Coral reefs can stretch for hundreds of kilometres, long enough to be easily visible from space. Yet these mammoth structures are built by some of the oldest, tiniest and most colourful animals on earth. This is their story.

By MALLIKA NAGURAN

tiny giants

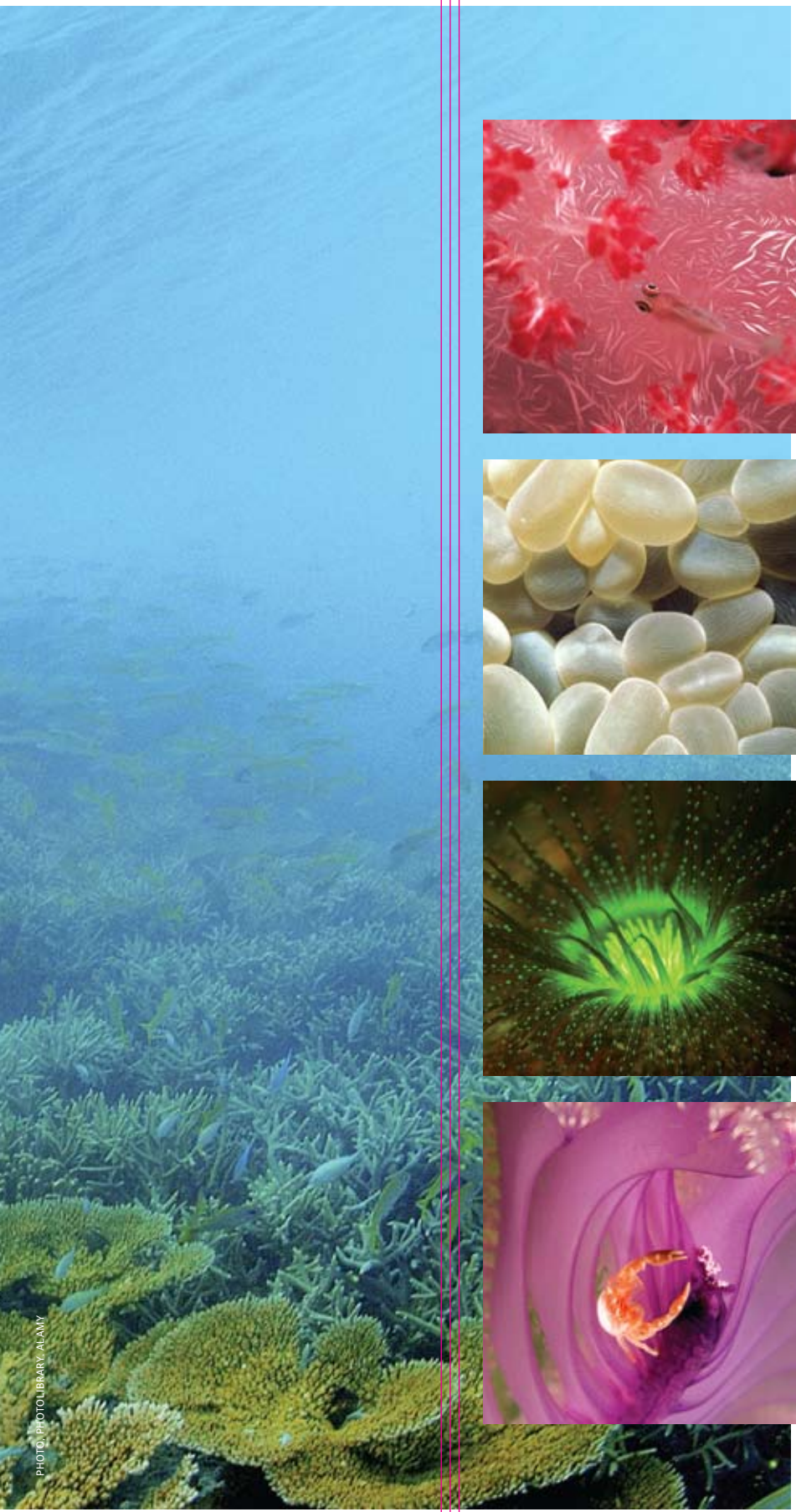


