

An underwater photograph of a coral reef. The water is clear and blue. In the foreground, there are large, flat, brownish-orange coral structures. In the background, a diver is visible, silhouetted against the light. The overall scene is vibrant and detailed.

UNIT 11: REEF ZONATION



Khaled bin Sultan
Living Oceans
Foundation

CORAL REEF ECOLOGY CURRICULUM



Khaled bin Sultan

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This unit is part of the *Coral Reef Ecology Curriculum* that was developed by the Education Department of the Khaled bin Sultan Living Oceans Foundation. It has been designed for secondary school students, but can be adapted for other uses. The entire curriculum can be found online at lof.org/CoralReefCurriculum.

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STANDARDS

- **CCSS:** RST.9-10.1, 2, 3, 4, 5, 7, 8, 10; RST.11-12.1, 2, 3, 4, 8, 10; SL.9-10.1, 2, 3, 6; SL.11-12.1, 2, 3, 6
- **NGSS:** HS-ESS2-1, HS-LS2-6
- **OLP:** 5.B.7, 5.B.8, 5.C.33, 7.A.5, 7.C.2, 7.C.3

ONLINE CONTENTS

- [Reef Zonation Quiz](#)
- [Coral Reef Zones Video](#)
Scientists divide coral reefs into zones. They base these divisions on location within the reef and characteristics such as depth, wave action, light intensity, temperature, and water chemistry. Zones of the reef include: lagoon, back reef, reef flat, reef crest, and fore reef.

REEF ZONATION

This lesson is a part of the *Reef Zonation* unit, which explains the characteristics and location of the reef zones. Below is a summary of what is included in the entire unit.

UNIT CONTENTS

A. [Background Information](#)

- Reef Zones
- Zonation Patterns

B. Lessons

[Watch it! Coral Reef Zones](#)

- A worksheet to accompany the [Coral Reef Zones](#) video

[Modeling the Reef](#)

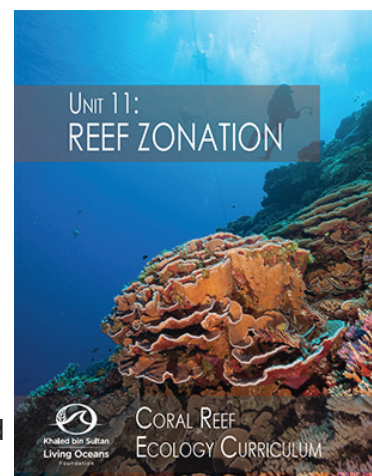
- An art project to research and model a coral reef

[GIS Mapping](#)

- An activity exploring interactive GIS mapping tools

[Read it! Let's Name the Zones](#)

- A worksheet to accompany the [Let's Name the Zones, the Zones, the Zones of the Reefs... of Raivavae and Tubuai](#) field blog



BACKGROUND INFORMATION

A) REEF ZONES

In *Unit 10: Reef Types*, we learned that there are three main types of reefs: **fringing**, **barrier**, and **atoll** (figure 11-1; see). Each reef type can be divided into zones. These zones are defined by location and **abiotic factors** such as depth, wave energy, light intensity, temperature, and water chemistry. It's important to understand the parameters of each zone because these factors influence the distribution of particular organisms, especially corals. In this lesson, we will learn about the characteristics and location of the following reef zones: the reef flat, reef crest, fore reef or reef front, and back reef.



FIGURE 11-1. a) Fringing reef; b) Barrier reef; c) Atoll

While the **lagoon** is not technically a zone, it can be used to help describe some of the zones. This shallow body of water is separated from the ocean either by a coral reef or by land (figure 11-2). They can contain **patch reefs**, seagrass beds, coral rubble (broken coral), and sand. Lagoons occur throughout the Pacific and Indian Oceans, while smaller ones (not as deep or wide) exist in the Atlantic Ocean.

