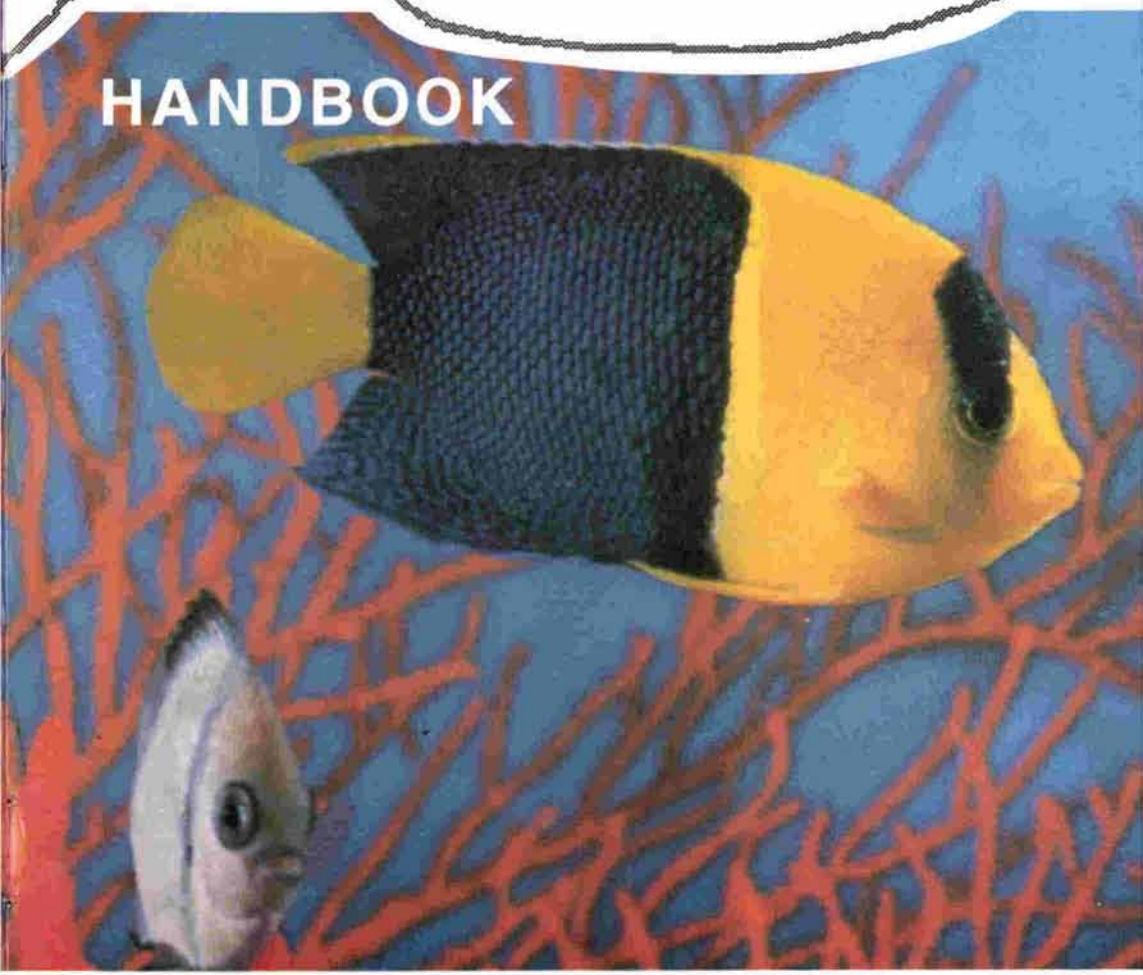
CORAL REEFS IN THE SOUTH PACIFIC

HANDBOOK



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HANDBOOK

CONTENTS

A SPECIAL NOTE TO TEACHERS

1. This handbook can be used with other teaching material such as a set of colour slides and student practical sheets available from...
SPREP (South Pacific Regional Environment Programme)
South Pacific Commission,
BP D5 Noumea,
New Caledonia.

2. Although this manual has been written in simple English, scientific terms and names of species have been included for students doing science subjects.

3. Questions on coral reefs are included on pages 37 and 38 of this handbook; the questions are presented in two levels of increasing difficulty.

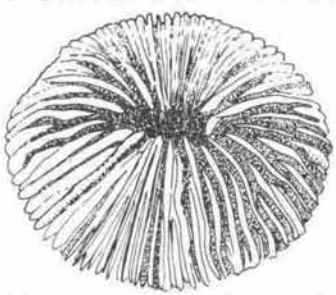
INTRODUCTION

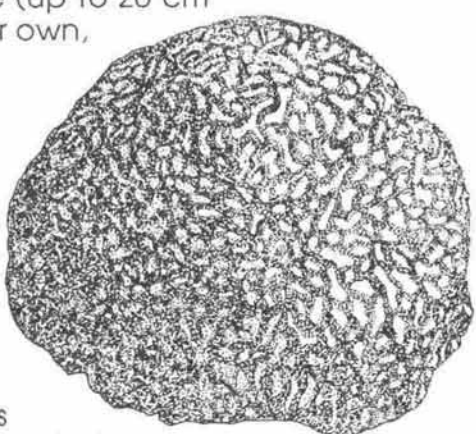
A coral reef is a complex system which consists of many animals and plants as well as corals. It provides food and shelter for a greater variety of living things than most other natural areas in the world. Many coral-reef animals, such as clams, crabs, lobsters and fish, are important food items for people living in Pacific Islands.

The fascinating combination of shapes and colours as well as the variety of corals and other animals on a coral reef are best illustrated by showing the set of slides (or video presentation) available from the South Pacific Regional Environment Programme. The purpose of this handbook is to provide an introduction to corals and coral reefs and to help students identify common coral reef life.

TYPES OF CORAL

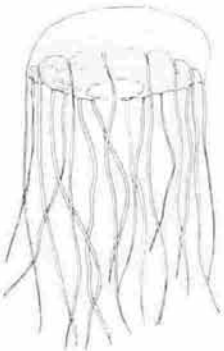
There are hundreds of different types of coral. All corals however, are made up of small animals called polyps. Some coral polyps are large (up to 20 cm in diameter) and live on their own, like the **mushroom coral** shown at the left below.





However, most coral polyps are small (less than 1 cm diameter) and live side by side in groups or colonies like the large **brain coral** shown at the right. Although they look like plants, corals are simple marine animals related to jellyfish and sea anemones which belong to the group **CNIDARIA**, summarized on the next page.

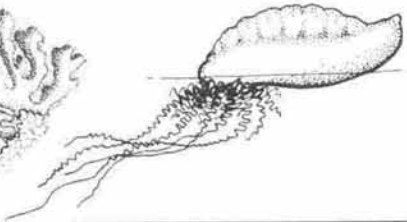
SCYPHOZOA
jellyfish



HYDROZOA

hydroids
fire corals

siphonophores
Portuguese man-of-war



ANTHOZOA

ZOANTHARIA

ACTINARIA
anemones

MADREPORARIA
stony corals

OCTOCORALLIA

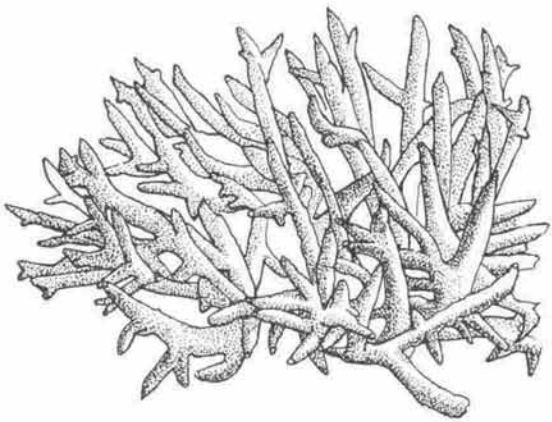
STOLONIFERA
organ-pipe coral

ALCYONACEA
soft corals

GORGONACEA
horny corals

Corals have a variety of shapes and sizes and their common names often reflect their appearance. Stony, or hard, corals make rock-like skeletons of limestone (calcium carbonate) and are known as 'reef builders.' The brain coral and mushroom coral shown on page 2 are hard corals.

Other common reef building corals include species of *Acropora* and *Porites*.



STAGHORN CORAL
(Acropora)
which forms dense branches in colours ranging from delicate pastel shades to brilliant green, blue and orange.

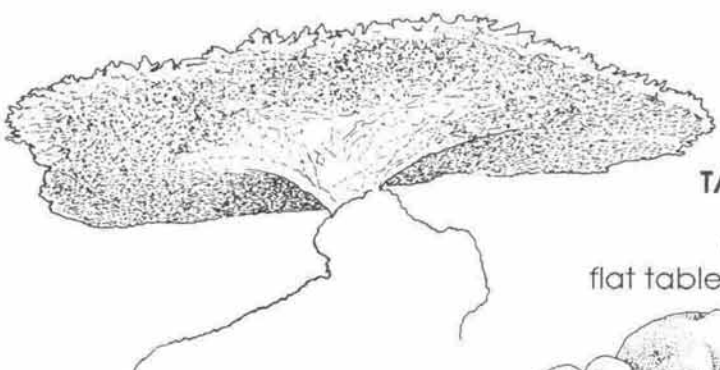


TABLE CORAL
(Acropora)
which forms flat tables and steps.

