
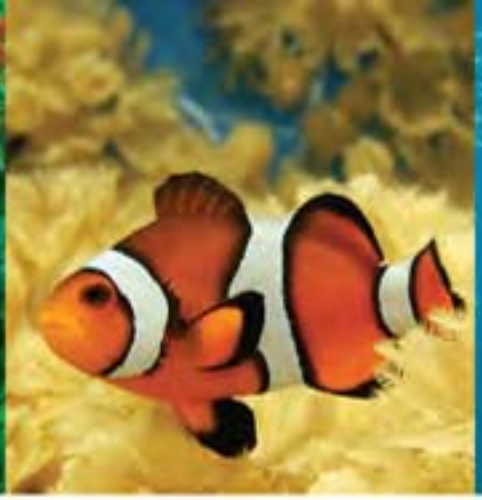


EXPLORING THE WORLD OF

AQUATIC LIFE

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EXPLORING THE WORLD OF AQUATIC LIFE

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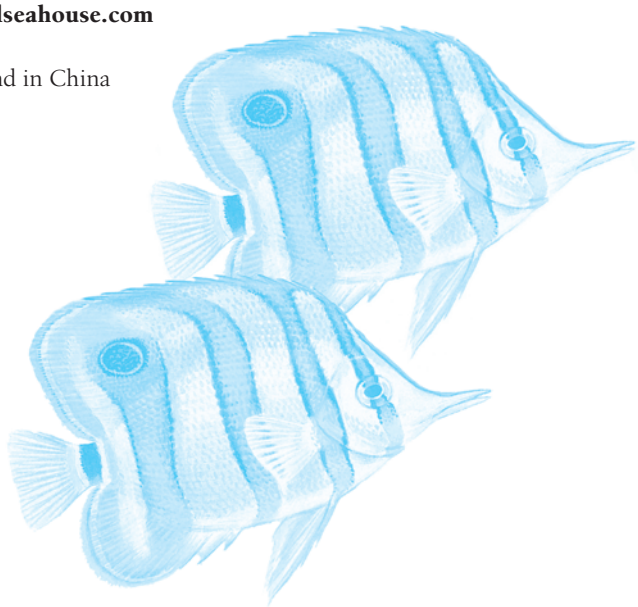

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INTRODUCING AQUATIC LIFE

Life originated in the prehistoric seas some 4,000 million years ago. The watery habitats of today (oceans, rivers, and lakes) contain the most amazing and varied animal life to be found anywhere on Earth. It ranges in size from the huge blue whale—the biggest animal ever to have lived—to tiny creatures that can only be seen with a microscope. It also includes the many colorful fish and other sea creatures that live on coral reefs, as well as the barnacles, limpets, and winkles that cloak our rocky shores. Then there are the ferocious piranhas, the huge sturgeons, and other animals that live in our rivers and lakes. These, and many more, are the subjects of this encyclopedia.

Three quite different groups of animals are described in this set. **Invertebrates** are animals that do not have a backbone. Apart from that feature, all the major groups of invertebrates are very different from each other. Here we look at invertebrates that live in sea and fresh water, although other invertebrates include the land-dwelling insects and spiders. Most of the invertebrates in this set belong to four major phyla (groups): the jelly animals (such as the soft-bodied jellyfish and sea anemones); the crustaceans (such as the hard-skinned lobsters); the mollusks (such as the eight-limbed octopuses); and the spiny-skinned animals (such as the prickly sea urchins). We also include the mostly microscopic life forms that make up a group called the Protista, or single-celled life.

Fish are found all over the world in seas, oceans, rivers, and lakes. Fish are cold-blooded vertebrates (animals with backbones). Most have streamlined bodies covered in scales. They also have fins and a tail for swimming. Fish breathe with the aid of gills, but some also have lungs.

Finally there are those **mammals** that spend all their lives in the sea—the whales and dolphins, the dugong, and the manatees. Mammals are warm-blooded, air-breathing vertebrates that feed their young with milk.

Exploring the World of Aquatic Life

From the American paddlefish to wrasses, these six volumes of *Exploring the World of Aquatic Life* provide more than one hundred articles that describe in detail particular species and groups of animals that live in watery habitats. Most are articles about individual animals (such as the whale shark or the goldfish), or groups of closely related animals (such as sturgeons or barnacles). Other articles provide a general account of a large group of animals, such as crustaceans or sharks. They are shown in bold type on the table of contents in each volume.

Each volume has a number of useful features. At the front of each book there are two family trees; they show how these varied animals fit into the animal kingdom and how they are related to each another. They also give cross references to articles in this encyclopedia. At the end of each book there is a glossary of terms used throughout the set; a section entitled Further resources, which includes further reading and Internet resources; and a volume-specific index. Volume 6 contains a complete set index.

Every article has a Fact File box which summarizes the classification (see opposite) of each animal or group and indicates how many species exist. In addition, there are facts about the animals' distribution, habitat, size, coloration, diet, breeding, and status according to the World Conservation Union (IUCN; see opposite). Other items include boxes that provide more in-depth information about specific details and Did You Know? features that present interesting facts about specific animals. Throughout, there are large, colorful photographs and illustrations that increase the reader's enjoyment and enhance an understanding of those animals that live in watery habitats.

Group ties

Above the Fact File in most articles there is a colored tag. This indicates in which general group of animals the subject is placed.

INVERTEBRATES are all those animals that do not have a backbone. The majority of them are built of many cells. However, also included in this group are the most simple forms of life that exist as a single cell; they make up the kingdom Protista.

PRIMITIVE FISH covers a varied group that includes the remnants of the very earliest fish to evolve, as well as their living descendants. Some, such as the hagfish, have primitive skeletons but do not have jaws. Others, such as the coelacanth, have a primitive bony skeleton. This group includes the sea squirts and lancelets. These small creatures are the ancestors of those animals, such as the bony fish and the sea mammals, that have a true backbone.

CARTILAGINOUS FISH have a skeleton that is made of cartilage, a gristlelike substance much softer than bone. Sharks are the best-known types of cartilaginous fish.

ADVANCED BONY FISH, also known as teleosts, are the largest and most varied group of fish. Over 24,000 species are known today.

SEA MAMMALS includes the whales and dolphins as well as the dugong and the manatees.

World Conservation Union (IUCN)

The World Conservation Union (IUCN) is the world's largest and most important conservation network. Its mission is to help protect all living organisms and natural resources by highlighting those threatened with extinction and therefore promote their conservation.

An organism may be placed in one of the following categories in the *IUCN Red List of Threatened Species*:

- **Extinct**—there is no reasonable doubt that the last individual has died
- **Extinct in the wild**—an organism survives only in captivity, in cultivation, or as a population well outside its past range
- **Critically endangered**—facing an extremely high risk of extinction in the wild
- **Endangered**—facing a very high risk of extinction in the wild
- **Vulnerable**—facing a high risk of extinction in the wild
- **Near threatened**—likely to qualify for a threatened category in the near future
- **Least concern**—is not threatened
- **Data deficient**—inadequate information exists to make an assessment

The status of each mammal or group of mammals according to the IUCN is highlighted at the foot of the Fact File in every article.

Classifying animals

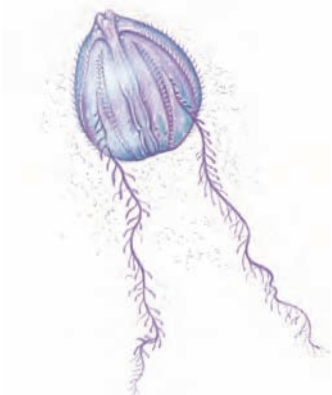
To talk about animals, we need names for the different kinds. An Atlantic salmon is one type of fish; all individuals look alike, can breed together, and produce young that look like themselves. This is the zoologist's definition of a species. Scientists use an internationally agreed system of naming animals so that it is possible for anyone in the world to know which animal is being described, whatever the language. The name for a species consists of a two-word name, usually in Latin or Greek. That of the Atlantic salmon is *Salmo salar*.

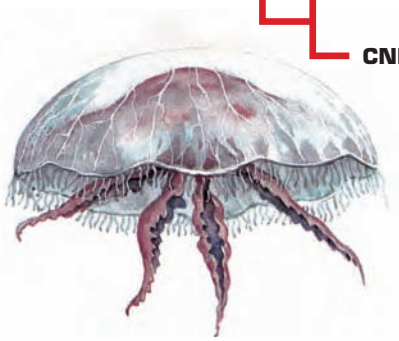
Scientists create family trees showing how one animal, or group of animals, is related to another. This is called classification. The largest group is the kingdom. The kingdom Animalia covers all animals. Between kingdom and species there are many other categories or groupings, indicating ever-closer relationships. The sequence for the Atlantic salmon is kingdom: Animalia; phylum: Chordata; subphylum: Vertebrata; superclass: Gnathostomata; grade: Osteichthyes; class: Actinopterygii; division: Teleostei; order: Salmoniformes; family: Salmonidae; genus: *Salmo*; species: *Salmo salar*. (See also page 78.)

INVERTEBRATE FAMILY TREE

SINGLE-CELLED LIFE (Kingdom Protista) → **Animals without a backbone—invertebrates** (Kingdom Animalia) → **PHYLA** include:
JELLY ANIMALS (Cnidaria)
MOLLUSKS (Mollusca)
SPINY-SKINNED ANIMALS (Echinodermata)
CRUSTACEANS (Phylum Arthropoda: Subphylum Crustacea)

The numbers below refer to volume and page numbers where a particular group is featured in an article.





PROTISTA

[Single-celled life 5:64]

ANIMALIA

PARAZOA [Sponges 6:16]

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- HYDROZOA [Hydrozoans 3:58]
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POGONOPHORA [Beard worms 1:42]

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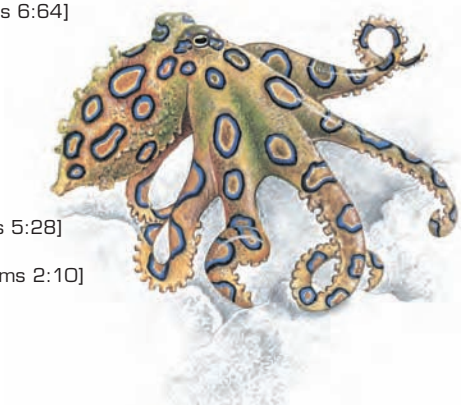
NEOGASTROPODA [Whelks and relatives 6:64]

NUDIBRANCHIA [Sea slugs 5:44]



BIVALVIA

DYSODONTA [Mussels 4:44]

OSTREIFORMES [Oysters 4:54]

PSEUDOLAMELLIBRANCHIATA [Scallops 5:28]

EULAMELLIBRANCHIA [Cockles and clams 2:10]

NAUTILOIDEA [Nautiluses 4:48]

CEPHALOPODA

OCTOPODIFORMES

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COLEOIDEA

DECAPODIFORMES

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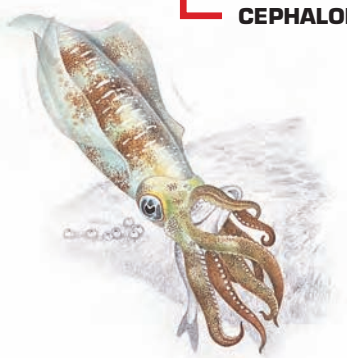
SPIRULIDA, SEPIOLIDA, TEUTHIDA [Squid 6:20]



[Spiny-skinned animals 6:14]

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ASTEROIDEA/OPHIUROIDEA [Starfish 6:24]

ECHINOIDEA [Sea urchins 5:48]

HOLOTHUROIDEA [Sea cucumbers 5:36]

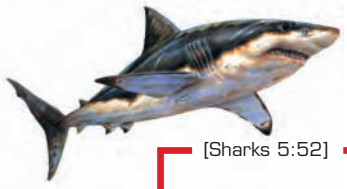
FISH AND MAMMALIAN FAMILY TREE

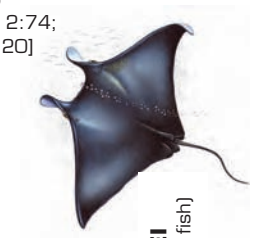
ANIMALS (Kingdom Animalia)

- **Animals without a true backbone (primitive vertebrates)** (Phylum Chordata: Subphylum Urochordata —**SEA SQUIRTS**; Subphylum Cephalochordata —**LANCELETS**)
- **Animals with a backbone** (Phylum Chordata: Subphylum Vertebrata)

MAIN GROUPS:
MAMMALS (Class Mammalia)
BIRDS (Class Aves)
REPTILES (Class Reptilia)
AMPHIBIANS (Class Amphibia)
HAGFISH, LAMPREYS (Superclass Agnatha)
CARTILAGINOUS FISH (Class Chondrichthyes)
LOBE-FINNED BONY FISH (Class Sarcopterygii)
RAY-FINNED BONY FISH (Class Actinopterygii)

The numbers below refer to volume and page numbers where a particular group is featured in an article.





CHORDATA (Chordates)

- CEPHALOCHORDATA [Lancelets 3:66]
- **VERTEBRATA** (Vertebrates)
  - **GNATHOSTOMATA** (Jawed fish)
    - **CHONDRICHTHYES** (Cartilaginous fish)
      - CHIMAERIFORMES [Chimaeras 1:66]
      - **ELASMOBRANCHII** (Sharks and rays)
        - [Sharks 5:52]
          - CARCHARHINIFORMES [Dogfish 2:46; Hammerhead sharks 3:48]
          - LAMNIFORMES [Great white shark 3:36]
          - ORECTOLOBIFORMES [Whale shark 6:56]
        - [Rays 5:12] — RAJIFORMES [Electric rays 2:74; Manta ray 4:20]
    - **OSTEICHTHYES** (Bony fish)
      - **ACTINOPTERYGII** (Ray-finned fish)
        - POLYPTERIFORMES [Bichirs 1:46]
        - ACIPENSERIFORMES [American paddlefish 1:10; Sturgeons 6:30]
        - AMIIFORMES [Bowfin 1:52]
        - SEMIONOTIFORMES [Garfish 3:22]
      - **SARCOPTERYGII** (Lobe-finned fish)
        - COELACANTHIFORMES [Coelacanth 2:16]
        - CERATODONTIFORMES, LEPIDOSIRENIFORMES [Lungfish 4:16]
  - **AGNATHA** (Jawless fish) — PETROMYZONTIFORMES, MYXINIFORMES [Hagfish and lampreys 3:44]
- UROCHORDATA [Sea squirts and salps 5:46]

TELEOSTEI (Advanced bony fish)

ELOPOMORPHA [Eels 2:64]

ANGUILLIFORMES [Conger eels 2:24; Freshwater eels 3:16; Moray eels 4:38]

ELOPIFORMES [Atlantic tarpon 1:32]

GYMNOTIFORMES [Electric eel 2:72]

CYPRINIFORMES [Barbs 1:34; Bitterlings 1:48; Clown loach 1:74; Common carp 2:20; Goldfish 3:26; Minnows 4:26]

SILURIFORMES [Catfish 1:58; Electric catfish 2:70]

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MULGILIFORMES [Mullets 4:42]

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BELONIFORMES [Flying fish 3:12]

CYPRINODONTIFORMES [Four-eyed fish 3:14; Guppy 3:40; Swordtails 6:36]

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PERCIFORMES [Angelfish 1:16; Archerfish 1:26; Barracudas 1:38; Blennies 1:50; Butterflyfish 1:56; Cichlids 1:68; Damselfish 2:44; Gobies 3:24; Gouramis 3:30; Mackerel 4:18; Marlins 4:24; Perches, freshwater 4:56; Remoras 5:16; Sea basses 5:34; Swordfish 6:34; Tuna 6:52; Wrasses 6:68]

TETRAODONTIFORMES [Boxfish 1:54; Molas 4:30; Puffers 4:74; Triggerfish 6:44]

AULOPIFORMES [Lizardfish 4:10]

ESOCIFORMES [Pikes and pickerels 4:60]

SALMONIFORMES [Atlantic salmon 1:28; Sockeye salmon 5:72; Trout 6:46]

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CLUPEIFORMES [Anchovies 1:12; Herring 3:54]

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LOPHIIFORMES [Anglerfish 1:20; Batfish 1:40; Frogfish 3:20]

OSTEOGLOSSIFORMES [Arapaima 1:24]

AMPHIBIANS

REPTILES/BIRDS

MAMMALIA (Mammals)

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MONODONTIDAE [Beluga and narwhal 1:44]

DELPHINIDAE [Dolphins 2:48]

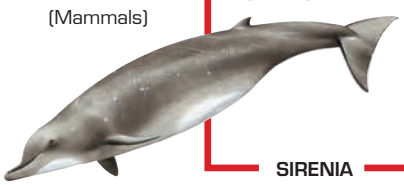
ESCHRICHTIIDAE [Gray whale 3:32]

PHOCOENIDAE [Porpoises 4:72]

BALAENIDAE, NEOBALAENIDAE [Right whales 5:18]

BALAENOPTERIDAE [Rorquals 5:22]

PHYSETERIDAE [Sperm whales 6:10]



SIRENIA — TRICHECHIDAE, DUGONGIDAE [Dugong and manatees 2:60]

AMERICAN PADDLEFISH

With a nose built like an oar and a huge, toothless, gaping mouth, the American paddlefish is one of the most unusual-looking fish to be found in the whole of North America.

It may look fierce, especially when it opens its cavernous mouth to its full extent, but the American paddlefish is a peaceful fish that feeds on tiny creatures called plankton. It filters these out of the water using a series of sievelike structures on its gills.

The paddle which gives the species its name can be over 2 feet in length in a fully grown specimen, but scientists are not really sure what it does. Since it is packed with special sensing cells, it is likely that it helps the fish find its food. It could also help balance the paddlefish as it swims through the water with its mouth wide open feeding on clouds of plankton—especially when in a strong current. This is not known for certain, however, since paddlefish that have lost their paddle through injury can still feed perfectly well.

Ancient Friends

Seeing a paddlefish swimming in the wild, or in a public aquarium, it is difficult to believe that the species has been around since the age of dinosaurs. In fact, fossils of paddlefish found in rocks show that these fish have a very long history dating back some 135 million years at least.

While most species of fish have bony skeletons, paddlefish have a skeleton made of a tough, elastic material called cartilage, except for the jaw. Cartilage is also found in the skeletons of another large group of primitive fish: the sharks and their relatives, the rays.

Today, paddlefish have very few living relatives. The closest are the sturgeons, another group of large, primitive fish, some of which live in fresh water.

Fact File

AMERICAN PADDLEFISH

Polyodon spathula

Family: Polyodontidae

Order: Acipenseriformes

Where do they live?: North America, mainly in the Mississippi River Basin and the Gulf Slope

Habitat: Slow-flowing bodies of water, such as backwaters, preferably over 4 feet (1.2 m) deep

Size: Up to 6.6 feet (2 m), and with a body weight of over 100 pounds (45 kg); females are larger than males

Coloration: Color of slate, often mottled and with lighter shades on the underside

Diet: Small free-swimming creatures (zooplankton) and insect larvae

Breeding: In April and May when water temperatures reach about 55°F (13°C); each female can produce around 7,500 eggs for each pound (450 g) of body weight; hatching takes about 1 week and the young are born without a paddle; females mature at the age of 10 years

Status: Listed as vulnerable

ANCHOVIES

What they lack in size, anchovies make up for in numbers. The largest shoals consist of countless millions of individuals, all making their way through the open sea in search of food.

Like all shoaling fish, anchovies communicate with each other and so are able to swim in close formation. formation. Their silvery sides help them do this by providing a visual aid. However, anchovies are unusual in that they can also use pulses of sound to keep in touch with each other when swimming at high speed. This sound is not produced through the mouth. It is made by shock waves that are generated when thousands—or even millions—of bodies are pushing against the water at the same time.

For an individual anchovy, being a member of a large shoal offers it a greater chance of survival than if it were to swim alone or as a member of a small group. This "safety in numbers" is especially important when a shoal is under attack from hunters. When this happens, each anchovy can "lose" itself among the mass of bodies of its fellow shoalers. Although some members of the shoal will be eaten, it is difficult for predators to pick out individual targets.

Year-round Breeding

There are around 140 species of anchovies widely distributed in the major seas and oceans of the world (as well as in some rivers). It is not surprising, therefore, that the anchovy family breeds throughout the year. This does not apply to every species, of course; each has its own breeding season, which often extends over several months. During this period, some species can

Part of a shoal of northern anchovies swim in tight formation. Anchovies have larger mouths than the similar-looking herrings and silversides.

Fact File

ANCHOVIES

Family: Engraulidae (around 140 species)

Order: Clupeiformes

Where do they live?: Atlantic, Pacific and Indian Oceans, many seas, and some rivers

Habitat: Mostly found in tropical, subtropical, and temperate (cooler) waters; some are found in estuaries and rivers

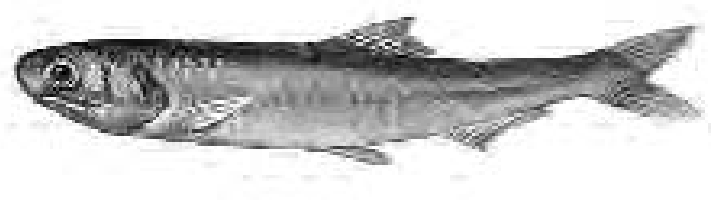
Size: Most species are small, measuring less than 6 inches (15 cm), but some are larger; the largest species, the freshwater anchovy, grows to 16 inches (41 cm)

Coloration: Slim body is usually silvery with darker shades along the back; several species have very shiny scales restricted to a stripe along the body; the body itself is translucent or dark in these species

Diet: Small free-floating plants and animals (phytoplankton and zooplankton); larger species also feed on small fish; some species use both feeding methods

Breeding: Large floating eggs are produced during the breeding season, which can extend over several months

Status: Generally not threatened, although stocks of some species are declining



The Peruvian anchovy is found in the southern Pacific Ocean. It is the most commercially important of all the anchovies.

spawn as many as twenty times, with each female producing several hundred eggs at each spawning.

It is at such times that the largest shoals of anchovies form. Spawning usually occurs under the cover of darkness. This gives the transparent eggs several hours of relative safety away from the eyes of predators, during which they are carried away by the ocean currents. The eggs then hatch and develop in the warmer surface waters of the open sea.

EL NIÑO EFFECT

Every seven or eight years, changes in the pattern of the winds and ocean currents in the South Pacific are disrupted. This causes the usually cold, food-rich waters off the western coast of South America to warm up. This phenomenon, which is called "El Niño," produces dramatic effects all over the world. For the Peruvian anchovy fishery, these effects can be disastrous. The annual catches of around 14.3 million tons of anchovies are severely interrupted during "El Niño" years. The anchovies' regular food supply (usually carried there by cold currents) disappears.

The Anchovy Industry

Although anchovies are still found in large numbers in many areas, there are less and less of these fish in other places. In the Black Sea, for example, overfishing has led to a sharp drop in the numbers of anchovies being caught. Elsewhere, the story is similar, although the drop may not be as severe as in the Black Sea.

Despite these losses, there are large industries that fish and process nothing but anchovies. The fish are sold either fresh or salted, or as fishmeal, fish oil, and fish paste.

Although other fish (including sharks), and marine mammals such as whales and dolphins, eat large quantities of anchovies, the biggest predators of all are seabirds such as penguins, cormorants, gannets, gulls, and pelicans. In fact, birds eat so many anchovies that in certain parts of the world their droppings—called guano—are collected and turned into fertilizer. For some countries, guano is a major industry. It is estimated that for every 8.8 tons of fish eaten, seabirds produce enough guano to make 1.1 tons of fertilizer.

Little-known Anchovy

Most anchovies live in the sea, but seventeen species live in estuaries (places where sea and fresh water mix together) or in rivers, spending either all, or most, of their lives there.

DID YOU KNOW?

- The freshwater anchovy can be found up to 560 miles away from the sea.
- The whiskered anchovy has an upper jaw that is three times as long as its head.
- Some anchovies can live for up to seven years.

One of these, the freshwater anchovy, is the largest anchovy known, growing to around 16 inches in length. It is also one of the least studied. For example, scientists do not know if it breeds in fresh water or if it migrates to the sea when breeding. Young freshwater anchovies are often caught in river estuaries, but it is not known if these have been born there, or have moved downriver after hatching upriver. They may even have hatched in the sea and then migrated into the estuaries. The breeding season is not known for sure, but is probably May to August.

Anchovies swim in a school around a reef in the Sea of Cortez, Baja California, Mexico.

ANGELFISH

Angelfish are colorful residents of coral reefs. They change their colors and patterns as they grow. Somtimes, the differences between the young and adults are so striking that they look like different species.

Along with their close relatives, the butterflyfish, angelfish are among the most visible inhabitants of tropical coral reefs. Most live in shallow water, and so they are easily spotted by swimmers and divers. This does not mean that all the species occur in large numbers, or in shallow water, however. Some species are not seen on most reef dives because they usually live in deep water. For example, the masked angelfish prefers to live in waters from around 60 feet down to 275 feet. Others are not often seen because they are rare and only found in a few places. For example, the resplendent angelfish only lives around Ascension Island in the southeastern Pacific Ocean.

Summer Breeders

It is quite normal for a single male to be accompanied by several females. During the breeding season, which usually extends over the summer months, he will breed with each of the females in turn in spawning sessions lasting eight to ten minutes.

First, the male will stage a spectacular display some distance off the bottom, in which he stretches out all his fins. One of the females will respond to this invitation by rising to meet him. As she approaches, the male will nuzzle the female's belly. Following this, the pair will perform a short, high-speed swim during which sperm and eggs are released. As soon as this happens, the pair dash back to the shelter of the reef.

The queen angelfish of the Caribbean and Atlantic gets its name from the speckled, blue-ringed mark above the head, which resembles a crown.

Fact File

ANGELFISH

Family: Pomacanthidae (around 85 species)

Order: Perciformes

Where do they live?: Widely distributed in all tropical areas; nearly 90 percent of all angelfish are found in the Indo-Pacific

Habitat: Most species occur in shallow, clear-water tropical reefs; a few are found in deeper water

Size: From 2.4–24 inches (6–61 cm)

Coloration: Adults usually brightly colored; juveniles often have a deep-blue body with white patterns

Diet: Most species feed on invertebrates found on coral reefs and on algae, and a few feed on small swimming invertebrates (zooplankton)

Breeding: Eggs and sperm are released into the water and are abandoned; hatching takes 18 to 30 hours; larvae disperse among the plankton before becoming adults

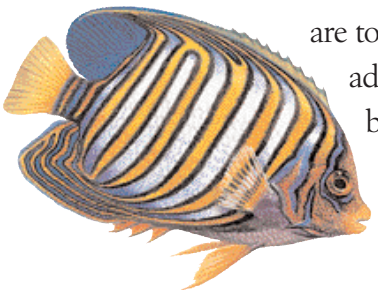
Status: Only 1 species, the resplendent angelfish, is believed to be under threat in the wild

The regal angelfish of the Indo-Pacific often lives around caves, where it feeds on sponges and other small creatures.

The eggs, which float, are carried away by currents and hatch within a day or so. The newly hatched angelfish look nothing like their parents and have spiny scales.

Angelic Delinquents

In many species, young angelfish develop body colors and patterns that are totally different from those of adult fish. For many years it was believed that these smaller angelfish were all separate species. It was only through patient observation that it became clear that these strikingly patterned and colored individuals—many of which carry bold white lines on a deep-blue body—were the young stages of well-known, but differently colored, species.



The behavior of juvenile angels toward adults, and vice-versa, is very interesting. For example, adult angelfish, particularly males, are quite aggressive toward rivals. However, they are considerably more tolerant toward juveniles, acting as if they know that the youngsters do not present a threat. Perhaps they fail to recognize them as members of their own species.

The juveniles, for their part, appear to have no respect for the adults, seemingly ignoring the basic rules of angelfish behavior. They swim boldly

DID YOU KNOW?

- Some angelfish can change sex from female to male.
- Despite their "angelic" name, angelfish have a strong, sharp spine on their cheeks which can cause painful injuries.
- Color differences between male and female angelfish are rare. In most species, both sexes are identically colored.

UNUSUAL FEEDING

The Japanese angelfish has some rather strange feeding habits. In at least part of its range it is known to eat fish feces, particularly those produced by damselfish and fairy basslets. Although feces seem like an odd source of food, it makes good sense as far as fish are concerned. Feces contain food which has not been fully digested and is still rich in proteins and other nutrients. Being partially digested, these foods are often easier for the body to use than raw foods. It is not surprising that some fish, among them Japanese angels, include feces in their diet, along with other, more "normal," foods.

into the territories of adult males—something that an adult angelfish would avoid, since it means having to face up to the resident male.

Pygmy Angels

In one group of angelfish the adults only grow to a few inches in length, usually under 3–4 inches. These are called pygmy angels. Some of these pygmy angels are especially beautiful, and have names such as the flameback angelfish, the multicolor angelfish, the orange angelfish, the resplendent angelfish, and the lemonpeel angelfish.

However, the word "pygmy" does not always indicate that a fish is small. Some species, such as the bicolor angelfish, the blacktail angelfish, and the Japanese angelfish are all very much bigger. They grow to around 6 inches in length, which is larger than the smallest "non-pygmy" angelfish. They include one called the conspicuous angelfish.

The Red Sea angelfish can grow to 20 inches. This species can be quite curious and often approaches divers.

The brown yellow spotted angelfish has a mouth designed for grazing reef crevices for small food items.

ANGLERFISH

A hungry fish dashes in, mouth wide open, to swallow a wriggling worm. In a flash, it's all over. However, it is not the worm that has been swallowed, but the hungry fish itself!

The hungry fish described opposite has been fooled by one of the most effective and deceptive hunters of the seas—an anglerfish. Anglerfish are the fishy equivalent of human anglers, except that they come complete with a built-in "fishing rod" and "lure."

The "fishing rod" consists of the first ray of the dorsal (back) fin. This ray is longer and more flexible than all the others and is placed close to the nose of the fish. At the tip, there is a fleshy part that may look like a worm or even a small fish. The rest of the anglerfish's body is well camouflaged. As a result, an angler lying still on the bottom is extremely difficult to spot.

The Perfect Confidence Trick

When it is hungry, all that an anglerfish needs to do is move its "fishing rod"—known as the illicium—around in the water. This makes the "lure," or "bait"—known as the esca—wriggle like a worm or a small fish. This in turn will attract any hungry fish that happens to swim by. As the would-be diner comes in to inspect or swallow its meal, the anglerfish simply opens its huge mouth and sucks in the unsuspecting victim at such high speed that few targets ever manage to escape.

This confidence trick is so effective that anglers have been using it for some 17 million years. Today, there are over 300 species of anglerfish found in all major seas, from the shallow clear waters of coral reefs down to depths of more than 16,000 feet.

The fanfin seadevils, such as the one shown here, are bottom-dwelling anglerfish found in very deep parts of the Atlantic, Pacific, and Indian Oceans.

Fact File

ANGLERFISH

Families: 16–18 (around 310 species)

Order: Lophiiformes

Where do they live?: All major seas and oceans, ranging in depth from surface waters down to 16,400 feet (5,000 m) or more

Habitat: Many species live on the sea floor; deep-sea species usually live off the bottom

Size: From around 1 inch (2.4 cm) to around 4 feet (1.2 m)

Coloration: Often mottled and well camouflaged; deep-sea species are usually black

Diet: All species feed on fish and/or invertebrates; "parasitic" males take their food directly from the female's blood

Breeding: Eggs and sperm are released into the water; fertilized eggs float and the young spend some time living among the plankton; in some species, the eggs are encased in a jellylike substance

Status: None of the species is believed to be endangered, although there is concern about the extent to which some goosefish are fished

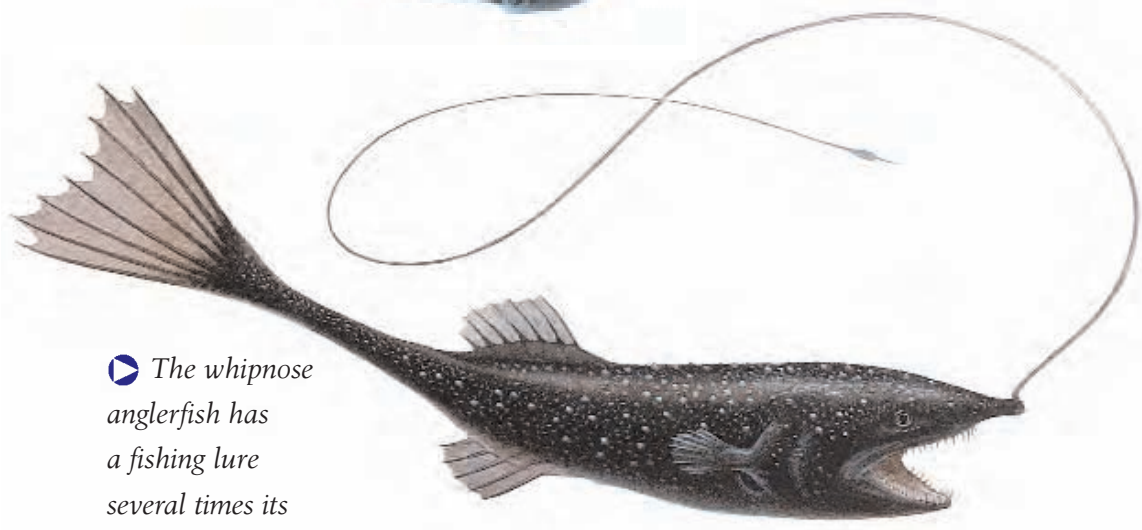
DID YOU KNOW?

- Some anglerfish species are widely eaten and have the taste and texture of lobster.
- Goosefish liver is considered a great delicacy in Japan, where it is known as *ankimo*.
- The eggs of the species belonging to one family of anglerfish are laid in a thin sheet of clear, jellylike material that can be 2–3 feet wide and 25–30 feet long.

Deep-sea Tactics

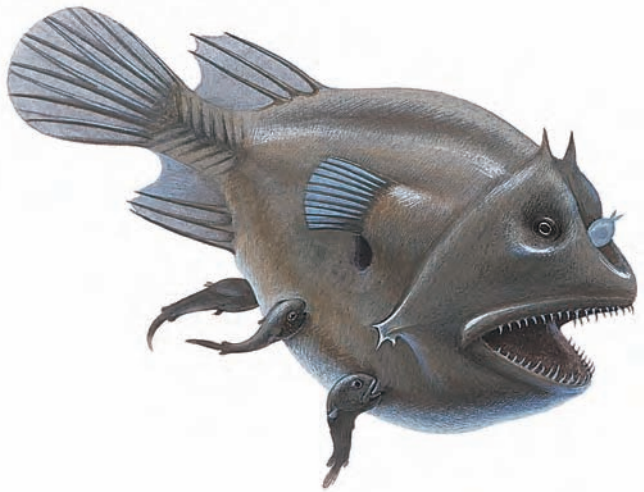
All but one anglerfish—the toothed seadevil—use the "rod and lure" technique. Because anglers live in many different places and depths, there are many differences in the lures and the way they are used. Whipnose anglerfish, for example, have been filmed at great depth swimming upside down along the bottom, dragging their extremely

Humpback anglerfish live in deep temperate and tropical oceans. Note the huge jaws typical of anglerfish.



The whipnose anglerfish has a fishing lure several times its body length.

Linophryne *has an elaborate lure on its nose and a branched barbel on its chin.*



MALE PARASITES

When deep-sea anglerfish were first collected, it was puzzling to find that they were all females but that they had small "parasites" attached to their bodies. When these were examined, they turned out not to be parasites at all, but male deep-sea anglerfish! Gradually, the full story has been revealed. When a male deep-sea angler is born, he has a keen sense of smell that helps him to find a female, which he then bites. His tissues and hers fuse, fixing him forever to the female's body. Over time, all his organs waste away, except his testes, which produce sperm every time the female is ready to spawn.

This 3-inch-long female Haplophryne *(top of page) has three tiny males attached to her body.*

long "rod and lure" along the bottom. It is thought that this behavior attracts the bottom-living creatures on which whipnose anglers feed.

Some deep-sea anglerfish live at such depths that no light ever reaches them. In this world of total darkness, some species have evolved their own lighting systems. These consist of two types: colonies of bacteria that glow in the dark (bioluminescent bacteria) and special light-producing cells within the fish themselves. The bioluminescent bacteria are usually only on the "lure," which can be made to flash. The light-producing cells are usually found on the long chin whiskers or barbels of anglers known as seadevils or net devils.

Fins and Fangs

In species that live on the bottom, the pectoral (chest) fins, and the pelvic (hip) fins, act as arms and legs. The fish uses them to walk or even climb. However, in species that spend most or all of their time away from the bottom, these fins are like those found in other midwater or surface species of fish, and are therefore used for swimming.

Some anglers live in parts of the deep sea where suitable prey is often hard to find and meals can be widely spaced out. It therefore makes sense to grab whatever comes along, even if it happens to be larger. Deep-sea anglers are well equipped for this, with needle-sharp fangs and flexible jaws. They also have stomachs that can stretch to take in prey that is twice the size of the anglerfish itself.

ARAPAIMA

If some reports of its size are correct, the arapaima is the largest living species of freshwater fish in the world. Yet, despite its massive size, it is an amazingly gentle, caring parent.

This Amazon heavyweight is reported to grow to 16 feet in length. However, most reliable reports indicate that it grows to about two thirds of this size. Even so, the arapaima, or pirarucu, is a real giant.

In areas away from those occupied by humans, the arapaima is believed to live in quite large numbers. Amazonian rivers and their main tributaries are also huge, and it is very difficult to reach some areas where arapaima are known, or believed, to occur. It is therefore certain that there are more arapaima than scientists once thought, but they do not know how many. Of one thing they are sure—in some areas close to human settlements, hunting has virtually wiped out this magnificent air-breathing fish.

Breeding with a Difference

One of the most interesting features of the arapaima is its breeding method. Unlike most large species, which shed huge numbers of eggs into the water, the arapaima produces relatively few eggs. Egg laying and fertilization takes place in a shallow pit dug in the riverbed. Once the eggs have been fertilized, one of the parents—believed to be the male—picks them up in its mouth, where they develop and hatch in safety.

The parent that protects the young in this way also produces pimplelike growths on its snout. It is thought that these growths produce nourishing substances on which the babies feed when they hatch out.

Arapaimas belong to a group of fish called the bonytongues. The name refers to the rough surface of the tongue, which helps the fish grasp and chew food.

Fact File

ARAPAIMA

Arapaima gigas

Family: Osteoglossidae

Order: Osteoglossiformes

Where do they live?: Amazon region, South America

Habitat: Large bodies of water, including lakes and main rivers and tributaries

Size: Up to 16 feet (5 m) and a weight of 375 pounds (170 kg), but more usually around 10 feet (3 m) and a weight of 220 pounds (100 kg)

Coloration: Mostly grayish, with some blue or green along the back and sides, with a lighter-colored belly; scales on the back half of the body edged in purple or red; this color may also spread onto the dorsal (back) and caudal (tail) fins

Diet: Mainly fish, but also eats other aquatic animals and even birds—it can jump out of the water to snatch them off branches

Breeding: Around 4,000 eggs (as many as 47,000 have been claimed) are laid in a shallow pit; these are incubated in the mouth by one of the parents; depending on location, the breeding season may begin in October and end in May

Status: Populations close to human settlements are under threat; elsewhere, they are believed not to be under threat, but detailed information is lacking

ARCHERFISH

In some tropical swamps, there are silent hunters beneath the surface that shoot down their prey—with jets of water. If this fails, they simply jump out and grab their meal.

The remarkable hunting skill described opposite belongs to the unusual and beautiful archerfish. Normally, these fish feed on insects and other small creatures that accidentally fall into the water, like so many other fish species do. Some archerfish also feed on mangrove plants. However, their eyes are always turned skyward, keeping an eye out for any insect that may land on a twig or leaf near the water surface.

When an archerfish spots a potential victim, it silently swims up to the surface and positions itself within shooting distance. It then fires powerful jets of water at the prey through its specially adapted mouth. It can do this with such force that it can knock an insect off its perch from a distance of 5 feet.

Bending Ability

The archerfish can shoot from under the water surface and hit a target perched in the open air because it can make an adjustment for the way light rays bend as they pass from water to air, and vice versa. If an archerfish were to aim its jets of water directly at where it sees an insect, it would always miss its prey. But it does not do this. The archerfish may not always be on target but, by making allowances for the different light-bending properties of air and water, it scores a hit often enough for the effort to be worthwhile. The skill has evolved to become an important part of the food-capturing armory of the archerfish.

An archerfish sends a well-aimed jet of water toward an insect on some leaves above the water. The force of the jet will knock the insect down to the waiting fish.

Fact File

ARCHERFISH

Family: Toxotidae (6 species)

Order: Perciformes

Where do they live?: From India to the Philippines, Australia, and Polynesia

Habitat: Although mostly marine, all species spend some time in fresh water and are frequently found in mangrove swamps and streams, usually with overhanging vegetation

Size: From about 6 inches (15 cm) to 18 inches (46 cm)

Coloration: Basically silvery with dark bands or blotches along the top half of the body; dorsal (back) and anal (belly) fins may have a yellow tinge

Diet: Mainly insects and other invertebrates; smaller fish may also be eaten; at least 2 species, the largescale archerfish and the common archerfish, also eat some plant matter

Breeding: Little is known; the largescale archerfish is said to lay between 20,000 and 150,000 eggs in fresh or brackish water

Status: None of the species is known to be threatened in the wild

ATLANTIC SALMON

Atlantic salmon are the "homing pigeons" of the fish world. After several years of living in the sea, they return to the same streams and rivers in which they were born, in order to breed.

Over countless generations, the Atlantic salmon has evolved into a fish whose extraordinary homing instincts can only be matched by very few other fish—the most famous of these being the European eel. The salmon's instincts are so powerful that they make the yearly return to home waters totally predictable.

Because of this, thousands of salmon are caught each year in nets and traps, as well as on hook and line by anglers, as the vast shoals of homing fish approach river estuaries and begin to move upriver. The timing of this migration, or run, varies from region to region, with greater numbers in spring, summer, and fall.

Epic Journey

Salmon that are ready to breed move from the open sea toward their home waters several months before they actually spawn. Precisely how they manage to do this is not yet fully understood. However, it is known that salmon remember certain characteristics of their home rivers, especially the chemical makeup of the water.

Once in their home rivers, they swim upstream toward their spawning grounds, overcoming all manner of obstacles along the way. Where dams and other structures block their way, special salmon "ladders" have been built to allow them to continue on their epic journey. These "ladders" are channels built in a series of steps with water running down them.

Like other members of their family, Atlantic salmon have a fleshy, second dorsal fin behind the main dorsal fin. It is called the adipose fin.

Fact File

ATLANTIC SALMON

Salmo salar

Family: Salmonidae

Order: Salmoniformes

Where do they live?: Both sides of the Atlantic Ocean; also introduced into many areas, including Australia, New Zealand, Argentina, and Chile

Habitat: Open seas, moving close to coasts prior to the breeding season and then upriver to spawn; landlocked populations prefer deep pools; clear, shallow waters rich in oxygen are needed for spawning

Size: Up to 4.9 feet (1.5 m); adults of landlocked populations are smaller

Coloration: Prespawning fish are silvery, with darker back and white belly; numerous black spots on side of body; colors become more intense during the breeding season

Diet: Young fish feed on plankton and small invertebrates, moving onto larger invertebrates, including insects; adults at sea feed on squid, shrimp, and fish; adults in lakes feed on freshwater crustaceans and fish

Breeding: Occurs in fresh water, usually October to January, in flowing streams with gravel bottoms; up to 40,000 eggs laid in a depression (redd), covered up, and abandoned; hatching can take several months

Status: Not known to be threatened; fishing activities are now strictly controlled

From the age of a few months to a couple of years, young salmon like this one are known as parr.

The salmons' instincts drive them to swim against this current. They overcome what would usually be impossible hurdles.

As the spawning run gets under way, the fish stop feeding. They will not feed again until they return to the sea. Gradually, the depth of color of the males increases. Their lower jaw also becomes longer, bending upward to form a distinctive hook called the "kype." Each male finds a territory and defends it against rival males.

Once they reach the spawning grounds, the females use their tails to dig out a small depression, known as a "redd," in shallow water. When this is complete, a male lines up his body alongside the female, facing the direction of the current. At this point, some eggs and sperm are released and fertilization takes place. This sequence of events is called a spawning bout. Such bouts are repeated over a period of up to two

DID YOU KNOW?

- Baby salmon, called alevins, are born with their own yolk sac that feeds them for up to six weeks.
- Some young salmon live in rivers for six years before they migrate into the sea.
- There are some populations of salmon living in lakes cut off from the sea. These landlocked salmon still keep their instincts, however. They migrate up the rivers that run into these lakes.

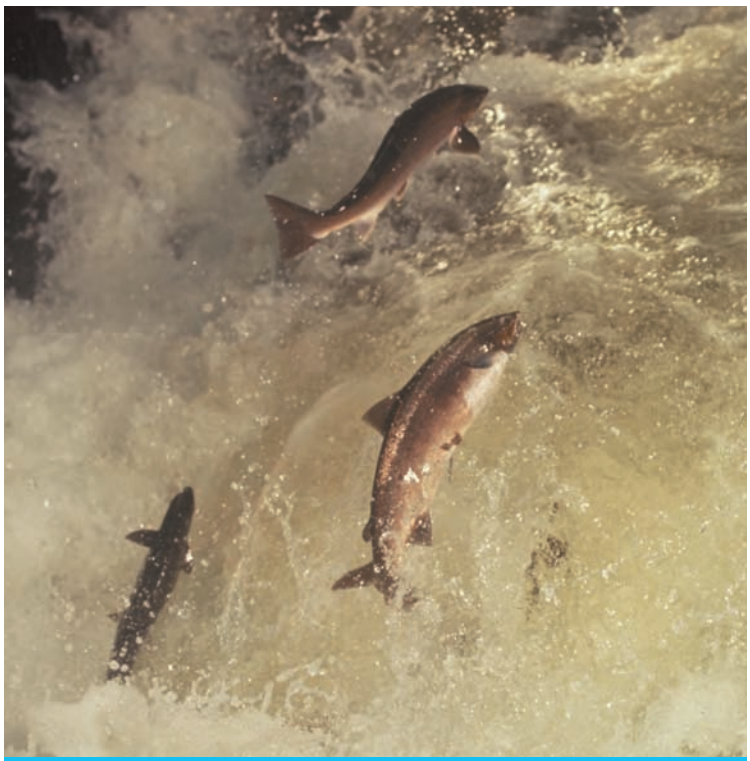
weeks. During this time, a female will lay as many as 40,000 amber-colored eggs which she covers with gravel by flapping her tail. The eggs are then abandoned and develop over the next few months before hatching out.

The Ultimate Price

Adults leave the spawning site after they have finished breeding. Many find the event so exhausting that they will soon die. The males in particular experience great stress as a result of their physical changes and constant fights with rivals, and very few make it back to the sea. A higher percentage of females survive, but they still suffer enormous losses.

In spite of everything, up to a quarter of the adults that swim upriver to spawn swim downriver again to the estuaries. However, by the time they get there, they are so weak that many more die. Studies carried out over many years show that, in some instances, as little as one per cent of the year's spawning population come back for a second season of breeding.

Remarkably, though, some salmon manage to perform their incredible spawning journey up to five times during their lifetime.



A SPAWNING MYSTERY

Salmon feed well while they are at sea, so they are fat and full of energy reserves when they gather offshore before starting their spawning run. Since the salmon then stop feeding, they must rely on their food reserves to carry them through their journey upriver, spawning, and journey back downriver. This raises a very puzzling question, however. If migrating salmon do not feed, why are so many of them caught by anglers using baited hooks at this time? If the fish are instinctively "programmed" not to eat, how is it that so many of them overcome this instinct and grab an angler's lure?

ATLANTIC TARPON

It may look nothing like an eel, but the Atlantic tarpon is related to these ancient snakelike fish. The evidence of this is to be found by looking at the tarpon's newly hatched young.

Both eels and tarpon lay eggs. These hatch out into ribbonlike larvae (young stages) known as leptocephali. The similarities between the larval phase of both these species mean that there is no doubt they are related. However, they bear little resemblance to each other when fully grown. The leptocephali, which look very different from the adults, migrate to coastal areas. There they complete their development and turn into the adult shape.

This relationship between tarpon and eels has had a long time to develop. Tarpon are known to have been around for about 130 million years, while the ancestors of today's eels have an even longer history. However, they have evolved along separate lines, ending up with their own unique characteristics.

In addition to breathing through their gills, tarpon can gulp in air at the water surface and pass it directly into their swim bladder. This acts as a lung and allows them to survive in areas where the oxygen content of the water is low. Despite this, tarpon require a lot of oxygen. Without it, they could not jump 10 feet vertically into the air, or 20 feet horizontally—something they do to escape danger.

They are able to generate great speed, and can grow very large and heavy—they weigh up to 350 pounds. They can cause serious injuries, or even death, to any human who is accidentally hit by one of these "flying" tarpons as it breaches the surface of the water.

Tarpon are hunted for food, while their silvery scales are used to make jewelry. They often form shoals in shallow water, making them easy to spot.

Fact File

ATLANTIC TARPON

Megalops atlanticus

Family: Megalopidae

Order: Elopiformes

Where do they live?: Both Atlantic coasts, mainly in tropical regions, but also swim in cooler seas

Habitat: Frequently found near coral reefs, although usually in brackish (slightly salty) or marine waters; older tarpon can be found in rivers

Size: Up to 8.2 feet (2.5 m)

Coloration: Silvery along the sides of the body; slight metallic blue along the back

Diet: Mainly fish, squid, and octopus

Breeding: Spawning occurs in shallow water; young then develop in brackish or fresh water; large females can produce as many as 12 million eggs

Status: Not known to be threatened

BARBS

Deep in a cave in Zaire lives a small, blind fish, while deep in shady forest streams in Sri Lanka lives a beautiful, cherry-colored jewel-like fish. Their whiskers tell scientists that they are cousins.

The whiskers—known as barbels—are not the only features that link the blind cave barb and the cherry barb. They share other similarities, not just between them, but with several hundred other species that form a group of mostly small fish known as barbs.

Scientists do not all agree about which fish should be called barbs. The largest barb grouping includes a wide range of species, such as the tinfoil barb, which is both an aquarium fish and a food fish, and the European barbel, which is often fished for by anglers.

Colorful Shoalers

Barbs are mostly active fish that live in shoals. Although they are not particularly aggressive, males constantly display toward each other. They show off their best colors and let each other know who is dominant, especially during the breeding season. Females are usually less colorful than males. They are also less aggressive toward each other.

Sadly, many barbs are under threat in the wild. Fortunately, though, a lot of species are popular as aquarium fish and, over the years, large numbers have been bred in captivity. This has proved so successful that numerous color and fin varieties of many species have been produced specifically for home aquariums; among them the cherry barb. At least one barb, the Odessa barb, is exclusively an aquarium fish—the species is not known to exist in the wild.

It is clear to see how the red-line torpedo barb gets its name. This attractive species lives in fast-flowing hill streams in Kerala, India.

Fact File

BARBS

Genus: *Barbus*

Subfamily: Cyprininae

Family: Cyprinidae (several hundred species)

Order: Cypriniformes

Where do they live?: Africa, Europe, and Asia

Habitat: Clear, flowing mountain rivers and streams to lowland water courses, ditches, canals, and flooded fields

Size: From about 1.2 inches (3 cm) to a maximum of 40 inches (1 m)—the size of the European barbel

Coloration: From dull greenish-brown to silvery—with or without dark bands or blotches; some with red and purple tinges; some with brightly colored fins

Diet: Plants, aquatic invertebrates, and insects; larger species may also eat small fish

Breeding: Sticky eggs are scattered among plants or over the bottom; numbers vary from a few hundred to around 50,000 in the European barbel; hatching may take as little as 1 day, or up to 15 days, depending on the species

Status: About 45 species are known to be under different levels of threat; at least 16 are critically endangered and 17 as endangered; 1 species, the short-barbeled barb, is now believed to be extinct

BARNACLES

Choosing the right place to settle is a major step for young barnacles, as they must choose a favorable spot where they can safely grow. If they make the wrong choice they will suffer, as they cannot move again.

Barnacles are marine animals, commonly found on rocks, driftwood, shells of turtles, whales, and among corals. The acorn barnacles are usually found on the middle part of the seashore. Here, they are regularly covered and uncovered by the tides which bring them food and oxygen. They have small volcano-shaped shells made of four to six plates cemented directly on the rocks. At the top is an opening guarded by more shell plates. These can be opened, and then closed tightly to keep water inside when the tide goes out. The protective shell is made of chalky calcium carbonate, which is formed by the skin.

Acorn barnacles cannot move around. They feed by pushing some of their limbs through the hole at the top of the shell and holding them out like a fine mesh basket. The basket shape is swept back and forth in the water or held still, allowing currents to sweep small food particles into it. Then the basket is pulled back and the food passed to the mouth inside the shell.

Goose Barnacles

These barnacles attach themselves to floating objects with their long stalks. They look very different from acorn barnacles. Goose barnacles got their name because they look like tiny geese. The stalk looks like the long neck of a goose and the white plates like folded wings. Once, goose barnacles were even thought to be the eggs of barnacle geese.

Acorn barnacles are cemented to the seashore rocks on which they live. The conical shape of their shells helps them withstand the force of the crashing waves.

Fact File

BARNACLES

Infraclass: Cirripedia (around 1,220 species)

Class: Maxillopoda

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Worldwide in all oceans

Habitat: In all seas and oceans at all depths, attached to rocks, shells, plants, floating objects, and other animals, such as corals, turtles, and whales; some are parasites on crabs and other creatures

Size: Maximum height a fraction of an inch to 10 inches (25 cm); maximum diameter 3 inches (8 cm)

Coloration: Shells generally white, chalky gray, or brownish

Diet: Feed on particles of animal or plant matter or detritus floating in the sea water

Breeding: Hermaphrodite; eggs are fertilized by close neighbors and develop inside the barnacles into larvae that are released into the sea; after 6 stages the final larva attaches itself to a rock and changes into an adult barnacle; live up to 10 years

Status: Not known to be threatened

BARRACUDAS

Barracudas are fast, streamlined hunters armed with fearsome teeth that can tear a victim to shreds in minutes. No wonder many people fear them even more than sharks.

Barracudas have a formidable reputation as fierce predators that hunt in packs and from which nothing is safe. However, not all barracudas are dangerous. Even species that are known to be aggressive will not usually attack without being provoked. This is very like what happens with other so-called "killers" such as piranhas and sharks.

When barracudas do attack, though, especially when they do so in numbers, they are lethal. Two species that do this are the great barracuda and the Guinean barracuda, both of which can grow to over 6 feet in length and have been known to attack humans. The former is also capable of lightning-fast bouts of speed of 36 miles per hour—that is nearly 52 feet per second!

Hunters Hunted

In sharp contrast, another giant, the Guachanche barracuda, that swims in large shoals, presents no threat to humans. Neither do most of the remaining 22 species, some of which only grow to around 12 inches in length and are themselves often regarded as prey by other larger fish.

In fact, despite being formidable hunters themselves, even large barracudas are hunted by other species of fish at different stages of their lives. Sharks, rays, dolphinfish—even large halibut (a type of flatfish)—feed on barracudas. Barracudas are also hunted by humans, who prize them as food and sport fish.

A shoal of barracudas swims over the clear waters of a reef. Although barracudas are often found in groups like this, many hunt alone.

Fact File

BARRACUDAS

Family: Sphyraenidae (25 species)

Order: Perciformes

Where do they live?: Tropical and subtropical regions of the Atlantic, Indian, and Pacific Oceans

Habitat: Usually found near the surface in open seas, as well as close to shore in harbors and lagoons; some species can descend to around 330 feet (100 m); young barracudas may enter brackish (slightly salty) water

Size: Small species, such as the yellowstripe barracuda, are around 12 inches (30 cm); largest species, such as the Guinean barracuda, grow up to 6.7 feet (2.1 m)

Coloration: Usually dark blue along the back, shading to silvery along the sides and belly; body often attractively marked with vertical bands; fins may be colored

Diet: All species feed on fish and squid; smaller species may also feed on shrimp

Breeding: Spawning usually occurs in groups in open water; eggs and sperm are released into the water; eggs are abandoned; few other details are available

Status: Not known to be threatened

BATFISH

Batfish look as if they have been half run over. The front end, just behind the head, has a flattened, almost squashed appearance, while the back end is almost round.

Such an unusual combination of body shapes hardly makes batfish look elegant or streamlined. However, over countless generations they have evolved features that suit them perfectly for their way of life. The batfish lifestyle is firmly linked to the sea floor, where they lie in wait for their meals to come to them. Batfish can swim, but do not swim well. They spend most of their time either not moving at all, or "walking" on the bottom, using their limblike pectoral (chest) fins and pelvic (hip) fins as arms and legs.

Angling Bat

Batfish are related to anglerfish and use similar hunting methods—in other words, they lie in wait to ambush their prey. Batfish sit on the bottom, against which they are perfectly camouflaged, doing nothing but breathing until they spot a suitable meal. At this point, the waiting batfish extends a "fishing rod." This consists of the specially elongated first ray of the dorsal (back) fin. At the tip of the fin is a fleshy "lure" or "bait" which the batfish vibrates in the water. The passing fish or shrimp sees the "lure" as a potential meal, makes a lunge for it, and ends up in the batfish's stomach as a meal instead.

Unusually, some batfish appear to be either right-handed or left-handed. While many extend their "fishing rod" both to the left or right, some individuals always choose one side in preference to the other.

Like most bottom-dwelling ambush predators, batfish have upward-facing mouths designed to quickly snatch prey as it swims into range above them.

Fact File

BATFISH

Family: Ogcocephalidae (62 species)

Order: Lophiiformes

Where do they live?: Found in all tropical oceans and seas

Habitat: Sea floor, usually found in deep water—down to 8,200 feet (2,500 m)—but have been reported swimming up to the surface in aquariums

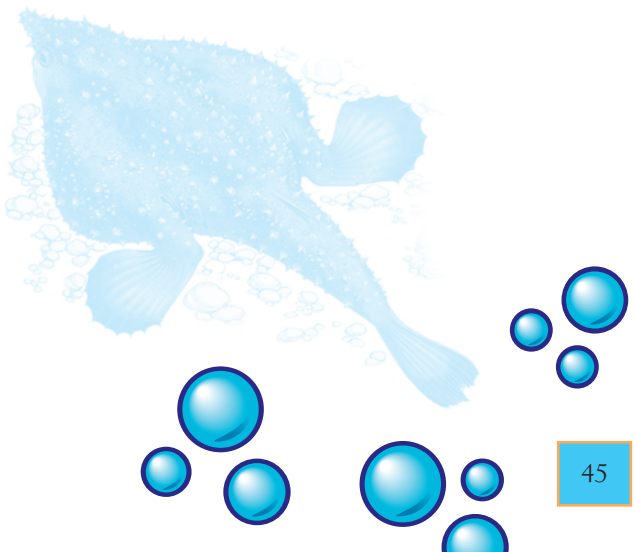
Size: Most species around 8 inches (20 cm), but the shortnose batfish grows to 14 inches (35 cm)

Coloration: Usually mottled, mainly in different shades ranging from light to dark brown

Diet: Fish and invertebrates, including crustaceans and, in some species, snails and worms

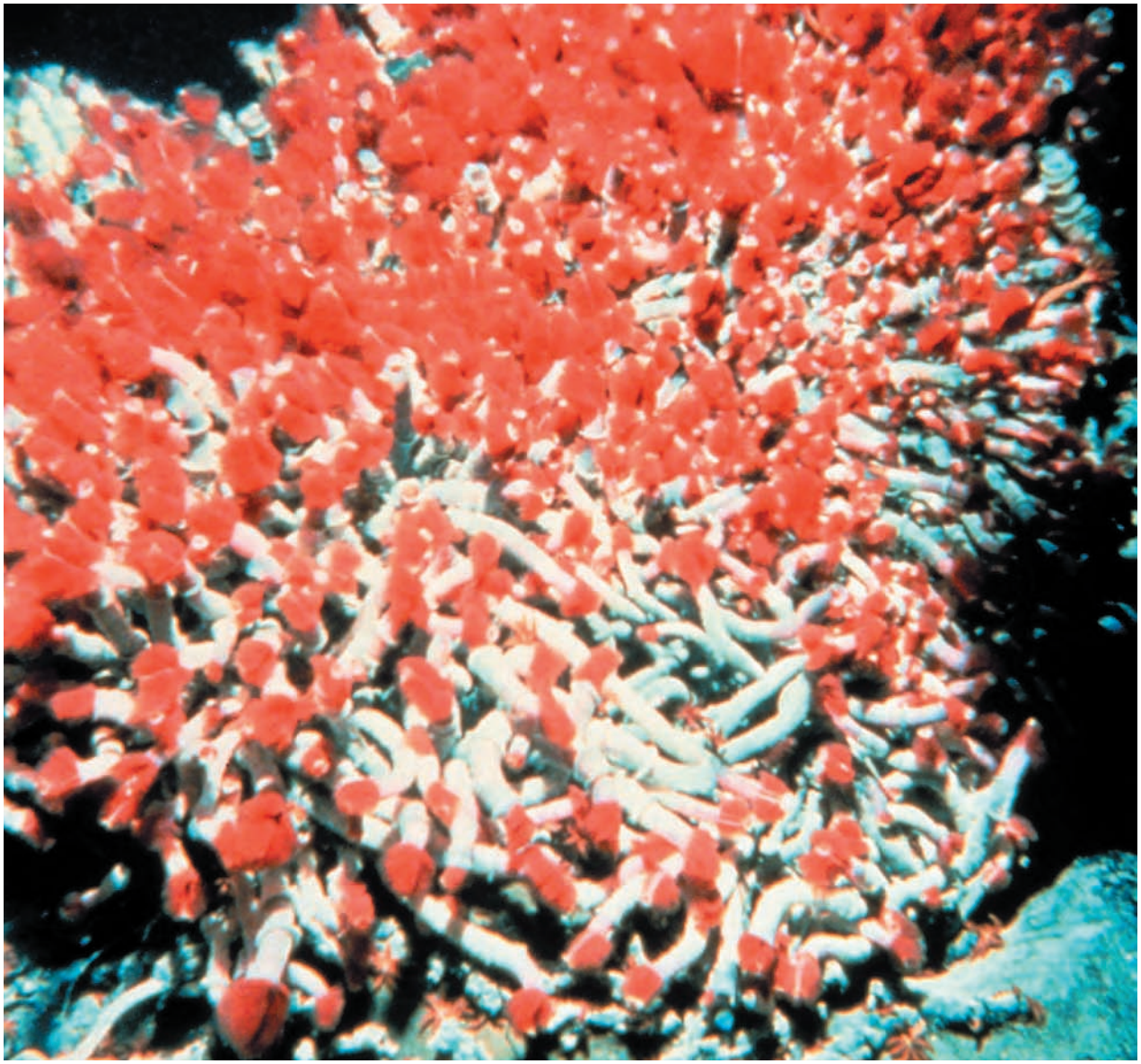
Breeding: Eggs and sperm are released into the water; larvae live in the plankton

Status: Not known to be threatened



BEARD WORMS

Beard worms live in the deep sea, often in thermal vents in the sea floor. Unlike most animals, they gain their energy from bacteria. These bacteria break down chemicals from the sea to release energy.



Sunlight never reaches the deep ocean floor, so animals living there cannot get energy from the Sun. Beard worms have solved this problem by using a chemical called hydrogen sulfide that spews into the water from underwater volcanoes. This chemical is poisonous to many animals, but beard worms can feed on it because their bodies contain special bacteria that turn the hydrogen sulfide into food for their bodies.

Unusual Bodies

Beard worms were once placed in a small group by themselves, the phylum Pogonophora. Because they are mainly small, fragile, and live in very deep water they are difficult to find. Whole animals, rather than broken parts, have only been discovered quite recently. Their bodies are encased in long, thin tubes, made from proteins like those in the outer covering of insects.

The front end of the animal itself has a "beard" made up of a number of tentacles (between 1 and 1,000) that stick out from the tube. The bottom of the tube lies buried in the seabed. Two more sections make up the body: a long, unsegmented trunk region and a shorter tail section. The tail section is very fragile and was missing from early specimens because it had broken off. Recent research has shown that the tail is made up of segments. So beard worms are really members of the large and widespread phylum Annelida—the same phylum that contains the earthworms.

This colony of beard worms lives round a thermal vent—a place where hot gases bubble into the water—1.5 miles down on the floor of the Pacific Ocean.

Fact File

BEARD WORMS

Orders: Athecanephria, Thecanephria, Vestimentifera (about 120 species known altogether)

Class: Pogonophora

Phylum: Annelida

Where do they live?: Worldwide in all oceans

Habitat: On the seabed from 330 feet (100 m) down to the deepest ocean trenches, usually part buried in mud; often near deep-sea hydrothermal vents

Size: Athecanephria and Thecanephria 2–30 inches (5–76 cm); Vestimentifera up to 6.5 feet (1.9 m)

Coloration: Tubes and worms variously colored

Diet: Organic food material absorbed from the sea water by special bacteria in the worms' bodies

Breeding: Separate sexes; males release sperm into sea water; sperm enters the female's tube and fertilizes eggs; larva develops and swims a little way from parent before settling nearby to begin adult life

Status: Not known to be threatened

BELUGA AND NARWHAL

Belugas are sometimes called white whales. Both the unusual narwhal, with its tusk like a mythical unicorn's horn, and the noisy beluga belong to the same small family (group) of toothed whales.

Narwhals and belugas are toothed whales, like dolphins and sperm whales. Belugas have thirty-two to forty teeth, but the narwhal has only two, both in the upper jaw. In male narwhals, the tooth on the left grows into an amazing spiral tusk up to 10 feet long. Males use their tusks for fighting and displaying.

Both these whales have a very thick layer of fat, called blubber, under their skin. The blubber helps them stay warm in the nearly freezing water. Healthy belugas can be so fat that their heads look too small for their bodies. Both whale species eat a lot of food. Belugas usually hunt close to the seabed for fish and shellfish. Narwhals hunt in very deep water for fish and soft invertebrates, such as squid, which they suck up and swallow whole because they have no teeth for chewing.

Whale Pods

Belugas and narwhals spend most of the year far out to sea, but large groups sometimes move close to shore in summer. Within these groups are lots of smaller groups called pods. Pods move about, so the large groups do not always have the same members. Some pods contain just males, others contain females with their offspring. A baby beluga or narwhal stays close to its mother. She produces milk for them for two or more years. In summer, belugas molt (shed) their skin. They gather in river mouths, close to melting glaciers, where the fresh water helps the old skin loosen.

Belugas use lots of different calls, such as whistles, coos, clicks, and warbles. They also communicate by moving muscles to make facial gestures.

Fact File

BELUGA AND NARWHAL

***Delpinapterus leucas* (beluga) and *Monodon monoceros* (narwhal)**

Family: Monodontidae

Order: Cetacea

Where do they live?: Far northern Pacific, Atlantic, and Arctic Oceans

Habitat: Cold seas

Size: Head–body length 10 feet–16.5 feet (3–5 m); weight 1,100–3,520 pounds (500–1,600 kg)

Coat: No fur; skin gray in young whales, fading to white in belugas and becoming mottled with white in narwhals

Diet: Fish, shellfish, and worms

Breeding: Single calf born after 14–15 months' gestation

Life span: 30–40 years

Status: Belugas are vulnerable

BICHIRS

Bichirs have a row of small fins along their backs that look like flagpoles and flags, hence their other name, the flagfish. Their pectoral (chest) fins also grow from tiny "fans."

The "flagpole and flag" arrangement is unique to bichirs and their closest relatives, the ropefish. Where other fish have one, or sometimes two, "normal" fins along the back, in bichirs each spine of the fin is separated from the others. Each carries a number of horizontal rays, creating a series of distinctive flagpoles and flags, which can number up to eighteen.

The "fans" are found in the pectoral (chest) fins that, instead of having the usual bone arrangement found in other fish, contain two flat, platelike structures that look like miniature fans. The fins grow from these fans.

Ancient Survivors

Bichirs are believed to be primitive fish with a long history. Their ancestors probably first swam in the waters of the planet 400 million years ago, but had probably become extinct by 190 million years ago. The earliest bichirs appear much later—from around 145 to 65 million years ago, so there are a few pieces of this jigsaw missing. There could still have been bichirs around earlier than this, but scientists will not know for sure unless they find their fossils.

Today's bichirs and ropefish can survive in poorly oxygenated water where other fish would struggle or die. They can do this because they have two lungs that allow them to gulp in air at the surface. In fact, bichirs have become so dependent on their lungs that they drown if they are prevented from surfacing for air.

The Congo bichir shown here is the largest species of bichir. All bichirs vary in color, depending on the food they eat and where they are found.

Fact File

BICHIRS

Family: Polypteridae (about 10 species)

Order: Polypteriformes

Where do they live?: Widespread in tropical and subtropical Africa

Habitat: Shallow water along river banks, lakes, swamps, and flooded areas, often close to vegetation; also found in waters that have low oxygen content

Size: From around 11 inches (28 cm) in the Guinea bichir up to 38 inches (97 cm) in the Congo bichir

Coloration: Dull or mottled in most species; attractive dark body markings and orange-red bands in pectoral (chest) fins in the case of the ornate bichir

Diet: Insects, aquatic invertebrates, frogs, and fish—usually taken at night

Breeding: Usually in flooded areas during the summer; 200–300 eggs are shed among vegetation and abandoned; hatching takes about 4 days; newly hatched young have external gills like frog tadpoles

Status: Not known to be threatened

BITTERLINGS

Many animals hide their eggs to keep them away from the prying eyes of predators. Bitterlings do this, but they go a fascinating step further by laying their eggs in a most unusual place.

While other fish lay their eggs among the gravel of a stream, scatter them among fine-leaved plants, or even carry them inside their own bodies, few go as far as bitterlings. These fish lay their eggs inside another animal! The unsuspecting foster parent can do nothing about this. It cannot swim away, attack the intruding bitterling, or even protect itself. It simply has to accept its fostering duties.

Two-way Relationship

During spawning, a female bitterling develops a very long and flexible egg-laying tube, while the male changes into his most brilliant breeding colors. Once he has found a suitable freshwater mussel, the male stands guard over the mollusk and defends it against rival male bitterlings. When a suitable female approaches, the pair hover over the mussel, constantly examining it closely to ensure it is suitable.

The female may then "tickle" the edge of the mussel's shell, which seems to make the mussel open slightly. As soon as the female judges that the two shells have opened enough, she inserts her egg-laying tube inside the mussel and releases some eggs. When she pulls the tube out, the male releases sperm which are sucked in by the mussel as it breathes in. This fertilizes the eggs (makes the eggs begin to develop). After spawning, the eggs develop safely inside the mussel until they are ready to hatch. Then the baby fish swim out and away.

When a bitterling lays her eggs inside a mussel, the mussel may also benefit because its own young attach to the bitterling and are spread by the fish.

Fact File

BITTERLINGS

Subfamily: Acheilognathinae (about 15 species)

Family: Cyprinidae

Order: Cypriniformes

Where do they live?: From mainland Europe to eastern Asia; some species have been introduced into countries outside their range, for example, the United States and Canada

Habitat: Ponds, lakes, and the backwaters of lowland rivers, usually with fine-grained bottoms and with vegetation

Size: Mostly between 2.4–4 inches (6–10 cm)

Coloration: Mostly olive-green on the back, with silvery sides; scales reflect several colors

Diet: Wide range of small invertebrates

Breeding: Generally occurs between April and June; females lay between 40–100 eggs which take 15–20 days to hatch inside a freshwater mussel; larvae remain inside the mussel for a few days until they use up their yolk sac

Status: Two species, the deepbody bitterling and the Tokyo bitterling, are listed as vulnerable; another, *Acheilognathus elongatus,* is listed as endangered

BLENNIES

Some blennies are among the best make-believe artists in the fish world. They look like another—harmless—species, but this is just a trick to get close enough to other fish to bite a chunk out of them.

In the struggle to eat and avoid being eaten, fish (including blennies) have evolved a vast range of survival techniques. One is the art of mimicry—that is, pretending to be something that you are not.

The sabre-toothed blenny, for example, looks almost identical to the cleaner wrasse. The cleaner wrasse is a harmless little fish that picks off parasites from other fish, relieving them of the irritation caused by the creatures. By looking like a cleaner wrasse, the blenny is able to get close to other fish. It can then bite a chunk of fin or skin from the unsuspecting victim, getting a meal for itself.

Versatile Survivors

Other blennies look like venomous species, and so they are avoided by predators. For example, the harmless Red Sea mimic blenny looks like the poisonous black-line fang blenny. Many blennies are also masters of camouflage, and blend in with the seaweeds and other growths found in the pools that these fish inhabit. This camouflage is so effective that it is easy to miss large specimens, even at close quarters.

Yet another survival technique is found among some species that live in shallow rock pools that heat up or become low in oxygen. At such times, the blennies leave these pools and hop overland to the nearest large pool where the water is cooler and has more oxygen. Such species, not surprisingly, are called rockskippers.

Many blennies have colors that help them blend in with the surroundings. More vividly colored blennies usually hide in caves and crevices for protection.