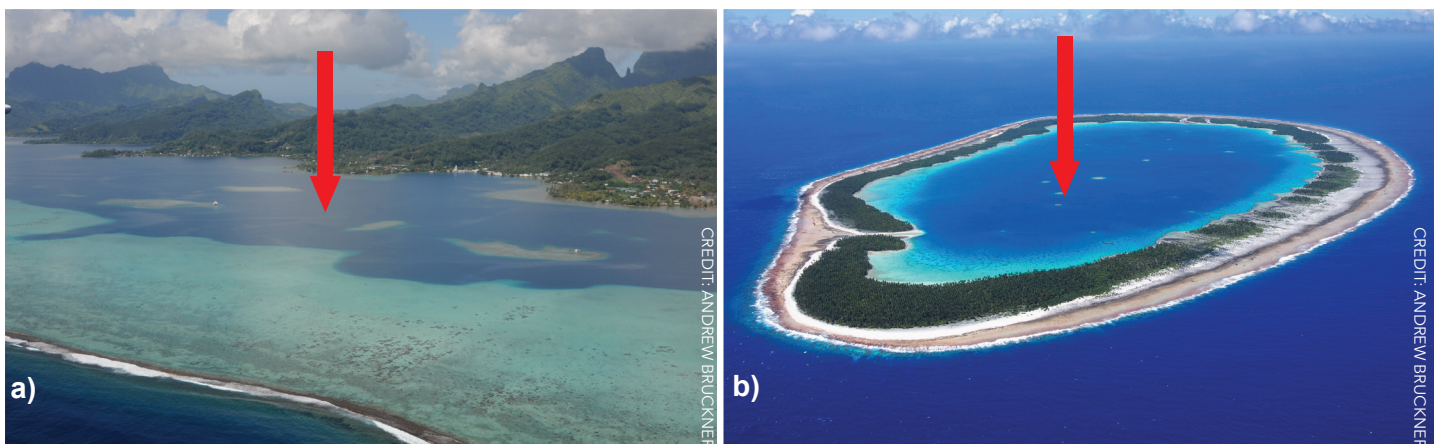


FIGURE 11-2. a) Barrier reef, Society Islands; b) Maria Est Atoll, Tuamotu Archipelago. The red arrows indicate the location of the lagoons.

Water temperature in the lagoon depends on the size and depth of the lagoon as well as the amount of wave action. For instance, a small, shallow lagoon with little wave action may get very hot.

Lagoons that are near mangroves or areas with human development may contain water with high nutrients and low visibility. It is difficult for many species of coral to thrive in this environment.

REEF FLAT

The **reef flat** is an area that is protected from wave action (figure 11-3). The reef flat can extend for feet to miles (meters to kilometers) and the depth can range from inches to several feet (centimeters to a meter). Corals in this zone have adapted to tolerate a wide range of temperatures, light intensity, and salinity. Additionally, corals have adapted to low levels of dissolved oxygen in seawater. When water temperatures are high (over 104°F/ 40°C), there is less dissolved oxygen in seawater. Sometimes during low tide, corals are exposed to air.

Due to these difficult living conditions, the diversity of life on reef flats is much lower when compared to the other zones. Species in this zone have adapted to these extreme environmental conditions and many are found exclusively in this zone.