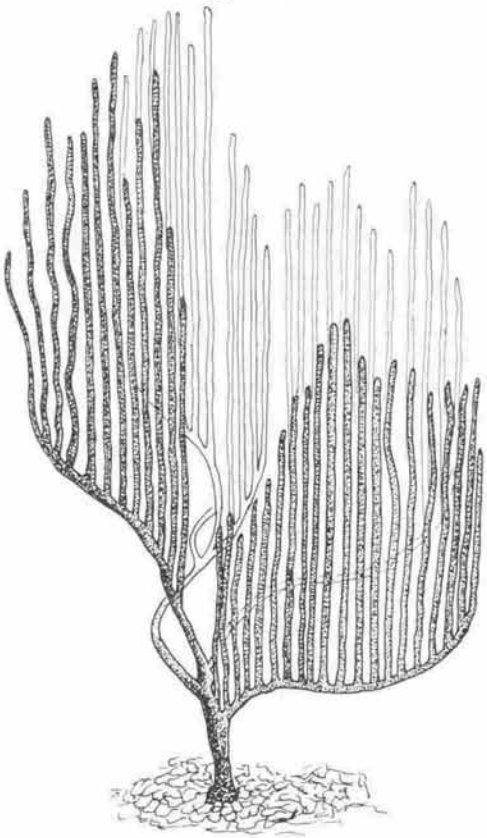
BOULDER CORAL
(Porites)
which forms large yellow masses and often the largest of the rocky outcrops on coral reefs.

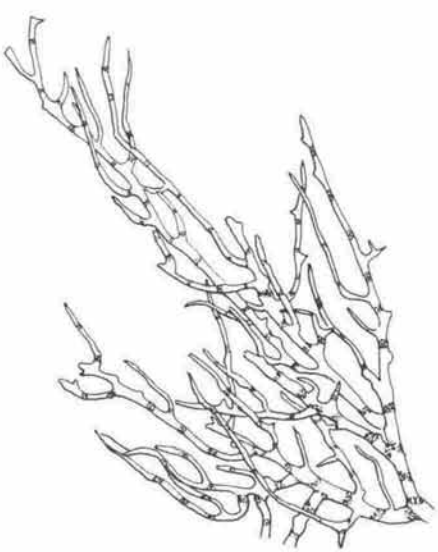
Although the hard corals produce a stony outer skeleton, other corals have an inner skeleton of calcium carbonate spikes embedded in their tissues.

SOFT CORALS (see drawing on page 3) are often thick and fleshy. Some soft corals are soft enough to move and wave in the water currents.

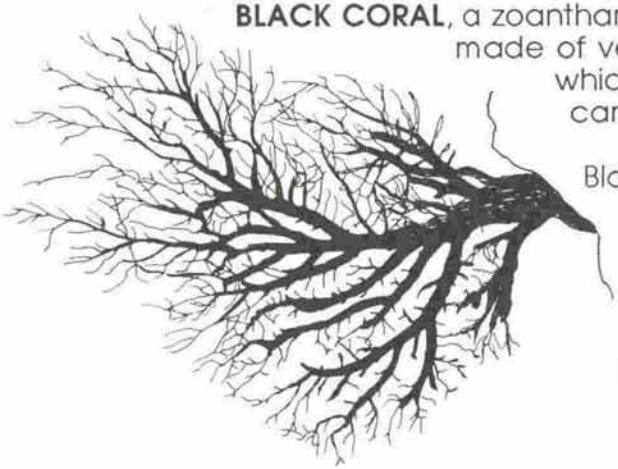
HORNY CORALS,
or gorgonians, have calcium carbonate embedded in a horn-like material.

This allows the formation of flexible coral fans or tree-like species like the one on the right.





SKELETON CORAL
(Isis hippuris)
is a gorgonian which has dense calcium carbonate segments separated from each other by dark rings of horn-like material.



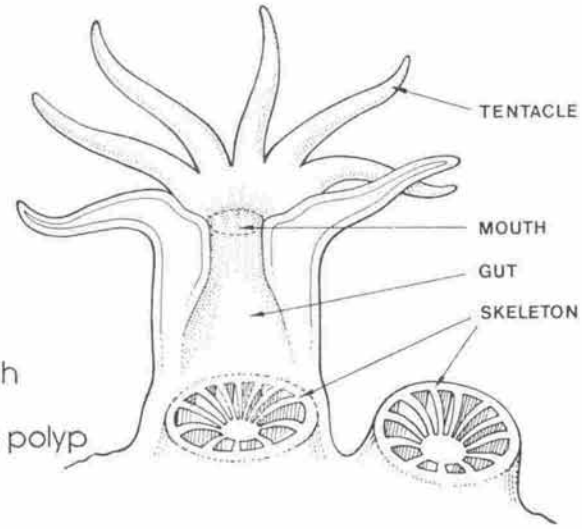
BLACK CORAL, a zoantharian, has a skeleton made of very dense material which is valuable when carved and polished.

Black corals have no symbiotic algae (see page 8 for explanation) and can live in great depths, beyond the reach of sunlight.

WHAT IS A CORAL POLYP?

Most corals consist of many small polyps living together in a large group or a colony. A single polyp has a tube-shaped body with a mouth which is surrounded by tentacles.

The polyp of hard corals produces a stony skeleton of calcium carbonate (limestone or chalk) beneath and around its base. Often the skeleton forms a cup-like structure in which the polyp lives.



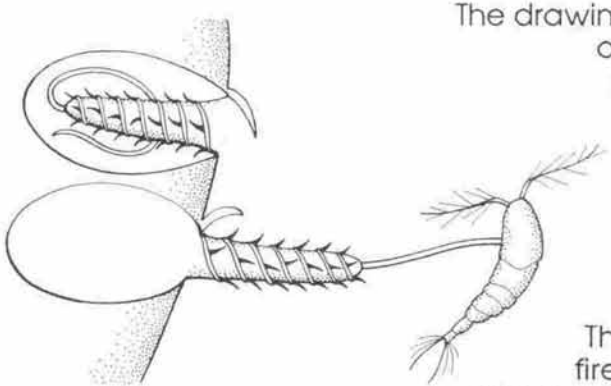
The **CORAL POLYP** shown at the right is cut away to show the gut and the skeleton beneath the polyp. A skeleton without its polyp is shown at the right.

When feeding, particularly at night, the polyps stretch out their tentacles to gather food. During the day, or when threatened, the polyps withdraw into their protective cups. Part of a coral branch is shown here.....

... **BY DAY**, with the polyps withdrawn into their skeletons, and, ...

... **BY NIGHT**, with the polyps out feeding

The tentacles have small stinging cells called nematocysts, which can shoot poison spears into small animals drifting by. These animals (called zooplankton) are used as food and are passed to the mouth by the tentacles.



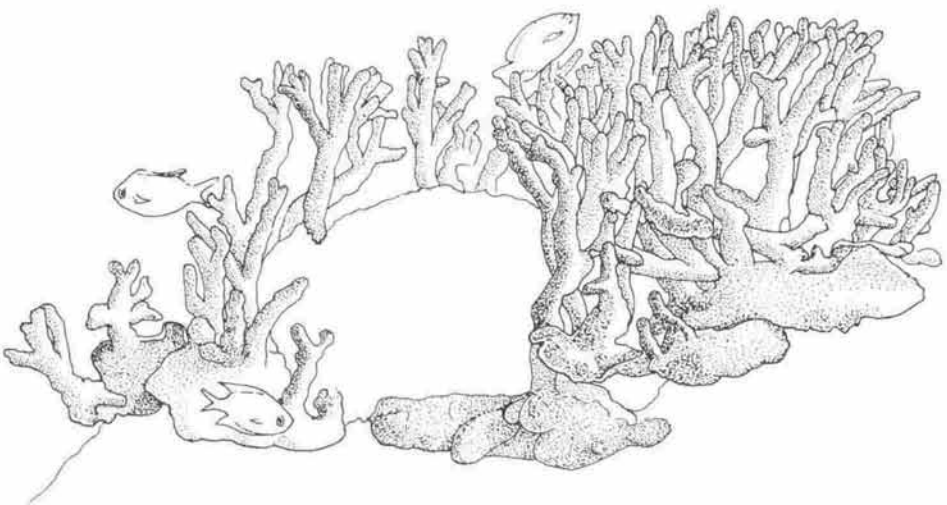
The drawing at the left shows an enlargement of part of a tentacle.

Two **stinging cells** are shown. The top cell has not fired its poison spear.

The bottom cell has fired its poison spear into a small floating animal.

Only a few corals, such as the fire corals (actually hydroids, see page 3), have stinging cells which are powerful enough to affect humans.

Contact with **fire coral** (shown below) will allow the spears of the stinging cells to penetrate the skin, causing pain and a burning sensation.



Beside capturing food drifting in the water currents, coral polyps get food from small plant cells (called zooxanthellae) which live inside their tissue. The plant cells use sunlight and nutrients in the sea water to produce food which is shared with the coral.

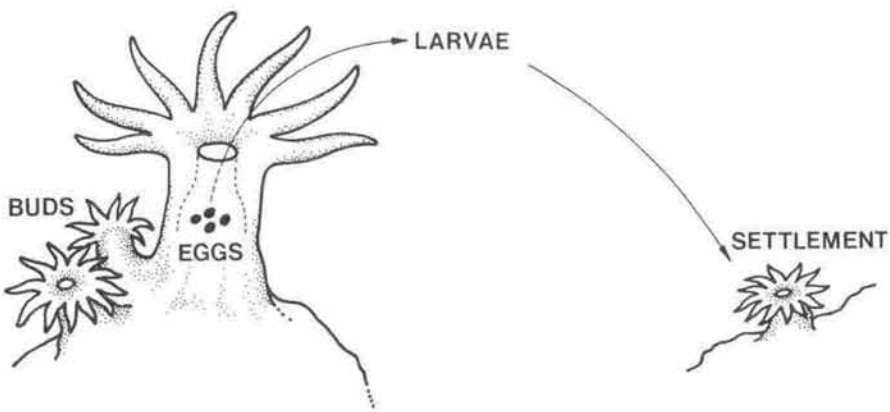
The plants gain shelter and the corals gain food from this relationship which is called **symbiosis**. Corals therefore, like plants, require sunlight for photosynthesis and can only live in clear, brightly lit waters.

Corals cannot survive in muddy water which contains silt, either from rivers or from human activity, such as the dredging of harbours.

HOW DOES A CORAL REEF GROW?