Fact File

BLENNIES

Family: Blenniidae (nearly 350 species)

Order: Perciformes

Where do they live?: Widely distributed in tropical, subtropical, and temperate Atlantic, Indian, and Pacific Oceans

Habitat: Nearly all species are marine and are found in shallow or very shallow waters; a few, such as the butterfly blenny, can be found in deep water of around 330 feet (100 m); most prefer rock pools, reefs, and rocky bottoms

Size: From under 1.2 inches (3 cm) to about 21.3 inches (54 cm); most species less than 6 inches (15 cm)

Coloration: Most species are mottled in browns and creams, but some brightly colored species also exist; some species mimic the colors of other species

Diet: Mostly algae and small invertebrates; some species have specialized diets—for example, fish scales and fins

Breeding: In some species, males will spawn with several females; eggs are laid in caves, cracks, or empty snail shells and are guarded by the male

Status: Not known to be threatened

BOWFIN

When its pond dries up, a bowfin can burrow into the mud at the bottom and go into a deep summer sleep until the rains return. This activity is known as aestivation.

The bowfin is a tough, cylinder-shaped fish that can survive conditions that few other fish can. It can even live out of water for a full day, so long as its skin does not dry out. The bowfin can do this because its swim bladder, as well as controlling buoyancy, can also function as a lung.

It has even been reported that farmers digging land that has been flooded have actually plowed up bowfins. The fish have burrowed into the mud in preparation for their summer sleep (aestivation).

Protected Young

Apart from the top rays of the caudal (tail) fin which has a faded black spot surrounded by a yellow to orange halo (known as an eyespot or ocellus), adult bowfins are rather drab-colored fish. In the young, though, the eyespot is brilliantly colored and stands out beautifully against the duller body color.

This feature is believed to give young bowfins some protection from predators that may attack the "false eye" instead of the real one, which is not brightly colored. An attack on the eyespot, while causing injury, is far less serious than losing a real eye. In time, the damaged fin will regrow, but an eye is lost forever.

Young bowfins are also protected by their fathers, which guard their many offspring for several months. This is a very advanced form of behavior for a fish that is believed to be primitive.

The skull and skeleton of a bowfin are made up of part bone and part cartilage—a feature that helps scientists conclude that this is a primitive species.

Fact File

BOWFIN

Amia calva

Family: Amiidae

Order: Amiiformes

Where do they live?: Widespread in eastern North America

Habitat: Lakes, still or slow-moving waters, including swamps; usually found near vegetation

Size: Up to 43 inches (1.1 m) in length and 9 pounds (4 kg) in weight

Coloration: Dark, drab color along the back, fading to lighter colors along the sides and belly; irregular blotches on the body; eyespot on the front top half of the caudal (tail) fin

Diet: Wide range of aquatic invertebrates taken, as well as fish, reptiles, and small mammals; young feed on plankton and aquatic insects

Breeding: Nest consisting of a matted depression built by male in spring; up to 30,000 eggs are laid; hatching takes about 10 days; male guards young for up to 4 months; young take 3–5 years to mature

Status: Not known to be threatened

BOXFISH

Boxfish have been described as cubes with holes for the eyes, mouth, and tail—and sometimes even horns. They also poison themselves on occasions, although the poison is really intended for their enemies.

When a boxfish is alarmed, it reacts by releasing a poison into the water. This is intended to deter any predator intent on making a meal out of the boxfish. However, if the poison is released in a confined space, such as a small cave, it can be powerful enough to kill some predators.

For the boxfish it is an excellent defense, allowing it to make a quick getaway while its attacker is struggling against the effects of the poison. Unfortunately for boxfish, however, it is not immune to its own poison. Therefore, if the poison is released in an aquarium (boxfish are popular aquarium fish) it can kill not just the other fish, but the boxfish as well.

Health Warning

Most people find boxfish interesting because of their vivid colors and because of their unusual shape and rigid boxlike body. The shape makes the fish swim in a style that looks "comical" to human eyes. Some species, such as the cowfish, are also attractive because they have two hornlike extensions on the forehead, above their very large eyes.

Despite their many attractions, boxfish also carry hidden dangers for humans. Some of the larger species are very tasty and are therefore fished for food in some parts of the world. Unfortunately, they have been linked with ciguatera poisoning, which is caused by eating other species whose flesh contains ciguatoxin.

A boxfish swims over a sandy reef. Boxfish are very variable in coloration—often the males and females of the same species are different colors.

Fact File

BOXFISH

Subfamilies: Aracaninae, Ostraciinae (about 37 species altogether)

Family: Ostraciidae (sometimes called Ostraciontidae)

Order: Tetraodontiformes

Where do they live?: Tropical, subtropical, and sometimes temperate regions of Atlantic, Indian, and Pacific Oceans

Habitat: Mainly shallow-water reefs; some species found in seagrass meadows or sand, rocks, or rubble; Aracaninae species prefer deeper water down to 660 feet (200 m)

Size: From 4.3–21.7 inches (11–55 cm)

Coloration: Very variable and often bright; from almost yellow all over, to green with blue spots and deep colors with light spots

Diet: Bottom-living invertebrates; some species eat seagrass as well

Breeding: In most species, a male gathers several females around him (a harem); eggs are released into the water and abandoned; hatching takes about 2 days

Status: Not known to be threatened

BUTTERFLYFISH

Today, butterflyfish are seen as beautiful reef fish both in the wild and in the aquarium. However, the first humans who set eyes on them were far more interested in how good they were to eat.

Butterflyfish are still caught for eating today, but only on a local basis and the numbers are small. Outside their home waters butterflyfish are popular not as food fish, but as aquarium fish. Their dazzling colors and body patterns, plus the unusual flitting swimming movements that have earned them their name, are the main reasons why they have become popular in aquariums all over the world.

Hidden Eyes, False Eyes, and Bony Plates

Many butterflyfish have a dark band that runs from the top of the head, through the eye and onto the chin. This band—or patch—hides the eye from view, and helps to protect it from attack.

In addition, many butterflyfish have one or more spots that look like eyes, either on their bodies or the dorsal (back) or caudal (tail) fins. These false eyes or eyespots help draw the attention of attackers away from the real eyes, also helping to protect the fish.

The development of young butterflyfish is very interesting. The eggs hatch into a larval stage known as the tholichthys stage. Tholichthys larvae are covered in tough bony plates that gradually disappear over a period of weeks or months. Juvenile butterflyfish look completely different from adults of the same species. Before scientists realized that this was the case, it was thought that there were many more species of butterflyfish than there actually are.

The golden butterflyfish, also known as the blue-cheek butterflyfish, is found in the Red Sea. It lives on reefs and grows to about 8 inches in length.

Fact File

BUTTERFLYFISH

Family: Chaetodontidae (about 128 species)

Order: Perciformes

Where do they live?: Tropical and subtropical Indo-Pacific, warm-temperate parts of the Atlantic Ocean

Habitat: Usually found at depths of less than 65 feet (20 m) on coral reefs; some species, such as the brown butterflyfish, are found at depths of about 623 feet (190 m)—or even to 650 feet (200 m) in the case of the threeband butterflyfish

Size: From around 3 inches (8 cm) to 12 inches (30 cm); most species 4.7–10 inches (12–25 cm)

Coloration: Most are brightly colored, often with vertical bands; real eye often hidden from view by a dark band or patch; false eyes common on body and dorsal and/or caudal fins; juveniles often colored differently from adults

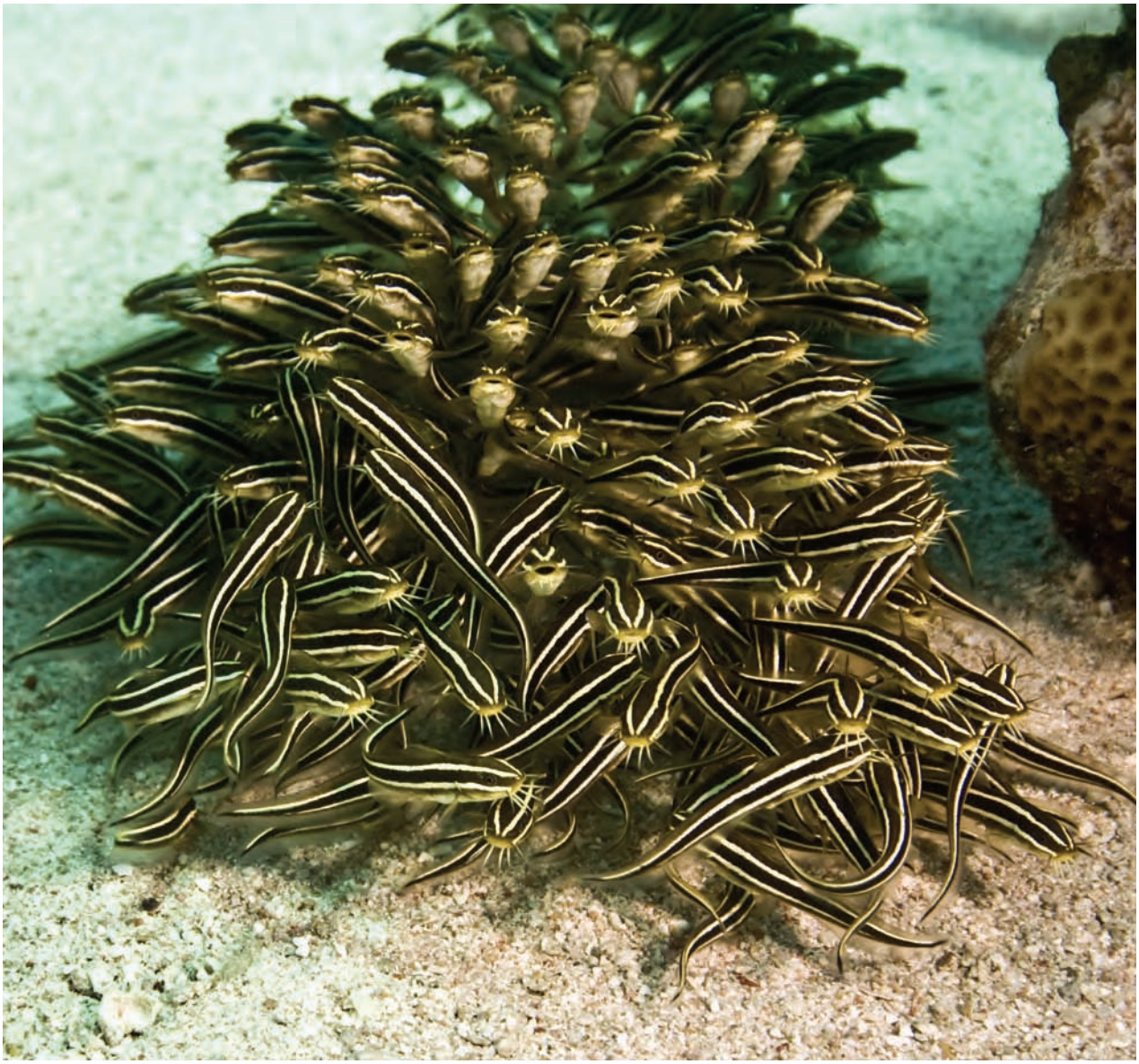
Diet: Small invertebrates and zooplankton, algae, and fish eggs; some species have very specialized diets

Breeding: Eggs and sperm released into the water and abandoned; hatching takes 18–30 hours

Status: 5 species are listed as being vulnerable

CATFISH

Catfish are fascinating creatures. Some wink, while others buzz. Some sting and can kill a human, while others drink blood. Some even use jet propulsion to move through the water.



Catfish are one of the easiest groups of fish to identify, due to their whiskers, or barbels. Most species have four pairs of whiskers. One pair is usually on the head, another on the upper jaw, and two more are on the chin. However, there are many variations.

Remarkable Sound Box

Catfish also have an unusual bony structure called the Weberian apparatus. It consists of some small bones that link the catfish's swim bladder with its inner ear. When the volume of the bladder changes, which happens when it receives sound vibrations, this information is transferred, via the bones, to the inner ear. As the sound waves are passed along, they are amplified (made louder), helping the catfish to detect sounds accurately. This is particularly useful for species that live in cloudy water where moving around, locating food, and avoiding predators can be a problem. By using the information they receive via the Weberian apparatus and the barbels, many catfish live successfully in water where there is poor visibility.

Some types of catfish can make sounds by vibrating their swim bladders. These catfish are known as croaking, talking, or squeaking catfish.

Upside-down Living

Although a few species of catfish spend all or part of their lives in midwater, most are bottom dwellers.

Coral catfish grow to about 12 inches long. They have highly venomous fin spines that can deliver a powerful sting to would-be predators.

Fact File

CATFISH

Families: 34 living families, 1 extinct family (around 2,500 species altogether)

Order: Siluriformes

Where do they live?: Widely distributed in North and South America, Asia, Africa, Australia, and Europe; there are more species in South America than elsewhere

Habitat: Wide range of freshwater habitats—rivers, lakes, swamps, and other bodies of water; some species found in the sea and in estuaries

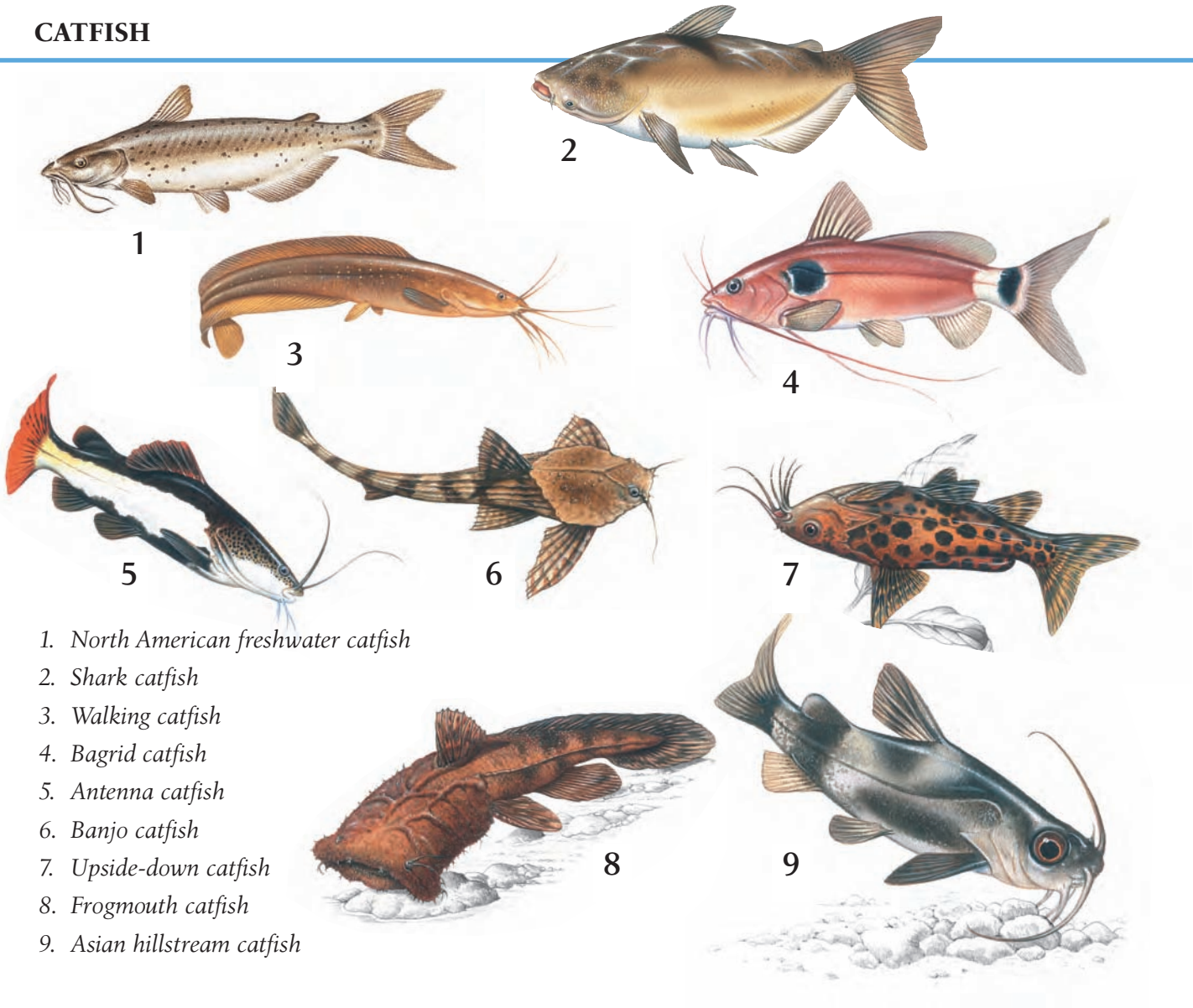
Size: From around 1.4 inches (3.5 cm) in the pygmy catfish to 10 feet (3 m) or more in the Mekong giant catfish and the wels

Coloration: Highly variable, ranging from almost transparent in the glass catfish, to jet back with a white body band in the black lancer

Diet: Wide-ranging, including plant matter, invertebrates, fish and other vertebrates, and even blood

Breeding: All catfish lay eggs that are guarded by one or both parents in many species; in a few species a parent carries the eggs in the mouth or attached to the body; in at least 2 species the eggs are cared for by cichlids—another species of fish

Status: 10 species are critically endangered, 12 are endangered, and 29 as vulnerable



1. *North American freshwater catfish*
2. *Shark catfish*
3. *Walking catfish*
4. *Bagrid catfish*
5. *Antenna catfish*
6. *Banjo catfish*
7. *Upside-down catfish*
8. *Frogmouth catfish*
9. *Asian hillstream catfish*

DID YOU KNOW?

- The skull bones of sea catfish look like a crucifix, hence one of the common names for these species: crucifix fish.
- Some catfish are bred in huge quantities as food fish, the most popular being the shark catfish and channel catfish.
- A few catfish species live deep inside caves. These have lost all their skin colors and are blind.

They have bodies adapted, or suited, to this lifestyle. Most catfish have a flat belly with which they hug the bottom. The mouth is also turned downward, so that they can feed directly off the bottom.

There are some catfish, though, that spend much of their lives swimming upside-down instead. These belong to

a family usually referred to as squeakers, squeaking catfish, or upside-down catfish. Not all members of the family perform the upside-down trick, but some spend considerable periods of time swimming on their backs.

Newly born squeakers do not flip over straight away. In fact, it may take several months before they start to swim upside-down. Once they are able to turn onto their backs, though, they can graze the underside of leaves for the algae and tiny creatures that make up their diet.

The species in which upside-down swimming is most highly developed even has its body shading reversed. Where other species have a dark back and lighter sides and belly, this squeaker has a dark belly and lighter back. In this way it is camouflaged just as well as its relatives that swim the "right" way up.

Aquatic Bees

There is a species of catfish that can buzz like a bee and sting with much greater venom. This is the coral catfish, which is also unusual in that it lives on coral reefs, while the vast majority of its relatives are found in freshwater habitats.

CUCKOO CATS

A most unusual, cuckoolike breeding method occurs in at least two species of squeaking catfish: the even-spotted synodontis and the cuckoo synodontis (shown below).

These catfish live in Lake Tanganyika, Africa, which is famous for its cichlids, a family of fish in which females hatch their eggs inside their mouths. When a pair of catfish see a pair of cichlids begin their courtship ritual, they home in on them and wait for spawning to get under way. As soon as some cichlid eggs have been laid, the catfish dive in, lay a few eggs of their own, and retreat. The female cichlid seems to ignore this intrusion and picks up the catfish eggs along with her own.
At the end of spawning, she will therefore be carrying a mixture of eggs in her mouth. From then on, she will protect them until they hatch, at which time the baby catfish swim off.

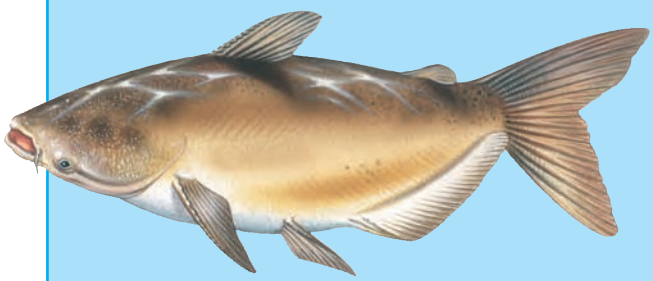
The marble highfin pleco is a popular aquarium catfish because it eats algae.

The sting from a coral catfish can be so severe that its effects can take up to six months to clear completely. Adding further danger is the fact that young coral catfish live in large shoals, with each individual carrying a powerful weapon in the form of its stout pectoral (chest) fin spines.

These shoals regularly come together to form large, tight balls of writhing bodies with each fish's head pointing toward the center. These balls move together in one direction or another as if they were a single organism. The juveniles are sometimes referred to as bumblebee catfish because of the light strips on their dark bodies, their distinctive swimming behavior and, more significantly, their ability to make buzzing sounds.

CRITICALLY ENDANGERED GIANT

The Mekong giant catfish (below) is perhaps the largest catfish in the world. A specimen caught in northern Thailand in 2005 measured 9 feet and weighed 646 pounds, and is thought to be the largest catfish on record.



The species is also one of the most endangered on the planet. The main threats come from overfishing for its flesh (its meat is believed to lead to a long, healthy and prosperous life) and its oil. The building of dams, the destruction of spawning habitats, and the build-up of sediments in its rivers as a result of deforestation also threaten its existence.

Since 1985, captive-bred giant catfish have been released into the wild, with 10,000 of these being released between 2000 and the beginning of 2008.

DID YOU KNOW?

- The airsac catfish packs enough venom in its pectoral fin spines to kill a human. It is also a bad-tempered cat!
- Baby shovelmouth catfish feed on "milk" secreted by their father from his body surface.
- The males of some suckermouth catfish carry their eggs on the underside of the back edge of the lower jaw until they hatch.

Versatile Cats

There are so many species of catfish that a wide range of interesting behaviors and features have evolved.

For example, frogmouth catfish are jet-propelled! These catfish normally lie very still on the bottom, waiting for prey and playing hard-to-see. However, when they need to make a quick escape, they gulp in water through their large mouth and clamp it shut. Then they push the water out through the gill covers with such force that they are thrust forward at great speed, escaping their attackers.

Walking catfish have modified gills that allow them to survive for long periods out of water. If their pool dries up, walking catfish leave their home and "walk" across land in search of a new home. They use the spines on their pectoral fins as limbs and wriggle their eel-like body.

Some parasitic catfish seek out victims (usually other fish), swim into their gill covers, and suck their blood. They have also been known to enter the urinary tract of humans and animals, with painful consequences!

Some armored catfish "wink." In reality, since they do not have eyelids, fish cannot truly wink. However, these catfish can roll their eyeballs downward in their sockets, perhaps to clean them. As they do this, the part of the eye which is normally visible disappears from view for a second or two, giving the impression that the fish is winking.

This red sailfin pleco shows the large, suckerlike mouth that helps it graze on its food. Note the whiskers.

CAVEFISH

There could be as few as one hundred Alabama cavefish left alive today. This makes the species the rarest fish known to science, as well as one of the most endangered.

The Alabama cavefish is teetering on the edge of extinction. One of the key reasons is because it is only found in Key Cave, which lies on the shore of manmade Pickwick Lake on the northern bank of the Tennessee River. It may have occurred in other caves in the past, but repeated searches have failed to find any of these fish. In addition, some of the other caves were flooded when Pickwick Lake was created.

Swamp Living to Cave Living

The Alabama cavefish belongs to a family of just six species. One, the swampfish, lives in swamps and other slow-flowing bodies of water. The springfish lives in springs. Both these species are only part-time cave dwellers, and have fully formed eyes.

The remaining four species are all true blind cavefish with tiny eyes that are covered with skin. They spend their entire lives underground and are found in cave rivers and pools which usually arise from springs. This is an important factor because it means that the waters in which these fish live receive little or no water flow from above-ground water courses.

To protect the Alabama cavefish, the Tennessee Valley Authority has fenced off the two Key Cave entrances and is constantly monitoring the quality of the water. It is also important to maintain the health of the cave's bat population, since their droppings provide the basis for the cave's food chain.

This blind cavefish is known as the Mexican tetra. It grows up to 3.5 inches long, and is found in Arizona, New Mexico, Texas, Mexico, and Panama.

Fact File

CAVEFISH

Family: Amblyopsidae (6 species)

Order: Percopsiformes

Where do they live?: Limestone regions of southeastern United States, particularly the Mississippi basin

Habitat: Springs, swamps, and caves

Size: Up to 5 inches (13 cm)

Coloration: Swampfish and springfish are brownish on the back and sides, with a light belly; all other species are pale pink

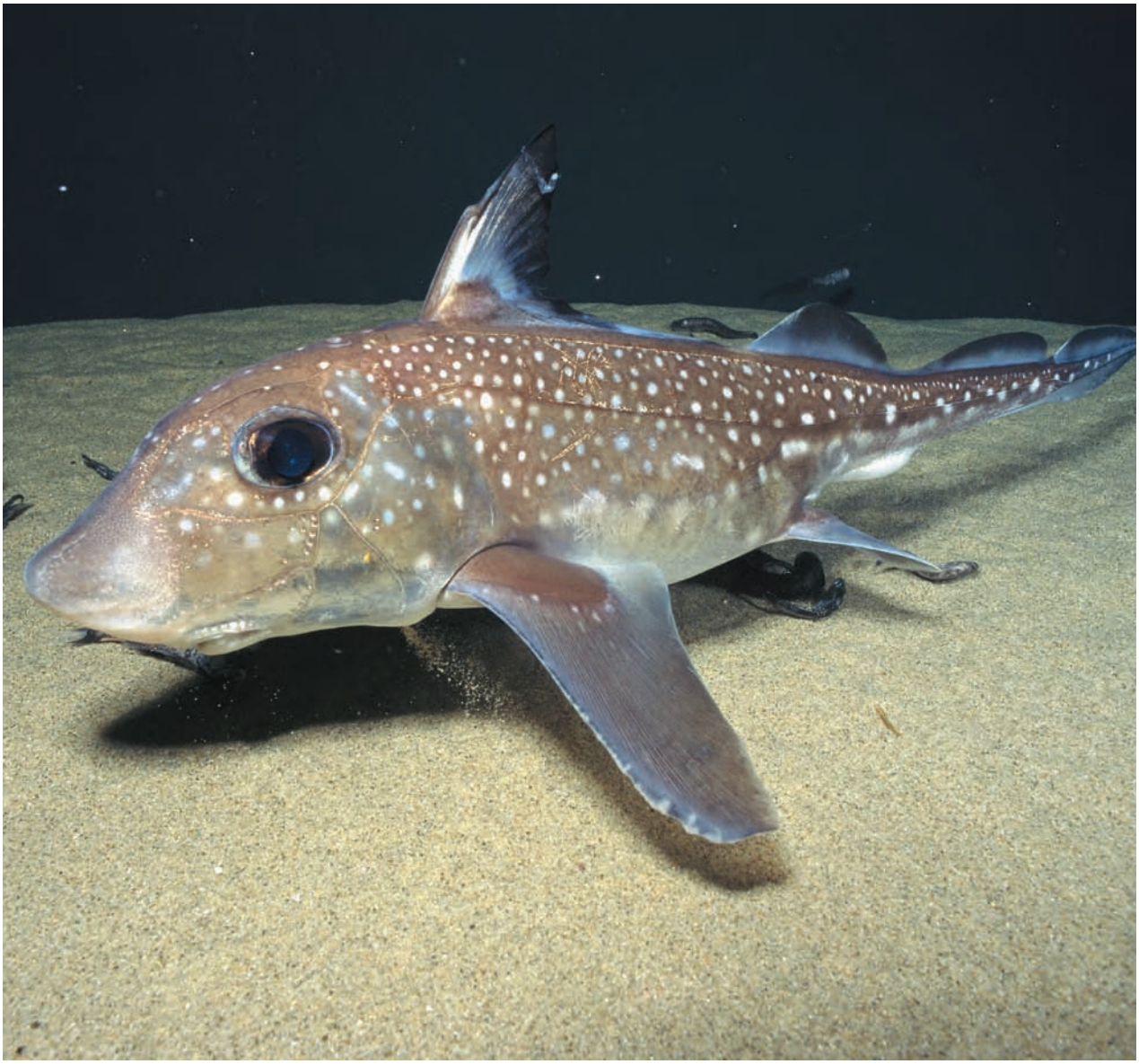
Diet: Small invertebrates, such as insects, spiders, small crustaceans

Breeding: Little is known; cave species appear to brood eggs and newly hatched larvae in their gill chambers

Status: Ozark cavefish, northern cavefish, and southern cavefish are listed as vulnerable; Alabama cavefish is listed as critically endangered

CHIMAERAS

Chimaeras are named after a mythical Greek she-monster which had the head of a lion, combined with the tail of a dragon or a serpent, and the body of a goat.



While chimaeras are obviously not a mixture of these animals, there is no doubt that they are odd-looking fish. Because they look a little like sharks, they are also sometimes called ghost sharks.

Unlike most sharks, however, chimaeras are weak swimmers, especially since they do not possess a "normal" fish tail. The most powerful fins in these fish are the pectorals (chest fins), which are shaped like fans. They use their fins to propel themselves along.

Special Features

Chimaera teeth grow throughout the fish's life, as they do in rodents such as rats and rabbits. There are three pairs of teeth that also look a little like those found in rodents, giving rise to the other common names, ratfish and rabbitfish. The teeth are fused together to form three crushing plates, one in the lower jaw and two in the upper jaw. These teeth are very tough and are used to crush the shells of the creatures that form their diet.

Chimaeras tend to be found in deep, cold water where light levels are very low. They cope with these conditions by having very large eyes. They can also track down food by smell and by using special sensory organs to detect their prey's electrical impulses.

One of the most unusual features of chimaeras is that while other fish breathe by taking in water through their mouth and passing it over their gills, chimaeras actually breathe in through their nostrils!

The white-spotted ratfish occurs off the western coast of North America from Alaska to California. It lives close to the bottom, feeding on fish and crustaceans.

Fact File

CHIMAERAS

Families: Chimaeridae, Rhinochimaeridae, Callorhynchidae (about 35 species altogether)

Order: Chimaeriformes

Where do they live?: Subarctic, subantarctic, temperate, and tropical seas

Habitat: Mainly in cold waters down to a depth of over 8,500 feet (2,600 m)

Size: From 24 inches (61 cm) to 8 feet (2.2 m) in the purple chimaera and Atlantic ratfish

Coloration: Most species are silvery-gray, but the purple chimaera is a purplish-plum color, while the white-spotted ratfish has numerous light spots on a light-brown body

Diet: Crustaceans, mollusks, worms, other invertebrates, and small fish

Breeding: Males introduce sperm into the females by means of special structures called claspers; egg-laying can take up to 30 hours; female carries the eggs for 4–6 days before releasing them; they may take up to 1 year to hatch

Status: No species are believed to be under serious threat, although current fishing levels for the Atlantic rabbitfish, the large-eyed rabbitfish, and Ogilby's ghostshark has resulted in these species being listed as near threatened

CICHLIDS

Unlikely though it may seem, some cichlids can actually remove snails from their shells before swallowing them. Others can make females "cough up" their babies—and then they eat them.

Cichlids form one of the largest and most varied families of freshwater fish known to science. Some are as small as a paperclip, and others are as large as a small shark. Some are circular, like a dinner plate, and others are thin, like a pencil.

Despite the wide range of sizes, shapes, colors, and behaviors found in cichlids, there is one unusual feature that is common to them all. While the vast majority of fish have two nostrils on each side of the head, cichlids have just one nostril on each side. Nevertheless, they still have a keen sense of smell—they just manage with half the number of nose openings of other fish. If they did not have a single nostril, it would be difficult to accept that some of the fish known as cichlids actually belong to this family.

Egg Protectors

Cichlid species have evolved some very clever ways of protecting their eggs and young from predators.

Many species stick their eggs to a leaf, a branch, a stone, or the roof of a cave. Sometimes they lay them in a pit. Some even use an empty snail shell as a "cave." In all these species, one or both parents then stand guard over their eggs and newly hatched young. These particular species are known as substrate spawners.

In others, protection is taken further. Spawning takes place in a shallow pit dug by the male, just as in many other cichlids. However, this pit does not act as a nest.

The Tanganyika frontosa is found in Africa's Lake Tanganyika. This is an adult fish, as can be seen by the cranial hump at the front of its head.

Fact File

CICHLIDS

Family: Cichlidae (probably well over 2,000 species)

Order: Perciformes

Where do they live?: Central and South America, southern United States, West Indies, tropical Africa (including rift lakes), Madagascar, India, Sri Lanka, Syria, Israel, and Iran

Habitat: From shallow, shaded forest streams and deep wide rivers, to estuaries, marshes, lakes, and backwaters; some species also live in brackish waters

Size: From around 1.5 inches (3.5 cm), to about 36 inches (90 cm) in the case of the Tanganyikan giant cichlid

Coloration: Very variable; males are usually more colorful than females; some African rift lake species have almost identical coloration

Diet: Most feed on a wide range of animals; many also feed on plants; some graze algae and micro-organisms; a few species feed on the scales or eyes of other fish

Breeding: All species protect their eggs and young; eggs are either laid on a surface or carried inside the mouth of the female

Status: Most species are abundant, but many of those in Lake Victoria face extinction owing to the introduction of the Nile perch

The kribensis or purple cichlid is a small species found in the rivers of Nigeria, Africa. Unusually among fish, the females of this species are more colorful than the males.

Instead, it is merely a spawning site. As the eggs are laid, the female carefully picks them up in her mouth and, when spawning has been completed, she swims off with the whole batch safely tucked away. She will keep these eggs inside her mouth until they hatch out. When they are ready to hatch, she releases her babies into the water, but continues to watch over them carefully. She takes them back into her mouth at the first sign of danger. These species are known as mouthbrooders.

DID YOU KNOW?

- The males and females of some species enter into a trial of strength to determine if they are suited to each other.
- In the blue gold-tip cichlid, females congregate in large shoals and use a "safety in numbers" strategy, releasing their babies from their mouths at the same time.
- In Lake Tanganyika there are some "hopping" species that look and move more like gobies than cichlids, and are therefore known as goby cichlids.

Freshwater "Coral Reef" Fish

Many cichlids are brightly colored, none more so that those found in the great rift lakes of Africa. Among these, the rock-dwelling cichlids, or mbuna, of Lake Malawi, are the freshwater equivalents of the colorful coral reef fish found in tropical seas.

The African rift lakes are true inland seas because they are so large

and deep. Lake Tanganyika, for instance, is nearly 430 miles long, 85 miles wide, and 4,800 feet deep. Lake Malawi is 350 miles long, 50 miles wide, and 2,300 feet deep. Lake Victoria is the shallowest, but is the one with the largest surface area of all. It is 200 miles long, 185 miles wide, and 145 feet deep. Only two other inland seas are larger than Lake Victoria: Lake Superior and the Caspian Sea.

Such large bodies of water are extremely rich in fish species and have many different habitats for them to occupy. The lakes are also virtually cut off from the outside world. As a result, the species that live there have evolved their own unique characteristics. These fish are termed

The jaguar cichlid is an aggressive, predatory species.

MILK-DRINKING BABY CICHLIDS

Although cichlids guard their eggs and young, four species go an important step further by feeding their babies on "milk." Discus, angelfish, pike cichlids, and uarus live in waters that have very few of the microscopic creatures that fry (baby fish) normally feed on. "Milk"—which is a special type of body mucus rich in nutrients (food)—therefore provides them with a solution to this problem.

"Milk" production begins when the eggs hatch out. The fry begin to feed on it (see right) as soon as they use up the yolk sacs with which they are born.

The "milk" is such a rich source of food that the young grow quickly on it and soon become independent.

The African moorii cichlid is one of several species that carry the developing eggs in the mouth until they are ready to hatch.

"endemic"—in other words, they are not found anywhere else.

Nile Perch Disaster

Sadly, a great many of the cichlids that are endemic to Lake Victoria have been wiped out. This loss of cichlids was caused by the introduction of a large predatory fish, the Nile perch, into the lake in the 1950s and 1960s. The Nile perch was introduced as a source of food for the people who live by the lake. However, it ate huge numbers of the cichlids in the lake—possibly as many as 50–90 percent of them according to some sources.

As the stocks of cichlids dwindled, the Nile perch found other foods, such as shrimp, other fish, and even its own young. Eventually, a balance was achieved between the various species living in the lake.

Unfortunately, part of the cost of reaching this balance in Lake Victoria

DID YOU KNOW?

- The Mozambique mouthbrooder has been introduced into many countries as a food fish but has spread to the extent that it is now considered a pest in certain areas.
- Most cichlids have brown-tipped teeth which look as if they have been stained by the water or the food they eat—although this is not the case.
- Some African rift lake cichlids feed on fish scales and fish eyes!

EGG DUMMIES

Mouthbrooding cichlids lay only a small number of eggs, which must be fertilized. Unless this happens, the female will simply brood a mouthful of eggs that will never develop. The solution is both simple and effective. Males have one or more spots that look like eggs on their anal (belly) fin (shown above). Every time the female releases a few eggs, she turns round and picks them up in her mouth. She also tries to pick up the false eggs on the male's anal fin. This stimulates the male to release sperm, which the female also sucks in. This fertilizes the eggs she is already carrying in her mouth.

has been the extinction of many species, including the cichlids.

Popular Aquarium Fish

Because such a wide range of attractive species is available, cichlids have been popular aquarium fish for over a hundred years. At first, all of them were collected from the wild. However, it soon became obvious that many species could be bred easily in aquariums. Therefore, very soon, the percentage of captive-bred cichlids increased dramatically.

It was also noted that some species appeared in different color and fin varieties. These were selected and developed further, and the popularity of cichlids rocketed. Two types of cichlid, angelfish and discus, proved to be the best species for producing different varieties. As a result, numerous variations of both these fish are available, and far fewer are now collected from the wild.

The same techniques have been applied to other types of cichlids, such as the African rift lake species. However, these fish are so spectacular and variable anyway that they have not been developed to the same extent as angelfish and discus.

The red flower horn is a hybrid cichlid created by mating several other types of cichlid together.

CLOWN LOACH

Like all animals, fish spend some of their life sleeping. However, no other fish sleep in quite the same way as the clown loach and its close relatives; they take their naps lying on their sides on the bottom.

The clown loach's unusual sleeping habit was totally unknown until an aquarist spotted it in one of his own fish. The clown loach was lying on its side, hardly breathing, and looking as if it was close to death. However, as soon as the clown loach was disturbed, it simply "got up" and swam away in typical fashion—at lightning-fast speed. Since then, this unusual behavior has been well documented.

Popular Clowns

The clown loach is collected in large numbers from the wild. Young specimens are collected mainly for home aquariums, since the species is very popular due to its attractive colors. Larger specimens are taken for food.

Despite this, the species is still abundant in its native rivers. The two main reasons for this are the fact that the young are only collected after the spawning season, and also the fact that the fish produce vast numbers of offspring. Furthermore, the island of Sumatra, where the fish is found, bans the export of specimens larger than 4 inches, protecting future breeding populations.

In any case, there is little demand for these larger specimens from aquarists because they prefer the brightly marked juveniles. As they grow, the bold black and orange/yellowish bands become less well defined, making the adults less attractive. Therefore, through a combination of factors, breeding populations of clown loach are protected from collectors.

Although the clown loach has vivid body markings, they help break up the fish's shape. This gives effective camouflage, not least when the fish is sleeping.

Fact File

CLOWN LOACH

Chromobotia macracanthus

Subfamily: Botiinae

Family: Cobitidae

Order: Cypriniformes

Where do they live?: Islands of Kalimantan (Borneo) and Sumatra (Indonesia)

Habitat: Flowing waters; mainly found in rivers whose waters are brown due to sediment, or black due to rotting vegetation giving off a dark substance called tannin

Size: Up to 16 inches (40 cm) but usually smaller

Coloration: Orange base color with three broad black bands, the first of which passes from the top of the head, through the eye, to the chin; pectoral (chest), pelvic (hip), and caudal (tail) fins reddish

Diet: Mainly bottom-living invertebrates, particularly worms; may also eat some plant matter

Breeding: Little is known; upriver migration occurs just before the wet season; spawns in fast-flowing water; eggs are probably hidden under rocks

Status: Not known to be threatened

COCKLES AND CLAMS

These are bivalve mollusks that burrow in sand or drill into soft rock. Many are edible and are sold for food. Some were introduced to Europe from America when they were thrown from the kitchens of ocean liners.

About twelve families make up this major grouping of burrowing bivalves. Bivalves are mollusks whose bodies are encased within two shells, or valves, joined by a fleshy ligament. The shells are hinged together so that they can open and close. The hinge itself is formed from teeth on each valve that fit together, like the hinge on a box or a door. When the muscles used for closing the shell pull the valves together, the ligament is compressed (made smaller). When the muscles relax, the springy nature of the ligament forces the valves apart so they open. The shape and the way the hinge works is important in determining the family in which the animal is placed.

Valuable Shells

All these bivalves can burrow in sands and muds. They live partially or totally below the surface. In the northeastern United States, clams are divided into two groups. Soft-shelled clams, some of which are called steamers, grow in muddy, flat coastal areas. Hard-shelled clams live in sandy bays and along sandy beaches. Hard-shelled clams are also known by the American Indian name *quahogs*.

Clams and cockles are important as food in North America, Europe, and Asia. Clams are used for making foods such as soups, pies, and fritters. In northern Europe the common cockle and the razor shell are highly regarded as food items.

This is a giant clam in the Indian Ocean. They can grow to more than 4 feet across. This particular animal's inner tissues are mainly blue.

Fact File

COCKLES AND CLAMS

Burrowing bivalves: Lucines, hatchet shells, astartes, cockles, Venus shells, carpet shells, razor shells, giant clams, soft-shelled clams, hard-shelled clams, jewel box shells, wedge shells, and piddocks (up to 20,000 species altogether)

Order: Eulamellibranchia

Class: Bivalvia

Phylum: Mollusca

Where do they live?: Worldwide in all seas and oceans

Habitat: Sandy and muddy seashores and seabeds

Size: From 0.04 inches (1 mm) to 4.3 feet (1.3 m) in the case of giant clams

Coloration: Various; often beautifully patterned

Diet: Organic particles sieved from suspension in sea water or deposits on sand

Breeding: Hermaphrodite (have both male and female sex organs); release sperm and eggs into sea water (via siphons) where fertilization occurs; a larva develops which swims as part of the plankton before settling on the seabed to become a juvenile

Status: Varies between species, in most cases not known; a few, such as some giant clams, are vulnerable

Empty common cockle shells are a familiar sight on many beaches.

Collecting them has become an important occupation in some regions. In the Mediterranean region, these shells are the basis of many delicious seafood dishes.

Despite the abundance of sandy and muddy seabeds, many animals are unable to live on them because there is nothing to which they can attach themselves. However, burrowing in sand and mud opens up huge opportunities. There is space, food is abundant, and predators are few. Different bivalve families have exploited these conditions. They have developed structures that allow them to burrow while keeping in contact with water. This means they can absorb dissolved oxygen and food particles. The outer skin of the bivalve, called the mantle, encloses its body. It also produces the shells and ligament. At certain points, where the mantle edge forms two openings, these develop as tubes or siphons. One draws in sea water (the inhalent siphon) and the other pumps it out (the exhalent siphon). Inside the mantle cavity are the gills and the foot. The foot is an efficient digging device. Some bivalves can dig very fast.

A file clam, with valves open, explores the seabed with its sensory tentacles.

Long and Short Siphons

Hatchet shells do not have extendible siphons. Instead, the animals use their foot to make a temporary inhalent siphon in the sand to get a supply of oxygen and food. Cockles have short siphons. They live partly buried, and their short foot holds them in position. The tellins, which are moderate burrowers, have two well-formed, separate siphons. The inhalent siphon curves out over the surface of the sand to vacuum up

DID YOU KNOW?

- Some very small bivalves live attached to the spines of burrowing sea urchins. They get protection from the spines.
- The outer surface of a bivalve shell is marked with rings, indicating periods when the animal is growing.
- Some bivalves, like shipworms, burrow into wood; others, such as date mussels, drill into rocks.

dead matter lying on the surface. The mollusk uses this dead matter as food. The clams and the razor shells are deep burrowers. They have long paired siphons that allow the animals to live deep below the surface of the sand. Their well-developed feet allow them to burrow fast.

Gills for Breathing and Feeding

The gills inside the mantle cavities of these bivalves are covered with tiny hairlike structures called cilia that pump water in and out. The stream of water carries dissolved oxygen and food particles in from the sea. Suitable particles are filtered out and passed to the mouth as food. Because this system is so efficient, enormous numbers of bivalves can be found living in marine sands and muds.

GIANT CLAMS

Despite adventure stories, divers cannot get trapped by the closing shells of a giant clam—the shells do not close completely. These bivalves lie with their scalloped shells opening upward, exposing their colored mantle edges to the light. Their bodies contain tiny plantlike algae that produce the bright vivid colors seen in giant clams. The algae get food debris from the clam, and in return the algae produce sugars by photosynthesis, some of which are passed on to the clam as food. The rest of the clam's food comes from filtering sea water. Giant clams live in shallow water on reefs down to a depth of about 65 feet if there is enough sunlight.

COD AND HADDOCK

Huge numbers of these important fish have been caught for food over the centuries. But now, in some areas, they have become scarce. This is largely because of overfishing.

Cod and haddock are similar in appearance, but their jaw structure is different. This means that the two species do not compete with each other for the same food. Haddock have very short lower jaws, so they can pick up worms and other creatures very easily from the seabed. The upper and lower jaws of cod are of similar length. They pursue their prey, grabbing it above the floor of the ocean. They can even suck food directly into their mouths simply by opening their jaws, because water rushes in. Unlike haddock, cod also have a single projection under their lower jaw. This is known as a barbel, and it helps the cod to detect food items by feeling them.

Building Up Numbers

Although cod populations in particular have fallen significantly, there is hope that their numbers will recover thanks to conservation measures, such as catching fewer cod in the North Sea. The recovery will be helped by the fact that cod are prolific breeders. A single female cod may produce as many as 60 million eggs in a single season. Larger, older females produce more eggs than those breeding for the first time.

Nevertheless, in areas where the population of these fish is declining, the survivors are breeding at an earlier age. This means that if they are protected by restricting fishing catches, their numbers will increase more quickly than in the past.

This Atlantic cod has a barbel, or whisker, beneath its chin. The smaller haddock has less rounded fins and a dark mark above the pectoral (chest) fin.

Fact File

COD AND HADDOCK

***Gadus morhua* (cod) and *Melanogrammus aeglefinus* (haddock)**

Family: Gadidae

Order: Gadiformes

Where do they live?: North Atlantic Ocean from the coast of North America across to Europe

Habitat: Near the floor of the oceans

Size: Atlantic cod typically reach up to 4 feet (1.2 m) or so and weigh 25 pounds (11.3 kg); haddock usually grow to about half this size, and are around 10 pounds (4.5 kg) in weight

Coloration: Varies depending on the area where the fish originate—cod from the area of Newfoundland are olive-green with golden or orange spots and a white belly, whereas those from Icelandic waters are brown with yellow spots

Diet: Worms and other marine invertebrates, and even other fish

Breeding: Lays eggs in spring; these become adult at 2–4 years old

Status: Atlantic cod are vulnerable; other species vary from stable to critically endangered

COELACANTH

A survivor from before the age of the dinosaurs, the coelacanth has existed in the fossil record for some 400 million years, and has changed very little during this time.

What makes the coelacanth even more unique is the fact that it was believed to have died out during the Cretaceous Period, about 140 million years ago. No later fossils of coelacanths have been found. When a strange-looking fish was hauled up off the coast of Africa in 1938, and turned out to be a living coelacanth, it was therefore an incredible discovery.

Most of these fish have been found in the deep waters of the Comoro Archipelago, off the southeastern coast of Africa. In 2000, another group of these primitive fish was discovered within the St. Lucia Marine Reserve, off the KwaZulu-Natal coast in South Africa. Previously, in 1997, a scientist had spotted a coelacanth in a local market in north Sulawesi, Indonesia. This was over 6,200 miles away from the first discovery, and the two fish are now known to be separate species, with distinct coloration.

Breeding Habits

Most fish produce eggs which they scatter randomly in the ocean. One of the most unusual features of the coelacanth's biology is that the eggs develop internally. Fish that do this are known as livebearers. Females have been discovered with as many as 19 mature eggs in their bodies. However, no-one knows how long it takes until the young are born. The eggs themselves measure some 3.5 inches in diameter, making them the largest eggs known in fish.

Coelacanths brought to the surface did not normally survive, but now a way has been found to release these fish safely back into the depths alive.

Fact File

COELACANTH

Latimeria chalumnae* and *Latimeria menadoensis

Family: Latimeridae

Order: Coelacanthiformes

Where do they live?: Off the southeastern coast of Africa and the Comoro Archipelago, as well as the area of sea off northern Sulawesi, Indonesia

Habitat: Deep water, down to depths of 330 feet (100 m), often in underwater canyons

Size: Up to 6 feet (1.8 m); weight up to 210 pounds (95 kg)

Coloration: African coelacanths (*Latimeria chalumnae*) are metallic blue with silver markings; those from Sulawesi (*Latimeria menadoensis*) are brown with gold flecks

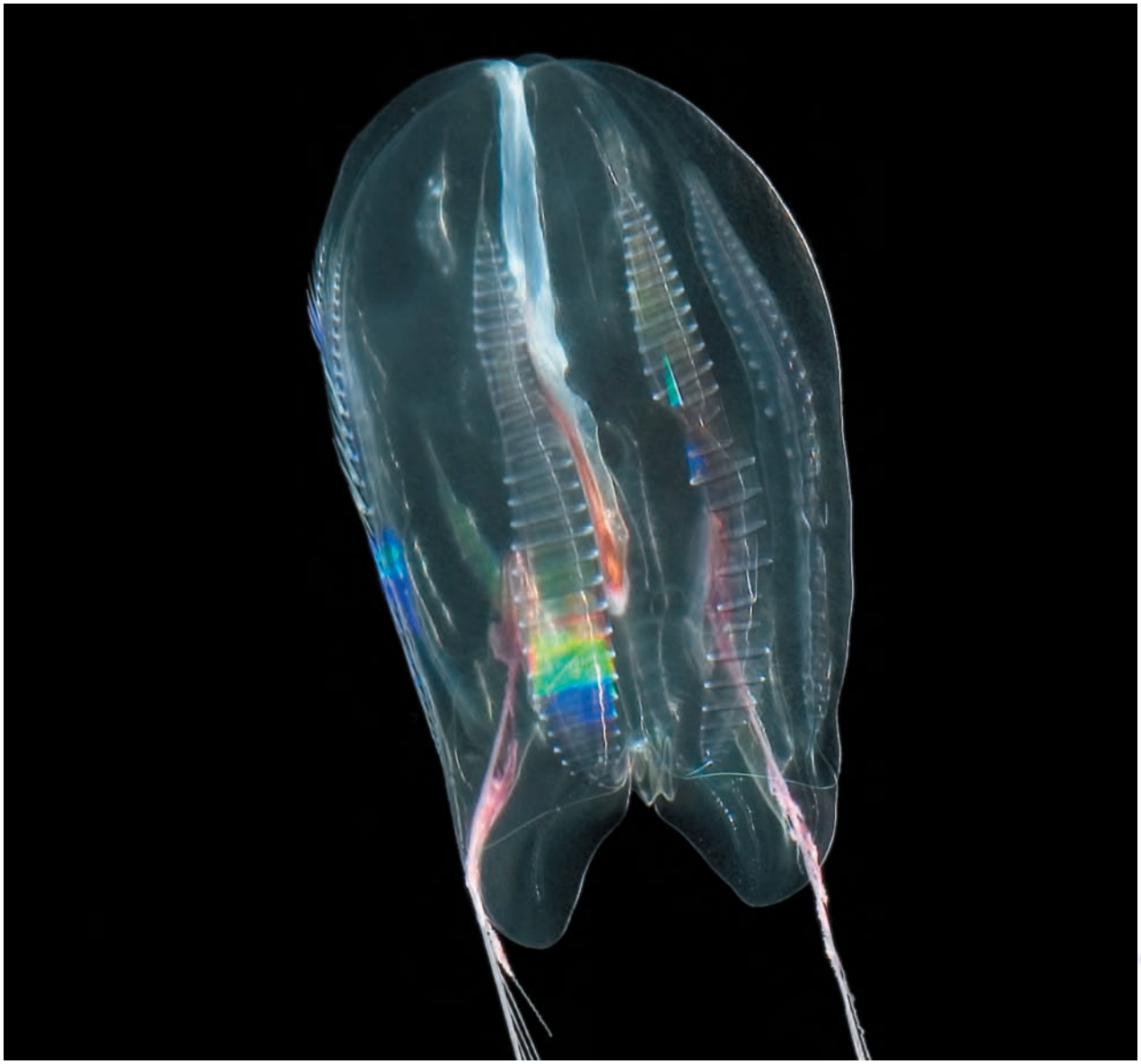
Diet: Smaller fish

Breeding: Produce live young; eggs weigh 10.6–12.4 ounces (300–350 g) and develop in the female's oviduct, which acts as a womb; young grow to at least 12 inches (30 cm) before birth

Status: Small populations; numbers unclear; classed as endangered

COMB JELLIES

Mysterious and beautiful, these little-known animals trap their prey as they drift in the surface waters of the sea. Some use elaborate fishing lines and some give off an eerie light in the dark waters.



These animals must not be confused with jellyfish. Comb jellies' bodies are not umbrella-shaped and they lack stinging cells. Most have oval or rounded transparent, jellylike bodies, but a few are ribbon-shaped. They are predators. Those that "fish" release their two tentacles (fishing lines) from pouches, one on either side of the body, and trail them in the water. Plankton is caught by special sticky cells on the lines which are then hauled in. Captured food is passed to the mouth on the underside of the comb jelly's body. The mouth leads to a series of digestive canals that end in minute pores on the top of the body. Comb jellies that lack fishing lines depend on chance collisions with their prey as they move through the water.

Flashing Lights

Eight rows of beating, hairlike cilia are arranged around the animal, running from top to bottom. In each row these cilia are formed into "combs," where the "teeth" are cilia and the back of the comb is hinged to the outside of the animal. All the cilia move together on each comb as it beats back and forth. Each of the eight comb rows has many combs, and when they all beat together they propel the animal through the water.

In the pitch-black ocean depths, where no daylight penetrates, comb jellies may give off pulses (flashes) of greenish or bluish light. These are probably used to frighten away predators.

In this sea gooseberry (shown magnified), many of the eight comb rows can be seen. The beating of the comb rows is controlled by nerves under the skin.

Fact File

COMB JELLIES (including sea gooseberries and sea walnuts)

Classes: Tentaculata (with tentacles or fishing lines), Nuda (without tentacles or fishing lines); about 200 species altogether

Phylum: Ctenophora

Where do they live?: Worldwide in all seas and oceans

Habitat: On the surface, mid-water, and near the seabed (one group lives on the seabed)

Size: From 0.2–40 inches (4 mm–1 m)

Coloration: Transparent, colorless to pinkish white, sometimes with whitish internal structures

Diet: Microscopic plankton, especially crustaceans, and some larger sluggish animals such as slow-swimming fish

Breeding: Sexual reproduction with hermaphrodite adults; release sperm and eggs into sea water where fertilization occurs and a swimming larva is formed; this develops into an adult

Status: Not known

COMMON CARP

These carp are now found worldwide. They are still a very popular food fish in some countries, and are also much sought after by anglers. The ornamental form of the common carp is widely kept in ponds.

Common carp were originally found in central Asia, to the east of the Caspian Sea, but they started to spread into China and also westward into Europe. The Romans then began to move these fish from the River Danube into other parts of Europe, where they were kept for food. This trend continued, and in Britain common carp were kept in "stewponds" in the grounds of monasteries, providing food for monks and their visitors. Today, carp are still a favorite fish for the table, especially in parts of eastern Europe, where they are often eaten at Christmas.

These fish are also popular with anglers, and fishing lakes and reservoirs are often stocked with carp. Large carp have big appetites, however. They can damage the local environment by eating their way through the aquatic plants and destroying the habitats of many other species as a result.

Feeding Habits

Common carp have small projections called barbels on each side of the mouth. These are sense organs that help the fish to locate food. Carp dig up the bottom with their jaws, searching for worms and other food. This can make the water muddy, so the barbels are vital in helping them to locate food in such conditions. Common carp are naturally bottom-feeders, and usually gather in the depths. They live in groups and may swim together, but do not form organized shoals.

Basking common carp are often seen at the surface. However, they mainly feed on the bottom, hunting out food items using their sensitive barbels.

Fact File

COMMON CARP

Cyprinus carpio

Family: Cyprinidae

Order: Cypriniformes

Where do they live?: Originally from central Asia, now found in most parts of the world

Habitat: Typically bigger, slow-flowing areas of water or large lakes; occasionally even in slightly salty waters; preferred temperature range is 37–95°F (3–35°C)

Size: Can grow up to 4 feet (1.2 m) or more in length and weigh around 82 pounds (37.3 kg)

Coloration: Greenish-brown, becoming paler yellowish-cream on the underparts

Diet: Plant matter and invertebrates

Breeding: In spring through to summer; lays eggs which stick among vegetation, with hatching occurring between 5 and 8 days later, depending on water temperature

Status: Some populations are endangered, largely because of environmental problems such as pollution, but overall, carp remain common

The mirror carp is a variety of the common carp that has some large scales on its body.

Carp are among the most long-lived of all freshwater fish. It is possible to work out their age with great accuracy by studying the growth rings in bones found in the ears. These are known as earstones or otoliths. It used to be thought that each ring represented a year's growth. This meant that some carp were thought to be much older than they really were. Sometimes, when there is lots of food about, these bones develop quickly, creating a white layer. Then, during the winter, when the water temperature falls and food is less plentiful, a darker, narrower band forms. Over the years, there may be more than one light and one dark

A common carp's head clearly shows the barbels. The downturned mouth is adapted for feeding on the bottom.

DID YOU KNOW?

- Carp have teeth in their mouth—not at the front of their jaws, but in the top part of the throat. They are called pharyngeal teeth and are used for grinding food.
- The full name for koi is actually *nishikigoi*, meaning "brocaded (decorated) carp."
- Koi are named according to their coloration. They have names such as *hi* (red), *sumi* (black), and *ki* (yellow).

band being developed each year. This suggests the fish is likely to be younger than the number of rings it has. In the past, carp were believed to have lived for over 220 years because of the rings. Now, it is thought that they are unlikely to be more than one hundred years old—still a long life!

Carp Breeding

Carp are most often seen in the summer during the breeding period, when they invade the shallows. Spawning is a noisy, splashing process, during which the fish thrash around energetically. They can easily injure themselves, losing scales and tearing their fins. These are usually minor injuries, however, and tend to heal without problems. Battle-scarred older carp are often seen.

The eggs are deposited among vegetation and hatch quite rapidly in relatively warm water. They usually take six to eight days to hatch if they are in water at a temperature of around 73°F (23°C). Quite a few of the young fry get eaten by predators and other carp, however. To improve their chances, carp lay many eggs. A female measuring just 18.5 inches may release over 300,000 eggs during a single spawning.

KOI

About 1,000 years ago, in the rivers of China, fishermen found some common carp that were much more brightly colored than their relatives. Some of them had orange areas on their bodies. From the early 1800s, the Nigata Prefecture of Japan have developed these colorful varieties. Early colors included red, white, and yellow. These koi, as such brightly colored carp are now called, were the first examples of those kept in ponds throughout the world today.

It is not just in Japan where such fish are being bred commercially, but also in many other countries, notably the United States and Israel. Today, there are over one hundred different varieties of koi recognized by fishkeepers.

CONGER EELS

These large, predatory eels can often be caught near the coast by anglers, because they often lurk around jetties. Conger eels are also frequently found by divers exploring wrecks.

Conger eels are shy fish, preferring to stay out of sight and retreating into their hiding places if they feel threatened. In shallow waters they are usually nocturnal. They emerge under cover of darkness and often swim out across sandy areas in search of prey, which they grab with their powerful jaws. In deep waters, congers are active by day as well as by night.

Breeding Behavior

Much is still to be learned about the breeding behavior of the conger eel. It is thought that they swim to traditional spawning grounds, one of which is the Sargasso Sea in the western Atlantic. Other spawning areas are the waters between Gibraltar and the Azores, on the eastern side of the Atlantic Ocean, as well as possibly the Mediterranean. Scientists know this because they have found young eels in these places. The young, called leptocephali, look very different from their parents, having a transparent, flattened body.

It is thought they are carried back to European waters from the breeding grounds on ocean currents—a journey taking about two years. The leptocephali are about 3 inches long at this stage. They use fingerlike projections called villi in their mouths to absorb nutrients, including minerals, from sea water. Once in coastal waters, their shape becomes cylindrical, and they start to look like small eels. They only get the adult coloration when they are about 12 inches long.

Conger eels have large, powerful teeth in their jaws. The upper jaw is longer than the lower jaw. The body of a conger eel does not have scales.

Fact File

CONGER EELS

Family: Congridae (150 species)

Order: Anguilliformes

Where do they live?: Atlantic, Pacific, and Indian Oceans

Habitat: Rocky areas on the seabed, reefs, and on wrecks—which all provide suitable hiding places

Size: The largest conger eels can measure up to 10 feet (3 m)

Coloration: Generally light grayish-brown but can change their color to match their background, appearing darker while in underwater caves

Diet: Predatory by nature, lurking out of sight and seizing other fish, and cephalopods such as octopus or squid, that venture within range

Breeding: All species of conger eel reproduce by means of eggs, with the spawning often occurring in the vicinity of the Sargasso Sea; newly hatched conger eels are called leptocephali

Status: Generally common

CORALS

The word "coral" suggests white tropical beaches and coral reefs. Most importantly it describes the beautiful marine animals that form these features with their chalky skeletal remains.

Corals are relatives of jellyfish and sea anemones. There are several types, but they all have a skeleton made of a chalky substance called calcium carbonate. The individual animals are called polyps. They have a saclike body, with a mouth at the top surrounded by a circle of stinging tentacles. Below the mouth, inside the body, there is a digestive chamber. Toward the bottom of the body there is a special area that forms the cuplike skeleton. Most types of coral polyp can retreat into their skeletons when danger threatens. Corals live either as single polyps, or joined together as colonies with many similar polyps all sharing a common skeleton.

Hard Corals and Soft Corals

The shape of the coral polyp is important in helping to identify the species. Corals with six-sided polyps have hard and inflexible skeletons. Their tentacles are unbranched. Reef-building corals are in this group. Six-sided corals are found in many marine habitats from shallow tropical seas—where they may build reefs—down into much deeper water.

Corals with eight-sided polyps form skeletons which are usually flexible. In these animals the skeleton is made of crystals called spicules and does not support or protect the colony so well. They are known as soft corals. Their tentacles are branched, and these corals occur in many forms, including sea fans and sea pens.

These colorful soft corals are on a reef in shallow water in the Pacific Ocean. Such colonies provide a wealth of habitats for other reef-dwelling creatures.

Fact File

CORALS

Order: Hexacorallia (hard corals), Octocorallia (soft corals); about 5,000 species altogether

Class: Anthozoa (part)

Phylum: Cnidaria

Where do they live?: Worldwide in all seas and oceans

Habitat: Rocky and stony seashores and seabeds, coral reefs

Size: Polyps usually less than 0.2 inches (5 mm), but a few larger; colonies up to several feet across; reefs can extend for miles

Coloration: Various, often beautifully patterned

Diet: Floating, minute animals and organic particles sieved from sea water; also get food from the algae that live in their bodies

Breeding: Asexual budding or sexual reproduction; in sexual reproduction sperm and eggs released into sea water where fertilization occurs; a swimming larva is formed, which settles on the seabed and becomes a juvenile

Status: Varies between species; in most cases not known, but some hard corals are vulnerable

Eight-sided corals live in similar places to six-sided corals but they cannot build reefs.

Colony shape varies enormously in corals, depending on the family and the living conditions. Some families, such as the stagshorn corals, are known for their branching shapes. Others, such as the brain corals, have massive boulder shapes. Colonies of dead man's fingers have a rubbery feel about them. They defend themselves against predators by giving off chemicals which give them a bad taste or smell.

Coral Growth and Reefs

Reef-building corals need to grow in a well-lit spot on the reef. Individual colonies compete for light; the faster-growing ones avoid being overgrown by slower ones. Branching forms grow more rapidly than boulder forms, but they break more easily in rough weather. Coral skeletons and fragments accumulate over many thousands of years, leading to the development of a coral reef. As he sailed around the world aboard HMS *Beagle*, the naturalist Charles Darwin (1809–82) noticed

Corals can grow quickly in shallow water, because sunlight encourages the chalky skeleton to form.

ANIMALS THAT ARE FED BY PLANTS

Hard corals that live in shallow, well-lit, tropical seas get their energy from sunlight, like plants. They can do this because tiny plants called algae live inside the polyps. The algae take in carbon dioxide and water and, using sunlight energy, they make carbohydrates. This is called photosynthesis. They also absorb the waste products of the polyps and make other substances the polyps need. These substances supply the polyps with energy. Corals with smaller polyps depend heavily on this plant energy. Those with larger polyps can also catch microscopic animals as food.

This sea fan coral lives in the Atlantic Ocean.

Tentacles surround the mouth of a yellow cave coral (top). Dead man's fingers has white polyps (bottom).

the different ways that coral reefs develop. He realized that corals grew in shallow places, and if the seabed sinks slowly, then the rate of upward coral growth can keep pace. This means that the newest corals remain near the surface. Darwin believed that the reef shape reflected the shape of the structure it was growing on. For example, a round atoll could develop on a sunken volcano cone. Fringing reefs are attached to coastlines, and barrier reefs are separated from the coastline by a deep lagoon. Scientists today agree with Darwin's theories.

Climate Change and Corals

The reef-building corals need temperatures above 72°F to develop well, but they can tolerate occasional drops to 64.5°F. They cannot live where freshwater flows bring sediments that clog the polyps and cut off light. Nor can they tolerate drops in sea levels or sudden rises in temperature. If these changes occur, the corals become stressed and may throw out the algae living in their bodies. This can lead to a loss of the color caused by the presence of the algae, and so affected corals appear pale and bleached. If the environmental conditions do not return to normal, the corals will die.

DID YOU KNOW?

- Various parrot fish, for example, the humpheaded parrot fish, feed on reef-building corals. They knock over branching colonies with their massive heads and chew through the chalky skeletons with their powerful teeth.
- The small female gall crab rubs against the growing tips of corals. As she grows, the crab becomes trapped in a stony chamber or gall formed by the coral. She feeds on items that get washed into the gall. The free-living male crab is small enough to go through an opening in the chamber to mate with her.
- The rich, pink-red skeleton of the much-prized Mediterranean coral has been used as jewelry since Roman times. It has also been used as a teething aid for babies to chew on!

CRABS

Most people probably think of crabs on the seashore, but these versatile animals are not just found in the oceans. Many species are adapted to live in fresh water, and some even thrive on dry land.

Crabs are among the most successful of the crustaceans—the group of mainly marine animals that also includes lobsters and shrimp. All these creatures have a hard outer covering to their bodies and limbs, called an exoskeleton. As well as acting as the animals' skeleton, this covering helps protect them against attacks by predators.

A Neat Design

Most crustaceans, such as shrimp, have a long slender body divided into segments. Each segment normally has a pair of jointed limbs. In crabs, the basic crustacean pattern is modified. The hind part of the body (the abdomen) has become tiny and bent under the rest of the body, making it invisible from above. A hard, protective shield, known as the carapace, covers the crab's upper surface.

Like lobsters and shrimp, crabs have five pairs of legs, including the pair of pincers at the front. Because a crab has a short body, it means that it is well balanced on its legs and can move at a speed that would be impossible for, say, a lobster. Crabs also run sideways; the way their legs bend means that this is much easier than walking forward or backward. The fastest-running crabs are a family called ghost crabs that live on beaches. Some crabs are also very good swimmers. In swimming crabs, the fifth pair of legs is flattened and beats with fast, propellerlike movements.

This brightly colored Sally Lightfoot crab lives on the Galapagos Islands. It scuttles among the rocks, feeding on algae and scavenging dead animal matter.

Fact File

CRABS

Infraorder: Brachyura (between 4,500–8,000 species)

Order: Decapoda

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Worldwide in suitable habitats

Habitat: Sea floors from the seashore to the deep oceans; also fresh water and dry land

Size: Adult body width ranges from 0.1–15 inches (2.5 mm–38 cm)

Coloration: Varies between species

Diet: Broad, including live and dead animals and plant material; some species sieve food particles from sea water or mud

Breeding: Sexual reproduction; females protect eggs under their bodies until they hatch; the young mostly swim in the plankton before settling on the sea floor

Status: Most are not known to be threatened

A red-legged swimming crab catches its fish prey. The crab's flattened rearmost legs are an aid for swimming.

Ways of Living

Crabs have varied lifestyles. At one extreme are the tiny crabs in the pea crab family, that often share homes with burrowing worms or even live inside oyster shells. These small crabs filter food particles from the water.

Many medium-sized crabs have a varied diet, eating live prey, dead animals, or seaweed. Some species graze on coral-like animals that are fixed to rocks. Swimming crabs can even chase and catch fish!

The overall shape of a crab's body is related to how it lives. Crabs living on rocky shores or in areas with strong currents tend to have short, sturdy legs for gripping on tight. By contrast, species such as spider crabs that live on soft muddy sea bottoms usually have long spindly legs that help spread out their weight.

Crabs have very good eyesight to hunt prey or avoid predators. Their eyes are on stalks.

Defense and Concealment

Crabs use various tricks to protect themselves against their enemies, in addition to having strong bodies and sharp claws. Many are active only at night, when they are less likely to be spotted by a hungry bird or fish. Most crabs can dig down into sand

or mud for protection, and some build permanent burrows. Others hide beneath stones or among coral.

Spider crabs, which have rough, spiny bodies, often stick seaweed or other material onto their backs to disguise themselves. Other crabs have rough, knobbly backs that look like a piece of stone or coral. Some species place living sponges on their backs.

Hermit crabs have soft bodies. They live inside empty seashells that are dragged around like mobile homes. Hermit crabs are not true crabs, however; they belong to a different, though related, group of crustaceans.

Crab Life History

After a male and female crab have mated, the female carries the fertilized eggs beneath her body, where they stay until they hatch. In sea-living crabs, the eggs hatch into tiny swimming larvae that look nothing like the adults. Young crab larvae are called zoea, and are a weird shape, with two huge spines, a tail, and big eyes. The larvae float as part of the plankton of the sea, but most get eaten before reaching adulthood. After a time, and after changing shape several times, the young crab settles down on the seabed.

DID YOU KNOW?

- A crab called the Columbus crab hitches rides across the ocean on driftwood or even turtles.
- Decorator crabs hide themselves by covering their shells with seaweed.
- Crabs have much shorter antennae ("feelers") than shrimp or lobsters.

The giant Japanese spider crab has the longest legs of any crab species.

THE BIG ONE

The world's biggest crab is the Japanese spider crab (shown above), which is found in the ocean off the coast of Japan. Although its body is not much more than a foot wide, its legs and claws are enormously long. When its legs are fully spread out, the distance between their tips may be more than 26 feet! Japanese spider crabs probably live for more than twenty years. They live in deep, still waters and eat seabed animals, including other crustaceans.

The ghost crab lives on warm, sandy beaches. It gets its name from its sandy coloration, which seems to make the crab disappear when it stops moving.

Now it starts growing into an adult. One of the problems facing a young crab is that its hard exoskeleton cannot stretch to allow growth. Instead, crabs must molt their hard coverings regularly. At first, the new covering underneath is soft, and makes crabs very vulnerable. They usually have to hide away until their new "skin" has hardened.

Beyond the Sea

Sea-living crabs have gills hidden in chambers down the sides of their bodies. They use these gills to take oxygen from the water so they can breathe. Some more adventurous crabs such as fiddler crabs (see box below) are amphibious—they live partly in water and partly on land. These species breathe air directly from their gill chambers.

Crabs do not always stay in the sea. Many species live around river mouths, where the water is less salty than in the sea. But living in fresh water is challenging for crabs, because the salt concentration in the water is much lower than in their own bodies. This means that the animals tend to lose salt, damaging

MAKING GESTURES

Fiddler crabs (right) live on beaches in many parts of the world, and are active when the tide is out. They feed by sieving out food particles from sand and mud. Male fiddler crabs have one huge claw and one normal-sized one. The big claw is not used for eating, but for waving and signaling to other crabs. Each species has its own signaling "language," which it uses to attract females and to warn off other males.

DID YOU KNOW?

- Crabs have "teeth" in their stomachs to help grind up food!
- Some crabs have knobbly backs that resemble coral to disguise themselves.
- Some crabs drum on the sand with their feet to communicate.

their tissues. Alternatively, fresh water rushes in and swells up their bodies.

In some crabs, the adults live in fresh water but the young cannot, so they return to the sea to breed. One family, the freshwater crabs, live their whole lives far from the sea. They are widespread in rivers and lakes in Africa and other warm regions. Unlike sea-living crabs, their eggs do not turn into swimming larvae, but hatch directly into miniature crabs.

Onto the Land

Some crabs can live their entire adult lives on land. Their gills have become lungs, and they would drown if held under water. Even these crabs, though, cannot breed on land, and must return to fresh water or the sea to breed, depending on the species. On Christmas Island in the Indian Ocean there is a famous wildlife event involving land crabs. Once a year, 200 million crabs leave their forest homes and walk down to the sea, covering roads, fields, and beaches with their scarlet bodies. They release millions of eggs into the sea, turning the sea red, too. The eggs develop and the young crabs return to land to start the cycle again.

A beach teeming with land crabs as they make their way to the sea to release their eggs.

CRUSTACEANS

The crustaceans are one of the most successful groups of invertebrate animals in the oceans. They include crabs, lobsters, shrimp, and a great variety of other smaller creatures, such as barnacles.

This southern rock lobster, from the Tasman Peninsula, Australia, lives among reefs and crevices, and is both a filter feeder and a carnivore.