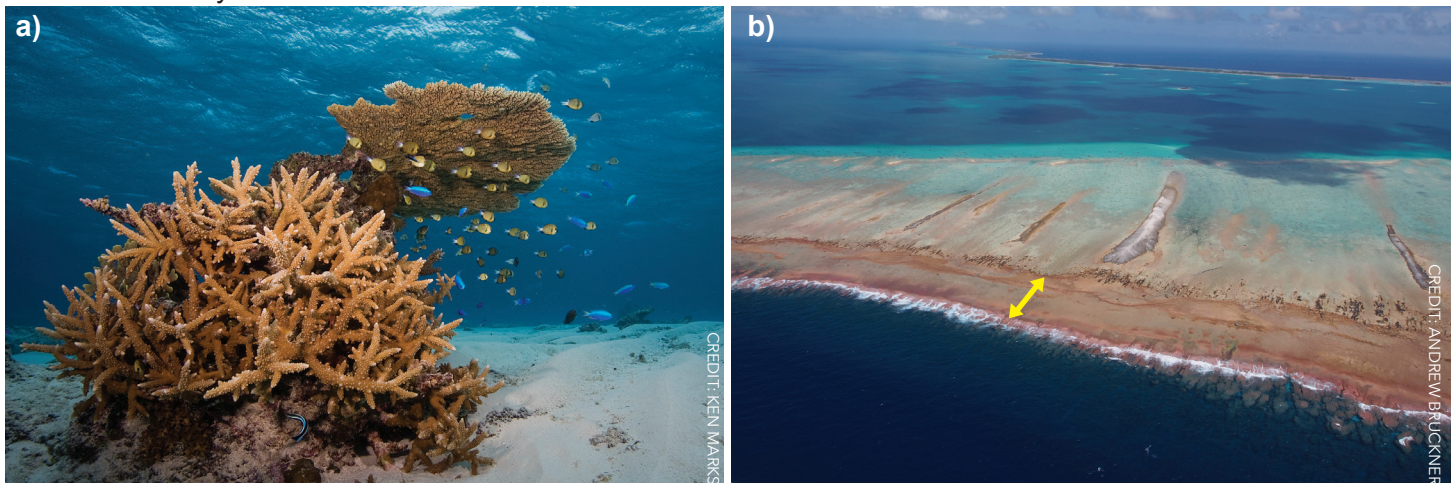


FIGURE 11-3. a) Underwater view of a reef flat; b) The yellow arrow is pointing to the width of the reef flat.

REEF CREST

The **reef crest** is the highest point of the reef (figure 11-4). The reef crest breaks waves and receives the fullest impact of wave energy. During low tide, reef crests can be exposed to air. This zone also receives the greatest amount of light intensity, as it is closest to the water's surface, or even above it. Due to these harsh conditions, not all organisms are able to live here. Corals that do live here must have strong structures that can withstand intense wave action, high light intensity, and aerial exposure in order to thrive in this zone.

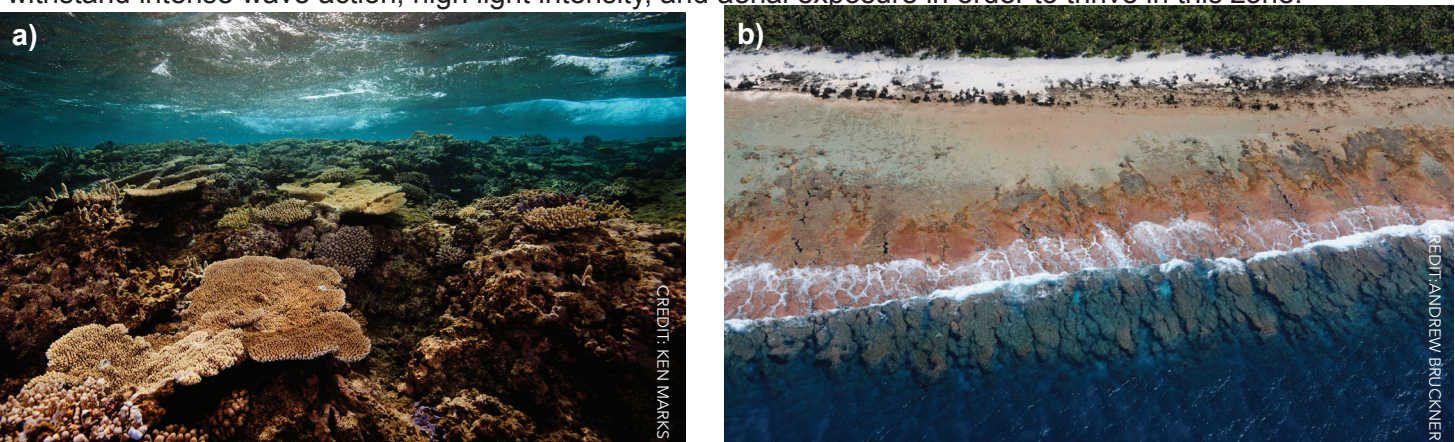


FIGURE 11-4. a) Underwater view of the reef crest; b) The area where the waves are breaking is the reef crest.

In the Pacific and Indian Oceans, this zone can be dominated by calcareous (composed of **calcium carbonate** CaCO_3) coralline red algae. In cases such as these, the zone is often referred to as the **algal ridge**. These hard algae are found in elevated ridges as well as **spur and groove reef** formations (figure 11-5) that extend seaward. Spurs refer to the areas that form parallel ridges of coral growth, while grooves separate these ridges and contain sediment and coral rubble that has eroded from the spurs.





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FIGURE 11-5. Spur and groove reef formation

REEF FRONT OR FORE REEF

The **reef front** or **fore reef** (figure 11-6) is found at the furthest distance from shore. It slopes downward and can reach great depths. Sometimes the reef front extends almost straight down forming a vertical wall called a **drop-off**.