Coral polyps can reproduce in two ways - either by producing eggs (sexual reproduction) or by "budding" (asexual reproduction).

In sexual reproduction, the coral polyp produces eggs which hatch into very small coral animals called larvae. After passing out through the polyp's mouth, the larvae drift in the surface layers of the sea. Most of these drifting larvae are eaten or lost in the open ocean. But a few manage to reach warm, shallow water and settle on suitable hard surfaces. The larvae attach themselves and grow into new polyps, as shown on the right below.



A coral polyp can also reproduce itself by budding. New small polyps first appear as buds on the side of the original polyp, as shown on the lower left of the above figure.

The buds eventually grow into separate polyps which form their own skeletons.

When a newly-settled polyp of a colonial coral grows to maturity it begins to form a colony by budding. Eventually a large number of polyps build a shared skeleton which has the shape of a particular kind of coral. Many coral

colonies collectively form the large masses of coral rock (limestone or calcium carbonate) called a coral reef. When polyps die, new polyps grow on top of the remaining skeletons. Living polyps are only on the thin outer layer of a coral reef which grows outwards and upwards with each generation. Most of the reef consists of dead skeletons - one kg of coral rock may contain over 80000 polyp skeletons!

Although it takes many years, some of the world's smallest creatures, coral polyps, are responsible for building some of the world's largest natural structures, coral reefs, which may be many kilometres long.

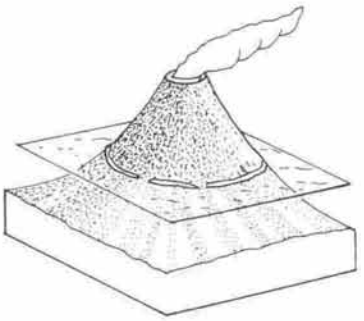
Coral reefs can only grow in waters that are warm, shallow and clear. The figure above shows the approximate distribution of sea-water which is warmer than about 20 degrees centigrade (shaded area) and coral reefs (dark areas) around the world.

The Pacific is the largest ocean in the world and has a large number and variety of coral reefs.

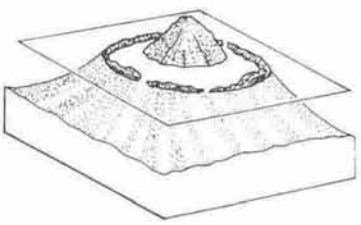
TYPES OF CORAL REEFS

There are three basic types of coral reefs - fringing reefs, barrier reefs and atolls.

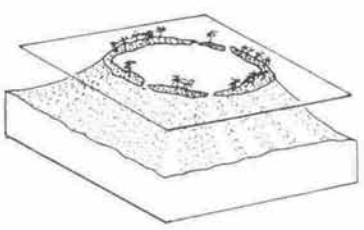
FRINGING REEFS
grow at the edges of continents and islands. The reef front contains actively growing corals, and pieces of broken coral are washed up as rubble on the reef flat.



BARRIER REEFS
are separated from the shore line by a lagoon which is often deep. Corals grow in the calm waters of the lagoon as well as on the reef front.



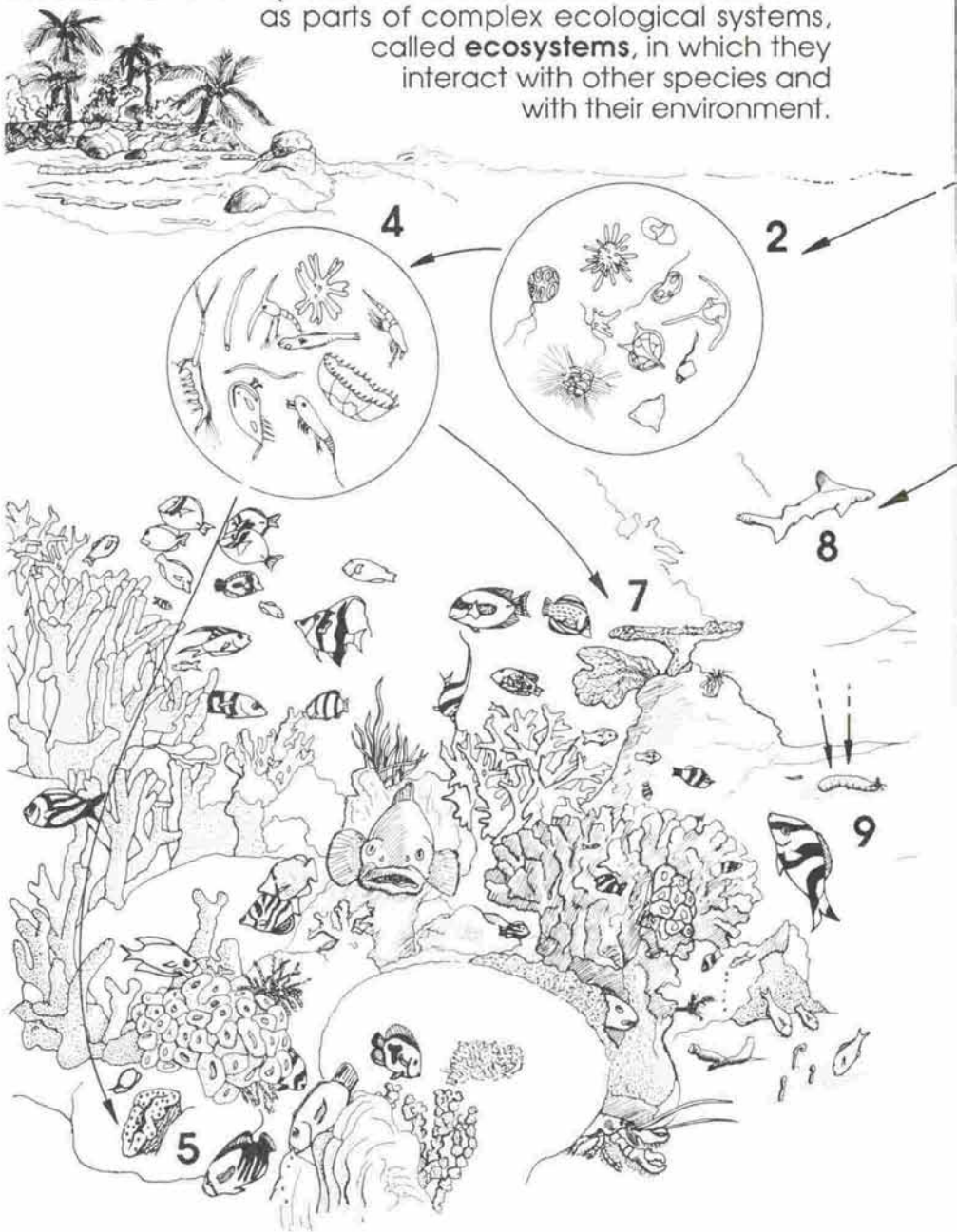
ATOLLS
are coral reefs growing in the shape of a circle. The reef, which often has small islets on it, surrounds a lagoon.



One explanation of how an atoll forms involves the gradual sinking of an oceanic island over thousands of years. The reef front of the fringing reef around the original island actively grows as the island slowly sinks. Eventually a lagoon forms between the sinking island and the growing coral which becomes a barrier reef. When the island sinks beneath the sea, the barrier reef becomes a circular atoll.

THE CORAL REEF ECOSYSTEM

In nature different species do not occur in isolation but exist as parts of complex ecological systems, called **ecosystems**, in which they interact with other species and with their environment.




6
1
3

Each organism is part of a food web in which material or energy accumulated at each step by plants or animals as biomass (weight of living material) is transferred as food to the next level.
The diagram on pages 12 and 13 shows a simplified coral reef food web. The numbers (**1** to **9**) on the diagram refer to organisms at the various trophic levels described below.

Primary Producers:

The first or lowest trophic level consists of marine plant material, produced by sunlight from carbon dioxide and mineral nutrients during photosynthesis. This includes:

Large plants such as...
1, marine algae and seagrasses.

Microscopic plants which live....
2, as phytoplankton (greatly magnified in the diagram) drifting in the surface layers of the sea, or,

3, in a symbiotic association with animals such as corals (see page 8) and giant clams (see page 21).

Herbivores (plant eaters):

The second level consists of animals which feed on plant material. These include....

4, small animals, called zooplankton (magnified in the diagram), which eat the phytoplankton,

5, filter feeders including two-shelled molluscs (bivalves) such as the giant clam shown here. Bivalves actively pump sea water to filter out phytoplankton for food, and,

6, Larger herbivores such as parrotfish, triggerfish, some snail-like molluscs, and sea urchins which graze on algae and seagrasses.

Carnivores (meat eaters):

The third and subsequent groups include animals which act as either....

> **7,** plankton-feeders which trap zooplankton using a variety of methods (including the corals, like the table coral shown here, which use stinging cells), or,
>
> **8,** active predators, (such as the shark shown here) which capture and eat larger herbivores or other carnivores. Animals such as anemones, jellyfish, cones, cuttlefish and many fish are carnivorous.
>
> As some of the carnivores are also herbivores, it is difficult to draw too fine a distinction between the above categories.

Scavengers and decomposers:

Many other animals feed on dead organisms or organic material on the sea floor.

> **9,** The sea cucumber, shown here, is a scavenger which sifts organic material from the sand.

