material.
16. Diatoms belong to the *Kingdom* _____.
17. Most plankton are captured by towing a _____.
18. Poisonous and nonpoisonous blooms of dinoflagellates cause _____ in coastal waters.
19. _____ are powerful, naturally occurring nerve poisons that can cause paralysis and even death.
20. _____ are believed to be the source of the ciguatera toxin in tropical fish.

TRUE -FALSE

1. Jellyfish are never larger than a basketball.
2. Planktonic organisms swim freely through seawater in search of prey.
3. Coccolithophorids are zooplankton.
4. Many plankton reproduce by simple cell division.
5. Diatoms must stay afloat in sunlit surface waters to survive.
6. Heterotrophic organisms produce their own nutrients from simple compounds and sunlight.
7. Coccolith rich sediments are typically found at depths in excess of 4000 m.
8. Representatives of nearly every animal phylum are found in the zooplankton.
9. Zooplankton populations are uniformly distributed through the water.
10. Zooplankton can migrate 10 to 500 m vertically in the water column.
11. Baleen whales are the primary food source for krill and reproduce their population three to four times

each year.

12. Krill has become a popular food source for humans.
13. Arrowworms are abundant at all depths in the oceans.
14. *Globigerina* form siliceous tests.
15. Pteropods are related to seaweeds.
16. The annual sea walnut crop in Fiji is worth millions of dollars to their economy.
17. Larval organisms are very rare in zooplankton populations.
18. Bacteria are found attached to nearly all available surfaces in the oceans.
19. Most plankton are sampled by dredges and cores.
20. Ciguatera marine toxin has no known antidote.

MULTIPLE CHOICE

1. The smallest size of plankton are the
 - a. nanoplankton.
 - b. ultraplankton.
 - c. microplankton.
 - d. miniplankton.
 - e. net plankton.
2. Which of the following is an animal?
 - a. diatoms
 - b. coccolithophorids
 - c. dinoflagellates
 - d. radiolarians
 - e. *Sargassum*
3. Diatoms
 - a. are single-celled phytoplankton.
 - b. have radial symmetry.
 - c. have pillbox shaped frustules.
 - d. are found in cold, nutrient-rich water.
 - e. all of the above.
4. Diatoms with bilateral symmetry are called _____ diatoms.
 - a. centric
 - b. autotrophic
 - c. pennate
 - d. oblate
 - e. elongate
5. Diatoms are able to stay afloat in the photic zone because
 - a. they have low density tissue that balances the high density frustule.
 - b. they produce oil as a storage product.
 - c. they have a pair of flagella for limited mobility.
 - d. a and b above.
 - e. all of the above.
6. Dinoflagellates
 - a. are animals.
 - b. have no mobility of their own.
 - c. have cell walls made of silica.
 - d. migrate vertically in response to sunlight.
 - e. all of the above.
7. Which of the following is a crustacean?
 - a. copepods
 - b. pteropods
 - c. euphausiids
 - d. a and b above
 - e. a and c above
8. Pteropods are related to

- a. jellyfish.
 - b. snails.
 - c. diatoms.
 - d. krill.
 - e. foraminiferans.
9. Copepods and euphausiids make up more than _____ % of the zooplankton population of the oceans.
- a. 60
 - b. 15
 - c. 80
 - d. 30
 - e. 50
10. Pteropods are
- a. autotrophic.
 - b. carnivores.
 - c. herbivores.
 - d. carnivores and herbivores.
 - e. none of the above.
11. Which of the following prefer warm water regions?
- a. diatoms
 - b. foraminiferans
 - c. radiolarians
 - d. a and b above
 - e. b and c above
12. Meroplankton include the larvae of
- a. oysters.
 - b. crabs.
 - c. worms.
 - d. all of the above.
 - e. a and c above.
13. Bacteria
- a. are phytoplankton.
 - b. are present everywhere in the oceans.
 - c. form frustules.
 - d. feed on krill.
 - e. have cilia.
14. Radiolarians belong to the *Phylum*
- a. *Protozoa*.
 - b. *Coelenterata*.
 - c. *Chordata*.
 - d. *Mollusca*.
 - e. *Arthropoda*.
15. Salps belong to the *Phylum*
- a. *Protozoa*.
 - b. *Coelenterata*.
 - c. *Chordata*.
 - d. *Mollusca*.
 - e. *Arthropoda*.
16. Bacteria belong to the *Kingdom*
- a. *Animalia*.
 - b. *Plantae*.
 - c. *Monera*.
 - d. *Protista*.
 - e. none of the above.
17. In sampling plankton it is important to
- a. tow the net as fast as possible to sample large volumes of water in short amounts of time.