Most corals thrive in the intermediate zone of the reef front between 15-65 feet (5-20 meters) deep. This is where the greatest diversity of corals exist. In both shallower and deeper parts of this zone, diversity declines and some corals have adapted to living at specific depths. Corals in this intermediate zone are exposed to relatively low wave action and light. Often, corals modify their growth forms in order to survive in different zones (see *Unit 9: Coral Growth*). For instance, plate corals have more surface area allowing for these corals to receive a greater amount of light. This in turn allows zooxanthellae to create food and nutrients for the corals (see *Unit 4: Coral Feeding*).



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FIGURE 11-6. Reef fronts

BACK REEF

The **back reef** is an area that slopes into a lagoon. The back reef is often shallow and more protected from wave action (figure 11-7). It can be exposed to air during low tide. Isolated patch reefs often exist here as well as coral rubble.



FIGURE 11-7. The red arrow is pointing to the back reef of the atoll in Tuamotu, French Polynesia. It is the area of turquoise water.

B) ZONATION PATTERNS

Fringing reefs, barrier reefs, and atolls may have different characteristics, yet, they have similar zonation patterns.

A fringing reef does not have a lagoon or a back reef. The reef flat extends from the shoreline, ending at the reef crest. The reef front is found on the oceanic side of the reef crest. See figure 11-8.

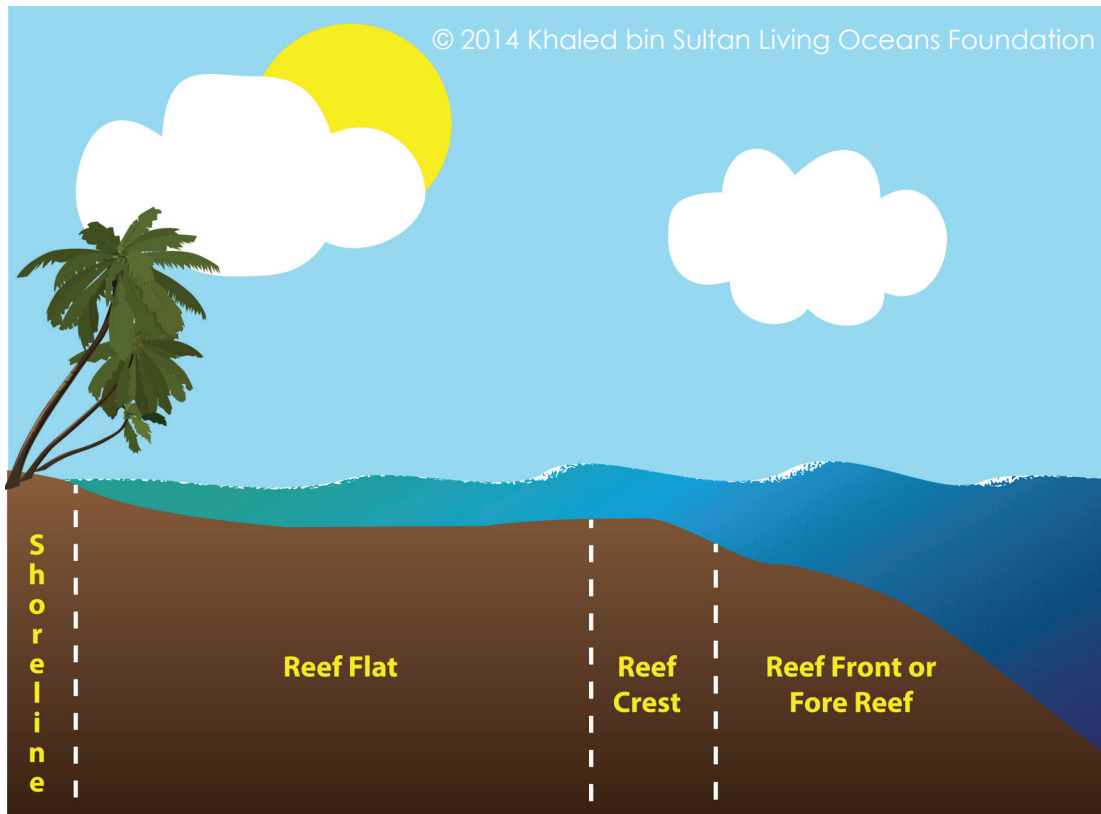


FIGURE 11-8. Cross-section of fringing reef

Barrier reefs are separated from land by a lagoon (figure 11-9). The reef crest is bordered by the back reef, on the shore side, and the reef front, on the oceanic side (when there is not reef flat). Barrier reefs can have a reef flat that is found between the back reef and reef crest (not seen in figure 11-9).