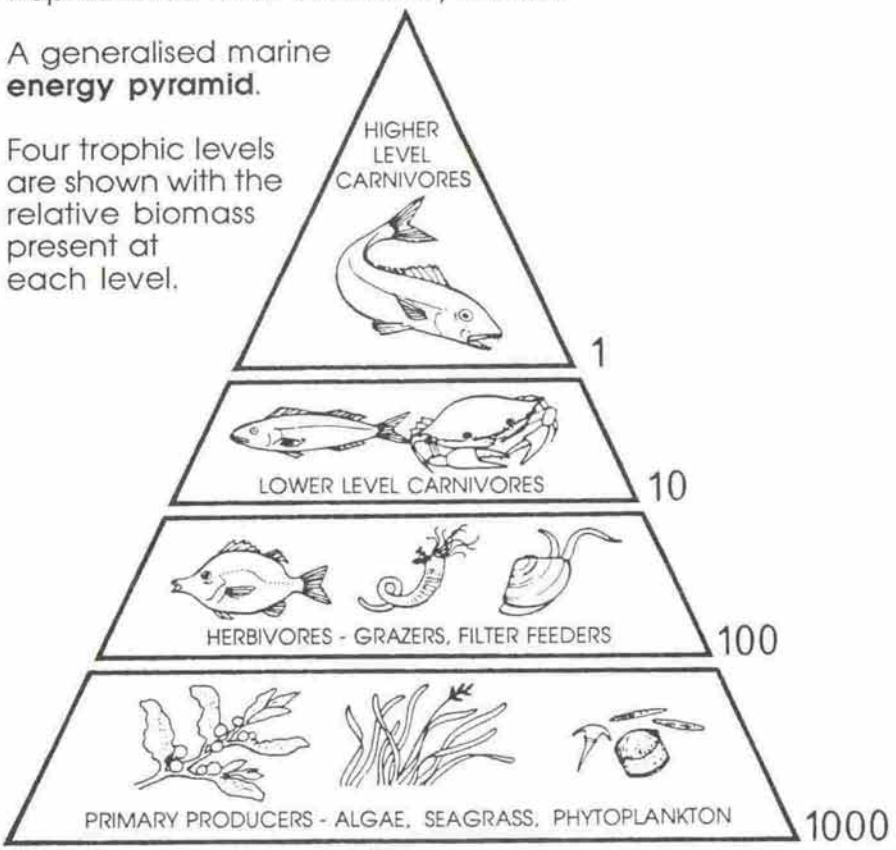
Bacteria, found on all reef surfaces, are also important in breaking down organic material. The presence of bacteria in tropical waters explains the almost immediate infection that accompanies coral cuts.

The flow of energy through food webs can be illustrated by reference to the 'energy pyramid' shown on the next page.
The first or lowest trophic level consists of marine plant material. This plant biomass is passed on to the next trophic level and this process continues to the highest level of carnivores.
The biomass values shown to the right of the energy pyramid arbitrarily assume an ecological efficiency (i.e. the

energy passed from one trophic level to the next) of 10 per cent. In fact, the efficiency of energy transfer between the trophic levels is not accurately known.

A generalised marine **energy pyramid.**

Four trophic levels are shown with the relative biomass present at each level.



Notice that each step in the process involves a 'cost' in which some energy is lost in metabolism. Each animal uses most of the food energy for its own bodily functions, converting only a fraction to growth (which may be transmitted to a predator). There is therefore, a decrease in total biomass at each succeeding trophic level. Thus animals at higher trophic levels are not able to maintain large populations - it takes about one tonne of plant material to produce one kilogram of a carnivorous fish such as a barracuda!

CRUSTACEANS

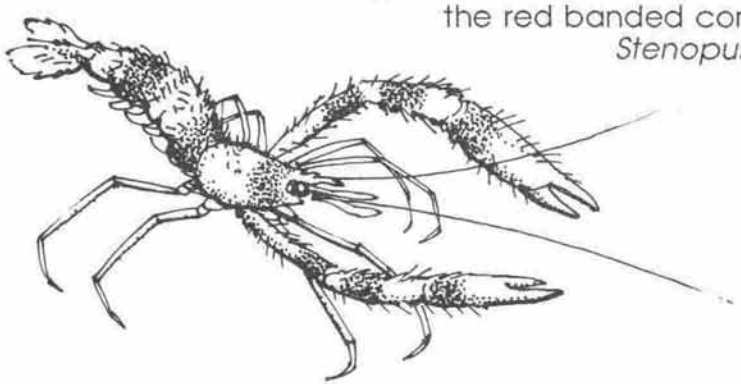
Crustaceans (including shrimps, lobsters and crabs) occupy a place in the sea similar to that occupied by insects on the land. Like insects, there is an enormous variety and number of different species and all have jointed limbs. They have an 'external skeleton' in the form of a rigid, armour-like shell.

To grow, crustaceans have to cast off their shells periodically, a process called moulting, during which the animal breaks and removes its body shell. When it has discarded its shell, it quickly increases in size before its new shell (which is initially soft) hardens. Another interesting feature is their ability to 'cast off' a limb in order to escape. A new one then automatically grows in its place.

Shrimps or prawns

Many different types of shrimps live in the pools of coral reefs.

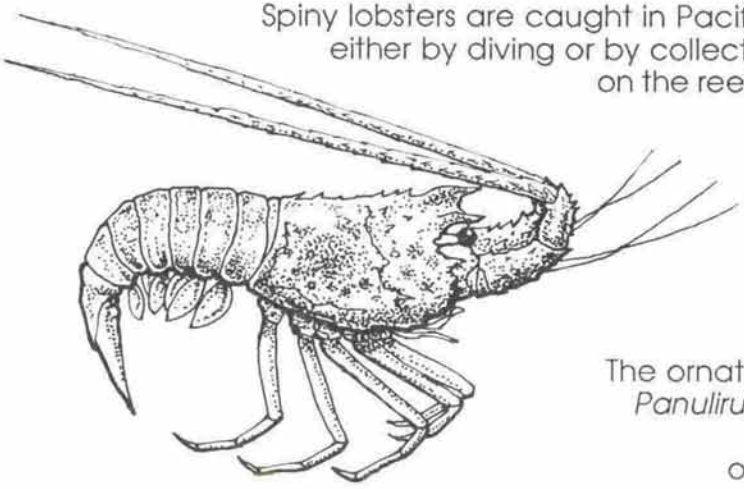
One of the most colourful of these is the red banded coral shrimp, *Stenopus hispidus*, shown at the left.



Some shrimps, known as snapping or pistol shrimps (family Alpheidae) can snap the end parts of their claws together to make a loud cracking sound - a sound that can be heard when walking across a reef, particularly at night.

Spiny lobsters
Several species of spiny lobsters live in ledges in coral reefs from which they crawl in search of food.

Spiny lobsters are caught in Pacific Islands either by diving or by collecting them on the reef at night.



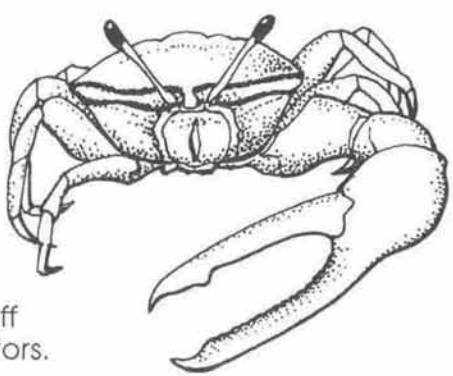
The ornate lobster, *Panulirus ornatus,* is shown on the left.

The eggs are carried on the swimming legs on the 'tail' (abdomen) of the female spiny lobster. They hatch as small larvae which drift with other zooplankton until they settle in new areas of the reef.

Crabs
A crab has the same type of body as a spiny lobster except that its abdomen is reduced to a mere flap which curls back and is tucked under its large "head" (or cephalothorax).

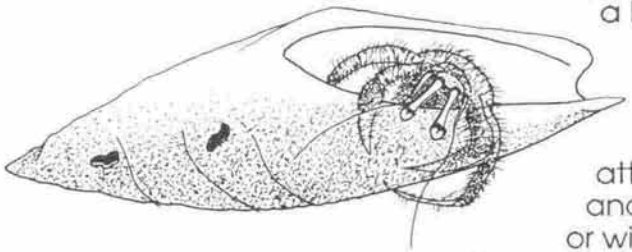
Crabs have two large claws one of which may be bigger than the other.

The fiddler crab, *Uca,* shown at the right, uses its large claw to attract females, and to warn off other males, as well as predators.



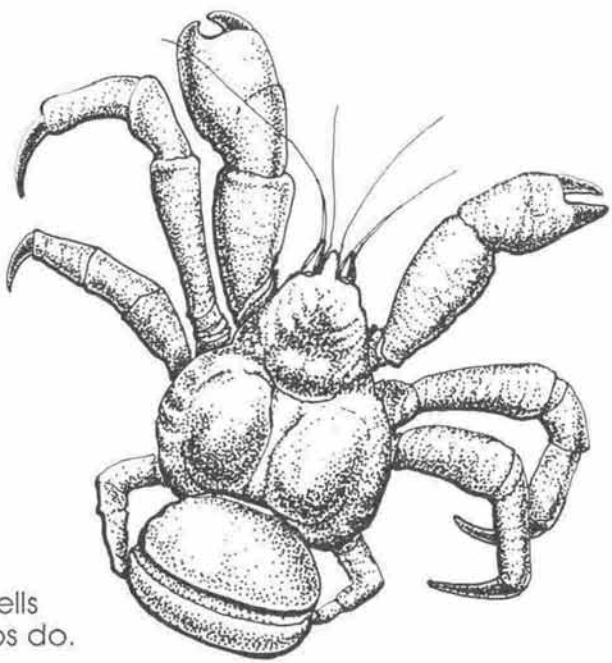
Hermit crabs, unlike true crabs, have a soft unprotected abdomen. To protect itself, the hermit crab uses the empty shells of molluscs as its home - as the one shown below.

As its body grows it must search for a larger shell to live in.



Sometimes hermit crabs will even attack a living mollusc and tear it from its shell, or will attempt to pull out another hermit crab from its home.

One family of hermit crabs (the Coenobitae) has moved from the sea and invaded the land. The large coconut crab, *Birgus latro*, is one of these.