Crustaceans are members of the arthropods, the huge group of jointed-legged animals that includes insects and spiders. There are more species of arthropods on Earth than all other animals put together!

The most important features shared by all arthropods are jointed limbs and a hard outer covering, called an exoskeleton. This is shed to allow them to grow. Crustaceans differ from other arthropods in various ways. For example, they have two pairs of antennae ("feelers"), whereas insects have only one pair.

1. *Opossum shrimp*
2. *Spiny lobster*
3. *Copepod*
4. *Water flea*
5. *Barnacle*
6. *Shrimp*
7. *Lobster*
8. *Mantis shrimp*


1


2


3


4


5


6


7


8

Fact File

CRUSTACEANS

Phylum: Arthropoda

Subphylum: Crustacea

Species: At least 45,000 species

Where do they live?: Worldwide in suitable habitats

Habitat: Oceans and fresh water; some on land

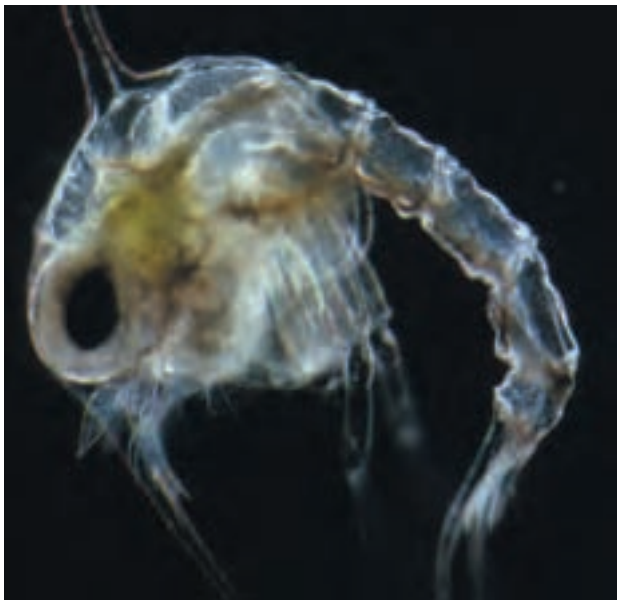
Size: Including leg span, adult sizes range from 0.01 inches–26.5 feet (0.25 cm–8 m)

Coloration: Variable, often brownish; some are transparent

Diet: Very varied between species—can include live or dead animals, seaweed, or tiny food particles sieved from water or mud

Breeding: Sexual reproduction; most species hatch into tiny swimming larvae that look quite different from the adults

Status: Not generally threatened



Zoea larvae—like this one from a shore crab—drift among the plankton before becoming adults.

Crustaceans usually have a thicker, harder exoskeleton than insects, reinforced by the mineral calcium carbonate.

Over millions of years, the basic crustacean body plan—a long body with jointed limbs—has evolved into a huge variety of species. In particular, crustaceans' limbs have become adapted for many different uses. These include walking legs, swimming organs, pincers, gills for breathing, and structures for holding eggs—or sometimes several of these purposes at once!

Drifting in the Ocean

Just as their cousins the insects are found in virtually all land habitats, so crustaceans are found in nearly all ocean habitats. In the floating life (plankton) of the open ocean, they form a vital part of the food chain. Tiny crustaceans called copepods swarm in their billions in sea water, eating even tinier living things. In turn, they themselves are sieved from the water as food by plankton-eating fish such as sardines. In the Southern Ocean, huge swarms of slightly larger shrimplike crustaceans called krill are the main food for many whales. Without these crustaceans, the food chain that leads from plankton to fish—and onto humans that catch the fish—would be totally disrupted.

DID YOU KNOW?

- The largest crustacean is the Japanese spider crab. Fully spread out, it can have a leg span of more than 26 feet!
- The name "crustacean" comes from the crustlike shells typical of crabs and their fellow crustaceans.

Becoming Grounded

As well as the many crustaceans that float in the open ocean, thousands of other species live on the sea floor, among coral reefs, or by the

DID YOU KNOW?

- Arrow crabs get their name from the triangular or arrowhead shape of their bodies. They live in the Atlantic Ocean.
- Most of the zooplankton that floats in the sea consists of the marine crustaceans known as copepods.

seashore. Among the most specialized are the barnacles—filter-feeders that cement themselves to rocks and look more like mollusks than crustaceans. Other kinds of crustaceans live in permanent burrows in sand or mud, sieving particles of food from the water or the mud itself. Many species have become parasites, living on or in the bodies of fish, whales, or even other crustaceans. These parasites often have unusual shapes, and look nothing like their free-living relatives.

Many kinds of crustaceans are referred to as "shrimp," but this is not an exact scientific term. It tends to be used for any medium-sized crustacean—especially one whose body is flattened from side to side and that is able to swim. The "true" shrimp are close relatives of crabs and lobsters, and are classified with them in a group called the Decapoda (which means "ten legs"). Even shrimp that can swim tend to stick close to the protection of rocks, seaweed, or coral. The fierce mantis shrimp, which are not true shrimp, can break the glass of an aquarium with their fast-punching front limbs!

All Kinds of Habitats

Some crustaceans can live in fresh water rivers or lakes. This is a more challenging environment because fresh water has much less salt than the animals' body fluids. This means it tends to draw salt out of the animals' bodies. Among the most successful freshwater crustaceans are the tiny swimming water fleas.

SEA SLATERS

A sea slater has long, sensitive antennae. Most sea slaters are about half an inch long, but one deep-sea species grows to 14 inches.

Among the many "creepy crawlies" found around damp wood and soil are the sowbugs or woodlice, which are land-living crustaceans. They have thousands of relatives living in fresh water or in the oceans. The marine ones are known as sea slaters. All of them have bodies that are flattened from top to bottom—a shape that helps them to squeeze under stones and among seaweeds. Different species of sea slaters may crawl, run, burrow, or sometimes swim. One kind can gnaw through wood and often damages jetties and wooden boats.

DID YOU KNOW?

- Many whale species would die if the small shrimplike crustaceans called krill that they feed on were to disappear.
- Crustaceans come in so many varieties that they are difficult to classify. Even today scientists do not have a complete "family tree" of how they are all related.
- Many crustaceans are parasites, and some live in the bodies of other crustaceans!

Larger crustaceans such as crawfish and some crabs also live in fresh water. A few crustaceans live on land, including land crabs and relatives of the sea slaters (see box page 39). In these species, the gills that aquatic crustaceans use for breathing have formed air-breathing lungs.

Crustacean Life History

Once male and female crustaceans have mated, the female normally carries the eggs around with her until they hatch. In sea-living species,

CRUSTACEANS AND PEOPLE

People find many crustacean species, including crabs, lobsters, crayfish, and shrimp, delicious to eat. Catching them is big business in some areas.

Traditionally, lobsters are caught in baited baskets with funnel entrances that are placed on the seabed. Lobsters crawl in and then cannot turn and crawl out again. Shrimp are now bred in huge shrimp farms by the seashore, especially in tropical areas. Unfortunately, these "farms" have often been created by clearing mangrove swamps, which are important ecosystems both for land animals and young sea fish in the tropics.

A fisherman checks his lobster catch. Lobsters only turn red once they are cooked.

A female red crab releases thousands of eggs from the underside of her abdomen.

the eggs usually hatch into small swimming larvae that look nothing like the adults. The most common kind of crustacean larva is called a nauplius; it is microscopic and has three pairs of limbs. Even when adult crustaceans live on the seabed, their larvae usually swim in the plankton. Eventually, the larvae that survive land on the seabed and metamorphose (change shape) into miniature versions of the adults.

But the challenge of growing is not over. Crustaceans' hard exoskeletons cannot stretch, and so they need to be molted regularly. The new soft skeleton underneath needs to stretch and harden. During this time the animal is very vulnerable, and must hide from predators. Molting continues in adulthood. Many crab "shells" found on the seashore may just be molted exoskeletons that the animal has outgrown and shed. Their owners may still be alive and well!

Freshwater crustaceans usually skip having a free-swimming larval stage, and their eggs hatch into miniature adults. Except for the sowbugs (see box page 39), even crustaceans that live on land as adults go back to the water to breed.

CUTTLEFISH

Despite their common name, cuttlefish are not fish at all but are relatives of squids and octopuses. They are skillful hunters, with an amazing ability to change color in a flash.

Cuttlefish hunt mainly at night, often lying half-buried in sand or mud during the day. Even when active, they spend most of their time near the seafloor, swimming slowly by rippling the fins running down their sides. They can also move faster by squirting water out through a tube beneath the head. Inside the flattened body of a cuttlefish is a lightweight structure called a cuttlebone. The cuttlefish can store air in the cuttlebone to make itself lighter in the water.

Cuttlefish can speedily change the colors and patterns on their skin, either to camouflage themselves or to signal to other cuttlefish. They do this by sending nerve signals to color-containing cells in the skin.

Feeding and Breeding

Like its squid relatives, a cuttlefish has ten flexible arms, or tentacles, around its head. The two longest arms are usually tucked out of sight. A cuttlefish can spot prey at a distance using its good eyesight. Once within range, it shoots out its long arms with lightning speed to grab the prey. The cuttlefish has a horny beak, allowing it to chop its victim into small pieces.

During the breeding season cuttlefish gather in groups. Male and female mate head to head, gripping each other with their arms. The females then lay eggs attached to objects such as rocks on the seabed. Young cuttlefish look like miniature versions of their parents. After the breeding season is over, the adults die.

A broadclub cuttlefish swims above a reef. This is the largest species of tropical cuttlefish. Note the large, well-developed eyes typical of cuttlefish.

Fact File

CUTTLEFISH

Family: Sepiidae (over 100 species)

Order: Sepiida

Superorder: Decapodiformes

Subclass: Coleoidea

Class: Cephalopoda

Phylum: Mollusca

Where do they live?: Warmer coastal regions around the world, except North and South America

Habitat: Shallow coastal waters

Size: Up to 5 feet (1.5 m) in the largest species; most are much smaller

Coloration: Able to change color rapidly

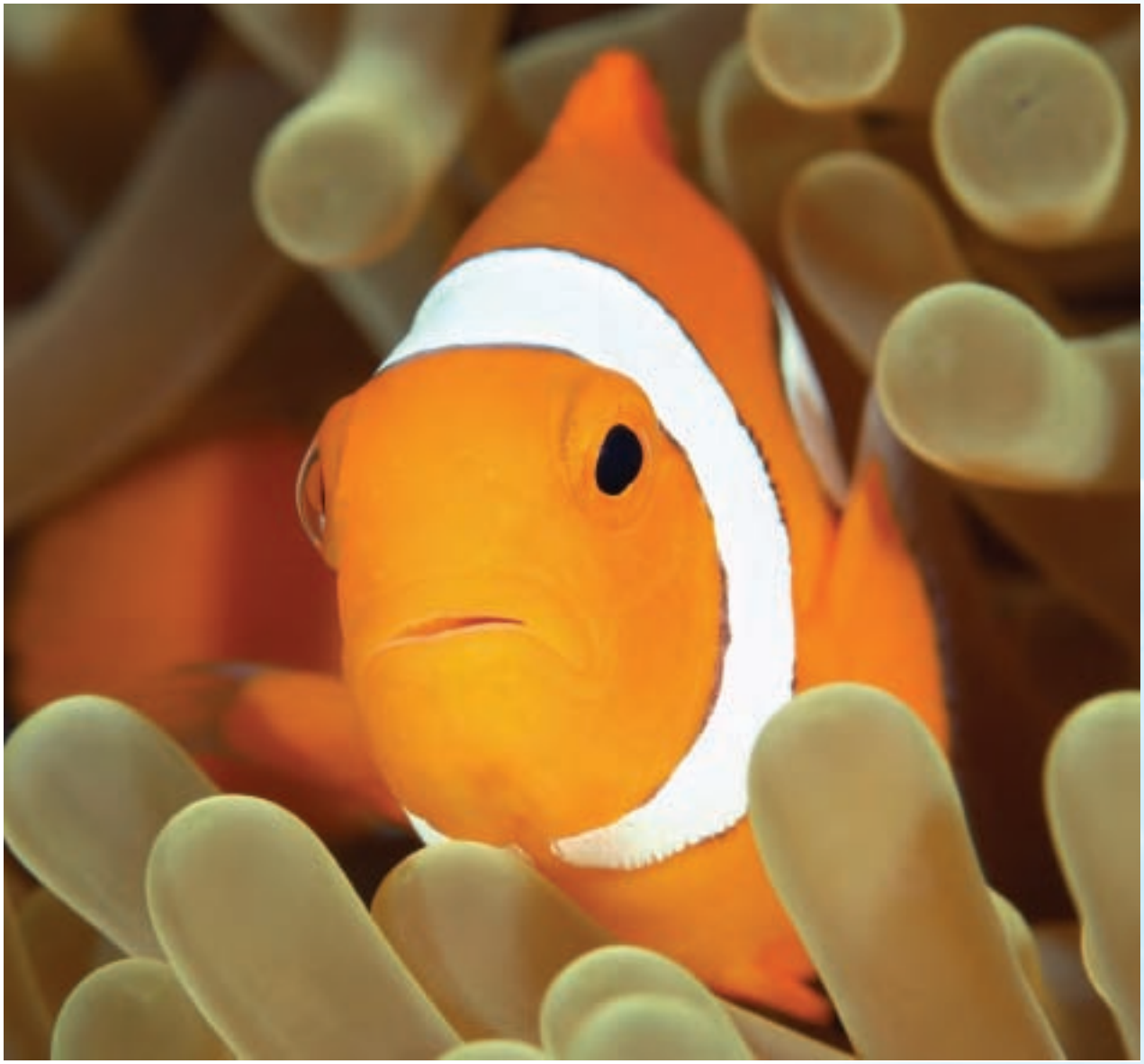
Diet: Shrimp and other crustaceans, plus some fish and mollusks

Breeding: Usually reach adulthood after 1 year; breed once and then die; females produce large yolky eggs

Status: Not known to be threatened

DAMSELFISH

In order to avoid predators, many of these colorful fish have adapted to live among the deadly stinging tentacles of sea anemones. They also have a remarkable ability to change sex.



Some members of this family have a unique relationship with certain sea anemones, for they are able to dart away from predators and hide among the anemones' stinging tentacles. This is made possible because the fish have special chemicals in the coating of protective mucus on their bodies. This makes them immune to the anemones' stings. In return, damselfish may also lead potential food near the host, so the fish feed on the anemone's leftovers. The aggression of these fish may also be sufficient to drive away much larger species, ensuring that the anemone itself is not attacked. This type of relationship, where both parties benefit, is called a symbiotic one.

Changing Sex

In birds and mammals, whether they are male or female is fixed by genes. This can be different in fish. Environmental factors such as water temperature, the chemical nature of the water, and the social structure within a group of fish all have an influence in deciding the gender. Among damselfish, the largest fish in a group is always female. She maintains her "top" status by bullying the smaller individuals in the group, all of which are males. If she is killed, however, the next largest individual changes into a female. This is possible because these fish have both male and female sex organs. In the presence of a dominant female, only the male organs develop in the others.

The tomato clownfish is a damselfish that gets protection from predators by living among the tentacles of anemones—hence its other name, anemonefish.

Fact File

DAMSELFISH

Family: Pomacentridae (about 335 species)

Order: Perciformes

Where do they live?: All tropical seas and in some warm temperate areas, such as off the coast of California and parts of Australia and New Zealand

Habitat: Shallow water, frequently in the vicinity of coral reefs and usually close to the bottom; a few species stray into estuaries and even into fresh water

Size: Averages from 3.2–4.7 inches (8–12 cm); ranges from about 1.6–14 inches (4–36 cm)

Coloration: Usually brightly colored with alternating black vertical stripes extending down each side of the body

Diet: Small invertebrates, often algae, and sometimes coral

Breeding: Eggs usually laid close to sea anemones, which give protection; male may guard the eggs

Status: 3 species of Atlantic Ocean damselfish are vulnerable, and only live in very small areas

DOGFISH

The dogfish is a true shark, occurring in temperate waters. Perhaps confusingly, it is actually a cat shark, and is sometimes described by scientists as the lesser-spotted cat shark.

Cat sharks as a group are one of the largest shark families, consisting of around 100 species. Like its closest relatives, the dogfish generally lives in shallow water, often in the intertidal zone (the area between high and low water). It rests here during daylight hours, usually hiding away among rocks. As darkness falls, the dogfish emerges and sets out in search of food. When feeding, a dogfish uses a rapid bite coupled with a sucking action that draws in food and water.

In winter, large numbers of female dogfish gather close to the shore, where they are joined by males as spring approaches. Mating and egg-laying occur later in the summer, as the water warms up. They usually mate in deeper water, with the male wrapping his body around the female. Fertilization takes place inside the female's body, and afterward the female dogfish returns to lay her eggs closer inshore. Each of the large egg capsules contains a big yolk, which nourishes the young dogfish pup while it is growing. The pup continues to feed on this for some time after hatching. By this stage, the pup measures about 3.5 inches in length. The egg pouches are known as "mermaid's purses" because of their shape.

Food Fish

Dogfish are one of the most widely caught food sharks. However, these fish are usually sold in fishmongers under the names "huss" or "rock salmon."

The doglike appearance of the snout of these fish explains their common name, although their large eyes are said to be more like those of cats.

Fact File

DOGFISH

Scyliorhinus canicula

Family: Scyliorhinidae

Order: Carcharhiniformes

Where do they live?: Eastern Atlantic, from Norway south to the Canary Islands; also in the Mediterranean

Habitat: Bottom dwelling, ranging from coastal areas to depths of about 330 feet (100 m), but may sometimes be found in much deeper water

Size: Grows up to a maximum size of 3.9 feet (1.2 m), but usually smaller

Coloration: Relatively light background color, covered with dark spots

Diet: Largely bottom-dwelling mollusks such as whelks and clams, as well as crustaceans such as shrimp and crabs, and other invertebrates including worms; may also prey on fish such as flatfish

Breeding: Internal fertilization, with females then laying 18–20 egg cases in pairs; these are wrapped around seaweed and similar underwater objects, and take 9 months to hatch

Status: Still relatively common throughout much of its range

DOLPHINS

The graceful, playful activities of dolphins are familiar to everyone. Yet science still has a lot to learn about these intelligent and fascinating mammals.

Dolphins are small whales that live in all the world's oceans. Four species of river dolphins live in rivers. There are at least forty species of ocean and river dolphins. The bottlenose dolphin is probably the best-known species and is often kept in dolphinaria (aquariums for dolphins). In the wild, bottlenose dolphins live in warm seas, usually near the coast.

The spinner dolphin is another common warm-water species. It prefers deep waters and, as with many dolphins, it enjoys leaping out of the water and then diving back in. When a spinner dolphin makes a leap, it spins around, which is how it got its name.

Many species of dolphins look quite similar, even when they are not closely related. That is partly because dolphins need to be streamlined to chase after their prey. Many dolphins also have similar patterns of spots or patches that are usually various shades of gray.

The largest member of the dolphin family is the killer whale, or orca (see box page 51). Unlike most dolphins, the orca has a blunt head, without a pointed beak. Next largest are two species of pilot whales. They also have a blunt head and grow nearly as long as killer whales but feed on much smaller prey.

Body Design

A dolphin has powerful muscles that move its flat tail up and down in the water. The tail movements push the dolphin along. Dolphins breathe air but, unlike

Dolphins, like the one seen here, usually have pointed beaks or snouts. Their close relatives the porpoises usually have shorter, blunter snouts.

Fact File

DOLPHINS

Families: Delphinidae (ocean dolphins; at least 36 species) and 4 families of river dolphins (4 species)

Order: Cetacea

Where do they live?: Worldwide

Habitat: Oceans and a few rivers

Size: Head–body length from 3 feet 6 inches (1.2 m) in Heaviside's dolphin to 23 feet (7 m) in the killer whale; weight from 88 pounds (40 kg) to 4.4. tons (4.5 metric tons) in the same species

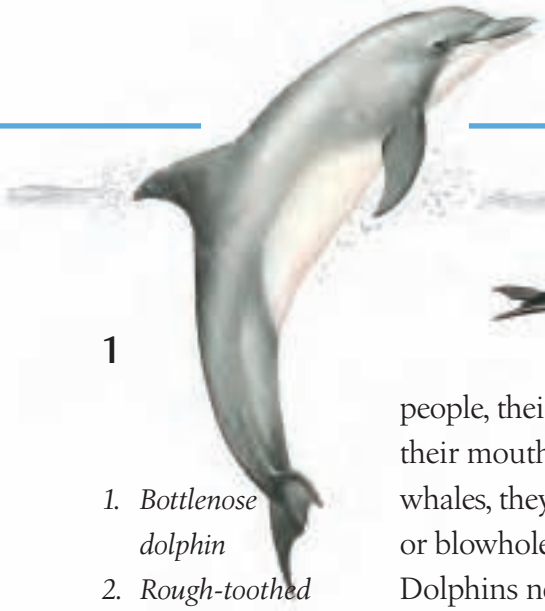
Coloration: Various shades and combinations of black, gray, yellow, and white

Diet: Fish or squid; killer whales also eat sea mammals and birds

Breeding: 1 calf (offspring) born every 2–3 years in most species

Life span: Up to 100 years in female killer whales

Status: 1 marine species endangered; river dolphins: 1 critically endangered; 1 endangered; 2 vulnerable



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2

3

1. *Bottlenose dolphin*
2. *Rough-toothed dolphin*
3. *Atlantic white-sided dolphin*
4. *Atlantic spotted dolphin*
5. *Short-beaked common dolphin*
6. *Northern right whale dolphin*
7. *Atlantic hump-backed dolphin*
8. *Melon-headed whale*
9. *Commerson's dolphin*
10. *False killer whale*
11. *Killer whale*
12. *Risso's dolphin*

people, their nose is nowhere near their mouth. Instead, like other whales, they have a single nostril, or blowhole, behind their head. Dolphins need to go back to the surface regularly to breathe.

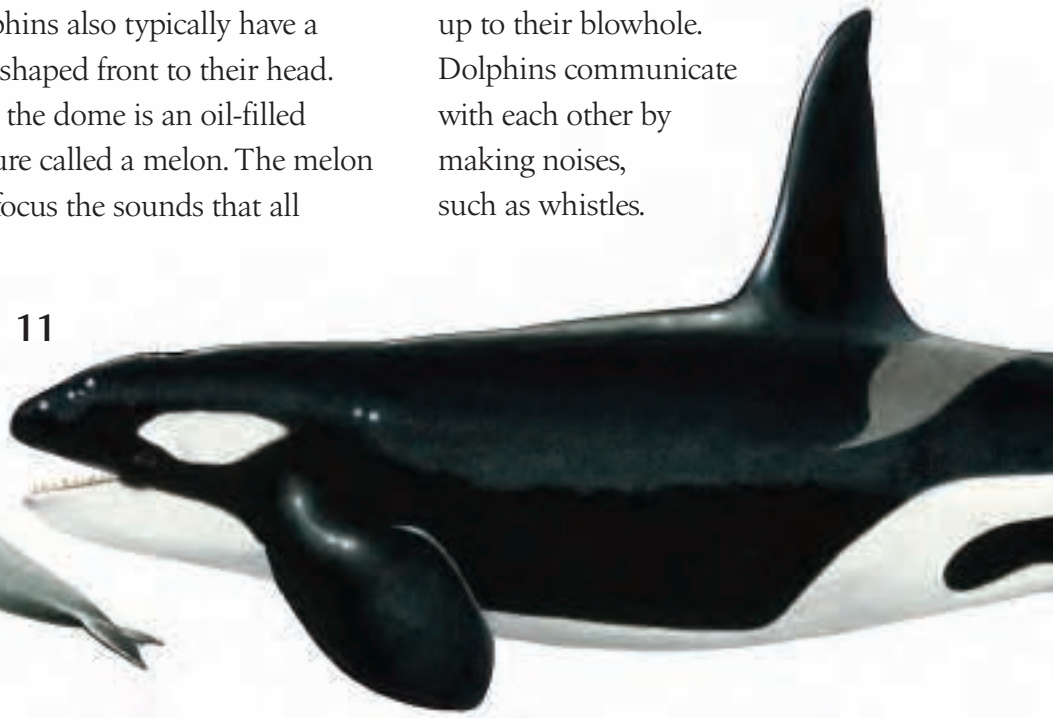
Dolphins have front flippers but no hind flippers. Most species also have a fin on their back called a dorsal fin.

Most dolphins have their mouth stretched out into a long beak, which contains many pointed teeth. This mouth shape helps dolphins grab the slippery fish and squid on which most of them feed.

Dolphins also typically have a dome-shaped front to their head. Under the dome is an oil-filled structure called a melon. The melon helps focus the sounds that all dolphins make. Sound is extremely important to dolphins because sound travels better through water than light does. Dolphins have no voice box but produce sound by moving air in the tube leading up to their blowhole. Dolphins communicate with each other by making noises, such as whistles.

DID YOU KNOW?

- A dolphin's brain is larger than a human's!
- Groups of dolphins are called schools or pods.
- Dolphins sometimes hold sponges in their mouths to protect their beak on coral reefs!



11

12

THE BIG ONE

The killer whale, also called the orca, is the largest member of the dolphin family. It lives in oceans worldwide. Males are bigger than females and have a much longer dorsal fin, up to 6 feet 6 inches long. Their black-and-white skin pattern varies, helping scientists recognize individual animals. That makes studying them long term much easier. Killer whales are unique among dolphins both in their diet and their social life.

They also produce high-frequency clicking sounds, which are outside the range of human hearing. These clicks bounce off objects such as reefs or nearby fish. By listening to echoes, a dolphin can figure out where objects are and how large they are; the dolphin can "see" with its ears by this process, called echolocation.

RIVER DOLPHINS

The four species of river dolphins are placed in their own family, separate from the ocean-going dolphin family, Delphinidae. River dolphins have a long, narrow beak and small eyes. Little is known about their social lives. The Yangtze River dolphin of China is the world's most endangered dolphin. There are also at least two species of ocean-going dolphins that live in rivers.

DID YOU KNOW?

- Killer whales sometimes catch seals by upending the ice on which the seals are lying!
- Dolphins sometimes swim peacefully with tuna fish. They probably help each other watch out for sharks!

Dolphins have good eyesight, even in dim light. They see well in both air and water. They can also taste, but not smell, because their blowhole is always closed under water.

Habitats and Food

The world's oceans are a vast habitat. Some dolphin species live near coasts, while others inhabit deeper water. Some live worldwide, while others live in only one ocean. Sometimes various populations of the same species lead quite different lifestyles.

Deepwater dolphins sometimes make long journeys to look for food, often traveling in large groups. They use ocean-bottom features as landmarks to help them navigate. Dolphins living near coasts tend to stay in the same home area, but within that area they have regular patterns of movement. For example, dusky dolphins living off Argentina

Bottlenose dolphins swim off Hawaii. Note the even, cone-shaped teeth adapted for catching fish and other aquatic prey.

spend the day feeding several miles out to sea. At night they usually come closer to shore, where there is less danger from sharks.

Most dolphins feed during the day, although spinner dolphins are mainly nighttime feeders. They also dive farther down from the surface to feed. They can therefore live in the same areas as other types of dolphins without competing for food. Dolphins eat a wide variety of fish, squid, and other animal prey. They probably eat whatever they can catch. Most species of dolphins catch prey that is swimming freely in the water. However, some dolphins nose around on the sea floor or coral reefs for food. The strong social bonds among dolphins help them cooperate for feeding. For example, a group of dolphins that comes across a shoal of fish may herd it to the surface by blowing bubbles and swimming around the fish. Once trapped at the surface, the fish are easier to catch and eat.

Killer whales are unique because they kill and eat other sea mammals, including the calves of larger whales. Sometimes they hunt in groups, sometimes alone. A killer whale will even launch itself up a beach to catch an unwary sea lion.

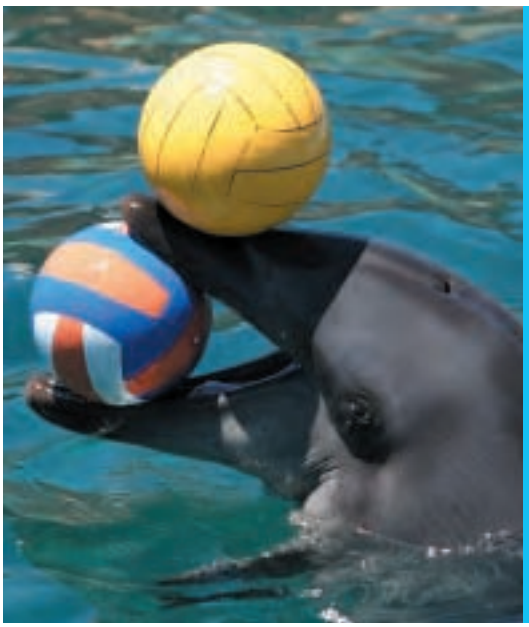
Social Behavior

Dolphins live complicated social lives, which vary from one species to another. Scientists still have a lot to learn about dolphin societies. Most species live in small groups, which may team up into larger groups, such as when rounding up a huge shoal of fish. Sometimes, thousands of deepwater dolphins may join forces to journey across the ocean.

Dolphins do not seem to be monogamous, with one male staying permanently with one female. Even small groups of dolphins may not always be permanent, with individuals switching from one group to another. However, dolphins are intelligent animals that can recognize other individuals, even if they have not seen each other for a while.

One of the whistling noises dolphins make is a so-called signature call. This call is different for each dolphin and helps other dolphins identify every individual. Sometimes two dolphins in a group may team up as buddies and stay together for months or even years. Teamwork requires team bonding. Once dolphins have fed and rested, they spend a lot of time playing, socializing with each other, and touching one another. Often, they just seem to be having fun. These playful habits are probably a reason why dolphins are also friendly toward people.

Killer whales and probably pilot whales, too, live in more permanent groups than other dolphins. Killer whales live in groups containing a mother and all her offspring,



DOLPHIN INTELLIGENCE

A dolphin's brain is larger than a human's, although a human brain is bigger relative to body size. Dolphins are obviously intelligent, as shown by their ability to work together in groups and to learn new behaviors, both in the wild and in captivity. Tests show they can also think using abstract concepts, such as numbers. Sometimes scientists have tried to communicate with dolphins in artificial languages that use signs and symbols. Other scientists have doubted that dolphins are really able to use language in the way that people do.

A school of short-beaked common dolphins leaps out of the water at full speed.

including daughters, sons, grandsons, and granddaughters. Males leave the group temporarily to mate, but otherwise the family sticks together permanently, year after year.

Mother dolphins give birth to a single calf at a time. Most births take place during the summer months. The mother feeds it on her milk. The calf may stay for her for months or even years, depending on the species. A female dolphin has a calf only once every two or three years at most. For a female killer whale or pilot whale, births are seven to eight years apart.

Dolphins and People

Although dolphins are popular animals, human activities have sometimes had a bad effect on them. In the past, people killed dolphins for food, although that is less common now. In the late twentieth century, nets spread in the ocean to catch tuna killed huge numbers of dolphins by accident. Nets are now designed to make it easier for dolphins to escape from or avoid them.

Captive dolphins are popular, and dolphins seem to enjoy human company. However, some people think that it is unfair to keep dolphins in an unnatural environment. Certainly, dolphins in captivity die younger than wild ones.

Sometimes groups of dolphins, especially pilot whales, strand themselves on beaches, where they die. Possibly they are following a leader that has fallen sick. Strandings do not necessarily have anything to do with people. But some scientists think that pollutants may affect the health of dolphins, making sickness and strandings more likely.

DID YOU KNOW?

- Two species of dolphins live in the Amazon River.
- Some patterns on dolphins probably disguise them by imitating light patterns in water.
- Dolphins have developed complex sound signals to stay in touch.

DRAGONFISH

These bizarre, often grotesque fish live in the dark depths of the world's oceans. They form part of a community of creatures illuminated by lights given off by their own bodies.

True dragonfish have rather long, eel-like bodies that are covered in a jellylike substance. They may have a very distinctive pattern of six-sided scales on their bodies, and large eyes that help them to see in the dark. Dragonfish also have a projection, known as a barbel, on the chin that allows them to detect food close by. They also have massive, wide-opening mouths. This is made possible by having the jaws hinged a long way back on the head.

Changing Appearance

Young dragonfish look very different from adults. The eggs hatch at the surface, and the larvae that emerge also float there. At first they are transparent and colorless. Their bodies are very long, thin and rounded. They also have no mouth at this stage. Their eyes are very distinctive; they are mounted on long stalks that can be almost half the total length of their body. It may be that having eyes on stalks gives them better all-round vision, helping them escape from predators and find food.

As the larvae grow older, the stalks are gradually absorbed back into the body. This draws the eyes into the fish's skull. Once the young dragonfish have reached a length of about 1.8 inches, they start to change dramatically in appearance, developing pigmentation (coloration) in their bodies, too, so that before long they resemble miniature adults.

This viperfish's head shows the long, daggerlike teeth, some almost half as long as the head itself. They are perfect for capturing anything edible within range.

Fact File

DRAGONFISH

Family: Stomiidae (about 278 species)

Order: Stomiiformes

Where do they live?: Atlantic, Pacific, and Indian Oceans

Habitat: Usually occur in deep water, down to depths of 9,850 feet (3,000 m) or more, but may come much closer to the surface at night

Size: From around 1 inch (2.5 cm) to approximately 20 inches (50 cm)

Coloration: Generally dark in color, frequently black, but some species are bioluminescent (make their own light)

Diet: Crustaceans and fish; capable of taking large prey

Breeding: Mating and breeding behavior unknown; eggs and larvae drift as plankton, with the larvae often looking quite different from the adult fish

Status: Unclear

DID YOU KNOW?

- Most of the male dragonfish's small body is occupied by its testes. Their gut is shrunken and they cannot digest food. They also have very few teeth in their mouth. This suggests they live just long enough to mate.
- Worldwide, there are up to 150 different species of fish that use bioluminescence.
- Courtship in the Asian dragonfish is a long process, lasting between two and three months.

Lighting Up

Dragonfish may have special structures called photophores that enable them to generate light. This light is known as bioluminescence, which means "living light." Some dragonfish can generate a type of red light from organs under their eyes. This is invisible to their prey, which can only see light from the blue and green part of the spectrum. It means the dragonfish can see prey without itself being detected.

Loosejaws

These members of the dragonfish family have a massive mouth that is longer than their skull. The jaws are arranged in such a way that they can unhinge when the loosejaw is swallowing large prey. It may be that feeding opportunities for these fish, certainly in the depths of the oceans, are very few and far between. This arrangement allows them to take advantage of whatever potential prey crosses their path.

The stoplight loosejaw also has two types of light organ on its head. There is a red light beneath each eye, while green lights are present further back, behind the eyes.

The stoplight loosejaw is found in waters down to 8,200 feet in the Atlantic, Pacific, and Indian Oceans.

Sloane's viperfish has a slender body and fanglike teeth. The long ray on the back (dorsal) fin carries a luminous tip that acts as a lure to attract prey.

A DIFFERENT DRAGON

There is another type of dragonfish that is highly prized in Southeast Asia. This is not a sea fish, but an inhabitant of still or slow-flowing fresh water, unrelated to the marine dragonfish in all but its common name. It is a large species that can grow to 35 inches in length and has a torpedo-shaped body (above). The dragonfish's coloration varies, tending to be gold or greenish-silver in Malaysia, and red or gold in Indonesia. They have been bred to produce other varieties. These include the rainbow dragon, which has iridescent scales. But the most valuable and sought-after variety has a deep red coloration.

In spite of their large size, Asiatic dragonfish eat small aquatic creatures, ranging from crustaceans and aquatic insect larvae to small fish. Dragonfish feed near the surface. Occasionally, they may leap up out of the water to catch invertebrates from vegetation overhanging the water.

Breeding usually occurs between July and December, with as many as ninety eggs being laid. The male carefully collects these in his mouth, and then broods them there for up to six weeks. The fry are nearly 3.5 inches long by the time they are released from his mouth.

DUGONG AND MANATEES

Dugongs and manatees are the only large, water-living mammals that eat plants. They are sometimes called sea cows. People have suggested that these gentle animals might be the origin of stories about mermaids!

At first glance, dugongs and manatees look a bit like small whales. However, scientists think that their nearest living relatives are elephants. Dugongs and manatees are also called sirenians, after the name of the scientific order to which they belong—Sirenia. The dugong lives only in warm, shallow seas; manatees live in sea and fresh water.

Streamlined

Like whales, sirenians have a streamlined shape for swimming and flippers instead of front legs. They also have a layer of blubber, or fat, under the skin, which helps them keep warm. The easiest way to tell the difference between a dugong and a manatee is to look at the tail. Manatees have a roundish, paddle-shaped tail. By contrast, a dugong's tail is forked, just like a whale's.

Sirenians' sense of touch is good, especially around their mouth, where they have many sensitive bristles that help them find the plants they eat.

A West Indian manatee swims in the warm, shallow waters of the Caribbean. It has large, flexible lips that help it feed on water plants.

Fact File

***Dugong dugon* (dugong), *Trichechus manatus* (West Indian manatee), *Trichechus senegalensis* (West African manatee), and *Trichechus inunguis* (Amazonian manatee)**

Families: Dugongidae, Trichechidae

Order: Sirenia

DUGONG

Where do they live?: Tropical sea coasts, from East Africa to Australia

Habitat: Shallow seas where sea grasses grow

Size: Length 3.3–13 feet (1–4 m); weight 500–2,000 pounds (230–900 kg)

Skin: Smooth, with a few bristles; brown to gray

Diet: Sea grasses

Breeding: Females give birth to 1 calf every 3–7 years

Life span: Around 60 years

Status: Vulnerable

MANATEES

Where do they live?: Florida, the Caribbean, northern South America, and western Africa

Habitat: Shallow coasts, river mouths, and fresh water

Size: Depends on species; head–body length 8–15 feet (2.5–4.6 m); weight 770–3,500 pounds (350–1,600 kg)

Skin: Grayish and hairless; Amazonian manatee has a pink patch on belly

Diet: Freshwater plants and sea grasses

Breeding: Females give birth to 1 calf every 2–3 years

Life span: 30 years or more

Status: Vulnerable

1. *Steller's sea cow (now extinct)*
2. *Amazonian manatee*
3. *West Indian manatee*
4. *Dugong*
5. *West African manatee (head)*

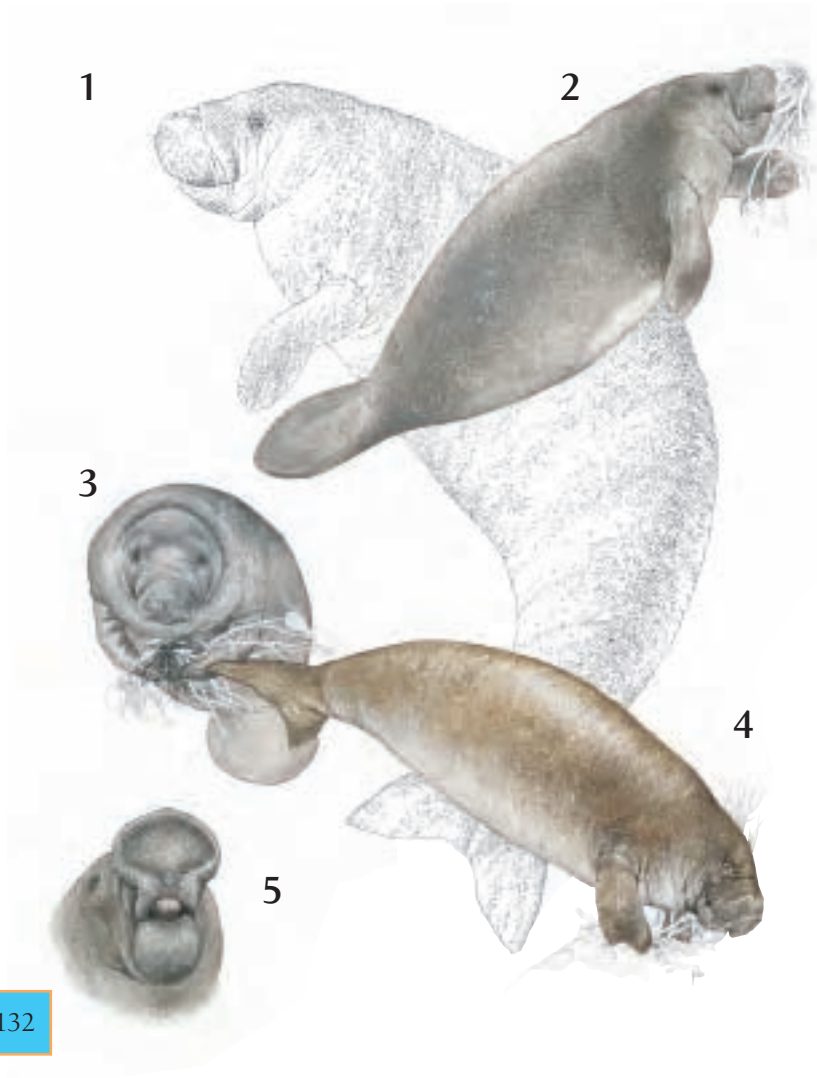
Sirenians also have good hearing, even though they have only tiny earholes. Their eyesight is not so good, however. Like all water-living mammals, they have to come to the surface to breathe.

Feeding

Sirenians have large, muscular lips, which they use to grab and pull at the water plants they feed on and to root around in mud at the bottom of shallow seas for food. Dugongs and manatees eat sea grasses. Sea grasses are flowering plants, unlike seaweeds. These plants grow under water in warm, shallow seas.

Manatees also eat freshwater plants. These plants are tougher to eat than sea grasses. Manatees have stronger teeth than dugongs. A manatee's teeth are replaced throughout its life because the plants it eats wear them down.

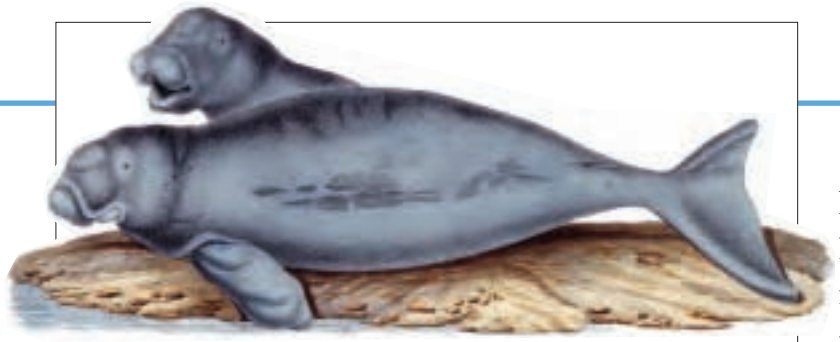
Plants are not easy to digest, so sirenians have bacteria (microscopic life-forms) living inside their digestive system. The bacteria help digest the plant food. Manatees have an intestine that is 150 feet long.



Living Together

Sirenians often gather together where there is food or warm water. Despite this, these animals do not seem to be social. However, scientists still have a great deal to learn about their behavior. For example, sirenians make chirping noises and squeaks to each other, but experts do not yet know what these are saying.

At breeding time, male dugongs gather together to show off in front of female dugongs. A female chooses the male she likes best. Unlike



STELLER'S SEA COW

Until the 1700s, a huge dugong relative called Steller's sea cow (above) lived in the northeastern Pacific Ocean. It weighed up to 6 tons. Steller's sea cow ate a large seaweed called kelp, not sea grasses. However, sailors passing by discovered Steller's sea cows and started hunting and killing them for food. Within a few years of its discovery, Steller's sea cow was extinct.

manatees, male dugongs have a pair of short tusks, which may play a part in courtship. Male manatees do not show off, but sometimes several males chase after a single female at the same time.

Sirenians, especially dugongs, have slow breeding cycles. A female dugong is not ready to breed until she is ten years old. In both dugongs and manatees, the calf stays close to its mother for one or two years before setting off to fend for itself.

Habitats and Survival

Dugongs and manatees live in different parts of the world. Dugongs live only in the sea, while West Indian and West African manatees move between saltwater and freshwater habitats. The smallest species of manatee, the Amazonian manatee, lives only in fresh water. It eats floating plants in the Amazon river in South America and the smaller rivers that flow into it.

Sirenians are slow-living animals that have few natural enemies. Humans are now the main threat to them. In Florida, many West Indian manatees are injured or killed by boats and boat propellers. Pollution also damages these animals. There are now safe, boat-free zones for manatees off the Florida coast.

Dugongs have often been hunted. They are rare or extinct in many places. However, in the seas off northern Australia there are still plenty of dugongs. Scientists are now studying these animals to understand their lives better.

DID YOU KNOW?

- The nearest relatives of dugongs and manatees are elephants!
- People use manatees to eat up the weeds in artificial water channels to keep them clear!
- Manatees relax by lying upside down on the seabed!

EELS

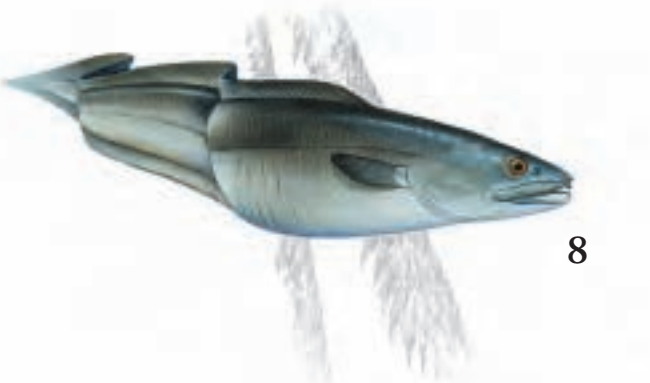
The cylindrical appearance we associate with eels developed over 400 million years ago, but the fish that evolved this shape died out. The ancestors of modern eels developed between 144 and 65 million years ago.

There is an advantage to eels in having a cylindrical body. It enables them to move easily in shallow water, or even travel overland if necessary, by adopting a similar pattern of movement to that of a snake. It is not possible to recognize all eels by their body shape, however, because there are also other groups of fish, such as lampreys, that have a similar appearance. Furthermore, there are a few other fish classified as eels. These include the tarpon, with its much broader body.

A Special Larva

The key feature that separates eels from other types of fish is their unique method of reproduction. They have a larval stage in their life cycle. The newly hatched young of an eel is called a leptocephalus, and it looks very different from the adult. The leptocephali of various species are also different from each other, so matching a leptocephalus to a specific species is not always straightforward either. Leptocephali usually have a leaflike shape. This helps them to float in the ocean's currents.

1. *European eel*
2. *Edward's spaghetti eel*
3. *Seagrass eel*
4. *Undulated moray eel*
5. Halosaurus ovenii



6. *Snipe eel*
7. *Deepwater arrowtooth eel*
8. *European conger eel*
9. *Pelican eel*

Fact File

EELS

Superorder: Elopomorpha

Orders: Elopiformes, Albuliformes, Anguilliformes. Saccopharyngiformes

Families: 24 (about 800 species)

Where do they live? Throughout the world's oceans, living in particularly large numbers in warmer waters

Habitat: Freshwater and marine environments, depending on the species; sometimes in relatively shallow waters around the coast or on coral reefs; some eels prefer to hide away in holes on a reef, on wrecks, or similar localities; some eels live in open water, especially in the ocean depths

Size: Varies from about 3 inches (7.5 cm) to over 6 feet (1.8 m), depending on the species

Coloration: Very variable, ranging from shades of silver to bright blue and also black

Diet: Predatory; prey ranges from invertebrates to other fish, depending partly on the species

Breeding: Generally have specific spawning grounds where egg-laying and fertilization take place, with the eggs being scattered randomly; eggs then hatch into leptocephali

Status: Most species common, but numbers of some have declined in certain areas; status of a few species unknown

Gradually, their bodies shrink in width as they turn into miniature adults.

Variations on a Theme

Although the general body shape of many eels is similar, their head structure can be quite different. Gulper eels have a huge, cavernous mouth, with a very loose lower jaw, which means that other fish can be swallowed easily.

DID YOU KNOW?

- Male spaghetti eels live in deeper waters, with females staying closer to the shore. This helps them to avoid competing for food, which consists of worms and other invertebrates.
- Some adult eels, including several false moray eels belonging to the family Chlopsidae, are only known at present from their leptocephali. No adults have been found.
- The collared eel is the smallest of the false moray eels, reaching a maximum length of just 6.25 inches. This enables it to hide from danger inside tubular sponges.

The same applies in the case of saccopharyngid eels. Both these species also possess very strange elongated tails. Snipe eels, which may also be found to depths of 16,400 feet, have a very different appearance. The narrow, bill-like mouth of these eels is said to resemble that of the wading bird known as the snipe.

An Unusual Lifestyle

Young snipe eels live quite close to the surface, whereas adults are found at depths of around 490 feet. As they mature, the appearance of the young eels is transformed, and the difference between the sexes becomes very obvious. Males have very much shorter jaws than females.

Ribbon eels are often highly colorful. They live partially buried in sand or crevices, waiting to grab unsuspecting creatures that come within range.

GARDEN EELS

Garden eels live in colonies. They are found in shallow water washed by currents. The currents waft food toward the eels, which lie partly buried in the sand with their heads protruding. They resemble plants waving in a breeze, hence the common name. If one fish senses danger, it will withdraw immediately into its burrow, and all the others will follow suit.

These remarkable eels spend their lives partially buried in this way, even mating from the relative safety of their burrows. The male reaches out and displays to a nearby female. If she is ready to mate, then she will stretch out toward him from her burrow.

A snake eel protrudes from the sand, attended by a cleaner shrimp that helps to rid it of parasites.

This gives them a somewhat stub-nosed appearance, with fewer teeth in their jaws. It led to the males once being classified as a separate species. Yet the small teeth of these eels are not just present inside their jaws, but also on the outside. They are not active hunters, however, resting vertically in the water with their mouths open waiting for food to pass by.

Snipe eels feed mainly on deep-sea shrimp. As these crustaceans swim past the eels their legs or antennae are likely to become entangled around the eels' tiny teeth. The jaws of the eel are highly flexible, allowing the shrimp to be swallowed easily. It is likely, given the reduction in the teeth of males, that they are relatively short-lived compared with females. They may only survive to spawn once, whereas female snipe eels may lay several broods of eggs in their lifetime. These eels spawn in groups, but little is known about their breeding habits.

Snake Eels

One of the most brightly colored groups of eels are the snake eels. The bright colors, complete with banded markings, help them resemble deadly sea snakes, which are also found in the tropical seas inhabited by the snake eels. This coloration protects the eels from predators that confuse them with sea snakes. However, snake eels do not have a venomous bite.

Snake eels are also distinguished by their rather stiff and rounded tails. These allow them to bore into the seabed where they remain for much of the day with just the head protruding.

DID YOU KNOW?

- The vertebral column of some species of snipe eels is made up of some 750 bones. By comparison, there are just 33 vertebrae in the human backbone.
- Snipe eels are not confined just to warmer waters. A specimen was caught off the Alaskan coast in 1890—the only example of its species so far discovered.
- Male eels are usually smaller than females of the same species.

Snake eels tend are usually nocturnal hunters, emerging under cover of darkness and usually preying on fish. The margined snake eel is somewhat different, however. It is a parasitic species that attaches to its prey—usually larger fish—and then eats its way through into the victim's body cavity, feeding on muscle tissue.

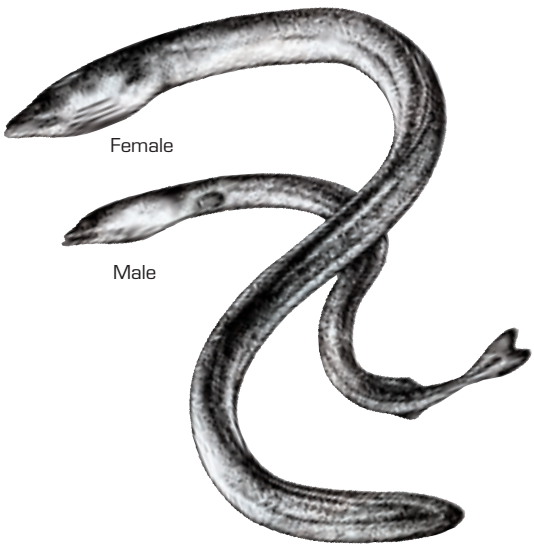
Spaghetti Eels

This family of fish are known as spaghetti eels simply because their body shape is said to resemble strands of spaghetti. In these eels, it is not only a marked size difference that allows the sexes to be distinguished. There is also a noticeable variation in the appearance of their fins. Females have a typically rounded, eel-like tail (caudal) fin, but the male has a bigger, forked caudal fin, which probably reflects his more active lifestyle. The shorter male also has fewer vertebrae in his spinal column, and his heart is located further forward in the body, being nearer to the head than the female's.

Their burrowing habits have also led to spaghetti eels being described as worm eels. Young eels, following the leptocephalus stage of their life cycle, will burrow headfirst into the seabed, only emerging from their hiding places to search for food when it is dark.

MYSTERIOUS EELS

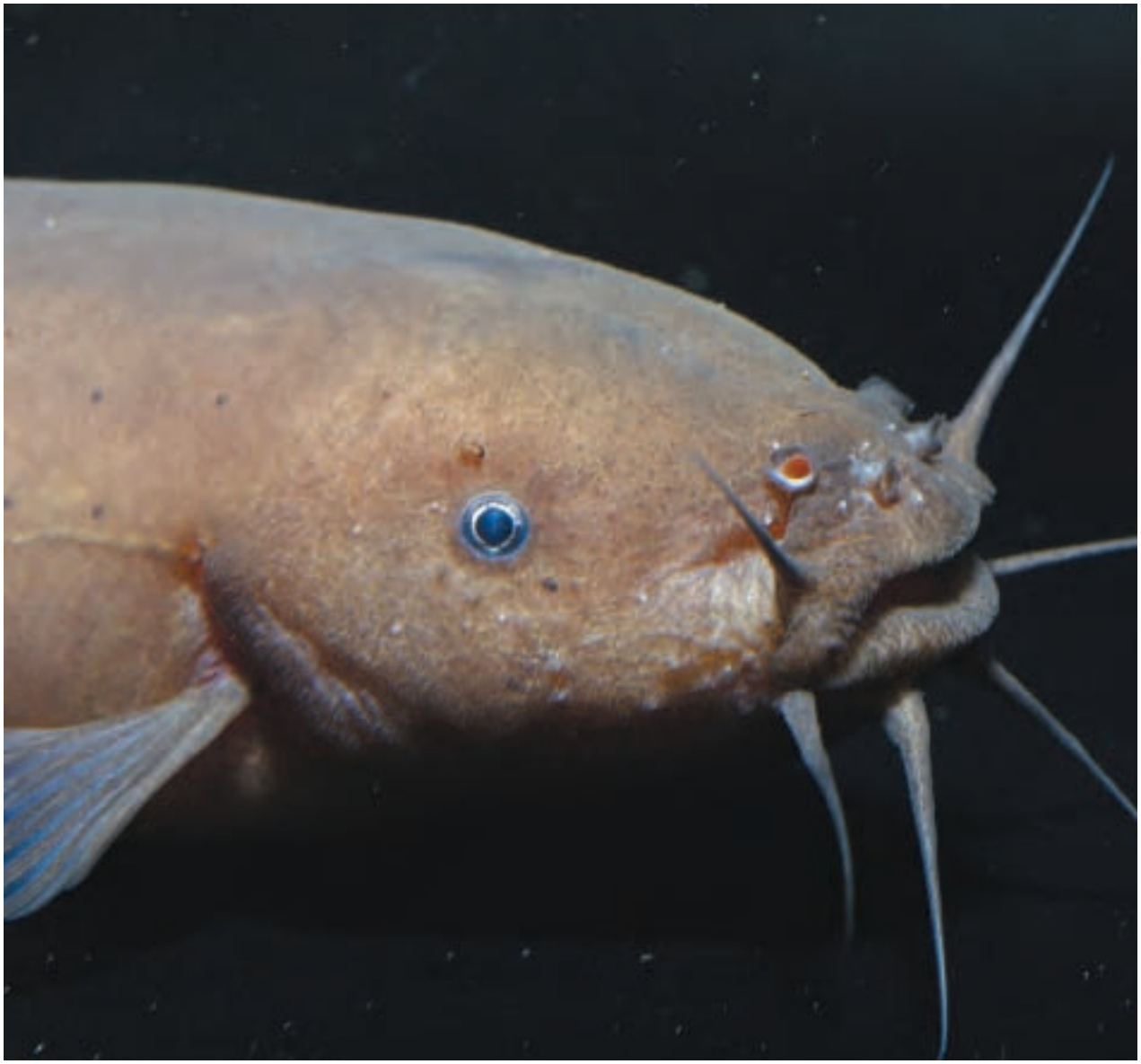
In the late 1930s, a strange eel was brought into a fish market near Kochi in Japan, but no one could identify it. The fish turned out to be a previously undiscovered species, now called the abyssal cutthroat eel. It is a deepwater species and thought to be rare in the wild. Even today, the distribution of many eels remain a mystery. The false moray eel *Chlopsis olokun* that was caught off the Ivory Coast, West Africa, in 1966 represented a breakthrough. It was the first species of false moray eel to be found in the Atlantic Ocean rather than in the Pacific Ocean.



This shows the differences in the size and shape between the sexes in the spaghetti eel.

ELECTRIC CATFISH

Although the electric catfish is not a very active fish, spending much of its time lying on the bottom, it can give a painful shock to a human—producing a charge of about 350 volts.



While an electrical shock from one of these catfish will not be powerful enough to kill a human, it is strong enough to stun prey. This is necessary because these catfish are not able to swim quickly and so prey could easily escape from them. They have a special organ in their body lying just beneath the skin that is responsible for generating the electricity. This organ extends backward from the head to a point approximately two-thirds along the length of the body. It does not reach into the fins, however. The electrical organ is formed from specialized cells called electrocytes that have evolved from pectoral (chest) muscle cells.

Using Electricity

The electrical organ in the catfish's body is for protection as well as for hunting. It keeps the catfish safe from would-be predators. Rather like radar, the electrical fields can also be used to navigate safely through the murky waters where these catfish often live, avoiding collisions with obstacles. They can also reveal the presence of prey—and other electric catfish. Electric catfish are very territorial and can be aggressive toward their own kind.

The strongest electric shocks produced by the electric organ are held back for use when stunning prey. They can last for up to 30 seconds and consist of several hundred separate pulses.

The ability of these fish to give an electric shock was well known in the ancient world, with the Arabic name for this fish translating as "Father of Thunder."

Fact File

ELECTRIC CATFISH

Family: Malapteruridae (11 species)

Order: Siluriformes

Where do they live?: The family occurs widely throughout tropical Africa, from the western side of the continent across to the Nile River

Habitat: Slow-moving or still areas of fresh water where there are hiding places amongst rocks or wood

Size: From around 4.8–48 inches (12.2 cm–1.2 m), depending on the species

Coloration: Relatively dark in color, with lighter bands and spots

Diet: Preys on smaller fish

Breeding: Unclear; females may lay eggs in holes in river banks, which they may excavate; it has also been suggested that electric catfish may be mouthbrooders, keeping their eggs in their mouth until the young have hatched

Status: Generally not under threat, although some species have restricted ranges

ELECTRIC EEL

The electrical shock produced by one of these eels is capable of killing not just a human but even a horse. Unsurprisingly, electric eels are among the most feared fish in South America.

Over 80 percent of this fish's body volume is taken up by its electrical organs. These are in the form of plates consisting of white, jellylike areas divided by harder tissue. There are about half a million plates in the body and they can generate an electrical discharge of at least 550 volts with a current of 2 amps, producing a kilowatt of power. Each shock lasts for only a very short time—about three-thousandths of a second. But electric eels can produce as many as 150 shocks in a hour, with no fall-off in output.

Electric eels are not powerful swimmers. They move by using the long, wavy underbody (anal) fin, together with writhing, snakelike body movements. Electric eels do not have a back (dorsal) fin.

Attack and Defense

Electric eels usually hunt at night, under the cover of darkness. They rely on their power output to stun or kill their prey. The force of a shock, which can extend for a distance of at least 3 feet around the fish, is also a strong defense against would-be predators. These include large turtles and caimans. Large mammals—even humans—can receive a shock simply because they accidentally frighten an eel.

The release of low-intensity bursts of electricity also helps the eels find their way about, and probably locate others of their own kind. They have special cells on their head that detect electrical impulses.

Despite its name, the electric eel is not a true eel. It belongs to a group of fish known as knifefish. Much remains to be learned about its habits and life span.

Fact File

ELECTRIC EEL

Electrophorus electricus

Family: Electrophoridae

Order: Gymnotiformes

Where do they live?: In the Amazon and Orinoco River basins in South America, including Peru, Venezuela, Brazil, and Guyana

Habitat: Restricted to freshwater areas; often occurring in muddy waters where the visibility is poor; tend to hide away during the day amongst rocks or vegetation

Size: Up to 8 feet (2.4 m) long

Coloration: Dark in color, sometimes with paler spotting on the sides of the body

Diet: Preys on aquatic creatures including larger invertebrates, such as shrimp, as well as fish and amphibians

Breeding: Courtship and egg-laying behaviors unknown

Status: Does not appear to be uncommon or declining through its range

ELECTRIC RAYS

The shocks produced by these fish can be painful but are unlikely to be fatal to humans. A special part of the ray's brain regulates how and when the fish is able to give a shock.

The ability of electric rays to inflict shocks was well known centuries before the power of electricity was understood. Their electrical output is about 220 volts—much less than that of the electric eel—so they do not represent a serious danger to humans. The electrical organs of these fish are located on each side of the body. They have evolved from muscles. These have developed the ability to generate a much stronger electrical current than those that normally travel along the nerves in the body triggering ordinary muscles movements. The ray's electrical organs consist of layers of disks packed with a jellylike substance along which an electric charge can pass. Up to a thousand of these layers are stacked on top of each other throughout the body.

Brain Power

A special part of the ray's brain called the electrical lobe connects directly via nerve fibers to the electrical organs. This in turn enables the ray to control the use of its electricity efficiently. It only discharges when its prey is within reach or danger threatens. This is important, because as with a battery, the voltage from the electrical organs will become drained if they are used all the time. It takes time for them to recharge. There is also an instant override in the system. When female rays give birth, for example, they will not electrocute their own offspring.

Electric rays usually lie in wait for their prey. They live close to the seabed, in sandy areas, often partially burying themselves to avoid detection.

Fact File

ELECTRIC RAYS

Families: Narcinidae, Narkidae, Hypnidae, Torpedinidae (about 55 species altogether)

Order: Rajiformes

Where do they live?: Atlantic Ocean, Pacific Ocean, and Mediterranean Sea

Habitat: Many of these rays are found in relatively shallow waters but the deep-sea blind ray can occur down to nearly 3,000 feet (1,000 m) and Pacific torpedo rays may be found in depths of 9,800 feet (3,000 m)

Size: May reach up to 6 feet (1.8 m), depending on the species

Coloration: Can change color to match surroundings; tends to be sandy-gray in color above, with pale underparts; common torpedo has blue spots on its body

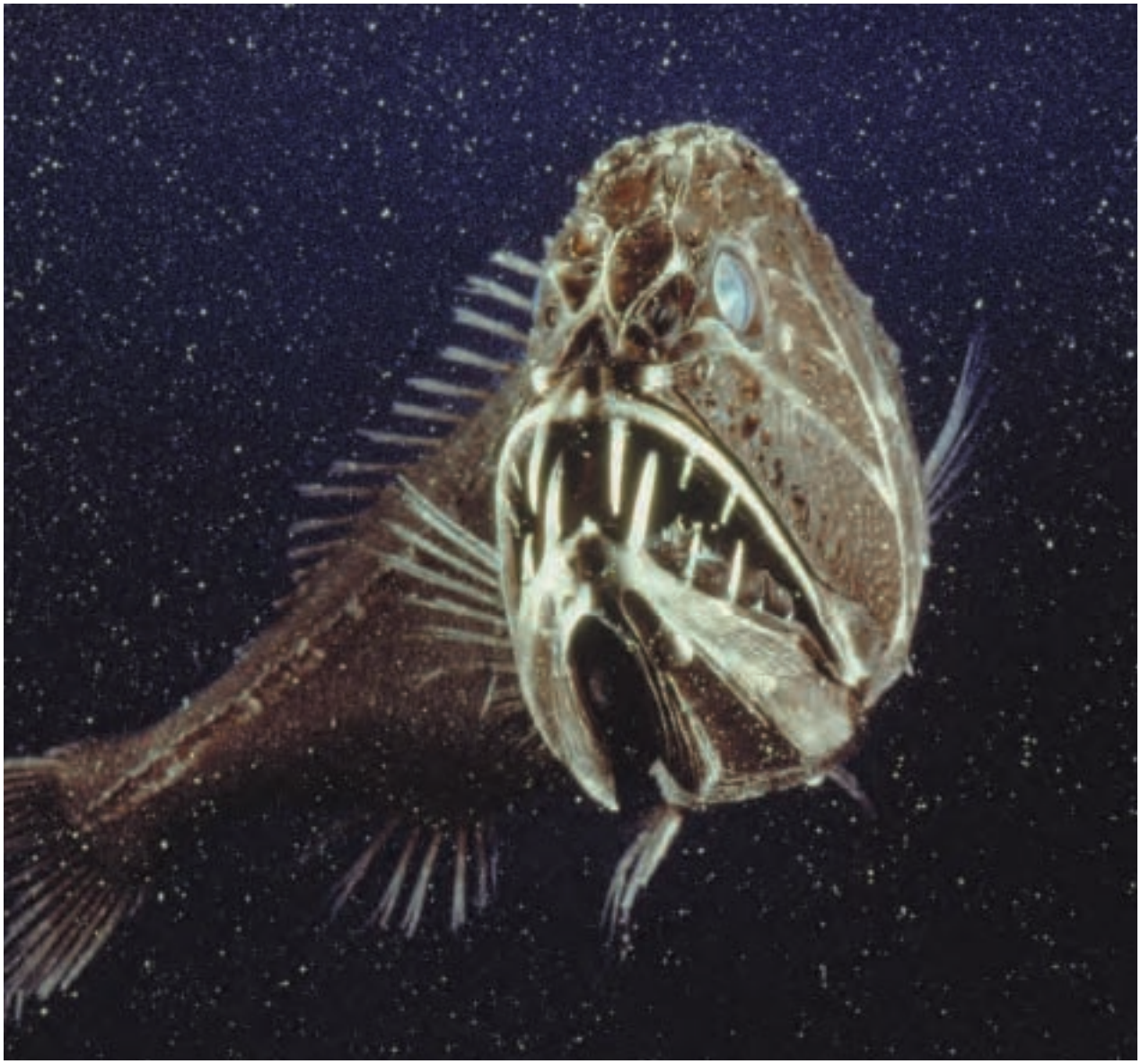
Diet: Predatory, feeding on animals ranging from invertebrates to fish

Breeding: Eggs are retained within the female's body, with live young, called pups, being born after about 9 months; this type of reproduction is known as ovoviviparity

Status: Generally not under threat

FANGTOOTHS

These voracious marine hunters have fearsome, sharp fangs and especially large mouths. Once seized, there is no escape for any unfortunate victim targeted by a fangtooth.



For all their reputation as deadly hunters of the deep, fangtooths are small fish that can themselves fall victim to larger hunters like tuna and marlin. Against such large predators, fangtooths have little defense. However, their hard, bony body gives them protection from many other smaller hunters. This hard body is an unusual feature in deep-sea fish, which normally have soft, flexible bodies, despite the high pressures experienced at great depths.

Young fangtooths also carry protection against predators in the form of a spine on top of the head and another on the bottom edge of one of the bones that cover the gills. Baby fangtooths look so different from adults that, for about a hundred years, they were each thought to belong to separate species.

Deadly Combination

Sharp teeth, large mouths, and (often) large stomachs are commonly found in deepwater predators. This combination allows such fish to survive in an environment where food is scarce. If a suitable meal comes along, no hunter can afford to let the opportunity swim away. It could be a long time before another meal happens to come within reach.

Not surprisingly, therefore, deepwater hunters like fangtooths have mouths and teeth designed to grab hold of such prey and swallow it whole—even if at first the meal appears to be too large to swallow.

Fangtooths are adapted to grab any potential meal. However, the widely spaced teeth are not suited to cutting food up, so any prey is swallowed whole.

Fact File

FANGTOOTHS

Family: Anoplogastridae (2 species)

Order: Beryciformes

Where do they live?: Common fangtooth: worldwide in deep tropical and temperate seas; shorthorn fangtooth: tropical Pacific and Atlantic Oceans

Habitat: Deep water: common fangtooth is found between 1,640–16,400 feet (500–5,000 m); shorthorn fangtooth is found in shallower water: 3,300–4,920 feet (1,000–1,500 m)

Size: Common fangtooth up to 7 inches (18 cm); shorthorn fangtooth just over 2.4 inches (6 cm)

Coloration: Deep brown to black

Diet: Fish (mainly) and shellfish

Breeding: Eggs and sperm are released into the water and float to the surface; the young spend some time among the plankton

Status: Not known to be threatened

FLYING FISH

Some fish blend in with their background, or huddle together to form large, tight balls of writhing bodies to escape from hunters, but flying fish can quite simply disappear from view.

It must be disconcerting for a hunter to discover that the prey it is chasing suddenly disappears. Yet, this is precisely what happens when flying fish are being pursued. When they sense danger, flying fish break through the water surface and put on a burst of speed using lightning-fast beats of their specially adapted tail—it can beat at up to fifty times per second! Once flying fish reach take-off speed, which can be around 37 miles per hour, they leave the water completely and glide above the surface on their highly modified winglike pectoral (chest) fins.

Gliders or Flyers?

To see a shoal of flying fish taking off and gliding over the water surface on a calm day is an unforgettable experience. From a distance, they look more like a flock of seabirds skimming the waves than a shoal of fish.

Although we call them flying fish, these fish are gliders rather than flyers. They do not flap their wings in the way that animals do when in true flight. Flying fish merely hold their pectoral fins at 90 degrees to their body and glide. The distances covered can be considerable, however. Just how far a flying fish glides depends on the severity of the threat, on wind speed, on the size of the individual, and on the species. The distance can range up to 80 feet in species that have the normal two "wings" and up to 650 feet in those that also possess winglike pelvic (hip) fins.

A group of flying fish takes to the air in an attempt to escape from an unseen predator, such as a tuna or a swordfish, in the waters below.

Fact File

FLYING FISH

Family: Exocoetidae (about 67 species)

Order: Beloniformes

Where do they live?: Most tropical and temperate seas

Habitat: Usually remain relatively close to the water surface

Size: From around 5.5 inches (14 cm) in the African sailfin flying fish to 20 inches (50 cm) in *Chelopogon pinnatibarbatus japonicus*

Coloration: Most species have deep blue coloration on the back, shading into lighter colors along the sides and silvery along the belly

Diet: Mainly plankton

Breeding: Some species spawn among mats of floating seaweeds; the eggs, which float, are abandoned

Status: Not known to be threatened

FOUR-EYED FISH

Four-eyed fish are not brightly colored, nor do they have elaborate fins. In fact, they look just like ordinary fish—except that they have the most incredible eyes.

As their name indicates, these cylinderlike fish have four eyes. At least, they give the impression of having four eyes. On closer examination, however, it can be seen that in fact they only have two eyes, just like most other fish. However, each eye has two colored strips of tissue that extend inward from the iris and meet in the center of the pupil. This effectively divides each eye into a top half and a bottom half, creating the illusion of four, instead of two, eyes.

Two-way Vision

This division is accompanied by changes to the lens inside the eye. These give four-eyed fish the ability to see above and below the water surface at the same time. The secret of this ability lies in the shape of the lens. Animals that live surrounded by air, rather than water, have long, slim eye lenses with the sides slightly curved outward. This is known as a convex shape and is the best one for seeing in air. However, the best shape for seeing under water is spherical.

The lenses in the eyes of four-eyed fish have both shapes: slightly convex sides facing upward into the air, and rounded ends facing the water. Inside each eye there are two retinas (the layers of tissue that receive images and pass them to the brain, allowing animals to see). One receives images from the air and the other gets images from the water. This gives the fish a unique and extraordinary ability.

The unusual structure of the eyes of four-eyed fish is shown here. Another surprising feature of these fish is their ability to survive out of water at low tide.

Fact File

FOUR-EYED FISH

Subfamily: Anablepinae (3 species)

Family: Anablepidae

Order: Cyprinodontiformes

Where do they live?: South America

Habitat: Found in fresh water and estuaries, almost entirely near the surface, with the top half of each eye exposed to the air

Size: From around 8.7 inches (22 cm) in the Pacific four-eyed fish to around 12 inches (30 cm) in the large-scale foureyes and the finescaled foureyes

Coloration: Drab, light-brownish on the back, fading to a white belly

Diet: Small fish, invertebrates, and vegetation

Breeding: Eggs are fertilized inside the body of the female, which subsequently gives birth to fully formed young

Status: Not known to be threatened

FRESHWATER EELS

From willow-leaved larvae to snakelike adults, eels have fascinated and mystified us for centuries. Even today, they still have many secrets, some of which we may never uncover.

The amazing story of European and American eels begins, not in the rivers where the adults are found, but in deep water in part of the western Atlantic known as the Sargasso Sea. In the case of the European eel, this is some 4,000 miles away from the home rivers of the adults. Larval eels (known as leptocephali) take up to three years to cover the distance from their place of birth to their eventual homes. For the American eel, the journey is much shorter, but it can still take the larvae about a year to complete the trip.

Mysterious Origins

Eels have been steeped in mystery for many centuries. For example, the ancient Greek writer Aristotle believed that eels, which have slimy bodies, were actually formed from slime. He also believed that baby eels arose from "the entrails [bowels] of the earth." Another Greek writer, Pliny, believed that baby eels were formed from pieces of the skin of adult eels scraped off by rocks. In the eighteenth century, there was a widely held belief that eels arose from the hairs of horses' tails. A century later, it was claimed that a particular beetle gave birth to baby eels.

