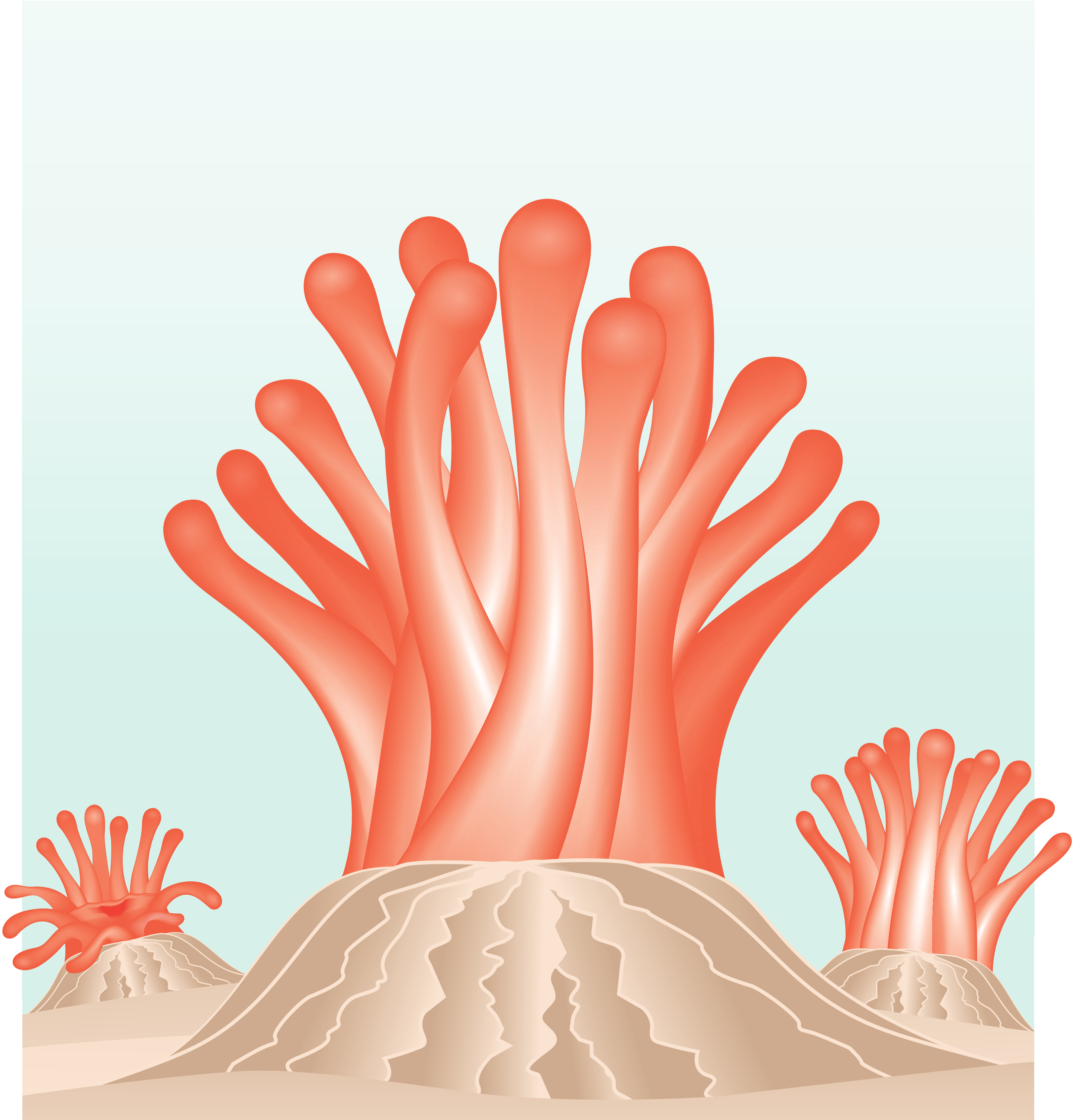


Coral Reef Ecosystems

YEAR NINE AND TEN STUDENTS

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK
Queensland Government

Introduction

The Queensland Museum has one of the largest coral collections in the world, with an estimated 46,000 specimens. Many of these coral specimens are from the Great Barrier Reef, but the collection also includes a large number of specimens from across all the major coral reef sites in the world. This collection is used by researchers from Queensland Museum and many other Australian and international institutions to identify and monitor coral species, describe new species, and monitor changes in coral reefs through time.