PHOTO: PHOTOLIBRARY, ALAMY

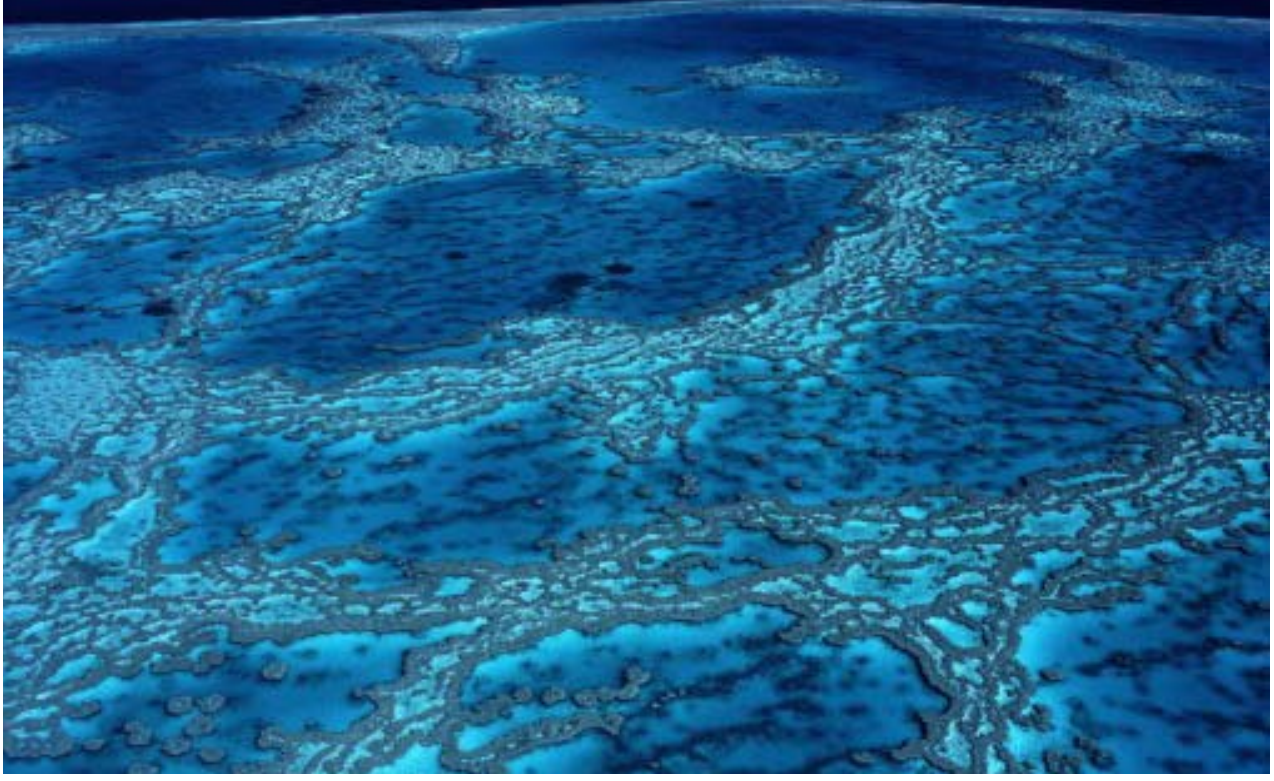
Red, yellow, purple, even glorious fuchsia, coral reefs are the Disneyland of the underwater world, complete with characters like shrimp, clown fish, batfish, turtles and evil-eyed moray eels.