Many eel mysteries still remain today. For example, although scientists know that American and European eels breed in the Sargasso Sea, no adults have ever been caught in the area. Amazingly, no eel eggs have ever been collected in the Sargasso Sea either.

A European eel swims along the river bed. When ready to breed, an eel will even travel over land at night in its determination to reach the sea.

Fact File

FRESHWATER EELS

Family: Anguillidae (around 20 species)

Order: Anguilliformes

Where do they live?: Eastern North America to northern South America, and much of Europe

Habitat: Young hatch and spend time at sea; adults live in fresh water

Size: From around 27.5 inches–6.6 feet (70 cm–2 m); but up to 4.9 feet (1.5 m) in the American eel and 4.3 feet (1.3 m) in the European eel

Coloration: Grayish-brown along the back, changing to yellow along the belly; belly becomes white when adult and upper parts darken

Diet: Feeding occurs in fresh water: invertebrates and fish are taken

Breeding: Thought to occur in deep warm water—probably down to 15,000 feet (4,500 m) in some species; American and European eels spawn in the Sargasso Sea; a large female can release up to 20 million eggs which hatch in about 48 hours; larvae (leptocephali) drift in the sea for an extended period of time before they reach their home coasts

Status: Not known to be threatened

From Leptocephalus to Eel

So how do adult eels find their way from their home rivers to the Sargasso, especially when they are such weak swimmers? Also, how can the larvae survive for two or three years without food, yet still manage to grow? (No food has ever been found in the guts of larval eels.) When young eels appear off the American and European coasts, they are already about 6 inches long. Yet, why are no smaller eels ever found?

In fact, the answers to these questions have been available since 1783. It was in that year that a transparent, leaflike fish was collected, described, and given the name "leptocephalus." About 130 years later, two other leptocephali were caught. This time, they were kept alive in an aquarium. Over a period of time, they changed into the familiar shape of the adult eels. At that point, it was realized that leptocephali were not separate species but, quite simply, eel larvae.

The leaflike leptocephalus larva of an eel.

DID YOU KNOW?

- Although they do not feed, larval eels have forward-pointing teeth.
- All twenty or so species of eel are believed to spawn in warm waters, probably at depths of between 600–15,000 feet.
- Eel blood contains a dangerous poison, but it is destroyed by cooking.

Breeding Grounds

Although countless millions of eels had been caught, gutted, and eaten

over the centuries, none was ever found with egg-filled ovaries, or ripe eggs, or even sperm inside them. The first of these discoveries had to wait until 1777, when developing ovaries were found in a female specimen. About a hundred years later, a mature male was found, followed, several years on, by a fully mature female.

It had nevertheless been observed that at certain times of the year adult eels showed an irresistible drive to reach the sea, even slithering over damp ground to do so. Gradually, it was realized that eels bred at sea.

After the leptocephali were discovered, a search was mounted to trace them back to their place of birth. Their size, and the location where leptocephali were collected, were recorded and a remarkable picture began to emerge. It was realized that the smallest leptocephali occurred in the Sargasso Sea and that it was here that adult eels spawned.

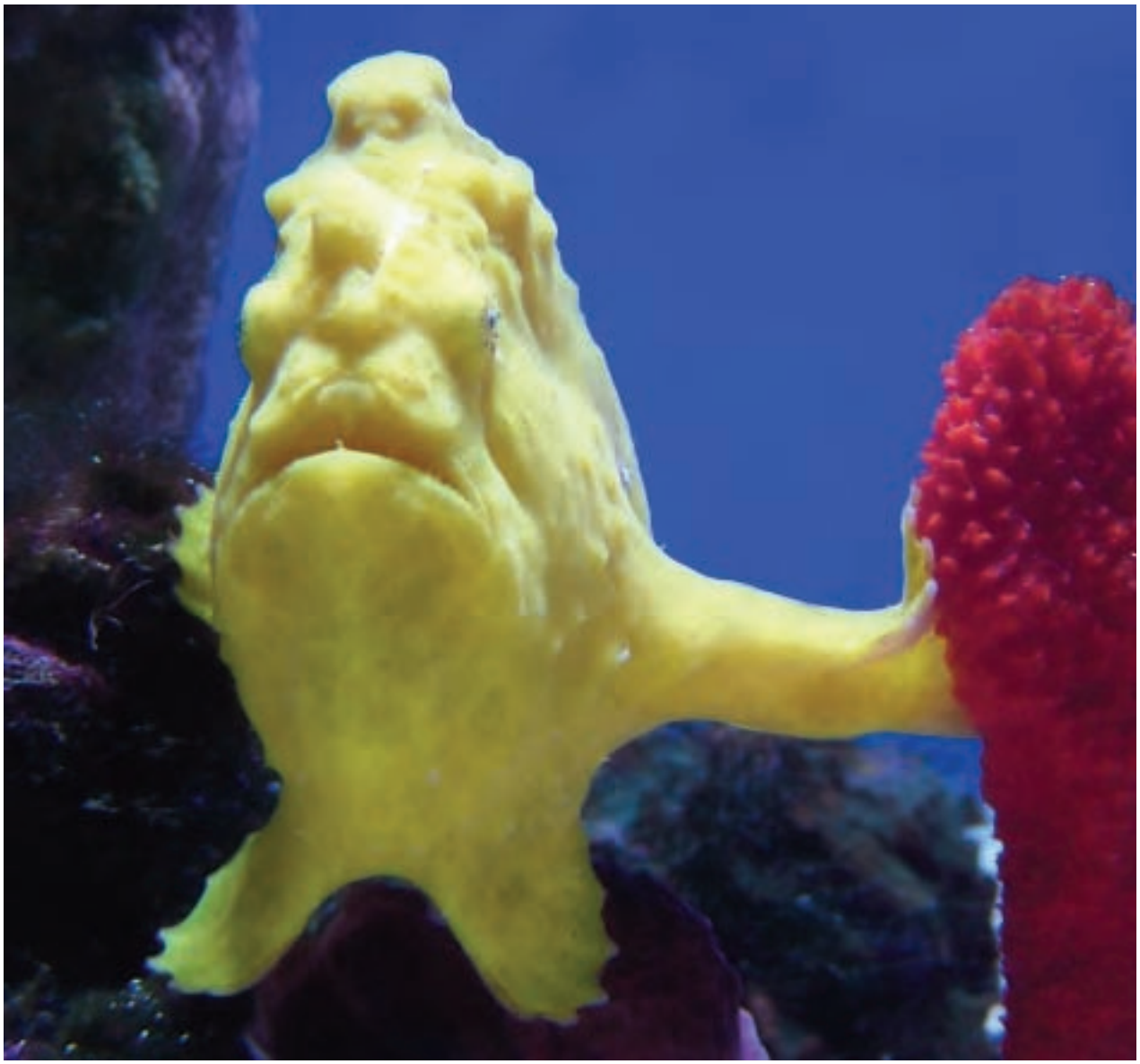
Eels up to two years of age are called elvers or glass eels.

FINDING THE SARGASSO SEA

How do young eels, that have never even entered the sea before, travel unerringly over thousands of miles to find the Sargasso Sea? Perhaps they are guided by a rise in water temperature? But this could not help those eels that migrate from the Mediterranean, since this sea is as warm as the Sargasso itself. Could changes in the saltiness of the water guide them? Probably not, since eels do not seem to be affected by whether salt is present in the water or not. Finally, it has been suggested that they might follow the Earth's magnetic field. But this also seems unlikely, because no organ has been found in eels that can detect magnetic fields. The eels' method of navigation remains a mystery so far.

FROGFISH

Some look like sponges, while others mimic algae-covered stones. Some even look just like seaweed—but no seaweed swallows victims in less than one-hundredth of a second!



Frogfish are close relatives of anglerfish, with which they share a number of characteristics. The most obvious of these is that they carry their own angling equipment in the form of a "rod and lure."

The rod consists of the first ray of the dorsal (back) fin while the lure, or bait, is a fleshy bit at the end that is used to attract prey. In the warty frogfish this lure not only looks like a fish, but is actually moved through the water as if it were a small swimming fish.

Master Hunters

Apart from the Sargassum frogfish, frogfish are very poor swimmers. They spend their time on the bottom or "'walking" over it using the pectoral (chest) and pelvic (hip) fins, which are muscular and can be moved like limbs. These allow frogfish to move around in search of a suitable hunting spot, undetected both by their prey and their own predators.

With their rod and lure, and some of the best camouflage in the fish world, it is hardly surprising that frogfish are such successful hunters. Some species can even change color over a period of hours to match their surroundings. In the case of the Sargassum frogfish, the body is mottled in such a way, and in such colors, that it blends in perfectly with the Sargassum seaweed in which it lives. It is therefore very difficult for a potential victim to spot this fish, even if it is only an inch or so away—by which time it is far too late.

Resembling little more than the colorful marine growths among which it conceals itself, a frogfish lies in wait for unsuspecting prey.

Fact File

FROGFISH

Family: Antennariidae (over 40 species)

Order: Lophiiformes

Where do they live?: Widespread in tropical and subtropical oceans and seas around the world

Habitat: Vast majority of species live on the bottom in shallow or relatively shallow water; the Sargassum frogfish lives among Sargassum seaweed; the Indo-Australian brackish water frogfish occasionally enters estuaries

Size: Many species measure 1–2 inches (2.5–5 cm); the largest species, the roughbar frogfish, can measure over 13 inches (33 cm)

Coloration: Extremely variable, often colorful—like the sponges, seaweeds, and encrusted rocks among which they live

Diet: Smaller fish and invertebrates; may also eat each other

Breeding: Eggs are laid covered in a jellylike substance, and are released close to the surface where they are abandoned in most species; in some, the eggs may remain attached to the body of the male for a time

Status: Not known to be threatened

GARFISH

The southern parts of the United States and Mexico are home to a fish that not only eats others of its own kind but also feeds on birds and alligators. There are also reports that it attacks humans.

The fish with the formidable reputation described opposite is the alligator gar. However, its name has nothing to do with an account in a book published in 1820 that tells of a fight between an alligator gar and an alligator. It ended with the gar cutting the alligator in two and swallowing it. The name actually comes from the fish's broad snout that gives the head an alligatorlike shape when it is viewed from above.

The attacks on humans are unconfirmed. However, there is no doubt that this species of gar is large enough, powerful enough, and sufficiently aggressive to mount such an attack.

Ancient Hunters

Gars are perfectly "built for the kill," with their long, cylinderlike, powerful bodies. Their long snouts are armed with numerous pointed teeth, and they have acute hunters' instincts. These characteristics have evolved over millions of years. The first gars probably appeared on Earth some 175–145 million years ago. They were widely distributed and ranged over North, Central, and South America, as well as Europe, Africa, and India—and possibly other places as well.

There have, therefore, been gars in American waters for a very long time. They are highly prized, primarily as game fish, although they are also eaten. The eggs of some gars are poisonous, however, and must be carefully removed prior to cooking.

In the southern United States the alligator gar (shown left) and the longnose gar are fished on a commercial scale, since the flesh of both these species is prized.

Fact File

GARFISH

Family: Lepisosteidae (7 species)

Order: Semionotiformes

Where do they live?: Central America, Cuba, and North America as far north as the Great Lakes

Habitat: Still or slow-flowing waters of large rivers, pools, lakes, and swamps, often containing submerged branches and vegetation; some species may enter estuaries

Size: From around 33 inches (84 cm) in the shortnose gar to around 10 feet (3 m) in the case of the alligator gar

Coloration: Brownish or other dark colors, accompanied by mottling along the back; lighter sides and belly

Diet: Mainly fish, crustaceans, and waterbirds

Breeding: Often occurs in groups in shallow warm water, either over vegetation or in a depression dug out by the female, depending on species; up to 77,000 eggs may be laid and hatch out between 6–9 days later

Status: Not known to be threatened

GOBIES

From record breakers to species with very unusual habits, gobies are among the most widespread and varied of all fish. Gobies also include some critically endangered species.

The male of the freshwater dwarf pygmy goby is just 0.4 inches long. A marine goby, known as *Trimmatom nanus*, is even smaller at 0.39 inches, while several others are only slightly larger.

It is only since the early 2000s that the goby world record for the smallest vertebrate (animal with a backbone) on the planet has been beaten—by another fish, a relative of the carp known as *Paedocypris*, that only reaches a length of 0.3 inches. Not all gobies are tiny, though. Some, such as the violet goby, are relatively large and can grow to more than 22 inches in length.

Varied Family

There are many different species in the family, and gobies are extremely varied in their habits. For example, mudskippers do as their name suggests. They skip over the mud at low tide in the mangroves where they live. They come out of the water to feed and display to each other on the exposed mudflats.

Other gobies share burrows with a species of shrimp. The burrow is dug out by the shrimp, which benefits from the association because the goby raises the alarm when any predator approaches. The gobies, for their part, get protection because they are able to dive into the burrows at the first sign of danger. The sponge goby also dives for cover when threatened—right into the body cavity of a loggerhead sponge. There are even some gobies that climb waterfalls!

The mottled coloration of this banded flaphead goby, seen in the waters off Sulawesi, Indonesia, helps it blend in superbly with the seabed.

Fact File

GOBIES

Family: Gobiidae (around 2,000 species)

Order: Perciformes

Where do they live?: Widely distributed in tropical and temperate regions; only a few species live in cooler waters

Habitat: Most are found in brackish (slightly salty) or marine conditions, but some are also found in fresh water; several species form partnerships with other creatures

Size: From around 0.39–28 inches (9.9 mm–71 cm), but most species are 3–8 inches (8–20 cm) long

Coloration: Extremely variable; some bottom-dwelling species are well camouflaged, while others are brilliantly colored

Diet: Most feed on invertebrates; some feed on plankton; larger species may also feed on small fish

Breeding: Eggs are usually laid on a carefully prepared site, such as a rock or the roof of a cave, and are guarded by the male

Status: 25 species are listed as being under serious threat; some, like the dwarf pygmy goby, are critically endangered

GOLDFISH

It has no scales on its head and is toothless. It does not even have a proper stomach. Yet, despite such apparent disadvantages, the goldfish is still the most widely kept pet in the world.

The goldfish is a close relative of the common carp and, like its cousin, it lacks scales on the top of its head. As a result, the goldfish has been referred to as being bald. Also, in keeping with its closest relations, the goldfish has no teeth in its jaws. However, it does have grinding teeth in its throat.

Another peculiarity of the goldfish is its gut. While it is very long—a feature typical of fish whose diet is made up largely of plant matter—it does not have a separate stomach. In reality, of course, these are not disadvantages. They are simply characteristics of a species that is highly successful and perfectly adapted to its particular way of life in the wild.

Fish of Many Colors

Another feature that is typical of wild goldfish is that they are olive-brown in color. This helps them blend in with their background—usually muddy bottoms with waterweeds—and offers protection from predators. Other colors, such as yellow or orange, are also seen in wild goldfish, but these are relatively rare.

The many colors of the varieties of goldfish kept as popular pets worldwide have been developed through careful breeding over the centuries. For example, it is reported that several red-scaled fish were first seen in China between CE 265 and 316—over 1,740 years ago. We do not have firm proof of this, but the first definite reports are between 730 and 1,050 years old.

The immense popularity of goldfish worldwide has resulted in people breeding them in an ever-wider range of colors and in different body and fin shapes.

Fact File

GOLDFISH

Carassius auratus

Family: Cyprinidae

Order: Cypriniformes

Where do they live?: Originally found in Central Asia, China, and Japan, but introduced to most parts of the world

Habitat: Wide range of waters, including lakes, rivers, and ditches; still or slow-flowing waters are preferred, particularly those with soft clay and mud on the bottom

Size: Up to 23.2 inches (59 cm) but generally smaller; some specimens can grow larger in captivity

Coloration: Mainly olive-brown to olive-green, but silver, yellow, gold, and other colors are also known in wild populations; bred varieties come in a wide range of colors

Diet: Wide-ranging, including vegetation and small invertebrates

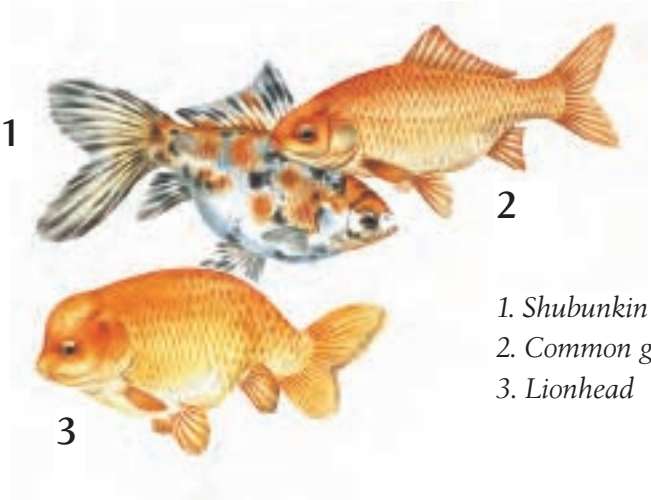
Breeding: Many thousands of sticky eggs are released among vegetation in spring; hatching can take up to 1 week, depending on temperature; eggs may develop without fertilization in some races

Status: Not known to be under threat

Since then, goldfish have been bred in a range of colors that includes white, black, brown, red, orange, yellow, and blue—with all shades in between. Breeding an animal or plant to produce a particular feature—such as color—is called selective breeding.

Many Shapes

As well as breeding goldfish of different colors, fishkeepers have also bred goldfish with unusual heads, body shapes, eyes, scales, fins, and nostrils. For example, there are goldfish with large bubblelike eyes, or with large eyes that are forever directed upward. Others have raspberrylike growths on their head and/or cheeks, two "bubbles" on their head, or pom-pomlike nostrils.. Yet more have double fins, maybe lack a back (dorsal) fin altogether, have long flowing fins, or short stubbly fins.



1. Shubunkin
2. Common goldfish
3. Lionhead

Some varieties have short egg-shaped bodies, scales that stand out like pearls, or even scaleless, shiny, or matt (non-shiny) bodies.

All of these features can occur in any combination, with the result that there are well over one hundred varieties of goldfish officially recognized today. Selective breeding

The veiltail is an attractive type of ornamental goldfish with long, flowing fins.

DID YOU KNOW?

- The longest cultivated goldfish ever recorded are over 18 inches long.
- The first official importation of the goldfish into America occurred in 1870.
- Goldfish eggs can sometimes develop without being fertilized.

continues, and new varieties of goldfish appear regularly, particularly in Far Eastern countries where there is great interest in breeding these fish.

Breeding Pimples

In the breeding season, male goldfish develop small, white, pimplelike growths (known as nuptial tubercles). These appear on their snout (nose), cheeks, gill covers, and the front edge of the pectoral (chest) fins. In some individuals, the growths can also extend to the top of the head and along the back.

While these growths may have a number of uses about which we are unsure, there is one that we have a good idea about. The body of a goldfish is covered in a layer of protective, slimelike mucus that makes these fish rather slippery. The rough texture of the growths may therefore help a male to keep in close body contact with the slippery female during spawning, when sperm and eggs are released.

The growths on the cheeks and pectoral fins would be particularly useful for this purpose. Those on the snout could, perhaps, also help the male encourage the female during spawning, or even repel rival males.

Since the male's tubercles disappear once the breeding season is complete, they are clearly only of use at this time of the year.

The oranda has a raspberrylike growth called a hood on its head.

HOODED GOLDFISH

Goldfish that have raspberrylike growths on their heads (above) are referred to as hooded varieties. Goldfish enthusiasts place great value on the size and position of the hood. If it is only on the top of the head, it is known as "cranial." If it is located under the eyes, it is known as "infraorbital." If the hood is on the cheeks, it is known as "opercular."

The relative sizes of these three features determine the quality of the goldfish and are the subject of heated debate among experts. There are even some goldfish fans who dedicate themselves exclusively to the care, breeding, and appreciation of just a single variety of hooded goldfish.

GOURAMIS

It seems unbelievable that a fish can drown. Yet this is precisely what happens in some species, such as gouramis, if they are prevented from surfacing regularly to take in a gulp of air.

Gouramis have evolved to live in waters that can become very low in oxygen. Under such conditions, most fish would sooner or later choke to death. In gouramis, however, some of the gills have developed into special organs that are very efficient at absorbing oxygen directly from the air.

The Price of Survival

This survival strategy comes at a price, though, since the highly modified gills can no longer absorb oxygen from the water. Therefore, even if there is an ample supply of dissolved oxygen in the water, gouramis cannot obtain as much as they need through their gills. They must regularly come to the surface to breathe. If they cannot do this, they will die.

Many species also use air to blow mucus-covered bubbles. During the breeding season the males of these species build bubble nests on the surface, or under a submerged leaf. Eggs are laid in these bubbles and develop in an oxygen-rich environment. In other species, males carry the eggs in their mouths until they are ready to hatch. Since these males must come to the surface for air, the eggs also receive plenty of oxygen, even if there is little dissolved oxygen in the water.

In the breeding season, males become very aggressive. In some species of fighting fish this aggression lasts all year. In the Far East, fish-fighting contests between these fish are held, with bets placed on the outcome.

A pair of Siamese fighting fish (male on the left) mating beneath their floating bubble nest. The eggs are placed in the nest and guarded by the male.

Fact File

GOURAMIS

Families: Helostomatidae, Osphronemidae, Belontiidae (about 90 species altogether)

Order: Perciformes

Where do they live?: Widely distributed in Southeast Asia, India, Pakistan, Thailand, and the Malay Archipelago

Habitat: Wide range of still or slow-flowing waters, often with overhanging and submerged vegetation; some of these waters may become depleted of oxygen

Size: From about 1 inch (2.5 cm), as in some croaking gourami species, to over 30 inches (76 cm) in the giant gouramis

Coloration: Vary variable and usually more pronounced in males, especially during the breeding season

Diet: Plants and small animals (mostly invertebrates)

Breeding: Bubble-nesting species build foam rafts on the water surface or under an overhang or submerged leaf; mouthbrooding species carry the eggs in the mouth; eggs usually hatch within a day or two

Status: 3 species of fighting fish are critically endangered; the jealous fighting fish and one species of the liquorice gouramis are endangered; 7 other *Betta* species are vulnerable

GRAY WHALE

Gray whales are long-distance travelers, feeding in the far north and breeding in the tropics. Every year gray whales migrate more than 12,000 miles. Because they nearly always travel in sight of land, these whales are easy to watch.

Gray whales are a fairly common sight along the west coast of North America. In spring and fall, thousands of people travel there every year to see gray whales pass by on their long migrations. However, fifty years ago, these huge mammals were almost extinct. They had been hunted for hundreds of years for meat and oil. The gray whale population had fallen to just a few thousand individuals. Today they are protected, and the only people allowed to hunt gray whales are Inuits and Native Americans, who use traditional methods and kill only a few whales each year. There are now around 25,000 gray whales living in the eastern Pacific Ocean.

Gray whales have a distinctive shape. Instead of a dorsal (back) fin, they have a row of bumps running along the lower part of the back. In adults, the skin is always blotchy and covered with big clumps of barnacles.

Winter Feeding, Summer Breeding

Female gray whales are pregnant for thirteen months and rear only one calf every other year. They mate one winter, give birth during the next winter, and mate again during the third winter. Newborn gray whales are much skinnier than adults. It takes the calf a few months to build up a thick enough layer of blubber, or fat, to cope with living in cold water, so the mother must travel somewhere warm to give birth. That is why gray whales travel south to gather every winter in the warm, shallow waters of Baja California, off the coast of Mexico.

A big, barnacled gray whale breaches. A breach is when a whale leaps halfway or more out of the water and then falls back onto its side.

Fact File

GRAY WHALE

Eschrichtius robustus

Family: Eschrichtidae

Order: Cetacea

Where do they live?: Coastal areas of Pacific Ocean, from Baja California and Japan to Arctic waters

Habitat: Coastal waters less than 330 feet (100 m) deep

Size: Head–body length 39–50 feet (12–15 m); weight 18–38 tons (16–34 metric tons)

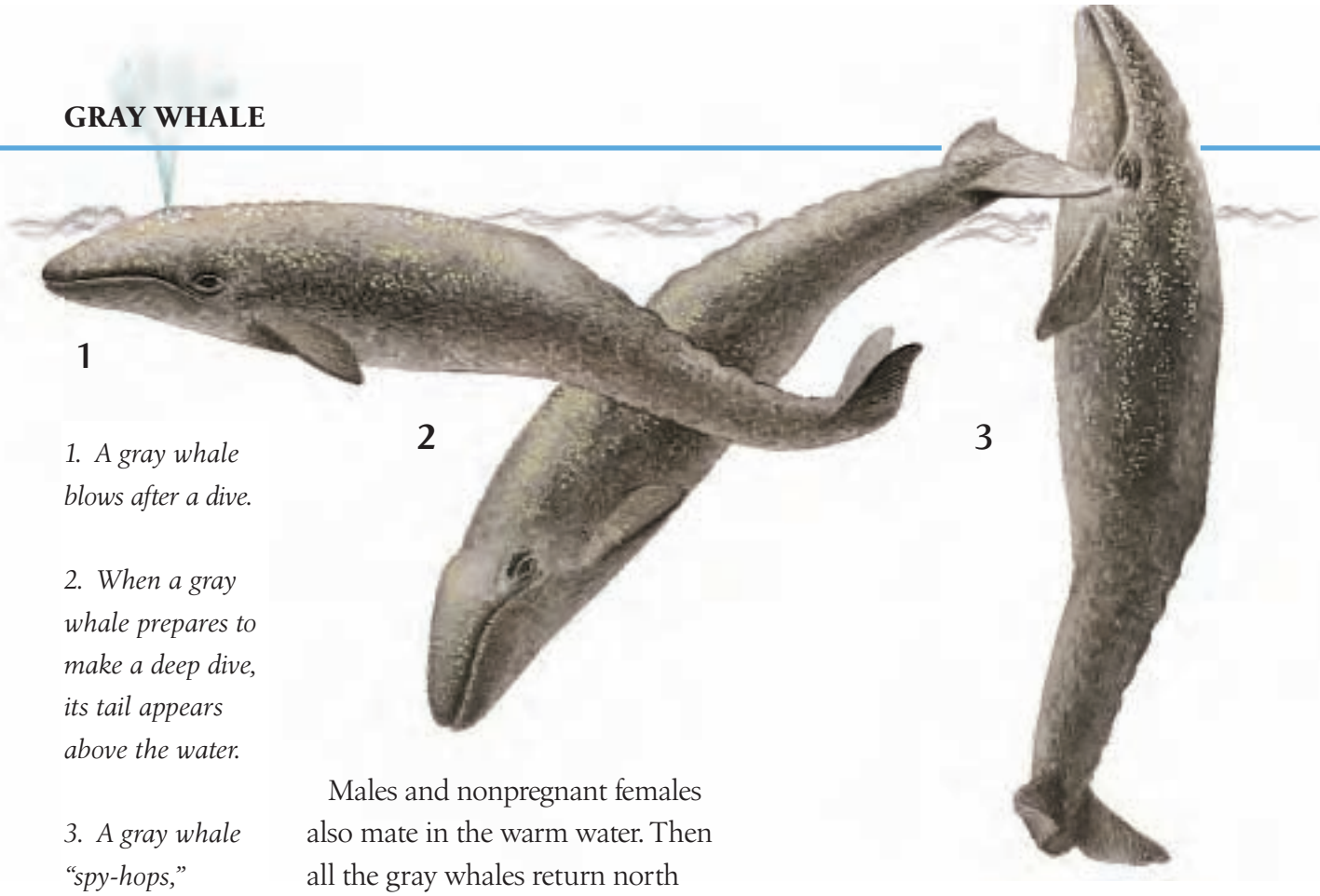
Skin: Mottled gray, with patches of barnacles and whale lice

Diet: Plankton and bottom-living invertebrates, mostly small crustaceans

Breeding: Single calf born after 13 months' inside mother's body; weaned at 7 months; able to breed at around 8 years

Life span: Up to 77 years

Status: No longer hunted intensively, but conservation measures needed to protect it; the population around Japan is critically endangered



1. A gray whale blows after a dive.

2. When a gray whale prepares to make a deep dive, its tail appears above the water.

3. A gray whale "spy-hops," sticking its head above the water to check its surroundings.

4. A gray whale mother swims with her calf.

Males and nonpregnant females also mate in the warm water. Then all the gray whales return north to cold waters in the spring.

Gray whale calves grow amazingly fast—the mother's milk is extremely fattening and a calf can gain up to 70 pounds a day. By the time the calves reach Arctic waters, at around six or seven months old, they are fat enough to survive the cold and ready to begin eating solid food.

Gray whales eat mainly small, flealike crustaceans called amphipods. In midsummer, billions of these creatures are present. The long hours of daylight encourage the algae and other plankton (microscopic animals and plantlike life-forms) on which amphipods feed to grow and reproduce superfast.

Sieve Eaters

Amphipods live in the seabed, and gray whales have an unusual way of feeding. The whales swim to the seafloor and plow along

the bottom with their mouth open. They take in lots of mud and sand, along with the amphipods and other small buried animals. Instead of teeth, gray whales have a mouth full of bristly combs, called baleen. Baleen acts as a sieve to collect the food, while the mud and sand pass through the baleen with the water and leave the mouth. From above, feeding gray whales are easy to spot because they create clouds of stirred-up mud from the ocean floor and leave long furrows in the seabed.

Gray whales often swim within half a mile of shore, which makes them easy to watch closely.

Having fed well all summer, adult whales return to Baja California in the fall. Males and females whose calves have just weaned go there to mate. Once the females are pregnant, the gray whales quickly travel north to begin feeding again.

Hunted by Killer Whales

Apart from humans, the only other animals that hunt gray whales are killer whales, or orcas. Orcas hunt in groups and target young calves. The gray whale mother can do very little to protect her calf once orcas begin an attack. Gray whale calves cannot swim fast enough to get away, but sometimes they can hide from orcas in dense patches of seaweed.

DID YOU KNOW?

- Most gray whales turn on their right side to feed on the seabed.
- A gray whale that lives to be seventy years old will have swum approximately 750,000 miles on migrations!
- A large gray whale may have up to 350 pounds of barnacles attached to its body!

WHALE WATCHING

Gray whales are curious animals. They often swim toward boats and seem interested in people. Some gray whales come right alongside small boats and even allow themselves to be stroked. Being so trusting and inquisitive once made gray whales easy targets for hunters. Now gray whales are protected, and the boats that go out in search of them are full of whale watchers instead of hunters.

GREAT WHITE SHARK

It is many people's worst nightmare. Yet, for all its awesome reputation, the superbly adapted great white shark has more to fear from humans than we have to fear from it.

The great white is the perfect hunting machine. It can detect prey from distances of over a mile. Then it homes in, using a battery of senses. These include the ability to detect electric impulses given off by the prey as well as chemical signals such as minute traces of blood. Its sight is also very keen, especially in clear water. The shark's streamlined, torpedo-shaped body and powerful tail allow it to put on impressive bursts of speed so it can quickly approach any selected victim. It also has massive jaws and fearsome teeth that can inflict fatal injuries in a split second.

Declining Numbers

While the great white shark is not primarily hunted for food, its numbers are declining worldwide. Sport fishing accounts for many deaths, but these top predators are also taken because their jaws and teeth are much sought after as curios. Nets set out along shark-threatened coastlines to protect bathers drown many of these sharks, as do nets and lines set out to catch other species.

Great whites take between ten and twelve years to mature. Since they produce very few young in each brood, this also creates further pressure on wild populations of the species. Some estimates put the total remaining number of these sharks at around 10,000. Since the 1990s there have been protection programs in place in an attempt to save this awe-inspiring fish.

Attacks on humans by great whites are actually very rare. Only a few of the fifty or so officially recorded shark attacks every year are attributed to this species.

Fact File

GREAT WHITE SHARK

Carcharodon carcharias

Family: Lamnidae

Order: Lamniformes

Where do they live?: Mainly warm-temperate and subtropical waters, but also found in warmer areas

Habitat: Wide range of habitats from the surf line to offshore (but rarely in mid ocean), and from surface waters down to depths exceeding 820 feet (250 m)—although it has also been reported from a depth of over 4,000 feet (over 1,200 m)

Size: Specimens in excess of 36 feet (11 m) have been reported, but confirmed data indicate a size of 18–20 feet (5.5–6 m)

Coloration: Top half of the body is slate gray to brownish; irregular line separates the top half from the pure white lower half of the body; the underside of the pectoral (chest) fins has blackish tips

Diet: Mainly fish—including other sharks—as well as turtles, seabirds, seals, sea lions, and dolphins

Breeding: Eggs are fertilized inside the body of the female and take up to a year to develop; female gives birth to 5–14 young which can measure 5 feet (1.5 m) at birth

Status: Listed as vulnerable

GRUNION

On some Californian beaches there is a spectacle like no other during nights of a full moon. Millions of fish launch themselves ashore in an apparent mass suicide attempt.

Although for a fish to launch itself onto a beach may seem like a life-threatening action, it is in fact simply a spawning technique. It is used by one or two fish species, including the grunion and the capelin. Many of these fish die during these dangerous onshore excursions, but it is all in the cause of breeding.

The goal is for egg- and sperm-laden fish to be swept far up shore by the waves and to be left stranded there for a few seconds. During this brief period, females bury the back half of their bodies into the soft wet sand, positioning themselves in an upright position. As this happens, a number of males surround each female. The female then releases her eggs under the sand, and the males release their sperm, thus fertilizing the eggs. With luck, the next large wave will sweep the females and males back into the safety of the surf.

Spring Tide Hatching

Spawning happens during the full moon when tides are at their highest. The eggs will remain buried in the sand above water level for the next two weeks, until the highest tides are due again. During this time, the embryos develop inside the eggs. They hatch within minutes of being wetted by the first waves of the incoming high tide and are washed into the sea.

It takes the young fish one year to mature. They then return to the beaches to breed and take part in the same dangerous life-and-death ritual.

Grunions spawn on a beach at night. This is a dangerous activity for a fish; many of them never make it back to the sea but fall victim to predators.

Fact File

GRUNION

Leuresthes tenuis

Subfamily: Atherinopsinae

Family: Atherinidae

Order: Atheriniformes

Where do they live?: West coast of North America, from southern California to Baja California

Habitat: Mainly found in shallow inshore seas, usually at or near the surface

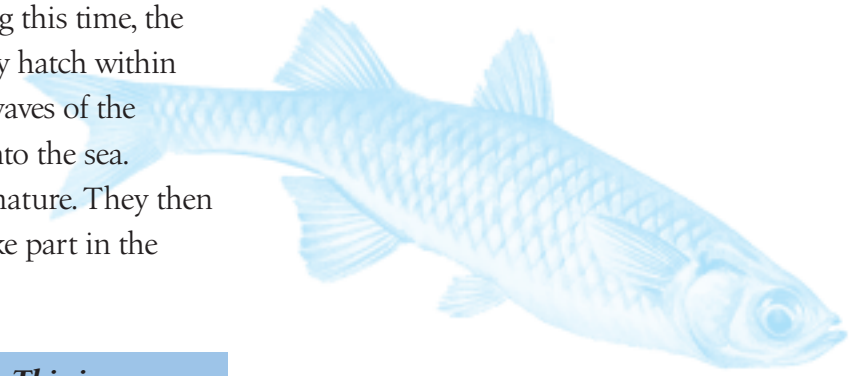
Size: Up to 7.5 inches (19 cm)

Coloration: Dark blue along the back, with silvery sides and belly

Diet: Mainly small invertebrates

Breeding: Eggs buried about 3 inches (8 cm) under the sand along the spring tide strandline and abandoned; hatching takes 2 weeks

Status: Not known to be threatened



GUPPY

Also once known as the "millions fish," because of the large numbers in which it was found in the wild, the guppy has been thrilling fishkeepers for around a hundred years.

This species was originally named the millions fish, but the name guppy is used mainly today. This is in honor of the Reverend Lechmere Guppy who discovered this fish in Trinidad in the 1860s—even though it had in fact been described a few years earlier by the German naturalist Wilhelm Peters.

Tiny Beauties

Wild male guppies are about an inch long. However, they pack much beauty into their tiny bodies, and have been hot favorites with fishkeepers for nearly as long as the hobby of fishkeeping has been in existence. Few fish can compete with male guppies in terms of the richness of color and fin variations seen in specimens bred by fishkeepers. The range of varieties that exists is bewildering, and more are created every year.

In a sense, guppy breeding is similar to goldfish breeding, because any combination of colors can be found with any of the various caudal (tail) fin shapes. Since wild populations are highly variable anyway, the scope for new combinations is infinite.

Today's guppies have larger bodies than their wild ancestors. The tail of the vast majority of modern-day varieties is also many times longer and broader; so is the dorsal (back) fin. The females have colorful bodies, which are in sharp contrast to the drab, uniform body color of wild females. These changes have come about through careful breeding by fishkeepers.

The guppy is bred in many different fin shapes and body colors. Any fin characteristic can be combined with any color, so the scope for new varieties is huge.

Fact File

GUPPY

Poecilia reticulata

Family: Poeciliidae

Order: Cyprinodontiformes

Where do they live?: Originally found north of the Amazon River in South America (in Venezuela and parts of northern Brazil) as well as the West Indies; it has also been introduced into many U.S. states—including Florida—as well as to parts of Africa and Asia

Habitat: Wide range of shallow freshwater habitats, including forest streams, lakes, and ditches

Size: Males around 1 inch (2.5 cm); females about twice this size; cultivated varieties are larger

Coloration: Extremely variable in males, which have numerous dots, patches, and streaks of different colors; wild females quite drab; in bred varieties, many females are also colored

Diet: Mostly small invertebrates and plant matter

Breeding: Eggs are fertilized inside the female and take 4–6 weeks to develop; broods can number nearly 200 but are usually much smaller than this

Status: Not known to be threatened

Worldwide Species

The guppy is a native of the Amazon River of South America and also of parts of the West Indies such as Trinidad and Barbados.

However, it has been introduced into many other countries over the years. One of the aims of these introductions has been to control the mosquitoes that carry malaria. Although guppies do not eat the adult mosquitoes, they eat large amounts of their aquatic larvae if given the chance. The species has also been introduced into all the countries and regions where fish are bred for home aquariums.

DID YOU KNOW?

- Baby guppies do not gain weight during development and are born weighing the same as, or less than, a fertilized egg.
- Female guppies can store sperm and can use these to fertilize a number of egg batches over a period of time.
- Guppies were first bred in captivity in 1908.

Back to Nature

Sometimes, guppies have escaped from breeding establishments into ditches and other waterways. Over many generations they have lost their large flowing tails and dorsal fins and

This guppy has a delta tail. Tail shapes in guppies include ones that look like flags and spades. Other guppy tails have long, pointed extensions.

have gradually become very much like their wild ancestors, with small bodies and short tails.

This happens because large-finned individuals cannot swim as fast as short-finned ones. Predators pick them off, while short-finned specimens escape. As a result, short-finned individuals soon outnumber their long-finned relatives. Eventually, these populations end up consisting just of guppies which are short-finned, well-adapted, fast swimmers.

Mother Care

Guppies belong to a large subfamily of fish that differ from many others because they do not lay eggs. Instead, they give birth to fully formed babies. In these fish, called livebearers, the eggs are fertilized inside the body of the females. Once fertilized, they are kept inside the female's body while they develop. They hatch there and the babies are released by the mother.

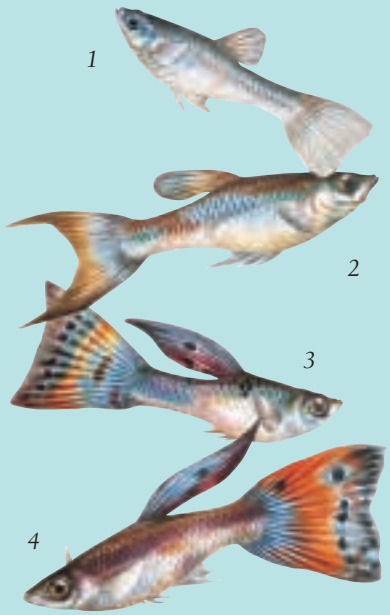
This way of breeding gives developing embryos a high degree of protection, since the female carries them with her wherever she goes. As long as the mother survives and does not fall victim to a predator, all her young stay safe until they are born. Once born, however, they are left to survive on their own.

1. A wild guppy male
2. A double sword male
3. A deltatail male
4. A long dorsal veiltail male

REMARKABLE BELLY FIN

Male guppies have a specially modified belly (anal) fin that looks like a rod. This "rod" consists of fin rays which lie one behind the other as in normal anal fins. However, each ray is highly modified, bearing hooks, blades, or claws.

This unusually structured anal fin—known as a gonopodium—is used by a male to introduce sperm into the body of the female during mating. As the gonopodium is swung forward to make contact with the female's belly opening (known as the vent), the rays fold over each other. They form a temporary groove or channel along which the sperm travel into the female's vent.



HAGFISH AND LAMPREYS

Hagfish and lampreys have no jaws, so they cannot bite like other fish. However, this has not stopped them being the only surviving species of an otherwise extinct group of primitive fish.

Fish first evolved in the Cambrian seas, between 400 and 500 million years ago. They were very different from the ones we know today. For example, some were armored and had a stiffening rod made of cartilage along their bodies, instead of a backbone. Two groups of these primitive fish, the hagfish and the lampreys, still exist today.

Hagfish and the lampreys have features in common, but they are not closely related. Neither of them have jaws, backbones, or paired fins, but they have paired eyes and a primitive third eye on top of the head. Unlike their ancient relatives, however, their eel-like bodies are not armored. Hagfish have a paddlelike tail and lampreys have one or two dorsal (back) fins.

Feasting and Fasting

Adult hagfish and lampreys prey on other animals. Hagfish scavenge on the flesh of dying or dead fish, dolphins, and whales. They can locate their food from great distances using their well-developed senses. They make a hole in the side of their victim's body, using a specialized biting tongue and rasping plates around the mouth. Hundreds of hagfish may feed on a whale carcass lying on the seabed. By burying their heads inside the carcass they can consume all of its flesh, leaving a bag of skin and bone! Adult lampreys can be parasites of live fish, feeding rather like hagfish by grasping the host with their suckerlike mouth and

The suckerlike mouth disk can be seen in this brook lamprey. The holes behind the eye are gill openings. Brook lampreys grow to a length of about 6 inches.

Fact File

HAGFISH AND LAMPREYS

Orders: Myxiniformes (hagfish; about 50 species), Petromyzontiformes (lampreys; about 40 species)

Class: Cyclostomata

Superclass: Agnatha

Where do they live?: Hagfish: worldwide in all oceans; lampreys: worldwide in all oceans, and in rivers and lakes

Habitat: Hagfish: seabeds below 72°F (22° C), often burrowing in mud; lampreys: midwater and on beds of seas, lakes, and rivers

Size: Hagfish up to 46 inches (1.2 m) long; lampreys up to 36 inches (92 cm) long

Coloration: Hagfish: depends on species—white, pink, blue-gray, or black; lampreys: larvae pale and transparent; adults orange, brown, gray, or black, paler below

Diet: Hagfish: carrion feeders or scavengers; lamprey larvae feed on organic particles; adults non-feeding or parasitic on other fish

Breeding: Hagfish and lampreys release sperm and eggs into water where fertilization occurs; a more complex life cycle with a swimming larva occurs in lampreys

Status: Hagfish: unknown; lampreys: in most cases not known, but some brook lampreys are rare or vulnerable

This hagfish eating its way inside a dead fish has formed its body into a knot to gain extra leverage.

opening a wound with the rasping tongue before eating its flesh and blood. Brook, or dwarf, lampreys do not feed at all when they reach adulthood. Instead, they rely on food reserves stored in their bodies when they are larvae.

A hagfish's central mouth is surrounded by sensory tentacles. The animal has no true eyes.

Lamprey Life Cycles

Hagfish live in the sea, laying a small number of eggs during spawning. They do not die afterwards.

Lampreys spawn in fresh water, so marine species must migrate, often 600 miles or more, to reach their breeding grounds. They swim in an eel-like fashion using their single dorsal (back) fin. Whether or not they return to the same river is not known. They get used to fresh water in the estuary before moving up river.

When the lampreys have found a suitable gravel bed, they dig out a shallow area to form a nest. They spawn in pairs, the female anchoring her body by sucking on a large pebble while the male attaches himself to her. Eggs and sperm are released and fertilization occurs in the water. The animals then writhe their bodies about to cover the fertilized eggs with gravel.

Lampreys that live in fresh water also migrate—for example, from lakes into streams. Brook lampreys spawn in groups over a shared nest. Once spawning is over, lampreys die.

Going to Sea

After two or three weeks the eggs hatch into larvae. They resemble minute, transparent lampreys, being colorless at night and dark by day. Their mouth is covered by a funnel-like hood bearing tentacles. These

DID YOU KNOW?

- Hagfish have four main hearts and two pairs of smaller secondary ones. Lampreys have one heart.
- Hagfish have five to fourteen pairs of gill openings. Lampreys have seven pairs of gill openings.
- Young hagfish hatch out as hermaphrodites (having male and female sex organs), but they lose one reproductive organ as they mature and become single sexed.

small animals are swept downstream by the current until they reach slower-flowing water. Then they burrow in the silt. They feed by filtering organic particles from the water, trapping them with their tentacles and a slimy secretion. As they grow they develop adult features and become yellowish brown in color. Then they are ready to go to sea and begin their parasitic lives.

Eating Lampreys

Lampreys have been thought of as a delicacy for centuries. King Henry I of England died of a "surfeit of lampreys" in 1135, but today there is no largescale commercial industry based around using lampreys for food. However, lampreys can be serious pests in fish farms where great numbers can ruin the fish stocks. Even in open sea fisheries they can cause damage to the catch.

Lamprey eyes are quite large compared with the tiny eyes of hagfish.

LIGHT AND VISION IN LAMPREYS

The eyes on either side of the head of lampreys resemble the eyes of other fish. Lampreys are active in the daytime and are thought to use both sight and smell to find their prey. Their third eye is situated on top, but not quite in the middle, of the head, and is formed from part of the brain. Along with light receptors in the skin in other parts of the body, it responds to changes in light intensity. In the larvae, whose paired eyes are covered with skin, this third eye may be important for controlling the color changes that the animals make. The eyes of hagfish are small, very basic structures.

HAMMERHEAD SHARKS

When viewed from the side, it looks very much like any other shark. However, when seen head-on, or from above or below, a hammerhead is one of the most unusual sharks you could imagine.

Other sharks have pointed or rounded snouts, but hammerheads live up to their name. Their unusual hammerlike heads make them the most easily identifiable of all the sharks. Although the head of these sharks is often described as being the shape of a hammer, it is, in fact, more like a "T" with a curved top.

Useful Hammer

In cross-section, the hammer is shaped like a wing. It may also act like a wing, giving some lift to these sharks. They spend a great deal of time hunting near the bottom, and their fins are well adapted for this way of life. But when they swim in open water, the winglike hammer may help them. Also, by having the nostrils and other senses on the tips of the hammer, the shark may more easily find its prey. The broadly spaced eyes cover a wider field of vision.

It is reported that the great hammerhead uses its hammer to head-butt skates and rays (two species of fish hunted by hammerheads) and pin them to the bottom. Having immobilized the prey, the shark spins round and bites pieces off the victim's winglike fins, preventing it from escaping.

Sometimes scalloped hammerhead sharks gather in huge schools (called shivers) numbering over 200 individuals. No hunting is involved when this happens, however. It is more likely that mating, rather than eating, is the reason for these mass get-togethers.

This scalloped hammerhead shark is swimming near the Galapagos Islands. Its "hammer" has a series of indentations or scallops, giving it its common name.

Fact File

HAMMERHEAD SHARKS

Family: Sphyrnidae (8 or 9 species)

Order: Carcharhiniformes

Where do they live?: Widespread in many tropical and warm-temperate regions

Habitat: Open and shallow waters, ranging from inshore reefs to around 1,000 feet (300 m) in the scalloped hammerhead; most species remain in the upper 260 feet (80 m); many species also hunt along the bottom

Size: From around 36 inches (92 cm) in the scalloped bonnethead to around 19.7 feet (6 m) in the great hammerhead

Coloration: Grayish-blue along the back, fading to a light-colored belly

Diet: Wide range of prey, from fish (including other sharks), to squid, crustaceans, and sea snakes

Breeding: Eggs are fertilized inside the mother's body and take around 8 months to develop; female gives birth to 6–40 young (known as pups), depending on size and species

Status: Great hammerhead is listed as endangered; concern also surrounds most of the other species because of uncontrolled overfishing

HATCHETFISH

Hatchetfish are the freshwater counterparts of the sea-dwelling flying fish. However, hatchetfish go a significant step further; they can genuinely fly, instead of simply gliding above the water.

Freshwater hatchetfish are sometimes called flying characins—a direct reference to the technique they use to escape predators. When threatened, they shoot out of the water and, quite literally, disappear. This usually confuses a predator sufficiently to allow the hatchetfish to escape.

Perfect Flying Equipment

Various body modifications make this remarkable ability possible. The chest, for instance, is very deep and hatchetlike—hence the common name for the fish. It has powerful muscles that can provide the thrust needed to propel the fish clear of the water. In addition, the chest is very narrow, and it forms a keel (a deep V-shape, like the bottom of a boat) that can cut through the water with very little resistance.

The pectoral (chest) fins are long and slim and have a strong, slightly curved front edge, almost like wings. The fins are high up on the body, just behind the head. The back, from the snout to the dorsal (back) fin, is straight. This shape makes it easier for the hatchetfish to swim near the water's surface.

As well as all these characteristics, the fish has a powerful tail. The combination of all these features means that a hatchetfish can jump out of the water and then fly by flapping its strong pectoral fins. When chased, hatchetfish can fly for a short distance at a height of 4 inches above the water surface.

The mouth of a hatchetfish (these are common hatchetfish) is turned upward. This helps the fish snatch insects from the surface as it feeds.

Fact File

HATCHETFISH

Family: Gasteropelecidae (9 species)

Order: Characiformes

Where do they live?: Panama and all South American countries except Chile

Habitat: Some species, such as the marbled hatchetfish, live in small streams and creeks; others, such as the spotted hatchetfish and the giant hatchetfish, live in more open waters

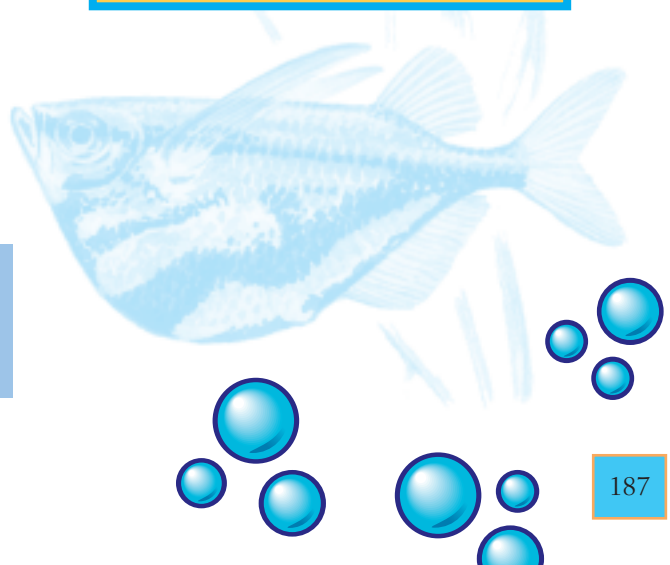
Size: From 1 inch (2.5 cm) to around 3 inches (8 cm)

Coloration: All species have silvery scales on the sides and belly; several species have dark central body lines extending as far as the tail

Diet: Mostly insects but also aquatic invertebrates

Breeding: Eggs are scattered among the roots of floating plants and among fine-leaved vegetation and abandoned; hatching takes about 1.5 days

Status: Not known to be threatened



HERMIT CRABS

Instead of growing a natural shell of its own, the hermit crab makes use of a secondhand shell for protection. It often shares this "home" with other animals such as sea anemones, barnacles, and worms.

Hermit crabs are scavengers on the seashore and seabed. They differ from the true crabs because they do not have a fifth pair of walking legs. Their fourth pair of legs is very small and can be seen only when the animal is removed from its snail shell home. This pair of legs grips the inside of the shell and holds the animal in place. The abdomen is not folded under the front of the body as it is in the true crabs. Instead it is long and twisted to the right so that it fits into the snail shell easily. The abdomen is also soft, so the protection given by the snail shell is very important.

When disturbed, the hermit crab retreats into its shell, but when it feels safe it emerges partially and the first three pairs of walking legs can be seen. The first pair has large nippers; the nipper on one leg is bigger than the nipper on the other. The nippers fit neatly into the opening of the shell and close it off when the crab is completely inside. The second and third pairs of legs have claws at the tips for walking.

Moving Home

A hermit crab outside its snail shell is vulnerable to predators, so moving house is a dangerous time. A growing hermit soon finds its shell is too small and goes in search of a new one, which it finds simply by looking. Having carefully checked out the new shell, it must move in quickly before another hermit grabs the shell or a predator spots the crab.

Hermit crabs often fight over ownership of shells. A large shell helps to make the crab appear bigger, too, helping it frighten off other crabs.

Fact File

HERMIT CRABS

Infraorder: Anomura (several hundred species altogether)

Order: Decapoda

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Worldwide in all seas and oceans

Habitat: Seashore and seabed

Size: Rarely longer that 6 inches (15 cm); a few relatives that lack shells may reach 12 inches (30 cm)

Coloration: The crab itself may be a variety of colors, from yellowish brown to dark red; some tropical species are brightly patterned; some are very hairy

Diet: Almost anything edible they can find; a few species filter water to get food particles

Breeding: Sexual reproduction: mating must take place when the crabs are out of their shells; the fertilized eggs adhere to the females' abdomen inside the shell until the larvae hatch out; these develop through several phases until the adult stage is developed

Status: Not known

HERRING

They are 140 million years old, perhaps even older. Yet, within a few human generations, we have managed to bring herring, pilchards, and sardines to the brink of extinction.

Herring, and their close relatives such as pilchards and anchovies, have long been extremely important to humankind. They have been responsible for the rise and fall of nations, making fortunes for some while ruining others. Countries have even gone to war in an effort to secure stocks of these valuable fish. Britain and Holland, for example, fought a bloody war in the late 1600s over fishing rights.

A most unusual battle was also fought in 1429 between the French and Scots on one side, and the English on the other. It began when a wagon train was attacked while transporting salted herring to English troops who were laying siege to the city of Orleans. The fish were on their way to the troops so that they could observe the strict religious rules of the day, which dictated that fish be eaten during Lent. Although the English won the Battle of the Herring, the wagonload of fish ended up being scattered all over the battlefield.

Feast and Famine

There have been times when stocks of herring, pilchards, and sardines have been so abundant that they have appeared limitless. At other times, stocks have disappeared and, with them, have gone wealth and a vitally important food resource.

An indication of the importance of these fish can be gained from the fact that, in the 1930s, herring and

In the Sea of Cortez, a brown pelican dives for herring. These fish, and similar species such as anchovies, are a vital part of the marine food chain.

Fact File

HERRING

Family: Clupeidae (about 180 species)

Order: Clupeiformes

Where do they live?: Oceans, seas, and coastal areas worldwide; some species live in fresh water

Habitat: Found in shallow waters or close to the surface; some species spend time in estuaries; others are found permanently in rivers and lakes

Size: Most under 20 inches (50 cm) long; "sardines" usually 4–6 inches (10–15 cm); pilchards 10 inches (25 cm); herring up to 18 inches (46 cm); largest species, the giant freshwater herring, 5 feet (1.5 m)

Coloration: Most species dark-gray or brownish-gray on back, with or without dark spots; sides and belly silvery

Diet: Almost exclusively plankton; fish larvae also eaten by some species

Breeding: Spawning in large schools; pilchards produce glassy floating eggs that hatch in 2–4 days; herring produce sticky sinking eggs that hatch after 8–9 days in warm water, or 6–7 weeks if the water is cold

Status: One member of the family, *Alosa vistonica*, is critically endangered; the Alabama shad and *Tenualosa thibaudeaui* are endangered; the Macedonian shad and the Venezuelan herring are vulnerable

Pilchards are a plentiful and cheap source of food for people in many parts of the world.

their closest relatives such as sardines accounted for one third of all the fish caught in the world. Even in the late decades of the last century, as many as 3,300 million tons of Atlantic herring were caught each year.

In the end, stocks were brought to the point of collapse. Today, though, there are fishing quotas that determine how many tons of these fish can be harvested. As a result, stocks are showing signs of recovery in some of the main fishing areas.

Healthy "Brain Food"

Herring, pilchards, sardines, and several other close relatives all look very similar. Most are dark blue along the back and silvery along the sides and belly. Their scales are sometimes said to be "deciduous,"

HERRING LIE ABOUT THEIR AGE

As they grow, herring (below) lay down rings in their scales, in the way that a tree produces annual growth rings. So by counting the rings, it is possible for scientists to figure out the age of the fish. However, many of the scales on an individual may be younger than the fish itself. It is therefore often difficult to tell the exact age of a herring without counting all the scales and using the oldest one as a guide—always assuming, of course, that this scale is one of the original ones the fish was born with and not a replacement scale.

DID YOU KNOW?

- Humpback whales hunt herring by blowing a net of bubbles around them. This drives the fish into a tight ball that can be easily swallowed by the whales.
- Nets set out for herring, pilchards, and sardines sometimes trap other victims, such as dolphins, that can drown as a result.
- About forty-four species of West African herring spend their entire lives in fresh water.

which means that they drop off easily (as leaves drop from deciduous trees in the fall).

The common names are also used quite loosely, so it is often difficult to tell which species is being described. In many countries, for example, a sardine is just a small pilchard. In others, the word sardine refers to a particular species. Most of these are, however, considerably smaller when fully grown than a herring, which grows to about 18 inches in length.

All species are tasty fish that contain a rich supply of Omega 3 oils. These are thought by many people to be good for human health, especially the heart. Because of these sorts of oils, herring, pilchards, and sardines are called "brain food."

School Protection

All the members of the herring family are schooling fish. In other words, they live in large groups or shoals. Often the schools consist of many thousands of fish. They can grow to countless millions during the migrations by these fish when on their way to new feeding grounds or to breed.

When schools are attacked, they form a tight ball, known as a "bait ball." The whirling bodies of fish can confuse attackers. Even if a "ball" does not have this effect, each fish benefits by being less likely to be eaten than if it were on its own, or among just a few other fish.

Young farmed herring in a pen—part of the Fish Enhancement Program in British Columbia, Canada. When released, they will help restore wild stock levels.

HYDROZOANS

Hydrozoans include a wide range of sedentary and swimming marine and freshwater animals. They are relatives of the sea anemones, corals, and jellyfish and have complex life cycles.

Each animal is known as a polyp, and it may live singly or as one individual in a colony with other polyps. Each polyp has a simple, saclike body with a mouth but no anus. This mouth is surrounded by stinging tentacles that are used to catch prey and for defense. The shape and style of the polyps vary between the different groups.

Hydroids form a large group within the hydrozoans. They may be solitary or colonial. A colony consists of many feeding polyps plus a few reproductive polyps. The hydrocorals are tropical hydrozoans with stony skeletons that resemble reef-building corals. They have powerful stinging cells, so they are called fire corals.

Complex Life Cycle

The life cycle of almost all hydrozoans starts when a bottom-dwelling colony produces a jellyfishlike stage called a medusa. Each medusa drifts in the plankton and develops male and female organs. In turn sperms and eggs are released into the sea and a small larva forms. This ultimately settles back on the seabed to form a new bottom-dwelling colony of polyps.

Siphonophores and chondrophores are hydrozoans that live in floating colonies. An example is the Portuguese man-o' war. It is an association of feeding, defensive, and reproductive polyps, all supported by a gas-filled float. The Portuguese man-o' war trails very powerful stinging cells in the water to catch prey.

Although most hydrozoans live in the sea,* Hydra *is a freshwater species. The long tentacles surround the central mouth, which is at the top of the saclike body.

Fact File

HYDROZOANS

Orders: Athecata, Thecata, Milleporina, Siphonophora, Chondrophora (about 3,000 species altogether)

Class: Hydrozoa

Phylum: Cnidaria

Where do they live?: Worldwide in all seas and oceans and occasionally in fresh water

Habitat: Seashore and seabed, on rocks, plants, and other animals; siphonophores and chondrophores found in mid water

Size: Very variable: many polyps are very small; hydroid colonies up to 6 inches (15 cm); floating siphonophores can be several feet long, including trailing tentacles

Coloration: Varies greatly: many are transparent, pinkish, brownish, or even yellowish

Diet: Small particles of food collected by the tentacles and small and medium-sized animal prey stung to death by stinging cells on the tentacles

Breeding: The medusoid phase of hydroids reproduces sexually, leading to a larval phase; many hydrozoans can reproduce by asexual budding

Status: Not known

JELLYFISH

A jellyfish's graceful and often beautiful appearance, coupled with its rhythmical and languid swimming behavior, hide the danger that lurks among the deadly trailing tentacles.

The adult stages of jellyfish are known as medusae. They usually have umbrella- or helmet-shaped bodies, often referred to as the bell, although some species are square or box shaped. Jellyfish get their name due to the jellylike layer between the outer and inner layers of cells in their bodies. Much of this jelly is composed of water. When jellyfish are stranded on the beach, their jellylike nature is very easy to see.

Under the Umbrella

The mouth is on the underside of the umbrella and leads up into the digestive cavity that spreads throughout the interior of the bell. There is no anus in jellyfish. There are many tentacles arranged around the edge of the umbrella, and these are armed with powerful stinging cells. They are used to catch prey and can be shortened or lengthened by the jellyfish at will.

The edge of the umbrella is folded into a series of flaps. Between these flaps, and arranged rather like the position of the numbers 12, 3, 6, and 9 on a clock face, are sensory structures or balancing organs. Sometimes there are eight of these structures present, sometimes four, depending on the species.

Underneath the bell, and around the mouth, are four, often frilly oral arms, also equipped with stinging cells. They are called oral arms because they help get food into the jellyfish's mouth when it feeds. In some species, the oral arms are used to look after developing larvae.

The yellowish, frilly oral arms are clearly visible in this Australian spotted jellyfish. It feeds on plankton, fish eggs and larvae, and marine snails.

Fact File

JELLYFISH

Classes: Scyphozoa (about 200 species), Cubozoa (19 species)

Phylum: Cnidaria

Where do they live?: All seas and oceans

Habitat: Usually swimming in the water column; some live upside-down on the seabed

Size: Adults 0.5 inches–6.5 feet (13 mm–1.9 m) in diameter

Coloration: Often transparent but with many shades of color; some patterning

Diet: Invertebrates including plankton plus animals as large as fish

Breeding: Sexes in medusae are usually separate; sperms and eggs are shed via the mouth; fertilization takes place in the sea; a swimming larva gives rise to the polyp phase and develops into a strobila, from which small larval jellyfish bud off by asexual reproduction; these grow into mature medusae

Status: Unknown

Jellyfish are efficient hunters of marine life, but many are themselves eaten by other sea creatures, including sea turtles such as the one seen here.

Stinger in the Sea

For many people, jellyfish are known because of their stings. The stings are produced by special microscopic cells, called cnidae, found especially on the tentacles and oral arms. The cnidae contain a capsule with a coiled-up hollow filament. This is called a nematocyst. When the cnidae are stimulated by a particular chemical, or by being touched, the nematocysts instantly shoot out the coiled-up filament. Some of them penetrate the flesh of prey or predators and inject venom. Others are longer and threadlike and are used to ensnare victims.

Nematocysts are the perfect weapon for soft-bodied animals like jellyfish, that cannot grip or bite their prey. Jellyfish often break up in rough water and broken pieces of tentacle can still cause as much discomfort as whole animals if they are touched by a swimmer, for example.

DID YOU KNOW?

- Some jellyfish glow in the dark and emit flashes of light.
- A group of jellyfish with trumpet-shaped bodies—known as stalked jellyfish—spends the medusa phase attached to weeds in shallow water or rock pools.
- The upside-down jellyfish does not swim about in the water, but instead lies upside-down with its "umbrella top" touching the seabed.

Box Jellyfish

All jellyfish sting, but the stings from the box jellyfish place them among the most poisonous animals in the world. Some box jellyfish have such powerful stings that they can kill a

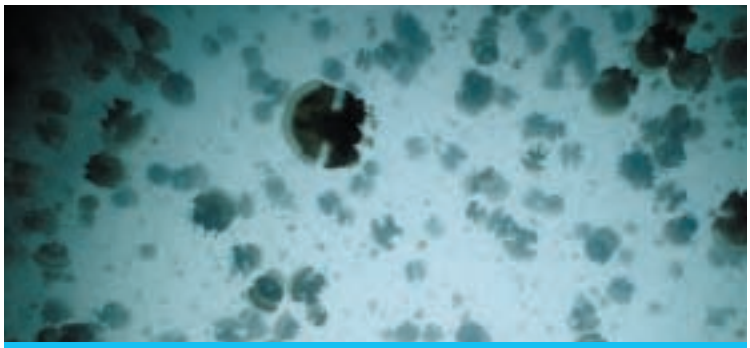
A deadly box jellyfish, or sea wasp, pulls a captured shrimp into its mouth.

Landlocked jellyfish in a lake on the island of Palau.

human. Divers gain some protection from the deadly stings by wearing protective clothing such as very thin nylon suits. The nematocysts cannot penetrate the material, and so cannot reach the divers' skin.

Having Young

Four reproductive organs alternate with the oral arms around the mouth of the medusa. There are separate male and female jellyfish in many species, but a few are hermaphrodites (having both male and female sex organs at the same time). The sex organs usually ripen in the spring or summer. Sperm and eggs are usually released, via the mouth, into the sea where fertilization takes place and a larva forms. The larva attaches itself to the seabed and develops into a polyp. The polyp then produces lots of tiny medusae by a process called budding. When the medusae reach a certain size they leave the polyp and swim away to grow into adult medusae, so completing the life cycle.



JELLYFISH FOR DARWIN

The island of Palau in the Pacific Ocean, east of the Philippines, has about seventy seawater lakes. Water seeps to and from the sea via minute holes in the island's rock, but even the smallest animal cannot get through. About five of the lakes contain imprisoned jellyfish. Each lake contains a unique jellyfish species, different from all the others. This is similar to Charles Darwin's discovery of different finch species on different Galapagos Islands. It supports his theory of evolution in the same way, by showing that isolated species develop special adaptations to suit their particular environment.

KRILL

Looking a lot like shrimp, these tiny crustaceans are found in enormous numbers in the world's oceans, where they are one of the main food sources for many other marine creatures.

Krill are tiny crustaceans (animals belonging to the group that includes shrimp and crabs). Krill are found worldwide as part of the plankton, often near the surface and especially in the polar seas. They are very abundant in the Southern Ocean around Antarctica, frequently occurring in huge numbers. Krill feed on minute floating plants called phytoplankton. In turn, krill are preyed on by whales which sieve the surface waters swallowing tens of thousands of them in one gulp—up to 4 tons in one day's feeding! Different whale species are adapted to take krill of different sizes. This reduces competition between them. The main krill feeders are blue, right, and fin whales, but other animals, such as seals, penguins, and seabirds, eat them as well. Commercial fisheries have been set up to catch krill but have not really been successful.

Light in the Water

Shallow-water krill species have conspicuous eyes. In temperate and tropical waters, they respond to the amount of light in the water, rising to the surface at night when fewer predators are about. Throughout the continuous daylight of the summer at the poles they remain near the surface, however. Krill have special light-producing organs along the body, which look like lines and dots. These light up under the control of the nervous system, and the bluish glow they generate is seen by other krill and helps keep them together.

Krill feed on algae on the underside of ice in Antarctica. Their hairy legs function as a basketlike sieve to collect the microscopic plant life.

Fact File

KRILL

Order: Euphausiacea (about 90 species in 2 families)

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: All seas and oceans

Habitat: Surface waters or at particular depths (according to species); not touching the seabed

Size: 1–2 inches (2.5–5 cm)

Coloration: Transparent with internal organs showing through in various colors

Diet: Marine phytoplankton, small zooplankton, and tiny food particles

Breeding: Separate sexes; adults mate while swimming; the fertilized eggs sink into deep water and hatch into a series of non-feeding, and then feeding, larvae; larvae then swim upward again to complete their development—this prevents the filter-feeding adults from eating their own young

Status: Not known, but krill numbers may have fallen by as much as four-fifths since 1970, possibly due to the shrinking of Antarctic pack ice

LANCELETS

Although they resemble eel-like fish, the humble lancelets are in fact a primitive group that are part way between those animals that do not have a backbone (invertebrates) and those that do (vertebrates).

Lancelets are small marine animals that spend much time burrowing in the seabed, although they can swim. Their narrow, fishlike body is pointed at both ends. They have a narrow dorsal (back) fin and a small, rounded tail fin. The head of a lancelet is small and has no eyes. There is a well-developed nerve cord that connects with a simple brain. The brain is not enclosed in a braincase. The mouth has no jaws or teeth, and is surrounded by sensory tentacles. The mouth leads into the pharynx or throat. Unlike fish, whose gills are in direct contact with the water, the gills of lancelets are in a cavity connected to the pharynx.

Lancelets are filter feeders. They draw water into the gills through the mouth and sieve out food particles. The particles are collected and passed along a channel to the animal's intestine. Lancelets use the gills to extract oxygen from the water at the same time.

How Backbones Evolved

The structure of a lancelet's body tells us a lot about the phylum Chordata (the group that includes vertebrate animals such as humans) and their origins. Despite their fishlike appearance and behavior, lancelets have no backbone. Instead, a stiffening rod of fibers and jelly runs from the front of the animal to the rear. This supports the body and provides muscle anchorage. This structure is an evolutionary forerunner of the spinal column found in vertebrates.

This* Amphioxus *shows the V-shaped pattern of the muscles of the body wall. These help the fish move along using side-to-side swimming movements.

Fact File

LANCELETS

Order: Amphioxiformes (about 25 species!)

Subphylum: Cephalochordata

Phylum: Chordata

Where do they live?: Worldwide in temperate and tropical seas and oceans

Habitat: Shallow seabed on gravel bottoms

Size: up to 4 inches (10 cm)

Coloration: Pink to white

Diet: Microscopic organic particles filtered from sea water

Breeding: Separate males and females; sperm and eggs released into sea water; a microscopic larva forms at fertilization, which lives in the plankton until ready to settle on the seabed and turn into a juvenile

Status: Not known

LEECHES

Many leeches are parasites—they live by sucking the blood from other animals. They can eat several times their own body weight in a single meal, and this can last them for months or even years.

About a quarter of leech species are predators, hunting prey such as earthworms and insect larvae. The rest bite and feed on the blood of other animals (known as hosts), clinging on while they often consume large amounts in one meal. A leech's body can stretch to accommodate its food. Leeches have sensory organs, including eyespots at the head end, which they use to detect prey. They are guided by changes in light intensity—caused by passing shadows—and scents. Their saliva has a numbing effect so that the host may be unaware of being bitten. Although leeches may seriously weaken an animal after taking a lot of its blood, they do not actually kill it in the process.

Aquatic leeches can swim, but they also move about using looping movements of their body.

Leeches in Medicine

Until the middle of the nineteenth century, leeches were used for treating a variety of ailments in parts of Europe. They were used to remove what was thought to be "bad blood." With medicinal advances, leeches lost their importance. However, by that time the medicinal leech had become almost extinct in some places. In recent years, leeches have again been used in medicine, but in different roles. For example, when leeches feed, they secrete substances that prevent the blood from clotting, and so they are useful in treatments where clotting is a risk.

These are medicinal leeches. Suckers at the front and rear of a leech's body are used for gripping onto rocks and vegetation, or for clinging to prey when feeding.

Fact File

LEECHES

Subclass: Hirudinea (about 500 species)

Class: Clitellata

Phylum: Annelida

Where do they live?: Temperate and tropical areas in fresh waters and humid environments like swamps and rainforests; some species are marine

Habitat: Freeliving, looping on soils or vegetation or swimming in search of hosts

Size: 0.4–19 inches (10mm–50 cm)

Coloration: Black, brown, green, and red, sometimes attractively patterned

Diet: Blood and animal tissue

Breeding: Hermaphrodites; individuals are males to begin with, changing to females with age; cross-fertilization of eggs by mating; embryos develop in a protective cocoon produced by the leech's body; there is no larva—embryos develop directly into juveniles

Status: Medical leech endangered, vulnerable, or rare over most of western Europe; status of other species not known

LIMPETS

Limpets are a common sight on many seashores, clinging firmly to rocks with their powerful suckers. Yet despite appearing to be fixed to the spot, they also move around in search of food.

Limpets are familiar residents of the rocky shore, where they may be found in great numbers. These relatives of slugs and snails live around the mid-tide level, and are regularly covered and uncovered by the sea. They feed when the tide is in, because it is easier for them to move then. When the tide ebbs they stop feeding and clamp their shells down to prevent moisture loss from their bodies. This also reduces the risks from predators such as birds and crabs. The large muscular foot also acts as a powerful sucker to grip the rocks. Experiments suggest that limpets return to the same place on the rocks at each low tide. The limpet's shell is a precise fit on its chosen bit of rock, and there may be a mark or scar where it has settled down.

Teeth on the Tongue

Limpets graze on young seaweeds. They do this using a special ribbonlike tongue which is coated with a complex array of sharp teeth. The tongue rasps backward and forward, like a strip of sandpaper, tearing the food from the rocks. It leaves characteristic marks behind. As teeth wear out at one end new ones grow at the other. Limpets are such efficient grazers that they keep the growth of algae on the middle shore in check. This helps to maintain the ecological balance of the seashore. If all of the limpets are removed from a rocky shore it can have a dramatic effect. The algae grow too vigorously because they are not being grazed.