A high proportion of coral reefs have either been lost or heavily degraded in recent years; the outlook for coral reefs is bleak due to factors such as coral bleaching, ocean acidification, and more frequent weather events associated with warmer oceans. In the "worst case scenario" this collection will act as a repository of at least some coral species, in much the same way that museums now house large collections of dinosaur skeletons.

Australian Curriculum Links

As this resource has been designed to complement classroom-based teaching and learning experiences, students are assumed to have developed knowledge about the following concepts:

— Calculation of surface area and volume of different shapes.

YEAR 9

Science Understanding

Biological Sciences

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems *(ACSSU176)*

YEAR 10

Measurement and Geometry

Using Units of Measurement

Solve problems involving surface area and volume for a range of prisms, cylinders and composite solids *(ACMMG242)*

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC project aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

Coral Reef Ecosystems

Coral reefs are beautiful and vibrant structures found in oceans around the world. These structures support a great diversity of organisms, including fish, crustaceans, sponges, worms, snails, slugs and starfish. The combination of all of these organisms and their physical environment make up the coral reef ecosystem.

The Great Barrier Reef is the largest coral reef ecosystem on Earth and can be seen from outer space. This network of reefs is home to more than 600 coral species, 1500 fish species, 1300 crustacean species, and 10,000 snail and bivalve species! It is easy to be overwhelmed by the great variety of organisms found on a reef, but it is important to remember that corals are the foundation of the entire ecosystem. Not only do corals provide food to other creatures, they also create the structure of the reef that provides homes for other reef-dwelling organisms. Given its importance, coral will be explored more on the following pages.

Coral reef. Image: Gary Cranitch, QM.

What is coral?

Although they can look like rocks, corals are living organisms made up of tiny animals called polyps (see Figure 1).

The polyps are soft animals, but they secrete a solid calcium carbonate base, or corallite, that they can retract into. These corallites form the hard surface of coral that we see on a reef.