Despite their stunning plant-like beauty, corals reefs are in fact made up of millions of tiny animals called polyps. Most of these are about as big as a pencil eraser and develop so slowly that some colonies only grow at a rate of 1 metre every 1,000 years. But, small as they are, they create the foundations for some of the underwater world's most intricate ecosystems.

"Without corals there would be no home for reef fish, crabs, lobsters, octopuses and innumerable other forms of life," says Dr Thomas Goreau, president of the Global Coral Reef Alliance. "Coral reefs support marine biodiversity, fisheries, shore protection and tourism."

"No other organism does all these things," added Goreau, who previously worked as a Senior Scientific

Snorkellers benefit from the wonders that are coral reefs. Some of the amazing sights on offer include (left, from top) tiny goby fish swimming through **spiral coral**; **bubble coral** polyps; a luminescent **Cerianthus polyp**; and **porcelain crabs** living in lush, soft coral beds.



Affairs Officer at the United Nations Centre for Science and Technology for Development, in charge of climate change and biodiversity.

Spread out around the world, mainly in equatorial regions, there are around 600 reef-building, shallow-water coral species. They are most diverse in warm water areas like the Coral Triangle, a 5.7-million-square-kilometre maritime that stretches westwards from the Solomon Islands, past the northern tip of Australia, taking in the eastern islands of Indonesia, Borneo and the Philippines.

Home to 75 percent of all coral species, the Coral Triangle also attracts 3,000 types of fish, rays and sharks, as well as a turtles and myriad of marine mammals including 22 different dolphin species.

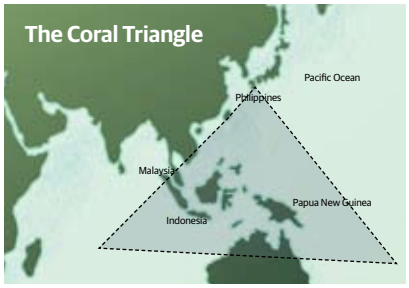
Coral reefs like these and "the Great Barrier Reef in Australia, the Barrier Reef of Belize and the Florida Reef Tract - are enormous and stretch for thousands of kilometres," says Richard Leck, who leads climate change strategy on the Coral Triangle for the WWF, the global conservation group, and is a key member of a campaign to protect Australia's Coral Sea.

It's surprising enough that corals are animals, rather than plants, but even more surprising is the fact that corals are relatives of jellyfish, belonging to a large animal group known as *Cnidaria*, which also includes sea anenomes. Although they share key characteristics with these other creatures, corals behave uniquely in the way they eat, grow and reproduce.

Hungry Mouths

Corals are ravenous and eat to gain energy to grow and reproduce. In essence, a coral polyp is a fleshy sac with a mouth at the top surrounded by tentacles that leads to a digestive gut. All cnidarians use stinging cells on their tentacles to stun and capture passing food sources like plankton, worms, urchins and fish, before swallowing and digesting them.

Reef-building (hermatypic) corals get most of their energy from sunlight, which is why they only thrive 30 degrees either side of the equator. The sunlight filters through the tropical seas and reacts with microscopic algae (*zooxanthellae*) that live symbiotically in their tissues. The algae then use photosynthesis to produce sugar, which the corals in turn use for energy to build their skeletons.



An aerial view of a section of the **Great Barrier Reef** (top) reveals a vast interconnecting network of corals. Jellyfish (centre) are free to roam but they are part of **the same family** of creatures as corals. The **Coral Triangle** (bottom) is home to 75 percent of all known coral species.

CORAL FACTS ◉ **41:** *number of major cold water reefs* ◉ **109:** *number of major warm water reefs* ◉ **284,300 sq km:** *total warm water reef coverage* ◉ **6,000-9,000 years:** *age of warm water reefs*

But not all of the corals' nutrition comes from the *zooxanthellae*. "Corals ... are very efficient carnivores with their stinging cells, at least on things smaller than themselves," says Goreau. "The role of the *zooxanthellae* is largely for (providing energy to) greatly speed up the rate of skeleton growth."