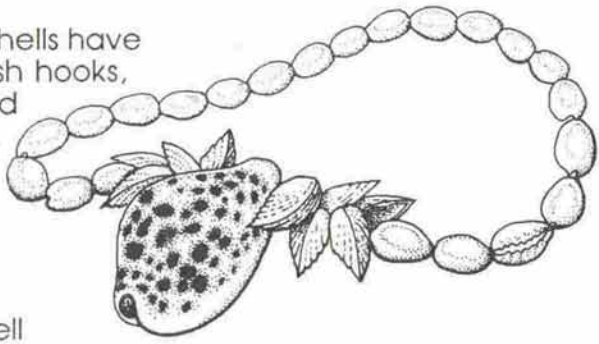
The coconut crab, shown on the right, is the largest of all land crabs.

It can weigh up to 4 kg and the adult is too large to live in empty mollusc shells as other hermit crabs do.

MOLLUSCS

Molluscs have soft bodies and many can produce hard shells, like the cowry and cone shells washed up on beaches.

In the Pacific Islands, shells have been used to make fish hooks, musical instruments and elaborate ornaments.

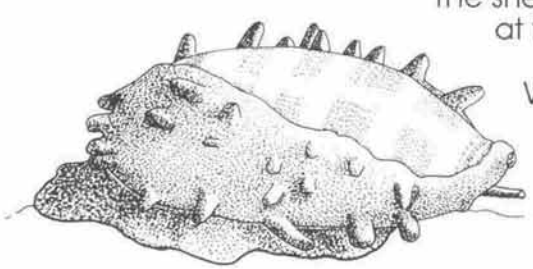


The necklace, shown here, includes a large tiger cowry shell and many small gold ring cowries.

The eggs of molluscs hatch into small larvae which drift as part of the plankton before settling on the substrate and transforming into adults. Molluscs include snail-like creatures (gastropods), two-shelled species (bivalves) and animals such as the squid and octopus (cephalopods).

Gastropods - snail-like molluscs

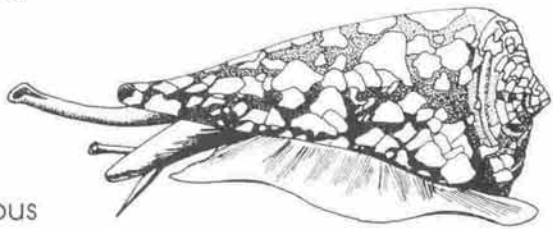
Most gastropods, such as the cowries, cones, and tritons, have one external shell - others, such as the sea slugs have no shell. Many live above the low tide mark and, when they are out of the water, remain tightly clamped to the rocks. At high tide, they move under the water looking for food.



The shell of the cowry, as shown at the left, is highly polished.

When the cowry is active, the shell is covered by the mantle (a sheet of tissue) which protects it and keeps its glossy finish.

The cone shell, *Conus*, captures moving prey such as sea worms and small fish, by spearing them with its tongue (or radula), which is in the form of a spear with grooves for carrying poison.



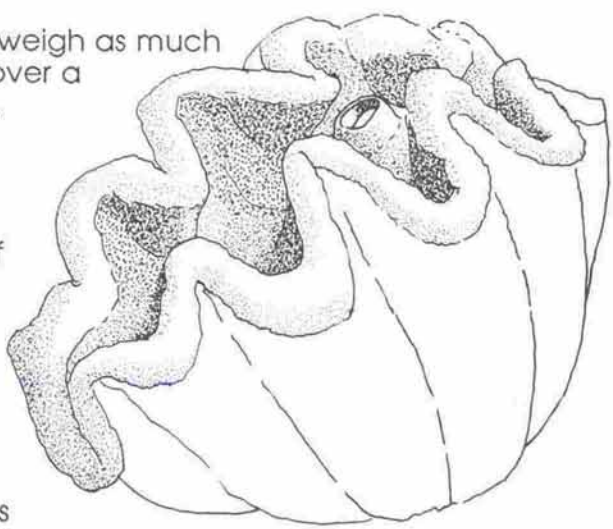
If handled carelessly, cones can be dangerous to humans.

Bivalves - two-shelled molluscs

The bivalves have two shells which are hinged at one end. The shells, which are held shut by one or two strong muscles, form a strong refuge from all except the largest predators which crush the whole shell, or small ones which bore through it. Bivalves feed by filtering phytoplankton from the surrounding water.

Giant clams, *Tridacna*, are the most conspicuous of the bivalves found on the coral reef.

A large clam may weigh as much as 250 kg and be over a hundred years old.

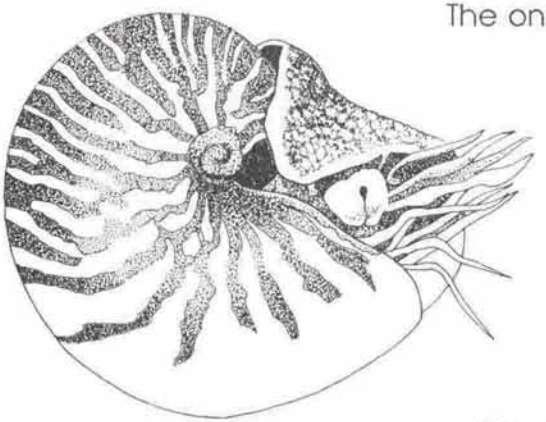


The shaded part of the clam in the drawing is the fleshy mantle which is often brightly coloured.

The mantle of a giant clam contains symbiotic algae (like coral polyps) allowing them to 'feed' on light as well as phytoplankton.

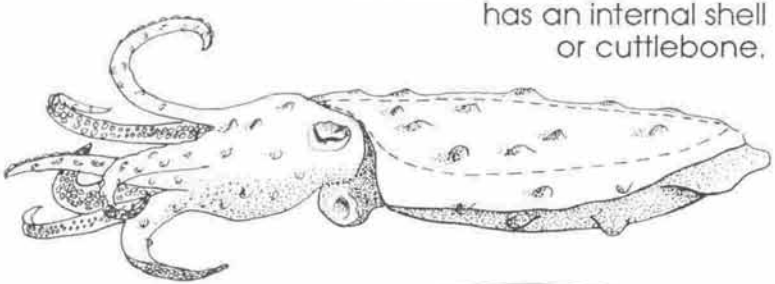
Cephalopods

Cephalopods are molluscs with a circle of arms, or tentacles, on their heads.

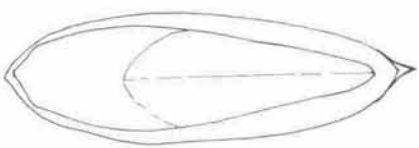


The only member of this group with an external shell is the beautiful *Nautilus*, found only in the western Pacific Ocean.

The cuttlefish (shown below) has an internal shell or cuttlebone.



The cuttlebone (at the right) is very light and often found washed up high on beaches.



The octopus, which has no shell at all, is commonly found under coral boulders on reef flats.

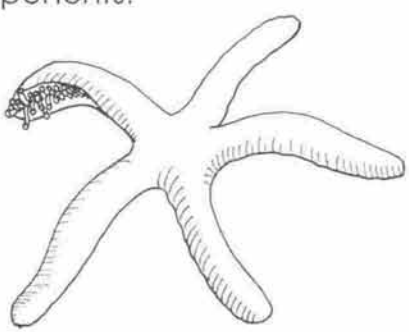
All cephalopods are active hunters and catch other molluscs, crustaceans and fish. Many have a powerful beak in addition to the radula of gastropods. The beak of some cephalopods has poison glands to kill its prey and can give a painful wound to humans.

ECHINODERMS

Animals in this group include the sea stars, sea urchins and sea cucumbers. Many have a radial symmetry in their body plan, like the spokes of a wheel. They also have tube feet which are connected to a special hydraulic (water vascular) system. Water is taken into the body and sent to the tube feet by a system of canals.

Sea stars

Sea stars have a set of arms (often five) which radiate from a central body. There is no head, and movement can be made in any direction using the two rows of tube feet on each of the arms. The arms are not mere appendages, but are actual extensions of the body, containing reproductive organs, digestive tract and other body components.

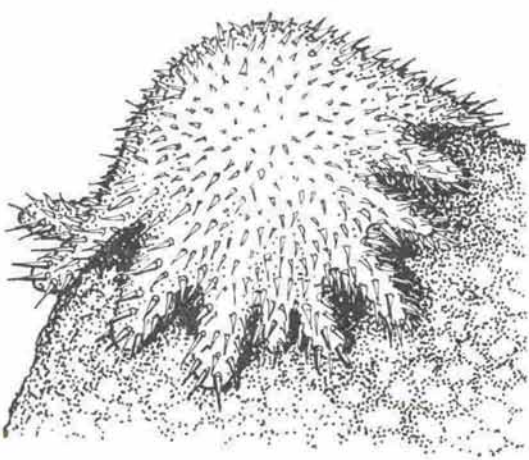


The bright blue sea star, *Linckia laevigata,* is common on Pacific coral reefs.

Note the tube feet on the up-turned arm.

One particular sea star, the Crown-of-Thorns, *Acanthaster planci,* feeds on corals.

Its stomach extends outside its body and over coral polyps which are digested.

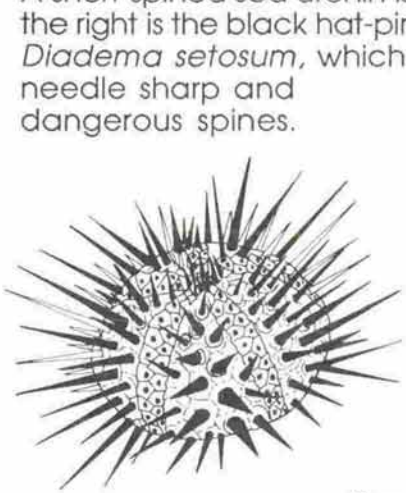


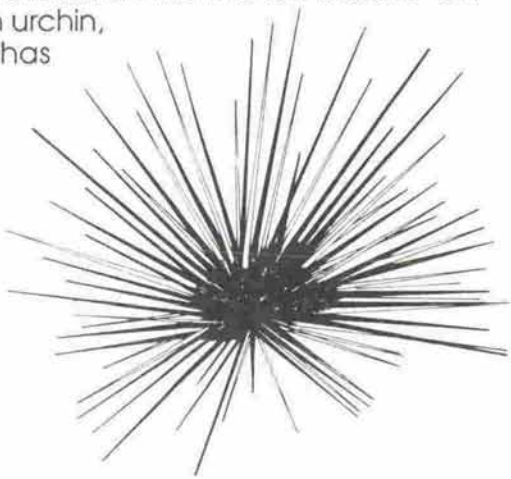
From time to time the crown-of-thorns has appeared in exceptionally large numbers in some parts of the Pacific and destroyed areas of reef. It has short poisonous spines and should not be handled.