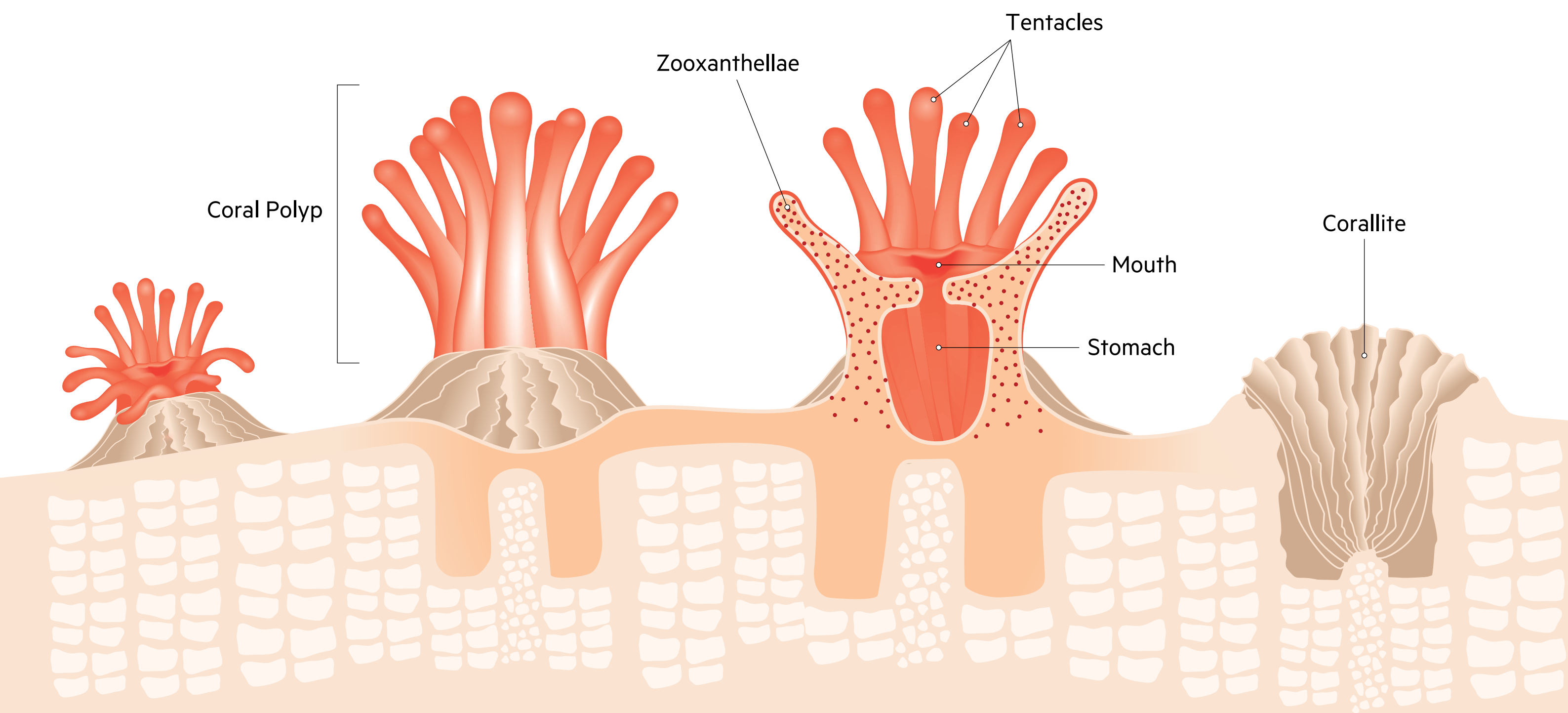


Figure 1: Anatomy of a coral polyp. Coral polyps can range in size from half a millimetre to over 20 cm!

Many corals get energy from microorganisms called zooxanthellae (zo-zan-THELL-ee) that live inside the cells of the polyp. These zooxanthellae are like tiny plants that provide food to the coral polyps in the form of glucose. Zooxanthellae do this by by performing photosynthesis, in which they convert carbon dioxide (CO_2) and water (H_2O) to glucose ($C_6H_{12}O_6$) and oxygen (O_2):

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Because photosynthesis can't occur without light, zooxanthellae need light to live, and therefore these corals can only live in clear, relatively shallow water. Zooxanthellae are also sensitive to temperature; if seawater gets too hot, the corals lose their zooxanthellae and turn white. This is called coral bleaching.

Branching Coral. Image: Gary Cranitch, QM & Paul Muir, QM

Mushroom Coral. Image: Gary Cranitch, QM & Paul Muir, QM

Brain Coral. Image: Gary Cranitch, QM & Paul Muir, QM

Did you know that the pigments zooxanthellae use for photosynthesis give corals their colour?

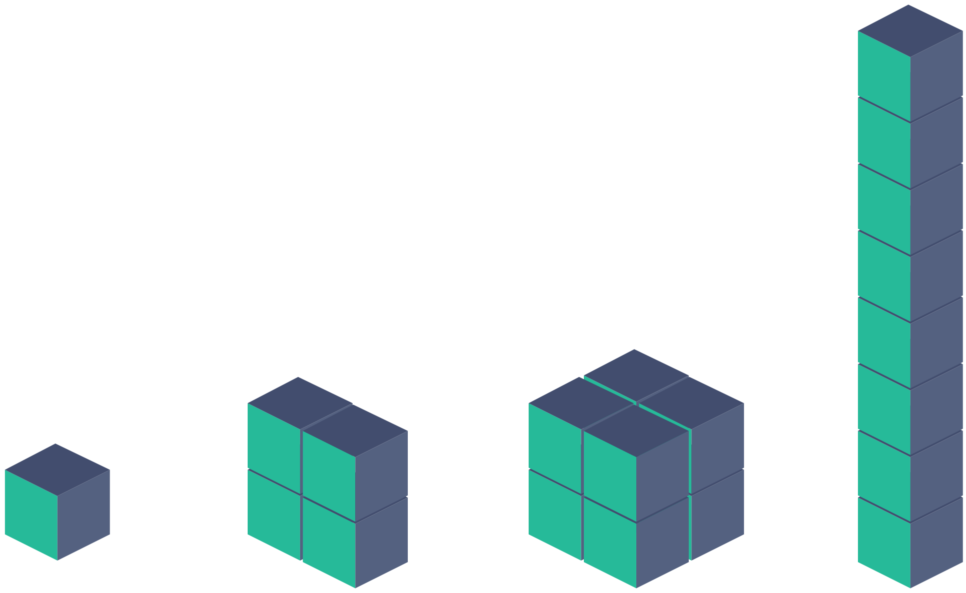
Corals come in a variety of shapes and sizes. Even one type of coral can look different in different places. This is because corals are colonies of polyps, and can change form much more than other animals in response to different environments.