Not all corals live the high life eating sugar in blue lagoons. Hiding way down in the ocean depths are non-reef building (ahermatypic) corals such as deep seamount corals. These are small and solitary, living in dark and freezing waters up to 5,000 metres beneath the surface, feeding on drifting plankton and organic particles. Some deep, cold water corals do build reefs like the surface corals, though they do so more slowly.

Life Cycles

When it comes to breeding, corals use asexual multiplication, which means polyps simply divide to form new ones. But they can also reproduce sexually. Some species carry out a mass spawning following a full moon, when millions of eggs and sperm clouds are released in an amazing display of underwater fertility.

Fertilised eggs then hatch into tiny planula larvae that swim to a bare patch of reef to start a new colony, a process that has been going on for millions of years. Corals come in soft and hard types, with tentacles numbering in multiples of six or eight. Soft corals, as the name suggests, lack a hard limestone skeleton. Looking much like fluffy cotton candy, furry mushrooms and lacy fans, soft corals are some of the the prettier ones in the family.

Hard corals are the backbone of the reefs. Their outer layer, the ectoderm, sucks in minerals from sea water to secrete calcium carbonate (limestone) forming a hard protective skeleton. Over time, all the polyp skeletons in a colony accumulate and form layers with

CORAL TYPES

>> **Sea or Gorgonian Fans** (*Subergorgia millis*) are finely branching colonies that form broad sheets, measuring up to 2 metres or more in diameter. Sea fans thrive where there are strong currents, which the polyps filter for food.

Deep sea corals (*Desmophyllum dianthus* or *Lophelia pertusa*) survive at depths of 4,000 meters by filtering krill, copepods and other tiny food particles from the water.

Sea Pens (*Pteroeidae*) are soft corals that resemble a writing quill. They form a rigid stalk with a bulbous base, and when touched, can emit a bright green bioluminescence.

>> **Finger Coral** (*Porites porites*) colonies form thick, stout branches. During the day, the extended polyps give the coral a fuzzy appearance. Colours can be yellow-brown, brown, grey and purple.

Mediterranean Sea Red Corals (*Corallium rubrum*) form branches that have been used to make jewellery for thousands of years. They occur on rocky reefs between depths of 10 and 250 metres.

Sea Whips (another Gorgonian) are a group of species that form long, whip-like strands with few or no branches.

>> **Lettuce Corals** (*Agaricia agaricites*) form thickly encrusted flat plates in mangroves and back reef areas.

Staghorn Coral (*Acropora cervicornis*) has cylindrical branches that break off from a colony in the asexual reproduction process. These reattach in a new location and grow again. It is the fastest growing coral, developing at a rate of 10 to 20 cm per year.

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◉ **51,020 sq km:** *warm water reef area off Indonesia* ◉ **Largest single reef:** *Great Barrier Reef (30,000 sq km)* ◉ **4-25mm/year:** *growth rate of cold water coral reefs*

TECHNOLOGY TO THE RESCUE

Invented by the late Wolf Hilbertz, the Biorock method is being used to restore destroyed and damaged reefs. It involves passing a low voltage current through a conductive frame anchored to the seabed. The electrolytic reaction causes calcium carbonate and magnesium hydroxide to grow on the structure, enabling transplanted coral fragments to grow up to six times faster than usual.

Dr Thomas Goreau has used the Biorock method in many areas. "No one believes what we do is possible until they see it themselves," he says, "growing coral reefs that swarm with fish in places that were barren only a few years before."

other polyp skeletons, fish skeletons, marine shells and sand to lay down a sedimentary "rock." These make up what we know as fringing, platform or barrier reefs.

It's an incredibly slow process. "Even with ideal conditions, reef building corals, like massive brain corals, may only grow 0.5 to 2 centimetres per year," says Leck, "although faster growing branching corals such as staghorn corals can grow vertically up to 10 centimetres a year."