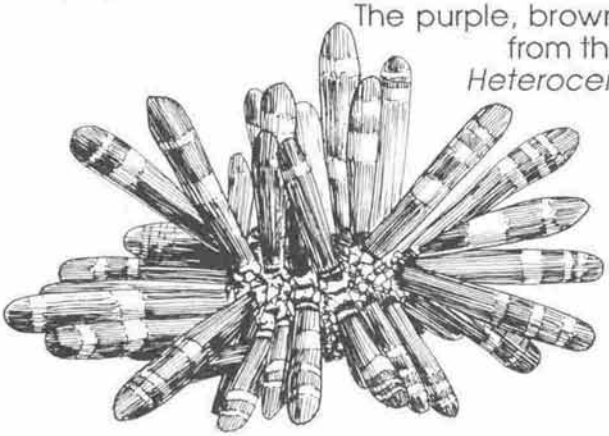
Sea urchins

Like the sea-stars, sea-urchins move by using their tube feet. The mouth, which contains powerful scraping jaws, is underneath. In amongst the tube feet are many spines, the shape of which differs from species to species.

A short-spined sea urchin is shown on the the left below. On the right is the black hat-pin urchin, *Diadema setosum*, which.has needle sharp and dangerous spines.



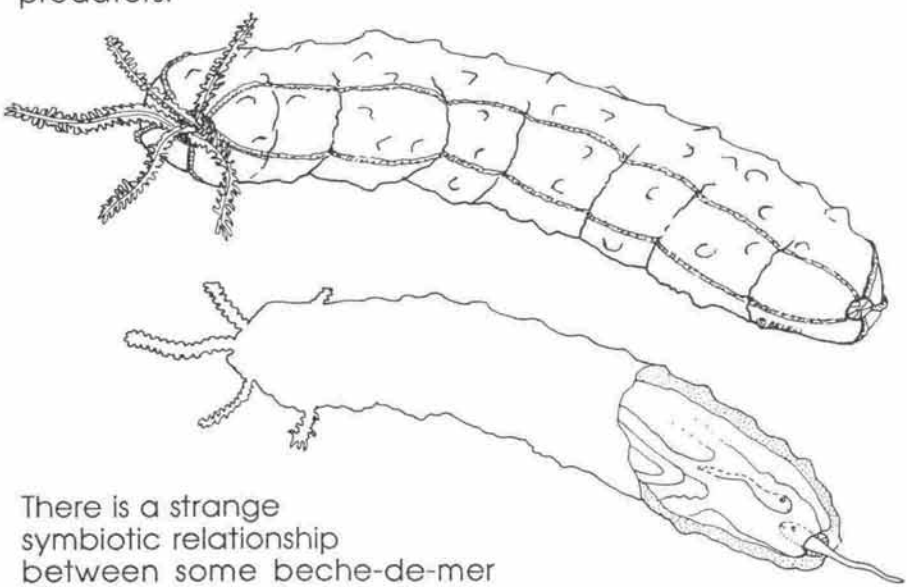




The purple, brown and mauve spines from the slate pencil urchin, *Heterocentrotus mammillatus*, (shown at the left) are often found on the beach.

Sea cucumbers

The sea cucumber or beche-de-mer does not have the radial shape of most members of the group. It has a sausage-shaped body with a mouth at one end, encircled by tentacles. Although it has the tubular feet characteristic of the group, it makes little use of these and instead moves about sluggishly by muscular movements of the body wall. When disturbed the beche-de-mer releases many white, sticky threads which can entangle its predators.



There is a strange symbiotic relationship between some beche-de-mer and the messmate fish, *Carapus* .

This small fish (as shown in the cut-away drawing above) lives inside the intestine of the beche-de-mer, coming out to forage for food, and retreating swiftly at the first sign of danger.

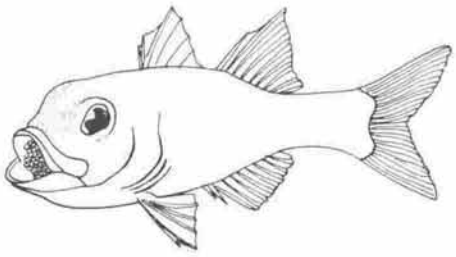
Beche-de-mer are found on the sandy sea floor of lagoons in many Pacific islands. Some species of beche-de-mer are collected, cooked and smoked for export to south-east Asian markets where they are high-priced delicacies.

REEF FISH

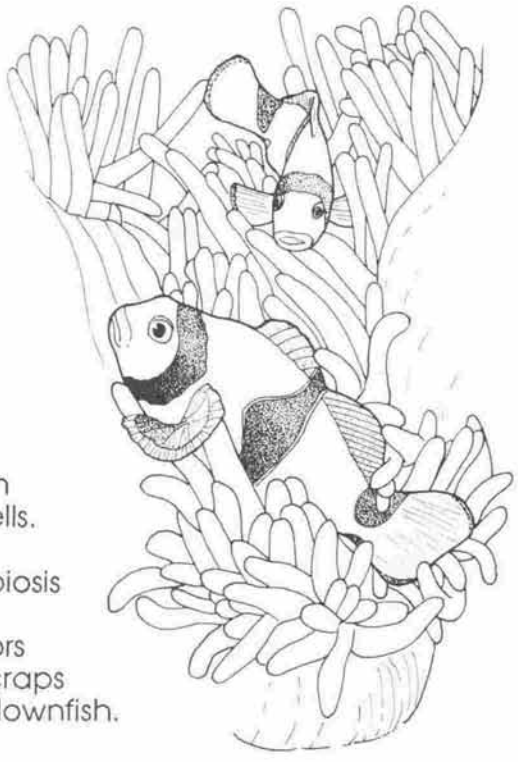
There are many different types of coral reef fish, some of which are bizarre and brilliantly-coloured. A few of the more common species are described below.

Cardinal fish (from the family Apogonidae), are small, mostly red-coloured, fish.

In most species, the male (shown on the right) carries the eggs and the young in its mouth.



Clownfish (family Amphiprionidae) are small brightly coloured fish (often red or black with white bands).

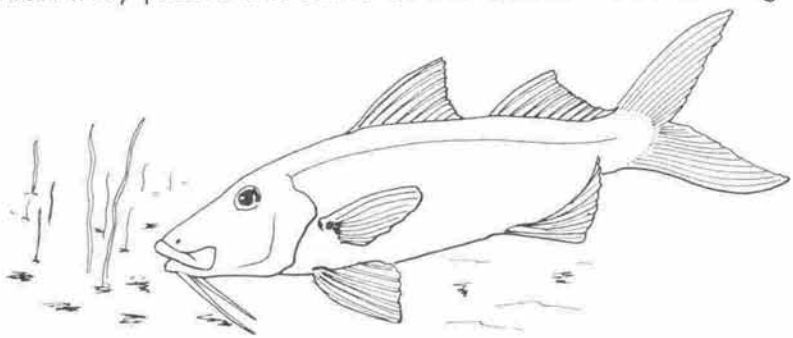


Clownfish usually shelter among the tentacles of sea anemones.

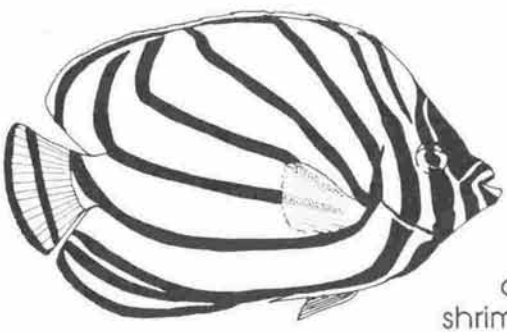
The fish give off a mucous substance to protect themselves from the anemone's stinging cells.

This is an example of symbiosis where the clownfish gains protection from its predators and the anemone uses scraps of food dropped by the clownfish.

Goatfish (family Mullidae), are mostly red or yellow in colour. They have a pair of large barbels under their chin with which they probe the sand of the ocean floor seeking food.



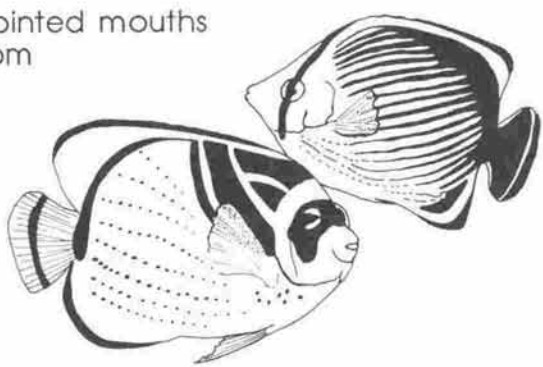
Butterfly fish (family Chaetodontidae), usually travel in pairs and have beautiful colours arranged in bold patterns, like their namesake the butterfly.



All butterfly fish have flexible, comblike teeth and show a wide variety of feeding habits.