We have established that corals need sunlight for their zooxanthellae. However, we have not explored *how many* zooxanthellae live within corals. This topic can be addressed by thinking about the relationship between zooxanthellae and the shape of coral. More specifically, we can examine the relationship between surface area and volume.

Surface area is the area covered by the surface of an object.

Volume is the amount of space occupied by an object.

As a warm-up, calculate the surface area and volume of the shapes below:



	H: 1 cm	H: 2 cm	H: 2 cm	H: 8 cm
	L: 1 cm	L: 2 cm	L: 2 cm	L: 1 cm
	W: 1 cm	W: 1 cm	W: 2 cm	W: 1 cm
Surface Area =	________	________	________	________
Volume =	________	________	________	________

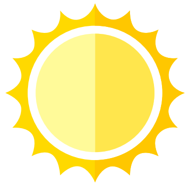
Extension Activity: Design your own coral shape, and have a partner calculate the surface area and volume.

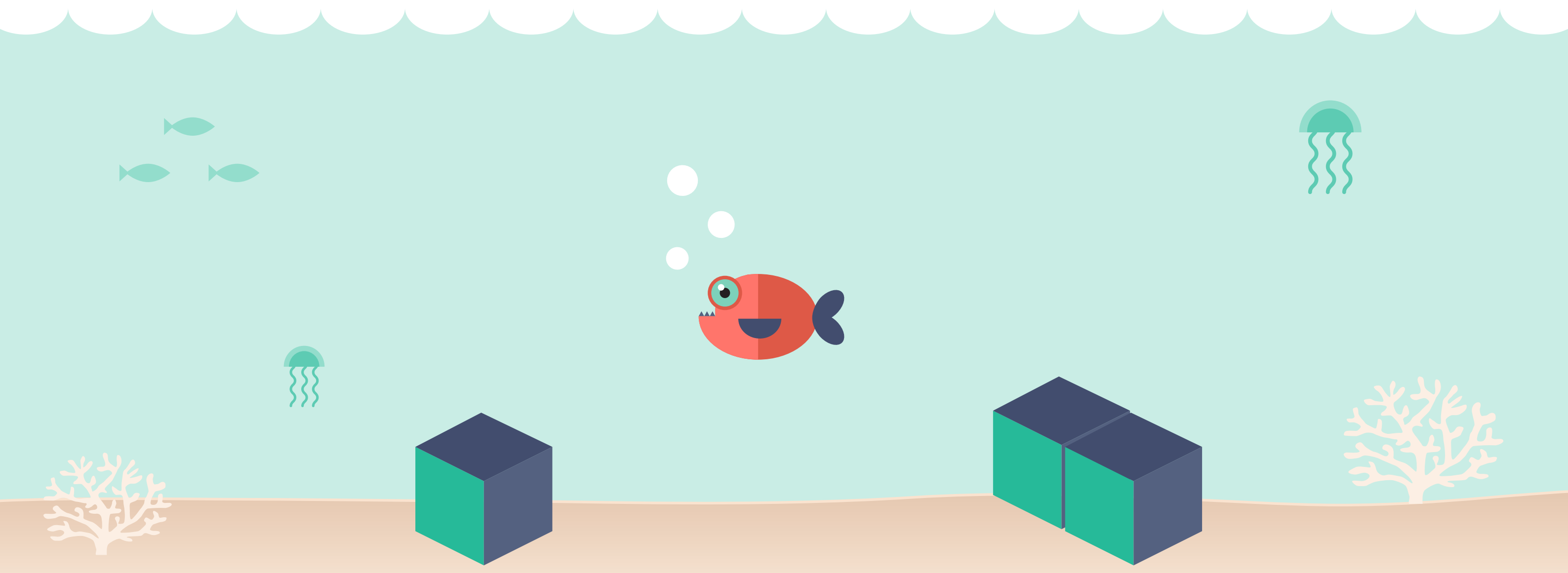
Coral: Surface area and volume

The surface area of a coral is the outermost layer of coral that is exposed to the environment. This is important because zooxanthellae can only live on the surface, where they get sunlight. Therefore, corals with greater surface area have more tissue exposed to sunlight, and more zooxanthellae.