This common limpet, on rocks in Cornwall, England, has lifted its conical shell, revealing the large muscular foot that it uses when creeping along.

Fact File

LIMPETS

Order: Archaeogastropoda (number of species unknown)

Class: Gastropoda

Phylum: Mollusca

Where do they live?: Worldwide in all seas and oceans

Habitat: Seashore and shallow seabed

Size: 0.08–5 inches (2mm–13 cm)

Coloration: Shells gray, brown, and bluish, and sometimes patterned with yellows and reds

Diet: Algae and other plant matter

Breeding: Hermaphrodite; individuals start life as males and then change into females; spawning is triggered by rough seas; fertilization occurs in sea water; a larva is formed which swims as part of the plankton before it develops into a young limpet that settles on the seabed

Status: Not known

LIONFISH, SCORPIONFISH

Lionfish may not look like lions, but they can hunt just as efficiently. Scorpionfish do not look like scorpions, either, but one feature they have in common is the ability to deliver a powerful, even deadly, sting.

Lionfish are known by many names, some more fanciful than others. The best-known of these are: turkeyfish, tigerfish, dragonfish, butterfly cod, and scorpionfish. The last of these is a little confusing, because the name scorpionfish is usually used to describe another group of around 180 species of venomous fish in the same family.

Both lionfish and scorpionfish carry venom in glands in their fin spines, and this can be injected into would-be predators. However, these fish never use their fearsome weapons in attack, only in self-defense.

Lionfish in Action

Although they belong to the same family, lionfish and scorpionfish use different hunting techniques.

Lionfish often hunt in open water. This, of course, makes them visible to their prey. However, once they spread their large fins, tip their head slightly downward and make no apparent swimming movements, they look more like a clump of drifting seaweed than a large-mouthed hunter. They can then float slowly toward their intended prey, which never suspects it is in any danger until it is too late—by which time it has been swallowed by the lionfish.

If they are hunting close to rocks, lionfish can use their large pectoral (chest) fins to herd prey into a corner before making a lethal lunge at their victim. They can also sit and wait for prey on a ledge or by the

The body coloration and fin design help this lionfish disguise itself as seaweed as it sneaks up on prey. For protection, the spines are armed with strong poison.

Fact File

LIONFISH, SCORPIONFISH

Family: Scorpaenidae (from 200–380 species, depending on the classification used)

Order: Scorpaeniformes

Where do they live?: All tropical and temperate seas

Habitat: Mainly shallow water marine environments, although some species enter estuarine water; some species can be found in deep water as well; lionfish (e.g. *Pterois* species) often swim in open water; others (e.g. *Scorpaena* species) usually lie on the bottom

Size: From around 1.6–40 inches (4 cm–1 m)

Coloration: Varied, ranging from bold dark and light bands in some lionfish, to mottled or drab in many scorpionfish and stonefish (*Synanceia* species)

Diet: Invertebrates and fish

Breeding: Eggs are fertilized inside the female's body in most species and are later released into the water and abandoned; the eggs of some species are laid inside a jellylike "balloon"

Status: The bocaccio rockfish is listed as critically endangered; the redfish and the shortspine thornyhead are endangered; the St Helena deepwater scorpionfish or deepwater jack is vulnerable

DID YOU KNOW?

- Queensland aboriginals have a dance which they use to teach their children about the dangers of stepping on stonefish.
- Many scorpionfish have delicate, white tasty flesh that is highly rated as food, particularly in Mediterranean countries.
- The lower rays of the pectoral (chest) fin in some species are specially adapted for "walking" along the sea floor.

Like many other members of the family Scorpaenidae, the lionfish has a large mouth for snatching prey.

entrance to a cave, where their unusual body shape makes it hard for prey to spot them.

Sitting Scorpions

Scorpionfish do not generally hunt in open water. Instead, they use a sit-and-wait technique. Being well camouflaged, many species look just like the sponge- and algae-covered sea floor that they live on.

Because scorpionfish lie on the bottom waiting for prey, they have an upward-facing mouth and eyes.

An exception to this is the leaf scorpionfish, where the dorsal (back) fin spines and rays are much longer than in most other scorpionfish. When the fin is spread out, and the front spines are tilted forward and extend over the head, the impression created is that of a leaf, rather than a fish. This effect is reinforced by the fish's movements, which consist of side-to-side swaying like a leaf being rocked by gentle currents.

In the decoy scorpionfish, the dorsal fin has a fishlike pattern. When a potential meal approaches, the scorpionfish—which lies motionless on the bottom—flashes its dorsal fin repeatedly, fooling its unsuspecting target into thinking that the fin is a food item. However, as soon as it is within striking

distance, the scorpionfish sucks its victim up in a single gulp.

Lethal Stones

Stonefish are often grouped in the same family as lionfish and scorpionfish (although opinions vary among scientists). Stonefish also have venomous spines. These are so dangerous that two species, the estuarine stonefish and one known simply as the stonefish, are the most venomous fish on Earth.

Stonefish are feared wherever they are found, and with good reason. At best, a sting from a stonefish is extremely painful. At worst, victims can die within a short time of being stung. This is because the venom affects nervous tissues—damaging them in the case of minor stings, or actually killing them in severe cases. The weapons a stonefish uses are awesome. They have thirteen dorsal fin spines, plus those found on the anal (belly) and pelvic (chest) fins. When threatened, the stonefish pumps venom into the puncture wounds created by the spines.

The deadly stonefish is another master of camouflage, blending in superbly among the rocks on the seabed.

HOT WATER REMEDY

Lionfish, scorpionfish, and stonefish are not aggressive and only use their powerful venom in self-defense. Few people get stung by these fish, and when they do it is usually by accident. Nevertheless, when someone is stung, prompt action is necessary, since—in serious cases—this can be the difference between life and death.

Surprisingly, the most effective first remedy when stung is an extremely simple one: hot water. If the affected part of the victim's body is immersed in water that is as hot as can be tolerated within a few minutes of being stung, the results can be quite remarkable. The reason for this is that heat breaks down the venom and helps to neutralize it.

LIZARDFISH

Bombay duck is a popular dish on many Indian restaurant menus, but in spite of its name this item of food is not a bird of any kind. It is actually a type of fish known as a lizardfish.

Lizardfish all live close to the floor of the ocean, using the strong pelvic fins on the sides of their bodies to prop themselves up. Some actually hide away in the sand here, with just their head or eyes visible, keeping their bodies out of sight. They are called lizardfish because in many ways they look like these reptiles. Their heads often have a similar shape, and when they move, lizardfish run in short, rapid bursts, scuttling quickly over the seabed to catch their prey rather like a lizard chasing an insect. These fish also snap very quickly at their prey, just like lizards. They have sharp, needlelike teeth in their mouths.

Sun-bathed Lizards

It is a particular type of lizardfish known as the bummalo or bommaloe macchli which is popular as Bombay duck. It has a slender, cylindrical body shape, and a soft dorsal (back) fin. These particular fish are caught in large numbers on the Indian subcontinent, especially in the estuaries of the Bay of Bengal. They return here from the sea to spawn inland in the rivers during the monsoon season, when the estuaries are swollen with water from the torrential rains.

Bummalo are prepared in a traditional way, with their bodies cut into halves, cleaned, and then left out to dry in the sun by being placed on cane frames. Once they are thoroughly dried out, the fish can be kept almost indefinitely in an airtight container.

Lizardfish have large mouths equipped with sharp teeth, to give them the best chance of grabbing and holding onto any prey that comes within reach.

Fact File

LIZARDFISH

Family: Synodontidae (about 64 species)

Order: Aulopiformes

Where do they live?: Relatively shallow waters, which may have either rocky or sandy bottoms; lizardfish inhabit the Atlantic, Pacific, and Indian Oceans

Habitat: Marine environments in general, although the Bombay duck enters rivers

Size: Can range in size from about 3.5–30 inches (9–76 cm)

Coloration: Variable in coloration, usually having a mottled appearance that allows these fish to blend in with their surroundings, breaking up their profile on the seabed

Diet: Predatory, feeding on fish and invertebrates, particularly crustaceans such as small crabs

Breeding: When lizardfish spawn, males generally release sperm into the sea, which fertilizes eggs released here by females; at least 2 species are hermaphrodite, which means they have both males and female sex organs in their bodies

Status: Not known to be threatened

LOBSTERS AND CRAYFISH

With their huge, heavy claws, lobsters are among the most impressive-looking creatures in the sea. In terms of numbers of species, however, they are easily beaten by their smaller freshwater cousins, the crayfish.

Lobsters and crayfish are relatives of crabs. Like crabs, they have a hard protective covering called an exoskeleton, plus five pairs of legs, including the claws at the front. Their shape, however, is quite different. The body is long and narrow, and ends in a fan-shaped tail. They also walk forward, not sideways like crabs. Although lobsters crawl along the sea floor and are too heavy to swim, if danger threatens they can use their tails to flick themselves rapidly backward in the water out of harm's way.

Lobsters and crayfish are both mainly nocturnal (active at night). They hide in burrows or rock crevices or among weeds during the day. At night they may wander long distances in search of food.

The word "lobster" is also used for other long-bodied crustaceans that live on the sea floor but are not true lobsters. These include the spiny lobsters (see box page 15), and the smaller squat lobsters that are actually relatives of the hermit crabs.

The Big Ones

Many types of lobster are found throughout the world, but the biggest and best studied are the American lobster and the European lobster. These two closely related species have long been popular as food for people. Their massive claws can account for up to 40 percent of their body weight! The two claws are not identical: there is a bigger, blunter one (the crusher) for

This common lobster has serrated edges on the inner surfaces of the massive pincers, or claws. These help the lobster get a firm grip on its prey.

Fact File

LOBSTERS AND CRAYFISH

Infraorder: Astacidea (many hundreds of species)

Order: Decapoda

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Lobsters: widespread in the world's oceans; crayfish: most common in North America, Australia, and Europe

Habitat: Lobsters: ocean floor; crayfish: rivers and streams

Size: Lobsters usually up to 24 inches (61 cm) long; occasionally up to 4.2 feet (1.3 m)

Coloration: Varies with species

Diet: Omnivorous (will eat most things)

Breeding: When first hatched, young lobsters swim as part of the plankton before settling on the seabed and developing into adults; newly hatched crayfish remain attached to the mother for several weeks before settling on the riverbed

Status: Some lobsters under pressure from overfishing; some crayfish at risk from disturbance to their river habitats

An American river crayfish adopts a defensive posture by rearing up to make itself appear bigger. It brandishes its pincers at any would-be attacker.

crushing hard shells, and a sharper one for cutting creatures such as worms in two.

Like other lobsters, these species have to molt their exoskeletons as they grow. This is a tricky business for a large lobster, and it is also very vulnerable to attack until the new exoskeleton underneath stretches and hardens. Lobsters are territorial, and often fight their rivals. Male and female usually mate in a protected burrow or lair. The female then carries the fertilized eggs around with her, glued onto the underside of her body, until they hatch. The eggs turn into tiny larvae that swim and feed in the plankton, before eventually settling on the seabed and turning into miniature adults.

Lobsters are long-lived animals and continue growing all their lives. The largest recorded lobster weighed over 44 pounds, but such giants are rare now because of people fishing.

Freshwater Cousins

There are around 500 species of freshwater crayfish worldwide. The largest, the Tasmanian crayfish, can grow to 2 feet long. Crayfish live in rivers and streams, where they are vulnerable to pollution. They are less heavily built than lobsters. As well as grabbing live or dead food with their claws, crayfish can also filter out tiny food particles from the water. In contrast to lobsters, crayfish eggs do not hatch out into swimming larvae, but into miniature adult crayfish. At first the young hold on to their mother's body for protection.

DID YOU KNOW?

- Lobsters can live for up to 100 years!
- True lobsters and crayfish have pincers on their first three pairs of legs—but only the front ones are big claws.
- Confusingly, spiny lobsters are called "crayfish" in some parts of the world.

SPINY LOBSTERS

The spiny lobsters (above) are only distant relatives of lobsters and crayfish. Although big and roughly lobster shaped, they lack the claws of true lobsters. Instead, they have spines on their bodies and on their antennae (feelers) to protect them. Spiny lobsters are found mainly in warmer seas. They have similar eating habits to true lobsters, and are also mainly nocturnal. Some types have very flat bodies, and are called slipper lobsters. Spiny lobsters in the Caribbean go on an amazing migration every year. In the fall, large numbers of them walk many miles along the seabed into deeper waters, navigating by using the Earth's magnetic field. Up to sixty individuals at a time may march along in single file, each touching the tail of the one in front!

LUNGFISH

Most fish use gills to obtain oxygen from water, but lungfish actually have lungs that allow them to breathe air. They can survive during periods when their watery homes dry up.

Young African and South American lungfish have external gills, just like young tadpoles. This means that they were once thought to be amphibians rather than fish. Lungfish are the only surviving descendants of a very ancient family of fish whose fossilized remains date back over 400 million years. At that time, there were at least 100 different types. Today there are just six. Fossils have shown that the Australian lungfish has remained unchanged in appearance for over 100 million years. The ancestors of this group lived in the sea, but today lungfish are found only in fresh water.

Survival Experts

When the waters in which they live begin to dry up through lack of rain, lungfish start to breathe air at the water's surface. Then they build themselves a cocoon in the damp mud, about 10 inches down from the surface. The lungfish produce large quantities of mucus, which helps to seal them into the cocoon. The mucus sets hard, but a breathing tube connects the chamber to the surface, providing oxygen. Their metabolism also slows down at this time, so they need less oxygen.

The lungfish usually remain in their cocoons for up to eight months, until the rains arrive. However, they sometimes stay as long as four years in this state of suspended animation before re-emerging when their habitat fills with water again.

The marbled lungfish is found in African swamps and rivers, as well as in lakes such as Lake Victoria. Adults eat mainly mollusks, but also insects and fish.

Fact File

LUNGFISH

Families: Lepidosirenidae, Protopteridae, Ceratodontidae (6 species in all)

Orders: Lepidosireniformes, Ceratodontiformes

Where do they live?: South America, Africa, and Australia

Habitat: Relatively shallow pools, and also deeper rivers in the case of the Australian lungfish

Size: From 33 inches (85 cm) in the spotted lungfish, to over 6.5 feet (2 m) in the Ethiopian lungfish

Coloration: Dark upperparts, but tending to have speckled underparts

Diet: Predatory, stalking prey usually at night; eats small fish, tadpoles, aquatic invertebrates such as snails and shrimp; may very occasionally eat plant matter

Breeding: Usually occurs soon after the rains when the pools are full; eggs of South American and African lungfish are laid in burrows guarded by the male, but Australian lungfish scatter their eggs among aquatic vegetation

Status: Generally not considered to be threatened, with the possible exception of the Australian species

MACKEREL

The streamlined bodies of mackerel mean that these fish can swim very fast through the ocean. Mackerel are also highly maneuverable, which helps them to escape from potential predators.

Mackerel are active fish, spending their lives swimming, and they have developed a body shape for this purpose. Their body tapers at both ends, meaning they can swim through the water easily, with their curved rear ensuring there is little drag to slow them down. The scales on the body are very small, lessening water resistance. Even the bones of their jaws are arranged so as not to disrupt their streamlined profile. And their eyes are set deep within their sockets, rather than protruding. The two dorsal (back) fins along the back are small, and there are special grooves that allow these to be folded down when the mackerel is swimming quickly, which reduces drag. The part of the body connecting to the caudal (tail) fin, called the caudal peduncle, is narrow. The tail itself is tall, narrow, and rigid. This design is ideal for long-distance, high-speed swimming. Keels on the caudal peduncle aid the movement of the tail through the water.

On the Move

Mackerel swim in shoals through open water. Their bodies are ideally suited for constantly being on the move, allowing them to accelerate rapidly if danger threatens. These fish are prey to many potential predators, ranging from penguins to humpback whales. However, their swimming abilities offer little protection against modern fishing methods, and people track and net mackerel in huge numbers.

Shoals of mackerel display remarkable coordination, with all the fish being able to alter direction in a split second to avoid an approaching predator.

Fact File

MACKEREL

Family: Scombridae (about 54 species)

Order: Perciformes

Where do they live?: Widely distributed through the world's oceans, although some, such as the Monterey Spanish mackerel from the Gulf of California, have a limited range

Habitat: Open sea, frequently near the surface

Size: From about 8 inches (20 cm) up to the wahoo, which may grow to 8.2 feet (2.5 m) long

Coloration: Blue back with a silvery belly in most cases

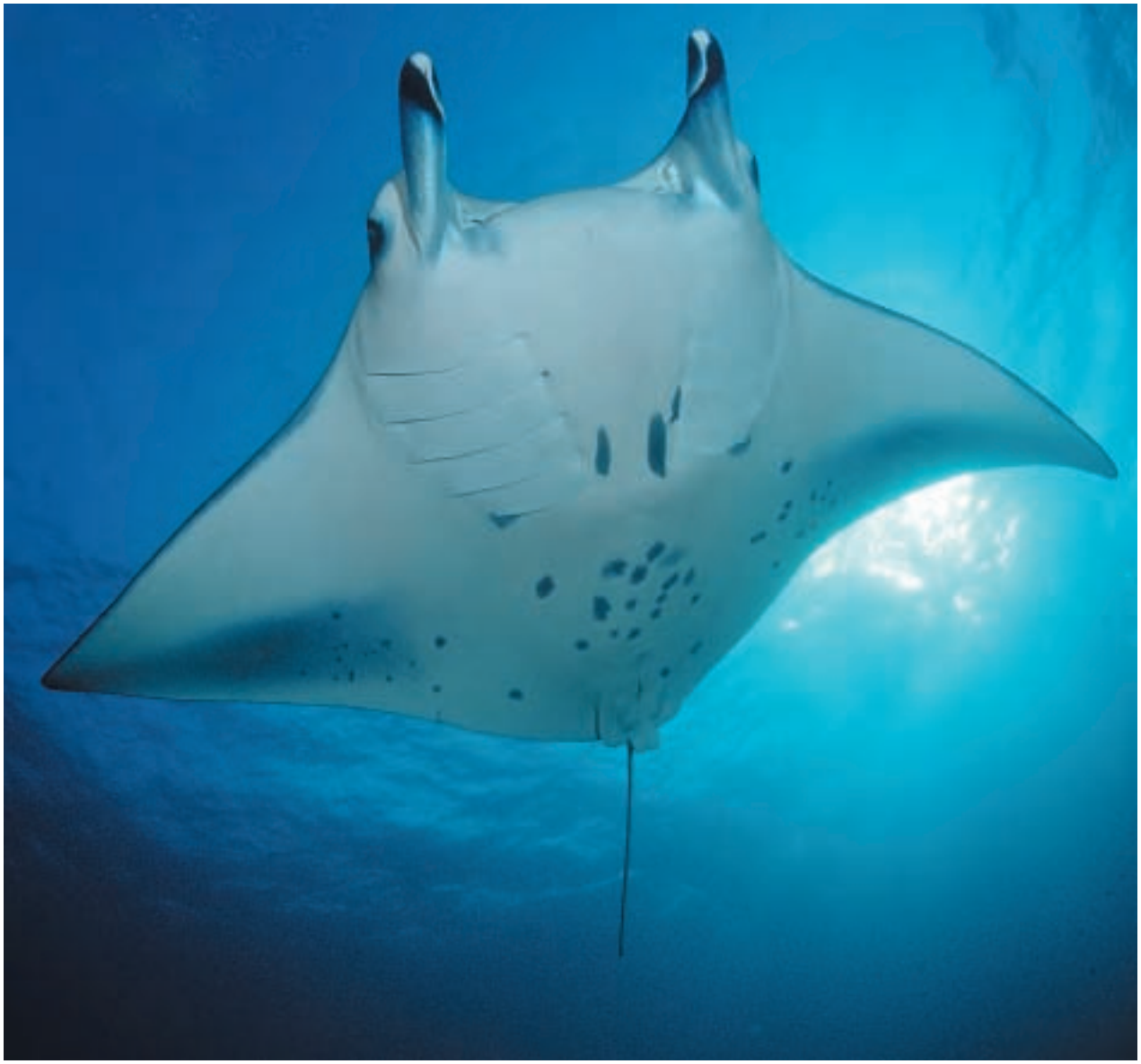
Diet: Generally smaller fish as well as crustaceans and squid

Breeding: All species are egg-scatters, with females laying their eggs which are then fertilized outside the body by the males' sperm

Status: Populations generally have probably declined, with the Monterey Spanish mackerel now regarded as endangered

MANTA RAY

By using their so-called wings, these gigantic fish can propel their massive bodies right out of the sea and can then glide at a height of up to 5 feet above the water surface.



Manta rays, which are closely related to sharks, have inspired fear among sailors for centuries. This is due to the fact that they often circle small boats and can even leap above the waves. It is thought that they may do this as part of their courtship display. Although their size means they can be dangerous if they actually collide with a boat, manta rays only feed on microscopic plankton which they filter out of the water using specially adapted gills. As water is drawn in through their cavernous mouth, special filters remove the plankton, which is then passed down into the stomach. The name "manta" comes from the Spanish word for "cloak," and describes the cloaklike appearance of these fish when they are swimming.

The Ray's Companions

Various smaller fish are often seen in the company of manta rays. These include pilot fish—so called because they tend to swim in front of the ray, as if guiding it along. Various types of "cleaner fish" may also be in attendance, including brightly colored wrasse. Rays seem to recognize these fish, and slow down, opening their gill slits to allow the small fish to dart in and remove any parasites that may be present there. Remoras may also be present on the body of a manta ray. They use their dorsal (back) fin rather like a suction cup to hitch a ride on the ray's body, and sometimes even hang on inside its mouth.

The armlike extensions at the front of a ray's body (known as cephalic fins) are used to help funnel plankton into the huge mouth when it is feeding.

Fact File

MANTA RAY

Manta birostris

Family: Mobulidae

Order: Rajiformes

Where do they live?: Throughout the world's tropical oceans

Habitat: Often in the upper part of the ocean, occasionally extending into estuaries and even rivers

Size: A "wingspan" of up to 22 feet (6.7 m) in the Atlantic manta rays; they can easily weigh 3,000 pounds (1,360 kg)

Coloration: Brownish-black above with an individual white collar and white underparts

Diet: Plankton

Breeding: Female gives birth to a single live youngster after a period of about 13 months; the young ray will already have a wingspan of more than 3 feet (1 m) at birth

Status: Not facing any immediate threats, but global warming may impact on its food supply

MANTIS SHRIMP

These colorful crustaceans are fierce hunters. Their front limbs pack a punch strong enough to break the glass of an aquarium! It is not surprising that this power is also used to capture prey.

Mantis shrimp are distant relatives of true shrimp, crabs, and lobsters. Their most famous feature is their second pair of limbs, which are enlarged into deadly attacking weapons. They can shoot out a sharp, jagged blade with a fistlike club, with lightning speed to attack prey. Different species can be classed as "smashers" or "spearers," depending on which part of their weapon is best developed!

Mantis shrimp are fierce hunters of live prey. They have the best eyesight of all crustaceans, combining excellent color vision with an ability to judge distances.

Varied Lifestyles

Mantis shrimp live exclusively in the sea. Most live in the tropics, although some are found in cooler regions. Mantis shrimp often sit at the entrances of burrows they have made, or in crevices in stones or coral. Some types wait to ambush prey, while others actively hunt for food. Although they usually crawl along the sea bottom, mantis shrimp can also swim.

Rival males sometimes fight, although they take good care to avoid being seriously injured! Males are very careful during courtship, since a blow from an unfriendly female could seriously injure them. After mating, the female looks after the eggs, keeping them in a safe place until they hatch. Young mantis shrimp swim in the plankton before settling down and starting their adult lives on the sea floor.

Mantis shrimp are the most colorful crustaceans, often sporting eyecatching patterns of red, green, and blue. Shown here is a peacock mantis shrimp.

Fact File

MANTIS SHRIMP

Order: Stomatopoda (about 400 species)

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Warm seas throughout the tropics

Habitat: Mainly shallow coastal waters, including coral reefs

Size: From 2–16 inches (5–41 cm) in length

Coloration: Often brightly colored

Diet: Live prey, including mollusks, worms, and other crustaceans

Breeding: Female guards eggs in a den

Status: Most are not known to be threatened

MARLINS

With their powerful, streamlined bodies, marlins are the fastest fish in the ocean, able to reach a speed equivalent to 80 miles per hour. This makes them even quicker than the cheetah on land.

Marlins are not only able to accelerate quickly, in spite of water resistance, but they can also swim fast over long distances. This is thanks in part to the way in which blood flows around their body. Their circulation ensures that the body temperature remains several degrees above that of the surrounding water. When they are away from the shore, marlins swim in the upper part of the ocean where the sea is warmer, typically at a temperature of 68°F (20°C).

The long spike present on the upper jaw of marlins helps to identify these fish. It was once thought that this was used to spear larger prey, based on eye-witness accounts of fish impaled in this manner. But now such "catches" are believed to be accidental, because the marlin has no easy way of removing the speared fish from the spike so it can be swallowed.

A Perilous Lifestyle

Most marlins live on their own for much of the year, although younger individuals sometimes gather in small groups. Adults will migrate, however, heading across the oceans to their traditional spawning grounds. From the huge numbers of eggs an adult female marlin produces, only a tiny percentage will develop into fish that will survive long enough to breed themselves. They face many dangers in the open ocean—from other fish when young, to fishermen who prize marlins when adult as sporting trophies.

It is now thought that marlins, such as this striped marlin, use their spikes to thrash around in shoals of smaller fish, stunning victims that they can then eat.

Fact File

MARLINS

Family: Istiophoridae (3 species)

Order: Perciformes

Where do they live?: In tropical and subtropical seas around the world

Habitat: Upper reaches of the open ocean; some species found closer inshore, over coral reefs

Size: Adult fish vary from 6 feet (1.8 m) through to the striped marlin which can grow to 13.8 feet (4.2 m) and weigh 970 pounds (440 kg)

Coloration: Blue-black on the back, becoming silvery on the flanks; may display blue vertical stripes

Diet: Mainly fish, squid, and crustaceans

Breeding: Females may produce up to 40 million eggs when spawning, which are barely 0.04 inch (0.1 cm) in diameter; after being fertilized by the male's sperm, these are simply left to drift on the ocean's currents

Status: Numbers have declined over recent years

MINNOWS

The word "minnow" is a term that is sometimes used to describe any type of tiny fish. However, the only true minnows are particular kinds of small, or smallish, members of the carp family.

Nevertheless, it is still not easy to decide exactly what a minnow is, because this name has been given to a host of different species. Even within the carp family, it is used for members of various subfamilies. The name is not therefore an indication of a close relationship between different fish, but rather a more general indicator of their size. But even this is inaccurate, since some minnows are quite big! To add to the confusion, some minnows are popularly known as dace—another description given to small fish.

What Is a Minnow?

Zoologists have discovered a number of features shared by all minnows. These include the absence of scales on the head, a single dorsal fin on the back, and the lack of an adipose fin (the small fatty fin behind the dorsal fin in some fish species). Minnows have no true supportive spines in their fins, only hardened rays. There are no teeth in their jaws, although there may be teeth present right at the back of the mouth.

Another minnow feature is the lack of sensory feelers, known as barbels, on the upper jaw around the mouth. Some of the bones in a minnow's skull are also different from those of other members of the family, and minnows have more bones in their backbone than in other types of carp. These features all help to distinguish true minnows—members of the subfamily Leuciscinae—from other members of the carp family.

A European minnow eating a worm. This attractively marked little fish can grow to about 4 inches, but most of the specimens encountered are much smaller.

Fact File

MINNOWS

Genera: *Phoxinus*, *Pimephales*, *Leuciscus*, and others

Subfamily: Leuciscinae

Family: Cyprinidae

Order: Cypriniformes

Where do they live?: North American landmass and Eurasia, with the exception of India and southeastern Asia

Habitat: Largely fresh water, from fast-flowing rivers with rocky bottoms to lowland slow-flowing, silty water

Size: From 2.8–31.5 inches (7–80 cm)

Coloration: Duller color across the back, often brighter on the flanks and belly, especially in males

Diet: Small aquatic invertebrates and insects to larger prey; also some plant matter

Breeding: Often migrate before spawning, with mating occurring in shallow water; eggs usually scattered amongst vegetation or over rocks, sand, or gravel, usually without any parental care

Status: Most species common or relatively so, but there are some under threat and several that may already be extinct

New Species

A number of minnows may have a very limited range in the wild, and can be easily overlooked. Some may even have become extinct before their uniqueness was appreciated. This could easily have happened in the case of the *Phoxinus* species known as the blackside dace. It first became known to science in 1975, when it was discovered living in a small area of the Cumberland River basin in the Daniel Boone National Park in Kentucky. At this time there were proposals to fell the forest, but these were rejected once the unique nature of this small fish was appreciated.

It took three years to gain a proper insight into the biology of the blackside dace. It is very sensitive to silt-laden water, so its distribution is restricted to clear water areas of streams, particularly pools of about 40 inches in depth, fed by flowing water from narrower, shallower stretches. These pools are generally edged by undercut banks and are fringed by dense vegetation. The bases of such pools vary from rocky to sandy or gravelly, but they do not

The ide is one of the larger members of the minnow group, growing to several pounds in weight. A golden variety, usually known as the orfe, is often kept as an ornamental fish.

contain fine sediment. The only other fish present in the area that seems relatively common in this type of environment is another dace, the southern redbelly.

KEEPING IN TOUCH

Minnows usually live together in small groups or larger shoals. In most cases, members of the shoal recognize each other by their coloration and patterning, but the European minnow (below) has developed an unusual means of communication with others of its own kind. Scattered over its body are special cells that secrete mucus with a distinctive smell. The fish can detect this odor in the water. It is so effective that even in water with virtually no visibility, European minnows will still be able to swim in shoals. This happens even if the group is split up temporarily by a predator.

DID YOU KNOW?

- The golden form of the fathead minnow is an ornamental variety that does not occur in the wild.
- Fathead minnows are unusual because instead of scattering their eggs, they carefully deposit them on the roof of a small cave or on a rock. Then the male guards them until they hatch.
- The anglers' use of fathead minnows as a bait fish to catch other, larger species has led to it becoming established in waters outside its natural distribution within the U.S. It also now occurs further afield in some European countries, as well as in Puerto Rico.

Still Under Threat

Water flowing in and out of these pools determines which species is most common. Where flow is reduced, the southern redbelly is present, rather than the blackside dace. Anything that affects the level of sediment in the water, and affects the flow, will have a bad effect on the population of the blackside dace.

Logging proposals would have increased the run-off of sediment, but they were rejected. Despite this, a subsequent survey found that only nine out of thirty known pools where these dace occur contain healthy populations of the fish.

MOLAS

The incredible appearance of molas suggests that half of their body is missing, but they have existed in this form for over twelve million years, according to fossil evidence.

Some species of molas actually have a recognizable tail when they are very young, but as they start to develop into adult fish this feature is lost. The tail becomes absorbed back into the body and is replaced by a pseudotail, called the clavus. The large dorsal (back) and anal (belly) fins, along with the clavus, help the molas to swim, pushing its body through the water. This is different from how most fish swim; usually, movements of the caudal (tail) fin provide the power that thrusts the animal forward.

A Lazy Lifestyle

Molas generally swim gently through the ocean, close to the surface. Often, they rest here by lying flat on their side, giving the impression that they are dying or even dead. Such behavior has also been likened to sunbathing, and helps to explain why all four species of these fish are often described as ocean sunfish. Molas may also dive down to the depths of the ocean on occasions, having been recorded as far down as 2,200 feet below the surface.

Molas prey on slow-moving invertebrates, including mollusks, crustaceans, and sea urchins. They also hunt jellyfish and squid, and browse on seaweed. Molas have a small mouth equipped with two fused teeth that allows them to break open thick-shelled prey. They themselves can be vulnerable to attack by sea lions and larger fish, including sharks and tuna.

Molas are the heaviest of all the bony fish, weighing as much as 5,070 pounds. They may have had similar ancestors to pufferfish, porcupinefish, and boxfish.

Fact File

MOLAS

Family: Molidae (4 species)

Order: Tetraodontiformes

Where do they live?: In tropical, subtropical, and warm temperate seas worldwide

Habitat: Open sea, usually close to the surface, but can dive to much greater depths

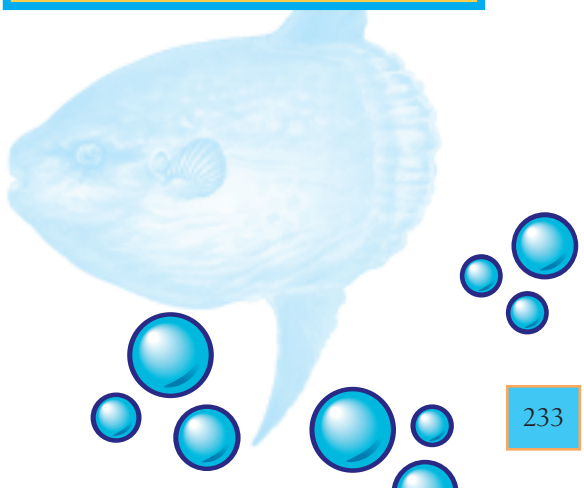
Size: 40 inches (1 m) up to 11 feet (3.3 m); may measure up to 14 feet (4.2 m) vertically across their body

Coloration: Generally a drab bluish-brown on the back of the body, becoming a lighter bluish-gray on the sides and along the belly

Diet: Mainly soft-bodied invertebrates such as jellyfish; also small fish, sea urchins, crustaceans, and seaweed

Breeding: Lays more eggs—up to 300 million—than any other bony fish; eggs are scattered in the ocean; young larvae have body spines at first

Status: No species of molas is currently believed to be seriously threatened



MOLLUSKS

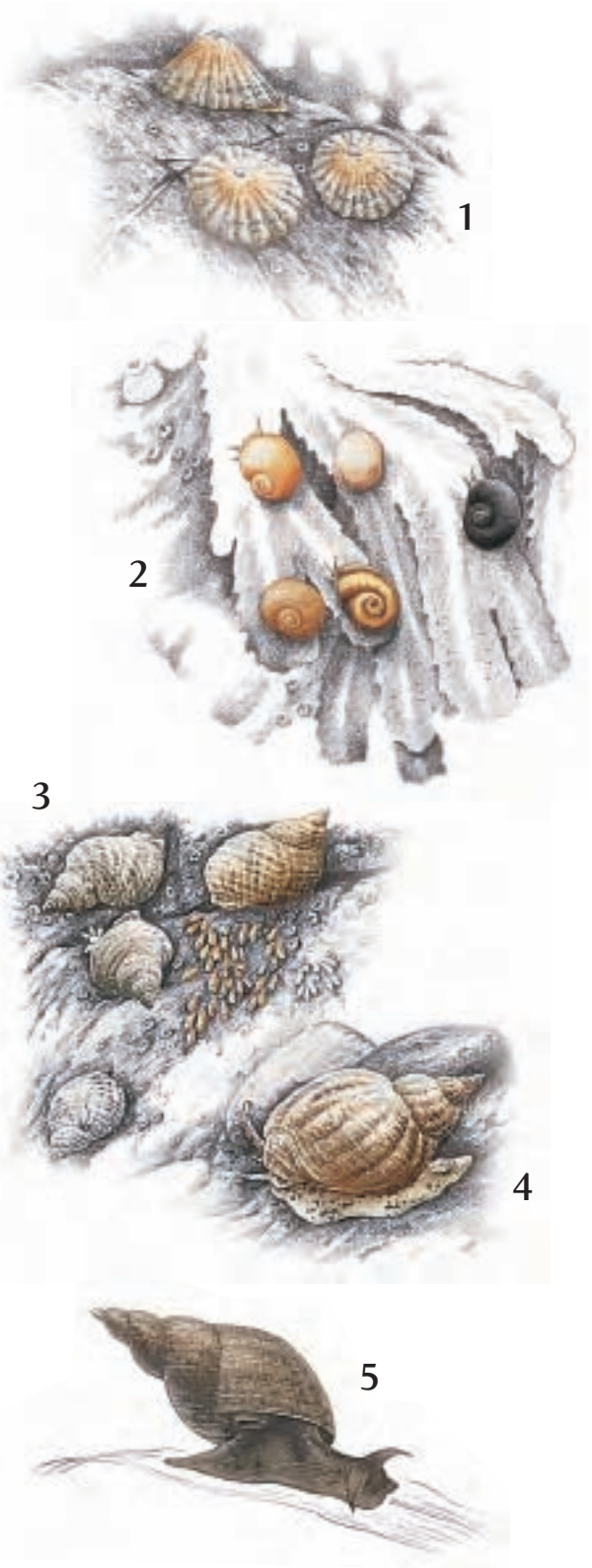
Mollusks are the group that includes snails, slugs, clams, squids, and octopuses. Many species live inside protective shells. They are one of the largest animal groups on Earth.

Mollusks are important animals in all marine ecosystems. Many of them also live in fresh water and on land. They come in a wide range of sizes, from tiny species living among sand grains to huge creatures such as the giant squid—this mollusk can grow to 60 feet in length including its tentacles!

The Mollusk Body Plan

Scientists think that the first mollusks to evolve, hundreds of millions of years ago, were simple crawling sea creatures that had developed a protective shell on their backs. Although the various kinds of mollusks alive today seem so different from each other, they all basically share the same body plan.

The basic design of a mollusk includes a head at the front with a mouth containing a rasping, tonguelike structure called the radula. In the earliest-known mollusks, as well as in most of today's species, the muscular lower surface of the body—called the foot—moves the animal along. The upper surface, known as the mantle, usually overhangs the sides of the body like a skirt. The mantle provides protection for the animal's gills, and also forms its hard shell.



Fact File

MOLLUSKS

Phylum: Mollusca (Around 90,000–100,000 known species)

Classes: There are 7 classes of mollusks in total, including:

Gastropods (snails and slugs) At least 70,000 species

Bivalves (clams, mussels, and relatives) 15,000–20,000 species

Cephalopods (squids, octopuses, cuttlefish, and nautiluses) Around 900 species

1. *Common limpet*
2. *Flat periwinkle*
3. *Dog whelk*
4. *Waved whelk*
5. *Great pond snail*
6. *Sea slug*
7. *Mussel*
8. *Atlantic bay scallop*
9. *Pearly nautilus*
10. *Cuttlefish*
11. *Octopus*

DID YOU KNOW?

- Octopuses are the most "intelligent" of all invertebrates. They can even perform simple problem-solving tasks.
- The largest bivalve, the giant clam, can weigh up to 500 pounds. It lives on coral reefs.
- The largest sea snail, the false trumpet shell, lives near Australia. Its shell can be 30 inches long.

All mollusks have well-developed digestive, nervous, and excretory (waste removal) systems. Their eyes range from simple light detectors in some species to sophisticated structures with lenses, like our own eyes, in others.

Reproduction in mollusks is very varied. Although most species are either male or female, many are hermaphrodite (having both male and female sex organs). One common breeding pattern involves producing thousands of eggs that hatch into tiny swimming larvae (young stages). The larvae feed in the plankton until they develop into adults. Other species of mollusks produce large eggs that hatch out as miniature versions of the adults.

Snails and Slugs

Around three-quarters of all living mollusks belong to the snail and slug group (class Gastropoda). Gastropods have most of the basic mollusk features such as the foot, the mantle, and the radula. Their single shell is usually coiled in the familiar snail shape. Sometimes, though, the shell is no more than a simple cap, as in limpets, or has been lost altogether, as in the slugs. Most gastropods that have shells can pull their bodies back into them for protection. Many species also carry a hard "door" on their bodies called an operculum that they use to seal the shell entrance once they are safely inside.

One peculiarity of gastropods, quite separate from their coiled shells, is that their whole body usually becomes twisted round inside as they grow. This process is called torsion, but it is not obvious from the outside.

Nudibranchs are a type of colorful sea slug. There is a cluster of gills at the rear end of each of these specimens and tentacles at the front end.

A tiger cowrie crawls on the seabed in the Indian Ocean. When the animal is active, the fleshy mantle envelops most of the shell, as shown here.

Today's gastropods are enormously diverse in shape, coloration, and habits. The most primitive kinds mainly scrape algae (tiny plants) from the rocks for food, using their rasping radulas. Many others, though, have adopted a meat-eating diet. These include the cone shells—the beautiful but deadly snails of warmer waters, whose poison is strong enough to kill people! Some sea snails burrow in sand or mud. Other gastropods called sea butterflies spend their lives swimming at the sea surface.

When not covered by the mantle, tiger cowrie shells appear glossy and beautifully marked. The slit seen here forms part of the opening of the shell.

THE MOLLUSK SHELL

Chiton shells (left) are made from hinged sections. Tusk shells (right) are hollow tubes.

Mollusk shells are mainly composed of calcium carbonate (the mineral found in limestone and chalk). The shell is created (secreted) by the mollusk's mantle, and is built up in several layers. The inner layer is often smooth and shiny. Unlike the "shell" (exoskeleton) of crabs and shrimp, a mollusk's shell is not shed and then regrown. It is simply added to at the edges as the animal grows.

On land it is more difficult to obtain calcium carbonate to build a shell, so land snails often have thinner, horny shells, and land slugs (and sea slugs) have no shells at all. Squids and octopuses seem to have no shells, either. However, many species—such as cuttlefish—have small shells buried deep inside their bodies.

DID YOU KNOW?

- There are more species of mollusk known than any other animals except insects.
- Some relatives of clams can burrow into solid concrete!
- Some mollusks can change sex from male to female and back again.

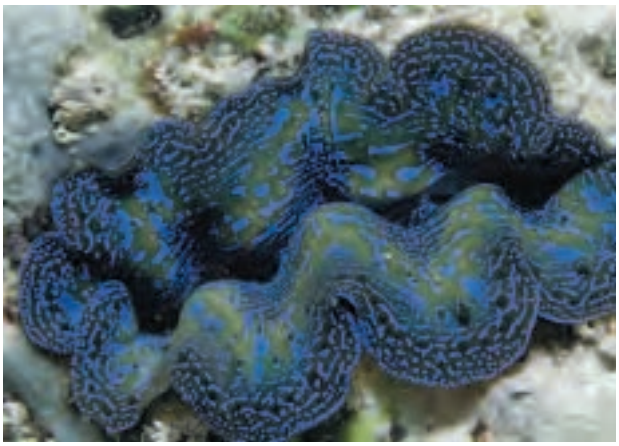
Gastropods are the only mollusks with species equipped with lungs so they can live on land; these are the familiar land snails and slugs. There are also many freshwater gastropods, some descended from sea snails and some from land snails that have returned to the water.

Clams and Relatives

At first sight, clams, mussels, and their relatives look quite different from snails, but they, too, share the same basic features. Their scientific name—bivalves—refers to the two "valves" or shells that they possess.

The two shells mark the left and right sides of the animal. They are joined by a hinge at the top. Bivalves still have a foot, but it is not used for crawling around. In most bivalves it pokes out like a tongue from between the two shells. The foot has different functions depending on the particular species.

Bivalves have no head, and the brain has become small and simple; most bivalves lead quiet lives filtering tiny food particles from water or mud. Some, such as mussels and



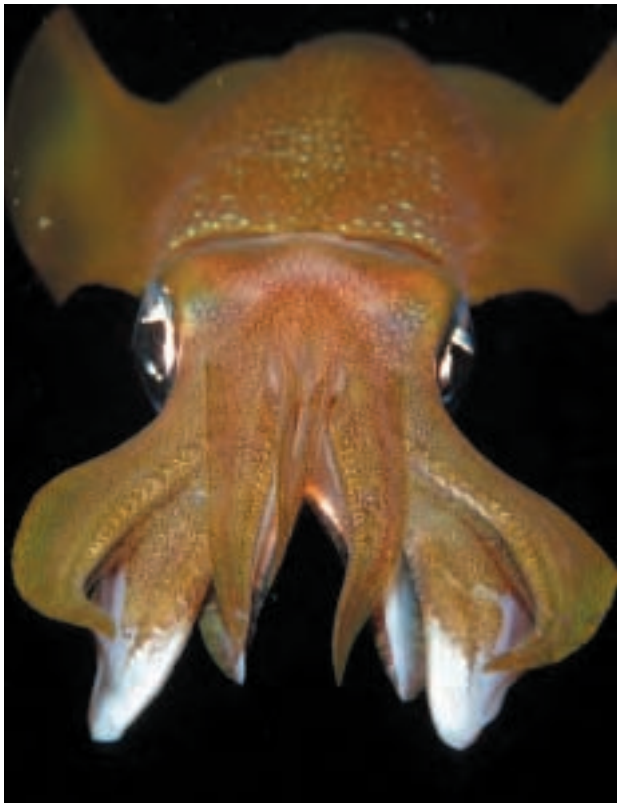
Giant clams are the largest of the bivalve mollusks. The bright colors of many species are produced by the algae that live in their bodies.

oysters, anchor themselves to hard surfaces, but many others use their foot to burrow into soft sand and mud, where they are safer from predators. These species often have long flexible tubes (siphons) to reach up into the water. A few bivalves can bore into wood and rock using their shells as scrapers. Some use acid to dissolve the rock as well. Scallops can even swim to escape danger by squirting water from between their shells in a type of jet propulsion.

Squids and Relatives

The cephalopods include the squids, the octopuses, and the cuttlefish. Scientists think that, compared with snails or slugs, squids have bodies turned on their sides. The original foot is now the front of the animal and has developed suckered tentacles (ten in squids and eight in octopuses). This is where their scientific name "cephalopods" comes from—it literally means head-foot." Apart from the primitive nautiluses, cephalopods have all done away with their external shells and are very mobile.

Cephalopods live only in the oceans, never in fresh water or on land, and they all hunt other animals for food. They have excellent eyesight and large brains. Many can change color at will to match their surroundings.



This cuttlefish, viewed head-on, has large, well-developed eyes and a ring of suckered tentacles surrounding the mouth.

MORAY EELS

Feared by divers, mainly because they may lunge unexpectedly from rocky caverns, moray eels are actually quite shy and secretive fish. But they can also deliver a powerful bite.

A number of species of moray eels inhabit the world's coral reefs, where they usually hide away in small, narrow crevices. They are very adaptable, and so they will often colonize wrecks, too. These provide plenty of hiding places from where they can suddenly emerge to seize unsuspecting prey. Moray eels usually hunt for their prey at night. They have large mouths equipped with fearsome teeth, and they also have additional teeth located in the throat.

However, only a few species of morays are a serious threat to divers. One of these is the giant moray eel—the largest member of the family. Even so, it usually only attacks a human when surprised or threatened at close quarters. It prefers to hide away if possible rather than reveal its presence.

Dangerous Eels

Placing a hand into a cavity where a moray eel may be lurking will probably result in a severe bite, and these wounds often turn septic (poisoned by bacteria). Divers who have tried to kill one of these eels with a spear gun, but have only caused a minor injury to the fish, have then sometimes found themselves being attacked. Often, the eel retreats into its lair, only to re-emerge through a second exit elsewhere. It then proceeds to react aggressively toward the diver. Moray eels are also protected by a toxic mucus that covers their bodies. Their flesh, too, may be poisonous if it is eaten.

Morays open and close their mouths repeatedly, revealing their teeth. But this is not an aggressive gesture; it simply aids the flow of water over the gills.

Fact File

MORAY EELS

Family: Muraenidae (about 200 species)

Order: Anguilliformes

Where do they live?: Present in all the world's oceans, although only 1 species occurs north of the Mediterranean Sea

Habitat: Usually in relatively shallow waters, typically in warmer seas around coral reefs; 2 species may be found in fresh water

Size: Up to 10 feet (3 m)

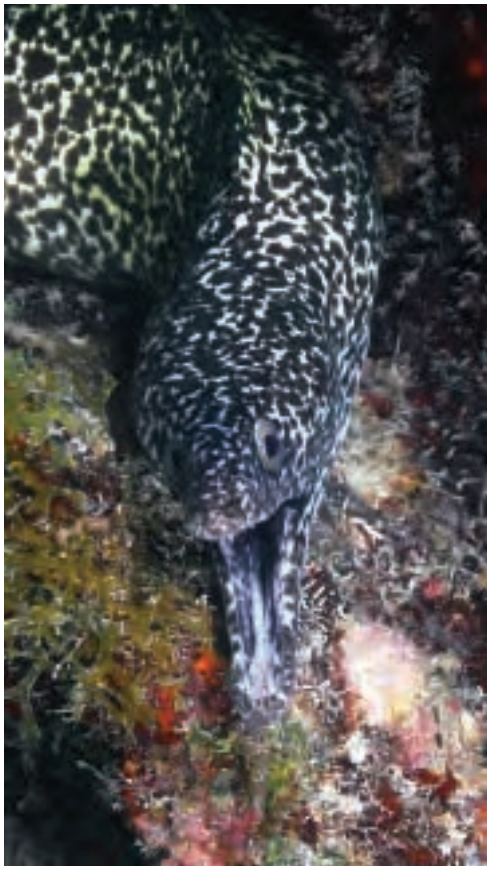
Coloration: Very variable; may be dark in color, speckled, or even banded and brightly colored in some species

Diet: Predatory; food includes crustaceans, mollusks, and other fish

Breeding: Life cycle unclear, but eggs hatch to give rise to a larval form known as a leptocephalus

Status: Generally not uncommon, but some species may be declining

Sometimes, more than one moray eel may share a hiding place among rocks and other crevices.



The leopard moray eel lives on reefs in the Indo-Pacific region. It grows to a length of about 36 inches.

Hunting Techniques

The way moray eels obtain their food varies greatly, depending on the individual species. Although many lie in ambush for unsuspecting prey, others actively pursue their quarry.

A remarkable hunting technique is shown by chain moray eels, which are mainly found along the northeastern coast of Brazil. Chain morays often ambush unwary crabs in the water. They can also catch them on land, hunting their quarry at low tide. They are able to locate the crabs by sight and can even travel about 16 feet or so over land in pursuit of their prey.

These moray eels are able to survive out of water for at least half an hour during these hunting expeditions, although they often submerge themselves in rock pools as they hunt. Many of the crabs caught by the eels are too big to be swallowed whole, and so they must first be crushed and torn apart in the mouth before being swallowed.

Another unusual hunting adaptation is seen in the leaf-nosed eels of the Pacific. They have bizarre projections resembling leaves on their snouts. It is thought that these may help the eels locate prey by scent.

GROOMING

Like a number of other reef fish, moray eels have formed an unusual partnership with cleaner wrasse. In this partnership, the normal rules of predator and prey have been put to one side. The wrasse, which could provide an easy meal for a hungry moray eel, actually removes pieces of food from previous meals lodged in the moray's teeth. It also nibbles off troublesome parasites from the moray's body. The eels will also tolerate the brightly colored cleaner shrimp because they perform a similar grooming task. Both the wrasse and the cleaner shrimp obtain not just food from this partnership. They also get some protection from predators that might otherwise try to eat them.

Cleaner fish and shrimp on a moray eel.

DID YOU KNOW?

- Some moray eels, such as the harlequin sea eel, have modified their appearance to resemble that of deadly sea snakes, to convince would-be predators to leave them alone.
- Moray eels that hunt crabs can be identified by their specially adapted teeth, which are much blunter than the teeth of other species.
- It used to be thought that moray eels constricted their prey by wrapping around it. This mistaken belief arose from the way in which they twist their bodies around if caught on a rod and line.

An Ancient Fascination

Moray eels were among the first fish to be farmed, with an eel farm being established in ancient Rome as long ago as 92 BCE. Eel farming became a successful industry. The generic name for the moray eels is *Muraena*, which commemorates the name of Licinius Muraena, a wealthy Roman who lived toward the end of the second century BCE. He provided 6,000 moray eels for a banquet he was giving, but rather than eating the eels, his guests were encouraged to decorate them with gems. However, some Romans had more sinister motives for keeping eels. Vedius Pollo is reported to have fed unwanted slaves to his morays as entertainment for his guests.

MULLETS

Mullets are streamlined, silvery flanked fish found in marine and freshwater habitats all over the world. The best-known species, the gray mullet, is an important food fish in many countries.

Gray mullet are highly versatile fish; they will adapt to freshwater, marine, or estuarine conditions. They are highly prized as a food fish and are widely farmed for this purpose in areas of the world such as Southeast Asia. These mullet can grow to a weight of nearly 18 pounds. Not only can they be sold either fresh or frozen, but particularly in less developed parts of the world they are also popular both in dried and salted form. Their eggs, called roe, are considered a delicacy, and these can be smoked as well as being sold fresh.

Mullets are generally social fish, and live in groups. There are some 75 recognized species, all of which look rather similar to each other.

Mullet in Fresh Water

Many species of mullet enter rivers from the sea at some stage in their lives, although they spawn in the sea. The abu mullet from Asia is a species that spends much of its life in fresh water. Another of these fish that lives in fast-flowing mountain streams is the goldie river mullet, whose distribution ranges from the Philippines southward to New Caledonia in the Pacific. The North American mountain mullet, found through the southern states down to Venezuela and Colombia, spends almost its entire adult life in fresh water, only migrating back to the sea to spawn. Its young live in brackish water at first.

This shoal of foldlip mullet is found in Indo-Pacific coastal waters. The fish's common name is derived from its distinctively shaped upper lip.

Fact File

MULLETS

Family: Mugilidae (75 species)

Order: Mugiliformes

Where do they live?: All tropical, subtropical, and temperate seas; also found in a number of river systems

Habitat: Marine, often close to the the shore; younger fish may be found in fresh or estuarine waters; adults spawn at sea

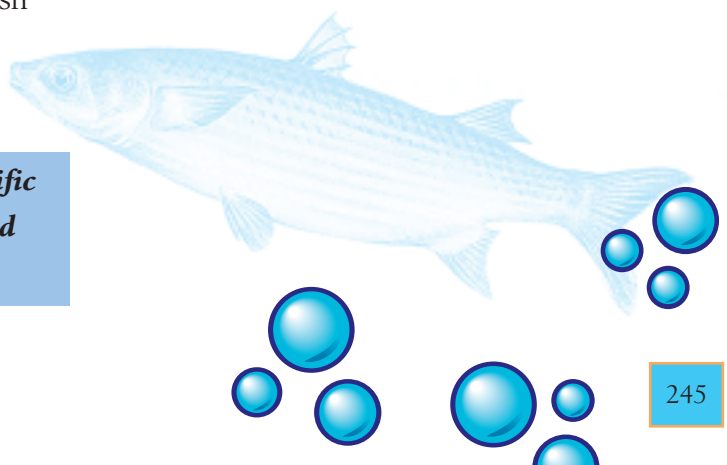
Size: From around 4 inches–4 feet (10 cm–1.2 m), with the majority averaging around 8 inches (20 cm)

Coloration: Typically bluish-green above, becoming a whitish-silvery shade on the belly, although species vary in appearance

Diet: Algae, plants, tiny free-floating organisms (zooplankton), and small invertebrates

Breeding: Spawning occurs from summer through to winter, with eggs simply scattered in the sea; these may hatch after just 1.5 days

Status: Not generally thought to be declining in numbers



MUSSELS

Mussels grow in huge colonies on some shorelines, clinging to rocks, piers, and other marine structures. People have taken advantage of this bountiful harvest from the sea since ancient times.

Mussels are two-shelled (bivalve) mollusks. Bivalves make up a large group that also includes clams and oysters. True mussels form a single family of bivalves that live in the sea. Their shells are usually long and taper at one end. Many freshwater bivalves are also called mussels (see box page 47), but these are not closely related to sea mussels. All mussels live by drawing into their bodies currents of water, from which they filter out tiny food particles.

Life on the Rocks

Most sea mussels live in shallow water, often in large colonies. They open their shells under water to feed, but clamp them tightly shut when they are exposed to air at low tide. Mussels have a muscular "foot" that they can protrude from their shells, but it is not used for crawling, or even burrowing. Instead, it is specially adapted to form strong, nylonlike threads called byssus. Using its byssus threads, a mussel can firmly anchor itself to a rock or a large pebble. Combined with its streamlined shell shape, this allows mussels to grow on exposed rocky shores, where the crashing waves would sweep most animals away.

Mussels also attach themselves to artificial structures. In some places people farm mussels, growing them on poles sunk into the water. But mussels can also grow where they are not wanted—clogging water inlets for seashore power plants, for example. Some species have

Mussels attach themselves to rocks and other objects with their tough, fibrous byssus threads. These are the so-called "beards" often seen on mussel shells.

Fact File

MUSSELS

Family: Mytilidae (about 250 species)

Order: Dysodonta

Class: Bivalvia

Phylum: Mollusca

Where do they live?: Most of the world's seas and oceans

Habitat: Mainly in shallow water, especially on rocks

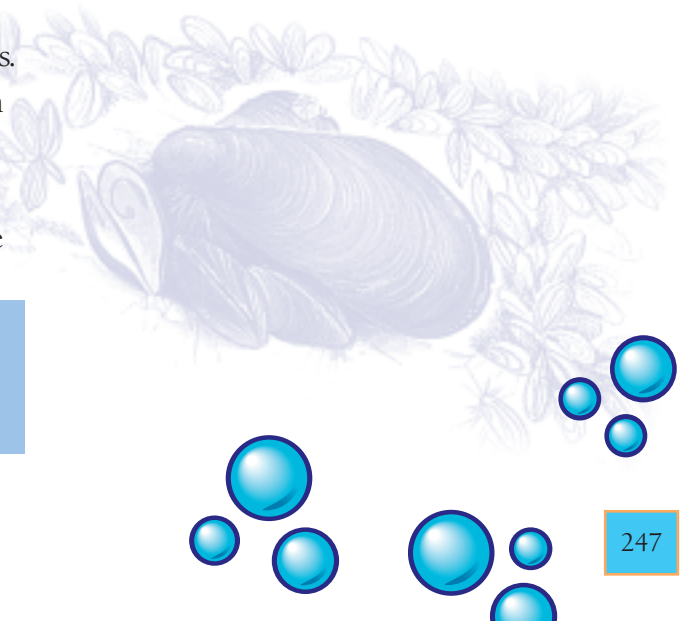
Size: Many species up to about 8 inches (20 cm) long; some bigger

Coloration: Shells usually brown, bluish, or green, depending on species

Diet: Tiny food particles filtered from the water

Breeding: Tiny swimming larvae (young stages) feed in plankton before settling on sea floor

Status: Marine mussels are not known to be threatened



A Mediterranean mussel extends its foot. This species grows to a length of about 4 inches.

spread throughout the world by growing on the hulls of ships.

Humans are not the only animals that eat mussels, however. Starfish can pull open mussel shells and then push their own stomachs into the mussel to digest it! Whelks (a type of sea snail) drill holes in mussels' shells to reach inside. But mussels are not completely defenseless. They can attach a whelk's shell to a rock with their byssus threads, tethering it there and starving it to death.

DID YOU KNOW?

- Mussels have no brain or head!
- The biggest sea mussel species grows off the coast of Chile, where people fish for it.
- You can find pearls in some freshwater mussels.

A freshwater mussel opens its valves, showing part of the mantle and other internal structures.

The color of the common mussel shell ranges from blue-black to brown. The shells often have animals such as barnacles growing on them.

Breeding and Growth

Depending on the species, mussels may either be male and female or hermaphrodite (both sexes at once). Female eggs and male sex cells are

Mussels are often commercially grown in special mussel beds, ready to be harvested when fully grown.

released separately into the sea, where fertilization takes place. The fertilized eggs develop into tiny swimming larvae (young stages), which live and feed in the open water for several weeks. They then seek out a hard underwater surface to settle on, and transform themselves into small adult mussels. Often, many mussel larvae settle together on previously bare rock, creating a new colony.

Mussels are not always anchored to the same place for life. Sometimes, as they grow bigger, waves will catch them, break their threads, and set them rolling around in the surf. This is not necessarily fatal, however. If they reach another rocky surface, they can spin new byssus threads and reattach themselves.

FRESHWATER MUSSELS

There are about a thousand species of freshwater mussels, grouped in several families. Most have lifestyles more like clams. Using their muscular foot, they bury themselves in mud at the bottom of rivers and ponds. Only part of the shell is left exposed, allowing them to take in water.

Some have an unusual life cycle. Their eggs hatch into tiny swimming mussels with hooks on their shells. These young stages attach themselves as parasites to the gills of fish, until they are big enough to drop off and start adult life. Another family, the zebra mussels, anchor themselves with byssus threads like sea mussels. Some freshwater mussels produce pearls. They are not as valuable as oyster pearls but are still used to make jewelry.

The waterways of the United States have more species of freshwater mussels than anywhere else in the world! This amazing diversity has been under threat from pollution. It also suffers because of soil runoff into rivers, which clogs up the mussels. Many agencies are now acting to protect the mussels.

NAUTILUSES

Nautiluses are relatives of squids and octopuses that are found in warm waters. Unlike them, but like other mollusks such as snails, nautiluses grow a protective shell on the outside of their bodies.

Present-day nautiluses live in waters between 250 and 1,000 feet deep, and swim mainly near the sea bottom. Nautiluses are nocturnal, retreating to deeper water during the day, presumably to avoid predators.

The beautiful coiled shell of a nautilus is divided internally into separate airtight compartments. Most are empty, and the animal's body occupies only the biggest and most recently formed compartment. The empty chambers, mainly filled with air at low pressure, make the nautilus lighter in the water. The animal is not light enough to float, however, and squirts water from its body to swim upward through the water.

Male and female nautiluses mate head to head, holding each other by their tentacles. The female lays only a few very large eggs per year. These hatch into fully formed small nautiluses, complete with shells.

An Ancient Group

Scientists have found fossil nautiluses that date back more than 400 million years. Modern-day nautiluses show many differences from their cephalopod (squid and octopus) cousins, apart from their shells. For example, nautiluses' eyes are more primitive than those of other cephalopods. They also do not have the special skin cells that allow squids and octopuses to change color. Finally, the nautiluses' ability to breed year after year is unique among cephalopods—squids and octopuses die after just one breeding season.

Modern-day nautiluses have many more tentacles than other cephalopods—as many as 90 in some species—but the tentacles do not have suckers.

Fact File

NAUTILUSES

Family: Nautilidae (about 6 species)

Order: Tetrabranchia

Subclass: Nautiloidea

Class: Cephalopoda

Phylum: Mollusca

Where do they live?: Western Pacific Ocean, between northern Australia and the Philippines

Habitat: Warm offshore waters

Size: Up to 10 inches (25 cm) shell diameter

Coloration: Shell has reddish-brown stripes on a light background

Diet: Mainly invertebrates such as crabs

Breeding: Not sexually mature until several years old; females lay 12 or fewer large eggs per year

Status: Not known to be threatened

OCTOPUSES

Octopuses are the most highly advanced of all the mollusks. Most octopuses live on the sea floor where they hunt live prey, but some kinds are specialized swimmers found in the deep sea.

Octopuses are relatives of squids, and have much in common with them. Both live only in the sea, both have soft bodies, both have suckered tentacles for grasping prey, and both have a horny beak to chop up food. Octopus eyes are similar in design to our own. Octopuses also have big brains. In fact, they are probably the most intelligent invertebrates. In captivity they quickly learn new tricks, such as unscrewing the lid of a jar to get at food inside! They are not sociable animals, though—most prefer to live on their own.

Unlike squids, the majority of which are streamlined for swimming fast through the ocean, octopuses are adapted for a life on the sea floor. Their bodies tend to be shapeless and baglike. They use their strong, muscular arms to pull themselves along, catch prey, or pick up objects—and to stroke each other during courtship! If danger threatens, octopuses can swim backward quickly by squirting water out of a tube beneath their heads, using a form of jet propulsion.

Typical Octopuses

There are several families of octopuses, but the best-known ones all belong to a single large family of mainly shallow-water species. These "typical" octopuses include the common octopus of Europe that has been caught and eaten since ancient times. The world's largest octopus, the giant octopus of the North Pacific, also belongs in this family.

The North Pacific bigeye octopus is a deepwater species. It is one of several species that has a large web of skin stretched between the tentacles.

Fact File

OCTOPUSES

Order: Octopoda (about 200 species)

Superorder: Octopodiformes

Subclass: Coleoidea

Class: Cephalopoda

Phylum: Mollusca

Where do they live?: Worldwide in seas and oceans

Habitat: Sea floor, deep sea, and open oceans

Size: Arm spans range from 2 inches to over 16 feet (5 cm–5 m)

Coloration: Most can change their skin color quickly; deep-sea octopuses sometimes dark red or purple

Diet: Live prey, including crabs, fish, and other octopuses

Breeding: Breed once and then die; females of some species guard eggs until they hatch

Status: Not known to be threatened

This octopus is using its long tentacles to crawl along the seabed. Note the double row of suckers on the tentacles, as well as the siphon (the large aperture beneath the eye).

The lifestyles of octopuses vary, but when they are not hunting they generally seek out a hiding place on the seabed, such as a rocky overhang. They may even excavate a hole for themselves, pulling rocks in front of the entrance for protection.

Some species are ambush predators, shooting out tentacles to grab an unwary crab or fish. Others actively hunt prey. Some are mainly nocturnal (active at night), while others only hunt at low tide, clambering about between rock pools on the shore.

For such large, intelligent creatures, octopuses do not live long—usually not much longer than a year. This is because they die after breeding once only. During mating, the male transfers packets of sperm to the

DID YOU KNOW?

- Squids have ten tentacles, but octopuses have only eight.
- One kind of deep-sea octopus is transparent!
- An octopus can taste and smell with its skin, and also detect light.

female using a specially modified tentacle. Females usually lay their eggs attached to rocks. In some species the females stay for months guarding the eggs without eating, but then die after the eggs hatch out.

Some baby octopuses start life by swimming in the plankton. Other species begin their seafloor existence immediately after hatching.

Blue-ringed octopuses are quite small (about 8 inches across), but they have a deadly bite.

OCTOPUS DEFENSES

Most octopuses can change their skin color to camouflage themselves if danger threatens. They can also squirt ink into the water to distract or confuse a predator. In addition, their beak can give a painful bite. Many octopuses have poisonous saliva to subdue prey or to defend themselves. The blue-ringed octopuses of Australia are so venomous that their bite can even kill people! Another species, the mimic octopus, can shape its body to imitate dangerous sea creatures such as poisonous sea snakes.

Weird and Wonderful

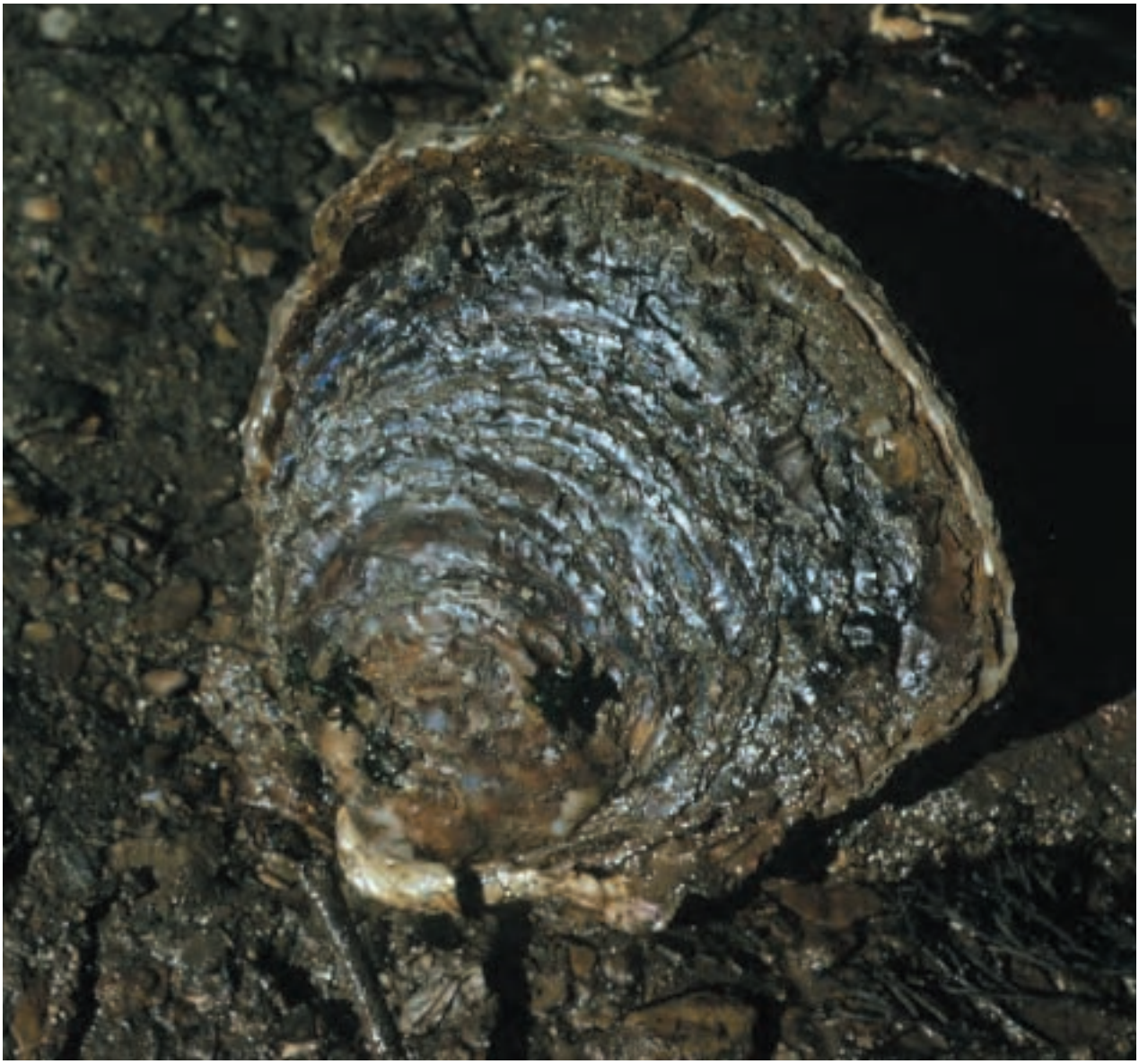
In the depths of the ocean live about forty species of strange octopuses that scientists are still trying to understand. Called finned octopuses, they swim using two ear-shaped fins on their bodies. Finned octopuses also have webs of skin between their arms, creating a shape rather like an umbrella. They can use this umbrella to swim slowly like jellyfish. The webbed arms may also help finned octopuses catch small prey, but scientists have not learned much about their feeding habits yet.

A unique animal called the vampire squid also lives in the deep sea. It looks like a finned octopus, but also has two extra "feelers" that are the remains of an additional pair of arms. Scientists think it may be an evolutionary "half-way house" between squids and octopuses.

A different family of octopuses—called the argonauts—float permanently near the ocean surface. The females build a beautiful papery shell using secretions from their arms. They use this shell (which is not a "real" mollusk shell) to hide in and to protect their eggs. Male argonauts are tiny compared with the females, and do not build shells.

OYSTERS

People have collected edible oysters for thousands of years. Pearl oysters, producing valuable pearls, belong to a separate family that is only distantly related to them.



Edible, or true, oysters are bivalves (two-shelled mollusks related to clams and mussels). Like other bivalves they have no head or brain, and live quiet lives on the sea floor. They feed by drawing currents of sea water into their bodies, from which they filter out tiny food particles.

Adult oysters stay in one place on the seabed, with their lower shell often cemented to a rock. Their shell gapes open when they feed, but they close it if danger threatens. Despite their thick shells, oysters have many enemies, such as predatory starfish and sea snails.

Oysters usually live in large "oyster beds" that can cover large areas of the sea floor. People sometimes create oyster beds artificially in suitable places, so they can "farm" the oysters. Several different species of oysters are suitable for eating.

Pearly Cousins

Members of the oyster family that produce pearls are only distant cousins of the edible oysters. They also live on the sea floor, mainly in tropical regions. Many bivalves produce pearls of some sort, but only pearl oysters produce the kinds considered really valuable. Pearls are produced when a particle such as a grain of sand becomes lodged in the pearl oyster's body. The oyster starts to coat it with the same shiny, hard material that it uses to coat the inside of its shell. In time a beautiful, rounded pearl may be the result.

An edible common oyster is exposed at low tide. The two valves are not the same shape; the lower one is saucer-shaped, but the upper one (shown) is flatter.

Fact File

OYSTERS

Family: Ostreidae (about 40 species)

Order: Ostreiformes

Class: Bivalvia

Phylum: Mollusca

Where do they live?: Most seas and oceans except in polar regions

Habitat: Shallow seas and estuaries

Size: Up to 8 inches (20 cm); occasionally larger

Coloration: Shells usually grayish

Diet: Tiny food particles filtered from water

Breeding: Some species alternate—male one season and female the next; others are hermaphrodite; in some cases male and female sex cells are released into the sea where fertilization takes place; oysters brood eggs in their bodies until they hatch into swimming larvae; larvae feed in plankton before settling on the sea floor

Status: Some populations affected by disease and human overfishing

PERCHES, FRESHWATER

Freshwater perches have long been popular with anglers, and this has resulted in their introduction to waters far away from their natural area of distribution—even to different continents.

The best-known member of this large group is the Eurasian or common perch, which can now also be found in the Azores, Cyprus, South Africa, Australia, and New Zealand. It is a predatory species. Another kind of perch, the yellow perch, whose distribution extends in a broad band running from the eastern United States through to parts of Canada and west to Ohio and Illinois, has very similar habits. There are now fears that the yellow perch could be at risk from the ruffe, a species of perch originally from Europe but introduced to parts of North America and now established in the Great Lakes.