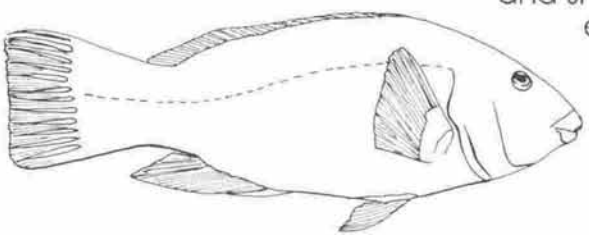
Different species are adapted to eat plankton, shrimps, sponges, and worms.

Some species have pointed mouths to suck coral polyps from their protective cups.



When alarmed, butterfly fish often wedge themselves into coral ledges by erecting their spines.

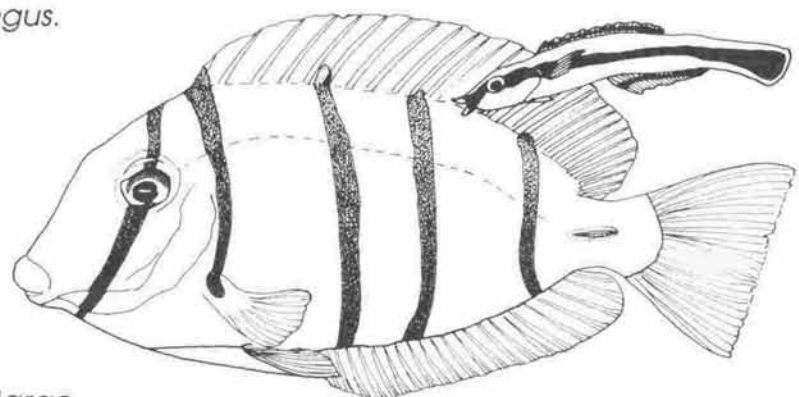
Wrasses (family Labridae), have a characteristic 'rowing motion' of their pectoral fins and only use the sweeping tail motion of other fish when they need to accelerate quickly.



Wrasses have small mouths and sharp pointed teeth to enable them to crush shelled animals and graze on plants.

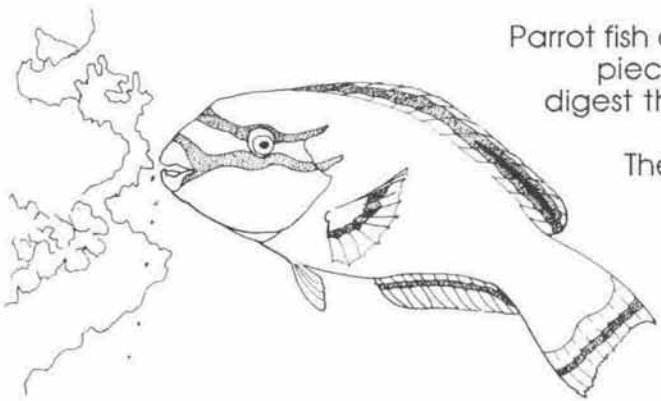
They are active during the day and often rest under the sand at night.

The cleaner wrasse, *Labroides dimidiatus*, is unusual in that it lives by picking particles of food and parasites from the teeth, mouth, gills and skin of larger fish. The picture below shows the cleaner wrasse cleaning the convict surgeonfish, *Acanthurus triostegus*.



Even large carnivorous fish wait placidly at 'cleaning stations' where they line up to have external parasites picked from their bodies. Unfortunately for the larger fish, a small but vicious blenny resembles the cleaner wrasse (see page 30).

Parrot fish (family Scaridae), have brilliant colours and a 'beak' formed by the fusion of their teeth, like their namesake the parrot. With this heavy beak they scrape algae from rocks and dead coral leaving characteristic marks on the surface. They also have rasp-like teeth in their throats to help grind their food.



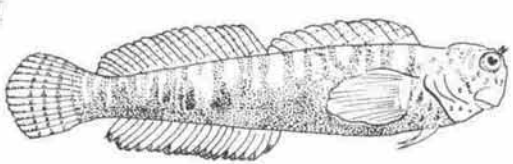
Parrot fish can also bite off pieces of coral and digest the coral polyps.

The remains of the coral skeletons then pass through the digestive tract as coral sand.

Much of the fine coral sand on the reefs may have passed through the guts of parrotfish.

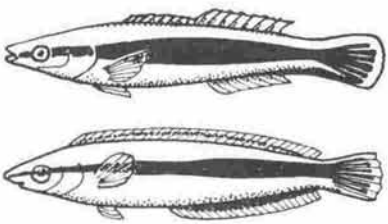
Blennies and Gobies (families Blenniidae and Gobiidae), are small, agile fish often found in shallow water and tide pools.

Some live under rocks and others, like the blenny shown at the left, live in burrows. The eggs are often laid in old shells which are guarded.



Some blennies are voracious carnivores. The sabre-tooth blennies *(Runula)* have sharp canine teeth and can give a painful bite if handled carelessly. They attack other much bigger fish from below or behind.

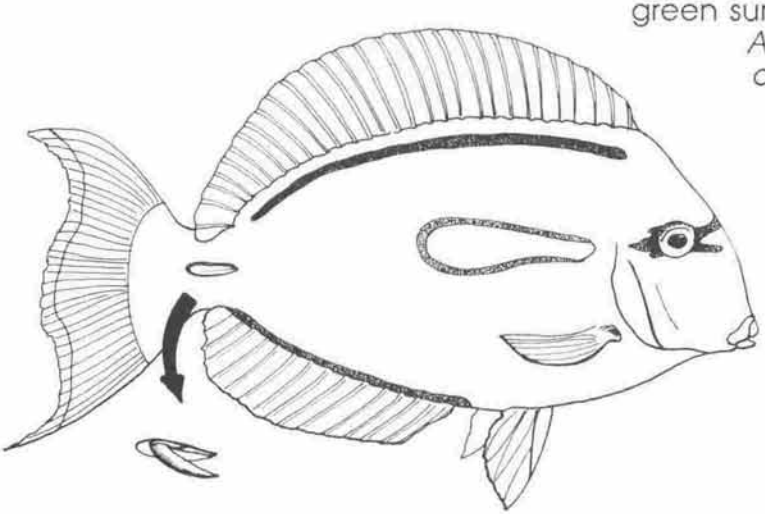
One blenny, *Aspidontus,* has grown to resemble (or mimic) the cleaner wrasse (see page 28) so closely that it can safely approach and bite pieces from large fish waiting to be cleaned.



The cleaner wrasse is shown at above right and its mimic, the blenny is shown below.

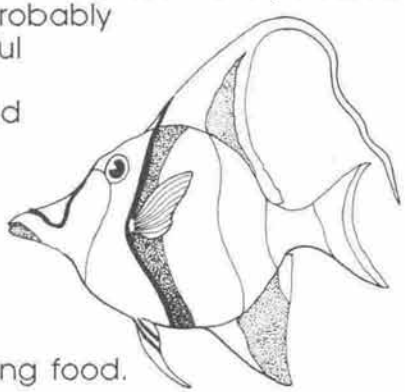
Surgeonfish (family Acanthuridae), owe their name to the knife-like spines near the base of their tail.

The figure below shows the green surgeonfish, *Acanthurus olivaceus.*



The single sharp spine folds into a recess at the base of the tail. It is erected when the fish feels threatened.

Moorish Idols (family Zanclidae), are closely related to surgeonfish. They are probably among the most beautiful of the reef fish with their graceful movements and distinctive colours of yellow, black and white.



Their extended mouths are used to poke into crevices seeking food.

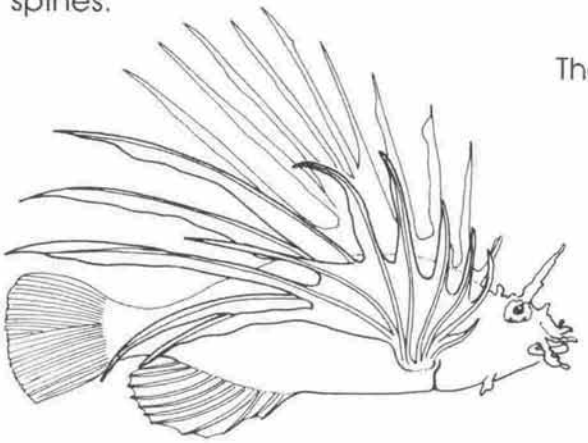
Stonefish (family Synanceiidae) are perhaps the most ugly and dangerous fish on the reef.

The stonefish has a scaleless, flabby body covered with wart-like formations.

It has poisonous spines on the dorsal fin which sticks up from the puckered skin.

The stonefish resembles the eroded limestone on which it lies. The fish is well camouflaged, as shown below, and so can easily be trodden on. The slightest skin puncture causes excruciating pain and even death.

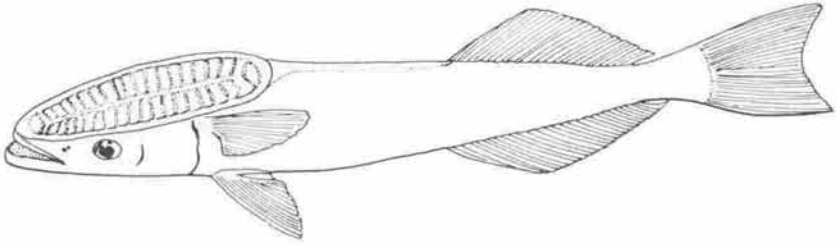
Scorpionfish (family Scorpaenidae), also have poisonous spines.



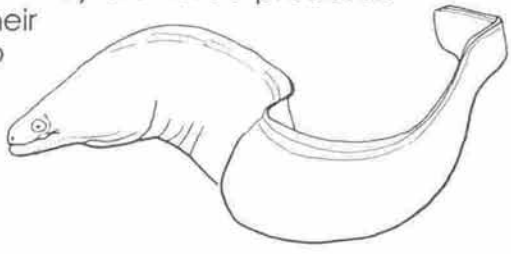
The group includes the spectacular lionfish or firefish *(Pterois)* shown at the left.

It has red or orange and yellow stripes and long, spine-tipped fins.