Coloured to Survive

Disappointingly for holidaymakers, not all corals are brightly coloured. It's mainly the hermatypic corals that offer the wonderful shades of red, green and yellow we see in books and on postcards.

PHOTOS GETTY IMAGES, PHOTOLIBRARY

Coral Timeline

Precambrian
570-650 million years ago. Oldest relatives of corals, soft bodied jellyfish-like organisms

Cambrian
504-570 million years ago. Stromatoporoids and rugose corals; first primitive fish develop

Ordivician
441-504 million years ago. Complex algae and reef communities with red coralline algae, stony bryozoans

Silurian
413-441 million years ago. Reefs develop from stromatoporoids, tabulate and rugose corals

Devonian
365-413 million years ago. Massive reefs develop, but become extinct

Coral Spawns a Darwin Theory

Early scientists believed for centuries that the earth was static and unchangeable, until a 28-year-old British geologist came along in 1837 with a brand new theory – based on his observations of corals.

Charles Darwin deduced that an oceanic atoll was formed by a fringing reef that grew on the shallow margin of a volcanic island as it sank. He presented his ideas in a paper, which met with strong criticism. But in 1946, over a century later, he was vindicated.

As part of US atomic bomb research on Pacific atolls, scientists bored test holes hundreds of metres deep. On Enewetak Atoll they hit olivine (volcanic) rock, which is exactly the same rock that forms the Pacific's high island peaks – and so Darwin's theory of sinking peaks and evolving colonies was right after all.

"*Zooxanthellae* give corals their background green-brownish hue," says Professor Chou Loke Ming from the National University of Singapore.

"The pigments that give the really bright colours are then manufactured by the coral species themselves. But as to why coral reefs are colourful, only nature knows."

One theory is that pigment colours act as a protective layer against excess radiation levels that can hinder photosynthesis.

Professor Ove Hoegh-Guldberg of Australia's University of Queensland believes coral pigments also work to absorb harmful ultraviolet rays, or perhaps to re-radiate light as the tide rises or sunlight diminishes, in order to maintain photosynthesis. Life as a coral isn't easy.

"The variety of shapes and colours are also nature's way of ensuring survival," explains Chou.

Different shapes help protect against nibbling fish, tsunamis, silting and plagues like the voracious crown-of-thorns starfish. This results in a mindboggling diversity of colours and shapes that can resemble cabbages, horns, mushrooms, fans, whips and even brains.

A Larger Threat

"The oldest stony corals are the reef-forming tabulate corals and stromatoporoids (sclerosponges), as well as rugose or 'rough' corals that originated around 500 million years ago," says Goreau. Those groups are now extinct, but their descendants have survived ice ages and the cataclysms that helped kill off the dinosaurs, is extremely impressive.

But many corals are under threat once more - from humans. Coral reef ecosystems are being damaged by pollution, sedimentation, dynamite fishing, irresponsible tourism and deep sea trawling, as well as by the effects of climate change.

The threats are not restricted to the reef's immediate surroundings. "The health of coral reefs is affected by the water they live in," Leck says. Man-made runoff from poor land management or pollution from households and industry all provide deadly poisons for corals. "Reefs are very delicate organisms," says Leck. "And it's our responsibility to make sure we understand and protect them as well as we can."

With a little help and care, corals may grace the world with their beauty for millions of years to come. ■

Carboniferous
290-365 million years ago. Reefs re-establish, similar to today

Permian
245-290 million years ago. Mass extinction wipes out 90% of species, including rugose and tabulate corals

Jurassic, Triassic
140-210 million years ago. Corals thrive again across the globe

Cretaceous
65-140 million years ago. Mass extinction of one-third of animal species, including dinosaurs and some reefs

Eocene-Miocene
5-37 million years ago. Formation of most diverse reefs ever