Fighting the Invasion

The ruffe is believed to have been brought to Lake Superior accidentally in ballast water that was discharged into the lake by ships after they had anchored there. Ruffe are now competing for the food resources in the area. Their numbers are growing at the expense of other fish species because they tend to breed more quickly. They are more adept at finding food and avoiding predators, too, allowing their population to flourish. Scientists have attempted to use biological control methods to reduce the numbers of ruffe by introducing species such as northern pike and walleye to prey on them. Now, however, a method of poisoning using a chemical called lampricide TFM is being used. It kills ruffe but leaves other fish unaffected.

The Eurasian perch is found in streams, rivers, and lakes. It is a greedy feeder with a huge mouth, swallowing food ranging from worms to other fish.

Fact File

PERCHES, FRESHWATER

Family: Percidae (160 species)

Order: Perciformes

Where do they live?: Tend to be most common in temperate areas within the northern hemisphere, with the vast majority occurring in North America, east of the Rocky Mountains

Habitat: Areas of fresh water, ranging from ponds and lakes to rivers

Size: From about 2 inches (5 cm) up to about 12 inches (30 cm) or more; species such as zander up to 4 feet (1.2 m)

Coloration: Variable, with some species more brightly colored than others

Diet: Small species eat mainly invertebrates, whereas larger species will also feed on other fish

Breeding: Egg-laying; capable of producing 200,000 eggs

Status: Some species are increasing their range, although an estimated 23 species of darter are under threat

The zander is a predatory species originally from eastern and central Europe, although it has been introduced elsewhere. It grows to a length of four feet.

This poison may offer the best hope of controlling the ruffe.

Darters make up the largest group within the freshwater perch family, making up approximately 150 out of the 160 species in the group. They are active, often colorful fish with an elongated body shape, that live on the bottom. Darters are so called because of the way they swim, darting in and out between rocks and other objects. Members of this group lack a swim bladder—the gas-filled organ present in the body of most fish that allows them to control their buoyancy in the water. This is why darters live their lives on the bottom.

All darters are small, with the larger members of the group, such as the logperch and greenside darters, being just 6.5 inches long.

A Restricted Environment

Some darters have a very restricted range in the wild and, as a result, they are at greater risk from changes in their habitat than many other fish. The watercress darter, for example, is known from just three springs in Jefferson County, Alabama—one of which is just 60 feet from a highway with shopping malls and homes nearby. Its future survival is now at risk from potential pollution, a drop

DID YOU KNOW?

- Unlike many fish, some perches, such as ruffe, tolerate a wide range of water temperatures and do not have specific habitat needs. This helps the perches to thrive when they are colonizing new areas.
- Darters account for one in five of the fish species occurring in North America.
- Twenty-one species of darter are found in Pennsylvania. Thirteen of these live in the river system called French Creek.

in the water level there and, potentially, the threat of introduced species in the waters as well.

Breeding Behavior

Female fantail darters prefer to mate with males already guarding clutches of eggs. Those males which have not mated before, however, will develop fleshy knobs on the tips of the spines of their first dorsal (back) fin. These are identical in appearance to the eggs laid by female darters.

As a result, these so-called egg mimics serve to attract a female to the nest site of the male. The female will then enter the area beneath a rock where he has excavated a nest, spawning there and leaving him to care for the brood.

A Breeding Host

Some darters are thought to play an important part in the breeding cycle of Pennsylvania mussels, which occur in the same waters in that state. If the darters were to become extinct, this could lead to the ultimate extinction of the mussels as well.

The critical role of the darters begins when the female mussel has released her microscopic larvae, called glochidia, into the water. These then attach themselves to the gills of the fish. As the fish move around, they unwittingly carry the young mussels to other areas nearby where they may form new colonies. In this way, since the glochidia cannot swim, the darters provide an effective dispersal method.

The ruffe is found in lakes and rivers over much of Europe, but has been introduced elsewhere. It eats bottom-dwelling invertebrates and small fish.

PIKES AND PICKERELS

These predators are highly aggressive, and will take prey up to half their own size, lying in wait to ambush their quarry. In turn, pikes and pickerels are themselves popular sport fish.

There is no mistaking these fish, with all five species being very similar in appearance. They have pointed heads with large mouths that extend back to the eye. The lower jaw is slightly longer than the upper jaw, and both are armed with large, sharp, pointed teeth. The body is long and muscular, with the dorsal (back) and anal (belly) fins located a long way down the body. Their camouflage is so effective, and the movement of the pectoral (chest) fins so tiny, that even a large pike can maneuver into position and then drift quietly to within striking distance of its prey.

Changing Lifestyles

When fully grown, adult pikes are loners, with strong territorial instincts. By this stage, they are unlikely to fall prey to other fish. Juveniles, however, are more likely to come into contact with each other. Because pike eat other pike, it means that two fish of similar size may be found locked together in a lethal embrace. One may have attempted to swallow the other and then choked as a consequence, with the other pike having been unable to free itself from its rival's mouth.

Young pike are prey to a host of creatures, however, ranging from birds and aquatic mammals such as otters, to other fish and even dragonfly nymphs. Young pike will feed on small invertebrates, but they progress to eating other fish and even bigger prey, such as ducklings, once they are fully grown.

The jaws of the northern pike are lined with many sharp, backward-pointing teeth. Once prey has been grabbed, there is little chance of it struggling free.

Fact File

PIKES AND PICKERELS

Family: Esocidae (5 species)

Order: Esociformes

Where do they live?: Throughout most of the northern hemisphere, but do not occur naturally in northern Scotland or northern Norway

Habitat: Slow-flowing or still, heavily plant-filled waters, sometimes venturing from fresh water into estuarine water; often found in shallow water but may be seen at depths down to 100 feet (30 m)

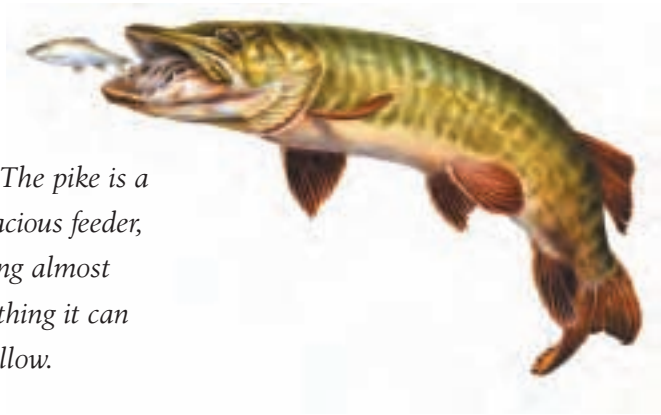
Size: From 15.5 inches (39.5 cm) to approximately 6 feet (1.8 m)

Coloration: Dark, usually greenish, with irregular streaks creating a mottled appearance on the sides of the body

Diet: Highly predatory at all stages of life

Breeding: Takes place in spring in plant-filled waters, and extends over several weeks; large females may each produce up to 600,000 eggs, which are fertilized externally and then fall among the plants

Status: These fish do not appear to be under threat



The pike is a voracious feeder, eating almost anything it can swallow.

Despite its wide distribution, the northern pike does not migrate. Individual fish tend to stay in the waters where they were spawned.

North American Tigers

There is a new, manmade hybrid member of this family, which was created during the 1940s. The tiger muskie was first produced by fertilizing muskellunge eggs with sperm from northern pike. It has attractive, tigerlike stripes along its body. It is also a ferocious fighter when hooked—it is not just its body pattern but also its temperament that contributes to its name. Tiger muskies can grow to a length of around 50 inches and weigh up to 32 pounds.

Male tiger muskies are infertile (unable to produce young). So are most females, but there are reports that some may be fertile (able to produce young). Countless tiger muskies have been introduced into angling waters in many U.S. states since the 1940s. Because males are infertile, such releases are needed to maintain numbers. It is also usually

DID YOU KNOW?

- The length of time it takes for the eggs of these fish to hatch is dependent on the water temperature, and can vary from several days to as long as a month. The number of fry that survive will fall as the water temperature rises.
- Northern pike are sexually mature by the time they are three years old. At this stage, they will have grown to a length of at least 18 inches.
- The muskellunge from North America is the largest member of the pike family.

a requirement that all tiger muskies must be put back after being caught by a fisherman.

A Matter of Size

Anglers have always been fascinated by the size to which northern pike can grow. A famous story concerns the emperor's pike, which got its name because it was said to have been released into a lake by Emperor Frederick II of Prussia. This massive fish was reported to be at least 267 years old, measured 19 feet in length, and weighed 350 pounds! Unfortunately, the story was revealed to be a hoax when an examination of the skeleton of the pike revealed that extra bones had been added to the backbone to stretch its overall length to a gigantic proportion.

A massive old pike was washed up on the shores of Loch Lomond in Scotland in 1934. Only its head was preserved, but this measured just over 12.5 inches. This would have made it bigger than any other pike on record. Unfortunately, however, no one measured its total length.

Young pike are called jacks. At this stage they are already highly predatory fish, using their speed and camouflage to catch prey.

THE FIRST YEAR

For spawning to take place, there must be underwater vegetation present, and the water temperature needs to be cool—preferably between 41 and 57°F (5–12°C). A female pike is likely to lay her eggs in batches over perhaps a month, with a large fish producing as many as 600,000 eggs during this period. Cannibalistic pike (ones that eat other pike) grow much faster than non-cannibals. As their growth accelerates, so does their appetite. This means that a young cannibalistic northern pike, which can be as tiny as 0.35 inch long just after hatching in the spring, can grow to reach 8 inches in length by the fall.

PIRANHAS

The teeth of piranhas are as sharp as scalpel blades, allowing a shoal of these fish to rip apart any unfortunate animal in the water in a matter of minutes, leaving just the bare bones.

Although piranhas can be induced into a feeding frenzy by the presence of blood in the water, this usually only happens under certain conditions—such as when the fish are extremely hungry, if their pool is drying up, or if their prey is injured or struggling to stay afloat. The size of the animal will not stop the piranhas; even horses are likely to be attacked by these fish, and dragged down as they wade into the water. Yet not all piranhas are dangerous, nor is size necessarily an indicator of the risk they pose. Some of the larger species, such as the green tiger piranha, which can grow 17 inches long, are no threat to people. On the other hand, the largest species, the blacktail or Saõ Francisco piranha, is definitely dangerous.

Piranhas rely heavily on their teeth, biting at anything in a feeding frenzy, even bone. This can lead to a piranha breaking its teeth. In some predators this could mean that the animal is no longer able to feed. Luckily for piranhas, however, they are able to grow new teeth to replace damaged ones.

Hard to Identify

It can be quite difficult to tell the difference between the various types of piranhas. This is because they often differ only slightly in color and other features from place to place. It means that many species can easily be confused, and it has resulted in these fish often being known by a variety of common names.

The head of a red-bellied piranha, one of the most common species, shows the razor-sharp, triangular teeth that can inflict so much damage to prey.

Fact File

PIRANHAS

Family: Characidae (about 33 species recognized)

Order: Characiformes

Where do they live?: Widespread in the Amazon region and other areas of tropical South America

Habitat: Streams, rivers, lakes, and even flooded forests at times

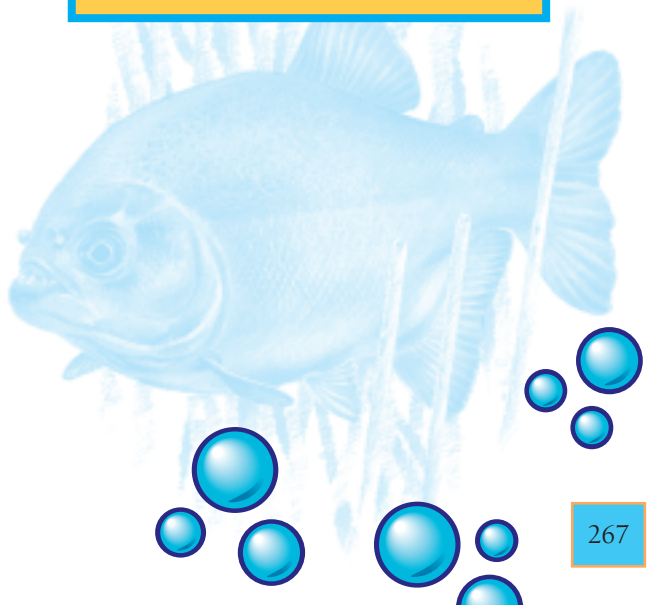
Size: From about 6–24 inches (15–61 cm)

Coloration: Tend to be grayish-silver, with reddish underparts, especially near the head

Diet: Fish and other vertebrates; often feed in shoals; may also consume some fruit and seeds

Breeding: Lay any number of eggs ranging from hundreds to over a thousand, which may be scattered or laid in a prepared site; eggs sometimes guarded

Status: Populations are not generally thought to be under threat



The blacktail piranha is the largest and most dangerous species. It is found in the Saõ Francisco River in Brazil and grows to 24 inches.

Furthermore, piranhas described under different scientific names have often turned out to be the same species when more detailed studies have been carried out.

Piranhas that breed in relatively clear water show clear differences in their coloration and in the appearance of their fins. Males, for example, often appear more brightly colored, as well as being slimmer. Species which spawn in water where visibility is non-existent do not show these differences, however. Instead of spawning in individual pairs, such fish breed in large groups. This increases the likelihood of eggs being fertilized.

Despite their predatory nature, about 10 percent of a piranha's diet consists of vegetation. They often feed on fruit that drops into the water from overhanging branches.

Egg-laying Habits

All piranhas reproduce by means of eggs, but the way in which these are laid varies significantly between the different species. Some simply scatter their eggs, and take no further interest in them. However, the spawning site itself may be prepared by the male, even sometimes being decorated with cut-up pieces of plants. In other cases, eggs are laid among trailing tree roots, where they are guarded, normally by the male. Alternatively, the eggs may be deposited in a depression on the bottom of the river or lake. Any vegetation there is first ripped away by the adult fish, creating a clear space for this purpose.

Floating Nurseries

As water levels rise in the South American rainforest during the wet season, large areas of what appear to be grassland break loose from the soil and start to float at the water's surface. The size of these floating meadows can be vast, particularly over the open flood plains. The tangled roots and other submerged objects in these floating mats create a unique environment. It provides shelter for the young piranhas, and a place where they can get food easily,. They feed on the fry (newly hatched young) of other fish species as well as on insects and other small creatures.

The young piranhas are also relatively safe there, and grow quickly. Later, they will start to move out into larger water channels as the water level begins to fall again. Although bigger by this stage, they will then be more exposed there to other predators, including larger piranhas.

DID YOU KNOW?

- The teeth of piranhas are often made into tools and weapons.
- Piranhas are hunted by local people as a source of food.
- The name "piranha" comes from the native words *pirá* (fish) and *ranha* (tooth).

PLAICE AND FLOUNDERS

Members of this group of fish go through a dramatic change in appearance as they grow older. Many are very popular as a source of food, and are often caught for sale in trawl nets.

The different species of flounders are divided into two groups, based on the positioning of their eyes. Lefteye flounders are so called because, when adult, their eyes are both located on the left side of the body. In righteye flounders, such as the plaice, both eyes are located on the right side of their body. Both lefteye and righteye flounders have a flattened body when they are adult. The dorsal (back) fin lies far forward on the body, above or in front of the eyes. The anal (belly) fin is around the opposite edge of the body.

However, the appearance of these fish is quite different when they are very young. At this stage, they do not have a flat body shape and the eyes are located on either side of the head, as in most fish.

Hiding Away

Flounders are mainly ambush predators, lying in wait to grab their prey, which consists of worms and other invertebrates, when these creatures come within reach. The markings on the upper part of the flounder's body help it to blend in well with its background. The fish can also often change the shade of coloration quite rapidly to match different environments. It may also burrow partly into the sand.

Despite the ability to alter their color, it is still generally possible to identify different species by their patterning. Plaice, for example, have a distinctive pattern of orangish spots on a dark background.

The plaice, seen here, is one of the best known of all flatfish. Because flatfish lie on or in the seabed, both eyes are located on the upper side of the head.

Fact File

PLAICE AND FLOUNDERS

Families: Bothidae (lefteye flounders: about 157 species), Pleuronectidae (righteye flounders: about 120 species)

Order: Pleuronectiformes

Where do they live?: Atlantic, Pacific, and Indian Oceans; Pleuronectidae species also found in the Arctic Ocean

Habitat: Nearly always marine, although some species may enter estuaries; usually live in sandy areas; lefteye flounders can be found to depths of 330 feet (100 m); righteye flounders can be found to nearly double this depth

Size: From 1.4 inches (3.5 cm) to 8.5 feet (2.6 m)

Coloration: Pale underside in contact with the seabed, with dark, often mottled, patterning above

Diet: Invertebrates, with larger species also preying on other fish

Breeding: Large numbers of eggs—up to 2 million—are released during spawning

Status: Most species are not threatened, but the Atlantic halibut is endangered and the yellowtail flounder is vulnerable; other populations are overfished

If disturbed, a flounder will swim off, remaining close to the seabed, and then settle down again some distance away.

However, these spotted markings are irregular, and they also vary noticeably between individual fish.

Fishing Rods and Pelicans

The angler flatfish, a lefteye flounder that lives in the Indo-Pacific at depths of around 100 feet, does not simply wait for food to come within reach. Instead, it has a similar lure to the one found in angler fish. Measuring 6 inches long, the angler flatfish conceals itself in the coral sand, but one part of its body—the rodlike first spine of the dorsal fin that looks like

DID YOU KNOW?

- The Dover sole sold in North America is quite different from the fish of this name available in Europe. It is larger, and is placed in the family Pleuronectidae. The European Dover sole is placed in the family Soleidae.
- Fishing pressures mean that many members of this group are caught before they reach their maximum size. Plaice can actually grow up to 40 inches long and weigh around 15.5 pounds.
- As they grow larger and older, members of this group of fish tend to spend their lives in much deeper water.

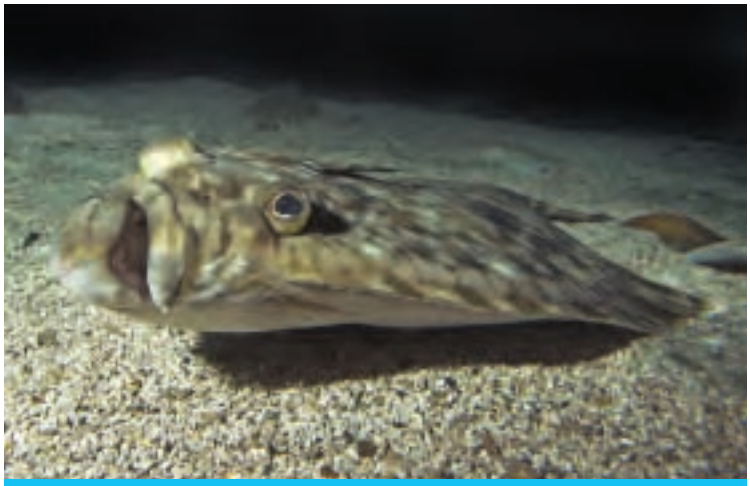
a small shrimp—is clearly visible. The angler flatfish waves this lure around, trying to attract prey. When a victim gets near, the angler flatfish quickly sucks it into its mouth.

There are other unusual flatfish from this part of the world, too, including the pelican flounder. This is a much larger species, potentially growing to 16 inches in length. It also lives in relatively deep water, between 200 and 330 feet. It has a huge gape, with a large saclike structure underneath, rather like a pelican's pouch. When it feeds, the pelican flounder can suck in large prey, including other fish.

Development of the Young

Plaice spawn throughout the winter and into early summer. The female fish release their eggs regularly, every three to five days over the course of a month. It takes about two weeks for the eggs to hatch. Then the young larval fish drift along as part of the plankton for up to ten weeks, until they begin to be carried inshore.

Once they have reached a suitable sandy site they start to turn into miniature flatfish. At this time they must avoid getting carried out to sea again. Throughout the next seven months or so, the young plaice will remain in the intertidal zone (the stretch of coastline between the low and high water marks).



A halibut is almost perfectly camouflaged in the muddy sand.

GIANTS OF THE SEABED

The halibut (above) is the largest of all the flatfish. The young of this species are again quite different in appearance from adults, as they have eyes on either side of the head. It takes about six months for the left eye to start migrating to the right-hand side of the body. Unfortunately, halibut are slow to mature, and they will not start breeding until they have grown to about 30 inches in length, by which time they will be at least eight years old. Any fish caught before this stage will be immature. Catching young halibut before they have attained breeding age has had a terrible impact on the Atlantic population of this species. However, there are still good numbers of halibut in the Pacific region.

PORPOISES

Relatives of dolphins and toothed whales, porpoises are small, shy sea mammals that swim fast in the sea. Many porpoises are threatened by human activities, such as fishing and pollution.

Porpoises and dolphins both evolved from a common ancestor around ten million years ago. Both animals have a sleek, streamlined body, a dorsal fin, flippers, and a blowhole on the top of their head. However, porpoises have a short, rounded snout, instead of the dolphin's long, beaklike snout. Porpoises also have flat, spade-shaped teeth, while dolphins have cone-shaped teeth. Both dolphins and porpoises feed mainly on fish and use their teeth to hold their prey rather than for cutting or chewing their food. Porpoises do not seem to help each other catch food, as do many species of dolphins. Harbor porpoises can dive deeper than 650 feet in search of prey.

Social Life and Conservation

Living alone or in small groups, most porpoises are hard to see or follow, and much of their social life remains a mystery. The only lasting links among porpoises is between a mother porpoise and her calf. Some older calves may stay with their mother for a short time after they stop drinking her milk.

The coastal waters where many porpoises live are also used by large numbers of people. Porpoises are badly affected by pollution, the noise of boat engines, and people digging deep channels for ships near the coast. However, the greatest danger occurs when many thousands of porpoises are trapped accidentally in fishing nets. Porpoises die if they cannot breathe air.

A harbor porpoise cruises above a bed of seaweed, looking for food. These porpoises have a triangular dorsal fin, a rounded snout, and a white underside.

Fact File

PORPOISES

Family: Phocoenidae (6 species)

Order: Cetacea

Where do they live?: Most major oceans and the Black Sea, but not the Mediterranean Sea

Habitat: Coastal waters, oceans, and seas

Size: Head–tail length 4–8 feet (1.3–2.4 m); weight 77–485 pounds (35–220 kg)

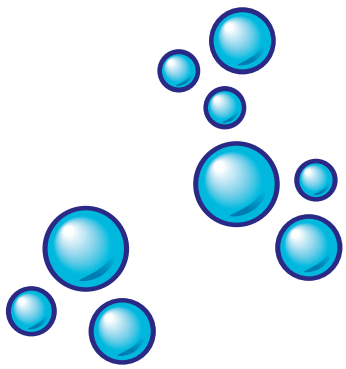
Coat: Light gray, dark gray, or black on back and sides; underside light or white; some have flipper stripes

Diet: Mostly small fish; also squid

Breeding: Reach adulthood at 4–7 years; gestation 11 months; usually 1 calf; many porpoises breed in late spring–early summer

Life span: 12–23 years

Status: Harbor porpoise vulnerable; vaquita critically endangered; Dall's porpoise lower risk, conservation dependent



PUFFERFISH

Pufferfish usually have a relatively elongated and broad body shape. If threatened, however, they can quickly inflate their prickly bodies, making themselves hard to swallow.

This is not the only way pufferfish can defend themselves. Their internal organs contain a strong poison. It can prove fatal to humans who eat these fish, although the strength of the poison varies from species to species. In Japan, where restaurants specialize in serving pufferfish—the dish is known as fugu—highly trained chefs carefully prepare the fish to ensure that it is safe for customers to eat.

Basic Body Structure

Pufferfish have large eyes, so they can see well. They also have sharp, powerful teeth, and this part of the body is often being referred to as the beak. It allows them to crack open the shells of marine mollusks and crustaceans that form the man part of their diet. Sometimes, however, the teeth grow too long—particularly in pufferfish kept in aquariums—and this makes it very difficult for the fish to eat. The teeth also provide scientists with a way of classifying (grouping) pufferfish. Members of the Triodontidae family have three fused (joined) teeth, and members of the Tetraodontidae family have four fused teeth.

The swimming action of pufferfish is relatively slow. However, being able to inflate their bodies is the pufferfishs' main method of avoiding danger. Left alone by a predator unable to swallow a pufferfish, it can then often escape simply by drifting away in the current, still inflated in a ball.

This freckled pufferfish has inflated its body almost into a ball, making it hard for a predator to eat it. The sharp spines give the pufferfish extra protection.

Fact File

PUFFERFISH

Families: Triodontidae (1 species), Tetraodontidae (176 species)

Order: Tetraodontiformes

Where do they live?: Mainly in the Atlantic, Indian, and Pacific Oceans

Habitat: Mostly marine, occurring in tropical and subtropical areas, also in brackish water and occasionally fresh water; range from shallow water down to 1,000 feet (300 m)

Size: From 1.6 inches (4 cm) up to 4 feet (1.2 m)

Coloration: Highly variable, often spotted above, becoming paler on the lower flanks and underparts

Diet: Invertebrates of various types, such as starfish and mollusks; may also eat small fish and plant matter

Breeding: Spawn in groups in shallow nests in beach areas; freshwater species spawn in pairs, with male guarding eggs and fry; hatching takes from 2 days to a month, with the larvae drifting among the plankton

Status: Populations generally not a cause for concern

RAGWORMS AND ALLIES

Thousands of species of ragworms and their relatives live in the world's oceans. They come in an amazing variety of shapes and sizes, and they are an important part of the marine food chain.

Ragworms and their allies are related to the earthworms. Most species have a long, wormlike body made up of a series of repeating units, called segments. The ragworms and their allies are also called polychaetes, meaning "many bristles." They get this name because the majority have bristles or scales sticking out from their bodies. They use the bristles to help them grip as they move about, or for other purposes. For example, fireworms have bristles that can give you a nasty sting if you touch them!

Wanderers and Burrowers

Ragworms are active hunters, crawling among rocks or burrowing in mud. They also have swimming relatives that seek out prey among the plankton. Some relatives of ragworms dig U-shaped burrows in the mud. They make sea water flow through these burrows, bringing oxygen for their gills and fresh mud which they eat. These worms often live in shallow estuaries,where they provide food for millions of the world's wading birds.

Other ragworm relatives build their own tubes for protection. Some make them from thousands of sand particles that they glue together. Others form hard, white tubes made of a chalky material. Many tube worms feed by filtering food particles from the water, only sticking their front ends out of the tube to feed. One family, the peacock worms, spread out beautiful delicate fans around their mouths to catch food.

These peacock, or feather duster, worms are found in the Caribbean. At the first hint of danger, the fans close and the worms shoot back inside their tubes.

Fact File

RAGWORMS AND ALLIES

Class: Polychaeta (almost 10,000 species)

Phylum: Annelida

Where do they live?: All the world's seas and oceans

Habitat: Mainly on the sea floor, from shallow waters to the greatest depths

Size: 0.04 inch–9.8 feet (1 mm–3 m)

Coloration: Variable, but many are brightly colored

Diet: Varies between species

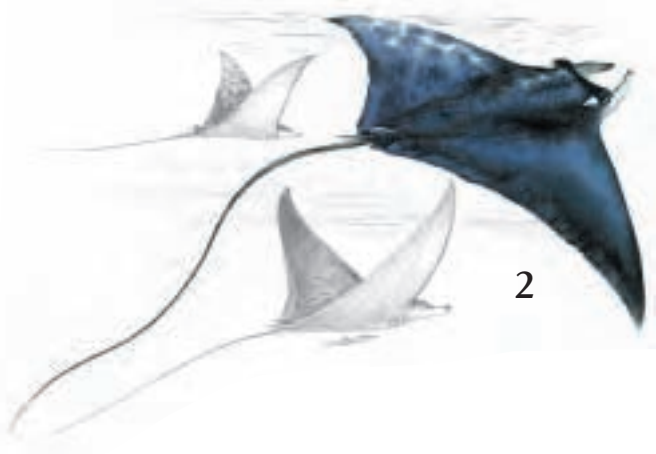
Breeding: Usually separate males and females; eggs and sperm normally released into the sea, where fertilization takes place; eggs often hatch into swimming larvae (young stages) that later settle on the sea floor

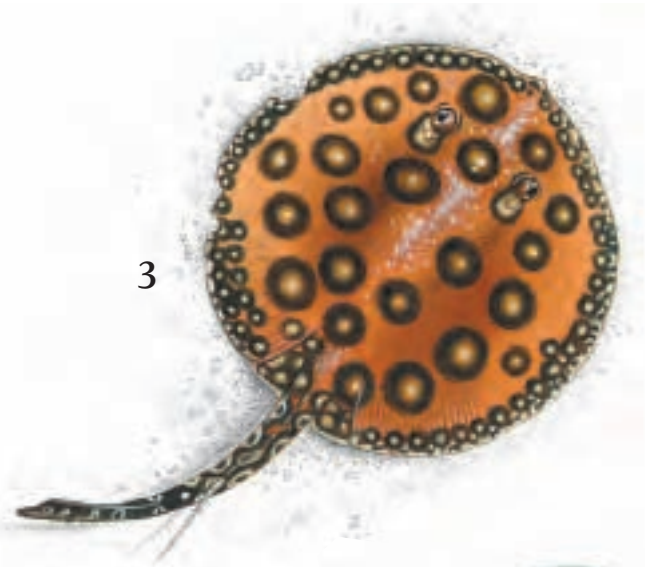
Status: Not known to be threatened

RAYS

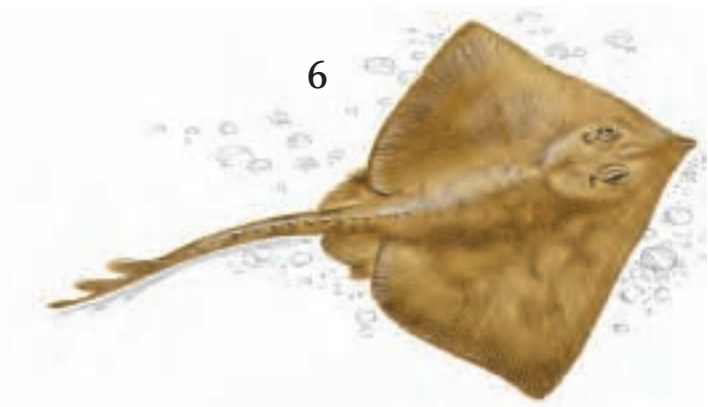
Rays propel themselves through the seas and oceans by flapping or rippling their winglike chest fins. This creates the impression that they are flying, rather than swimming.

If we look at the body shape of a ray, it quickly becomes obvious that it is unlike that of most other fish species. In rays, the body is flattened to form a fleshy disk with a tail sticking out at the back. The tails of a few species—such as the spotted eagle ray—may be up to three times the length of the rest of the fish's body. Some species, such as the skates,





1. *Marbled ray*
2. *Japanese devil ray*
3. *Ocellate river stingray*
4. *Common stingray*
5. *Common guitarfish*
6. *Blue skate*
7. *Thornback skate*



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also have a pointed snout at the front of the disk. Rays have very large pectoral (chest) fins. The fins are attached along almost the whole length of the fish's body, with the outer edges forming part of the disk itself.

Disks and Spines

There are lots of interesting and varied body designs to be seen among the 500 or so ray species. Some, such as the guitarfish, have long bodies and small wings. Others, such as the larger species like the devil ray, have extremely long wings. The electric rays have almost completely circular body disks.

There are also differences to be seen in the tail. The guitarfish has a tail shaped like that of many other fish, which it uses for swimming. In most other ray species, the tail is more or less circular in cross-section and is of little use for swimming. Instead, some species have one or

Fact File

RAYS

Order: Rajiformes

Families: 21 families

Species: Around 250 species

Where do they live?: Worldwide

Habitat: The vast majority are found in marine environments, although some enter brackish water and about 18 species live in fresh water—for example, the motoro stingray; most species typically remain on or near the bottom, but some occur in open water

Size: From just over 4 inches (10 cm) to over 22 feet (6.7 m)

Coloration: Varied coloration on the top, ranging from drab brown to slate blue/gray, with or without spots (which can be brightly colored) and other markings; underside almost invariably white

Diet: Mostly smaller fish and invertebrates; a few species feed on microscopic plankton

Breeding: Eggs are fertilized inside the female's body; in most species, the eggs are retained within the body of the female for periods lasting up to 1 year, at which point live young are produced; in skates, the eggs are laid after fertilization and develop over a period of several months inside a hard leathery case known as a "mermaid's purse"

Status: 12 species are listed as critically endangered, among them the Maltese skate and the Caribbean electric ray; 19 species are endangered and 34 are vulnerable

more poisonous spines along the top of the tail. This turns the tail into a defensive weapon, rather than a swimming organ. In some types of ray that do not have these spines, the tail may be very small or even missing altogether.

Purse Births

The skates make up a large section of the ray order, the Rajiformes. Although most skates and rays have the same flattened body shape, there are various differences between them. For example, unlike rays, skates do not have venomous spines or electric organs that can be used in defense or to catch prey.

Another big difference can be seen in their breeding behavior. Both rays and skates fertilize their eggs while they are inside the female's

Like all stingrays, the blue-spotted stingray has poisonous spines on the tail. It often lies on the sea bottom, flicking sand over itself for concealment.

STINGS AND VOLTS

A black-blotched stingray glides over the seabed. It is commonly seen around reefs.

Some stingray species have very strong poison in their tail spines. In fact, this poison has sometimes been known to kill humans, although such deaths are uncommon. As with other fish poison, hot water helps to lessen the effects. Female stingrays lose their ability to sting when giving birth—this protects their newborn young.

The electric rays get their name because they produce an electric shock from special cells in their body. It can be as powerful as 220 volts. These fish use their electricity to stun prey, making it easy to capture, but the rays can also use it in defense. In ancient Greece, electric ray shocks were used to treat headaches and other illnesses.

body—this is known as internal fertilization. However, female rays keep the eggs in their bodies until the fully developed young are ready to hatch. Skates leave their fertilized eggs on the bottom or among seaweeds, protected inside leathery egg cases.

The egg cases, known as "mermaid's purses," are often sticky, and sand grains become attached to them. This helps them remain on the bottom and may even hide them. The corners of each "purse"also have long threadlike growths (known as tendrils) that twist around submerged objects, such as seaweed stalks, preventing them from being swept away.

Skate embryos develop within their individual egg cases until they are ready to hatch, some six months later. Then, they force their way out of their "purse" as fully formed miniature skates.

Live Birth

Although nearly all of the skates' relatives give birth to live young, the way in which these are nourished (fed) during development varies quite a lot. In some, the embryos depend completely on the yolk in the eggs at the time of fertilization. In these species, the females keep the eggs in their bodies until they hatch, and then give birth to their young.

In some species, the embryos are bathed in nutrients inside the female's womb, or uterus, and are fed from this rich source during their whole development. In other species, the developing embryos get food directly from the mother via special body tissues. This is similar to the way in which baby mammals get nourishment from their mothers.

The embryos usually develop fully within a few months. However, in the bat ray it takes almost one year, while the marbled ray gives birth only once every three years.

This spotted eagle ray clearly shows the "flying" motion of the pectoral fins as it moves through the water. It is found in most oceans.

DID YOU KNOW?

- Rays are sometimes called "batoids" because their swimming movements look like the flapping wings of flying bats.
- The earliest-known fossil rays are about 195 million years old.
- Skates and rays are popular food fish in many parts of the world.

REMORAS

Most fish use their fins to swim from place to place. But the remoras have found another way—they cling onto other sea creatures with a special sucker and then hitch a ride.

Remoras are hunters and scavengers. However, they do not actively look for prey or meaty scraps. Instead, they allow themselves to be carried to food sources by clinging onto larger fish such as sharks, swordfish, and rays, sea-going mammals like dolphins and whales, sea turtles, and boats. Some remoras, such as the spearfish remora, have even been found riding inside the gill chambers and mouths of sharks!

Amazing Back Fin

Remoras attach themselves to their host with a highly unusual first dorsal (back) fin. This is located directly on top of the remora's head and does not look like a fin at all. Instead, it is an oval-shaped sucker. The spines of the first dorsal fin—which are hard, pointed, and unbranched in most other fish—have split sideways to form a series of ridges, called lamina. The remora makes the ridges slide in one direction to create suction, and in the other to release the suction.

When the remora wants to attach itself, it simply swims up and presses the sucker against the host. The remora is then carried wherever the host goes. It does not matter whether the remora attaches itself to the back, side, or belly of its host. It is just as comfortable traveling upside down or the right way up.

When the host finds and eats a meal, the remora releases its hold and swims about, feeding on any scraps of food that may be scattered in the water.

Two remoras have attached themselves to a manta ray. Remoras do this to save energy when looking for food, even although they are excellent swimmers.

Fact File

REMORAS

Family: Echeneidae (8 species)

Order: Perciformes

Where do they live?: Widespread in the Atlantic, Indian, and Pacific Oceans

Habitat: Open waters, but also in shallow waters around reefs

Size: From around 12 inches (30 cm) in the white suckerfish to about 43 inches (1.1 m) in the sharksucker

Coloration: Variable, but often consisting of dark and light bands extending from the snout to the tail

Diet: Mainly scraps of food scattered by their hosts, but may also prey on fish; also feed on parasites

Breeding: Eggs are scattered in open water and then abandoned

Status: Not known to be threatened

RIGHT WHALES

Right whales were named because they were the "right" whales to hunt. They were easy to catch because they swam slowly and floated when they were killed. Protected since 1935, their numbers are still low.

There are four species of right whales—the northern right whale, the southern right whale, the bowhead whale, and the pygmy right whale. The pygmy right whale is much smaller and slimmer than the other right whale species. It is also the only right whale to have a small, triangular fin on its back.

All right whales share several features in common, including a large head, a top jaw shaped like an arch, and long, slender baleen plates in the mouth, which are used for filtering food from sea water. The larger species of right whales do not have throat grooves, but the pygmy right whale has two such grooves. These pleatlike grooves enable the throat of the pygmy right whale to expand and take in lots of water as it feeds.

All right whales, except bowhead whales, have patches of thick skin, called callosities, that form above the eyes and along the lower jaw. Each whale has a different pattern of patches, which is larger in males than in females. Callosities help scientists identify individual whales. Colonies of tiny creatures called whale lice live within the patches. These patches may be important when males compete for females. During courtship, female right whales call to attract males but do not sing complex songs, as do humpback whales.

Right whales often leap out of the water or slap the water with their tails, in an action called lobtailing. Experts do not know why the whales do this, but it may help them communicate their position to other

Showing its enormous flippers, a southern right whale partially clears the water—an activity called breaching—before returning with a mighty splash.

Fact File

RIGHT WHALES

Families: Balaenidae and Neobalaenidae (4 species)

Order: Cetacea

Where do they live?: Arctic and temperate oceans

Habitat: Coastal waters, oceans, and seas

Size: Head–tail length: right and bowhead whales up to 66 feet (20 m); pygmy right whale 7–21 feet (2–6.5 m)

Skin: Black with white patches; pygmy right whale gray, lighter below

Diet: Plankton and krill

Breeding: Reach adulthood at 6–9 years; 1 calf; calf separates from mother after 10–12 months

Life span: At least 65 years

Status: Northern right whale is endangered; bowhead whale: local populations are either critically endangered or endangered

whales in the area—especially if the ocean is noisy on the surface because there are a lot of people or boats moving around. Pygmy right whales do not jump around like their splashy, much larger right whale cousins.

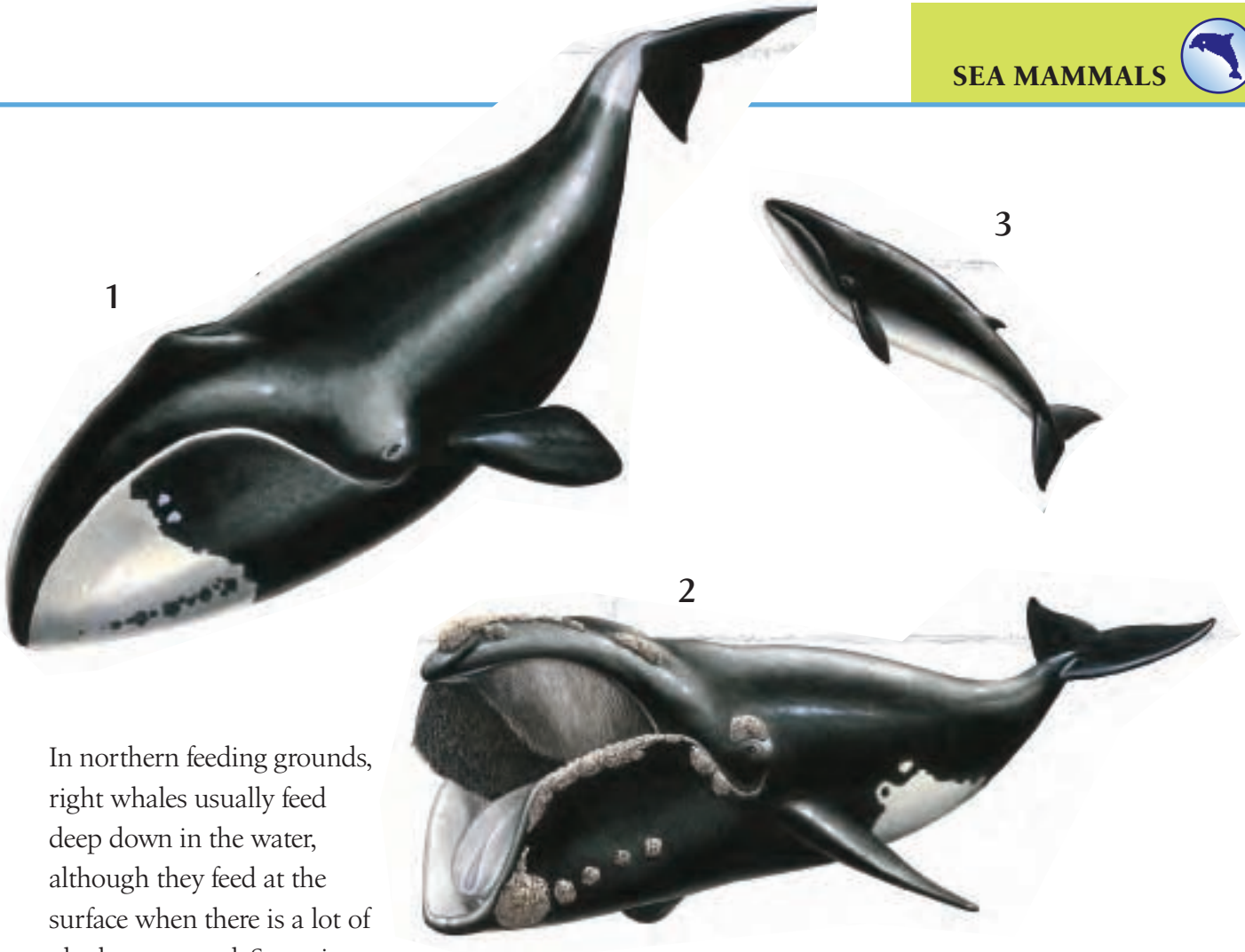
Enormous Appetites

Right whales feed on tiny animals called plankton, which drift through the oceans. The whales usually swim along with their huge mouth open, skimming the plankton from the water using their baleen plates.

A southern right whale floats just below the surface of the ocean. Right whales are easy to hunt because they swim slowly.

INUIT WHALE HUNTING

For thousands of years, the Inuits of Alaska have hunted bowhead whales, killing only a small number so that the overall whale population was not affected. However, American and European whaling companies killed too many whales in the nineteenth century. In 1915, the whaling companies stopped killing bowhead whales, but the Inuits still carried on with their hunting. In 1977, the International Whaling Commission recommended that the Inuits should also stop hunting bowheads. However, the Inuits argued that they needed to hunt whales for the survival of their people and to preserve their culture. Eventually, the Inuits were allowed to hunt small numbers of whales each year—and the numbers of bowheads are increasing, even with the Inuit harvest.



In northern feeding grounds, right whales usually feed deep down in the water, although they feed at the surface when there is a lot of plankton around. Sometimes, right whales feed side by side.

Mother and Baby

Female right whales give birth to one calf during the winter months. The calf grows inside its mother for around one year before it is born, and feeds on its mother's milk for at least another year. Mother and baby stay close together for the first six months of the calf's life. When the calf stops drinking its mother's milk, it usually leaves to start a life of its own.

DID YOU KNOW?

- The head of a bowhead whale makes up 40 percent of its body length.
- Right whales can dive underwater for eight to twelve minutes at a time.
- Right whales and bowhead whales need to eat between 2,200 and 5,500 pounds of food every day.
- A right whale calf is 26–30 feet long when it is only a year old!

1. *Bowhead whale*
2. *Northern right whale*
3. *Pygmy right whale*

RORQUALS

Rorqual whales include the largest animal in the world, the blue whale, as well as the acrobatic humpback whale, which is famous for the males' long, complex songs.

Rorquals include blue whales, fin whales, sei whales, minkes, and humpback whales. *Rorqual* means "furrow whale" in Norwegian. These whales are named for their furrowlike throat grooves, which allow them to expand their mouth when feeding. Rorquals have a sleek, streamlined shape, with a large head that takes up about one-quarter of their body length. The lower jaw is bowed and sticks out beyond the end of the snout. The flippers are thin and narrow in all species except the humpback whale, which has large, wavy-edged flippers at the front. A rorqual's wide tail has a clearly visible notch in the middle.

Like all whales, rorquals have to come to the surface of the ocean to breathe air. Rorquals have a double blowhole on top of the head. As they breathe out, they create a single spout of misty air, the height and shape of which varies between species.

Great Migrations

The life cycle of rorquals is closely related to their pattern of seasonal migrations, or regular journeys. During winter, these whales mate in warmer waters nearer to the equator. Then they migrate to feeding areas in the colder oceans around the poles, where they spend three to four months feeding on plankton (tiny animal and plantlike life in the ocean) and fish. After that, rorquals journey back to the warmer waters once more, where the females give birth to one calf each time.

This view of a sei whale shows the very large mouth, extending all the way back to the eyes. However, like all rorquals, sei whales only eat small food items.

Fact File

RORQUALS

Family: Balaenopteridae (9 species)

Order: Cetacea

Where do they live?: All major oceans

Habitat: Most species migrate between summer feeding grounds in polar regions and winter breeding grounds in warmer waters

Size: Head–tail length 30–90 feet (9–27 m); weight 10–167 tons (9–150 metric tons); females slightly larger than males

Coat: Black or gray above, often lighter on belly and lower surface of flippers

Diet: Plankton and fish

Breeding: One calf born 10–12 months after mating; usually two years between pregnancies

Life span: 45–100 years

Status: Blue whales, fin whales, and sei whales are endangered; humpback whales are vulnerable; minke whales are lower risk

DID YOU KNOW?

- The giant blue whale is the largest mammal that has ever lived. It weighs up to 167 tons, the weight of twenty-five 7-ton male African elephants. A female blue whale may be 110 feet long, which is larger than the male!
- A large blue whale weighing 111 tons needs to eat 4.5 tons of krill (tiny shrimplike animals) every day during the summer feeding season.
- A newborn rorqual calf is about one-third of its mother's length, and 4–5 percent of her weight.
- Rorquals travel thousands of miles on their migration journeys between their breeding and feeding grounds.
- Male humpback whales may sing for more than twenty-four hours to attract females.

Feeding Time for Calves

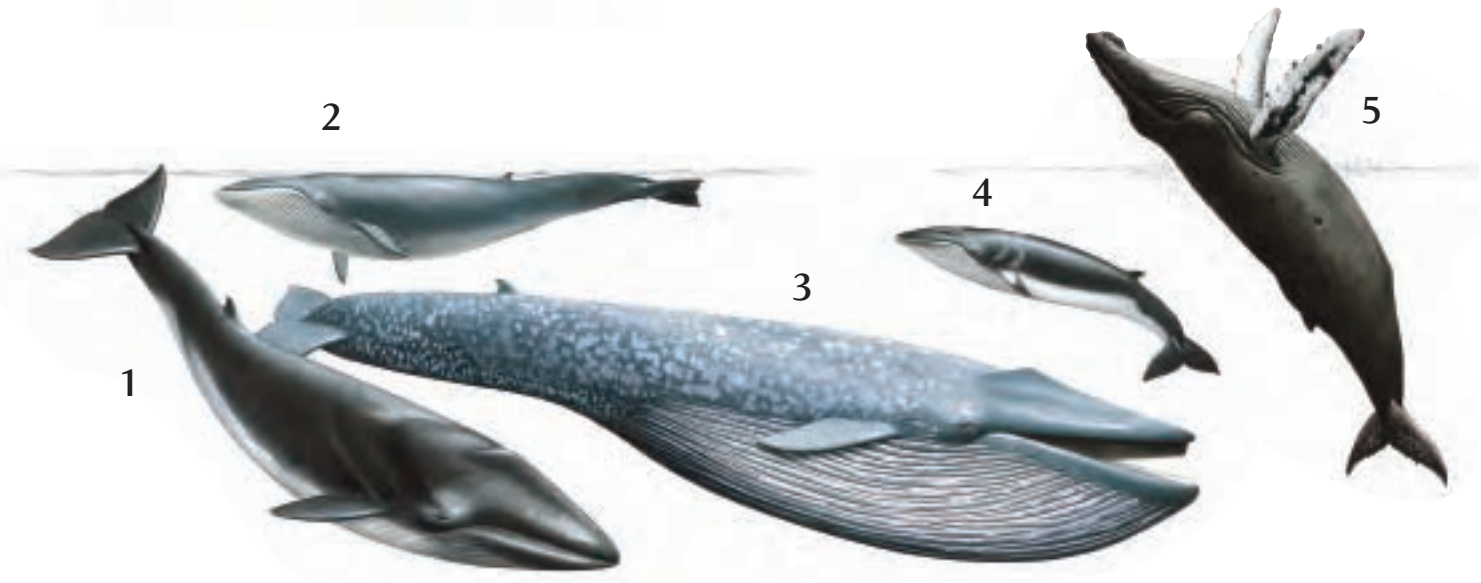
The mother whale squirts rich milk into the mouth of her calf. Her milk has a fat content of up to 46 percent, compared with only 3 to 5 percent fat in human milk or cows' milk. The rorqual calf grows quickly on this high-energy diet, gaining as much as 200 pounds in a day.

When it is around seven or eight months old, the calf stops drinking its mother's milk. At this stage, it is around 33 feet long.

Conservation

The future of these whales now depends on conservation measures taken in recent years to protect them from overhunting. Many rorqual

1. *Fin whale*
2. *Eden's whale*
3. *Blue whale*
4. *Northern minke whale*
5. *Humpback whale*



BIG APPETITES, SMALL PREY

Rorquals sieve plankton from sea water using fringed plates of baleen hanging from the roof of their mouth (see below right). The whale opens its mouth wide and lets the water flow through the plates, which trap tiny pieces of food for the whale to swallow. Sei whales also feed by skimming through the water with their mouth half open. When enough food has been collected, the whale closes its mouth and swallows the food.

The shapes and sizes of the baleen plates and the texture of the bristly fringes vary among the different species of rorquals. This affects the type of food the different whales eat. Blue whales feed mainly on shrimplike food, especially krill, while minke, humpback, and Bryde's whales eat a lot of fish, such as herring, cod, and sardines. Minke whales circle schools of fish and then shoot straight up through the water with their mouth open to grab a meal. Humpback whales may also herd their prey by releasing a circle of bubbles, which work rather like a fishing net to prevent the fish from escaping.

species, including blue whales, are endangered; it will take a long time for their numbers to increase because these huge whales only breed slowly. It takes up to twelve months before a baby is born, and there are usually two years between pregnancies.

Meanwhile, rorquals have to survive changes in the oceans brought about by climate change and pollution, including noise pollution from ships. Changes in ocean temperatures, as a result of climate change, and holes in the ozone layer may both affect the food on which these great whales depend. Rorquals also drown if they become trapped in fishing gear. Colliding with ships is becoming more of a hazard for these whales as the number of vessels increases.

SAND HOPPERS

Sand hoppers springing into the air as you walk along a beach are a familiar sight to many people. Yet these tiny "athletes" are merely the most obvious members of a group of animals found everywhere from the deep sea to mountain streams.

Sand hoppers—also called sand fleas or beach fleas—are the best-known members of the amphipods, a large group of crustaceans related to shrimp. Sand hoppers feed on dead matter, especially rotting seaweed. They have curved backs and are flattened from side to side. Leglike structures at their back ends allow them to jump several feet. Many freshwater and marine amphipods are a similar shape to sand hoppers. Other species are long and spindly to help them climb easily on rocks and seaweed.

Varied Lifestyles

Amphipods can swim, but they are mostly found at the bottom of muddy seas and lakes or clambering among underwater vegetation. In cooler regions especially they may live in huge numbers on the ocean floor, where they are an important part of the marine food chain.

Some amphipods live closely together with other marine animals, such as sea anemones. Whale lice live on the skin of whales. Other amphipods live on land, among fallen leaves in damp forests. But it is in the sea that the greatest variety is seen.

Depending on the species, they may be predators, grazers, or scavengers. Many tunnel in mud, creating a safe home from where they can stretch out their limbs to filter food particles from the water. Some species dig a hole for this purpose, but others make delicate tubes from sand, plant, or shell fragments.

These amphipods are feeding on algae on the seashore. The cream-brown colored bodies of many amphipods help them remain hidden in the sand.

Fact File

SAND HOPPERS

Order: Amphipoda (5,000 species)

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Worldwide in suitable habitats

Habitat: Mainly in seafloor and freshwater habitats; a few live in open water or on land

Size: 0.04–12 inches (1 mm–30 cm)

Coloration: Mainly dull grayish or brown, but a few brightly colored; may be translucent (let through light)

Diet: Very variable between species

Breeding: Females usually carry eggs around until they hatch

Status: Not known to be threatened

SCALLOPS

Clams and most of their relatives are slow, inactive animals, but this is not the case with scallops. If disturbed, they can swim off the sea bottom and away from danger, flapping their shells frantically.

Scallops are members of the two-shelled (bivalve) mollusk group, along with clams, mussels, and oysters. Scallops live on the sea floor. Like other bivalves, they feed by filtering tiny food particles from the water with their special gills. When they first settle on the sea floor, many scallops tether themselves securely to a rock or other firm surface by forming strong threads called byssus. As they grow, some species cut these ties and are then free to move about.

Humans have long been fascinated by scallops. Images of scallop shells have been used in many ancient paintings and carvings. Scallops are harvested in huge numbers today as a source of food.

A Quick Escape

Many scallops have a series of small, brightly colored eyes on the fleshy part of their body, close to the shell opening. When the scallop is in its normal feeding position, with the shell slightly apart, the eyes are able to detect any shadow falling on the animal that might be a predator. If the eyes sense danger, or if the shell is touched by a predator such as a starfish, scallops have an unusual way of escaping. The strong central muscle that joins their shells contracts (shortens) repeatedly, making the shells open and close. This causes jets of water to be squirted out, and the scallop swims jerkily away. Escaping scallops are said to look rather like a pair of swimming false teeth!

Doughboy scallops have bright blue eyes around the edges of the shell. The shells of these scallops are also encrusted with small marine sponges.

Fact File

SCALLOPS

Family: Pectinidae (about 60 species)

Order: Pseudolamellibranchiata

Class: Bivalvia

Phylum: Mollusca

Where do they live?: Worldwide in suitable habitats

Habitat: The sea floor, mainly in shallow seas

Size: Up to 6 inches (15 cm)

Coloration: Variable; some species have brightly colored shells

Diet: Small food particles filtered from sea water

Breeding: Adults are able to change sex; larvae (young stages) swim in plankton before settling as miniature adults on sea floor

Status: Overfishing has reduced populations of some species

SEA ANEMONES

Sea anemones may look delicate and flowerlike, yet these simple animals are dangerous predators lying in wait for any small prey that may blunder into their outstretched tentacles.

Sea anemones were popular with early naturalists who found them easy to keep in their marine aquariums. Worldwide, there are many beautifully colored and patterned species. Sea anemones are closely related to corals. The sea anemone's saclike body is a hollow column with the mouth at the top. It is surrounded by one or more rings of tentacles. There are stinging cells all over the body, but most of them are on the tentacles. When a small animal touches the tentacles, the stinging cells shoot out a spiky thread into the animal. Then the prey is passed to the slitlike mouth of the anemone to be swallowed. The mouth opens into a digestive chamber inside the column.

Most species have a sucker disk at the bottom of the column that is used to attach them to rocks or other surfaces. The wall of the column has muscles arranged in several directions. Some muscles circle the column; when these contract (shorten), the animal becomes tall and thin. Other muscles run up and down the column, or at an angle; when these contract, the animal becomes short and fat.

A Useful Shape

Sea anemones have round bodies with no front or back. Nor do they have a head. Since they hardly ever move, do not chase their prey, and do not need to seek out mates, this is not important. They are sit-and-wait predators. Their shape is ideal for this,

An anemone sways in the current, its outstretched tentacles ready to trap any unwary animal that touches it. This species lives in a protective tube.

Fact File

SEA ANEMONES

Order: Actinaria (about 1,000 species)

Class: Anthozoa

Phylum: Cnidaria

Where do they live?: Worldwide in all seas and oceans

Habitat: Rocky, sandy, and muddy seashores and seabeds

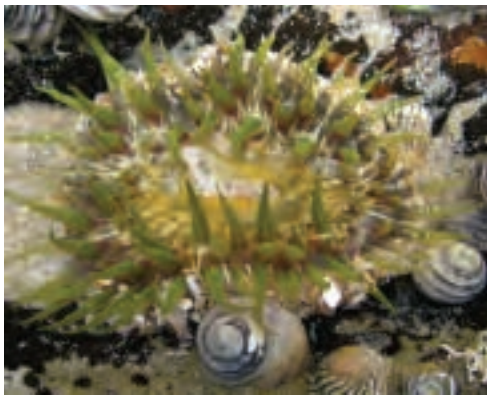
Size: 0.04–40 inches (1 mm–100 cm)

Coloration: Various, often beautifully patterned

Diet: Various invertebrates and small fish; some species gain energy from commensal algae living inside their bodies

Breeding: Sexual reproduction produces a swimming larva; the larva eventually settles and develops to form a new adult; most species can also reproduce by splitting to form new individuals

Status: Largely unknown; 1 species endangered



The eastern sand anemone usually remains buried with just the tentacles and oral disk visible. It grows to about 3 inches across.

since they can catch prey equally well from any direction. They can also defend themselves from attacks by predators and other enemies in the same way.

A Variety of Habitats

Despite their relatively simple way of life, sea anemones have managed to colonize a variety of habitats, often with great success and in huge numbers. Rocks and reefs are favorite places, but jetties and other manmade structures are also popular, especially in places where there are currents that bring in a supply of floating food material. Some sea anemones are also found on sandy shores.

Unlike some marine animals, such as barnacles and tubeworms, sea anemones are not permanently fixed to the same spot. They can move slowly about, creeping along on their adhesive disk. A few species can actually swim small distances.

Instead of having a sucker disk, some species have evolved a digging organ called a physa, which is at the base of the column. This enables them to burrow in sand so they can live off the rich supply of food on the sandy seabed.

This hermit crab in waters off Bali, Indonesia, is carrying several sea anemones around on its shell. Both species benefit from the arrangement.

Sharing a Home

A fascinating aspect of sea anemone behavior is the way in which these animals often live closely with other species. A very common example is one in which an anemone attaches itself to the outside of a snail shell occupied by a hermit crab. It is thought that the sea anemone prevents the hermit crab from being

DID YOU KNOW?

- When some hermit crabs grow too big for their shells and move into a larger one, their sea anemone partner moves onto the new shell with them.
- Large tropical sea anemones also provide "homes" for colorful clownfish that live among their tentacles while being unaffected by the stinging cells.
- Some anemones are nocturnal, only emerging to feed at night.

eaten by octopuses, while gathering crumbs of food dropped by the crab when it feeds. Sometimes the base of the sea anemone wraps right around the shell and forms a protective tube. When this happens the hermit crab no longer needs to find a larger shell to move into as it grows bigger.

Recycling Sea Slugs

Despite their defensive stinging cells, anemones do have some predators. Among these are sea slugs, some of which prey almost entirely on one or two anemone species. Remarkably, the sea slugs are not put off by the stinging cells and actually eat them. The stinging cells later emerge from the skin of the sea slugs, which use them, second-hand, as their own method of defense against enemies!

AGGRESSION IN ANEMONES

Sea anemones can be aggressive toward other members of the same species, and they often compete with each other for living space. The beadlet anemone (below), a common seashore species, often reproduces by asexual reproduction. It occurs in a number of colors—red, orange, brown, and green—and creates colonies of identical offspring on the shore.

Individuals do not attack other members of the same colony but are hostile to any that are not part of the colony. They attack them with stinging cells carried on blue beadlike structures near the top of the column, just below the tentacles. In these battles for territory, red individuals win against green ones, for example.

SEA BASSES

Some fish change sex as they grow older, turning from female into male, or vice versa. In some species of sea basses, however, an individual may be male and female at the same time.

The sea basses are a family of fish found all over the world. The smallest members of the family are not much bigger than your thumb, yet the biggest—the giant grouper—grows to 10 feet in length and can weigh over 880 pounds. Some of the smaller, more colorful species, such as the wreckfish, are popular aquarium fish. The juveniles (young) of some of the bigger species, such as the coral trout, are also prized for their colors and interesting body patterns.

Sea basses are popular food fish and they are collected in large numbers, making several species extremely rare in the wild. The flesh of some species may be poisonous, however, and can cause an illness known as ciguatera poisoning in humans.

More Than One Sex

Not only can sea basses change sex, but they can also be hermaphrodite (have both male and female sex organs at the same time). But a sea bass cannot fertilize its own eggs. Instead, sperm and eggs are exchanged between two hermaphrodite individuals. This ensures that genetic material from different animals combines together during spawning. The larger fish in a spawning pair usually acts as the male, releasing sperm rather than eggs. When this individual mates with a larger fish, though, it acts as a female and releases eggs. Switching between acting as male or female can happen several times a day and takes as little as 30 seconds.

The red sea coral grouper grows to a length of about 4 feet. It is found in lagoons and around reefs. Prized as a game and food fish, it is now quite rare.

Fact File

SEA BASSES

Family: Serranidae (about 450 species)

Order: Perciformes

Where do they live?: Most tropical, subtropical, and temperate waters

Habitat: Most species are marine, but some may enter estuaries; all species tend to remain close to the bottom, frequently sheltering in caves or under overhangs

Size: From around 1.2 inches (3 cm) in species such as the pink maomao to around 10 feet (3 m) in the giant grouper

Coloration: Varied, often with streaks, irregular patches, and/or spots

Diet: All species are hunters; smaller species feed mainly on invertebrates; bigger species feed on large invertebrates, as well as fish

Breeding: Eggs and sperm are released into the water; fertilized eggs are then abandoned

Status: 3 species are critically endangered: the calico or strawberry grouper (or speckled hind), the goliath grouper, and the black or Warsaw grouper; 5 other species are endangered; 16 species are considered vulnerable

SEA CUCUMBERS

Sea cucumbers are sluggish, often brightly colored creatures with cylindrical or sausage-shaped bodies. Yet, despite their unusual looks, they have many remarkable qualities.

Sea cucumbers belong to the large group of animals known as echinoderms (spiny-skinned animals) that includes the starfish and the sea urchins. Sea cucumbers are closely related to sea urchins. The sea urchins have a rigid outer skin, called a test, but the outer skin of sea cucumbers is not rigid. Instead, it is made up of chalky plates loosely set in a flexible body wall. The body wall has muscles that allow it to change shape. Three rows of tube feet run along the underside of the body and two run along the top. Tube feet are narrow, flexible, water-filled organs that enable echinoderms to move about.

The anus is set at one end of the sea cucumber's body. The mouth is located at the other end of the animal, and is surrounded by a crown of oral tentacles. These are used when feeding, but they can be withdrawn by powerful muscles if danger threatens. Some sea cucumbers can protect themselves by ejecting sticky white threads from their bodies to tangle up predators. Sea cucumbers are highly prized as food in parts of Asia. Some are also used in medicine.

Clean Sweepers

These animals feed either by sieving food particles from sea water or by sweeping up particles which have settled on the seabed. Different species are adapted to eat particles of different sizes, so they can live side by side without serious competition.

The yellow bumps running down the body of this sea cucumber are some of its tube feet. The red and white feathery structures are the ring of oral tentacles.

Fact File

SEA CUCUMBERS

Class: Holothuroidea (about 1,150 species)

Phylum: Echinodermata

Where do they live?: Worldwide in all seas and oceans

Habitat: Rocky, sandy, and muddy seashores and seabeds including the deep ocean floor; occasionally swimming just above the deep ocean floor

Size: 0.1 inch–5 feet (3 mm–1.5 m).

Coloration: Various—cream, gray, brown, black, occasionally yellow, orange, and red; also spotted or patterned

Diet: Tiny floating creatures and minute particles collected by filter or deposit feeding

Breeding: Sexual reproduction; eggs and sperm released into the sea; a swimming larva is formed that settles on the seabed and turns into a new adult

Status: Unknown

SEAHORSES

With their upright posture, horselike head, curious swimming action, and their habit of hanging onto seaweeds with their tail, seahorses do not really look like fish at all.

Despite their strange appearance, seahorses are true fish. They are placed in a family that boasts several other "unfishlike" members. These include the seadragons and pipehorses, as well as the pipefish. Some of these species look like bunches of drifting seaweed and others look like thin tubes.

Unfishlike Features

A seahorse swims with its body held vertically in the water, instead of horizontally as in other fish. Therefore its head is positioned at right angles to the rest of the body so that the seahorse can see and feed properly.

The seahorse's tail is also unusual. It does not have a fin. Instead, the tail is a long, rounded extension of the body. The seahorse twists its tail around seaweeds or other objects so it can hang onto them, in the same way that monkeys use their tails to hang onto the branches of trees.

Seahorses do not have pelvic (hip) fins, while their pectoral (chest) fins are small and look like ears. Because of the upright posture of the body, the dorsal (back) fin, which is located about halfway down the back, points backward instead of upward as in other fish. It therefore does the job of the caudal (tail) fin of other fish and is the main fin used in swimming.

The body is not covered in scales, but in hard bony plates, known as scutes. They act as body armor and make seahorses hard for predators to swallow.

The seahorse in the foreground has its long tail wrapped around some water weed. Note the long snout and the spines running down the back.

Fact File

SEAHORSES

Subfamily: Hippocampinae (33 species)

Family: Syngnathidae

Order: Gasterosteiformes

Where do they live?: Tropical, subtropical, and warm temperate regions of Atlantic, Indian, and Pacific Oceans

Habitat: Mainly found in shallow coral reef areas and seagrass meadows

Size: From 0.5 inch (1.3 cm) in Denise's pygmy seahorse to nearly 14 inches (35 cm) in the Australian pot-belly seahorse

Coloration: Variable, ranging from dull brown—with or without markings—to bright reds and yellows

Diet: Small invertebrates

Breeding: From 100 to 1,570 eggs produced, depending on species, age, and size of female; eggs are transferred to belly pouch of male where they are fertilized; birth takes place some 2–4 weeks later

Status: The Cape or Knysna seahorse is listed as endangered; 7 other species are listed as vulnerable

Floating almost motionless in the water, the leafy seadragon looks just like a bunch of seaweed. This camouflage lets it get up close to its prey without being spotted.

DID YOU KNOW?

- The smallest seahorse is Denise's pygmy seahorse. It reaches a length of only 0.52 inch from its head to its tail.
- Seahorses can produce as many as three broods of young during a single breeding season.
- The earliest-known seahorse fossils are about 13 million years old.

Not-so-faithful Partners

It is often said that seahorses pair for life. Although this is true of some pairs within certain species, it is not always the case.

For example, in the pot-bellied seahorse, there is no pairing for life, and males and females mate with many other partners. At the other extreme, White's seahorse pairs only mate with each other. These pairs keep the bond between them all their life. It only comes to an end when one partner disappears, dies, or is eaten by a predator.

The tigersnout seahorse lies somewhere in between. In a study carried out in the wild involving fourteen pairs of this seahorse species, it was discovered that eight males mated with the same partner twice in succession. However, the other six males each chose a different partner for their second brood.

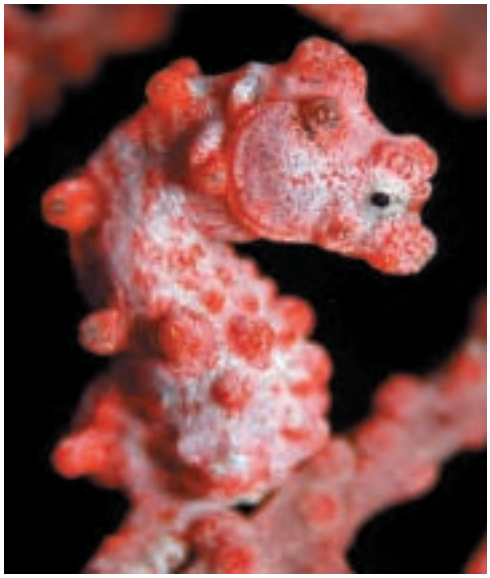
The Seahorse Trade

People trade in seahorses in several different ways. By far the largest involves traditional Chinese medicine. For this form of medicine, dried seahorses are sold in huge numbers. They are either sold whole, powdered, or in tonics. A wide range of ailments are treated using seahorses, or medicines made from them. These include asthma, thickening of the arteries, and broken bones. It is estimated that in Asia

about 15 million seahorses are imported annually for this trade.

Dried seahorses are also sold as curios or ornaments, mainly in seaside vacation areas. The seahorses are usually sold dried or varnished, or made into items such as key rings or lampshades.

Once, live seahorses numbering many hundreds of thousands were caught every year for home aquariums. However, studies carried out in recent years showed that the numbers had dropped to a few tens of thousands. The quantities are even lower these days, since there is a growing number of farms where seahorses are bred in captivity instead, to cater to the needs of the home aquarium market.



A pygmy seahorse wraps its tail around some gorgonian coral. The seahorse's knobbly body and red color help it remain hidden among the coral.

This male golden sea pony is close to giving birth.

PREGNANT FATHERS

Courting in seahorses consists of a long series of displays, often lasting many hours and involving graceful "dancing." During this, the pair may curve their tails around each other. Afterward, they bring their bellies close together and the male opens the top of his abdominal pouch (belly sac). The female then transfers some eggs into it, via her egg-laying tube, known as the ovipositor. This process is repeated until all the eggs have been transferred. The male keeps the eggs in his pouch (right) for two to four weeks. He then gives birth to miniature seahorses over a period lasting for several hours by releasing them from his pouch.

SEA LILIES

The sea lilies and their relatives the feather stars are echinoderms (spiny-skinned animals) that have survived for 500 million years with hardly any changes. They give us a glimpse of what life was like in the ancient Cambrian seas.

Sea lilies and feather stars belong to the same family of spiny-skinned animals as starfish, sea urchins, and sea cucumbers. The body of an adult sea lily is attached to the deep ocean floor by a stalk. Feather stars usually live in shallower water. They are only attached to the ocean floor when they are growing; when they become adults they can move around.

The cuplike bodies of sea lilies and feather stars are supported by jointed, limblike structures called cirri. These grip the substrate when needed. The arms are arranged around the mouth at the top of the body cup.

Both these echinoderms collect floating food particles and minute animals by sieving the sea water with their tube feet. Unlike other echinoderms, in sea lilies and feather stars the tube feet are not used as feet at all! The tube feet are arranged along the upper side of the arms and on the side branches of the arms (these are known as pinnules). Food is first trapped by the tube feet. Then it is wrapped in mucus and passed down the arms in a groove to the mouth, pushed along by the action of tiny hairlike cilia.

Limited Movements

Sea lilies can bend and flex their stalks and arms. They move their body on the stalk in order to get the best flow of water through the branched arms. Feather stars are also able to swim about by flexing their arms in a beautiful, rhythmic swimming motion.

A feather star clings to a coral where it waits for water currents to bring floating food particles. These are captured by the animal's many waving arms.

Fact File

SEA LILIES

Class: Crinoidea (about 625 species)

Phylum: Echinodermata

Where do they live?: Worldwide in most seas and oceans.

Habitat: Rocky, boulder, sandy, or muddy seabeds including the deep ocean floor; feather stars occasionally also swim just above the seabed; feather stars rarely on the rocky shore

Size: 0.1–36 inches (3 mm–1 m)

Coloration: Various—gray, cream, brown, yellow, orange, and red

Diet: Tiny floating creatures and food particles collected by filter feeding

Breeding: Reproductive organs located on the arm pinnules; sexual reproduction; eggs and sperm released into the sea, resulting in a swimming larva that settles on the seabed and attaches itself to form a new adult; in feather stars the adult then breaks free to move around actively

Status: Unknown

SEA SLUGS

Many sluglike mollusks live in the world's oceans. They are relatives of the slugs that live on land, but unlike them, these marine creatures often come in bright colors and unusual shapes.

The most important group of sea slugs are the nudibranchs. "Nudibranch" means "naked gills," because the gills grow as feathery tufts on the back, not hidden from view as in other mollusks. Nudibranchs live mainly on the sea floor, crawling along on their muscular foot. Many can swim if necessary to escape predators. A few kinds of nudibranchs are free-floating, and hunt prey close to the sea surface.

Nudibranchs are nearly all carnivores (eat animal prey). They feed mainly on animals that grow on rocks or seaweed. Some specialize in eating sponges, others in eating sea anemones or even fish eggs. Without shells, they have to rely on other defenses. Their bright colors advertize that they are unpleasant to eat, or worse. Some kinds produce acid from glands on their backs. Others that eat sea anemones are able to push the anemones' stinging capsules out of their own skins, so that a fish that tries to eat them will get stung!