Suckerfish or remoras have a suction disc made up of 16 or more movable vanes on the top of their heads. With this disc, the fish attaches itself to sharks, turtles, and even hulls of boats, feeding on debris from its host.

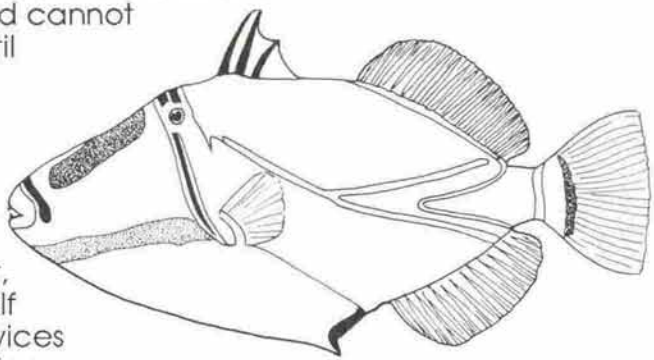


Moray eels (family Muraenidae). Although snake-like, moray eels are fish. They are fierce predators and will dart from their holes in the coral to attack their prey.



Moray eels do not have poison glands but the wound caused by their bite may turn septic.

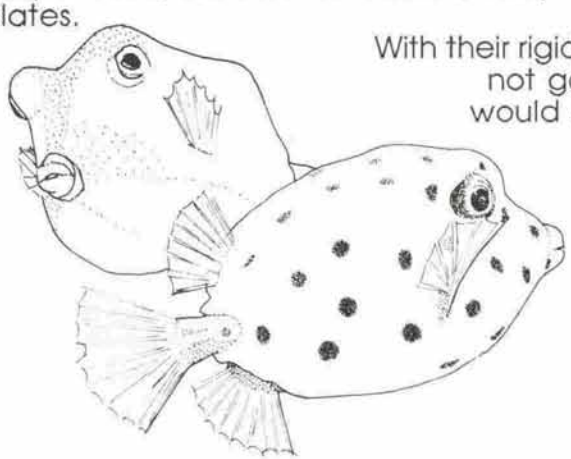
Triggerfish (family Balistidae), owe their name to the trigger-like mechanism which locks the dorsal spines erect. The long front spine of the dorsal fin locks upright and cannot be released until the smaller second spine (the trigger) is released.



The trigger fish, when in danger, can wedge itself into narrow crevices by locking its spine.

The Triggerfish has exceptionally strong teeth and jaws which enable it to eat tough plants and hard-shelled creatures like sea urchins.

Boxfish (family Ostraciontidae), have a peculiar box-like shape and, instead of scales, they have heavy bony plates.



With their rigid bodies, boxfish are not good swimmers, and would appear to be easy prey for predators.

They do, however, release poisons from their skin as a warning to predators.

The flesh of boxfish is poisonous to eat.

The juveniles of the blue-spotted boxfish (shown above) live in shallow reef pools and have been described as looking like slowly revolving, yellow dice.

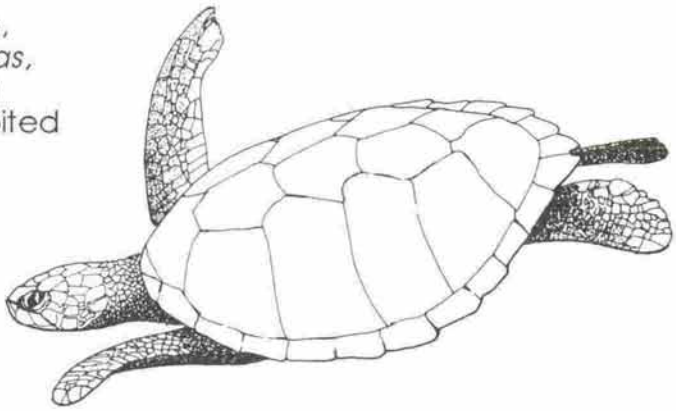
OTHER REEF LIFE

A coral reef supports such a great variety of living things that this handbook has been able to introduce only a few of the many different species. Whole groups of interesting invertebrate animals, such as the sponges and worms, have had to be left out.

One group of common vertebrate animals, the reptiles, is represented in the drawings below.

Turtles lay eggs on tropical beaches. The newly-hatched young make a dash across the sand and swim to the reef, dodging their many predators.

The green turtle, *Chelonia mydas,* (shown at right) is heavily exploited for its meat and eggs.



Sea snakes are air-breathers with flattened tails and are therefore very different animals from moray eels (page 32). They do however, give birth to their young in the water.

Although the turtle-headed sea snake, *Emydocephalus annulatus,* (shown at right) is relatively harmless, all sea snakes have poisonous fangs and should be avoided.

BEWARE OF THESE REEF ANIMALS

This handbook has pointed out some dangerous reef animals. Although they may look beautiful, many animals have had to develop mechanisms including poisons, spines and stings to protect themselves from predators; many of these protective measures are dangerous to humans.

Animals which should not be touched are listed below.

Box jellyfish
Bristle worms
Cones
Crown-of-thorns starfish
Lionfish
Moray eels
Sea snakes
Sea urchins
Stinging anemones
Stonefish
Portuguese man-of-war
Fire corals

WHY ARE CORAL REEFS IMPORTANT?

The skeletons of corals break down to rubble and eventually to sand which helps build up shore-lines and beaches. Coral reefs also protect coastlines and coastal villages from large ocean waves created by storms and cyclones.

Barrier reefs form sheltered lagoons where more delicate plants and animals can live and where people can safely go fishing. Coral reefs create a place where animals such as crabs, lobsters, clams and reef fish can live and provide food for nearby villages.

Without coral reefs, many coastal areas in the Pacific would be without protection from the sea and without such a large variety of seafood.

HOW ARE CORAL REEFS DAMAGED?

Corals have few natural enemies. Some fish, such as parrot fish, have jaws strong enough to break off pieces of coral. Other fish, such as some butterfly fish, have tube-like mouths to suck up coral polyps.

Some animals burrow into the coral for shelter or food.

A few plants and animals, such as the sponge, shown here, can grow over the coral and smother it.

But the activities of people present the greatest threat to corals and coral reefs.
People damage reefs by.....

a) collecting coral as building blocks or as souvenirs for sale to tourists,

b) damaging live coral by anchoring or landing boats on the reef - corals can take a long time to grow back,

c) overfishing or taking too many animals of one type from the reef - this affects the delicate balance between living things on the reef (the ecosystem on pages 12 and 13),

d) using destructive methods of fishing, such as explosives and poisons - these methods kill not only fish but also coral polyps.

e) allowing pollution from factories and oil from ships to be released into the water, and,

f) dredging harbours, coastal building projects and forestry - these activities release silt into the water which blocks off sunlight or smothers the coral polyps.

QUESTIONS FOR STUDENTS

LEVEL 1

1. In the underwater scene shown on pages 12 and 13, try and find the animals listed below and write down their local names:

SHARK.....	SEA CUCUMBER.....
TABLE CORAL.....	GIANT CLAM.....
SEA STAR.....	STAGHORNCORAL.....
PARROTFISH.....	SURGEONFISH.....

2. Name the three different types of coral reefs.

3. Why is the shell of a living cowry shiny and clean?

4. How did the surgeonfish get its common English name?

5. What does the hermit crab use as its home?

6. What does a giant clam feed on?

7. How does the blenny (shown in the drawing on page 30) get its food?

8. Which of the following Pacific countries have coral reefs?

Western Samoa
New Zealand
Vanuatu
Tahiti
Japan
Kiribati
Tonga

QUESTIONS FOR STUDENTS

LEVEL 2

1. The animals listed below are dangerous to handle. Say *why* each of the animals is dangerous.

Cone Shell
Black long-spined (or hat-pin) urchin
Lionfish
Fire coral

2. Describe one theory on how coral atolls are formed. Discuss the time taken for this to happen and how this relates to the growth of coral.

3. Why is it that only the outer layer of massive coral reefs contains living corals?

4. Give three examples of symbiosis in a coral reef ecosystem.

5. What weight (biomass) of primary production (phytoplankton and algae) is required to produce one kilogram of shark?
Why is this?

6. Make a list of animals which are collected or caught in large numbers on nearby coral reefs.
Discuss how this activity could affect the coral reef ecosystem.

7. Discuss the ways in which coral reefs can be damaged by the activity of people.

A GLOSSARY OF CORAL REEF TERMS

(with English pronunciations)

Calcium carbonate: The white limestone material which makes up the skeletons of coral polyps and the shells of molluscs such as giant clams and trochus. The chalk used on blackboards is mostly calcium carbonate.

Carnivore: An animal which eats another animal.

Coral polyp: (pronounced "pol-lip"): A small individual coral animal with a tube-shaped body and a mouth surrounded by tentacles.

Herbivore: An animal which eats plant material.

Larvae (pronounced "lar-vee"): The young stages of many marine animals including corals. Most larvae are small and drift in the sea before becoming adults.

Limestone: The calcium carbonate material which makes up coral reefs.

Photosynthesis (pronounced "fo-to-sin-the-sis"): the process by which plant material is formed from water, nutrients and carbon dioxide using energy absorbed from sunlight.

Phytoplankton (pronounced "fy-to-plank-ton"): Small plants, which drift in the sunlit surface layers of the sea.

Primary producers: Plants, including algae and phytoplankton which use sunlight and nutrients.

Symbiosis (pronounced "sim-by-o-sis"): A relationship between two different creatures which live together for the benefit of both. Plant cells (called Zooxanthellae) have a symbiotic relationship with coral polyps.

Tentacles (pronounced "tent-a-culls"): The "arms" which surround the mouth of a coral polyp. Other animals, such as the octopus, also have tentacles.

Zooplankton: Small animals, or the larvae of larger animals, which drift in the sea.

Zooxanthellae (pronounced "zo-zan-thell-eye"): Small plant cells living within coral polyps.