- b. carefully document the depth of the net.
 - c. use a constant size mesh for zooplankton and phytoplankton.
 - d. all of the above.
 - e. none of the above.
18. Red tides are produced by certain species of
- a. tropical fish.
 - b. mollusca.
 - c. diatoms.
 - d. pteropods.
 - e. dinoflagellates.
19. Ciguatera poisoning
- a. is caused by over 400 species of tropical fish.
 - b. is caused by blooms of dinoflagellates.
 - c. can be avoided by proper cooking.
 - d. can be treated by antitoxins.
 - e. none of the above.
20. The first trophic level of the sea is made up of
- a. meroplankton.
 - b. fish.
 - c. jellyfish.
 - d. diatoms.
 - e. none of the above.

Visual Aids: Test Your Understanding of the Figures

1. The frustules of diatoms are not solid. They are pierced by pores that allow the organisms tissues to have direct contact with seawater. Look at figure 16.3 and take note of the density of pores in a typical frustule.
2. Many marine organisms that move freely as adults are meroplankton in their larval stage. Figure 16.15 illustrates some of the wide variety of meroplankton that exist. Some resemble their adult forms and others are quite different.

Study Problem

1. Using the size classification for plankton determine what kind of plankton each of the following are: *Dinophysis* (fig. 16.5), *Acanthometron* (fig. 16.9), and *Ophiopluteus* (fig. 16.15).

Answer Key for Key Terms and Test Your Recall

KEY TERMS

autotrophic (III)

Cnidaria (IV)

test (IV)

picoplankton (II)

ctenophore (IV)

copepod (IV)

Sargassum (III)

microplankton/net plankton (II)

chaetognath (IV)

heterotrophic (III)

bloom (III)

auxospore (III)

cyanobacteria (V)

coccolithophorid (III)

salp (IV)

frustule (III)

ciguatera (VIII)

phytoplankton (I)

herbivore (IV)

carnivore (IV)

omnivore (IV)

euphausiid (IV)

bilateral symmetry (III)

zooplankton (I)

tintinnids (IV)

red tide (IX)

krill (IV)

holoplankton (IV)

diatom (III)

meroplankton (IV)

foraminiferan (IV)

bacteria (V)

nannoplankton (II)

radiolarian (IV)

crustacean (IV)

radial symmetry (III)

filament (III)

cilia (IV)

FILL IN THE BLANK

1. plankton

2. "grasses"

3. holoplankton

4. autotrophic
7. flagella
10. deep scattering layer
13. test
16. *Protista*
19. toxins

5. frustule
8. zooplankton
11. krill
14. meroplankton
17. net
20. dinoflagellates

6. bloom
9. pycnocline
12. biological indicators
15. bacteria
18. red tide

TRUE - FALSE

1.F 2.F 3.F 4.T 5.T 6.F 7.F 8.T 9.F 10.T 11.F 12.F 13.T 14.F 15.F 16.T(SURE!) 17.F 18.T 19.F 20.T

MULTIPLE CHOICE

1.b 2.d 3.e 4.c 5.d 6.d 7.e 8.b 9.a 10.d 11.e 12.d 13.b 14.a 15.c 16.c 17.b 18.e 19.a 20.d

STUDY PROBLEMS

1. a. nannoplankton
b. picoplankton
c. macroplankton