Plant-eating Sea Slugs

The sacoglossans are another big group of sea slugs. Unlike the nudibranchs, sacoglossans mainly eat algae. They resemble nudibranchs in their colors and shapes. Sea slugs include the bigger, seaweed-eating sea hares, which have long earlike tentacles. Neither of these groups is closely related to land slugs., although some true land slugs have become adapted to sea life. These live on the shore between the tides.

A vividly colored nudibranch crawls across a reef. The gills are the feathery structures at the back. The projections at the front are sensory tentacles.

Fact File

SEA SLUGS

Order: Nudibranchia (about 1,700 species)

Class: Gastropoda

Order: Mollusca

Where do they live?: All the world's seas and oceans

Habitat: Mainly on the sea floor, especially in shallow seas

Size: 0.04–8 inches (1 mm–20 cm)

Coloration: Often brightly colored

Diet: Mainly eat live animals

Breeding: Hermaphrodite; colorful egg-masses are laid that contain thousands of eggs; after hatching, larvae swim in the plankton before turning into adults

Status: Not known to be threatened

SEA SQUIRTS AND SALPS

Many sea squirts and salps resemble curious little flasks, blobs, or sacs, yet they share important features with more advanced animals—the fish, amphibians, reptiles, birds, and mammals.

An adult sea squirt lives fixed in one place. The body is enclosed in a tough tunic made from a substance called cellulose. Beneath the tunic is a muscular body wall. Inside the body wall lie the pharynx (throat), with its many gills, the gut, digestive and reproductive organs, and the circulatory system with its heart. Water is drawn in through a hole at the top of the body (called the inhalent siphon), passes into the pharynx, and across the gills, where oxygen and food are extracted. It flows out through another hole (the exhalent siphon) on the side of the body. There are simple light and taste sensors located around the sea squirt's inhalent siphon.

Salps are relatives of sea squirts that drift in the plankton. Their entire life cycle is spent in open water. Both salps and sea squirts are sometimes found living in colonies of many individuals joined together.

Relative Proof

During reproduction, fertilization of the eggs results in the development of a larva known as an ascidian tadpole. This has a large head with a pharynx, sense organs, and a tail for swimming. The tail is supported by a stiffening rod called a notochord. This does a similar job to the backbone of a fish. The presence of a notochord in the larva stage shows that sea squirts and vertebrates (animals with backbones, such as fish, birds, and mammals) are related.

This pair of sea squirts in the Pacific Ocean shows the inhalent siphon (at the top) and the exhalent siphon (at the side) through which water passes.

Fact File

SEA SQUIRTS AND SALPS

Classes: Ascidiacea (sea squirts; about 1,800 species), Thaliacea (salps; about 70 species)

Subphylum: Urochordata

Phylum: Chordata

Where do they live?: Worldwide in all seas and oceans

Habitat: Rocky seashores and seabeds, coral reefs; some species on softer seabeds and open water

Size: 0.04–8 inches (1 mm–20 cm)

Coloration: Various—cream, gray, brown, blue, green, orange, and red; often beautifully patterned

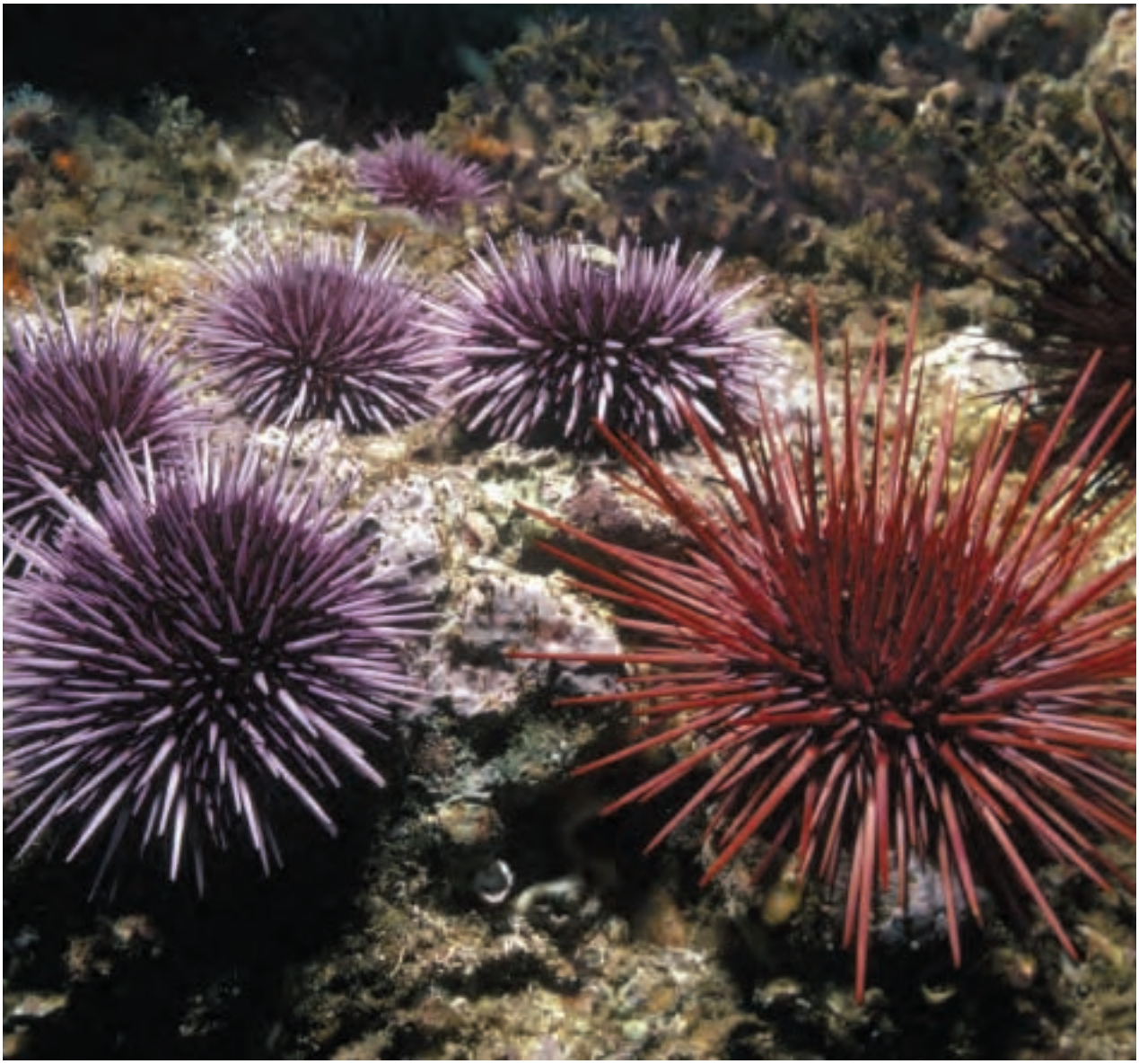
Diet: Planktonic organisms and detritus particles collected by filter feeding

Breeding: Hermaphrodite; sexual reproduction; eggs and sperm released into the sea or body cavity; embryo develops into a swimming larva that either settles on the seabed or completes the life cycle in open water; asexual reproduction takes place by budding

Status: Unknown

SEA URCHINS

These prickly animals have highly developed, moveable spines used for defense as well as for moving around. Sea urchins have colonized most types of seabed from rocky shores to deep-sea bottoms.



Sea urchins are echinoderms (spiny-skinned animals). They are related to the starfish, sea lilies, and sea cucumbers. They come in two basic body shapes. Round ones are called regular echinoids. Oval or heart-shaped ones are called irregular echinoids. All urchins have a chalky body called a test, which is covered in spines of varying lengths. They also have water-filled tubes called tube feet that poke through the test. In regular echinoids the tube feet are arranged in five equal double rows up and down the body. In irregular echinoids the tube feet are arranged to form five petal-like patterns on the animal's upper surface.

Sea urchins usually live on rocky surfaces and may climb about among large seaweeds and sea grasses. They scrape away at smaller animals and plants living on the surface of the rocks, or chew larger plants with their jaws, which are just inside the mouth. The species known as sand dollars and heart urchins usually burrow in sand and mud.

Water-filled Feet

Like other echinoderms, sea urchins crawl about with the aid of their tube feet. These form part of a complicated network of water-filled canals inside the urchin. The network is known as the water vascular system. The animal uses water pressure to extend the tube feet. They can attach to a surface with their suckers, and they can make stepping movements before

These purple sea urchins (left) and giant red sea urchin (right) are well covered with big, moveable spines on the surface of their bodies, or tests.

Fact File

SEA URCHINS

Class: Echinoidea (about 950 species)

Phylum: Echinodermata

Where do they live?: Seas and oceans worldwide

Habitat: Seashore and seabed

Size: 0.1–7 inches (3 mm–17 cm) in diameter

Coloration: Black, gray, brown, red orange, pink red; some patterned

Diet: Encrusting algae, small invertebrates, and organic particles

Breeding: Separate sexes; eggs and sperm are released into the sea where fertilization takes place; this produces a larva that floats as part of the plankton before settling on the seabed to become a juvenile urchin

Status: Unknown

The banded sea urchin has two kinds of spines. The thinner, brown ones have sharp, venomous tips.

being pulled back in by internal muscles. In the irregular urchins the tube feet are not used so much for moving around. Their main job is to help move the particles of sediment in which the animals live. They are also used to maintain burrows that connect to the water above the sediment's surface.

A close-up of some of the short, poisonous spines of a fire urchin. This species lives in the Indo-Pacific region.

Life Without a Head

Despite having no head or brain, sea urchins can locate food, avoid predators, and find suitable mates using their well-developed senses and nervous system. Sense organs, including touch, chemical, and light sensors, are scattered all over the outer surface of the animal, as well as on the tube feet. All the sense organs are connected to a central nervous system. Urchins respond very quickly to scents drifting toward them in the water. The sea urchin's light sensors can also sense changes in light intensity. However, they cannot form images in the way that eyes can.

Spines for Every Need

Because predators can approach from anywhere, the sharp spines of regular sea urchins can point in any direction to protect the urchin from attack. They respond to the touch and scents of other animals. Special muscles move the spines, and the spines can then be locked in any position. In some tropical and deep-sea urchins the spines are very long, covered with thorns, and carry poison which they can inject into other animals. Spines are also important in helping regular sea urchins move around.

DID YOU KNOW?

- Sea urchins are caught in the Mediterranean Sea, Caribbean Sea, Indian Ocean, and Japanese waters, where their eggs are regarded as a delicacy.
- One group of regular sea urchins is not round, but oval, in shape.
- Some sea urchins can drill into rocks much harder than their own spines.

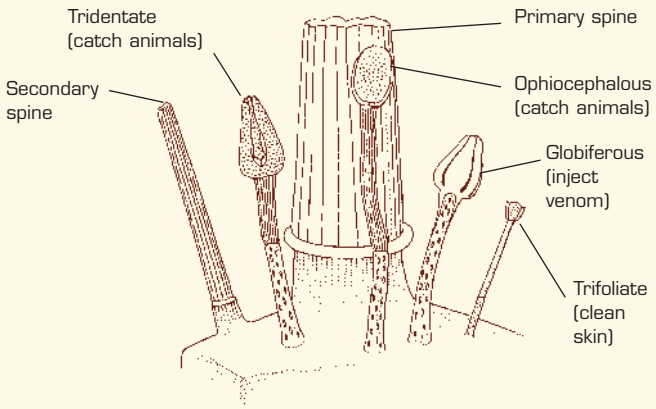
Some urchins that burrow into hard rocks catch drifting food on their spines, and a few Antarctic species have some flat-topped spines that resemble parasols. These species brood the young under the "parasols" instead of producing larvae that float as part of the plankton.

Burrowing in Sediments

Sand dollars live in both fine and coarse sand and mud. They use their soft, almost furlike spines, as well as their tube feet, to move the sediment particles over their bodies. The spines also sift the organic material and transfer edible portions to the urchin's mouth where they are dealt with by the jaws. Some species have slots in their disklike bodies that help them move more efficiently through the sediment. Heart urchins generally burrow deeper than sand dollars. They have a number of different types of spines and tube feet that are adapted for either manipulating sediment particles, burrowing, or maintaining their burrows.

KEEPING CLEAN

If you looked at the outside of a sea urchin with a magnifying glass, you would notice thousands of minute forcepslike structures between the spines. These are grooming organs called pedicellariae (see below). They are jaws or pincers on moveable stalks, slightly resembling the spines themselves, but with a flexible section at the end. There may be four different types, depending on the species of urchin. These minute organs pick sediment particles from the skin of the test. They also catch small animals that settle on the test and may harm it. Some have glands that inject poison into predators like starfish to deter them.

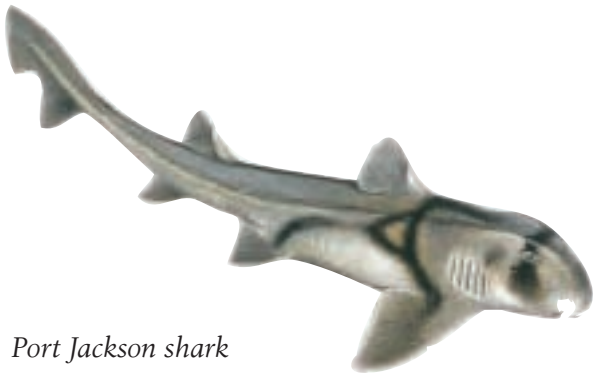


SHARKS

It may sound impossible, but some of the smallest sharks in the world prey on some of the largest, while the largest sharks of all only eat tiny creatures.

Ask most people to draw a shark and they are likely to come up with a torpedo-shaped fish with a large upright back (dorsal) fin, huge mouth, and fearsome teeth. Many sharks are like this, but they are outnumbered by other species that do not fit in with this popular image at all.

The angel sharks, for instance, could not be more different. They have a flat body and an



1. *Port Jackson shark*
2. *Nurse shark*
3. *Bull shark*
4. *Whitetip reef shark*
5. *Megamouth shark*
6. *Basking shark*
7. *Greenland shark*
8. *Bluntnose sixgill shark*
9. *Common angel shark*
10. *Longnose saw shark*

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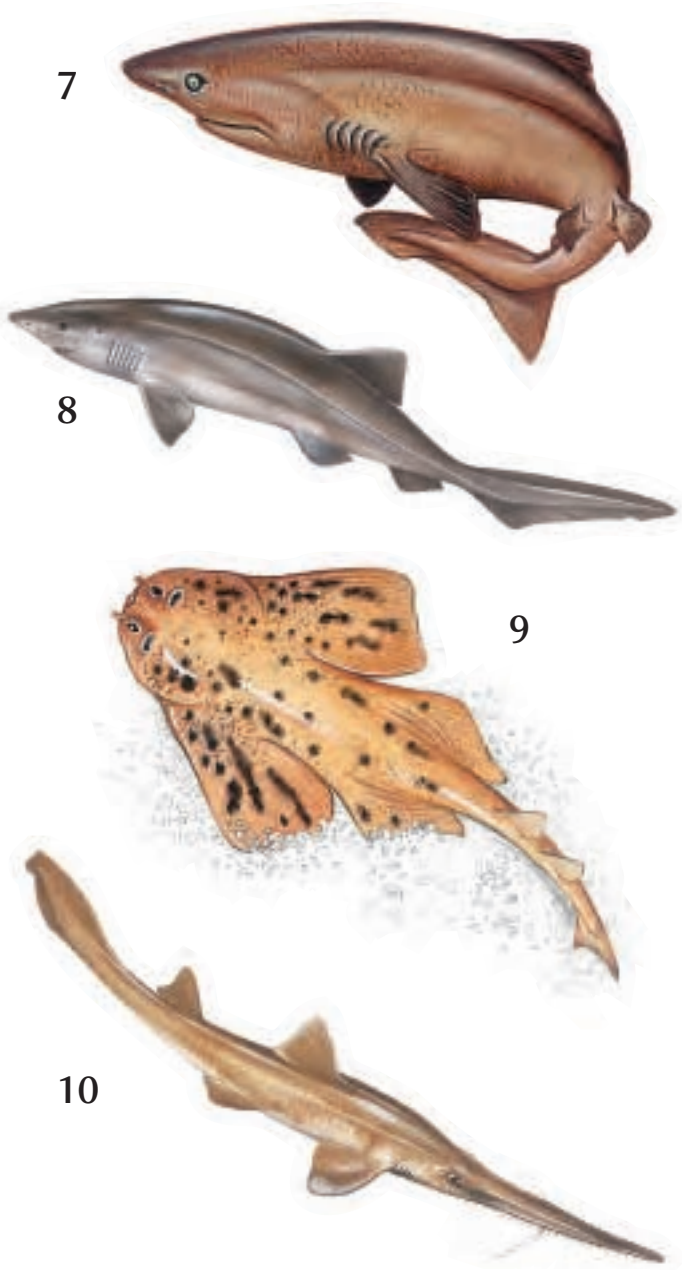


equally large, flat head. Their pectoral (chest) fins look like broad wings, their pelvic (hip) fins are a similar shape—only smaller— and their eyes are positioned on top of their head. And instead of actively hunting, angel sharks spend most of their time lying on, or buried in, the seabed, waiting for an unsuspecting victim to swim within reach.

Fact File

SHARKS

Class: Chondrichthyes

Subclass: Elasmobranchii

Orders: 8 orders

Families: 29 families (around 460 species)

Where do they live?: Worldwide in tropical, subtropical, temperate, and polar oceans

Habitat: From very shallow water down to more than 12,000 feet (3,700 m) in some lantern sharks; some species—such as the cookiecutter shark—can migrate from the surface to depths of around 11,500 feet (3,500 m); many sharks live in open water, while others live close to, or on, the bottom

Size: From about 7 inches (18 cm) in the spined pygmy shark to 59 feet (18 m) in the whale shark and 50 feet (15.2 m) in the basking shark

Coloration: Highly variable: open-water species often dark blue along the back, with light belly; bottom-dwellers often brownish or tan-colored with patches, spots, and other body markings

Diet: All species are hunters, preying on a wide variety of organisms, ranging from plankton to fish, reptiles, and marine mammals

Breeding: Eggs are fertilized inside the female's body; in about 70 percent of species these are kept in the body of the female, which will give birth to live young after a pregnancy lasting from a few months to 2 years; in about 30 percent of species, the eggs are laid after being fertilized internally; embryos develop for periods up to 15 months inside hard, leathery egg cases known as "mermaid's purses"

Status: 10 species are critically endangered, including the dumb gulper shark, the Ganges shark, and the spiny angel shark; 9 species are endangered; 30 species are vulnerable

The jaws of a great white shark are lined with triangular-shaped teeth several inches long. The teeth have serrated edges to help saw through prey.

Special Senses

Despite their different body shapes and feeding habits, all sharks are hunters. They go about hunting in different ways, although they tend to use the same senses to find their prey.

The ears are particularly sensitive and can pick up low-frequency sound waves from a distance of over a mile. Low-frequency vibrations—such as those created by an injured fish or other animal—are picked up from a distance of about 300 feet by a special system known as the lateral line organ. This organ runs down both sides of the fish's body.

Sharks can also detect very weak electrical signals, such as those given off by fish and other prey animals. Using highly sensitive pits on their snout, which are known as the ampullae of Lorenzini, sharks can even detect their prey if it is buried under the sand or mud.

The eyes, too, are very efficient. They can detect movement even in dim light, making sharks efficient night hunters. Some, such as the great white shark, also have good color vision that allows them to hunt in bright light.

It is their ability to smell blood, however, for which sharks are most famous. It is why sharks are sometimes called "bloodhounds." A blacktip shark has been shown to be able to smell grouper flesh (groupers form part of the diet of many sharks) at a dilution of one part of flesh to 10 billion parts of sea water! Many sharks can smell the tiniest hints of blood from distances of around one-third of a mile.

Caribbean reef sharks can grow to over 6 feet in length. They live close to the bottom, and when not feeding will often rest in underwater caverns.

Shark Attacks

Sharks rarely attack humans, but when they do, it can often lead to serious injury and, occasionally, death. In total, there are only about seventy to one hundred officially recorded shark attacks on humans each year, although there may be others that go unreported.

Despite the severity of some of these attacks, especially those from large species such as great white sharks and bull sharks, many people survive, although sometimes with major injuries. One reason why the victims survive is the "bite and spit" method used by some species of sharks, in which they let go of their prey after the first major bite. This may be the shark's way of protecting itself from getting scratched or bitten by its prey, while it waits for it to bleed to death or become weak. At this time it is therefore sometimes possible for a mother. In some of these species, the largest embryos can end up eating their smaller and weaker brothers and sisters while they are still in the womb!

DID YOU KNOW?

- Megalodon was a fossil great white shark that grew to over 50 feet and swam in the ancient seas 3–25 million years ago.
- Sharks replace worn or broken teeth throughout their lives.
- Shark skin feels like sandpaper due to its small toothlike scales known as denticles.

LIVEBEARERS AND EGG-LAYERS

About 70 percent of all shark species give birth to fully formed young. They are known as livebearers. The remaining 30 percent lay eggs in hard, leathery cases known as mermaid's purses. They are the egg-layers. Despite these differences in breeding methods, all sharks produce eggs. In all species, these are fertilized inside the body of the female.

In egg-laying species, embryos get all their nourishment from their egg yolk. The same also applies to about 50 percent of the livebearing sharks. In the other 50 percent, the embryos are provided with food via the bloodstream of their

A fully formed baby swell shark hatches from its egg case off the coast of California.

swimmer who has been bitten to struggle to safety or be rescued before the shark returns for a second, and often final, bite.

Attacks may sometimes be the result of a shark mistaking a human for a seal, sea lion, or turtle. Whatever the reason, there is no doubt that the consequences of being bitten can be very serious, even when the shark responsible is only a modest size. Even generally peaceful species such as nurse sharks, angel sharks, or wobbegongs may attack when provoked.

DID YOU KNOW?

- Some sharks can become hypnotized when they are flipped over onto their backs.
- The giant species like the basking shark and the whale shark are filter feeders which sift out tiny invertebrates (plankton) with special gill sieves.
- The cookiecutter shark is a small species that bites cookie-sized chunks out of other fish (including large sharks), dolphins, whales, and even the rubber sonar domes of nuclear submarines!

Sharks in Peril

Although sharks occasionally attack and kill humans, they have more to fear from us than we have from them. We kill countless millions of sharks each year. Many are killed accidentally by being caught in nets set out for other species. However, many more sharks are targeted directly for a variety of purposes, ranging from sport fishing to the shark fin soup industry.

During the nineteenth and twentieth centuries, shark oil was in great demand as a useful fuel for lamps. It was also an excellent source of vitamin A. However, electricity replaced the need for oil lamps, and from the middle of the twentieth century, demands for shark oil for Vitamin A decreased greatly when it became possible to make the vitamin instead. Today, shark oil is still used for some cosmetics

Shark flesh is hung out to dry in the sun in Baja California, Mexico (far left). Shark fins, intended for shark fin soup, dry in the sun, also in Baja California, Mexico (left).

and soaps, as a high-quality machine oil, and in some dietary and other health products.

Shark meat has also become quite popular since the 1980s, particularly in parts of the United States. Shark fins have been in great demand in the Far East for around 2,000 years as the main ingredient for shark fin soup. Shark skin is also used for handbags, purses, and other expensive goods. Other shark parts, especially teeth, are sold as jewelry, decorations, curios, knives, and ceremonial items.

The result of this wide-ranging onslaught on shark populations has led to some species facing a serious threat to their survival. It is only relatively recently that shark protection and conservation programs and laws have been developed and put into action.

The whale shark is the world's largest fish. Despite its huge size and vast mouth, it only eats tiny plankton, small fish, and other small animals.

MASTERS OF DISGUISE

A wobbegong lies on the seabed. Some species can grow to a length of 12 feet.

Wobbegongs lie still on the bottom, looking more like colonies of sponges and seaweeds than sharks. The body and head of the shark are flattened and have an irregular mottled pattern. There are also many skin flaps and barbels (whiskers) around the mouth. These help disguise the wobbegong. It is therefore quite easy for an animal, or even a diver, to swim near a wobbegong and completely miss it, even when only a few feet away.

Despite being thought of as a non-dangerous species, wobbegongs have been known to attack humans. This usually happens when they are teased, accidentally stepped on, or otherwise disturbed. In Papua New Guinea, the tasselled wobbegong is known as a "man killer," but scientists have no real evidence to support this.

SHRIMP AND PRAWNS

Most of us are probably more likely to see these creatures on a dinner plate than in their natural habitats, but the several thousand species of shrimp and prawns worldwide lead fascinating lives.

Shrimp and prawns are related to the crabs and lobsters. The head and the thorax (the middle part of the body) are joined together and enclosed in a protective shell called the carapace. The carapace has a pointed area at the front, known as the rostrum, between the stalked eyes. The head also has two pairs of antennae, or feelers. There are eight paired structures on the thorax. The first three pairs of these form the mouthparts, and the last five pairs act as walking legs. Some of these legs have nippers or claws on the ends. The nippers are used for feeding and for activities such as fighting over territory.

The abdomen (the last section of the body) can be seen behind the carapace. The abdomen carries five paired structures. They are used for swimming, and brooding eggs in the female. The last pair forms the tail fan. Some prawns live most of their life swimming around, and they do this by using their tail fan.

Shrimp or Prawn?

In many parts of the world the words "shrimp" and "prawn" mean more or less the same thing; often the only difference is that shrimp is used for small species, and prawn for larger ones. Sometimes the term prawn is not used at all. In Britain the difference is slightly clearer, as shrimp in particular live near sandy bottoms and have small rostrums, while prawns inhabit rocky grounds and mid water and have larger rostrums.

The banded coral shrimp defends its territory strongly against rivals. For this reason it is also sometimes known as the banded boxer shrimp.

Fact File

SHRIMP AND PRAWNS

Infraorders: Penaeidea, Caridea, Stenopodidea (about 3,000 species altogether)

Order: Decapoda

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: All seas and oceans

Habitat: Open water, seashore, and seabed

Size: 1–14 inches (2.5–36 cm) long

Coloration: Transparent through to a wide range of colors; some beautifully patterned

Diet: Almost anything edible

Breeding: Usually separate sexes, occasionally hermaphrodite; females usually carry the eggs until hatching; a larva forms that swims as part of the plankton before eventually settling on the seabed

Status: Unknown

Two harlequin shrimp crawl over a starfish, picking off tiny food items from its skin.

Varied Lifestyles

Shrimp and prawns may look similar, but their lifestyles vary quite a lot. Most shrimp and prawns live alone, foraging for food on seaweeds, the seabed, or in open water. But others have chosen to live closely with other animals. Some inhabit cold polar waters, some live in the tropics, some live in fresh water, but most are marine. Some shrimp live in the perpetual darkness of the deep ocean floor. Others never touch the seabed, spending their whole lives swimming about in the water. Some shrimp live buried in soft mud or sand, and others have special ways of moving delicately over soft bottoms without sinking into them.

Living Together

When two or more different animal species live together in a way that benefits them both, the arrangement

Crinoid shrimp live on the arms of crinoids (an echinoderm). They keep the crinoid clean, in return for a safe place to hide. The shrimp's body coloring matches that of its host.

A cleaner shrimp removes food particles and parasites from the mouth of a moray eel "customer."

is known as symbiosis. Shrimp and prawns are among the species that often form these relationships. Boxer shrimp live inside sponges. They do no harm to their host, which keeps them safe from predators. Coleman shrimp live among the poisonous spines of some sea urchins, where they also gain protection. The harlequin shrimp lives on the outside of large starfish, picking up pieces of detritus that fall on the starfish skin.

GOING TO THE CLEANERS

Some species of shrimp show a remarkable relationship with certain fish. The shrimp, known as cleaner shrimp, are often found in tropical reefs. They usually remain at special "cleaning stations," where they are visited by all kinds of fish so they can have parasites and dead tissue removed. The cleaner shrimp usually remain partly hidden from view in nooks and crannies until a "customer" arrives. If the fish shows no sign of aggression toward them, the shrimp will come out and start the cleaning service. The shrimp always remain cautious and sudden movements send them back into hiding.

Pistol Shrimp

One family of shrimp has evolved a clever way of catching prey, as well as driving off other shrimp and even predators. It has developed a huge front nipper—usually the right one. The muscle that closes the "finger" of the nipper is very powerful. The finger can be locked open, and then the muscle contracts (shortens), building up huge tension, like a coiled spring. When danger threatens,

DID YOU KNOW?

- Boxer shrimp are so called because their oversized nippers can pack a powerful punch.
- Some shrimp species change their sex as they grow. Individuals start life as males and then undergo a sex change to become females.
- The developing eggs of shrimp are usually attached to the paired abdominal structures of the mother. Here they can be protected and kept well oxygenated by the movements of the abdomen until they hatch.

A pistol shrimp lies in wait for prey among marine growths.

or when a minute prey animal swims by, the finger is released, snapping shut with a loud click. This can frighten potential predators away and may even temporarily stun very small prey animals nearby.

The pistol shrimp often shares its sandy burrow with a small fish called a goby. When danger threatens the goby dives for shelter, at the same time alerting the shrimp.

Growing a New Shell

For crustaceans to grow bigger, they must shed their old shell and grow a new one. This is known as molting. Before molting happens, a new, slightly larger, soft shell forms underneath the old. The old shell splits at the top of the carapace and the animal wriggles out.

Molting is a dangerous time, because the animal is very vulnerable to predators until the new shell hardens. Crustaceans keep tiny sand grains in their body to help them balance. These must be replaced after each molt so that the animal's sense of balance can be restored.

A Shortage of Minerals

Freshwater shrimp live in an environment where many of the minerals they need are in short supply. One of these is the calcium

DID YOU KNOW?

- Some species of shrimp live in deeper water during the daytime and migrate to the surface to feed at night.
- Shrimp can be found in freshwater, estuarine, and fully marine environments.
- About 3,000 species of shrimp are recognized worldwide.

they need to grow their carapace. While there is plenty of calcium present in sea water, it is scarce in fresh water. Therefore, freshwater shrimp must get what they need from their food. Often their carapaces are fragile in comparison with those of marine shrimp and prawns because there is less calcium.

Shrimp and Prawn Industry

Shrimp and prawns are fished worldwide, often by trawling (dragging a net in the water from a ship). Shrimp and prawn fisheries are important to the economies of many countries. Over 2.7 million tons of these shellfish are harvested from the sea annually worldwide. The Chinese prawn is one of the most important commercial species, but many other species are caught as well.

Shrimp farming has become an important new and reliable way of producing this valuable food. Shrimp can be reared easily in pools and quickly processed, saving the expense of maintaining fishing boats and gear. Most shrimp farms are situated in coastal locations with access to sea water. Chinese prawns and tiger prawns are often farmed in this way, and so are some freshwater species.

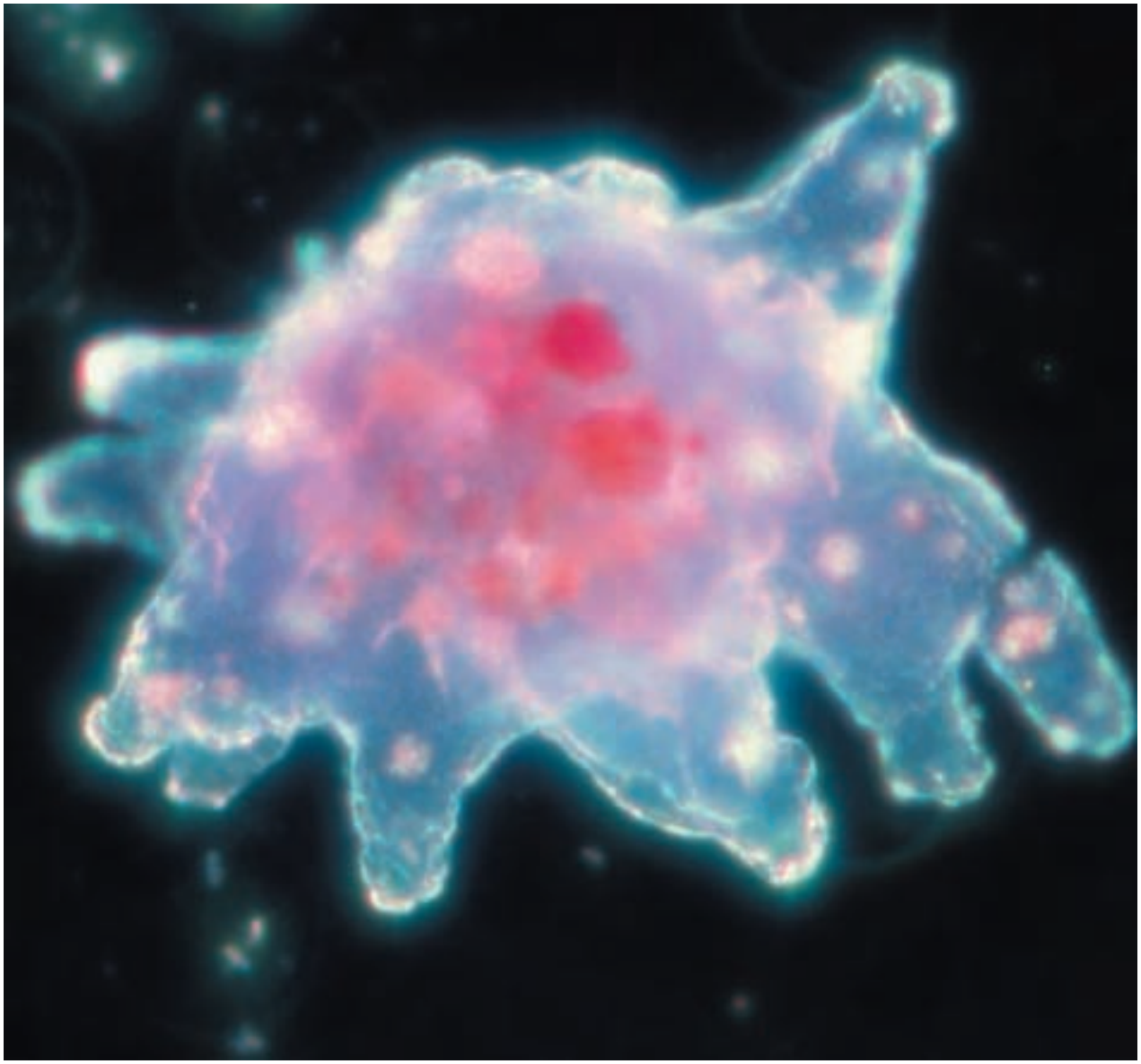
ENVIRONMENTAL IMPACT OF FISHING AND FARMING

Intense fishing and farming methods often cause problems for the environment. For example, in many tropical areas shrimp-rearing ponds have been dug out of mangrove swamps (below). This destroys the mangroves, which are now known to be places of great importance for marine life. They are the "nursery" areas where many species of invertebrates (animals without backbones) and fish rear their young.

Trawling for shrimp causes environmental damage, too, particularly in areas such as the Gulf of Mexico and Bay of Bengal where rare turtle species come to breed. Turtles get caught in shrimp nets and, because they are air breathers, can drown. In the Gulf of Mexico special devices are fitted to shrimp nets that let the turtles escape if they are caught.

SINGLE-CELLED LIFE

Millions of organisms consist of just a single cell. Yet this has been a recipe for success rather than failure, as these organisms can be found in a great variety of habitats, including the bodies of many other living creatures.



Single-celled organisms, or protozoans, belong to one of the five major kingdoms (groups) of life on Earth—the Protista. They were once known as "simple animals," yet they are not really simple at all. They can carry out all the complicated processes necessary for life within one cell. This includes eating food, reacting to their surroundings, moving, and reproducing. Single-celled organisms are very tiny—most cannot be seen without a microscope. Single-celled organisms eat other small animals or bacteria. Parasitic ones absorb food from their hosts. Some protozoans live as part animal and part plant; they move about like animals, but they make some of their food using the energy from sunlight—the way that green plants make food.

Inside the Cell

Every protozoan cell is surrounded by a fatty covering called a membrane. Sometimes there is a harder coat as well, as in the chalky forams. Inside the membrane there may be one or more structures called nuclei. They control how the cell works. Most of the cell is filled with a type of fluid called cytoplasm. Food is normally taken into the cytoplasm through a temporary opening in the cell membrane.

Single-celled organisms reproduce in a number of ways. In the amoebas, the cell splits in two and each part becomes a new amoeba. In most parasitic species, the life cycle is often much more complicated.

Amoebas are one of the most common forms of single-celled life. Amoebas live in water, where they move about using a flowing motion.

Fact File

SINGLE-CELLED LIFE

Subphyla: Mastigophora (flagellates), Sarcodina (amoebas and their allies, Ciliophora (ciliates), Microspora (microsporidians), Apicomplexa (malarial parasites)

Phylum: Sarcomastigophora

Kingdom: Protista

Where do they live?: Sea and fresh water, damp soils, and as parasites of many other creatures

Habitat: Free-living in water bodies, parasitic in body fluids of animals—for example, the blood and the digestive tract

Size: A few thousandths of an inch (1–2 microns) to 0.2 inch (5 mm) in diameter; a few foraminiferans up to 1 inch (2.5 cm)

Coloration: Transparent, opaque, with various pigments

Diet: Bacteria, very small planktonic and bottom-dwelling animals, detritus particles, and body tissues of hosts

Breeding: Asexual reproduction mainly by splitting or budding; sexual reproduction also occurs; life cycles of parasitic species are complicated

Status: Unknown

1. *Flagellate*
2. *Amoeba*
3. *Ciliate*
4. *Malaria*

Euglena *is a flagellate. The flagellum is the whiplike thread at one end of each of these cells.*

Flagellates

Flagellates are protozoans that have one or more long, hairlike whips called a flagellum to drive them through water, blood, or the other liquids in which they live. Flagellates may be round, pear-shaped, long and thin, or may even change shape. They may live singly or in colonies.

Some flagellates, especially the ones called trypanosomes, live as parasites in the blood of people and domestic cattle. In humans they can cause illnesses such as sleeping sickness. These are transmitted by a biting insect such as a fly or bug. Giardiasis is an intestinal parasite causing diarrhea. It affects people all over the world who drink water infected with the species called *Giardia*.

Amoebas

Amoebas do not have a flagellum to help them move about. Instead, they can change the texture of their cytoplasm from stiff to runny, to form flowing pseudopodia, meaning "false feet." They can also use their pseudopodia to engulf prey as they flow about their watery environment.

Many amoebas are harmless to other animals and humans, but a few, like *Entamoeba,* cause diseases such as amoebic dysentery where hygiene and sewage disposal are poor.

Ciliates

Ciliates are the most complex single-celled organisms. They are found in almost all types of water, including the water film around soil particles.

DID YOU KNOW?

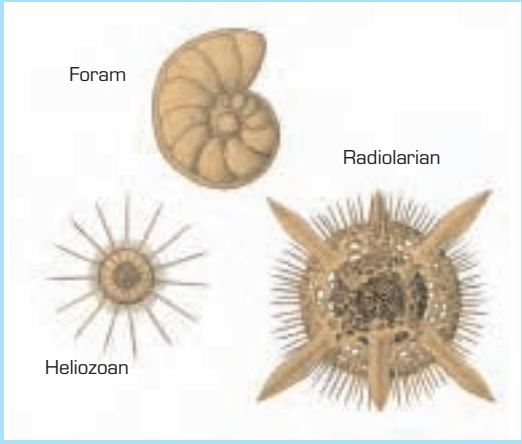
- Dutch scientist Antonie Van Leeuwenhoek was the first person to observe single-celled organisms, in 1674.
- Scientists began describing and naming single-celled organisms in the late-eighteenth century.
- Water is essential to single-celled organisms, but if they dry out, many species can survive in a dormant (sleeping) state until water returns.
- Some flagellates live inside the bodies of other animals and do good—for example, by aiding the digestion of cellulose in cows.

Ciliates have two types of nucleus. One type takes part in sexual reproduction. The other, bigger, type, called the macronucleus, controls the everyday workings of the cell. The cell itself may be rounded or horseshoe shaped, according to the species. Ciliates such as *Paramecium* are encased in a fatty membrane known as the pellicle. It has many small, hairlike cilia that beat to help *Paramecium* move about and capture food. The pellicle also has very tiny sacs called trichocysts. They can discharge a thread with a barb attached to it to capture food. Some species can also use substances called toxicysts that release digestive enzymes and paralyzing chemicals.

The purple organisms are trypanosome parasites among red blood cells. Trypanosomes cause sleeping sickness.

FORAMS, RADIOLARIANS, AND HELIOZOANS

Some relatives of the amoebas, like the forams, secrete chalky shells. They live mainly on the seabed and include the largest known of all protistans. As the shells grow, they make up a series of connected chambers containing the cytoplasm. The remains of many millions of these shells form the chalk deposits in the Earth. Other marine relatives include the radiolarians. They float in the plankton. They have a skeleton of silica or other chemicals. They also have long, thin pseudopodia, called axopodia. These are not used for movement, however, but for trapping food. The freshwater heliozoans, or sun animalcules, have many thin axopodia and a skeleton made of glassy silica.



Some of the tiny species of forams, radiolarians, and heliozoans form beautiful shapes that are among the wonders of the natural world when seen magnified.

DID YOU KNOW?

- Ciliates swim by using the movements of their many cilia, all beating together like many oars in a boat. The organisms can move backward by reversing the direction of the beating cilia.
- Special threads, called myonemes, lie within the pellicle of a ciliate. When they shorten, the ciliate can change its shape.
- Ciliates are widely used in the pharmacological industry where drugs are tested on living cells.

On the Menu

Ciliates feed mainly on bacteria or other protistans, but some bigger ones like *Didinium* and *Stentor* can eat larger prey, including very small crustaceans. The food is taken in through the mouth and goes into the organism's throat. In ciliates this is known as the cytopharynx.

Once inside the throat the food is engulfed in a pouch formed from the cell membrane. This is known as a food vacuole. Then digestive enzymes are poured into the vacuole so that the food can be absorbed by the cell. Any waste matter then leaves the cell via the cell membrane.

Ways of Reproducing

Asexual (non sexual) reproduction is the commonest means of making new individuals. In this method, essential parts within the cell are duplicated (copied) and then the cell divides, forming two new cells.

Sexual reproduction occurs only occasionally in ciliates, usually when environmental conditions are poor. Ciliates do not exist as different sexes, but as different reproductive forms or mating types. The exchange of DNA (genetic material) is called conjugation. It takes place between two different forms. They pair up and exchange DNA from their micronuclei. A new micronucleus forms in each partner. Following this, the cells may divide to produce more identical new cells.

Paramecium *is a ciliate that lives in water and soil. It eats bacteria (the small dark blobs are food particles). Cilia surround the outer body.*

Two Paramecium *are reproducing sexually by a method called conjugation. In the background are blue-green algae.*

Malaria and its Spread

Malaria, the disease resulting from an infection with the parasitic protistan

Plasmodium, has killed countless humans over thousands of years. However, its complicated biology and the exact way in which it is spread from one person to another were discovered only relatively recently. A breakthrough came in 1898, when the British scientist Sir Ronald Ross discovered the part played by mosquitoes in the *Plasmodium* life cycle. Only female mosquitoes bite. They need the blood to help their eggs develop properly. It is female mosquitoes of the genus *Anopheles* that transmit the disease to humans.

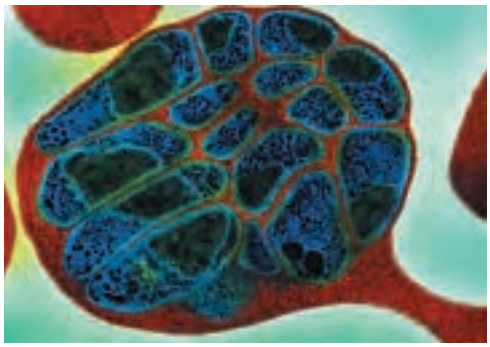
About ten species of *Plasmodium* cause malaria in humans. Birds and mammals are infected by different species, and other types of mosquito are involved in their infection.

Around 300 million humans worldwide are infected with malaria. Cerebral malaria, caused by *Plasmodium falciparum*, is probably responsible for more deaths in the tropics than any other parasite. *Plasmodium* vivax also causes malaria. It may lie dormant (resting)

Stentor *is a freshwater ciliate protozoan. Food is drawn in via the trumpetlike mouth at the top of the organism.*

FRIENDLY CILIATES

Many ciliates are harmless guests that live in the bodies of animals. For example, some ciliates that are found in the intestine of animals such as horses and pigs help them digest their food properly. One ciliate (shown above) is harmless to pigs, but it can infect people—particularly pig farmers—causing sickness and diarrhea. Other ciliates are used in the pharmaceutical industry to investigate the effects of new drugs on living cells. The presence or absence of some ciliates in freshwater habitats can help tell scientists whether the ecosystem is healthy or polluted.



Here a human red blood cell is shown infected with the malarial parasite. The red blood cell has swollen due to the many parasites.

in the host's body for several years before developing into the disease.

The symptoms of malaria include fever, chills, sweating, and shivering. These usually appear in three-day cycles in the case of *Plasmodium vivax*. The patient feels better after one bout of fever, only to suffer another bout a few days later.

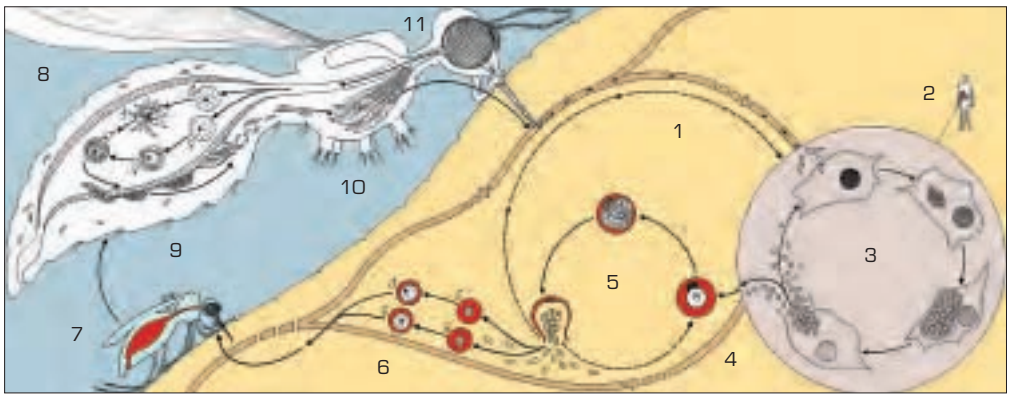
Malarial Life Cycle

In the malarial life cycle there are cells called sporozoites that infect new hosts. When the infected female mosquito bites a person to feed on blood, she injects saliva into a small blood vessel in the skin. This saliva carries sporozoites that find their way, via the bloodstream, to the liver. Here they enter a liver cell, where it is difficult for them to be attacked by the host's immune system. In the liver cell the sporozoites reproduce, dividing to form two new cells called merozoites. These can divide again and again, creating thousands of infectious merozoites in the liver cell.

After a few days the infected liver cell breaks, and the escaping merozoites may infect other liver cells or may enter blood vessels and infect red blood cells. The merozoites divide more and more in the infected blood cells. Every three days or so the infected red blood cells burst and release more merozoites and poisons into the bloodstream. These are the

HOW MALARIA IS SPREAD

Sporozoites invade human blood during mosquito feeding (1) and travel to liver (2); merozoites form, infect liver (3), and enter red blood cells (4), where they burst from time to time (5). Some form gametes – sex cells (6). Mosquito takes up gametes during blood feeding (7); zygote develops in mosquito's gut (8), penetrates gut wall ((9), and develops into sporozoite (10); sporozoites move to mosquito's salivary glands (11).



MICROSPORIDIA—FUNGI OR PROTISTANS?

Microsporidia are very small parasitic organisms. Scientists now think that these organisms may be fungi and not protistans. Microsporidia are oval spores. Inside the spore is a fluidlike material called sporoplasm. It contains nuclei, but unusually it lacks mitochondria. Mitochondria are the minute structures found in other protozoan cells that are involved in supplying energy for the cell.

When the single-celled spore enters the host's body, a long coiled tube emerges from one end. The tube pierces a cell in the host, and the sporoplasm from the spore is injected into the chosen cell. Once this has happened, reproduction starts to take place. The contents of the sporoplasm divides many times to form new organisms, and these then produce even more spores. Infection usually takes place when the host, for example, a rodent, a fish, or an insect, eats the feces from infected individuals.

DID YOU KNOW?

- Microsporidia infections are more common in people who have damaged immune systems.
- Malaria contributes to about 3 million deaths worldwide each year. Over 40 percent of the world's population is at risk of getting malaria.
- Microsporidians are of huge medical and commercial importance, because many species infect humans as well as commercially important animals from cattle to silkworms.
- Several thousand children die of malaria every day.

events that cause the three-day cycle of fevers in the host. Some of the merozoites in the red blood cells turn into male and female gametes (sex cells) and may be taken in with the mosquito's next blood meal. The gametes escape when the red cells are digested in the mosquito's gut. Then they pair together and form a zygote (resting stage) that moves into the mosquito's tissues and develops into more sporozoites. These then go to the salivary glands of the insect ready to begin the cycle all over again.

Microsporidia spores lie on human lung cells. Microsporidia are single-celled parasites, and these spores are the infective phase of the life cycle. The tubes that inject sporoplasm into the host's cell can be seen here.

SOCKEYE SALMON

It can take a sockeye salmon up to seven years to become fully mature. The fish then makes the hazardous journey back to the river where it was born to breed, and then dies.

Life is full of dangers for young sockeyes. First, the eggs may be eaten by aquatic insects and other animals even before they hatch. These and other predators will prey on the babies once they do hatch. As the babies grow, yet more predators take their toll, including fish-eating birds. All these dangers and more are faced even before the young fish reach the relative safety of the sea, a journey that takes one to three years.

Once in the sea, young sockeyes feed and grow rapidly. After a further one to three years, during which time they are preyed upon by animals such as seals, sea lions, and killer whales, the newly matured sockeyes begin the return journey to their home waters to breed.

Perilous Return

As they return home, they face more challenges and predation. Some lose their way and never make it back. The others must overcome strong currents, nets set out by fishermen, dams, and other obstacles—even the sharp teeth and claws of grizzly bears.

In spite of these hazards, millions make it back to the spawning grounds where they were born. Here, the males, which develop a hooklike kype (jaw), will compete to spawn with the females. Once the last eggs have been laid and fertilized, all the breeders will die. But nothing is wasted in nature, and many other animals will feed on the corpses and make the fats that their bodies need to survive the harsh winter ahead.

Landlocked populations of sockeyes, like this breeding pair, are known as kokanee salmon. The male, with his larger jaw, is seen at the top.

Fact File

SOCKEYE SALMON

Oncorhynchus nerka

Family: Salmonidae

Order: Salmoniformes

Where do they live?: Pacific coasts—in the east from Alaska to California, in the west around Japan and Russia; introduced into several countries, such as India and Sweden

Habitat: Fish mature in open sea; adults found on coasts and estuaries before migrating upriver; newly hatched young and juveniles found in lakes or rivers before moving out to sea; some landlocked populations spend their whole lives in lakes

Size: From 16–33 inches (40–84 cm)

Coloration: Blue-black along the back with silvery belly and small black spots along the back and tail (caudal) fin; body brilliant red during breeding season; head becomes green; fins—except the pectoral (chest) and caudal (tail)—also become red

Diet: Young fish eat plankton, then small fish and invertebrates; adults eat smaller fish at sea

Breeding: Occurs in shallow, flowing, oxygen-rich gravelly streams; some breed on lake or island shores; female excavates a redd (nest); as eggs are laid and fertilized, female covers them with her tail; hatching takes 6 weeks to 5 months

Status: Some populations endangered in the United States

SOLES

Viewed from above, a sole looks like many other bottom-living fish, but appearances can be deceptive. A closer look reveals that the sole's body is specially adapted for a life spent lying on its side.

Soles are members of a widespread group of fish known as flatfish. Like many other types of flatfish—such as plaice and halibut—soles are highly prized as a food for humans. Flatfish have evolved to spend their lives on the seabed. Other fish lie on the bottom, too, but they rest on their bellies. Flatfish spend their adult life lying on their side instead.

If a fish lies on its side on the bottom, then one of its eyes—the one on the bottom-facing side of the head—is in contact with the seabed. It cannot be used to see things in the water, such as predators or prey. Flatfish have solved this problem, however. Although they lie on their side, both their eyes are on the same side of the head—the side that faces upward.

Horizontal Living

Soon after a sole is born, its larva (young) stage looks similar to the larva of most other fish. But when the baby sole is still between 0.04 and 0.1 inch long, the left eye begins to move. It migrates right over the top of the head and ends up on the other side.

As the change is being completed, the young sole sinks to the bottom to lie on its blind side. From then on, it will live and swim in this horizontal position. In keeping with such a lifestyle, the skull bones, muscles, fins, nerves, mouth, teeth, coloration, and other features all gradually undergo changes. These make it possible for the fish to live the rest of its life lying on its left side.

A sole lies on the ocean floor. Flatfish such as sole can swim away when danger threatens, but their body coloring helps them stay hidden from most enemies.

Fact File

SOLES

Families: Soleidae (soles; nearly 150 species), Archiridae (American soles; about 33 species)

Order: Pleuronectiformes

Where do they live?: Soles are found mainly in European, African, Asian, and Australian seas; American soles occur on both coasts of North and South America, Indonesia, Australia, New Guinea and, perhaps, the Philippines

Habitat: Shallow or relatively shallow tropical and temperate zones; a few species found in water down to 4,430 feet (1,350 m); a few others occur in estuarine and fresh water, for example, the saltpan sole; most species occur over, or on, fine-grained bottoms

Size: From 1.2 inches (3 cm) in *Rhinosolea microlepidota*, to 30 inches (75 cm) in the West coast sole

Coloration: Top side—in other words, the right side of the body—usually mottled or banded in various colors; bottom side—in other words, the left side of the body—white or light-colored

Diet: Invertebrates and smaller fish

Breeding: Eggs and sperm are released into the water and abandoned

Status: Not known to be threatened

SPERM WHALES

The largest of the toothed whales, a sperm whale has the largest brain on Earth and probably dives deeper in the oceans than any other animal. This group also includes the far smaller dwarf and pygmy sperm whales.

There are three species of sperm whales. The largest species of sperm whale has been living on Earth for around thirty million years. Pygmy sperm whales and dwarf sperm whales evolved around eight million years ago. All three species have a barrel-shaped head, a long, narrow bottom jaw with teeth, paddle-shaped flippers, and a blowhole (breathing hole) on the left side of the head. Between dives, the whales come to the surface around every eight minutes to breathe air. Two nasal passages lead from the blowhole; one is used for breathing, while the other produces sound.

Dwarf and pygmy sperm whales spend a great deal of time lying quietly on the ocean surface with their tail hanging down. They are timid and slow moving. When threatened, these whales produce a reddish brown liquid, which may help them escape predators such as large sharks or killer whales.

Whale Talk

Inside the sperm whales' large forehead is a structure containing a sticky, waxy oil called spermaceti. The structure containing the spermaceti, and the air sacs and air passages around it, form a powerful sonar, or echolocation, system. The whale produces clicking sounds and picks up echoes from its surroundings. That helps it find food in the ocean depths. The whale also uses clicks to communicate with other whales. A large male makes slow, ringing clicks around once

An enormous sperm whale makes its way through the ocean. Its barrel-shaped head contains a brain that is larger and heavier than any other animal.

Fact File

SPERM WHALES

Families: Physeteridae (1 species), Kogiidae (2 species)

Order: Cetacea

Where do they live?: Worldwide, except extreme arctic and Antarctic waters; mature male sperm whales live near the edge of the polar ice

Habitat: Mainly deep oceans; younger whales inhabit shallower inshore waters

Size: Head–tail length 7–52.5 feet (2.1–16 m); weight 300 pounds–63 tons (136 kg–57 metric tons)

Coat: Gray on back; white or pinkish on the belly

Diet: Squid, octopus, fish, and crabs

Breeding: Reach adulthood at around 30 years; 1 calf; males independent at 6 years; females stay in family group

Life span: From 17 years (pygmy sperm whale) to at least 60–70 years (sperm whale)

Status: Sperm whale is vulnerable; pygmy and dwarf sperm whales are probably rare

every six seconds. These clicks may help him attract a female, tell other males to keep away, or show off his fitness and size.

Males and Females

Little is known about the reproduction of pygmy and dwarf sperm whales. In the larger sperm whale, males are much bigger than females and live until they are around fifty years old. The largest males swim close to the edge of the Arctic and Antarctica. They journey to warmer waters nearer the equator to find females for mating. Breeding males usually avoid one another, but sometimes rival males fight using their teeth.

A group of sperm whales swims together. The adults stay close to the calves to protect them from predators, such as killer whales.

GROUP PROTECTION

Female sperm whales gather in family groups of around twelve often closely related individuals, such as these sperm whales (above). This means young calves are protected by some of the adults on the surface while their mothers dive into the depths of the sea to feed. Adults also protect each other from predators. Sperm whales sometimes surround an injured whale, forming a shape like the petals of a flower, with their head or tail in the center. They can then defend the injured whale using their teeth or powerful tails.

Living in Groups

Male sperm whales leave the family units, which are made up of several mothers and their calves, when they are around six years old. They join other young males to form bachelor schools. As they grow older, males are more likely to live alone. In contrast, male dwarf sperm whales may live in groups with females and their calves. In addition, groups of young whales also form. Groups of dwarf sperm whales may number up to ten individuals, while pygmy sperm whales either live alone or in groups of up to six whales.

The Human Threat

Around 300 years ago, there were more than a million sperm whales. There are now only around 360,000 left, and they are in danger of extinction. Dwarf and pygmy sperm whales are probably also rare, but scientists are not sure of their numbers. Sperm whales are no longer hunted for their oil and blubber (thick fat under the skin). However, they are still threatened by pollution, becoming trapped in fishing gear, and colliding with ships. Noise pollution from ships, oil drilling, underwater explosions, and military exercises are a particular problem because sperm whales rely so heavily on sound for all aspects of their underwater life.

The massive tail flukes of a sperm whale break the surface of the water as the whale dives to the ocean depths.

DID YOU KNOW?

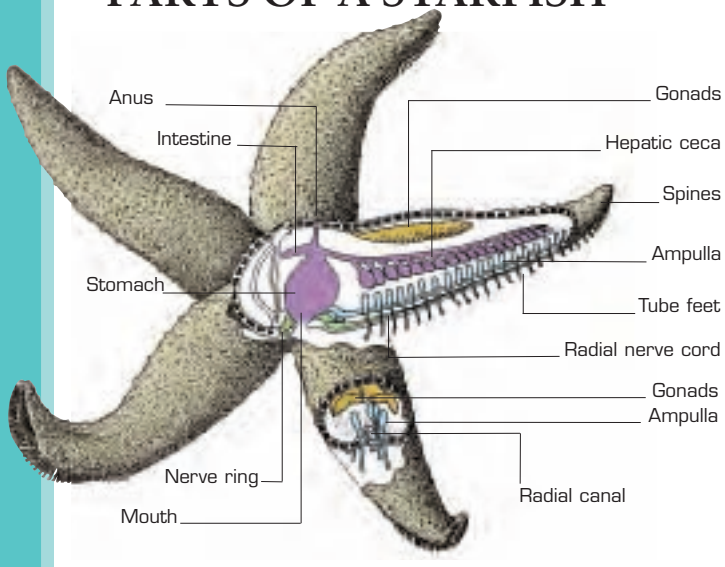
- Male sperm whales weigh three times as much as females.
- Sperm whales can dive to depths of more than 3,300 feet and stay underwater for longer than an hour!
- Sperm whales sometimes hunt giant squid and jumbo squid.
- Sperm whales dive to the seabed for food, shoveling up anything lying there, including stones and tin cans!
- Baby sperm whales, called calves, are around 13 feet long at birth and may weigh as much as 2,200 pounds!

SPINY-SKINNED ANIMALS

The spiny-skinned animals are only found in the sea. Some, like the starfish and sea urchins, are familiar animals sometimes washed up on beaches. Others, like the sea lilies, feather stars, brittlestars, heart urchins, sand dollars, and sea cucumbers are mysterious and rarely seen.

The scientific name for these animals—echinoderm—means spiny-skinned. The spines are much bigger in some species than in others. The earliest-known echinoderms date back 500 million years to the Cambrian Period. All echinoderms are free living; none is a true parasite. (Parasites are animals that feed off the tissues of other living animals.)

PARTS OF A STARFISH



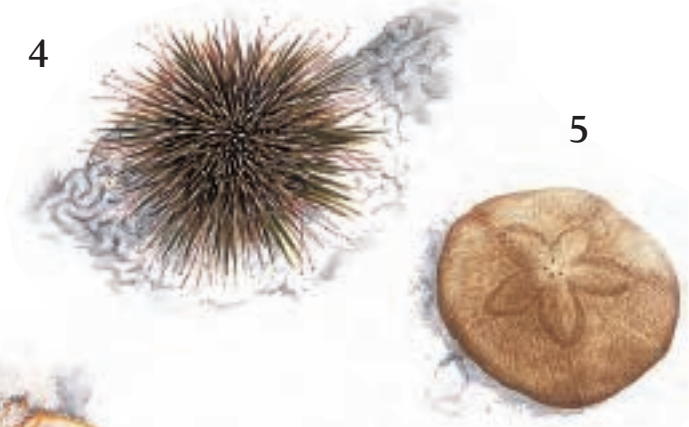
A typical starfish, partly cut away to show the inside. Each arm carries rows of tube feet and is linked to the nervous system by a radial nerve cord.

Adults have five-sided bodies with no head. Many, such as starfish and sea urchins, can move in all directions. Some, such as stalked sea lilies, cannot move at all; they are attached to objects such as rocks, corals, or the seabed.

The body of an echinoderm is called a test. The body walls of the test are supported by chalky crystals. Sometimes, these crystals interlock to make a rigid skeleton, as in sea urchins. In other cases they are only loosely held together by connective tissue. Inside the test there is a large body cavity that contains the gut and the reproductive organs. Brittlestars do not have an anus, but all other species have a mouth and an anus. There is no brain in echinoderms, and the sense organs are simple.

Water System

Inside the body of all echinoderms there is a system of water-filled tubes and reservoirs known as the water vascular system. Only echinoderms have this system, and it has several uses. It enables materials to be moved around inside the body. It also pumps fluid to extend (push out) and retract (pull back) small tubelike structures called tube feet, that poke through the test. Tube feet are used for moving about. In many cases they have adhesive suckers. Sometimes they collect food particles from the sea water.



Fact File

SPINY-SKINNED ANIMALS

Classes: Crinoidea, Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea (about 6,000 species altogether)

Phylum: Echinodermata

Where do they live?: All seas and oceans at all depths

Habitat: Adults on the seashore, on the sea bed or very close to it; larvae in the plankton

Size: 0.2–39.5 inches (4 mm–1 m) or more

Coloration: Various; often beautiful and patterned

Diet: Tiny food particles, plankton, invertebrates, fish, algae and other marine plants, organic particles in sediments

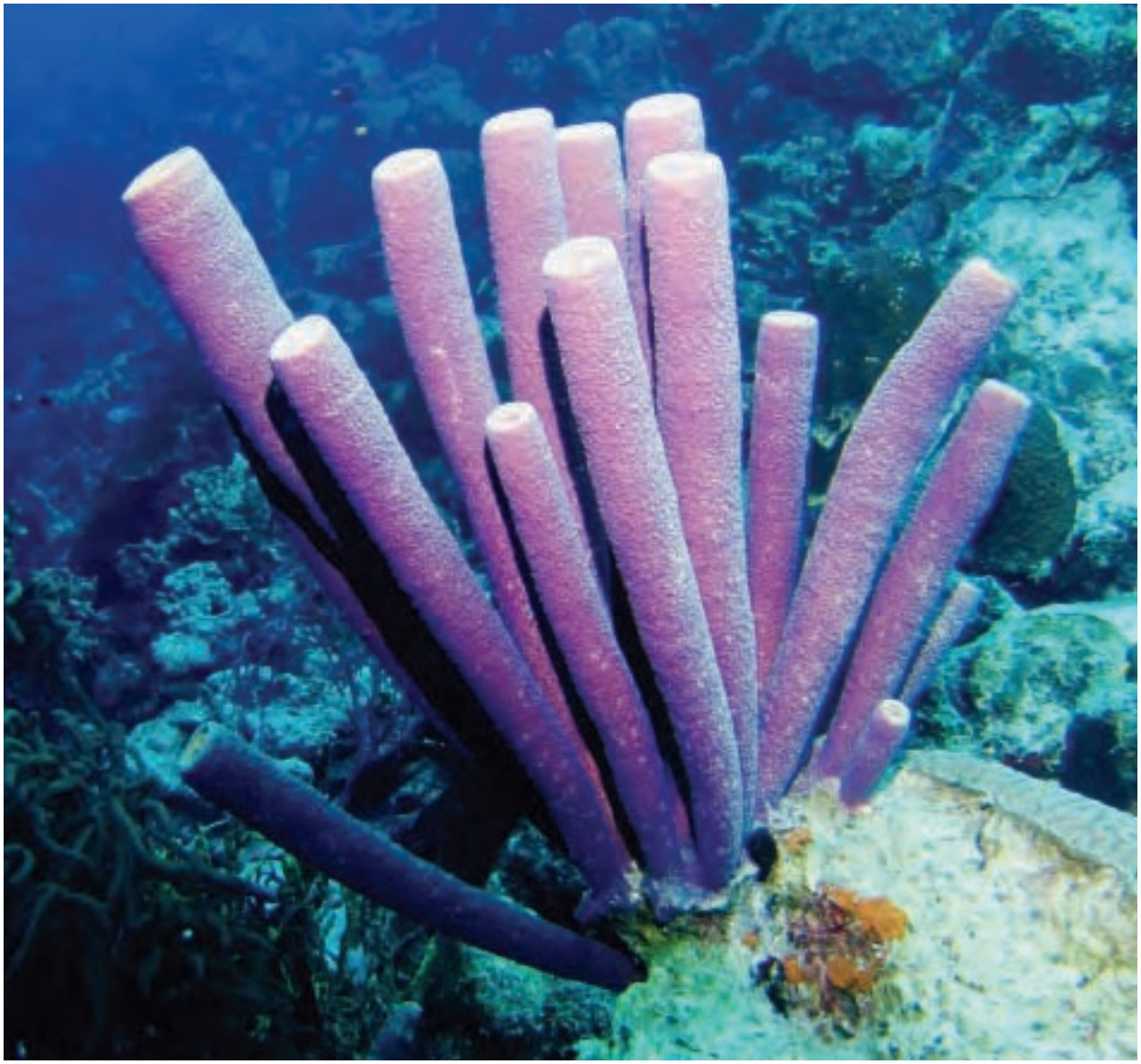
Breeding: Separate sexes in most cases; fertilization in sea water, a larva forms that swims as part of the plankton before it eventually settles on the seabed and develops into a juvenile

Status: Not known

1. *Rosy feather star*
2. *Starfish*
3. *Brittlestar*
4. *Sea urchin*
5. *Heart urchin*
6. *Sea cucumber*

SPONGES

Extremely ancient animals, sponges have existed since Precambrian times, 540 million years ago, and have changed little since that time. The familiar bathroom sponge is made from a sponge skeleton.



Sponges live mainly attached to the seabed. They are supported by a skeleton lying between the outer and inner layer of cells of the body. The skeleton is made of calcium carbonate, spongin (a protein) or glasslike silica, depending to the type of sponge. The large number of hard skeletal parts in sponge bodies means there are many fossils to explore.

Sponges get their food and oxygen from sea water, which is pumped into their body cavity. Water enters the sponge body through many small pores (holes) scattered over the outer surface and passes to the central cavity. Here it is moved around by many beating hairlike structures called flagella, carried on cells called choanocytes. Choanocytes also catch and swallow food particles. Water and waste materials leave the sponge through one or more large central openings.

Friends and Neighbors

Sponges often live closely with other organisms. Some species associate with tiny algae that are taken in with sea water. The algae are not eaten by the sponge, so they are able to photosynthesize (make food using the energy from sunlight). They produce carbohydrates that help provide food for the sponge host. Glass sponges—ones with silica skeletons—trap passing invertebrates that become caught on glassy projections on the skeleton. The impaled prey is digested by amoebalike cells within the sponge body.

Purple tube sponges grow on rocks in the Caribbean Sea. Sea water leaves the sponges via the large opening seen here at the top of the tubes.

Fact File

SPONGES

Phylum: Porifera (about 5,000 species)

Subkingdom: Parazoa

Where do they live?: Worldwide in fresh water, seas, and oceans

Habitat: Rocky, sandy, or muddy lakes, riverbeds, and seabeds provided there is something to grow on; in fresh water tree roots may be used

Size: 0.1–40 inches (2.5 mm–100 cm) or bigger

Coloration: Various—gray, cream, brown, green, yellow, orange, and red

Diet: Plankton and other tiny food particles

Breeding: Sexual reproduction; sperm fertilizes the eggs inside the sponge body; asexual reproduction is done by releasing small packets of cells called gemmules that develop into new sponges; budding also occurs

Status: Not known

SQUAT LOBSTERS

Despite the "lobster" part of their name, these small, colorful crustaceans are relatives of hermit crabs, not true lobsters. The huge pincers of squat lobsters are often much longer than their bodies.

Hiding by day in a rock crevice, a squat lobster's huge pincers make it look like a much bigger animal. Unlike true crabs—but like their hermit crab cousins—squat lobsters have only three visible pairs of legs, apart from their pincers. (There is a fourth pair of legs, but it is small and tucked out of sight.) Squat lobsters do not carry seashells around for protection like hermit crabs, but their abdomen (hindquarters) is small and curls beneath the body.

Squat lobsters have close relatives called porcelain crabs that have evolved to look like true crabs. As well as having fewer legs visible, they have long antennae (feelers). True crabs have short antennae.

Lively Lifestyles

Squat lobsters are mainly nocturnal (active after dark). They are lively animals, capable of moving fast over the seabed. Many are commensal (live closely with other animals without harming them). One bright pink kind with violet markings lives inside sponges, for example.

Some "commute" up into the water at night to feed, returning to the safety of the sea floor by day. The red squat lobster regularly swims near the surface, feeding on tiny plants. Like other marine crustaceans, squat lobsters lay eggs that hatch into free-swimming larvae (young) that feed in the plankton of the open water. Half-grown and adult squat lobsters are often good swimmers, too, flapping their abdomens to move along.

Many squat lobsters have hairy bodies. As well as using the pincers to catch big prey, they use the hairs to trap small prey, which they comb into their mouth.

Fact File

SQUAT LOBSTERS

Infraorder: Anomura (several dozen species)

Order: Decapoda

Class: Malacostraca

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Widespread throughout the world

Habitat: Various seafloor habitats; a few swim near the surface

Size: Carapace (shell) up to 5 inches (13 cm) long; the pincers may be four times this length

Coloration: Varies, but often brightly colored and patterned

Diet: Omnivorous (will eat most things)

Breeding: Young stages (larvae) swim and feed in open water

Status: Not known to be threatened

SQUID

With their torpedo-shaped bodies, powerful suckers, and acute senses, as well as their ability to move or conceal themselves with great rapidity, squid are among the most sophisticated of all ocean hunters.

Squid belong to the group of mollusks known as cephalopods, which also includes octopuses and cuttlefish. The word "cephalopod" means "head-foot." In cephalopods, the muscular foot seen in most other mollusks has been modified into powerful, suckered tentacles that are attached to the front of the head.

Squid are only found in the sea. They have been in existence since the Cambrian Period, 500 million years ago, and were the dominant hunters in the early seas before the fish evolved. The most famous of these animals are the giant squid, made popular in many adventure stories and even in the media!

Squid are also distant relatives of snails and clams, but instead of being slow creepers or stationary burrowers, they have evolved into elegant swimmers and powerful predators. The cigar-shaped body of the squid is encased by powerful muscles. It encloses a space, the mantle cavity, that is filled with sea water. When the muscles contract (shorten) rapidly, water is squirted quickly out of the cavity through a funnel-like opening. This can be aimed in various directions, allowing the animal to move about by jet propulsion. Slower swimming is achieved by using the fins.

Well-developed Nervous Systems

To be able to swim fast and hunt efficiently, squid need well-developed senses. The squid's body is very sensitive to touch. There are also well-developed

Breeding squid glide about the waters off southern California while they carpet the seabed with their egg cases, from which larvae (young stages) hatch.

Fact File

SQUID

Orders: Spirulida, Sepiolida, Teuthida (about 350 species altogether)

Superorder: Decapodiformes

Subclass: Coleoidea

Class: Cephalopoda

Phylum: Mollusca

Where do they live?: All seas and oceans

Habitat: Surface waters, shallow and deep seas

Size: Mostly from 0.2 inches–5 feet (4 mm–1.5 m); giant squid up to 60 feet (18 m) long

Coloration: Wide range of colors; some patterned

Diet: A variety of marine animals from small plankton to large fish

Breeding: Separate sexes; courtship behavior and mating often in large shoals; male places spermatophore on or in female's body using specially modified tentacle; planktonic larva hatches from egg case and develops into a juvenile squid

Status: Unknown

A close-up of the suckers of the giant Humboldt squid. They are lined with razor-sharp claws or teeth to help grip the prey.

balance organs located in the head. The eyes of cephalopods are among the most advanced of all the invertebrates (animals without backbones). They form images, rather like our own eyes. The brain is relatively large for the size of the animal. The nervous system contains nerve fibers that pass nerve impulses rapidly to the muscles surrounding the mantle. The animal can swim well and escape quickly if necessary.

A Caribbean reef squid displays its attractive glowing colors. The colors are used by the squid for communicating with others of its own kind.