Greater surface area of coral = more zooxanthellae = more food for the coral

This relationship can be seen in the Figure 2, which shows two example "corals." Let's calculate the amount of surface area in each coral that is exposed to sunlight (the space where zooxanthellae can live). We can do this by calculating the total surface area, and subtracting out the surface area of the base, because the base is not exposed to the sun. (Remember, surface area is expressed as cm^2.)





Coral A

H / L / W: 1 cm

Sun-exposed surface area = 5 cm^2

Coral B

H: 1 cm / L: 2 cm / W: 1 cm

Sun-exposed surface area = 8 cm^2

Figure 2. The amount of surface area exposed to sunlight in two different corals.

Zooxanthellae are tiny. In corals A and B on page 7, let's say that 100 zooxanthellae can live in every 1 cm^2 that receives sunlight (the sun-exposed surface area of the coral). Calculate how many zooxanthellae live in coral A and B.

The statistic of 100 zooxanthellae per square centimetre is given to make the calculation simple - in real coral there are many more zooxanthellae! For example, one study* found 1.8 million zooxanthellae per cm^2!

*Fujise, L. *et al.* (2014). Moderate thermal stress causes active and immediate expulsion of photosynthetically damaged zooxanthellae (Symbiodinium) from corals. PLoS One 9: e114321.

Number of zooxanthellae in coral A

= Sun-exposed surface area x 100 zooxanthellae

= 5 x 100

= 500 zooxanthellae live in coral A

1. Number of zooxanthellae in coral B (show working):

2. Coral B is double the size (volume) of coral A. Looking at your calculations, does it have double the zooxanthellae? Why/why not?

We have now looked at how surface area determines how many zooxanthellae a coral can have. What is the importance of a coral's volume? The bigger the size (volume) of a coral, the more food it needs to stay alive. We observe this relationship all the time. For example, an adult person needs to eat more calories each day than an infant.

Greater volume = more food required to stay alive

3. Calculate the volumes of coral A and coral B. (Remember, volume is expressed as cm^3.)

   Volume of coral A:

   Volume of coral B:

Let's say every 1 cm^3 of coral needs 500 zooxanthellae to make enough food to survive.

4. Calculate the number of zooxanthellae each coral needs to stay alive.

   Coral A:

   Coral B:

5. Do both corals have enough zooxanthellae to survive?

One coral's volume is "too big" for its surface area. It does not get enough sunlight to make enough food! This difference between corals A and B exists because, as objects get bigger, *volume increases faster than surface area*.

In real life, many corals do not get 100% of their energy from their zooxanthellae; they also have to feed on plankton (tiny floating plants and animals) to fulfil their energy needs. However, different types of corals have to eat more than others, depending on their surface areas and volumes. We will be able to figure out which coral shapes get more energy from zooxanthellae if we look at one last relationship: the ratio of sun-exposed surface area to volume.

Surface area to volume ratio

Sometimes the surface area and volume of an object is written as a ratio, which is a relationship between two numbers. Ratios can be written in three ways.

For example, if a cube has a surface area of 6 and a volume of 1, its surface area to volume ratio is 6 to 1, 6:1, or 6/1 (these are different ways of writing the same ratio). If we divide the fraction out (6 ÷ 1), we get 6.

Go back to the shapes on page 6 and calculate the surface area to volume ratio of each shape. Write as a fraction, then divide the fractions out to get a number.

Which shape has the highest surface area to volume ratio? Which has the lowest?

The surface area to volume ratio is important because it allows us to compare which coral shape has more zooxanthellae per unit volume. As you can see in Figure 3 (page 10), the coral with the higher ratio (coral A) has more zooxanthellae per unit volume; coral A is getting more energy from its zooxanthellae than coral B, and needs to eat less plankton than coral B.

Now that we know more about the relationship between surface area and volume, look at the different types and shapes of coral shown in Figure 4 (page 11).