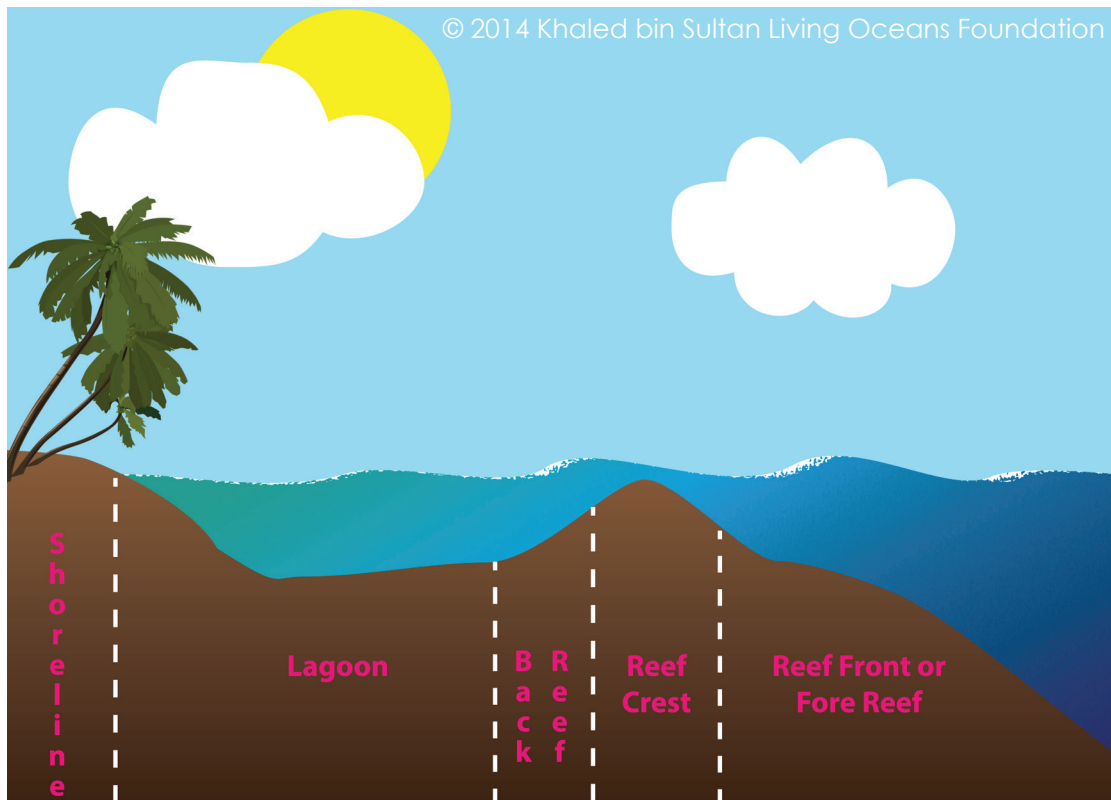


FIGURE 11-9. Cross-section of barrier reef

Remember that atolls are a somewhat circular shape. In the center of the atoll is a lagoon, which can be completely enclosed by land (figure 11-2b) or partially surrounded, allowing for water to flow in and out of the lagoon through channels. Most of the reef is on the outside of the atoll. In atolls, reef flats can be found on the ocean-facing side of land (figure 11-10) or next to the back reef (not in figure 11-10). The reef front is found on the outer, oceanic side of the atoll. There can be a back reef on the inner part of the atoll that slopes into a lagoon.