Tentacle Power

The arrangement of the tentacles varies among squid species. Some have eight short and two long ones, while others have six short, two medium length, and two long ones. Depending on the species, squid eat food ranging from tiny planktonic animals to large, rapidly swimming fish. Squid that specialize in catching fish have powerful tentacles and suckers. Passing prey is seized by the two long suckered tentacles that are suddenly shot out from pockets near the mouth. It is then brought to the mouth by the shorter tentacles. Grabbing a slippery fish is a tricky operation, so suckers are attached to the tentacles by short muscular stalks. The suckers help grip the prey.

Some squid have claws on their suckers. The claws can be drawn into the suckers or extended and thrust into the flesh of the prey to grip it more tightly. In some species, the bottom part of the flared tentacle ends are armed with "poppers" that fit into the same part of the next tentacle to help subdue the prey.

As the victim is drawn near the mouth, the jawlike beak shoots forward and bites into the prey. In large squid the beak can be a very

DID YOU KNOW?

- Many shallow-water squid carry light-producing bacteria located near the mantle funnel. The squid use them to produce underwater light at night.
- Some other squid species have luminescent organs that they use to generate light by chemical reactions.
- Squid can eject a cloud of ink as an underwater "smoke screen" to confuse potential predators while they make their escape.
- Some small tropical squid can jet about so powerfully that they fly in the air for short distances.
- Squid generally have quite short lives—lasting for only around three years or so.

powerful tool. It has been used to cut wire fishing lines and bite pieces out of wooden poles.

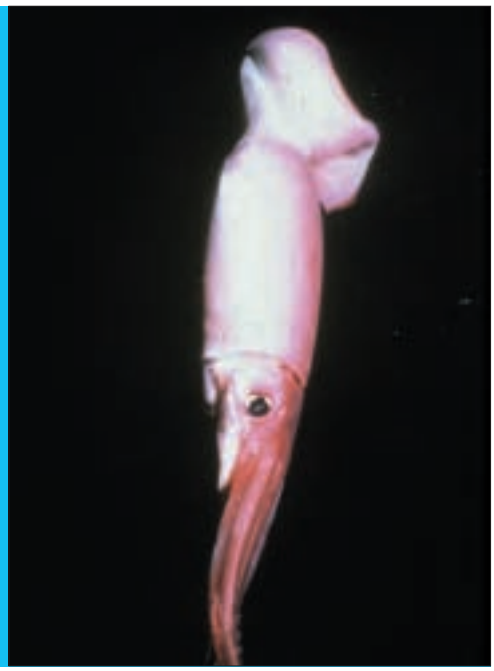
Communal Breeding

Squid frequently move inshore to breed, sometimes in great shoals. They may swim in a special manner, using short puffs of water from the funnel. Two squid will embrace, accompanied by color changes to their bodies. Then a spermatophore (packet of sperm) containing many sperms is passed from the male to the female. The female releases her eggs, which are fertilized and become attached to the seabed as an eggmass.

A Humboldt squid swims in the Sea of Cortez, Mexico. Although not the biggest squid, this species can grow to a length of 7 feet.

GIANTS OF THE DEEP

The first indication that giant squid really existed came when 26-foot-long tentacles were found in the stomachs of sperm whales in the 1890s. Evidence for the final battle between whale and squid was shown by the imprints of the suckers on the whales' skin. The conflict between such huge predators and prey must be a battle worthy of science fiction. When healthy, these squid live in the mid-depths of the oceans and are beyond capture by humans. One specimen washed up in New Zealand had a body 10 feet long and tentacles 52 feet long. Specimens sometimes found cast ashore are probably sick or dying.



STARFISH

With their perfectly shaped and attractively colored bodies, starfish are reminders of happy seaside vacations. But behind their charming looks lie voracious predators, able to stalk and overwhelm even the best-protected prey.

Starfish are the most commonly seen members of the echinoderms—the spiny-skinned animals. All echinoderms have five-sided bodies, and this shape can be seen in many starfish. When adult, the body of a typical starfish is drawn out in five rays, or arms, radiating from a central point. The tube feet are arranged in paired rows on the undersides of the rays and are used for moving about and getting prey. The mouth is on the underside, and the anus is on the top of the central part of the body.

Inside the body there is a large cavity that contains the reproductive and digestive organs. The body surface is adorned with spines, particularly along the edges of the rays and on the upper side. However, starfish spines are not as big as those of sea urchins. The spines are also less mobile and do fewer tasks. Pedicellariae are found on starfish, too. These tiny, snapping jaws help in defense and grooming.

A Variety of Shapes

Although many starfish have five large rays shaped like a classic star, some are cookie shaped with a pentagonal outline. Some are wafer thin, others are plump. Some even have more than five rays—generally multiples of five, but occasionally odd numbers like seven or twenty-three. Some of the pentagonal types are less predatory. Organic food particles land on their upper surface and are carried to the mouth by cilia.

A blue star crawls over the rocks off Papua New Guinea. Less predatory than many starfish, it eats mostly tiny organisms that it grazes from the rocks.

Fact File

STARFISH

Class: Asteroidea (starfish; about 1,500 species), Ophiuroidea (brittlestars; about 2,000 species)

Phylum: Echinodermata

Where do they live?: All seas and oceans

Habitat: Seashore and seabed

Size: From 0.2 inches–5 feet (4 mm–1.5 m) in diameter

Coloration: Wide range of colors; some patterned

Diet: A variety of marine animals, organic particles, small planktonic creatures, eggs of other species, and carrion (dead animals)

Breeding: Separate sexes; fertilization in sea water; a planktonic larva forms that eventually settles on the seabed and becomes a juvenile starfish

Status: Unknown

A mating starfish lifts its body to release eggs or sperm into the current.

The crown-of-thorns starfish feeds on coral polyps and can seriously damage reef communities.

DID YOU KNOW?

- Some tropical starfish are colored blue possibly to prevent them from getting sunburned.
- Starfish have a well-developed eye spot at the tip of each ray, although this cannot form an image like our own eyes can.
- One group of brittlestars, with long branching arms, is known as basket stars because of the shape into which they can fold their bodies.

Slow Hunters

Most starfish are carnivores, and they hunt both moving and stationary animals. A favorite prey is an animal like a clam. Such mollusks are well protected, but they are no match for the starfish with its hundreds of suckered tube feet. Climbing onto the prey, the starfish attaches some tube feet to the two shells and begins to pull them apart. At first the bivalve resists, but the starfish keeps up the pressure on the shells. Eventually the bivalve tires and its shell opens a tiny amount. Then the starfish pushes part of its own stomach out of its mouth and between the victim's shells. It starts to digest the mollusk while it is still inside its shell!

Some starfish feed on corals, smothering the polyps with their stomachs. Others catch and eat fish. One Pacific starfish uses pedicellariae to trap small fish. The fish settles for a moment on the bottom, touching the starfish. The pedicellariae snap shut, catching the fins, and the fish is trapped and slowly engulfed.

Commercial Pests

Oyster fishermen have long known that starfish can be a serious pest in oyster beds, feeding on valuable

Granulated seastars are found on reefs in the Indo-Pacific region, down to depths of 130 feet. They feed on algae and detritus.

oysters and breeding there. One ploy was to catch the starfish, cut them up, and throw the pieces back. But starfish can regrow missing parts, and the pieces that were thrown back sometimes grew into new animals!

Another idea was to try to control the starfish pest by introducing a second species of starfish that preyed on the first starfish. But this second species devoured the oysters first!

Burrowing in Sediments

Some starfish live as burrowers. Such species may have relatively flattened bodies. Their tube feet lack suckers, but they have more pointed ends that assist their movements under the sand. Once in the sand, they can move well, track down prey, follow its scent, and capture it. To see a burrowing starfish emerge from below the sand is a dramatic sight.

BRITTLESTARS

Brittlestars (right) are closely related to starfish. They get their name from their brittle, snakelike arms that are covered with spines. The body organs are contained within the central disk, with the mouth on the underside. There is no anus. Brittlestars move by flexing the arms.

The suckerless tube feet of brittlestars are used for food gathering in a variety of ways. These animals feed by filtering the water for organic particles, engulfing small organisms and fish eggs whole, and eating carrion. In ideal conditions, brittlestars can appear in very large numbers, dominating the seabed and providing a plentiful source of food for various bottom-feeding fish.

STICKLEBACKS

A number of sharp, pointed spines run along the back of these small fish. They protect the stickleback by sticking in a predator's mouth, making it hard for them to be swallowed.

One of the ways in which sticklebacks can be told apart is by the number of spines along their back. The most widely distributed species is the three-spined stickleback. Unlike most fish, it can be found living in both fresh water and salt water throughout its range. However, the fish's name is not always an accurate indication of the number of spines on its back. For example, the nine-spined stickleback has between six and twelve spines on its back; to add to the confusion, it is also known as the ten-spined stickleback. The largest member of the family is the fifteen-spined stickleback, but this species may have between fourteen and seventeen spines on its back.

Nest-building

Male sticklebacks establish territories at breeding time, which they will defend vigorously. They build a tunnel-like nest with strands of aquatic vegetation anchored together using a special gluey material made by their kidneys. Once the nest-building is complete, the male attracts a mate by means of spectacular dancing displays, with plump females seeming to be the most desirable. Each female may lay up to 600 eggs, with several in succession often visiting the nest. The male then guards the eggs until hatching begins after a week or so. The young sticklebacks remain close to the nest for a similar period of time, being watched over by their father until they leave to live on their own.

In the spring, male three-spined sticklebacks become much redder on their underparts, while nine-spined sticklebacks turn almost black.

Fact File

STICKLEBACKS

Family: Gasterosteidae (11 species)

Order: Gasterosteiformes

Where do they live?: Occur very widely throughout the northern hemisphere, as far north as Baffin Island in North America

Habitat: Typically in shallow water, where there is aquatic vegetation and a gentle current, but can occur at depths down to 180 feet (55 m)

Size: From 2–9 inches (5–23 cm); those living in marine habitats usually slightly larger than examples of the same species living in fresh water

Coloration: Variable; can include shades of blue, green, black, brown, and red, with males being more vibrantly colored

Diet: Invertebrates; also eat fish eggs, larvae, and small fish

Breeding: Male builds a nest, in which females are enticed to lay their eggs

Status: Generally not threatened, apart from the Greek nine-spine stickleback, which is regarded as being critically endangered

STURGEONS

Sturgeons are famed for their long lifespan, with some individuals living for over a century. They are also well known for their eggs, which are sold as the delicacy called caviar.

Sturgeons are an ancient group of fish, extending back in the fossil record for over 100 million years, to the Cretaceous Period. The family today includes the beluga, which is the largest freshwater fish in the world. Although it grows up to 28 feet in length, it is a fish that is not often seen. Instead, the beluga hides away, remaining close to the river bottom, where it digs in the sediment in search of food such as worms. The white sturgeon, that can grow to about 20 feet, is the largest of North America's freshwater fish.

Body Make-up

Unusually, sturgeons have skeletons made of cartilage (gristle) instead of bone. Unlike many fish, their backbone also extends into the upper part of their tail. One of the more obvious features of sturgeons is the presence of five rows of bony plates, called scutes, that run along each side of the body. They also have structures called gill rakers that enable them to filter food particles from the water as it passes over the gills located on each side of the head. Their mouth is on the underside of the body, and can form a sucking tube. There are four sensitive barbels, or feelers, surrounding the mouth. Adult sturgeons have no teeth in their jaws.

These huge and ancient fish have undoubtedly suffered from overfishing, with sturgeons being caught primarily for their eggs, which are sold as caviar. Habitat changes have also had a serious effect on their

The position of the sterlet's mouth on the underside of the body shows that these fish feed mainly on the bottom, with their barbels helping them to find food.

Fact File

STURGEONS

Family: Acipenseridae (24 species)

Order: Acipenseriformes

Where do they live?: Throughout the northern hemisphere, in North America, the Atlantic Ocean, and the Mediterranean, as well as in Adriatic, Caspian, and Black Seas and associated river systems

Habitat: Some species occur in fresh water—in lakes and larger rivers; marine species migrate from the sea to spawn in rivers

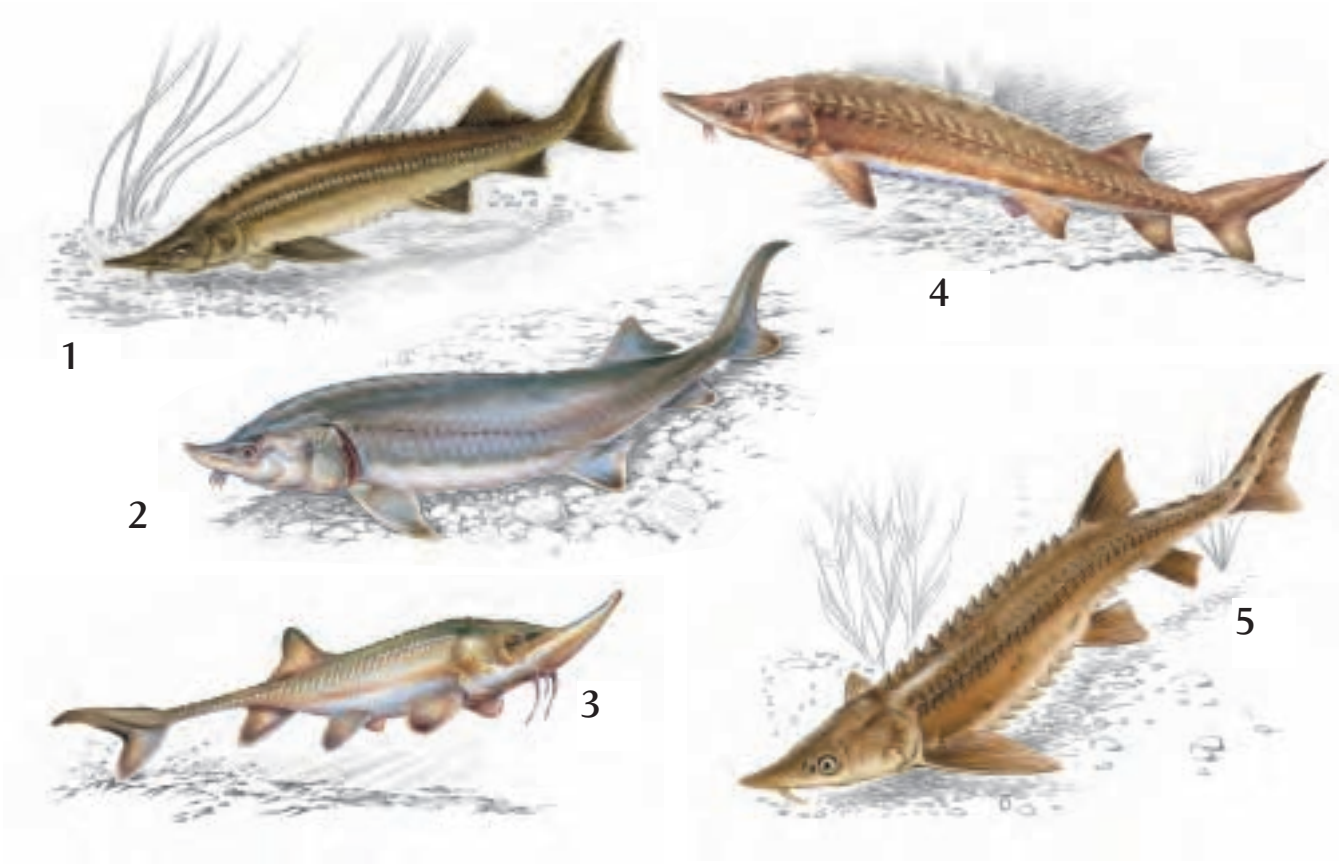
Size: From about 4–28 feet (1.2–8.6 m)

Coloration: Quite dull in color, generally shades of gray and black, with the flanks and belly whitish

Diet: Usually bottom-living invertebrate animals

Breeding: Spawning occurs in flowing waters, typically over gravel or sand, with millions of eggs being laid by individual fish

Status: Ranges from vulnerable to critically endangered, depending on the species; the Baltic sturgeon and beluga are most under threat



1. *Sterlet*
2. *Beluga*
3. *Pallid sturgeon*
4. *Baltic sturgeon*
5. *Lake sturgeon*

numbers in certain parts of their range. The Syr-Dar shovelnose sturgeon is now believed to be extinct in the wild for this reason.

Sturgeons will migrate when it is time for spawning, and changes to the river systems—such as the building of dams, canals, bridges, and other obstructions—may block off the usual routes back to their spawning grounds. Those species that inhabit the oceans grow to a larger size than their freshwater relatives because they can find food more easily there throughout the whole year.

Spawning Rituals

Sturgeons usually spawn every three to five years, rather than annually. Having spawned, marine sturgeons then head back toward the sea. By this stage they will be weakened and in poor condition due to the effort of making the journey upriver to spawn, and by having to cope with the changing water conditions that affect their biology. Furthermore, they will not have fed during their migration.

The young sturgeons, too, will soon be starting to move down river. Some of them will reach the sea by the

DID YOU KNOW?

- The heaviest sturgeon ever caught was a beluga, taken in 1926. It weighed over 2,200 pounds and yielded some 400 pounds of roe—worth over half a million dollars, based on today's prices for caviar.
- Beluga is the most highly prized variety of caviar, being distinguished largely by its color, which can vary from gray to black.
- A female sturgeon may produce over 3 million eggs during a single spawning.

following fall, although other individuals may remain in freshwater surroundings for up to four years. Their development then depends to a large degree on their surroundings. Males typically mature before females, at seven to nine years old, although those in cold northern waters may not breed until they reach an age of about thirty years.

Females usually do not spawn until they are between eight and fourteen years old, but this period can also be prolonged, depending on their surroundings. The female's ovaries account for about a quarter of her body weight. A 440-pound female sturgeon can produce more than 100 pounds of roe (egg mass), made up of 1.6 million individual eggs.

A FARMED FUTURE ?

In the past, female sturgeons have been killed to obtain their eggs in order to satisfy the huge demand for caviar. But now some sturgeons are being farmed and the eggs removed by a process called "stripping," which does not kill the fish. Not only could such farms help ease the pressure on wild-caught sturgeons, but they could also help to repopulate river systems with young fish in areas where sturgeons have become scarce or even died out (see above). The only problem is that it will take probably a decade or more, due to the life cycle of these fish, before farming can have a real impact on populations.

SWORDFISH

The swordfish is a streamlined, fast-swimming fish. As its name suggests, it also has a fearsome, long swordlike structure complete with sharp edges extending out from its snout.

The purpose of the swordfish's elongated snout is not entirely clear. It does not seem to be used as a weapon, although occasionally there are reports of swordfish ramming boats. In one case, the sword had penetrated the wooden hull to a depth of 22 inches! Whales have also been found with swords from these fish embedded in their blubber. Almost certainly, however, these are the result of accidental collisions.

The swordfish has a streamlined body shape, which allows it to swim at speeds of up to 56 miles per hour. Hitting any type of obstruction at this speed would result in the sword becoming embedded and snapping off. It is much more likely that the sword is used for waving through shoals of fish, inevitably injuring some, which the swordfish can then catch more easily.

Swordfish Breeding

Swordfish tend to live on their own for most of the year. However, at the start of the breeding period they migrate to their traditional spawning grounds in the Sargasso Sea, in the North Atlantic Ocean south of Bermuda. A single female may be accompanied by up to three males. A female swordfish may produce as many as 29 million tiny eggs, each measuring 0.04 inch across, which she scatters randomly in the water.

By the time the young swordfish reach 0.4 inch in length, they already have a well-formed sword and are efficient predators of tiny planktonic creatures.

Swordfish meat is highly prized. These ocean giants are sought by commercial fishing boats and by game fishermen, who try to catch them on a rod and line.

Fact File

SWORDFISH

Xiphias gladius

Family: Xiphiidae

Order: Perciformes

Where do they live?: In tropical and subtropical seas

Habitat: Generally in the open ocean, but may be found closer to the coast on occasions

Size: Can grow up to 15 feet (4.6 m)

Coloration: Blackish, fading to light brown or gray on the lower part of the body

Diet: Mainly fish, squid, and crustaceans

Breeding: Migrate to breeding grounds in the Sargasso Sea, which is an area covered with huge mats of seaweed that provide a relatively secure environment and food for the young swordfish

Status: Numbers of these fish have declined over recent years, and protective measures may be needed

SWORDTAILS

The popular aquarium varieties of the swordtail are far removed in appearance from their drabber-looking wild relatives, although both types give birth to live young.

The name "swordtail" was given to these fish due to the elongated swordlike extension on the lower part of the tail (caudal) fin of many males. This feature is also reflected in their scientific name, which comes from the Greek word *xiphos*, meaning "sword." Females have rounded tails. As with other livebearers, female swordtails also grow larger than males. In the wild, these fish are quite plain in color—often greenish overall. Captive-bred strains are much more variable in coloration, frequently being bright orange, sometimes with black markings. The fin shape has also been affected by domestication, with the variety known as lyre swordtails having a symmetrical extension, in the shape of another sword, at the top of the dorsal fin.

Unusual Breeding Habitats

Another difference between the sexes is that the male's belly (anal) fin has developed into a tubelike structure called a gonopodium. This provides a means of fertilizing the eggs internally in the female's body. They will then develop there, with live young being produced. The number of offspring that a female produces depends on her size, with larger individuals having bigger broods of up to 200 young.

Unfortunately, swordtails have no maternal instincts, and particularly in aquarium surroundings, the tiny young will be eaten by their mother unless they can be separated by a partition or placed in another tank.

A small shoal of ornamental swordtails swims in an aquarium. Males can be quite aggressive toward each other, but less so if more than two are kept together.

Fact File

SWORDTAILS

Genus: *Xiphophorus*

Family: Poeciliidae

Order: Cyprinodontiformes

Where do they live?: Eastern parts of Central America, from Vera Cruz in Mexico southward to northwestern parts of Honduras; introduced populations of these fish also now occur in various parts of Africa

Habitat: Favor relatively swift-flowing stretches of fresh water, where there is plenty of aquatic vegetation growing; also encountered in springs and canals

Size: Male's sword fin can be up to 6 inches (15 cm) long; the fish are otherwise 3–4 inches (7.5–10 cm) in length

Coloration: Olive-green with variable red speckling, particularly on the dorsal fin

Diet: Omnivorous, feeding on plant matter, small invertebrates, and other smaller fish

Breeding: Females can give birth to several broods in succession after mating, producing offspring every month or so under favorable conditions

Status: Generally not thought to be under threat

TETRAS

Such is the beauty of these little jewel-like fish that when the first neon tetras became available to fishkeepers in the 1930s, they changed hands for the equivalent of a month's pay.

Tetras have a wide distribution, but in general it is the Central and South American species that are most commonly bred for the aquarium trade. One of the most popular species is not kept for its color or its beauty, however, but as a zoological oddity. Occurring in a dark cave system in the San Luis de Potosi area of Mexico is a small, eyeless, pink-bodied fish known as the blind cave characin. Above the caves lives a silvery Mexican tetra of similar size, which can see well. Scientists think that these Mexican tetras are the direct ancestors of the cave-dwelling fish, whose appearance has been dramatically changed by their environment.

A Life in the Dark

Occasionally, floods carry Mexican tetras from the rivers above into a cave known as Cueva Chica. When this happens, these fish and the blind ones interbreed in the darkness, suggesting they are actually the same species. The results of such matings produce offspring with a range of features. Some look like the normal Mexican tetras; some are partly colored and can see well; others look just like the blind cave fish.

Blind cave characins are not blind when they hatch. Instead, fatty deposits and skin grow over their eyes, which would be of no use in the darkness. These fish find their food and escape danger by detecting pressure changes nearby in the water. They do this using sensory canals that run along each side of the body.

The attractive neon tetra, a popular freshwater aquarium fish, grows to a length of 1.5 inches. In the wild, it is found in the Putumayo River, Peru.

Fact File

TETRAS

Families: Characidae (New World tetras), Alestidae (African tetras); several hundred species altogether

Order: Characiformes

Where do they live?: From the southern United States and Mexico down to tropical and subtropical parts of South America; also in tropical areas of Africa

Habitat: Fresh water, from creeks to large lakes—such as Lake Malawi in Africa—as well as rivers and flooded forests; 2 species live entirely in caves

Size: Typically 0.8–4.7 inches (2–12 cm), but can be larger

Coloration: Variable, from pink through silvery shades to brightly marked multicolored species

Diet: Mainly predatory, hunting invertebrates and other fish; some mainly eat plant matter

Breeding: All species reproduce by means of eggs, which are scattered randomly

Status: Generally not uncommon, although the naked tetra from Argentina is regarded as endangered, while the blind cave characin is considered vulnerable

A shoal of black neon tetras swim in an aquarium. These fish grow to a length of 2 inches. They originate from the Taquari River in Brazil.

They are connected directly to the brain and are known as the lateral line system. Blind cave characins also probably have a keen sense of smell.

Most tetras are small, relatively peaceful fish, but there are some exceptions. One such example is the fierce fang-toothed tigerfish that inhabits the Zaire River in Africa. These fish actually look more like piranhas than tetras. Tigerfish do not just look like piranhas, they also have a similarly strong appetite for flesh. Also known as water dogs because of their feeding habits, tigerfish have powerful, streamlined bodies and a large forked tail that help them accelerate. They can usually swim faster than many other fish and invertebrate prey. Once grasped by their large, fanglike teeth, there is no chance of escape for their prey. The teeth of the upper jaw alternate with those in the lower jaw, creating a superefficient trap.

DID YOU KNOW?

- Some Amazon fish, such as the uaru, produce special food for their young fry in the form of body mucus which the young fish nibble, while staying close to their parents. Rummy-nosed tetras will zoom in on this protein-rich food as well, darting in among the young uarus to feed.
- Tetras can hear sounds under water, giving added protection against predators, thanks to the connection between their inner ear and swim bladder.
- Tigerfish eggs may hatch in as little as fifteen hours after laying, while the young of the Congo tetra may not emerge from their eggs for six days.

FOOD FISH AND GIANTS

The majority of tetras are too small to be useful as food fish, with the notably exception of the African silver tetra, also known as the silverside. These common fish can grow up to 17 inches in length and weigh up to 1 pound.

The largest tetra in the world is also a member of this family. The goliath tigerfish (see above) can grow up to 4.5 feet in length and may weigh as much as 110 pounds when fully grown.

Black Water

South American tetras in particular are found in so-called "black water" areas, where visibility is poor. This is caused by decomposing plant matter in the water, which often results from overhanging vegetation, and it releases chemicals called tannins. These cause the water to become acidic and also highly colored. The tannins are so important to the well-being of the fish that breeders of such species in aquarium surroundings normally use an artificial black water extract to create suitable conditions for spawning, as well as adding aquarium peat to the tank filter, which has a similar effect.

The red-eyed tetra is a peaceful but active species that grows to a length of 4 inches. Its native home is the Niger River Delta as far as Lagos in Nigeria.

Safety in Numbers

Tetras are lively fish that live in shoals. They have a very sleek, streamlined shape. This enables them to swim easily and quickly through the water. They can turn together in a tight formation to avoid a predator if necessary. Living in a shoal makes it harder for a predator to home in on an individual. These fish also have good vision to help them see danger.

Tetras tend to inhabit the mid-level in streams, lakes, or rivers. When feeding, they may dart up to the surface for a morsel of food—such as an insect—or down to the bottom.

TOADFISH

Squatting in a cave on the seabed with their bulging eyes and wide-gaping mouth, it is quite easy to see how these unusual fish get their common name, for they bear a striking resemblance to toads.

Toadfish even resemble toads in their coloration. Their skin is smooth, slimy to the touch, and almost entirely scaleless. Toadfish have irregular growths and whiskers around the eyes, the jaws, and the head. These break up the body's outline and help to disguise this fearsome ambush predator. They also have many very sharp teeth, and they will snap aggressively at anything that comes within range.

Self Protection

Toadfish are well protected against predators. They have three spines in the first dorsal (back) fin, that can be raised as a threat gesture. Some species have added protection from predators in the form of venom. This is present in the spines of the dorsal fin, which are hollow, and is injected into the jaws of any creature that tries to seize one of these fish. A sting from a toadfish is not usually powerful enough to kill a human, but the venom contains powerful digestive enzymes, so the tissue damage can be severe, and the injury is also very painful.

Toadfish Parenting

When seeking a mate, a male toadfish will grunt and hum, generating sounds from his swim bladder. Once the female has been attracted to his lair and has spawned, the male fertilizes the eggs, fans them with his fins, and stands guard over them until they hatch.

Toadfish have big mouths for grabbing anything that comes within range, and powerful jaws that can easily crush the hard shells of crustaceans and mollusks.

Fact File

TOADFISH

Family: Batrachoididae (about 69 species)

Order: Batrachoidiformes

Where do they live?: Mainly restricted to Atlantic and Pacific waters off North and South America

Habitat: Essentially marine and bottom-dwelling, although the large-eye toadfish may venture into both estuarine and fresh water

Size: Up to 15 inches (38 cm)

Coloration: Typically drab brown and greenish-yellow, with the color being distributed in blotches and bands

Diet: Omnivorous, but mainly feed on other fish, mollusks, and crustaceans

Breeding: Occurs in shallow water in spring and summer; the eggs are large—typically about 0.25 inch (0.5 cm) in diameter; they are guarded by the male on his own

Status: Not generally thought to be declining in numbers

TRIGGERFISH

Like chameleons, triggerfish can swivel their eyes independently. This allows them to watch out for predators with one eye, while using the other eye to deal with their own prey.

The triggerfish has an unusual dorsal (back) fin. The fin has two spines; the first one is long and stout, and the second one is shorter and more slender. The dorsal fin normally lies flat. But when the fish is alarmed or needs to defend itself, it raises the first spine. Once raised, the spine helps the triggerfish to wedge itself securely in a small cave or crevice, out of reach of a potential predator. As soon as the first spine is raised, the second spine is also pulled up, and it automatically locks the first spine firmly in position. The locking system is operated by a bony knob at the base of the second spine. It fits into a hollow at the bottom of the first spine, stopping it from being lowered so long as the bony knob is in position.

Sharp, Spiky Food

Sea urchins form a big part of a triggerfish's diet—in spite of the fact that the urchins' bodies are well protected by spines, and may be able to inject poisons, too. The triggerfish's body is designed to enable it to prey on these invertebrates in relative safety. Its head is long and tapering, with the easily damaged eyes set high up and well back from the mouth. There are also powerful teeth in the triggerfish's jaws. When feeding on sea urchins, triggerfish pick them up and drop them onto the seabed. Once the sea urchin lands upside down, the triggerfish can then rip away the shorter spines there, reaching the soft inside parts of its body.

The triggerfish's body is covered with thick, tough scales and smaller spines. These provide more protection. Triggerfish can also inflict a painful bite.

Fact File

TRIGGERFISH

Family: Balistidae (40 species)

Order: Tetraodontiformes

Where do they live?: Atlantic, Mediterranean, Indian, and Pacific Oceans, mainly in tropical and sub-tropical seas

Habitat: Often encountered in the vicinity of coral reefs, in shallow water typically down to a depth of about 165 feet (50 m)

Size: From about 12–43 inches (30–110 cm)

Coloration: Highly variable, with some species having vivid patterning, while others are relatively plain in appearance

Diet: Sea urchins, as well as various crustaceans and other invertebrates

Breeding: Eggs are laid on a rock, with the site being cleaned by the male fish beforehand; the female then usually guards the nesting site after spawning, until the eggs hatch

Status: Not generally thought to be declining in numbers

TROUT

Each of the various races of trout differs throughout its wide geographical range, causing the fish to be called many different names. However, all are famed as both game and food fish.

The different races (types) of *Salmo trutta* are distinguished by their appearance and often also by the habitat in which they live. There is the Aral sea trout and the Amu-Darya trout, as well as the great spotted trout. The other three races are the river trout (also known as the brown trout), the lake trout, and the sea trout. The sea trout is described by a wide variety of other local names, including the brook trout, the Orkney sea trout, and the gillaroo.

Living in Different Environments

Few fish adapt more readily to different environments than these trout, changing in appearance and habits to suit their surroundings. This is shown by the river trout that live in Lough Melvin, a lake lying between Northern Ireland and the Irish Republic. There is the sonaghen variety, which is heavily spotted, steely blue in color, and lives in the open area of the lake, filtering invertebrates from the water as it swims. The gillaroo has a sandy colored lower half to its body, with red spots, and lives on the western side of the lough, where it hunts bottom-dwelling invertebrates. The third variety of river trout that has evolved to live in the lake is the ferox. It is silver or brown in color, and is highly predatory on other fish species.

The river or brown trout is bred commercially in large numbers, both as a food fish and also for anglers to catch. Where conditions are ideal, and food plentiful,

River trout are territorial fish, and are likely to establish an area on the river bottom, which they will defend by driving away would-be intruders.

Fact File

TROUT

Salmo trutta

Family: Salmonidae

Order: Salmoniformes

Where do they live?: Widely distributed through Eurasia; also introduced outside its natural range—to North America, for example—as a popular game fish

Habitat: Some types, such as sea trout, spend parts of their lives at sea, but return to spawn in fresh water, whereas the lake trout is found only in well-oxygenated fresh water

Size: From about 9.4 inches–4.6 feet (24 cm–1.4 m)

Coloration: Generally, sea and estuarine trout have relatively few dark spots, whereas freshwater trout are heavily spotted; black or brownish along the back, becoming paler on the underparts

Diet: Mainly aquatic and flying insects, as well as crustaceans; larger individuals will eat amphibians and fish

Breeding: Usually occurs between October and March, in fresh water

Status: Generally not under threat, with the exception of the endangered Aral trout

The brown trout can reach a weight of about 44 pounds.

these trout can grow up to 39 inches, with a maximum life expectancy of around five years. In less ideal surroundings, however, they may only grow to about 8 inches long.

These trout are found in relatively shallow areas, often in fresh water, but they will range into brackish water (part fresh water and part sea water), and even the sea. However, they will swim back into the rivers when they are ready to spawn. They favor fast-flowing streams, where the water is well-oxygenated. They often feed by facing upstream, waiting for invertebrates and other small creatures to be swept downstream almost directly into their mouths.

River trout do not migrate for the purposes of breeding. Instead, they spawn close to their established territory. If they encounter rapids or waterfalls on the way to their breeding grounds, they will leap over the obstructions. Pairs spawn on the riverbed, digging a small depression and then covering the eggs with gravel, which helps to prevent them from being swept away in the current. Trout are likely to spawn several times during their lifetime, instead of just once like salmon.

Newly hatched brown trout carry their yolk sacs, which provide them with food for the first few weeks of life.

DID YOU KNOW?

- The Amu-Darya trout is found in the river of this name that flows into the Aral Sea. But the fish's population there is quite stable, because the water is flowing into the sea rather than out of it, and the saltiness of its habitat has not increased significantly.
- Trout can be relatively slow to mature. Lake trout, for example, may not spawn for the first time until they are seven years old.
- Amu-Darya trout live either in rivers or lakes. Young fish which hatch in rivers may remain there for up to three years before moving to lakes.

RAINBOW TROUT

The rainbow trout (*Oncorhynchus mykiss*) is a quite different species from *Salmo trutta*. This particular trout is native to North America, but it has been widely introduced elsewhere, with populations of rainbow trout now established in over 80 countries. The rainbow trout is distinguished by the beautiful pinkish sheen present on its flanks. Some populations are migratory, heading downriver to the sea, whereas others remain in fresh water throughout their lives. Those found in sea water are often referred to as steelheads, because they lose their rainbow coloration during this phase, being transformed to a steel-gray and silvery appearance instead. They again become rainbowlike in color when they return to fresh water to spawn.

Steelhead rainbow trout turn steel-gray in color during migration (above left), but the freshwater varieties remain rainbowlike in their coloration (above right).

Great Spotted Trout

This race is only found in the seas around the Mediterranean island of Corsica. It is unusual because it may be found in quite deep water, from 3,300 down to a depth of 8,200 feet. It may also be found in freshwater streams as well as near coasts and in estuaries in the Corsican area. Not much is currently known about the habits of this fish, however. It is possible that it favors shallow water like other races of trout, and only occasionally disappears into the depths of the sea.

Trout in Danger

The Aral trout is only found in the Aral Sea, which extends into the Asian state of Kazakhstan, and the

Trout can be farmed successfully. Some are supplied directly as food, and others are used to stock waters with sport fish for anglers to catch.

mouths of rivers flowing into it. Unfortunately, the Aral Sea has become significantly smaller in area, from about 25,660 square miles in the 1960s down to a third of this size today. Alongside this change, the saltiness of the water in the lake has increased enormously. It is now about three times higher than it was thirty years ago. Some of this water may be seeping away naturally, but huge amounts are taken to irrigate the neighboring fields. Water pollution is also a problem that threatens the survival of the Aral trout.

Sea Trout

The sea trout shows the highly adaptable nature of this species. For much of their lives, these fish live in the sea, but they can also live in fresh water, from lakes to mountain streams. After hatching, most young sea trout move downriver from where they were spawned, out to sea. Some, however, wait about three years before they migrate out to sea. And some one to two percent of these fish stay in fresh water all their lives.

Sea trout usually spend two to five years at sea before returning to fresh water to spawn. These fish are the giants of the group, weighing up to 110 pounds. This is because they have a wider range of nutritious food always available to them while at sea. In spite of the challenges of returning

When early European settlers arrived in America, they thought that the brook char was very similar in appearance to the sea trout. They therefore named it the brook trout, which is another of the sea trout's local names. This created confusion between these two fish.

to fresh water to spawn, sea trout are longlived fish, with a life expectancy of up to thirty-eight years. Large females produce up to 10,000 eggs during each spawning, usually between October and January.

Lake Trout

These fish can also grow quite big, because they live in large expanses of water where food is likely to be plentiful. This trout is also called the salmon trout because of its pink flesh, resembling that of a salmon. The color is due to a natural coloring substance found in the crustaceans it eats. It also has a particularly striking spotted patterning on its body. Unlike its other relatives, the lake trout spends all its life in fresh water.

Trout on the Move

Trout have been introduced to many places around the world, often far from their natural range in Europe and Asia. Their adaptability is such that they have often settled readily in new habitats. The first introductions into the United States took place in 1883, when German fish were transported to New York State and Missouri. Earlier, in 1864, trout from Britain had been introduced into Australia, and in 1867, German stocks of this fish were taken to New Zealand. In 1882, Australian trout were taken and released in Sri Lankan waters, but there, however, they did not become established.

In spring, cutthroat trout gather together in Henry's Lake, Idaho, ready for breeding.

CUTTHROAT TROUT

The cutthroat trout (*Oncorhynchus clarki*) is a western North American species closely related to the rainbow trout, with which it will readily interbreed. Most populations stay in fresh water throughout their lives. However, some live mainly in the Pacific Ocean as adults and return to fresh water from fall through early spring, to feed and to spawn. Their coloration can range from golden to gray to green on the back, depending on subspecies and habitat. However, all have distinctive red, pink, or orange marks on the underside of the lower jaw.

TUNA

These large marine fish live in shoals, and they are capable of swimming through the oceans at high speed, with their body shapes and special biology designed to match their athletic lifestyles.

The body of a tuna is like a spindle—in other words, it is tapered at both ends. This shape allows the fish to cut through the water with little resistance. It means that the fish uses less energy when swimming—particularly as its entire body, including the fins, are streamlined. Furthermore, the swimming muscles are deep within the fish's body, not just under the skin as in other fish. This arrangement prevents the tuna's body from flexing from side to side as it swims, which also helps it swim very efficiently. The tuna's swimming behavior appears almost effortless, even when they accelerate in quick bursts.

Warm-bodied Fish

Unlike most other fish, tuna can keep their body temperature higher than that of the water in which they are swimming. This helps their muscles to work better. It also gives them a great advantage when chasing prey whose body temperature depends on the temperature of the sea around them. Tuna are able to achieve this feat thanks to an unusual arrangement of blood vessels, known as the rete mirabile. It works by transferring heat from one set of blood vessels to another. Cold, oxygen-rich blood from the gills is channeled so that it passes very close to blood vessels carrying much warmer blood from the depths of the body. This warms up the cold blood before it flows to the fish's muscles, making them work better.

Some tuna are very rare. The southern bluefin tuna (left) is the most endangered species. Over 90 percent of its total population has been lost since the 1950s.

Fact File

TUNA

Family: Scombridae (about 54 species)

Order: Perciformes

Where do they live?: Widely distributed in the world's tropical and subtropical seas, with most species ranging widely through the oceans

Habitat: The open sea, generally quite close to the surface

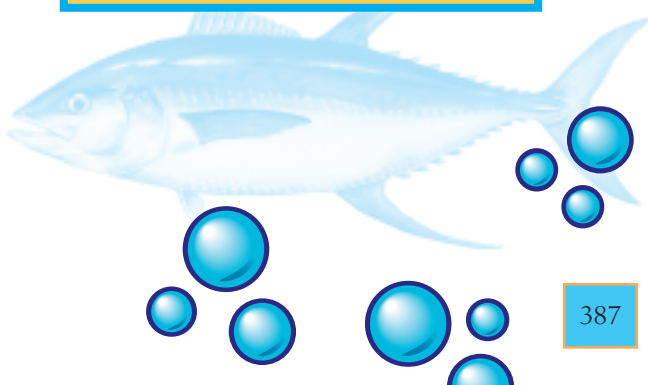
Size: Up to 15 feet (4.6 m), with northern bluefin tuna of this length weighing up to 1,500 pounds (685 kg)

Coloration: Generally bluish-colored backs, becoming more silvery on the underparts

Diet: Mainly other fish, crustaceans, and squid

Breeding: The season is defined by locality and species—some spawn throughout the year, but southern bluefin tuna may only spawn once in their lifetime; all scatter their eggs in the water, releasing as many as 10,000 eggs at a time

Status: Commercial fishing pressures are threatening a number of species; the southern bluefin tuna is critically endangered



WATER FLEAS

Water fleas are very common freshwater animals, swimming jerkily about by flicking their limbs. They and their relatives have unusual life cycles, often existing in extreme conditions.

Water fleas are related to crabs, lobsters, and shrimp. They are very successful in their chosen habitats. Water fleas live mainly in ponds and lakes, where they swim in the open water, sometimes in huge numbers. Fish love eating them, which gives water fleas a problem! So they have developed an unusual life cycle to help them cope with predators. In the summer, the number of water fleas can grow quickly, because the eggs develop without the need for males to fertilize them. Summerborn water fleas are also bigger, spikier, and more transparent, helping them avoid predators. In the fall, males appear, and fertilized eggs are produced that can survive through the winter period.

Extreme Lifestyles

Water-flea relatives go about their lives in various ways. Tadpole shrimp root around in the muddy bottoms of ponds, whereas the delicate fairy shrimp filter food from the water as they swim—but always upside down! They both live in temporary pools that may dry up after a few weeks, but where there are no fish to eat them. They produce eggs that can survive dry conditions for many years, during which dust storms may blow the eggs to new places. Brine shrimp can live in salt lakes where fish and other predators would die. With no competition, trillions of brine shrimp may live in some locations. This can provide a feast for many birds, which may fly miles to eat the brine shrimp.

Daphnia ***(left) is one of the most common species of water flea. Despite their common name, water fleas are not related to true fleas, which are insects.***

Fact File

WATER FLEAS

Order: Cladocera (100 species)

Class: Branchiopoda

Subphylum: Crustacea

Phylum: Arthropoda

Where do they live?: Worldwide in suitable habitats

Habitat: Fresh water, including pools that dry up seasonally; some live in salt lakes

Size: Most species from about 0.01–0.1 inch (0.3–3 mm)

Coloration: Mostly dull brown and gray; some partly transparent

Diet: Most filter tiny food particles from water; a few are predators

Breeding: Females keep eggs in their bodies until they hatch; many species produce special eggs to survive dry conditions

Status: Not known to be threatened

WHALE SHARK

In spite of its fearsome appearance, the huge whale shark is an inoffensive filter-feeder that consumes vast amounts of microscopic marine plankton. It is the largest of all living fish.

Whale sharks face an uncertain future in the world's oceans, for they are being caught in increasing numbers. Whale sharks often gather in large groups, and this makes it easy for people to catch them. No one knows how many whale sharks are caught every year, but in areas where they have been heavily fished, their numbers have dropped significantly. Even when they are not being caught, whale sharks are often disturbed by the constant attention from divers and ecotourists who try to get close to them.

A Mystery Solved

In 1953, an egg case containing a whale shark embryo was netted in the Gulf of Mexico. Unusually, though, this egg case had very thin walls compared with the tough, leathery egg cases of other known egg-laying species of shark. It also lacked the characteristic tendrils—the fibrous strands on the egg case that help it become attached to seaweeds and other objects in the sea, rather than drifting in the ocean currents.

It seemed, therefore, that the whale shark might be an egg-laying shark species, albeit one with unusual egg cases. Then, in 1995, a pregnant female was caught off the coast of Taiwan. Its body contained 300 embryos in a range of development stages. Most were still in their egg cases, but some had already hatched out and were about to be born. This discovery confirmed that the whale shark is actually a livebearing species.

A whale shark cruises through the ocean, its huge head dwarfing the escorting remoras—smaller fish that hitch a ride on other marine species like sharks.

Fact File

WHALE SHARK

Rhincodon typus

Family: Rhincodontidae

Order: Orectolobiformes

Where do they live?: Tropical and temperate waters in the Indian, Pacific, and Atlantic Oceans

Habitat: May swim close inshore and in the open ocean, to a depth of about 425 feet (130 m)

Size: Typically around 39 feet (12 m) but may grow to 59 feet (18 m)

Coloration: Grayish body color, with a highly individual pattern of spots and streaks; the underside of the body is white

Diet: Feeds on zooplankton (tiny marine life); also small fish and similar creatures filtered out in vast volumes by sievelike structures known as gill rakers

Breeding: Live-bearing, producing hundreds of offspring; newborn whale sharks measure approximately 28 inches (71 cm) in length

Status: Considered vulnerable, and has declined in some areas

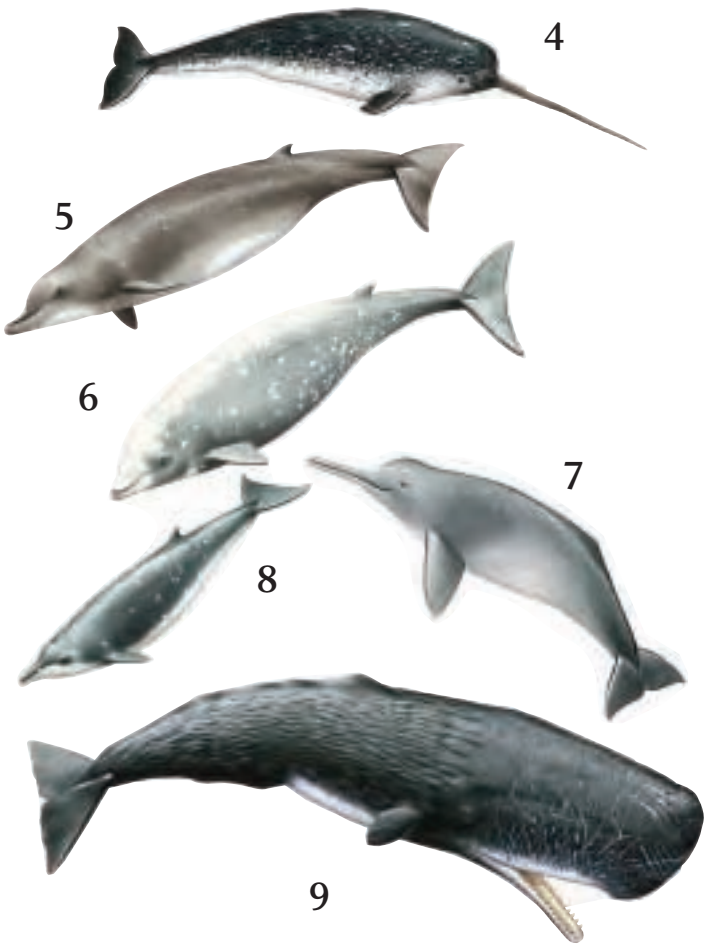
WHALES AND DOLPHINS

Whales, including dolphins, were once mistaken for fish because they have a similar body shape and cannot survive out of water. However, unlike fish, whales and dolphins breathe air, have warm blood, and give birth to live offspring, which they nurse on milk.

TOOTHED WHALES

1. *Bottlenose whale*
2. *Dall's porpoise*
3. *Shepherd's beaked whale*
4. *Narwhal*
5. *Baird's beaked whale*
6. *Cuvier's beaked whale*
7. *Ganges river dolphin*
8. *Sowerby's beaked whale*
9. *Sperm whale*

Leaping high out of the water, a dolphin reveals its sleek, muscular body. Dolphins may use this behavior to herd fish and attract mates. Note the large blowhole on top of the head.



Fact File

TOOTHED WHALES

Families: 10 families (72 species)

Order: Cetacea; suborder Odontoceti

River dolphins: 4 species of freshwater dolphins from South America and Asia

Dolphins: 36 or more species of athletic, streamlined small- to medium-sized toothed whales; worldwide oceans and seas

Porpoises: 6 species; shallow and coastal seas

Beluga and narwhal: 2 species from the far northern waters

Sperm whales: The largest toothed whale, and the deepest diving of all cetaceans

Pygmy sperm whales: 2 species of small, toothed whales; temperate and tropical oceans

Beaked whales: 21 or more species of medium-to-large toothed whales from deep waters

BALEEN WHALES

Families: 4 families (14 species)

Order: Cetacea; suborder Mysticeti

Gray whale: Coastal waters; usually heavily encrusted with barnacles

Rorquals: 9 species of groove-throated great whales, including the blue whale, the largest animal ever to have lived on Earth

Right whales: 3 species from polar seas, with high-arching jaws

Pygmy right whale: 1 little-known species from the southern oceans

No other mammals are as perfectly adapted to life in water as whales and dolphins. Other mammals, such as seals and otters, are fine swimmers but they return to land to rest or breed. Dugongs and manatees spend their whole lives in water but do not go far from the shallows. However, whales live in all the oceans and seas. They include several of the largest and most intelligent animals on the planet.

Whales and dolphins have a streamlined body, ending in a large tail with big, horizontal fins called flukes. Large muscles in the whale's back make the tail beat up and down, which moves the animal through the water. The front fins, or flippers, are used for steering, touching and caressing other whales, and for signaling. Most species also have a dorsal (back) fin, which acts as a keel to keep the animal steady.

Teeth, Baleen, and Blubber

Whales and dolphins are split into two main groups, based on the way in which they catch their prey. Toothed whales have a narrow snout and jaw and conical teeth, with which they catch fish, squid, seals, and other whales. Baleen whales have a mouth full of stiff, bristly fringes called baleen, or whalebone. Baleen whales are filter feeders. They take huge quantities of water into their mouth and through the baleen. Small animals, such as shrimplike krill, are trapped by the baleen and swallowed.

Unlike most mammals, whales are not hairy or furry. Instead, they develop a thick layer of blubber (fat) under the skin, which acts as a layer of insulation to keep the animal warm in cold water. In warmer water, whales can have a problem with overheating. That is solved by a network of blood vessels in the skin. When the whale is too hot, these vessels bring blood to the surface, where it is cooled.

Diving Deep

Whales have to return to the surface because they breathe air, but many can make one breath last for an hour or more. Some whales dive to incredible depths to find food or to avoid

DID YOU KNOW?

- Dolphins have been trained to respond to hand signals and spoken commands from people, and they even understand some written symbols!
- The fastest whale is the sei whale, which has been clocked at around 35 miles per hour.
- A blue whale can take in 2,500 cubic feet of water in one gulp!

A humpback whale breaches (clears the water). Northern humpbacks eat mainly fish, while the southern variety filter krill (tiny, shrimplike animals).

predators. When a whale dives deep, its lungs are squashed by the water pressure, and air is forced into the windpipe. Oxygen and other gases can no longer pass into the whale's blood for distribution to the body. So, the whale's muscles have to use the oxygen already stored inside them in a substance called myoglobin.

For whales and dolphins, the most important sense is hearing. Sound travels much farther through water than does light, especially in water that is cloudy or dark. Toothed whales send out pulses of sound produced in the nostrils. In a process called echolocation, the sound waves bounce off objects, and a whale's sensitive hearing picks up the echo. A whale's brain can change these echoes into a sound picture of its surroundings. The picture is so detailed that whales and dolphins can find their

WHALE EVOLUTION

The first whales appeared around 50 million years ago. They had four legs and were able to move around on land and in water. By 40 million years ago, there were many different species of whales, which lived only in water. Their front legs had become flippers and the back legs had all but disappeared. Toothed and baleen whales emerged as separate groups thirty million years ago.

Experts have uncovered a whale's backbone. By analyzing the bones, scientists will be able to figure out the shape of the whale's body.

LOST AND STRANDED WHALES

Whales are usually extremely good at finding their way in the oceans. However, it seems that strandings and cases of whales becoming lost and trapped in rivers or shallow bays are increasing. Conservationists think one reason for this might be sound pollution. Loud noises made by drilling operations or underwater explosions, for example, might cause these animals to flee in panic or to make serious mistakes in their navigation. Noises from boat engines may also confuse whales.

Long-finned pilot whales lie stranded on a beach. Volunteers spray them with water to keep them cool until high tide returns.

way around in pitch blackness and even find small fish buried in sand. Sound is also important in communication. Most toothed whales use clicking calls around other whales, and the larger baleen whales produce calls and songs that carry for hundreds of miles.

Summer Feeding and Winter Breeding

Small toothed whales, such as dolphins and beaked whales, live all around the world. Some live in social groups, while others live alone, but most seem to spend their life within a large home range. Baleen whales, however, are among nature's great travelers. For example, gray whales, blue whales, and right whales spend their summers feeding in the polar waters of the Arctic and Antarctic but migrate to the warmth of the tropics in winter to breed.

Whales breed slowly, rearing just one calf at a time. Females of the smallest species, such as porpoises, may produce a calf every year, but larger whales may take several years to do so. To make up for this extremely slow breeding rate, large whales live for a long time—more than 100 years in the bowhead whale.

Whales have been hunted for centuries for meat, oil, and whalebone. By the early twentieth century, exploding harpoons and factory ships

meant more whales were killed than ever before, and several species were on the verge of extinction. Whaling was banned in 1986 by the International Whaling Commission, with just a few traditional hunts by Arctic people still allowed. However, a few countries, such as Japan, Norway, and Iceland, continue to kill whales despite the ban.

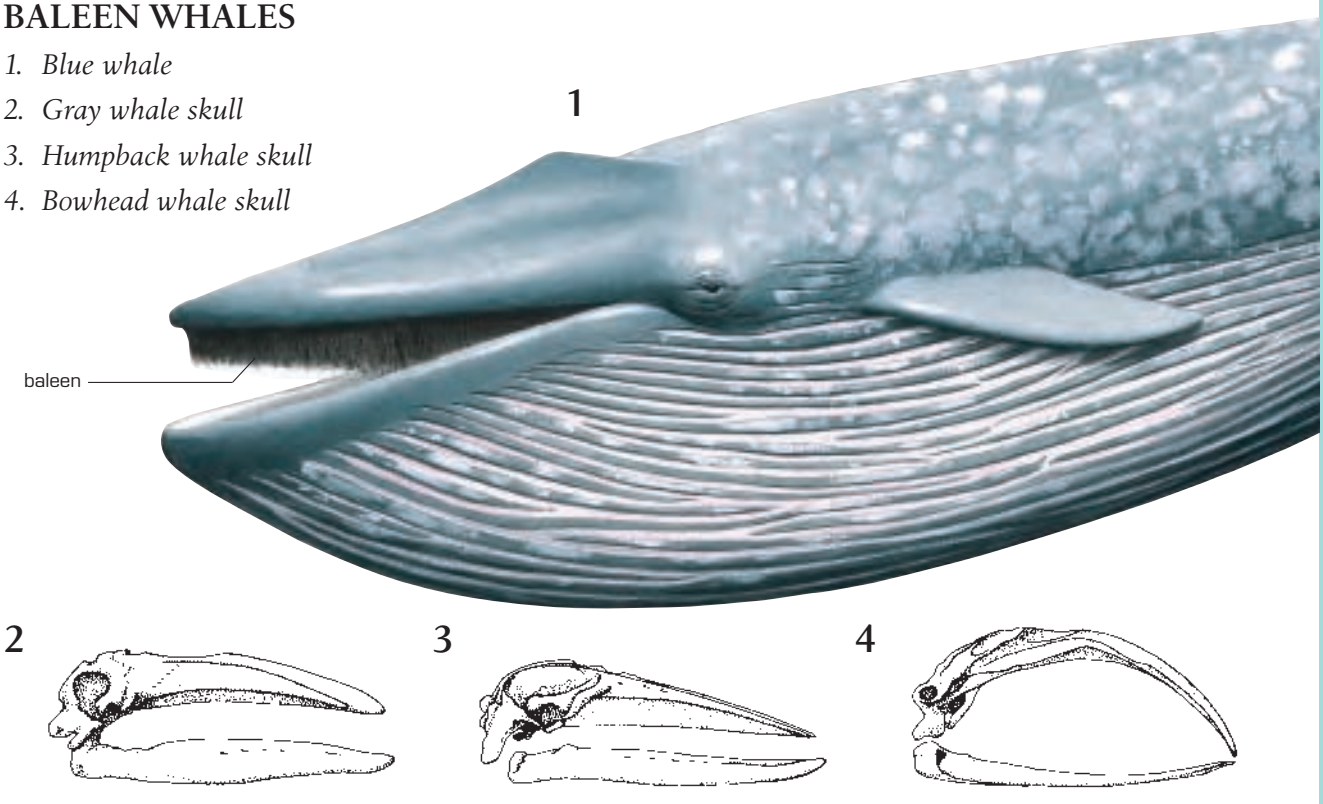
Fortunately for the whales, there are now better ways to make money from whales other than hunting them. People have a deep interest in these mammals, and many people travel the world for a chance to watch whales swimming. In the United States alone, for example, the whale-watching industry makes more than $1 billion a year. That amount of money is far more than could ever be made from simply hunting and killing whales.

DID YOU KNOW?

- The scientific word for whales and dolphins, cetacea, comes from the Greek word for whale, *ketos*.
- Baleen is made of keratin, the same material from which human hair and fingernails are made!
- The loudest call of any animal is the whistle of the blue whale, at 188 decibels!

BALEEN WHALES

1. *Blue whale*
2. *Gray whale skull*
3. *Humpback whale skull*
4. *Bowhead whale skull*



WHELKS AND RELATIVES

Whelks and their relatives the cone shells are sea snails that actively hunt large prey. They include some of the most beautiful—and also some of the most deadly—creatures in the oceans.

Like all snails, the whelks and their relatives have a coiled shell, a muscular foot for crawling, and a tongue covered with rasping teeth. But they have some extra features. Their mouth is at the end of a flexible proboscis (snout) that they push into the soft parts of their prey. Whelks also hold up a long tube called a siphon as they crawl along. By sucking in water through this siphon, they can detect prey. The siphon also carries oxygen-rich water for their gills.

Many whelks hunt for clams and other mollusks. Some drill holes in their victims' shells with their rasping tongues. Others force the clam shells apart, prying them open with their own shells.

Tropical Splendor

The greatest number of whelk relatives live on coral reefs and in other shallow tropical waters. There are many different families with names such as augers, mitres, olives, and volutes. The colorful shells are great favorites with shell collectors—especially cone shells.

As well as feeding on worms and other mollusks, some cone shells also hunt fish. Each tooth on their tongue is long and harpoonlike, and used only once. When a cone shell gets close to prey, it shoots out its harpoon-tipped proboscis, which can be as long as its own body. The harpoon injects poison, and the cone shell then swallows its prey whole. Some cone shells have poison so deadly that it can even kill people!

A venomous cone shell crawls over rocks in the Red Sea. The trunklike structure emerging from the shell on the right is the mollusk's siphon.

Fact File

WHELKS AND RELATIVES

Order: Neogastropoda (number of species unknown)

Class: Gastropoda

Phylum: Mollusca

Where do they live?: Worldwide in seas and oceans

Habitat: Seafloor habitats including rocks, reefs, and muddy sea bottoms

Size: 0.04–30 inches (1 mm–76 cm)

Coloration: Many tropical species have brightly colored and patterned shells

Diet: Mainly eat other animals; also eat dead matter

Breeding: Males and females are separate; eggs hatch directly into miniature snails

Status: Some tropical species are threatened due to overcollecting

WINKLES AND RELATIVES

Winkles are very common small sea snails found on rocky shores around the world. Their relatives include large, exotic species such as conchs and cowries.

Winkles are small mollusks found mainly on rocky shores. To stop themselves from drying out at low tide, winkles seal themselves tightly into their shells using a horny "door" called an operculum. They are herbivores (plant-eaters), scraping algae and other food off rocks with their rasping tongues.

Other relatives include the huge, heavy conchs, whose shells are popular as ornaments. Conchs live in shallow, warm seas in places like the Caribbean, where they eat seaweeds. The helmet shells are predators. Their prey includes sea urchins, which they can smash open with their heavy shells! Cowries are a favorite of shell collectors. The shell of adult cowries is oval, with a long slit underneath where the living animal comes out. Cowries eat small animals attached to rocks.

Many and Varied

Many other lifestyles are found among winkle relatives. The slipper limpets anchor themselves to rocks, and to each other, and filter their food from the water. They also change from male to female as they get older! Another group, the heteropods, have small shells or even no shells at all. They swim after their prey in the open ocean. Many species of freshwater snails are relatives of winkles. They breathe using gills, and so can stay under water all the time. Other freshwater snails, which are descended from land snails, still breathe air and have to come to the surface regularly.

A beautiful spotted cowrie crawls along the bottom in the Indian Ocean off Indonesia. The animal's fleshy foot can be seen extending beneath the shell.

Fact File

WINKLES AND RELATIVES

Order: Mesogastropoda (number of species unknown)

Class: Gastropoda

Phylum: Mollusca

Where do they live?: All the world's seas and oceans; most common in shallow water

Habitat: Rocky or sandy sea floors and shorelines; a few are swimmers; others live in fresh water

Size: 0.04–18 inches (1 mm–46 cm)

Coloration: Very varied

Diet: Quite varied

Breeding: Usually separate males and females; young stages (larvae) normally swim in the plankton before turning into miniature adult snails

Status: Some conchs and cowries threatened by overcollecting

WRASSES

Only one other fish family—the gobies—has more species in it than the wrasse family. Wrasses come in all sorts of different shapes and sizes, and they have many unusual lifestyles.

Wrasses range from large, colorful fish with projecting teeth, such as the harlequin tuskfish, to small, slim-bodied species, such as the cleaner wrasse. Wrasses live on tropical reefs and in other rocky places on the seabed. They are quite often seen swimming about during the day, searching for their prey among the reef crevices and seaweeds. But as night falls, they suddenly disappear, and only a few larger individuals may still be found lurking under rocky ledges or in caves at this time. The majority of the wrasses have buried themselves in the sand to hide from night-hunting predators. They even use this method of escape in the daytime; if danger threatens they simply quickly bury themselves out of sight.

Nibbling Away

One group of wrasse are unlikely to fall victim to predators, however; these are the cleaner wrasses. Other fish instinctively seem to know that it is good for them to be groomed by these small cleaners. The cleaner wrasses will dart into their gill chambers and remove harmful parasites, even venturing into the "clients" mouths to clean their teeth. There are certain places on the reef known as "cleaning stations," where this activity is carried out. Fish that are seeking the attentions of the wrasses display at the cleaning stations, indicating to the cleaner wrasses that it is safe for these small fish to approach and do their work.

The humphead wrasse is the largest member of the wrasse family. This species lives on coral reefs, where it eats starfish, sea urchins, crabs, and marine worms.

Fact File

WRASSES

Family: Labridae (500 species)

Order: Perciformes

Where do they live?: Occur widely throughout the Atlantic, Indian, and Pacific Oceans, and most seas, including the Mediterranean and Red Seas

Habitat: Tropical, temperate, and subarctic coastal waters, preferring rocky and reef habitats

Size: From about 1.8 inches (4.5 cm) to over 8 feet (2.5 m); most about 6–8 inches (15–20 cm)

Coloration: Highly variable, often brightly colored, particularly males

Diet: Predatory, with smaller species feeding mainly on invertebrates, and larger wrasses also eating other fish; some have more specialized feeding habits, including cleaner wrasses and those feeding on generally poisonous creatures such as sea urchins

Breeding: Spawning may occur in pairs or shoals, occurring close to the surface

Status: A few, such as the hogfish, are listed as vulnerable, but most of the 500 species are not threatened

GLOSSARY

antenna Sensory feeler on the head of some creatures, such as lobsters and prawns
appendage Any external part of the body that is joined to the trunk, such as a whale's flipper
aquatic Living in, or relating to, water
arctic Of, or relating to, the north pole or surrounding area
asexual reproduction Reproduction that does not involve the joining of male and female sex cells

bacteria (singular: bacterium) Tiny, single-celled microorganisms that, in some cases, cause disease
baleen Thick, curtainlike substance that hangs from the upper jaw of baleen whales; filters krill out of the sea water
barbel A tentaclelike feeler near the mouth of some fish that is used for touch and taste
binary fission Asexual reproduction in which the parent cell splits into two equal parts
bioluminescence The production of light by a living organism
bivalve Type of mollusk, such as a clam, in which the shell is formed of two halves (valves) that are hinged together
brood Offspring (young) of a single birth, or clutch of eggs; also means to care for the eggs or young
budding Reproduction in which part of an organism develops into a new individual

camouflage Pattern of coloration, or body shape, that allows an animal to blend in with its surroundings
carapace Shell of a crustacean
carnivore Meat eater; animal that catches other animals for food
carrion Dead and decaying animal flesh used as food
cellulose Tough substance that makes up the cell walls of plants
chordate Animal belonging to the phylum Chordata; these animals either have a primitive or full backbone
cilium (plural: cilia) Short, beating, hairlike structure usually found on the outer surface of some cells
class Category in classification, ranking above order and below phylum (see p.78)
classification Organization by scientists of different organisms into groups (see p.78)
cnidarian Soft-bodied invertebrate animal that has stinging tentacles (for example, a jellyfish or anemone)
crustacean Invertebrate animal with paired, jointed legs and a hard outer shell (for example, water flea or shrimp)

digestion The breakdown of food into small, easily absorbed molecules in the digestive system
DNA Deoxyribonucleic acid; the molecule present in the cells of all living organisms that carries the information needed to create new life
dominant Highest-ranking
dormant Inactive and in a deep sleep, during which the animal's processes slow down

echinoderm Invertebrate animal with a spiny skin (for example, starfish or sea urchin)
echolocation Use of sound echoes by animals such as dolphins to build a picture of the surroundings
embryo Early stage in the life cycle of an organism while it is in the egg or in its mother's body
endangered species Any species that is extremely close to becoming extinct in the wild
estuarine Of an estuary; describes water that is a mixture of sea and fresh water
estuary Stretch of water where fresh water from a river mixes with sea water; estuary water is less salty than pure sea water
evolution The way in which species of living organisms slowly change over very long periods of time

extinct Any species not found in the wild for a very long time, and which is therefore thought to have disappeared forever
extinction The dying out of a species

family A category in classification that ranks above genus and below order (see p.78)
feces Expelled waste products of digestion
fertilization During sexual reproduction, the joining of a male sperm with a female egg to form an embryo
filter feeder Animal that feeds by straining tiny food particles from the water
fin Winglike or paddlelike organ attached to parts of the body of some aquatic animals that helps them move in water
flagellum (plural: flagella) Long, whiplike structure found on the cells of some organisms and used to help them move
fossil The hardened remains or imprint of an animal or plant from the past found in rock

gamete Sex cell (sperm) of a male organism or the sex cell (egg) of a female organism
gene Section of DNA that carries the code for one inherited feature
genus A category of classification for groups of closely related species (see p.78)
gestation Time an animal spends developing inside its mother (pregnancy)
gill Organ found in fish and many other aquatic animals that is used for breathing
gill chamber Part of the body where gills are located

habitat The environment in which an animal or plant usually lives or grows
hatch Break out of an egg
herbivore Plant-eating animal
hermaphrodite Animal (or plant) that has both male and female sex organs
hibernate To spend a period of time in an inactive, or dormant, sleeplike state
host Animal or plant that is preyed upon by a parasite

incubation Period during which an egg develops before hatching
intertidal Between the tides
invertebrate Animal without a backbone

krill Tiny shrimplike planktonic animal life that floats in the oceans and forms the main food of some animals such as whales

larva (plural: larvae) First stage in the life cycle of some animals after hatching
leptocephalus (plural: leptocephali) Ribbonlike, transparent larvae of an eel
ligament Elasticlike tissue that holds certain parts of an animal's body together
livebearer Animal that gives birth to fully formed young

mantle Folded tissue covering the body of mollusks; its outer layer makes the shell
medusa Swimming, usually bell-shaped, stage in the life cycle of a jellyfish
metabolism The chemical changes in living cells that provide energy for essential life processes such as growth and repair
migration Seasonal, long-distance journey by animals, such as whales, often to feed or breed
mollusk Invertebrate animal that usually lives inside a protective shell (for example, clam, sea snail, or whelk)
molt To shed or lose (for example, the carapace of a crustacean)
mucus Slimy liquid produced by the bodies of some animals and used to lubricate or protect

niche The place of an organism in a community of plants and animals
nocturnal Active during the night

nucleus (plural: nuclei) Structure found in the cell of living organisms that controls many of the activities of the cell
nutrient Food that gives an animal or plant energy to grow

omnivore Mammal that eats both plants and animals
order Category of classification ranking above family and below class (see below right)
organ Specialized group of cells in an animal's body that carry out particular tasks (for example, lungs and heart)
organism Any living thing

parasite Organism that gets its food from another living organism (the host); parasites usually harm the organism on which they feed
photosynthesis Process by which green plants make food from water and carbon dioxide using the energy of sunlight
phylum Major category of classification, above class and below kingdom (see right)
plankton Microscopic animal and plantlike life in water
polyp Tiny, anemonelike creature, usually living inside a protective, chalky cup; coral polyps form coral reefs
predator Animal that kills and eats other animals
prey Animal caught and eaten by another animal

range Geographic area within which a species usually lives
ray One of the bony rods that supports the fin of a fish
reproduction Process by which an organism produces new individuals like itself; reproduction may be sexual or asexual

scavenger Organism that eats anything it can find, living or dead (for example, some crabs)
sedentary Staying in one place; for example, barnacles attach themselves permanently to a rock or a whale
sediment Material that settles on the seabed; a mixture of tiny living organisms, sand, mud, and fragments of dead organisms
sexual reproduction Reproduction that involves the joining of male and female sex cells
shell Hard outer covering of some animals, particularly many mollusks and crustaceans
species Related organisms that resemble one another and can breed among themselves, but are not able to breed with other species
substrate Any surface upon which an organism lives (for example, the seabed or rocks)
symbiosis Relationship between two or more unrelated species of organisms in which each organism gets benefit

territory The area that an animal occupies and defends against intruders

vertebrate Animals belonging to the subphylum Vertebrata; these animals have a full backbone

zooplankton Minute invertebrate animals that form part of the plankton

The kingdom Animalia is subdivided into a number of categories. Shown here is the classification of the Atlantic salmon.

Category	*Scientific Name*	*Common Name*
Kingdom	Animalia	animals
Phylum	Chordata	animals with a stiffening structure in their back
Subphylum	Vertebrata	animals with a true backbone
Superclass	Gnathostomata	fish with jaws
Grade	Osteichthyes	fish with a bony skeleton
Class	Actinopterygii	fish with fins made of webs of skin and rays
Division	Teleostei	advanced bony fish
Subdivision	Euteleostei	catfish, minnows and relatives
Superorder	Protacanthopterygii	pikes, smelts and relatives
Order	Salmoniformes	salmon-like fish
Family	Salmonidae	salmon, trout, char, and relatives
Genus	*Salmo*	salmon and trout
Species	*Salmo salar*	Atlantic salmon

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INTERNET RESOURCES

Corals
A seaworld coral site with lots of information. Very user friendly. The seaworld site also has many other interesting categories of marine life to explore.
http://www.seaworld.org/infobooks/coral/home/html

Crustaceans
Extensive information on all the major (and some minor) groups of crustaceans. Includes a simple search facility.
http://www.crustacea.net

Enchanted Learning
Check out all kinds of marine creatures, such as octopuses, clams, sharks, whales, and dolphins, as well as information about oceans and many other aspects of the natural world. Full of informative diagrams, activities, and printouts.
http://www.enchantedlearning.com

Fishbase
An amazing Web site full of information even on rare and obscure fish, with lots of references to other sources.
http://www.fishbase.org

Florida Museum of Natural History
Superb site full of pictures and information about all kinds of fish and other marine life. Includes how to become a biologist, how to avoid a shark attack, puzzles, games, and much more.
http://www.flmnh.ufl.edu/fish/

Marlin
The Marine Life Information Network for Britain and Ireland is a fascinating site providing information about sealife and conservation. With games, quizzes, virtual tours, and photographs.
http://www.marlin.ac.uk

Microbus
Click on the applications section for a tour of the microscopic life in ponds, on beaches, and inside other animals.
http://microscope-microscope.org

Mollusks
A basic introduction to this large group of mainly marine animals.
http://www.ucmp.berkeley.edu/mollusca/mollusca.html

Monterey Bay Museum
This site has an online tour to the aquarium with live-cams in various exhibits.
www.mbayaq.org

Save the Whales
Education about marine mammals and their conservation. The site provides descriptions of a variety of whales, dolphins, porpoises, and other marine mammals.
www.savethewhales.org

Zoology
A broad introduction to zoology, with lots of interesting information, plus links to other aspects of the subject, such as classification, famous zoologists, and the various branches of the science.
http://www.wikipedia.org/wiki/zoology

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