6. Which shapes do you think would have a high surface area to volume ratio? Why?

7. Which shapes do you think would have a low surface area to volume ratio? Why?

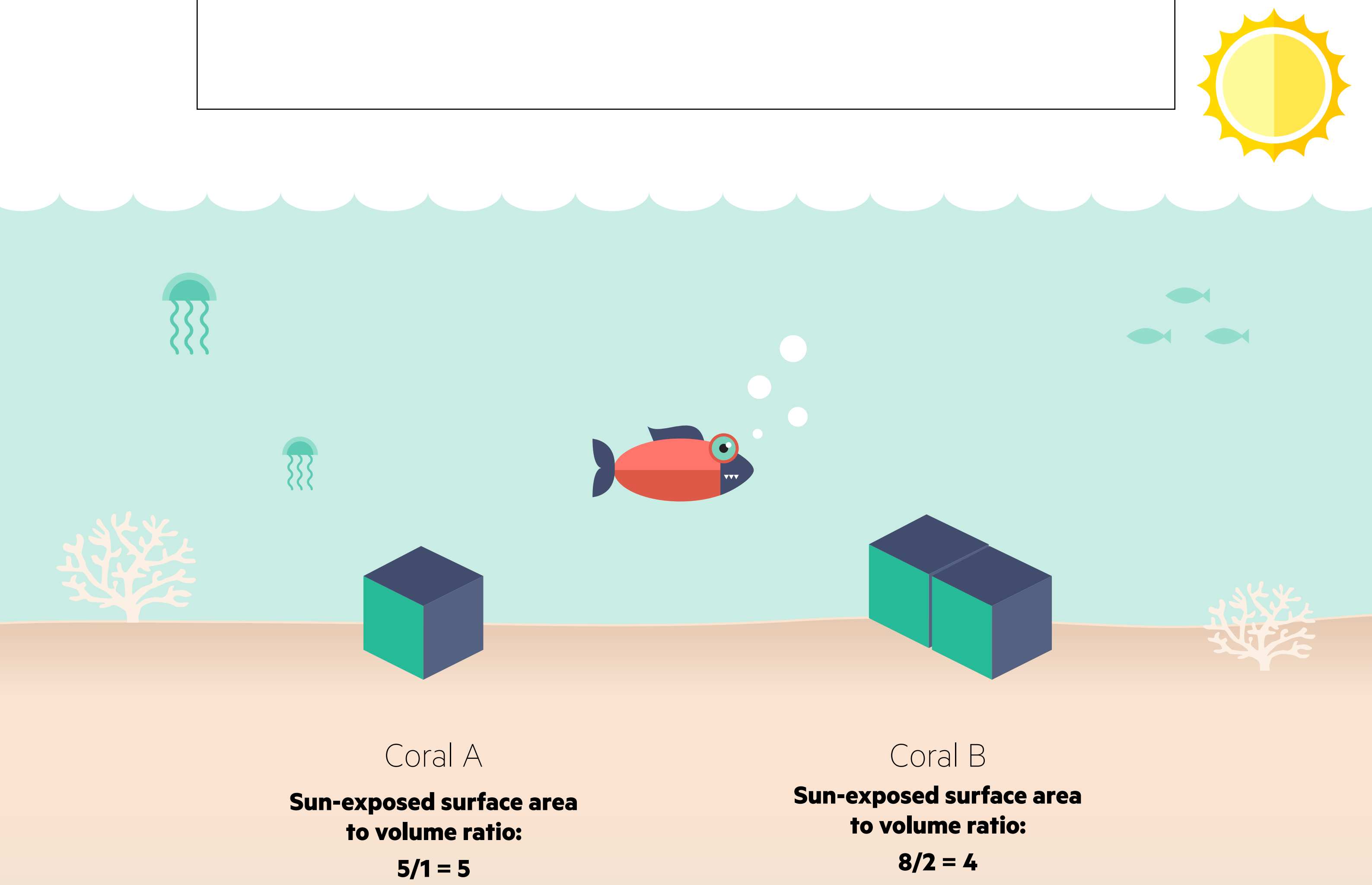


Figure 3. The sun-exposed surface area to volume ratio for corals A and B.