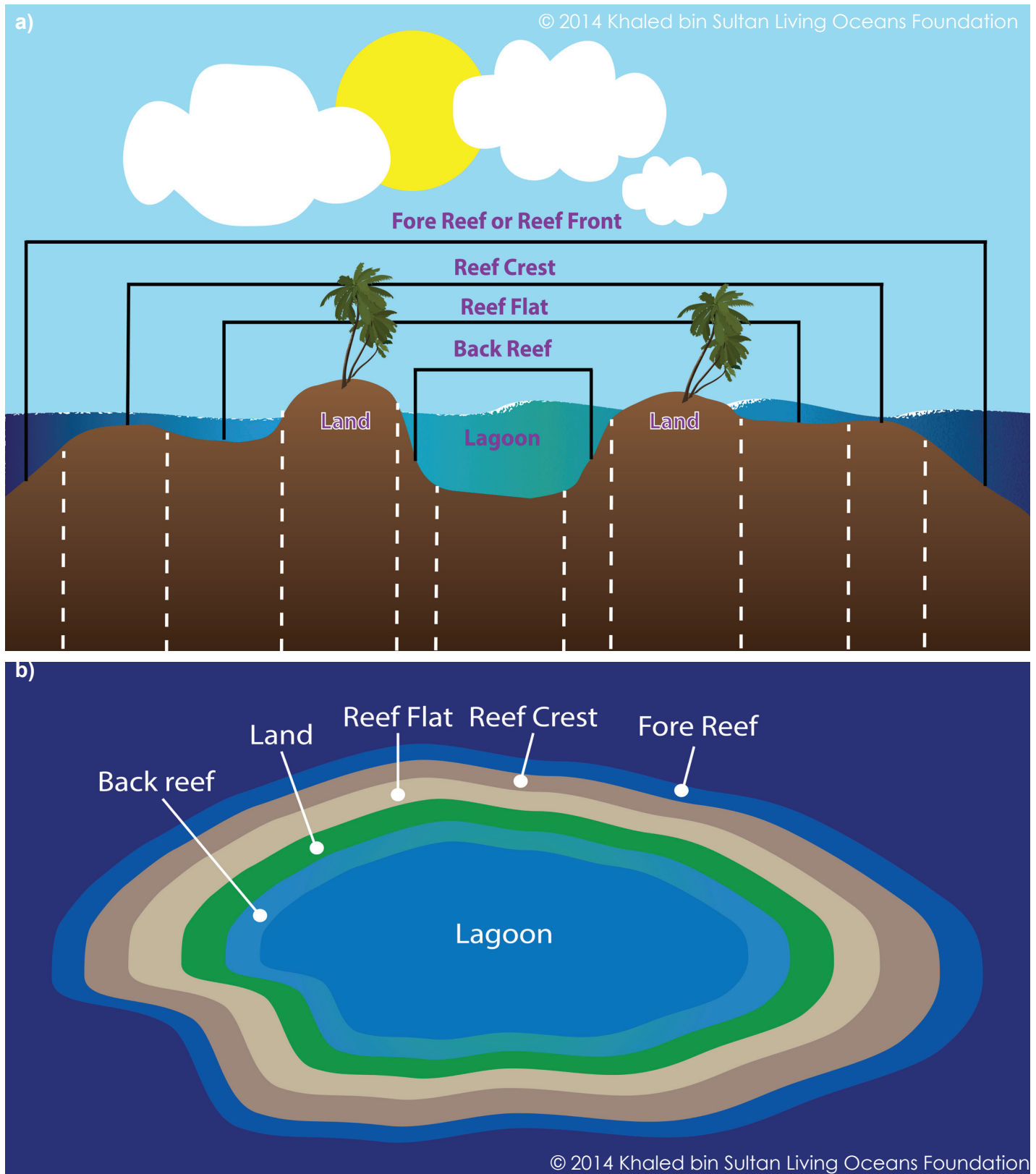


FIGURE 11-10. a) Cross-section of atoll; b) Aerial view of an atoll



ATTRIBUTION

Figure 11-8-11.10a. Palm tree vector by Sergio Fiallo [CC0 1.0 Universal (<http://creativecommons.org/publicdomain/zero/1.0/>)], 08 May 2011 via Clker.com. <http://www.clker.com/clipart-alone-palm-tree.html>.

An underwater photograph of a coral reef. In the upper left, a diver is visible in silhouette against the bright blue water. The reef itself is a complex structure of various coral species, including large, flat, table-like corals in shades of brown, orange, and red. The water is clear and blue, with some light rays visible. The overall scene is vibrant and detailed.

CORAL REEF ECOLOGY CURRICULUM

The Coral Reef Ecology Curriculum is a comprehensive educational resource designed to educate people about life on coral reefs. Developed by educators and scientists at the Khaled bin Sultan Living Oceans Foundation, this curriculum strives to increase ocean literacy by creating awareness about coral reefs, the threats they face, and how people can help to preserve these diverse ecosystems.



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The Khaled bin Sultan Living Oceans Foundation is a US-based nonprofit environmental science organization. The Foundation was established to protect and restore the world's oceans through scientific research, outreach, and education.