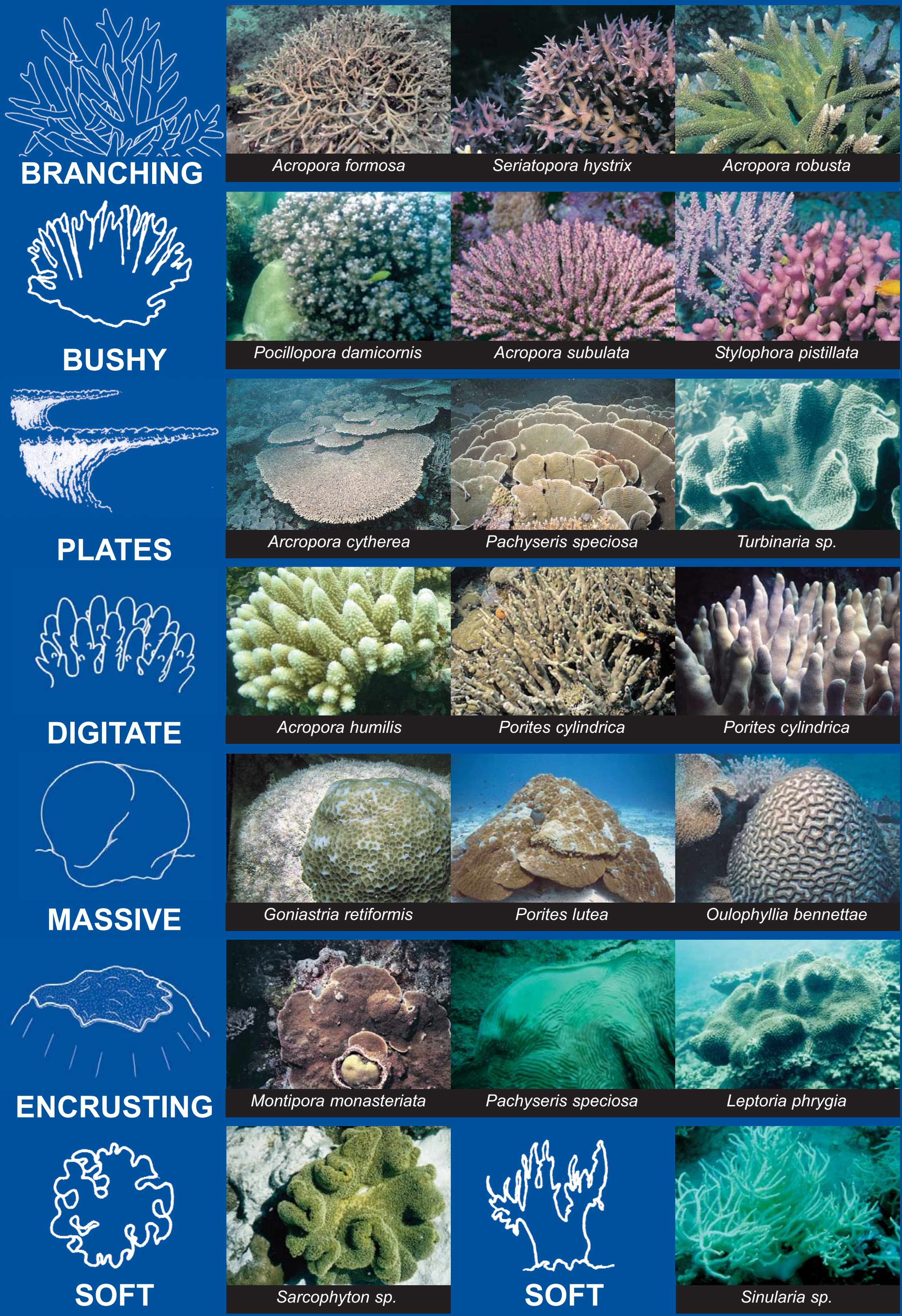


Figure 4. Some different types of coral, organised by shape.
Figure used with permission from the Great Barrier Reef Marine Park Authority.

Corals in Trouble?

There are many threats to coral reef ecosystems today, including cyclones, crown-of-thorns starfish, and coral bleaching. In 2015 and 2016, coral bleaching was especially severe on some parts of the reef due to high water temperatures (find out more at the Great Barrier Reef Marine Park Authority website).

When corals lose their zooxanthellae, they lose a crucial source of food, as this activity has demonstrated. Without zooxanthellae, corals can starve and die. This is alarming, as coral reefs are the foundation of these ecosystems, sustaining thousands of species, and supporting valuable industries like fishing and tourism.

Researchers at the Queensland Museum are investigating whether corals that live in deep water can help replenish the population of corals in shallow water that are severely affected by coral bleaching. (Corals in deep water are usually not as strongly affected by bleaching caused by high water temperatures.)

You can also watch a video of Dr Paul Muir, one of Queensland Museum's coral researchers, at this link: https://learning.qm.qld.gov.au/resources/1568357